PART 3

Come Fly with Me—The eCFI

The University of Iowa's prototype pilot sensor system monitors multiple physiological parameters.

We offer some hardware ideas for those who may want to build their own systems.

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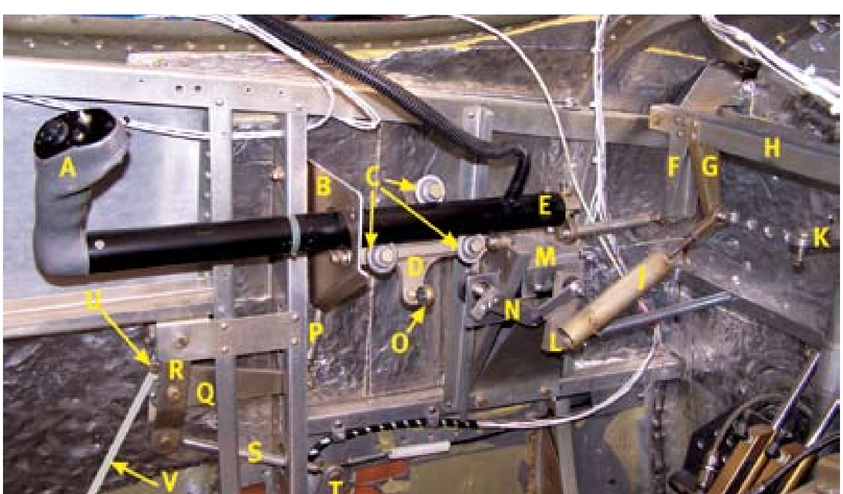
This article presents some control, sensor and display hardware ideas to help builders begin planning their eCFI systems. Intermediate and advanced eCFIs should be capable of commanding the controls of the aircraft, much as would a real Certificated Flight Instructor (CFI). For this to happen, the control system must have actuators of modest size and power. The aircraft must be designed to have handling qualities whose control forces are not too stiff and are somewhat linear in force buildup.

When we rent a car, we pretty much expect the seat belt warning chime and that there will be a steering wheel, automatic transmission shift lever, speedometer, etc. Ideally, the personal air vehicle (PAV) controls, eCFI functions and displays will become similarly generic in both look and feel. Transitioning from one model of PAV to another would be much easier that way.



The Questair Venture side-stick control linkage. See the text for an explanation of each labeled part.

The Model

To expedite such development, Jim Griswold, designer of the Questair Venture, and Dave Anders, CAFE Triaviathon Champion and Venture builder, have kindly provided images of the Venture's control system to serve as a suitable model for an eCFI. You can watch its operation on a web video at *http://cafefoundation.org/v2/video/questair_test.html*. The photo shows the key components. Besides being a side-stick control, the Venture's design includes provisions for use of trim spring "cartridges" and an interlink for flaperon function. Both of these are valuable features for PAVs to be able to achieve the desired generic control feel.

The Venture's side-stick operation was designed to emulate that of the F-16, that is, by having minimal translational movement and relying more on the pilot modulating control by forces detected as "feel" and skin pressure. This design

NASA's Naturalistic Flight Deck uses this fly-by-wire side-stick control with Stirling Dynamics servo motors and built-in strain gauge sensors.

also seeks to minimize friction and thereby give designers the ability to tailor the breakout forces and their harmony by using spring cartridges (item J in the photo).

How it works: The black tube (E) pushes on F and G to rotate H, the torque tube, which moves another arm (not shown) up and down to move the elevator. The left-right tiller bar for the rudders is K. Item N is a stiffener brace that supports the trim position indicator's stub shaft just aft of the motor shaft (M), which houses the electric trim motor, and J is the elevator trim spring cartridge. The three items labeled C are tapered rollers that fit inside thin slots cut in the black tube (E), and allow fore-aft stick movement for elevator control. Items P, Q, R and S allow T, the flap actuator, to bias the position of the aileron pushrod (V), which attaches to the small bolt (U) on the bellcrank just aft of pivot R. Pushrod V was PhotoShopped into the picture. It provides the linkage to achieve flaperon action when flaps are down.

Ailerons move when the captive tube (E) rotates casting D about the longitudinal axis of the fuselage. Item B is the instrument panel bulkhead. Item O attaches to a transverse push-pull tube that is behind the instrument panel (item W in the second photo); W

eCFI Collaborators

The web site at www.landings.com/_landings/pages/avionics.html contains a comprehensive list of resources, but here are a few to get you started.

Jim Hauser's helpful site
www.aerospectra.com
303/499-2584

Dylan Schmorrows at ONR Navy
email: SchmorD@ONR.Navy.Mil
703/696-4259

Tom Dollmeyer from "Open EFIS"
email: Tom@Dollmeyer.com
812/350-2701

John Retelle at DARPA
email: jretelle@potomacinstitute.org
571/218-4595

Manufacturers and Other Contacts

Advanced Flight Systems
www.Advanced-Flight-Systems.com
503/263-0037

Avionics Hangar
www.avionicshangar.com
888/833-5487

Blue Mountain Avionics
www.bluemountainavionics.com
423/496-3510

Comant Antennas
www.comant.com
714/870-2420

Crossbow Technology
www.xbow.com
408/965-3300

Dynon Avionics
www.dynonavionics.com
425/402-0433

Electronics International
www.Buy-Ei.com
877/318-6060
email: Support@Buy-Ei.com

Garmin International
www.garmin.com
800/800-1020
A good story on the $8000 ADS-B unit from Garmin can be found at www.garmin.com/products/gdl90/

Grand Rapids Technologies
www.grtavionics.com
616/245-7700

Icom America
www.icomamerica.com/
425/454-8155

I-K Technologies
www.i-ktechnologies.com
818/302-0606
email: techsup@i-ktechnologies.com

JP Instruments
www.jpinstruments.com
800/345-4574

Maemo.org
https://garage.maemo.org/projects/katix-efis/

Microsoft
www.microsoft.com
800/642-7676
email: ronm@microsoft.com

OP Technologies
www.optechnologies.com
503/690-0800

PC Avionics
www.mountainscope.com/autopilot.jsp
Can connect to many low-cost autopilots using NMEA GPS standard

PC Flight Systems
www.pcflightsystems.com
email: info@pcflightsystems.com

Porcine Associates
www.porcine.com/gps/sc/sc_frameset.html

The Ray Allen Company
www.rayallencompany.com
760/599-4720

Sigtronics
www.sigtronics.com/air
909/305-9399
email: tech@sigtronics.com

Trio Avionics
www.trioavionics.com
Low-cost autopilot with NMEA GPS standard
619/448-4619

TruTrak Flight Systems
www.trutrakflightsystems.com
866/878-8725

University of Iowa Operators Performance Lab (Tom Schnell)
www.mie.engineering.uiowa.edu/Research%20Presentations/Tom%20Schnell%20Research.pdf

University of Iowa Pilot-Avionics Interface Engineering Study
www.news-releases.uiowa.edu/2007/February/020507pilot-avionics.html

Vision Microsystems
www.visionmicrosystems.com
360/714-8203

Vista Nav
www.VistaNav.com
866/627-1671

Pulse Oximetry

Simple, unobtrusive pulse oximeter sensors are available and could be used to monitor the pilot while providing a signal out to the eCFI system. Check these sites for more information.

FlightStat Oximeter
www.flightstat.nonin.com/

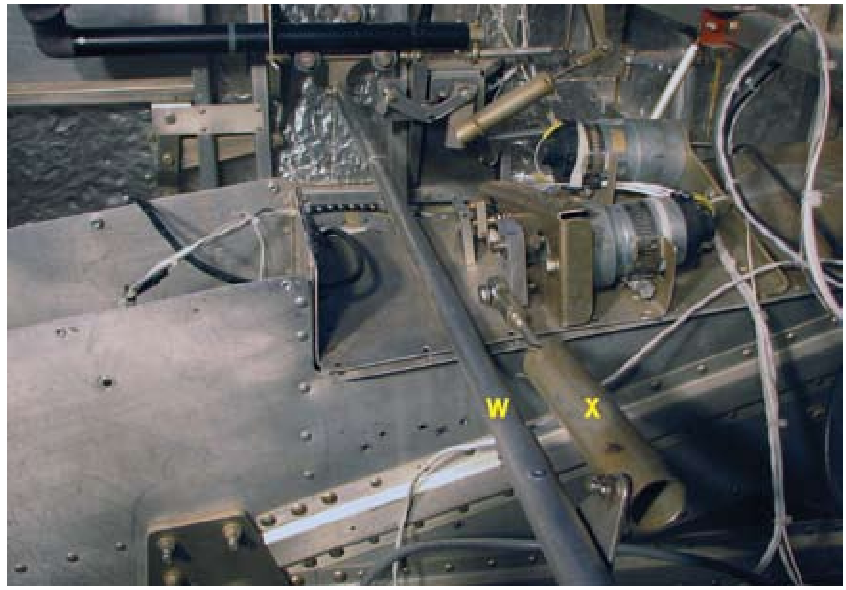
Nonin PureLight Sp02 Sensors
www.nonin.com/products.asp?ID=22&sec=1&sub=7

Nonin OEMIII Pulse Oximetry Module
www.nonin.com/productsasp?ID=26&sec=2&sub=9

Photos: Brien Seeley and Courtesy Tom Schnell (University of Iowa) attaches to the tunable roll-trim spring cartridge (X) and cross-links pilot and co-pilot stick movements for roll control. In the Venture, once the control linkages leave the forward cabin, both aileron and elevator are operated by cables and pulleys.

The spring cartridges for both the elevator and aileron trim contain two captive compression springs separated by a thick washer (piston) welded to the movable center shaft. The stiffness of both of these springs can be changed to alter the feel of push or pull, respectively. The web video illustrates this operation.

For advanced eCFI purposes, the linkages described above would need to be connected to a servo/positioning motor and strain gauge sensors. The motor would be capable of applying enough force to fly the aircraft on its own. It would use information obtained from the strain gauge sensors on the control pushrods to keep abreast of how much force was being used. How to apply these pieces of hardware is beyond the scope of this article, but strain gauges are small devices that can be bonded directly onto the metal pushrods. Ideally, the motors and strain gauges would be mounted in accessible/serviceable locations along the sidewall of the fuselage.



The Questair Venture control linkage illustrates the spring cartridge for roll trim.

Other Essential Hardware

NASA's Langley Research Center has developed a sophisticated eCFI system called the Naturalistic Flight Deck (NFD). Ken Goodrich, a principal leader there, was kind enough to supply the images showing the fly-by-wire side stick-control and its underpinnings. The high quality servo/positioning motors shown in the photo are made by Stirling Dynamics of the U.K. (*http://www.stirling-dynamics.com*), where an enthusiastic contact is Stephen Judd (*sjudd@stirling-dynamics.com*).

Tom Schnell's group at the University of Iowa is developing what they call the Synthetic Flight Bag or SFB. Their work has expanded from being a low-cost synthetic vision system toward being a full-on eCFI that uses elaborate sensors to evaluate pilot physiological state. The prototype system will evaluate dense array electroencephalogram (EEG), electrocardiogram (EKG), electromyogram (EMG), facial feature points, facial temperature changes, eye movements, respiration frequency and amplitude. (See the photograph of the prototype's sensor-equipped pilot.) The SFB's display system is designed to be added to conventional instrument panels and consists of the hardware shown in the photos.

I hope that this series of three articles about the eCFI concept will stimulate kit-aircraft builders to begin making their own versions of an eCFI. Toward that end, a list of contacts in this field is included. +

CORRECTION

The statistic about CFI accident rates in Part 1 of this series was based on the number of fatal accidents per student pilot compared to the number of fatal accidents per ATP (airline pilot) from the NTSB 2001 report. However, that analysis does not account for the flight hours spent, nor the difficulty of the flying conditions. Consequently, rather than saying that student pilot flights with human CFIs aboard have a lower fatal accident rate than even air carriers, it is more accurate to say that student pilot flights with human CFIs aboard have about one-third as many fatal accidents as occur in personal and business flying. The 2006 Nall Report from AOPA likewise shows a dramatic improvement in GA safety with CFIs aboard.

—B.S.