Prologue:

The following article was written and published in the EAA Sport Aviation magazine in 1971, and subsequently re-printed in both Rotorcraft and Wings of Tomorrow magazines soon after. It is truly amazing to me that the U.S gyroplane sport and community has so extensively dismissed realities of physics for so long – and for so long has allowed so many unnecessary deaths to continue! This article is re-printed here in response to a recently published letter by the distinguished Ken Wallis. With great respect for Ken's pioneering efforts with gyroplanes, for his contribution to the sport of "gyros", and for his tremendous piloting abilities, I regret that I and others must differ from his interpretations of what actually makes gyros stable and safe! In my opinion, too many needless fatalities have continued because of continued misleading and inadequate technical promotion by many popularly respected personalities in this sport.

Mr. Tervamaki, way back in 1971, along with others, had tried apparently in vane to correct the dangerous characteristics of many popular gyros. Mr. Tervamaki by the time of this article, had an MS degree in Aeronautical Engineering, had worked for 6 years with the Finnish Air Force as a helicopter specialist, and from 1969 worked in the Helsinki Institute of Technology designing the PIK-19 all fiberglass 2-seat aircraft. Mr. Tervamaki had designed fiberglass rotor blades for his gyros in 1965. He had designed his popularly acclaimed JT-5 in 1969, eventually applying stability features verified on his ATE-3 testing as a result of the discouraging gyroplane fatalities in Europe.

In 1989, stirred by yet another familiar accident in a KB-3 in Finland, Mr. Tervamaki again attempted to influence the continued faulty designs proliferating mainly from the U.S. Formal letters to the FAA and EAA were apparently dismissed again by technical opinions of some popular "experts" in the U.S.! It is very high time that we begin in earnest to endorse the proven principles of safe gyroplanes. To ignore these issues further is inviting the death of more gyro pilots and the actual death of the sport. To adopt and promote proven principles of stability may allow a "new generation" of gyroplanes to achieve their true potential to be the safest and most fun form of sport aviation!

- Greg Gremminger

Losing Faith in Autogyros—and Gaining it Back Again!

By Jukka Tervamaki

Fatal Crashes

In September, 1970, the Society of British Aerospace Companies had its famous air show week well going on in Farnborough, near London, when the unbelievable happened. The famous Wallis autogyro, which holds world's records in altitude and in speed for its class, disintegrated in the air in front of 20,000 invited guests, fell

200 ft. and crashed. One of Britain's most famous and experienced test pilots, John Judge, lost his life in the machine. He, if anyone, should have known the tricks a small autogyro could teach to a pilot. I was in Farnborough at the time of the crash, and it made me deeply sorry and put me thinking over and over again—why? You will notice that I am an owner of a single-place autogyro, the ATE-3, which somewhat resembles the Wallis machine.

Only a couple of weeks later when back home in Helsinki, I and Mr. Eerola, my co-builder of the ATE-3, received a sudden phone call from Finnish civil aviation authorities who asked us to investigate a fatal Bensen B-8M "Gyrocopter" crash which had happened a few hours earlier at Pori, a town 150 miles northwest of Helsinki. Seeing the wreckage and the dead pilot finally caused me to ask myself whether or not I should fly autogyros anymore.

After a thorough examination of the crash site, and after hearing the many witnesses, we came to the conclusion that the B-8M accident at Pori was again a perfect example of the so-called porpoising or zero-G accident, many of which have taken place around the world in recent years. The pilot in the Pori case had 1000 hours of experience in fixed-wing machines, and a few hours in the mentioned gyrocopter. He had been warned about zero-G and knew how to avoid it. So again, the questions arose: why?

Restrictions on flying small non-type certificated autogyros have been set now in many countries. Operating limitations have been imposed for the time being on the craft in England as a direct result of the Wallis accident and, in Denmark, flying these machines is prohibited completely.

A lot has been written about zero-G flight with autogyros and how things develop in the air during it. It is already known that reasons such as high speed, gusty winds, high power setting, low rotor loading, and incorrect pilot reactions to longitudinal oscillations, will contribute to zero-G conditions. However, recently some quite mysterious explanations have been given for zero-G accidents. One reason for this is that no pilot, so far, has returned alive from a zero-G flight to tell us about the experience. Examination of the above mentioned accidents and a lot of thinking have convinced me that the following sequence of events usually is what really happens.

In normal flight, forces and moments acting on the autogyro are in balance, i.e. lift=weight, thrust=drag, and there are no residual moments about the CG. The sequence of a zero-G accident normally starts with a pilot or turbulence-induced longitudinal oscillation. The pilot tries to stop it by pushing and pulling the stick, but may use too large corrective stick movements or the corrections are not in proper phase in relation to the oscillations. This will increase the oscillations instead of decreasing them. Things become dangerous when the autogyro fuselage is rotating nose down (and tail up) and to correct it, the pilot is pulling the stick full back. This will rapidly reduce the clearance of rotor to vertical tail and propeller. Now, if the rotor has even momentarily reached a zero angle of attack during previous oscillations, it has also lost some of its rpm, resulting in an increase in flapping motion during the pull-up maneuver. At this moment, rotor blades will flap over the flapping stop limits, hitting the propeller and vertical tail. The wasted, crushing energy will further reduce rotor rpm and a part of the lift is lost. Now, residual nose-down moment about the autogyro's CG is generated because of engine thrust and reduced rotor drag. The autogyro will continue nose-down rotation with the rotor following it to a negative angle of attack. Finally, as a result of this, the rotor blades will build up a large negative cone angle striking very hard against the propeller and vertical tail. Usually rotor blades, propeller and vertical tail are completely lost and split into pieces, and shortly after that the machine crashes inverted.

Why not a Horizontal Tail?

It is a well-known fact that the autogyro is statically and dynamically stable at normal flight speeds. However, it is well, known, too, that the dynamic stability deteriorates and control sensitivity increases with speed if no horizontal tail surfaces are installed, which is the case in nearly all typical, single-place autogyros built today. I think this practice derives its origin from the Bensen "Gygoglider," which indeed does not require a horizontal tail because of the stabilizing effect of the tow rope and the very low forward speeds it is usually flown at in tow. The gyrocopter, however, has a free-flight capability with a much higher speed range. I think the mistake was made here when the tiny and only decorative horizontal tail plate was mounted under the propeller. Designers throughout the world followed this design practice and configuration, including I and Mr. Eerola in our ATE-3. Peter Krauss in West Germany has also installed a horizontal stabilizer on his TSR-II autogyro. And all the gyros flew well—usually.

It should be noted that Juan de la Cierva, the father of the autogyro, always designed a large horizontal stabilizer for his autogyros. Similar large-size horizontal stabilizers are also installed on all FAA type-certificated autogyros today, such as the Air & Space U-18 and McCulloch J-2.

Function of the Horizontal Stabilizer

In an airplane, the horizontal stabilizer is required to give the machine both static and dynamic stability. In an autogyro we have good static stability without it because the fuselage is "hanging" from the rotor and since we have the offset gimbal rotor head.

The matter is different with dynamic stability and control sensitivity at high speed. To kill the longitudinal oscillations we need damping provide by either a skillful pilot at the controls, an electronic "black box" and hydraulics, or simple a horizontal stabilizer which gives aerodynamic damping.

A V–Tail on the ATE-3

To test in practice how the above philosophy works out, we installed a V tail on the ATE-3. Previously, we had flown the machine with two different tail configurations, the latter being a purely vertical tail only. The machine was normally very easy to fly, but in gusty conditions or at very high speed, we had noticed some unpleasant longitudinal oscillations which gave the pilot an uncomfortable feeling in the stomach.

Lacking time to make a really thorough study on the required horizontal tail area, I decided to install the biggest surfaces possible without endangering the clearance between the rotor and tail. I also compared the ratio of tail volume to rotor volume of some Cierva autogyros and present-day FAA-certificated gyroplanes. The "volume" means the surface area multiplied by the distance from its center of pressure to the autogyro CG. Rotor volume is the disc area multiplied by the distance from the flapping hinge to the CG (of the rotor blades). I found that only large H or U-type tails could give the desired tail areas. This is verified by the fact that the Air & Space U-18, McCulloch J-2, and the Cierva machines have this type of tail. If a linkage between the control stick and horizontal tail is arranged as show in NACA TM879, smaller areas could be used. However, needing a quick solution to the problem, a more readily available V-tail configuration was selected.

The new V-tail on the ATE-3 has two surfaces of similar size set at a 90-degree angle of which we had only one surface in the pure vertical tail. Material used for these surfaces is fiberglass and epoxy. Weight is 12 lbs., and thickness is about two inches. Torsionally, the tail was designed so stiff that no balancing weights were needed for the rudders. At first a 110-degree angle was used, inspired by the Beechcraft "Bonanza" which has a 120-degree V angle, but this offered too-low stability in yaw.

In the final configuration, the ATE-3 has increased rotor-to-tail clearance and possesses improved longitudinal stability at high speeds and power settings. In calm air, the machine can be flown at the height of one foot at 80 to 90 mph with ease. Judging from the still quite limited experience we now have with the new tail, oscillations in turbulence have been eliminated to a remarkable degree, too. Possible hazards of over-controlling the machine have been greatly minimized, as at least twice greater fore and aft control movements are now required with the stick to achieve the same effect as before. This is true at speeds over 60 mph. Below that speed, handling qualities of the machine are unchanged.

Captions for pictures:

Pic 1: The author and builder is seen in the ATE-3 while it had the vertical tail

Pic 2: The ATE-3, OH-XYV, with its new V-tail

Pic 3: The ill-fated Wallis Wa-117 gyro is seen at the Farnborough Show before the accident

Pic 4: The V-tail receives the full wash from the propeller