

UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT



CV-22B, T/N 08-0037

**8th Special Operations Squadron
1st Special Operations Wing
Hurlburt Field, Florida**



LOCATION: Kandahar Air Base, Afghanistan

DATE OF ACCIDENT: 11 October 2011

BOARD PRESIDENT: Colonel Brett D. Sharp

Conducted IAW Air Force Instruction 51-503

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION CV-22B, T/N 08-0037 KANDAHAR AIR BASE, AFGHANISTAN 11 OCTOBER 2011

On 11 Oct 11, at 19:53:49 Zulu (Z) time, the Mishap Aircraft (MA), a CV-22B, tail number (T/N) 08-0037, departing Kandahar Air Base (KAF), Afghanistan, operated by the 8th Special Operations Squadron, sustained damage to the right propotor hub and propotor gearbox when the aircraft maneuvered to avoid collision with another aircraft in its formation immediately upon takeoff and impacted the ground. The aircraft was assigned to the 20th Special Operations Squadron, 27th Special Operations Wing, Cannon Air Force Base, New Mexico. No deaths and one minor injury resulted from the mishap. The MA sustained \$2,047,493.13 in damage.

The MA was the third aircraft in a three aircraft formation supporting a nighttime mission. The formation was taxi complete at 19:52:43Z, and cleared for takeoff by tower at 19:53:23Z. As the formation commenced with takeoff, the Mishap Copilot (MCO) performing the takeoff applied takeoff power and became airborne prior to Chk 2 (Chk2), who was located 150 to 200 feet in front of the MA. The takeoff procedure was a formation 75 degree short takeoff (75 STO) which was understood to include a spacing delay of about five seconds between aircraft. Lack of clarity on the formation 75 STO procedures regarding aircraft spacing, coupled with shortening the six second power push to less than three seconds, contributed to the MCO responding to forward motion from Chk2 with an anticipatory response and taking off out of sequence prior to Chk2.

The out of sequence takeoff by the MA caused the mishap pilots to assess a risk of collision between the two aircraft. The MCO tried to arrest his forward motion and avoid overtaking Chk2 by pulling back on the cyclic control stick and pulling the thrust control lever (TCL) back to idle. This reduced aircraft power and pitched the aircraft nose up. These control inputs produced a high sink rate, prompting the MCO and Mishap Pilot (MP) to rapidly apply full power. The MA had only achieved approximately 13 feet (ft) in altitude, as measured by the MA's radar altimeter, and was unable to arrest the sink rate before impacting the ground at 525 ft per minute. The MA impacted first on the ramp, then pitched forward onto the main landing gear, and finally the nose gear before immediately becoming airborne again. The movement of the TCL from idle to full power in six-tenths of a second, in conjunction with striking the ground and the rapid application of three and one-half inches of aft cyclic, caused excessive flapping of the rotor blades resulting in damage to the propotor hub and propotor gearbox.

The Accident Investigation Board (AIB) President determined, by clear and convincing evidence, the causes of the mishap were: 1) The MCO's failure to maintain formation discipline during takeoff; and 2) The MCO's aggressive application of control inputs, after prematurely becoming airborne, in conjunction with impacting the ground. Additionally, the AIB President found, by a preponderance of the evidence, the non-standardized procedures for executing a formation 75 STO substantially contributed to the mishap.

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

**SUMMARY OF FACTS AND STATEMENT OF OPINION
AIRCRAFT ACCIDENT INVESTIGATION
C/V 22-B, T/N 08-0037
KANDAHAR AIR BASE, AFGHANISTAN
11 OCTOBER 2011**

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

AC	Aircraft Commander	FOB	Forward Operating Base
ADI	Attitude Director Indicator	FPM	Feet Per Minute
AF	Air Force	Frag	Fragmentary Order
AFB	Air Force Base	Ft	Feet
AFE	Aircrew Flight Equipment	GC	Ground Control
AFI	Air Force Instruction	HLZ	Helicopter Landing Zone
AFSAS	Air Force Safety Automated System	HUD	Heads up Display
AFSOC	Air Force Special Operations Command	HQ	Headquarters
AFSOCH	Air Force Special Operations Command Handbook	IAW	In Accordance With
AFTTP	Air Force Tactic Techniques Procedures	IFD	Individual Flight Data
AGL	Above Ground Level	ITS	Individual Training Summary
AHLTA	Armed Forces Health Longitudinal Technology Application	IVO	In Vicinity Of
AIB	Accident Investigation Board	JOC	Joint Operation Center
AIMWITS	Aeromedical Information Management Waiver Tracking System	KAF	Kandahar Air Field/Base
AOR	Area of Responsibility	KCAS	Knots Calibrated Airspeed
Approx	Approximately	kts	Knots
ARMS	Aviation Records Management System	LA	Legal Advisor
AMEGS	Aircraft Maintenance Event Ground Station	LC	Local Control
ATC	Air Traffic Control	LRU	Line Replaceable Unit
ATO	Air Tasking Order	Lt Col	Lieutenant Colonel
Attach	Attachment	MA	Mishap Aircraft
AWACS	Airborne Warning and Control System	Maj	Major
C1CP	Chalk 1 Copilot	MAJCOM	Major Command
C1FL	Chalk 1 Formation Lead Aircraft Commander	MC	Mishap Crew
C2AC	Chalk 2 Aircraft Commander	MCC	Mishap Squadron/Unit Commander
C2CP	Chalk 2 Copilot	MCO	Mishap Copilot
C2T	Chalk 2 Flight Engineer, Tail Scanner	MDS	Mission Design Series
CAMS	Core Automated Maintenance System	MFD	Multifunction Display
Capt	Captain	MFS	Mishap Flight Surgeon
CAS	Close Air Support	MLG	Main Landing Gear
CFETP	Career Field Education and Training Plan	MP	Mishap Pilot/Aircraft Commander
Chk2	Chalk 2	MS	Mishap Flight Engineer, Seat
Col	Colonel	MT	Mishap Flight Engineer, Tail Scanner
CV	Cargo Vertical	MU	Mishap Unit
DoD	Department of Defense	NAVAIR	Naval Aviation
DoD-HFACS	Department of Defense Human Factors Analysis and Classification System	NCOIC	Noncommissioned Officer in Charge
DNIF	Duties Not Include Flying	Np	Power Turbine Speed
DOV	Squadron Standardization and Evaluation	NATOPS	Naval Air Training and Operating Procedures Standardization
CRM	Career Resource Management	NM	New Mexico
DVRS	Digital Video Recording System	NOTAM	Notice to Airmen
FAE	Functional Area Expert	NVG	Night Vision Goggles
FCIF	Flight Crew Information File	OEF	Operation Enduring Freedom
FHR	Flight History Report	OGV	Group Standardization and Evaluation
FL	Florida	Ops Tempo	Operations Tempo
		Para	Paragraph
		POD	Period of Darkness
		PHA	Physical Health Assessment
		PFCs	Primary Flight Control System
		PIMR	Preventive Health Application and Individual Medical Readiness

PRGB	Proprotor Gearbox	TCL	Thrust Control Lever
QA	Quality Assurance	TCTO	Time Compliance Technical Order
QRF	Quick Reaction Force	T/N	Tail Number
RTB	Return to Base	TOC	Tactical Operational Center
ROE	Record of Evaluation	TOD	Tech Order Data
SCIF	Sensitive Compartmentalized	TOT	Time on Target
	Information Facility	TST	Time Sensitive Target
SOF	Special Operations Forces	TX	Texas
SOS	Special Operations Squadron	USAF	United States Air Force
SOG	Special Operations Group	VFR	Visual Flight Rules
SOW	Special Operations Wing	VSLED	Vibration Structural Life and
Sq/CC	Squadron Commander		Engine Diagnostic
STA	Station	Wt	Weight
TAR	Technical Assistance Request	Z	Zulu Time

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

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 18 Nov 11, Major General Otis G. Mannon, Vice Commander, Air Force Special Operations Command (AFSOC), United States Air Force (USAF), convened an Accident Investigation Board (AIB) in accordance with (IAW) Air Force Instruction (AFI) 51-503, Aerospace Accident Investigations, 26 May 10, to investigate the 11 Oct 11 crash of a CV-22B Osprey aircraft, tail number (T/N) 08-0037, at Kandahar Air Base, Afghanistan (KAF). The following USAF personnel served as board members:

Colonel Brett D. Sharp
Captain (Redacted)
Captain (Redacted)
Captain (Redacted)
MSgt (Redacted)
SSgt (Redacted)

Board President
Legal Advisor
Medical
Pilot
Maintenance
Recorder

b. Purpose

This is a legal investigation convened to inquire into the facts surrounding the aircraft or aerospace accident, to prepare a publicly-releasable report, and to gather and preserve all available evidence for use in litigation, claims, disciplinary actions, administrative proceedings, and for other purposes.

2. ACCIDENT SUMMARY

On 11 Oct 11, at 19:51:50 Zulu time (Z), the mishap aircraft (MA), CV-22B, T/N 08-0037, taxied into position as the chalk three aircraft in a three CV-22B formation at KAF (Tabs EE-3, EE-4, EE-5). At 19:52:43Z, the MA completed taxi to foxtrot taxiway (Tab EE-5). At 19:53:23Z, the chalk one aircraft commander (C1AC), the formation lead, requested and received clearance from the local control tower to takeoff from taxiway 23 foxtrot (Tab FF-4).

At no later than 19:53:41.800Z, the chalk one copilot (C1CP) applied takeoff power to the thrust control lever (TCL) and was airborne two seconds later at 19:53:43.800Z according to the weight on wheels switch (Tab EE-12). Following takeoff sequence, the second aircraft in the formation, chalk two (Chk2), applied takeoff power no later than 19:53:44.450Z, and was airborne two seconds later at 19:53:46.450Z (Tab EE-13). The MA should have sequentially taken off after Chk2; however, the MA had already taken off (Tab EE-15).

The MA takeoff was performed by the mishap aircraft copilot (MCO) instead of the mishap aircraft pilot (MP). The MP was the MA aircraft commander (Tab V-5.4). Executing takeoff was a normal duty for the copilots (Tab V-5.5). At approximately 19:53:41Z, the MCO observed the

chalk one aircraft (Chk1) moving forward and beginning to takeoff (Tab EE-12). The MCO then observed Chk2 moving forward and interpreted this movement as Chk2 beginning their takeoff sequence (Tabs V-14.7, V-14.8, R-15).

The MCO announced, "I'm going to push in the power," and without pause, he immediately pushed in power (Tab V-5.16). At approximately 19:53:43.350Z, the MCO started his TCL takeoff push. This occurred prior to Chk1 leaving the ground, prior to Chk2 applying takeoff power, and approximately three seconds prior to Chk2 breaking ground. At 19:53:45.550Z, the MA became airborne two seconds after applying takeoff power and nine-tenths of a second prior to Chk2 becoming airborne (Tabs EE-7, EE-8, EE-9, EE-10, EE-12, EE-13, EE-15).

As the MA became airborne, the MP saw that Chk2 was still on the ground and beginning to disappear below the glare shield. He directed the MCO to abort the takeoff, saying "whoa, whoa, whoa," and began to reach for the controls (Tabs R-4, R-13). The MCO then pulled the TCL back to idle (zero inches TCL) and applied aft cyclic in an attempt to arrest forward motion of the aircraft; this aggressively pitched the nose up (Tabs R-4, EE-7, EE-8, EE-9, EE-10, EE-11). The MA then began to experience a high sink rate (Tabs R-4, R-13, R-15, EE-7).

Witnesses stated the MA climbed to an altitude of approximately 30 feet (ft) (Tabs R-4, R-13, R-17). However, radar altimeter information as recorded in the MA Vibration Structural Load and Engine Diagnostic (VSLED) data indicates the MA peaked at 13 ft during the mishap event (Tab EE-11).

To arrest the high sink rate, both the MCO and the MP pushed the TCL to maximum power (four inches TCL) (Tabs R-4, R-15). The reapplication of full power did not prevent the aircraft from hitting the ground. The MA impacted first on the ramp and then pitched forward onto the main landing gear and finally the nose gear (Tabs V-13.7, EE-8). The main landing gear impacted the taxiway at 19:53:49.950Z (Tab EE-8). When the aircraft impacted the ground, the mishap flight engineer, tail scanner (MT) fell, pinching his right hand between his body and the ramp mounted weapon. Also, a belt of ammunition fell from its carrier onto the taxiway and the MP's night vision goggles (NVG) broke away from his helmet (Tabs R-4, R-5, R-13). At 19:53:50.350Z, the aircraft posted a Flapping Critical caution (Tab EE-18). With the MA still at full power, it took off again almost immediately, becoming airborne at 19:53:50.750Z (Tab EE-7). The MCO regained control of the aircraft (Tab R-4). The Mishap Flight Engineer, Seat (MS) announced the Flapping Critical caution. The MP put his NVGs back on and directed the MCO to turn around and land back at the taxiway (Tab R-4). The MCO made a left hand turn to enter the downwind traffic pattern to taxiway 23 foxtrot while the MP radioed Chk1 that he was returning to base for maintenance and coordinated landing clearance with the local tower (Tabs R-4, R-5). While en route back to KAF the MC performed a check of the aircraft prior to landing to ensure they were able to land safely (Tabs R-5, R-13).

The MA landed on taxiway 23 foxtrot, taxied back to parking, and shutdown without incident (Tabs R-5, R-13). While still on the parking ramp, the MP briefed the Mishap Squadron Commander (MCC) on what had happened (Tabs R-5, R-19). The MCC stood down the MC because they "seemed rattled" and replaced them with the night functional check flight crew (Tab R-19). The MC then debriefed with maintenance (Tab R-5). Upon inspection of the aircraft

by the MU maintenance personnel, damage was found to the propotor drive system. Total monetary damage to MA was calculated by MU maintenance personnel to be \$2,047,493.13 (Tab P-3). The MT's right hand was examined by the mishap flight surgeon (MFS) who determined it was only a mild hand injury with no functional deficit. There were no other reported injuries (Tabs V-8.11, V-8.12).

3. BACKGROUND

The MA, CV-22B, T/N 08-0037, is an asset of the 20th Special Operations Squadron (20 SOS), 27th Special Operations Wing (27 SOW), Cannon Air Force Base (AFB), New Mexico (NM). The 27 SOW belongs to Headquarters (HQ) Air Force Special Operations Command (AFSOC), Hurlburt Field, Florida (FL). At the time of the mishap, the CV-22B was controlled by the 8th Special Operations Squadron (8 SOS). 8 SOS is a unit within the 1st Special Operations Group (1 SOG) under the 1st Special Operations Wing (1 SOW) assigned to AFSOC (Tabs CC-3, CC-4, CC-8, CC-11, CC-13, CC-20, CC-21, CC-22).

a. Air Force Special Operations Command

AFSOC is headquartered at Hurlburt Field, FL, and is one of ten major Air Force commands. AFSOC's mission is to present combat ready Air Force Special Operations Forces to conduct and support global special operations missions. AFSOC provides Air Force Special Operations Forces for worldwide deployment and assignment to regional unified commands. The command's Special Operation Forces (SOF) are composed of highly trained, rapidly deployable Airmen, conducting global special operations missions ranging from precision application of firepower, to infiltration, exfiltration, resupply and refueling of SOF operational elements (Tab CC-3).



b. 23rd Air Force

The 23rd Air Force (23 AF) is the only numbered air force in AFSOC, and is designated as AFSOC's unit of execution to U.S. Special Operations Command. It was established 1 Jan 08, at Hurlburt Field, FL. The mission of the 23 AF is to provide highly trained special operations command and control, intelligence, weather, and reach back support force to deployed air commanders for execution of assigned missions (Tab CC-4).



c. 1st Special Operations Wing

The 1 SOW is at Hurlburt Field, FL. It is one of two Air Force active duty special operations wings and falls under AFSOC. The wing's mission focus is unconventional warfare: counter-terrorism, combat search and rescue, personnel recovery, psychological operations, aviation assistance to developing nations, "deep battlefield" resupply, interdiction and close air support (Tab CC-8).



d. 1st Special Operations Group

The 1 SOG, located at Hurlburt Field, FL, is one of four groups assigned to the 1 SOW. The group plans, prepares, and executes special operations, foreign internal defense, and security assistance worldwide in support of theater commanders. 1 SOG also provides aircraft and instructors of the Air Force Special Operations Training Center school for AC-130H/U gunship, MC-130E/H Combat Talon I/II, and U28 pilatus qualification (Tab CC-11).



e. 8th Special Operations Squadron

The 8 SOS is one of nine flying squadrons in the 1 SOW. The primary mission of the 8 SOS is insertion, extraction and re-supply of unconventional warfare forces and equipment into hostile or enemy controlled territory using airland or airdrop procedures. Other missions also include psychological operations and aerial reconnaissance (Tab CC-13).



f. CV-22B Osprey

The CV-22B Osprey is a tilt-rotor aircraft that combines the vertical takeoff, hover and vertical landing qualities of a helicopter with the long-range, fuel efficiency and speed characteristics of a turboprop aircraft. Its mission is to conduct long-range infiltration, exfiltration and resupply missions for SOF (Tab CC-22).

4. SEQUENCE OF EVENTS

a. Pre-deployment Training

Since the MP and MCO initially reported to the MU at home station, the following documents were published as guidance regarding the execution of a formation 75 STO procedure: 1) Air Force Special Operations Command Handbook (AFSOCH) 11-222, *Combat Aircraft Fundamentals, CV-22*, dated 22 Oct 10¹; and 2) 8 SOS Standard Operating Procedures (SOP), dated 1 Nov 09 (Tabs BB-3, BB-8, BB-12, BB-15).

At the time of the mishap, the formation 75 STO procedure was the standard prepared surface takeoff procedure for the MU (Tab V-10.24). However, guidance on the procedure had changed since 2009. The MU SOP from 1 Nov 09, para 2.6.6 stated, "During STOs or rolling takeoffs, subsequent aircraft will delay five seconds following takeoff power application by the preceding aircraft." Further, AFSOCH 11-222, dated 22 Oct 10, para 5.5.6.3, also requires the five second delay but omits when to initiate the five second count. The updated CV-22 SOP, dated 1 Jan 11, para 2.7.2, omits reference to the five second delay altogether. The Air Force Tactics Techniques and Procedures (AFTTP) 3-3, *Combat Aircraft Fundamentals, CV-22*, dated 8 Jul 11, para 5.5.5.3, references a 75 STO, but does not cross-reference the five second delay stated in para

¹ AFSOCH 11-222 was rescinded on 12 Aug 11 and replaced by AFTTP 3-3, dated 8 Jul 11 (released 11 Aug 11). Final version of AFSOCH 11-222 was dated 22 Oct 10 and previous versions were unavailable for reference.

5.5.2. Furthermore, para 5.5.1 states a "wing takeoff" (a simultaneous takeoff) can be used for a STO (Tabs BB-3, BB-8, BB-12, BB-15).

Within two years the MU SOP, dated 1 Nov 09, and AFSOCH 11-222, dated 22 Oct 10, were rescinded and replaced with guidance that was less specific regarding takeoff procedures from prepared surfaces (Tabs BB-3, BB-8, BB-12, BB-15). No other published guidance exists that defines formation spacing for the 75 STO departure, however, there is technical data regarding the amount of time the pilot should use to push the TCL from zero inches to full power, "As the aircraft begins to roll, smoothly advance the TCL to full forward in about 6 seconds." (Tab BB-22).

Techniques varied amongst pilots in the MU to ensure adequate separation from a preceding aircraft. Some pilots initiated a delay count when the preceding aircraft initiated a takeoff roll, some initiated a delay count when the preceding aircraft lifted off, and others viewed the delay count as a guide for what ultimately they believed was a visual maneuver (Tabs V-15.12, V-7.7, V-10.6).

b. Pre-deployment Spin-up

The MP, MCO, and MS, deployed temporary duty (TDY) to Cannon AFB, NM, for five days to conduct desert environment and formation training in preparation for their deployment to the area of responsibility (AOR) (Tabs V-5.4, V-7.9). While TDY, they flew approximately four night tactical formation sorties that were designed to establish them as a hard crew and emulate the conditions and procedures used in the AOR (Tabs V-5.4, V-7.9).

The MP arrived in the AOR on 24 Sep 11 (Tab V-5.3). The MP had completed six flights in the AOR before the mishap (Tabs AA-10, AA-36, AA-54, AA-55, AA-74, AA-75). The MCO arrived in the AOR on 27 Sep 11 (Tabs V-5.3, V-14.2). The MCO had completed five flights in the AOR before the mishap (Tabs AA-10, AA-25, AA-26, AA-31, AA-55). On 26 Sep 11, the Tactical Operations Center Chief (TOC Chief) gave the MP a local area briefing that included the standard takeoff and departure procedures (Tab V-7.5). The MCO received the same brief on 27 Sep 11 (Tab V-7.5). Both the MP and MCO flew with instructor pilots in the AOR prior to flying together as a hard crew (Tab AA-55). The MP and MCO had flown together in the AOR as a hard crew two times prior to the mishap (Tabs AA-10, AA-55).

c. Mission

On 11 Oct 11, the MA was supporting a classified air tasking order in the AOR (Tab R-11).

d. Planning

On 11 Oct 11, at 15:30Z the MC assembled at the TOC for the daily alert assumption briefing (Tab R-4). Notices to airmen, weather, and other items were covered at the alert assumption briefing (Tab V-10.4). At approximately 15:45Z the alert assumption brief ended and the MC and mishap formation aircrew were placed on standby for final mission specifics to be released (Tab R-11). From about 17:00Z to approximately 1745Z, the MP was away from the mission planning area for a teleconference (Tab R-4). At approximately 17:30Z the time on target (TOT)

for the mission was set for 19:30Z (Tabs V-6.5, V-15.4). At approximately 17:45Z the MP returned to the mission planning area (Tab R-4). The MC and the other two crews in the aircraft formation continued planning the specific logistics for the mission (Tab V-15.4). The mission for that night was described by all members of the MC as routine relative to the types of missions being flown during this deployment (Tabs V-1.4, V-5.9).

e. Preflight

At approximately 18:00Z, the MS, MT, and MFS, were released by C1FL to begin the preflight duties on the MA (Tab R-17). At approximately 18:00Z, the close air support (CAS) element supporting the formation relayed that the weather near the objective was below their required minimums for flight, and at that time would not be able to provide CAS to the formation aircraft at the TOT (Tab R-11). The C1FL recalled the mishap flight engineers and MFS (Tab R-11). The mishap flight engineers and MFS returned to the TOC at approximately 18:50Z to wait for the weather to improve (Tab R-17).

At approximately 18:45Z, the CAS element relayed that the weather at the objective area was now above their minimum limits and the mission was a go with an updated TOT of 20:30Z (Tabs R-4, R-11). At approximately 19:15Z, the MS, MT, MCO, and MFS were released by C1FL to begin preflight duties and prepare the MA for engine start (Tabs R-11, R-17). The Chalk 2 Aircraft Commander (C2AC) and the MP remained in the TOC to finish mission planning and attend a time sensitive target (TST) aircrew brief given by C1FL in accordance with Annex F of the CV-22 SOP, dated 1 Jan 11 (Tabs R-11, BB-19). During the TST aircrew brief, the departure was briefed as "standard" (Tab R-11). Under ideal circumstances, all formation aircrew members are present at the formation aircrew briefing; however, in a time sensitive situation it is acceptable to release aircrew to prepare the aircraft for flight and permit the aircraft commander attending the briefing to back brief the crew before takeoff (Tab V-15.4).

At approximately 19:35Z, the MCO arrived at the MA (Tab R-17). A few minutes later the MP arrived at the MA and gave the MC an informal back brief of the TST briefing (Tabs V-5.10, V-5.11, V-14.9). At about the same time, several passengers boarded the MA for transport to a forward operating base (Tab R-4). At approximately 19:40Z, the MA started in accordance with (IAW) the aircrew checklist and readied for taxi (Tab V-5.10). At approximately 19:45Z, all but one of the passengers de-planed the MA (Tab V-5.10).

f. Summary of Accident

At approximately 19:51Z, the MA taxied out of parking onto the taxiway, heading 230 degrees, approximately 150-200 ft behind and 25 ft to the right of Chk2 (Tab EE-5). The MA was the third of three aircraft in the formation (Tab R-17). Chk2 had a white landing light on, the position lights on steady dim, and the proprotor tip lights set to NVG bottom (bottom of blade tips illuminated only if wearing NVGs) (Tab V-5.17). At 19:53:17Z, the C1FL contacted the local control tower for permission to takeoff (Tab FF-4). The control tower cleared the formation for takeoff at 19:53:23Z (Tab FF-4). At 19:53:41.800Z, the formation lead aircraft initiated its takeoff roll (Tabs EE-3, EE-12).

It should be noted that both Chk2 pilots stated that prior to the formation lead taking off, the C2CP released the brakes and began a slow forward roll in anticipation of takeoff (Tabs R-9, V-12.7, V-12.5). The C2AC told the C2CP to stop, that the takeoff was to be a 75 STO, and to wait until the formation lead aircraft was airborne to begin the takeoff sequence (Tabs R-9, V-12.9, V-12.5). The C2AC told C2CP to stop forward roll because he wanted to avoid miscuing the MA (Tab V-1.12). C2CP then applied the brakes and came to a complete stop (Tabs V-12.5, V-12.9). The C2CP testified that he had in fact been initiating his takeoff sequence early when he was stopped by the C2AC (Tabs V-12.5, V-12.10). However, it cannot be determined with the VSLED data precisely when this event occurred (Tab EE).

The MCO saw formation lead begin the takeoff roll (Tab R-15). At this point the MCO perceived Chk2 to be rolling forward (Tab R-15). The MCO then looked to the right to clear his immediate area of hazards and then looked forward at Chk2 (Tabs V-14.4, V-14.5). The MCO then released the brakes and applied takeoff power at 19:53:43.350Z. At the time of power application, the MA was at 0.69 kts (Tab EE-5). Formation lead lifted off at 19:53:43.800Z, and was at full power two and four-tenths of a second after TCL push at 19:53:44.200Z (Tabs EE-12, EE-25). At 19:53:44.450Z, the C2CP began applying power (Tab EE-13). Chk2 had 6.68 kts at the time the TCL was moved from eight-tenths of an inch toward full power (Tab EE-13). The MA became airborne at 19:53:45.550Z, nine-tenths of a second earlier than when Chk2 became airborne and was at full power two and four-tenths of a second after initial power application at 19:53:45.750Z. Due to the out of sequence takeoff, the MA was airborne before and closing on Chk2 (Tabs EE-11, EE-15, EE-25, R-4, R-15). At this time, the MP told the MCO to abort the takeoff by stating, "whoa, whoa, whoa" (Tabs R-4, R-13). The MCO then exercised aggressive control inputs to arrest forward motion and avoid what he perceived as risk of collision with Chk2 (Tabs EE-7, R-4, R-15).

Released CV-22 data provides the following guidance regarding control inputs and maneuvering:

1) "Rapid or excessive application of aft stick during and after liftoff may result in high flapping" (Tab BB-23).

2) "A rapid power increase to arrest a descent in CONV can lead to both undesired pitch-up and a FLAPPING CRITICAL caution. Slower TCL increases (i.e. full power over 4 to 5 seconds) may reduce the pitch-up and flapping severity" (Tab BB-23).

3) "Damage to the rotor due to high flapping can occur in two ways. Very high flapping causes damage when there is hard contact near the hub. When (sic) total flapping at the transient flapping limit, the FLAPPING CRITICAL caution will post. This flapping level is indicative of potential contact damage in the rotor hub area. The resulting damage is typically cosmetic in nature; however, severe impacts could result in more significant damage. Flapping stop contact is typically associated with aggressive maneuvering, particularly between 75 degrees and 60 degrees nacelle or in low speed VTOL mode flight with high relative wind components" (Tab BB-23).

Each of the above emphasis items occurred as the MCO applied control inputs.

To arrest forward motion, the MCO simultaneously pulled back on the cyclic control stick and pulled the TCL from full takeoff power (four inches of TCL travel) back to idle power (zero inches of TCL travel) (Tabs EE-7, R-4, R-17). The combination of these two control inputs caused the MA to pitch approximately 10 degrees nose up and develop a high sink rate from an altitude of approximately 13 ft (Tabs EE-9, EE-11). Both the MCO and MP responded to the sink rate by pushing the TCL from idle to full power (zero inches to four inches) in six-tenths of a second. After reapplying full TCL power, the MCO then continued to apply aft cyclic, moving from two inches of aft cyclic to three and one-half inches of aft cyclic from 19:53:48.950Z to 19:53:50.150Z, keeping the aircraft in a nose high attitude (Tabs EE-7, EE-9, R-4, R-17).

It should be noted that the TCL moves to six inches, but there is no additional power produced by pushing the TCL from four inches to six inches (Tab BB-21). Data shows the pilots pushed the TCL to six inches, however, once the TCL was moved to four inches at 19:53:48.950Z no additional power was gained by continuing the TCL push to six inches (Tabs BB-21, EE-7).

The MA could not arrest the descent in time to avoid impacting the ground (Tab EE-7). At 19:53:46.450Z, Chk2 lifted off the ground and was at full power two and six-tenths of a second after initial TCL input at 19:53:47.050Z (Tab EE-13, EE-25). The Chk2 Flight Engineer Tail Scanner (C2T) stated that he witnessed the MA impact the ground as his aircraft (Chk2) was taking off (Tab R-6).

All three aircraft applied full takeoff power in less than three seconds, which is counter to technical data that calls for a power push of about six seconds (Tab BB-22).

g. Impact

The MA impacted taxiway 23 foxtrot on 11 Oct 11, at 19:53:49.950Z, heading 230 degrees (southwest) (Tab EE-8). The MA impacted ramp first, then on the main landing gear, and finally the nose landing gear (Tab EE-8). The aircraft was configured with the landing gear down and locked, nacelle angle at 75 degrees, and interim power active (Tab EE-10). The aircraft had a vertical velocity of 525 ft per minute upon impact (Tabs EE-7, EE-16). The right hand flapping sensor registered a Flapping Critical caution at 19:53:50.350Z (Tabs EE-18, EE-19). A Flapping Critical caution alerts the aircrew that the proprotor system has exceeded the flapping limit (vertical movement of the proprotor blades) and may be damaged (Tab BB-22). Since the TCL was at full power on impact, the MA bounced and became airborne again at 19:53:50.750Z (Tab EE-7). During the impact, the MCO continued to apply aft cyclic, increasing his pull to three and eight-tenths of an inch aft cyclic (Tab EE-7).

The MCO regained control of the MA and flew a left downwind pattern while the MP and MS ran the Flapping Critical checklist procedure (Tabs R-4, R-5, R-17). The MP radioed C1FL that the MA had to land for maintenance issues and would be breaking out of the formation (Tab R-5). The MA proceeded back to taxiway 23 foxtrot and landed from a hover (Tabs R-5, R-15, R-18). After landing the MA taxied to parking and shutdown at approximately 19:59:57Z (Tabs FF-3, R-5, R-15).

The below figure utilized comparison of Aircraft Maintenance Event Ground Station (AMEGS) TCL and weight on wheel data to graphically display the sequence of events during the mishap. A detailed description of this figure's data can be found in Tab EE (EE-24).

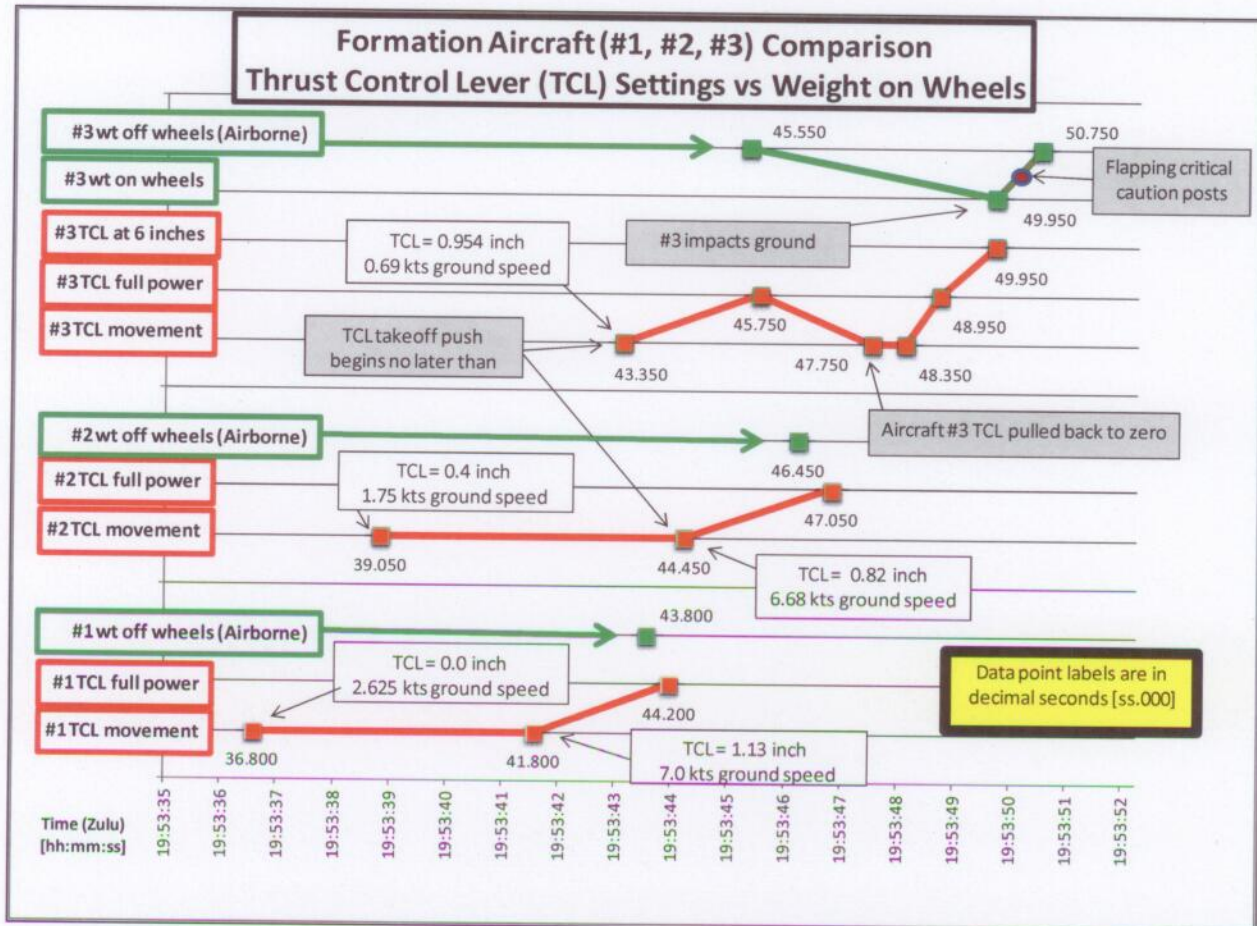


Figure 1 – Comparison of TCL and Weight on Wheel data of Mishap Formation

h. Egress and Aircrew Flight Equipment

The MP and MCO were using NVGs at the time of the mishap (Tabs R-4, V-14.6). The MP's NVGs fell off of his helmet mount when the MA impacted the ground, but were functioning normally before, during, and after the impact (Tabs V-5.16, R-4, H-3). The MCO reported no problems with his NVGs on the night of the mishap (Tab V-14.16). An aircrew flight equipment technician conducted a post flight inspection of the MP's and MCO's NVGs and found no damage or defects in the NVGs or the batteries that were used to power the NVGs (Tab H-3).

i. Search and Rescue

Not applicable.

j. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation and Inspections

The MA preflight inspection occurred IAW AFI 21-101, *Aircraft and Equipment Maintenance Management*, 26 Jul 10 (Tabs R-20, R-22, R-23). The preflight inspection identified no discrepancies or defects in the right proprotor gearbox, right proprotor hub, or other systems related to safety of flight or relevant to this investigation (Tabs R-20, R-22, R-23). On 11 Oct 11, at 1530Z the Maintenance Supervisor (Production Supervisor) completed, and signed, the Exceptional Release of the MA confirming there were no mechanical defects that would prevent the aircraft from performing flight operations, and releasing the aircraft for flight (Tab R-20).

There were no Time Compliance Technical Orders (TCTO) relevant to the mishap. The MA historical records, the Integrated Maintenance Document System (IMDS) 380, *Maintenance Report*, did not reveal any recurring maintenance problems (Tabs U-3 to U-37).

The Air Force Technical Order (AFTO) 781H, *Aerospace Vehicle Flight Status and Maintenance*, documenting the preflight inspection that occurred on the MA before the mishap was not available for review by the AIB because it had been destroyed prior to the convening of the AIB by the MU's Maintenance Plans and Scheduling Office IAW AFI 21-101, para 7.2.11.1.4.

b. Maintenance Procedures

None relevant to the mishap.

c. Maintenance Personnel and Supervision

A review of the aircraft historical documents revealed nothing relevant regarding maintenance personnel and/or their supervision. There is no evidence the preflight servicing of the MA, the relevant maintenance personnel, or their training or supervision, contributed to the mishap.

d. Fuel, Hydraulic and Oil Inspection Analyses

Not applicable.

e. Unscheduled Maintenance

None relevant to the mishap (Tab D).

6. AIRCRAFT AND AIRFRAME

a. Structures and Systems

(1) Right Hand Proprotor Gearbox Mast

The MA sustained damage to the right propotor gearbox (PRGB) mast (Tabs J-5, J-6, J-7). The maintenance superintendent submitted a Technical Assistance Request (TAR) detailing the data from the VSLED download and the visual damage to the PRGB mast (Tabs J-5, J-6, J-7). Upon further inspection, it was determined that the right PRGB mast was damaged due to the right propotor hub assembly contacting the propotor gearbox mast (Tabs J-5, J-6, J-7). The complete list of parts replaced is enumerated in Tab P-3 of this report (Tab P-3).

(2) Right Hand Proprotor Hub Assembly

The MA sustained damage to the right propotor hub assembly, including the right hand pitch change links, pitch change horns, and the pendulum damper mast adapter (Tabs J-5, J-6, J-7). The maintenance superintendent submitted a TAR detailing the data from the VSLED download and the visual damage to the hub assembly (Tabs J-5, J-6, J-7). Upon further inspection, it was determined that the hub assembly was damaged due to the right propotor hub contacting the propotor mast (Tabs J-5, J-6, J-7). The pitch change links and horns were damaged due to severe flapping (vertical blade movement) of the propotor blades (Tabs J-5, J-6, J-7). The pendulum damper mast adapter was damaged by the forces imparted on it during the impact and rapid power application (Tabs J-5, J-6, J-7). The complete list of parts replaced is enumerated in Tab P-3 of this report (Tab P-3).

b. Repair Station

Not applicable.

c. Functionality of Aircraft and Equipment

There is no evidence the MA or relevant equipment were functioning abnormally at the time of the mishap.

d. Test and Evaluation of Components

No components of the MA were suspected of failure and therefore, no further evaluation of components was required.

7. WEATHER

a. Forecast Weather

The following was the forecasted weather for KAF the day of the mishap: 1) winds 030 degrees at 3 knots; 2) runway temperature of 17 degrees Celsius; 3) pressure altitude of 3,098 ft;

4) lunar illumination of 99%; 5) few clouds at 6,500ft and broken cloud deck at 13,000 ft; and 6) visibility at 7 statute miles (Tab F-2).

b. Observed/Post-mishap Weather

On the night of 11 Oct 11, MP and MCO stated the weather was good, above visual flight rules (VFR) limits, and there was no degradation to their night vision due to obscurations (Tabs V-5.16, V-5.17). At 19:51:23Z, the observed weather was reported by the local control tower as "wind two three zero at four" (winds blowing from heading two three zero at four kts per hour) (Tab FF-4). No weather anomalies or conditions were reported at the airfield at the time of the mishap (Tabs FF-4, V-5.17). There was no change to the weather reported by the local control tower post mishap (Tab FF-4).

c. Space Environment

Not applicable.

d. Operations

Weather at the time of the mishap was within operational limits of MA (Tab F-2).

8. CREW QUALIFICATIONS

a. Mishap Aircraft Commander

(1) Training

The MP was a certified Mission Aircraft Commander and had been qualified in the CV-22B since 17 Jul 09 (Tab T-6). The MP had been a certified Mission Aircraft Commander since April 2011 (Tab V-5.22). The MP was sent on Temporary Duty (TDY) for five days to Cannon AFB, NM, for high altitude and desert environment training with the MC in preparation for deployment to the AOR (Tab V-5.4). The MP completed all required pre-deployment training and met all flying training currency requirements at the time of the mishap and at all times relevant to this investigation (Tabs G-10, G-11, G-12).

(2) Experience

The MP had 392.9 hours in the MV-22 and CV-22B Osprey, with 214.1 of those hours being on Night Vision Goggles (NVGs) (Tabs G-13, G-14). The MP's flight time during the 30, 60, and 90 days before the mishap were as follows (Tab G-7):

MP	Last 30 Days (11 Sep-11 Oct)	Last 60 Days (11 Aug-11 Oct)	Last 90 Days (11 Jul-11 Oct)
TOTAL HOURS	15.5	32.8	47
TOTAL SORTIES	11	19	28
NVG HOURS	12.5	22.7	33.1

b. Mishap Copilot

(1) Training

The MCO was a certified Mission Aircraft Commander and had been qualified in the CV-22B since 12 Feb 09 (Tab G-67). The MCO was sent TDY for five days to Cannon AFB, NM, for high altitude and desert environment training with the MC in preparation for deployment to the AOR (Tab V-14.2). The MCO completed all required pre-deployment training and met all flying training currency requirements at the time of the mishap and at all times relevant to this investigation (Tabs G-26, G-27, G-28).

(2) Experience

The MCO had 466.9 hours in the MV-22 and CV-22B Osprey, with 246.8 of those hours on NVGs (Tabs G-20, G-21). The MCO's flight time during the 30, 60, and 90 days before the mishap were as follows (Tab G-22):

MCO	Last 30 Days (11 Sep-11 Oct)	Last 60 Days (11 Aug-11 Oct)	Last 90 Days (11 Jul-11 Oct)
TOTAL HOURS	14.7	41.6	64.5
TOTAL SORTIES	9	25	38
NVG HOURS	14.6	33.6	50.6

c. Mishap Flight Engineer, Seat

(1) Training

The MS was a mission flight engineer and had been qualified in the CV-22B since 17 Feb 09 (Tab G-69). The MS was sent TDY for five days to Cannon AFB, NM for high altitude and desert environment training with the MC in preparation for deployment to the AOR (Tab V-6.4). The MS had completed all required pre-deployment training and met all flying training currency requirements at the time of the mishap and at all times relevant to this investigation (Tabs G-59, G-60, G-61).

(2) Experience

The MS had 331.5 hours of CV-22 time with 118.4 of those on NVGs at the time of the mishap. The MS's flight time during the 30, 60, and 90 days before the mishap were as follows (Tab G-56):

MS	Last 30 Days (11 Sep-11 Oct)	Last 60 Days (11 Aug-11 Oct)	Last 90 Days (11 Jul-11 Oct)
TOTAL HOURS	12.5	29.7	33.3
TOTAL SORTIES	11	18	22
NIGHT HOURS	6.0	12.9	26.3

d. Mishap Flight Engineer, Tail Scanner

(1) Training

The MT was an Evaluator Flight Engineer and had been qualified in the CV-22B since 6 Oct 06 (Tabs T-3, T-4). The MT had completed all pre-deployment training required and had met all flying training currency requirements at the time of the mishap and at all times relevant to this investigation (Tabs G-42, G-43, G-44).

(2) Experience

The MT had 812.5 hours of CV-22 time with 170.5 of those on NVGs at the time of the mishap. The MT's flight time during the 30, 60, and 90 days before the mishap were as follows (Tab G-39):

MT	Last 30 Days (11 Sep-11 Oct)	Last 60 Days (11 Aug-11 Oct)	Last 90 Days (11 Jul-11 Oct)
TOTAL HOURS	15.3	25.6	46.3
TOTAL SORTIES	11	15	28
NVG HOURS	6.6	9.8	18.8

9. MEDICAL

a. Qualifications

Medical qualifications for flying duties were reviewed for the MP, MCO, C2AC, C2CP and C2T. At the time of the mishap, and all times relevant to this investigation, all of the above mentioned members had current flight physicals and were medically qualified for flying duties without restriction (Tab DD-3).

b. Health

The AIB medical member reviewed the Armed Forces Health Longitudinal Technology Application (AHLTA), the Department of Defense electronic medical system, hard copy medical records from Oct 10 to Oct 11, the Preventive Health Assessment and Individual Medical Readiness (PIMR) system, and Aeromedical Information Management Waiver Tracking System (AIMWITS) for MP, MCO, C2AC, C2CP and C2T (Tab DD-3). Preventative Health Assessments (PHAs) and flight physicals were current for all of the above mentioned members (Tab DD-3). There were no members that had been issued a certificate restricting flight duties or "Duties Not Including Flying (DNIF)." There were no pending or expired medical waivers for any of the members. The members had no significant medical conditions that could have contributed to the mishap. None of the members were on any medications other than those which were previously recommended, ground tested, approved and prescribed by licensed medical providers (Tab DD-3). There was no evidence that medication was a factor in the mishap (Tab DD-3).

The MP, MCO, C2AC, and C2CP were all asked by the AIB to complete, a written 72 hour history and a 14 day history documenting nutrition, hydration, sleep patterns, fatigue, exertional activities, and medical concerns for the 72 hour and 14 day time periods prior to the mishap. They all complied and completed these histories to the best of their ability. Their written histories revealed no erratic sleep patterns, fatigue, unusual eating habits, dehydration or other abnormal stressors (Tab DD-3).

c. Toxicology

Blood and urine samples of the MC, to include the MP, MCO, MS, MT and MFS, were taken within 24 hours of the incident. On 8 Nov 11, the toxicology samples were received by the Armed Forces Medical Examiner System, Division of Forensic Pathology, Rockville, Maryland. The blood and urine samples were tested for the presence of carbon monoxide, ethanol, and drugs of abuse (to include screening for amphetamine, barbiturates, benzodiazepines, cannabinoids, cocaine, opiates and phencyclidine). The carbon monoxide results were all within normal limits. All toxicology testing resulted in negative findings for ethanol and drugs of abuse (Tab DD-3).

d. Lifestyle

No lifestyle factors were found to be relevant to the mishap (Tab DD-3).

e. Crew Rest and Crew Duty Time

Air Force Instructions require pilots to have proper "crew rest" prior to performing in-flight duties and adhere to proper duty time requirements as defined in AFI 11-202, Volume 3, *Flying Operations-General Flight Rules*, Chapter 9, dated 22 Oct 10. No crew rest or crew duty time requirements were violated nor found to be a factor in the mishap. Furthermore, there was no evidence that fatigue was a factor in the mishap (Tab DD-3).

10. OPERATIONS AND SUPERVISION

a. Mishap Aircraft Commander

The MP was supervising the MCO during the mishap (Tab V-5.4). The MP confirmed the MCO briefed the crew during the Before Takeoff Crew Brief that the procedure for takeoff would be a 75 STO (Tabs V-5.5, V-5.13). The MP stated that after formation lead took off, and before he had perceived Chk2 to move, the MCO applied takeoff power (Tab R-4). The MP directed the MCO to "abort the takeoff to avoid a collision with chalk 2..." (Tabs R-4, V-5.17). On feeling the MA rapidly descending, the MP and MCO simultaneously took action and pushed the TCL to full power (Tabs R-4, R-15, V-5.17, V-5.18, V-5.21). During the mishap, the MP did not take control of the MA due to the speed of the event and his NVGs breaking away from his helmet upon impact with the ground (Tab R-4). By the time the MP had regained the use of his NVGs, the MCO had stabilized the MA (Tabs V-5.21, R-4).

b. Chalk Two Aircraft Commander

The C2AC was supervising his co-pilot, the C2CP, executing the takeoff procedure (Tabs V-1.7, V-1.8). The C2AC took action to correct his perception of the C2CP initiating takeoff prematurely (Tabs V-1.12, V-1.13, R-9). When the C2CP took his feet off the toe brakes too early relative to formation lead's departure, the C2AC advised the C2CP to stop and wait for the proper delay prior to the application of power (Tabs V-12.5, V-1.11, R-9). Due to the release of the brakes, the Chk2 aircraft rolled forward (Tabs V-1.11, R-9). The C2CP was in fact about to apply takeoff power too soon, and the correction by C2AC was appropriate (Tab V-12.9).

c. Flight Lead

During the TST brief the formation flight lead, C1FL, briefed the C2AC and the MP on the night's planned mission (Tabs V-5.11, R-11). The takeoff portion of the TST brief was briefed by C1FL as "standard" (Tabs V-15.8, R-9, R-11). The C1FL's technique was to brief "standard" if the takeoff was to be a 75 STO from KAF (Tabs V-15.8, R-9). The MP and the C2AC concurred that they understood when C1FL briefed "standard" that the takeoff from KAF was to be a 75 STO with delay (Tabs V-1.5, V-5.13, R-9).

d. Standardization and Evaluation Personnel

At the time of the mishap, there was no formal standardization and evaluation position or function in the MU at KAF (Tabs V-10.9, V-10.10). The TOC Chief on 11 Oct 11 was also a flight lead in the MU but was not flying on 11 Oct 11 (Tab V-10.10). Additionally, the TOC Chief was the 1 SOG CV-22 standardization and evaluation section chief (OGV) (Tab V-10.3). The TOC Chief did not perform official functions as OGV while deployed, however did call on his experience to advise the commander and other pilots regarding standardization and evaluation when appropriate (Tabs V-10.9, V-10.10). The TOC Chief stated the overarching requirement during a formation takeoff is for the pilot to ensure safe separation between his aircraft and the preceding aircraft (Tab V-10.19). The TOC Chief had not noticed a trend of takeoff spacing becoming shorter in the MU; however, he had not regularly observed the takeoff of the other formations when he was not flying (Tab V-10.21). Further, when flying, he would have been in the lead aircraft and thus unable to observe the takeoff interval of other aircraft in the formation (Tab V-10.10). The TOC Chief gave a standards brief to the MP and MCO on 26 and 27 Sept 11 as part of their AOR in-processing (Tab V-7.5). The standards brief specified the standard takeoff from KAF was as a 75 STO (Tab V-10.12).

e. Mishap Unit Commander

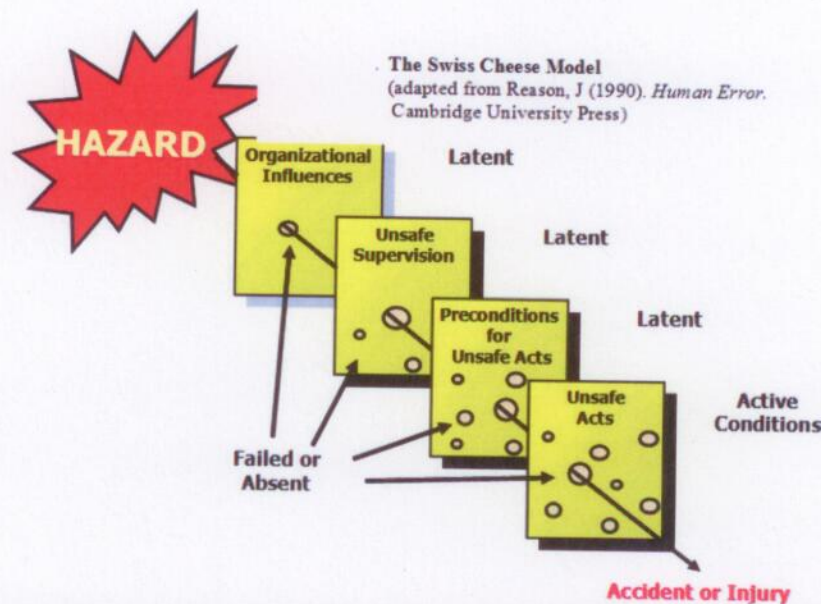
The MCC usually observed formation takeoffs from KAF. It was not unusual for the MCC to see formation aircraft takeoff nearly simultaneously when executing a 75 STO (Tab V-7.7). The formation 75 STO was not an emphasis item because it had never been a problem in the past (Tabs V-7.10, V-7.11). The 75 STO was the standard takeoff procedure from KAF. There was a common understanding in the MU of a five second delay between the takeoff of aircraft in a formation 75 STO, however the rigid adherence to the five second delay had never been an emphasis item in the MU (Tab V-7.10). The MCC interpreted the formation 75 STO procedure as primarily a visual maneuver with the key criteria being the pilot ensuring safe separation from

preceding aircraft, rather than relying on a specific requirement such as a five second delay (Tab V-7.8).

11. HUMAN FACTORS

a. Overview

A DoD taxonomy was developed to identify hazards and risks, called DoD Human Factors Analysis and Classification System (DoD-HFACS), referenced in Attachment 5 of AFI 91-204, *Safety Investigations and Reports*, 24 Sept 08. DoD-HFACS describes four main tiers of human factors: 1) Acts; 2) Preconditions; 3) Supervision; and 4) Organizational Influences (AFI 91-204, attach 5).



Acts are those factors that are most closely tied to the mishap, and can be described as active failures or actions committed by the operator that result in human error or unsafe situation (AFI 91-204, attach 5).

Preconditions are factors in a mishap if active and/or latent preconditions such as conditions of the operators, environmental or personnel factors affect practices, conditions or actions of individuals and result in human error or an unsafe situation (AFI 91-204, attach 5).

Supervision is a factor in a mishap if the methods, decisions or policies of the supervisory chain of command directly affect practices, conditions, or actions of individual and result in human error or an unsafe situation (AFI 91-204, attach 5).

Organizational Influences are factors in a mishap if the communications, actions, omissions or policies of upper-level management directly or indirectly affect supervisory practices, conditions or actions of the operator(s) and result in system failure, human error or an unsafe situation (AFI 91-204, attach 5).

After reviewing the facts from the investigation, including witness testimony, the human factors that directly relate to the mishap are enumerated and discussed below. The DoD-HFACS taxonomy nanocodes are also included for reference (AFI 91-204, attach 5).

b. Causal – Acts

(1) AE103 Procedural Error

Procedural error is a factor when a procedure is accomplished in the wrong sequence or using the wrong technique or when the wrong control or switch is used (AFI 91-204, attach 5). In this mishap, the MCO committed procedural error by initiating takeoff of the MA prior to the takeoff of Chk2 (Tabs V-5.23, EE-13, EE-15, V-14.15). Several witnesses, including the MCO, stated that the MCO failed to execute the proper formation takeoff procedure by taking off too early (Tabs V-5.23, V-7.18, V-14.15, V-6.9, V-6.10). Furthermore, when comparing the weight on wheels data of MA and Chk2, it is easily recognized that the MA broke ground when Chk2 was still on the ground (Tabs EE-13, EE-15). This was procedurally incorrect and created an unsafe situation (Tabs V-10.7, V-14.15).

It was briefed by the C1FL and understood by all the pilots that the takeoff procedure on 11 Oct 11 would be a formation 75 STO (Tabs R-9, R-11, V-1.5, V-5.5, V-12.4, V-15.9, V-11.4). The 75 STO was understood as including a delay between aircraft when in formation (Tabs R-9, V-1.5, V-5.12, V-14.10). Furthermore, despite any objective time delay between two aircraft, the ultimate responsibility of a pilot is to ensure that the flight path is cleared and safe prior to takeoff (Tabs V-10.13, V-10.18). The MCO failed to ensure adequate spacing; therefore, he committed procedural error and created an unsafe situation.

(2) AE203 Necessary Action – Rushed

Necessary Action – Rushed is a factor when the individual takes the necessary action as dictated by the situation but performs these actions too quickly and the rush in taking action leads to an unsafe situation (AFI 91-204, attach 5). The evidence in this mishap shows that the MCO rushed a necessary action in two instances:

1) The first instance was when the MCO rushed the takeoff procedure resulting in the MA taking off before Chk2. The mishap launch occurred very quickly (Tabs R-4, V-5.17). MA's takeoff speed was 0.69 kts, whereas Chk2 and formation lead had approximately 6.68 kts and 7 kts, respectively, at similar points in their takeoff profile (Tabs EE-3, EE-4, EE-5). This suggests the MA takeoff was rushed because MCO applied takeoff power more rapidly after releasing the brakes when compared with the other aircraft in the formation. The weight on wheels data, which shows the MA airborne prior to Chk2, also supports the takeoff being rushed (Tabs EE-13, EE-15). By rushing takeoff power and accelerating the launch, the MCO failed to maintain formation discipline (Tabs V-5.23, V-7.14).

2) The second instance was when the MCO rushed control inputs to correct his position after takeoff. Once the MA became prematurely airborne, the MCO assessed the need to arrest his forward motion by simultaneously pulling back on the cyclic and pulling the TCL to zero which

produced a high sink rate. This prompted the MCO to then apply full power to arrest the sink rate. During this three and two-tenths of a second timeframe, the MCO moved the TCL from full power to zero and back to full power (Tabs EE-7, EE-9, EE-18). The rushed control inputs resulted in the aircraft impacting the ground and damaging the proprotor system (Tab EE-18).

(3) AE104 Over-control/ Under-control

Over-control/Under-control is a factor when an individual responds inappropriately to conditions by either over-controlling or under-controlling (the aircraft/vehicle/system). The error may be a result of preconditions or a temporary failure of coordination (AFI 91-204, attach 5). The human factor of "Over-control/Under-control" was a factor in the mishap. Over-control occurred when the MCO reduced the TCL from full power to zero in an attempt to arrest his forward motion (Tab EE-7). This excessive reduction in the TCL resulted in the aircraft entering a sink rate due to lack of power from an altitude of 13 ft (Tab EE-11). At 13 ft, the aircraft was unable to recover from the descent before impacting the ground (Tab EE-11). Similarly, the MCO over-controlled the aircraft when he reapplied power and pulled back the cyclic in response to the sink rate (Tab EE-7). Both of these actions were cautioned against in aircraft technical data (Tabs BB-22, BB-23). Hence, the pilot's over-control in response to the out of sequence takeoff, followed by over control in response to the self induced sink rate were causal to the mishap.

c. Causal – Preconditions

(1) PC214 Response Set

Response Set is a factor when the individual has a cognitive or mental framework of expectations that predispose them to a certain course of action regardless of other cues (AFI 91-204, attach 5). This human factor occurred when the MCO took off prematurely after seeing Chk2 roll forward. The MCO's response set was to initiate takeoff power almost immediately after Chk2 started takeoff. Per the MCO, he initiated takeoff because he interpreted the roll of Chk2 to be the start of Chk2's takeoff. The MCO's response set was conditioned to immediately initiate takeoff when he saw the aircraft in front of him initiate takeoff (Tab V-14.20).

(2) PC506 Expectancy

Expectancy is a factor when the individual expects to perceive a certain reality and those expectations are strong enough to create a false perception of the expectation (AFI 91-204, attach 5). As discussed in the human factor Response Set, the MCO expected Chk2 to be airborne a few seconds after he visually perceived Chk2 to begin moving forward (Tab V-14.20). Because the MCO expected the forward roll of Chk2 to immediately result in takeoff, the MCO initiated takeoff before verifying that Chk2 had actually become airborne (Tabs R-15, V-14.14, V-14.15 V-14.20).

(3) PC504 Misperception of Operational Conditions

Misperception of Operational Conditions is a factor when an individual misperceives or misjudges altitude, separation, speed, closure rate, road/sea conditions, aircraft/vehicle location within the performance envelope or other operational conditions and this leads to an unsafe

situation (AFI 91-204, attach 5). Misperception of Operational Conditions occurred in this case because the MCO stated he visually perceived Chk2 to be further ahead of its actual distance; thus, he misjudged separation and closure rate (Tabs V-14.20, V-14.21). Based on the misperception of Chk2's movement and distance between Chk2 and the MA, the MCO initiated takeoff out of sequence and created an unsafe situation (Tabs R-4, R-5, V-5.23, V-14.15).

d. Causal – Supervision and Organizational

None identified.

e. Contributory – Acts

(1) AE201 Risk Assessment – During Operation

Risk Assessment – During Operation is a factor when the individual fails to adequately evaluate the risks associated with a particular course of action and this faulty evaluation leads to inappropriate decision and subsequent unsafe situation. This failure occurs in real-time when formal risk-assessment procedures are not possible (AFI 91-204, attach 5). By initiating takeoff before Chk2 took off, the MCO failed to evaluate the risk of inadequate spacing between the MA and Chk2, resulting in an unsafe situation (Tabs V-5.23, R-4, R-5, R-15, V-14.15).

(2) AE301 Error due to Misperception

Error due to Misperception is a factor when an individual acts or fails to act based on an illusion, misperception, or disorientation state and this act or failure to act creates an unsafe situation (AFI 91-204, attach 5). The MCO stated he visually perceived Chk2 to have advanced farther in his takeoff roll than what was later determined to be the actual distance (Tab V-14.15). He also stated he perceived the rear wheels of Chk2 to rotate, uncompress, and the aircraft begin to lift; however, Chk2 had not actually taken off (Tabs V-14.4, V-14.6, V-14.13, V-14.14, V-14.15). The MCO misperceived the timing of Chk2's takeoff based on observed forward motion. From the MCO's experience, Chk2's forward roll would have resulted in Chk2 being airborne in seconds, giving the MA a clear flight path. Based on this misperception, the MCO committed an error by initiating takeoff out of sequence (Tabs V-5.23, V-14.6, V-14.7, V-14.8, V-14.15).

f. Contributory – Preconditions

None identified.

g. Contributory – Supervision

(1) SV001 Supervision – Discipline Enforcement (Supervisory act of omission)

Supervision – Discipline Enforcement is a factor when unit (organizational) and operating rules have not been enforced by the normally constituted authority (AFI 91-204, attach 5). While there was published guidance of a formation 75 STO, the understanding, implementation, and execution techniques varied amongst the pilots (Tabs V-7.10, V-15.13). Strict adherence to a specific procedure was not an emphasis item because it had never been highlighted as a problem

in the past (Tab V-7.10). Additionally, formation takeoffs and aircraft separation in a 75 STO was not a per se pilot evaluation item (Tab V-10.9). Therefore, because the takeoffs were not practiced with a standardized delay, the topic had never been highlighted for command interest, nor specifically required to be evaluated. The result was a lack of disciplined enforcement for the formation 75 STO procedure.

h. Contributory – Organizational

(1) OP003 Procedural Guidance/Publications

Procedural Guidance/Publications is a factor when written direction, checklists, graphic depictions, tables, charts or other published guidance is inadequate, misleading or inappropriate and this creates an unsafe situation (AFI 91-204, attach 5). In the two years preceding the mishap the MU SOP, dated 1 Nov 09, and AFSOCH 11-222, dated 22 Oct 10, were rescinded and replaced with guidance that was less specific regarding takeoff procedures from prepared surfaces. Also, other published guidance, the relevant CV-22 technical order, did not specifically define the procedures for a formation 75 STO departure. As such, the published guidance at the time of the mishap was less specific than years prior and inadequate in providing the specific requirements for formation departure procedures.

It should be noted that all human factors enumerated in AFI 91-204, attach 5, were carefully considered for their possible contribution to the mishap sequence. Non-contributory human factors worthy of discussion are listed below:

i. Non-Contributory - Acts

None identified.

j. Non-Contributory – Preconditions

(1) PC102 Channelized Attention

Channelized Attention is a factor when the individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of others of a subjectively equal or higher or more immediate priority, leading to an unsafe situation. This may be described as a tight focus of attention that leads to the exclusion of comprehensive situational information (AFI 91-204, attach 5). Although the human factor of “Channelized Attention” was considered as a possible factor contributing to the mishap, it was ultimately found to be non-contributory. Although one could generally state the MC may have had channelized attention focusing on the mission or other circumstances, there is no direct evidence this was a factor in the mishap.

(2) PP106 Communicating Critical Information

Communicating critical information is a factor when known critical information was not provided to appropriate individuals in an accurate or timely manner (AFI 91-204, attach 5). The human factor of “Communicating Critical Information” was considered when evaluating causal or contributing factors to the mishap. However, when assessing the knowledge and

understanding of the takeoff procedures expected on 11 Oct 11, all the pilots flying that night stated that they knew and understood that the take off procedure was to be a 75 STO. They all knew and understood that the "standard" procedure of a 75 STO implied a delay in taking off between aircraft in a formation. Therefore, the human factor of "Communicating Critical Information" is not considered contributory to the mishap. There is no direct evidence that the information for the takeoff expectations was not sufficiently communicated.

(3) PP102 Cross-Monitoring Performance

Cross-monitoring performance is a factor when crew or team members failed to monitor, assist or back-up each other's actions and decisions (AFI 91-204, attach 5). The human factor of "Cross-Monitoring Performance" was considered when evaluating causal and contributing factors to the mishap. This factor was considered when the MP (MA aircraft commander) did not intervene prior to the MA taking off. Although he ordered that the takeoff be aborted, the timing of intervention was after the causal actions. The MP attempted to cross monitor his MCO; however was unable to successfully prevent the mishap due to the rushed application of takeoff power applied by the MCO and the short time frame in which the mishap occurred. Due to time constraints, the AIB determined that failure of cross monitoring performance was not contributory or causal to the mishap (Tabs V-5.16, R-4).

(4) PC208 Complacency

Complacency is a factor when the individual's state of reduced conscious, attention due to an attitude of overconfidence, under-motivation or the sense that others "have the situation under control" leads to an unsafe situation" (AFI 91-204, attach 5). The human factor of "Complacency" was considered when evaluating causal and contributing factors to the mishap. The MP's hands were not on the controls prior to takeoff, and therefore, he was not able immediately respond to prevent the mishap from occurring; however, this is normal when the co-pilot performs the takeoff procedure. The AIB determined that the MP had the appropriate amount of confidence in his MCO given the amount of flying hours, qualification upgrades and missions executed by the MCO (Tabs V-5.4, V-5.5, G-29, G-30). Because the MP's confidence in the MCO was appropriate, complacency was not causal or a contributing factor to the mishap (Tabs V-5.4, V-5.5).

k. Non-Contributory – Supervision and Organizational

None worthy of discussion.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Directives and Publications

- (1) 8th Special Operations Squadron, *Squadron Standard Operating Procedures*, 1 Nov 09
- (2) *CV-22 Standard Operating Procedures*, 1 Jan 11
- (3) Air Force Special Operations Command Handbook 11-222, *Combat Aircraft Fundamentals*, CV-22, 22 Oct 10

CV-22B, T/N 08-0037, 11 October 2011

- (4) Air Force Tactics, Techniques, and Procedures, 3-3.CV-22, *Combat Aircraft Fundamentals*, CV-22, 8 July 11
- (5) AFI 21-101, *Aircraft and Equipment Maintenance Management*, 19 Oct 11*
- (6) AFI 11-202, Volume 3, *Flying Operations General Flight Rules*, 22 Oct 10*
- (7) AFI 51-503, *Aerospace Accident Investigations*, 26 May 10*
- (8) AFI 91-204, *Safety Investigations and Reports*, 24 Sept 08*

* Available digitally at: <http://www.e-publishing.af.mil>.

13. ADDITIONAL AREAS OF CONCERN

None.

20 DEC 11

BRETT D. SHARP, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

AIRCRAFT ACCIDENT INVESTIGATION CV-22B, T/N 08-0037 KANDAHAR AIR BASE, AFGHANISTAN 11 OCTOBER 2011

Under 10 U.S.C. §2254(d), any opinion of the accident investigators 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

I find by clear and convincing evidence that the cause of the mishap was the Mishap Copilot's (MCO) failure to ensure formation discipline between the Mishap Aircraft (MA) in the chalk 3 position, and the chalk 2 aircraft (Chk2) during takeoff. Additionally, the MCO subsequently applied rapid control inputs and overstressed the MA's right propotor drive system. The MCO applied takeoff power and became airborne prior to Chk2 who was located 150 to 200 feet (ft) in front of the MA, creating a risk of collision between the two aircraft. To arrest his forward motion, the MCO simultaneously pulled back on the cyclic and pulled the thrust control lever (TCL) to idle (also referred to as zero inches TCL). These control inputs produced a high sink rate, prompting the MCO and Mishap Pilot (MP) to rapidly reapply full power (four inches TCL). However, the MA still impacted the ground at 525 ft per minute. The movement of the TCL from zero inches to four inches in six-tenths of a second, in conjunction with striking the ground and rapid application of three and one-half inches of aft cyclic, caused excessive flapping of the rotor blades and \$2,047,493.13 in damage to the right propotor hub and propotor gearbox.

Further, I find by a preponderance of the evidence, non-standardized procedures for executing a formation 75 degree short takeoff (75 STO) substantially contributed to the MCO not establishing a proper takeoff interval between the MA and Chk2. Published guidance on the departure interval between aircraft executing a formation 75 STO was ambiguous, and the mishap unit (MU) leadership had not perceived a need to make this an area of emphasis. Additionally, the MU had become accustomed to closely spaced departure intervals between aircraft executing a formation 75 STO and the pilots did not consistently apply the six second power push. This set the stage for the MCO to react to the forward motion of Chk2 in an undisciplined and anticipatory manner, unchecked by standardized and reinforced emphasis, resulting in his out of sequence takeoff.

2. DISCUSSION OF OPINION

a. Cause: Copilot Error – failure to maintain formation discipline

The pilots and copilots in the formation understood the departure procedure on 11 Oct 11 would be a formation 75 STO, and that implicit in a formation 75 STO, was a takeoff delay between

aircraft of five seconds used to create safe separation. However, this standard was not uniformly applied.

The MCO observed the formation lead moving and beginning to take off. Simultaneously, the MCO observed Chk2 moving forward and interpreted this motion as a takeoff roll, and based on experience, anticipated Chk2 would be airborne in approximately two seconds. The MCO started his TCL takeoff push at approximately 19:53:43.350Z. This was prior to the lead aircraft leaving the ground, prior to Chk2 applying takeoff power, and approximately three seconds prior to Chk2 breaking ground. The MA became airborne two and two-tenths of a second after applying takeoff power and nine-tenths of a second prior to Chk2 becoming airborne. As the MA became airborne, the MP recognized the out of sequence takeoff and feared collision with Chk2. The MP directed the MCO to abort the takeoff. The MCO took aggressive action to avoid Chk2 which resulted in damage to the MA. The burden exists on all pilots to maintain formation discipline and safe separation between their aircraft and the aircraft they are following. The MCO's out of sequence takeoff and failure to maintain formation discipline and safe separation was causal to the mishap.

b. Cause: Copilot Error – copilot applied aggressive control inputs causing proprotor system damage

Due to the out of sequence takeoff of the MA, the MCO exercised aggressive control inputs to arrest forward motion. The MCO simultaneously pulled back on the cyclic and pulled the TCL from full takeoff power back to idle (zero inches TCL) resulting in a high sink rate from an altitude of approximately 13 ft. The MCO and MP both responded to the sink rate by pushing the TCL from zero inches to four inches (full power). The aircraft could not arrest its descent in time to avoid impacting the ground. Simultaneous with impact, the MCO pulled the cyclic to three and one-half inches aft. Since the TCL was at full power on impact, the aircraft bounced from the ground and immediately took off again.

CV-22 technical guidance warns against both rapid power increases to arrest descent and rapid or excessive application of aft stick during and after liftoff, as possibly leading to high flapping conditions. The technical guidance also warns about potential damage to the proprotor system from rotor blade flapping due to aggressive maneuvering with the nacelles set at 75 degrees. All of the above risk items were applied to the MA within a period of two seconds. The aggressive movement of the TCL from zero inches to full power to arrest the sink rate occurred in approximately six-tenths of a second. The MCO was aggressively applying cyclic, moving from two inches aft to three and one-half inches aft in the one and two-tenths of a second immediately prior to the Flapping Critical caution posting. The aircraft also experienced rapid deceleration when it impacted the ground. Overstressing of the proprotor system was indicated by a Flapping Critical caution posting as an alert to the pilots after impacting the ground. Therefore, the MCOs aggressive and rapid control inputs were causal to the MA's right proprotor hub and proprotor gearbox damage.

c. Substantial Contributing Factor: Guidance and standardization – non-standardized procedures for establishing formation 75 STO separation

Guidance on the formation 75 STO procedure and the delay had become ambiguous. The 8 SOS Standard Operating Procedures (SOP), dated 1 Nov 09 states, "subsequent aircraft will delay five

seconds following takeoff power application by the preceding aircraft.” Air Force Special Operations Command Handbook (AFSOCH) 11-222, *Combat Aircraft Fundamentals CV-22*, dated 22 Oct 10, also requires a five second delay but omits when to begin the five second count. The updated CV-22 SOP, dated 1 Jan 11, omits reference to the five second delay. The Air Force Tactics Techniques and Procedures (AFTTP) 3-3, *Combat Aircraft Fundamentals CV-22*, dated 8 Jul 11, states a “wing takeoff” (simultaneous takeoff) can be used for a STO and does not explicitly cross-reference the five second delay with a 75 STO.

Interviews with the MU pilots, standardization and evaluation expert, and unit commander, showed a lack of standardization or emphasis as to how the five-second interval was applied in a formation 75 STO procedure. Some pilots applied the five-second count from when the preceding aircraft began their take off roll, some from when the preceding aircraft’s wheels left the ground, and some said the five seconds were a guide but that safe separation was a visual determination. Further, the six second power push had been approximated down to less than three seconds. In practice, the actual interval between aircraft had become ill-defined and the two and one-half second separation between the formation lead and Chk2 on the night of the mishap was described by the Mission Squadron Commander as appearing normal. Interval discipline had not been an emphasis item because no problems had been highlighted. This left the formation 75 STO procedure a matter of individual pilot technique.

Lack of clear and enforced standards for the formation 75 STO procedures contributed to the mishap in three ways: 1) It reduced predictability amongst the formation; 2) Facilitated a trend of eroding safety margins; and 3) Enabled the MCO to establish his own departure cadence which was rushed and eliminated the remaining safety margin. This resulted in an anticipatory action by the MCO leading to a premature takeoff with insufficient time to correct the mistake before it became an unsafe situation.

3. CONCLUSION

I arrived at my opinion by examining witness testimony, Vibration Structural Life and Engine Diagnostic data from all mishap formation aircraft, applicable technical data, recreation of the event in the CV-22 simulator, computer animated recreation, and consulting with subject matter experts. All evidence is consistent with the following causes: 1) The MCO failed to maintain formation discipline between his aircraft and the Chk2 aircraft during takeoff, resulting in unsafe positioning of his aircraft relative to Chk2; and 2) Once in an unsafe situation, the MCO’s execution of aggressive control inputs resulted in damage to the aircraft.

20 DEC 11

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