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Educating the Avionics Professional in the 21st Century

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AS a professor at a university dedicated to aviation-related education I have two major concerns; getting qualified students in the front door and giving them the knowledge the aviation industry requires in four short years. Neither of these goals has proven to be easy. It would probably be more enlightening if we consider the required knowledge for our industry, as this will affect how I attract students.

In the period following World War II, the well-equipped aircraft would have only a fraction of a modern aircraft's electronics. For navigation, the 1950s aircraft was equipped with a VOR for en route navigation; an ILS for landing; a non-directional beacon receiver, for an aid to navigation and for listening to baseball games. For surveillance, larger aircraft had a 64-code transponder. For communications, an aircraft had a VHF transceiver and, if the aircraft flew transoceanic routes, a high frequency transceiver.

All of the equipment mentioned in the previous paragraph is radio based. In fact, before the term avionics was coined from aviation electronics the industry was aviation radio. There were no computers, nothing was digital, except the transponder and that is a stretch, and indicators were mechanical. Sure, that was fifty years ago, but every one of the mentioned systems is in operation today. The best avionics engineer would be a good "radio" engineer. Many universities had programs that would satisfy the need for a radio engineer. Remember, the current IEEE was the product of the merger of the Institute of Electrical Engineers and the Institute of Radio Engineers, where the latter were the electronics types and the former were involved with power generation.

The decades following World War II was a period of intense development of electronic systems and nowhere was this more evident in aircraft and in particular military aircraft. The invention of the transistor and later the integrated circuit was the catalyst that propelled this period of development. The state of the art in avionics became quite broad and even though the radio part was still present there was a much broader range of other systems.

In the "good old days" when aircraft electronics were much simpler than today, small companies with a small engineering department could handle nearly all the electronics that would be found in both military and commercial aircraft. Typically, electrical engineers were the avionics engineers because it was "aviation electronics". However, that started to change in the late 1970s when the microprocessor appeared. A new skill appeared which was the computer programmer.

It was not long before engineering organizations realized that what a system does, how it behaves, or how reliable the operation will be has more to do with the software than any other aspect of the design. The new software engineers did not have the appreciation for the hardware, the system operation or, certainly the radio part of the system. In most cases the new software engineers did not have an appreciation of how their software would affect the aircraft and its role in the airspace system.

What constitutes the ideal skill set for an "avionics" engineer today? Consider the development of the Terrain Awareness and Warning System, TAWS, which will reduce controlled flight into terrain, or CFIT. This very recent system involves hardware and software and will be found on large and small aircraft in increasing numbers. To perform the initial design of this system the design engineers must be familiar with the normal geometry of en route flight and landings. The most difficult phase of flight to provide CFIT warnings is during the terminal phase of flight. A landing is, in fact, a controlled flight to terrain rather than into terrain. The difficulty is distinguishing a valid landing from a potential crash and not cause false alarms. The geometry of a normal landing involves the guidelines set out by the Terminal Operating Procedures or TERPS, which is an ICAO document. To provide a warning, some understanding of flight dynamics is required to insure an aircraft can perform a safe evasive maneuver. Because the terrain information is stored in a data file or terrain database, the construction of such databases should be understood. These disciplines are required just to create the geometry of the TAWS system.

Beyond the geometry, there are the sensors, which are, for the most part GPS or differential GPS (DGPS) when it is available. Other sensors such as very high frequency omni range (VOR), instrument landing system (ILS),

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inertial navigation system (INS), etc. may also enhance the TAWS system. The TAWS designer only needs to understand the basic operation of the systems and their limitations and the signals and protocols of the interfaces. The TAWS system is primarily a computer. To handle this design task, hardware and software engineers would be required. Of course, this is no ordinary computer and it must operate in the harsh aircraft environment and has strict electromagnetic compatibility, EMC, requirements. TAWS provides aural warnings as well as visual displays. Human factors engineering must be considered to insure that when a warning is announced and displayed flight crews take the correct action. What skill set would be required to design the example TAWS system? Clearly the depth and breadth of knowledge is more than one normal human could posses to single-handedly design TAWS. The clue is that not one skill set could handle the modern avionics system.

A word used in the previous paragraphs, which probably is the key to the modern avionics engineer, is "system". Nothing in an aircraft stands alone any more. The modern aircraft has more systems than one can imagine and is, itself, part of an even larger system, our National Airspace System. The modern avionics engineer should be a systems engineer. Someone needs to insure all the components, software, hardware, regulations, human factors, and so on meets the needs of the aviation system.

Embry-Riddle Aeronautical University began avionics programs more than 25 years ago and ultimately offered a four-year baccalaureate program in avionics engineering technology. The four-year program grew for a number of years, held its own during the downturns in the aviation industry but never really became a large program. Why more students were not interested in avionics was a common topic of discussion.

From this writer's vantage point, most high school students, and probably their guidance counselors, have no idea what avionics is all about. Furthermore, engineering technology programs had a bad reputation as being nothing more than super technicians. Probably the best source of new students was ex military personnel that did understand what avionics was all about.

However, graduates found employment without difficulty and employers were very satisfied with their performance. Because there were only about five four-year avionics programs in the United States, not every entering avionics professional was an avionics student. Most avionics professionals were educated in the classic electrical engineering programs.

What was it about avionics engineering technology that employers praised? "They know the language," was one phrase I heard more than anything else. Where else could a sentence such as, "On a CAT II ILS approach to 7L at DAB the aircraft received a false TCAS RA at the MAP" make sense? New electrical engineers probably had more knowledge of electronic circuits than engineering technology graduates but it would take a few years before they knew the language and understood how that science fit into the overall system.

At Embry-Riddle we are launching an electrical engineering (EE) degree program at our Daytona Beach campus. It will be a conventional EE program and we will attempt to provide an avionics "flavor" in every way we can. We will provide design projects with aviation applications. We intend to introduce multidisciplinary projects so the EEs appreciate what the mechanical engineers, software engineers, and systems engineers do. We have a common freshmen year so that an entering freshman can spend his or her first year understanding the differences between various engineering disciplines without losing any credit. We will encourage students to do this.

We will maintain an industrial advisory board to provide feedback from industry as to how to best serve them. Even that offers a challenge. Who shall be a member of our board? Airframe? Avionics manufacturers? Airlines? Government? To the best of our ability we will involve every one of these.

Clearly educating the 21st century avionics professional will be a challenge. I fully expect the industry to be as vibrant in the 21st century as it was in the last.

References and Further Reading

Two schools that provide EE programs with an aviation specialty are Embry-Riddle Aeronautical University, www.embryriddle.edu, and Ohio University, www.ohio.edu. Avionics programs are available at Spartan College of Aeronautics, www.spartan.edu and College of Aeronautics, www.aero.edu.

Some comments on the shortage of avionics engineers and technicians can be found at the United States Department of Transportation, Federal Aviation Administration, Office of Training and Higher Education, Aviation Education Division Aviation Careers: The Sky's the Limit, http://ntl.bts.gov/data/sky.pdf. Also Air Force Materiel Command, "Air Force, AFMC Tackle Science and Engineering Retention, 2003" can be a useful resource. *Aviation Maintenance* magazine, www.aviationtoday.com is another source.

An interesting insight into how aviation electronics evolved is in the book, *Electronics in the Evolution of Flight*, by Albert Helfrick, Texas A&M Press, available November 2004.