# UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

**F-22A, T/N 07-4146**
**90TH FIGHTER SQUADRON**
**3RD WING**
**Joint Base Elmendorf-Richardson, Alaska**

**LOCATION: NAVAL AIR STATION FALLON, NEVADA**

**DATE OF ACCIDENT: 13 APRIL 2018**

**BOARD PRESIDENT: COL JACOB TRIGLER**

*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.*

# Conducted IAW Air Force Instruction 51-503

## EXECUTIVE SUMMARY
## UNITED STATES AIR FORCE
## AIRCRAFT ACCIDENT INVESTIGATION
## F-22A, T/N 07-4146
## Naval Air Station Fallon, NV
## 13 April 2018

On 13 April 2018 at approximately 1745 Zulu (Z), 1045 Local (L) time, an F-22A Raptor, T/N 07-4146, assigned to the 90th Fighter Squadron, 3rd Wing, Joint Base Elmendorf-Richardson, Alaska, took off from runway 31 Left (31L) at Naval Air Station (NAS) Fallon, Nevada. The mishap pilot (MP) initiated a military power (MIL) takeoff and rotated at 120 knots calibrated airspeed (KCAS). As the MP recognized his visual cues for the mishap aircraft (MA) becoming airborne, he raised the landing gear handle (LGH) to retract the landing gear (LG). Immediately after main landing gear (MLG) retraction, the MA settled back on the runway with the MLG doors fully closed and the nose landing gear (NLG) doors in transit. The MA impacted the runway on its underside and slid approximately 6514 feet (ft) until it came to rest 9,419 ft from the runway threshold. Once the MA came to a complete stop, the MP safely egressed the aircraft. There were no injuries, fatalities, or damage to civilian property.

The Accident Investigation Board (AIB) President found by a preponderance of the evidence that the causes of the mishap were two procedural errors by the MP. First, the MP had incorrect Takeoff and Landing Data (TOLD) for the conditions at NAS Fallon on the day of the mishap, and more importantly, he failed to apply any corrections to the incorrect TOLD. Second, the MP prematurely retracted the LG at an airspeed that was insufficient for the MA to maintain flight. Additionally, the AIB President found by the preponderance of the evidence that four additional factors substantially contributed to the mishap: inadequate flight brief, organizational acceptance of an incorrect technique, formal training, and organizational overconfidence in equipment.

# SUMMARY OF FACTS AND STATEMENT OF OPINION
# F-22A, T/N 07-4146
# 13 April 2018

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| 2FLUG | Two-Ship Flight Lead Upgrade |
| 3 WG | 3rd Wing |
| 4FLUG | Four-Ship Flight Lead Upgrade |
| 31L | 31 Left |
| 90 FS | 90th Fighter Squadron |
| AB | After Burner |
| AF | Air Force |
| AFB | Air Force Base |
| AFE | Air Flight Equipment |
| AFI | Air Force Instruction |
| AFPAM | Air Force Pamphlet |
| AGE | Aerospace Ground Equipment |
| AGL | Above Ground Level |
| AIB | Accident Investigation Board |
| AK | Alaska |
| AMRAAM | Advanced Medium Range Air to Air Missile |
| AMXS | Aircraft Maintenance Squadron |
| AMAD | Airframe Mounted Accessory Drive |
| AOA | Angle of Attack |
| ASL | Above Sea Level |
| AVEL | AMRAAM Vertical Ejection Launcher |
| B-Course | Basic Course |
| BFM | Basic Fighter Maneuver |
| BRAG | Breathing Regulator/Anti-G |
| C | Celsius |
| Capt | Captain |
| CAUT | Caution |
| CDM | Climb Dive Marker |
| CIP | Core Integrated Processor |
| Col | Colonel |
| CSMU | Crash Survivable Memory Unit |
| DoD | Department of Defense |
| DMVR | Data Transfer/Mass Memory and Video Recorder |
| DTC | Data Transfer Cartridge |
| ECS | Environmental Control System |
| EOS | Emergency Oxygen System |
| EPS | Emergency Power System |
| F | Fahrenheit |
| FCIF | Flight Crew Information File |
| FDP | Flight Duty Period |
| FL | Flight Lead |
| FLCS | Flight Control System |
| FPS | Fire Protection System |
| FRC | Fault Reporting Codes |
| FS | Fighter Squadron |
| ft | Feet |
| g | Gravitational Force |
| GX | Gravity Exercise |

| | |
|---|---|
| HUD | Heads-Up Display |
| IAW | In Accordance With |
| ICAWS | Integrated Caution, Advisory and Warning System |
| IFDL | Intra-Flight Data Link |
| IFPC | Integrated Flight/Propulsion Control |
| IMDS | Integrated Maintenance Database System |
| IMIS | Integrated Maintenance Information System |
| IP | Instructor Pilot |
| ITS | Index of Thermal Stress |
| IVSC | Integrated Vehicle Subsystem Controller |
| JBER | Joint Base Elmendorf-Richardson |
| K | Thousand |
| KCAS | Knots Calibrated Airspeed |
| KTAS | Knots True Airspeed |
| kts | Knots |
| L | Local Time |
| LG | Landing Gear |
| LGH | Landing Gear Handle |
| LM-Aero | Lockheed Martin Aeronautics Company |
| Lt Col | Lieutenant Colonel |
| LO | Low Observable |
| LWD | Left Wing Down |
| M | Mach |
| MA | Mishap Aircraft |
| Maj | Major |
| MAJCOM | Major Command |
| MFL | Mishap Flight Lead |
| MIL | Military (Power) |
| MOA | Military Operating Area |
| MP | Mishap Pilot |
| MQT | Mission Qualification Training |
| MRT | Maintenance Recovery Team |
| MS | Mishap Sortie |
| MSL | Mean Sea Level |
| ND | Nose Down |
| NM | Nautical Miles |
| NOTAMs | Notices to Airmen |
| OBIGGS | On-board Inert Gas Generating System |
| OBOGS | On-board Oxygen Generating System |
| OG | Operations Group |
| OPR | Officer Performance Report |
| Ops Tempo | Operations Tempo |
| ORM | Operational Risk Management |
| OSS | Operation Support Squadron |
| PA | Public Affairs |
| P&W | Pratt and Whitney |
| PACAF | Pacific Air Forces |
| PHA | Preventive Health Assessment |
| PM1 | Pilot Member 1 |

| | |
|---|---|
| PM2 | Pilot Member 2 |
| PM3 | Pilot Member 3 |
| PMP | Packaged Maintenance Plan |
| PR | Pre Flight |
| PSI | Pounds Per Square Inch |
| QA | Quality Assurance |
| RPM | Revolutions Per Minute |
| RWD | Right Wing Down |
| SAR | Search and Rescue |
| SEFE | Standardization & Evaluation Flight Examiner |
| SIB | Safety Investigation Board |
| SII | Special Interest Item |
| SM | Statute Miles |
| SOF | Supervisor of Flying |
| TCTO | Time Compliance Technical Order |
| T/N | Tail Number |
| TDY | Temporary Duty |
| TO | Technical Order |
| TOD | Technical Order Data |
| TOLD | Take-Off Landing |
| VFR | Visual Flight Rules |
| VVI | Vertical Velocity Indication |
| WSEP | Weapon System Evaluation Program |
| WPAFB | Wright-Patterson Air Force Base |
| 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 2 May 2018, Major General Russell L. Mack, Deputy Commander, Pacific Air Forces (PACAF), appointed Colonel Jacob Trigler to conduct an aircraft accident investigation on the 13 April 2018 crash of an F-22A Raptor, tail number (T/N) 07-4146, at Naval Air Station (NAS) Fallon, Nevada (Tab Y-3). The investigation was conducted at NAS Fallon from 15 - 16 May, and Joint Base Elmendorf-Richardson (JBER), Alaska from 17 May 2018 - 11 June 2018. The following board members were also appointed: a Major Legal Advisor, a Captain Pilot Member, a Captain Medical Member, a Captain Maintenance Member, and a Staff Sergeant Recorder (Tab Y-5 to Y-11).

### b. Purpose

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

## 2. ACCIDENT SUMMARY

At approximately 1745 Zulu (Z), 1045 Local (L) time, on 13 April 2018, the mishap pilot (MP), flying the mishap aircraft (MA), an F-22A Raptor, T/N 07-4146, took off from runway 31 Left (31L) at NAS Fallon, Nevada for a TOPGUN graduation exercise. The MP initiated a military power (MIL) takeoff and rotated at 120 knots calibrated airspeed (KCAS) (Tab DD-4). Rotation occurs when the pilot initiates back stick pressure to lift the nose of the aircraft off the ground and set the takeoff pitch attitude. Once the MP recognized his visual cues for takeoff, he raised the landing gear handle (LGH) to retract the landing gear (LG). After main landing gear (MLG) retraction, the MA impacted the runway with all but the nose landing gear (NLG) doors fully closed (Tab J-4).

The MA impacted approximately 2,905 ft from the runway threshold on the centerline and slid approximately 6,514 ft until it came to rest 9,419 ft from runway threshold (Tab S-13). While the MA was sliding down the runway, the MP shut off both engines. Once the plane was at a complete stop, the MP safely egressed the MA (Tab V-1.3). There were no injuries, fatalities, or damage to civilian property (Tab P-1).

## 3. BACKGROUND

The MA belongs to the 3rd Wing (3 WG) at JBER. It is operated by the 90th Fighter Squadron (90 FS). The MP is a member of the 90 FS and was on a temporary duty (TDY) to NAS Fallon to conduct a Basic Fighter Maneuver (BFM) sortie for a TOPGUN graduation exercise (Tab R-26). During the MP's takeoff, the MA impacted the runway with the landing gear retracted (Tabs J-4, S-2 to S-4).

### a. Pacific Air Forces (PACAF)

PACAF delivers rapid and precise air, space and cyberspace capabilities to protect and defend the United States, its territories and our allies. PACAF provides integrated air and missile defense and warning; commands and controls joint airpower and integrated air and missile defense assets; promotes interoperability in a power projection theater; and is postured to respond across the full spectrum of military contingencies in order to restore regional security. PACAF's area of responsibility is home to 60 percent of the world's population in 36 nations spread across 52 percent of the Earth's surface and 16 time zones, with more than 1,000 languages spoken. The unique location of the Strategic Triangle (Hawaii-Guam-Alaska) gives our nation persistent presence and options to project U.S. airpower from sovereign territory. The command has approximately 46,000 military and civilian personnel serving in nine strategic locations and numerous smaller facilities.

### b. 3rd Wing

The 3 WG provides premier combat-ready aerospace forces to warfighting commanders tasked to defend and protect U.S. interests in the Pacific region and around the world. The Wing trains, mobilizes, and employs squadrons comprised of C-17 Globemaster, C-12 Huron, E-3 Sentry, and F-22 Raptor aircraft, providing unmatched air dominance, global mobility, and command and control for Combatant Commanders. Additionally, the Wing sustains installation operations at Joint Base Elmendorf-Richardson for critical force-staging and throughput operations in support of worldwide contingencies.

### c. 90th Fighter Squadron

The 90 FS is assigned to the 3rd Operations Group, Joint Base Elemendorf-Richardson, Alaska. The Squadron is equipped with the F-22 Raptor Fighter. The 90 FS is one of the oldest units in the United States Air Force, first being organized as the 90th Aero Squadron on 20 August 1917 at Kelly Field, Texas.

### d. F-22A Raptor

The F-22A Raptor is a single seat, multi-role fighter aircraft. Its combination of stealth, supercruise, maneuverability, and intergrated avionics represents an exponential leap in warfighting capabilities and makes it the world's most advanced fighter. The Raptor performs both air-to-air and air-to-ground missions allowing it to project air dominance and defeat threats attempting to deny access to our nation's Air Force, Army, Navy and Marine Corps. This capability provides a critcal edge to joint force commanders and acts as an effective deterrent to future adversaries.

## 4. SEQUENCE OF EVENTS

### a. Mission

The mission was scheduled and briefed as a TOPGUN graduation exercise sortie. The mission was to take off from NAS Fallon and fly to a predesignated point in the assigned airspace in order to fight BFM against a Navy F-18 Hornet, piloted by a TOPGUN student. This mission would include advanced maneuvering, including aggressive gravitational forces imposed on each pilot during the fight. The MP's callsign was TOPGUN65, and he was flying as a single-ship for the departure with the intent to join with his opponent in the airspace (Tab K-2 to K-3).

### b. Planning and Preflight

The MP's duty day began with a mass brief at 0800L, given by a local Navy pilot (Tab R-44). All participants in the exercise were briefed on local operating procedures, as well as the weather, Notices to Airmen (NOTAMS), and Special Interest Items (SIIs). Participants planned to fly a Visual Flight Rules (VFR) departure in accordance with (IAW) the brief and their specific lineup card (Tab K-2). The brief focused on the unfamiliar airspace, the VFR departure, and collision avoidance with other aircraft, both on the departure and during the fight (Tab V-3.8). No applicable NOTAMS were active for the airfield (Tab R-41). None of the 90 FS pilots interviewed noted anything abnormal about the brief (Tab V-1.18, V-3.5).

The four 90 FS pilots conducted a flight brief after the mass brief and discussed hydration, high-G maneuvering, airspace deconfliction, entry and exit procedures, as well as normal risks and how to mitigate them in accordance with the SIIs (Tab R-44 to R-45). An Operational Risk Management (ORM) sheet was not filled out due to being TDY. Takeoff and Landing Data (TOLD) was not computed IAW applicable technical order data (TOD) for the conditions at NAS Fallon on the day of the mishap, and the TOLD displayed on the MP's lineup card was incorrect (Tabs K-2, V-1.8, V-3.7).

Following the flight brief, the MP and Pilot Member 3 (PM3) had about 45 minutes prior to stepping to the aircraft. The MP and PM3 went to get some water and food before returning to the hangar. During this time, the two pilots discussed the upcoming mission and PM3 noted that the MP seemed prepared and comfortable with the mission. The MP then donned his flight gear and stepped to the aircraft (Tab V-1.12). The MA's preflight was accomplished IAW all applicable technical order procedures, and no deficiencies were noted (Tab V-1.5 to V-1.6). Ground and taxi operations for the sortie were uneventful.

### c. Summary of Accident and Impact

The MP started engines at 1024L. At 1036L, the MP was cleared to taxi to runway 31L and proceeded to taxi without incident. The MP was subsequently cleared for takeoff and then advanced the throttles to MIL to begin his takeoff sequence (Tab DD-4). All actions up to this point were uneventful.

The MP accelerated down the runway until reaching a speed of 120 KCAS, at which point he began his rotation sequence by applying slight aft stick pressure to pull the nose to a 10-degree pitch attitude (Tabs V-1.3 and CC-3 to CC-4). The aircraft continued to accelerate and at 135 KCAS the weight-on-wheels switch indicated that the aircraft was lifting off of the ground (Tab CC-3 to CC-4). As the MA accelerated to 142 KCAS, the MP recognized his visual cues for takeoff and retracted the LG (Tabs CC-3 to CC-4, V-1.3). The LGH was raised 1.0 second after the weight-on-wheels switch indicated "off" (Tab DD-4). As the LG retracted, the aircraft reached a maximum speed of 148 KCAS (Tab DD-4). At approximately this time, and at 2,905 ft from the runway threshold, the aft section of the aircraft made contact with the runway and the nose of the aircraft began to drop down (Tab S-13). Approximately one second later the MA's belly had completely made contact with the runway surface (Tab DD-4).

As the MA contacted the runway, the MP selected maximum afterburner (AB) thrust for one second then reduced the throttles to idle as the MA fully abutted the runway (Tabs J-13, V-1.6, V-1.3 to V-1.4). Both throttles were reduced so quickly that neither engine actually initiated AB (Tab J-13). At 4,877 ft from the runway threshold, the MP lowered the tail hook IAW abort procedures (Tabs S-13, V-1.3). As the MA slid down the runway, the MP shut off both engines (Tabs J-13, V-1.3). The tail hook continued to intermittently impact the runway surface until the aircraft came to a complete stop 9,419 ft from the runway threshold and offset several feet to the right of the runway centerline (Tab S-2 to S-4, S-13).

### d. Egress and Aircrew Flight Equipment (AFE)

The MA stopped on the runway 9,419 ft from the runway threshold (Tab S-13). The MP then raised the canopy and safely egressed the aircraft (Tab V-1.3). Emergency crews responded and the scene was contained without any indication of fire and without injury to the MP (Tab X-3).

The MP's aircrew flight equipment (AFE) inspections were current and deemed serviceable by the 3rd Operations Support Squadron (OSS) AFE personnel (Tab T-3 to T-5). The MP wore all required flight equipment for the mission and there were no indications of any malfunctions with the equipment during the mishap (Tab T-3 to T-5).

### e. Search and Rescue (SAR)

This section is N/A for this mishap.

### f. Recovery of Remains

This section is N/A for this mishap.

## 5. MAINTENANCE

### a. Forms Documentation

The F-22A features a digital forms documentation process located on the Integrated Maintenance Information System (IMIS). Data on IMIS is input directly onto portable maintenance aid laptops by personnel who utilize an aircraft forms drive as they perform each task. The data is then uploaded to a master IMIS server. The Integrated Maintenance Database System (IMDS) is an additional management information system used by the USAF which contains F-22 data transferred from IMIS. After the mishap, the Safety Investigation Board (SIB) secured the MA's forms drive (Tab Q-2). A comprehensive 30-day review on the MA's IMIS and IMDS records showed that the aircraft was deemed mission capable and airworthy on the day of the mishap (Tab D-3 to D-11).

### b. Inspections

In the 24 hours prior to the mishap, the following maintenance tasks were performed: A 50-hour scheduled inspection on the aircraft refueling door latch, an auxiliary power unit bay hydraulic clamp inspection, and a left and right engine oil servicing door latch inspection (Tab U-31). Upon arrival at NAS Fallon, JBER maintenance personnel performed a basic post-flight/pre-flight inspection. Specifically, they completed a pre-flight walk around of the entire aircraft, engine oil sampling and servicing, and left and right engine inlet/exhaust inspections (Tab U-24 to U-29). A fuel top-off to 17.4K pounds (lbs) was performed utilizing a NAS Fallon fuel truck IAW applicable TOD (Tab U-27). Servicing checks were accomplished on the stored energy system, MLG tire pressure, system one and two hydraulic fluid levels, fuel quantity, automatic breathing oxygen system, and weapons stations (Tab U-24 to U-29). Of the items checked, only the stored energy system, the #2 engine oil level, and the station nine Advanced Medium Range Air to Air Missile

(AMRAAM) Vertical Ejection Launcher (AVEL) required servicing (Tab U-25 to U-29). On the morning of the mishap, servicing checks were re-accomplished with no changes noted. All aerospace ground equipment (AGE) used to service safety of flight systems was evaluated and verified to be in good working order (Tab U-38 to U-41).

### c. Maintenance Procedures

Preflight inspections were accomplished IAW applicable TOD. (Tab U-24-29).

### d. Maintenance Personnel and Supervision

No maintenance personnel or supervision issues were identified.

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

Post-mishap samples of engine oil and hydraulic fluid were pulled from the MA for analysis at the Air Force Petroleum Lab at Wright-Patterson Air Force Base (WPAFB), Ohio. Testing of the samples did not reveal any abnormal findings for in-use fluids (Tab U-10 to U-14). Samples of JET-A from the Tyndall AFB and NAS Fallon fuel trucks that serviced the MA on the day prior to the mishap were tested, and all were within normal limits (Tab U-16). There are no records of fuel samples being taken from the MA. There are also no records of fuel samples from the fuel trucks used at the two intermediate stops, Sheppard AFB and Colorado Springs Municipal Airport.

Sensors in multiple locations monitor the oxygen system of the F-22A. On 23 February 2018, a scheduled 90-day breathing system test was performed on the MA's oxygen system indicating zero abnormalities (Tab U-38). On the day of the mishap, the MA detected no oxygen system faults during the sortie (Tab V-1.13). While oxygen and air pressure sensors actively monitor the system's performance, they are located outside of the Breathing Regulator/Anti-G (BRAG) valve (Tab DD-3). To further rule out any mechanical factors related to the breathing system, the BRAG valve and pilot breathing hose were removed for evaluation. There is no indication that these parts contributed to the mishap.

### f. Unscheduled Maintenance

In the 96 hours prior to the mishap, four unscheduled maintenance tasks were accomplished. One involved troubleshooting an Electronic Warfare Software anomaly on 10 April 2018, which required no physical maintenance actions and cleared with a reset of the system (Tab U-30). Additionally, Low Observable (LO) coating evaluations were accomplished after flights on 9 April 2018 and 10 April 2018 and were deemed unrelated to safety of flight (Tab U-32 to U-34). On 9 April 2018, the MA landed with a "seat not armed" indication, which was repaired by replacing the "seat not armed" light switch (Tab U-37).

# 6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

## a. Structures and Systems

Data Transfer Cartridge & Crash-Survivable Memory Unit:

The F-22A contains a fault reporting and health monitoring system in which data is captured and ultimately recorded on the Data Transfer Cartridge (DTC) (Tab J-7, J-20). The DTC records raw performance data from aircraft subsystems collected throughout the sortie and is utilized for post-mission troubleshooting (Tab J-20). Similar to the DTC, the Crash Survivable Memory Unit (CSMU) onboard the aircraft collects approximately two hours of data on aircraft performance and is used to determine the events leading up to the crash of an aircraft (Tab J-10 to J-11). On 12 April 2018, the DTC on the MA malfunctioned and was unable to record data for the cross-country sorties from Tyndall AFB to NAS Fallon. However, the MA had a functioning DTC during the mishap sortie on 13 April 2018. The CSMU functioned normally and recorded data for the sortie from Colorado Springs to NAS Fallon and for the mishap sortie (Tab J-11).

The LG system on the F-22 consists of a single NLG and two MLG assemblies (Tab J-22). Each MLG provides inputs to a system in the aircraft through two weight-on-wheels switches designed to sense when the aircraft becomes airborne. Sensors on the strut unlock the LGH to allow LG retraction when weight off wheels is detected (Tab J-23). The associated brake system is controlled electronically through rudder pedal inputs utilizing hydraulic pressure. Both MLG shock struts were last serviced on 13 January 2018 (Tab U-35 to U-36 ). During the mishap sortie the MLG and MLG doors were fully retracted and closed before the MA impacted the runway with the only damage sustained from sliding down the runway (Tab S-2 to S-5). The NLG was fully retracted, but the NLG doors contacted the runway while closing (Tab J-23).

The F-22 is powered by two Pratt & Whitney F-119-PW-100 turbofan engines. The engines provide thrust levels sufficient to sustain supersonic flight without the use of AB (Tab J-36). The MA's DTC indicated that both throttles were set at MIL for the takeoff sequence, with revolutions per minute (RPM) parameters reading normal through engine start, taxi, and takeoff (Tab J-19). Performance data retrieved from the MA indicated the engines were performing normally from engine start through shutdown (Tab J-37). The AIB Maintenance Recovery Team (MRT) accomplished full borescopes of the left and right engines and no abnormalities were discovered (Tab U-8 to U-9).

A visual disparity between the left and right engine nozzle positions was noted after the mishap (Tab S-2). During a typical engine shut down with a positive weight-on-wheels indication, the nozzles are commanded to a full open and locked position (Tab J-36). During flight, the nozzles are commanded by one of the aircraft's systems based on current flight conditions (Tab DD-3). With an in-flight engine shutdown, the nozzles will "float" as opposed to being locked in the full open position as during a ground shutdown (Tab J-36). During the mishap, the MA transitioned to an in-flight state when the LG retracted. Therefore, when the engines were subsequently shut off while the MA was sliding down the runway, the engines responded IAW an in-flight shutdown and allowed the nozzles to float (Tab V-1.3). Rather than being commanded to the fully open and locked position as prescribed during a normal ground shutdown, in this situation, both nozzles remained dynamic and continued to move until the aircraft came to a complete stop (Tab J-36).

### b. Evaluation and Analysis

An AIB MRT provided additional support in evaluating the MA at NAS Fallon. The team identified a right alpha probe transducer with multiple small nicks within the first two inches. It is unclear whether the damage occurred before, during, or after the mishap. IAW TOD, this is a non-airworthy condition and would cause an aircraft to be grounded (Tab U-7). The alpha probe is used by the F-22 to calculate speed, angle of attack, and angle of sideslip (Tab DD-3). The right alpha probe was removed for non-destructive evaluation with no significant findings.

Additional analysis was performed on the following components to rule out causality in relation to the mishap. Further evaluation of these items has not highlighted any issues of significant concern in relation to the root cause of the mishap:

-Side Stick Controller Assembly
-BRAG Valve
-Pilot Breathing Hose

## 7. WEATHER

### a. Forecasted and Observed Weather

The NAS Fallon forecasted weather at the scheduled takeoff time for the mishap was: calm winds, visibility of 10 statute miles (SM), few clouds at 8000 ft above ground level (AGL), no weather hazards, and an altimeter setting of 30.45 inches of mercury (in Hg) (Tab F-6). The forecasted temperature was 8 degrees Celsius (C) and the dew point temperature was -6 degrees C, which set the condition of the airfield as normal on the Index of Thermal Stress (ITS) (Tab F-6).

### b. Space Environment

This section is N/A for this mishap.

### c. Operations

This section is N/A for this mishap.

## 8. CREW QUALIFICATIONS

### a. Mishap Pilot

On the day of the mishap, the MP was a 4-ship flight lead (Tab G-2). He had accumulated 340.8 hours in the F-22 and 234.5 hours in the F-22 simulator (Tab G-3). Prior to flying the F-22, the MP flew T-38As as an adversary air pilot at Tyndall AFB and had accumulated 192.9 hours in the T-38 (Tab G-3). The MP had a total time of 575.3 hours in F-22A, T-38A, and T-38C aircraft

(Tab G-4). The MP accomplished an annual instrument checkride on 7 March 2018 and demonstrated the required proficiency in all areas assessed with no additional remarks or discrepancies noted (Tabs G-21 to G-22). The checkride also included an emergency procedures simulator on 27 February 2018, during which the MP successfully demonstrated proficiency in executing emergency procedures during all phases of flight (Tab G-19 to G-22). On 5 September 2017, the MP completed his mission checkride and demonstrated the required proficiency in all areas with no additional remarks or discrepancies noted (Tab G-23 to G-24). The MP's Basic Course (B-Course), Mission Qualification Training (MQT), Two-Ship Flight Lead Upgrade (2 FLUG), and Four-Ship Flight Lead Upgrade (4 FLUG) gradebooks were reviewed with nothing abnormal noted (Tab G-35).

At the time of the mishap, the MP's flight time was as follows (Tab G-5):

| | Hours | Sorties |
|---|---|---|
| 30 days | 21.9 | 15 |
| 60 days | 35.4 | 24 |
| 90 days | 38.4 | 26 |

## 9. MEDICAL

### a. Qualifications

The MP was medically qualified for flying duties at the time of the mishap. He had an unremarkable Preventive Health Assessment on 25 January 2018 and an unremarkable dental exam on 28 July 2017. A comprehensive review of medical records revealed that the MP had no acute or chronic medical issues that required an aeromedical waiver. A search of the Aeromedical Information Management Waiver Tracking System database revealed no prior waivers (Tab X-3).

### b. Health

A post-mishap flight surgeon exam as well as 72-hour and 7-day histories collected on 26 May 2018 demonstrated no performance-limiting illness. The MP was in good overall health and no contributory medical findings were found (Tab X-3).

### c. Pathology

The Armed Forces Medical Examiner System tested blood and urine samples for the MP and seven on-site 90th Aircraft Maintenance Squadron (AMXS) personnel. IAW AFI 91-204, *Safety Investigations and Hazard Reporting* (Tab BB-3 to BB-4), blood and urine samples were used to measure carbon monoxide and blood alcohol levels, and for toxicology screening. All results from the MP and seven 90 AMXS maintenance personnel were negative or otherwise unremarkable (Tab X-3).

### d. Lifestyle

The MP had typical life stressors associated with a demanding job in the squadron and being TDY. His peers and leadership had not noticed a change in his work habits, behavior, or personality prior to the mishap (Tab V-2.9, V-3.14, V-4.2, V-5.1, V-6.1). Additionally, the MP stated that these stressors did not affect him (Tab V-1.19). The 72-hour and 7-day histories did not reveal any significantly unusual lifestyle habits including sleep, diet, hydration, or physical conditioning (Tab X-3).

### e. Crew Rest and Crew Duty Time

According to AFI 11-202, Volume 3, PACAF Supplement, *General Flight Rules*, 23 June 2015, paragraphs 2.2 and 2.1, the flight duty period (FDP) begins when an aircrew member reports for a mission, briefing, or other official duty and ends when engines are shut off at the end of the final flight. The maximum FDP for a single pilot aircraft such as the F-22 is 12 hours (Tabs BB-5 to BB-7). The MP's 13 April 2018 duty day started with the graduation exercise mission briefing at 0800L (Tab V-3.11). At the time of the mishap, 1045L, the MP was less than three hours into his FDP (Tab J-5).

AFI 11-202, Volume 3, PACAF Supplement, paragraph 2.1, notes that crew rest is a minimum of 12 non-duty hours before the FDP begins and must include an opportunity for at least eight hours of uninterrupted sleep (Tab BB-5 to BB-7). Based on MP's arrival time at NAS Fallon on 12 April 2018, he had approximately 15 hours of crew rest prior to start of the FDP on 13 April 2018 (Tab V-3.17).

## 10. OPERATIONS AND SUPERVISION

### a. Operations

The four 90 FS pilots assigned to participate in the TOPGUN graduation exercise experienced a high operations tempo prior to the mishap. They flew from JBER, Alaska, to Tyndall AFB, Florida with other members of their squadron on 2 April 2018 (Tab V-1.3). At Tyndall AFB they participated in the Weapons System Evaluation Program (WSEP) for about 10 days, flying frequently during that time (Tabs R-26 to R-28, V-1.3). Then on 12 April 2018, they flew to NAS Fallon, Nevada, making stops at Sheppard AFB and Colorado Springs Municipal Airport along the way (Tab V-1.3, V-3.7 to V-3.8). The pilots felt that this was a significant amount of flying and indicated feeling some fatigue, but none felt fatigued to the point where safety of flight was at risk (Tabs R-63, V-4.17, V-1.19, V-2.4, V-3.10).

### b. Supervision

The flight authorizations for the cross-country sorties were approved and signed by the 90 FS/DO. The mishap sortie was authorized by the 90 FS/DO and was supervised by the flight lead, PM2 (Tab K-4). On the day of the mishap, each pilot was flying single-ship (Tab V-1.5).

# 11. HUMAN FACTORS ANALYSIS

## a. Introduction

Human factors contributing to this mishap were evaluated using the Department of Defense Human Factors Analysis and Classification System, 01 October 2015 (DoD-HFACS). This guide is designed for use as a comprehensive event/mishap, human error investigation, data identification, analysis and classification tool. It is designed for use by all members of an investigation board in order to accurately capture and recreate the complex layers of human error in context with the individual, environment, team and mishap or event (Tab BB-8). The following human factors were relevant to the mishap:

## b. AE103 Procedure Not Followed Correctly:

Procedure Not Followed Correctly is a factor when a procedure is performed incorrectly or accomplished in the wrong sequence (Tab BB-9).

### (1) Incorrect Application of TOLD

A normal F-22 takeoff sequence begins with the pilot advancing the throttles and accelerating to the computed rotation speed. The pilot then applies slight aft stick pressure to raise the nose to 10-12 degrees pitch attitude. While holding this pitch attitude, the aircraft will become airborne at the computed takeoff speed (Tab DD-4). The computed rotation and takeoff speeds vary based on weight of the aircraft and pressure altitude and are calculated prior to takeoff. For the MA on the day of the mishap, the rotation speed and takeoff speed should have been 143 KCAS and 164 KCAS respectively. However, the MP rotated at 120 KCAS, and the MA first registered weight off wheels at 135 KCAS (Tab DD-4). The MA momentarily became airborne, but there was insufficient lift for the MA to maintain flight (Tabs J-4, V-1.3).

### (2) Prematurely Raised Landing Gear Handle

A normal F-22 takeoff ends when the pilot ensures that a positive rate of climb is established and retracts the LG. Common indicators of a positive rate of climb in the F-22 include visual cues, the climb dive marker (CDM) above the horizon, and an increasing vertical velocity indicator (VVI) (Tab V-1.4 to V-1.5, V-2.9, V-5.1, V-6.1, V-7.1, V-10.1). Takeoff should occur at calculated takeoff speed, and LG should be retracted after the airplane is safely airborne (Tab DD-4). Therefore, LG retraction should not occur prior to takeoff speed.

During the mishap sortie, after rotation and achieving weight off wheels, the MP described using peripheral vision, and the surroundings getting smaller to determine he was airborne (Tab V-1.3). The MP quickly retracted the LG upon recognizing those visual cues (Tab J-4). He did not utilize the CDM or VVI to verify a positive rate of climb (Tab V-1.12). While the MP sensed that the MA was airborne and raised the LGH 1.0 second after weight off wheels, the MA's speed was 22 knots below takeoff speed (Tab DD-4). The lift being generated at this point was insufficient to maintain flight, which resulted in the MA settling back to the runway on its belly (Tabs S-2 to S-4, V-1.3).

### (3) Damage to Alpha Probe

Per TOD, before every flight, one qualified crew chief is required to inspect the left and right alpha probes for damage or obstruction. Damage is defined by "noticeable to the touch by rubbing hand or thumb nail over suspected damage area" (Tab DD-3). If either probe is damaged, the jet is considered to be non-mission capable and the jet is to be grounded pending further maintenance action. On the day of the mishap, the MA was inspected, but no damage was noted. The AIB MRT identified a right alpha probe transducer with multiple small nicks within the first two inches (Tab U-7). It is unclear, however, when this damage occurred.

## c. PC109 Distraction

Distraction is a factor when the individual has an interruption of attention or inappropriate redirection of attention by an environmental cue or mental process. During previous sorties flown, the MP had consistent timing of LG retraction. During five sorties flown over a five-month period prior to the mishap, the MP's LG retraction timing was comparable to his peers; his rates averaged 5.6 seconds after initiating rotation and 2.1 seconds after weight-off-wheels indication. For each sortie flown from a sea level airfield, the MP retracted the LG after the aircraft had achieved takeoff speed (Tab CC-3 to CC-4). During the mishap sortie, the MP retracted the LG twice as fast as his usual timing after weight off wheels. During the interview of the MP, he did not indicate any stressors or distractions in the cockpit during the mishap takeoff sequence (Tab V-1.4). He noted some fatigue, but not excessive fatigue that would affect safety of flight (Tab V-1.19). The MP also stated that there were no aircraft systems issues on the day of the mishap, and ground operations prior to takeoff were normal (Tab V-1.4). No abnormal radio calls were made during his taxi or takeoff sequence (Tab V-1.4). Although the MP did not remember any specific distractions, it is worth noting that the timing of his LG retraction was faster than his previous sorties.

## d. PP109 Task or Mission Planning or Briefing Inadequate

Task or Mission Planning or Briefing Inadequate is a factor when an individual, crew or team fails to complete all preparatory tasks associated with planning or briefing the task or mission.

### (1) Incorrect TOLD

Most mission planning for the Fallon TDY was completed earlier in the week while the 90 FS was TDY to Tyndall AFB for WSEP (Tab V-3.15). During mission planning, PM1 created line-up cards for each of the three cross-country sorties and the sortie at NAS Fallon (Tabs K-2, V-3.7, V-4.3). The TOLD on all four cards was based on an 80 degrees Fahrenheit (F) day and was not re-calculated for each airfield during the cross-country trip (Tab K-2). The TOLD on the cards was computed using a 90 FS Excel spreadsheet tool that assumes JBER conditions including sea level elevation and a 10,000 foot runway length (Tab V-3.6). The 90 FS tool was created to increase mission planning efficiency as it allows the user to skip manually calculating TOLD for each mission. However, at NAS Fallon, the field elevation is 3,934 feet and the runway length is 13,961 feet (Tab S-13). Additionally, PM1 used a temperature of 80 degrees F whereas the temperature on the day of the mishap was 46 degrees F (Tab F-2). Therefore, the TOLD on the MP's line-up card was incorrect for the mishap sortie at NAS Fallon.

#### (2) Inadequate Flight Briefs

IAW AFI 11-2F-22v3 paragraph 2.4.1, flight leads are responsible for presenting a logical briefing that will promote safe, effective mission accomplishment. This AFI also specifically states that a briefing will "review takeoff data, and ensure every member of the flight understands it" (Tab BB-19). A briefing was conducted on each leg of the cross-country, but did not cover the specific TOLD considerations for the mission airfields (Tab V-3.7 to V-3.8).

On the day of the mishap, a mass brief was conducted from 0800-0820L for all TOPGUN graduation exercise participants during which the local operating procedures, weather, NOTAMS, and SIIs were covered (Tabs R-45, V-2.3). There was not a formal brief among the four 90 FS pilots, though they did have informal discussions at breakfast and prior to entering their respective jets (Tabs R-44, V-2.5, V-2.4). During that time, they discussed hydration, procedures to get to the airspace, airspace deconfliction, and high-G maneuvering (Tabs R-44 to R-45, V-2.3). However, at no point did the pilots discuss TOLD considerations (Tabs R-44, V-2.5, V-4.3).

### e. SI007 Failed to Identify Unsafe Practices

Failed to Identify Unsafe Practices is a factor when a supervisor fails to identify unsafe tendencies and fails to institute remedial actions. This includes hazardous practices, conditions or guidance.

#### (1) Improper Rotation Technique

The MP stated, "There is a technique that I heard from somewhere (I don't know where, whether it was at the B-Course or the 90th) to initiate [rotation] – if you have a 136 [rotation speed], kind of standard below 2,000 feet – that you initiate aft stick pressure at 120 so that the nose is up at that rotation speed, and that has been my habit pattern" (Tab V-1.10). Data from five sorties flown over a five-month period prior to the mishap clearly shows that the MP initiated rotation at 120±5 KCAS (Tab CC-3 to CC-4).

This technique of rotating early does not appear to be limited to the MP. Data from multiple sorties flown by 90 FS pilots are presented in Figure 1 and Figure 2. The data shows that in 64.3% of sorties, rotation was initiated greater than 5 knots prior to the calculated rotation speed; in 52.1%, rotation occurs at 120±5 KCAS (Tab CC-3, Figure 1). In 80.4% of these sorties, takeoff was accomplished greater than 5 knots prior to takeoff speed (Tab CC-3, Figure 1). All pilots who were interviewed noted that they check their TOLD before takeoff (See, e.g., Tab V-5.1, V-9.1, V-13.1). After the mishap, at a pilot meeting attended by 20 to 30 F-22 pilots, about half noted that they consistently use an early rotation technique (Tab V-2.16, V-4.14, V-4.17). There is a clear trend of rotating early among a significant number of F-22 pilots, including the MP, despite being aware of computed TOLD.

Rotating early has two major negative effects on TOLD. First, by rotating early you are increasing your induced drag at a premature point, thus slowing down the jet's acceleration and extending your takeoff roll. This invalidates the abort speeds that are calculated by the applicable technical order. More importantly in the case of this mishap, early rotation usually leads to getting airborne prematurely in ground effect, which is the effect of additional buoyancy produced by a cushion of air below a vehicle moving close to the ground. The AIB discovered that 80.4% of all pilots sampled became airborne greater than 5 knots before achieving their takeoff speed (Tab CC-3, Figure 1). At sea level, this technique doesn't "hurt" the pilot substantially because of the acceleration and power of the F-22; however, it builds a bad habit which can be compounded when flying at high elevation airfields. This technique has further consequences when the pilot retracts the LG too early. Becoming airborne in ground effect can have similar visual signals to becoming airborne at the correct takeoff speed, resulting in the pilot initiating LG retraction. The technique of rotating early has led to 26.8% of sampled pilots retracting their LGH prior to achieving takeoff speed, and 10.7% of those pilots retracting their LGH over 10 knots slower than their takeoff speed (Tab CC-3, Figure 1). This technique can create a situation where the LG is retracted prior to their aircraft achieving a safe, flyable airspeed.

Because every F-22 base (except Nellis) is at sea level, F-22 pilots do not have much experience taking off at high elevation airfields. It should be noted that while taking off at a high elevation airfield such as Colorado Springs (KCOS), Sheppard AFB (KSPS), and NAS Fallon, there are no observed changes to any of the sampled pilots' rotation speeds or takeoff speeds (Tab CC-3). Every pilot continued to fly the aircraft as if he were taking off at his home airfield, with many still using the incorrect technique of rotating at 120 knots regardless of TOLD (Tab CC-3, Figure 2). This caused 91% of the aircraft to become airborne ≥5 knots prior to achieving takeoff speed, with 54.5% of them becoming airborne at least 20 knots early (Tab CC-3). By focusing only on these cross-country sorties, we see that 81.8% of the pilots retracted their gear prior to achieving takeoff speed at these high elevation airfields (Tab CC-3, Figure 1). This data suggests that pilots are not referencing their airspeed prior to retracting the gear, but instead relying on a visual sensation of the aircraft leaving the ground, as well as having an "internal clock" which tells them when to retract the gear based off of "experience". Because acceleration is slower at high elevation airfields, it takes noticeably longer to accelerate to the required takeoff speed. Specifically, during the mishap, the MA's military thrust was approximately 87% what it would have been at sea level (Tab J-37). It should be noted that in 72.7% of these cases, the pilots retracted their gear prior to even achieving a takeoff speed that would have been normal at sea level, which continues to suggest that they are not referencing airspeed data even while flying at sea level (Tab CC-3). This has put many pilots and aircraft at an unnecessary risk.

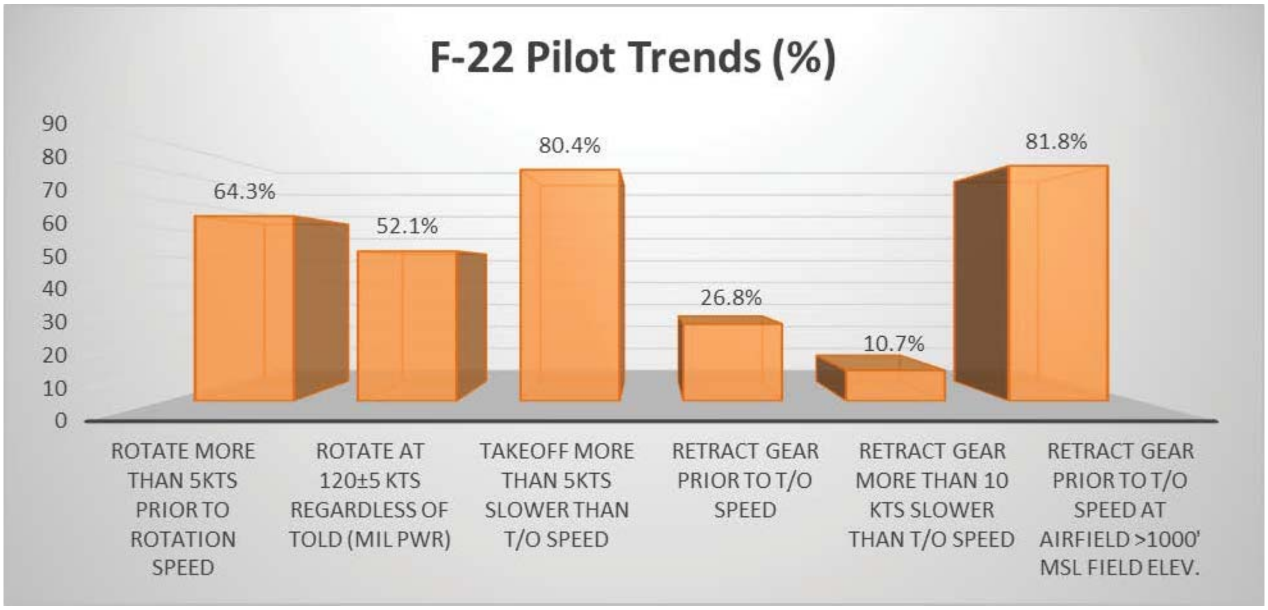


Figure 1: F-22 Pilot Trends. Data includes 56 sorties analyzed by the AIB.

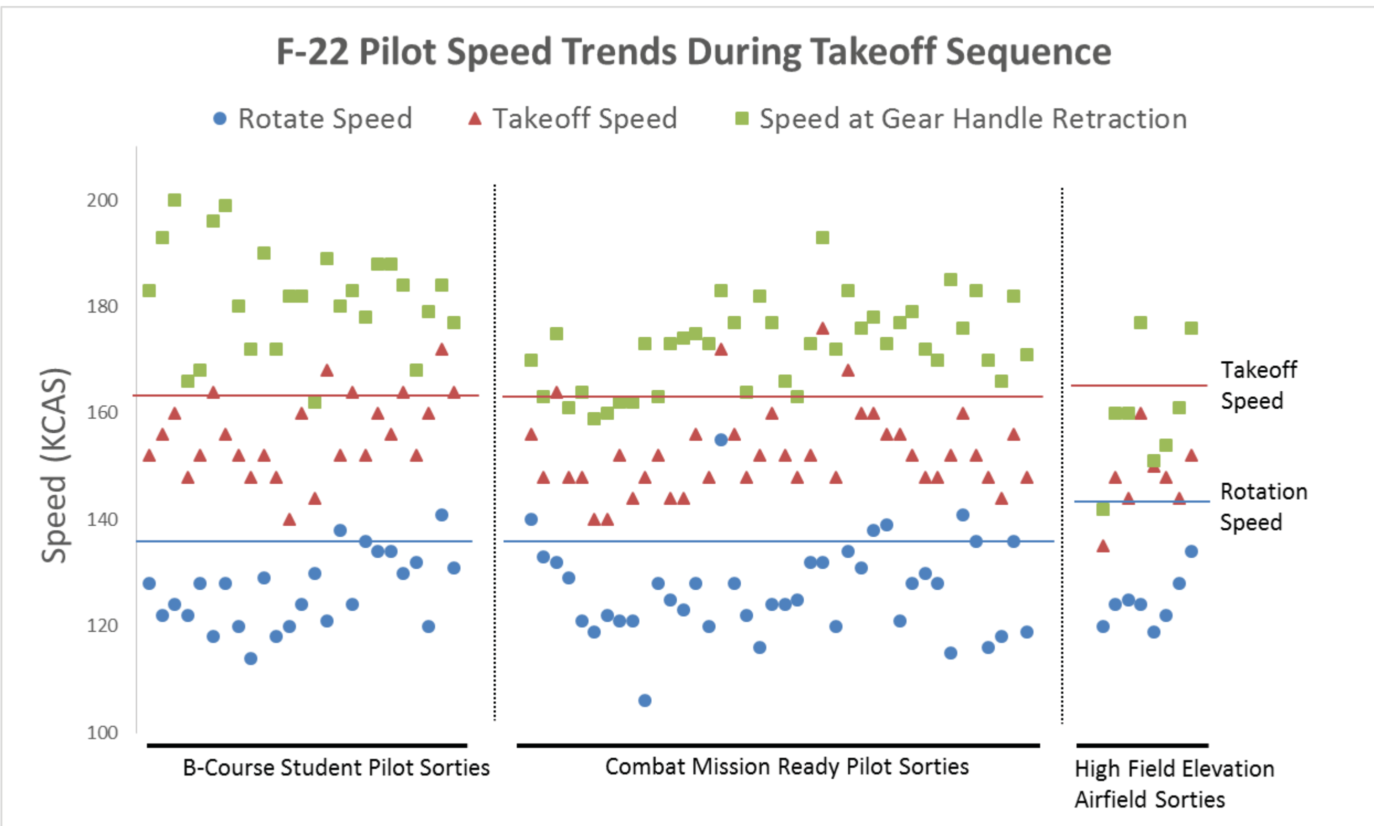


Figure 2: F-22 Pilot Speed Trends during Takeoffs. Data includes 73 sorties analyzed by the AIB.

### f. OP004 Formal Training

Formal Training is a factor when one-time or initial training programs, upgrade programs, transition programs or other training that is conducted outside the local unit results in undesirable outcomes. The F-22 B-Course teaches pilots the fundamentals of flying the F-22. Data from multiple sorties from two recent B-Course classes was analyzed by the AIB and is shown in Figure 2 and Figure 3 (Tab CC-3 to CC-4). This sample set showed that 64.3% of the students rotated greater than 5 knots below the computed rotation speed and 44.0% rotated at 120±5 KCAS. The data shows that 100% of the students retracted their LG after achieving takeoff speed (Tab CC-3 to CC-4). There is a clear trend of rotating early among a significant number of F-22 student pilots at the B-Course.

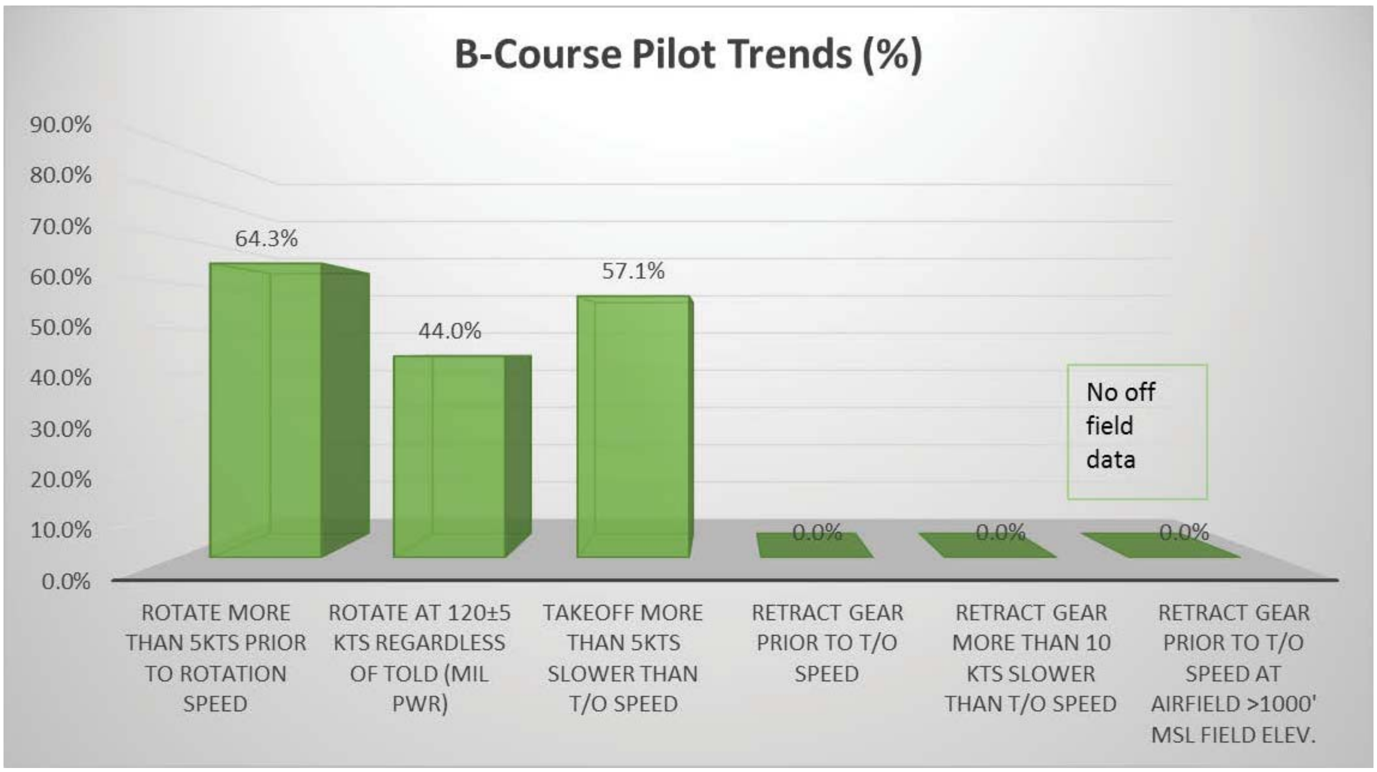


Figure 3: B-Course F-22 Pilot Speed Trends during Takeoffs. Twenty-eight sorties analyzed by the AIB.

### g. OC003 Organizational Overconfidence in Equipment

Organizational Overconfidence in Equipment is a factor when there is organizational overconfidence in an aircraft, vehicle, device, system, or any other equipment. The F-22 engines produce more thrust than any other current fighter engine (Tab BB-14). Most pilots acknowledged that the high thrust of the aircraft provides confidence that the jet will easily get airborne. One pilot commented that the F-22 community "takes it for granted that we have a lot of power and that this jet will generally take off from any runway that you want it to take off from" (Tab V-4.9). Another commented, "I can't think of a time where I've been concerned with TOLD . . . based on the thrust available" (Tab V-3.21). Multiple pilots, including the MP, noted that the TOLD is emphasized more in the T-38 community than the F-22 (Tab V-1.13, V-7.1, V-10.2). Due to the lower thrust to weight ratio of the T-38, adherence to TOLD is more critical for safety of flight (Tab V-1.14, V-7.1). There is a clear perception among F-22 pilots that the aircraft has sufficient thrust and braking capability to overcome deviations from TOLD. This perception has led to a decreased emphasis on TOLD (Tab V-5.1, V-9.1, V-15.1).

## 12. GOVERNING DIRECTIVES AND PUBLICATIONS

### a. Aviation Directives and Publications Relevant to the Mishap

(1) AFI 11-202, Volume 3, General Flight Rules, 2 October 2017
(2) AFI 11-202, Volume3, PACAF Supplement, General Flight Rules, 23 Jun 2015
(3) AFI 11-2F-22A Volume 3, F-22 -- Operations Procedures, 8 December 2009
(4) AFI 11-418, Operations Supervision, 14 October 2015
(5) AFI 51-503, Aerospace and Ground Accident Investigations, 14 April 2015
(6) AFMAN 11-217, Volume 1, Instrument Flight Procedures, 22 October 2010
(7) Department of Defense Human Factors Analysis and Classification System 7.0, 01 October 2015
(8) 3WG, 176WG, 477FG In-flight Guide, November 2016
(9) F-22 IFG Supplement, Change 1, December 2016
(10) 3rd WG F-22 Admin Standards, July 2017

### b. Maintenance Directives and Publications Relevant to the Mishap

(1) TO 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures*, 15 June 2011
(2) TO 42B-1-3, Change 3, *Fluids for Hydraulic Equipment*, 15 March 2012

### c. Known or Suspected Deviations from Directives or Publications

None not already discussed above.

**NOTICE:** The AFIs listed above are available digitally on the AF Departmental Publishing Office internet site at: **http://www.e-publishing.af.mil.** All other TO's and publications are not publically releasable.

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30 October 2018

JACOB TRIGLER, Colonel, USAF
President, Accident Investigation Board

# STATEMENT OF OPINION

**F-22A, T/N 07-4146**
**Naval Air Station Fallon, Nevada**
**13 April 2018**

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

## 1. OPINION SUMMARY

On 13 April 2018 at approximately 1745 Zulu (Z), 1045 Local time (L), an F-22A Raptor, T/N 07-4146, assigned to the 90th Fighter Squadron, 3rd Wing, Joint Base Elmendorf-Richardson, Alaska, took off from runway 31 Left (31L) at Naval Air Station (NAS) Fallon, Nevada. The mishap pilot (MP) initiated a military power (MIL) takeoff and rotated at 120 knots calibrated airspeed (KCAS). As the MP recognized his visual cues for the MA becoming airborne, he raised the landing gear handle (LGH) to retract the landing gear (LG). Immediately after main landing gear (MLG) retraction, the mishap aircraft (MA) settled back on the runway and with the MLG doors fully closed and the nose landing gear (NLG) doors in transit. The MA impacted the runway on its underside and slid approximately 6514 feet (ft) until it came to rest 9,419 ft from the runway threshold. Once the MA came to a complete stop, the MP safely egressed the aircraft. There were no injuries, fatalities, or damage to civilian property.

The mishap occurred on the MP's only scheduled sortie for the day. This mission was scheduled and briefed as a TOPGUN graduation exercise sortie. The MP's mission was to take off from NAS Fallon and fly to a predetermined point in the assigned airspace in order to fight Basic Fighter Maneuvers (BFM) against a Navy F-18 Hornet. The MP was flying as a single-ship for the departure with the intent to meet his opponent in the airspace. The day was uneventful up to the point when the MP initiated takeoff.

I find by a preponderance of the evidence that the causes of the mishap were two procedural errors by the MP. First, the MP had incorrect Takeoff and Landing Data (TOLD) for the conditions at NAS Fallon on the day of the mishap, and more importantly, he failed to apply any corrections to the TOLD during his takeoff sequence. Second, the MP prematurely retracted the LG at an airspeed that was insufficient for the MA to maintain flight.

I find by a preponderance of the evidence that four additional factors substantially contributed to the mishap: inadequate flight brief, organizational acceptance of an incorrect technique, formal training, and organizational overconfidence in equipment.

## 2. CAUSE

### a. Incorrect Application of TOLD

During mission planning for the cross-country flights, including the sortie at NAS Fallon, all of the lineup cards produced for the formation listed TOLD for a military power (MIL) takeoff at 80 degrees Fahrenheit (F) using a 10,000 ft runway at sea level. The elevation of NAS Fallon is 3,934 ft, runway 31L is 13,961 ft long, and the temperature on the morning of the mishap was 46 degrees F. The rotation and takeoff speeds listed on the lineup card were 136 KCAS and 163 KCAS respectively. The calculated rotation and takeoff speeds for the conditions at NAS Fallon on the day of the mishap are 143 KCAS and 164 KCAS respectively.

In addition to having incorrect TOLD, the MP failed to apply any corrections to the TOLD. The MP stated that he understands the effects increased density altitude will have on TOLD (increased airspeeds and distances), but he still performed his normal technique of rotating at 120 KCAS. Not applying any corrections to the TOLD allowed the MA to get to a position where the MP sensed his visual cues for becoming airborne, but the MA had not accelerated to a sufficient speed to maintain flight.

### b. Prematurely Retracted the Landing Gear

Takeoff should occur at calculated takeoff speed and the LG should be retracted after the aircraft is safely airborne and the pilot ensures a positive rate of climb is established. Therefore, LG retraction should not occur prior to takeoff speed. While the MP observed his visual cues, he did not confirm a positive rate of climb by crosschecking the climb dive marker or the vertical velocity indicator. The MP raised the LGH 1.0 second after weight off wheels at an airspeed of 142 KCAS; 22 knots below the correct takeoff speed. The MA was not at an appropriate flying airspeed and the aircraft settled back on the runway as the LG retracted.

## 3. SUBSTANTIALLY CONTRIBUTING FACTORS

### a. Substantially Contributing Factor 1: Inadequate Flight Brief

Flight leads are responsible for presenting a logical and thorough brief to promote a safe and effective mission. Among other required items, flight leads will brief TOLD and ensure each member of the flight understands it. During each of the cross-country sorties, including the sorties at NAS Fallon, an abbreviated flight brief was conducted, but the designated flight lead never briefed or discussed TOLD for any of the airfields. All four pilots involved in the cross-country were flight lead qualified. Although they all stated that they understand the effects of increased density altitude on TOLD and aircraft performance, none of them recalculated TOLD or discussed TOLD considerations for the high elevation airfields at Colorado Springs and NAS Fallon.

### b. Substantially Contributing Factor 2: Organizational Acceptance of an Incorrect Technique

The improper technique to rotate 10-15 knots prior to the calculated rotation speed appears to be common among F-22 pilots. Given that all F-22 bases but one are at sea level, the TOLD does not vary much between each base and a calculated rotation speed of 136 KCAS is common. Data for 56 sorties from the 90th Fighter Squadron (90 FS) was analyzed and 52% of the pilots rotated at 120±5 KCAS. However, every pilot interviewed stated that they review the TOLD prior to takeoff. The early rotation starts a sequence of events that can lead to early takeoff and early LG retraction.

### c. Substantially Contributing Factor 3: Formal Training

The MP stated that he does not remember where he learned the technique to rotate early, either during the B-Course at Tyndall AFB, Florida or in the 90 FS. Therefore, a sample of 28 sorties from the two previous B-Course classes was analyzed. The analysis showed that 44% of the students rotated at 120±5 KCAS. Consequently, it is likely that this technique is being taught at the B-Course.

### d. Substantially Contributing Factor 4: Organizational Overconfidence in Equipment

The F-22 produces a significant amount of thrust and most pilots acknowledged that the high thrust provides confidence that the jet will easily get airborne. It is clear that TOLD is not emphasized as much in the F-22 as in lower thrust-to-weight ratio aircraft, and the main considerations in the F-22 are for the abort speed and the landing data. There is a definite perception among F-22 pilots that the aircraft has sufficient thrust and braking capability to overcome deviations from TOLD. This perception has led to a decreased emphasis on the takeoff data.

## 4. CONCLUSION

By the preponderance of evidence, I find the cause of the mishap was pilot error. The MP failed to ensure that he was operating the aircraft IAW valid TOLD and then prematurely retracted the LG. If the MP had performed his takeoff sequence IAW the correct TOLD or if he delayed his LG retraction until the MA had accelerated to the correct takeoff speed, this mishap would not have occurred. I also find by the preponderance of evidence that four additional factors substantially contributed to the mishap: inadequate flight brief, organizational acceptance of an incorrect technique, formal training, and organizational overconfidence in equipment.

Although this mishap occurred due to the specific procedural errors of the MP, the organization factors contributing to this mishap were significant in influencing and shaping the MP’s actions. The technique of rotating early will not by itself cause this type of accident. However, rotating early starts a sequence of events that can lead to an early takeoff and early gear retraction. This situation is magnified when an aircraft is operating at a high elevation airfield where aircraft performance is decreased.

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30 October 2018

JACOB TRIGLER, Colonel, USAF
President, Accident Investigation Board

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