OPERATIONS

CRASH AND ESCAPE

Most fast, man-carrying vehicles are high-energy devices. The helicopter fits this description better than most. When flying, it has potential energy associated with its height above the ground. It also has kinetic energy--that of forward speed and that stored as rotational energy in its rotor.

Almost always, the pilot has good control of these various energy types, but on those rare occasions when he loses control the result may well be a crash.

Even though a crash is a rare occurrence, the designer--being a realist--must take it into consideration and try to make certain that its detrimental effects are as minimal as possible. That is, he must make an effort to make his helicopter "crashworthy," while at the same time being careful to do it within a reasonable budget of weight and cost.

The use of "crashworthy" is perhaps an unfortunate choice of words. It seems to promise more than it can deliver. A recent attempt to change the semantics has been prompted by the Legal departments of aircraft manufacturers who suggest replacing "crashworthy" with "crash resistant."

Design considerations

There are, of course, many possible impact conditions for a crashing helicopter. One of the most stringent, used as a recent design requirement by the U.S. military, is an injury-free crash with a vertical touchdown at 42 feet per second (fps)--the equivalent of a free fall from 28 feet. This is much more severe than most civil requirements of only 10 fps.

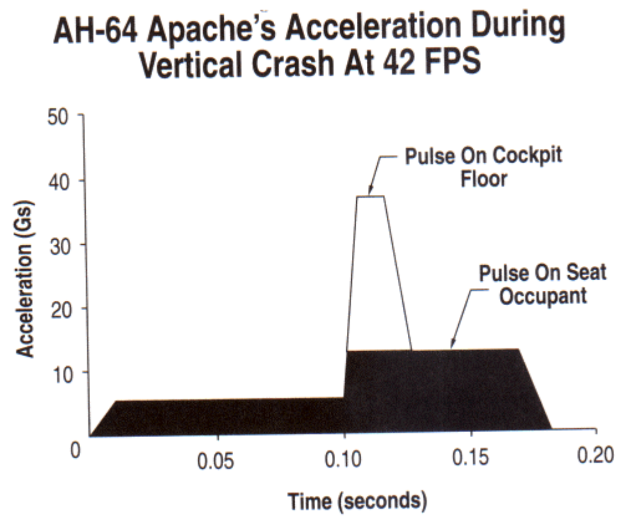
The design problem is to somehow absorb the energy before it is applied to the crew and passengers while at the same time making sure that the structure around them does not collapse and that they are protected from flying objects or from striking anything that might cause injury.

Apache solutions

On the Apache, the energy absorption is first done as the "trailing arm" landing gear is forced up. Special diaphragms in the oleo shock strut are punctured and fluid is squirted through the resulting orifices to provide a damping action. If this is not enough, the bottom of the fuselage collapses, absorbing more energy. Finally, the seats "stroke" as the occupants are lowered to their final position.

McDonnell Douglas AH-64 Apache

The figure on the next page shows the chain of crash-energy attenuation provided by the landing gear, the fuselage crushing and the seat stroking during a crash with the specified 42-fps vertical touchdown velocity. The landing gear and fuselage crushing result in a 37-G acceleration at the cockpit floor and the crew seats reduce this to a livable 13 Gs for the occupants.



The Apache's forward fuselage is built with two keel-like structural members serving as skids in case of a crash with forward speed. This prevents the nose from "plowing in" and also provides space for the turreted gun to be forced up into the lower fuselage without entering either cockpit.

For crashes in which the Apache might roll over, the designers have made use of the sturdy transparent blast shield between the two cockpits as a "roll bar" and a stationary rotor pylon securely fastened to basic structure.

As part of his concern about crashworthiness, the designer must guard against the possibility of the crew or passengers being trapped by doors or canopies that cannot be opened after being deformed. The usual solution is to provide explosive devices that can blow a door off or create a new exit where none existed before.

Ditching

Not all crash landings are on land. Helicopters intended for operation at sea must also be capable of being safely ditched. This means that not only must the structure be strong enough to withstand the impact loads on contact with the water, but the helicopter must float upright and remain water-tight in specified sea states long enough to ensure rescue.

For the unfortunate cases where the helicopter sinks, provisions must be made for quick emergency egress and for taking along all the equipment that is required for survival at sea.

Emergency exits should be clearly marked with lights and be big enough that they can be used by people wearing emersion suits and life preservers. One set of tests resulted in the interesting observation that if the exits appear too large, two people would try to go through at the same time with the result that both would become trapped.

Jump!

There may be situations in which the crewmembers wish that they did not have to depend on crashworthiness but could get out before impact. Since World War I, fliers have had the option of wearing parachutes to give them a chance of surviving if something goes wrong in the air.

Most helicopter pilots do not take advantage of that option. There are three reasons for this situation. The first is that the rotor's proximity makes it very difficult to find a safe escape route. The second is that the helicopter is often flying too low to give a parachute time to open. The third reason is that the helicopter carries its own "parachute" in the form of its rotor which in most cases of something going wrong can provide for a safe landing through autorotation.

Despite these reasons, helicopter test pilots that I have observed will usually take a chute along if the test plan calls for flying at altitudes of more than a couple of thousand feet--and several have actually been glad they did. John Wheatley, who was at NACA during the 1930s when it was evaluating the Pitcairn autogyro, says that he was the second person to ever bail out of a rotary-wing aircraft. He would have been the first, but the pilot beat him to it!

For many modern test programs, more exotic means than just jumping overboard are provided. NASA's Rotor System Research Aircraft (RSRA) was designed with upward ejection seats that would be used after the rotor blades were jettisoned by explosive charges cutting through each blade root. The Lockheed Cheyenne prototype was equipped with a downward ejection seat for flight-test conditions deemed to have an element of danger.

Upward ejection for the crew is a flight-test feature of the Bell-Boeing V-22 Osprey--a relatively easy choice since the rotors are never above the cockpit. Of course, when this aircraft is carrying passengers, it will have to abide by the rule that has always applied: "Either everybody has a parachute, or nobody does."

From *Rotor and Wing*, March 1989 and Chapter 23 of *Even More Helicopter Aerodynamics*