GLOSSARY of GYROPLANE TERMS

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By Greg Gremminger and participants of the Rotorcraft.com Conference Forum

This Glossary is intended as a knowledge resource for gyroplane enthusiasts for consistent understanding of technical and training discussions and articles.
The latest version of this Glossary can be found at http://www.magnigyro.com/gyroterms.pdf

1-Per Rev:

Usually referring to rotor vibration cycles that occur once for every complete revolution of the rotor. 1-Per Rev rotor vibrations are caused by mass or aerodynamic imbalance of the rotor – the Center of Mass and aerodynamic Centers not concentric to the spinning axis of the rotor.. Rotor vibrations may be felt in either the cyclic control stick or in the airframe. 1 Per Rev vibrations can be verified if they continue in a zero airspeed vertical flat decent – no forward airspeed to create confusing 2-Per Rev vibrations. *See also "Center of Mass," "Aerodynamic Center," "Rotor Shake," "Tracking," and "2-Per Rev."*

2-Per Rev:

Usually referring to rotor vibration cycles that occur twice for every complete revolution for a 2-bladed rotor system. Some 2-Per Rev rotor vibrations are inevitable to some extent in semi-rigid 2-blade rotor systems at forward airspeeds due to varying total rotor drag as the blades move from lateral alignment to longitudinal alignment. Other 2-Per Rev rotor vibrations can be generated by a mis-match of the teeter height and the coned CG of the rotor, and by looseness or "slop" in the teeter pivot and support. 2-Per Rev rotor vibrations or shake is usually felt more in the cyclic control stick rather than in airframe vibrations. 2- Per Rev vibrations can be verified if they decrease or disappear at very low or zero forward airspeeds. *See also "Coning Angle," "Rotor Shake," and "1-Per Rev."*

Acceleration:

A change in velocity. A change in either speed or direction or both. In physics, the rate of change of velocity over time. An accelerating object is speeding up, slowing down, or changing the direction in which it is moving. Acceleration is a vector quantity—that is, it has both a magnitude and a direction. Acceleration describes both the magnitude of an object's change in velocity, and the direction in which it is accelerating. Acceleration can thus involve changes of speed, changes of direction, or both. As acceleration is a rate of change of velocity over time and velocity *See also "Velocity," "Vector" and "Force."*

Advancing Blade:

The rotor blade that is moving into the oncoming airstream caused by forward flight of the aircraft. For most gyroplanes, the advancing blade is on the right side of the aircraft. The advancing blade has a higher relative airspeed than the retreating blade. *See also "Retreating Blade" and "Dissymmetry of Lift."*

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.

Aerodynamic Center:

In discussions of rotors, the point on a rotor at which the lift (or thrust) is assumed to act. Ideally, the aerodynamic center of all rotors would be located exactly on the spinning center of the rotor. Concentricity of the Aerodynamic Center with either the Center of Mass or the Geometric Center is a function of the precision fabrication of the rotor. Ideally, all three "centers" must be mutually concentric for minimum rotor, airframe and stick vibrations. See also "Geometric Center" and "Center of Mass." For a wing or airfoil, Aerodynamic Center is often used similarly to Center of Lift. *See also "Center of Lift."*

Airfoil:

The profile of a rotor blade (or wing) that would be present if the blade was sliced from the leading edge to the trailing edge. The term "airfoil" also often used to refer to the actual airfoil or lifting surface itself.

Airframe:

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

Airspeed:

Motion relative to the air. The air may be moving past a point or a body may be moving through the air. An airfoil requires airspeed to maintain lift. Airspeed is typically indicated as Miles per Hour (MPH) or feet per second. *See also "Velocity," "Speed" and "Vector."*

Airspeed Stability:

The tendency of an aircraft to self-restore airspeed to the "trimmed" airspeed upon an airspeed disturbance. Typically, the horizontal stabilizer is configured with an amount of down-lift proportional to free airspeed so as to balance the CG located forward of the Thrust Vector (of the rotor or a wing). As airspeed decreases below the "trimmed" airspeed, the down-lift of the horizontal stabilizer would also decrease, allowing the nose to lower and restore airspeed to the "Trimmed" airspeed. Vice-versa upon an increase of airspeed. The amount of down-lift (or the incidence angle) of the horizontal stabilizer typically helps determine the "trimmed" airspeed. *See also "Power Stability" and "G-Load Stability."*

Airstream:

The flow of air past a reference point. Airstream is normally depicted as a vector with amplitude and direction. *See also "Airspeed," "Free Air," and Vector."*

All Flying Tail**:**

An all moving vertical surface on the tail of an aircraft that serves as both a Vertical Stabilizer and a Rudder. The all flying tail pivots on a vertical axis via normal rudder controls. *See also "Vertical Stabilizer" and "Rudder."*

Amplitude:

A term borrowed from physics which is used to indicate the height of a curve or the maximum value of some variable under measurement. Amplitude often refers to the maximum deviation of an oscillation. *See also "Oscillation."*

Angle of Attack – AOA:

The angle between the chord line of an airfoil (rotor blade) and the relative wind or airflow acting on that airfoil. The AOA and airspeed on an airfoil determine the lift and drag of that airfoil. AOA may be positive or negative – positive refers to an AOA that creates an upward lift on the airfoil. Sometimes AOA can also refer to the angle between the longitudinal axis of an object (aircraft, enclosure, etc.) and the relative wind.

Angle of Incidence – AOI:

The angle between the chord line of an airfoil and the angle of the airframe. AOI typically refers to the angle at which an airfoil is mechanically mounted on an airframe.

Anti-Servo Tab:

The servo tab is a small hinged surface on the trailing edge or a movable control surface that deflects via a link such that it always acts to return the control surface to center. It provides force feedback to the pilot's controls and restores the surface to neutral in the event of a cable failure. Used commonly on Tall Tail designs and other control surfaces that are pivoted about the quarter chord point. *See also "Tall Tail."*

Attitude:

The angle of an aircraft or body with respect to a reference axis. Commonly used to define an aircraft's orientation in roll, pitch and yaw. For instance, "pitch attitude" would refer to the nose-high or low attitude of an aircraft. Attitude could also refer to the attitude of a rotor or other component on a gyro.

Autorotation:

A self sustaining rotational mode of a rotor wherein flight RPM is sustained from the air passing up though the rotor disk. For autorotation, the AOA of the rotor blades are reduced to near zero so that an unstalled condition exists on most of the rotor blade length. An inner portion of each rotor blade produces lift in a direction that tends to drive the rotor forward, and portions nearer the tips produce lift in a direction that tends to retard the rotor. The "driving" and "driven" forces exactly match at the operating RRPM and sustain rotation. Autorotation requires no power to the rotor and is the mode employed in gyroplane rotors to provide lift. Autorotation is utilized in helicopters when power to the rotor is lost. *See also "Driving Area," and "Driven Area."*

Axial:

Orientation or movement in line with an object's axis of rotation. A jet engine's thrust is an example of axial flow.

Axis:

The imaginary line around which something rotates. The major axes of an aircraft are Lateral, Longitudinal, and Normal and motions about these axes are pitch, roll, and yaw.

Balance:

The state of equilibrium at which an object or system remains at its steady state condition. Think of a child's teeter-totter balanced at level with two people of equal weight on each end. Balance is most often used in discussions of gyroplanes as the condition at which all the forces or moments acting on the gyro total to zero. For instance, the total nose-down pitching moments and the total nose-up pitching moments acting on a gyro might add to zero when in a steady, "balanced" 5 degree nose-down steady flight attitude. *See also "Moment" and "Force."*

Blade Flap:

A term commonly used to describe excessive, violent rotor blade motion. Most often occurs when rotor rpm is too low in relation to the forward speed of the gyro during takeoff roll. The word "Flapping" by itself is used to refer to the normal in-flight teetering or articulation of a rotor which helps reduce dissymmetry of lift. *See also "Rotor Blade Flapping."*

Bump:

See "Mast Bumping"

Bunt-Over:

A sudden uncontrolled forward tumble about the pitch axis in a gyro; unrecoverable 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 Power Push-Over. 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" and "Power Torque-Over."*

Center of Drag – CD:

The point within an aircraft or aircraft component where all of its drag can be considered to act. I.e.: CD is the point on an airframe where there is equal drag above and below. The CD of a rotor acts through the spinning center of the rotor. *See also "Center of Lift" and "Center of Pressure."*

Center of Gravity – CG:

The point within an aircraft or aircraft component where all of its mass can be considered to be concentrated and the point at which the weight of the aircraft can be said to be acting. The aircraft will rotate around the CG point if all the forces on it are not balanced about this point. An object at rest will be balanced if the object is supported or hung from its CG. *See also "Mass" and "Inertia."*

Center of Lift - CL:

The point on an airfoil, on an aircraft, or on any aircraft component where all its forces of lift can be considered to act with no resulting pitching moment. On a rotor blade, the center of lift exists as a line, usually about 25% back from the leading edge. On a complete rotor, the CL is approximately at the spinning center of the rotor. On an airframe, the CL is a complex function of all the surfaces on that airframe that often result in a pitching moment about the aircraft CG.

Center of Mass:

Another term for Center of Gravity (CG). On a gyroplane rotor, the static center of mass is the point on the rotor hub rotor at which the rotor with all of its blades balances. Ideally, the center mass of a rotor would be located exactly on the spinning center of the rotor. "Geometric "Stringing" of a 2-blade rotor system is intended to align the chordwise center of mass directly over the spinning center of the hub bar in order to minimize mass unbalance and shake of the rotor system. However, concentricity of the Center of Mass with either the Geometric Center or the Aerodynamic Center is a function of the precision fabrication of the rotor. Ideally, all three "centers" must be mutually concentric for minimum rotor, airframe and stick vibrations. *See also "Aerodynamic Center" and "Geometric Center."*

Center of Pressure – CP:

The average location of the aerodynamic pressure on an airfoil. The pressure varies around the surface of an object moving through the air and results with lift and drag on the object. Aerodynamic forces act through the center of pressure. The location changes with angle of attack, so engineers define the aerodynamic force which acts at the aerodynamic center, while the aerodynamic pitching moment varies with angle of attack. CP is often used synonymously with Center of Drag. *See also "Center of Drag."*

Centerline Thrust – CLT:

A gyro configuration which has the propeller thrust passing through or very near the vertical center of gravity (VCG) of the aircraft. This minimizes the static pitching moments on the aircraft due to propeller thrust.

Chord: (Line):

The straight line distance from the leading edge to the trailing edge of an airfoil (rotor blade). The chord line is used as a reference for the angle of attach of airflow around that airfoil. *See also "Airfoil."*

Chord Balance:

The procedure whereby a rotor blade or wing is mass balanced with respect to Center of Lift - a line running parallel to the leading edge and roughly 25% back from the leading edge. Chord balance also is used commonly to refer to the procedure or mechanism whereby the chord-wise CG of a 2-blade rotor is adjusted to coincide with the spinning axis of the rotor. *See also "Span Balance" and "Center of Lift."*

Commanded:

A pilot control input, usually 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."*

Compressibility:

The ability of air molecules to be packed more tightly under pressure at airspeeds approaching the speed of sound, leading to changes in lift and drag at a rotor's tip called compressibility effects. The affects of compressibility become more prominent at the tip of rotors at high rotor RPM and can lead to decreased efficiency and possible blade "runaway." *See also "Speed of Sound" and "Runaway."*

Coning Angle:

The rotor disk assumes a slight cone shape in flight with load or weight on the rotor system. The degree of "coning" is the result of the combination of centrifugal force and lift on each blade causing each rotor blade to assume a slight up upwards tilt a few degrees. The coning angle changes with g-load changes and with Rotor RPM. The coning angle determines the vertical center of mass of the coned rotor. The nominal center of mass or coning angle determines the proper "teeter" height to minimize 2-per rev rotor shake as a result of cyclic input into the rotor system. Changes in coning angle from changes in g-load serve to immediately change Rotor RPM due to conservation of momentum in the rotor – similar to a skater spinning faster when their arms are drawn closer to their body. *See also "Rotor RPM," "Teeter Height," Rotor Shake" and "2-Per Rev."*

Converge:

To move or change toward a central point or final stable condition. The opposite of diverge. Convergence usually indicates positive stability – upon disturbance, the system returns to a specific stable condition.

Convergence:

The condition or property of a system to converge. *See also "Converge."*

Couple:

Engineering term referring to an effect on one component from a movement or change in another. Uncommanded cyclic inputs from a pitching gyro airframe are said to be "coupled" to the rotor through movement of the spindle with the airframe. *See also "Cyclic"and "Spindle."*

Cyclic:

The joystick, or control stick in a gyro or helicopter used to cause the individual rotor blades in a spinning rotor system to change in pitch in a cyclic fashion according to it's rotating position around the full circle. The cyclic control is normally used to maneuver a gyro or helicopter in roll and pitch much as the joystick in an airplane. Also used as an engineering term to refer to synchronously varying forces or conditions on the individual rotor blades as the rotor (or any spinning object) rotates through a full circle.

Damping (Dampening, Dampen):

The effect of a component or configuration that tends to reduce the natural oscillations of an object or system and restore 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."*

Damping Moment:

A dynamic or changing moment on the airframe that tends to act in a corrective direction of instantaneous rotation of the airframe so as to reduce the amplitude and stop or prevent the oscillation. As applies to gyroplanes and all aircraft, the horizontal stabilizer is a component that tends to exert a moment on the tail of the aircraft in the direction so as to resist or restore pitch attitude and deviation to restore the system to static equilibrium. *See also "Damping."*

Density:

Mass per unit volume. The density of air changes with temperature, pressure, and humidity, affecting takeoff distance, engine performance, etc.

Density Altitude:

A calculation based on air temperature and pressure which determines the effective altitude of a location compared to the same location at sea level on a standard day. A higher density altitude infers thinner air and reduced performance of engines and airfoils and the resultant reduced performance of aircraft.

Dissymmetry of Lift:

In a rotorcraft in forward flight the advancing blade will have a higher airspeed than the retreating blade. This causes unequal lift on opposite sides of the rotor known as Dissymmetry of Lift. A teetering or flapping rotor provides a means to re-establish equality of lift by effectively changing the angle of attack between the advancing and retreating rotor blades. *See also "Teeter."*

Disturbance:

An engineering term for any changing external force initiating a dynamic change in equilibrium. In flight, a wind gust will cause a disturbance to the trimmed or steady flight condition. A pilot may introduce a disturbance in the form of a control input to maneuver or change the flight condition of the aircraft. A disturbance, such as a wind gust or pilot reaction may initiate other dynamic responses of the aircraft or pilot. In engineering terms, a disturbance can initiate a "transient" response in an aircraft or object or component of an aircraft. *See also "Transient" and "Wind Gust."*

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."*

Drag:

The tendency of an aerodynamic object to resist the flow of air over its surface. The equivalent of friction between moving objects. Drag is a force on the object that is considered to act in the direction exactly opposite to relative airflow direction – acting to try to slow the object's airspeed. Drag is always acting in a direction exactly perpendicular to Lift. The vector sum of both lift and drag is the Thrust Vector. *See also "Lift" and "Thrust."*

Driven Area (of Rotor):

The outboard portion of the rotor in autorotation which provides the bulk of the lift and drag of the rotor system. *See also "Driving Area."*

Driving Area (of Rotor):

The inboard portion of a rotor in autorotation which has part of the lift force directed forward along the path of the rotor, propelling it. This forward acting component of the lifting force provides the force that propels the rotor to spin against the drag forces produced by the outer, driven portion of the rotor. *See also "Driven Area."*

Drop Keel:

A gyro configuration that arranges the rear most part of the central keel lower than the front keel, allowing the seat to be raised and the propeller lowered so the center of gravity of the gyro can be placed closer to or lower than the propeller thrust line. *See also "Centerline Thrust."*

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. *See also "Static."*

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".*

Dynamics:

The study of objects or systems in changing motion.

Embedded (HS):

Placed inside. An embedded horizontal stabilizer is in the propeller propwash to some degree so as to be influenced by the propwash as a function of engine power applied.

Energy:

The capacity of an object (mass) to perform work as the result of its motion or its position in relation to forces acting on it. Energy associated with motion is known as kinetic energy (i.e.: inertia of a gyro in flight), and energy related to position is called potential energy (i.e.: altitude of a gyro in flight).

Feathering Axis:

The axis about which a rotor blade rotates as it increases or decreases its pitch. The position of this feathering axis forward or aft of the center of lift line of a rotor blade affects the stability of the rotor blade and the forces that rotor blade transmits into the rotor controls.

Feedback:

The process of a portion of an output or result influencing an input control. For example, feedback from the feel of the controls and the attitude of the aircraft provides information (feedback) to the pilot to influence the pilot's control inputs. Negative feedback – in the opposite sense or direction of the output result - tends to reduce a disturbance and usually serves to stabilize a system. Positive feedback tends to amplify or worsen a disturbance and can lead to unwanted divergence or oscillations or PIO. Improper feedback timing, lag or lead, can also result in overshoot or divergence or oscillations in the resulting response of the system. A common example of positive feedback is the squeal of a sound amplifier when the microphone is in front of the output speakers. *See also "Negative Feedback" and "Positive Feedback."*

Fixed-Stick:

A test flight procedure in which the pilot locks the control stick and rotor head spindle. A fixed-stick condition in a gyroplane causes the rotor disk to follow aircraft attitude and changing attitude through cyclic action of the spindle with the movement of the airframe. In a fixed-stick flight test, the test pilot notes the response of the aircraft to disturbances from trimmed flight. Fixed-stick is the opposite condition to Free-Stick. *See also "Free-Stick."*

Flap:

See "Rotor Blade Flapping"

Flapping:

See "Rotor Blade Flapping"

Force:

In physics, any action or influence that accelerates an object. Force is a vector, which means that it has both direction and magnitude. When several forces act on an object, the forces can be combined to give a net force. The net force acting on an object, the object's mass, and the acceleration of the object are all related to each other by Newton's second law of motion. Force is created by a propeller or rotor as thrust. *See also "Thrust," "Acceleration" and "Vector."*

Free Air:

Refers to the undisturbed air flowing past an aircraft. Free air flowing over an aircraft in flight causes lift and drag on aerodynamic surfaces on an aircraft. Stabilizing surfaces on an aircraft are intended to react in lift and drag according to the free air flow over the aircraft in order to compensate for the free air reactions of the aircraft or aircraft components. Another component of the airflow over a stabilizing surface may be the accelerated air in the propwash of the propeller. *See also "Embedded" and "Horizontal Stabilizer."*

Free-Stick:

A test flight procedure in which the pilot allows the control stick and rotor head spindle to float or move free – hands removed from the cyclic stick. A free-stick condition minimizes the influence of any gyroplane airframe movements on the rotor disk and generally allows improved stability of a naturally unstable gyro. In a free-stick flight test, the test pilot notes the response of the aircraft to disturbances from trimmed flight. Free-stick is the opposite condition to Fixed-Stick. *See also "Fixed-Stick."*

Frequency (of Oscillation):

The rate of oscillation normally indicated as Cycles per Minute or Cycles per Second. Higher frequencies of oscillations have shorter periods between peaks of that oscillation. *See also "Oscillation" and "Period."*

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. *See also "Dynamic."*

G - Load Stability:

The tendency of an aircraft to restore any g-load disturbance or variation back to the original 1g loading. Any disturbance, wind or flight path change, will change the g-load of the aircraft – it's effective weight. G-load stability infers that the attitude of the rotor disk and its resultant lift force will self-adjust to restore the g-load back toward normal 1g. In a gyroplane, g-load stability means that the Rotor Thrust Vector (RTV) is physically located aft of the CG of the aircraft. This is verified in flight testing by increasing the g-load on the aircraft by establishing a steady bank, and verifying that aft stick pressure is required to maintain the original straight and level trimmed airspeed. In the banked and turning flight, the CG located forward of the RTV, causes the nose to pitch lower, requiring aft stick pressure to maintain original airspeed. This is analogous to g-load stability in an airplane that also requires the CG to be forward of the Thrust Vector of the wing. G-load instability would be indicated by the requirement to provide forward stick pressure to maintain original straight and level airspeed while in a banking turn. G-load instability would result in divergent pitch and airspeed resulting from a g-load disturbance – upon reduced g-load in a down gust for instance, the nose of the aircraft would drop, further reducing the g-load on the aircraft and continuing this process to increasing nose-down pitching. *See also "Airspeed Stability" and "Power Stability."*

Geometric Center:

The point on the rotor hub rotor that is equidistant from the blade tips and symmetrically aligned chordwise with the rotor blades. Ideally, the geometric center of a rotor would be located exactly on the spinning center of the rotor. "Stringing" of the rotor blades is the process by which the blade attach angles are adjusted so that the blades are geometrically symmetrically aligned chordwise with the center of the hub bar. "Stringing" the rotor blades is intended to align the chordwise Center of Mass directly over the spinning center of the hub bar in order to minimize mass unbalance of the rotor system. However, concentricity of the Geometric Center with either/both the Center of Mass or the Aerodynamic Center is a function of the precision fabrication of the rotor. Ideally, all three "centers" must be mutually concentric for minimum rotor, airframe and stick vibrations. *See also "Aerodynamic Center" and "Center of Mass."*

Ground Effect:

The improvement in lift as a wing or rotor is close to the ground - within about one rotor diameter or wing span from the ground, due to interaction of the circulating air around the airfoil with the ground. Ground effect increases with closer proximity to the ground.

Groundspeed:

The speed of an aircraft relative to the ground. Ground speed is different than airspeed if there is any wind.

Harmony:

The interaction of two or more dynamic components or systems that create or support beneficial or sympathetic dynamic responses in each other. Harmony occurs when interacting dynamic components, such as the pitching of the airframe, the pitching of the rotor and the reactions of the pilot support or combine their natural response rates toward a beneficial result. Harmony refers to DYNAMIC interactions of inertial components in motion as opposed to STATIC "balances" or equilibrium. When used to describe gyroplane dynamic responses, "harmony" infers that the dynamic inertial components of the gyroplane combine to resist or prevent (or "harmonize") the interactions of the airframe, rotor and pilot so as to avoid or prevent oscillations or divergence or overshoot of gyroplane reactions. *See also "Resonance" and "Dynamic."*

Harmonic:

Referring to two or more frequencies of oscillation that are even multiple (2, 4, ½, ¼) of each other frequency, so that one frequency may excite a resonance with the other frequency. *See also "Resonance" and "Harmony."*

High Propeller Thrustline:

Propeller thrust which acts on a line or "Vector" passing above the center of gravity of the gyroplane, tending to a nose-down pitching moment on the airframe. A high propeller thrustline tends to move the longitudinal CG aft with the nose-down tendency when power is applied – reducing stability when power is applied. The larger the propeller offset, the larger horizontal stabilizer moment is required to compensate for the nose-down moment from propeller thrust. *See also "Centerline Thrust" and "Low Propeller Thrustline."*

Hinging:

Australian term for "flapping". *See "Rotor Blade Flapping."*

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 more precision and reduced overshoot in control response. The Horizontal Stabilizer serves to dampen 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. A HS can be arranged to react to both Free Airflow and accelerated airflow from propwash. *See also "Damping," "Horizontal Tail Volume," Airspeed Stability," Vertical CG," "Rotor Thrust Vector," "Moment," "Stabilizer," "Embedded" and "Free Air."*

Horizontal Tail Volume:

The mathematical product of the area of the horizontal stabilizer times its effective moment arm from the CG of the aircraft. Horizontal Tail Volume is a formula intended to provide a quantitative measurement of the effective power of a horizontal stabilizer on a gyro. However, the effectiveness of the horizontal stabilizer is dependent additionally upon other factors such as HS airfoil shape, enhancement from propwash immersion, other static aerodynamic moments the HS must compensate, and the dynamic/inertial factors of the airframe and rotor combination. As a simple comparison tool, the horizontal tail volume is often expressed as a percentage of the Rotor Disk Volume. *See also "Tail Volume" and "Rotor Disk Volume."*

Inertia:

The property of a moving or stationary physical object (an object having mass) to remain in that motion or to remain stationary. The property of matter that causes it to resist any change of its motion in either direction or speed. Inertia is what a person has when they fly forward against a seat belt when their car comes to a sudden stop. Inertial energy is stored in the speed of an object, and must be exchanged or dissipated in order to change or stop the motion of that object. Heavier (more massive) objects have more inertia. *See also "Momentum."*

Instability:

The property of an (unstable) object or system that causes its motion or condition to diverge or oscillate once disturbed. An unstable object or system will not self-maintain equilibrium or self-restore to equilibrium once disturbed. External stabilization is required to maintain equilibrium of an unstable object or system – i.e.: pilot skill, horizontal stabilizer, autopilot, etc. An example of instability is a ruler balanced on end – once disturbed from vertical balance, it starts to fall over at a faster and faster rate. External control and/or effort would be required maintain the ruler balanced on its end. *See also "Stability."*

Lateral:

Across, or side to side. The Lateral axis of an aircraft runs from one side to the other through the CG of the aircraft. An aircraft pitches around the lateral axis. See also "*Longitudinal*."

Lift:

The force produced by a rotor or other aerodynamic surface moving through the air. Lift acts in a direction exactly perpendicular to the relative flow of air. The amount of lift is determined by the angle of attack of the rotor or airfoil or object moving through the air. Lift is normally considered to be acting upwards, but may in fact be a downward force such as on a normal horizontal stabilizer. Lift is always acting in a direction exactly perpendicular to Drag. The vector sum of both lift and drag is the Thrust Vector. *See also "Drag" and "Thrust."*

Load:

The weight carried or supported by the lift of a rotor or wing.

Longitudinal:

Front to back. The Longitudinal axis of an aircraft runs from the nose through the CG of the aircraft, to the tail. An aircraft rolls around the longitudinal axis. The position of the longitudinal CG – forward or aft – in relation to the Lift Vector of the rotor or wing, determines the g-load stability of a gyroplane. *See also "Lateral" and "Longitudinal CG."*

Longitudinal CG – LCG:

The front to back location of the CG on the longitudinal axis of the aircraft. *See also "Center of Gravity" and "Vertical CG."*

Long-Period Oscillation:

A natural oscillating frequency of an aircraft in pitch where the period between oscillations are relatively long in time – slower rate or frequency. Typically, an oscillation period above (slower than) about 10 seconds long is considered a Long-Period. A natural oscillation period longer than about 10 seconds is more likely to be compensated by an average pilot's control timing. Long-Period oscillations, technically also referred to as Phugoid oscillations, are slow enough that the average pilot is not as likely to contribute to the resonant pitch oscillation at that slower frequency. All aircraft may exhibit both a Short-Period and a Phugoid oscillatory tendency. *See also "Phugoid," "Resonance," "Pilot Induced Oscillation," "Damping," "Period (of Oscillation)," and "Short-Period Oscillation."*

Low Propeller Thrustline:

Propeller thrust which acts on a line or "Vector" passing below the center of gravity of the gyroplane, tending to a nose-up pitching moment on the airframe. A low propeller thrustline tends to move the longitudinal CG forward with the nose-up tendency when power is applied – improving stability when power is applied. The larger the propeller offset, the larger horizontal stabilizer moment is required to compensate for the nose-up moment from propeller thrust. *See also "Centerline Thrust" and "High Propeller Thrustline."*

Low Speed Blade Flap:

See "Rotor Blade Flapping."

Maneuvering Stability:

Another term for G-load stability. *See "G-Load Stability."*

Mass:

A physics term for the quantity of matter that an object possesses as measured by its inertia. The mass of an object affects its weight on earth and its acceleration when acted on by a force. *See also "Inertia," "Weight" and "Acceleration."*

Mass Center:

The point within an object where all of its mass can be considered to be concentrated and the point at which the mass of the aircraft can be said to be acting. Often used synonymously with Center of Gravity. The Center of Mass of a rotor, to minimize rotor shake, should be located exactly on the spinning axis of the rotor. Mis-alignment of the Center of Mass to the spinning center results in 2-Per Rev rotor shake. *See also "Center of Gravity," "Mass" and "Rotor Shake."*

Mast Bumping:

Abnormal excess teeter or flapping action of the rotor blades that exceed the mechanical limits; and the excess teeter or flapping is transmitted into the cyclic stick or mast as a "Bump". A "Bump" would most often occur on takeoff roll as a result of extreme Dissymmetry of Lift where the rotor RPM has not increased appropriately to the forward takeoff airspeed of the gyroplane. An excessive or destructive "Bump" may occur upon significant Retreating Blade Stall, and may damage or even roll the aircraft. The "bump" is usually in the direction to the side of the retreating blade of the rotor. In semi-rigid 2-blade rotor systems, "Mast Bumping" is often referred to as a "Flap" or "Flapping" *See also "Rotor Blade Flapping."*

Moment:

A term used to represent a "torque" on an object such as a gyroplane that tends to rotate the aircraft about an axis. A moment is the product of a force acting on an arm ("moment arm") and the length of the arm. A moment can be thought of as leverage applied to turn or twist an object. For instance, an offset propeller thrustline provides a force pushing on a "moment arm" equal to the offset of the propeller from the vertical CG of the aircraft – tending to cause the nose to pitch up or down. Moments can be said to "balance" when the total moments in one rotation direction equal the total moments in the opposite rotation direction – i.e.: a child's teeter-totter with a weight of 50 Lbs located 10 feet from the pivot and a weight of 100 Lbs located 5 feet from the pivot on the other side. Both moments equal 500 Ft-Lb, but in opposite or "balancing" directions. *See also "Moment Arm."*

Moment Arm:

The distance from the pivot point (usually from the CG) to the point at which a perpendicular force is applied. For instance, a mechanic pulling on a 1ft long wrench would be applying that force to a 1 ft moment arm. The total moment applied would be the product of that force and the 1 ft moment arm. *See also "Moment."*

Moment of Inertia – MOI:

The rotational inertia of an object such as a gyroplane, or spinning rotor, that tends to resist a change in that rotation – either slowing down or speeding up a spinning object or starting a rotationally stationary object to rotate or spin. The MOI of an object is calculated by multiplying each chunk of mass in an object, by the square of its distance from the CG of that object (its "moment arm"). A higher MOI tends to be more difficult to start rotating or to stop rotating. The MOI of the airframe and of the rotor are important factors in the natural oscillatory frequency of a gyroplane. *See also "Inertia."*

Momentum:

The inertia of an object in motion. A physical object in motion tends to resist changes in its speed or direction due to its momentum or inertia. Momentum is the mathematical product of the mass of a moving object multiplied by its linear velocity. Momentum is a vector quantity, which means that it has both magnitude and direction. *See also "Inertia" and "Vector."*

Negative Feedback:

Reversed direction (opposite polarity) feedback from the output result to a controlling input that tends to reduce a disturbance and usually serves to stabilize a system. *See also "Feedback" and "Positive Feedback."*

Negative Stability:

The condition of instability. The tendency of an object or system to diverge from or oscillate around an equilibrium condition. An object or system that has negative stability will not maintain equilibrium or return to equilibrium once disturbed. A good website is http://142.26.194.131/aerodynamics1/Stability/Page3.html *See also "Instability."*

Neutral Stability:

The condition exactly between negative stability and positive stability. An object or system has neutral stability when it tends to neither worsen or improve its movement after a disturbance. An example of neutral stability would be a ruler pivoting on the 6-inch central pivot – when disturbed it neither returns to vertical or falls completely over. *See also "Stability," Negative Stability," and "Positive Stability."*

Offset Gimbal:

A rotor system configuration which places the pitch pivot slightly forward of the spin axis of the rotor. This offset between the pitch pivot axis and the spindle attach point results in nose-down tilting of the rotor disk with load on the rotor. This nose-down disk pitching tendency is balanced to an equilibrium or "trimmed" condition by the Trim Spring An increase in rotor thrust and g-load (from a gust) will result in the rotor tilting forward pulling against the spring to reduce the increased g-load, a stabilizing response. A rotor, of itself, is a naturally unstable system. The Offset Gimbal is an innovation used by Igor Bensen to improve the natural stability of the rotor system itself. *See also "Trim" and "Trim Spring."*

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."*

Over-Running the Blades:

A term used in gyroplane training that refers to takeoff acceleration that is too quick for the rotor to efficiently gather spinning energy from the relative wind. Such improper takeoff acceleration, without Rotor RPM that increases proportional to the airspeed, results in a "Bump" or possibly even damaging Rotor Blade Flap – Retreating Blade Stall. For the rotor to efficiently gather airspeed energy for RPM increase to flight RPM, the gyroplane must be accelerated such that airspeed proportionately matches the Rotor RPM. *See also ""Bump", "Rotor Blade Flapping" and "Retreating Blade Stall."*

Overshoot:

An engineering term used in discussions of controls that describes when the intended operation is more than or faster than intended by the control input. In discussions of gyroplane pitch control and stability, overshoot would describe the gyro pitching more quickly and further than intended by the pilot, requiring a revering control input from the pilot. This would indicate that the gyro is perhaps pitch unstable and that additional pitch damping is required. Such a condition can lead to pilot over control and Pilot Induced Oscillations. This condition was common in early gyrocopters and some current derivatives as indicated by a typical necessity to fly with "jabs and counter jabs". Proper damping design of the gyro should eliminate overshoot without reducing pitch control reaction. *See also "Pilot Induced Oscillations," "Dynamic Stability" and "Pitch Stability."*

Period (of Oscillation):

The time between peaks in an oscillation. A faster or higher frequency oscillation has a shorter period. The period of pitch oscillations is important in aircraft and gyros because the pilot's reactions to short-period natural oscillations in pitch of an aircraft is less likely to be properly timed or applied for the quicker or shorter period pitch oscillations. All aircraft have "natural" frequencies of oscillations that can be excited by a disturbance (wind or pilot input). In a gyro with very short period natural oscillatory tendencies, it is more likely that a pilot's mis-timed or mis-applied reactions to pitch could contribute to pitch resonance or PIO in that aircraft. *See also "Short-Period Oscillation."*

Phase:

The time relationship or time spacing between two synchronously oscillating motions or changing conditions. The phase or timing of a pilot's control input can either stabilize an unstable gyro or cause an unstable gyro to diverge or it's oscillations to worsen – Pilot Induced Oscillations.

Phugoid:

Technical term for Long-Period pitch (or roll) oscillations of an aircraft. *See "Long-Period Oscillation."*

Pilot Induced Oscillations – PIO:

Normally refers to the rapidly increasing pitch oscillations of a gyro due to improperly applied or improper "phase" pilot control inputs. PIO is the result of pilot actions that cause the natural pitch oscillatory tendencies of an unstable gyro to grow those oscillations to extreme amplitudes. PIO is the result of Positive Feedback from the pilot control inputs that causes the gyro to resonate in increasing amplitude pitch oscillations. PIO can be thought of a Resonance between an unstable gyro and improper pilot control inputs. PIO, when not immediately corrected by the pilot, often rapidly results in a Bunt-Over. PIO occurs with unstable gyros as a result of inadequate pilot skills to stabilize that gyro. *See also "Oscillation," "Phase," "Bunt-Over" and "Power Push-Over."*

Pitch:

Rotational movement about the pitch or lateral axis of an aircraft. The pitch of an aircraft is defined by the nose-up or nose-down attitude of the aircraft and generally affects the airspeed of an aircraft. The ability of an aircraft to maintain its "trimmed" pitch attitude and airspeed or to self-restore to the "trimmed" attitude and airspeed after a disturbance is the measure of its pitch stability. Pitch stability of a gyroplane is an essential safety element or criteria of a gyroplane. The Horizontal Stabilizer serves to stabilize the aircraft's pitch attitude to point into or return to pointing into the relative wind.

"Pitch", used as a verb, refers to the action of changing pitch. *See also "Roll," "Yaw," "Airspeed," "Trim," "Stability" and "Horizontal Stabilizer."*

Pitch Damping:

The action of a stabilizing component on an aircraft to prevent or reduce the natural pitch oscillations of the aircraft. Pitch damping can be accomplished on a gyroplane from proper application of a horizontal stabilizer, by the appropriate action of the pilot, or by an active stabilizing system such as an autopilot. *See also "Oscillation," Damping," "Pitch" and "Horizontal Stabilizer."*

Pivot:

The mechanical or physical point or line about which an object rotates. *See also "Teeter" and "Rotor Blade Flapping."*

Positive Feedback:

Feedback in the same sense or direction as the output result that tends to amplify or increase a disturbance and can lead to unwanted divergence or oscillations or PIO - instability. Improper feedback timing, lag or lead, can also result in positive feedback, overshoot, divergence or oscillations in the resulting response of the system. A common example of positive feedback is the squeal of a sound amplifier when the microphone is in front of the output speakers. *See also "Feedback" and "Negative Feedback."*

Positive Stability:

The condition of stability. The tendency of an object or system to maintain or self-restore equilibrium after a disturbance. *See also "Negative Stability" and "Stability."*

Power:

The rate of doing work, or expending energy over time. For instance, an engine produces power from its energy source (gasoline). Power delivered for a certain amount of time is a quantity of energy. *See also "Energy."*

Power Loading:

The gross weight of an aircraft divided by its takeoff power – normally expressed in Lbs/HP.

Power Push-Over – PPO:

By definition, PPO is a specific variety of bunt-over that is the result of a high propeller thrustline that is suddenly no longer balanced by other moments on the airframe – thereby, the "power" pushes the nose over downward. Therefore, by definition, a Power Push-Over can only occur in a high propeller thrustline configured gyroplane. But, a PPO is not necessarily the only form of a "Bunt-Over". A PPO is self-sustaining when the balancing rotor thrust is rapidly decreased at zero or near zero angle of attack of the rotor disk. *See also "Bunt-Over."*

Power Stability:

The tendency of an aircraft to maintain a reasonably fixed airspeed upon changes in engine power. To be considered "power stable", an aircraft should maintain "trimmed" airspeed at all power settings with minimal pilot control stick pressure or displacement. *See also "Airspeed Stability" and "G-Load Stability."*

Power Torque-Over – PTO:

A situation whereby the torque on the airframe by the engine causes an uncontrollable Roll-Over upon loss or rotor thrust and control at low g or zero g load on the rotor. This is the roll equivalent of a Bunt-Over in pitch. In many accidents, it would be difficult to determine that PTO, rather than PPO or Bunt Over, was not the final mechanism of the accident. In all cases, the results might be exactly the same – severe extreme blade flap, precession stall, impact of a rotor blade on the airframe, and/or separation of the blades in flight. Avoidance of low-G maneuvers reduces, but does not eliminate, the risk of torque-over in a susceptible craft. The propensity for a possible PTO in any gyro would be dependent on the torque produced by the engine, any torque compensation or aggravation from the airframe aerodynamic configuration, and the inertial reaction of the airframe. *See also "Bunt-Over," "Torque," "Precession Stall" and "G – Load."*

Prerotation:

The act of spinning up the rotor blades on the ground in preparation for flight in a gyroplane. Prerotation is accomplished either by hand ("patting" up the blades), or by mechanical connection so that less of a takeoff roll is required to achieve flight Rotor RPM. Higher Prerotation rotor RPM allows shorter takeoff roll. For lower Rotor RPM prerotations, care must be exercised on takeoff roll so as to not "overrun" the rotor blades. *See also "Over-Running the Blades."*

Precession:

The property of a spinning object (gyroscope, child's top, rotor, propeller, etc.) that resists a change in angle of it's spinning axis. The strength of the precession resistance is a function of both the RPM of the spinning object and its Moment of Inertia – or the Inertia (mass or weight) of the spinning object. Precession causes a spinning rotor disk to resist changing attitude. This resistance to changing attitude is fundamental to the cyclic action of a gyroplane's rotor control. A characteristic of precession in a spinning object is that the spin axis (or plane of rotation of a rotor) responds in tilt 90 degrees after a force is applied to try to tilt the spinning object. The cyclic change in the rotor blade AOA applies a lift force at that point in the rotation, and the rotor disk responds in tilt ¼ of the rotation later. *See also "Cyclic" and "Moment of Inertia."*

Precession Stall:

Refers to the stalling of one or more individual rotor blade(s) due to too rapid and too large of cyclic input to the rotor system. Due to the precession tendency of the rotor disk to maintain its initial disk attitude, a rapid and large cyclic input will create an immediate large angle of attack of at least one rotor blade – upon cyclic input, one blade will see more positive AOA, while the other blade(s) may see nearly as large negative instantaneous AOA. It is this cyclic unbalance between the rotor blades that initiates the rotor disk attitude to follow the cyclic input. However, if the cyclic input is too large or too quick before the rotor disk can adjust, it is possible that the large cyclic input will result in individual blade stall AOA. If significant high blade AOA or stall continues too long, the increased drag on the rotor blade can slow the rotor dramatically. The physical limits of 10 degrees on the rotor teeter stops and on the range of cyclic control input is intended to limit or prevent cyclic inputs over about 10 degrees where significant rotor drag would be occurring. Precession stall could be initiated by too rapid and large of cyclic input from the pilot or by a similar uncommanded cyclic input from airframe motions. Precession stall that slows the rotor too much will be unrecoverable as the centripetal forces on the slowed rotor may no longer sustain the weight of the gyro.

Propeller Offset (Thrustline):

The amount of vertical distance between the thrust vector of the propeller and the CG of the gyro – how high or low the propeller is mounted above or below the CG. Propeller offset can be either high or low, plus or minus. An offset propeller thrustline presents a moment, proportional to engine power that tends to pitch the gyro either nose-up or nose-down. The propeller offset moment is one pitching moment that affects the equilibrium pitch attitude of the gyro. Typically, the propeller offset, plus or minus, should be "balanced" by the horizontal stabilizer so as to maintain stable attitude (G-Load Stability) of the airframe and gyro. *See also "Centerline Thrust", "Horizontal Stabilizer," "Moment" and "G-Load Stability."*

Propeller Thrust:

The forward force produced by the propeller under engine power. The propeller thrust, which is proportional to engine power, provides the motive force for forward flight of an airplane or gyroplane. Propeller Thrust is a vector with direction and amplitude. Propeller Thrust also provides a pitching moment on the airframe if the thrustline is offset above or below the CG of the gyro. *See also "Propeller Offset," "Thrust," "Thrustline" and "Vector."*

Propeller Thrustline:

The imaginary line that defines the direction in which propeller thrust is being produced. The thrustline of a propeller passes through the axis of rotation and is depicted as a vector closely aligned with the axis of rotation. *See also "Thrust," "Vector" and "Propeller Thrust."*

Propwash:

The stream of swirling air accelerated by the propeller, usually an expanding spiral of fast moving air. Propwash airstream velocity is greatest near the propeller blade outer circumference and minimum near the center of the propeller. Propwash can be utilized to enhance lift or effectiveness of the vertical or horizontal stabilizers and control surfaces placed in the propwash - when engine power is applied.

Rate:

How fast something moves or changes – synonymous with "speed" or "velocity" for linear moving objects Rate is usually expressed in "per hour" or "per minute", such as in miles/hr, ft/min or RPM.

Resonance:

Physical objects can vibrate at a particular "natural" frequency or frequencies more easily than at other frequencies – "tuned" to a "natural" frequency such as a tuning fork. Resonance occurs when that object is subjected to or "excited" by external pulses or oscillations at the same frequency causing the object to continuously vibrate at that or a "harmonic" frequency – or even for the vibrations in the object to grow to destructive amplitudes. At the resonant frequency, the vibrations are sustained rather than damped out. PIO would be an example of resonance where the pilot's control inputs are of such phase and frequency so as to cause the gyro to PIO or resonate in pitch oscillations. A child swinging his/her legs at the right frequency and phase is exciting resonance in the "natural" swing rate of the swing when it is made to swing higher or keep swinging. *See also "Harmony" and "Harmonic."*

Retreating Blade:

The rotor blade that is moving aft with the ongoing airstream caused by forward flight of the aircraft. For most gyroplanes, the retreating blade is on the left side of the aircraft. The retreating blade has less relative airspeed than the advancing blade. At higher airspeeds and low Rotor RPM, the retreating blade can possibly stall more easily than the advancing blade – resulting in Flap. *See also "Advancing Blade," "Retreating Blade Stall" and "Rotor Blade Flapping."*

Retreating Blade Stall:

Excessive aerodynamic stalling of the rotor blade as it turns from nose to tail. Caused when the forward airspeed of the aircraft is high enough or the rotor RPM is low enough so that the relative airspeed over the retreating blade develops inadequate lift to balance the advancing rotor blade lift. The retreating blade may be either fully or partially stalled so that the teetering or flapping rotor limits are exceeded and a large or possibly even violent "bump" to the retreating blade side is experienced. Retreating blade stall is most common on takeoff when the rotor RPM is too slow and the aircraft airspeed is too high ("Over-running the blades or rotor"). *See also "Retreating Blade," "Rotor Blade Flapping" and "Mast Bumping."*

Revs (Revolutions) per Minute – RPM:

The rate of rotation expressed in the number of complete revolutions per minute of time. 60 RPM is equal to one revolution per second.

Roll:

Rotational movement about the roll or longitudinal axis of an aircraft. An aircraft is "rolled" in order to establish a turn. The roll attitude of an aircraft establishes the turning rate and radius of turn. *See also "Pitch" and "Yaw."*

Roll-Over:

A term normally referring to a gyro rolling over on the ground, as the result of severe blade flapping from over-running the rotor blades on takeoff roll, or the instability of a short-couple wheel base, high center of gravity and poor directional control. Roll-over can also refer to the uncontrolled in-flight torque roll of a gyro under low or zero load on the rotor. *See also "Over-Running the Blades," "Blade Flap" and "Power Torque-Over."*

Rotor:

Normally refers to the complete assemblage of all rotor blades that comprise the rotor – the entire rotor assembly that spins as one assembly. The rotor normally consists of two or more Rotor Blades. *See also "Rotor Blade."*

Rotor Blade:

One individual blade of the rotor system. Two or more Rotor Blades comprise the Rotor. *See also "Rotor."*

Rotor Blade Flapping:

In traditional "Flapping Hinge" rotor systems, "flapping" refers to the normal action of the rotor to allow cyclic action of the rotor – similar to "Teeter" for semi-rigid 2-blade rotor systems. The flapping amplitude of the rotor increases with increasing airspeed (forward cyclic input) in order to compensate for the increasing Dissymmetry of Lift between the Advancing Blade and the Retreating Blade. Flapping action also allows cyclic maneuvering inputs to the rotor. *See also "Dissymmetry of Lift" and "Teeter."*

In semi-rigid 2-blade rotor systems, the term "flapping" is commonly used to refer to the abnormal excessive forceful Teeter action of the rotor impacting the teeter stops upon significant Dissymmetry of Lift or Retreating Blade Stall – such as on takeoff. Sometimes referred to as "Flap", "Blade Flap", or "hinging" (in Australia) on semi-rigid 2-blade rotor systems. *See also "Teeter Limits" and "Semi-Rigid Rotor."*

Rotor Blade Tracking:

See "Tracking"

Rotor Disk:

The circular area traced out by the rotating blades. It is an imaginary disk that can be envisioned as the solid "wing" actually comprised of the rotating individual rotor blades. Lift is developed and distributed around the disk by the each rotating blade as it rotates to the various positions around the disk. The disk angle of attack is varied to develop and adjust the total lift and drag of the rotor disk. The rotor disk is tilted via cyclic action of the rotor blades to change the lift direction and accomplish maneuvers of the gyroplane. The rotor disk typically flies at an angle of attack of between 7 degrees to 10 degrees for normal straight and level flight. It is important in the understanding how a rotor works to be able to separately envision the actual rotor and rotor blades (their individual AOA and lift/drag forces) from the AOA, lift and drag of the whole rotor disk). The rotor disk affects the maneuvers and lift and drag of the "wing" of the rotorcraft. The individual rotor blades are controlled via cyclic differential action of their individual AOAs to result in a change in the rotor disk AOA and its lift and drag and direction of lift.

Rotor Disk Angle of Attack (AOA):

The angle that the plane of the rotor disk makes with the relative airflow through the rotor. Since a rotor disk is actually a shallow cone shape, the disk angle is the median angle of the forward and aft surfaces of the cone. The rotor disk angle is perpendicular to the spin axis of the rotor.

Rotor Disk Loading:

Total weight that the area of the Rotor Disk is carrying, usually expressed on pounds of gross weight per square foot of rotor disk. The rotor disk area is computed as the radius (in ft.) squared times pi (3.1417)

Rotor Disk Volume:

A mathematical computation to quantify the power of a rotor. Rotor disk volume is the product of the rotor blade area and the diameter of the rotor disk. Cierva specified that the Horizontal Tail Volume (tail area X distance from 1/4 chord to rotor axis) for autogyros of that day should be 12-15% of rotor volume. *See also "Tail Volume" and "Horizontal Tail Volume."*

Rotor Drag:

The component of total rotor thrust that is acting in the direction exactly opposite to the relative airflow on the rotor disk. Rotor drag is a force that is tending to resist forward motion of the rotor through the air. Rotor drag is considered to be acting on and emanating from the center of the rotor disk. The vector sum of both Rotor Drag and Rotor Lift is the Rotor Thrust Vector. *See also "Drag" and "Rotor Disk."*

Rotor Drag Vector – RDV:

The engineering depiction of the Rotor Drag force having both a specified amplitude and direction – usually depicted as an aft directed arrow of a specific length to represent the amplitude of the force. The direction of the rotor drag vector is exactly opposite to relative airflow on the rotor disk. The Rotor Drag Vector and the Rotor Lift Vector can be combined into a single Rotor Thrust Vector. *See also "Rotor Lift Vector" and "Rotor Thrust Vector."*

Rotor Lift:

The component of total rotor thrust that is acting in the direction exactly perpendicular to the relative airflow on the rotor disk. The amount of lift is determined by the angle of attack of the rotor or airfoil or object moving through the air. Rotor lift is considered to be acting on and emanating from the center of the rotor disk. Rotor lift is usually considered to be in the upward direction – negative rotor lift would be a situation to be avoided that would likely result in an unrecoverable situation. The vector sum of both Rotor Lift and Rotor Drag is the Rotor Thrust Vector. *See also "Lift," "Rotor Drag" and "Rotor Disk."*

Rotor Lift Vector – RLV:

The engineering depiction of the Rotor Lift force having both a specified amplitude and direction – usually depicted as a vertical. The direction of the rotor lift vector is exactly perpendicular to relative airflow on the rotor disk. The Rotor Lift Vector and the Rotor Drag Vector can be combined into a single Rotor Thrust Vector. *See also "Rotor Lift Vector" and "Rotor Thrust Vector."*

Rotor RPM – RRPM:

A measure of the rotating speed of a rotor. The number of revolutions of a rotor that occur in the time span of one minute. RRPM of a gyroplane's rotor varies or responds according to the load on that rotor. The RPM of a rotor is a factor, along with load, that determines the coning angle of a rotor in flight. *See also "Coning Angle."*

Rotor Shake:

The vibration of the rotor system felt in the controls and in the fuselage of a rotorcraft. The predominant vibrations are either "1 per rev" (at the same frequency as the rotor is turning) or 2-per rev (twice the freq of the rotor) in a two bladed rotor system. 1-per rev rotor shake can be the result of a mass and/or aerodynamic imbalance of the rotor. 1-per rev imbalance rotor shake can be thought of as the either the Mass Center or the Aerodynamic Center not being exactly concentric with the spinning axis of rotation of the rotor. Imperfect rotor blade tracking is a contributor to aerodynamic imbalance leading to 1-per rev rotor vibrations. 2-per rev shake can be the result of a teeter height that does not match the vertical CG of the coned rotor, mechanical "looseness" or "slop" in the rotor teeter joint, or (unavoidably) from the forward airspeed of a semi-rigid 2-blade rotor. *See also "Mass Center," "Aerodynamic Center," "Tracking," "1-Per Rev" and "2-Per Rev."*

Rotor Thrust:

The total force produced by the rotor in a direction approximately parallel and in-line with the spin axis of the rotor. Rotor thrust is the combination of both Rotor Lift and Rotor Drag. *See also "Rotor Lift" and "Rotor Drag."*

Rotor Thrust Vector – RTV:

The vector representation of Rotor Thrust usually depicted as an arrow with a specified magnitude and direction. In a gyroplane, the RTV is represented to be an upward and slightly aft pointing arrow approximately parallel and in-line with the spin axis of the rotor. The Rotor Thrust Vector is the vector sum of the Rotor Lift Vector and the Rotor Drag Vector. A common error in describing or attempting to understand the moments and forces acting on a gyro is to confuse or intermingle the use of both Rotor Drag and Rotor Thrust – one or the other convention must be utilized consistently throughout an analysis. For instance, if Rotor Thrust (combined lift and drag) is the representation of rotor forces used, then additionally describing the affect of a loss of Rotor Drag would be "double-dipping" the Rotor Drag component. *See also "Vector," "Rotor Lift Vector" and "Rotor Drag Vector."*

Rudder:

Normally the moveable vertical control surface on the tail of an aircraft that controls the yaw of the aircraft. *See also "All-Flying Rudder," "Yaw" and "Vertical Stabilizer."*

Runaway (Blade Runaway, Rotor Blade Runaway):

The uncontrollable continuing increase in Rotor RPM as a result of compressibility effects on the rotor blades as the rotor blade tip speeds approach the Speed of Sound. As the rotor blade tips approach the Speed of Sound, the Center of Lift on the rotor blade moves aft on the blade and can cause the rotor blade to twist from root to tip to a lower AOA of the rotor blade airfoil. The effectively lower AOA of the blade causes further increase of RRPM to maintain autorotation, which further increases rotor blade tip speed – a continuing cycle of increasing RRPM – "runaway". The repositioning aft location of the center of lift on the rotor blade also increases the forward cyclic stick pressure – eventually overpowering the ability of the pilot to pull the stick back at higher blade runaway speeds.

Semi-Rigid Rotor:

Refers to the 2-blade teetering rotor system that is common on most light sport gyroplanes, where the two rotor blades are rigidly attached to each other but allowed to Teeter on a central teeter pivot. *See also "Teeter" and "Cyclic."*

Short-Period (Oscillation):

A natural oscillating frequency of an aircraft where the period between oscillations are short in time. The period or frequency of natural pitch oscillations of a gyro are typically the result of the gyro's Moment of Inertia and the effectiveness of the Horizontal Stabilizer. Typically, an oscillation period below about 10 seconds long is considered a Short-Period which is best eliminated by aerodynamic design because a pilot's normal reactions may not be adequate or timed properly to dampen or prevent continued oscillations. If a natural oscillation period is shorter than about 10 seconds, it is more likely that the pilot's mis-timed reactions may contribute to resonance of the aircraft in pitch at this natural oscillatory rate. All aircraft exhibit some natural oscillatory frequencies. Long-Period oscillations, commonly called Phugoid oscillations are slow enough that the average pilot is not as likely to contribute to the resonant oscillation of that aircraft in pitch. Short-period oscillations are likely the result of low MOI airframes and resonance interaction with the rotor inertia. Specific flight test procedures are required to identify any Short-Period oscillation tendencies in an aircraft. Such Short-Period oscillations can be eliminated or lengthened with proper attention to aerodynamic dampers in the configuration such as a horizontal stabilizer of sufficient volume for that gyro. Short-Period oscillations are particularly difficult to eliminate by design in light gyros, and the existence of a Short-Period oscillatory mode in a gyro is likely the cause of PIO. All aircraft may exhibit both a Short-Period and a Phugoid oscillatory tendency. *See also "Period," "Phugoid," "Resonance," "Pilot Induced Oscillation," "Damping," and "Moment of Inertia."*

Solidity Ratio:

The ratio of the total actual area of all rotor blades in a rotor system to the total rotor area; expressed in percent (%)

Sonic Speed:

See "Speed of Sound."

Span Balance:

Balance of a rotor such that each rotor blade has equal weight that balances around the teetering axis of the rotor. Static Span Balance would be similar to the balance of child's teeter-totter. Due to variations of mass concentrations along the span of individual rotor blades, Dynamic Span Balance is more complicated and is not necessarily assured by statically balancing the rotor. *See also "Chord Balance," "Center of Mass," and "Rotor Shake."*

Speed:

Measurement of rate of movement, velocity, indicated as distance per unit of time (i.e.: feet per minute, MPH).

Speed of Sound:

The rate at which sound (a pressure wave) travels in air. Also referred to as Sonic Speed. At normal atmospheric temperature and pressure it is approx 750 mph or 343 meters/sec. In discussions of gyros and rotors, Compressibility becomes an important factor as the rotor blade tips approach a significant fraction of the Speed of Sound. *See also "Compressibility."*

Spindle:

The central rotating pivot of the 2-Blade semi-rigid rotor system commonly used on sport gyroplanes. The spindle employs a bearing upon which the rotor spins and the weight of the gyro is supported. The Spindle of a 2-Blade semi-rigid rotor system is normally moveable around the lateral and longitudinal axis (pitch and roll) in order to provide cyclic control inputs to the rotor via cyclic stick inputs. The angle mis-match between the spindle axis and the axis of rotation of the rotor creates the cyclically differential AOA of each rotor blade according to its position around the rotor disk. The spindle axis angle also can change upon pitch or roll movements of the airframe ("uncommanded" cyclic inputs) or g-load pitch compensation provided by the offset gimbal arrangement on common 2-Blade semi-rigid rotor systems.

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."*

Stabilizer:

On an aircraft, normally refers to a flying surface such as a horizontal or vertical fin intended to keep an aircraft tracking into the relative wind. Stabilizers add stability in pitch and yaw in the form of reduced lag and overshoot in control response. A stabilizer serves to damp the natural oscillatory 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 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 line for pitch stability. *See also "Damping," Horizontal Stabilizer" and "Vertical Stabilizer."*

Stall:

The loss of lift that occurs when an airfoil reaches a critical angle of attack – typically 13-15 degrees. Stall occurs when the angle of attack is large enough that the airflow on the lifting side of the airfoil turbulently separates from that surface. At the stall point, the lift of the airfoil suddenly reduces and the drag of the airfoil suddenly increases. A stalled condition will be corrected upon reduction of the AOA below the critical stall AOA. *See also "Angle of Attack."*

Stalled Area (of Rotor):

The inner portion of a rotor disk that is not producing lift due to low relative airspeed and high AOA in that portion of the rotor. *See also "Stall."*

Static:

Not changing, as opposed to dynamic or changing. Static usually refers to an object's steady motion or attitude as a result of not being disturbed from that initial condition.

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."*

Statics:

The study of forces acting on objects that are stationary or in steady motion.

Steady State:

The condition of an object or system in equilibrium or steady motion. An object is in steady state when all the forces and moments on the object are balanced. An example of Steady State would be an aircraft in straight and level unaccelerated flight – lift is balancing the weight of the aircraft and the drag is balancing the propeller thrust; the attitude of the aircraft is steady because the moments acting to pitch or roll the gyro are also balanced. A gyro in constant descent at steady airspeed would also be considered as being in that particular steady state – all forces and moments balanced so that the motion of the gyro is steady. *See also "Static."*

Stick Shake:

The shaking of the cyclic stick which can be felt by the pilot. Stick Shake is a direct manifestation of rotor shake being transmitted through the controls. It can range from barely noticeable to severe and is often the primary way the pilot estimates the amount of rotor vibration. The pattern of stick shake can be circular, linear or even double circles or figure eights – as a function of the 1 and 1 per rev rotor shake. See also "Rotor Shake," "1-Per Rev", and "2-Per Rev."

String (Stringing):

The process to align a semi-rigid 2-blade rotor lengthwise so that the rotor blades are in-line (180 degrees opposite each other). This alignment is intended to adjust the chordwise CG of the rotor directly over the spin axis to minimize rotor shake from misalignment of the Center of Mass from the spin axis. A piece of string is often strung between the tips of the rotor, passing over a mark on the hub to facilitate alignment. This is called "stringing" the blades. *See also "Chord Balance," "Center of Mass" and "Rotor Shake."*

T-Tail:

Commonly refers to a Tall Tail that also has a Horizontal Stabilizer mounted in a cruciform shape with the tall rudder. Typically, the Horizontal Stabilizer moves with the Tall Tail. The T-Tail commonly positions the Horizontal Stabilizer centered with the center of the propeller to take advantage of the accelerated air enhancement effect in the propwash. *See also "Tall Tail," "All-Flying Tail,," "Horizontal Stabilizer" and "Embedded (HS)."*

Tail Volume:

The mathematical product of the area of either the vertical stabilizer and rudder area or the horizontal stabilizer area times it's effective moment arm from the CG of the aircraft. Tail Volume is a formula intended to provide a quantitative measurement of the effective power of either the horizontal stabilizer or of the vertical stabilizer and rudder on an aircraft. However, the effectiveness of a stabilizer is dependent upon other less quantifiable factors such as stabilizer airfoil shape, enhancement from propwash immersion, other static aerodynamic moments the stabilizer must compensate, and the dynamic/inertial factors of the airframe and rotor combination. *See also "Horizontal Tail Volume."*

Tall Tail:

Commonly refers to a type of All-Flying Tail (rudder) that extends from the tail keel tube to nearly the top of the propeller arch so s to take full advantage of the prop wash for yaw control effectiveness when power is applied. Typically a Tall Tail is pivoted on the ¼ chord point to minimize control forces. *See also "Anti-Servo Tab" and "All Flying Tail."*

Teeter:

The rocking action of a rigid 2-blade rotor on its "Teeter Pivot", allowing cyclic action of the rotor. The teeter amplitude of the rotor increases with increasing airspeed (forward cyclic input) in order to compensate for the increasing Dissymmetry of Lift between the Advancing Blade and the Retreating Blade. Teeter action also allows cyclic maneuvering inputs to the rotor. Maximum Teeter amplitude is normally limited by mechanical Teeter Limits or stops - beyond which destructive Rotor Blade Flap or "Mast Bumping" may occur. Teeter Limits are normally set at around plus/minus 10 degrees of Teeter. *See also "Cyclic."*

Teeter Height:

The vertical distance from the hub of a rotor to the teeter pivot. Another term for this is Undersling. Teeter height or offset above the hub of the rotor is intended to match the vertical CG location of the coned rotor under normal steady state load in flight. With the teetering point of the rotor at the same location as the VCG of the rotor, mismatch of the spinning axis of the rotor and the spindle axis (during cyclic inputs and forward airspeed) will not result in 2-Per Rev rotor shake. Mismatch of the Teeter Height to the actual coning angle of the rotor is the most common source of rotor shake – especially with forward airspeed which requires steady mis-match of the spindle with the rotor spin axis. *See also "Coning Angle" and "Teeter Pivot."*

Teeter Limits (Teeter Stops):

Mechanical stops which limit the rotor from teetering beyond a certain amount, usually +/- 10 degrees or so from centered. *See also "Teeter."*

Teeter Pivot:

The axis (usually the teeter bolt) upon which the 2-blade-semi-rigid rotor pivots. The joint around which the 2-blade semi-rigid rotor is free to "flap." The Teeter Pivot and the ability of the rotor to teeter are fundamental to the cyclic control function of the common 2-blade semi-rigid rotor system. *See also "Teeter" and "Rotor Blade Flapping."*

Thrust:

In gyroplanes, Thrust usually refers to the force produced by a propeller or rotor as it accelerates a mass of air in the opposite direction. *See also "Force."*

Thrust Vector:

The vector representation of a thrustline having both force amplitude and direction. *See also "Vector."*

Thrustline:

The imaginary line that defines the direction in which thrust is being produced. The thrustline of a propeller or rotor normally passes through the axis of rotation and is depicted as a vector closely aligned with the axis of rotation. *See also "Thrust", "Vector" and "Rotor Thrust Vector."*

Tip Speed:

The speed of the tip of the rotor blades, usually expressed in ft/sec.

Torque:

Force acting at a distance from an axis of rotation of an object that tends to rotate that object. Torque is often used synonymously with "Moment". Torque can be thought of as leverage applied to turn or twist an object. Torque of a motor turning a propeller can be computed as 5252 times the Horsepower divided by the RPM (ft-Lbs). *See also "Moment" and "Moment Arm."*

Tracking (Rotor Blade Tracking):

The process of adjusting the pitch of individual rotor blades in a rotor system so that they all travel in the same path, at the same height as they rotate past a reference point. Tracking error in a rotor typically results in rotor shake that is mostly felt by vertical "hop" in the airframe. Tracking is most easily monitored at the blade tip, however, imperfect aerodynamic balance between the blades might require a mis-match of blade tip "tracking" in order to produce the smoothest rotor shake results. *See also "Rotor Shake" and "Aerodynamic Center."*

Transient:

A short, usually non-repetitive disturbance that comes and goes quickly. A transient usually initiates a dynamic reaction in an object such as an aircraft. A transient acting on a gyroplane can be either wind or pilot control input. A transient input by a test pilot is normally used to examine the dynamic response of an aircraft – determine its dynamic stability criteria. *See also "Disturbance" and "Dynamic Stability."*

Trim:

The condition of adjusting flight controls to a specific equilibrium condition that the aircraft will maintain on its own without additional control input. Normally referring to an attitude (pitch, yaw or roll) of an aircraft that establishes a constant condition or airspeed, turn or yaw condition. Of most importance in discussions of gyroplane stability, trim refers to the pitch attitude and airspeed condition established by the offset gimbal / trim spring arrangement on the common 2-Blade semi-rigid rotor system. Adjustment of the Trim Spring tension on such rotor systems, establishes the "trimmed" airspeed of the gyroplane. At this pitch "trimmed" condition, the sum of moments acting to rotate the aircraft in pitch around the lateral axis is zero – the total nose-down moments equal the total nose-up moments. The resultant "trimmed" condition establishes the in-flight pitch attitude/airspeed. Pilot inputs or wind disturbances will cause deviations from the "trimmed" condition. A pitch stable gyro would self-restore to the "trimmed" pitch attitude/airspeed condition. *See also "Offset Gimbal."*

Trim Spring:

Spring or springs that are arranged on the rotor system spindle pitch control to balance the aft offset of the rotor spindle relative to the pitch axis of the rotor system. The offset spindle provides that the lift of the rotor, acting though the spindle tends to pitch the rotor disk nose-down under load or increasing g-load. The Trim Spring is configured to balance this tendency and to allow the rotor disk AOA to respond to g-load changes and thereby self-compensate for changing g-loads. The tension on the trim spring serves to adjust the trimmed rotor AOA of the rotor disk and is used to set the "trimmed" airspeed of the gyroplane in flight. *See also "Offset Gimbal" and "Trim."*

Trimmed Airspeed:

The airspeed at which the aircraft flies when its pitch attitude is in equilibrium. The trimmed airspeed of a 2-blade semi-rigid gyroplane is commonly adjusted or set by the tension of the Trim Spring in the rotor system. The Trimmed Airspeed is the airspeed to which a stable aircraft self-restores after a disturbance (wind or pilot input). *See also "Offset Gimbal," "Trim" and "Trim Spring."*

Turbulence:

Unsteady or changing airflow, gusty winds or wind transients that disturb an aircraft in that airflow. Air can be turbulent due to atmospheric conditions such as thermals or thunderstorm activity, or from flow of wind over or around objects such as trees or buildings or other aircraft. Severe turbulence can occur behind large aircraft. Wind turbulence causes an aircraft to deviate from "trimmed" condition (attitude or airspeed), making the stability of that aircraft an important safety consideration. *See also "Disturbance," "Transient", "Trimmed Airspeed" and "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 attitude angle. *See also "Commanded."*

Undersling:

See "Teeter Height."

Unstable:

Property of an object or system that exhibits the property of instability. *See "Instability" and "Stability."*

Vector:

An engineering depiction of a force having both a specified amplitude and direction – usually depicted as an arrow with both direction and length (to represent the amplitude of the force). Vectors can be trigonometrically or graphically added to determine a resultant, or combined, single vector. The rotor thrust is often treated as a vector because it has magnitude (thrust) and it is oriented in a direction which can be controlled by tilting the rotor head. The Rotor Thrust Vector is the vector sum of both the Rotor Lift Vector and the Rotor Drag Vector. *See also "Rotor Thrust Vector," "Rotor Lift Vector" and "Rotor Drag Vector."*

Velocity:

Rate of movement, velocity, of an object or entity (aircraft, air, etc.) indicated as distance per unit of time (i.e.: feet per minute, MPH). Speed and direction taken together form a vector known as velocity. *See also "Speed," "Airspeed" and "Vector."*

Vertical CG – VCG:

The vertical location of the center of gravity on the "Normal" or vertical yaw axis. *See also "Center of Gravity" and "Longitudinal CG.."*

Vertical Stabilizer – VS:

A vertical flying surface placed on the tail of an aircraft to provide a stabilizing moment tending to keep the aircraft aligned in yaw with the relative wind upon disturbance. The VS adds dynamic yaw stability in the form of reduced lag and overshoot in control response. The Vertical Stabilizer serves to damp the natural oscillatory yaw tendencies of the aircraft. The effectiveness of the VS 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. The Vertical Stabilizer is often integral with the Rudder or combines the rudder and vertical stabilizer in one "All Flying" controllable vertical surface. *See also "Damping," "Vertical Tail Volume", "Stabilizer" and "Rudder."*

Vertical Tail Volume:

The mathematical product of the area of the vertical stabilizer and rudder times it's effective moment arm from the CG of the aircraft. Vertical Tail Volume is a formula intended to provide a quantitative measurement of the effective power of the vertical stabilizer and rudder on a gyro. However, the effectiveness of the vertical stabilizer is dependent upon other less quantifiable factors such as HS airfoil shape, enhancement from propwash immersion, other static aerodynamic moments the HS must compensate, and the dynamic/inertial factors of the airframe and rotor combination. *See also "Tail Volume" and "Horizontal Tail Volume."*

Weight:

Mass of an object times the acceleration of gravity, usually expressed in units of lbs. The weight of an aircraft is carried by the lift of the rotor or wings. Weight changes with varying g-forces. Mass is a constant. *See also "Mass."*

Wind Gust:

A change in wind speed. A wind gust presents a disturbance to an aircraft in flight. Multiple erratic and significant wind gusts is often referred to as wind turbulence. *See also "Disturbance" and "Transient."*

Yaw:

Rotational movement about the yaw or "Normal" or vertical axis of an aircraft. An aircraft can be "yawed" by deflection of the rudder. In normal flight, an aircraft's yaw attitude should be straight into the wind for aerodynamic efficiency. The Vertical Stabilizer serves to stabilize the aircraft's yaw attitude to point into or return to pointing into the relative wind. *See also "Rudder," "Vertical Stabilizer" "Pitch" and "Roll."*

Yaw String:

A string that is secured at one end and allowed to fly in the wind, often mounted on or in front of the windscreen, to indicate any side slip of the aircraft – yaw attitude not aligned with the relative wind. A Yaw String indicates the coordination of a turn or any yaw angle in straight and level flight. Rotors do not exhibit adverse yaw during a rolling action as a wing would, and therefore coordinated turns in a gyroplane can normally be accomplished without rudder input.

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