CULTURAL PARADIGM:

- “Gyros can handle high winds”

- Greg Gremminger

(To be published in *Rotorcraft* magazine)

It is our hope that we can help more gyro pilots make safer decisions about how they fly their gyro – especially about flying in windier conditions. Toward that goal, to perhaps provide more and better background information to make better decisions, I would like to expand on an issue that may not be well-enough understood or respected.

Sometimes there are long-promoted cultural paradigms that promote poor decisions. It is an often-heard statement: “Gyro's can fly in high winds.” This may be our most dangerous paradigm about gyros. While it is true that a rotor is much less sensitive to turbulent wind because of its effectively very high “wing loading,” it is an improper conclusion that the entire gyro would therefore safely handle gusty winds. Whether a gyro is safe to fly in gusty winds or not is a factor of the aerodynamic stability characteristics of the AIRFRAME – the rest of the gyro – the dynamic response of that airframe to a disturbance (wind gust or g-load).

The presumption that a gyro can handle gusty winds must be highly qualified as to the characteristics of THAT particular gyro and the skill of the gyro pilot to control THAT particular gyro

While it may be true that a rotor is much less sensitive (than a wing) to wind turbulence, it is not always true that the gyro, itself, is therefore insensitive to the wind or safe to be flown in gusty winds. The rotor is a very powerful “wing,” and can respond very quickly and powerfully to cyclic inputs. Any “un-commanded” cyclic inputs from improper pitch responses of the airframe can dramatically amplify those improper airframe movements and further aggravate the gyro response.

Whether a gyro is stable and safe to fly in gusty winds depends in large measure on the aerodynamic stability of the AIRFRAME – the response of the airframe to wind or g-load disturbances. An airframe which responds in the wrong or divergent direction to wind or g-load transients can readily couple improper direction, un-commanded cyclic inputs into the rotor. It would take a pilot, very highly skilled in that particular gyro, to “dampen,” prevent, or correct these un-commanded rotor cyclic inputs. That pilot control reaction must be of proper timing and amplitude to prevent rapid divergent or oscillatory response of the whole gyro. On some gyro configurations, these airframe divergent responses can occur at a rate that would be very difficult, if not impossible, for even the most skilled pilot to properly react to and correct. In many cases on such gyros, the pilot’s reactive response would likely be of such improper timing (“phase”) so as to actually amplify or “resonate” the disastrous divergent response of the gyro/pilot system – Pilot Induced Oscillations (PIO) or Bunt-Over.

Gyros can, however, with proper aerodynamic stability design, be very much less sensitive to wind turbulence or even pilot commanded disturbances. A gyro, whose airframe is aerodynamically configured to respond in pitch in the proper direction and at the proper rate, will couple those un-commanded stabilizing cyclic inputs to the rotor. The rotor will then cause the whole gyro to respond in the stabilizing or corrective direction to dampen or prevent divergent or oscillatory response of the whole gyro – without pilot input, and without exciting improper pilot reaction. These un-commanded rotor cyclic inputs themselves, on a well-stabilized gyro, will then reduce or prevent any improper divergent or oscillatory gyro response.

A horizontal stabilizer is the most important component of a stabilized airframe. Although, a horizontal stabilizer, alone, does not necessarily assure a properly stabilized gyro, it is probably not possible to properly stabilize a gyro without one. A stabilized airframe, which responds in pitch in the proper direction and rate, is not wholly the function of the horizontal stabilizer. The horizontal stabilizer must be properly designed to “balance” other aerodynamic and inertial factors of the airframe.

It is not a simple matter to determine if proper gyro stabilization and insensitivity to gusty winds is present in a particular gyro. Certainly the presence of a very large horizontal stabilizer, placed well aft on the airframe is a good indication. Also, a propeller thrustline and an airframe or fuselage Center of Drag relatively well-aligned with the Center of Gravity (CG) of the airframe is a good indication. But, often, a subjective determination can be misleading – good or bad! Probably the best indication that a gyro MAY fly safer in gusty wind conditions would be the accident record of similar configuration gyros – do your research and make your decisions accordingly - of what to fly in what winds by a pilot of your skills and experience!

It would be well for all gyro pilots to exercise a high degree of caution in any gyro that has “questionable” historic safety in turbulent wind. But, don’t assume anything. The insidious nature of PIO and other pitch-related issues is that they are not readily apparent, and in fact are deceptively unapparent for many gyros that might seem to be “stable” when flown in typical mild conditions. The dangerous responses of a particular gyro may not be apparent until just the right conditions are present, and only after it is too late!

Have a safe Day!

(Rotorcraft Editor, The partial Glossary below is intended to be a separate complete single page in the mag. This might be a standard page in every issue – a Glossary of Gyro Terms. The page below has terms selected because they are used in the article above. Each issue of the mag would have a page for the Glossary of Gyro Terms that might be specific for articles in that particular issue. The gyro terms selected below are related to the discussion in the article above. – Greg)

GLOSSARY OF GYRO TERMS

- By Greg Gremminger

The Glossary of Gyro Terms is provided as a technical resource to help the gyroplane community better understand the technical and safety discussions and issues with gyroplanes. The Gyro Terms detailed below are a portion of the full Glossary of Gyro Terms available on the PRA website at : http://www.pra.org/gyroterms.pdf. Each issue of **Rotorcraft** *will publish selected Gyro Terms.*

Aerodynamic: Relating to the flow of air around a body and that body's reaction to that flow of air. An aerodynamic shape is one that allows air to flow smoothly.

Airframe: The structure of an aircraft. The frame itself often made of tubes, or the entire fuselage. Typically, "airframe" refers to the entire gyroplane less the rotor.

Bunt-Over: A sudden forward uncontrolled forward tumble about the pitch axis in a gyro; unrecoverably fatal. A bunt-over is a self-sustaining divergent nose-down pitching motion, accelerated and propagated by rapidly changing or diminishing balancing moments on the airframe. Typically, when the nose-down pitch of the airframe and/or rotor disk reaches a certain point, the nose-down pitching self-perpetuates and accelerates (positive feedback) to result in a full forward tumble. "Power Push-Over is one form of a "Bunt-Over", but not necessarily the only form of a bunt-over. A "Bunt-Over" is not necessarily a PPO. Without adequate gyroplane configuration design, a bunt-over can be initiated by wind gust, pilot over-reaction, or sudden power changes. See also "Power Push-Over".

Center of Drag – CD: The point on an aircraft or aircraft component where all of its drag can be considered to act. CD is often specified separately for vertical and horizontal axes. I.e.: VCD is the point on the airframe where there is equal drag above and below.

Center of Gravity – CG: The point on an aircraft or aircraft component where all of its mass can be considered to be concentrated. The aircraft will rotate around the CG point if all the forces on it are not balanced about this point.

Commanded: An input from the pilot in the form of a control movement. Commanded inputs by the pilot may be intentional or unintentional such as a reaction to a sudden perception of attitude change. See also "Uncommanded".

Damping: The effect of a component or configuration that tends to reduce the natural oscillations of an object or system and restore it the system back to stable equilibrium. All physical systems can exhibit rotational dynamic oscillations, such as in pitching the nose up and down. Without damping in such systems, the oscillations will continue indefinitely. As applies to gyroplanes, damping may be affected by a horizontal stabilizer, the offset gimbal/trim spring configuration, the pilot, friction or even an autopilot system. See also "Damping Moment". Without damping

Diverge: To move or change farther from a central point or initial condition. The opposite of converge. Divergence usually indicates negative stability or instability – upon disturbance, the system continues to change further from it's initial condition.

Divergence: The condition or property of a system to diverge. See also "Diverge".

Dynamic: Changing, as opposed to static or not changing. Dynamic usually refers to an object that changes its motion or rotation or forces or moments as a result of a disturbance – a change from the initial or static condition. PIO or pitching actions are examples of DYNAMIC reactions of a gyroplane to wind gusts or pilot reactions.

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

G – Load: The force due to accelerating a mass so that its effective weight is more or less than it is when at rest or steady movement. G-load on an aircraft in straight and level calm air is 1 "g". G-load on an aircraft deviates dynamically when the aircraft is maneuvered or disturbed from straight and level flight such as in a turn, upon flare for landing, with pitch commanded pitch maneuvers from the pilot or by uncommanded lift or pitch disturbances from wind gusts. On a gyroplane, g-loads significantly below 1 "g" , or zero "g" or negative "g' should be avoided as the autorotating rotor will slow in RPM – Rotor RPM is a function of the "g" load or lift provided by that rotor.

Horizontal Stabilizer – HS: A horizontal flying surface placed on the tail of an aircraft to provide a stabilizing moment tending to keep the aircraft aligned in pitch with the relative wind upon disturbance. The HS adds dynamic stability in pitch in the form of reduced lag and overshoot in control response. The Horizontal Stabilizer serves to damp the natural oscillatory pitch tendencies of the aircraft. A horizontal stabilizer on an aircraft is normally arranged to provide a down force or negative lift to balance the CG forward of the lift vector so as to provide airspeed stability. A horizontal stabilizer on a gyro is normally rigged for the same purpose but is also arranged so that the down force on the tail maintains the VCG forward of the Rotor Thrust Vector for pitch stability. The effectiveness of the HS is a function of its size, its moment arm from the CG of the aircraft, its airfoil shape efficiency, and any enhancement from the effect of propwash immersion. See also "Damper", "Horizontal Tail Volume", Airspeed Stability", Vertical

Center of Gravity", "Rotor Thrust Vector" and "Stabilizer".

Oscillation: A dynamic (moving) condition of an object or system alternating between opposite peaks. An oscillation has both amplitude and frequency. Most Oscillations are Sine waves or sinusoidal. An example of an oscillation is a pendulum in a Grandfather clock. Oscillations can be constant, such as in a clock, or diminishing to zero amplitude such as when a child's swing comes to a rest when the child stops swinging his/her legs. Oscillations can also be of divergent amplitude, meaning the swings get larger and larger. An example of such "divergent" oscillation is the destructive "flutter" of an airplane's "un-damped" elevator control surface. Another example of a "divergent" oscillation is Pilot Induced Oscillations. See also "Frequency", "Period", "Amplitude" and "Pilot Induced Oscillation".

Stability: The property of an object or system that self-maintains or self-restores that object or system 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".

Un-Commanded: A control input that is not commanded by the pilot. Usually refers to a cyclic input from motions of the airframe that cause the rotor Spindle to change. See also "Commanded".