The Evolution of Crew Resource Management Training in Commercial Aviation

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Abstract

Changes in the nature of CRM training in commercial aviation are described, including its shift from Cockpit to Crew Resource Management. Validation of the impact of CRM is discussed. Limitations of CRM, including lack of cross-cultural generality are considered. An overarching framework that stresses *error management* to increase acceptance of CRM concepts is presented. The error management approach defines behavioral strategies taught in CRM as error countermeasures that are employed to avoid error, to trap errors committed, and to mitigate the consequences of error.

The roots of *Crew Resource Management* training in the United States are usually traced back to a workshop, *Resource Management on the Flightdeck* sponsored by the National Aeronautics and Space Administration in 1979 (Cooper, White, & Lauber, 1980). This conference was the outgrowth of NASA research into the causes of air transport accidents. The research presented at this meeting identified the human error aspects of the majority of air crashes as failures of interpersonal communications, decision making, and leadership. At this meeting, the label *Cockpit Resource Management* (CRM) was applied to the process of training crews to reduce "pilot error" by making better use of the human resources on the flightdeck. Many of the air carriers represented at this meeting left it committed to developing new training programs to enhance the interpersonal aspects of flight operations. Since that time CRM training programs have proliferated in the United States and around the world. Approaches to CRM have also evolved in the years since the NASA meeting. The focus of this paper is on the generations of CRM training that reflect this evolution and on the problems that have been encountered in changing the attitudes and behavior of flight crews. CRM training in the military has followed its own path of growth and evolution and will not be addressed here (see Prince & Salas, 1993, for a discussion of military CRM programs).

We use the term ‘evolution’ in describing the changes in CRM over the last two decades. Evolution, as formally defined refers to the process of growth and development, a description that aptly fits CRM. Similarly, the very different content and foci of programs called CRM justifies defining them in terms of generations (although temporally a CRM generation is closer to that of the Drosophila than the human). Our focus is on the most recent approaches to CRM training. Early generations are described briefly to show their context and emphases (see Helmreich & Foushee, 1993, for a more complete description of early programs).

First Generation Cockpit Resource Management

The first comprehensive U.S. CRM program was initiated by United Airlines in 1981. The training was developed with the aid of consultants who had developed training programs for corporations trying to enhance managerial effectiveness. The United program was modeled closely on a form of training called the ‘Managerial Grid’ developed by psychologists Robert Blake and Jane Mouton (Blake & Mouton, 1964). The training was conducted in an intensive seminar setting and included participants’ diagnoses of their own managerial style. Other airline programs in this era also drew heavily on management training approaches. These programs emphasized changing individual styles and correcting deficiencies in individual behavior such as a lack of assertiveness by juniors and authoritarian behavior by captains. Supporting this emphasis, the National Transportation Safety Board (NTSB, 1979) had singled out the captain’s failure to accept input from junior crewmembers (a characteristic sometimes referred to as the "Wrong Stuff") and a lack of assertiveness by the flight engineer as causal factors in a United Airlines crash in 1978. First generation courses were psychological in nature, with a heavy focus on psychological testing and general concepts such as leadership. They advocated general strategies of interpersonal behavior without providing clear definitions of appropriate behavior in the cockpit. Many employed games and exercises unrelated to aviation to illustrate concepts. It was also recognized that CRM training should not be a single experience in a pilot’s career and annual recurrent training in CRM became part of the program. In addition to classroom training, some programs also included full mission simulator training *(Line Oriented Flight Training)* where crews could practice interpersonal skills without jeopardy. However, despite overall acceptance, many of these courses encountered resistance from some pilots, who denounced them as "charm school" or attempts to manipulate their personalities.

Second Generation *Crew* Resource Management

NASA held another workshop for the industry in 1986 (Orlady & Foushee, 1987). By this time a growing number of airlines in the U.S. and around the world had initiated CRM training and many reported on their programs. One of the conclusions drawn by working groups at the meeting was that explicit (or stand alone) CRM training would ultimately disappear as a separate component of training when it became imbedded in the fabric of flight training and flight operations.

At the same time, a new generation of CRM courses was beginning to emerge. Accompanying a change in the emphasis of training to focus on cockpit group dynamics was a change in name from *Cockpit* to *Crew Resource Management.* The new courses, typified by the program developed by Delta Airlines (Byrnes & Black, 1993) dealt with more specific aviation concepts related to flight operations and became more modular as well as more team oriented in nature. Basic training conducted in intensive seminars included concepts such as team building, briefing strategies, situation awareness and stress management. Specific modules addressed decision making strategies and breaking the chain of errors that can result in catastrophe. Many of the courses still relied on exercises unrelated to aviation to demonstrate concepts. Participant acceptance of these courses was generally greater than that of the first generation, but criticisms that the training was heavily laced with "psycho-babble" continued (for example, the notion of ‘synergy’ in group dynamics was often condemned by participants as representative of irrelevant jargon). Second generation courses continue to be used in the U.S. and other parts of the world.

Third Generation CRM - Broadening the Scope

In the early 1990s, CRM training began to proceed down multiple paths. Training began to reflect characteristics of the aviation system in which crews must function, including the multiple input factors such as organizational culture that determine safety. At the same time, efforts began to integrate CRM with technical training and to focus on specific skills and behaviors that pilots could use to function more effectively. Several airlines began to include modules addressing CRM issues in the use of flightdeck automation. Programs also began to address the recognition and assessment of human factors issues. Accompanying this was the initiation of advanced training in CRM for check airmen and others responsible for training, reinforcement, and evaluation of technical and human factors.

Accompanying this greater specificity in training for flight crews, CRM began to be extended to other groups within airlines such as flight attendants, dispatchers, and maintenance personnel. Many airlines began to conduct joint cockpit-cabin CRM training. A number of carriers also developed specialized CRM training for new captains to focus on the leadership role that accompanies command.

While third generation courses filled a recognized need to extend the concept of the flight *crew*, they may also have had the unintended consequence of diluting the original focus on the reduction of human error.

FOURTH GENERATION CRM – INTEGRATION AND PROCEDURALIZATION

The Federal Aviation Administration introduced a major change in the training and qualification of flight crews in 1990 with the initiation of its *Advanced Qualification Program* (AQP: Birnbach & Longridge, 1993). AQP is a voluntary program that allows air carriers to develop innovative training that fits the needs of the specific organization. In exchange for this greater flexibility in training, carriers are required to provide both CRM and LOFT for all flight crews and to integrate CRM concepts into technical training. Most of the major U.S. airlines and several regional carriers are transitioning into AQP from the older model expressed in Federal Aviation Regulations, Parts 121 and 135. To complete the shift to AQP, carriers are required to complete detailed analyses of training requirements for each aircraft and to develop programs that address the human factors (CRM) issues in each aspect of training. In addition, special training for those charged with certification of crews and formal evaluation of crews in full mission simulation is required (*Line Operational Evaluation* or LOE).

As part of the integration of CRM, several airlines have begun to proceduralize the concepts involved by adding specific behaviors to their checklists. The goal is to ensure that decisions and actions are informed by consideration of "bottom lines" and that the basics of CRM are observed, particularly in non-standard situations.

On the surface, the fourth generation of CRM would seem to solve the problems of human error by making CRM an integral part of all flight training. It would also appear that the goal of making explicit CRM training "go away" is starting to be realized. Although empirical data are not yet available, there is general consensus among U.S. airlines that the AQP approach yields improvements in the training and qualification of flight crews. However, the situation is more complex and the resolution not so straightforward. Before considering the latest iteration of CRM, it may be valuable at this point to pause and examine what has been accomplished in the past two decades of CRM training.

SUCCESSES AND FAILURES OF CRM TRAINING

Validation of CRM. The fundamental question of whether CRM training can fulfill its purposes of increasing the safety and

efficiency of flight does not have a simple answer. The most obvious validation criterion, the accident rate per million flights, cannot be used. Because the overall accident rate is so low and training programs so variable, it will never be possible to draw strong conclusions about the impact of training during a finite period of time (Helmreich, Chidester, Foushee, Gregorich, & Wilhelm, 1990). In the absence of a single and sovereign criterion measure, investigators are forced to use surrogate criteria to draw inferences more indirectly (Helmreich & Foushee, 1993; Helmreich & Wilhelm, 1991). Reports of incidents that do not result in accidents are another candidate criterion measure. However, incident reporting is voluntary and one cannot know the true base rate of occurrences, which is necessary for validation. We will discuss new developments in incident reporting later.

The two most accessible and logical criteria are behavior on the flightdeck and attitudes showing acceptance or rejection of CRM concepts. Formal evaluation during full mission simulation (LOE) is a start. However, the fact that crews can demonstrate effective crew coordination while being assessed under jeopardy conditions does not mean that they practice these concepts during normal line operations. We feel that the most useful data can be obtained from line audits where crews are observed under non-jeopardy conditions (Helmreich & Merritt, in press; Hines, 1998). Data from such audits has demonstrated that CRM training that includes LOFT and recurrent training does produce desired changes in behavior (Helmreich & Foushee, 1993). This finding is congruent with participant evaluations of training. Crews completing course evaluations report that it is effective and important training (Helmreich & Foushee, 1993).

Attitudes are another indicator of effect as they reflect the *cognitive* aspects of the concepts espoused in training. While attitudes are not perfect predictors of behavior, it is a truism that those whose attitudes show rejection of CRM are unlikely to follow its precepts behaviorally. The attitudes that have been measured to assess the impact of CRM were ones identified as playing a role in air accidents and incidents (Helmreich & Foushee, 1993; Helmreich, Merritt, Sherman, Gregorich, & Wiener, 1993). Data from a number of organizations show that attitudes about flightdeck management also change in a positive direction (Helmreich & Wilhelm, 1991).

CRM does not reach everyone. From the earliest courses to the present, a small subset of pilots have rejected the concepts of CRM (Helmreich & Wilhelm, 1991). These CRM failures are found in every airline and are known to their peers and to management. Any chief pilot can identify these individuals, who have come to be known by a variety of names – *Boomerangs, Cowboys*, and *Drongos* to mention a few. Efforts at remedial training for these pilots have not proved particularly effective.

While CRM is endorsed by the majority of pilots, not all of its precepts have moved from the classroom to the line. For example, a number of airlines have introduced CRM modules to address the use of cockpit automation. This training advocates verification and acknowledgment of programming changes and switching to manual flight rather than reprogramming Flight Management Computers in high workload situations or congested airspace. However, a significant percentage of pilots observed in line operations fail to follow these precepts (Helmreich, Hines, & Wilhelm, 1996).

Acceptance of basic concepts may decay over time. We have surveyed pilots in a number of organizations several years after they received initial CRM training. A disturbing finding from this research is a slippage in acceptance of basic concepts, even with recurrent training (Helmreich & Taggart, 1995). Figure 1 shows shifts in CRM-related attitudes over time within two airlines. The reasons for the decay in attitudes are not immediately apparent, but it is possible to speculate about likely causes. One candidate is a lack of management support for CRM and a failure by evaluators such as line check airmen to reinforce its practice. Another is the broadening of training to include flight attendants and other personnel, because a program stretched to fit all groups may lack the specificity needed to change behavior. As training has evolved from one generation to the next, the original, implicit goal of managing error may have become lost. Proceduralizing CRM (that is, formally mandating the practice of CRM precepts) might also obscure the purpose of the behavior. Support for this view comes from informal interviews of crews asked "What is CRM?" A typical response is "Training to make us work together better." While this is certainly true, it only represents part of the story. It seems that in the process of teaching people *how* to work together we may have lost sight of *why* working together well is important. The overarching rationale for CRM, reducing the frequency and severity of errors that are *crew-based* has been lost.

CRM did not export well. As first and second generation CRM training programs began to proliferate, many airlines in the U.S. and around the world began to purchase courses from other airlines or training organizations. Even in the U.S., courses imported from other organizations had less impact than those that were developed to reflect the organizational culture and operational issues of the receiving carrier. The situation was much worse when training from the U.S. was delivered in other nations. In many cases, the concepts presented were incongruent with the national culture of the pilots.

Figure 1. Changes in CRM attitudes over time in a two major U.S. Airlines.

The Dutch scientist, Geert Hofstede (1980) has defined dimensions of national culture, several of which are relevant to the acceptance of CRM training. High Power Distance cultures, such as China and many Latin American countries, stress the absolute authority of leaders. Subordinates in these cultures are reluctant to question the decisions and actions of their superiors because they do not want to show disrespect. Exhortations to junior crewmembers to be more assertive in questioning their captains may fall on deaf ears in these cultures. Many cultures which are high in Power Distance are also collectivist. In collectivist cultures where emphasis is on interdependence and priority for group goals, the concept of teamwork and training which stresses the need for effective group behavior may be readily accepted. In contrast, highly individualistic cultures such as the U.S. stress independence from the group and priority for personal goals. Individualists may cling to the stereotype of the lone pilot braving the elements and be less attuned to the group aspects of flightdeck management. A third dimension, Uncertainty Avoidance, refers to the need for rule-governed behavior and clearly defined procedures (Merritt, 1996). High Uncertainty Avoidance cultures such as Greece, Korea, and many Latin American countries, may be much more accepting of CRM concepts that are defined in terms of required behaviors. The U.S. is low in Uncertainty Avoidance, which is reflected operationally in greater behavioral flexibility, but also weaker adherence to Standard Operating Procedures (Helmreich, Hines, & Wilhelm, 1996). Management of cockpit automation is also influenced by national culture. Pilots from high Power distance and/or Uncertainty Avoidance cultures show more unquestioning usage of automation while those from cultures low in Power Distance and/or Uncertainty Avoidance show a greater willingness to disengage (Sherman, Helmreich, & Merritt, in press). The low Uncertainty Avoidance of U.S. pilots may account, in part, for frequent failure to complete checklists and the imperfect acceptance of proceduralized CRM in this country.

There is a growing trend for carriers outside the U.S. to include national culture as part of CRM training and to customize their programs to achieve harmony with their own culture. This is an important development that should enhance the impact of CRM in those organizations. Malaysian Airlines, for example, has made national culture a part of its program (Helmreich & Merritt, in press).

Considering both the observed limitations of CRM in the United States and the differing reactions to the training in other cultures, let us now turn to the fifth generation of CRM training --one which we believe addresses the shortcomings of earlier training approaches.

FIFTH GENERATION CRM – SEARCH FOR A UNIVERSAL RATIONALE

We have been searching for a rationale for CRM training that could be endorsed by pilots of all nations--including the Drongos. Returning to the original concept of CRM as a way to avoid error, we concluded that the overarching justification for CRM should be ***error management*** (Helmreich & Merritt, in press; Merritt & Helmreich, 1997). In reaching this position, we were much influenced by the work of Professor James Reason (1990, 1997). While human error was the original impetus for even the first generation of CRM, the realization and communication of this was imperfect. Even when the training advocated specific behaviors, the reason for utilizing them was not always explicit. What we advocate is a more sharply defined justification that is accompanied by proactive organizational support.

CRM as error management. Underlying the fifth generation of CRM is the premise that human error is ubiquitous and inevitable--and a valuable source of information. If error is inevitable, CRM can be seen as a set of error countermeasures with three lines of defense. The first, naturally, is the avoidance of error. The second is trapping incipient errors before they are committed. The third and last is mitigating the consequences of those errors which occur and are not trapped. This error management *troika* is shown in Figure 2. The same set of CRM countermeasures apply to each situation, the difference being in the time of detection. For example, consider an advanced technology aircraft which experiences a controlled flight into terrain (CFIT) because an improper waypoint is entered into the Flight Management Computer (FMC). A careful briefing on approach procedures and possible pitfalls, combined with communication and verification of FMC entries would probably avoid the error. Cross-checking entries before execution and monitoring of position should trap erroneous entries. Finally, as the last defense, inquiry and monitoring of the position should result in mitigating the consequences of an erroneously executed command before CFIT.

To gain acceptance of the error management approach, organizations must communicate their formal understanding that errors will occur, and should adopt a non-punitive approach to error. (This does not imply that any organization should accept willful violation of its rules or procedures.) In addition to normalizing error, organizations need to take steps to identify the nature and sources of error in their operations. The U.S. Federal Aviation Administration has announced a new initiative, Aviation Safety Action Programs, to encourage incident reporting within organizations to deal with safety issues proactively (FAA, 1997). For example, American Airlines is participating in the program with the cooperation of the pilots' union and the FAA. This confidential, non-jeopardy reporting system allows pilots to report safety concerns and errors. The program has proved to be a resounding success, with nearly six thousand reports received in a two year period. Data generated by this system allow the company to take steps to prevent or minimize the recurrence of incidents.

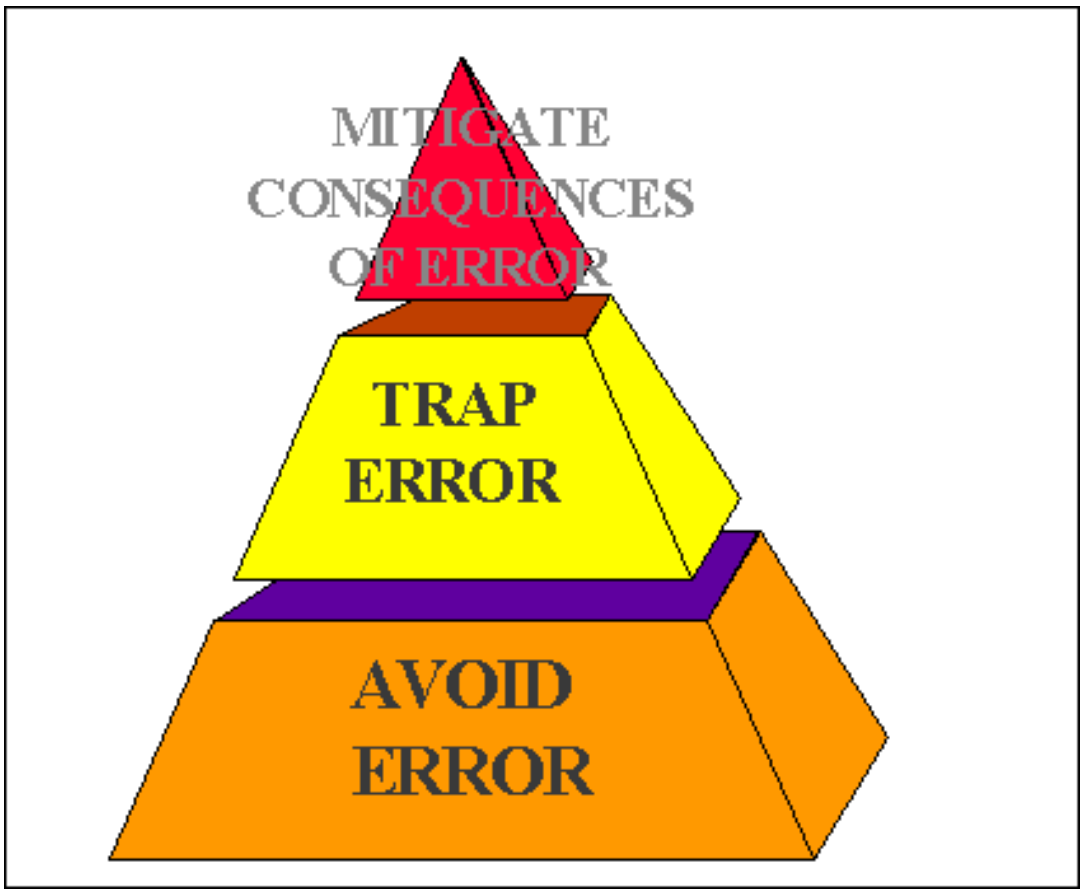

Figure 2. The error *troika.*

Considerations for fifth generation CRM. Instruction in the fifth generation has at its aim the *normalization* of error and the development of strategies for managing error (Helmreich, 1997). Its basis should be formal instruction in the limitations of human performance. This includes communicating the nature of cognitive errors and slips as well as empirical findings demonstrating the deleterious effects of stressors such as fatigue, work overload, and emergencies. These topics, of course, require formal instruction, indicating that CRM should continue to have its own place in initial and recurrent training. These can be dramatically illustrated with examples from accidents and incidents where human error played a causal role. Indeed, the analysis of human performance is common to all generations of CRM training. We would argue, however, that even more powerful learning may result from the use of positive examples of how errors are detected and managed.

Pilots from all regions of the world have been found to hold unrealistic attitudes about the effects of stressors on their performance -- the majority feel, for example, that a truly professional pilot can leave personal problems behind while flying and that their decision making ability is the same in emergencies and normal operations (Helmreich & Merritt, in press; Merritt & Helmreich, 1997a). This attitude of personal invulnerability is a negative component of the professional culture of pilots and physicians (Helmreich & Merritt, in press). Training that demonstrates that these are erroneous or over-confident beliefs and that every individual is subject to stress can foster more realistic attitudes by reducing the onus attached to personal vulnerability. In turn, pilots who recognize the performance degradation associated with stress should more readily embrace CRM training as an essential countermeasure.

In theory, the error management approach should provide a more compelling justification for CRM and human factors training, but the impact remains to be evaluated empirically. Continental Airlines has refocused both the basic awareness and recurrent components of CRM as error management. As part of their commitment to this approach, all pilots were given the new basic course. Data on the outcomes of this program should help determine the effectiveness of the fifth generation approach. At the same time that error management became the primary focus of CRM training, Continental introduced a new program to train instructors and evaluators in the recognition and reinforcement of error management (Tullo, in press). This training stresses the fact that effective error management is the hallmark of effective crew performance and the well-managed errors are indicators of effective performance.

As part of our development of strategies for using the line audit as an organizational assessment strategy, we have modified the Line/LOS Checklist, which is used to measure team performance to include data on error types and error management (Helmreich, Butler, Taggart, & Wilhelm, 1994). In preliminary observations at a U.S. airline, we found that observers could

readily identify errors, their sources, and management strategies. Examples were found of errors avoided, errors trapped, and errors mitigated. Instances of errors never detected by crews and errors whose consequences were exacerbated by crew action were also found. We feel that a focus on error management both in LOFT and in line checking can provide valuable feedback and reinforcement for crews.

HOW DOES ERROR MANAGEMENT CRM RELATE TO EARLIER GENERATIONS?

Fifth generation CRM is compatible with earlier generations. Special training in the use of automation and the leadership role of captains as highlighted in the third generation can be neatly subsumed under this model. The error management approach should strengthen the AQP approach to training by providing an all-important demonstration of the reasons for stressing CRM in all aspects of flight training. In the same vein, the integration of CRM into technical training and the proceduralization of CRM also fit under this umbrella, and are likely to be better understood and accepted when the goals are clearly defined and organizationally endorsed. Pilots should also be better able to develop effective strategies for error management in situations where procedures are lacking and provide a focal point for CRM skills which are not amenable to proceduralization.

Training modules such as situation awareness and the nature and importance of briefings can be seen as basic error management techniques. Similarly, joint training of cabin and cockpit crews can be seen as extending the scope of error management to all employees in a safety culture (Merritt & Helmreich, 1997b). Finally, clarification of the basic goals of CRM training may be the best way to reach the Drongos who should find it difficult to deny the importance of error management.

CRM IN CONTEXT

CRM is not and never will be the mechanism to eliminate error and assure safety in a high risk endeavor such as aviation. Error is an inevitable result of the natural limitations of human performance and the function of complex systems. CRM is one of an array of tools that organizations can use to manage error.

The safety of operations is influenced by professional, organizational, and national cultures and safety requires focusing each of these toward an organizational *safety culture* that deals with errors non-punitively and proactively (Helmreich & Merritt, in press). When CRM is viewed in the context of the aviation system, its contributions and limitations can be understood. What we do know is that the rationale for human factors training is as strong now as it was when the term CRM was first coined.

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