GYROPLANE ASTM STANDARDS – PART 4

AIRSPEED Longitudinal Static Stability

By Greg Gremminger

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Part 3 of this series of articles discussed the ASTM Gyroplane standard section on POWER Longitudinal Static Stability. This part in this series of articles is specifically addressing the standard's section on AIRSPEED Longitudinal (pitch) Static Stability. The next part in this series will review the third Longitudinal Static Stability issue of G-Load Static Stability.

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

<u>AIRSPEED Longitudinal Static Stability:</u>

What the standard says:

4.5 Stability (*Note 1*)

4.5.3 Static Longitudinal Airspeed Stability

4.5.3.1 The longitudinal control must be such that, with constant engine power, an aft force and movement of the cyclic control is necessary to achieve an airspeed less than any available trim airspeed;

4.5.3.2 The longitudinal control must be such that, with constant engine power, a forward force and movement of the control is necessary to achieve an airspeed greater than any available trim airspeed; and,

4.5.3.3 The control force gradient must not reverse during any progressive application of control movement at airspeeds greater than Vmin up to Vne.

4.5.3.4 Conditions--Static longitudinal airspeed stability must be met at the following power and trimmed airspeed conditions:

(1) Steady altitude at MPRS,

(2) Full power at the lesser of Vh or of Vne,

(3) Engine idle at MPRS, and

(4) Engine idle at 80 % Vne.

MPRS -	minimum power required airspeed
Vh -	straight and level airspeed at full power
Vmin -	minimum controllable level flight airspeed, IAS
Vne -	never exceed airspeed, IAS

Note 1: Extracted, with permission from F2352-04a Standard Specification for Design and Performance of Light Sport Gyroplane Aircraft, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. A copy of the complete standard may be purchased from ASTM (www.astm.org).

(The following discussion assumes calm air, no wind disturbances. This is the condition that all associated flight testing should be conducted in.)

HOW TO TEST A GYRO FOR AIRSPEED LONGITUDINAL STATIC STABILITY:

There are a variety of methods that could be used to understand a gyro's safety and the limits of operation in according with the standard. An example of a simple and effective test is described below. This test does not purport to identify a totally failsafe aircraft, but it should be very indicative of potential problem areas. This is not intended to be a fully definitive test method for gyroplane manufactures who wish to "comply" with the full ASTM Gyroplane standard. But, for those of us who would want to determine how safe our gyro is, ask more informed questions, or determine the safe limits of operation of our gyro, the following Airspeed Stability test is described:

Airspeed Longitudinal Static Stability Test:
(Note this test is similar to, and accomplishes the same thing as the *Static Speed Stability test* described in the ***Thrustlines and Horizontals Stabilizers*** article published in the August, 2003 issue of *Rotorcraft* magazine.)

CAUTION: Do not perform this test, if the Power Stability test was not completed satisfactorily in the test in the previous part of this series of articles.

CAUTION: The following test should only be conducted by a pilot who is experienced and proficient in that particular gyro. Higher airspeeds and gyros that are highly airspeed unstable may be a precursor to Pilot Induced Oscillations (PIO) and buntover incidents.

NOTE: Take special note to differentiate between cyclic stick **POSITION** and the **PRESSURE** (or pilot force) on the cyclic stick. **POSITION** of the stick is different than the pilot **PRESSURE** that must be applied to the stick. Stick **POSITION** and stick **PRESSURE** are two different parameters that should be measured and considered separately. It is entirely possible – on an unstable gyro – for the stick **POSITION** and the stick **PRESSURE** changes to be in opposite directions.

- Perform this test only in calm, no wind conditions at an altitude of at least 2000 ft.

  NOTE: A cockpit adjustable trim makes the testing very simple to do. Simply adjust the trimmed airspeed to the initial test airspeed, and verify that forward cyclic pressure and POSITION is required for an approximate 10 mph higher airspeed. Then verify that aft cyclic pressure and POSITION is required for approximately 10 mph slower airspeed than the "trimmed" airspeed. Repeat these tests at 10 mph "trimmed" airspeed steps between Vmin and Vne, at MPRS power, full power and idle power. The intention of the test is simply to assure that the cyclic PRESSURE and POSITION are in the same direction as airspeed changes – under all airspeed and power conditions. The following provides a step-by-step procedure – even if cockpit airspeed trim is not available.

- **Test at MPRS Power:** Establish steady straight and level airspeed and power for MPRS. This is the airspeed that requires minimum power to maintain altitude. (For a typical single-seat gyro, this might be about 50-55 mph with about 65% power setting.)
- Note your "trimmed" airspeed.
- Without changing the engine power setting, slowly apply forward cyclic stick pressure to slowly increase airspeed to about 10 mph higher airspeed. Hold the cyclic stick steady and allow the airspeed to steady out at this higher airspeed.
- Forward stick PRESSURE and a further forward stick POSITION must be required to maintain that higher airspeed. If less forward stick PRESSURE or less forward stick POSITION is required to maintain the higher airspeed, the aircraft is not statically speed stable at that airspeed and further testing should not be continued. This condition might indicate a divergent airspeed condition requiring proficient pilot skill to prevent possible initiation of PIO.

  CAUTION: DO NOT proceed to testing at higher airspeeds if the initial criteria above are not satisfied. This would be an indication that possible stability concerns are present and the test should not be conducted at higher airspeeds where those concerns might be worsened.

- Without changing the engine power setting, slowly further increase the airspeed again by approximate 10 mph, hold the stick steady and allow the airspeed to steady out at this higher airspeed. More forward sticks PRESSURE and a more forward stick POSITION must be required for every increase in airspeed. If at any airspeed, less forward stick PRESSURE or POSITION is required to maintain the higher airspeed, this indicates an unstable divergent airspeed condition at this airspeed.

  NOTE: If adjustable trim is available, it will be easier to detect increasing stick PRESSURE and POSITION if the aircraft is trimmed for hands-off at each initial condition.

- Repeat the above step with increasing airspeeds up to Vne (Never Exceed Speed).

  Note: If at a higher airspeed, reduced forward stick PRESSURE or POSITION are required to maintain that higher airspeed, a lower airspeed than this should be considered Vne for that aircraft. Above that Vne airspeed, airspeed would be statically unstable and those higher airspeeds should be avoided.

- **Repeat test at FULL Power:** Repeat the above steps with **FULL** power, starting again at MPRS airspeed. This full power condition at MPRS will likely result in a strong climb. Increased incremental airspeeds – approximately 10 mph at a time – should require increasing forward stick PRESSURE and POSITION to establish the incrementally higher airspeeds. Continue testing at incrementally higher airspeeds – increasing forward stick PRESSURE and POSITION, up to Vne airspeed. If at any point, less stick PRESSURE or POSITION is required to maintain that airspeed, discontinue testing – this airspeed should be considered Vne for that aircraft. (This testing is exactly the same as the first steps above, except that it is conducted at **full** power, rather than MPRS level flight power.)

  NOTE: If available, adjusting the airspeed trim to each incrementally higher airspeed will make it easier to determine if increasingly forward stick PRESSURE or POSITION is required for each increased airspeed. From the trimmed condition at any airspeed, forward stick PRESSURE and POSITION must be required to establish a higher airspeed. Increase trimmed airspeed incrementally about 5 mph on each step, to see if forward stick PRESSURE and POSITION is required to increase airspeed above that "trimmed" airspeed.

- **Repeat test at IDLE Power:** Repeat the above steps with engine **IDLE** power, starting again at MPRS airspeed. This idle power condition will result in a considerable descent – especially at higher airspeeds in the test. Increased incremental airspeeds – approximately 10 mph at a time – should require increasing forward stick PRESSURE and POSITION to establish the incrementally higher airspeeds. Continue testing at incrementally higher airspeeds – increasing forward stick PRESSURE and POSITION, up to 80% of Vne airspeed. If at any point, less stick PRESSURE or POSITION is required to maintain that airspeed, discontinue testing – this airspeed should be considered Vne for that aircraft. (This testing is exactly the same as the steps above, except that it is conducted at **idle** power.)

- Repeat the above tests, at the three different power levels, each starting at MPRS airspeed, this time with **DECREASING** 10 mph airspeed decrements – **AFT stick PRESSURE and POSITION for decreasing airspeeds.** Decreasing airspeeds should be tested down to Vmin – not zero airspeed! At all points the stick PRESSURE and stick POSITION must be incremental increases in **AFT** PRESSURE and further **AFT** POSITION. If less aft stick PRESSURE or less aft stick POSITION is required to maintain a lower airspeed, the aircraft is not statically speed stable at that airspeed and further testing should not be continued.

This condition also might indicate a divergent airspeed condition requiring proficient pilot skill to prevent possible initiation of PIO. (This testing is exactly the same as the steps above, except that it is conducted for speeds **below MPRS airspeed**, down to Vmin)

NOTE: Stick PRESSURE and stick POSITION from "trimmed" condition must always be in the direction of speed changes – Positive slope of the control curve. If the stick PRESSURE or stick POSITION reverse direction – negative slope of the control curve – at any point in the test above, the discontinuity in control PRESSURE or stick POSITION can lead to difficult control and possibly to PIO or bunt-over.

CAUTION: DO NOT conduct additional tests if any of the above tests do not meet the stick PRESSURE or POSITION criteria.

- The above tests should also be conducted at different aircraft loading conditions of normal, minimum and maximum gross weight, and CG extremes. For 2-place gyroplanes especially, testing should verify stability under all loading conditions. Any loading conditions that result in an unstable condition should be considered outside the allowable loading conditions, and identified on the weight and balance documents in the aircraft.

Figure 4A illustrates the proper airspeed (and pitch) reaction to cyclic fore/aft pressure and movement for a fixed power setting.

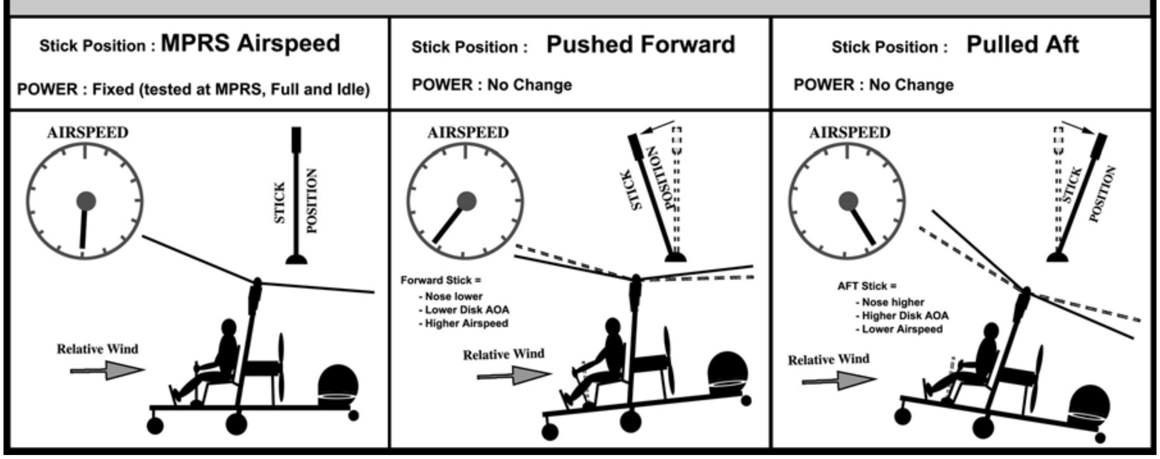

Figure 4A

Forward Cyclic Position and Pilot Push - Higher Airspeed
Aft Cyclic Position and Pilot Pull - Lower Airspeed

EXPLANATION of CONCEPTS:

This concept of longitudinal static airspeed stability is the cornerstone of aircraft stability requirements. As described in the previous part 3 of this series of articles, any statically airspeed stable aircraft will inherently "trim" to maintain a steady airspeed without pilot input. To be able to "trim" the gyroplane to any airspeed, and have that gyroplane maintain that airspeed, or tend to return to that airspeed if disturbed from it, indicates that gyroplane is statically airspeed stable – at that airspeed and under those loading and power conditions. However, the traditional way to verify airspeed pitch stability is with the test described above. The technical description of this criterion is that the slope of the control curve of stick PRESSURE AND stick POSITION should be positive in relation to the resultant airspeed. That should be true at all airspeeds (and all power conditions which were also tested in the previous article – Part 3.) In simple words this means that to go faster you must push the stick further forward, and to go slower, you must pull the stick further aft. If at any point in this test, or at any airspeed, it requires less "push" on the stick to go faster, the aircraft is statically airspeed unstable at that airspeed. The same is true if it requires less "pull" on the stick to go slower at any point or airspeed. The slope of the control curve should be positive, or upward sloping at all points.

Gyroplanes are notorious for often having little or no "feel" in the cyclic stick. The "feel" of the stick can be the result of the rotor arrangement or of the actual airframe static stability. Gyro pilots often successfully learn how to fly gyros with "no feel" in the stick. However, it is by more desirable for any aircraft to have some tactile "feel" or stick "feedback" PRESSURE to the pilot. To have "no feel" in the stick may be acceptable for the very experienced pilot, but it will be more difficult for the novice pilot to master the pitch control of the aircraft. "No feel" in the stick can lead to pilot over-control and Pilot Induced Oscillations (PIO).

In most cases, the fore or aft POSITION of the stick will result in faster or slower gyroplane airspeed. Except for gyros that would have a radically unstable airframe, the positive slope of the stick POSITION vs. airspeed curve is assured because the rotor head spindle tilt directly controls the rotor cyclic action and the airspeed. Unless the airframe pitch reaction (in the wrong direction) to airspeed would completely exceed the rotor disk angle of attack at that airspeed, a forward stick **POSITION** will likely result in a higher airspeed. However, the cyclic stick **PRESSURES** are not so assured. Even if there is little or no "feel" in the stick, there should at least be a real POSITION change in the stick for different airspeeds. That POSITION control curve, vs. airspeed, should always have a positive slope – forward to go faster and aft to go slower.

For this test, we start at a moderate cruise airspeed, or MPRS, to start verifying that stick pressures and movements are in the positive direction relative to airspeed. Then we incrementally repeat the test at increasing airspeed steps – up to Vne. Note, an airspeed point where the slope of the control curve might reverse itself – become airspeed unstable – might be the determination of Vne – never exceed airspeed! Ideally, the aircraft would achieve positive slope of the control curve all the way up to and beyond it's structurally or power derived Vne. But, if an aircraft becomes unstable at any high airspeed, that airspeed, less some margin of safety, should be considered the Vne of that aircraft. The “control curve slope” should be positive also under all power conditions – idle power up to full power.

Figure 4B illustrates an airspeed stable control curve and a couple of examples of airspeed unstable control curves.

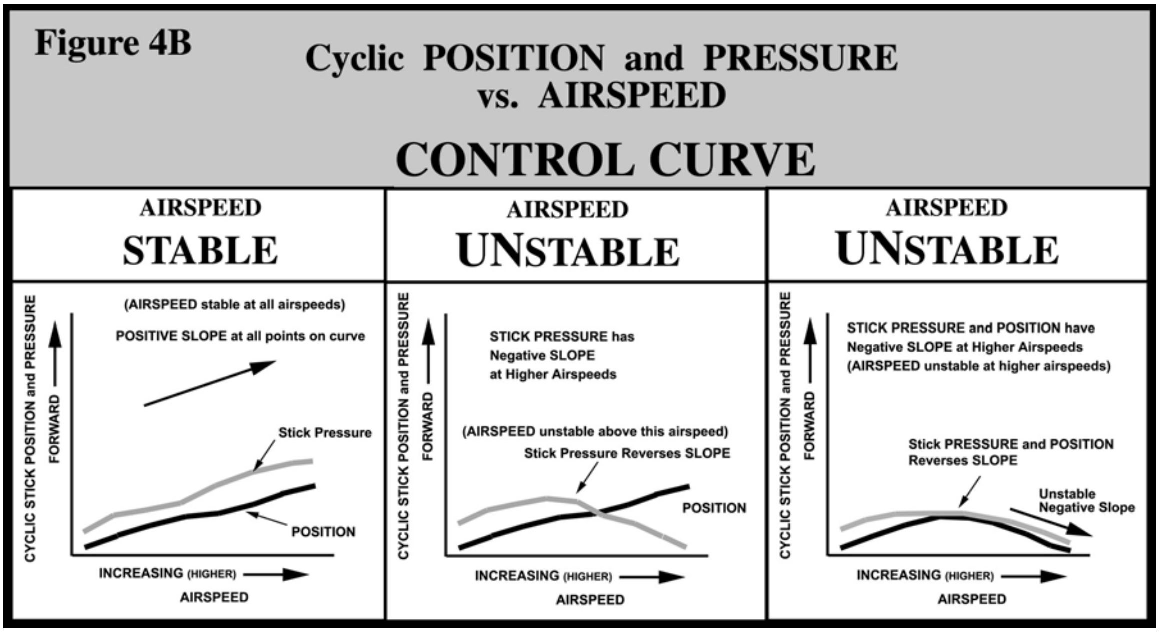

Figure 4B Cyclic POSITION and PRESSURE vs. AIRSPEED — CONTROL CURVE

How could the control curve have a reverse slope? The rotor and rotor arrangement (airfoil, “feathering hinge” point, RPM, blade flexibility, etc) can affect the “feel” or even reverse pressures in the cyclic stick. Typically, forward cyclic movement will lower the nose and initiate an increase in airspeed. However, as that airspeed builds, it is also possible that the aerodynamic moments on the airframe (large sloping windscreens, long, draggy landing gear, floats, etc.) can “drag” the nose to far lower attitude as airspeed increases. If this airspeed induced lower airframe flight attitude is more than that attitude change required for the rotor to maintain that higher airspeed, as airspeed builds to higher speeds, the stick position and pressure required to maintain that higher airspeed can be even further aft than the original starting stick position and pressure!

Because this airspeed stability can be different for different airspeeds, we repeat the tests at incrementally decreasing airspeed points – to verify positive slope of the control curve all the way down to Vmin. Vmin, minimum controllable airspeed, is the airspeed below which there is inadequate power available to maintain altitude. This is a point in airspeed way below the peak of the power curve. For numbers of reasons, many gyros might not provide a continuing positive control slope at all airspeeds below Vmin. The requirement in the ASTM Gyroplane standard is only that this positive control slope be maintained at airspeeds down to Vmin. However, it is important and covered in other sections of the ASTM standard that, at any airspeed and with any power setting, the pilot be able to reestablish higher airspeeds by lowering the nose with forward cyclic. At airspeeds below Vmin, this is more a function of the CG balance (proper hang test arrangement), than of the stability characteristics of the gyroplane.

All of these criteria should be verified at all conditions of aircraft weight and balance. Especially for 2-seat gyroplanes, these tests may require repeating at different loading weights and balance – at least at the midpoint and extreme conditions.

Sidebar 1:

As a student pilot, you may recall your instructor constantly drumming two concepts into your head:

- **STICK controls AIRSPEED**
- **POWER controls ALTITUDE.**

This is actually an expression of the different concepts of AIRSPEED stability vs. POWER stability. The pilot should control airspeed by adjustments in the fore/aft POSITION of the (cyclic) stick. A change in stick POSITION should result in a change in airspeed. A change in power should result in a change in altitude – not airspeed. The pilot should control climb or descent or level altitude by adjustments in power. This is true for airplanes as well.

Although an aircraft may be set up differently, where a change in power results in a change in “trimmed” airspeed, it is has been traditionally found that pilots relate more readily, especially in the learning phase, to the Power/Altitude, Stick/Airspeed correlation. And, aerodynamically, it is easier to arrange that correlation in most aircraft.

WHY AIRSPEED STABILITY?

This ASTM standard section 4.5.3 requires that the gyroplane inherently, without pilot input, tend to maintain the “trimmed” airspeed and tend to return to that airspeed automatically if disturbed from that airspeed. This is the traditional definition of airspeed static longitudinal stability. Aviation history and experience has confirmed that this characteristic makes aircraft control most intuitive to pilots.

Some may argue that “airspeed” might be the only static longitudinal stability criteria necessary for gyroplanes. Other measurable parameters, such as angle of attach, G-Load, climb, etc. are also interactive with each other and with airspeed, and might be solely measured or specified to establish longitudinal static stability. However, stability testing techniques do typically include related testing of other stability indicators. Especially for gyroplanes, where there are additional “freedoms of movement” (non-fixed wing and other rotor parameters), it is helpful and insightful to specify multiple pitch parameters as a function of disturbances. Therefore, for the gyroplane standard, and for more definitive determination of stability issues and causes, we verify three longitudinal static stability criteria – Power, Airspeed, and G-Load.

These three static stability criteria and tests, conducted in sequence as described in this series of articles, provides a progressive determination of pitch static stability - working up to perhaps the most important criteria, G-Load stability. But, all three of these static longitudinal stability criteria are important, and can reveal important aspects of possible hazard potentials of a particular gyro. Therefore, the gyroplane standard addresses all three sets of criteria and the sequential testing of all three tests as outlined in this series of articles is recommended.

HOW DOES THIS AIRSPEED TEST WORK?

This test is quite simple in concept. It simply means that to fly at a faster airspeed, the cyclic stick must be pushed forward to a new POSITION. This cyclic POSITION establishes a new “trimmed” airspeed. Further increases in steady airspeed must require further forward cyclic stick PRESSURE (push) and stick POSITION – to establish a new, faster “trimmed” airspeed condition. The cyclic stick POSITION sets the “trimmed” airspeed of an airspeed statically stable aircraft.

The same is true for decreasing “trimmed” airspeed – aft stick PRESSURE and POSITION must be required for to fly at slower airspeeds. This test simply verifies that the pilot must push or pull the cyclic stick to a new POSITION to go faster or slower. And, the direction of this stick push or pull and POSITION must be in the same direction as the change in airspeed.

The cyclic stick POSITION should determine the “trimmed” airspeed of that aircraft for that power and loading condition. When we “trim” the airspeed of the aircraft, we essentially adjust the spring and other forces to balance the cyclic stick in a fore/aft “trimmed” POSITION. But, this “balanced” trimmed stick POSITION is what actually establishes the “trimmed” airspeed of a longitudinally statically stable aircraft.

When something disturbs the airspeed from its “trimmed” airspeed, such as a strong wind gust, the statically stable aircraft will automatically tend to return the airspeed back to its “trimmed” airspeed. This means if the wind were to suddenly let up and the instantaneous airspeed of the aircraft would be much less than the “trimmed” airspeed, the aircraft will automatically drop its nose to try to restore the airspeed to its higher “trimmed” airspeed. The opposite is true for a strong wind gust that suddenly presents more airspeed to the aircraft – the nose will rise to try to slow the airspeed. These automatically airspeed restoring pitch changes do not require any pilot input or any change in the cyclic stick POSITION.

This test, where the pilot simply determines if stick PRESSURE and POSITION are required to establish a new “trimmed” airspeed condition, is the simple way to verify positive static stability. The test pilot needs no instrumentation or special testing equipment or even special expertise. The pilot must simply be able to determine if increased stick PRESSURE and a different stick POSITION are required to establish a different "trimmed" airspeed – and that that PRESSURE and POSITION change is in the same direction as the airspeed change. This is a simplified form of exactly what professional test pilots do with much more sophisticated test equipment and skills. Professional test pilots often attempt to quantify the degree of stability or stability margins. For LSA purposes, and for practical safety evaluation, this test simply verifies that airspeed longitudinal static stability curve is positive, not negative, at all airspeeds over the range of available power.

Positive stability is not a cause for gyroplane accidents. Gyroplane accidents are often associated with negative, statically (and dynamically) unstable, gyros. This test is intended to determine when, and perhaps under what conditions, the longitudinal airspeed static stability might be negative and unsafe.

WHAT DO THE RESULTS MEAN?

What if my gyro does not meet the Airspeed Stability test above? If the cyclic stick POSITION does not correlate in the right direction with increasing or decreasing "trimmed" airspeeds, that gyro is dangerously unstable. The airframe itself is aerodynamically unstable – probably not near enough horizontal tail "volume" to balance the area in the front! Correct this situation before proceeding.

If the stick POSITION correlates properly with airspeed, but there is little or no PRESSURE "feel" on the stick, this can make pitch control of the aircraft less precise, less precisely timed, and can lead to over-control by less experienced pilots. Ideally, stronger cyclic stick "feedback" pressures might allow novice pilots to more readily master flight control. A stronger tactile "feel" to the pilot inherently tempers pilot reactions on the stick. If a pilot can "feel" the pressure he or she is exerting on the stick, that tactile "feedback" path is more immediately perceived by the pilot – even subconsciously. This immediate tactile "feedback" reduces over-reaction and over control by the less experienced pilot. The "feel" of the stick can provide a precise and immediate feedback measure of the pilot's control input. When the aircraft pitch (and airspeed) reacts predictably, in the right direction and amount, the pilot quickly "tunes" the stick "feel" with the desired aircraft response.

If there is little or no tactile "feel" in the stick, the pilot must wait for other "feedback" indicators to verify the stick movement has resulted in an aircraft reaction. Normally, that next "feedback" indicator, if the tactile "feel" of the stick is not present, is when the nose of the aircraft raises or lowers – a visual cue! The delay in this "feedback" cue can result in a delayed timing reaction, or over-reaction because of the delay in response of the nose. With no "feel" in the stick, the pilot must wait a bit longer to also gage the amount of the reaction to his/her stick input – and make corrective inputs based on that delayed and less precise feedback.

As pilots becomes more experienced, they develop another important instantaneous "feedback loop" in their control of the pitch and airspeed of the aircraft. Even if there is little or no tactile pressure feedback – "feel" – in the stick, an experienced pilot begins to sense or "feel" the result of stick movement in the "seat of their pants" – G-Load on the butt! This is a real pilot "feedback loop", how heavy they feel in the seat as a result of the G-Load produced, that aids in precise airspeed and pitch control. The "seat of the pants" flight sensation can only be developed through practice. This sensory "feedback loop" helps to explain the improvement of flight proficiency skills as a pilot develops experience. And, this developed "seat of the pants" control skill probably helps explain why some experienced gyro pilots seem to be able to safely fly their unstable gyro very precisely and safely. The more "feedback" sensory "loops" available to the pilot, especially instantaneous "feedback loops" such as stick "feel" and seat-of-the-pants, the more precisely the pilot controls the aircraft and avoids over-control that can lead to buntovers and PIO in gyros. But, without the initial instantaneous cyclic "feedback" stick pressure, sensed immediately in the pilot's arm and hand on the stick, it can take a lot of flight experience for new pilots to develop the compensating skills – especially the "seat of the pants" sensory "feedback" loop.

The more traditional reason to require longitudinal static airspeed stability is that this reduces the skills and continuous workload required to fly and maintain a consistent airspeed. Maintaining a consistent and controlled airspeed is important for a number of reasons. During landings, takeoffs and close-to-the-ground flight, it is essential to maintain the airspeed that provides performance margins. All aircraft fly best at a certain airspeed that should be maintained on landing approaches and on climb-outs. Flight at lower airspeeds, behind the power curve, can result in steeper approaches and hard landings, or even getting caught "behind the power curve" and sinking to the ground. Even at altitude, proper maintenance of the desired airspeed assures speed and range performance.

Consistent and precise airspeed control is a full time job in the air. An airspeed statically stable aircraft does most of this work for you. Without having to constantly "chase" airspeed with cyclic stick inputs, the pilot of an airspeed statically stable gyroplane mostly needs to just monitor and maintain height and direction. In an airspeed unstable aircraft, the pilot, even an experienced pilot, at least subconsciously needs to constantly work to maintain consistent or desired airspeed. We often hear gyro pilots exclaim how they find it much easier and much less tiring to fly a stable gyroplane as opposed to an unstable gyro that requires constant work – even if that "work" might be automatic and subconscious to an experienced pilot! The effort to fly an unstable gyro is akin to balancing a yardstick vertically in the palm of your hand – you can learn to do it, and with practice it can be easily done without thinking. But, your brain and arm is still working! Compare this to the statically stable condition of hanging the yardstick from one end from your fingers – takes no learning curve and really no effort – the yardstick is doing all the work hanging there because it is inherently statically stable!

When airspeed or precision pitch control becomes important, on landing flare or in response to a disturbance for instance, it is imperative that the aircraft quickly respond to pilot inputs in the expected or normal direction and amount – the pilot doesn't have time to wait for a slow visual cue – "feel" in the cyclic stick is immediate and can be the critical tactile cue!

So, if your gyro does not meet the criteria of the tests above, if the slope of the control curve actually reverses at some airspeed or condition, that aircraft can present real risks to any pilot that has not become precisely skilled in those control quirks! Reverse control can certainly lead to over control and PIO, or even over-reactive buntover responses from the pilot. If the "slope of the curve" is negative at any point, fix the problem before proceeding, and certainly avoid flying in those conditions.

If your gyro has minimal cyclic stick PRESSURE ("feel") or POSITION correlation with airspeed, this gyro does require superior skills to learn to fly. This may not be a safe gyro for a student in the learning phase – the learning phase to develop proficiency to fly such an aircraft can be hundreds of flying hours. (Look at an aerobatic aircraft – specifically set up to have light controls and rapid responses. I know of no regular airplane pilots, even if they have hundreds of flight hours, that would dare try to fly a Pitts Special without long hours of dual training).

This airspeed stability criteria can be much different between different aircraft, and especially among gyros. Two place trainer gyroplanes may have more cyclic stick "feedback". Flight skills mastered to fly such trainer gyroplanes may not be adequate practice toward flying your lighter, much different "feeling" gyro. For this reason, even after development of good flight skills in the trainer gyroplane, a lot of supervised "transition" practice can be required to develop similar handling skills in your different gyro. The value of investigating the airspeed static stability of your gyro is to recognize and respect possible deficiencies or reduced margins of safety and how to avoid those potential safety concerns – don't fly in turbulence or in questionable flight conditions (power/airspeed, etc.) These sometimes very different control reaction and "feel" characteristics of less stable gyros, as compared to the handling characteristics of airplanes or stable gyroplanes, can help explain why there seem to be a lot of buntover and PIO accidents among experienced airplane pilots in gyros. Know the limits of your gyro and what that means to your pilot proficiency limits as well. Don't expect that just because it "feels" good to you at your normal flight conditions, those docile handling characteristics may be the same at different corners of the "flight envelope" of speed, power, turbulence and loading. Test your gyro to see where there may be areas of operation that require more caution or even avoidance.

HOW CAN I FIX ANY PROBLEMS?

Do not continue to the next static stability tests (G-Load static stability) until any negative stability characteristics uncovered in this test are resolved. If, at any operational airspeed, the cyclic stick PRESSURE or POSITION is reversed from the required positive control slope – this issue must be fixed.

Negative airspeed static stability can be the result of a rotor or rotor head design. Rotor systems can be designed to minimize stick feedback PRESSURE. Often, people have presumed light stick forces are desirable in gyro rotors to provide rapid maneuvering capabilities. However, this can be taken too far where the airspeed stability is even negative. Actually, rotors are inherently statically **UN**stable. This is certainly undesirable and was addressed by Igor Bensen himself in the employment of the offset gimble" rotor head design. A properly employed offset gimble, with its balancing "trim spring", can neutralize the natural static instability of the rotor. Some gyros rotor heads may not employ either the offset gimble or the integral trim spring. Without these components, the fixed "trimmed" airspeed may be higher than operational airspeeds and require constant and tiring stick back pressure by the pilot to fly the gyro slower than its natural "trimmed" airspeed. Essentially, the pilot is the "trim spring"; and flight at any airspeed other than the inherent "trimmed" condition of that gyro requires constant pilot pressure or pull on the stick. Even though the stick PRESSURES and POSITION may be in the proper direction and amount, with the lack of an inherent" trimmed" condition, it is hard to say the gyro is statically stable if it is always trying to go faster. In this case, a normal offset gimble and trim spring arrangement is recommended. Just the application of a trim spring will greatly reduce pilot workload and improve enjoyment, not to mention the control and safety benefits!

Most airspeed unstable gyros are not unstable because of the rotor. Basic airspeed static instability is most often the result of airframe instabilities – wrong direction pitch reactions of the airframe to disturbances (wind, pilot input, power changes, G-Loads). Any disturbance to the aircraft or airframe must cause the airframe pitch to respond in the direction that will correct for that disturbance. For airspeed, that means a loss of airspeed will automatically cause the nose to drop to recover airspeed. Vice versa for a sudden increase in airspeed – wind gust.

The most common way to ensure that the airframe pitches in the stabilizing direction in response to an airspeed change, is to do it the same way an airplane does it. I am not saying here that a horizontal stabilizer (HS) is the only way to stabilize a gyro. But, in an airplane, the down-lift of the HS balances the nose-down pull of the CG forward of the wing lift. The most straight forward way to stabilize a gyro airframe may be to install a HS arranged to provide a down-lift in response to airspeed - to lift and balance the CG forward of the rotor lift. As in basic airplane aerodynamics 101, that you study to be an airplane pilot, the down-lift of the HS changes with airspeed and causes the nose to rise or fall appropriately to compensate for that change in airspeed. Therefore, when the aircraft deviates from the "trimmed" airspeed, the HS down-lift changes and raises or lowers the nose to cause the aircraft to speed up or slow down to recover its "trimmed" airspeed.

The key to a HS providing airspeed static stability is that the HS produce a down load in response to airspeed. For a gyro, due to some intricate rotor technicalities, some may technically argue that the HS of a gyro does not actually need to be producing an actual download. This argument suggests that a gyro may be slightly positively stable even if the HS is producing neutral lift (no up or down lift). This would suggest that a neutral lift

HS, or even no HS might provide some degree of static airspeed stability. However, the gyro airframe is a major aerodynamic element that must also respond in a stable manner to external disturbances. Any erroneous pitching of the airframe couples into the rotor and may aggravate stability. The margin of static airspeed stability, with only stabilized rotor effects, is meager and may produce no helpful stick “feedback” PRESSURES. Typically also, with no HS, the changes in CG location, up, down and fore/aft with loading, power, and airspeed, can present destabilizing attributes that may far overcome any stabilizing rotor effects!

Conversely, a strongly uplifting HS can also destabilize the gyro simply because it will cause the pitch to change in the wrong direction as a result of an airspeed change. Note, that the down-lifting HS prescription for static airspeed stability is likely the same prescription suggested for Power stability in the previous article. There may be other ways to “skin the cat” of gyroplane stability, but the HS remedy is probably the most straight forward and easiest to employ and understand.

If you haven’t deciphered the answer as to what you can do to improve airspeed static stability, the short answer is to install an effective HS with at least a neutral or negative angle of incidence relative to the keel. Determining whether this properly improves airspeed stability or not, requires re-testing the static longitudinal airspeed stability as described above. From that point, a bit of thoughtful interpretation may be required. Adding more HS negative incidence, will add static airspeed stability by forcing the CG further forward of the rotor lift. This is very good, as long as the reaction to power changes does not negatively affect the Static Power Stability criteria in the Part 3 article. If the power (propwash) reaction on the HS is too much, the remedy might include less “immersion” of the HS in the propwash and a more effective HS to react to free-air stream airspeed changes. (A “more effective HS” can include larger, airfoil shaped and/or mounted further aft on the tail.) And, the application of an effective HS to remedy static stability issues, will also provide a strong degree of dynamic stability – a necessary attribute as well, and a natural by-product of using a HS for these static stability reasons.

In the Part 5 of this series we will investigate the ASTM standard criteria for G-Load Longitudinal Static Stability – the next step in this process.

Fly safe, Greg