<u>The Downsides of Automation: Staying Alive in Modern Aviation</u>

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Abstract

As aircraft automation becomes more and more prevalent in the professional aviation industry, it is of vital importance the crews be trained to work together and with the automated system in such a way that promotes the reduction of errors and the awareness of potential technology conflicts. The following is a discussion of the breakdown patterns of human/technology interfaces, and some recommendations to combat the problem.

While technology has advanced exponentially over the past hundred years, the life of the average human being in urban, industrialized nations has become staggeringly more complex. The automobile undoubtedly speeds our passage on land, but the troubles it causes—the deaths, the maintenance, law enforcement, and cost, among other things—certainly subtract from the revolutionary improvements which came about due to its creation. The same might be said for a variety of technologies—microwaves cause cancer; pesticides poison our drinking water; antibiotics lead to stronger, more resilient bacteria. Aircraft automation—though undoubtedly an improvement in many ways over previous methods of flying—is, similarly, a double-edged sword. While technologies including Electronic Flight Information Systems (EFIS), autopilots, computerized navigational systems such as Global Positioning System (GPS) and Flight Management System (FMS), automated pressurization, fuel management, and system monitoring (which were previously left to the Flight Engineer, a rapidly disappearing species) have incredible benefits, they do not necessarily lessen the workload of the pilot.

Consider, first of all, the study done by Diane L. Damos, Richard S. John, and Elizabeth A Lyall (1999) which observed the effects of automated systems on time looking outside for traffic (a critically important duty, in lieu of PSA Flight 182 in September, 1978, where a Boeing 727 ran into a Cessna 172 in perfect VFR weather with the traffic centered in the windshield for several minutes, NTSB 1979). Logic would dictate that a properly designed automated system would relieve pilots of some of the duties inside the cockpit, thus allowing them to concentrate on searching for traffic; the aforementioned study tends to disagree. Automated systems, possibly due to their complexity, actually reduce the amount of time that pilots spent looking outside *during landing, arguably the most important time to be looking for traffic*. This "heads down time" is magnified anytime the automated system requires reprogramming, as in an amended clearance or difference in what is received from what is expected.

The reprogramming process itself is inherently faulted as well. Though often the automated system itself does not make errors per se, the events of a controller reading a clearance to a pilot, the pilot understanding it, and then programming it correctly all induce a great possibility for error. A classic Cockpit Resource Management (CRM) example deals with an American Airlines Boeing 757 which was headed into Cali, Columbia, in 1995 (Kaiser, 1997). While the copilot understood that they were cleared to the 'ROZO' NDB, with identifier 'R,' he programmed it into the FMS incorrectly, typing in a facility with the same identifier but located almost 150 miles northeast from where they wanted to be. Since the copilot did not verify the coordinates of the point he entered (which is tedious and *typically* unnecessary), the airplane blindly complied, turning to the left on autopilot. The Captain realized that something had gone wrong, but his decision to fly directly to the NDB caused them to turn directly into a mountain.

It is, then, of vital importance that the pilot check, double check, and perhaps triple check the information which is put into the automated systems in the airplane. There is obviously, however, a conflict between the amount of time pilots must now spend ensuring that the data they have entered is correct and looking outside of the airplane. Even after programming the system, pilots must monitor the automated system during its use to ensure that neither the human has failed nor the computer itself.

Unfortunately, as it turns out, human beings make terrible babysitters. Pilots have often been trained for several thousand hours on the operation of the aircraft, only to spend many long, boring hours "monitoring the systems" while the airplane does their job for them, and much more precisely and smoothly.

Boredom is the result. Experts define boredom as "a heightened sense of arousal and a frustration over a need for something to do" (Jensen, 1995). When pilots find themselves in the absence of danger in a mentally excited state with no stimulus (no control forces to feel, no throttle levers to push, no radios to tune), boredom can be the result, leading to a heightened stress level and fatigue, both of which reduce the pilot's capacity (even the best and most astute) to loyally monitor the automated system (which, by design, is supposed to monitor the pilots!). "We must realize that the end product of taking tasks away from pilots may be increased stress [sic] not reduced stress" (Jensen, 1995).

Sooner or later, pilots learn to trust the automated systems, perhaps too much. Eventually, pilots develop what is coined "automation bias," which is a predisposition to believe what the picture tube says in lieu of more pertinent or accurate information (an approaching mountain would be an extreme example). In another study, done by Linda J. Skitka, Kathleen L. Mosier, Mark Burdick, and Bonnie Rosenblatt (2000), the effects of training and number of crew members on the ability to *accurately* monitor an aircraft's systems were observed, and the results were somewhat disheartening.

For the study, a computer was set up with gauges which mimic the typical panel seen on a modern airliner (EGT, EPR, ITT, etc.), as well as an automated alert messaging system (dubbed the "Automated Monitoring Aid") which was to alert the crew when one of the values exceeded the limitations which were given to the subjects. There were two major groups: the first had only a single "pilot" monitoring the gauges, while the second group had a second individual, or "copilot," who was assigned duties outside of monitoring the systems (navigation, communications, etc). These two groups were further subdivided into three more groups, of which the first received no training regarding the occurrence of automation induced human errors and were told that if an error occurred, they *could* verify the error before taking action (pressing a button as directed by the computer). The second group was told that errors could occur, and that they *must* verify the error before taking action. The third group was trained to specific types of human errors which could occur in relation to the automatic monitoring system, and were also told they *must* verify the error before taking action. There were a total of 100 "events" which took place during the experiment that the automated controller would report. Six of these events were to attempt to draw an "omission" error from the participants, or one in which the participant would ignore improper values on the "gauges" which the automated system did not report. Six more events were used to attempt to draw "commission" errors from the pilots, or errors in which the participants would respond inappropriately to incorrect messages given by the computer (the computer "duped" the pilots into following directions which disagreed with the data given to them by the gauges on the panel).

The results were, again, disheartening. First of all, the number of crew members had practically no effect on the number of errors made, and the training only reduced the number of commission errors made (omission errors remained unaffected). The participants (who were not pilots), quickly became complacent, it seems, in monitoring the gauges; it is much more laborious and *usually* right. Obviously, whether due to operator or programmer error, the automated systems are *usually*, *but not always* right, and the consequences of this automation bias can be severe. Consider SAS Flight 901, which landed fast after the autothrottle accelerated to sixty knots above the appropriate landing speed without command of the pilots and went unnoticed until the aircraft ran out of runway (Beaty, 1995). Further, consider Swift Aire Lines Nord 62, whose autofeather inappropriately feathered the perfectly operating starboard engine, which was compounded by the crew's accidentally shutting down the port engine as well (Beaty, 1995). Another accident was caused by "commission" as described above; a 737-400 near Kegworth, England in 1990 crashed after the crew misinterpreted the indications on the CRT engine panel, and reacted to surging of the number one engine by reducing power *on the number two engine*. The number one engine subsequently failed on final approach, and the crew (surprised, no doubt) crashed, killing 47 people (Hughes & Dornheim, 1995). The important thing to note is "the machine…doesn't care if it gets home safely" (Hawkins, 1987).

These challenges have been particularly difficult to overcome in the human factors arena. Crew Resource Management (CRM), a training philosophy built on using all of the resources (people, computers, and otherwise) in the most efficient manner, has stressed the importance of monitoring the automated systems on the aircraft, and has explicitly doled out responsibilities to each pilot in order to make clear who is monitoring the system and who is looking outside at any given time. Emphasis has been been put on redundancy, self-checks and crew double-checks of data entered and computer response. Further, CRM has stressed the importance of "dumbing down" the system during times of confusion such as amended or unexpected clearances or when the system is behaving in a manner which the pilots do not understand (airplanes will fly without FMS, GPS, and autopilot). However, the challenges of overcoming complacency, boredom, and automation bias has still eluded training experts, and has lead to the statistics which prove that the airplanes are nearly 100% reliable in doing what they are told to do, unfortunately whether it is really what the pilot wanted it to do or not.

Of course, one begins to wonder if the goal of technology should be to remove humans altogether. Airbus builds aircraft based on that philosophy, in fact; "Airbus Industrie officials believe that if the technology exists to automate a function that would prevent a pilot from inadvertently exceeding the safety limits, it should be done. Airbus fly-by-wire aircraft…will prevent a pilot…from pulling more than 2.5g even in an emergency" (Hughes & Dornheim, 1995). Boeing's philosophy has consistently been that automation is a tool to aid the pilot, but even the 777 will attempt to restrict the pilot's ability to exceed certain bank angles, for instance, by inducing increased force requirements on the control yoke to perform the action (Hughes & Dornheim, 1995).

The future of aviation safety will undoubtedly focus on humans, since pilots themselves account for nearly three quarters of the accidents, many of which are due to misunderstanding the systems which were placed there, in theory, for the their benefit. Whether the problem will be resolved with further training on the human side or further innovation on the computer side remains to be seen. Perhaps, however, the reality of the matter is that if a mistake can be made by either the pilot, the programmer, the designer, or the computer, it will eventually occur, and will eventually cause an accident. Fortunately, pilots are by nature goal oriented, and their never-ending pursuit of perfect flying (though defined previously by how well he could hold his altitude, heading, and airspeed) will lead to a further reduction in aviation mishaps caused by the technology which was implemented to relieve the pilot from his previous hurdles. Perhaps perfection is unattainable, but there certainly is not any good reason not to try.

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