CIVIL ROTORCRAFT RISKS

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INTRODUCTION

Safety has always been a factor in the growth or lack-of-growth of the helicopter industry. The perception of the lack of safety has caused fleet groundings and the prohibition of helicopter operations. There are many facets of safety, but the bottom line is that occupant safety is achieved by the management of risk. If you can reduce the risk, safety has improved.

CIVIL HELICOPTER HISTORY

The civil helicopter history started with the first civil certificated helicopter in 1946, the Bell Model 47, registry of NC1H (Fig.1.). The civil helicopter industry, like the military helicopter industry, has since grown and spread throughout the world. The Model 47 series included about 4,600 civil and military models until all Model 47 production was stopped in 1974. The safety history of the Bell Model 47 series, which was the most popular helicopter in those early days, is typical of the early aviation. The 47 accident rate was very high at the start of civil helicopter aviation, as the operators were finding new ways to use the helicopter. The designers were fixing those problems due to the aircraft as they became evident from accident investigations. The annual accident rate decreased over time with the maturing of the 47 fleet, but it stabilized to a fairly constant rate (Fig. 2). The large fluctuations in annual accident rates in the later years are due to inaccuracies of the FAA's estimates of Model 47 flight hours. Basically, the Model 47 accident rate has been the fairly constant for the last 40 years.

WHAT IS AN ACCIDENT?

When an unusual occurrence happens in or around an operating aircraft, the severity of the damage or possible injuries can vary widely. Thus there is a threshold beyond which the government must be notified of a serious occurrence. Events severe enough to be called accidents are required to be reported to the government and some type of investigation is warranted. Events less than this threshold level, such as maintenance or very minor events, are generally not reported to government. Therefore the location of this dividing line between required reportable and non-reportable events becomes quite important and must be defined. Each government has an agency tasked to investigate such serious occurrences with the goal of reducing that type of problem in the future for the flying public. In the United States of America (USA), that government agency is the National Transportation Safety Board (NTSB). Each of the Military Services has a similar segment of the service that is tasked to do accident investigations. Countries that are signatories of the International Civil Aviation Organization (ICAO) have agreed to standardization of accident investigation (as much

Fig. 1. NC1H, the first civil certificated helicopter.

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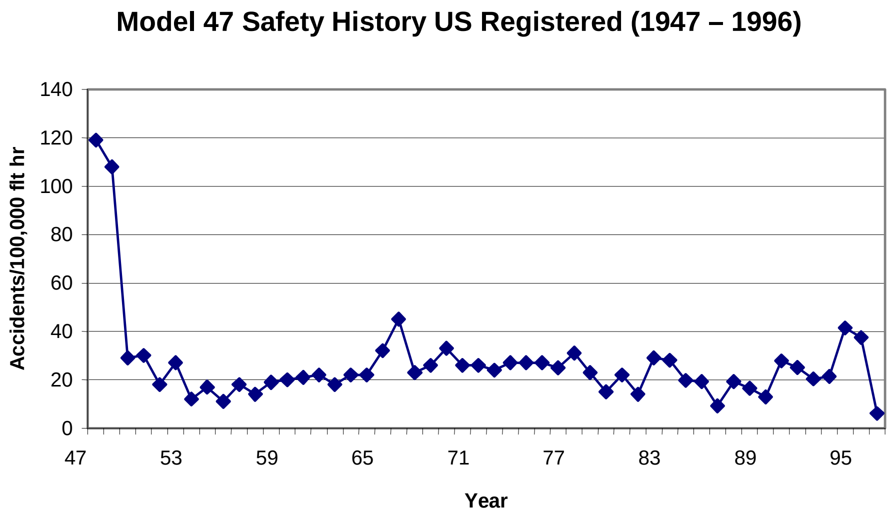


Fig. 2. Model 47 annual accident rates for 50 years.

as possible) based on ICAO Annex 13. Each country then bases its definition of a reportable event on the definition in Annex 13. NTSB's definition is defined in 14 CFR Part 830.2, which states:

> "Aircraft accident" means an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage.

Substantial damage requires further definition, as the range of damage may be quite wide. Therefore 14CFR Part 830.2 continues and states:

> "Substantial damage" means damage or failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft, and which would normally require major repair or replacement of the affected component. Engine failure or damage limited to an engine if only one engine fails or is damaged, bent fairings or cowling, dented skin, small puncture holes in the skin fabric, ground damage to rotor or propeller blades, and damage to landing gear, wheels, tires, flaps, engine accessories, brakes, or wingtips are not considered "substantial damage" for the purpose of this part.

Examples of this wide range of what is considered an accident with substantial damage range from a minimal accident of a wrinkled tail boom requiring maintenance with no injuries during a poor landing (Fig. 3.) to a very serious accident where the aircraft is destroyed by fire and all occupants were fatally injured (Fig. 4). As a side note, the aircraft data plate from this foreign accident shown in Fig. 4, was sold for $1.00, and another aircraft was counterfeited using that plate and a military surplus UH–1 fuselage. That counterfeited aircraft later crashed in the USA due to a military surplus part failure.

Accident rate comparisons should always use a common definition of what constitutes an accident. Otherwise, one data set will be including only extremely severe events whereas the other data set will be considering minimal damage events as well as severe fatal events. With civil aviation around the world, the definition of an accident is quite commonly based on the ICAO Annex 13, and does not change over the years. The U.S. Military Services under Department of Defense (DOD) use a different classification system. Both the civil NTSB and the U.S. Military Services include a serious or fatal injury as part of the accident definition threshold, but differ in the aircraft damage. The DOD definition for aircraft damage is based on the cost to repair. This level of aircraft damage cost for a Class A mishap has changed over the years from:

- $100,000 or more, then changed to
- $200,000 or more, then changed to
- $500,000 or more, then changed to
- $1,000,000 or more (present level)

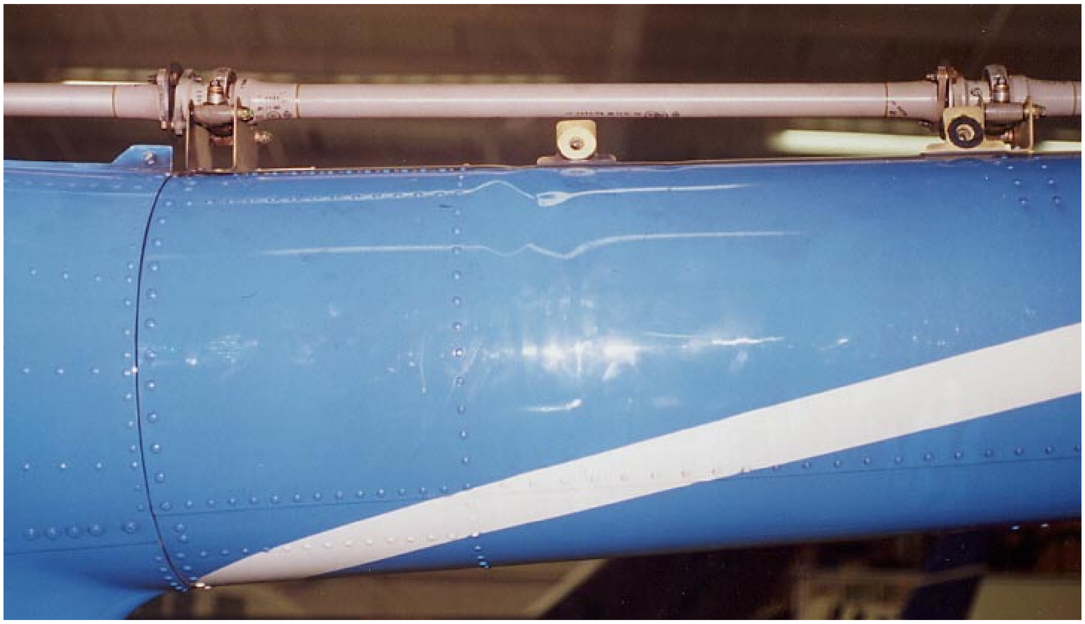


Fig. 3. Wrinkled tail boom accident.

Fig. 4. Aircraft destroyed by fire with fatal injuries.

Thus one should not attempt safety comparisons between civil helicopter safety and military helicopter safety, due to the lack of a common event being measured. Safety comparisons should stay within common guidelines of events and types of exposure to be meaningful.

PERIOD OF EXPOSURE TIME

Measuring risk can only be done by knowing the amount of exposure to risk. Some people express risk in terms of accidents per departure or takeoff, which is quite misleading. You are at risk at all phases of flight, not just during the departure/takeoff. In flying, you are exposed from the time you leave the ground until you return to the ground; that period is referred to as the flight time, measured in hours. Thus the flight hours of an aircraft type must be known in order to develop the different types of risks relative to that aircraft type. The only official U.S. Government source of flight hours is the FAA General Aviation Avionics and Activities Survey (now called General Aviation and Air Taxi

Activity Survey), which is conducted on an annual basis. The FAA sends out a questionnaire to a sampling of operators of U.S. Registered aircraft base on models and the state of the owners. The FAA then develops annual flight hours based on the questionnaire responses. Unfortunately, the FAA has stopped providing flight hours by model series, beginning in 1997. Thus the latest year for developing meaningful risk measurements is 1996.

The helicopter accidents used to determine frequency of occurrence must be applicable to the flight hours available for that model. The amount of flight hour exposure was determined for this study by helicopter model for the last 10-year period of 1987 through 1996 from the FAA data. Helicopter models deleted to improve accuracy were those models with less than 50,000 flight hours for the 10-year period, homebuilt/kit helicopters, and those with non-U.S. registry numbers. Also, if a model had an accident in a year in which there were no FAA flight hours estimated, that accident was deleted. This resulted in the elimination of 181 accidents. The remaining 1534 accidents and their respective flight hours were separated into five groups for analysis.

The "Military Surplus UH–1" group was separated out. This is a rapidly growing segment due to the U.S. Department of Defense (DOD) services (Army, Navy, Marine Corp, and Air Force) release of military aircraft as surplus aircraft into the civil fleet. These single turbine-powered helicopters were designed and produced by Bell to military requirements and not to civil certification requirements. These aircraft include UH-1A/B/C/D/E/F/H/K/L/M/P/V military models. The military services have modified their aircraft design over the years before their release into the civil world. Some of the UH–1s are being used well beyond what they were designed to do, which has caused a growing number of accidents. The military surplus UH–1 aircraft are in many severe uses, such as repeated heavy lift and logging. The FAA flight hour estimate is a mixture of these military surplus UH–1s and the Bell civil certificated 204B and 205A1. The 204B and 205A1 flight hours in some years were separate; in other years, the flight hours were combined into the military surplus UH–1. The 1996 U.S. registry showed that 93.2% of this group of 616 aircraft (UH–1, 204B, 205A1) were actually military UH–1 aircraft. Therefore this single turbine-powered helicopter group is predominately military surplus UH–1s and is treated as such. Since more UH–1 aircraft are scheduled to be surplussed in the future, they will continue to be major growing segment of civil aviation.

The "206" series is a group of its own, since it flew 40.9 % of all helicopter flying during this 10-year study period. The single-turbine-powered 206 helicopter continues to be the most prevalent helicopter in the USA and the world. The "Other Single Turbine" group consists of the remaining single turbine-powered helicopter models with FAA flight hours, which are the 369/500/600, AS350, and SA316/319 models.

The "Single Piston"-powered group consisted of the following series: R22, 47/H13, 269/300/TH55, F28/280, and UH12/H23. The term "piston" is commonly used to describe a reciprocating engine that has pistons. Those accidents of aircraft where the original piston-engine certificated configuration was modified to a single turbine configuration were also deleted.

The "Twin Turbine" group consisted of the following series: BO105, BK117, 412, 212, AS355, 222/230, A109, S76, S61, and S58T. The flights hours of exposure and the number of accidents for these five groups are Table 1.

The helicopter models within this study of Table 1 accounted for 9,841 U.S. registered helicopters as of the end of 1996. The percentage of each group's fleet is Fig. 5.

RISK TO THE AIRCRAFT

When the amount of damage or injury exceeds the definition of an accident discussed earlier, that event is an accident and must be reported to the government authorities. The frequency of those reported accidents also determines the financial risk of operating fleet of those aircraft. The proper metric is the common accident rate calculated as the number of accidents of a time period divided by the flight hours flown during that time period. This rate determines the likelihood of having a reportable accident for all causes, but that

Table 1. Helicopter groups with 10-year accidents and exposure

Helicopter Group	Accidents (1987 – 1996)	Flight Hours (1987 – 1996)	Percentage of Flight Hours
Single piston (reciprocating engine)	864	4,974,421	23.3
206 Single Turbine	306	8,739,554	40.9
Other Single Turbine	226	3,734,015	17.5
H–1 Military Surplus Single Turbine	55	496,204	2.3
Twin Turbines	83	3,406,927	16.0
Totals	1,534	21,351,121	100.0

is not the same as the likelihood of the occupant being injured or killed. Different types of aircraft have different accident rates. Further, the types of operations (missions) being flown by these aircraft are likewise very different. Some types of operations are extremely safe and others are extremely hazardous. So the same helicopter model can have significantly different accident rates, depending on how it is being used. As a starting point, the risk to the aircraft of a government reportable accident is shown in Fig. 6. The five helicopter groups of this study are noted in red color. "R/W" indicated rotary-wing aircraft (helicopter), whereas "F/W" indicates fixed-wing (airplane). Fixed-wing airplane segments of U.S. Aviation are noted in blue color. Scheduled 121 Air Carriers and Scheduled 135 Air Carrier (Commuter) operations are the typical airlines used by the flying public. The Non-Scheduled 135s group is made up of commercial operations called Air Taxi, which are predominately fixed-wing airplanes.

The "HSAC Gulf of Mexico" is a select group of helicopters (single-turbine and twin-turbine) that operate offshore in the Gulf of Mexico to and from oil/gas rigs. Note that the HSAC aircraft risk of a reportable accident is significantly lower than the other three turbine helicopter fleets of this study that include all types of operations, even though their over-water operations can be quite hazardous. HSAC (Helicopter Safety Advisory Conference) is a group of oil companies and helicopter operators who have banded together as an organization to improve safety for all that operate in the Gulf of Mexico. Their accident rate is about the same as General Aviation turbojet airplanes and the Commuter Airlines.

Accident rates are risk of a reportable accident occurring, which is not the same as the risk of injury to an aircraft occupant.

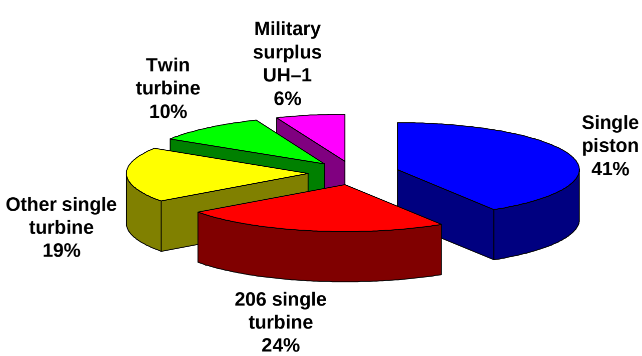


Fig. 5. US Registered Helicopter Fleet in 1996.

RISK OF ACCIDENT DUE TO INITIATING CAUSE

The overall accident rate just shown in Fig. 6 is the total of all of the accident causes that required the reporting of an accident to the government agency (NTSB). Accident causes are separated into two major categories. One category consists of those accident causes that were due to the aircraft (called airworthiness causes, as they directly relate to the certification of airworthiness). The other category consists of the non-airworthiness causes of pilot error, weather, maintenance error, other persons, and unknowns. The accident rates from all causes and airworthiness-only causes are shown in Fig. 7. The Twin Turbine helicopters had the lowest accident rate (risk to the aircraft) for all causes and the Single Piston helicopters had the highest accident rate. Considering only the accidents that are due to the aircraft (e.g., airworthiness failures), the lowest accident rate is shared by the Twin Turbine and the 206 (a single turbine) at a rate of 0.7/100,000 hours. The highest accident rate due to the aircraft airworthiness failures was the Military Surplus UH–1s at 5.4/100,000 flight hours. This is an indicator of the severe use (and sometimes abuse) of using an aircraft to do missions for which it was not designed.

Again all of these aircraft are used in many different types of operations (Table 2).

ARE YOU SAFER WITH A TWIN ENGINE OR A SINGLE ENGINE?

This question has been around for years and the myth has unfortunately continued into the turbine helicopter fleets. The two-engine safety myth is based upon early 1900s aviation, when airplanes were equipped with extremely unreliable reciprocating engines that failed quite often. This historic multi-engine airplane thinking has mistakenly been applied to helicopters. In commercial airline operations, we started with two-engined airplanes, then went to three-engined airplanes, and then went to four-engined airplanes. The commercial airlines then switched from reciprocating engines to the new and reliable turbine engines. In the last decade or so, commercial airlines have gone from four-turbine engines, to three-turbine engines, and to the present two-turbine engine aircraft. The reliability of the present-day turbine engine in airplanes and helicopters is extremely high. Even on the latest large transport airplanes (Boeing 767, etc.) used by the airlines, ETOPS regulations allows the two-turbine engine airplane in commercial service, after an engine failure or is shutdown, to fly up to 3 hours on the remaining engine (now it is a single engine aircraft) before it is required to land. Even with the major engine reliability improvements is aviation over the years, some people still mistakenly believe the myths of Table 3.

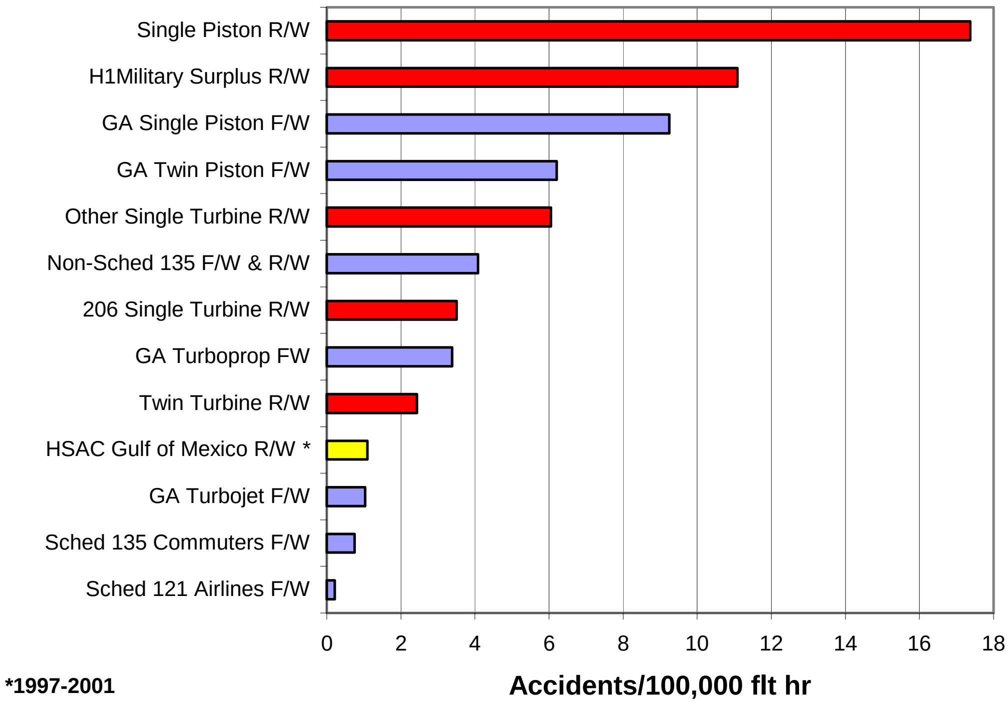
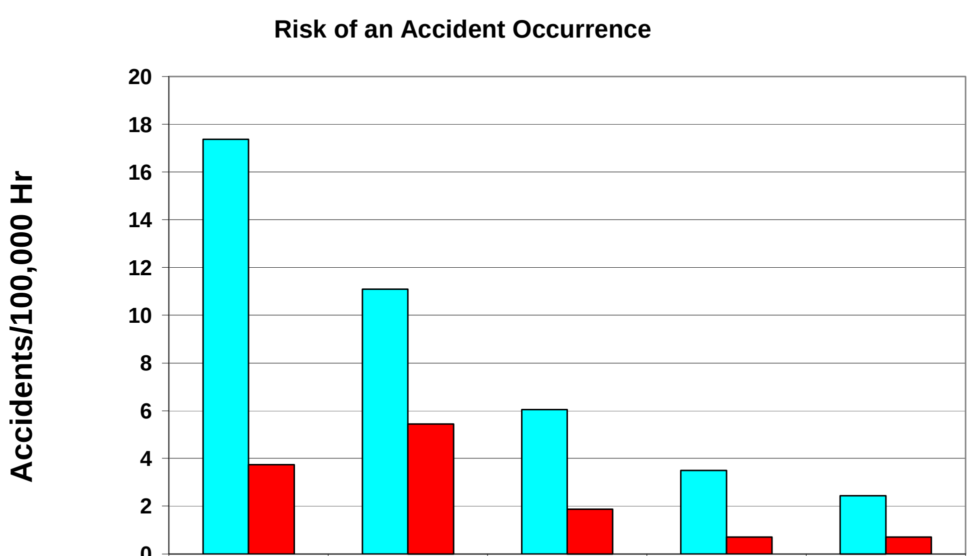


Fig. 6. Risk of Reportable Accident of US Registered Aircraft (1987-1996).



	Single Piston	Military Surplus UH1	Other Single Turbine	206 Single Turbine	Twin Turbine
All Causes	17.4	11.1	6.1	3.5	2.4
Airworthiness	3.7	5.4	1.9	0.7	0.7

Fig. 7. Risk of a reportable accident.

Table 2. Helicopter civil types of operations.

FAR	TYPE OF CIVIL OPERATIONS
137	Aerial Application
133	External Loads (Logging)
133	External Loads (Others)
135	Air Taxi (Air Medical Service)
135	Air Taxi (Commercial Air Tour)
135	Air Taxi (Commercial Passenger – Other)
135	Air Taxi (Cargo)
91	Aerial Observation/Patrol
91	Air Medical Service
91	Business
91	Commercial Air Tour
91	Corporate/Executive
91	Electronic News Gathering
91	Instructional (Part 61/145)/Training
91	Maintenance/Test Flight
91	Personal/Private
91	Positioning/Ferry
91	Sightseeing
91	Utility Patrol & Construction
91	Other Aerial Work
N/A	Public Use/Government Use (FARs not applicable)

All of the beliefs in Table 3 are FALSE. They are only myths that are not supported by actual facts.
The single-turbine 206 and twin turbines from Fig. 7 had the same airworthiness accident rate of 0.7/100,000 flight hours. Airworthiness includes failures of all components of the aircraft such as the engine(s), airframe structure, rotors, drive systems, hydraulics, electrical, controls, etc. Comparing just the engine failure portion to the rest of the aircraft failure causes shows a different distribution of where the airworthiness failures are being initiated (Fig. 8). On the 206, 80% of the airworthiness accidents were due to the engine, and the Twin Turbines had 12% of their airworthiness accidents still caused by engine failure. So the second engine in a twin did not eliminate all accidents due to power loss and thus dispels one of the myths. The non-engine airworthiness (the rest of the aircraft) causes accounted for 20% for the 206s and 88% for the Twin Turbine's airworthiness accidents. It is obvious that the "remainder-of-the-aircraft-stays-the-same" belief is not true, and is only a myth.

There are many factors at work. One should not count number of engines, as that is misleading from a safety point of view.

Sometimes a single turbine is best choice for safety; sometime a twin turbine is the best choice for safety. Most of the time, it doesn't matter for safety reasons, and the choice should be based on payload and economic issues. The specific type of operation being planned, where it is to be done, and how you will do that operation are far more important than an engine count. The above is only related to the chance of a reportable accident occurring and does not consider the myths related to the actual risk of an occupant being hurt, which will be discussed later.

Table 3. Twin-Engine Safety Myths

1.	You are automatically safer with two engines than with one engine, since you have one engine left when the other one fails such that you can always fly away.
2.	That the effects of the remainder of the aircraft failing is the same with one or two engines installed.
3.	That the increase of pilot errors from the additional pilot workload, decisions, and mistakes in normal and emergency procedures is the same with one or two engines installed.
4.	That safety regulation should be based on One Engine Inoperative (OEI) performance and the failures of the rest of the aircraft can be ignored
5.	That the injury risk resulting from an engine failure is eliminated by having a second engine.
6.	That the injury risk is the same in all types of helicopters.
7.	That the injury risk is the same regardless of what caused the accident.
8.	Regardless of being in a helicopter or in an airplane, if you lose all engine power, you will likely die.

WHAT CAUSES HELICOPTER ACCIDENTS?

The causes of the accidents of the five separate helicopter groups are Fig. 9. The Engine Airworthiness (Eng AW) and Non-Engine Airworthiness (Non-Eng AW) were those accidents where the failure was confirmed (i.e. fatigue, broken, etc.). There was another group in which the pilot “claimed” that he had a power loss and that was the reason he crashed. However, during the accident investigation, the engine subsequently ran fine and no failures in the engine or related systems such as fuel, could be determined. The dilemma for the investigator then becomes what/who to believe. The hard facts (nothing found wrong with the engine or related systems) or the pilot’s statement? This is a difficult situation that will not likely improve in the future until there is some type of recording device onboard, such as a Flight Data Recorder (FDR) or Cockpit Audio Visual Recorder (CAVR). Until the investigator can prove one way or the other, this group of accident causes (Suspected Eng AW) will continue.

During this 10-year study, the Suspected Engine AW accidents were considered as actual Engine AW accidents, with the exception of Fig. 9. This Fig. 9 is in descending order of all Airworthiness failures (Engine, Suspected Engine, and Non-Engine AW). Pilot Error is the most common cause of helicopter accidents. The segment labeled “Maint-Other” is accidents due to gross maintenance errors and other persons (other than the pilot or mechanic) that caused the accident. This could include interfering with flight controls or a non-pilot attempting to fly. The remainder was Unknown causes. Although most accidents have several causes, the initiating cause was used in this study.

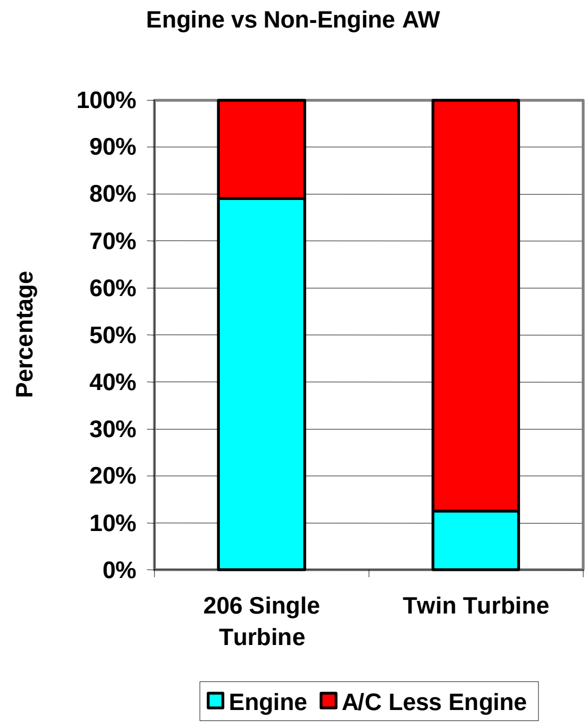


Fig. 8. Airworthiness failure causes of accidents.

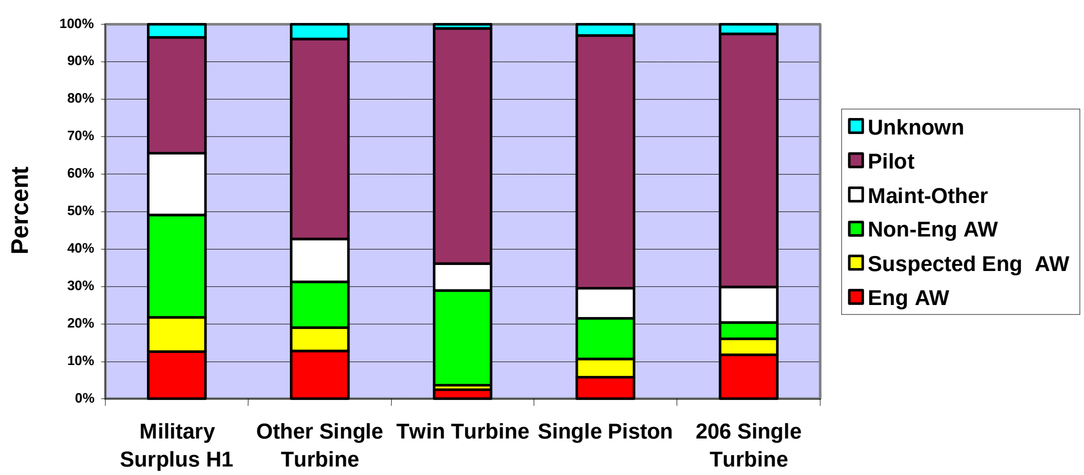


Fig. 9. Accident causes.

SURVIVAL IN HELICOPTER ACCIDENTS

Is the risk of an occupant injury determined by the aircraft accident rate? No. Most of the occupants in accidents are not seriously hurt. Survival depends on many factors, such as

- Aircraft attitude at impact,
- The amount of impact load and direction,
- The type of restraint worn,
- Occupant impact load tolerance,
- Impact surface,
- Aircraft,
- Type of seat,
- Post-crash fire protection,
- Emergency egress

Fig. 10 shows the percentage of occupants that received a fatal injury or survived in Airworthiness caused accidents and the remaining accidents (Non-AW causes) for each of the five groups. Fig. 10 is ordered by descending percentage of fatalities. About 5% of the occupants received fatal injuries in accidents from airworthiness failures (includes engines and non-engine airworthiness failures). Overall, 90% of the occupants survived in helicopter accidents. It is interesting to note that the Twin Turbine had the highest percentage of fatalities for all airworthiness failure of the five study groups. Again, it is apparent that the number of engines is not the controlling factor in occupant survival and the remaining myths are dispelled. Although these values are percentages, they are consistent with the injury rates that are discussed in a later section.

SAFETY IS THE LACK OF INJURY RISK

Webster's Dictionary defines "safety" as "the condition of freedom from harm, loss, or injury." There is no absolute safety in aviation. If you minimize the risk to the occupants, you have improved their safety. Safety is the management of risk. The key is to remember that safety is primarily an outcome related to the occupant, whereas an accident is an event primarily related to reporting aircraft damage.

Some people incorrectly use fatal accident rates as a measure of safety. A fatal accident in any accident in which at least one person receives a fatal injury. The fatal accident rate then is the number of fatal accidents divided by the hours of exposure. As an example, consider a Model A aircraft had an accident in which one of the two occupants received a fatal injury and that fleet had flown 100,000 hours. The Model A fatal accident rate is 1/100,000 hr. Model B also flew 100,000 hours, and one aircraft crashed and 235 occupants of the 300 occupants onboard received fatal injuries. The Model B fatal accident rate was 1/100,000 hr, which was the same fatal accident rate of Model A. Therefore Model A and B have the same safety? No, there is a vastly different societal loss. Fatal accident rates are misleading and should not be used.

RISK OF FATAL INJURY

Safety is measured by an individual's risk of being seriously injured. Risk of fatal injury (RFI) is the method to calculate that individual's risk as the likelihood of an accident

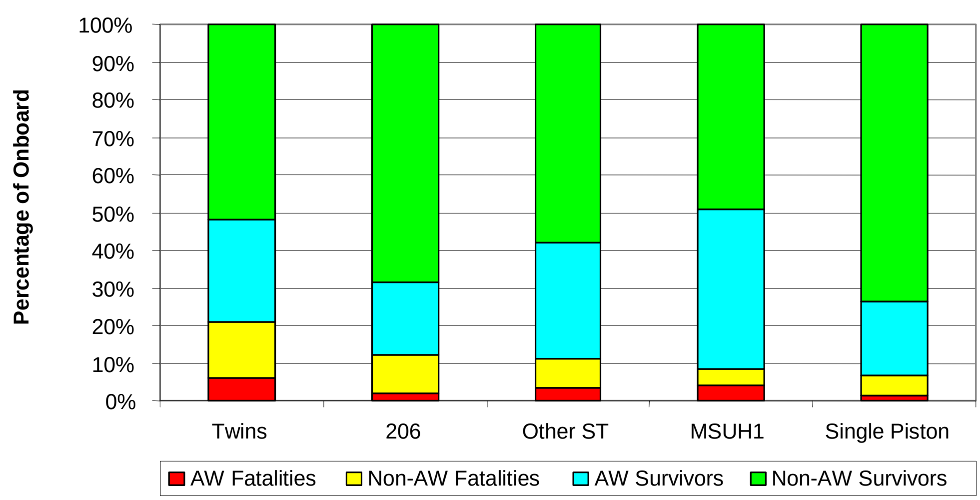


Fig. 10. Survival percentage in helicopter accidents.

occurring, times the likelihood of receiving a fatal injury. Thus RFI can be expressed as follows:

$$\text{RFI} = \frac{\text{Number of accidents}}{\text{Flight hours flown}} \times \frac{\begin{array}{c}\text{Number of people}\\ \text{with fatal injuries}\end{array}}{\begin{array}{c}\text{Total number of people}\\ \text{on board in accidents}\end{array}}$$

RFI is your individual risk of receiving a fatal injury per 100,000 occupant hours to which you are personally exposed (flying) in that aircraft. The RFI for the five groups was determined for all accidents (all causes) and for just those caused by airworthiness failures (Fig. 11).

First, consider what your individual risk is, due to the aircraft itself. The lowest individual's RFI was 0.09/100,000 occupant hours for all airworthiness-caused accidents (including suspected airworthiness causes) was the single engine 206. This occupant risk in a 206 was a 43.8% lower risk than for an occupant in the Twin Turbine group. This indicates that the number of engines on a helicopter is certainly not the predictor of an individual's risk of a fatal injury—and more myths are dispelled. Likewise, the 206 occupant RFI for airworthiness-caused accidents was 59.1%, 65.4%, and 80.9% lower than the Other Single Turbine group, Single Piston group, and Military Surplus UH–1 group, respectively. This points out that the individual aircraft design and how the aircraft is used, and the type of operation being conducted, are extremely important. The detrimental effect of the Military Surplus UH–1 being used in operations for which it was not designed is quite evident. The laws of physics always apply, regardless of civil aviation regulations and aviation myths.

The reality is that you will not die from just airworthiness failures. Your true risk in flying must include accidents due to all causes. The lowest individual's RFI for all causes was 0.43/100,000 occupant hours in the single-engine 206; that was a 17.3 % lower risk than for an occupant in the Twin Turbine group. Again, this points out that the number of engines installed is not the determinator of your safety. The 206 occupant RFI for all causes was 35.8%, 54.7% and 64.2% lower than the Other Single Turbine group, the Military Surplus UH–1 group, and the Single Piston group, respectively. Again, there are many facets of safety that affect your likelihood of a fatal injury to include the design of the aircraft, its design simplicity and forgiveness in an emergency, crash survival features such as the use of a shoulder harness, the type of operation being conducted, abusive use, maintenance, and pilot skills and judgment. Once again, the actual facts regarding occupant risk prove that the "twins are always safer" beliefs are all myths.

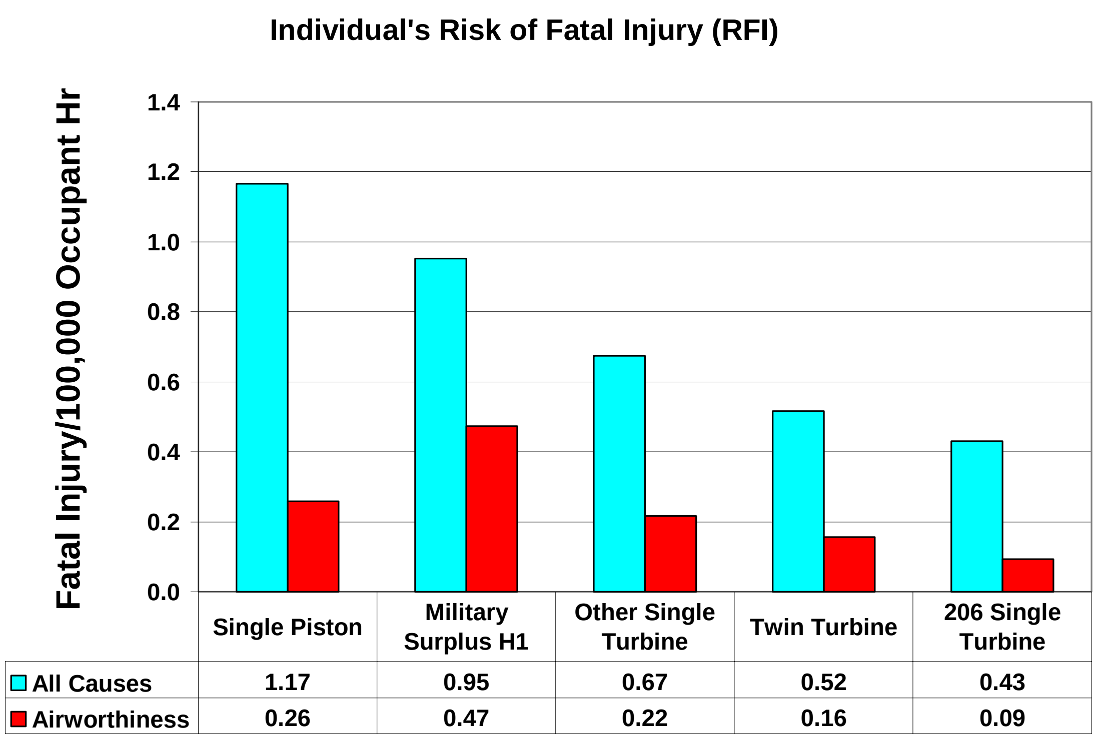


Fig. 11. Individual's risk of fatal injury.

LIFE SPAN IN FLIGHT

An individual RFI is an extremely small number and comparisons of such small numbers are difficult for the flying public to comprehend. A more understandable interpretation of the RFI would be the answer to "On the average, how many hours can I fly before I would die in a helicopter accident?" The Flight Life Span is the inverse of RFI or 1/RFI, which answers that question. Another way to express this is, using the average hours of occupant flight exposure that are expected to occur between fatal injuries. Since each of us is only allocated one fatal injury, it becomes our life span average in the flight environment. Your Flight Life Span when flying in the five study groups for accidents due to Airworthiness and All Causes is Fig. 12.

If one could only die from just an Airworthiness failure, the individual's Flight Life Spans would range from 384,475 to 1,071,300 occupant hours. The Flight Life Spans for All Causes (what each of us are truly concerned about) ranges from 85,684 to 232, 265 occupant hours. That is a long, long time.

As a general comparison, how does your Flight Life Span compare to when you are flying in the highly standardized and consistent environment of the Part 121 Air Carriers (Scheduled and Unscheduled) and the Commuter Air Carriers (Part 135)? That comparison, plus the inclusion of Unscheduled Air Taxi (consisting of mostly airplanes) under Part 135, is shown in Fig. 13. This shows that your individual risk in turbine-powered helicopters falls between the typical Unscheduled Air Taxi operation under Part 135 and the Air Carriers. The excellent history of the Large Transport Airplanes operating under Part 121 gives us, the helicopter industry, a safety direction for the future. Unfortunately, that airline safety level is an unrealistic and non-achievable goal, even as a safety target, for helicopters due to unique missions that are the only reasons that helicopters even exist. Regulators should not expect helicopters to match airline safety. The helicopter can do unique tasks that no airplane can. These helicopter tasks are always riskier that the highly structured (and expensive) tasks of going from Airport A to Airport B in controlled airspace and returning. We in the helicopter industry must use a multi-faceted and continuing approach to reduce risk of an accident occurring as well as to reduce the risk of an injury when the accident does occur. There is no single solution. Safety is the continuous process of improvement by the management of risks.

Since no one individual flies 24 hours a day, every day of the year, a conservative estimate of your flight career longevity in helicopters can be made. Assume you fly 8 hours a day on each day of the year. The number of years of your Flight Life Span is shown in Fig. 14.

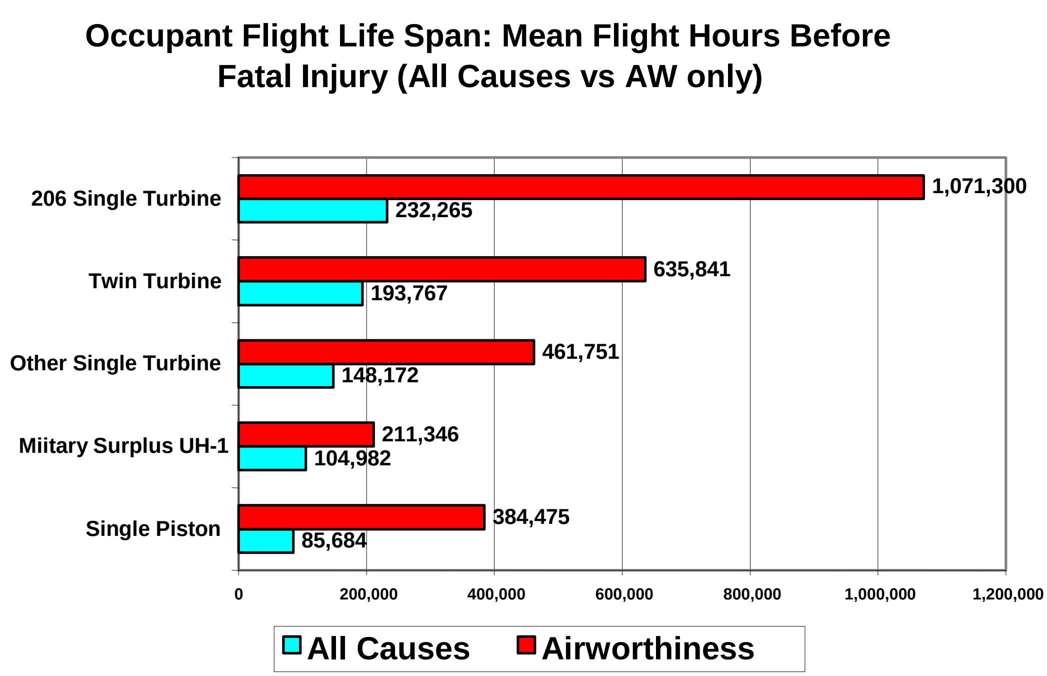


Fig. 12. Occupant flight life span.

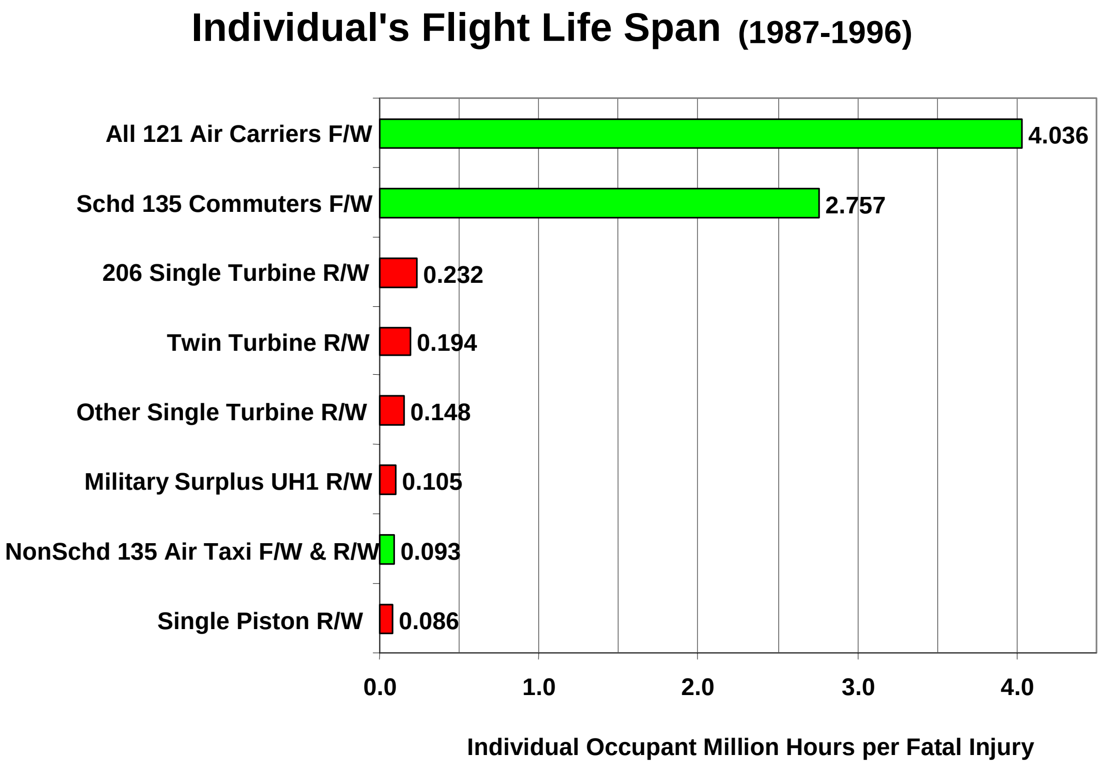


Fig. 13. Individual flight life span in helicopters and airplanes.

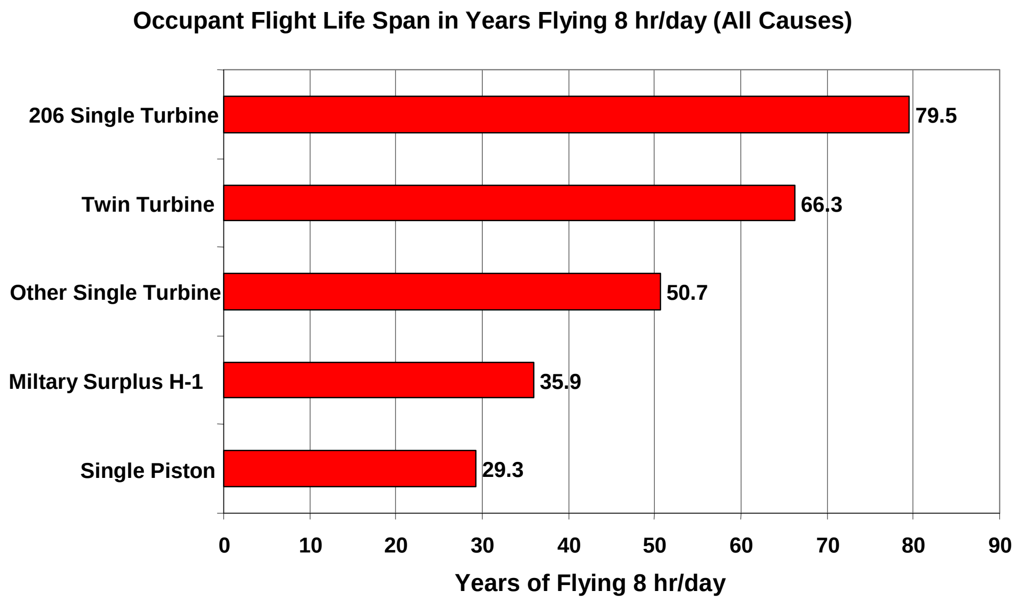


Fig. 14. Occupant flight life span in years.

Thus a helicopter occupant could expect a Flight Life Span period of 29.3 to 79.5 years of flying 8 hours/day (e.g. 2,292 hours/year). In reality, there are very few people who are in the air 2,292 hours each year, so this is quite conservative. This does show that an individual is safe when flying in all helicopters.

SUMMARY

A study of 1,534 U.S. registered helicopters in five groups for the last 10-year period of 1987 through 1996 found that

- For all helicopter accident causes, your individual Risk of Fatal Injury ranged from once in 85,684 to 232,265 occupant hours of exposure, based on today's fleets and different types of operations.
- For only airworthiness causes, your individual Risk of Fatal Injury ranged from once in 384,485 to 1,071,300 hours of occupant exposure.
- Accident rates are more related to airframe damage, and are poor indicators of occupant safety. Individual Risk of Fatal Injury is a better indicator of occupant safety.

Further, the myths related to "twin-engines are always safer than one engine" was dispelled by actual helicopter safety history. An occupant in the single-engine 206 has a risk of a fatal injury due to all airworthiness failures (engine and the rest of the aircraft) that was 43.8% lower than an occupant in a Twin Turbine helicopter. Likewise, an occupant in the single-engine 206 has a risk of a fatal injury due to all causes that was 17.3% lower than an occupant in a Twin Turbine helicopter. Overall, it was shown that there are many more factors to be considered rather than the counting of engines. In some cases, a single turbine helicopter is safer; in some cases, a twin turbine helicopter is safer. However, in the majority of cases, the number of engines does not make any difference, and other issues such as payload, type operation, pilot issues, and economic factors should determine what type of helicopter should be used.

All helicopters are safe with some more than others, but we must improve much further for wider public acceptance. The key to moving to a new safety plateau level will require recording devices to document what is actually occurring in the cockpit during the accident sequence. Only then with understanding those actions and sequences, can we correct those elusive human errors.