AVIONICS magazine

Thursday, June 1, 2006

Q&A: Bill Strauss: Academic Look at Interference

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Electromagnetic interference (EMI) from portable electronic devices (PEDs) is a growing concern, given the omnipresence of cell phones. RTCA's Special Committee 202 (SC-202) is addressing the issue in preparation for technology being developed to permit cell phone use in commercial aircraft. Bill Strauss, a founding member of SC-202, wrote a dissertation on the subject for his Ph.D. in engineering at Carnegie Mellon University. The dissertation also formed the foundation for a Carnegie Mellon study for FAA. Strauss has worked for the U.S. Naval Air Warfare Center (NAWC) for 17 years, performing system-level electromagnetic environmental effects (E3) testing on naval as well as commercial aircraft. He is the former deputy for NAWC's E3 Test and Evaluation division and has represented the U.S. government in E3 standards development activities. He participated in the development of Mil-Std-464 (E3 interface requirements and verification criteria) and sits on IEEE Working Group 473, developing recommended practices for EMI site surveys. This background makes him well suited to comment on the PEDs issue.

Avionics: Does your study represent a first?
Strauss: I chose my words carefully--something to the effect that it's the first time anybody has tested for interference on board with passengers on revenue flights and gathered this type of data. NASA has taken cell phones in the laboratory, simulated the aircraft environment and figured out how much attenuation you get. That's valuable information that I used, but I wanted to validate what's going on for real.

Avionics: You say there has been an interference problem for 40-plus years?
Strauss: It's closer to 50 at this point. Since the `50s and `60s timeframe, commercial aviation has had interference problems with passenger electronics. You can actually find the first regulation governing the issue in May of `61. That had to do with portable FM radios affecting some of the older-type navigational aids, which weren't as sophisticated and hardened to interference.

Avionics: Where did you get the historic data?
Strauss: I looked at the NASA work, work done by the civil aviation authorities in Europe, the RTCA committee reports and a number of individual studies. Then I spent time on the unfortunate term, "anecdotal evidence." I wanted to give this ... some credibility by showing who was talking about it, where this data was really gathered from, and if certain parts of it didn't seem to prove out, why they didn't prove out.

Avionics: Has EMI from portable electronic devices caused accidents?
Strauss: There is no documented case of interference causing an accident from portable electronics [because] we haven't been able to show when EMI is involved. But we looked at 385 commercial aviation accidents over a 10-year period and determined which accidents potentially could have been interference-related. That was done subjectively by Jay Apt, a former NASA astronaut and certified pilot, and myself.
We went through these accidents and categorized them. We came up with an upper-limit number of 6.5 percent of all accidents that could have been caused by interference. We believe the NTSB [National Transportation Safety Board] should begin looking at RFI [radio frequency interference] as a possible cause in cases where flight instrumentation may have been affected. I also read Aviation Safety Reporting System [ASRS] data, and from that I tried to come up with reputable reporting rates. I came up with about 25 incidents a year of documented interference on aircraft attributable to PEDs.

Avionics: What else did you get from the ASRS data?
Strauss: One thing you get is some sense of the incidents' criticality. For example, the pilot may have noticed some interference on his VOR, but it was a clear day, so he didn't have to rely on the instrument. Then there are other cases where the pilots are relying solely on instruments, and you have air traffic control saying, "You're five miles off course."
The other thing that the ASRS data shows is which combination of PEDs and avionics seems to be getting more incident reports. Basically, it said cellular phones and VOR was the combination most reported. VOR was the primary navaid, certainly at the time I did the study, in 2002, and most of the [ASRS] data is from the `90s. So you're not going to see as much involving GPS. But we looked at GPS because we know that's where we're going.

Avionics: What did the ASRS data tell you about PED use during flight?
Strauss: We found that most reports of interference were during cruise, but there was a significant number during departure and a lot during approach. The effect of cellular phones on ILS systems was found to be significant, given the fact that people often use their cell phones during the approach phase of flight.

Avionics: Did you get passenger data?
Strauss: I did passenger surveys through a travel agency, concentrating on business flyers. I tried to establish whether or not passengers understood why there were rules against using their electronics and whether they violated rules and used cell phones in flight. I basically concluded that people don't believe there's a safety issue, and that people do violate FAA regulations. And then the last part of my research was doing the in-flight spectrum measurement, and that involved 37 commercial revenue flights. That's really where the Carnegie Mellon study starts.

Avionics: What equipment did you use for onboard research?
Strauss: It was pretty rudimentary: a portable spectrum analyzer, a laptop computer and an antenna, as well as batteries, cables and boxes. It all fits in luggage that goes into an overhead compartment.

Avionics: How did you prepare for it?
Strauss: We did a lot of pre-work for safety purposes. When my instrumentation package was complete, we ran it through a number of RF emissions tests, similar to what a new piece of avionics would undergo prior to installation on aircraft. We did this in the lab at Carnegie Mellon. We wanted to make sure our equipment didn't emit any signals, because what we were doing is basically counter to what passengers are allowed to do. They must turn off their laptops, etc., and we were specifically leaving them on below 10,000 feet.
Once we knew we passed normal avionics standards, the next step, through agreement with the airlines and FAA, was to test the instrumentation on the types of aircraft we were going to fly on. We mostly flew in Boeing 737-series aircraft and one Airbus A320. We had to test our instrumentation on each of those aircraft on the ground. Ultimately, we had to fly on a maintenance flight to make sure there were no interferences.
We did that in connection with some of the cell phone testing that was going on at the time, to approve cell phone use on the taxi end of a flight. A lot of the airlines were qualifying their equipment for that purpose and I piggybacked onto that testing. This was in the fall of 2003.

Avionics: With equipment tested, were you then ready to gather data?
Strauss: The last safety precaution was to fly the first four flights with two representatives from the airlines. One sat next to me and one was in the cockpit. Once we cleared all tests, then the remaining 33 flights were done with me on the aircraft--but with the full knowledge of the flight crew and flight attendants.

Avionics: Can you quantify your testing?
Strauss: Overall, I took about 51 hours of data. About 32 hours were in flight, about eight hours during taxi time, and about 10 hours taken in the gate.

Avionics: Did you test multiple bands?
Strauss: We started with nine frequency bands and then narrowed it down to six. We concentrated a lot on cell phones, trying to establish how often and where [in flight] they were being used.

Avionics: Were cell phones used in violation of the rules?
Strauss: I was able to specifically identify eight signals that were cellular calls in flight. Some were at very high altitude, which is technically not possible, according to most cell phone manufacturers. They say calls can't be made that high. Well, we found differently.
Now, did those calls hold for minutes? Probably not. But were they completed? Yes. Calls actually were initiated at, for example, 7,000 feet, 12,000 feet, 18,000 feet and two at 35,000 feet.

Avionics: Do service providers fear that cell phone use at such altitudes would damage their ground transmitters?
Strauss: That was the original concern. That's why the FCC originally came with the ban on cell phones in the air. The FAA has always deferred to that ban.
In some cases the FCC took care of the FAA's work. Now the FCC is saying, "We no longer see this as an issue because of the sophistication of the cellular network." FCC feels it can probably lift the ban, even if there are problems of interference. They're saying to FAA, "If you want a ban, that's your territory."

Avionics: Did you get much crew input?
Strauss: With most crews I had a few minutes of debrief; other crews sent e-mails. For the most part, there was no recorded interference in the cockpit that the crew detected. We detected a lot of [RF energy] going on; the crew didn't.

Avionics: Did your equipment pick up more than initiated calls?
Strauss: People are leaving their cell phones on, and my equipment detected that more than once a minute cell phones on aircraft were chirping a signal to either reach the ground or make a call. That, in and of itself, is not bad news. The bad news comes from what we know from other studies, for example, from NASA, which found pilot complaints [about momentary outages of avionics systems], and from general aviation pilots who used their phones illegally, or just left them on, and found, "Oh gee, it knocks my GPS system out."

Avionics: Did you pick up signals in the GPS band?
Strauss: We saw something there about one-third of the time. That's semi-alarming, given the avionics community's hard work to make sure nothing gets into that band. Sometimes we could see cell phone emissions and quickly after that we also saw emissions in the GPS band. One of the signals we observed would have been strong enough to cause interference if there was a GPS system on board, assuming it was a continuous wave signal. I had no way of knowing whether it was pulsed or continuous wave.

Avionics: If cell phones are the worst violators, what are the second-worst?
Strauss: The second-worst are laptops, and we know this by looking at the ASRS data. And then, way down on the list, you occasionally get an electronic game or AM radio causing interference.

Avionics: Would pico cells eliminate EMI problems from cell phones?
Strauss: There's good news and bad news about pico cells. The good news is that with the pico cell on board, most cell phones go to low power.
The bad news is that it's highly likely, for example, that Sprint may win the contract [to provide in-flight cell phone service] with United and Verizon winning the contract with US Air, and you'll have different services on different aircraft. The passenger is not in tune with what service the airline has, so he's going to turn on his phone and try to use it. And if it's not compatible, no one has convinced me that the pico cell will be able to tell that person, "You can't make a call here."

Avionics: The phone won't be low power?
Strauss: Right. His phone will be screaming. We had clear, concrete rules in the past--you cannot use your cell phone during flight, period--and people still used them with some consistency. I guarantee you that with pico cells, everyone will try to make calls. And with what we talked about

with the intermodulation and what NASA has found, it's a bad path to go down, unless we're doing some other things to monitor the situation.
I'm not coming down on not wanting cell phones on airplanes, even though that's what many people would like to read into my study. I did my research as an unbiased scientist, and what I'm saying is you need to do some more things before you go down this path.

Avionics: What is intermodulation?
Strauss: [If] you have a cell phone at frequency A and another cell phone at frequency B, and when they're both emitting energy at the same time, the A and B frequencies will actually combine to create a C, D, E or F frequency. Those frequencies will all be at lower power levels, but nonetheless, [intermodulation] creates them.
Intermodulation doesn't have to happen because of like components. A cell phone and a passive device, such as a laptop computer, could cause combined frequencies and produce a problem. Or, another scenario, the aircraft itself may have frequencies that could combine with cell phone frequencies and create a third frequency that is harmful.

Avionics: Your study suggests expanding industry-government cooperation?
Strauss: Going back historically for a second, I have nothing bad to say about RTCA, other than how they're being utilized. The first time RTCA was utilized for this subject was 1963. The next time they were used was 1988, and then the next time after that was 1996. Those are actually the report dates, but you get the idea.
And it was 2004 when they issued their fourth study. There are a lot of years between those studies, and with what we know about the pace of technology, eight years is way too long to reconvene. You need a standing body.
The second problem with government-industry cooperation is that with the old system, Delta, a leader in this area, for example, freely shared its research with other airlines. But when economics changed, airlines started charging for their data, and now we don't have the common knowledge base. That's why I'm advocating government dollars given to RTCA. That funding used to be a line item in [FAA's] budget; it seems to make sense to go back to that.

Avionics: Another point you make is to augment the ASRS?
Strauss: Right. In a given month, the ASRS gets about 3,600 reports; that's a lot of reports. And because the system is anonymous, NASA has had to go through each report and take out the identifying information. It's very, very time consuming.
So FAA, which owns the data, can only keep about 15 percent of the reported incidents. The ones considered most critical are kept. Eighty-five percent of the data gets burned within six months.
The good news is that for a small window of time, 1995 to 2001, every 10th report was included, regardless of how significant it was. This allowed a true random sample for guys like me who want to find trends and statistics.
But then NASA said it couldn't do that any more unless it got more money. FAA was going to give more money for ASRS, but it was cut in half. The money was redirected after 9/11. So the augmentation would be to give NASA more money and go back to some random sampling.

Avionics: You say the in-flight spectrum measurements should continue?
Strauss: I'm suggesting that someone continue what I've been doing. Two ways you could do that: You could install more sophisticated devices on sample aircraft; [or] a more advanced concept would be to tie the devices into black boxes--and an airline might do that for financial reasons.
The Navy found a high percentage of issues with avionics--gripes pilots had with equipment that was put back into service with no corrective action. I think the number was 75 percent. But the technician couldn't duplicate the problem. One theory is that EMI caused some of these problems.

Avionics: You suspect this situation exists on the commercial side, too?
Strauss: I do. If you tie the [EMI detection] equipment into a black box, you might have a scenario where the maintenance technician testing a VOR system could run a diagnostic that tells whether we had many cell phone calls during the same time period. He still would have to run some basic safety checks [on the VOR] but maybe not have to dive in as far. This is the carrot that gets the airlines interested in my work.
In the Navy they found that if you could reduce 2 percent of the no fault found and indicate that the problems were caused by EMI, you could save millions of dollars.

Avionics: You also want cabin crews to do real-time monitoring?
Strauss: I'm really advocating a non-specific system that would simply indicate to the cockpit that we have high levels of RF going on in the cabin. If the pilot senses too much RF activity, he could make an announcement. Now, what's behind the scenes could be more sophisticated. The system could be analyzing frequency bands, power levels and other things before turning the warning light on. It would simply be an addition to the advisory caution system.

Avionics: How feasible is your point about harmonization among agencies?
Strauss: FCC considers itself a regulatory body, like the EPA [Environmental Protection Agency], but FAA thinks of itself as a promoter of the industry. That was its original charter. It leaves safety issues to the industry because, after all, it's in its best interest to be safe. ... The two [organizations] should coordinate on issues.

Avionics: Could something more formal be developed?
Strauss: Theoretically, the RTCA does this. But they focus too infrequently on the [EMI] problem, and RTCA is kind of driven by FAA and its timeline. You need to give RTCA more autonomy to do what it needs to do.

Avionics: How has RTCA used your research?
Strauss: I'm an author on the most recent RTCA study. RTCA has invited me back to [present] my data, although I think I'm in a minority in how I've approached this issue. I don't have an economic stake in the issue, and you have groups in the RTCA committee who do have a stake.

Avionics: Is there a better solution?
Strauss: A system could be employed in aircraft in which the pilot throws a switch that would disable everybody's phones until they get on the ground. That's the type of system we would like to see. You want to have a pico cell system, fine; have them at 30,000 feet. But when you get to 10,000 feet, nobody will be able to transmit. That's the kind of system that would be more foolproof and worth exploring because it could also be used in movie houses ... and government buildings where there are hearings going on.

Avionics: Does such technology exist?
Strauss: There's technology that jams the phone. You can still transmit, but the phone won't [function]. I'm talking about something that would stop the transmit.

Avionics: What's the awareness level about the EMI problem?
Strauss: I found that the airline engineers are much more aware of this subject than I imagined. They knew all the studies, so this is a genuine concern among the airlines. I was pleasantly surprised. When you talk to the cell phone manufacturers, they also have a good grip on what the potential issues are. The downside is the economic pressures. Even though people in the trenches want to do the right thing, there's a lot of pressure on them.