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The Maintenance Factor

What Goes On Behind the Hangar Door? Part 1

MEET THE AUTHOR



Joe Schmaltz retired from the US Army after 21 years. He served 6 years as a NCO and crew chief and 15 years as an officer and helicopter pilot. In the US Army he flew the Bell AH-1F and UH-1H. He is also retired from the Colorado Springs Police Department after serving 10 years as a police officer and pilot with the Helicopter Air Support unit flying the OH-58C. He holds a Certified Flight Instructor Rotorcraft, Private Pilot fixed wing and an Airframe & Powerplant Mechanic certificate. He started with Bell Helicopter in 2006 as Instructor Specialist at the Bell Helicopter Training Academy. Joe holds a Bachelor of Science degree in Aviation Administration from the University of North Dakota and a Master's degree in Aeronautical Science from Embry-Riddle Aeronautical University.

In aviation, whenever there is a discussion of Human Factors, we immediately think of the pilot and flight crew because the emphasis is on flight safety. It has traditionally targeted the activity that surrounds the cockpit. Accident investigators have discovered that focusing on the flight crew only attacks part of the safety equation.

Another very important variable in this equation is found within the maintenance team itself. What happens behind the hangar door with the maintenance organization is equally important as what goes on in the cockpit. We must refocus our attention to that of understanding the human factor and its negative affect on human performance regardless of where it occurs. It is imperative to include maintenance if we are going to solve the safety equation. The purpose of this article is to provide you an understanding on how this can be accomplished by discussing the following:

- The fundamentals of "Human Factors" and the role they play in the causation of incidents and accidents.

- Identify, define and discuss "Human Factors Behavior" that can negatively affect a maintenance team.
- Identify and discuss types of human errors and the elements of the SHEL model.
- To define and discuss the elements of an incident / accident and effects of stress.
- Provide you with some safety suggestions on how you can improve your safety posture using human factors.

Human factors can be simply defined as the study of how human behavior and performance interacts with our environment. The human element is without a doubt the most complex but adaptable and valuable part of the

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HumanAD

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The Maintenance Factor Continued...

aviation system. One must beware; it is also the most vulnerable to influences that can adversely affect human performance.

The term “human error” does not adequately address or define the problem. It simply describes “where” there was a breakdown in the system. It offers no useful information as to “why” the breakdown occurred. If we can determine the “why” then perhaps we can reduce or even eliminate the “where.” The effort of uncovering why we make mistakes is within the realm of the study of Human Factors. We can do this by addressing the following:

- Gathering information about human abilities, limitations and other characteristics and applying it to our work environment.
- Understanding how humans can most safely and efficiently be integrated with the technology and the surrounding work environment.
- Translating this knowledge into changes in designs, training, policies and procedures to help humans perform safer and better.

Let’s continue by looking at four hypothetical accident and incident scenarios:

1. A helicopter main rotor retaining mast nut is removed for maintenance. No entry was made in the aircraft log books. The next day a pilot flew the aircraft to perform an avionics check and shortly after takeoff the main rotor system separated from the aircraft.
2. Aircraft had just come out of an annual inspection. The pilot noticed a strange smell just after takeoff and landed. Inspection discovered a wooden handle screwdriver next to the engine exhaust that had caught fire.
3. A helicopter came out of annual inspection and was signed off as “returned to service.” During the pre-flight inspection the pilot discovered an open, full can of cleaning solvent in a gearbox compartment.
4. Mechanic performing 100 hour inspection on a helicopter drained the oil and was then called away

to handle another problem. He returned and forgot to refill the engine oil. At run-up the engine made a load squealing noise and the engine seized.

Each of the scenarios are totally unrelated but all have one common denominator. The accident or incident described was not caused by a mechanical or equipment failure; but instead by human error. We can reduce the probability of equipment failures by creating redundant systems or making components from reliable materials. What we have not been able to do is correct the errors caused by human action or omission. Humans have no back-up systems to rely on other than the knowledge of our own limitations and weaknesses.

Errors Defined

According to FAA Advisory Circular 120-72 “Maintenance Resource Management Training” there are two basic type of errors in any maintenance operation. They are defined as:

Active Errors: A type of human error whose effects are felt immediately in a system. An active is the catalyst for the accident to occur. They are usually a result of actions taken or not taken. Since these errors are immediate we can more easily identify causation factors and develop training or procedures to prevent the possibility of recurrence.

Latent Errors: A type of human error whose affects may lie dormant until triggered later, usually by other factors. Latent errors are separated by either time or space. They set the stage for an accident which may happen at any time thus making it more difficult to identify causation factors after the accident occurs.

How Behavior and Human Errors Interact

We are all creatures of habit and great developers of routine. Many of our daily tasks are done without any real conscious thought because we do them continuously. We most likely do the same activities each morning, drive the same route to work, listen to the same radio station and park in the same spot. About ninety-nine percent of the time everything goes without a hitch until something comes up that interrupts that routine. That is when we become vulnerable to error because now we are out of our routine and have to develop alternative responses. There is no difference in maintenance. When the mechanic’s routine is interrupted for whatever reason, they become vulnerable to human factor errors.

When we research the type of errors that have occurred in maintenance over the years, at the top of the list are eight maintenance errors shown below in order of occurrence: (Graber & Marx, 1992)

1. Incorrect installation of components
2. The fitting of wrong parts
3. Electrical wiring discrepancies (including cross connections)
4. Loose objects (tools, etc.) left in aircraft
5. Inadequate lubrication
6. Cowlings, access panels and fairings not secured
7. Fuel/oil caps and refuel panels not secured
8. Landing gear ground lock pins not removed before departures

How do these errors happen? We have stringent training and licensing requirements for our maintenance team. We have also engineered so many check and balances into the system that it would seem we can avoid these simple mistakes. When dealing with human behavior nothing is simple and nothing is guaranteed.

Human Behavior Patterns

The best way to understand human factor errors is to relate them to our behavior patterns. We can list our behaviors into three categories.

Skill-Based Behavior: Skill-based behaviors are most often the first behavior pattern a new mechanic will experience especially in the early stages of their training or employment. Early in their training, mechanics become intensely focused on the tasks required to be performed and a great deal of conscious thought is applied. As skills are developed and learned they require less conscious thought and become more automatic or habitual. It is extremely important that skills be taught correctly in the beginning because once it is embedded it becomes increasingly difficult to unlearn or change. The simple task of ground handling aircraft in and out of the hangar can easily result in an accident if improper procedures are taught first. Both active and latent errors can occur.

Rule-Based Behavior: are behaviors for which a routine or procedure has been developed and learned by the mechanic. The use of checklists, manuals or Standard Operating Procedures (SOP's) are excellent examples of rule-based behaviors. They provide the mechanic with a tested and proven framework for the application of skills that need not be memorized. Mechanics rely on established "rules" or "procedures" as a guide in performing tasks and decision-making. For example, a mechanic will use a check list when performing inspections, or the aircraft maintenance manual when conducting repairs. The most common error associated with rule-based behavior is found when the mechanic incorrectly troubleshoots a problem and applies the wrong procedure. This could easily result in a both an active or latent errors if the incorrect procedure is not identified. Training and supervision is your best defense.

Knowledge Based Behavior: applies when a mechanic is presented with a situation that has no pre-packaged solution. The mechanic's decision process to solve a problem is based mostly on personal knowledge and experience which often is not uniform across the spectrum. Whether you are a seasoned mechanic or a novice mechanic, knowledge-based solutions tend to be the highest form of problem solving that is subject to a wide range of human errors. Getting creative in solving a difficult problem can often lead to making the situation worse rather than better. Careful study and analysis of the problem, to include consulting with the aircraft manufacturer, can help determine the best course of action and reduce the possibility of human factor errors in these situations.

Human Error Resulting from Behavior Patterns

Human Error is the unintentional act of performing a task incorrectly that can potentially degrade the system. There are three common types of errors that can be associated with any of the above behavior patterns:

1. **Error of omission:** Not performing an act or behavior. This could easily occur if the mechanic is performing multiple tasks or becomes distracted, such as answering the phone. The use of checklists will help reduce this type of error. It affords the mechanic with a bookmark to determine where to restart a task once it has been stopped.
2. **Error of commission:** Substituting an act or behavior. This is when a shortcut is introduced into the task or by-passing a procedure to shorten the process. It may seem to save time and effort but it is subject to latent type errors. In other words, it will catch up to you sooner or later.
3. **Extraneous error:** Performing an additional action or step. This has the potential for errors if the added step results in a delay or mistimed action. The more pipes you put into the plumbing the easier it is for the pipes to get plugged.

When maintenance is improperly trained or supervised, takes a shortcut, makes an educated guess or becomes distracted, these types of errors can easily occur and worse yet, go unnoticed. Again, training and supervision are your best defense.

Software-Hardware-Environment-Liveware (The SHEL Model)

The next step is to determine how to develop and implement a human factors program into your organization. How do we take something that is intangible

and make tangible? The best way to accomplish this is to incorporate a management tool called the SHEL Model.

The SHEL Model is used to determine the degree of interaction the maintenance team has between daily activities and the environment which influences those activities. Once identified, management can conduct a risk assessment to determine what kind of errors maybe experienced.

Software. This describes the rules, regulations, orders, standard operating procedures, customs, and practices which govern the environment in which the mechanic operates.

Hardware. This is the physical property, tangible items such as buildings, vehicles, equipment and materials.

Environmental. External factors which management has little to no control over such as political climate, economic or social factors.

Liveware. This title represents the human beings who interact with, and control the system.

The key to using this model is

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Heliprops

Helicopter Professional Pilots Safety Program


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The primary objective of the HELIPROPS program and the HUMAN A.D. 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:

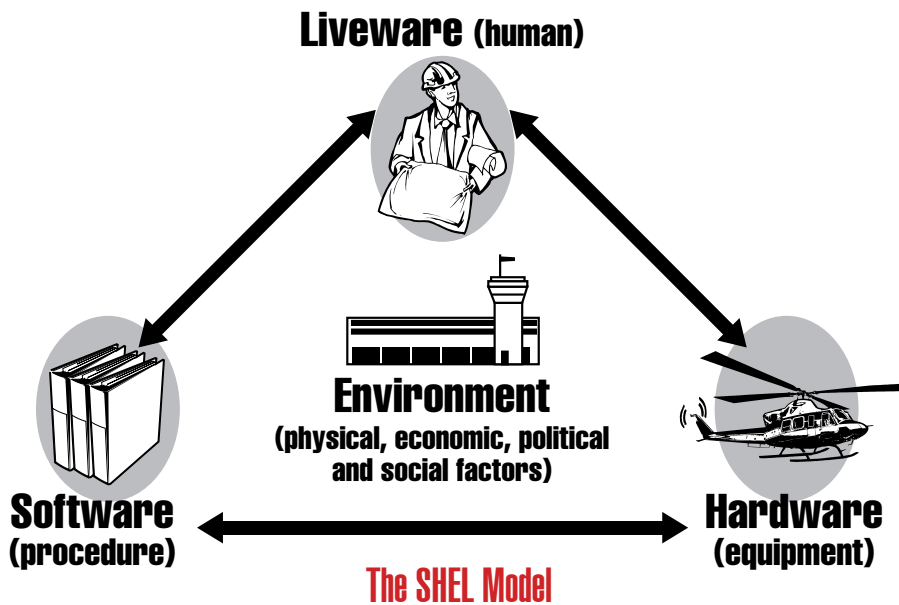
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The Maintenance Factor Continued...

*Hazards + Human Error =
Incident or Accident*



to understand the interface each element has with the others. The common denominator in this model is the Liveware element. It is the most critical and most flexible. You always begin your analysis with comparing Liveware and another element. For example you purchase a new piece of equipment (hardware) that the mechanic (liveware) must learn to use and be certified. Now you need to identify the training, procedures and regulatory requirements (software) that governs the use of the item. Next, determine where and when the training (environment) will be performed. By using the SHEL model in your daily activities you can help filter out any errors created by behavior patterns and improper decision making.

Accidents, Incidents and Stress

An accident is a sequence of events that produces unintended injury, death or property damage. The term accident refers to the event, not the result of the event. It usually involves some form of human intervention. It may be the result of some active or latent error. Since an accident results in some type of injury or property damage, it will become tangible. Thorough investigation techniques we can capture the causation factors and implement corrective procedures. The elements of an accident or incident are as follows:

Hazards: A condition or activity that is inherently dangerous and could result in injury or damage in uncontrolled conditions.

Human Error: omission, commission, substitution, mis-timed action

Incident: The culmination of the above elements that caused no injury or damage. We often referred to as the "close call".

Incident: The culmination of the above elements that resulted in a loss of life, injury or damage.

There is always some kind of hazard and human interaction that creates a chain of events which leads to any accident. When this chain of events unfolds but does not result in injury or damage, we call it an incident. These are the close calls that make the hair on the back of your neck stand out. It has all the ingredients of an accident without the end result. We don't do a very good job at capturing the causation factors of incidents because it did not result in any injuries or damage. The challenge to any maintenance team is to develop a procedure or system that captures not only the accident data but the incidents as well.

When dealing with human factors remember this simple formula:

Stress

The increasing awareness that stress plays on the negative performance factors in people is steadily becoming a major issue of concern in the aviation industry. Once again, stress management and prevention seemed to focus only on the flight crew. Now accident investigators are discovering that stress is not just limited to the flight crew. It includes the ground crews as well. What exactly is stress? If you ask a dozen people for the definition of stress you most likely will get a dozen different answers. That's because what is stressful to one person may very well be pleasurable to another. Let's just say that stress is the result of any emotional, physical, social, economic, or other factor that requires a person to respond or change.

The degree in which we react to stress varies differently with each individual. However, we share many common responses. The common responses associated with stress are: anxiety, preoccupation, depression, frustration, aggression, fatigue, insomnia and irritability.

There are stresses in life that we have little to no control over such as the amount of traffic on the road to work each morning, or the current political and economic situations. Regardless, these life stresses can cause degradation in our daily performance. I want to focus on two categories of stress: Self-inflicted Stress and Environment Stress.

*Look for Part 2 of
this story in the next
issue of "Heliprops." A
complete download of
the full article of "The
Maintenance Factor –
What Goes On Behind
the Hangar Door?"
is available on the
www.heliprops.com
website.*

Accounts from our Readers

The Padre's Hat

By Lloyd D. Knight

BIOGRAPHY

Lloyd Duncan Knight was born in Sydney, Australia in 1932. He left high school at a pre-matriculation level and joined the Royal Australian Air Force in 1951. His flying career spanned an unbroken period to his retirement in 2003.

Lloyd flew fighters in the Korean conflict. He flew over 2000 hours in the C130A Hercules. His final air force tour was as a helicopter pilot during the Vietnam War. He retired in 1970 with the rank of Squadron Leader (Major).

Lloyd worked as a Commercial helicopter pilot for Esso Australia offshore oil and gas operations, Examiner of Airmen and Flying Operations Inspector with the Civil Aviation Safety Authority, Australia. In his career, he has logged over 5,000 hours fixed wing and 11,000 rotary.

Not willing to "retire," Lloyd published a home study course in Instrument Flying, that was published in 1980 and a novel, "Rainbow, no end." He is currently writing a book of 52 short stories about his flying career and lives in Melbourne, Australia with his wife Bonnie.

Here's a little ditty about helicopter rotor down-wash. Those who may not be familiar with helicopter boarding procedures will at least have seen on the screen, the way people approach, or depart from a helicopter while the rotors are turning. Usually they are at a low crouch, head uncovered or with secured headgear, and normally in the sector between ten and two o'clock.

Some rotor systems dip to head height at the front, so they are approached from the side. Helicopters are never approached from the rear, unless they are rear-loaders and a trained person directs the boarders. This is because most tail rotors are extremely dangerous. Of course, loose objects, like headgear, can fly up into the rotors and cause serious damage, or be thrown down again and cause injury.

One day I was tasked to pick up a bunch of about six senior officers and bring them back to base. As we sat with rotors turning, they all ran in from about two o'clock with their service caps removed, except for one. He was holding the brim of his cap, which he let go a couple of times as he stumbled on the rough terrain. Even though one of his companions pointed to his cap as they ran, he stubbornly kept it on his head.

As they approached the helicopter, I saw that the recalcitrant one was wearing a white back-to-front collar under his service jacket. He was a chaplain.

They boarded, secured their seat belts and the crewman advised that we were clear to take off. Once we were up and settled in the cruise, I called to the crewman on the intercom. When he answered, I said, 'John, would you give the padre my compliments, and ask him to please remove his cap when he departs the aircraft?'

John acknowledged, and after about five minutes came back with, 'The padre has a problem.'

'That's unusual,' I replied. 'It's usually us who approach him with our problems. What's the padre's quandary?' John answered, with a little snicker in his voice, 'He's wearing a toupee, and said he thought it would blow off if he took his hat off. He's asking for permission to leave it on.'

After a moments consideration I said, 'Tell the padre he can keep his cap on, but to place one hand firmly on top 'til he's clear of the rotor down-wash.'

When we landed, the padre trotted away from the aircraft, one hand dutifully planted on top of his head.

The crew found the incident had lightened their day, and we all wondered why a chaplain, especially in a war zone, would be so vain. But, who are we to judge? Actually, I felt a bit sorry for him. It would not have been funny if his cap had been blown up into the rotors or the engine intake.

What's Your Story?

If you have an account that you would like to share with other *HumanAD* readers, please send them to:

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EDITOR'S NOTE



Jon Ehm's article in the last issue of the HELIPROPS newsletter, Vol. 20 No. 3, "Helicopter Ditching and Underwater Egress Training," generated some vivid memories for one Gulf War veteran whose experience is worth repeating. Erik Eriksen a Senior Production Test Pilot Specialist and Bell Helicopter Training Academy Flight Instructor felt it was important to recount his night-time "controlled flight into water" experience so others would realize the necessity of water safety training.

At the time of Erik's accident he was an active duty U.S. Army helicopter pilot flying combat, NVG missions in the Persian Gulf. Admittedly, what happened to Erik was uncommon to most pilots given the combat environment in which he flew. But, the lessons he learned that night would apply to anyone flying over water.



The following is the Headline I read concerning my own helicopter crash. Fortunately, I lived to read the account and tell the story: "Pilots rescued from crash of Army Helicopter in the Persian Gulf in September, 1989." The article begins, "On 18 September 1989, an OH-58D crashed during night gunnery practice and sank, but with no loss of personnel. This operation was in the Persian Gulf, a very dark environment with the crew on NVGs and flying low to the water."

My Story: During and after the crash, the loss of orientation, the emergency egress, the descent below the surface made for a very confusing and high-anxiety experience. Disentanglement from all the straps and wires associated with modern combat flight operations while sinking, added to the confusion. After surfacing, we assessed our precarious situation and looked up to find our wingman right on the spot.

Our sister ship was on the scene within minutes to pull us from the water. To pull us out of the water, the Army had outfitted the OH-58D with a device called a caving ladder by which we could cling. It was attached to the underside of the aircraft.

After lifting us out of the water, the OH-58D started to exceed temperature and torque limits. Our armament left no margin for any extra

weight, especially water-saturated pilots weighed down by survival gear. Our temporary rescue bird was forced to abort the rescue attempt lest they suffer the same fate. We were returned to the water and watched our rescue bird head back to the mother ship for a replacement rescue helicopter.

Immediately upon reentering the water, I activated the PRC-90 emergency radio to initiate a mayday signal. Our wingman also transmitted our coordinates to the USS Rentz (the Frigate from which our Army Helicopters operated). The Frigate acknowledged our mayday and immediately deployed their Navy Seahawk for the rescue operation. After what seemed to be "forever," we could finally make out the Seahawk's flashing beacons. I then proceeded to give vectors to our position.

The crew of the Seahawk was not flying with any night vision devices and did a great job. Having spent approximately 45 minutes in the water, and still bleeding from the accident, we were hoisted into the Seahawk and were flown back to the USS Rentz. The crashed OH-58D was eventually found and recovered 30 days later in approximately 300 feet of water. Guess we weren't going to be "shark bait," after all.

Before the Ill-fated Mission

All of the advanced water training was very useful, but with that said, I felt it was important to internalize what I learned. I knew that my reaction to an "event" could mean the difference between life and death. My pre-mission routine: prior to each night flight I would visualize the location of the "beaded handles" on the life preserver unit PFD (Personal Flotation Device). By continued rehearsal of a worse case scenario, I wanted my reactions to be automatic.

Another precaution I took was to swim with the Navy Seals who were co-located with our helicopter unit. They were the experts that could show me more survival techniques, especially ones at night. In summary, I kept up with the training long after the formal instruction.

This was supposed to be another "routine" night mission in the Persian Gulf. What happened is I inadvertently flew an armed OH-58D helicopter into the water at approximately 60 knots. One moment everything was okay and the next I found myself plunging into the black abyss with a full complement of survival gear and a pair of NVGs attached to my helmet. Before impact, I remember scanning outside the helicopter with my goggles and checking my airspeed when the crash occurred. It was a total surprise.

My copilot was working with the mast mounted sight and uttered the only communication between us, "waaa-t." The full word "water" was cut short midway through the utterance.

The helicopter submerged immediately, helped in part by the fact the crew doors were removed

for better visibility. The helicopter was additionally weighted by mission armament which made the use of floats untenable. I estimate being pulled underwater to about 15 feet before releasing my helmet from the ICS cord. I was able to avoid panic because the excellent chin strap design allowed for a very fast release.

Now that I was successfully disconnected from the sinking helicopter, I swam away by pushing off the airframe with my feet. I was running out of air and I felt around my flight suit pant leg for the Heeds Bottle. The Heeds would give me a couple of minute's air and just enough time to surface.

Then it hit me. I began to panic when the Heeds bottle wasn't where I expected; but talked myself out of it. So as a last resort, I pulled the LPU handle and rocketed toward the surface and a very large breath of fresh air.

My copilot was also able to successfully egress to the surface. We began swimming towards one another from about 25 feet away. Once together, we immediately interlocked our legs in order not to drift apart.

Fortunately, we were quickly rescued. It was none too soon because my upper leg had been cut on some

metal during the egress process; I was now bleeding in shark infested waters and ready to release the shark repellent. Later, I did find my Heeds bottle dangling from my left leg. It had been knocked loose somehow during the accident.

Aftermath

My physical injuries healed quickly. However, it took me several months to regain my self confidence. I began to question everything in my personal and professional life. I must have played the accident over and over in my head, hundreds, if not thousands of times. I give a lot of credit to my pilot friends who constantly encouraged me to fly again. Eventually, my confidence returned and I was able to complete my military career and continue later as a civilian pilot.

After the accident, my Unit Commander gave me the task of insuring that the members of our entire unit could swim. The aircrews were previously dunker qualified, but my boss wanted everyone in the unit to be current in water survival techniques and rescue procedures regardless of their job. Reading Jon Ehm's article brought back a lot of memories.



Remains of Erik's crashed OH-58D after 30 days on the ocean bottom.



Special Series

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The History of Helicopter Safety Part Four

In this issue, the last part of four on "The History of Helicopter Safety" is featured. The original version in its entirety was presented by Roy G. Fox at the International Helicopter Safety Symposium in Montréal, Québec, Canada on September 26-29, 2005. A complete download of the full article is available on the www.heliprops.com website.

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ROADBLOCKS

There are several myths in helicopter safety that need to be understood and corrected. We must work with facts, and not perceptions that are not necessarily true. These perceptions prevent the industry from moving forward based on facts. Some continuing myths are "Twin-engine helicopters are always safer than single engine helicopters. The rest of the aircraft other than the engines are the same on single or twin engine helicopters, so it can be disregarded, etc." These myths are not *always* true and draw attention away from the rest of the aircraft and the largest and far more complex problem of the human pilots. Concentration on the myths further ignores the different hazard levels of different types of missions, which can have significant effects. Over the last 20 years, these myths and ramifications have been discussed in Refs. 2, 12, 13, and 17. There are situations where an occupant in a twin-engine helicopter is safer than in a single engine helicopter, but the reverse is also true.

Another myth is that all helicopters are created equal and their safety is equivalent. That is not true either. Every helicopter model is different and has good and less-desirable features and characteristics. The author considers all helicopters to be safe, but some are safer than others. To illustrate this fallacy of these myths, see Fig. 11 from Ref. 17, which shows the occupant's flight life span, which is the average number of hours, an occupant can fly before receiving a fatal injury. This is the reciprocal of the RFI or 1/RFI. The time period is 1987 to 1996 for U.S. registered helicopters. The red bars are the flight life span, if you could only die from all airworthiness failures (including engine). Of course, "All Causes" data are the real measure of concern, and even 85,000 hours is a long, long time for an individual to be in the air.

A roadblock to the helicopter industry is the lack of accurate flight hour

Occupant Flight Life Span: Mean Flight Hours Before Fatal Injury (All Causes vs AW Only)

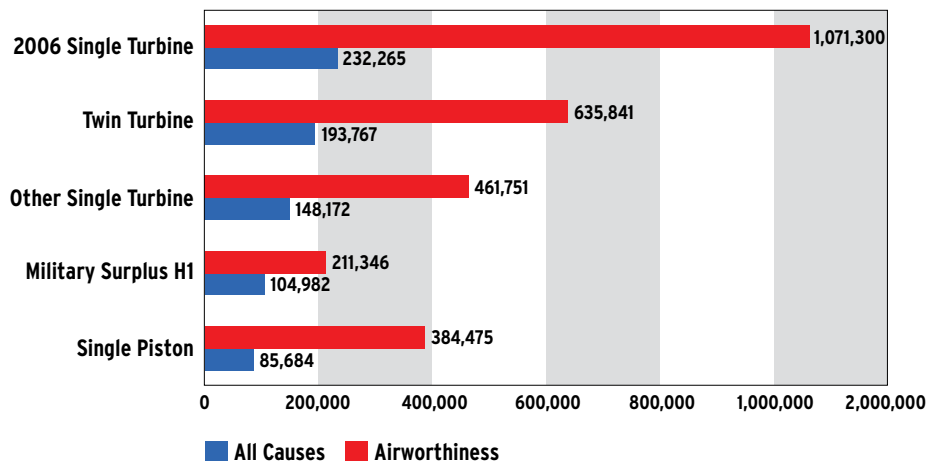


Figure 11 – Occupant flight life span.

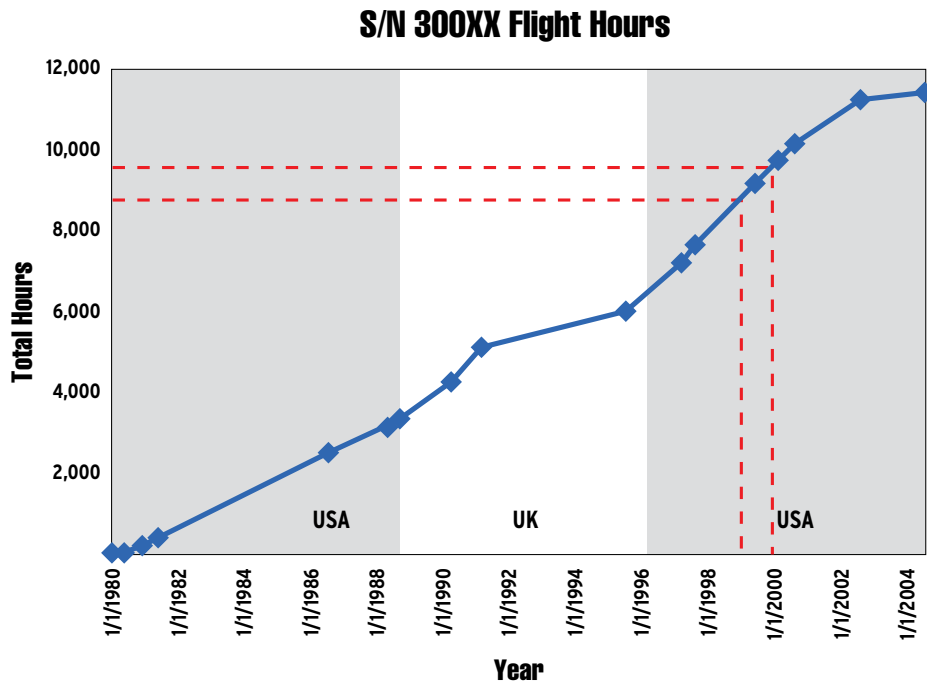


Figure 12 - Individual helicopter flight hours tracking.

exposure data. If we cannot measure risk, we cannot tell whether our “improvement” is an actual “improvement in safety,” or whether it made the problem “worse” or just moved the problem into another area. We must be able to accurately measure the “bad outcomes” per “units of exposure.”

Exposure data is critical, but difficult to obtain. Availability of flight hours has been a constant problem. FAA General Aviation and Avionics Survey used a sampling technique to estimate flight hours on an annual basis. Although this technique produced errors from year to year on an individual model, hours over 5+ year period has improved accuracy, as the annual high/low errors start to cancel each other out. The FAA stopped providing helicopter model flight hours in 1997, so there are no Government flight hour data available at the model level for the years since 1996.

Bell in the 1970s became aware of lack of exposure data, which precluded measuring safety degradation or improvements. Bell started tracking every Bell helicopter individually by serial number. The concept is to determine airframe total flight hours at different dates. Once that data is entered, the computer can interpolate between data points for any given date to determine the flight hours. Setting the interpolation point at January 1 of each year develops the annual airframe hours for that serial number aircraft. Limiting this to only U.S. registered aircraft makes the data comparable with FAA data, which is strictly U.S. registered aircraft. Then the annual hours of each serial number helicopter for that given year are totaled. Flight hours for a specific serial number aircraft are pulled from various sources such as (1) accident or incident reports, (2) discrepancy reports, (3) warranty claims, (4) Bell Customer Service Representative visits to operators, and (5) “for sale” sites on Internet.

An example of one serial number helicopter flight hour history is Fig. 12. This aircraft had left the US, was on the UK registry, and returned to the US registry. There is hope in the future to have good Government flight hour data. Bell has worked with HAI and the FAA to use this same technique for all helicopters. There is an FAA funded research program underway where

HAI is combining their electronic formatted Maintenance Malfunction Incident Report (MMIR) for flight hours generation by using this same Bell process to develop annual flight hours at meaningful model levels. At the end of each year, HAI would total the flight hours flown under U.S. registry to the helicopter model level and provide that to the FAA. If we can prove the effectiveness of this process on the helicopter fleet, a similar computerized system could be used on General Aviation airplanes in the future.

A common misconception is that the exposure to risk should be related to number of takeoffs, such as accidents per departure. Helicopters appear safer that way, since helicopters make many takeoffs per hour, compared to an airliner that will fly for hours before landing. That is a false measure that should not be used, since there is a risk of injury throughout the entire flight, not just during a takeoff throughout the entire flight, not just during a takeoff or landing. Departure data is required to be reported to the FAA for all scheduled Part 121 air carriers, but nothing is required for the helicopter and General Aviation world. The NTSB in a recent recommendation is pushing for reporting of flight hours and departures for non-scheduled Part 135 operators, which will include some helicopters. This would not affect the majority of helicopters, which do not operate under Part 135.

The single most-important improvement in helicopter safety could be driven by documented information of what happened (or not) in the cockpit during an accident sequence. We accident investigators and regulators don't know details. Pilot error is largely based on circumstantial evidence, and ends up with accident causes such as “failed

CONTINUED ON PAGE 10

The History of Helicopter Safety Continued...

to maintain RPM,” “failed to maintain clearance,” “fuel exhaustion,”— the list goes on.

FUTURE CHALLENGES AND DIRECTIONS

The helicopter industry, including the regulatory side, needs to work on these major roadblocks. For example, HUMS—S/N 30XX Flight Hours possible maintenance credits and alerting a pilot of an impending problem—is always a good subject for a lively discussion. We need research and trial programs to build a more robust and useful HUMS, to be able to validate that the HUMS indication occurs XX hours before a catastrophic component failure. With such confidence, the pilot should be alerted that the helicopter requires an inspection before another flight. We in the industry and the regulatory agencies must work together to find ways to make improvements and also make use of technologies developed from outside of aviation. Figure 13 provides a roadmap of basic safety investment approaches that could allow an 80% reduction of accident rates in the future.

The largest single problem that prevents helicopters from rising to the safety level of the airlines is that we do not know what is happening in the cockpit. If you don't understand what happened in a crash, you cannot fix anything and these human error accidents continue year after year. We must find a way to document what is happening in the cockpit, and that information must be

retained in crashsurvivable media or transmitted outside of the aircraft. Many contend that we already have Flight Data Recorders (FDRs) and Cockpit Voice Recorders (CVRs) to provide this information. This comment is misleading. Reference 14 discussed the fallacy of this, as very few helicopters have FDRs. Since the FDR requirement of 14CFR135 is for multi-turbine powered helicopters with 10 or more passengers, the maximum number of helicopters meeting those requirements (including those not operating under 14CFR135) would be only 6.5% of the U.S. civil helicopter

The helicopter industry needs a Cockpit Information Recorder (CIR) to provide information inside the cockpit before and during a crash. This information will allow the accident investigators to understand

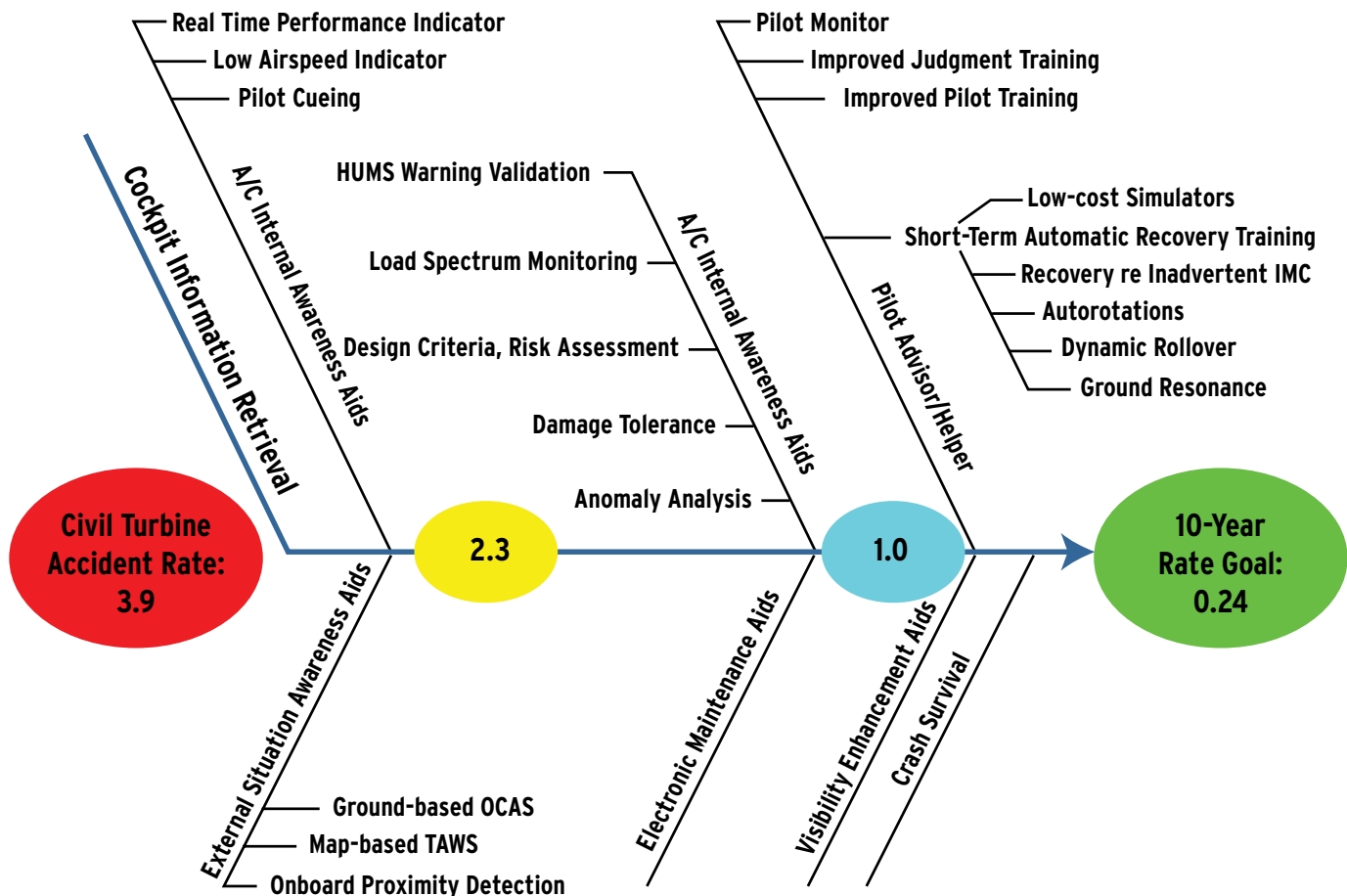


Figure 13 – Safety investments for the future.



Figure 14 – CIR view of cockpit.

what actually happened (or not) in those human and unknown caused accidents. Once we can document and understand the actions and sequences, we can make the appropriate corrections. This knowledge on every helicopter accident can save costs/time of accident investigations, reduce regulatory concerns, and speed up corrections to the field. Most importantly, it would allow us to correct and mitigate the human error

accidents and raise helicopter safety to a new level. Reference 14 describes these benefits and issues regarding a CIR. A CIR should contain:

- A still color camera (day/night)
- An area microphone
- A GPS
- Data processing/memory capability
- Crash survivable recorder.

A CIR unit would likely contain the first four items and provide output to existing crash-survivable recorders. A typical still shot photo is shown in Fig. 14, which would include the instrument panel and the pilot's controls (cyclic, collective, and pedals). A CIR could be a "poor man's FDR/CVR."

Further in the future, we should make the CIR wireless. An onboard transmitter would be added to transmit analyzed critical data to a satellite, to a land line via Internet to the Operator's PC and the Manufacturer's PC (Fig. 15). The PC would be programmed to determine if a crash occurred (e.g., analysis of GPS data for anomalies). If analysis indicates a crash and no human action occurred from the operator in a few

minutes, the PC would automatically notify the Search and Rescue function. The PC alert message would provide aircraft identification, time of last contact, and Fig. 14. CIR view of cockpit, longitude/latitude of the wreckage. This would shorten rescue response time, which increases the probability of survival. This satellite transmission approach is already being used now for helicopter flight following with a small GPS unit. The automotive industry has this GPS tracking and crash alerting capability (when airbag deploys) in GM's OnStar® system in many of their automobiles.

SUMMARY/CONCLUSIONS

Helicopter safety has been improving over the years. The accident frequency appears to be flat or even increasing. The accident rates due to airworthiness issues remain very low and consistent year-to-year. Industry will continue to keep airworthiness issues corrected. The largest single potential area to make significant improvement in safety is in understanding what went on in the cockpit of each helicopter. Once we can document the cockpit information and sequence, we can finally understand and aggressively attack those accident causes. A Cockpit Information Recorder (CIR) tied to a crash-survivable recorder can allow quicker, more complete, less costly accident investigations. This would allow safety problems to be corrected in weeks, not years. The CIR provides the potential to reduce our helicopter accident rate by at least half if not two-thirds. The CIR can provide facts and understanding, which is required to go to the next level of safety.

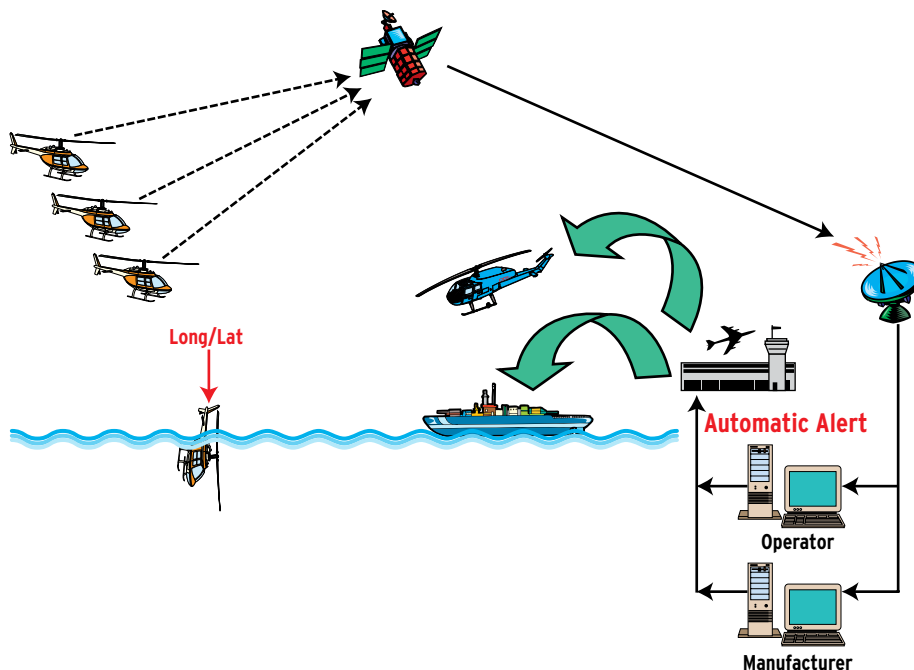


Figure 15 – CIR wireless automatic crash alert via satellite.

A complete download of the full article of "The History of Helicopter Safety" is available on the www.heliprops.com website.



BELL HELICOPTER AWARD PROGRAMS

Many Bell pilots and operators have requested information on what type of Bell Helicopter wings and safety awards are available to them. There are two ways to obtain recognition for pilots who fly Bell helicopters. The first recognition is a Pilot Safety Award issued on the basis of safe flying hours in Bells. The second is a wings award based on the pilot's flight hours in Bell helicopters. It is possible for a pilot to obtain both awards.

Bell Flight Time Wings Award

The second recognition is for a pilot's flight time in Bell Helicopters. The Bell Training Academy issues this Certificate of Achievement and a Wings Lapel Pin in the following flight time hours:

- 1,000 hrs.** plain wings pin + certificate
- 5,000 hrs.** 5,000 hr. wings pin + certificate
- 10,000 hrs.** 10,000 hr. wings pin + certificate
- 15,000 hrs.** 15,000 hr. wings + certificate
- 20,000 hrs.** 20,000 hr. wings + certificate

Example: If a person had 6,500 hours in Bells he would receive a 5,000 hour pin, although the certificate would read 6,500 hours. Their next opportunity for a higher hour level pin would be at the 10,000 hour level.

For the hour level recognition to be awarded, the pilot (or company) must provide the following: Name of pilot as they would like it printed on a certificate, a verified flight time in Bells by either the Chief Pilot or a Company Administrative Official. In the case of an individual pilot making the request, a signed copy of the page in the pilot's log book that verifies the hour level for the wings requested.

Mail or email the information (including copy of documentation) to Rosalind Larmer at: rlarmer@bellhelicopter.textron.com. Bell Helicopter Textron Inc., P.O. Box 482, Rosalind Larmer, Dept. 9S, Bldg. 61, Fort Worth, TX 76101 USA

Pilot Safety Award

Recognizing an individual pilot for flying safely is far too rare. Most pilots only hear of mistakes made by another pilot in an accident. Bell provides a Pilot Safety Award certificate for hours flown without an accident in a Bell helicopter. This can be achieved in either military or commercial aircraft. The award is given in thousand hour increments to recognize those pilots with a proven commitment and history of safe flying. To apply for this recognition certificate, please send a request letter from the chief pilot, CEO, military commander, or other individual who can confirm how many accident-free flight hours you have flown in Bell helicopters. If you are an individual pilot/owner, you can write the statement yourself. Let us know how you would like the name to appear on the certificate. If you want to include a military rank, you need to indicate that.

The award is maintained through the Bell's Flight Safety Department within Bell Engineering; Lee Roskop (ldroskop@bellhelicopter.textron.com) is the Bell point of contact. His mailing address is: Bell Helicopter Textron Inc., Attn: Lee Roskop, Dept. 81, Group 60, P.O. Box 482, Fort Worth, TX 76101 USA

The pilot's name and safe flight hours are posted on Bell's Flight Safety web page www.heliprops.com. Follow the link to the Heliprops Pilot Safety Award Program.



Significant Achievement

Bell Training Academy Director Trey Wade presents a Certificate of Recognition after 40 years of service in aviation, to FAA Inspector Angelo Spelios upon his retirement. He also received a 5,000 flight hour certificate for pilot flight time in Bell Helicopters. Standing with Mr. Spelios is his friend and FAA Attorney, Elynn Ponton.

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