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# Unanticipated Right Yaw At Low Speeds

***A single-rotor helicopter pilot must learn to properly control tail rotor effectiveness during low speed flight characteristics to avoid unanticipated right yaw. The author details the four aircraft characteristics and relative wind azimuth regions to be aware of, to help the pilot understand the importance of timely corrective action.***

Testing of the Bell OH-58 series (civil version is the HB-206) helicopter operated by the U.S. Army revealed the occurrence of an unanticipated right yaw under certain low- speed mission conditions.

The Army referred to the right yaw characteristic as loss of tail rotor effectiveness (LTE). The following is a discussion of low-speed flight characteristics which can result in an unanticipated right yaw if appropriate attention is not paid to controlling the aircraft. **These characteristics are present only at airspeeds of less than 30 knots and apply to all single-rotor helicopters.**

## Definition of Unanticipated Right Yaw

Unanticipated right yaw is the occurrence of an uncommanded right yaw rate which does not subside of its own accord and which, if not corrected, can result in the loss of aircraft control. The term “loss of tail rotor effectiveness” is misleading. The tail rotor of the OH-58 and the 206-series helicopters has exhibited the capability to produce thrust during all approved flight regimes.

## Low Speed Flight Characteristics

Four aircraft characteristics during low speed flight have been identified through extensive flight and wind tunnel tests as contributing factors in unanticipated right yaw.

For this occurrence, certain relative wind velocities and azimuths (direction of relative wind) must be present. The aircraft characteristics and relative wind azimuth regions are:

1. Weathercock stability (120 to 240 degrees)

2. Tail rotor vortex ring state (210 to 330 degrees)

3. Main rotor disc vortex interference (285 to 315 degrees)

4. Loss of translational lift (all azimuths)

The aircraft can be operated safely in the above relative wind regions if proper attention is given to controlling the aircraft. However, if the pilot is inattentive for some reason and a right yaw rate is initiated in one of the above relative wind regions, the yaw rate may increase unless suitable corrective action is taken.

## Weathercock Stability (Relative Wind from 120 to 240 Degrees)

Winds within this region will attempt to weathervane the nose of the aircraft into the relative wind. This characteristic comes from the fuselage and vertical fin. The helicopter will make an uncommanded turn either to the right or left, depending upon the exact wind direction, unless a resisting pedal input is made. If a yaw rate has been established in either direction, it will be accelerated in the same direction when the relative winds are from 120 to 240 degrees (shaded area in Figure 1, see page 2) unless corrective pedal action is made. The importance of timely corrective action by the pilot to prevent high yaw rates from occurring cannot be overstressed.

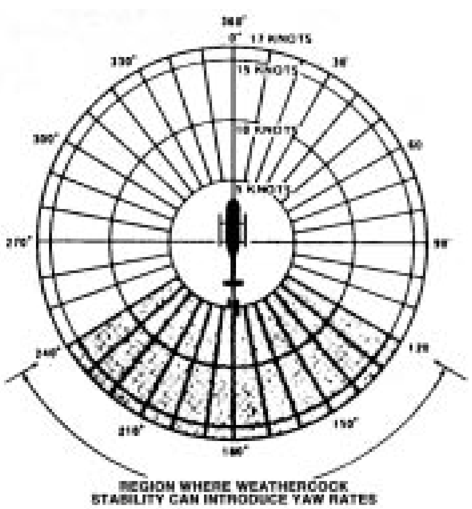


**Figure 1. Weathercock Stability**

## Tail Rotor Vortex Ring State (Relative Wind from 210 to 330 Degrees)

Winds within this region (Figure 2) will result in the development of the vortex ring state of the tail rotor. The vortex ring state causes tail rotor thrust variations, which results in yaw rates. Since these tail rotor thrust variations do not have a specific period, the pilot must make corrective pedal inputs as the changes in yaw acceleration are recognized.

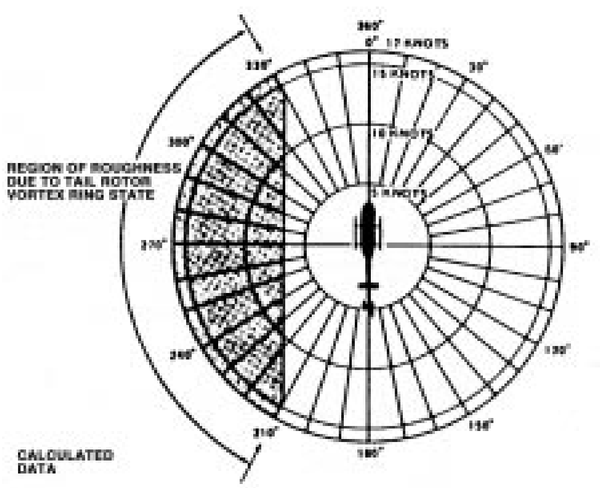


**Figure 2. Tail Rotor Vortex Ring State**

The resulting high pedal workload in tail rotor vortex ring state is well known, and helicopters are operated routinely in this region. This characteristic presents no significant problem unless corrective action is not timely. If a right yaw rate is allowed to build, the helicopter can rotate into the wind azimuth region where weathercock stability will then accelerate the right turn rate.

Pilot workload during vortex ring state will be high; therefore, the pilot must concentrate fully on flying the aircraft and not allow a right yaw rate to build.

## Main Rotor Disc Vortex (Relative Wind from 285 to 315 Degrees)

Winds within this region can cause the main rotor vortex to be directed onto the tail rotor. The effect of this main rotor disc vortex is to change the tail rotor angle of attack. Initially, as the tail rotor comes into the area of the main rotor disc vortex during a right turn, the angle of attack of the tail rotor is increased. This increase in angle of attack requires the pilot to add right pedal (reduce thrust) to maintain the same rate of turn.

As the main rotor vortex passes the tail rotor, the tail rotor angle of attack is reduced. The reduction in angle of attack causes a reduction in thrust, and a right yaw acceleration begins. This acceleration can be suprising, since the pilot was previously adding right pedal to maintain the right turn rate.

Analysis of flight test data during this time verifies that the tail rotor does not stall. The helicopter will exhibit a tendency to make a sudden, uncommanded right yaw which, if uncorrected, will develop into a high right turn rate. When operating in this region, the pilot must anticipate the need for sudden left pedal inputs.

## Losing Translational Lift

The loss of translational lift results in increased power demand and additional anti-torque requirements. If the loss of translational lift occurs when the aircraft is experiencing a right turn rate, the right turn will be accelerated as power is increased unless corrective action is taken by the pilot. When operating at, or near, maximum power, this increased power demand could result in rotor rpm decay.

This characteristic is most significant when operating at, or near, maximum power and is associated with unanticipated right yaw for two reasons.

First, if the pilot's attention is diverted as a result of an increasing right yaw rate, he may not recognize that he is losing relative wind and, hence, losing translational lift.

Second, if the pilot does not maintain air- speed while making a right downwind turn, the aircraft can experience an increasing right yaw rate as the power demand increases, and the aircraft develops a sink rate.

Insufficient pilot attention to wind direction and velocity can lead to an unexpected loss of translational lift. The pilot must continually consider aircraft heading, ground track and apparent ground speed, all of which contribute to wind drift and airspeed sensations. Allowing the helicopter to drift over the ground with the wind results in a loss of relative wind speed and a corresponding decrease in the translational lift produced by the wind.

Any reduction in translational lift will result in an increase in power demand and anti-torque requirements.

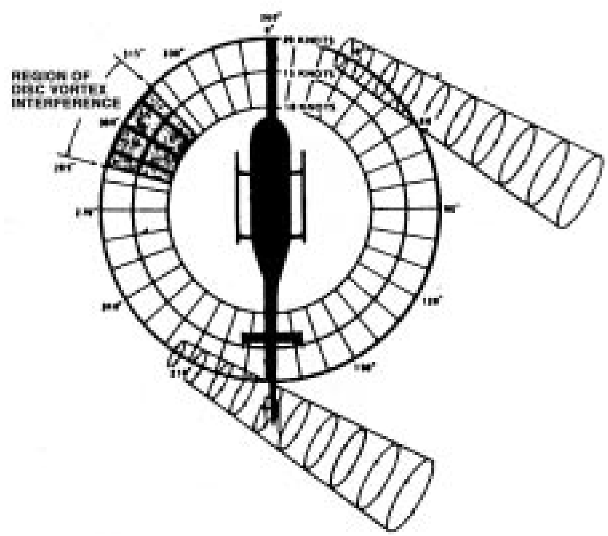


**Figure 3. Main Rotor Disc Vortex Interference**

## Recovery Technique

If a sudden unanticipated right yaw occurs, the following recovery technique should be performed.

1. Pedal-Full left; simultaneously, cyclic-forward to increase speed.

2. As recovery is effected, adjust controls for normal forward flight.

## Caution

**Collective pitch reduction will aid in arresting the yaw rate but may cause an excessive rate of descent. The subsequent large, rapid increase in collective, to prevent ground or obstacle contact, may further increase the yaw rate and decrease rotor rpm.**

**The decision to reduce collective must be based on the pilot's assessment of the altitude available for recovery.**

3. If aircraft rotation cannot be stopped and ground contact is imminent, an autorotation may be the best course of action. Maintain full left pedal until the aircraft rotation stops, then adjust to maintain heading.

## NOTE

The various wind directions can cause significantly differing rates of turn for a given pedal position. The most important principle for the pilots to remember is that: **The tail rotor is not stalled.** Thus, the corrective pedal position to be applied is always in the normal direction of **opposite pedal** to the turn direction. ♦

# For Want of a Pin ...

***... a helicopter was lost. Proper control connections and inspections are vital to safe rotorcraft operation.***

Results of an investigation into the crash of a Royal Air Force Whirlwind helicopter during a demonstration flight illustrates once again the importance of the correct installation of flight control connections and follow-up inspections to assure that they remain in that condition.

In this particular case, the helicopter was to have made a demonstration of winching techniques. At the beginning of the demonstration, the pilot approached the airfield in a descending turn. At a speed of approximately 80 knots and at an altitude of about 50 feet, the Whirlwind suddenly rolled to the left in a nose-down attitude.

## Loss of Control

The pilot was unable to correct the helicopter's flight path through his control input. The rotor blades struck the ground first, followed by the fuselage, which cartwheeled and broke up before coming to a halt on its right side.

One of the crew men was seriously injured. The pilot and two others sustained only minor injuries and managed to remove the seriously injured crew man from the wreckage, which was leaking substantial quantities of fuel. Fortunately, rescue vehicles were on the scene within 90 seconds, and there was no fire, despite the leaking fuel.

Accident investigators found that the linkage between the pilot's flight controls and one of the hydraulic jacks that control the movement of the main rotor blades had become disconnected.

Ground tests of another Whirlwind showed that, when the linkage was removed, the hydraulic jack moved to the full travel position, with no means for the pilot to control the flight path or attitude.

## Missing Pin Makes a Point

The nut and bolt that should have secured the disconnected joint were found in the wreckage. The nut, which apparently had not been locked into position by a split pin as specified, had worked its way free of the bolt.

The investigation report surmised that the nut probably had not been secured properly when the joint was last reconnected after servicing approximately two months and 30 flight hours before the accident. The helicopter's normal vibration did the rest, working the nut free of the bolt. ♦




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