Discussion Topics

- Background of Accidents
- Challenges
  - Not high risk missions
  - Personal, instruction, aerial application
    - (fuel exhaustion, wirestrikes, general pilot error)
    - (Note: EMS accidents occur after patient is delivered)
  - Need to instill safety culture in new pilots
- NASA's current projects
  - COATT, autorotation trainer, safety website
- Still needed - training modules

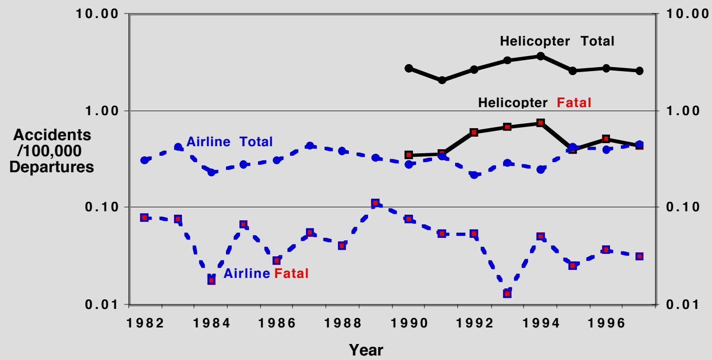
So many of you have told me that you're looking forward to my talk. I suspect that what I have to say may surprise you and disappoint you.

- Surprise you because you seem to think that accidents are a result of the complex nature of helicopters and their high risk missions. And while that is a perfectly reasonable assumption, it is completely false.

- Disappoint you because the problems are not exciting and quite frankly somewhat embarrassing to the industry.

What I will show you is a brief look at what does cause helicopter accidents, not in any great detail. I will propose to you what I believe the challenges are, and tell you a bit about what NASA is doing in the area of training and what we hope to do.

How do helicopters compare to airliners?



- Helicopters are 10 times more likely to have an accident
- Chances of survival given an accident are the same

To start the accident analysis, we looked at the safety records of other aircraft.

It's generally acknowledged that airliners are the safest form of air travel. So , though it seems an unfair comparison, how do helicopters stack up against airliners when it comes to accidents?

This graph compares helicopters to airliners. This semi-log graph shows that helicopters have about 10 times as many accidents per 100,000 departures as airliners.

Well, we expected that… after all, helicopters are much more complicated machines and fly much more hazardous missions, right?

Why are helicopters more likely than airliners to have an accident?

Four areas of difference

	Helicopters	*Airliners*	General Aviation
Pilot	student, private, professional	professional highly trained	range - student to professional
Equipment	mostly piston engine, VFR-only certified	high -end	mostly piston engine, VFR-only certified
ATC	mostly uncontrolled	controlled	mostly uncontrolled
Mission	hover, external load, near obstacles,	point to point @ altitude	point to point

So this raises the question - Why are helicopters more likely than airliners to have an accident? There are 4 general areas of difference: pilot, equipment, environment and mission.

Airline pilots are highly trained and generally highly experienced. Helicopter pilots run the full gamut from students to weekend pilots to highly trained professionals.

Similarly airline equipment is high-end, typically state of the art. While some of the most expensive helicopters have turbine engines and sophisticated avionics, most are piston powered VFR only certified aircraft.

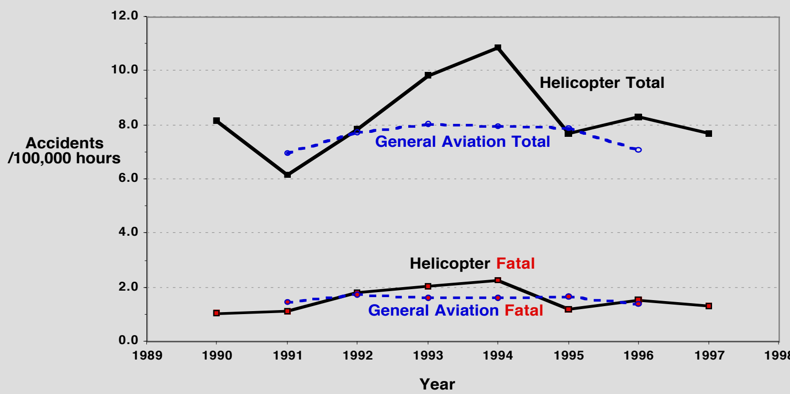
Operating environment differs as well. Airliners are controlled by Air Traffic Control from push back to shut down. Helicopters operate mostly in uncontrolled airspace unless they are operating out of a controlled airport.

And finally, the mission differs also. Airliners fly point to point at altitude. Helicopters rarely do that. They typically do much more maneuvering into and out of unprepared areas, encountering all sorts of hazards.

Now let’s consider general aviation. Helicopters have a lot more in common with GA than with airliners. Both are flown by a wide range of pilots from students to professionals, and with a wide range of equipment. The bulk of both fly in uncontrolled airspace. (or at least cover the range) The major difference between Helicopter and GA is the missions they fly -- hovering and maneuvering around obstacles, taking off and landing from just about anywhere. When you think helicopter, you think high risk mission, whereas when you think fixed wing, you think airport to airport…

Army/NASA Rotorcraft Division

How do helicopters compare to general aviation?



➢ Mission risk factors are not driving the accident rate

So it's easy to assume that helicopters would have more accidents than fixed wing general aviation as well. I mean helicopters fly such dangerous high risk missions….

This graph compares the accident rates of helicopters and general aviation. Both the total accident rate and the fatal rate per 100,000 hours are shown. Here we see that helicopters and general aviation have very similar safety records.

This suggests that factors common to both are driving the accident rate. So the one thing that differs between them, mission risk factors - are NOT causing helicopter pilots to have more accidents. This comes as a bit of a shock. People usually think that a higher accident rate would naturally go hand in hand with the high risk factors inherent in helicopter's specialized missions.

What is driving the helicopter accident rate?

Three possibilities remain…

	Helicopters	Airliners	General Aviation
Pilot	student, private, professional	professional highly trained	range - student to professional
Equipment	mostly piston engine, VFR-only certified	high -end	mostly piston engine, VFR-only certified
ATC	mostly uncontrolled	controlled	mostly uncontrolled
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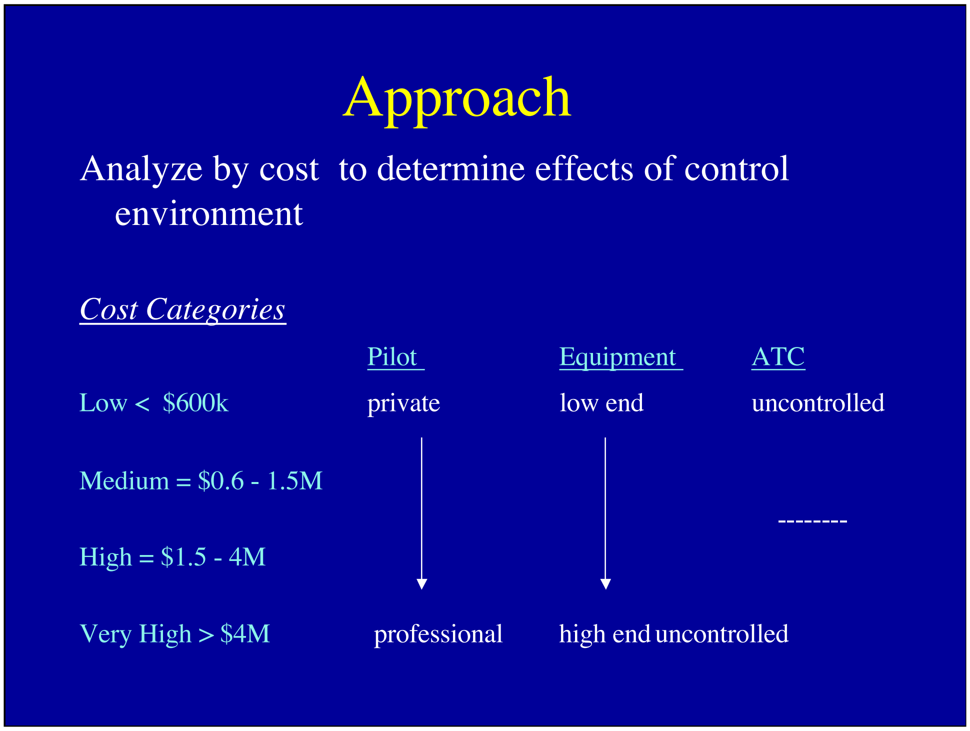
So we're down to 3 possible factors…

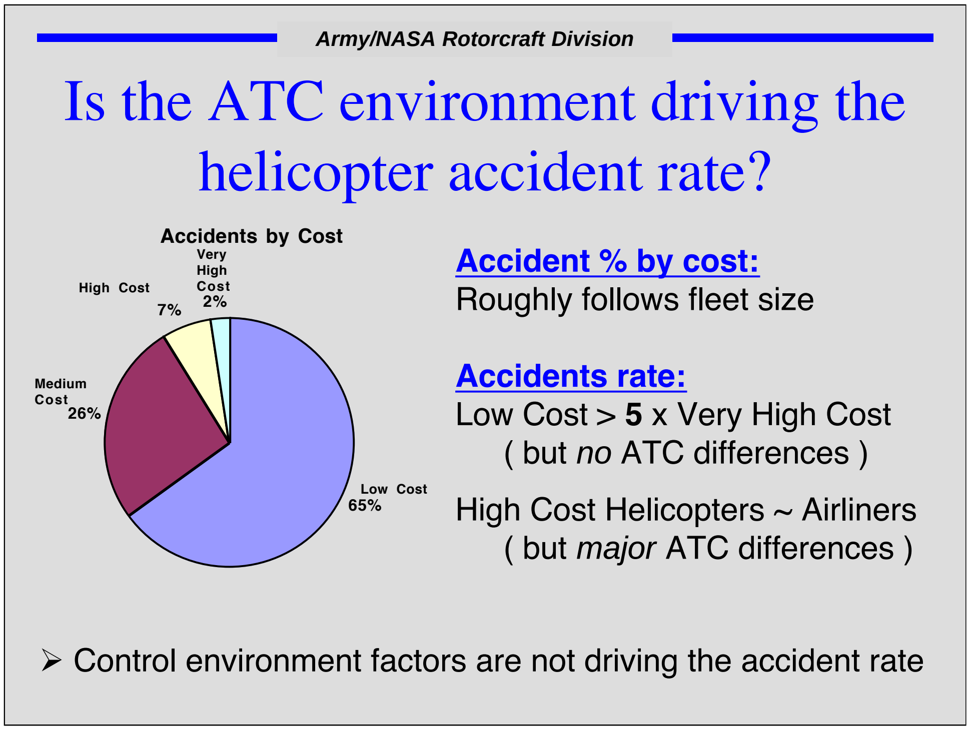


Our options now are pilot, equipment and control environment. To break these out, different categories of helicopters were examined.

Helicopters were grouped into 4 broad cost categories, based on 1994 prices of newly equipped aircraft.

Going from lower to higher cost helicopters, the pilots become more highly trained and experienced and the equipment becomes more sophisticated. Control environment, on the other hand, stays relatively the same.

To determine the major differences across the fleet, the accident rates of the very high cost and low cost groups were compared.



This is the breakdown by cost for helicopter accidents.

This division roughly parallels the fleet size. This would seem to indicate that everybody has the same rate of accidents, but it's a deceptive statistic.

When a calculation was done of flight hours for low cost and very high cost, something interesting turned up. The low cost accident rate per 100,000 flight hours was more than 5 times as high as the very high cost accident rate!

Looking back to the first graph comparing helicopters to airliners, we see that the adjusted rate for the very high cost helicopters now approximates the airliner accident rate!

These findings - the difference between cost groups and the similarity of high cost helicopters and airliners cannot be attributed to control environment, since the level of air traffic control is roughly the same where the accident rates differ and different where the accident rates are the same.

This leaves two potential drivers of the helicopter accident rate: pilots and equipment.

What is driving the helicopter accident rate?

Two possibilities remain…

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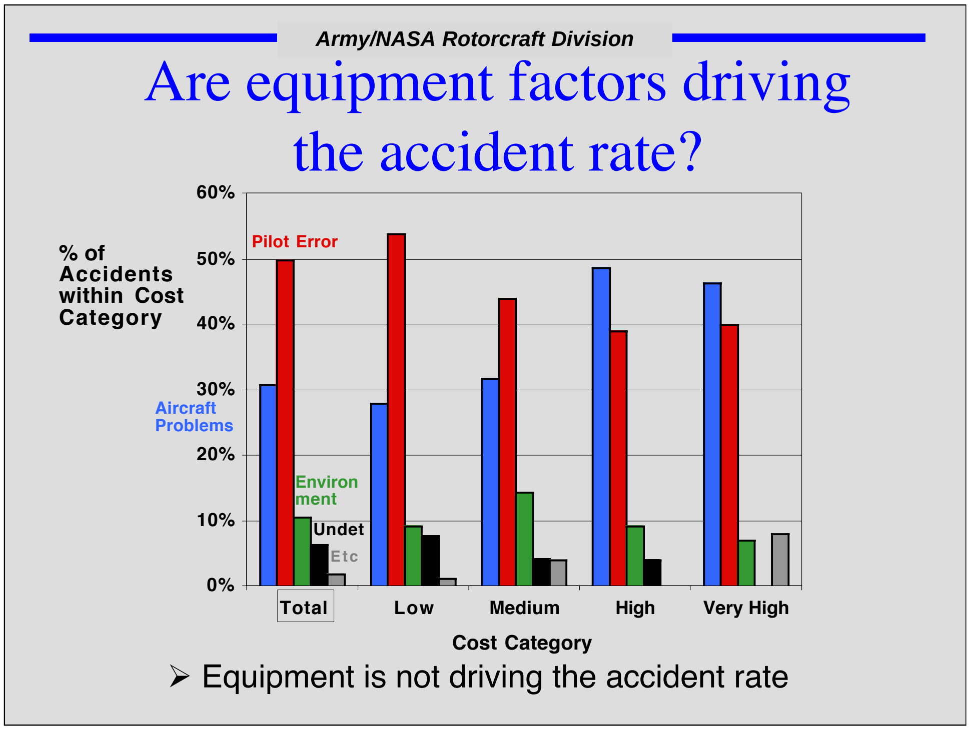
So we're down to 2 possible factors…



The NTSB reports contained detailed cause information which were consolidated in fewer manageable categories which are listed at the side here. Of these categories, aircraft problems, is the most prevalent across the board.

Since pilot error far outweighs aircraft equipment as a cause of the low end accidents and since low end accidents dominate the accident data, we can surmise that pilot skill level is driving the accident rate.

Private pilots dominate the low cost category while professional pilots dominate the high end.

What is driving the helicopter accident rate?

Whatever remains, however improbable,…

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So it must be pilot factors driving the accident rate…

As Sherlock Holmes "When you have eliminated the impossible, whatever remains, however improbable, must be the truth."

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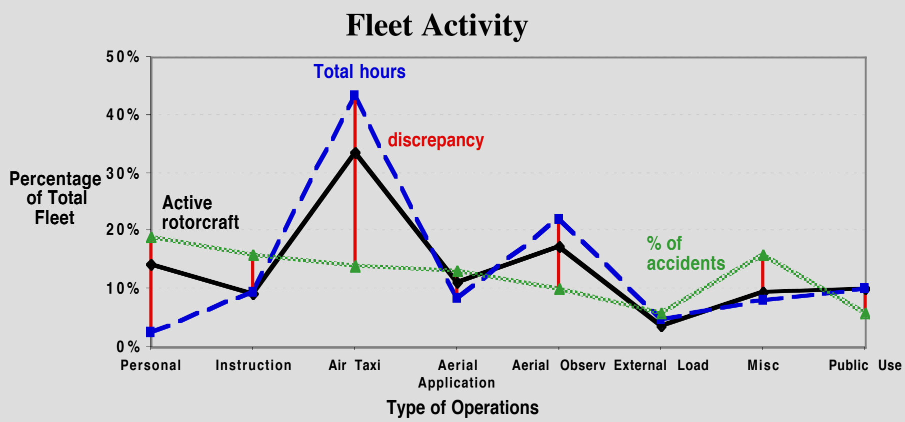
Intra-mission Effects



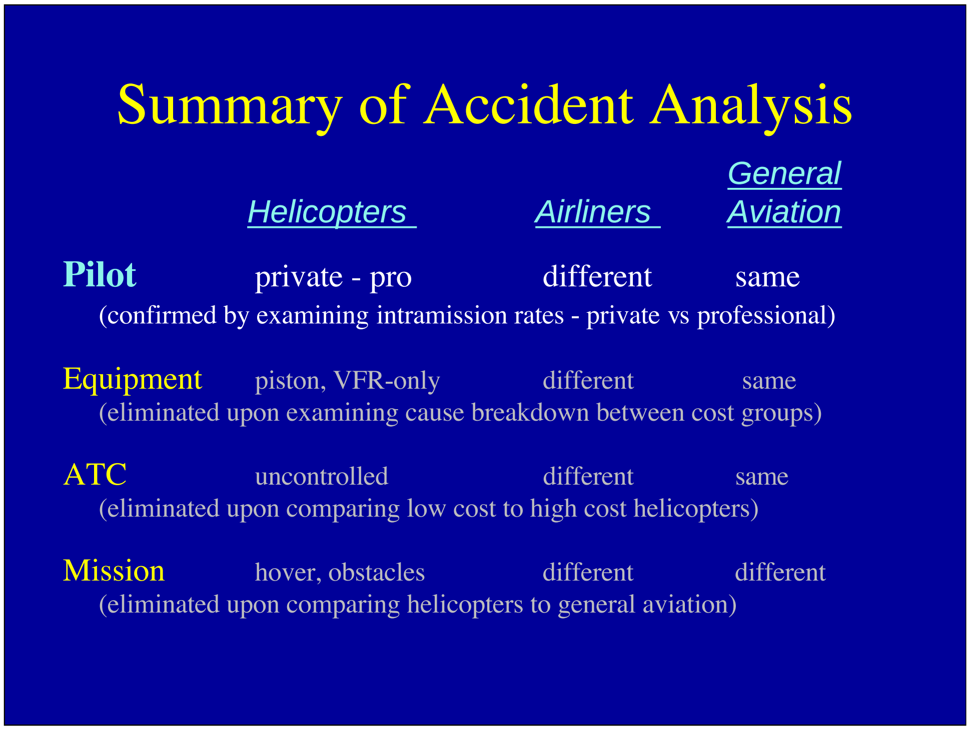
Accident Rates: High - Personal 44.9
Low - Air Taxi 2.5
Observation 2.4

Now you might wonder why I'm talking about missions, when I already discounted the mission risk factors from the accident drivers. Although mission factors do not drive the overall rate to be higher than other segments of aviation, they do affect the rates within the helicopter industry and confirm the role the pilot plays.

Shown here is a graph of fleet activity by mission. The black diamonds indicate fleet size, and the blue squares indicate flight hours. Flight hours for personal use helicopters comprised only 2% of the total fleet's flight hours (despite being about 15% of the fleet size), while flight hours for air taxi comprise over 40% of the fleet hours.

The green line shows the percentage of total accidents for each mission and the red vertical lines indicate the discrepancy between the percentage of flight hours and the percentage of accidents. (That is, their safety record relative to an average rate.) Red lines going up from the green indicate operations safer than the norm, and red lines below the green indicate less safe.

This being said, most low cost helicopter accidents occur during personal and instructional missions. The accident RATE for personal flight is 45 accidents per 100,000 flight hours whereas air taxi and aerial observation have a rate of only 2.5. This highlights again the difference in private versus professional pilots. Private pilots are having the bulk of the accidents in large part due to their own mistakes.



To recap, we started with 4 potential factors to account for the differences in the safety records between airliners and helicopters: pilot, equipment, air traffic control and missions. We ruled out missions when we compared helicopters to GA. Their safety records were similar despite their very different missions. We ruled out ATC upon comparing low cost to high cost helicopters - their safety records are quite different despite their similar ATC environments. We eliminated equipment when we looked at the breakdown of causes between cost groups. This left the type of pilot as the determining factor in the helicopter accident rate. This was confirmed when we looked at the intra-mission rates. Professional pilots have a relatively low accident rate while the private pilot’s accident rate is extremely high.

In light of this - I must commend you all for the great job that you’re doing in mission training because those complicated missions are not what is causing accidents. I would like to steer you in a slightly different direction if I may from what you have been discussing. Unfortunately, I’m afraid your real challenge is more difficult. In the course of training pilots, you have to affect their attitude towards safety.

First Events of Accidents

First Event	Specific Problem	Training Solution
Loss of Power	Fuel exhaustion	Safety culture Autorotation trainer
Loss of Control	Loss of rpm, altitude, Lack of S.A. Student in training	Situation Awareness Instructor training
Collisions with Object or Terrain	Lack of S.A.	Situation Awareness
Malfunctions	Preflight Maintenance	Safety culture Maintainer training

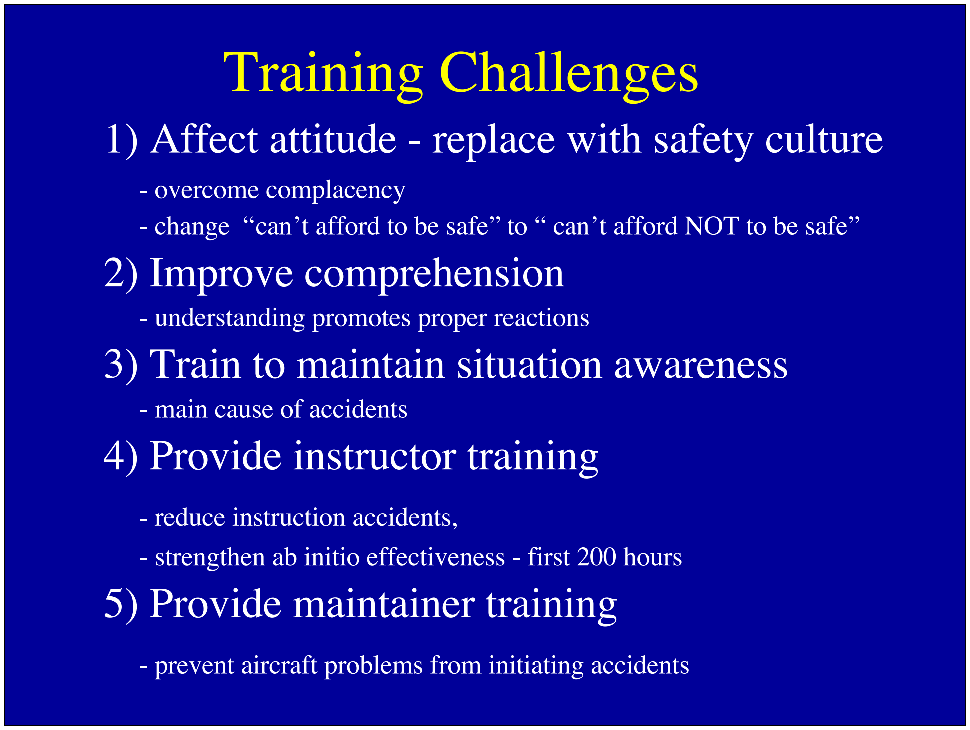
Let me first take a quick look at the most prevalent first events of accidents

In Loss of power accidents, running out of gas is the primary problem. Training solutions with the most potential involve instilling safety attitude or culture and recovery training in the form of an autorotation trainer.

Loss of control accidents have specific causes of loss of rpm, loss of altitude, and general lack of situation awareness. Many of these accidents occur during training, so improved instructor training is a potential solution, in additional to training addressing situation awareness.

Collisions with object or the ground accidents are also due primarily to lack of situation awareness and could benefit from SA training.

And finally a large number of the malfunctions accidents could be prevented by proper maintenance, and proper preflight which boils down to instilling a safety culture, and providing maintainer training.



As I see it, the challenges to the training industry are 5 fold:

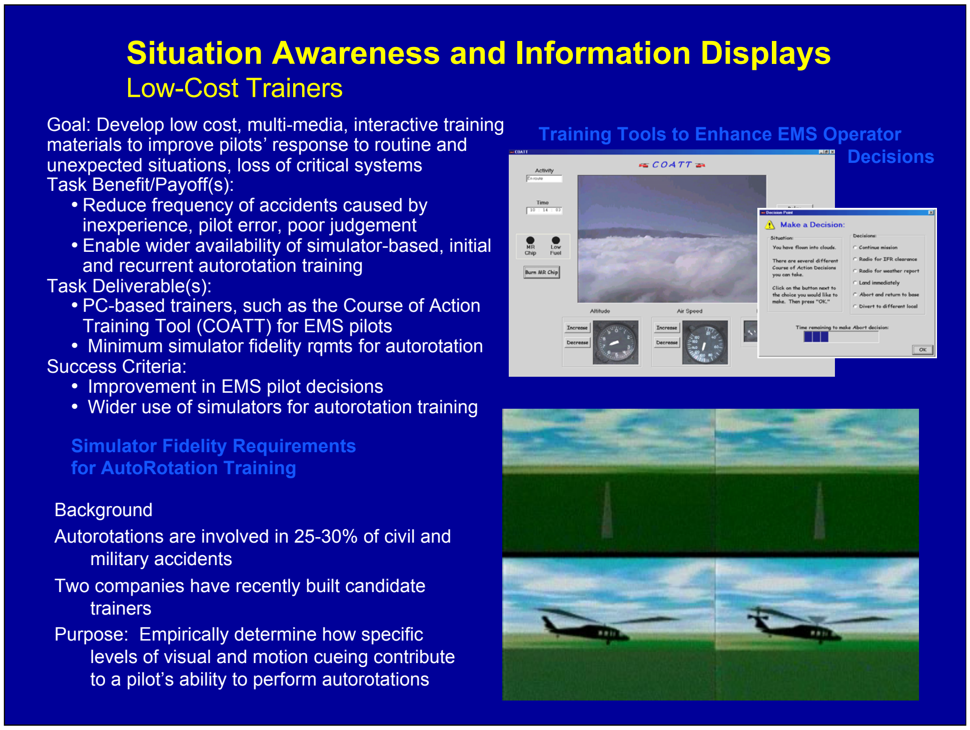
The first is to affect the pilot's attitude. This includes two distinct pieces. One is to overcome complacency and urge pilots to be vigilant. As Patrick Corr mentioned, the first 200 hours of flight time mold the pilot. It is important to make a good safety attitude an integral part of the experience. In addition to fighting complacency, we need to replace the attitude that pilots and operators have that they "can't afford to fly safe" to they " can't afford NOT to fly safe",

The second challenge is to improve comprehension. The theory behind this is that if you understand how something works, you are more likely to respond properly than if you had simply memorized a procedure. This would beg for improved basic level training but for comprehension rather than proficiency.

The third challenge is to train to maintain situation awareness. By situation awareness, I mean awareness of aircraft states (including fuel), environment and pilot state. This is a tough one - how do you teach someone to observe and evaluate everything around them despite distractions and deterrents?

The fourth challenge is instructor training. A large number of accidents occur during training, and despite the benign nature and lack of injuries, they do result in damage, and affect our safety record, reputation and insurance rates. Instructors need training to know when to intervene for safety but without interrupting the training.

The fifth challenge is maintainer training. For the professional side of the industry, aircraft problems pose a larger problem. Improved maintenance could potentially prevent a portion of these accidents.



NASA has a couple training projects underway. The first is a Course of action training tool known as COATT. It was originally developed for the EMS community to address decision making skills, but can be broadened to address other missions as well.

The other project is developing requirements for an autorotation trainer. Over a quarter of helicopter accidents involve either emergency or practice autorotations. Obviously, there is room for improvement in the outcome of these autorotations since the definition of an accident includes substantial damage or serious injuries. NASA is conducting simulations to determine just how much visual and motion fidelity is required for a useful autorotation trainer.

Interactive Simulator for Pilot Decision Training

Goal: Assist in reducing the aircraft accident rate by a factor of 5 in 10 years and 10 in 25 years

Task Benefit/Payoff(s):

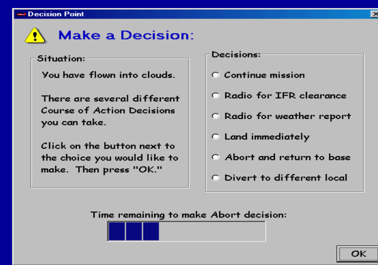
- Reduce frequency and severity of accidents caused by pilot error, poor judgment and inadequate preparation

Task Deliverable(s):

- Course of Action Training Tool (COATT) simulation

Approach:

- A prototype, low-cost decision trainer was developed and is ready for field evaluation.



Pilot decision window

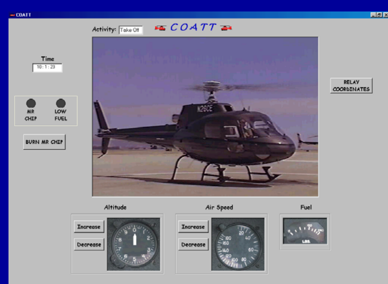


Figure 2. GUI with video clip

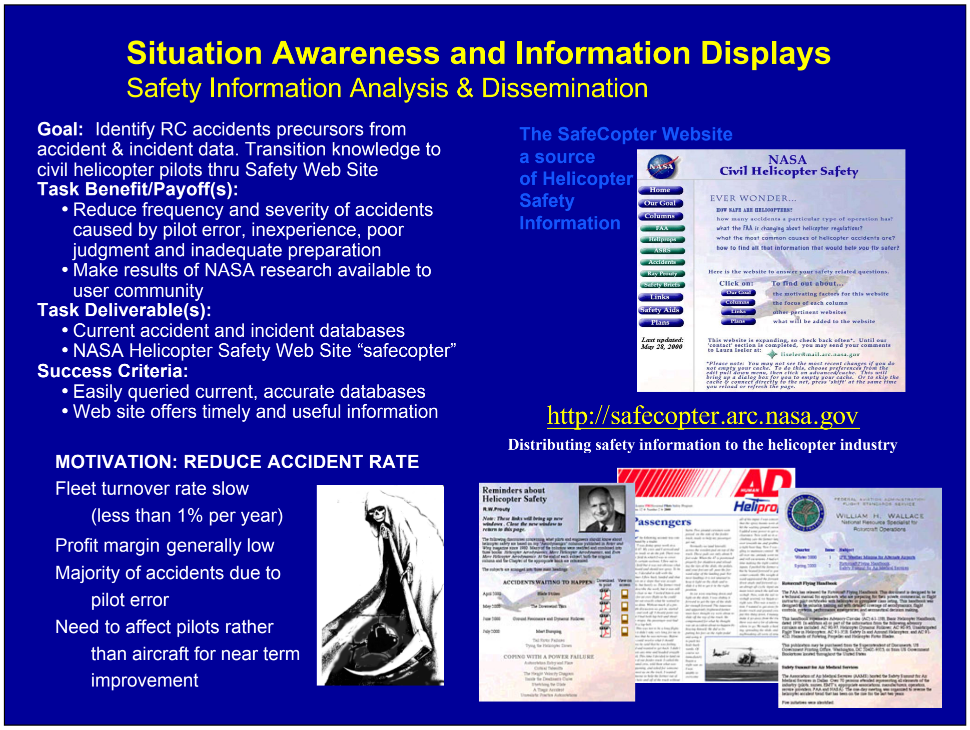
Approach (cont'd):

- Emergency medical transport (EMT) missions were defined as a network of nodes representing the environment, discrete events, and pilot decisions. The simulation integrates computer simulation, full motion video, still photographs, and audio.
- The realistic scenarios in this low-cost simulation include events that require pilot trainees to make critical decisions. The subsequent course of the mission changes to reflect trainees' decisions, allowing them to experience the consequences of different courses of action.

Partner(s): EMS RWO

Customer(s): EMS programs/RWO

This shows a bit more on the Course of Action training tool. The pilot is given a particular flight scenario with degraded conditions and has to make decisions throughout the flight. Included are video clips, selected instruments, audio clips and various other bits of information. The pilot has a limited amount of time to make each decision. The pilot then gets to see what the consequences of his or her actions would have been.



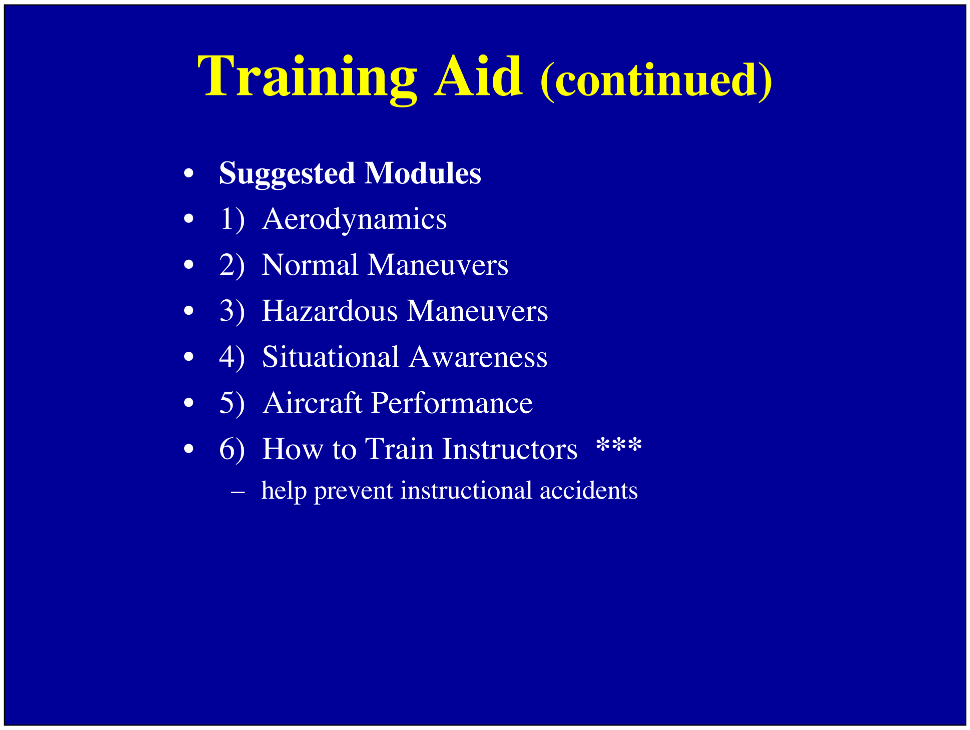
The safety website was developed to raise awareness and to foster a safety culture. It provides a one-stop shop for helicopter safety information. NASA has typically been very focused on high tech research, however, with the goal of improving safety, they have had to change their approach. With a fleet turnover rate of less than 1% per year, and a profit margin too low to expect operators to be buying upgrades, the website seemed the best way to reach the pilot and reduce pilot error which is part of so many accidents.

Training Aid

- Ground School integrated with Pre-flight briefings
- **Format**: Computer program
  - Animated model for tutorial & interactive lesson
  - Some out the window scenery - limited
  - Videos (Helicopter Adventures or military) with voice-overs and/or arrows
  - Incorporate clips of classroom instruction
  - Videos (recreations) or still shots of accidents with voice-overs and/or arrows
  - Quizzes – hazardous operations - require a pilot action to prevent or handle

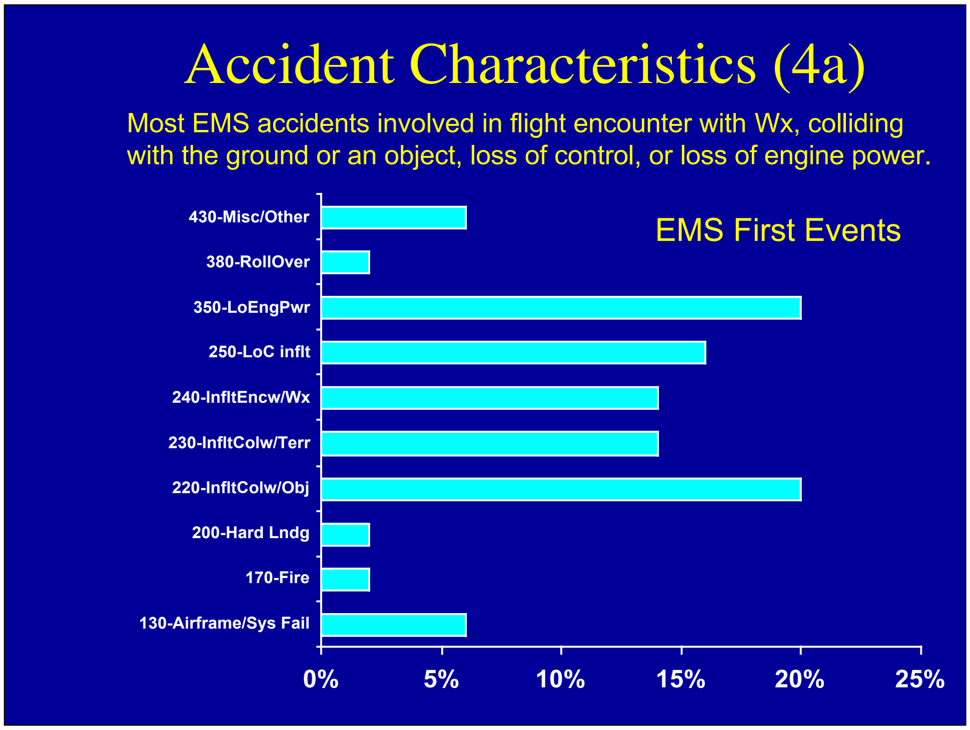
I'm not telling you that we don't need all the trainers - we do. What I am telling you is that we need basic training aids which improve comprehension and show pilots how to maintain situational awareness. You saw the forgetting curve yesterday which shows how quickly learned material can be forgotten. If a student understands the material (rather than just memorizes it) and relearns it on a continuing basis, they will be more likely to react appropriately in a emergency situation. NASA originally planned to fund development of these modules. However, with not only the zeroing of our budget for next year, but also recent cuts to this year's money, we no longer have money available. So it would be ideal if we could convince the FAA (as Patrick suggests) or other parties to fund such modules. NASA would be happy to support such development with what resources we have available to us.

Everybody learns in different ways and the more methods we have available to students, the more complete the learning will be. These modules are focused on comprehension rather than proficiency.



In talking to flight schools, we came up with the following list of desired modules. Each module would be designed to coordinate with in-flight lessons. A student would review an element prior to experiencing it in flight. Some elements would not have an in-flight portion per se - the hazardous maneuvers, but the instructor could discuss what types of things to watch out for to avoid doing those maneuvers by accident.

Instructors would also have a module on tips for helping students learn without letting them go too far and have an accident. After personal flights, instructional flight result in more accidents per flight hour than any other mission. This is understandable given the nature of the flight. And though fairly benign, these accidents are a good starting point for improving safety.



As a final note, since there has been so much talk of EMS accidents, I wanted to give you a little more EMS information. People seem to think that poor weather and night flying contribute to most of the EMS accidents.

These particular elements contribute to the EMS mission accidents more so than any other mission, however they still cause a very small number of the accidents. Loss of engine power, loss of control, and collision with object or terrain are the most frequent first events. The causes of these accidents fall primarily under pilot error.

And interestingly enough, over two thirds of EMS accidents occur after the patient has been delivered. The difficult part of EMS operations - going to an unknown, perhaps unprepared site in potentially poor conditions, is not the part that gets these pilots into trouble -- it's going from the hospital to home base. Let me suggest that once the patient has been delivered, the pilot considers his or her job done and the pressure is off. That pilot is more likely to be less stringent in the decision making process, in part because everybody is anxious to get home. This is the EMSaccident factor that we need to fight. It falls right into what we've already talked about - safety culture and attitude.