WHITHER CRM? FUTURE DIRECTIONS IN CREW RESOURCE MANAGEMENT TRAINING IN THE COCKPIT AND ELSEWHERE

Robert L. Helmreich
NASA/University of Texas/Federal Aviation Administration
Aerospace Crew Research Project
Austin, Texas

The past decade has shown worldwide adoption of human factors training in civil aviation, now known as *Crew Resource Management*. The shift in name from cockpit to crew reflects a growing trend to extend the training to other components of the aviation system including flight attendants, dispatchers, maintenance personnel, and Air Traffic Controllers. We are here to report findings and new directions in research into human factors. Since our presentation at the Sixth International Symposium, the NASA/University of Texas/Federal Aviation Administration Aerospace Crew Research Project has expanded its scope to obtain data from additional major international air carriers, regional airlines, several foreign operators, and the NASA astronaut corps. Our database on flightdeck management attitudes and reactions to CRM training now contains more than 35,000 surveys from commercial airlines. Our observational database on crew behavior in line operations and simulation derived from check airmen and instructors trained in recognizing behavioral markers (Helmreich, Wilhelm, Kello, Taggart, & Butler, 1991) now has more than 25,000 flight segments from airlines. One of the most significant findings is that longitudinal data from organizations with intensive, integrated CRM/LOFT programs show continuing improvement in crew performance over time (Helmreich & Foushee, 1993; Helmreich & Wilhelm, 1991). A particular advantage of the large, de-identified databases on attitudes and behavior is that they allow the exploration of new issues and aspects of training and behavior as will be described in papers to follow.

Another component of the NASA/UT/FAA project has involved using a core team of expert observers, largely active or retired airline pilots with strong human factors and technical backgrounds, to observe line flights and LOFT across fleets and airlines in advanced technology "(glass cockpit") and standard ("steam gauge") aircraft. This database, now including more than 1,400 segments from six airlines, has had immediate practical application. One airline used the data to target particular areas for special attention during recurrent training and is in the process of implementing this strategy. Also not covered in the presentations is a new survey instrument designed to assess attitudes regarding flightdeck automation that has been incorporated into a revision of the Cockpit Management Attitudes Questionnaire (CMAQ: Helmreich, Wilhelm, & Gregorich, 1991). Another example of organizational use of the project's data is provided by Smith and Hays (in press).

The notable successes of CRM training should not be interpreted as meaning that CRM training is now fully developed and optimally effective. The data show large and significant differences between organizations in the impact of training and in the levels of performance achieved. Even within organizations, large variability in performance continues to exist and recognizable subcultures that differ in human factors practices can be recognized. Just as CRM training has evolved over time, the enabling research has changed in direction and focus. We are no longer concerned with the basic question of whether there is a measurable impact of human factors training but rather with a new set of questions that have arisen from the earlier investigations. Using our experience at NASA/UT/FAA as the basis, I will discuss seven areas where additional research and development efforts are urgently needed to capitalize on the progress made to date.

EXTENDING CRM BEYOND THE COCKPIT DOOR

One of the strongest lessons learned from evaluation of existing CRM programs is that CRM concepts and training should not be limited to flightdeck crews. Flight crews interact with a number of outside groups -- cabin crews, air traffic control, maintenance, dispatch, ground operations, etc., in the course of their work. It is also apparent that many of the observed problems in the aviation system involve these areas of interface among groups. Encouraging progress is being made in extending CRM training into these domains, but much remains to be learned (e.g., Bertipelli, in press; Chidester, in press; Helmreich, Wiener, & Kanki, 1993; Taylor, in press).

A particularly exciting development is the use of CRM as a template for human factors training in other
professions and industries. The tone of a recent symposium on the human factors of the operating room was reminiscent of the seminal 1979 NASA Workshop, *Resource Management on the Flightdeck* (Cooper, White, & Lauber, 1980). Similar issues of communications breakdowns, questions of leadership, and failures in situational awareness, and vigilance were identified. These parallels with aviation were striking in a domain where multiple teams work in a multi-tasking environment (Ewell, in press; Helmreich, 1993; Helmreich, Wiener, & Kanki, 1993; Howard, Gaba, Yang, Fish, & Sarnquist, 1992). Aviation related and based CRM training has also been initiated in the nuclear power and petrochemical industries (Helmreich, Wiener, & Kanki, 1993). I believe that information from these differing environments will further enhance our understanding of human factors issues in aviation.

It is important to recognize that the most innovative new CRM courses are very different from their historical roots in management development programs. Third generation CRM programs are much more focused on specific behaviors and behavioral strategies for the target environment and less centered on psychological jargon (or psychobabble) and vague concepts. The newest programs also take a systems approach and deal with organizational and interface issues (Helmreich & Foushee, 1993). Based on what we know about the specificity of the latest CRM programs, successful translation from the aviation to other domains necessitates careful analysis of the situation and issues in each setting.

**REFINING CURRICULA AND PROGRAMS**

The notable success of CRM training does not indicate that curricula have reached their full potential. There is a substantial need for detailed examination of curriculum elements and the effectiveness of particular training techniques (Gregorich & Wilhelm, 1993). Chidester (1993) discusses a family of CRM courses that an individual may experience throughout a flying career. One intriguing finding from the NASA/UT/FAA research has been the differential importance of specifically defined behavioral markers for different crew positions. Law (in press) discusses behaviors associated with the effective (and ineffective) performance of captains and first officers. These data were obtained from analyses of superior and substandard crews in our observational database.

Taggart (in press) describes a new human factors course for first officers upgrading to captaincy. This course had its origin in the analysis of position specific-behaviors described by Law (in press) and focuses on those related to captains and on the interface of the flight crew with other organizational elements. It includes cabin, maintenance, ground and dispatch, and air traffic control personnel as participants. Interestingly, this course has been extended to the senior management of the organization, showing yet another area where CRM has found a niche.

There are several important issues that need to be researched and could lead to revisions and extensions of CRM training. One of these is multi-tasking. As Predmore (1991; 1993) demonstrated in his analyses of communications during accidents and in research LOFTs, crews are faced with coping with multiple tasks at the group level. While there is a substantial literature on individual multi-tasking, the topic needs further investigation at the group level and could result in additional training to enhance the process.

Ultra-longhaul flight operations, especially in advanced technology transports, require augmented crews. Such extended teams raise issues of leadership, shift changes, and the utilization of extra crewmembers in emergency situations. Research into these issues could result in new guidelines for operations and specialized training.

**ENHANCING THE USE OF SIMULATION IN TRAINING AND EVALUATION**

Full mission simulation (LOFT: Line Oriented Flight Training) has become a central part of fully developed CRM programs. The NASA/UT/FAA group has been collecting data on crew performance, scenario quality, and instructor behavior in LOFT at a number of organizations (e.g., Butler, 1993). Crews rate CRM highly as both human factors and technical training, but it is also clear that the technique has not begun to reach its full potential. We have observed unevenness in scenario design, poor briefings and debriefings, a focus on technical rather than human factors elements, and failure to simulate the full operating environment, including realistic air traffic control. However, several airlines, including United and Ansett Australia, have developed "chatter" systems that allow more faithful reproduction of this environment. The flaws in LOFT execution do not negate its usefulness as currently delivered, they only indicate how much more can be achieved. I think of LOFT as being somewhat like sex - even at its worst it is very good.
LOFT, as currently practiced, also requires expensive, high fidelity simulators and considerable blocks of time. This precludes the training for operators lacking state of the art simulation facilities. We need to know much more about the effectiveness of this type of training in less elaborate facilities. Can we achieve the same impact in a training device as in a high fidelity simulator with full visuals and motion? We need also to understand the utility of more limited simulations that do not encompass a full mission (SPOT: Special Purpose Operational Training) in communicating and reinforcing CRM concepts.

INTEGRATING CRM AND TECHNICAL TRAINING

CRM training has developed outside the domain of traditional technical training and checking. Indeed, most CRM courses are led by facilitators who are line pilots rather than members of the training department. This strategy has been highly effective, but it has hindered the integration of technical and human factors training. Many participants conceive of CRM as something outside of and in addition to their technical training and evaluation. To obtain maximum impact, CRM concepts should be fully integrated with all aspects of training from ab initio, to initial qualification, to transition, to recurrent training. Fortunately, the provisions of the Federal Aviation Administration's new Special Federal Aviation Regulation, Advanced Qualification Program (SFAR 58: AQP. FAA, 1991) mandate integration of CRM and technical training and a number of organizations are working on the task (Birnbach & Longridge, 1993). Unfortunately, the task is a daunting one and no one strategy appears to be optimal (Helmreich, Wiener, & Kanki, 1993). However, it is a critical and achievable goal. One of the central elements that is already underway at a number of airlines is to provide instructors and check airmen with specialized, advanced training in CRM concepts. This training should address particularly the evaluation of crew performance and strategies for debriefing and reinforcing effective behaviors.

Additional data on the interplay of technical and human factors components of crew performance come from comparing ratings of the CRM-related behaviors of crews rated as satisfactory and unsatisfactory by check airmen during enroute checks and in the simulator (Wilhelm, Helmreich, Butler, & Taggart, 1993). These data show significantly lower performance on the human factors components for those crews whose technical performance is below standards. These data clearly support the view that human factors elements are highly correlated with technical performance -- and probably causal determinants.

IMPROVING INPUTS INTO THE SYSTEM -- SELECTION

We have gradually come to realize that technical expertise, aptitude, and training are not sufficient to make an optimally effective aviator. Candidates need to have strong interpersonal skills as well as technical competence in order to work effectively in the team environment that is the flightdeck. We have found that personality factors may be one of the limitations on the effectiveness of CRM training (Helmreich & Wilhelm, 1989; 1991). We must also recognize that the system is changing with the advent of advanced technology aircraft and that the mix of skills and motivations that was appropriate in previous, white scarf years may not be optimal in the future. Clearly, we must devote much energy to research into selection strategies (Chidester, 1993; Hackman, 1993; Helmreich & Foushee, 1993).

Many airlines that have committed significant resources to CRM and LOFT have also recognized the need to select individuals who will embrace these concepts. Validation of hiring criteria is difficult because organizations are reluctant to place operations at risk by hiring individuals who vary on dimensions presumed to be critical. Increased pressures placed on hiring practices imposed by the Americans With Disabilities Act also make the task more difficult. However, the task is too critical to ignore and we can only hope that a collaboration between the research and operational communities will provide equitable guidelines.

DETERMINING THE HEALTH OF THE SYSTEM

It is essential that we know what is working and not working in the aviation system if we are to make it as safe and effective as possible -- and if we are to know how well our training is working. One approach is to determine how effectively crews behave in normal, line operations and in LOFT. As noted, the NASA/UT/FAA team has developed a series of behavioral markers of crew performance and a methodology to assess crew performance. This has been employed by a number of airlines and has generated a valuable database with reliable information on observed strengths and weaknesses in the human factors area (Helmreich, Wilhelm, Kello, Taggart, & Butler, 1991). Further research should help optimize and extend this evaluation methodology.
It is also important to know exactly how human factors issues are manifested when the system fails and crews face extreme emergencies. Predmore (1991; 1993) has refined a methodology for classifying and coding crew verbal behavior from cockpit voice recorder tapes and transcripts. Similarly, digital flight data recorders provide an objective record of control inputs and aircraft performance. These analyses, particularly of crews showing very effective responses to catastrophic mechanical failures, demonstrate that CRM concepts do generalize to extreme situations. Fortunately (for the traveling public) and unfortunately (for research), the incidence of accidents where such information can be analyzed is very small and many years will be required to understand trends in crew behavior in emergencies as they relate to CRM.

The unrealized potential for a better understanding of human factors issues in non-standard situations can be realized in a more comprehensive analysis of incidents that do not achieve the status of accidents. These are much more common and can give us a snapshot of the system and factors that need to be addressed by regulatory, organizational, and training interventions. Jones (in press) discusses a conceptual framework and approaches to obtaining more useful data on human factors components of incidents -- including those with exemplary as well as substandard crew performance. This is an area in need of much more research and combined efforts that include the air traffic system.

UNDERSTANDING THE IMPACT OF ORGANIZATIONAL AND NATIONAL CULTURES

The model of crew performance developed by Helmreich and Foushee (1993) stresses the influence of organizational and national cultures on crew behavior. Johnston (1993), Maurino (in press) and Yamamori and Mito (1993) all stress the importance of understanding cross cultural issues. Merritt (in press) discusses preliminary data showing differences among pilots and flight attendants in U.S. and Asian cultures and describes an ongoing project exploring these factors.

As we become a global village and begin to see further integration of crews from differing cultures, we need to be sensitive to these issues, to explore optimal organization structures, and to develop training strategies that are sensitive to important cultural differences. Consider, for example, the fact that cultures differ greatly in relationships between subordinates and superiors and in their individualistic versus collectivist orientation (Hofstede, 1980). It seems likely that a better understanding of cultural issues will allow us to sharpen the focus of training and will help us understand better the dynamics of group interaction. Ultimately, training in communications and leadership in cultures that differ on these dimensions should recognize and reflect these factors.

CONCLUSION

CRM provides an excellent example of the interplay between basic and applied research. Many of the findings that came from basic research into attitudes and group dynamics have been translated into specific practices in the aviation community. Starting with the seminal conference on Cockpit Resource Management hosted by NASA in the 1970s (Cooper, White, & Lauber, 1980), there has been an effective collaboration between the public and private sectors that as resulted in significant transfers of technology. I have tried to lay out an agenda for future research and development. We have reached a turning point in the development of CRM where we need both to broaden our scope and to build on the solid base that has been established. It is unfortunate that the severe international economic crisis, particularly in aviation, poses a threat to further work. There is a real danger that those funding future work may conclude that enough has been accomplished and resources could be better applied elsewhere. It must be stressed that if we focus entirely on applied, immediate needs we can lose the chance for innovative, basic research that can lead to major progress in optimizing human performance. It is our responsibility to get the message across that the payoffs from investments in this area will be great in terms of the safety and effectiveness of the system.

REFERENCES


I. The research reported here was supported partly by NASA-Ames Research Center, Cooperative Agreement NCC2-286 and by FAA Grant 92-G-017, Robert L. Helmreich, Principal Investigator.