HUMAN AD

Heliprops

HELIcopter **PRO**fessional **P**ilots **S**afety Program
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TAIL ROTOR GEARBOX MALFUNCTION

Bell 47G2 C-FKNQ – Report Number A00P0077

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

SUMMARY

The Bell 47 helicopter … piloted by a student pilot and his flight instructor, took off …in visual meteorological conditions at approximately 0850 … On departure, as the helicopter climbed through about 700 feet above ground level, still over the airport, it lost tail-rotor thrust and began to spin to the right. The nose then dropped and the spinning turned into a spiral. As it descended further, the helicopter appeared to be totally out of control. It struck the ground in a steep, nose-down attitude on the infield of the airport, broke apart, and a post-impact fire ensued. Both occupant were fatally injured by the impact forces.

OTHER FACTUAL INFORMATION.

Inspection of the wreckage at the accident site revealed damage to the tail-rotor consistent with that demonstrated by a tail rotor not turning on impact. It also revealed that the gears in the tail-rotor gearbox suffered heat distortion and the gears had uncoupled. Further inspection at the TSB regional wreckage examination facility and an independent engineering facility confirmed that the gears in the tail-rotor gearbox had overheated, smeared, and disengaged. No remnant of oil or burnt oil was in the tail-rotor gearbox. Inspection of the controls, including the forward cables for the horizontal stabilizer, revealed no anomalies.

During the afternoon of 09 May, 2000, maintenance personnel conducted a 100-hour inspection on the helicopter. Among other details, this inspection required that the tail-rotor gearbox oil be changed. While the aircraft maintenance engineer (AME)[1] conducted other portions of the inspection, he assigned an apprentice AME the job of changing the oil. The apprentice AME drained the tail-rotor gearbox oil, inspected it for metal particles, and installed and lock-wired the drain plug. In addition to the normal actions of the 100-hour inspection, the forward section of the cables that move the horizontal stabilizer were replaced. The AME signed the aircraft journey log book as having completed the 100-hour inspection. The 100-hour inspection check sheet item that called for draining and refilling of the tail-rotor gearbox was initialed by the apprentice AME.

On the morning of 10 May, 2000, the student pilot conducted a pre-flight inspection on the helicopter in the hangar. An item on the inspection was to visually check, through a small sight gauge (window), the oil level in the tail-rotor gearbox. It is sometimes difficult to tell whether there is oil behind the window. The instructor was not involved in the pre-flight inspection[2], but was aware that a 100-hour inspection had been completed and a control cable had been changed. He joined the student pilot in the helicopter after the student had started the helicopter.

The helicopter had been operated for about 15 minutes on the ground and about 2 minutes in the air before the loss of yaw control. The helicopter was about 700 feet above ground level (agl) when it started spinning to the right, around its main-rotor mast. It then smoothly attained a nose-low attitude and started to descend. As the helicopter descended, the axis of rotation moved from the mast to a point beyond the nose. As the descent continued, the helicopter was rolling and pitching up to

about 100 degrees from level. The main rotor appeared to be turning at normal speed, and the descent was more consistent with that demonstrated in a power-on descent rather than that of an autorotation.[3]

Two common techniques are taught to pilots to stop the helicopter from rotating should yaw control be lost as a result of a loss of tail-rotor thrust. One is to maintain enough airspeed or airflow to allow the helicopter's vertical stabilizer to be aerodynamically effective enough to oppose the torque generated by the engine and main-rotor. The other is to remove the engine torque by lowering the collective and, if required, shutting off the engine (enter autorotation). If yaw control is not re-established, it is easy for a pilot to become disoriented and not be able to coordinate control inputs to maintain other control parameters. For tail-rotor failures, the Bell 47 flight manual stipulates "immediately execute an autorotative descent…"

The helicopter was being operated within the limits prescribed in the flight manual and the pilots were appropriately certificated for the flight. The student pilot held a student pilot permit and had logged about 50 hours of flight time on helicopters. The instructor pilot held a commercial helicopter pilot license rated for class 3 instruction. He had about 2,100 hours flight time on helicopters, about 600 of which was giving flight instruction. The apprentice AME had experience in the Canadian Forces as an aircraft technician and had just completed training for and received his commercial helicopter pilot's license. The AME had 23 years experience in conducting maintenance on helicopters, most of which involved the Bell 47.

Neither the pilots nor the maintenance personnel were on duty for any extraordinary time and had been rested the night before. Both occupants were wearing four-point personal restraint systems, but the impact forces were not survivable.

ANALYSIS

Since there was heat distortion of the gears and no remnant of oil in the tail-rotor gearbox, it is concluded that no oil was in the gearbox when the helicopter started operating on the morning of the accident. It is also concluded that, since the lack of oil was not detected prior to flight, the apprentice AME, the AME, the student, and the instructor did not check the oil level or erred in reading the sight gauge. As indicated earlier, it is sometimes difficult to tell whether there is oil behind the window.

It is likely that the pilot lowered the nose to increase airspeed in an attempt to arrest the rotation by making the vertical stabilizer/fin more effective. If that is the case, the attempt was not effective, probably because of the helicopter's relatively small vertical stabilizer/fin. Given the continued rotation, it is likely that the pilot's control inputs became out-of-phase with the helicopter's movements, and attitude control was lost.

Findings

1. Maintenance was conducted (100-hour inspection) on the helicopter just before the accident flight and oil was removed from the tail-rotor gearbox. The oil was not replaced; however, the inspection was signed as having been completed.
2. The apprentice AME, the AME, the student pilot, and the instructor did not detect the lack of oil in the tail-rotor gearbox prior to the flight.
3. Due to a lack of oil, the gears in the tail-rotor gearbox overheated, smeared, and disengaged, and tail-rotor thrust and

yaw control were lost.

4. When yaw control was lost, the helicopter began to spin to the right, and the pilot did not immediately execute an autorotative descent.
5. The pilot was unable to stop the helicopter from rotating and subsequently lost control

Other Findings

1. The pilots were certificated by Transport Canada (TC) for the flight, and the AME was certificated to conduct maintenance on the helicopter.
2. The helicopter was being operated within the limitations prescribed in the flight manual."

In the preamble to this report the TSB clearly states that the purpose for their investigation is to advance transportation safety. Their search for the causal factors always includes an exhaustive look for aircraft system failure, and for human error. When these failures and errors are found, they are usually described in the smallest detail in the investigation report. There is a tendency, when we read of the human errors in accident investigation reports, to criticize the individuals involved, and perhaps feel a bit smugly that we would never commit such errors. It's pretty easy to do that and feel that way when the errors that are described are often involved with simple, everyday, easy-to-do tasks. The kind of routine tasks that many of us have often done, or many of us think we could do, correctly, each and every time - such as changing the oil in a 47 tail-rotor gearbox. Anyone with just a bit of mechanical sense and the simplest tools could probably do an acceptable job of removing the drain plug and filler cap, draining the oil, replacing the drain plug, replenishing the oil, and replacing the filler cap and safety wire.

Our criticism of those who commit errors in easy tasks is often accompanied by a failure to imagine what could have caused such a failure to occur.

We can however, without attributing them directly to the persons involved in this Bell 47 Tail Rotor Accident, make some assumptions. The following are solely the opinions of the author.

SENSE OF JOB COMPLETION/ DISTRACTION/SHORT-TERM MEMORY. In many maintenance tasks the last significant action accomplished is to install safety wire, a cotter pin, or torque seal. When the pin goes in or the wire is installed the task is essentially done, and a sense of job completion can accompany these simple acts. The 47 tail-rotor gearbox drain plug is safety wired. Imagine if you will, the apprentice AME removing the safety wire and drain plug, draining the oil, replacing the drain plug, and electing to install the safety wire before replacing the oil - and then being distracted. The distraction could have been anything – a phone call from his wife, the need to use the restroom, the AME asking for assistance, having to get a bandage for the finger that was pricked and bloodied by the safety wire, etc.

Distractions can be innocent and minor, that cause only the turn of the head. But distractions can be significant, and require leaving the

work underway to attend to something else that is urgent. We often rely on our short-term memory to take us back to where the distraction pulled us away from our work. Unfortunately short-term memory has a limited capability and often fails us. We use all sorts of methods to try to remind us of a job to be done or to get us back to where we left off – strings on fingers, bookmarks, yellow sticky notes, and comments to our colleagues to "remind me to …"

This combination of a sense of job completion, a distraction, and a failure of short-term memory could have been factors that led to the failure to replenish the tail-rotor gearbox oil but yet signing the job off as complete.

VISUAL ACUITY/ COMPLACENCY/ TRUST

Determining via a sight gage that a gearbox contains the appropriate amount of oil is not a difficult task. However it is not always easy, nor done correctly. Low ambient light, a stained or frosted sight gage face, and clear oil have perplexed even the most professional pilot looking at a sight gage during a preflight check.

Complacency is insidious. Some pilots have never during their entire flying career seen a low gearbox oil level during a preflight check. This complacency can lead us to lower our usual standard, and to be casual and less precise in checking something that has always been OK.

The Bell 47 tail-rotor gearbox sight gage is small – 1/2 inch in diameter. Sometimes the oil level can be determined only by shaking the tailboom and looking for the movement of the oil. Can you see how this student pilot may not have recognized the importance of having oil in the tail-rotor gearbox; and looked at the sight gage casually, expecting that there was oil, trusting that the maintenance work the previous day was performed correctly.

We all trust others to do their jobs correctly. Pilots put their trust in manufacturers, mechanics, air traffic controllers, and other pilots. The two pilots who perished in this accident both trusted the mechanics; and the instructor pilot trusted the student pilot to perform an adequate pre-flight check.

ROUTINE/ EASY JOBS

Many of the tasks mechanics and pilots perform are routine, everyday, simple tasks. Many tasks are straight-forward and obvious, requiring no checklist or written procedure for guidance. Pushing the aircraft out of the hangar, refueling, and preflight checks are typically done from memory. Many maintenance tasks – such as draining and replenishing the Bell 47 tail-rotor gearbox oil – are simple and obvious.

But just because a task is simple does not mean that it is unimportant. Simple jobs omitted or done incorrectly can kill you. Small things do count.

As Benjamin Franklin wrote: *"A little neglect may breed mischief: for want of a nail the shoe was lost; for want of a shoe the horse was lost; and for the want of a horse a rider was lost."*

[1] *Person responsible to conduct maintenance on the helicopter, for the operator.*

[2] *After students have gained experience and have demonstrated proficiency in conducting these tasks, flight instructors normally delegate the pre-flight inspections to them.*

[3] *Autorotation is a state attained by a helicopter when the main-rotor speed can be maintained without engine power, normally in a descent, at a specified airspeed range and main-rotor pitch angle.*

THE ACCIDENT PRONE PILOT

by Gerry Binnema, Regional Aviation Safety Officer, Pacific Region

A survey revealed that 58% of people believe they have above average intelligence (Wylie, 1979). Clearly, some of these people have an overly optimistic view of their cerebral powers; however, they are not alone. This tendency to hold optimistic opinions about our own ability seems to be part of human nature. Studies have repeatedly shown that a majority of people in a variety of professions believes they are better than the average practitioner. Pilots are not immune to this optimistic bias. A recent study done by Wilson and Fallshore at the Central Washington University indicated that the majority of the pilots in the their study believed that they were less likely than others to experience a visual flight rules (VFR) into instrument meteorological conditions (IMC) accident, that they were more capable than average at avoiding inadvertent flight into IMC, and that they were better able to successfully fly out of IMC.

Clearly, not everyone can be better than average, and it would seem that an overly optimistic opinion of our skills might lead us to take risks that are unwise. Where does this optimism come from? I believe one source is the myth of the accident-prone pilot. This myth claims that most pilots who get in accidents are the kind of people who make frequent mistakes, or display bad judgment on a regular basis. A casual read of accident reports often seems to support this myth, since the report details exactly what the pilot did or failed to do, that led to the accident. In hindsight it is easy to spot the errors and gain a great deal of confidence that we would never be that foolish or incompetent. So we read the accident reports, see the mistakes, and increasingly believe that accidents only happen to the foolhardy, the incompetent, or the accident-prone.

My experience, as a pilot who has lost friends in aircraft accidents, as an accident investigator, and as a safety officer, tells me that pilots who are involved in accidents are not accident-prone. They are as competent, and as careful as any other pilot out there. How can that be? How can the people who commit these errors, or display such poor judgment, be as careful and competent as you and me?

The fundamental error we make when we read these accident reports is that we attribute the errors to the personality of the person committing them. We don't try to understand the situation from the perspective of the pilot who is experiencing them as they unfold. When we read the accident report we know that the events will end in an accident, and we judge the pilot's actions from that perspective. The question we should be asking is this: "Why did this make sense from the pilot's perspective, at that time?"

Any accident investigation has a great deal of difficulty uncovering what was occupying the attention of the pilot leading up to the accident. We cannot measure what stress the pilot was feeling. There is no blood test to measure how tired, distracted, or uncomfortable the pilot was. We do know that our attention is easily distracted from routine tasks, and focused on exciting or stressful events surrounding us. We all know how difficult it is to pay attention to tasks when we are tired, thirsty, hot, or stressed.

There I Was...

Here are some accounts sent to us by readers.

Battery Compartment Door

"I was in a 206B, giving flight instruction to the pilots of a Law Enforcement unit. Just before I began the post-flight debriefing for the first pilot, I asked the next pilot to go out to the aircraft and give it a preflight check, strap in and start it up. I'd be out there to go flying soon. I made as much of a walk-around inspection as one can make with the engine/rotors turning. I climbed in, buckled up and we took off. As we began to level and accelerate to cruise I could see the battery compartment door quivering in the airflow. It had been opened while on the ground and hadn't been closed and locked shut. I took the controls and tried to keep the aircraft in an attitude and airspeed combination that would maintain an airflow that would keep the door shut and prevent damage. I tried but couldn't do it. The door flapped open a couple of times and managed to bend itself out of shape and put some dents and scratches on the battery compartment frame as well as on the windscreen and center post."

UH-60

"So there we were ... myself and another pilot had been designated to fly some ROTC Cadets around our local training area. Easy money. The cadets asked the routine questions – "How many passengers can the UH-60 hold? How long have you been flying? Ever had an accident? How fast can you fly? Can you give us a cool ride? Since we were hoping to encourage a few of them to become aviators we decided to oblige.

I guess I should have paid more attention to the part in the checklist (Before Landing Check) that says "Crew, passengers, and equipment all secure' – but we weren't landing and everything was secure during our last routine traffic pattern. However, after a couple of tight turns, and some negative "G's" a set of chock blocks landed on my hand resting on the center console. That was an early warning sign that we failed to recognize. After checking to make sure everything was secure in the rear of the aircraft we continued our flight. The next negative "G" ended up being our last one (for a very long time). Everything was fine until we tried to pull in power to recover. I was in the right seat, not on the controls, and thinking we were really letting this one ride out a little longer than the others. At that exact moment I heard a concerned voice over the ICS, knowing something was wrong. I checked the instrument panel. We were pulling very little power providing no lift capability. I quickly checked my station area and noticed that there was a Gatorade bottle that had landed on top of my collective, wedged in a position that was preventing us from pulling in any more power. Once I moved the bottle we had normal power to pull us out of our sink rate while passing through 200 feet and fully recovering just below 100 feet. At that point we ended our flight and headed back to the airfield. Except for the cadets, we were all aware of the

"nature of the beast." We flew back in silence.

First, after some years of experience I have learned the importance of securing all of your cargo and equipment. Gatorade bottles included! Although you may be experiencing a time crunch, and are only going from Point A to Point B - unexpected turbulence can turn a simple mission into an article for a safety magazine. Also, performing evasive maneuvers can shift things around, a lesson I learned while flying in Central America. The second lesson I have learned is that it doesn't take much for passengers to get excited. If you find that hard to believe, just take a ride in the back of a UH-60 and feel all the movements you are "deprived" of while buckled into one of the front seats.

Just remember, think twice and be safe. More than likely your passengers know little about the capabilities of the aircraft, so it would be a lot smarter to entertain or impress them in some other way."

206B

"I finished my walk-around of the Jet-Ranger and was all strapped and ready to push the starter button when somehow I thought something was wrong. I hesitated for a few moments to try to decide precisely what was not right. Nothing seemed to come to mind. I again turned my attention to the engine start, but before I could push the starter button, I again had that feeling that something was wrong. I released the seat belt and got out to look again at the aircraft. Wow! There it was. As obvious as can be – the bottom of the tail boom just aft of the fuselage attachment was bent and wrinkled! Further inspection revealed additional damage that the engineering/maintenance folks claim would not have survived even a short flight. We later learned that the damage occurred the previous flight – a training flight in which touchdown autorotations had been performed."

Water

"I was operating out of Prince Rupert BC (Canada) several years ago, in inclement weather and had an emergency flight to Masset on the Queen Charlotte Islands. The flight involved open water for about 75 nautical miles and the weather was borderline VFR. Once into destination and passengers taken care of, I went back to the aircraft and opened the fuel cap to refuel, as I wanted a contingency of full fuel in case weather changed my plans. The fueler interrupted me and advised that he had forgot to NOTAM the fact that there was no fuel that day at the airport. I had marginal reserve for the return flight over open water and my mind instantly went to that concern. As the weather was near closing for VFR, I hurriedly got back into the aircraft and departed. I noted a very strong fuel smell on departure and pondered it for several minutes, never having had that happen before. I was able to determine that I had left the fuel cap open and in looking back from the open door, to confirm. Had I not realized and continued on, somewhere halfway across open water, I may have run critically short of fuel."

AS350

This was several years ago. It was late afternoon, and I was on approach to landing on a ridgeline. The ridgeline was high above the bottoms of the valleys on both sides, and the slope down was very steep. On short final the aircraft began to yaw to the left. Right pedal alone didn't stop the yawing. I tried to fly out of this condition but I could only turn the

left yaw into a left spiral. I lowered the collective to try to stop or control the yawing, but before I was able to do so I was almost at the bottom of the valley, and there was no place to land – big trees everywhere. I reapplied power and began to climb, but the yawing accelerated. I thought I could accept the yawing if I could climb back up to the top of the ridgeline. During the climb I felt some strong vibrations. I couldn't tell you where the vibrations came from or describe them other than to say that the whole aircraft was shaking. I got to a point where the climb slowed and stopped and then began to descend even though I was pulling power. The descent accelerated but it was not as rapid as when I descended without power the first time. I was still yawing/spiraling down toward the valley bottom. Still no place to land. Not many options left. I decided to force the aircraft into the steep slope. I saw a tree that stood apart from others and decided I would try to force the tailboom to hit the tree to slow or stop the yawing. WHAM! The yawing almost stopped and I forced the aircraft into the slope. The dense underbrush and small trees seemed to absorb me and the aircraft thrashed itself into a sudden but miraculous and almost upright stop. The rotors were torn up, and there was some smoke, and I shut down the still running engine. I was, needless to say, very lucky. If there is any lesson in this it is that you should never give up."

YOUR ANSWERS. . . . .

In our last issue we asked : "Have you ever experienced Flicker Vertigo?" Only a few responses here they are.

Human AD.

Long Island

"Yes. On a night flight over Montauk, Long Island as I was performing a turn I felt funny. My flight instructor advised that I immediately utilize the instruments. The feeling of dizziness and nausea soon subsided. Quite a feeling. I believe it to have been caused by low lights and turning."

Nam

"I flew in Hueys in Nam but also played clarinet in the Navy Band. After a long night of clarinet playing with the boys, I had an early morning mission in the Delta. Just after takeoff in the predawn light I was just beside myself. My head was just spinning and I completely lost my faculties. The moonlight reflected off the ocean and back through the rotor system. This strobe effect put me on my knees. To this day I preach "Flicker Vertigo" to my civilian colleagues."

Robby

" Not long ago I attended the Robinson Helicopter factory safety course for the R-22. The last day involved a 1.5 hour flight with a factory test pilot to go over some maneuvers that had been covered in class. The factory is in Los Angeles, and on climbout he had me go to 1,300 feet msl, heading west toward the harbor. At that altitude, the brown haze was really pronounced, and while it certainly did not create a hazard to navigation or collision avoidance, it certainly was something I was aware of. Away from traffic, out over the harbor, he asked me to enter a high OGE (out-of-ground-effect) hover to set up for a settling-with-power condition and observe my recovery, part of what we'd discussed on preflight. As I slowed through ETL (effective translational lift) my eyes scanned the instruments to hold my altitude and vertical speed, watching the engine power climb to max and the airspeed drop to zero. As we all know, the trick to holding a stable OGE hover is to constantly check ground references to stay over one spot. Given our orientation, I was looking out over the Pacific in front of me, and right into the thick brown haze. I felt a certain queasy feeling coming over me, and felt myself getting slightly dizzy. The factory pilot I was flying with was talking to me, and I heard myself responding, but there was a strange disconnected sensation, and to this day I have no idea what he was talking about. The aircraft shuddered about me as I descended through the column of air, and I began losing tail rotor authority. It was very difficult to concentrate on flying when all I wanted was to be back on the ground. Trying to focus my attention outside on ground references only made the dizziness and sweating worse. After what seemed like hours, we finished that portion of the flight and turned back toward land. As we picked up speed I opened the door vent to let the cool air in, and immediately felt much better. The rest of the flight was more productive, although I kept replaying in

my head the feeling of nearly losing control of my aircraft, and it bothered me greatly. I didn't realize I'd just experienced my first case of vertigo until that evening, when the entire sequence played itself out again in my mind. I'd been trained to recognize the onset and how to deal with spatial disorientation, but when it came on, I failed to connect the dots in my head until it was over. In retrospect, at the first sign of feeling like something was out-of-sorts, I should have asserted to the pilot next to me, who had thousands of hours more experience than I, to take over the controls. The most troubling part of this incident, however, is that it happened on a sunny, summer afternoon in southern California – not at all the conditions you would think would lend themselves to a screaming dose of vertigo. Yet it did, and it happened to me. The NTSB accident review board would have been at a loss to explain how I managed to lose control and crash a perfectly good aircraft in VFR weather. I don't know what I could have done differently, other than to recognize what I was feeling, and changed my heading to keep the ground in view. The ship I was in, like most R-22's, had not even basic gyroscopic instrumentation. I can Monday morning quarterback this event until I am blue in the face, but instead I choose to take what I had learned and add it to my helicopter bag of tricks to become a better, safer pilot. I hope that you take that from this as well. Be assertive and know that, yes it can happen to you too."

Fort Smith

"I was returning from Fort Smith Northwest Territory from a fire to the east, and was following the cut-line that was the 60th parallel. The sun was about 15 degrees to the right of my nose of my Bell 47G5, and about a foot above the blade tips. I had my hat brim down to shade my eyes. About thirty minutes into the flight and about thirty miles out of Fort Smith it started to get uncomfortably warm in the cockpit. The open windows and fan didn't seem to help.

I was perspiring freely and began to feel bloated and nauseous. I started to look for a suitable place to land when my vision began to narrow.

I picked out a swamp, and practically autorotated into it. My vision closed in to zero about two feet off the ground, and the landing was a bit abrupt before the aircraft could do something I couldn't see to correct.

Feeling that I was about to pass out, I immediately throttled back to idle, tightened the frictions, and got out to lie down on the cargo rack and float. The cool air from the rotor felt good and kept the mosquitoes at bay.

When my vision returned I sat up but felt dizzy. In a few minutes I had returned to normal and continued the flight, feeling as if nothing had happened.

I didn't connect the incident with Flicker Vertigo until much later. I've had the onset of it a couple of times in the intervening 32 years, but have managed to avoid the effects by turning away from the sun for a few minutes, or having my copilot take control while I covered my eyes with my hands to eliminate the flicker effect."

Vertigo and Spatial Disorientation.

Vertigo is a term that is used broadly to describe a variety of sensations including dizziness, spinning, discomfort, uneasiness, and/or nausea. Spatial disorientation is partial or complete loss of your attitude, direction and speed of movement. Vertigo can provoke spatial disorientation, and spatial disorientation can lead to loss of aircraft control. We maintain orientation through the use of three separate system – the visual, vestibular, and proprioceptive systems.

***Visual**. The visual system is the most effective and powerful of the three systems. Whenever we can see the (reasonably flat and level) ground, surface of the earth, horizon, or a representation of a horizon we are able to orient ourselves with respect to the center of the earth. That is, "we know which way is down." Furthermore, if we are moving, and can see objects on the ground and understand their relationship to each other, we can determine speed and direction of travel. The visual system works as well in the air as it does on the ground; but it requires sufficient cues for us to maintain orientation. Those cues can be external (the ground, water surface, horizon, etc) or internal (attitude indicator, turn indicator, etc.). In IMC conditions, as when flying in the clouds, the external cues are totally absent and dictates the need for and use of appropriate instruments. In VMC conditions, in which the visibility meets basic VFR requirements, certain situations can make it very difficult to maintain orientation. With an indistinct horizon, such as at night over terrain with few lights and with little celestial illumination; or during the day over a large body of calm water, there may be too few visual cues to maintain orientation – as in the JFK Jr. accident. Having insufficient visual cues can, but certainly does not always, lead to spatial disorientation and loss of aircraft control.*

***Vestibular**. The vestibular system is generally the mechanisms in our inner ears which give us the internal sensation of movement (acceleration) in pitch, roll, and yaw; and well as longitudi-*

nally, laterally, and vertically. We humans were developed to be land-based creatures.Our vestibular system was developed for humans who moved about on the surface of the earth at walking speeds; and it generally works OK under those conditions. This system, however, was not developed for flight; and it cannot reliably provide long-term sensations to maintain orientation by itself. The vestibular system alone cannot sustain orientation in flight.

This system provides the sensations that are usually associated with vertigo and some types of spatial disorientation. An example of a mild case of vertigo/disorientation is the "Leans." The "Leans" is a condition in which, after correcting to straight-and-level from a previously undetected slight roll, the aircraft can be straight- and -level, but the pilot sensations make it feel that the aircraft is in an opposite roll. This can occur when there are few external visual cues to provide a horizon, and can, but certainly does not always, lead to loss of aircraft control.

The vestibular system can also provide a nasty spatial disorientation illusion called the "Coriolis Effect." This is most apt to occur when, during a turn, the pilot makes an abrupt movement of the head in any other plane than the turn of the aircraft. This can result in an overwhelming sensation of not only rolling, but pitching and/or climbing as well. Because this sensation can be so strong it is difficult to avoid reacting to it; and can be particularly dangerous in IMC or in conditions with few external visual cues, and can, but certainly does not always, lead to loss of aircraft control.

Keep in mind that vestibular sensations like the Leans and the Coriolis Effect, can occur in VMC conditions too. Many people have experienced them, but in VMC, the Visual System is sufficiently capable of maintaining orientation until the sensations pass.

***Proprioceptive**. The proprioceptive system is our whole body – skin, bones, hair, guts and all – being acted upon by gravity. The system too was developed in humans over a long period of moving about the surface of the earth on our feet. It works great whenever we are in touch with the earth. Whenever we are touching the earth we always know which way is down. Blind people are more attentive to cues from the proprioceptive system to maintain their balance. But, this system was not developed for flight, and it cannot reliably provide long-term sensations to maintain orientation by itself. The proprioceptive system alone cannot sustain orientation in flight. For instance, in a prolonged, mild, coordinated turn the proprioceptive system alone cannot distinguish which way is down. When there are few external visual references, this condition can, but certainly does not always, lead to loss of aircraft control.*

So we've established that neither our vestibular system, nor our proprioceptive system is capable of providing long-term, reliable orientation in flight. That leaves only our visual system for long-term, reliable orientation in flight. We've also established that the visual system requires sufficient cues to maintain orientation. As a take-off on an old American Express television commercial – "Your horizon, don't go flying without it."

Flicker Vertigo. "Flicker vertigo is a term to describe an imbalance in brain cell activity created by a light source that emits a flickering rather than a steady light. Light flickering from 4 to 20 times per second can produce dangerous and unpleasant reactions in some people, including nausea, dizziness, migraines, unconsciousness, and even epileptic seizures.

Both natural and artificial light sources – especially florescent lighting and television screens - may precipitate flicker vertigo. In aviation operations, problematic light sources including windmilling propellers that cut the sun (helicopter main rotor too, Ed.) to give a flashing effect, and rotating beacons or strobes in certain lighting atmospheric conditions."[4]

[4] *NASA Callback 268*

WHAT'S YOUR ANSWER ?

QUESTION:

What is the longest you have flown with a Low Fuel Light illuminated? Tell us about it.

_____

_____

_____

_____

_____

Mail your ANSWERS to: Bell Helicopter Textron, Inc.
Jim Szymanski
HELIPROPS Manager
P.O. Box 482
Fort Worth, Texas 76101

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The primary objective of the HELIPROPS program and the ***HUMAN AD*** is to help reduce human error related accidents. This newsletter stresses professionalism, safety and good aeronautical decision-making.

Letters with constructive comments and suggestions are invited. Correspondents should provide name, address and telephone number to:

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HUMAN AD Heliprops

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