Chesapeake Chapter INCOSE
International Council on Systems Engineering

Print Article
Sign up for the Newsletter
Go to Back Issues

December 2010

Feature Article

E6B

by George Anderson

Spock uses E6B in *Who Mourns for Adonis*

The E6b aircraft navigational computer was introduced in its earliest form in the early 1930's and evolved into its present form just prior to WWII. During the war thousands of aviators learned to operate and depend on this simple device for their routine flight planning and in-flight calculations. As aviation technology improved in the post WWII period, the E6B soldiered on as a full-fledged part of every pilot's initial and annual refresher training. Even today with hand held electronic calculators performing exactly the same tasks, many pilots still carry the E6B and use it frequently.

By any standard of longevity, this is an admirable record and one that has implications for the Systems Engineer (SE) in approaching the design of new Information Technology applications and products. As systems engineers, can we identify some lessons learned from the E6B experience?

To establish a foundation for the lessons learned, we must describe the requirements that are met by the E6B. This is actually a reverse engineering task given that the E6B has been in use for over 73 years.

I have created a decomposed list of hardware independent requirements that cover two major areas. These are:

1. What are the fundamental computational requirements associated with flying?
    a. Provide the capability to make mathematical calculations that include graphic solutions of vector math.
        1. Multiply and divide to at least three significant digits
        2. Solve at least two cases of the Navigation Wind triangle
            1. Case one, the wind vector is known and the True Course and True Airspeed is known. Solve for True Heading and Ground Speed.
            2. Case 2, the True Course (or drift angle) and Groundspeed are known along with the True Airspeed and True Heading. Solve for wind direction and magnitude.
    b. Provide the capability to make conversions between units of measure.

Return to Newsletter

Our Chapter now has a presence on LinkedIn

Check it out and join our group so we can together discuss the latest in Systems Engineering news and events.

Mark your Calendars with these upcoming events:

Our End-of-the-Year Holiday Dinner/Awards Ceremony

Date: **Thursday, 16 Dec 2010 6 - 10PM**
Sit-Down Meal: **Either Beef Tenderloin Forester or Maryland Crab Cakes.**
Location: **The Engineers Club** at the Garrett-Jacobs Mansion; Baltimore, MD
Join us for an enchanted evening of fine food, glitzy awards and stimulating conversation with friends and colleagues.
Special Registration Page
>>HERE<<

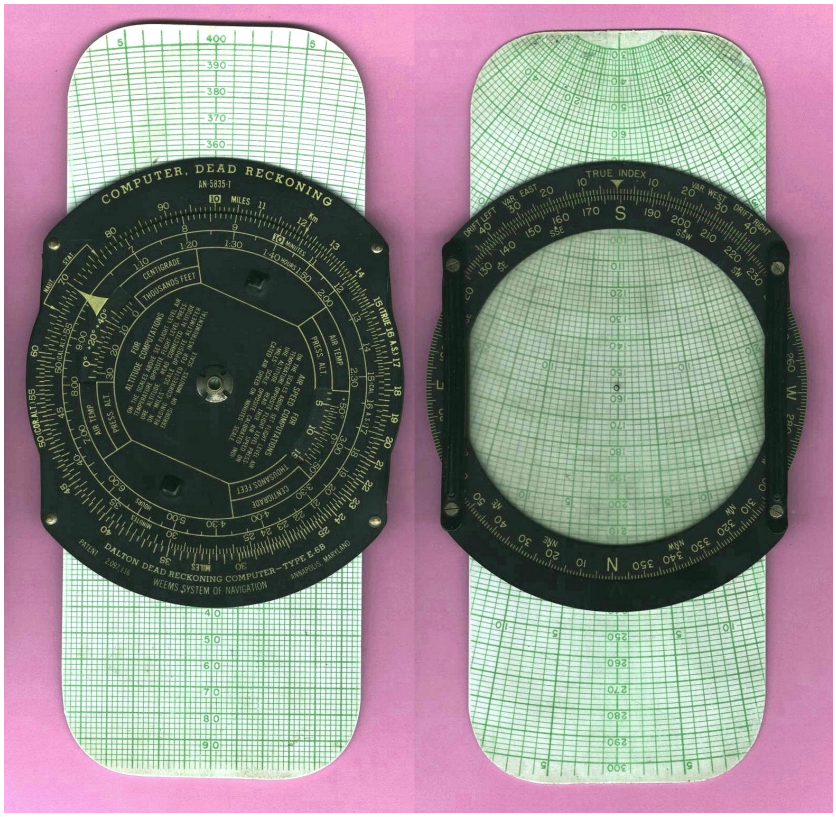
The Chesapeake Chapter is always looking for volunteers to speak at our upcoming meetings! Please contact our

1. Temperature in degrees F to C.
2. Nautical miles to Statute miles
3. Angles: degrees to radians

c. Conversions using aerodynamic formulas

1. Indicated to Calibrated to Equivalent to True Airspeed. Acronym- ICET
2. Mach number to True Airspeed
3. Temperature correction applied to Mach and True Airspeed
4. Temperature correction applied to Indicated vs. True Altit

2. What are the essential operating requirements associated with flying?
   a. Portable, lightweight, rugged, cheap, injury proofed and expendable
   b. Passes MIL-STD-810 Temperature Cycle Testing from -55°C to 125°F
   c. Hand operated preferably using only one hand in certain phases of flight.
   d. Legible and unambiguous scales even in bright sunlight or reduced visibility or during operations in turbulence and lightning.
   e. Small enough to carry in flight suit pocket.
   f. Standardized display format -no variations in display size, orientation, color, or position.
   g. Complete initial and recurring training support.
   h. Capabilities integrated with other instruments and processes used on the aircraft such as Sextant calculations, LORAN, GPS, RNAV, Pressure Pattern, etc.
   i. Professional icon. Must look neat hanging out of a leather pocket in a way similar to a doctor wearing a stethoscope.



World War II era E6B showing the three moving parts: circular slide rule, Plexiglas circular plotting area and sliding grid on which both Airspeed and Groundspeed are read. See operating model >>HERE<<

I believe that the E6B addresses the requirements by using two classic mechanisms. These are the circular slide rule and a clear Plexiglas™ screen with an underlying sliding plastic grid. Physically, the slide rule is on one side and the grid and rotating screen used for wind triangle problems on the other.

Programs Director, Mr. Donald York, if you would like the opportunity to speak or can recommend someone.

The Chesapeake Chapter of INCOSE is proud to recognize the following organizations for sponsoring our endeavors to expanding the understanding and appreciation of Systems Engineering in the local area:

R4IT
R4 INFORMATION TECHNOLOGIES, LLC
A SERVICE DISABLED VETERAN OWNED SMALL BUSINESS

serco
Bringing service to life

camber
Customer Focused, Employee Driven

CyberCore TECHNOLOGIES

The circular slide rule is a conventional design with added scales to accommodate the requirements for unit conversion and aerodynamic calculations. Technically, it functions the same as any slide rule made during the last 100 years. As such, we can conclude that the technology is adaptive and therefore already well proven.

In the case of the Plexiglas™ grid or wind side of the E6B, we have a more elegant and original design. By using a pencil to mark a shorthand notation of the wind triangle, the pilot is able to quickly solve for two unknowns by mechanically selecting the remaining four known variables. The speed of this process is comparable if not faster than entering a problem in a computer and has the advantage of a large visual display. Many pilots believe this is better than any existing electronic display under adverse environmental conditions. While this may be an item of contention, comparing the cost and reliability between a mechanical device composed mainly of sliding elements vs. a hand held electronic computer leaves the E6B at a clear advantage.

Attribute	E6B	CX-2 calculator	Electronic E6B	Remarks
Accuracy	Meets Req.	Exceeds Req.	Exceeds Req.	Higher accuracy not compatible with interfacing aircraft instruments
Speed	Faster	Adequate	Adequate	slide vs. key entry
Durability	Rugged	Fragile	Fragile	mechanical vs. electrical
Error rate	Low	High	High	significant display size & readability differences
Cost	Low	High	Higher	$25 vs. $75

Requirements Comparison Matrix

The lessons learned would appear to be that the mechanical slide rule is far from obsolete for the class of applications that does not require more than three significant digits in each calculation. And, in the case of the wind triangle solution, there is an elegance and economy of effort that that is both easy to use and less prone to misreading under stressful and distracting conditions. To summarize, the human interface design of both sides of the E6B still appears to command admiration, acceptance and imitation.

To support my conclusion, I have only to point to the current generation of men's wristwatches. The slide rule face of the E6B is displayed in all its glory in high-end watches that include models from Seiko, Citizen, Torgoen and most expensively the iconic Breitling Navitimer.

The Breitling NAVITIMER with E6B circular slide rule outer dials

While most persons able to afford a Navitimer (approx.$5000) are probably too old to easily read the legend on the watch's E6B scale, the design holds a fascination beyond its function. Why, for instance, would Jerry Seinfeld, in character, choose to wear a Navitimer watch? Why does John Travolta wear the exact same model even though there are many other aviation models available from Breitling? The answers are probably a great topic for another article on watch styles.

Return to Newsletter.