USHST United States Helicopter Safety Team

Our Vision: A Civil Helicopter Community With Zero Accidents

Airmanship Bulletin
The Vuichard Recovery

Objective

This Airmanship Bulletin is intended to introduce pilots to the Vuichard Recovery, a faster, and more efficient recovery technique from the vortex ring state (VRS). Since minimum altitude loss is the most critical factor in the recovery from VRS, the Vuichard Recovery technique can reduce altitude loss to as little as 20 to 50 feet.

Background

On August 23, 2013 an AS332 Super Puma with 18 persons on board was on the final stage of an instrument approach to Sumburgh Airport in the Shetland Islands. As the aircraft neared the minimum descent altitude (MDA) the nose began to pitch up, the airspeed decreased below 30 kts and the descent rate increased. As the aircraft descended through 100 ft the airspeed was still less than 30 kts, the engine torque had been increased to 115% and the rate of descent was approximately 1800 ft/min. The aircraft impacted the water 1.5 nm short of the runway killing 4 people and seriously injuring another four. The UK Air Accident Investigation Branch's (AAIB) initial analysis placed the aircraft in the perfect conditions to enter the vortex ring state.

On March 4, 2003 a Robinson R44 with three on board was the subject of a TV commercial being filmed in Jakarta, Indonesia. The aircraft was making a steep approach to a hotel's rooftop helipad with a 12-15 kt tailwind. The aircraft developed a very high descent rate, which the pilot never arrested. The helicopter impacted the helipad, bounced into the air then rolled off the edge of the building, falling 15 stories into a third story swimming pool. All three on board were killed.

Both of these accidents are classic examples of a pilot's failure to recover from the vortex ring state, (sometimes called "settling with power"). Traditionally pilots have been taught to lower the nose (forward cyclic), reduce power and, essentially, "fly out" of the condition. But there is a much more efficient method called "The Vuichard Recovery" after Claude Vuichard, a senior Flight Inspector/Examiner for the Federal Office of Civil Aviation (FOCA) in Switzerland, who developed the technique conducting long line operations in the Swiss Alps.

Terminology

In the United States there is a great deal of confusion on whether the vortex ring state should be properly or improperly referred to as "settling with power" or, by some, "power settling". The controversy stems from a condition, completely different from VRS, in which engine power required exceeds engine power available. For example, departing a confined area at a

high density altitude with a high gross weight and the engine power is not sufficient causing decay in RPM and a "settling" of the aircraft. Over the years the US military has used conflicting terminology discussing these two very different conditions. In the 1950's the US Navy referred to the vortex ring state as "power settling" and the term "settling with power" was used for the power available vs power required situation. The revised 1965 Navy technical manual, "Aerodynamics for Naval Aviators" (NAVWEPS 00-80T-80) stated "True "power settling" occurs only when the helicopter rotor is operating in a rotary flow condition called vortex ring state".

However, the US Army reversed the Navy's terminology. The 1974 US Army field manual FM 1-51 "Rotary Wing Flight" uses the other term "settling with power" in its discussion of the vortex ring state. The linage of most, if not all US helicopter pilots can be traced back to the US military especially since the Vietnam War so, depending on which branch of the service a pilot's instructional linage goes back to normally dictates which term is considered correct. The FAA uses "settling with power" in its discussion of VRS in both the Helicopter Flying Handbook (FAA-H-8083-21A) and the Practical Test Standards. Outside the US the picture is much clearer – neither the term "power settling" or "settling with power" is used. Rather, the correct aerodynamic term "vortex ring state" is used.

The US Helicopter Safety Team (USHST) feels the proper terminology is "vortex ring state" and should be used instead of some vague term that has different meanings to different pilots.

The Vortex Ring State

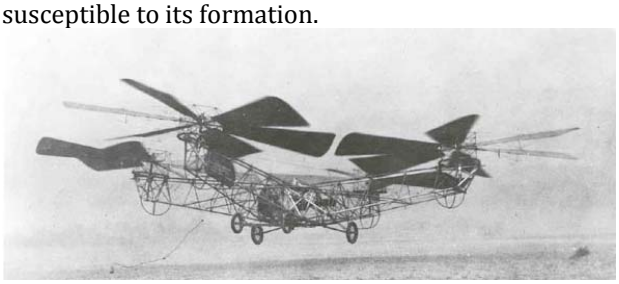
The vortex ring state (VRS) is one of three distinct working conditions for a helicopter's rotor. The common condition in which airflow is directed downward through the rotor and the rotor disc is moving in the direction of rotor thrust, as in a vertical climb, is called the propeller-working state or sometimes the normal-working state.

The static thrust condition in this propeller-working state is hovering. If the hovering helicopter descends at greater than 300 ft/min it enters the vortex ring state. Here, the rotor is still directing the air downwards but some air begins to move upward relative to the rotor and air below the rotor is forced out radially and upwards outside the rotor disc. Some of this upward flowing air outside the disc is drawn inward and back down through the rotor forming a large circulating pattern called the vortex ring state (Smaller vortices are formed inboard on each blade near the rotor hub but are of little consequence.).

The vortex ring state can be recognized when airspeed is less than ETL (effective translational lift), an increasing descent rate more than 300 ft/min, random yawing and pitching movements that produce a kind of wallowing effect and a buffeting or shuddering of the aircraft. Classic examples are OGE hovering and steep approaches downwind. Since the vortex acts perpendicular to the main rotor if the pilot applies forward cyclic to recover the tailwind blows the vortex in the same direction as the aircraft, delaying recovery. If this descent is allowed to continue to greater than 2000 ft/min the aircraft will enter the windmill-brake state where the flow of air is entirely upward through the rotor.

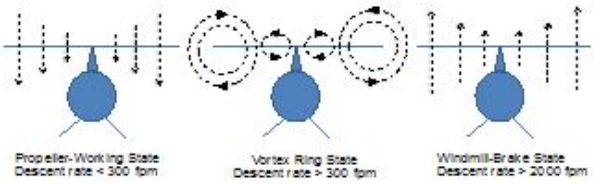
In this state rotor thrust is achieved by actually slowing down this upward flow of air through the rotor and the force generated by the rotor is equivalent to that produced by a parachute of the same diameter as the rotor. Interestingly, the boundary between the vortex ring state and the windmill-brake state is the ideal autorotation condition.

George de Bothezat first recognized the vortex ring state in 1922 with his "flying octopus", a machine with four massive six bladed rotors (very similar to many drone designs we see today). Since then numerous flight tests, wind tunnel experiments and mathematical modeling have refined our understanding. The number of rotor blades, rotor RPM and rotor diameter have little effect on the vortex ring formation but helicopters with higher disk loading and increased blade twist are more susceptible to its formation.



George de Bothezat and his "flying octopus"

Here are the three airflow patterns through the rotor at a hover:



The Vuichard Recovery

The Vuichard Recovery actually uses the upward flowing portion of the vortex to assist in the recovery. In aircraft with a counterclockwise rotation begin the recovery by increasing the collective to climb power, keeping the nose straight with left pedal. Simultaneously apply right cyclic (10° to 20° bank angle).

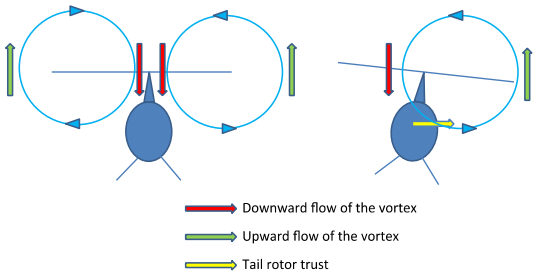
The combination of thrust from the tail rotor and the shallow right bank produces lateral aircraft movement to the right. Once the advancing blade (right side) reaches the upward flowing portion of the vortex the recovery will be complete (In helicopters with a clockwise rotation the cyclic and pedal inputs are the opposite: left cyclic and right pedal.).

A common student error is not coordinating enough left pedal with the increase in collective, allowing the nose to yaw to the right. Remember, it's the tail rotor thrust that helps move the helicopter to the right enabling the recovery so the left pedal is essential.

It may be easier for pilots to initially break the procedure down into two steps. First, apply the right cyclic to establish a 10° - 20° bank angle, then increase the collective to climb power coordinated with left pedal. Once the two-step process is mastered, it's quite easy to then progress to smooth, simultaneous control inputs.

The Vuichard Recovery procedure (aircraft with counterclockwise rotation)

- Increase collective to take off power and left pedal to maintain heading.
- Simultaneously apply right cyclic (10° to 20° bank) to get lateral movement.
- As soon the advancing rotor blade reaches the upward flow of the vortex, the recovery is completed. Average loss of altitude is 20-50 ft depending on the duration of the recovery maneuver.



In helicopters with a clockwise rotation the control inputs are the opposite: left cyclic for bank and right pedal when power is applied.

As with the traditional method of recovery, it is recommend practicing the Vuichard Recovery so that the recovery can be completed above 1000 feet AGL.

For demonstration purposes it is acceptable to allow a high descent rate to build prior to initiating the recovery to clearly show how efficient this technique is. However, in the real world early recognition and initiation of the recovery is key to minimal altitude loss.

Once proficiency with the technique is achieved pilots should practice recovering from the vortex ring state as soon as the condition is recognized. Another interesting comparison is to look at the two techniques at the point the aircraft exits the vortex ring. With the traditional technique when the aircraft is clear of the vortex the helicopter is in a dive caused by the nose low attitude, power has been reduced and the descent rate is high. The entire time the pilot is correcting to a climb attitude and climb power the aircraft is losing altitude. With the Vuichard Recovery at the point the aircraft is clear of the vortex, climb power and attitude are already present minimizing altitude loss.

Result of a steep approach downwind. Both the pilot and copilot suffered broken backs.

Conclusion

The Vuichard Recovery offers a significant improvement over the traditional recovery technique and can greatly improve the safety of operations close to the vortex ring boundaries. Instruction should begin at the student pilot level to build an instinctive, intuitive reaction and continue throughout one's training. It is important for the FAA to include a specific discussion of the Vuichard Recovery in the Helicopter Flying Handbook and the Helicopter's Instructor's Guide (FAA-H-8083-4) so pilots and instructors can benefit from a quick exit from this potentially fatal condition.

(Thanks to Richard Chapuis, of Air Glaciers, Switzerland for the spraying photographs.)

This Airmanship Bulletin is a peer reviewed publication by an expert panel of the IHST/USHST Implementation Team. More information about the IHST/USHST, its reports, its safety tools, and presentations can be obtained at these web sites: (www.IHST.org or www.USHST.org).