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Advanced Cockpit Technology In the Real World

Automation, properly integrated with the human interface, can play an important role in increasing safety.

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by
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The latest transport aircraft are a triumph of advanced technology. They have enhanced performance characteristics, improved noise control, considerably advanced economic characteristics, many automated subsystems formerly the province of the flight engineer, further automation of pilot controlling and navigational tasks, noteworthy advances in the display of cockpit information to the flight crew, and in many of them, significantly extended operating ranges. There is no question that they represent a major advance in transport aviation.

Unfortunately, while it is clear that advanced technology aircraft represent substantial achievements, a number of controversies have been created regarding these aircraft. These controversies include:

- the selection of pilots to fly advanced technology aircraft
- the role of the pilot in these new aircraft, including maintenance of the captain's authority
- the adequacy of current training and procedures
- the real-life workload that exists under normal, abnormal and emergency conditions
- the existence and, much more important, the operational consequences of fatigue, boredom and complacency that might be caused by these aircraft
- the loss or gain of situational awareness in the cockpit
- utilization of these aircraft in the current (and future) air traffic control (ATC) system
- the overall safety and efficiency of these aircraft with a two-person crew, including extended range operations (EROPS)

Much of the data in this discussion came from two series of requests for information from air crew members. Follow-up queries were made to pilots flying advanced technology aircraft in regular service who had submitted aviation incident reports to the confidential Aviation Safety Reporting System (ASRS) administered by the U.S. National Aeronautics and Space Administration (NASA) . NASA and ASRS personnel were interested in evaluating any safety problems that might be introduced along with the advent of the automation that could be inherent in advanced technology aircraft. To survey crews, they selected those ASRS reports that indicated the reporter was flying a Boeing 757, 767, 737-300, McDonnell Douglas MD-80 or Airbus 300 and, while retaining the anonymity of the incident reports, called the reporting pilots with a set of prepared questions regarding the advanced technology aircraft they were flying. The pilots proved willing participants and frequently spent more than an hour answering questions by telephone researchers.

The two series of requests for information by ASRS were conducted approximately four years apart. The first series was made shortly after the inauguration of advanced technology airplanes, and the main purpose was simply to learn more about the use of these airplanes in the real world. An advantage of the second study is that it went beyond the "shakedown period" of advanced technology aircraft and provided a longitudinal study (albeit a short one) of their operation.

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To illustrate the pilot and airline distribution we found among responses, the second study interviewed 92 pilots who flew for 13 of the 44 airlines operating in the United States. Approximately one-third of the pilots interviewed flew for the same airline, so any averaged results may be biased toward the opinions of these pilots.

This imbalance of responses raises a real problem for the researcher because there are significant differences both among and between airlines, and among and between pilots. If one uses only simple generalizations and averages, these differences will be missed. Although they make it much easier to tabulate the results, over-generalization and too simple averages can also result in some very wrong answers.

It is far from easy to determine which of the many variables are the important ones and which variables just provide more "noise" in an already "noisy" system.

Some of the variables that may be relevant include organizational factors such as operating philosophy (which can vary by company, by domicile and even by fleet within companies), the quality of the training program and the sensitivity of training to individual needs. Other variables are individual factors such as age, overall experience, recency of training experience, timing of the transition to the advanced technology aircraft, individual differences and many others.

Consider several general comments that cover many of the critical operational issues of today:

1. Pilots like to fly advanced technology airplanes.

2. Technological change is not new to this industry. It is one of the many reasons that our present state of automation is evolutionary, rather than revolutionary.

3. There are at least two human factors issues that should be kept separate. The first involves system design and manufacture — including both the aircraft and its software. The second issue involves implementation — or simply the ways pilots are trained and the new airplanes are operated. If they are intermingled and problems are discovered, the wrong problems might be fixed.

4. Problems associated with aircraft differences — especially as they affect the ability of pilots to adapt to the particular design philosophy or operating idiosyncrasies of different aircraft — seem to be minimal. Instead, problems seemed to be associated with the differences in training programs and in operating philosophies among the airlines.

5. Equipment purchased by an airline may be superbly or poorly designed, and procedures for its utilization may or may not be optimum. But after it is acquired, those questions become almost academic because the new equipment must be operated safely and efficiently in a regular line operation. Training provides the interface mechanism that makes this possible. Too often, there has been a dependence upon the ability of the pilots to adapt to make the system work.

6. Although training should not be used as a remedy for poor design, it is important to evaluate the overall quality of both the operating procedures that are utilized and the training that is provided.

7. There have been definite improvements in the quality of advanced technology pilot training. This is not surprising, because there are "shakedown periods" in new training programs and in the operation of new equipment during which many people identify problems and improve the system. Unfortunately, shakedown problems have not always been recognized as such and not as inherent problems.

8. A great myth of automation is that it reduces training needs and costs. This is not so, particularly in the areas of manual skills, system knowledge and the logic of the automatic equipment.

   Today's automation has created another evolutionary requirement in the skills and knowledge to fly these airplanes safely and efficiently in the present environment. There is little evidence that training requirements for automation can be considered a substitution for, instead of an addition to, previous training requirements.

9. Although airlines provide the training they deem necessary, there are variations in the quality and quantity of that training. There are very strong economic reasons for airlines not to provide more than minimum training to meet the requirements of rules and regulations.

10. Manufacturers of both aircraft and their software must play an even greater role in developing training programs for advanced technology aircraft. The following is quoted from "Flight Deck Automation: Promises and Realities," final report of a NASA/FAA/ industry workshop, Carmel Valley, Calif., U.S. Aug. 1-4, 1988. "Determination of the general training requirements needed to enable pilots to operate new equipment safely and efficiently should be considered an integral part of the design process.... These requirements need not be, and probably should not be specific, ... but should clearly indicate what the designer of the system believes the pilot should know in order to operate that system safely and efficiently."

11. The development of training devices, the complexity of these devices and the expense involved might make responsibility for training and training devices either a very poor individual allocation of resources for financially secure airlines, or they might be beyond the financial means of airlines that purchase this new equipment. Manufacturers must get much more directly involved in both training devices and in pilot and maintenance training itself.

12. One problem is that the workload level in previous airplanes is considered the norm and, by implication, at least, acceptable. We have almost reached the point where any increase of workload is by definition "bad" and any decrease "good" regardless of where or when it occurs, its duration and its operational consequences.

    Pilot workload is an extremely complex subject, because there are a great many relevant variables. For example, training becomes extremely important. A task that is very difficult for a poorly-trained person can be a simple task for one adequately trained. There may well be a big difference between "acceptable" and "optimum" workload, but very little research has been done in this area — we are still a long way from having a neat method for measuring pilot workload.

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13. One of the major changes that is happening in our industry is recognition of the role of top management in the achievement of aviation safety. Safety, and all that this implies, must be part of the corporate culture, and this is just beginning to be understood. [See "Investigating the Management Factors in an Airline Accident," May 1991 *Flight Safety Digest*]

14. Finally, another major change has been that human factors now is recognized as a core technology at both regulatory and operating levels. Although this was not true a few years ago, today it has become almost taken for granted.

Follow-Up Questions Sifted

In order to make analytic and operational sense of the nearly 30 specific training issues that we considered in the follow-up questions, these complex issues were divided into four arbitrary categories: company policy, procedural and implementation issues; conceptual or generic issues; transition training issues; and recurrent training issues. There is some overlap among these categories.

Company Policies, Procedures, and Implementation Issues

In this category at least two areas were identified where root causes are often ignored or misattributed. The first of these is the maintenance of basic flying skills. Company policies can either exacerbate or minimize problems in this area. Operational reality prevents them from completely eliminating problems here regardless of the equipment involved,

Historically, a problem with the maintenance of basic flying skills has been found in any schedules or situations that furnish an inadequate opportunity to practice. The problem has been found in long, non-stop segments, among flight engineers who moved up to copilot after extended periods as a flight engineer, among new hires, among some retired military personnel who have a minimum of recent flying, and even among some management personnel.

In the first ASRS study of advanced technology aircraft operation, pilots were asked "Do you believe that maintenance of manual flying skills is more of a problem with this airplane than with others you have flown?" Most of the pilots answered yes.

However, four years later when we asked the same question, four out of five pilots said maintenance of manual skills was not a problem with these airplanes. Only 21 percent of the copilots stated unequivocally that manual skills were important with these aircraft.

Incidentally, a problem in the manual skills area that may need greater recognition is the problem of the low-time pilot who has never had an opportunity to develop an appropriate level of skills, let alone maintain them. This could represent a very real problem for the ab-initio or other low-time pilot.

A second problem related to the company policies, procedures and implementation issue is the allocation of duties for both the pilot-flying (PF) and the pilot-not-flying (PNF). This varies considerably among the airlines. It has become more important with the advanced technology aircraft and its two-person crew. There seems little question that allocation of duties needs a narrower definition and (to the extent possible among fleets), greater standardization among some airlines.

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The training implications of present levels of automation on intracockpit communication and crew coordination are a concern throughout the industry. The basic philosophies of intracockpit communication and crew coordination are independent of the type of aircraft.

Many pilots stated a belief that there is a greater need for good operational communication between pilots flying advanced technology aircraft than there was among their predecessors. Although there are some wide differences among airlines as to exactly what constitutes good operational communication, there were only minimal differences in the responses to the question. However, some provocative comments were made by the pilots who believed there was "less need" for good operational communication with these airplanes. Three of those comments are below:

"The annunciator panel does much of the communication because with automation you can read what he [the other pilot] is doing — or planning to do."

" … the annunciator panel does much of this communication. If you are operating manually, it is about the same."

"At first I thought there was a greater need (for good operational communication), however, the really important thing is that you can see just about everything by looking at what he [the other pilot] has set in."

These pilots were considering only verbal communication between crew members. The important point is that they were not saying that there is "less need" for good operational communication, but instead that mode selection — which is immediately available to the other pilot — is unobtrusively fulfilling that function. As with any one-way communication, the mode selector transmits its message and fulfills a communication function without any sort of confirmation that the message was received.

Conceptual or Generic Issues

This second category includes several basic problems with airline pilot training and is independent of type of airplane. In spite of the fact that, in some cases (such as less opportunity for pilots to practice and maintain skills), advanced technology aircraft can exacerbate a problem, these kinds of issues should not be restricted to advanced technology aircraft. Such constraints can camouflage both the fundamental issue involved and any other issue that might be involved only in automation. Equally serious, such constraints can prevent examination of the root causes of the real issues.

Current examples of conceptual or generic issues are the changing functions of the flight crew — monitoring and diligence in advanced technology (and other) aircraft, short- vs. long-haul operations, instructor selection and training, and the role of companies and regulatory authorities in training.

It is somewhat surprising that we are still talking about the changing role of the pilot. Although a great many of the things a pilot does in performing basic tasks have changed through the years, the basic pilot role has not changed: the pilot ensures that the airplane flies from point A to point B safely and efficiently in the existing environment.

Transition Training Issues

This category involves training for a new or different type of equipment or a change in cockpit position. For some pilots, transition training can involve both. (We will not discuss the problems that some advanced technology copilots have encountered in transitioning to become pilots of aircraft with older or standard technology cockpits.)

The transition training areas covered with respondents to queries include the pilot's perception of the adequacy of current programs, the sensitivity of current transition training programs to varying pilot or line operating needs, the use of initial operating experience and the efficacy of computer-aided instruction for advanced technology aircraft. Additional questions included the adequacy of the pilot's basic systems knowledge, understanding of the operational logic of the software that controls the flight management systems and the emphasis given to PF and PNF duties. Transition training is an extraordinarily important area.

Among other things, it was learned that:

- The addition of sophisticated automated systems has not reduced the level of basic airmanship skills that are required of an airline pilot.

- Virtually all advanced technology pilots believe they should receive more training in the use of flight guidance and flight management systems.

- Many pilots believe that they also should receive more systems training. There seem to be significant differences in this area among airlines.

- Although major advances in information display, as exemplified by glass cockpits, have created problems related to both design and training, moving-map displays seem to be an outstanding exception. They are universally liked. However even here, there can be problems. "Map shift" seems to be a relatively rare but nevertheless recurring and potentially lethal problem. Another basic problem for some airlines is over-reliance on moving map displays particularly when flying under marginal navaid reception conditions.

It is ironic that, because of the versatility and tremendously expanded display capabilities of new systems, the establishment of a priority system of information has become a major human factors problem. We are sometimes faced with an information glut.

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- Despite glowing testimonials in its support from training experts and budget-minded executives, computer-based training (CBT) is not yet an unqualified success, although the technology is changing quickly. At the moment, it appears that a combination of CBT and traditional classroom training is best for most people.

- The question of "computer literacy" is frequently raised. An attempt was made to start toward the answer when pilots flying advanced technology aircraft were asked if they owned a home computer. About one-half of them did. That group was then asked if having a home computer helped them learn about their advanced technology airplanes. About one-half of them thought it did, and the other half reported that it did not make any difference.

- Finally, there seems to be a growing perception among pilots that the cabin crew/cockpit crew interface has become even more important with advanced technology aircraft — especially in extended range operations. Each group has its own union, schedules, and often diverse goals, but these differences should not be allowed to obscure operational realities.

Recurrent Training Issues

The last category involves the maintenance, and in some cases the re-achievement, of previously established skills and knowledge. Issues include the adequacy of recurrent training programs for advanced technology aircraft and the utilization (if implemented) of line oriented flight training (LOFT) and cockpit resource management (CRM) training in a recurrent training context. Recurrent training issues are an important category, and there are some critical lessons to be learned. For example:

- It became clear that the question of sensitivity of recurrent training to line operation needs to be resolved on the basis of the real needs of line operations. While pilots need training and practice in responding to events or emergencies that are not normally part of day-to-day operations, they also want exposure to things that other pilots have learned while flying the line. There are substantial differences in the identification of and the balance of these items among airlines.

  - Throughout the industry, two of the relatively new concepts in a training, LOFT and CRM, garnered the approval of pilots. However, the industry has not yet achieved consensus on the specifics of either concept.

  The U.S. Federal Aviation Administration (FAA) and several airlines are working to prove the efficacy of CRM and LOFT, and to identify the factors in each which are important. Determination of these answers and of methods to obtain an optimum balance between traditional training and these new concepts need continued research.

- Well-designed recurrent training programs provide a very good means of determining virtually all flight crew performance problems as well as providing an optimum time for an airline to review its procedures. Each airline, regulatory agencies and all pilot groups should ensure that this opportunity is not neglected.

- Finally, the acid tests of any transition or recurrent training program are the performance of pilots at the completion of the program and their ability to fly their aircraft safely and efficiently during line operations.

Automated airplanes, although perhaps still not being used optimally, really do have a good record. In spite of the fact that new technology has not proved to be the solution of all of the industry's difficulties, there is very little evidence to suggest that increased automation has decreased aviation safety. The record rather clearly tells us that the converse is true. ♦

(Adapted from a presentation before the Royal Aeronautical Society Conference on Human Factors on Advanced Flight Decks, March 14, 1991, in London, England.)

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