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The Philosophy and Realities of Autorotations

Like the power-off glide in a fixed-wing aircraft, the autorotation in a helicopter must be used properly if it is to be a successful safety maneuver.

by
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In all helicopter flying, there is no single event that has a greater impact on safety than the autorotation maneuver. The mere mention of the word "autorotation" at any gathering of helicopter pilots, especially flight instructors, will guarantee a long and lively discussion.

There are many misconceptions about autorotations and they contribute to the accident rate when an autorotation precedes a helicopter landing accident. One approach to a discussion of autorotations is to look at the subject from three views: first, the philosophy of the subject; second, the reality of the circumstances that require autorotations; and third, the execution of the maneuver.

An important step in understanding the philosophy of a subject is to know its history, because it is only by studying a long period of time that we can recognize a trend in events and acquire a better understanding of why we do some maneuvers in a certain manner. The airplane preceded the helicopter by about 40 years. If we consider today's public attitudes regarding helicopters, their regulation, training concepts and the evolution of their designs and uses, there is an amazing parallel between airplane history and helicopter history — offset by 40 years. We can use this parallel of history to predict some things about the helicopter.

In the early years of airplane flight, the fear of engine failure, or that the airplane might have structural problems during flight, was very strong. If either of these events took place, the pilot's ability to get the airplane safely on the ground quickly was important. The time it took to get the airplane on the ground was directly in proportion to the altitude at which the airplane was being flown. It is therefore logical that all early flights were flown at low altitudes, often at less than 500 feet above the ground (agl).

At these low altitudes, the pilot did not always have the time to turn the aircraft into the wind prior to making an emergency landing. Although landing into the wind was the best thing to do, very seldom were flights made on windy days, anyway. With stalling speeds of 20 to 30 miles per hour and low wind speeds, a downwind landing into trees or a rough field may have almost always resulted in a loss of the aircraft, but the pilot and any passengers were usually not severely injured.

The first airplane fatality occurred on September 17, 1908, almost five years after the first flights by the Wright brothers in 1903. U.S. Army Lt. Thomas Selfridge was killed while flying as a passenger on the "Wright Flyer" after a structural failure of the propeller. Selfridge had designed, built and flown his own airplane, the "Red Wing" in March of that same year.

As time went on, in response to public demand, laws were written that required airplanes to fly higher and to be built safer (according to the justification of the first U.S. aviation laws as stated in the preamble of the Civil Aeronautics Act of 1926). Airplanes and their engines became more reliable and were being designed to fly faster — which meant that the speeds at which these airplanes would stall were increasing. By then, always landing into the wind became more important. This meant that pilots could fly at altitudes that would allow them to turn into the wind in the event of an engine failure (structural failure of the aircraft was becoming less common). For this reason, airplane pilots changed their habits and increased their normal flying altitudes to 1,000 feet agl or higher. It was not until modern cross country flights began, that even higher cruising altitudes became the norm.

If the pilot doubled his altitude, he would increase his potential landing area by eight times.

The helicopter industry seems to be fascinated with 500-foot agl cruising altitudes. Looking back on history, possibly related to the rotorcraft's hovering capability, all flights were made close to the ground. The first recorded major helicopter mishap in the United States was December 9, 1939, some 90 days after Igor Sikorsky's first flights. This is when the Sikorsky RX-4 rolled over during a test flight. Since these flights were made under tethered conditions, the action of the restraining cable may have caused the accident. (Sikorsky's first untethered flights in a helicopter were not made until May 1940.)

Mirroring the initial years of airplanes, in the early years of helicopter experiments there were many material failures. Even Bell Aircraft Corp., which began serious helicopter flights almost 10 years after Sikorsky, suffered accidents due to material failures. The first major accident for Bell was in its Model 47. A main rotor hub broke on April 5, 1946, which resulted in serious injuries to the test pilot. Some engine failures did occur, usually because the helicopter ran out of fuel, as was the case in the world's first real autorotation during the Sikorsky flight test program. Most helicopter manufacturers were using modified airplane engines, so mechanical engine failures were reasonably rare.

One good thing about helicopter test flying is that much of it can be done in a hovering mode, or at least at a fairly low forward speed and at low altitudes. As helicopter structures became more reliable, the major fears during test flights were vibration and loss of aerodynamic control. More than once, a test pilot, accustomed to flying at 50 feet or lower, would perceive that it took an eternity to get back on the ground if trouble developed while flying at 500 feet agl and it took as much as 15 or 20 seconds before landing.

However, most pilots flying today's helicopters are not acting as test pilots, and should have little fear of material failures which would make flying close to the ground desirable in the event there is a need for a rapid descent and landing. Helicopters can be autorotated to a safe landing in the case of an engine failure, much as the fixed-wing, single-engine aircraft can be glided to safety if the sole power plant fails. There is a concern, however, that in preparing for such emergencies by practicing their procedures too much, the risk of actual emergencies could be induced. An analysis published by *Flight* magazine in 1975 pointed to the risk-reward ratios of excessive autorotation training. Data from all branches of the U.S. military showed an equal loss ratio between helicopter crashes during autorotation training and the crashes that resulted from improper autorotational techniques when actual emergencies were in progress. For the army and navy, almost one helicopter was lost during autorotation training for each helicopter lost while performing an actual autorotation landing. The loss ratio for the air force was eight times better, not because the air force had better pilots, but because air force helicopters flew at higher altitudes during their missions.

The author of the *Flight* article, George Saunders, described how it took five to eight seconds after engine failure for a pilot to react and to stabilize a helicopter in an autorotational descent. He presented graphs indicating that for every 1,000 feet of altitude, a pilot could select a circular area under the helicopter equal to about one statue mile in radius. If the pilot doubled his altitude, he would increase his potential landing area by eight times. Saunders also documented that stretching the glide should only be accomplished by changing airspeed and not by raising the collective.

Subsequently, Bill Gabella, a helicopter flight instructor, wrote a five-part article in *Flight Operations* magazine titled "Autorotation Pointers for Pilots." Both he and Saunders made a strong case for using cruising altitudes much higher than 500 feet agl. This raises the question of how did helicopter pilots acquire this flying habit. The obvious answer must be "from their instructors." Perhaps it is time to take a hard look at how we are instructing people to fly helicopters in the 1990s.

How do we teach someone to fly a helicopter? According to a recent informal survey by this author, most of today's rotary-wing instructors teach others to fly using the same methods, examples and techniques that were used by their instructors. As is said in almost every text on educational techniques, the first training or impressions an instructor gives to his students are very long-lasting, and in some cases permanent. If something is learned in an incorrect manner, it is very difficult for another instructor to modify a previously developed habit.

A look at records of the first helicopter students during the early 1940s reveals that they averaged about four hours total of helicopter flight instruction prior to solo. Today, in spite of modern, easier-to-fly helicopters and 50 years to perfect training programs, most students receive about 15 hours of instruction in a helicopter prior to solo. Even with this amount of training, there is still concern about students' ability to cope with emergencies that might require autorotational landings during their early flights. This brings us to the important question, "What is a good way to teach autorotations?"

The ideal way to do this would be to teach the student certain aspects of maneuvers and let him or her practice them during dual flight periods until the student feels very comfortable doing the maneuvers within acceptable standards. This educational technique is known as taking the whole and breaking it into parts, teaching the parts, and then rejoining the parts into a new whole.

We can take the whole (autorotation) and break it into four parts, or maneuvers:

- Pilot reaction to sudden helicopter yaw caused by engine power loss. Maintain directional yaw/control using the pedals. Do not overreact. Do not move the cyclic.

- Rapid entry into full power-off descent. Make collective reduction with positive yaw control and good attitude/airspeed control.

- Entering into quick stops from both level flight and power-off descents. Use aft cyclic to slow the helicopter without climbing. Do not fly to a full stop, but transition into air taxi at 10- to 20-knots airspeed. Avoid adding too much collective during the leveling-off process.

- Learn how to make landings from engine failures

CIERVA Emergency Autorotation Checklist

C	Collective full down	1. If you delay this action, the rotor rpm will decay very rapidly, about 10 percent per second.
		2. If you do not put the collective fully down, the rotor rpm will decay faster than normal. Are you or something preventing it from moving to the full down position?
		3. If you raise the collective to stretch the glide, the rate of descent will increase rapidly and the touchdown will probably be a very hard one and will occur a shorter distance along the ground than it would if proper airspeed were maintained.
		4. If the collective is lowered too rapidly, especially during training, you may cause an engine power problem and turn a practice event into a real emergency. Be prepared for this.
I	Into the wind	1. Even with light winds, it is always best to touch down into the wind or crosswind with the lowest possible ground speed.
		2. Always fly high enough so you can turn as much as possible into the wind before the touchdown. Make the turn early if you can.
E	Engine status	1. Is the engine still running? If yes, try to add some power if it will help. If it is not running, you are probably too busy to try a restart from low altitude.
		2. If this is a training exercise, is the engine still running properly? If not, this is now a real emergency. Always be ready for such an occurrence.
R	Rotor rpm	1. Is the rotor rpm below the low limit? If so, is the collective fully down or were you just slow in lowering it at the beginning?
		2. Is the rpm a little high? Probably that is OK. Save the extra rpm for the touchdown.
		3. Raising the collective always lowers the rpm. Wait as long as possible before you raise the collective, save some rpm for touchdown.
V	Velocity (Airspeed)	1. What is the nose attitude of your helicopter? The airspeed may not be reading correctly. Just fly the correct helicopter attitude.
		2. Use velocity (airspeed), not collective, to adjust glide angle and ground path length.
A	Area to land on	1. What you see is what you get, don't change your mind at the last minute.
		2. Try to touch down into the wind or at least crosswind, rather than downwind. Keep your ground speed low.
		3. Hitting any obstacle under control is much better than losing control trying to avoid the obstacle. The helicopter is expendable.

during air taxi at five- to 15-foot heights and 10- to 20-knot taxi airspeeds. Try to not use much collective; leave it where it was prior to the engine loss if possible.

If a pilot can do these four maneuvers comfortably, he is ready to attempt them in rapid sequence, one after the other. If the pilot successfully does so, he has rejoined the four parts into a new whole — the autorotation.

A final comment about teaching the autorotation maneuver involves a memorized emergency procedures checklist. Student pilots have long been taught to memorize certain abbreviated checklists in addition to using the printed ones in the aircraft. Many pilots automatically go through the pre-landing litany of GUMP, for Gas, Undercarriage, Mixture and Prop. These short generic drills also can be used on the spur of the moment during an emergency, and then followed by the manufacturer's checklist when time allows.

I have created my own emergency checklist for use during autorotations, with a memorization aid (see page 3) based on a acronym spelled like the name of a rotary-wing pioneer. (Juan de la Cierva was the name of the developer of the autogiro which, with unpowered main rotors, always flew in a state of autorotation. Pulled through the air by a standard aircraft engine and propeller, the autogiro was the forerunner of today's helicopter.) When I ask a student for the engine out at altitude procedure, I expect him to state as a response the acronym CIERVA. This reminds him to do the following: Collective down, Into the wind, Engine status, Rotor rpm, Velocity and Area for landing. ♦

About the Author

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Hynes is a certificated as a flight instructor by the U.S. Federal Aviation Administration (FAA) and is a designated pilot examiner for airplanes and helicopters, a ground instructor and an accident prevention counselor. He also is an authorized inspector, and an airframe and powerplant mechanic. With more than 15,600 flying hours, Hynes has conducted more than 700 airman flight certification examinations, and has participated in more than 150 accident investigations.

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