

From: [REDACTED]
To: [Stein Stephen](#)
Subject: RE: Final report and discussing accident characteristics
Date: Thursday, June 1, 2023 8:07:00 PM
Attachments: [Dynon - Rotax Combo Graphs - 1Sec Avg Flt period.pdf](#)

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Hi Stephen,

Relative to you observation on Blade Flapping below:

There may be some confusion with the FAA Rotorcraft Flying Handbook – For Gyroplane Use Only (H-8083-21). This handbook was previously used for both Helicopters and Gyroplanes. The Gyroplane section in the back sometimes refers to the helicopter section on some common attributes – rotor aerodynamics, regions of the rotor blade, Dissymmetry of Lift in forward flight, etc. But, the Gyroplane specifically does not have any torque created by in-flight drive to the rotor, and therefore a tail rotor is not required. Rotor RPM speed is created by autorotation only and does not create any torque on the airframe. So, gyroplanes require only a rudder to control yaw – exactly similar to the need for a rudder on an Airplane.

A brief summary of the differences. I expect some of this may be familiar and understood, but I'd like to try to simplify some possible confusions between Gyroplanes and Helicopters:

A mayor difference of a Gyroplane to a Helicopter is the mechanical simplicity - fewer moving parts - of the Gyroplane cyclic control system. There is no collective blade pitch control to change the blade AOA - as in a Helicopter. The Gyroplane blades are rigidly attached to a teetering hub bar with a fixed blade AOA – no flapping or lead/lag or blade pitch bearings. Rotor Teeter of the 2-blade Semi Rigid Rotor compensates for Dissymmetry of Lift from forward (or even sideways or backwards flight direction) with blade flap – similar to the teeter function of a 2-blade Helicopter rotor. (Multi-blade rotor systems require individual flapping hinges on each blade, rather than the simple teeter see-saw action on a 2-blade Gyroplane.)

The rotor autorotating spinning DISK acts simply as a wing, creating lift (climb and descent) - same as an airplane - with combinations of rotor disk (wing) AOA and engine power. Roll and Pitch are controlled by a simple spindle tilting with the cyclic stick. The Pilot controls and commands the rotor disk Pitch and Roll attitudes relative to the airframe by tilting the spindle. The rotor disk adjusts its attitude due to blade cyclic action and resultant gyroscopic precession created by the spindle and teetering hub. The tilted or pitched rotor flies the whole thing in the direction the rotor dish takes it – as does a Helicopter tilted spinning disk. The airframe follows this rotor disk direction due to the tail surfaces responding to airflow direction. This would be analogous an airplane control that moved the main wing (which is mechanically difficult to do), rather than ailerons and elevator moving the whole airframe with the wing. The 2-blade teetering rotor/spindle creates the same cyclic action without need for swash plates and hinges on the rotor (Except for the teetering spindle single hinge).

Buntover:

The H-8083-21 Handbook statement you mention does describe buntover somewhat correctly for gyroplanes in that Low G or zero rotor load does automatically slow the autorotation speed of the rotor. This requires more teeter action in forward or lateral flight, and the rotor can then reach it's flapping limits – hard bumps on cyclic control system. Lower rotor thrust also does reduce the control authority of the rotor – at zero G rotor load, there would be no pitch or lateral control. These were certainly issues with original gyrocopters that often had very inadequate horizontal stabilize Static stability and Dynamic pitch damping. Most current gyroplanes have adopted the “Big Tail Way Back” strategy that essentially prevents and slows pitch action that can result in such rotor low G events. In fact, with large and “Way Back” tail stabilizers, the pilot is strongly warned when excessive pilot inputs are being commanded – the rotor teeter hits it's teeter stops and creates strong bumping of the cyclic stick. Upon excessive cyclic stick inputs, the stick creates such alarming “bumping” that I pilot would not purposefully continue with those excessive inputs. The “bumping” is even much stronger than a stall “Stick Shaker” of an airplane. The buntovers described in the handbook are relevant only in original gyrocopter configurations with no Horizontal Stabilizer Volume (area of the HS X moment arm from CG). So, detection of low G-factor is more than pilot lightness, it is also the strong resistance of a well stabilized airframe to actually pitch so quickly as to create sever low Gs.

Gyroplanes rotors can, and often do experience less than 1 G load for short intervals (turbulence). They can actually endure zero G loads for short intervals. The rotational inertia of the rotor carries through short intervals of low G. The length and amplitude of such a disturbance is what is critical. With an adequately damping Horizontal Stabilizer action, those extremes are

very difficult to exceed. The static stability, augmented by the dynamic stabilizing action of the HS prevents excessive turbulence responses.

(An interesting side note to this is that rotor positive G-load is not really possible for a structurally sound airframe and rotor. An autorotation rotor actually “spills” excessive G-Loads through it’s aerodynamic principles of blade coning and RPM reaction to G-loads. A properly designed rotor will “spill” rotor loads over 1.5 – 2 Gs. Normal airframe designs are designed to 3.5 Gs.) The rotor’s RPM response to G Load is also the reason to avoid long-term G-Loads less than 1G because the rotor will slow – possibly to blade “flapping” range. Hence, the reason for the “BTWB” to avoid, limit, and correct low G pitch movements.) Air turbulence can also make sudden gyroplane airframe pitch movements. But, as in an airplane, an adequate Horizontal Stabilizer reacts to vertical and forward wind gusts in the same way an airplane stabilizes its airspeed and “wing” loading from the tail surfaces.)

My thoughts relative to this accident and the issue of zero load on the rotor:

- The blades did severely flap – they experienced long term – more than a few seconds – zero or even reversed load.
- I believe the blades severely flapped when and because the aircraft went through 90-degree left roll.
- Your attached Dynon Roll data shows a severe roll (and pitch) quick extreme within 2 seconds. Roll went past 180 degrees and back. Pitch went past vertical at the same time. (But, I am unclear on how the Dynon sensed both roll and pitch in these extreme attitudes. Roll relative to earth, or to nose axis. Pitch relative to earth in such extreme roll attitude?) If you accept roll and pitch as relative to earth, it appears the gyro essentially did a Hammerhead maneuver – which would certainly unload the rotor and result in severe blade flapping as well as airframe severe gyrations.
- Certainly at 90+ degrees of roll, without appropriate back stick to maintain G-Load on the rotor, the rotor experienced zero G-s and severely slowed and flapped.
- Cause of sever left roll – not clear:
 - This is the main reason I have been really wanting to confirm the timing of the Dynon Roll data with the Rotax Throttle/RPM data:
 - Torque Roll:
 - Severe sudden roll can unload the rotor and cause sever blade flapping.
 - A sudden decrease of throttle and engine torque, especially on the 915 engine because of it’s high power and torque, can cause a sudden roll to the left.
 - This is more severe at slow speeds and high initial power settings.
 - If the aircraft might already be in a significant left roll attitude, a sudden left roll could result in low or rotor load and loss of rotor autorotating airflow.
 - My attached combo graph – my best attempt to correlate the Dynon and Rotax data – shows correlation of aircraft response and engine power. It is unclear which came first! My graph does not have the resolution of the Dynon Data graph you attached. My Graph is limited to 1 second sample rates due to size of the excel file and the graphing limits of my computer.

Sorry for the length of this. Just trying to document my thoughts.

Thanks, Greg Gremminger

From: Stein Stephen [REDACTED]
Sent: Thursday, June 1, 2023 2:00 PM
To: [REDACTED]
Subject: RE: Final report and discussing accident characteristics

Thanks, Greg...and I agree as there is nothing in the data to suggest a sudden down pitch. If that’s the case then could it have just been the turn that did him in at 0800:32? If so then I don’t have anything that tells me why he needed to make such a hard left turn.

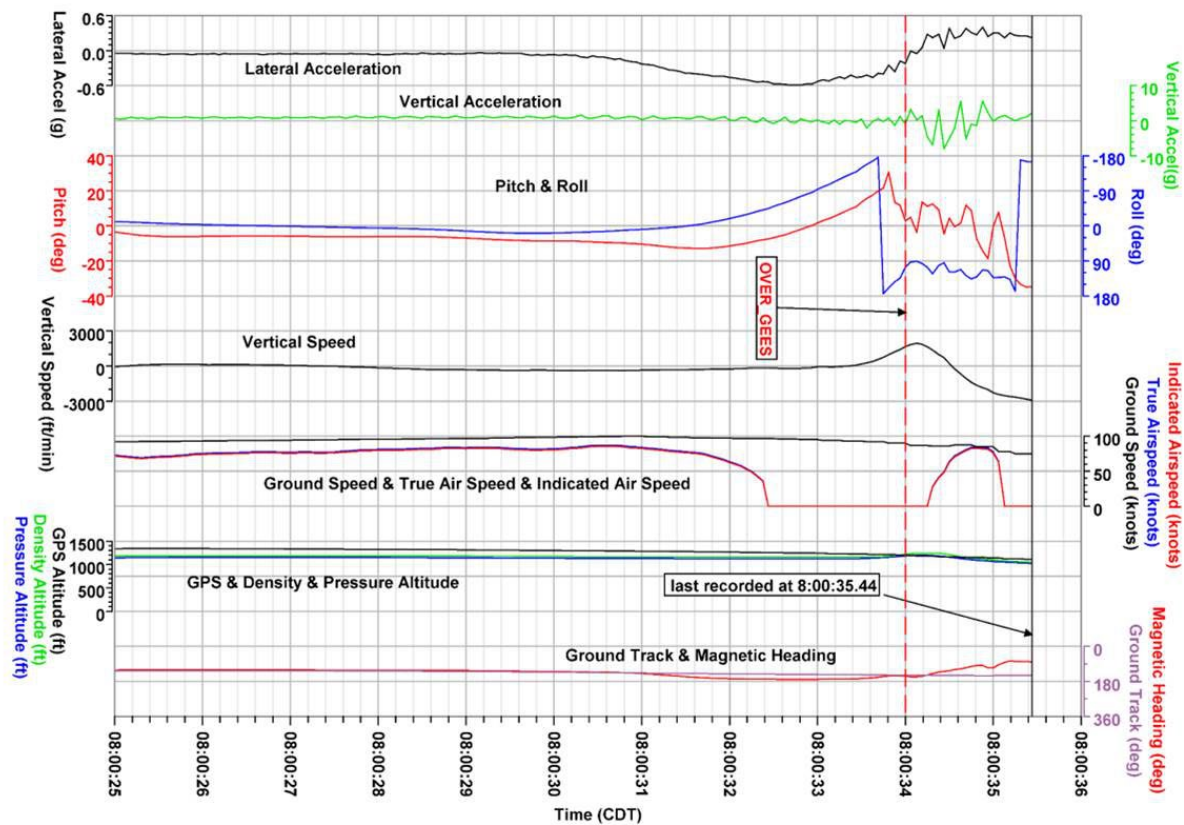


Figure 4. Plot of data parameters for the last 10 seconds of the event flight recording.

From: [REDACTED]
 Sent: Thursday, June 1, 2023 11:54 AM
 To: Stein Stephen [REDACTED]
 Subject: RE: Final report and discussing accident characteristics

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Hi Stephen. You are right, we should discuss. The rotor blade will flap is it low load or unloaded for too long (seconds). This does not appear to me this was a Buntover - sudden nose down pitch which would reduce or eliminate, or even reverse the rotor load. But, it is very difficult to Buntover a gyro with a "Big Tail Way Back" - it is too dynamically and statically stable.

In my estimation, this gyro experienced low load or unloaded rotor when it rolled 90+ degrees to the right.

I need to absorb your note for a bit. I'll try to do that and respond as soon as I can.

Greg.

Sent from EarthLink Mobile mail

On 6/1/23, 1:29 PM, Stein Stephen [REDACTED] wrote:

Good afternoon Greg,

I'm working on the final report and am trying to focus on what caused the flapping. From what I've read it looks like low G is the main condition that can lead to rotor flapping and may have been the primary influencer in this case.

Reading the FAA gyroplane publication it appears that a push over (cyclic?) can cause this, but I'm confused a bit here because the FAA's description attributes a rapid roll to the RIGHT due to continued tail rotor thrust over the main rotor thrust component, but how would this work in the M24 which has no tailrotor??

Also, the flight manual says a load factor of 1 g can lead to flapping. Is this vertical accel, not lateral accel? And how does this work exactly? Is the gyroplane always supposed to carry a g load of 1+g and if so how is the pilot supposed to maintain this? And if they can't what is the appropriate recovery procedure?

Blade Flapping

The FAA Rotorcraft Flying Handbook – For Gyroplane Use Only (H-8083-21), includes a discussion on the effects of a low G flight condition and blade flapping

“In forward flight, when a push-over is performed, the angle of attack and thrust of the rotor is reduced, causing a low G or weightless flight condition. During the low G condition, the lateral cyclic has little, if any, effect because the rotor thrust has been reduced. Also, in a counter-clockwise rotor system (a clockwise system would be the reverse), there is no main rotor thrust component to the left to counteract the tail rotor thrust to the right, and since the tail rotor is above the CG, the tail rotor thrust causes the helicopter to roll rapidly to the right. If you attempt to stop the right roll by applying full left cyclic before regaining main rotor thrust, the rotor can exceed its flapping limits and cause structural failure of the rotor shaft due to mast bumping, or it may allow a blade to contact the airframe.”

According to the accident aircraft flight manual,

“Load factors less than 1g cause a rapid decay in rotor rpm and could lead to blade flapping. Detection of low g-factor is pilot sensor cue of lightness in the seat.”

Stephen Stein

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