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Helicopter Autopilots Demand Careful Management

Increasingly, helicopters are equipped with autopilots. When an autopilot's operation is understood by the pilot, safety is enhanced. If the autopilot's operation is not fully understood, the consequence can be an incident or accident.

Joel S. Harris
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An air ambulance helicopter departed the scene of an automobile accident with a critically injured patient aboard, en route to a hospital. Shortly after the night takeoff, the pilot inadvertently encountered instrument meteorological conditions (IMC). The helicopter was equipped with an autopilot, and the pilot elected to use the autopilot so that he could direct his attention to finding an approach plate with the frequency of a local approach control facility.

After rotating the heading selector to the proper course, he engaged the heading select mode of the coupled flight director mode selector (Figure 1, page 2). Next he selected the vertical speed mode and selected a climb rate of 244 meters per minute (800 feet per minute).

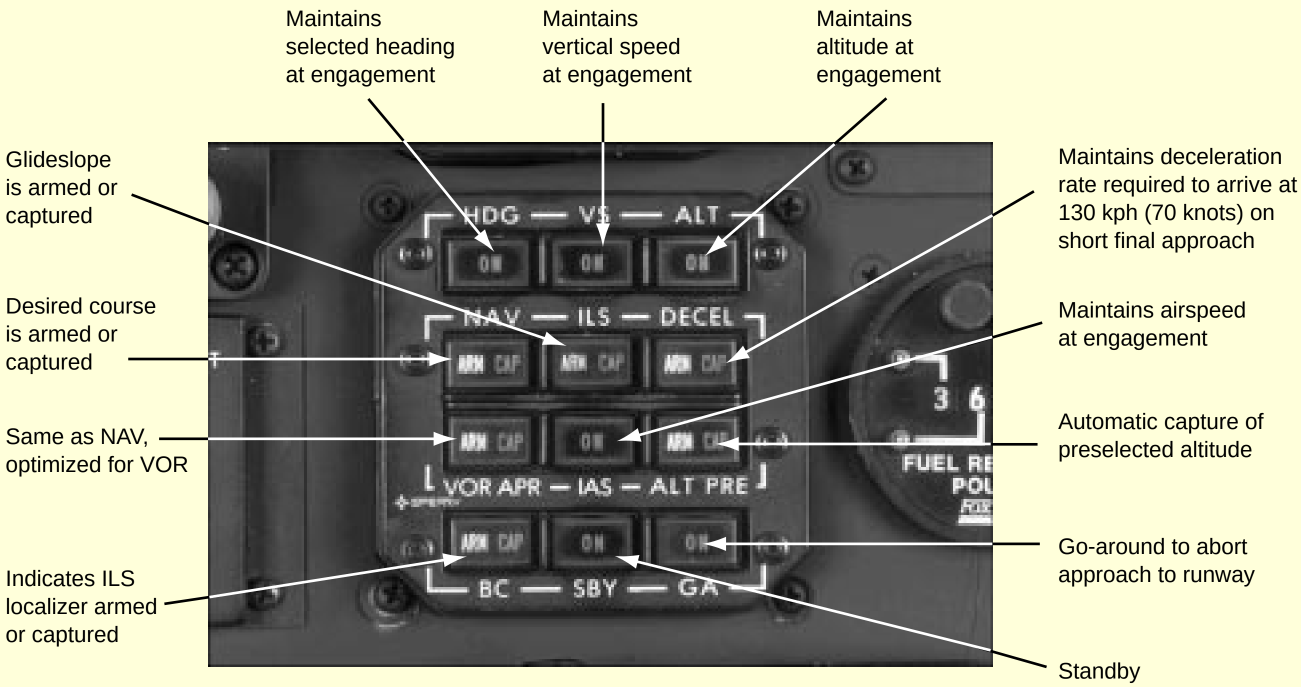
Then the pilot began searching the cockpit for the approach plate. While searching, he felt an unusual sensation and looked at the instrument panel. He was surprised to see that the attitude directional indicator (ADI) was indicating extreme nose-up pitch. A quick scan of other instruments showed that the airspeed was rapidly decreasing, and the vertical speed indicator was showing a descent. The pilot quickly took manual control of the aircraft, increasing the collective pitch and lowering the aircraft nose to recover from the unusual attitude. He succeeded, but after landing he said that he was shaken by the event.

That incident was caused by mismanagement of the autopilot. The air ambulance pilot used the autopilot to establish a 244-meter-per-minute climb rate. The pilot did not make a corresponding collective pitch input and the autopilot attempted to satisfy the command by using aircraft pitch attitude. As the autopilot increased the pitch attitude, a corresponding reduction occurred in airspeed.

When the airspeed decreased below the best-rate-of-climb airspeed (V_{broc}), vertical speed began to diminish. As a result, the autopilot increased the pitch attitude; the final result was a zero-airspeed unusual attitude with a high rate of descent in night IMC with one pilot.

As the number of autopilot-equipped helicopters increases, proper use of autopilots becomes increasingly important. It is sometimes taken for granted that experienced pilots will know how to use these devices properly. Some check pilots and trainers assume that "anyone can fly using the autopilot," and

Flight Director Mode Selector (Honeywell MS-700)



NAV = Navigation VOR = Very high frequency omnidirectional radio range ILS = Instrument landing system

Source: Honeywell Inc.

Figure 1

they ask only for a demonstration of "hand flying" the aircraft. Data show this assumption is not always correct.

Another in-flight incident and a training session in a level-C full-motion/visual helicopter flight simulator illustrate mismanagement of the autopilot.

The two-pilot crew of a corporate twin-turbine helicopter flying at 915 meters (3,000 feet) mean sea level (MSL) was cleared by air traffic control (ATC) to descend and maintain 610 meters (2,000 feet). During the descent, the pilot flying (PF) armed the flight director's altitude-preselect mode, setting it to level off the helicopter on reaching 2,000 feet. He then engaged the vertical speed mode, selecting a descent rate of 305 meters per minute (1,000 feet per minute), and made a corresponding decrease in collective pitch to maintain airspeed during the descent.

As the aircraft approached the target altitude, the altitude preselect feature enunciated a "capture." Illumination of the altitude-hold button on the flight director followed. A few seconds later, the gear-up warning horn began to sound, triggered by an airspeed below 111 kilometers per hour [kph] (60 knots).

Surprised, the pilots scanned the instruments and saw that the airspeed was rapidly decreasing, the aircraft pitch attitude was very nose-high and the aircraft was in a descent. The PF quickly increased collective pitch and lowered the nose of the aircraft to increase airspeed before climbing to the assigned altitude.

In the simulator example, a medium twin-turbine helicopter experienced a single-engine failure in cruise flight while operating under instrument flight rules (IFR). The crew correctly followed checklist procedures and secured the failed engine.

The pilot not flying (PNF) then contacted ATC, advised it of the situation, declared an emergency and requested radar vectors to the nearest instrument landing system (ILS)-equipped airport. ATC issued a new heading and advised the pilots of the expected approach. After the pilots had completed their approach briefing, ATC issued an intercept heading for the final approach course and cleared the crew for an ILS approach.

The PF turned the autopilot heading selector to the new heading and armed the ILS function on the coupled flight director. On intercepting the course, the flight director enunciated a capture of the localizer and turned the aircraft onto the final approach. The pilots completed the prelanding checklist, noting that the airspeed was 185 kph (100 knots), and that the landing gear indicator showed “down and locked.”

As the glideslope pointer on the ADI descended toward the centered position, the autopilot enunciated the capture of the glideslope and the aircraft began its descent. The PF reduced the collective pitch until the engine power gauge indicated approximately 40 percent for the operating engine. The pilots, over-confident that the autopilot would complete the coupled ILS approach without further difficulty, relaxed their instrument scans.

Spin Induced During Descent

As the aircraft descended on the glideslope, the pitch attitude began to increase. As a result, the airspeed began falling. At 111 kph, the vertical speed indicator began to show an increasing descent rate; and pitch attitude continued to increase, resulting in slower airspeed.

At 74 kph (40 knots), the pilots became aware that something was wrong but were unsure what corrective action to take. The airspeed indicator decreased to zero, the vertical speed indicator was racing toward the maximum position of 1,068 meters-per-minute (3,500-feet-per-minute) descent, and the aircraft began to spin to the right.

As the aircraft passed though 152 meters (500 feet) above ground level (AGL), the PF, having taken over manual control of the aircraft, raised the collective until the engine power meter reading was above the maximum one-engine-inoperative (OEI) power range, with an accompanying rotor droop.

This seemed to have no effect on the excessive descent rate, but instead increased the rate at which the helicopter was spinning. Seconds later the aircraft impacted the terrain about 1.6 kilometers (one mile) short of the intended destination. Almost certainly this would have been a fatal accident had it been an actual flight.

Although these examples occurred in different models of aircraft, equipped with different autopilots, they have a common factor: mismanagement of the autopilot. Understanding both the function of a helicopter autopilot and the power-required curve is essential to careful autopilot management.

Although some helicopter autopilots can couple to and control collective pitch, most cannot. Even in those that can, the capability is often not used. When a pilot selects airspeed, vertical speed, altitude or glideslope modes on the flight director, the autopilot — unless these commands are accompanied by a collective input — will use aircraft pitch attitude to accomplish these actions. Airspeed will increase or decrease, depending on the command.

For example, if a pilot selects the vertical speed mode and commands a climb of 152 meters per minute, but makes no corresponding collective pitch input, the helicopter’s airspeed will decrease as aircraft pitch attitude increases to satisfy the command. If the pilot (or capable autopilot) does make a collective input, airspeed and pitch attitude can be maintained during the climb.

The reverse is true during a descent; an autopilot-controlled descent, whether it is in vertical speed mode or on an ILS glideslope, will cause an increase in airspeed unless a corresponding decrease in collective is made.

Increasing Pitch Attitude Can Cause Either Climb or Descent

Increasing pitch attitude, for example, will result in a climb as long as the airspeed is above V_{broc} as published in the rotorcraft flight manual. After the aircraft slows below V_{broc}, however, increasing the pitch attitude will diminish the climb rate (Figure 2, page 4).

The figure shows that at a nominal airspeed of 222 kph (120 knots) and a power setting of 58 percent, a generic twin-engine helicopter maintains level flight. As the airspeed decreases without a corresponding collective pitch change, an increasing rate of climb is established. The rate of climb continues to increase until the aircraft reaches its V_{broc} (135 kph [73 knots]). But as airspeed decreases below V_{broc}, the aircraft becomes less efficient and the rate of climb decreases until the aircraft begins a descent. As pitch attitude is further increased, the airspeed falls to zero and the descent rate falls to 458 meters per minute (1,500 feet per minute).[1]

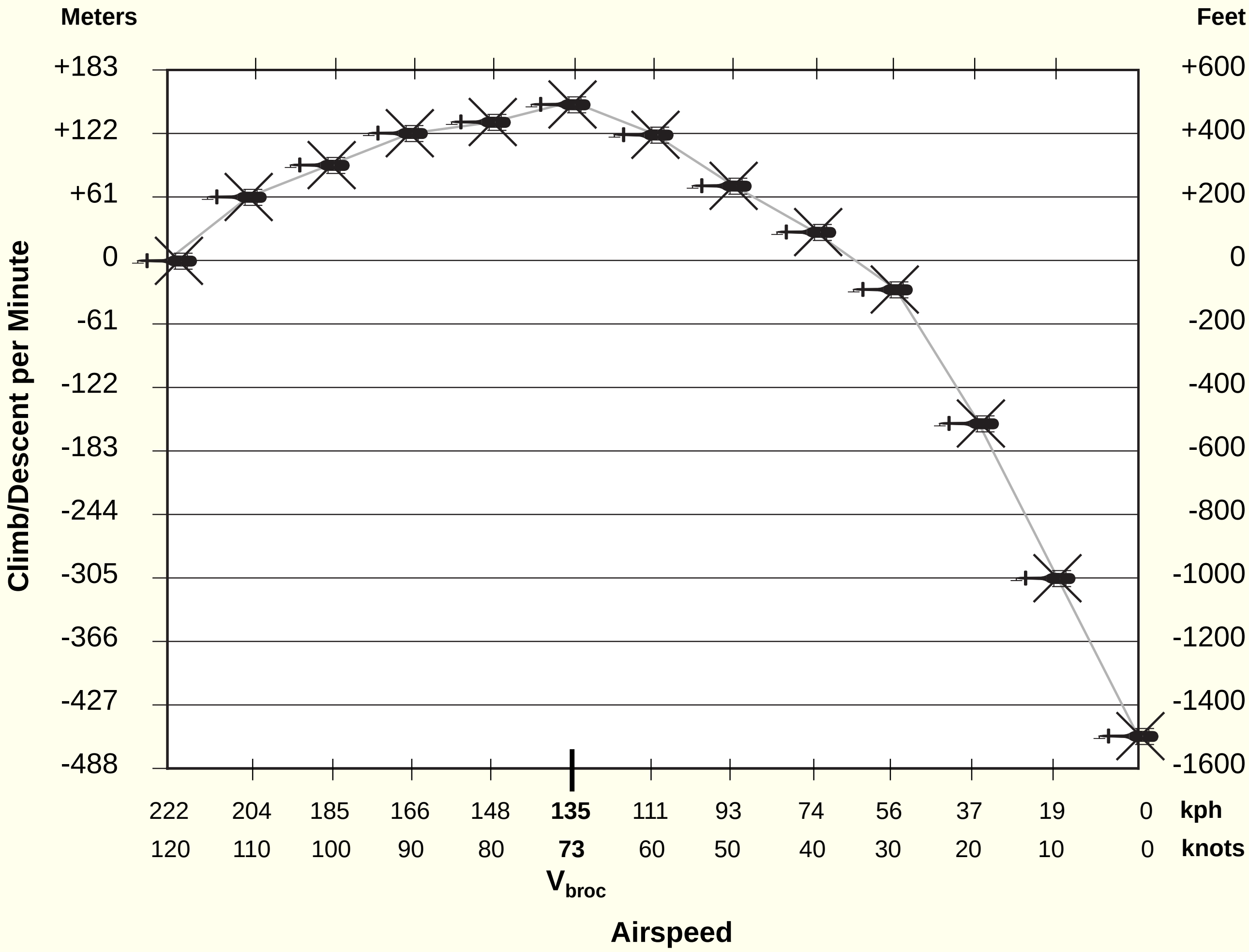
Using Autopilot to Descend/Climb Requires Changes in Collective Pitch

The pilots of the corporate twin-turbine helicopter used the autopilot to descend to a newly assigned altitude. The PF correctly made a reduction in collective pitch to maintain airspeed for the selected descent rate of 305 meters per minute.

Nevertheless, on leveling off at the new altitude, no corresponding collective pitch increase was made. Therefore, the autopilot attempted to maintain altitude by increasing pitch attitude, thus decreasing the airspeed. At the selected power setting, the descent could not be prevented by the autopilot and airspeed decreased until the gear-up warning horn alerted the pilots.

In the simulated OEI ILS approach, the autopilot was attempting to maintain the glideslope by adjustments in aircraft pitch attitude. Because the pilots had set the power to a value of only 40 percent on the operating engine, the autopilot was unable to maintain the glideslope at any airspeed. In trying to do so, pitch attitude increased until the aircraft was at zero airspeed in a

Rate of Climb/Descent at 58 Percent Power and 1,000-foot Density Altitude
Generic Twin-engine Helicopter1



kph = kilometers per hour V_{broc} = best-rate-of-climb airspeed

Source: Joel S. Harris

Figure 2

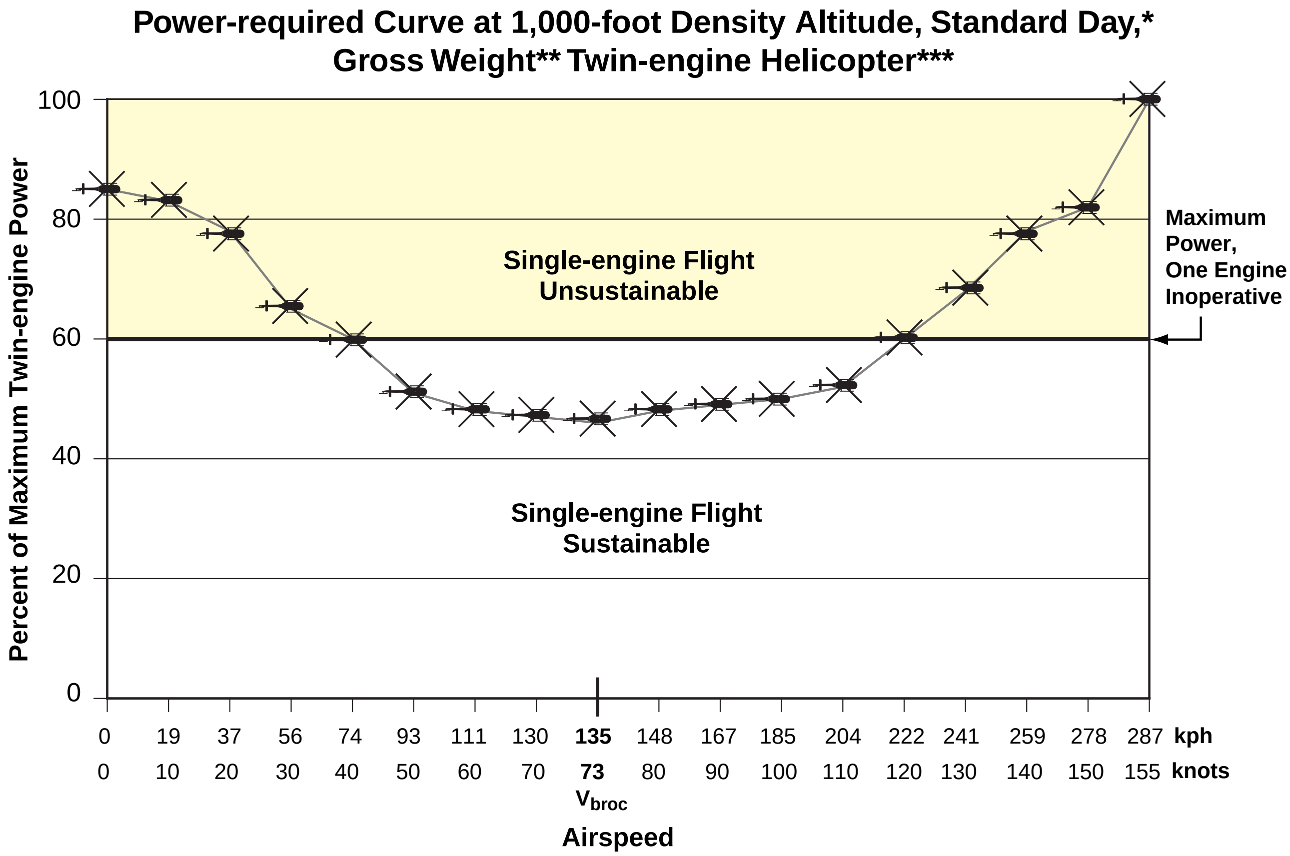
very high descent rate. With only one engine operating, the only viable recovery would have been to lower the nose of the aircraft to achieve flying airspeed. There was not sufficient altitude left to complete that successfully.

The power-required curve (Figure 3, page 5) shows that as airspeed decreases from 287 kph (155 knots), the power required to maintain level flight also decreases until the airspeed reaches V_{broc}. At V_{broc}, the aircraft is most efficient and requires the least power to maintain level flight. Nevertheless, as speed falls below V_{broc}, the power required for level flight increases. This increase in required engine power continues to the point of zero airspeed.

If, for some reason, full power is not available, the pilot's judicious use of the autopilot is even more important. When flying with one engine inoperative, for example, the maximum power available is somewhat more than half of the power available with both engines operating. Figure 3 shows that, in this example, maximum OEI power is about 60 percent of the maximum twin-engine power. The line representing maximum OEI power intersects the power-required curve at airspeeds both below and above those at which single-engine flight cannot be sustained. For example, the represented aircraft cannot maintain level flight at less than 74 kph or more than 222 kph.

The availability of operating information, however, does not preclude good judgment.

In June 1992, at Mariposa, California, U.S., an accident occurred shortly after takeoff. According to the U.S. National Transportation Safety Board (NTSB) accident report, the pilot started the



* Standard day = 15 degrees C (59 degrees F), altimeter 1013.2 hectopascals (29.92 inches of mercury).
** Maximum certified gross weight = 5,307 kilograms (11,700 pounds).
*** Data based on Sikorsky S-76C helicopter.
kph = kilometers per hour

Source: Joel S. Harris

Figure 3

Bell 222's engines on an intended flight the day before the accident flight. A medical crew member saw sparks emerging from the right engine, the engine temperature gauge "reading well above normal" and the engine's chip-detector light illuminating. After experimenting with the throttles in an effort to bring the temperature under control, the pilot secured the engines.

The next morning, the pilot attempted to perform a single-engine ferry flight. The report said that "the pilot ... performed a takeoff with both engines running. After takeoff, the right engine's temperature rose and the pilot shut the engine down. The helicopter could not fly adequately with the power from the left engine and altitude could not be maintained. The helicopter collided with a tree and then the ground."[2] The aircraft was destroyed and the pilot was injured.♦

References

1. Figure 2 was generated by the author using FlightSafety International's U.S. Federal Aviation Administration (FAA)-approved Level-C helicopter flight simulator, stabilizing at each 18.5-kph (10-knot) increment of airspeed until transitory cyclic climb had dissipated.

2. U.S. National Transportation Safety Board (NTSB), Report no. LAX92LA237 (June 7, 1992).

About the Author

Joel S. Harris holds an airline transport pilot certificate and a flight instructor certificate with ratings in both helicopters and airplanes. He is an FAA-designated pilot proficiency examiner, U.S. Federal Aviation Regulations (FARs) Part 135 checkairman and safety counselor. He is the director of pilot standards at FlightSafety International's West Palm Beach Learning Center in Florida, U.S., and has given over 10,000 hours of flight, simulator and ground-school training to professional helicopter pilots.

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