GYROPLANE ASTM STANDARDS – PART 2

Flight Static Stability

By Greg Gremminger

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This series of articles will address specific sections of the ASTM Gyroplane Design and Performance standard. The intent of this series of articles is not to publish the entire standard. The intent of these articles is to address gyroplane issues which historically have been the safety challenges of gyroplanes. Hopefully, the impact of this series of articles is that people flying gyroplanes will be better equipped to make good safety decisions about what we fly and how we fly it. Specifically, the ASTM standards sections to be addressed in this series of articles address the flight characteristics of static stability, controllability, and maneuverability.

I would like to point out one thing often as we go through these articles. We focus on the issues of pitch stability, not to infer these are inherent and unavoidable safety issues. This new standard is the good news about gyroplanes – they need not be the dangerous machines that earned the stigmas of the past. When properly designed, especially in the flight stability areas, gyroplanes can be inherently the safest form of sport aviation. And, they can be that safest form of flight WITHOUT sacrificing the unique maneuverability and performance capabilities that attract us to gyros in the first place! We are spreading the good news and knowledge that we do know how to do this, and the negative reputation of the past need not continue!

STATIC and DYNAMIC PITCH STABILITY:

Longitudinal (pitch) stability has been a traditional major safety issue with many gyros. Pilot Induced Oscillations (PIO), Buntovers, and Power Pushovers (PPO) are pitch stability issues. Technically, these issues involve both STATIC and DYNAMIC stability performance.

As it turns out, the STATIC longitudinal stability performance issues are rather easily and safely specified and tested. DYNAMIC longitudinal stability performance is not nearly as easily or safe tested. DYNAMIC pitch stability testing should only be attempted by professional test pilots and engineers that fully recognize the implications of possible DYNAMIC instabilities. Even though the ASTM Gyroplane standard does specify

DYNAMIC longitudinal stability criterion, we will not be suggesting that anyone, other than manufactures with the proper expertise and resources, attempt to verify DYNAMIC longitudinal stability of gyros!

But, if we don't test dynamic stability, can we really tell if our gyro is safe from PIO, buntovers or PPO? The answer is a conditional "yes" – STATIC pitch stability testing may also significantly reduce susceptibility to the dynamic stability issue of PIO. Buntovers and PPO (a form of a "buntover") are STATIC pitch stability issues. Meeting the STATIC criterion can significantly reduce the possibility of both a buntover and of PIO.

PIO is a dynamic pitch stability issue!! Dynamic pitch stability in aircraft is most commonly achieved with an adequately effective horizontal stabilizer (HS) – on any aircraft. But, an adequately effective HS is also a common required element for effective STATIC stability – sized and tuned to balance other airframe static moments such as propeller offset and airframe aerodynamic pitching moments (large sloping enclosures, windscreens, long draggy landing gear, etc.) As it turns out, especially when reasonable static stability criteria are met by the effective use of a HS, that HS is most likely of adequate effectiveness to provide acceptable dynamic stability as well.

The point here is, for most common gyros, achieving reasonable STATIC stability with the use of a horizontal stabilizer will likely also assure reasonable dynamic stability. Except for LSA manufacturers who are required to actually test dynamic stability, most of us can feel assured that, if our gyro uses an effective HS to meet the ASTM STATIC longitudinal stability criteria, dynamic stability will be reasonably safe! On such gyroplanes that use a horizontal stabilizer to achieve static stability, we probably do not need to test the dynamic pitch stability performance - we only need to test the STATIC pitch stability performance to be reasonably assured that that gyroplane will not either bunt or PIO. Note also that PIO is not the real "killer" in PIO incidents. A (dynamic) PIO becomes fatal when it ends in a (static) "buntover" or PPO! If static pitch stability criteria are met, it becomes very difficult to "buntover"! Even if you were able to initiate a PIO – which can be very difficult with a HS effective enough to make the gyro statically stable – it really will have very little tendency to dynamically PIO to the stage of a buntover!

"STATIC" STABILITY vs. DYNAMIC STABILITY:

What is "STATIC" stability? The "*Glossary of Gyroplane Terms*" is available at http://www.magnigyro.com/USA/feature_articles/GyroTerms.pdf. (This glossary is recommended as an important reference for better technical understanding of gyroplanes and technical articles such as these.) The *Glossary* includes the following explanations:

Stability:
The property of an object or system that self-maintains or self-restores that object or system to steady state or equilibrium. A stable object or system will maintain equilibrium and will self-restore equilibrium if disturbed. An example of stability is a ruler hung from one end – when disturbed from vertical, it restores itself to its original vertical hanging

position and remains in that steady state hanging position – disturbances do not cause it to "fall over" as it would if it were balanced on the other end. Restoration to equilibrium is accomplished without external control or effort. *See also "Instability," "Positive Stability" and "Negative Stability."*

Static Stability:
The property of a system or object to self-restore to equilibrium or steady state condition upon a disturbance. For aircraft, static stability is the tendency to return to trimmed state after a disturbance is introduced. The tendency to return to equilibrium can go too far, resulting in overshoot of the target, resulting in dynamic instability. Static stability infers positive static stability as opposed to negative static stability. *See also Stability", "Dynamic Stability," "Positive Stability" and "Negative Stability."*

Dynamic Stability:
The property of a dynamic system or object whereby oscillations or movements, once started, tend to damp out or reduce in amplitude over time. Dynamic stability infers positive dynamic stability as opposed to negative dynamic stability. *See also "Stability" and "Dynamic".*

Pitch static stability means that if the airspeed or G-load is disturbed from its "trimmed" or steady state, the gyro will inherently try to return to that original "trimmed" or steady state condition. Aircraft pitch stability can be indicated by other parameters such as climb or descent, airframe angle of attack, deck attitude or even rotor RPM. But, all of these parameters are interactive in such a way that they can most readily be observed and measured in terms of airspeed and G-Load.

A "disturbance" can be either natural or pilot-induced. Disturbances often come in the form of an airspeed or G-load disturbance, either from the wind or a pilot input. An important disturbance that is often overlooked can be a power or thrust change.

We normally measure STATIC stability by introducing a disturbance in the form of a pilot input, and watch to see that the aircraft returns to its normal "trimmed" steady state condition. A statically stable aircraft will return to the initial steady state condition – maybe after a few oscillations, but it will return to original steady state. An unstable aircraft will, once disturbed, continue to "diverge" from its "trimmed" steady state condition, and not return to the original "trimmed" condition without pilot help!

Only a system (or aircraft flight parameter) that is "statically stable" will try to restore itself to the "trimmed" condition. In doing so, it may do so quickly, it may do so slowly, or it may even "overshoot" and oscillate around the steady state condition until it settles down to the steady condition again. This is the DYNAMIC stability response of the aircraft or parameter. If a system or aircraft is not statically stable, it will also not be dynamically stable because it never tries to return to its steady state. In the extreme, a buntover is an example of static pitch instability – once it pitches nose-down, sometimes even just a little bit, instead of trying to re-steady itself, it inherently just continues to pitch the nose lower even faster. The point is, there is no need to worry about Dynamic Stability until you have a Statically Stable system or aircraft.

HOW DO I TEST IF MY GYRO MEETS THE STATIC STABILITY CRITERIA?

For the ASTM Gyroplane standard, we examine the two aircraft parameters of airspeed and G-Load to verify that the aircraft tends to return these parameters to steady state upon a "disturbance". The disturbances examined are Power, Airspeed and G-Load changes. The intent is to determine that the aircraft inherently restores itself to the original "trimmed" condition ("trimmed" airspeed or 1g) – without pilot input. If the trimmed condition tends to continue or "diverge" from that 1g or "trimmed" airspeed condition, this gyro has the potential to "buntover".

We express these STATIC stability criteria in terms of static disturbances:

- **Power Longitudinal Static Stability,**
- **Airspeed Longitudinal Static Stability, and**
- **G-Load Longitudinal Static Stability.**

The next three parts of this series will examine these criteria, a simple testing method for each of them, and some of the aerodynamic principles involved with those criteria.

These STATIC criteria are safe and easy to measure, and will readily indicate the degree of static stability of a particular gyro. But, perhaps more important to many of us, these criteria, or flight tests, will identify certain flight limits beyond which our gyro may exhibit negative, or unstable static stability traits – PIO or buntover potential. It is important to know these limits. Even though a particular gyro might not exhibit the "perfect" static stability characteristic as set as a criteria in the ASTM standard, we can identify the limits, such as Vne, beyond which we should not venture lest the inherent instability beyond that limit surprise us some day!

These static tests may also help us identify when aerodynamic configuration improvements might stretch the operating envelope of our gyroplane and further increase the safety margins of our normal operations.

Fly safe, Greg