Some lessons learned about pilots and flight deck automated systems

by Dr Kathy Abbott

There has been a lot of recent press about various opinions, studies, and views on automated systems. This article talks about lessons learned, including positive lessons and vulnerability areas, with respect to automated systems and pilot interaction.[18] Although the focus is on pilots, many of the lessons also apply to air traffic personnel.

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LESSON 1: Automated systems have contributed significantly to improvements in safety, operational efficiency, and precise management of the aircraft flight path. However, vulnerabilities exist in pilot interaction with automated systems. These include:

- Pilots sometimes rely too much on automated systems and may be reluctant to intervene. In effect, they delegate authority to those systems, which sometimes results in deviating from the desired flight path under automated system control.
- Autoflight mode confusion errors continue to occur: autoflight mode selection, awareness and understanding continue to be common vulnerabilities.
- We continue to see FMS programming and usage errors, such as mis-programming, data entry errors.

LESSON 2: Automated systems, not "automation.

"Many times, we refer to "automation," as in flight deck automation or air traffic automation. However, that implies that "automation" is a single system, when the reality is that there are many different automated systems on an aircraft (or in an air traffic management system), and those systems represent automation of different types of tasks. Billings[19] described three categories of aircraft automation. The first was "control automation" or automation whose functions are the control and direction of an airplane (a system such as the autopilot is an example of control automation). The second category was "information automation" or automation devoted to the calculation, management and presentation of relevant information to flight crew members (for example, moving map displays or alerting systems). The third category was "management automation," or automation of the management tasks.

There is significant growth in the use of Electronic Flight Bags (EFBs) as a mechanism to introduce applications of information automation (e.g., electronic navigation charts) into the flight deck. The number of EFBs is growing. The number and types of applications implemented on these devices are also increasing, many of which affect flight path management.

EFBs (and other future "information automation" systems) have the potential to be beneficial in many ways, and enable applications in the flight deck that would be difficult to provide in other ways. However, EFBs may have negative side effects if not implemented appropriately. They could

18- This article is based on lessons learned from the work of the Flight Deck Automation Working Group (see http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs400/parc/parc_reco/media/2013/130908_PARC_FltDAWG_Final_Report_Recommendations.pdf). However, the lessons and views stated are those of the author.

19- Billings, C. E. (1997). Aviation automation: The search for a human-centered approach (Human Factors in Transportation). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

increase pilot work load, increase head-down time, distract the flightcrew from higher priority tasks, and contribute to crew communication and coordination issues. These potential impacts of EFBs and other "information automation" systems need to be addressed during both design and evaluation[20].

Note that automated systems for air traffic are all "information automation." Similar concerns arise with respect to potential issues with workload, distraction, and communication and coordination.

LESSON 3: Lack of practice can result in degradation of basic knowledge and skills.

There has been concern expressed about degradation of basic flying skills because of automated systems in the flight deck. The data show that pilot knowledge and skills for manual flight operations (including both "stick and rudder" and cognitive skills), are a vulnerability area in some cases. However, automated systems do not directly cause degradation in knowledge and skills for manual flight operations – but lack of practice does. The presence of automated systems in an aircraft does not prevent the pilot from flying manually, and the FAA has published a Safety Alert for Operators (SAFO) 13002 that encourages airlines to find opportunities for pilots to practice and refine those skills.

LESSON 4: "Levels of automation" is a useful concept for communicating ideas about automated systems, but can be hard to put into practice.

Many operators define levels of automation described as a simple hierarchy in a rigid and prescribed fashion. After gaining operational experience with training and operational use of these rigid definitions, several operators concluded that such a description assumed a linear hierarchy that does not exist. The various features of the autoflight system (autopilot, flight director, autothrottle/autothrust, FMS, etc.), can be, and are, selected independently and in different combinations that do not lend themselves to simple hierarchical description. As a result of this experience, those operators revised their policies to allow the pilot to use the appropriate combination of automated system features for the situation, without rigidly defining them in terms of levels, except for the highest (everything is on) or the lowest (everything is off).

LESSON 5: Use a flight path management policy, instead of automation policy.

Many operators have an automation policy, and they vary significantly. The policies range from allowing the pilots to use whatever they consider appropriate, to policies that require use of the highest level of automation possible for the circumstances. Even operators of the same airplane type, which are supported by common, manufacturer-based philosophy and procedures, differed markedly from each other. These differences are because of a variety of valid reasons that include the operators' unique history, culture and operational environment.

However, the focus on management of automated systems was not always well integrated with the focus on managing the flight path of the aircraft, and may distract from the tasks associated with flight path management.

Operators should have a clearly stated flight path management policy that includes (but is not limited to) the following:

- The policy should highlight and stress that the responsibility for flight path management remains with the pilots at all times. Focus the policy on flight path management, rather than automated systems.
- Identify appropriate opportunities for manual flight operations.
- Recognise the importance of automated systems as a tool (among other tools) to support the flight path management task, and provide operational policy for the use of automated systems.

For air traffic personnel, a similar idea applies - focus the policy on the aviation task, with the automated systems as tools for the human to use.

20- See http://www.volpe.dot.gov/coi/hfrsa/work/aviation/efb/vreppub.html for references that discuss EFB considerations.

One more upgrade and I will be the Captain...

Some lessons learned about pilots and flight deck automated systems (cont'd)

LESSON 6: Use of automated systems can reduce workload during normal operations but may add complexity and workload during demanding situations.
Pilots often described long periods of time in modern, highly automated aircraft where workload was very low. It appears that use of automated systems may reduce workload during much of normal operations, but during demanding situations (e.g., certain phases of flight when the pre-planned flight path is changed, such as being vectored off a complex procedure, then vectored back on to resume the procedures, or programming and verifying an RNAV approach, change of runway assignment during taxi, or during non-normal or emergency procedures), use of the automated systems may add complexity and workload to the pilots tasks.[21 22 23] In normal operations a highly automated airliner may be easier to fly than previous generations of aircraft but, in a non-normal situation, it sometimes is comparatively harder.

LESSON 7: Sometimes we attribute vulnerabilities to automated systems when we should look at complexity.
Some of the vulnerabilities we identify with automated systems can be attributed (at least partially) to the fact that these systems and their operations are inherently complex from the pilots' perspective, rather than simply because the systems are "automated." Areas of complexity include pilot tasks related to use of the systems, the pilot-machine interface and interaction with the system, and operating with certain airspace procedures. Future airspace operations are expected to be more complex and are expected to use more automated systems to support Performance-Based Navigation operations.

LESSON 8: Be cautious about referring to automated systems as another crewmember.
We hear talk about "pilot's associate," "electronic copilots" and other such phrases. While automated systems are becoming increasingly capable, they are not humans. When we attribute human characteristics to automated systems, there is some risk of creating false expectations about strengths and limitations, and encouraging reliance that leads to operational vulnerabilities (see Lesson 1).

Last but not least, **LESSON 9: Pilots (and controllers) mitigate safety and operational risk on a regular and ongoing basis.** Pilots fly thousands of flights every day that are conducted safely and effectively. They provide the ability to adapt to operational circumstances, deal with operational threats, detect and mitigate errors by others in the system, mitigate equipment limitations and malfunctions, and provide flexibility and adaptability to address non-routine and unanticipated situations.

I hope these lessons will stimulate some discussion about the practical aspects of automated systems. Automated systems have contributed significantly to safety and efficiency of the aviation system, and we expect them to do so increasingly in the future. However, we hold the pilots, controllers, and other humans in the aviation system responsible for its safe operation. We should never forget that the safety and effectiveness of the civil aviation system rely on the risk mitigation done by professional, well trained and qualified pilots (and controllers) on a regular basis.

21- E. L. Wiener, "Cockpit automation," in Human Factors in Aviation, E. L. Wiener and D. C. Nagel, Eds. New York: Academic Press, 1988, pp. 433-461.
22- R. Parasuraman and V. A. Riley, "Humans and automation: Use, misuse, disuse, abuse," Human Factors, vol. 39, June 1997 pp. 230 - 253.
23- Parasuraman, Sheridan, and Wickens, "A Model for Types and Levels of Human Interaction with Automation," IEEE Transactions on Systems, Man, and Cybernetics – Part A: Systems And Humans, Vol. 30, No. 3, May 2000 pp. 286 - 297.