The Fall of TWA 800, Swissair 111, and EgyptAir 990: The Possibility of Electromagnetic Interference

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Abstract --The article examines the possible role of electromagnetic interference in three plane crashes, reviews the EMI research already completed and describes why more work is needed.

I.INTRODUCTION

Between July 17, l996 and October 31, 1999, three planes took off from JFK International Airport and crashed: TWA 800 (a 747); Swissair 111 (an MD-11); and EgyptAir 990 (a 767-300). No other large passenger plane taking off on United States soil crashed during this three year and three month period. Although the United States National Transportation Safety Board and the Canadian Transportation Safety Board have carefully examined many aspects of the three accidents, comprehensive research still needs to be carried out on the possibility that the crashes were caused by electromagnetic transmissions from high-powered civilian or military transmitters in the region.

II. EMI RESEARCH ON TWA 800: WORK COMPLETED AND WORK STILL NEEDED

In the first two years following the July 17, l996 TWA 800 crash, the National Transportation Board investigation centered on three areas: a mechanical accident, a bomb, and a missile. These first two years did not include attention to the possibility that electromagnetic interference from one or more of the ten military craft in the area of TWA 800 could have contributed to the accident.

Aircraft crashes from external EMI or High Intensity Radiated Fields (HIRFs) were by that date well documented in existing military literature, but were not yet audible in discussions of civilian aviation accidents. A 1988 Air Force study of military craft indicated that five black hawk helicopters crashed during the l980s as a result of EMI. In l986, an F-111 in a mission over Libya burst into flames and fell into the ocean; during the same mission, five other Air Force F-111s and two Navy A-6s attack jets suffered anomalies in their navigation instruments and bomb-dispensing mechanisms, and had to be grounded.[1] A 1994 NASA study of the effect of HIRFs on civilian craft reported a double engine failure on an airship that was passing directly over a Voice of America transmitter in North Carolina, as well as the crash of a German fighter plane (Tornado) 1.7 miles from a Voice of America transmitter near Munich. [2] An F-16 also crashed near a Voice of America transmitter, according to a 1995 NASA study describing the work undertaken to prevent EMI on the space shuttle. .[3]

These studies -- along with many related pieces of information (such as the discrepancy between levels of shielding on military and civilian planes) -- were brought to the attention of the NTSB in March l998.

The NTSB eventually became persuaded that their investigation of TWA 800 should include attention to the problem of HIRFs from the complex array of military and civilian transmitters in the region. During the first two years of the investigation, the NTSB had concluded that a central wing tank explosion had taken place; but had not yet been able to find the ignition source. (The FBI and the NTSB had together concluded that no bomb or missile was involved.) The third and fourth years of the NTSB's investigation (l998-2000) were dedicated to a continuing search for the ignition source. The major candidates were short circuit, static electricity, and external EMI.

In July of l998, the NTSB contracted with two agencies -- the Joint Spectrum Center (inside the Department of Defense) and NASA -- to assess the severity of the electromagnetic environment surrounding TWA 800 at the time of the accident. The JSC has an extensive library of frequencies and signal strengths for emitters used throughout the world; it also has 400 scientists whose daily work involves anticipating and eliminating problems arising from the shared use of the electromagnetic spectrum, primarily by various branches of the US military. The JSC was asked to analyze the frequency and signal strength of every transmitter in the vicinity of TWA 800 and to list those that would have had signal strength higher than 1 volt per meter on the surface of plane. They found 45 such transmitters.[4]

The Joint Spectrum Center figures were forwarded to the scientists at NASA in January l999, who for the next year-and-a-half worked to determine the level of energy from the 45 external transmitters that would have reached the wiring that runs into the central wing tank (the Fuel Quantity System Indicator or FQIS wire). In March 2000, NASA forwarded to the NTSB a completed study concluding that the transmitters in the external environment of TWA 800 did not serve as the ignition source: they determined that the transmitters could at most have introduced 0.1 millijoule of energy into the accident craft, half of the 0.2 millijoule level required for ignition.[5]

The JSC and NASA research on TWA 800 brought about significant advances in EMI research: it was the first time the resources of the Joint Spectrum Center had ever been used on behalf of a commercial passenger plane; it was also the first time the NTSB had looked at EMI as a potential ignition source (in the past, it had looked at EMI originating inside a plane that could cause transient problems on navigation instruments); in the course of its work on TWA 800, NASA (according to its own report) advanced its own methods of EMI analysis.

While the JSC and NASA reports constitute major steps in evaluating the electromagnetic envelope surrounding TWA 800, seven factors indicate that more work is needed.

1. Uncertainty about the 0.2 millijoule standard. The NASA report forwarded to the NTSB was accompanied by a second NASA report that called into question the accuracy of the 0.2 millijoule standard of ignition when talking about RF ignition: "There is little to suggest that data on ignition levels from high voltage sparking is particularly applicable to sparking from breaking contacts excited from an RF source."[6]

2. The difference between the ignition standard (0.2 mJ) and what was assessed to be present at the accident (0.1 mJ) is small. D.V. Giri, a leading scientist on electromagnetic theory and practice, has stated that given NASA's reliance on modeling and huge reliance on mathematical extrapolation, a factor of two is tiny: "NASA's conclusion may be correct; but it has not provided a basis for that conclusion."[7]

3. One transmitter in the accident region exceeds the 0.2 millijoule ignition standard. At the moment TWA 800 entered its catastrophe, the Navy P3 was 2.9 miles from the passenger plane and -- according to JSC and NASA calculations -- had a field strength of 23.8 volts per meter on the outside surface of the plane and could introduce 0.032 millijoules into the wire running into the central fuel tank. But fifteen seconds before the accident began, the P3 was 1 mile from TWA 800: at that distance, its field strength at the surface would have been 70 volts per meter and it would have been capable of introducing 0.27 millijoules into the wiring.

4. The NASA study focused on a single signal at a time, rather than the interaction of the forty-five transmitter signals.

5. The NASA study focused exclusively on a two-step path of entry: it calculated the strength as it passed through the windows into the passenger cabin, then through the interior cabin wall to the FQIS wiring. Unexamined was the direct route from outside the plane into the wheel well, through which the unshielded FQIS wires runs for a distance of ten feet. Since the accident, the FAA has issued an Airworthiness Directive that requires shielding on the FQIS wiring of all 747s: "To prevent electrical transients induced by electromagnetic interference (EMI) or electrical short circuit conditions from causing arcing of the fuel quantity indication system (FQIS) electrical wiring or probes in the fuel tank(s), which could result in ignition of the fuel tank(s)."[8]

6. The Joint Spectrum Center has stated that its evaluation of the electromagnetic envelope is only as accurate as the list of craft forwarded to them by the NTSB is complete. The list of craft appears to be very incomplete. For example, NTSB radar of the accident region (presented at their December 1997 Public Hearing and available in their printed documents) shows one ship three miles south of TWA 800, and three ships two-to-six miles north of TWA 800 that neither the NTSB nor the FBI has been able to identify.

These six factors suggest that the important research undertaken by the JSC and NASA should be regarded as important first stages of work, rather than completed work. A seventh factor also indicates the need for additional research. While the JSC and NASA studies on TWA 800 were being carried out, two other large passenger planes that passed through the same region crashed.

III. SWISSAIR 111 AND EGYPTAIR 990:

Similarities between the crashes of TWA 800 (July 17, l996) and Swissair 111 (September 2, l998) appear to reinforce the possibility that something in the external environment may be playing a part.

-1) Both planes took off from JFK airport.

-2) Both took off on the same day of the week and minute of the day: Wednesday at 8:19 p.m.

-3) Both traveled along the Southern coast of Long Island on the "Bette" route, the route assigned to civilian planes when military exercise zones W-105 and W-106 are in use.[9]

-4) Both encountered a major problem between 8:31 and 8:33 p.m. TWA 800 suffered a central wing tank explosion and fell into the ocean at 8:31p.m. Swissair 111 experienced a radio blackout at 8:33 p.m while passing through the region where TWA 800 fell; the blackout continued for thirteen minutes as the plane continued to fly up the eastern coast of the United States toward Nova Scotia (where it eventually fell).[10]

-5) Both accidents have been consistently identified by investigative agencies --the U.S. NTSB, the Canadian Safety Board, and Boeing -- as overwhelmingly "electrical" in nature.

-6) Both remain unsolved, despite years of intense investigation. The Safety Board of Canada has found evidence of arcing in twenty wires in the Swissair 111 plane, but has not located a cause. (As of July 2001, the Canadian Safety Board continues to examine the wiring systems that run above the cockpit ceiling; the wiring involves many systems, no one of which is a greater focus of suspicion than any other).[11]

In its August 2000 Public Hearing about TWA 800, the U.S. NTSB acknowledged that it had not found the ignition source for the central fuel tank explosions, even though the last two years of the four-year long investigation had been almost exclusively devoted to that search. It identified "short circuit" as the most likely candidate, but acknowledged that there was no direct physical evidence of a short circuit nor even a probable location. One piece of *indirect* evidence was cited, but it is evidence equally relevant to electromagnetic interference: one minute and fifty seconds before all electricity ceases, the pilot twice directs the first officer to "Look at that crazy fuel flow indicator. . ."

-7) Military exercise area W-105 was in use by the military on both evenings; and Navy records indicate that crafts such as Navy P3 planes and submarines[12] were in use in the New York-New England region on both nights.

EMI can as easily occur on an irregular as on a regular schedule, but cases where it occurs on a regular schedule are more often solved because the regularity directs attention to the fact that something in the external environment is playing a part (something that is itself on a regular schedule). The similarities between TWA 800 and Swissair lll may be a set of interesting, but ultimately insignificant, co-incidences; or they may instead be significant parallels that together expose the structure of the accident. Careful and comprehensive research can tell us which of the two is true.

EgyptAir 990 -- which took off from JFK on a Sunday morning at l: 19a.m. -- also needs to be scrutinized for the possibility of electromagnetic interference. Both the NTSB and the media in the U. S. have emphasized the possibility that the co-pilot committed suicide; but almost nothing presently in the public record supports that interpretation. For example, the pilot's words to the co-pilot "Pull with me. Pull with me," have been widely cited as indicating that the co-pilot was not co-operating with the pilot; but in a l994 crash near Pittsburgh, the pilot spoke almost the identical words to his co-pilot, and no one ever surmised that the co-pilot in that crash was unco-operative or suicidal.

EgyptAir 990 crashed 50 miles south of Long Island inside military exercise zone W-105. The fact that the plane was permitted to fly through this area indicates that no formal military exercise was underway, a fact confirmed by F.A.A. logs. But the FAA tapes show that air controllers that night expressed unease about EgyptAir 990's routing; no other civilian planes were directed to fly through the region.[13] The absence of formally announced military exercises does not guarantee the absence of all military planes from the region: in the Spring of l997, for example, the pilot of a commercial passenger plane cleared to fly through W-105 had to put his plane into a sudden dive when two F-16s traveling through the same region came so close to the civilian plane that its collision avoidance alarm sounded. The NTSB needs to learn what craft-- and hence what transmitters -- were in the vicinity of EgyptAir 990 so that the complexity and severity of the electromagnetic environment can be assessed.

The features of the EgyptAir 990 accident -- the disengagement of the autopilot, the sudden dive, the anomalous action of the elevators -- are compatible with the existing record of electromagnetic interference as registered in a 1988 Air Force and l994 NASA studies. The author of the Air Force study specified "sudden uncommanded dives" as a major manifestation of the electromagnetic interference. Commercial pilots cited in the NASA study specify "autopilot malfunctions" and "unmotivated autopilot disconnect" as an effect of EMI: in most cases, the autopilot disengaged by itself; in several cases, the pilot disengaged the autopilot once the plane began to carry out an uncommanded action.[14]

In assessing the vulnerability of the 767-300 to High Intensity Radiated Fields, it may be relevant to notice that the next generation of the plane, the 767-400, has much high shielding requirements. In specifying these new shielding requirements, the l999 *Federal Register* acknowledges the aviation industry's uncertainty about the nature of external EMI: "It is not possible to precisely define the HIRF to which the airplane will be exposed in service. There is also uncertainty concerning the effectiveness of airframe shielding for HIRF. Furthermore, coupling of electromagnetic energy to cockpit-installed equipment through the cockpit window apertures is undefined."[15]

In conclusion, comprehensive research is urgently needed on the electromagnetic environments of TWA 800, Swissair 111, and EgyptAir 990.

Certain general practices also need to be instituted. The reconstruction of the electromagnetic environment needs to be made a routine part of every accident investigation, as urged by the former director of the Joint Spectrum Center, as well as by Air Safety (a leading aviation industry U.S. newsletter). The military needs to notify civilian pilots and air controllers whenever powerful transmitters will be in use --a proposal introduced by Rear Admiral (retired) Eugene Carroll, Jr. -- just as they already routinely announce live fire exercises. Finally, new studies need to be undertaken to advance our understanding of the frequency with which commercial planes experience transient and enduring HIRF effects.[16]

REFERENCES

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[2]Martin Shooman, "A Study of Occurrence Rates of Electromagnetic Interference (EMI) to Aircraft with a Focus on HIRF (External) High Intensity Radiated Fields," NASA, Langley Research Center, April l994, pp. 6, 8.

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[4] Joint Spectrum Center, Department of Defense, "TWA Flight 800 Electromagnetic Environment" (Project Engineer, R. DeSalvo; Consulting Engineers, M. Macrae, D. Hughes), Annapolis, Jan. l999.

[5] J. Ely, T. Nguyen, K.Dudley, S. Scearce, F. Beck, M.Desphande, C. Cockrell, "Investigation of Electromagnetic Field Threat to Fuel Tank Wiring of a Transport Aircraft," NASA/ TP-2000-209867, March 2000, p.39.

[6] F.A. Fisher, "Some Notes on Sparks and Ignition of Fuels," NASA -TM-2000-210077, pp.1, 34.

[7] D.V. Giri, Conversation with Author, August 2000.

[8]FAA, Airworthiness Directive, Large Aircraft, 98-20-40 Boeing, Amendment 39-10808, Docket 97-NM-272-AD.

[9] Swissair 111's take off time and use of the Bette route are verified by FAA flight slips and tower transcripts obtained by the author through Freedom of Information.

[10] FAA Air Controller tapes of first 45 minutes of Swissair 111 flight, obtained by author through Freedom of Information, May 19, 1999.

[11]Phone Conversation with Vic Gerden, Lead Investigator of Swissair 111 Accident; and Chair, Transportation Safety Board of Canada, July 11, 2001**.** Contrary to U.S. media reports, neither the entertainment system nor the map light are considered higher candidates than the many other wiring systems running through the same area.

[12] Letters to author from W.A. Peters, Captain, U.S. Navy, Chief of Staff for Commander Submarine Group Two, April 21, l999; and from M. E. Newcomb, Commander, JAGC, US Navy, Force Judge Advocate, Atlantic Fleet, February 8, l999.

[13] FAA Air Controller Logs, available to public on NTSB accident website.

[14] Appendix D, Description of Events, in Shooman, "Occurrence Rates . . ." pp. 93-96.

[15]*Federal Register*, Vol 64, No. 139, July 21, l999, Proposed Rules, p. 39097

[16] The author's published articles (l998-2000) documenting more fully the foregoing arguments are available at www.nybooks.com.