SUMMARY OF FACTS AND STATEMENT OF OPINION
F-22A ACCIDENT
20 OCTOBER 2005

TABLE OF CONTENTS

COMMONLY USED ACRONYMS & ABBREVIATION

ACC	Air Combat Command
AFB	Air Force Base
AFI	Air Force Instruction
A1C	Airman First Class
Acft	Aircraft
ADCC	Assistant Dedicated Crew Chief
ADO	Assistant Director of Operations
AF	Air Force
AFTO	Air Force Technical Order
AMU	Aircraft Maintenance Unit
APU	Auxiliary Power Unit
ARS	Air Recharge System
B-Man	Aircraft Launch Assistant
Callout	Computer hyperlink on the PMA
CAMS	Core Automated Maintenance System
Comm	Communications
CFETP	Career Field Education and Training Plans
CND	Could not duplicate
DCC	Dedicated Crew Chief
Edwards	Edwards AFB
L	Local Time
EOT	Engine Operating Time
EST	Eastern Standard Time
FOD	Foreign Object Damage
FOI	Foreign Object Inspection
FS	Fighter Squadron
GBU	Guided Bomb Unit
Hill	Hill AFB
hrs	Hours
ICAW	Integrated Caution Advisory and Warning
IOC	Initial Operational Capability
IMIS	Integrated Maintenance Information System
IPT	Integrated Process Team
JDAM	Joint Direct Attack Munition
L	Local Time
Langley	Langley AFB
LG	Landing Gear
Lt Col	Lieutenant Colonel
MA	Mishap Aircraft
Maj	Major
MCC	Mishap Crew Chief
MOS	Maintenance Operations Squadron
MP	Mishap Pilot
MSgt	Master Sergeant
MSL	Mean Sea Level
MX	Maintenance
MXG	Maintenance Group
Nellis	Nellis AFB
NLG	Nose Landing Gear
Ops Desk	Operations Desk
OBIGGS	On Board Inert Gas Generating System
OBOGS	On Board Oxygen Generating System
PMA	Portable Maintenance Aide
PHA	Preventive Health Assessment
PPE	Personal Protection Equipment
Pro-Sup	Production Superintendent
Pro-Super	Production Superintendent
PSI	Pounds per square inch
Raptor	Nickname for F22A
Red Ball	Situation requiring a sense of urgency and priority actions.
ROE	Rules of Engagement
S/N	Serial Number
SAM	Surface to Air Missile
SAT	Surface Attack Tactics
SES	Stored Energy System
Step	Pilots walk to aircraft
T.O.	Technical Order
TCTO	Time Change Compliance Order
Tech Data	Technical Order Data
Top 3	Operations Supervisor
Tyndall	Tyndall AFB
USAF	United States Air Force
WSEP	Weapons System Evaluation Program
WX	Weather
Z	Zulu/Greenwich Meridian Time
#1	Left Engine
#2	Right Engine

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

SUMMARY OF FACTS

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority.

On 12 Dec 05, General Ronald E. Keys, Commander of the Air Combat Command (ACC), appointed Lieutenant Colonel Steven M. Schneider to conduct an aircraft accident investigation of the 20 Oct 05 damage to an F-22A aircraft, serial number (S/N) 03-4045, at Hill AFB, Utah. The investigation was conducted at Langley Air Force Base (AFB), Virginia, from 4 Jan 06 through 13 Jan 06. Technical advisors were Lieutenant Colonel Daniel F. Holmes (Pilot), Captain Michelle A. Quitugua (Legal), Captain Everett L. Perry (Medical), Master Sergeant Vincent S. Stone (Maintenance), Staff Sergeant Stephen W. Smith (Recorder) (Tab Y-3 thru Y-8).

b. Purpose.

This aircraft accident investigation was convened under Air Force Instruction (AFI) 51-503. The primary purpose is to gather and preserve evidence for claims, litigation, and disciplinary and administrative actions. In addition to setting forth factual information concerning the accident, the board president is also required to state his opinion as to the cause of the accident or the existence of factors, if any, which substantially contributed to the accident. This investigation is separate and apart from the safety investigation, which is conducted pursuant to AFI 91-204 for the purpose of mishap prevention. The report is available for public dissemination under the Freedom of Information Act (5 United States Code (U.S.C.) §552) and AFI 37-131.

c. Circumstances.

The accident board was convened to investigate the 20 Oct 2005 Class A accident involving an F-22A aircraft, S/N 03-4045, assigned to the 27th Fighter Squadron, 1st Fighter Wing, Langley Air Force Base (AFB), Virginia (VA).

2. ACCIDENT SUMMARY

On 20 Oct 05, at approximately 2030 local time (L) or 0230 Zulu (Z) at Hill AFB, Utah (UT), while preparing to take part in a Night Surface Attack Tactics mission, an F-22A, S/N 03-4045, ingested a Nose Landing Gear (NLG) pin into the right engine. After the pin was ingested into the engine, the mishap pilot (MP), Major Evan Dertien, immediately shut down the aircraft and safely egressed the aircraft (Tab V-2.12). There were no injuries. The damage to the aircraft was confined to the right intake, engine and related components. The loss was valued at $6,754,275.36 (Tab D-2). Several media agencies were present at the time of the mishap due to the high interest in the F-22A program. Several inquiries were fielded at the time of the mishap however media interest has been minimal since then (Tab DD-3).

3. BACKGROUND

The 1st Fighter Wing (FW), stationed at Langley AFB, VA, maintains a combined wing of F-22A and F-15C aircraft. The 27th Fighter Squadron (FS), a component of the 1st FW, provides air superiority for the United States or allied forces by engaging and destroying enemy forces, equipment, defenses or installations for global deployment. The unit is in the process of transitioning to the F-22A Raptor, the new air-dominance fighter. The 1st FW and its subordinate units are all components of the United States Air Force's Air Combat Command (ACC), also based at Langley AFB (Tab EE-4 thru EE-5).

On 15 Oct 05, the 27th FS deployed to Hill AFB, UT, for an Air-to-Ground Weapons System Evaluation Program (WSEP). The purpose of the WSEP was to evaluate the unit's ability to employ the GBU-32 Joint Direct Attack Munition (JDAM), a 1000 pound guided bomb, from the F-22A (Tab V-2.23). During the deployment, the 27th FS also flew training missions to build day and night tactical employment proficiency. This deployment was the first F-22A operational deployment for the 27th FS and the deployment was an important step in the squadron's efforts to have the F-22A achieve initial operational capability (IOC) (Tab V-2.23). The mishap occurred 5 days into the deployment during engine start in preparation for a high altitude night training mission.

4. SEQUENCE OF EVENTS

a. Mission.

The mishap mission was a continuation training sortie to practice night surface attack tactics. The aircraft was to depart as part of a 4-ship of F-22A's, proceed to the working airspace, and then split for simulated attacks on separate targets. An embedded training mode would be used to simulate threats and weapons release (Tab V-2.4). The 27 FS Assistant Director of Operations authorized the mission (Tab CC-2; Tab K-2).

b. Planning.

Mission planning was thorough and fully understood by all pilots. The mission was briefed by the lead of the 4-ship using the 27th FS standard briefing guide, which was derived from AFI 11-2FA-22V3, F-22A Operations Procedures (Tab V-2.5). Both the mission lead and the MP are squadron supervisors (Tab CC-2). At 1900L, the flight went through a normal briefing covering training rules and other items (Tab V-2.5). At 2000L, immediately before the pilots stepped to their aircraft, the Operations Supervisor gave the pilots their step brief (Tab V-2.5). Of note, sunset occurred at 1839L, civil twilight ended at 1939L, and the moon did not rise until 2030L resulting in a very dark ramp during preflight operations (Tab F-2 thru F-3; Tab V-2.6).

c. Preflight.

The F-22A fleet has had a history of Air Recharge System (ARS) failures. The ARS is designed to pressurize the Stored Energy System (SES). The SES is used to start the Auxiliary Power

Unit (APU). An F-22A pilot cannot takeoff with a "SES LOW" advisory. The aircraft's "SES LOW" advisory asserts whenever SES pressure drops below 3000 PSI. The "SES LOW" advisory is cleared during recharging at 3200 PSI (Tab CC-5; Tab V-2.7).

The F-22A can not operate above 35,000 feet MSL if the SES pressure is inadequate. Above 35,000 feet, an "SES LOW" advisory will assert anytime SES pressure falls below 90% of maximum allowable SES pressure. The maximum allowable SES pressure is temperature dependant. An "SES LOW" advisory requires the pilot to descend the aircraft below 35,000 feet MSL which usually results in a non-effective mission (Tab V-2.1; Tab V-9.1) (Tab CC-5; Tab V-2.7).

The pilot exterior inspection procedure does not include inspection of SES pressure; however pilots are trained to check it (Tab V-3.1). Maintenance launch inspection procedures have a link to checking / servicing SES pressure and specify that the SES pressure must be above 2000 PSI or at an "adequate level" for the expected aircraft usage timeline. The SES system recharges at a rate of 600 PSI per 20 min. Above 35,000 feet, an "SES LOW" advisory will assert anytime SES pressure falls below 90% of maximum. The normal time from engine start to takeoff is 30 minutes. So 2000 PSI is inadequate for a normal aircraft launch as it would take too long to recharge to 3200 PSI for takeoff or 90% for flight above 35,000 feet. (Tab V-2.7)

During 2005, 14 of the 19 F-22A's assigned to the mishap unit had 39 separate maintenance write-ups for an inability to start the APU due to insufficient pressure in the SES (Tab U-3). Because of the history of ARS problems, SES servicing during launch is not an uncommon procedure. There have been several software modifications and additional T.O. guidance added over the last two years to help the ARS recharge properly (Tab CC-5).

In the present mishap, due to the history of ARS failures, SES servicing was anticipated for the mishap aircraft (Tab V-2.7). If SES servicing is needed, prompt action is required to preserve the aircraft's launch. Since the SES system recharges at a rate of 600 PSI per 20 minutes, if the SES pressure is at 2000 PSI or below, there is generally insufficient time to recharge the SES to meet the scheduled launch. F-22A pilots are sensitive to ARS problems and have been taught during training to service the SES with the APU running if the SES level is too low to allow takeoff or mission accomplishment (Tab V-2.8).

The mishap crew chief (MCC) arrived a few minutes before the MP (Tab R-3). When the MP arrived at the aircraft, the hard drive for the Portable Maintenance Aide (PMA), which is used for operations and servicing procedures, maintenance records, and pilot acceptance, was still being transported from the maintenance building to the aircraft (Tab V-1.6). While waiting for the hard drive and the initialization of the PMA, the pilot accomplished an exterior inspection of the MA (Tab V-2.6).

The MP and MCC then discussed and agreed to leave the landing gear (LG) pins installed for the anticipated SES servicing (Tab V-2.8). The MP then accepted the aircraft on the PMA and climbed into the cockpit. When the MP started the APU, the SES did not deplete excessively and began to recharge normally. The MP then informed the MCC that SES servicing would not be required (Tab V-2.9).

The MCC informed the SES servicing crew that servicing was not required and he helped them move their equipment away from the aircraft (Tab V-1.11). The MCC prepared the mishap aircraft for launch and after visually scanning the aircraft, he cleared the pilot to start engines. After both engines were running, the MP queried the MCC if the Nose Landing Gear (NLG) pin had been removed (Tab V-1.12).

After the MCC replied that the pin had not been removed, the MCC directed the MP to shut down the left (#1) engine so he could remove the NLG pin. (See Figure 1.)

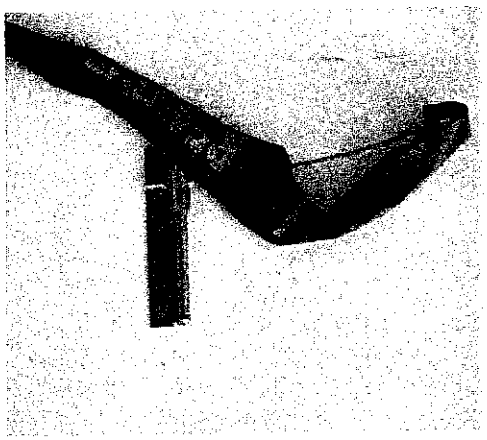

Figure 1 – NLG pin with lanyard and streamer

After the MP confirmed the engine was shut down and no longer rotating, the MCC disconnected his headset and approached the aircraft, checked the left engine inlet, and proceeded into the NLG well to remove the pin. As he removed the NLG pin, the streamer (flag) attached to the pin was drawn towards the idling right engine intake by the air suction. The streamer pulled the NLG pin out of the MCC's hand and into the right (#2) engine (Tab V-1.12).

The MP heard a crunch and winding down sound. Then all of the MP's displays went blank. Simultaneously with the crunching sound, one of the SES servicing crew saw sparks coming from the engine and he visually signaled the MP to shut down the engine. The MP immediately shut down the right (#2) engine (the left was already off) using the throttle and both fire buttons and ensured the APU was off (Tab V-2.11).

The MP delayed turning off the battery due to his uncertainty of the MCC's location and because of the potential of a nose gear collapse if the NLG pin was not installed. After the MP saw the MCC come out from under the jet, he turned off the battery and safely egressed the aircraft (Tab V-2.11 thru 2.12).

d. Flight.

Not applicable.

e. Impact.

Not applicable.

f. Life Support Equipment, Egress and Survival.

After shutting down the engines using the throttles and fire switch lights, the MP safely egressed the aircraft using normal procedures (Tab V-2.12).

g. Search and Rescue.

Not applicable.

5. MAINTENANCE

a. Forms Documentation.

Maintenance histories for the F-22A aircraft and its components are documented in a computerized system known as the Integrated Maintenance Information System (IMIS) database server, which is accessed through a portable computer called a Portable Maintenance Aide (PMA). The PMA interfaces with the aircraft for maintenance, servicing and diagnostics. After the PMA collects information from the aircraft's IMIS database, the PMA is then used to transfer the data to the Core Automated Maintenance System (CAMS) for long term storage. This board conducted a thorough review of the maintenance data for the mishap aircraft for the previous 30 days leading up to the mishap from both IMIS and CAMS databases. Our review of the aircraft's maintenance records yielded a series of in-flight Stored Energy System (SES) discrepancies intermittently throughout the week leading up to the mishap (Tab U-1 thru U-16).

Recent SES-Related Discrepancies Which Occurred In-Flight:

Sortie Date	Sortie of the Day	Discrepancy
06 October 2005	1	APU failure due to insufficient SES pressure
15 October 2005	1	ARS incapable of pressurizing the SES
18 October 2005	2	SES does not recharge
19 October 2005	1	SES is not recharging very well. When I landed it was down to 89% and not going back up.
19 October 2005	2	SES stuck at 65% the entire flight and would not charge
20 October 2005	1	SES does not recharge--91% at take off.

There were 50 outstanding maintenance discrepancies at the time of the mishap. None of these open discrepancies would have prevented the mishap aircraft from flying. Except for the maintenance discrepancies concerning the SES air recharge, none of the outstanding maintenance discrepancies had any bearing on the mishap (Tab U-1 thru U-16).

Recent SES Maintenance Discrepancies Open and/or Corrected:

Job Control #	Discrepancy	Corrective Action	Date/time Disc	Date Corrected
52796809	APU failure due to insufficient SES pressure		10/6/2005	Open at time of Mishap
52883243	ARS incapable of pressurizing the SES		10/16/2005	Open at time of Mishap
52913229	SES does not recharge	Engine Run C/W CND	10/19/2005	10/19/2005
529223224	SES does not recharge	APGS operation check good, SES bottles serviced prior to each flight	10/20/2005	10/20/2005
52933224	SES does not recharge		10/20/2005	Open at time of Mishap

The mishap aircraft's F119-PW-100 engines are maintained by Pratt & Whitney. On 25 July 2005, the mishap engine, S/N PW0E730059, was installed in the #2 position (right) on the mishap aircraft. At the time the engine was installed, the engine had 348.5 hours of operating time (EOT). At the time of the mishap, the right engine had 418.7 EOT. There were no engine factors concerning the mishap besides the Foreign Object Damage (FOD) (Tab J-2).

TCTO 1F-22A-638, Relocation of Power Source for Landing Gear Select Valve, 1F-22A Aircraft, had been accomplished on the mishap aircraft. This TCTO was enacted to prevent un-commanded NLG retraction upon shutting off electrical power (Tab V-2.10; Tab V-6.2) .

b. Inspections.

All scheduled inspections were satisfactorily completed.

c. Maintenance Procedures.

Maintenance procedures that were directly related to the mishap were SES air servicing during the launch, Safe for Maintenance for the SES servicing, and the Launch procedure itself.

The operations supervisor asked the production superintendent to have an SES cart available for the mishap aircraft due to the known history of the SES not charging correctly (Tab V-3.1). The production super tasked the expediter to ensure the requested equipment was on hand (Tab V-7.1).

While the mishap aircraft's PMA drive was still "docking" (downloading aircraft data in the maintenance building) from the aircraft's previous training flight, the MCC heard Operations inquiring about an early step time. Accordingly, the MCC proceeded to the aircraft to prepare it for the MP while the crew chief expediter waited for the PMA drive to finish docking (Tab R-3).

Technical Order (T.O.) guidance governing launch procedures require the removal of all safety devices, including the inlet covers, grounding wire, and the landing gear safety pins. During the

launch procedures, if SES servicing is required, maintenance personnel are referred to another T.O. for procedures to render the aircraft Safe for Maintenance. To render the aircraft Safe for Maintenance, all landing gear pins must be installed prior to SES servicing. After SES servicing is completed, the T.O. governing Safe for Maintenance procedures refers the user back to the launch procedure step where the pilot communicates to the crew chief to prepare for engine start by ensuring the areas forward and aft of the engines are clear and by monitoring engine start (Tab CC-7 thru CC-9).

After the MP and MCC accomplished the pilot "walk-around," the PMA drive arrived. (Tab V-2.6) There is conflicting testimony concerning whether the main landing gear pins were removed at this time, or if they were still installed at the time of the mishap (Tab V-1.12; Tab V-2.8; Tab V-6.1). However, it is undisputed that at least the NLG pin was intentionally left installed.

After the MP reviewed the active aircraft forms in the PMA, he accepted the aircraft and climbed inside the cockpit. The aircraft was ready for launch procedures knowing SES air servicing would be performed after APU start-up (Tab V-2.8).

After APU start-up, the SES servicing crew arrived and prepared the aircraft for servicing by uncapping the SES air port valve and positioning the equipment at the right side of the nose wheel well (Tab V-6.1). However, shortly after the SES servicing crew set up, the MP determined the SES was recharging adequately, and servicing was not needed (Tab V-2.9).

The MP then told the MCC the SES system was charging up normally on its own, and SES servicing was not needed (Tab V-2.9). The MCC asked the MP to verify that the SES did not require servicing and was he was told a second time that it did not (Tab V-1.10). The SES servicing crew then secured the air servicing port valve with its cap (Tab V-4.1; Tab V-5.1). The SES servicing crew member intentionally left the nose landing gear pin installed since MCC was in charge of the launch. This way, the MCC could pull the pin and be certain that it was removed (Tab V-7.1). The SES servicing crew began to remove the equipment from the area (Tab V-6.1).

The MCC ensured his fire guard maintained visual contact with the pilot while the MCC disconnected communications and assisted the SES crew with removal of the servicing cart (Tab V-1.11). After removing the equipment, the SES crew cleared the area outboard to the right rear of the aircraft (Tab V-6.1; Tab V-8.1). The MCC moved "briskly" across to the left side of the aircraft and reconnected communications with the pilot (Tab V-1.11 thru V-1.12). The MCC glanced the aircraft over to see if everything was clear and ready for engine start. The MCC did not notice the NLG pin streamer (Tab V-1.17; Tab V-2.9). The NLG pin streamer was not tied to the NLG strut (Tab V-1.13). The streamer was to the rear of the NLG well and extended parallel to the NLG strut (See Figure 2).

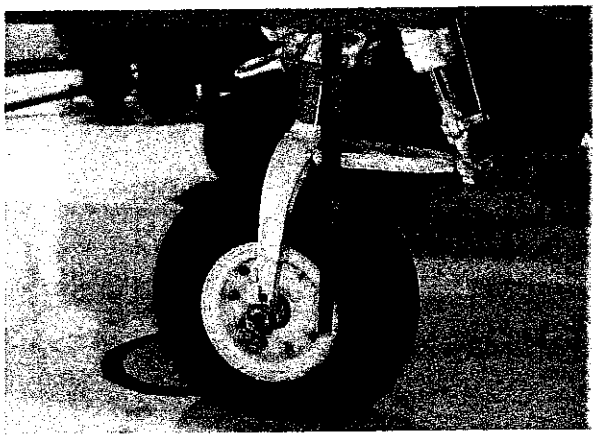

Figure 2 – Example of the streamer's position at the time of the mishap

On 20 Oct 05, while the MCC accomplished launch procedures, the area around the mishap aircraft was very dark and winds were light (Tab V-2.6). The NLG pin streamer was dark red in color, approximately two to three feet in length, and lacked any reflective material (Tab V-1.22; Tab V-1.24). The color and lack of reflective material diminished the MCC's ability to spot the streamer as he visually scanned the aircraft. In tests conducted under similar conditions, the board was unable to discern the NLG streamer.

The MCC cleared the MP to start engines without knowing the nose landing gear pin was still inserted (Tab V-1.12). Engine start was normal and resulted in air turbulence in the areas surrounding the intake, which included the NLG strut. After both engines started, the MP specifically asked the MCC if he had removed the nose gear pin (Tab V-2.10 thru 2.11). The MCC "scrunched" down to look directly at the NLG and this time saw that he had not removed the NLG pin (Tab V-1.12; Tab V-2.11).

The MCC told the MP to shut down the left engine so that he could remove the NLG pin. After the RPM (rounds per minute) of the left engine was at zero, the MCC approached the left engine inlet, put his hand across the inlet to ensure there was no suction, and then he knelt down on the left side of the nose wheel well. The MCC extended his left arm fully to try to remove the nose gear pin but was unable to reach it (Tab V-1.12). (See Figure 3)

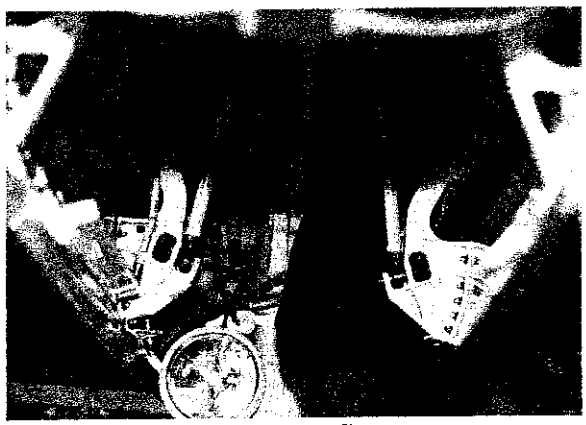

Figure 3 – Example of the MCC's first attempt to remove the NLG pin

The MCC physically put his upper torso up into the gear well and used his right hand to remove the pin (Tab V-1.12). (See Figure 4)

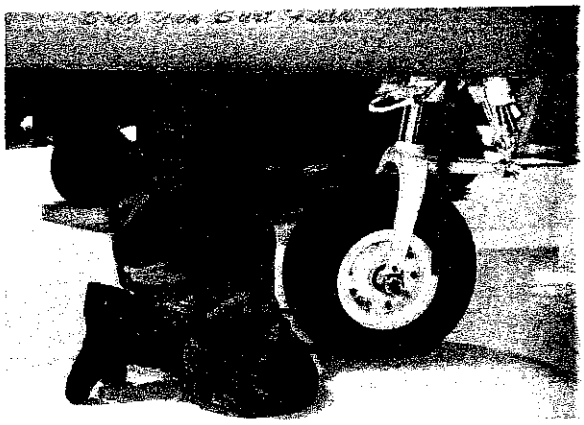

Figure 4 – Example of an individual's position as he attempts to remove the NLG pin

However, the MCC did not secure the pin's streamer. The streamer caught the suction from the right engine and pulled the pin from his hand directly into the left engine (Tab V-1.12). The board accompanied the MCC to a static F-22A to observe exactly how the MCC maneuvered to extract the pin. The MCC attempted to place his entire torso into the confined space of the nose wheel well. The MCC was only able to feel the NLG pin and was not able to completely see the NLG pin as he attempted to remove it (See Figures 4 & 5). Such maneuvering made it difficult to both control the streamer and remove the NLG pin (Tab V-1.12).

Figure 5 – Example of an individual's hand and head positions as he attempts to remove the NLG pin

As stated previously, T.O. guidance requires the removal of all landing gear pins before engine start. There is no F-22A T.O. guidance for removing the NLG pin while an engine is running. Additionally, there is no T.O. guidance for the F-22A regarding procedures for rendering the aircraft safe when a maintenance problem is detected during launch or recovery operations ("Red Ball Safe for Maintenance"). Similar aircraft, such as the F-15, have specific T.O. guidance to "safe" the aircraft for maintenance during "Red ball" conditions. According to the F-15 T.O., 1F-15C-2-05JG-00-1, such guidance include that a serviceable fire extinguisher exists; aircraft

chocks are installed; a static ground cable is installed; communications with the aircrew established; and all live ordnances safe. It does not include installation of landing gear pins. Air Force Instruction (AFI) 21-101, paragraph 18.20.1, dictates that Red Ball Maintenance does not permit any shortcuts or deviation from any T.O. guidance, from personal safety requirements, or from the requirement to document any maintenance actions.

There is F-22A T.O. guidance for installing a NLG pin with the right engine operating. This procedure was developed to help prevent un-commanded NLG retraction upon shutting off electrical power. Following an F-22A NLG collapse mishap at Edwards AFB in March 2004, aircraft shut down procedures were changed to insert the NLG pin after left engine shutdown and before right engine shut down. This alternate shut down procedure is still in place for all F-22A's that do not have Time Compliance Technical Order (TCTO) 638 accomplished. This TCTO is a modification to the aircraft to address the deficiency that resulted in the NLG collapse at Edwards AFB. (Tab V-2.10)

At the time of the mishap, all F-22A's assigned to Langley AFB were produced with this TCTO 638 incorporated during production. However, until July 2005, the 27th AMU also was operating two F-22A's on loan from Tyndall AFB that did not have the TCTO 638 incorporated (Tab V-6.1). To avoid confusion between modified and unmodified aircraft, the 27th FS Director of Operations (DO) and the 27th AMU officer in charge (OIC) directed 27th FS pilots and 27th AMU personnel to shut down all F-22A's at Langley using pre-TCTO 638 procedures, that is shut down the left engine, install the NLG pin then shut down the right engine (Tab V-2.10; Tab V-7.2)

The TCTO 638 procedure requires the following: (1) the gear pinner will wear coveralls and ear/head protection with serviceable chin strap secured and (2) the gear pinner will have, in hand, the gear pin with lanyard attached (approximately 7" in length) and streamer rolled up and secured. Also, the lanyard will be clamped to the gear pinner's arm with rubber bands/Velcro as a safety precaution if pin is dropped (Tab V-8.2).

d. Maintenance Personnel and Supervision:

This board thoroughly inspected the mishap MCC's training records to include his Career Field Education and Training Plans (CFETP), AF Form 623As, AF Form 797s, and Special Certification Rosters. At the time of the mishap and during the board's investigation, no specific F-22A CFETP exist, therefore all F-22A specific training are tracked using the AF Form 797. According to the AF Forms 797s, the MCC had been adequately trained on F-22A aircraft launch and SES air servicing procedures (Tab G-15 thru G-26).

On 6 May 2005, after an incident involving the "open/close canopy electrically" procedure, the MCC was decertified on that specific maintenance task. On 8 July 2005, the MCC was re-certified on that specific maintenance task. The board found no training factors that led to this mishap (Tab G-23).

e. Fuel, Hydraulic and Oil Inspection Analysis.

Fuel, Hydraulic and Oil were not factors in this mishap.

f. Unscheduled Maintenance.

The IMIS and CAMS history from 20 Sep 05 to 20 Oct 05 were reviewed. All unscheduled maintenance events that were completed were done so in accordance with applicable technical orders and established procedures. There were five open unscheduled maintenance items in the forms at the time of the accident and none of the open items would have prevented the MA from flying. Three of the open unscheduled maintenance items were related to the SES air build-up system. The remaining two unscheduled maintenance discrepancies had no impact on the mishap (Tab D-1 thru D-77).

6. AIRCRAFT AND AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Condition of Systems.

After the mishap, the F-119-PW-100 engine was removed and examined by Pratt & Whitney personnel from Kirtland AFB, New Mexico (NM). The engine was torn down and inspected at the F-119 Heavy Maintenance Center at Tinker AFB, Oklahoma (OK). All engine damage was consistent with the ingestion of a hard solid object (Tab J-5). Extensive damage and debris were noted throughout the engine including the engine case, fan module, core module and low pressure turbine module. The augmenter liner had to be replaced due to debris ingestion. Pieces of pin fragments, coiled wire and red fabric found in the nozzle module required the nozzle be completely disassembled, cleaned and reassembled. The mishap aircraft sustained a repairable 1" gouge in the intake coating of the right engine. The engine had 418.7 hours of engine operating time at the time of the mishap with a normal maintenance history. The engine, Air Recharge System (ARS), and SES were all functioning normally at and after the time of mishap (Tab J-1 thru J-6).

7. WEATHER

a. Forecast Weather.

Forecast weather was few clouds at 5000 MSL and scattered clouds at 20000 MSL (Tab F-2).

b. Observed Weather.

The observed weather at 0159 Z was winds variable direction at 2 knots, 7 statute miles visibility, scattered clouds at 20000 MSL, and a temperature of 12 degrees Celsius. At 0259 Z, the weather was winds variable direction at 4 knots, 7 statute miles visibility, few clouds at 20000 MSL, and a temperature of 12 degrees Celsius (Tab F-3).

Sunset occurred at 2339 Z with nautical twilight ending at 0039 Z. Moonrise did not occur until 0229 Z (Tab F-2). The mishap occurred at approximately 0230 Z. It was very dark on the ramp during preflight operations (Tab F-2 thru F-3).

c. Space Environment.

Not applicable.

d. Conclusions.

Operations were conducted under normal weather conditions.

8. CREW QUALIFICATIONS

a. Mishap Pilot

As a highly experienced fighter pilot and USAF test pilot school graduate, the MP is one of the most experienced F-22A pilots in the USAF. At the time of the accident, he was (and still remains) the 1st Operations Group (OG) chief of F-22A standardization and evaluation, a position commensurate with his high experience level. He qualified in the F-22A at Edwards AFB, California (CA), in January 2004. At the time of the mishap, the MP had 214.5 hours flying the F-22A. He also had 2179.2 total hours flying other aircraft, primarily in F-15A-D and F-16A-D aircraft. He arrived at the 27th FS in July 2005 and was accepted by the 27th FS as a qualified flight lead, mission commander, instructor pilot, flight examiner, and functional check flight pilot. The MP's currency met the Basic Mission Capable (BMC) rate required by AFI 11-2F/A-22V3. The inflow of new aircraft, pilots, and maintainers and working the unique challenges associated with a new aircraft made Combat Mission Ready levels of currency difficult to maintain. Recent flight time is as follows (Tab G-2 thru G-10):

	Hours	Sorties
30 days	4.4	4
60 days	17.9	13
90 days	27.4	21

9. MEDICAL

a. Qualifications.

The medical and dental records of the MP, the MCC and other relevant maintenance personnel were thoroughly reviewed. At the time of the mishap, all were medically qualified for worldwide duty and the MP was qualified to fly high performance aircraft.

b. Health.

The MP was immediately returned to flying status by the Hill AFB Flight Surgeon.

c. Toxicology.

Post mishap toxicology laboratory values, to include carbon monoxide, urine drug screen and urine alcohol were all completely normal (negative findings) for all personnel, including, the MP and the MCC (Tab X-3 thru X-7).

d. Lifestyle.

There is no evidence that unusual habits, behavior, or stress contributed to this mishap.

e. Crew Rest and Crew Duty Time.

All crew rest requirements were met.

10. OPERATIONS AND SUPERVISION

a. Operations.

For several months before the mishap, the 27th FS and 27th Aircraft Maintenance Unit (AMU) had been very active to ensure that the F-22A would achieve Initial Operational Capability (IOC) by December 2005. The deployment to Hill AFB was a critical factor for demonstrating the aircraft's capability to deploy and operate from a deployed location. Additionally, the deployment provided the majority of squadron pilots their first actual air to ground munitions employment from the F-22 (Tab V-2.23).

The 27th FS pilots were all experienced fighter pilots who transferred from other aircraft to fly the F-22A. Their experience in the F-22A varied widely as the squadron built up its initial cadre of pilots. The 27th AMU maintenance personnel were also experienced on other aircraft before they transitioned to the F-22A and, for the most part, they were hand picked to be part of the unit. At the time of the incident, the 27th FS had been actively flying the F-22A for approximately eight months (Tab V-9.1).

b. Supervision.

The mission was properly scheduled, planned and briefed.

11. HUMAN FACTORS ANALYSIS

a. Overview.

The board considered all the Environmental and Individual Human Factors Elements contained in AFPAM 91-211, Attachment 8, and analyzed them to identify potentially relevant factors that may have contributed to the mishap.

After a thorough review of all potentially relevant human factors, ED503 (Written Procedures) was determined to be a contributing factor in the mishap. There was a clear deficiency in the

Aircraft Launch Inspection T.O. guidance for removal of landing gear (LG) pins after SES servicing and before engine start up. Also, IB207 (Habit Interference) was determined to be a contributing factor in the mishap. There is no T.O. guidance for removing a NLG pin with engines operating; therefore the MCC reverted to training and experience from the F-15C and F-22A. Furthermore, EB407 (Exercises/Evaluations) was determined to be a contributing factor in the mishap. The MCC was deployed under high stress conditions, which generated a greater sense of hurriedness. In addition, IB606 (Risk Assessment) was determined to have been a causal factor in the mishap. The MCC failed to adequately evaluate potential threats associated with removing the NLG pin with the right engine operating.

b. Written Procedures.

Written Procedures is a factor when written procedural guidance or publications are clearly deficient.

(1) Events leading to Written Procedures.

The T.O. guidance governing launch procedures requires the removal of all safety devices, including the inlet covers, grounding wire, and the landing gear safety pins. During the launch procedures, if SES servicing is required, maintenance personnel are referred to another T.O. for procedures to render the aircraft Safe for Maintenance. To render the aircraft Safe for Maintenance, all landing gear pins must be installed. After SES servicing is completed, the T.O. refers the user back to the launch procedure step where the pilot communicates to the crew chief to prepare for engine start by ensuring the areas forward and aft of the engines are clear and by monitoring engine start. Nowhere in the T.O. guidance for Safe Maintenance Procedures does the procedural flow again direct the removal of the LG pins. Instead, the current T.O. guidance simply returns the user after completion of the SES servicing to where he left off in the previous procedure – engine start (Tab CC-7 thru CC-9).

(2) Evidence suggesting Written Procedures.

Technical Order guidance clearly states to make the aircraft safe for maintenance prior to servicing, and part of that process is the installation of the LG pins. However, once it was discovered that SES servicing was not needed, there was no T.O. guidance to direct the MCC to remove the LG pins (Tab CC-7 thru CC-9) The above deficiency in written procedural guidance is a contributing factor in the mishap.

c. Habit Interference.

Habit Interference is a factor when the individual reverts to previously learned response modes which are objectively inappropriate to the task at hand.

(1) Events leading to Habit Interference.

Familiarity with installing the NLG pin with the right engine operating was a contributing factor to this mishap. Following an F-22A NLG collapse mishap at Edwards AFB in Mar 04, aircraft

shut down procedures were changed to insert the NLG pin after left engine shutdown and before right engine shut down (Tab V-2.10) The MCC was accustomed to performing this procedure on every F-22A until the departure of the last Tyndall loaner F-22A in July 2005 (Tab V-1.24 thru V-1.25). In addition, the MCC and MP were previously qualified on the F-15C. During F-15C operations, the NLG pin is removed after right engine start and installed before right engine shut down (Tab V-2.10). On the F-15C, the MCC was accustomed to not having to secure the LG pin streamer during install or removal with the right engine operating.

(2) Evidence suggesting Habit Interference.

After the MCC realized the NLG was still installed, and considering his familiar habit pattern of installing the NLG pin in the F-22A, he may have reverted to a previously learned habit pattern from the F-15C for pin removal (Tab V-1.14 thru V-1.18).

Although there is no F-22A technical guidance for removing the NLG pin while an engine is running, there is guidance for how to insert a landing gear pin while an engine is running. The MCC's past experience removing an F-15C pin without securing the pin streamer while an engine is on could have lead him to disregard the need to do so for an F-22A. This reversion to previously learned responses was a contributing factor in the mishap.

d. Exercises/Evaluations.

Exercises/Evaluations are a factor when the conditions surrounding a mission generate excessive stress for the individual. These conditions are often present during deployments, exercises, high-visibility missions or flights where the air crew will be evaluated.

(1) Events leading to Exercises/Evaluations.

The MCC's unit was TDY to Hill AFB on a deployment required for IOC declaration of the F-22A. As this was the F-22A's first operational deployment, everyone was under a higher degree of scrutiny and visibility as evidenced by the media attention throughout the TDY. Maintenance personnel were keenly aware of the importance of a successful deployment (Tab V-9.1).

(2) Evidence suggesting Exercise/Evaluations.

When the MP arrived at the aircraft, the PMA drive was not installed, and the PMA was not ready for the MP to sign off the acceptance. This was an uncharacteristic chain of events for the MCC. These unusual events within the context of the higher stress environment lead to the MCC feeling "rushed." (Tab V-1.17; Tab V-2.6 thru V-2.7). The high stress environment was a contributing factor in the mishap.

e. Risk Assessment.

Risk assessment is a factor when the individual fails to adequately evaluate potential risks associated with a selected course of action, and this failure leads to an unsafe situation.

(1) Events leading to Risk Assessment.

The MCC was accustomed to removing and installing the NLG pin in an F-15C and installing the NLG pin in the F-22A with the right engine operating. The F-15C does not require securing the streamer when removing the NLG pin. In his experience and while completing the NLG installation on the F-15C, the MCC has only noticed minimal suction from the F-15C's right engine. There is, however, a noticeable difference in suction between the F-15C and the F-22A when an individual is standing in a similar position to install the NLG pin. Suction from the F-22A was more powerful (Tab V-1.15 thru V-1.16).

(2) Evidence suggesting Risk Assessment.

The MCC was accustomed to both removing the NLG pin in the F-15C with the right engine running and to doing so without securing the pin streamer. There was an absence of perceived threat from the higher suction present from the F-22A, and the MCC did not secure the streamer, as is done when installing the NLG pin with the right engine running (Tab V-1.18). This failure to adequately evaluate the threat posed by greater suction power was a causal factor in the mishap.

12. ADDITIONAL AREAS OF CONCERN

The board had no additional areas of concern.

13. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operations Directives and Publications.

1. T.O. 1F-22A-1
2. AFI 11-2FA-22V3
3. T.O. 1F-22A-1, *Flight Manual for F-22A Raptor*
4. T.O. 1F-22A-1CL-1, *Flight Crew Checklist for F-22A Raptor*
5. AFI 11-2F-A22V1, *F-22A Aircrew Training*
6. AFI 11-2F-A22V3, *F-22A Operations Procedures*
7. AFPAM 91-211, Attachment 8, *USAF Guide to Aircraft Safety Investigation*

b. Maintenance Directives and Publications.

1. AFI 21-101, *Aerospace Equipment Maintenance Management*
2. AFI 21-101, ACCSUP1, *Aerospace Equipment Maintenance Management*
3. AFI 21-101, LAFBSUP1, *Aerospace Equipment Maintenance Management*
4. PMA T.O. 1F-22A--*Aircraft Launch* (CDM ID: F728193144)
5. PMA T.O. 1F-22A--*Stored-Energy System Servicing* (CDM ID: F707192144)
6. PMA T.O. 1F-22A--*Verify Safe For Maintenance* (CDM ID: F700071144)
7. PMA T.O. 1F-22A--*Aircraft Recovery* (CDM ID: F14820144)

c. Known or Suspected Deviations from Directives or Publications.

(1) Mishap Crew.

None

(2) Lead Crew/Others.

None.

(3) Operations Supervision.

None.

(4) Maintenance.

None.

14. NEWS MEDIA INVOLVEMENT

Several media agencies were present at the time of the mishap due to the high interest in the F-22A program. Several inquiries were fielded at the time of the mishap; however media interest has been minimal since then. (Tab DD)

13 Jan 06

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