experimental aircraft association

THE LEADING EDGE

NEWSLETTER OF MUROC EAA CHAPTER 1000

Voted to Top Ten Newsletters, 1997, 1998 McKillop Award Competition

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http://www.eaa1000.av.org *May 2019*

Chapter 1000 meets monthly on the third Tuesday of the month in the USAF Test Pilot School Scobee Auditorium, Edwards AFB, CA at 1700 or 5:00 PM, whichever you prefer. Any changes of meeting venue will be announced in the newsletter. Offer void where prohibited. Your mileage may vary. Open to military and civilian alike.

This Month's Meeting:

Project Police Flyout to KPRB

Saturday, 18 May 2019
1000 hrs (10:00 AM Civilian Time)
Paso Robles, CA

For this year's EAA Chapter 1000 May Aviation Event, we a planning a Fly-Out to the Paso Robles airport (KPRB). It is 128 nm from Rosamond Skypark, a 1.5 hour flight in the **Combat Bearhawk**. We will be visiting the Estrella Warbirds Museum (http://www.ewarbirds.org). We have been granted permission to park our aircraft on the museum's taxiway, right next to some of the display aircraft. Be careful they don't put a museum information sign in front of your airplane!

We have arranged to meet with **Jerry Jones**, the museum coordinator, for the Cook's tour of the museum. Admission is $12, $10 for military veterans. Active Duty military are FREE! The museum is open 1000 to 1600.

Also joining us will be **George Marrett**, Vietnam Skyraider pilot (like **JDIII**), Air Force Test Pilot (also like **JDIII**), and test pilot for **Hughes Aircraft Company**. Read about him at https://en.wikipedia.org/wiki/George_J._Marrett before we get there. You can also review the museum's web site as part of your studying.

There is no food service available at the museum, but our **Schmoozemistress** is preparing a lunch spread for us to be served under the wing of the **Combat Bearhawk**. Bring your folding chair or picnic blanket and we can have quite the picnic. Donations will be gladly accepted.

If you have an airplane and think you will be able to participate in this fly-out, contact **Erbman** to tell him so. Really, you should have done that long ago. Tell him how many people you are bringing and how many empty seats you have that you are willing to fill with other ***PPOs***.

If you don't have an airplane but would still like to participate in this event, contact **Erbman** to be matched up with an empty seat. No guarantees—we're currently short of seats.

TASKING: Plan your flight to be at the museum with your airplane chocked and secured before 1000. Some of our members are on a short schedule so we want to get started as early as we can. Communicate with **Erbman** by text at 661-754-0524.

Last Month's Meeting

EAA Chapter 1000
USAF Test Pilot School
Scobee Auditorium
Edwards AFB, CA
16 April 2019
Gary Aldrich, Presiding

The March meeting was held at the Test Pilot School Manned Orbiting Laboratory Conference Room at Edwards AFB with 12 members and guests attending. Social hour began at 1700 with an elaborate spread of goodies. **Schmoozemistress Tuki**, although not in attendance, provided **TWO** kinds of home-made **Tuki-Cookies**, traditional Tollhouse chocolate chip, and chocolate cookies with white chocolate chips, with the usual chips and sodas. **Russ** far exceeded expectations and is restored to the good graces of the chapter (thanks, **Tuki**!)

Guest speaker was "**Evil Bill**" **Gray**, TPS Chief Test Pilot, briefing us on the Digitally Enhanced Aiming THrough Control LAW (DEATH CLAW) project, an autopilot enhanced gunnery Proof of Concept Flight Test program using the NF-16D Vista, a joint program between the USAF TPS, Lockheed Skunkworks and Calspan.

DEATH CLAW is a software approach that integrates existing aircraft sensors (electro-optic, infra-red, radar) with the aircraft flight control system to put bullets on both stationary and moving targets more quickly and accurately.

Given that bullets are a mere fraction of the cost of missiles and bombs, and considering that the F-16 has only 500 or so rounds, and 181 rounds for the F-35, improving the accuracy of their guns is a no-brainer.

In 1981, the AF tested an F-15 using a hardware approach to do much the same thing, using 7 boxes with the Integrated Flight/Fire Control (IFFC) Firefly program which was very successful but was not implemented.

Whereas IFFC was a complex hardware approach, DEATH CLAW was software only, with automation increasing lethality with less risk. It locks a target quicker and smoother, giving the pilot more time on the target with better results, or a quicker shot to get off the target quicker to reduce vulnerability. As Evil Bill says, "it makes some schmuck off the street better than the best F-16 pilot."

The Proof of Concept program took 3 months' time from funding to 1st flight, completing 9 sorties in 2 weeks (4 flights for systems checkout, 5 data flights using F-16 and F-35 test pilots) followed by demonstration flights for the F-16 Weapons School, Air National Guard Commander and the 412th Test Wing Commander.

Block 30 Air National Guard integration has begun with flight test scheduled for 2020, and Block 40/50 implementation is likely. The F-35 and F-22 programs have also expressed high interest.

Kommandant Aldrich closed the meeting with the assuring declaration that **Victory!** had been achieved.

Activities were subsequently moved to the Burger King Dead Cow Emporium for dinner and additional Q&A and discussion with Evil Bill.

Most of this is true.

- Kent "Cobra" Troxel
Minister of Propaganda
Chapter 1000 of the Experimental Aircraft Association of these United States of America and Occupied Territories
"We have more zeroes in our chapter than any other!"

Kommandant's Korner

Readers of the **'Edge** are familiar with the terrible affliction **Gadgetosis Nervosa**, from the Latin for, "**Hey, I want that!**". This disease inflicts several of our hearty band of aviators, yours truly included, and is manifested by the inexplicable desire to buy the latest cool gewgaw, widget, or thing-a-ma-jig that is (usually, but not necessarily) related to our collective flying passions. I've chronicled several recurrent bouts of GN I've had in these pages, way back to the mid-1990s when the condition was first given the name.

Many know of its effects on gross weight and bank balance but some may not know just how contagious the condition is…easily rivaling the current measles outbreak. It can be carried by folks who don't give outward signs of the symptoms, e.g. drooling, shortness of breath, and making outlandish justifications for the credit card bills. Thus, it was that I suffered a recent flare-up that I have traced to the 20-plus hours I have spent in the **Combat Bearhawk** torturing…er, enlightening **NLE Erb** in the finer points of flight without visual references.

In recent issues, Erbman has recounted all the fun of staring intently at his electronic flight displays and praying that some parameter…any parameter…remains stable at the proper value. His electronic displays, engineered by Dynon Avionics for the Experimental-Amateur Built market are revolutionary in their ability to present critical information in a concise, efficient, reliable, and (relatively) inexpensive way. Those of us with aircraft possessing Standard Airworthiness Certificates have been left watching, enviously, as these technological wonders have been rolled out by Dynon and others but were not legal to install in our air machines. This was the case until the last few years when your EAA and other aviation alphabet groups led the charge to loosen the certification wickets. Manufacturers of these gizmos have responded with a plethora of new devices, including one from the avionics BIG DOG, Garmin. While prices still reflect the cost of producing FAA-mandated testing and paperwork, the fact is the magic is now available to the "certified" fleet of aging general aviation aircraft at reasonable cost.

So it happened, that I presented **Jeff Landon** of **High Desert Avionics** a check at Burger King after last month's gathering to initiate procurement and installation of a **Garmin G5** "Electronic Flight Instrument" (https://buy.garmin.com/en-US/US/p/570665/pn/K10-00280-00#). Note here, the "generic-ness" of the nomenclature. That's because the G5 unit is capable of replacing several conventional instruments by using simple software-driven controls to change the display from an attitude indicator (AI, or ADI) to a directional gyro (DG) to a full-blown horizontal situation indicator (HSI). I chose to install my G5 in the lower middle position in my "six-pack" instrument cluster, replacing the mechanical, "spinning mass" DG I had installed several years ago when I did the "**Electric Skywagon**" upgrade (see K^2, December 2006 'Edge). With the G5 upgrade I was able to replace the single-purpose DG and the primary VOR/LOC/GS indicator with one compact display that delivers all the capabilities of the mechanical instruments and much, much more. I gained a solid state attitude and heading reference system (AHRS), a magnetometer (or flux gate) for magnetic heading input, and a four-hour backup battery. I've flown the aircraft twice to test the installation and I am increasingly impressed at the utility of the new display and its capabilities for control of my existing autopilot. Look for more pilot reports in future columns.

Garmin "G5 Electronic Flight Instrument for Certificated Aircraft" shown in Directional Gyro mode

Position of the G5 in the Fightin' Skywagon panel

G5 in EFIS mode

Of course, there is a down side to all this. It is the GN-related malady known as "**Empty Hole Syndrome**" or EHS. All this new technology in such a compact package has left a blank spot in my previously well-populated and symmetric panel. I don't know how long I'll be able to fly the **Fightin' Skywagon** around with the glaringly vacant instrument hole caused by the removal of the

VOR/LOC/GS indicator. Well, I am going to **AirVenture** this year….

The source of "Empty Hole Syndrome"

Fly Safe, and Check Six!

- Gary Aldrich
Kommanding

Weird New Dynamic Modes Discovered In Combat Bearhawk

Based on the experiences of many hours in the **Fightin' Skywagon**, the original design of the avionics in the **Combat Bearhawk** included a two-axis autopilot, primarily for workload reduction during the cruise phase of flight. The autopilot selected was the TruTrak ADI Pilot II, one of their newest autopilots at the time and "reasonably" priced.

Because the ADI Pilot II was designed for installation in Experimental Amateur Built aircraft, there was no way that it could be optimized for all of the possible installations. Instead, it was built with a large range of adjustments to allow it to be optimized for each installation. Unfortunately, there was no real guidance for what settings to use, so initially it was somewhat of a crap-shoot.

I picked some settings for the autopilot, and it seemed to do okay initially. If the air was smooth, the autopilot controlled the airplane just fine. However, if it got into the slightest amount of turbulence, the autopilot seemed to over-react and controlled in a very twitchy fashion.

I put up with a twitchy autopilot initially, not really knowing how it should respond. At Copperstate 2010 I discussed this with a rep at the TruTrak booth who suggested that the gain settings should be reduced. I tried that, and it got a little better. At Oshkosh 2013, I again asked the TruTrak rep how I would know that I had adjusted the gains properly. His advice was that the gains would be correct when "the autopilot flies in turbulence the same way that you do." I reduced the gains to half of their current value and flew the airplane, not really sure how to evaluate the settings.

Several months later I made an afternoon flight with a visiting C-130 pilot. After climbing to altitude, I engaged the autopilot so that I could take care of another task, probably determining the proper mixture to lean to. The air was noticeably bumpy, but at some point I forgot that the autopilot was flying and assumed that the C-130 pilot was flying. I finished my task, and eventually noticed that he was not controlling the stick. At this point I realized that the autopilot was flying in such a fashion that I thought it was another human pilot flying. At that point I realized that I had set a reasonable gain. The autopilot was slower to react than it had been before, but the lag in the control was much more similar to a human pilot.

Fast forward to 2019 when the **Kommandant** and I were trying to figure out how to fly the **Combat Bearhawk** under IFR procedures. The FAA believes that a pilot should be able to use any installed equipment in his airplane, to include an autopilot. In this case, the autopilot should be used when appropriate. I have heard stories about pilots in a Garmin G1000 equipped Skyhawk that engage the autopilot shortly after takeoff and leave it on until just before touchdown. Clearly I couldn't do that, since my autopilot doesn't have any vertical modes. In fact, all it will do is follow a GPS track, follow a GPS NAV course, and maintain altitude. It can adjust altitude up and down by small amounts, but this really doesn't count as vertical guidance.

Even so, the autopilot could conceivably be used to track a lateral course on a GPS approach while I managed pitch and throttle to control the descent. Because of the system architecture, the autopilot would not track VOR or ILS approaches. The **Kommandant** has actually done these coupled approaches in the **Fightin' Skywagon**.

The autopilot works well at cruise airspeeds of 110 KIAS, but would it work at an approach airspeed of 75 KIAS? The problem is the controls become more sluggish as the airspeed slows. Pilots automatically change their input gains (make larger control inputs) as airspeed reduces, but the autopilot gains are fixed.

Since this was well within the normal flight envelope, the best way to answer a question like this was to do a flight test. Thus the **Kommandant** and I established level flight at a cruise altitude at 75 KIAS in our approach configuration (two notches of flap). I engaged track and altitude hold on the autopilot and let go to see what would happen. What happened was quite an entertaining ride, and not in a good way.

As stated before, at slower airspeeds the controls become more sluggish. This requires a higher input gain (bigger, quicker inputs) to compensate. If the gains do not increase, then the inputs lag behind the output and the oscillations around the desired position become larger.

Just to make things more entertaining, another moment becomes significant – P-factor. As the FAA taught you in your ground school, P-factor is one of those moments that try to turn your airplane to the left when you don't want it to. It happens because when the air inflow is not exactly aligned with the propeller axis, the blade going down on the right has a higher angle of attack and produces more thrust than the other blade. In level flight, the higher the pitch angle of the propeller axis, the stronger the P-factor moment is. P-factor is normally managed by applying right rudder. However, the two axis autopilot is connected to the elevator and the ailerons, not the rudder. This little fact leads to the fun that we experienced.

The fixed trim tab on the rudder is set to "center the ball" while at cruise airspeed. However, we were now at approach speed, so the pitch angle was noticeably higher than at cruise speed, about 2.5 degrees higher. Because of the higher pitch, the P-factor moment was greater. Without any additional compensating rudder, the nose yawed to the left. When the nose yawed to the left, the airplane started turning away from its commanded track. The autopilot responded by doing the only thing it could—it started banking to the right. This put the airplane in a cross-controlled sideslip, which has more drag and causes the airplane to slow down.

The airplane responds to reduced airspeed with a stable response, which is to pitch the nose down. This reduces the pitch angle, which reduces the angle of attack on the propeller disk. The reduced angle of attack on the propeller disk reduces the P-factor moment, so the stabilizing effect of the vertical fin brings the nose back to the right. With the nose coming back to the right, the track of the airplane approaches the commanded track, so the autopilot levels the wings.

Now the wings are level, but the airspeed has increased, which pitches the nose up. Additionally, the loss of altitude causes the autopilot to pitch the nose up to return to the set altitude. This puts the nose at a higher pitch angle, which increases the P-factor moment, and the whole cycle begins again. Lather, rinse, repeat.

Because of the laggy response of the autopilot due to the lower-than-required gains, and because of the somewhat weak directional stability of the Bearhawk, this cycle never stabilizes to a particular state. Instead it becomes a Limit Cycle Oscillation (LCO) that just goes around this path over and over.

Of course, it's tough to fly an approach with your nose wobbling around some weird dutch roll/phugoid combination. Thinking that the problem was simply the autopilot had no control of the rudder, I tried actively using the rudder to center the ball as the nose went around this bizarre loop. It turned out that the rudder movement required was not simple, and I rapidly realized that the amount of workload to use the rudder to center the ball in this scenario was quite high. Because this was a control motion that had not been practiced, the workload to center the ball with the rudder was significantly higher than the workload to simply hand-fly the approach without the autopilot engaged.

Thus came to an end any thoughts of trying to fly an autopilot coupled approach. However, that's not the end of autopilot usage for my instrument training. For anything at cruise speed, such as the enroute portions, the autopilot works very well. It creates a significant workload reduction, which is very useful for other tasks such as making sure the avionics are set up properly for the approach.

- Russ Erb

Assorted Pictures From The May 2017 Palm Springs Museum Trip

JDIII with the Doolittle Raid Model

The group yaps about something

Web Site Update

Just a reminder that the EAA Chapter 1000 Web Site is hosted courtesy of Quantum Networking Solutions, Inc. You can find out more about Qnet at http://www.qnet.com or at 661-538-2028.

Chapter 1000 Calendar

EAA Chapter 1000 Board of Directors Meetings are now held on an unscheduled, as needed basis. If you need to know when, you're already on the e-mail notification list. (661) 609-0942

May 18: EAA Chapter 1000 Annual Aviation Event, Fly-Out to Estrella Warbird Museum, Paso Robles CA (KPRB). (661) 609-0942

Jun 18: EAA Chapter 1000 Monthly Meeting, 5:00 p.m., Edwards AFB. USAF Test Pilot School, Scobee Auditorium. (661) 609-0942

Jul 16: CNX EAA Chapter 1000 Monthly Meeting, Cancelled in lieu of AirVenture. (661) 609-0942

Jul 22 - 28: EAA AirVenture. Oshkosh WI.

Aug 20: EAA Chapter 1000 Monthly Meeting, 5:00 p.m., Edwards AFB. USAF Test Pilot School, Scobee Auditorium. (661) 609-0942

Sep 17: EAA Chapter 1000 Monthly Meeting, 5:00 p.m., Edwards AFB. USAF Test Pilot School, Scobee Auditorium. (661) 609-0942

Oct 15: EAA Chapter 1000 Monthly Meeting, 5:00 p.m., Edwards AFB. USAF Test Pilot School, Scobee Auditorium. (661) 609-0942

Nov TBD: EAA Chapter 1000 Monthly Meeting, 6:30 p.m., Flying Dog Ranch, 4400 Knox Ave, Rosamond CA. (661) 609-0942

Dec 17: EAA Chapter 1000 Festivus Etc Celebration, 6:00 p.m., Kommandant's Kwarters, 42370 61st Street West, Quartz Hill CA. (661) 609-0942

Jan 21: EAA Chapter 1000 Monthly Meeting, 5:00 p.m., Edwards AFB. USAF Test Pilot School, Scobee Auditorium. (661) 609-0942

Feb 18: EAA Chapter 1000 Monthly Meeting, 5:00 p.m., Edwards AFB. USAF Test Pilot School, Scobee Auditorium. (661) 609-0942

Mar 17: EAA Chapter 1000 Monthly Meeting, 5:00 p.m., Edwards AFB. USAF Test Pilot School, Scobee Auditorium. (661) 609-0942

To join Chapter 1000, send your name, address, EAA number, and $20 dues to: EAA Chapter 1000, George Gennuso, 3119 Lennox Ct, Palmdale CA 93551. Membership in National EAA ($40, 1-800-843-3612) is required.

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Inputs for the newsletter or any comments can be sent to Russ Erb, 661-256-3806, by e-mail to erbman@pobox.com

*From the **Project Police** legal section: As you probably suspected, contents of The Leading Edge are the viewpoints of the authors. No claim is made and no liability is assumed, expressed or implied as to the technical accuracy or safety of the material presented. The viewpoints expressed are not necessarily those of Chapter 1000 or the Experimental Aircraft Association. **Project Police** reports are printed as they are received, with no attempt made to determine if they contain the minimum daily allowance of truth. So there!*

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MUROC EAA CHAPTER 1000 NEWSLETTER
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THIS MONTH'S HIGHLIGHTS:
FLYOUT TO KPRB 18 MAY
DEATHCLAW REVIEW
GADGETOSIS NERVOSA FLAREUP
AUTOPILOT UNSUITABLE

EAA™
THE SPIRIT OF AVIATION