GYROPLANE ASTM STANDARDS – PART 6

Gyroplane Stability for DUMMIES!

By Greg Gremminger

Parts 1-5 of this series of articles addressed detailed technical issues of gyroplane flight stability. Some people are discouraged from trying to understand the full depth of these technical details. I will try to keep this article length to just **TWO** pages – some simple answers to common questions and perceptions.

The most important questions or issues people ask about gyro flight safety have to do with **BUNTOVERS** and **PIO** (Pilot Induced Oscillations). These are the important issues people want and need answers to!

Some Concepts:

- **PPO** (**P**ower **P**ush **O**ver) is a form of, but not the only form of a **BUNTOVER**. PPO is popularly attributed to high prop thrustline gyros (HTL) because PPO is more easily visualized in terms of a "push over."
- **BUT - All gyros** are **capable of BUNTOVER** – even Centerline Propeller Thrust (CLT) and Low Propeller Thrustline (LTL). **BUNTOVER** is a function of **rotor** thrustline, not **propeller** thrustline!
- Prop Thrustline is just one element (maybe less than 1/2) of whether gyros can buntover. The other equally important elements are airframe, enclosure, and Horizontal Stabilizer (HS) aerodynamics.
- Prop Thrustline can be an important stability factor, but only when power (prop thrust) is significantly applied – higher throttle settings.
- The aerodynamic factors of airframe, enclosure, and HS are very important at higher speeds too – whether power is applied or not!
- A propeller thrustline that is relatively closely aligned to the Vertical CG (VCG) of the gyro (rotor included!) can be a good thing! – But not the only thing. A smaller prop offset makes it easier for the HS to assure **G-Load stability (buntover resistance)** at higher power!
- But, it can be dangerously misleading to overly-simplify gyro flight stability / safety into just using a HS or "Centerline Thrust" – for your safety, there is more to it than that! It must be done right **AND tested**!
- Perfect and consistent CLT is almost impossible. An effective HS can "balance" some reasonable prop thrustline offsets.

What is really important for stability / safety:

- Gyros are **buntover capable** if/when they are **G-Load unstable?** If/when a gyro is G-Load unstable, it can buntover – regardless of prop thrustline! G-load instability CAN occur on even "stable" gyros - at certain power or airspeed or loading combinations.
- **G-Load stability** means that when a **de**creasing G-Load is induced or encountered, the gyro automatically tries to increase the G-load **back to 1 G** – stable.
- **G-Load instability** means that when a **de**creasing G-load is induced or encountered, the gyro inherently further pitches the nose down to further decrease the G-load – ultimately resulting in a rapidly progressing buntover – statically unstable!
- **When** gyros are **G-load stable** they are highly, if not totally, buntover / PPO resistant.
- Flight testing for G-Load stability is much easier than trying to measure the Vertical CG and CLT – and much more conclusive!

  ***Flight test it:* From straight and level flight, and without power or airspeed change, roll into a bank and verify AFT stick pressure and movement IS necessary to maintain the original straight and level airspeed.**

- If it meets this simple test, the gyro is **G-Load statically stable** and is buntover (and PPO) resistant - at that airspeed and power setting!
- But, if **forward stick pressure or position** is required to maintain original airspeed, the gyro is **G-load unstable** and **capable of buntover** at that airspeed and power combination! – avoid that combination!

- Test it at other airspeeds and power (and loading) combinations! Many "stable" gyros become G-Load unstable (capable of buntover and PPO) at high airspeed and/or different power levels – high or low! The test under those conditions will identify flight you should avoid in that gyro – Vne!
- G-Load stability (Buntover and PPO resistance), as verified by the simple flight test, indicates that the CG is on or forward of the Rotor Thrust Vector (RTV). **This** condition is important for buntover resistance – regardless of propeller thrustline, the in-flight CG must be on or forward of the RTV. You can't determine this from VCG – you have to flight test it!
- Propeller thrustline offset is just one of the elements that affect G-Load stability. But, a reasonable propeller thrustline offset is more easily and efficiently "balanced" by a HS.
- Spend as much time and trouble as you want trying to accurately determine VCG and propeller offset, but the final verification of buntover and PPO resistance still needs at least the simple flight test to verify G-load static stability – and, this flight test is much easier to do than to measure VCG!

<u>How about PIO:</u>

- Pilot Induced Oscillations are a **<u>DYNAMIC</u>** stability issue – this has little to do with propeller thrustline, a static stability issue!
- **PIO** is not the "killer"! The buntover in the G-load extremes of PIO kill you!
- But, to avoid a "killer" buntover at the end of a PIO, the gyro should be PIO resistant too!
- The easiest and most common way to inherently resist PIO or be DYNAMICALLY stable is to use an effective HS. (Also a simple element of improved G-Load stability!)
- A HS is most effective if it is:
  - o A large area and placed far aft of the prop.
  - o Aerodynamically efficient shape (airfoils, tip plates, smooth, etc.)
- A smaller HS can be made more effective if positioned (embedded) in higher propwash – but this helps only when there is significant propwash. PIO (and buntover) resistance might be less at low or no power settings. When propwash is relied on for good HS effectiveness, stability and handling and control can degrade at lower power settings.
- But, some propwash on the HS is definitely effective at high power settings, and may be necessary, to a degree, to balance higher propeller thrustline offsets.

<u>Simple Answers!</u> (If you understand nothing else, here are some simple design guidelines):

- Keep the propeller offset (from VCG) minimal – visual determination is probably adequate. Reasonable offset makes it easier for a HS to "balance" the offset.
- Use an effective HS – large, far aft, aerodynamically efficient airfoil shape. (I want to shake the hand of anyone who finds a better, easier and more reliable pitch stabilizer than a HS!)
- Avoid large, nose-lowering windscreens and low, draggy airframe parts. Any dragline offset (from CG) or other aerodynamic forces that, unbalanced by the HS, cause the airframe to fly nose lower, are G-load destabilizing and increase the HS requirement! – Just as does a high prop thrustline!
- Plan to make the HS mounting angle of incidence adjustable for later fine tuning of Power and Airspeed static stability.
- Test it to verify G-Load stability.

(Please note this discussion above does not address yaw stability or ground handling stability which may also contribute to accidents. This "dummies" discussion also does not address Airspeed or Power static stability – discussed in earlier parts of this series of articles. Poor airspeed or power stability can affect G-Load stability or make gyroplanes more difficult to fly or learn to fly. Poor airspeed or power stability can contribute to accidents. In the end though, G-load static stability, as verified by flight testing, is the true assurance of buntover resistance. But, I do not believe simplistic answers and understanding make the safest pilots. I believe all pilots should fully understand the deeper technical issues involved with their safety. Knowledge is safety! Better knowledge and understanding allow better and safer decisions. I would encourage gyro pilots to try to understand the detailed parts of this series of articles, but I managed to keep this part 6 shorter to help as many people as it can!)

I did it! Two pages! - Fly safe, Greg