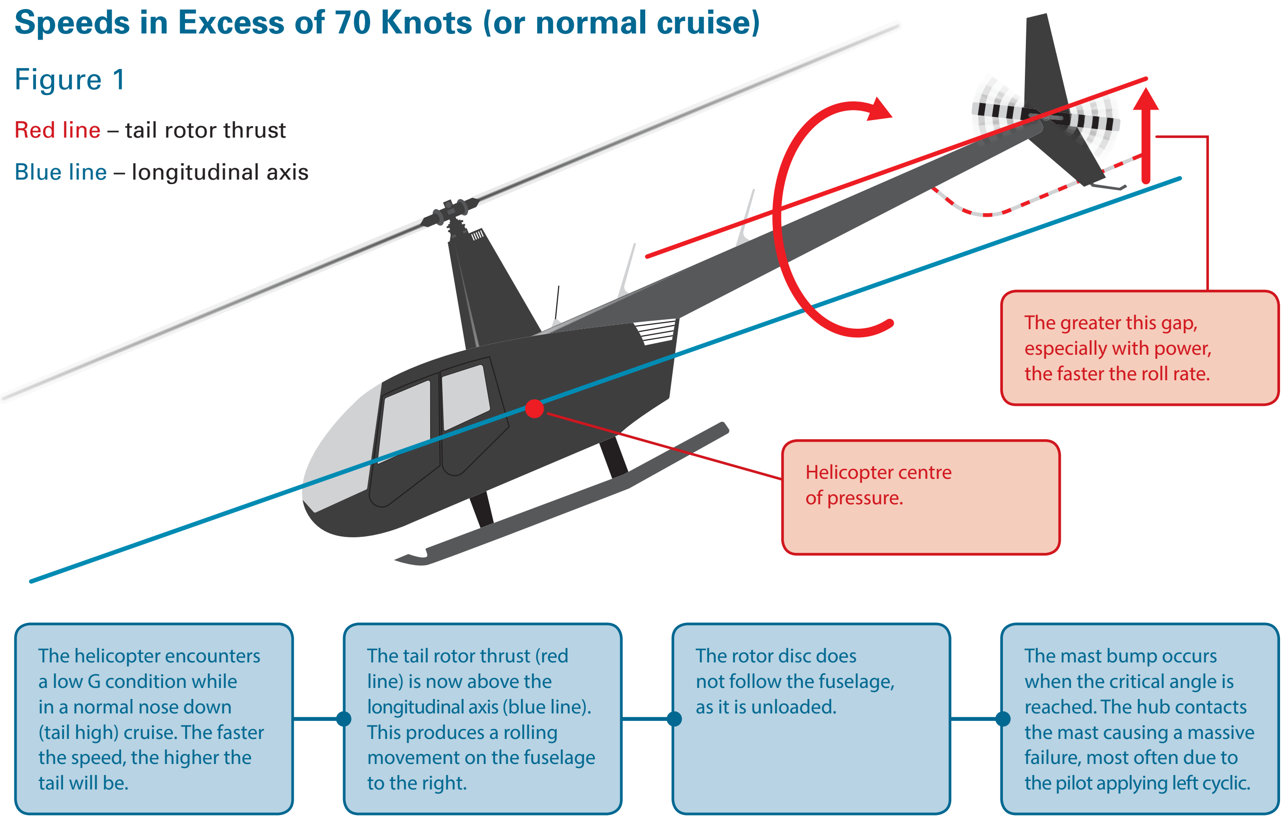
Low G Effects – Fli



Helicopters with the two-bladed semi-rigid rotor system are susceptible to mast bumping when subject to negative or low G forces. It's critical that pilots fly to avoid this condition, and that they act immediately if they inadvertently encounter it.

Mast bumping is a term used to describe an impact between the rotor hub and the main rotor shaft (mast) that can cause severe damage, even detachment. It affects the two-bladed semi-rigid system.

Mast bumping is generally caused by incorrect control inputs when the helicopter is subject to negative or low G forces.

Much has been written on the topic, and it hasn't been without controversy, although those contributing to the discussion are doing so in a genuine effort to save lives.

In an effort to clarify the situation, CAA Aviation Examiner, Andy McKay, has prepared a paper to provide further education on the subject. He also invited Robinson to comment.

Here's Andy's paper:

"I want to map the relationship between speed, low G, and a low G roll on a two-bladed helicopter – specifically the Robinson.

"Low G is any loading below 1 G force (1 G is the level of gravitational pull we experience in normal conditions). Below 1 G we start to feel weightless, and above 1 G we feel more weight pressure. This is sometimes referred to as an increase or decrease in loading."

Andy takes a look at Robinson's advisory material.

Robinson Safety Notice SN-32

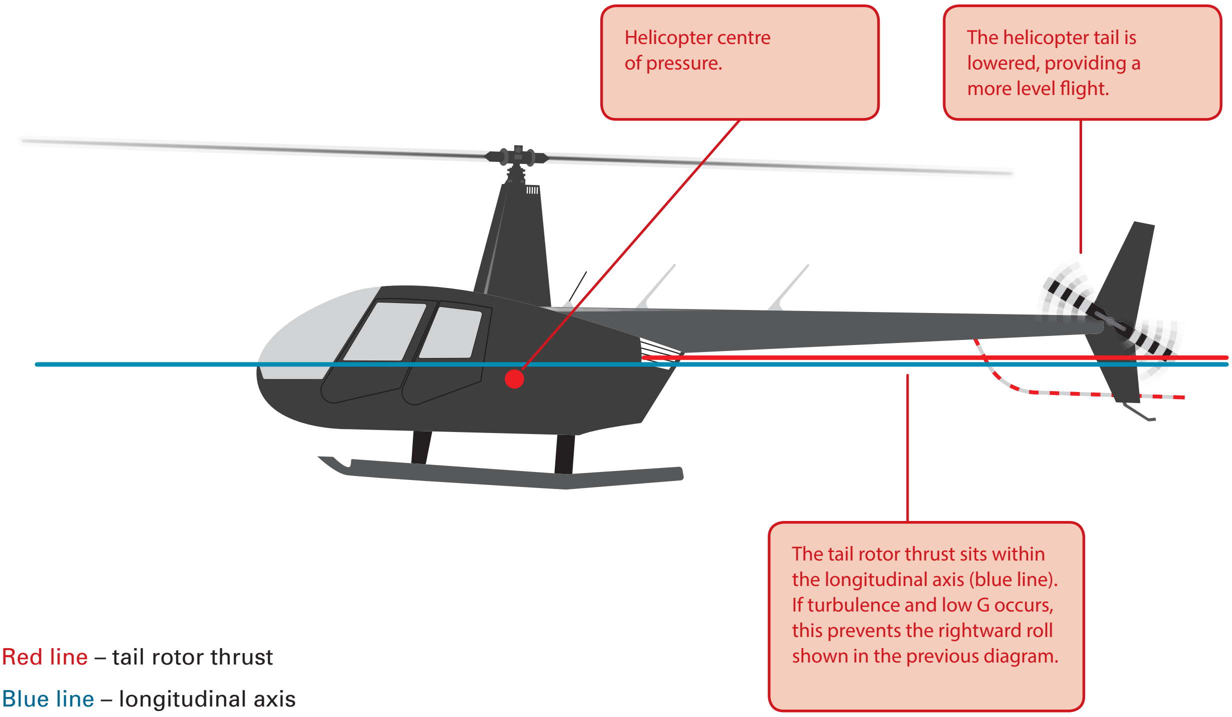
A pilot's improper application of control inputs in response to high winds or turbulence can increase the likelihood of a mast bumping accident. The following procedures are recommended:

1. *If turbulence is expected, reduce power and use a slower than normal cruise speed. Mast bumping is less likely at lower airspeeds.*
2. *If significant turbulence is encountered, reduce airspeed to 60 – 70 knots.*

ght into Turbulence

Speed Reduced to 60 – 70 Knots

Figure 2



3. Tighten seat belt and firmly rest right forearm on right leg to prevent unintentional control inputs.

4. Do not over-control. Allow the aircraft to go with the turbulence, then restore level flight with smooth, gentle control inputs. Momentary airspeed, heading, altitude, and RPM excursions are to be expected.

5. Avoid flying on the downwind side of hills, ridges, or tall buildings where the turbulence will likely be most severe.

The helicopter is more susceptible to turbulence at light weight. Use caution when flying solo or lightly loaded.

Andy continues:

To recover from a low G condition, Robinson recommends that pilots first apply gentle aft cyclic (to recover from the low G condition). Second, apply lateral cyclic (to recover from the right roll). If mast bumping has occurred or is suspected, land immediately. This should become second nature with training.

So why does Robinson recommend slowing down in significant turbulence?

Simply put, it's to avoid a low G induced right roll that could lead to mast bumping. Additionally, it reduces aerodynamic shock loading.

The effects of shock loading damage are often unique to each helicopter and rotor head. For example, Hughes 500 heads have a tendency to break strap packs in significant turbulence.

What constitutes 'significant' turbulence may differ from pilot to pilot. If you think the turbulence is significant, then slow down.

The G force doesn't need to be negative to have an adverse effect on a two-bladed helicopter.

Robinson typically flight test to a threshold of 0.5 G. One flight test showed that a pull up and push over in an R66 from 124 knots created a 0.478 G loading. The test pilot involved indicated that the subsequent recovery roll was at the limit of what he would have been comfortable with.

Low G demonstration is strictly prohibited now, but in the past, low G conditions were used to demonstrate what low G felt like, and roll recovery. It normally involved a gentle pushover using a power setting of 18 to 20 inches manifold pressure.

In these controlled low G conditions, the pilot could anticipate the required recovery. In normal flight, however, by the time negative G is experienced, and depending on the power applied, the roll rate is likely to be extremely high – and possibly unrecoverable.

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Photo courtesy of Robinson Helicopter Company

Watch Out

When crossing a ridge or saddle at 70 knots or more in windy conditions, be careful not to let the nose drop excessively on the downside or leeward side, as this is a bad time to encounter low G. Remember, during any 'nap-of-the-earth' flying, especially in the mountains, in a two-bladed helicopter, always lead with collective while watching the nose and tail attitude.

However, even with low airspeed and less power in use (provided the tail rotor is still producing thrust), the helicopter can still roll if the tail rotor is significantly above the longitudinal centre of gravity – the roll rate will just be lower. Be especially careful when climbing up to a high saddle from a valley where turbulence was present. If you abort the crossing and turn downwind and downhill, allowing the nose to drop excessively in the process, the resulting loss of horizon and high tail attitude will put you at risk.

Prevention

In significant turbulence, you will often feel a combined increase and decrease in loading as the helicopter reacts to disturbed air. Most of the time, the situation should correct itself without the need for any significant control input. However, during a prolonged decrease in loading, a low G condition may develop and you need to be prepared.

But rather than dealing with the symptoms, the best defence is conservative flying. Speed control is one means of achieving that.

With experience, you should learn to anticipate where turbulence is likely, and either slow down, or avoid it entirely.

Remember that the lighter the helicopter, the more susceptible it is to low G. Additionally, the higher the speed (ie, an R66 at 130 knots) the longer it takes to reduce to 60 – 70 knots. Additionally, the higher the speed and power setting, the higher the roll rate if low G is encountered.

Figure 1 illustrates a helicopter encountering low G conditions in excess of 70 knots. In contrast, figure 2 depicts a helicopter flying 60 – 70 knots.

The tail rotor's position relevant to the longitudinal centre of gravity is extremely important. Simply put, in a low G situation at speeds above normal cruise, the tail rotor thrust sits above the longitudinal centre of gravity. That may cause a roll to the right.

At speeds of 60 – 70 knots, the tail rotor thrust sits within the centre of gravity, reducing the chance of a right roll.

Robinson's Comments

Timothy Tucker, Robinson's Chief Instructor, provided a response to Andy's submission. Here's a summary:

We would like to emphasise there are three main reasons to slow down in turbulence:

1. *At slower speeds the effect of the turbulence, hence the amount of low G, is greatly reduced.*
2. *Less power means less tail rotor thrust to roll the helicopter.*
3. *At slower speeds the location of the tail rotor relative to the aircraft's centre of gravity will reduce rolling tendencies.*

Another point that needs to be emphasised is the importance of the weightless feeling as a key to recognition of the low G condition. In many instances, this weightless feeling will occur well before the right roll, making a recovery possible before the roll ever begins.

There seems to be a growing perception in New Zealand that lowering the collective is a preferable method and a more instinctive response to recover from a low G condition. This was quite evident to me in November last year when I conducted a one-day seminar in the North and South Island.

We think the most important focus should be on the weightless feeling caused by the low G condition, which can occur before the roll even starts and is when a recovery should be initiated.

Aft cyclic treats the cause, down collective treats the symptom. We also feel the cyclic is the first control pilots naturally use to effect a change in aircraft attitude.

Lowering the collective will cause a momentary pitching down of the nose, which could aggravate the roll. ■

The November/December 2013 issue of *Vector* included an article by long-time pilot and instructor, Simon Spencer-Bower. A subsequent comment from a reader was published in the March/April 2014 issue.

In response to a number of accidents involving Robinson helicopters in the last few years, the CAA issued a consultation document in April 2015 exploring the need for changes in regulation. Consultation has since closed, but you can still view the document on the CAA web site, www.caa.govt.nz, "General Aviation".

This could result in changes to an Advisory Circular (AC). To be advised of any changes to rules or ACs, subscribe to our email notification service, www.caa.govt.nz/subscribe.