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Electromagnetic Interference with Aircraft Systems: why worry?

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Abstract: There are worries about suspected electromagnetic interference with aircraft systems from electronic devices used by passengers. Some first-hand incident reports from colleagues are included. The phenomenon seems to be hard to pin down -- colleagues explain why. It may be that the current regulatory situation affects reporting and investigation of suspected incidents. Finally, I suggest some ways in which the regulatory environment could be changed to aid investigation.

Everybody knows how difficult listening to the radio or watching TV becomes when someone is using the vacuum cleaner in the next room. The vacuum cleaner causes significant interference with the radio signal. I used to live in a house in Kensington, CA, with an electric garage door opener, activated from the road by a small radio device carried in my car. The door would occasionally open by itself, early in the morning, on some rainy days when SFO was using RWY 19 for arrivals, and the flight path came more-or-less overhead. Now, there's an anecdote. I don't know it was aircraft transmissions; I don't know it wasn't a passing taxicab whose driver was talking to base; I don't even know it wasn't a fault in the door opening mechanism. We may presume that the system was not very well shielded from electromagnetic interference, and it is certainly not certified to the same rigorous standards as avionics ('*aviation electronics*').

Nevertheless, there are similar worries in aviation at the moment. Passengers use electronic devices on board aircraft, including some such as cellular phones that they shouldn't in any case be attempting to use, and pilots have reported anomalies with their navigation equipment that seem to correlate with use of personal electronics in the cabin. An overview of the technical issues may be found in (Hel96).

There have been to my knowledge no reports so far of interference with *electronic flight control* on the Airbus A320/330/340 series or the Boeing B777. These systems are shielded very well against electronic signals, because they have to fly through radar beams and other electromagnetic fields that may be occasionally very strong. There is nevertheless some experience with electromagnetic interference with electronic flight controls. Five crashes of Blackhawk helicopters shortly after their introduction into service in the late 1980's were found to be due to electromagnetic interference from

very strong radar and radio transmitters with the electronic flight control systems (1). So concern about this phenomenon is not purely the result of speculation. It has actually happened, and it is appropriate to be concerned about the possibility of similar phenomena in transport aircraft.

Bruce Nordwall (Nor96), writing in Aviation Week and Space Technology in September 1996, reported on the topic of an RTCA report to the FAA Administrator. At the request of the FAA, RTCA Special Committee 177 was formed in 1992 to look into the possibility of interference with aircraft systems from electronic devices operated by passengers during flight. Such devices include laptop computers, Gameboys and, more insidiously, portable personal telephones employing cellular technology.

Nordwall reported the RTCA advisory group to be worried that no group was testing or systematically tracking the potential effect of passenger electronics on avionics. The group was also concerned that the flying public is not being educated about the potential hazard, and that the airlines must largely figure out how to deal with the issue themselves. Most airlines in the US already prohibit use of passenger electronics of any sort below 10,000ft altitude. There is most concern for the future; that rapid increases in the technology of personal communications may allow passengers to bring aboard with them, and inadvertently or surreptitiously use, devices such as personal satellite phones that may be capable of significant levels of electromagnetic radiation. The RTCA report recommends developing and installing devices in aircraft cabins that could detect and locate potentially harmful radiation coming from within the aircraft.

Navigation systems are particularly vulnerable for two reasons:

- they have parts devised to detect and act on signals coming from ‘outside’;
- radio-based systems are particularly susceptible to low levels of interference.

Aircraft control systems are located entirely within the aircraft and are shielded from absolutely any signals not coming from one of their own devices; they are also not radio-based, but are based entirely on electrical signals conducted through wires as are most computer networks (in the future, maybe also light signals conducted through glass-fibre cables). Navigation avionics, on the other hand, must have some designed sensitivity to environmental radio signals in order to perform their function. Nordwall says

> THe antennas of radio-based avionics may be affected by [electromagnetic] field intensities of only microvolts per meter. But being outside the aircraft, the antennas get some protective attenuation from the fuselage of radiation originating inside the aircraft. Non-radio systems generally have higher signal levels, and so are less susceptible to low levels of interference.

The hull of a metal aircraft forms an effective electromagnetic boundary between the outside and the inside of an aircraft. Electromagnetic signals find it hard to get in, or to get out. That is why the navigation and radio antennae on an aircraft need to be placed outside the aircraft hull. But while outside they must be sensitive, the navigation electronics inside the hull can be in principle just as well and securely shielded as control avionics, because there is no reason at all for navigation systems to be sensitive to electromagnetic signals coming from *inside* the aircraft -- indeed, very good reasons for these systems to be very *in*sensitive, namely, that there is lots of other electronics working there as well.

The Regulatory Environment

US Federal Aviation Regulation 91.21 prohibits the use of any portable electronic devices on board aircraft, with the exception of voice recorders, hearing aids, heart pacemakers, shavers, and any other device that the operator of the aircraft has determined will not cause interference with the navigation or communication systems of its aircraft:

> 91.21 Portable electronic devices
>
> (a) Except as provided in paragraph (b) of this section, no person may operate, nor may any operator or pilot in command of an aircraft allow the operation of, any portable electronic device on any of the following U.S.-registered civil aircraft:
>
> (1) Aircraft operated by a holder of an air carrier operating certificate or an operating certificate; or
>
> (2) Any other aircraft while it is operated under IFR.
>
> (b) Paragraph (a) of this section does not apply to--
>
> (1)Portable voice recorders;
>
> (2)Hearing aids;
>
> (3)Heart pacemakers;
>
> (4)Electric shavers; or
>
> (5)Any other portable electronic device that the operator of the aircraft has determined will not cause interference with the navigation or communication system of the aircraft on which it is to be used.
>
> (c) In the case of an aircraft operated by the holder of an air carrier operating certificate or an operating certificate, the determination required by paragraph (b)(5) of this section shall be made by that operator of the aircraft on which the particular device is to be used. In the case of other aircraft, the determination may be made by the pilot in command or other operator of the aircraft.

The regulation puts the responsibility firmly on an individual airline to determine that there is no interference. However, as Nordwall points out, '*Compact consumer electronic devices have proliferated in numbers that defy cataloguing, let alone testing*.' The question is what would constitute an appropriate 'determination of no interference'. In contrast to the US Federal Aviation Regulations, the International Civial Aviation Organisation (ICAO) has no regulations relating to portable electronics.

US airlines implement a general ban on using any portable electronic devices (PEDs) below 10,000ft. According to former FAA associate administrator for regulation and certification, Tony Broderick, this action was first initiated by Northwest Airlines, and other airlines quickly followed suit. Broderick notes that use of PEDs during takeoff and landing phases is to be discouraged anyway, not only because of possible consequences of EMI but also to encourage passengers to pay attention to the cabin crew in case an emergency should arise during these critical phases of flight (Bro97) (a commercial aircraft is below 10,000ft usually only during the takeoff and landing phases of flight, and according to the Boeing statistics, 20.9% of all fatal accidents to jet aircraft have happened during takeoff and initial climb, and 46.6% during initial and final approach and landing (Boe96)). Broderick also believes that the FAA, in cooperation with the industry, will need to determine if there is indeed a problem with PEDs on board aircraft, and that it will soon become commonplace to have PEDs on board that are doing things (for example, transmitting) that their owners aren't really aware of.

Some Issues Particular to Cellular Phones

Cellular phones, often called *Cellphones* in the US and *Handy's* in Germany, are a particular source of problems because, regardless of whether they may interfere with aircraft systems, the technology on which cellular telephones are based precludes their effective use on aircraft. This applies to all cellular phones, including the analogue technology in the US and the digital GSM technology in Europe. It may be worthwhile first to explain the known problems associated with attempted use of cellular phones while flying.

The technology of cellular phones is based on small local ground-based reception areas called '*cells*'. A cellphone user is served by just one cell, and when reaching the boundary of a cell, will be 'handed over' to another cell which (s)he is about to enter. The topology of coverage is based on the assumption that the user is on or near the ground, and it is a technical assumption on which the entire system is based that a user will be within 'sight' of just one cell except when nearing a cell boundary. When in an aircraft, however, a user is within radio 'sight' of many cells, simply because (s)he is way off the ground. An attempted call or reception from an aircraft would activate many if not all cells in the local area, which 'breaks' the technology -- it causes many transmission problems and the system is disturbed. Therefore the various communication authorities, such as the US Federal Communications Commission (FCC), ban the attempted use of cellular phones while on board aircraft. However, such attempted use is not ipso facto rendered *dangerous*. It is technically inappropriate and antisocial, as well as mostly futile.

On Saturday 1 March 1997, German Transport Minister Matthias Wissmann was reported in the German and international press as wanting a fine and up to two years in jail for people attempting use of cellular phones on board aircraft. He was reported as saying that

> In order to further increase air transport safety there will be new regulations in the use of these dangerous things [...] In future the use of electronic equipment by passengers in aircraft will be banned.
> (Uhr97)

Herr Wissmann's comment mentions the *danger* of attempted cellphone use. He therefore seems to be speaking about the possibility of interference with aircraft systems, which if true is certainly dangerous, rather than simply the problem that it causes the cellphone technology to malfunction.

While one may applaud Herr Wissmann's proactive stance in addressing a potential hazard, one may also query the wisdom of publically declaring aerial cellphone use to be dangerous in the absence of any concrete proof. My colleague Prof. Dr. Klaus Brunnstein of the University of Hamburg, who avidly follows various potential public computer risks, commented that

> [...] German law still forbids mobile communication (with specific exemptions) [...] It is interesting that airlines don't specifically refer to this law when announcing that [attempted use of] mobile telephones [is] not permitted on board.
> (Bru97)

Brunnstein is not aware of any concrete proof of electronic interference on German aircraft, but reports that EUCARE has more than 60 pilot reports of potential cases of interference, including some with cellphones. He laments the anecdotal nature of these cases, since one requirement for accurate '*forensics*', as he aptly terms it, is verifiability of the source data.

General Worries on Interference

Nordwall reports that the RTCA Committee 177 inquiry found 137 '*incidents*' (pilot reports, anecdotes) reported either to them, or to the FAA/NASA Aviation Safety Reporting System (ASRS) program, or to the International Air Transport Association (IATA). VOR reception (2) was affected in 111 incidents -- by far the most common occurrence. From the 33 reports direct to RTCA, 21 incidents related to laptop computers and only 2 to cellular phones. Navigation systems were affected in 26 of those incidents; fuel systems, warning lights and propulsion reported one incident each. Rough correlation of suspect with effect by turning the suspect device on and off was found in 14 cases, on-off-on in 6 cases, and no correlation in 13 cases.

Some Anecdotes and Discussion

Jim Irving is a colleague who flies B737 aircraft for a major US carrier. He has an anecdote:

> [...] One day departing Portland Oregon we noted that the FMC [Flight Management Computer] Map display showed a disagreement with the "raw data" VOR position. Our training is such that we would normally immediately switch over to "raw data" and assume the FMC was in error.
>
> We would have done that except that it was a beautifully clear day and I looked out the window and was able to determine that the FMC seemed to be right on. I called back to the cabin and asked the flight attendants to check for someone using a cell phone or computer. A few minutes later they called back to say that a man had been using his cell phone and it was now off. Strangely (?) our VOR and FMC map now agreed.
>
> Later in the flight the flight attendants called back and said that they had caught the man using his cell phone again but this time we had not noticed any problems, perhaps because we were in cruise far from the ground and not paying as much attention.
> (Irv97),

André Berger (who also has a homepage) is a colleague who flies B737 aircraft for a major European airline and who has had first-hand experience of some of these incidents. While interference is not proven, he believes it gives considerable cause for concern; and that while it may be difficult to demonstrate the relationship using Brunnstein's 'forensic' criterion, this could be due to the fact that the equipment needed to do so is not on board the aircraft at the times the incidents occur. Berger monitors the IATA confidential incident reports, and also has some experience of his own to contribute:

> In our company we recently had a Localizer deviation (out of tolerances) on a B737-200 related to a GSM (mobile phone) being operated by a passenger (who was disregarding our company regulations). When requested by the cabin crew to switch off his GSM, localizer indications became normal. Is this scientific proof? Certainly not, but good enough for me as a captain to insist that all the electronic toys, computers, mobile phones, etc., are OFF during critical phases of flight. [...]
>
> I had fuel indications on the FMC going crazy on board the B737, that returned to normal when all electronic stuff in the back was switched off. I suspect a "Gameboy" electronic game device to have interfered, but this is no more than a guess. No, I did not ask to switch

> the toy back on again and investigate more in depth as I was responsible for the safety of 140 passengers and this would have been extremely irresponsible! This is not a situation in which to do such testing! This [ever-present responsibility accounts for why] there is no "proof" of the relationship.
>
> I also recall experiencing *impossible* mode annunciations on the FMA (flight mode annunciator) on B737. Having both the autothrottle AND the pitch channel of the autopilot trying to maintain speed (both in MCP SPD mode) for example, not programmed by the pilot (you *cannot* program that). After an expensive in-depth troubleshooting session by our maintenance department, the incompatible mode annunciations were traced to a ... faulty cockpit window heat wiring. This caused electronic interference with the auto flight system. (Ber97.1),

Berger has also recounted two more incidents:

> June 07, 1997. B737-300: *Verify position* was indicated on the CDU. Both IRS and radio position were correct, the FMC position was not. The difference rapidly increased to 8 nautical miles. After switching a GSM in the cabin from STBY to OFF, the FMC updated normally. FMC was correct for the remainder of the flight and on the return flight.
>
> April 30, 1997. B737-400: During level cruise, the AP pitched up and down with ROC/ROD of 400 fpm indicated. Other AP was selected: no change. Cabin was checked for PC's and other electronic devices: nothing was found. Requested passengers to verify that their mobile phone (GSM) was switched OFF. Soon after this request all pitch oscillations stopped.
>
> Just glitches or did interference really occur? Don't know, but EMI (electro-magnetic interference) is a problem that needs more research.
> (Ber97.2),

Apparently, there are also some incidents with older aircraft. Here is Berger's response to a query from another colleague:

> > Has anyone heard of EMI incidents involving older Aircraft, i.e. 707,
> > DC9,747-200, where system signal strengths are larger, and a lot more
> > are analog?
>
> [There was one incident reported with a] B737-200. During approach to MAN (Manchester International, UK), the LOC for landing runway 24 oscillated and centered with the aircraft not on track (but offset), confirmed visually. Ground equipment was monitored and working normally. When a GSM in the cabin was switched off, all indications became correct.
> (Ber97.3),

Frank McCormick, an aerospace engineering colleague who is also a FAA Designated Engineering Representative, wonders about the physics of such possible incidents:

> The threat levels presented by the gadgetry in question -- personal computers, cellular phones, compact-disk players, hand-held video games and so on -- are mere background noise compared to the threat levels that must be demonstrated during environmental

> qualification testing [of the aircraft systems]. How could an FMC [Flight Management Computer] pass, say, DO-160C [standard certification] tests, yet lose its mind in the presence of a cell phone on standby?
> (McC97),

and Peter Mellor, of the Center for Software Reliability at City University in London, reports that

> The cabling on the A320 has not only been tested for resilience to "normal" EMI, but for its ability to withstand the much greater pulse that would result from the aircraft flying through a powerful radar beam, for example.
> (Mel97),

While doubting that the suspected-EMI phenomenon is ubiquitous, McCormick suggests that some sort of systematic investigation could proceed by inviting protagonists (actual airplane, pilots, customer with suspect device) to participate in attempts to reproduce the incidents. Berger reports that in fact very few systematic tests are performed anyway: he asked a major portable phone manufacturer's representative what tests they performed for EMI from their devices in aircraft. The manufacturer performed none because use of cellphones is illegal in aircraft. Berger notes that nevertheless such tests are relevant, because these phones are frequently used surreptitiously or inadvertently on aircraft. He also notes that most electromagnetic interference testing is 'bench-testing', performed on independent subsystems, and that this may suggest an interesting suspect point of weakness in the aircraft, namely the system interconnections. Recall one of the incidents he noted above: neither the electronics nor the well-shielded wiring itself, but the wiring *connections* seem to have been problematic. He reports incidents to specific aircraft (whose registration 'tail numbers' are also given in the reports):

> On a specific B737-300, a MCP (mode control panel) was doing weird stuff intermittently during several flights. I mean really weird: like letting both pitch and autothrottle fight each other to maintain speed. Nearly all boxes involved (MCP, FCC, several AFDS boxes) were changed before a clever mechanic found out that the windshield heat was not correctly grounded. This is located just a few inches from the MCP and is one of the big consumers on board. Tightening a few nuts solved an engineers nightmare.
>
> On a specific B737-400, the FMC was doing weird things, mainly in cruise. Some pilots reported that after a request to the passengers to switch off electronic equipment, the problem was solved, others said it did not help anything even with every electronic gadget switched off in the cabin. Others reported nothing abnormal with CD's, PC's, Gameboys and more of that stuff trying to jam the system unsuccessfully. Troubleshooting was done and it was decided to replace another black box that was suspected. It was pulled out but, no spare was available. So the same black box was pushed in again. Problem solved, it never happened again!
>
> Connections are a possible weak point. And difficult to duplicate if a problem exists. Can an imperfect connection make a tested system EMI susceptible or not?
> (Ber97.3),

He emphasises, as do the RTCA and the other correspondents, that more research and systematic methods of testing are urgently to figure this situation out.

John Dimtroff is an electrical engineer on the Transport Standards Staff of the FAA Transport Aircraft Certification Directorate in Seattle. He is also a member of the Joint Airworthiness Authority/Federal Aviation Administration Electromagnetic Effects Harmonization Working Group. He has been a Federal Communications Commission investigator and inspector, a Boeing RF design engineer and a US Air Force Radar Specialist. Dimtroff reports some incidents first-hand:

> ...even the aircraft's own certified airborne equipment can play games on itself. [A few] years ago I was involved in identifying the source of [navigation instrument indicator] needle swings and voice modulations in the pilot's headset. [The culprit turned out to be a] certified airborne-authorized telephone broadcasting on a frequency which just happened to be commensurate with a piece of [navigation] equipment.
>
> [Another case involved] the Flight Guidance Computer/Air Data Computer [which was] radiating unwanted signals, the 15th, 20th & 22nd harmonics of 6 & 8 MHz clock frequencies, [which are] right on the 120MHz & 132MHz VHF band! [But] each piece of [this] equipment met all the required RTCA DO-160 level testing [requirements].
>
> ...my experience with the FCC has taught me [to wonder] how many [PED] devices transmit with a clean, zero-spur signal, especially after being dropped, banged, klunked, fondled and sat upon. [In] my former FCC investigative days, [I saw] a number of devices (computers, stereos, TV's, etc., etc.) which purportedly met FCC Part 15 requirements as indicated by their label, [but] were either bogus marked, illegally imported or were just outside the manufacturing quality bell curve. [My personal view is] that every carry-on electronic device is suspect -- until it has been individually tested, which, of course, is impossible.
>
> [My experience suggests to me that] it is nearly impossible to predict/replicate an EMI event on an aircraft when the event involves a portable carry-on device (PED). Location, orientation, power output, modulation, inconjunction with ALL the other PED's/electronics/electrics/avionics active at that time all play a role in the EMI event. And we must not exclude the terrestial based emitters (radars, etc). ...
> (Dim97),

ARSR Summary of Reports, 1986 - June 1994

The following summary prepared by the ASRS was forwarded by Peter Mchugh of the FAA's Office of Aviation Safety, taken from Quick Response No. 271 dated November 30, 1994 (Mch97).

> The following synoptic analysis of passenger electronic devices incidents was accomplished by the ASRS staff [at the request of the FAA]:
>
> - There were a total of 46 passenger electronic devices related incidents in the ASRS data base covering the period Jan 1, 86 thru June 30, 94. This number is in contrast to the 51,337 full form reports covering all types of incidents reported to the ASRS during the same period.
> - Passenger electronic devices incidents comprise .08 percent of the total full form reports in the ASRS database. Full form reports receive full analysis processing and include the reporter's narrative as part of the database record.
> - 45 incidents involved passenger carrying operations. 33 of the incidents involved

aircraft in the 60,000-300,000 lbs. weight classifications.

33 of the incidents referenced alleged aircraft systems interference from an onboard passenger electronic device. 10 of the incidents referenced alleged interference from an unknown onboard source. The remaining 3 reports make reference to FAA policy about the use of passenger electronic devices.

- The breakdown of aircraft systems {reported} affected by passenger electronics devices interference included: nav equipment (37 incidents), aircraft communications equipment (9 incidents), radar altimeter equipment (1 incident) and fly-by-wire throttle controls (1 incident).
- 21 passenger electronic devices were specifically identified to be the sources of the aircraft systems interference. The reporters noted the interference ceased after the devices were turned off. The identified passenger electronic devices included:
  - Cell phones (4)
  - Laptop computers (4)
  - Portable AM/FM Radio Cassette Players (4)
  - Portable CD Players (3)
  - Electronic Games (3)
  - HF Radio (1)
  - Heart Monitor (1)
- One report cited interference from 23 passengers using AM/FM radio cassette players.
- One report cited unknown onboard interference causing ILS signal interference resulting in two missed approaches.
- Two reports cited passenger use of cell phone as a cause of dual VOR nav failure.
- None of the passenger electronic devices incidents had a critical impact on the safety of the flight.

Mchugh urges caution in interpreting the data. It has limited statistical significance because

- reporting is voluntary and there is no statistical understanding of the total reporting population or any way of estimating what the actual number of events might be;
- reporting is subjective and influenced by biases, including that reporters gain protection from FAA regulation-enforcement procedures and it is undoubtedly the case that some reports are generated mainly for that reason, and this may affect the quality of the report.
  (Mch97).

(Indeed, many private pilots I know, including myself, carry ASRS reporting forms with us in our flight bags on every trip!) Accepting these caveats, however, the ASRS assembles many more anecdotes than other systems, and Mchugh notes that it is in many cases the "*only game in town*". And the personal, subjective nature of the reports can *provide insight into the human factors issues resident in some events* (Mch97).

Social and Administrative Pressures

The physical phenomenon of EMI interference seems to be relatively emphemeral. It is hard to determine if specific incidents are examples of the phenomenon, partly for the reasons Dimtroff remarks. In this respect, as McCormick points out, it distinguishes itself from other recurring problems such as icing, controlled flight into terrain (CFIT), and cargo-hold fire prevention and detection. These

latter problems have clear, undisputed instances, and the question is what to do to prevent them. The question with EMI is what kind of a problem it is, and how to obtain clear instances.

There may be social and legislative pressures on participants which may color their response to this situation. Consider the following circumstance. US airlines may only allow use of PEDs if they are known to the airline not to cause interference (FAR 91.21). As we have noted, it is largely impractical to submit devices to stringent test, considering the number of devices on the market, and the varying condition of individual devices. Suppose a US airline reports and investigates an incident, suspected to be EMI. Ipso facto, that airline cannot therefore be deemed to have 'determined ... non-interference', as required by FAR 91.21. Just the opposite, in fact -- they have suspected interference! Therefore, FAR 91.21 prohibits use of such a device on board that aircraft. A strict reading of the legislation thus leads directly from suspected-incident report to prohibition *on that airline*.

However, other airlines permitting use of such devices could legally continue to do so until they themselves were subject to an incident. A US airline fastidious about reporting and pursuing alleged EMI incidents could therefore find itself at a competitive disadvantage as it must prohibit PED use, and laptop and Gameboy users and cellphone owners with a penchant for not turning their devices off might well move their custom to rival airlines. Thus may airlines find themselves in a situation in which they must downplay reports or risk losing business, as a consequence of requirement FAR 91.21.

In Europe, many aircraft and crews are certified for the demanding automated approach procedures known as Category III (CAT III), in which the autopilot, following navigation signals, flies the aircraft on landing all the way to main gear touchdown on the runway. A reported incident of suspected EMI with PEDs on board such an airplane could seriously bring into question the aircraft's CAT III certification, since the aircraft electronic systems must be demonstrably highly reliable in order to exercise CAT III authority. An airline reporting such incidents officially could suffer the loss of CAT III certification on the incident airplane until the problem is discovered and rectified. Since EMI incidents, as we have remarked, appear to be very difficult to reproduce on the ground, one could imagine a scenario in which an airline reporting a suspected EMI incident is unable to trace the source, and therefore cannot exercise the CAT III capability on that airplane again. This would be a serious service limitation in the European environment. Again, this situation reveals a potential competitive disadvantage to airlines which take suspected EMI incident reports seriously.

If social pressures exist for airlines to downplay potential EMI incidents, one could also foresee the possibility of pressure from airline management on line pilots also to downplay observed avionics anomalies in service. It is easy to see that both of these social pressures could result in general underreporting and underinvestigating of suspected EMI incidents.

Finally, the pilot in command is directly responsible for the safety of those on board the aircraft. As André Berger has remarked, this responsibility includes avoiding all potential safety degradations, no matter how minimal. Thus, if EMI from a passenger PED is suspected, the only appropriate recourse, according to this legislative responsibility, is for the pilot to require the device immediately be turned off completely. This precludes any kind of correlation testing, benign or otherwise. However, recycling the device and trying to reobserve the interference is the most obvious simple test one can perform, and could be deemed benign in many circumstances. A fastidious interpretation of regulations concerning pilot responsibilities will, however, preclude it.

Since the current regulatory situation may thus unwittingly discourage reporting and investigation of

suspected EMI incidents, there is a significant role for regulators to play in encouraging both reporting and investigation of such phenomena. I see five proactive ways for regulators to help:

- in limiting the regulatory pressures towards underreporting and underinvestigating noted above;
- in establishing reporting standards for such incidents;
- in providing guidelines for, and allowing, if not encouraging, in-flight impromptu tests by the flight crew if certain sorts of benign influence from passenger electronics is suspected;
- in providing guidelines for ground-based testing procedures in the wake of such incidents, possibly involving also the suspect PED equipment and its owner/user;
- based on a classification of reports of the incidents, in clarifying which kinds of incidents would be considered to constitute a maintenance problem, and of which sort, and how those kinds would be considered to alter the certification status of the aircraft (particularly with regard to no-go and CAT III status).

The last of these measures, of course, could only be taken in a regulatory environment in which an absolute ban such as that in FAR 91.21 did not apply. The question of just what such an environment could look like is the topic of the first measure.

Conclusions

There are plentiful anecdotes of possible electromagnetic interference with aircraft systems. While the systems are subjected to thorough bench-tests under conditions of electromagnetic interference to demonstrate adherence to certification standards, there appears to be no systematic process for investigating and attempting to reproduce in-flight incidents, although the British Airways BASIS system, ASRS and EUCARE provide systematic logging of such reports, as one presumes do individual airlines for internal use.

Possible explanations of the lack of reproducibility of such incidents center on the environmental differences between the ‘bench tests’ for certification, in which individual subsystems are tested independently, and the integrated aircraft environment. While entire aircraft are also subjected to some testing during certification, there may be individual differences between aircraft: if wiring connections are susceptible to interference, for example, then aircraft with a longer maintenance record may be more prone to interference incidents than brand-new ones.

While there is considerable disagreement amongst experts as to whether the phenomenon -- or phenomena -- are indeed cases of electromagnetic interference from passenger electronic devices, the call for more systematic testing appears to be unanimous. I have argued that some change in the regulatory environment will help. Nevertheless it appears clear that, whatever one’s view on the reality of the phenomenon, an increasing number of reports on correlation will continue to appear at ASRS, BASIS and EUCARE.

Acknowledgements

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Peter Ladkin

Footnotes

(1): The Blackhawk problems were discussed in a series of articles in the RISKS-Digest volumes 5-7, namely in sequence (Woo87), (New87), (Coo87), (Nor87), (Lad87), (Bro87), (Hor88), (Wol88). There is also a RISKS report of possible electronic interference with F-111 systems during the 1986 US intervention in Libya (Dav89).
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(2): Very-high-frequency Omni-Range (VOR) beacons are still the standard mode of en-route navigation in developed countries. Some non-precision approach-to-landing procedures are also based on VOR. A VOR beacon is a ground transmitter, which sends radio signals which enable an aircraft to determine which *magnetic radial* it is on in relation to the transmitter. A magnetic radial of, say, 137° is a straight line emanating from the transmitter in a direction of 137° from magnetic north. Simple trigonometry tells us that two VOR signals from different transmitters are therefore sufficient for an aircraft to determine its exact 2-dimensional position over the ground (modulo the inevitable local and systematic errors, which are usually minor). Back

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Peter Ladkin, 1997-03-13