2007

Designing, Evaluating, and Training Flight Decks of the Future

L. Ricardo Prada

Dr. Deborah A. Boehm-Davis

Dr. Victor Riley

Carl F. Smith

DESIGNING, EVALUATING, AND TRAINING FLIGHT DECKS OF THE FUTURE

Organizer and Chair
L. Ricardo Prada
CTS Technical Services
and George Mason University
Seattle, WA

Panelists
Dr. Deborah A. Boehm-Davis
George Mason University
Fairfax, VA

Dr. Victor Riley
User Interaction Research and Design, Inc
Point Roberts, WA

Carl F. Smith
George Mason University
Fairfax, VA

Research into pilot cognition has shown that existing flight deck interfaces can hamper optimal performance on a number of important tasks. The goal of this panel is to describe recent efforts to understand how future flight decks might be designed, and how redesigns affect pilot training and performance. Examples and new experimental results will be provided from ongoing research and development efforts.

Introduction

For nearly a century, psychologists have been conducting research on flight deck systems with the express goal of informing redesigns that can improve performance and safety. As airliner flight decks have become increasingly computerized, with the introduction of glass cockpit displays, automated flight systems, and the ability to preprogram flight plans, new areas of research and development have opened up (Pritchett, 2003).

In particular, recent efforts have tried to understand how increasingly automated aircraft affect performance and pilot training, and how new displays should be designed in order to reduce cognitive loads and minimize errors (Sarter & Woods, 1995; Parasuraman & Riley, 1997; Wickens, 2003).

This panel will discuss these new approaches to flight deck design, their effects on performance, and how they might reduce training footprints—an important economic consideration that has been shown to affect flight deck adoption rates (Gunter, 2005). Examples will be drawn from studies of existing flight deck systems, as well as ongoing research projects such as the Boeing Flight Deck of the Future autoflight panel, and the Institute for Human and Machine Cognition's Oz display (Still & Temme, 2002; Mumaw, Boorman, & Prada, 2006).

Panelist Abstracts

Victor Riley—UIRD, Inc.

Sawing Down Some Old Saws

The autoflight system in current generation aircraft is the product of a long evolutionary process, with some intelligent design thrown in and a few disruptive events such as the introduction of the FMC. However, as the underlying technology has continued to evolve, flight deck designers have persisted in following some basic principles in the design of the autoflight system interface. For example, the pilot still has to distinguish between the autopilot and the FMC at the level of the interface, and manage modes that determine which of these two entities is guiding the airplane. Furthermore, the glareshield controller is typically reserved for tactical operations such as headings and flight level changes while the flight management interface is reserved for strategic changes.

These principles are so ubiquitous and have persisted for so long that they have almost become dogma within the industry. But why are they necessary, or even useful? Why should the pilot have to distinguish between the autopilot and FMC, rather than simply managing the flight path targets themselves? And why shouldn't the pilot be able to manage some strategic targets through the glareshield controller? Is it possible that doing away with these assumptions could lead to a more simple, less error-prone, and less complex autoflight system interface overall?

In this presentation, I intend to explore these questions and look at some examples of autoflight interfaces that violate these principles, and realize significant benefits by doing so.

L. Ricardo Prada—CTS Technical/GMU

Early Evaluations of Boeing's Flight Deck of the Future

Operational issues with the current generation of flight control panels in modern airliners are well documented, and include opaque operating modes, limited feedback when modifying settings, and inconsistent interactions that can result in unexpected aircraft behaviors. This, in turn, leads to costly training programs. Boeing engineers have proposed a redesigned autoflight panel known as the Flight Deck of the Future (FDF), in an attempt to address these issues.

This presentation will describe the collaboration between Boeing engineers and aviation psychology researchers at George Mason University in evaluating this revolutionary design.

In an experiment comparing the performance of regional jet pilots on the FDF panel and a baseline current generation panel, FDF users experienced reduced training time, improved near transfer rates to new tasks, and greater success in diagnosing aircraft mode states.

Analyses performed on the new design suggest that these performance differences were tied to two design decisions: the decision to simplify interaction procedures and the decision to improve labeling and feedback for tasks that are poorly supported in existing aircraft. Implications for the adoption of this and other similar designs will be discussed, as well as the challenges in managing this kind of public/private collaboration.

Deborah A. Boehm-Davis—GMU

Conceptual Knowledge in Training and Design

A key factor in airlines' decisions to adopt new flight deck designs is the cost of training. Can good system design reduce the need for training? To address this question, it is important to understand what kinds of training improve performance and then to examine whether a given system design can provide that information.

Currently, much of the training within aviation focuses on the development of procedures for executing tasks, such as the use of the autopilot. However, this leaves pilots vulnerable to misunderstandings about what the system is doing, especially when an error is made or when the system cannot achieve the desired behavior.

This presentation will discuss recent research that demonstrates the value of conceptual knowledge in the performance of autoflight tasks. Conceptual training was provided to supplement a current generation autoflight interface. This training did not require any additional study time, and it lead to improved performance on a paper-based test of procedures for various maneuvers. This suggests that a system design that conveys conceptual knowledge about how it operates should improve performance and reduce training time.

Carl F. Smith—GMU

Improving Pilot Knowledge through Functional Displays

Can a new display make training more effective? If using novel displays with current training regimes can improve novice pilots' knowledge base, the inclusion of alternative displays in aviation training could be the next step towards increasing flight training efficiency. Towards this end, displays that provide visualizations of the functional relationships among system components may improve piloting skill and knowledge (Lintern, Waite, and Talleur, 1999). By reducing the cognitive burden of intensive mental computations, a new pilot is free to explore the underlying relationships between system functions, and may develop a more accurate mental model of system operation.

Previous research using a functional display has shown knowledge improvements among novices (Smith & Boehm-Davis, 2005). Novices trained on a functional display provided more accurate and complete answers to questions on maneuver procedures, the effect of functional relationships on aircraft performance, and the prediction of future system state based on current system conditions. Recent studies have used concept mapping to examine novice piloting knowledge in more detail. The concept maps of pilots who trained with a functional display displayed twice as much agreement with an expert as pilots trained on a conventional display. This presentation will focus on these knowledge improvements, along with results on how effectively this knowledge will transfer to other displays.

References

Gunter, L. (October, 2005) All decked out: Similarities between 777, 787 help airlines, passengers and Boeing. *Boeing Frontiers.* 4(6).

Lintern, G., Waite, T., and Talleur, D.A. (1999). Functional Interface Design for the Modern Aircraft Cockpit. The International Journal of Aviation Psychology, 9(3), 225-240.

Mumaw, R.J., Boorman, D.J., Prada, L.R. (2006). Experimental evaluation of a new autoflight display. *Proceedings of the International Conference on Human-Computer Interaction in Aeronautics:* Seattle, WA.

Parasuraman, R. & Riley, V. (1997) Humans and automation: Use, misuse, disuse, and abuse. *Human Factors*, 39-230-253

Pritchett, A.R. (2003). Human-Computer Interaction In Aerospace. In J.A. Jacko and A.Sears (Eds) The Human-Computer Interaction Handbook. Malwah, NJ: Earlbaum

Sarter, N.B. & Woods, D.D. (1995). “Strong, Silent, and ‘Out-Of-The-Loop’”. *CSEL Report 95-TR-01*. February 95.

Smith, C. F., & Boehm-Davis, D. A. (2005). Improving novice flight performance using a functional display. *Proceedings of the International Symposium on Aviation Psychology 13th Annual Meeting, Oklahoma City, OK.*

Still, D.L., & Temme, L.A. (2002). OZ: A human-centered computing cockpit display. Retrieved January 14, 2005, from http://www.ihmc.us/research/projects/OZ_UCAV/downloads/OzHumanCenteredComputing.pdf

Wickens, C.D. (2003). Aviation displays. In P. Tsang & M. Vidulich (Eds.), Principles and prac-. tices of aviation psychology. Mahwah, NJ: Erlbaum