Managing Automation in the Cockpit

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Abstract: Automation has been promoted as a way to improve both aviation safety and efficiency. In many ways automation has indeed kept its promise; in many other ways it has been found to be lacking. This study's data were collected using questionnaires, interviews, flight observation, and simulation training observation. While the findings were supportive of the earlier work of Wiener and Nagel, they also identified several new problems. The pilot-computer interfaces are generally non-intuitive for pilots. In addition, several interface problems were due to the inadequate memory of the host computer. These design shortfalls create management challenges for pilots and operators alike.

Key words: human factors, ergonomics, automation, human-computer interface, corporate aviation, regulations, safety, training

INTRODUCTION

Corporate aviation[1] is expanding its use of automation, with some corporate aircraft having greater sophistication than air carrier aircraft. Previous studies (Wiener & Curry, 1980; Wiener, 1989) have identified a number of safety concerns associated with automation in the airline industry. The problems identified were often associated with periods of change (e.g., amendments in flight plan, vectors for traffic). Because the *raison d'être* of corporate aviation is flexibility and change, it would appear to follow that the corporate aviation industry may be more susceptible to some of the negative effects of automation. As a matter of fact, NASA's Aviation Safety Reporting System[2] identified 84 self-reported incidents between 1986 and 1991 (Aviation Safety Reporting System, 1992) that involved advanced automated corporate aircraft.

Corporate aviation by its nature describes a very wide range of activities and sophistication. Operations vary from a small business where the owner personally flies herself to meetings, to dispersed fleets of large aircraft. As a result, the levels of automation vary from a simple two axis autopilot to sophisticated computer based flight management systems capable of flying the aircraft from lift-off to touch down while maintaining optimum performance throughout. It was therefore necessary to limit the scope of this study to only a those aircraft with both cathode ray tube based displays and computer-based flight management systems. The study included observations of flight departments that varied from dispersed multiple location operations to an operation where one person acted as manager, maintainer, and pilot (the aircraft used was approved for single-pilot operation).

Another area that makes corporate aviation unique is that its pilots are usually type-rated in more than one aircraft. While this was a challenge in the days of conventional controls and displays — where the pilots had to learn basic systems and flight characteristics of the various aircraft — the new world of automation *also* makes it necessary that pilots essentially learn different computer operating systems. This problem is exacerbated by the fact that the interface for

1 Corporate aviation is the part of general aviation that supports the travel of businesses and corporations, particularity the upper management of those organizations.

2 It should be noted that since it is a voluntary report, only a fraction of all incidents are reported to the System.

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mechanical designs, and it may be some time until familiarity with the systems and creativity mix to allow the creation of a truly superior interface. But, improvements are needed if the real potential of the automation is to be achieved.

One area of the human-computer interface that needs significant work is coding. Much of the coding techniques have become aircraft and/or manufacturer specific. In some ways we have come full circle and now transitioning between automated aircraft is often like transitioning between aircraft in the '30s and '40s, when each manufacturer put the basic flight instruments where they wanted. Every time one changed airplanes (often within the same aircraft model) one had to learn a new cross-check sequence. Basic coding standards need to be developed and followed.

Standards are especially needed for color coding. Color appears to be primarily used as a marketing tool and very seldom is based on the perceptual and cognitive attributes of the color. Basic principle driven criteria need to be established and followed for color coding. The application of color without such guidelines can and often does result in decreased performance (e.g., errors).

Awareness of the mode within which the system is operating is an aspect of automation use which shows a steep learning curve that never asymptotes (even for those who spend over 400 hours per year in automated aircraft). The mode awareness survey showed that unexpected or unexplained FMS events tend to be infrequent, minor in nature, and quickly detected. However, the open ended responses were frequent and describe a variety of surprises experienced by the pilots. Such errors suggest that the feedback should be improved so that pilot awareness of system mode and expected action is more easily accomplished. For example, several inflight experiences demonstrated pilots changing from "Heading" to "FMS" mode and being surprised by the abrupt change in direction of flight. Such actions are technically correct for the automation, but not what the pilot intended. A clearer display of mode and/or the design of the system to more typically match the mental model pilots have of how things operate would reduce such experiences.

The pilot-computer interface problems identified by this study can usually be resolved by altering the human, the computer, or both. In many cases, the errors made by pilots are design-induced errors; that is, if the interface was designed differently, these errors would not occur. Thus, while it often appears easier to alter the human side of the equation (i.e., training), it is usually most efficient in the long run to alter the computer side of the equation. The following recommendations are offered for discussion.

- Human factors criteria for the human-computer interface of civilian aviation equipment should be developed. These criteria should be principle driven rather than "design specifications".

- A minimal set of interface standards needs to be developed that would be required for all automated systems. An aircraft's equipment behavior and the pilot's expectations of that behavior should match and should be system independent.

- The amount and type of feedback from the automated systems to the pilots should be improved in order to decrease mode errors.

- Automated systems should be designed to be as consistent as possible, both within and across aircraft. Consistency is an overriding principle that affects usability of a system.