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KEYES, COCKPIT RESOURCE MANAGEMENT

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Cockpit Resource Management

A New Approach to Aircrew Coordination Training

by

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Foreword

In fiscal year 1992, the Air Force plans to shift to a program of specialized undergraduate pilot training. Under this program, student pilots, in the latter part of their flying training, will learn to fly the class of aircraft they will pilot on active duty. Because of this shift, the Air Training Command (ATC) will have to make significant changes in the curriculum of its flying training programs. ATC will become responsible for training student pilots to fly multiseat aircraft and to function as members of an aircrew.

Maj Ricky Keyes examines the effects of this change on ATC's undergraduate pilot training program. He discusses at length the advantages of training pilots as members of aircrews and how such training helps reduce the number of aircraft accidents. Major Keyes identifies the critical elements of aircrew coordination training and provides insightful recommendations on how ATC should incorporate these elements in the new specialized undergraduate pilot training curriculum.

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About the Author

Maj Ricky J. Keyes

Maj Ricky J. Keyes received his commission through Air Force ROTC at Lamar University, Beaumont, Texas, where he received a BS degree in psychology. He completed undergraduate pilot training at Reese AFB, Texas, in 1975 and was assigned to the 909th Air Refueling Squadron (AREFS), Kadena AB, Japan, as a KC-135 pilot. In 1978 he was assigned to the 7th AREFS, Carswell AFB, Texas, where he upgraded to instructor pilot and served as an evaluator for the 7th Bombardment Wing (BMW). While at Carswell AFB, Major Keyes completed an MS degree in industry and technology at East Texas State University, Commerce, Texas.

In 1983 Major Keyes was assigned as an instructor pilot conducting initial qualification training for KC-135 pilots in the 93d AREFS, Castle AFB, California. He moved to the 93d BMW as a curriculum development manager for the Combat Crew Training School in 1984. Major Keyes quickly advanced to a position as branch chief with responsibility for the integration and utilization of all training devices and simulators, including the multimillion dollar KC-135 and B-52 weapon system trainers. In 1987 Major Keyes became the first operations officer of the newly formed 3907th Systems Evaluation Squadron. In this position he was responsible for developing and implementing the Strategic Air Command's simulator certification program.

Air Training Command sponsored Major Keyes's research for this report while he was assigned to the Air University Center for Aerospace Doctrine, Research, and Education. Major Keyes—accompanied by his wife, Ginger, and their three sons, Ricky, Christopher, and Kevin—is now assigned to Headquarters ATC, Randolph AFB, Texas, where he will assist in the implementation of specialized undergraduate pilot training.

Introduction

Lt Gen John A. Shaud, former commander of the Air Training Command, recognized the opportunities for enhancing aircrew coordination training created by the planned implementation of specialized undergraduate pilot training (SUPT) in fiscal year 1992.[1] He directed Air Training Command (ATC) to prepare for including this training during SUPT. In this study, I describe cockpit resource management (CRM) training as a new approach to training aircrew coordination and recommend ways to implement this training during SUPT.

Specialized undergraduate pilot training will include a common primary flight training phase, followed by two separate, advanced training tracks: bomber-fighter (BF) and tanker-transport (TT). Placing student pilots in these specialized tracks of flying training will allow ATC to tailor advanced flying training to meet the specific needs of gaining Air Force major commands (MAJCOM).[2] Aircrew coordination is one of the specific MAJCOM requirements that specialized training in the tanker-transport track will address. This training is also an element that the bomber-fighter track and undergraduate navigator training should address.

The basic concepts and skills of CRM introduced during SUPT will establish attitudes that will contribute to effective teamwork among pilots and crews. The Air Force will gain significantly by establishing the proper crew "mind-set" in student pilots early in their aviation careers.[3] Initial CRM training in SUPT, strengthened by follow-on CRM training in the major commands, will increase the safety and mission effectiveness of Air Force flight crews.

I begin with a review of the development of cockpit resource management as a training program designed to enhance aircrew coordination skills. Cockpit resource management is the effective use of material and human resources "to achieve safe and efficient flight operations."[4] Material resources include everything from operating manuals, regulations, and charts to the automatic pilot and advanced avionics. Human resources refer to air traffic control, the command post, other crew members, or anyone with whom the crew may communicate to obtain information or assistance about or during the mission. Although this study is directed at pilot training, CRM training applies to all crew positions. (Crew member refers to all aircrew members—e.g., pilot, copilot, navigator, flight engineer, boom operator, and loadmaster.)

Cockpit resource management training evolved from applying classical business management concepts to cockpit operations.[5] In chapter 2, I

describe five critical elements of CRM: leadership, communications, situational awareness, problem solving, and critique. I review the training methods and media used in existing civilian CRM programs in chapter 3. In chapter 4, I expand this review to include existing military programs. I also contrast the operational environments of civilian and military aviation to point out the even greater need for CRM training in the Air Force. In chapter 5, I state the steps that ATC must take to implement cockpit resource management training in specialized undergraduate pilot training.

Notes

1. Lt Gen John A. Shaud, "New Focus on Aircrew Coordination," *Flying Safety*, March 1988, 2.
2. Ibid.
3. *Department of Defense 1989 Trainer Aircraft Masterplan* (Randolph AFB, Tex.: Headquarters Air Training Command, Directorate of Requirements, 1989), 1-18, 1-19.
4. John K. Lauber, "Cockpit Resource Management: Background and Overview," in *Cockpit Resource Management Training: Proceedings of a NASA/MAC Workshop*, ed. Harry W. Orlady and H. Clayton Foushee, conference publication 2455 (Moffett Field, Calif.: NASA, Ames Research Center, 1987), 9.
5. Ibid., 7.

Chapter 1

History of Cockpit Resource Management

Advances in aviation technology have dramatically changed the resources available to pilots. Sophisticated avionics, computers, and other automations in the cockpit provide new sources of information and assistance. Pilots and other crew members must develop new skills to utilize these new technologies effectively. In multiseat aircraft, crew members with unique skills become the pilot's most valuable asset. The critical question is: Have changes in pilot training kept up with these changes in flight operations?

If the answer is yes, why are approximately 80 percent of all jet aircraft accidents the result of poor management of cockpit resources?[1] The ratio of aircraft accidents to the total number of flying hours has steadily declined over the past three decades, largely because airplanes are built and maintained better. In contrast, the percentage of aircraft accidents attributed to "pilot error" has increased.[2] Further examination of these pilot-error accidents has revealed that they did not result from deficient "stick-and-rudder" skills but from insufficient decision-making, leadership, and communication abilities.[3] These findings led National Aeronautics and Space Administration (NASA) researchers to the conclusion that accidents in multicrew aircraft that were previously blamed on pilot error were actually the result of "failure on the part of all cockpit crewmembers to utilize resources which were readily available to them."[4] These researchers would answer the question above in the negative, saying that traditional pilot training does not adequately address many of the human-factors skills required for safe and efficient flight operations in multicrew aircraft.[5]

The crash of a wide-body aircraft in December 1972 is a classic example of poor resource management and a breakdown in crew coordination. The aircraft was in the radar traffic pattern at 2,000 feet for landing at the Miami airport when the crew discovered a burned-out light bulb in the nose-gear position indicator. The official National Transportation Safety Board (NTSB) investigation reported that the crew had flown the aircraft to a safe altitude and had engaged the automatic pilot to reduce the work load. However, the first officer and captain were preoccupied with the problem and did not positively delegate control of the aircraft to another member of the crew. The flight crew devoted approximately four minutes to the distraction, assuming that the automatic pilot was maintaining altitude. During this time the aircraft gradually descended 2,000 feet and crashed into the

Everglades. The NTSB concluded that the captain failed to ensure that a pilot was monitoring the status of the aircraft at all times.[6] In short, a perfectly flyable aircraft was destroyed because the flight crew did not effectively utilize all of the resources available in the cockpit.

The first recorded mention of a need for training in managing cockpit resources came following an accident in December 1968. In its report on this accident, the NTSB recommended renewed emphasis on cockpit discipline, procedures, and flight management.[7] After a Boeing 737 crashed short of the runway at Midway Airport in Chicago in 1972, the NTSB report stressed "that the accident sequence was triggered by the captain's failure to exercise positive flight management earlier during the approach."[8] In yet another case, the NTSB noted that the captain failed "to delegate any meaningful responsibilities to the copilot, which resulted in a lack of effective task sharing during the emergency."[9] Despite these NTSB recommendations and findings and the nearly 20 similar ones that followed, investigators have continued to find and list pilot error as the cause of accidents.

NASA Research

In the midseventies, researchers at the Man-Vehicle Systems Research Division at NASA's Ames Research Center began studying the underlying causes of these pilot-error accidents.[10] In 1973 the researchers conducted structured, confidential interviews with airline crew members.[11] They found general satisfaction among crew members with the technical training they received. However, these aircrews reported difficulties "related more to issues such as how to be a more effective leader, and how to achieve more effective crew coordination and improved communication within the cockpit."[12] One new captain said, "My company trains pilots very well, but not captains—command training is needed."[13] These interviews gave NASA's researchers their first insights into the nature of the problem.

The next step was taken early in 1976, when Ruffell Smith and several colleagues at NASA's Ames Center, using a full-mission simulator experiment, exposed flight crews to low and high work loads and evaluated changes in performance with respect to errors, levels of vigilance, and decision-making abilities. They conducted the study in a Boeing 747 high-fidelity simulator with motion and visual systems included. The researchers designed two mission scenarios, one requiring a low work load and the second a more challenging series of events including an aircraft emergency. Researchers recorded the behavior of the 20 volunteer crews—captain, first officer, and flight engineer—that participated in these simulated flights.[14]

Trained observers noted the errors made by the flight crews relating to safety of flight and efficient operation. The researchers' comments included the following observations:

The kind of scenario and recording techniques used in this study demonstrated to the volunteer aircrews and training personnel how easy it is for errors to be made in high work load situations. This has implications for training. Many of the discrete errors and wrong decisions were related to overloading one particular crew member, particularly when he was engaged in reading and complying with checklists for the procedures connected with abnormal operation. It was also seen how in some cases compliance with these procedures could interfere with the monitoring cover built into standard operating procedures.[15]

By observing and comparing the performance of the captains in realistic full-mission simulations, the researchers were able to record large behavioral variations in leadership, resource management, and decision making. Leadership appeared to be lacking in some crews; occasionally the void was filled by the first officer.[16] The researchers saw wide differences in the methods that crews used to obtain and verify information, "varying from the meticulous confirmation of remembered information by reference to documents, to the use of preconceived values that were not checked."[17]

Another particularly disturbing observation was the difficulty in identifying which pilot (captain or copilot) was in control of the aircraft, both with and without the autopilot engaged. The failure to anticipate the overloading of individual crew members and the subsequent failure to set priorities and delegate tasks greatly contributed to the errors. The large differences in the way the crews reached decisions reflected the effectiveness of the captains in managing the available resources. Effective captains gave "full attention to assimilating the information from documents, ATC [air traffic control], and other crew members and to [using] these data to make unhurried decisions."[18]

The Ruffell Smith study has been recognized for identifying resource management as a critical variable in the performance of aircrews. It has been a catalyst in developing training programs to improve cockpit resource management and a stimulus for further research. Further evidence was gathered by the NASA Ames project through a review of NTSB accident reports from 1968–76. They identified 600 accidents in that period in which resource management problems played a significant role.[19] During their analysis of these reports, the researchers noted that the accidents had many common factors. Seven of the most frequently observed problems were preoccupation with minor mechanical problems, inadequate leadership, failure to delegate tasks and assign responsibilities, failure to set priorities, inadequate monitoring, failure to utilize available data, and failure to communicate intent and plans.[20] These common problems suggested the training objectives that CRM programs should address.[21]

The next project that the NASA Ames researchers undertook was a detailed analysis of aircraft incident reports submitted anonymously through the Aviation Safety Reporting System (ASRS). These incident reports provided many examples of crew errors resulting from poor aircrew

coordination and resource management. For example, a crew was given a heading change to 160 degrees and clearance to climb to 14,000 feet. The crew members did not remember setting 160 in the altitude reminder, but the airplane subsequently levelled off at 16,000 feet—2,000 feet too high[22] Many ASRS reports described errors and poor performance resulting from personality clashes and unresolved conflicts in the cockpit.

A summary of the skills, organization and process variables, and resources identified by the NASA researchers from the incident reports is presented in table 1. This data is consistent with data from each of the other NASA studies. These findings provide insight into the cockpit resource management problem and point to the need to improve the ability of crew members to utilize the resources available on the flight deck. The tragic loss of life in preventable accidents spurred the development of cockpit resource management training programs. The term *cockpit resource management* is now accepted in the aviation industry as a generic name for training programs designed to correct these deficiencies.

TABLE 1

Classification of Identified Problems

I. Social and communication skills

a. Strained social relations
b. Assertiveness
c. Nonverification of communications
d. Unnecessary communications
e. Withholding communications
f. Assumptions about other understanding
g. Assumptions about meaning
h. Assumptions about message

II. Leadership and management skills

a. Delegation of authority
b. Erosion of authority
c. Captain's trust-doubt dilemma
d. Lack of decisive command
e. Discipline and leadership in applying regulations
f. Casualness in cockpit
g. Crew coordination
h. Time-structuring priorities

III. Planning, problem solving, and decision skills

a. Inadequate planning
b. Information retrieval
c. Quality and timeliness of information
d. Credibility of information
e. Problem-solving strategies
f. Staying ahead of the problem (crisis prevention)
g. Decision under stress
h. Group think

Table 1 (cont'd)

IV. Role

a. Definition/understanding (pilot–copilot)
b. Command responsibility of captain when first officer flying
c. Responsibility of first officer when captain deviates from safe or legal practices
d. Reduced command options
e. Work load
f. Task allocation
g. Monitoring
h. Backup
i. Call outs

V. Resources

a. Human
   (1) Individual differences in knowledge, proficiency, experience, motivation, stress reaction
   (2) Fatigue

b. Material
   (1) Facilities
      (a) Availability
      (b) Adequacy
      (c) Human engineering
   (2) Equipment
      (a) Availability
      (b) Access
      (c) Adequacy
      (d) Human engineering
      (e) Automatic versus manual
   (3) Textual information
      (a) Availability
      (b) Access
      (c) Adequacy
      (d) Human engineering
   (4) Environmental information
      (a) Availability
      (b) Adequacy

Source: John R. Lauber, "Resource Management on the Flight Deck: Background and Statement of the Problem," in *Resource Management on the Flight Deck: Proceedings of a NASA/Industry Workshop*, ed. George E. Cooper, Maurice D. White, and John K. Lauber, conference publication 2120 (Moffett Field, Calif.: NASA Ames Research Center, 1979), 14–15.

FAA Recognition of Cockpit Resource Management

In 1979 the first direct reference to cockpit resource management appeared in NTSB Recommendation A-79-047. This recommendation was issued following a United Airlines DC-8 crash in Portland, Oregon, which occurred after the engines died of fuel starvation. The NTSB recommended that the Federal Aviation Administration (FAA) urge all air carriers to indoctrinate crew members in the principles of cockpit resource management.[23] Also, in 1979 NASA sponsored the first workshop on CRM. It attracted participants from "a broad spectrum of the industry and stimulated the development of a number of training programs."[24]

Ten years after introducing the CRM concept to the industry, many experts, such as NTSB member Dr John Lauber, believe that the development of CRM programs is still in a transition period.[25] Continued NTSB accident investigation recommendations, combined with the apparent success of existing CRM programs, have resulted in the publication in 1989 of a draft FAA Advisory Circular on the subject of cockpit resource management.[26] It is probable that CRM will soon be required for all airlines.[27]

Notes

1. J. E. Carroll and Dr William R. Taggart, "Cockpit Resource Management: A Tool for Improved Flight Safety," in *Cockpit Resource Management Training: Proceedings of a NASA/MAC Workshop*, ed. Harry W. Orlady and H. Clayton Foushee, conference publication 2455 (Moffett Field, Calif.: NASA, Ames Research Center, 1987), 40.
2. Hisaaki Yamamori, "Optimum Culture in the Cockpit," in Orlady and Foushee, 75–76.
3. Orlady and Foushee, iv.
4. Ibid.
5. Ibid.
6. John K. Lauber, "Resource Management on the Flight Deck: Background and Statement of the Problem," in *Resource Management on the Flight Deck: Proceedings of a NASA/Industry Workshop*, ed. George E. Cooper, Maurice D. White, and John K. Lauber, conference publication 2120 (Moffett Field, Calif.: NASA, Ames Research Center, 1979), 5–6.
7. John K. Lauber, "Cockpit Resource Management: Background and Overview," in Orlady and Foushee, 12.
8. Lauber, "Resource Management on the Flight Deck," 7.
9. Ibid.
10. Orlady and Foushee, iv.
11. Lauber, "Resource Management on the Flight Deck," 3.
12. Ibid.
13. Ibid.
14. H. P. Ruffell Smith, *A Simulator Study of the Interaction of Pilot Work Load with Errors, Vigilance, and Decisions*, technical memorandum 78482 (Moffett Field, Calif.: NASA, Ames Research Center, 1979), 1–2.
15. Ibid., 21.
16. Ibid., 28.
17. Ibid.
18. Ibid.
19. Lauber, "Resource Management on the Flight Deck," 5.
20. Ibid., 7.
21. Ibid.
22. Ibid., 8.
23. Lauber, "Cockpit Resource Management," 12.
24. Orlady and Foushee, iv.
25. Jan W. Steenblik, "Two Pilots, One Team: Part Two," *Air Line Pilot*, September 1988, 14.
26. Federal Aviation Administration, "Cockpit Resource Management Training," draft FAA Advisory Circular, 1–14.
27. Steenblik, 11.

Chapter 2

Critical Elements of Cockpit Resource Management

While technical flying skills are critical to keeping an aircraft flying during an in-flight emergency, CRM skills are essential to analyzing emergency situations and taking appropriate actions. As Robert L. Helmreich, University of Texas at Austin, notes, the dynamics of aircrew behavior are similar to the behaviors of any other small group.[1] Thus, cockpit resource management training programs draw heavily on the concepts of social psychology and small group dynamics. Although the training programs of specific airlines may differ in the emphasis they put on a particular area and in their methods of presentation, they all include the following five critical elements of cockpit resource management: leadership, interpersonal communications, situational awareness, problem solving, and critique. The following discussion explains how the human factors associated with each of these elements influence pilot behavior and affect team performance. This discussion should promote a better understanding of the scope of cockpit resource management training and its importance to achieving improved levels of aircrew coordination.

Leadership

Aircraft commanders exert the greatest influence on aircrew performance. They must be skilled in three highly interdependent leadership roles: commander, leader, and manager. The authority of the aircraft commander is statutory--all crew members are bound to preserve the authority of command.[2] Researchers have found that the aircraft commander's effectiveness as a leader is a function of his or her personality and situational factors.[3] None of the CRM concepts are intended to infringe on that lawful authority and the responsibility of the pilot in command. This point is emphasized in CRM programs to dispel any misconceptions that could develop in discussions of team leadership.

The aircraft commander's role as the team leader extends beyond statutory authority. A pilot's effectiveness as the crew leader depends on his or her ability to involve all crew members in pursuit of team goals. CRM programs teach crew members to recognize effective and ineffective leadership styles and how those styles affect aircrew performance. In critical

situations that require input from all crew members. The best results occur when the aircraft commander shows a high degree of concern for people as well as performance.[4] Performance-oriented leadership styles that ignore the feelings of other crew members have been linked to numerous aircraft accidents; such leadership styles cause breakdowns in aircrew coordination.

Many CRM programs teach the concept of functional leadership to improve team performance. Aircraft commanders must recognize that the crew member who has the most information about a given situation should assume a leadership role in advocating a course of action based on unique expertise. As a corollary, the aircraft commander must be willing to become a functional follower and defer leadership momentarily to the expert. These temporary roles emerge as a result of specific situations and have no effect on the authority of the designated leader, the pilot in command.[5]

Functional leadership is linked to each crew member understanding his or her role and to the pilot's responsibility in defining those roles. Poor crew performance often results when "role boundaries" are not clear.[6] To be an effective team leader the captain must ensure that each crew member understands his or her team role. All crew members should know what is expected of them and what to expect from other crew members. The crew's team performance in crisis situations is enhanced when individual roles are fulfilled as expected.

Leadership training provides aircraft commanders with the skills they need to build effective teams. Lt Col Robert Ginnett of the United States Air Force Academy, in a study of team formation in a major airline, documented the impact the captain's preflight briefing had on subsequent crew performance.[7] The best captains, as measured by observed performance during flight, conducted thorough briefings that tailored normal crew expectations "to fit as well as possible with the special circumstances" of a particular flight.[8] In the worst case, the captain made comments during the briefing that shattered normal crew expectations, causing confusion which led in turn to poor crew performance.[9]

Another key to being an effective team leader is skill at resolving conflicts among crew members and in winning the support of the entire crew for the final decision. Crew members advocating conflicting opinions can cause vital information to surface in the problem-solving process. Effective conflict resolution reduces defensive behavior by individual crew members by focusing on "what is right" instead of "who is right."[10] A review of aircraft accidents attributed to pilot or crew error showed that unresolved conflicts were a factor in most of them.

The aircraft commander must also manage human and material resources. The most critical aspect of this element of the leadership role is controlling the work load of all crew members. The captain must recognize the potential dangers of crew member overload during periods of high stress. In the opposite case, task underload, he or she must make sure that boredom and fatigue do not lead to complacency that results in

inattention to detail.[11] The aircraft commander can manage crew activities by setting priorities and delegating tasks.[12]

Although Air Force commissioning and professional military education programs emphasize leadership, traditional pilot training programs do not provide training or supervised practice in developing leadership or management skills for specific application in the cockpit. In fact, undergraduate pilot training has stressed teaching pilots to perform independently, allowing attitudes to develop that are detrimental to performance in a crew. There are many indications that training in effective cockpit leadership during Air Force pilot training programs will improve crew performance.

Situational Awareness

Besides excellent hand-eye coordination and the other physical abilities necessary for stick-and-rudder skills for controlling the aircraft, the pilot and other crew members, just as importantly, must "stay ahead of the aircraft." That is, they must relate continuously "what is going on at the moment . . . to what has gone on in the past and what may go on in the future."[13] For many individuals developing and maintaining this sense of situational awareness is more difficult than learning stick-and-rudder skills.

Learning the former skills may be harder for these individuals since their perception of the situation is dependent on their individual perceptions of events. Different backgrounds, experience, and training contribute to differing perceptions of situations.[14] During CRM training, crews will learn to identify clues that should alert them that their perceptions are in error. For example, the situation may prove to be ambiguous when two independent sources of information conflict. Failure to meet targets such as the estimated time of arrival at a reporting point should alert the crew to possible problems. Any unresolved discrepancy is a clue that the "situation" may be other than it appears on the surface.[15] When a crew member attempts to accomplish too many tasks at one time, he or she becomes overloaded and may overlook some tasks. On the other hand, during long periods of low activity boredom sets in and crew members may become indifferent to what is going on around them. In either case, cockpit distractions can focus attention on single items to the exclusion of others, lowering the crew's situational awareness.[16]

In addition, the feelings and attitudes of crew members can diminish situational awareness. Complacent crew members will contribute less than 100 percent to assigned duties and, thus, will overlook critical details. Crew members who are uncertain about their roles may withdraw from active involvement in the situation to avoid embarrassment. If crew members are suffering from fatigue, stress, frustration, and anger, they may pay too little attention to the details of their assigned tasks.[17] CRM training can help

crew members develop skills that raise the situational awareness of the entire crew.

Occasionally crews get caught up in group behaviors that are detrimental to accurate perceptions of the situation. "Press on, regardless" is the tendency for a crew to continue a course of action despite indications that it needs to change its behavior. "Get-home-itis," management pressures, "macho" attitudes, and professional pride influence crews to press on regardless of risks. "Group think" reflects the willingness of crews to agree on a course of action because "it is always done this way." Any group behavior that results in the crew not looking for or using all available information or resources is known as "not playing with a full deck." "Too much too soon, too little too late" characterizes a crew's failure to act within an appropriate time frame. A pilot may act too soon if he or she shuts down an engine for a low oil pressure indication without verifying the reading on other gauges. The pilot acts too late if, after verifying the low oil pressure, he or she waits too long to shut the engine down, resulting in failed engine bearings. The negative effects of these types of behavior can be avoided through an awareness of these crew pitfalls combined with a constructive skepticism about the flight environment.[18]

A constructive skepticism during flight motivates a pilot to continuously update his or her understanding of the existing situation and stay mentally ahead of the aircraft. When his or her perceptions are in error, the pilot needs to have available and use information that shows that error.[19] An analysis of aircraft accidents indicates that someone on the crew usually had information that, if successfully communicated to the pilot, could have helped the crew avoid the accident. Lee Bolman, Harvard University, suggests that obtaining and utilizing information effectively requires skills in interpersonal communications.[20]

Problem Solving

If crews do not quickly recognize and correct problems, those problems may worsen: low oil pressure can cause an engine to seize, or a hydraulic leak can lead to a loss of flight controls. The crew's analysis of the problem is affected by its perceptions of the situation. For example, one pilot mistakenly identified a problem as a high-speed buffet when it was in fact a stall warning. By reducing power, the pilot caused the aircraft to enter a full stall.

A crew can accurately identify a problem only by analyzing all pertinent information. The significance of the information that each crew member has may not be understood until it is analyzed as part of a larger picture.[21] A crew that works together and shares information will arrive at a better solution to a problem than if each individual works alone to solve a piece of the puzzle. Most CRM training programs preach synergy: the whole is greater than the sum of the parts. To achieve synergistic solutions to

problems, each crew member must be assertive in advocating ideas and opinions and flexible in understanding the ideas and opinions of others.[22]

When the pilot in command obtains all pertinent information, he or she must exercise judgement to arrive at the best possible decision. Judgement may be thought of as "experience applied."[23] Training methods that broaden an individual's experience base contribute to better judgement. Group problem solving provides a larger pool of experience on which the aircraft commander may base his or her judgement. Still, the final decision is the responsibility of the pilot in command.

Once an aircraft commander decides on a course of action, he or she should brief the crew on that plan. Every flight begins with mission planning and a crew briefing. However, problems encountered during the flight may require revision of the original plan. The aircraft commander must then brief all crew members to ensure that they are aware of and understand the changes in procedures, duty assignments, and observable limits to be monitored.[24]

The plan should be validated and updated through continuous reviews. A review should be conducted at the end of each problem-solving cycle to validate the plan and ensure that nothing has been overlooked. Each crew member should call for a formal review by the crew anytime the individual is uncomfortable with the current situation.[25] These reviews as well as the entire problem-solving process require skills in interpersonal communications.

Communications

The aircraft commander must establish an environment that promotes the free flow of information within the cockpit. Positive feedback regarding the value of inputs from other crew members encourages them to make further contributions in problem-solving situations. Negative feedback can cause them to withhold vital information in critical situations. An aircraft commander should be skilled at expressing disagreement when appropriate without causing the other crew member to feel personally rejected or ignored.[26]

Cockpit communications are greatly enhanced when crew members are skilled in inquiry and advocacy. Inquiry is a process of actively seeking information from all available sources. It is a form of constructive skepticism that helps overcome complacency.[27] Advocacy is an obligation to speak out assertively in support of an alternate course of action while remaining open to opposing viewpoints.[28] A lack of assertiveness by crew members is suspected as a leading cause of crew error. Flight safety is enhanced when inquiry and advocacy are used together as basic communicative tools for effective problem solving.

Interpersonal communications may be verbal or nonverbal. For communication to be effective, the receiver must understand the intended

message. Barriers to communication may interfere with the intended message being received and accurately understood. Four specific barriers are discussed in CRM training: semantic distortion, status differential, serial distortion, and information load.

Status differential frequently causes problems in communications in the military. Individuals with high rank may go unchallenged, even when they are evidently wrong. Lower-ranking individuals may be hesitant to speak up or they may withhold comments entirely. Status differential often results in the messages of junior crew members being unjustifiably rejected.[29] After CRM training, for example, Military Airlift Command C-5 crews have realized that the loadmasters (junior crew members) are one of the most underutilized resources on the aircraft.[30]

Critique

Aircrews must practice excellent skills in communication if they are to conduct thorough and meaningful critical analyses of their performance. They conduct these critiques at three points in their mission. The first occurs during premission planning. The second type of critique is the ongoing review conducted as part of the in-flight problem-solving process. The third occurs after the fact as a posimission debriefing of crew performance.

Critique is an area of CRM where Air Force pilot training is generally ahead of the civilian industry. The following guidelines for successful critique are widely used in the Air Force:

- Critique performance not the person; do not place blame.
- Be specific and provide suggestions.
- If it is not correctable, leave it alone.
- Critique should be well timed and tactful.
- Analyze both strengths and weaknesses.
- Be sincere with praise.
- Be open and honest; ask for feedback.
- Get everyone involved.[31]

Constructive critique results in better planning, promotes learning from past experiences, and keeps the channels of communication open. Critique should be emphasized because it is a useful tool for improving aircrew performance that is often overlooked or forgotten by flight crews.[32] Structuring critiques in standardized formats will enhance the completeness and accuracy of critiques.

Leadership, communications, situational awareness, problem solving, and critique are interdependent and complementary skills. It is difficult to be skilled in one of these areas without substantial skills in the other four. These related skills are essential to achieving the primary goal of cockpit resource management, namely, "improving the quality of crew coordination

and resource utilization."[33] The next chapter reviews some of the unique approaches that cockpit resource management programs have employed to train these skills.

Notes

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Chapter 3

Civilian Cockpit Resource Management Programs

Based on NASA's research many civilian airlines have developed CRM training programs to improve interpersonal skills, resource management, and aircrew coordination. The relatively new and evolving training techniques used by the civilian aviation industry can provide insights that may be helpful in developing similar training courses to improve aircrew coordination and resource utilization in the Air Force.

Training Methods and Media

Most of these programs include workshops that average three days of intensive study of CRM concepts. During these workshops, facilitators guide the participants through multimedia presentations and group exercises. Since the participants are experienced, professional pilots from a variety of backgrounds, the facilitators encourage them to share their insights and experiences. Learning takes place duringgroup exercises and seminar discussions.

Most workshops provide an overview of CRM training through textual materials, classroom lectures, and seminars. This introductory material develops a common language for discussing the principles and concepts of cockpit resource management. The workshops use a variety of media such as workbooks, audiocassettes, and sound-slide and videotape presentations. Some CRM programs send these course materials to students to complete before they arrive at the workshop. Many of the CRM training programs use questionnaires at the beginning and end of the course to measure changes in attitudes and to indicate the effectiveness of the training program. Feedback from these instruments can increase a crew member's awareness of his or her own cockpit behaviors and of how attitudes affect crew performance.

Most, if not all, CRM training programs rely on case studies as a primary training method. These courses use transcripts from cockpit voice recorders and official NTSB accident reports to analyze the causes of aircraft accidents. Accident re-creations on videotape and other media provide excellent opportunities for facilitators to emphasize CRM principles and create an awareness of what students should look for in the real world.

These videotapes can provide examples of effective and ineffective crew coordination that will stimulate discussion, motivate participation, and promote understanding of CRM concepts and principles.

Many of the group exercises identify effective leadership styles and improve communicative skills. Some of the most effective group exercises demonstrate synergistic problem solving and its effect on team performance. In these exercises, each student first works alone to solve a separate task out of a set of tasks assigned to the group. He or she then acts as a part of a small group to arrive at group solutions to the same set of tasks. The collective results of the individual solutions and the interactive group solution are compared. If the group score is higher than the sum of the individual scores, then the group has achieved synergy.

Many CRM workshops also use role-playing exercises to develop leadership and communication skills. Participants act out a scenario as members of a flight crew in positions for which they may or may not be qualified. None of the students know what is in the other crew members' scripts. The scenarios require the crew members to perform as a team in arriving at a solution. Such role-playing can be a cost-effective method of accomplishing training objectives that would otherwise be accomplished in expensive simulators. Successful role-playing requires tightly structured, realistic scenarios and very skilled facilitators to motivate participants to take the situation seriously.

In role-playing and other group exercises, much of the learning takes place during postactivity discussion and critique. Learning is enhanced when the activities are videotaped for replay during the critique. Group feedback, aided by videotape replays, helps individuals to see their own behaviors as they are seen by other crew members. Such differences between one's perception of self and the manner in which he or she is perceived by others are risky in most occupations, "but nowhere [are they] risider than in the cockpit."[1] Role-playing and similar group exercises provide a starting point for adopting more effective cockpit behaviors.

The most valuable tool for acquiring CRM skills in a military setting is mission-oriented simulator training (MOST) in high-fidelity simulators. MOST provides an opportunity for students to practice the skills they learned in the CRM workshop. These full-mission scenarios are designed to accurately replicate flight operations. The facilitator does not instruct during mission-oriented simulator training. He or she guides the scenario to ensure its realism and takes notes for the critique. The instructor introduces problems that the crew must solve. The crew members must live with the consequences of their decisions and actions until the mission ends; the simulator is not reset as in part-task training scenarios. A pan camera records the entire mission. The instructor marks portions of the tape that will enhance the postmission critique. The camera picks up nonverbal communications that would be missed by sound alone.

The postmission debriefings are a valuable part of the MOST learning experience. The instructor encourages crews to critique themselves first;

he or she will guide and aid in the critique as necessary. The replay of the videotape of the MOST exercise enhances the effectiveness of these postmission debriefings. The videotapes are erased after each critique to ensure that the students do not see the MOST exercises as a threat to their careers.

Mission-oriented simulator training and other training methods are common to many of the CRM programs in the private sector. However, each program has unique characteristics and features. In the rest of this chapter, I briefly review the approach to training taken by a representative sample of civilian CRM programs.

United Airlines

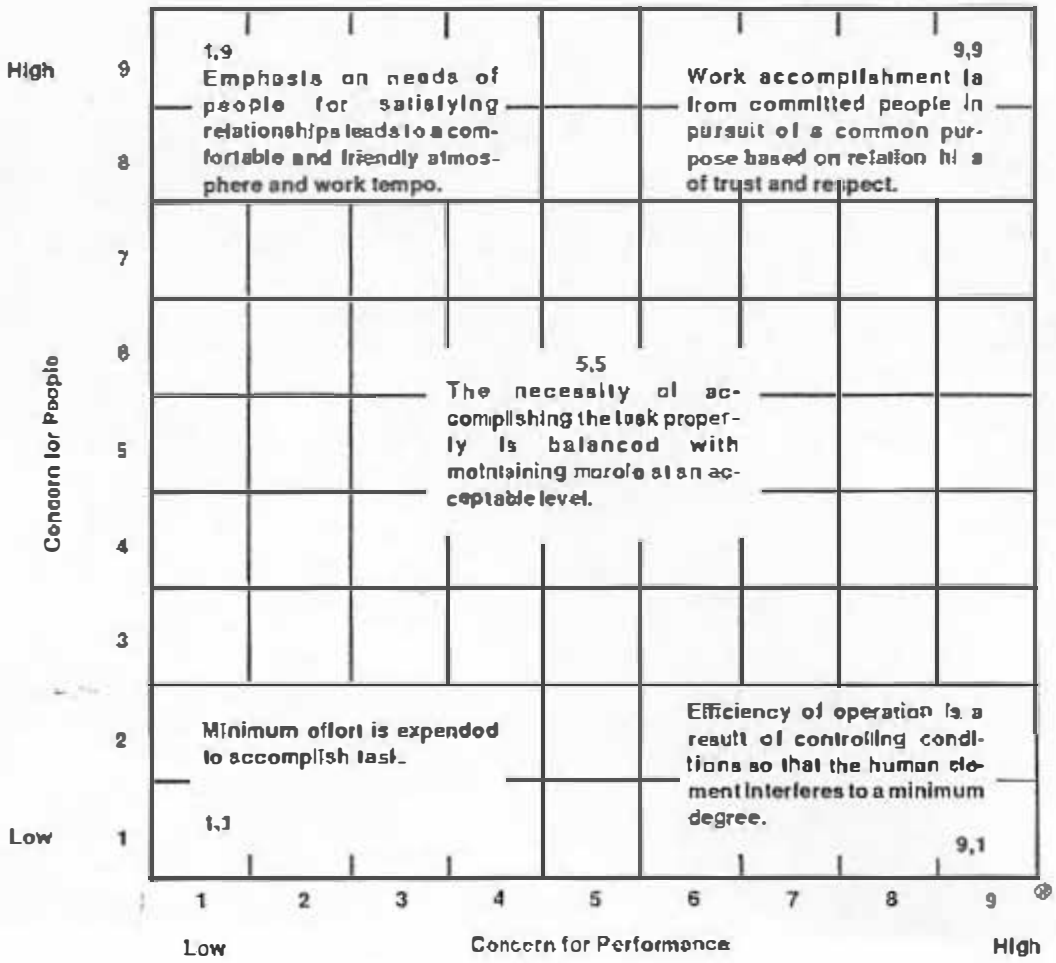
United Airlines implemented the first comprehensive program dedicated specifically to cockpit resource management training in 1979. United recognized the need to apply business management principles to the cockpit and entered a collaborative agreement with Scientific Methods, Incorporated, to develop a new training program. In 1982 United and Scientific Methods began a joint venture that offered a generic version of United's cockpit resource management training to the aviation industry.[2] United's CRM program includes home study, a workshop, and line-oriented flight training (LOFT)—the civilian equivalent of MOST.

Each participant receives a workbook as part of the home-study portion of the course. The home-study phase of the course introduces the students to the terminology and theory of team dynamics. They are expected to complete the workbooks before reporting for the start of the workshop. The intensive, three-day workshop includes seminar discussions, group exercises, role-playing exercises, and case studies. During the workshop "learning comes about from the structured experience contained in the training itself as opposed to listening to a trainer, psychologist, or other . . . expert lecturing from the front of a . . . classroom."[3]

A cornerstone of United's CRM program is the use of the Cockpit Resource Management Grid* developed by Scientific Methods.[4] This matrix (fig. 1) depicts five leadership styles. Participants in the workshop are divided into teams to work on group exercises, after which the team members critique one another on individual contributions to effective teamwork and leadership styles.[5] The critique is conducted in relationship to the five key elements of teamwork and effective leadership: inquiry, advocacy, conflict resolution, decision making, and critique.[6] This feedback from peers lets crew members compare their own behavior to the leadership styles depicted on the management grid.[7]

The workshop concludes training for those in the joint venture CRM program unless their parent organization has follow-on training. United crew members continue their CRM training during annual LOFT exercises

*Cockpit Resource Management Grid is a trademark of Scientific Methods, Inc.



Source: Robert R. Blake and Jane Srygley Mouton (Scientific Methods, Inc.) and Corporate Leadership/Resourcement Management Steering Committee and Working Groups (United Airlines), *Cockpit Resource Management* (Denver, Colorado: Austin, Texas: Cockpit Resource Management). Copyright © 1982, Page 15. Reproduced by permission.

Figure 1. Cockpit Resource Management Grid

conducted in state-of-the-art simulators. These annual exercises allow crew members to practice their skills under realistic conditions. Each annual LOFT mission covers only one of the subject areas—leadership style identification, communications, decision making, critique, or judgement. Thus, a United crew member will require five years to complete the entire CRM training program.[8]

The crew's performance during each LOFT mission is recorded on videotape. Portions of the videotape are replayed and the crew conducts a self-critique under the guidance of a well-trained instructor. The no-threat environment of the critique is enhanced by the fact that the tape is erased at the conclusion of each critique.[9]

Participants in the workshop are asked to fill out questionnaires that assess their attitudes about effective cockpit behavior. Their responses indicate that the workshop strengthens the participants' attitudes about effective behavior and that the participants develop a better understanding of their own behavior.[10]

People Express

People Express has included CRM as an integral part of its training since the airline began passenger service in 1981. The company implemented a new CRM program in 1986. It emphasizes practical methods which provide simple and effective tools for improving cockpit management and leadership.[11] The program consists of semiannual seminars, LOFT exercises in state-of-the-art simulators, and a new academic program authored by Robert W. Mudge of Cockpit Management Resources, Incorporated.[12]

The academic program consists of 12 study units, which begin with an overview of cockpit resource management, including the roles and responsibilities of crew members and the nature of command. The overview stresses the importance of positive attitudes and an open mind. The remainder of the course concentrates on 17 specific CRM elements. The program seeks to teach pilots to understand each element and its relationship to the whole, to recognize the presence of the element and its impact on flight operations, and to control these elements effectively.[13]

The self-study academic course consists of workbooks used interactively with audiocassette tapes. The workbooks contain text, self-evaluation flash cards, hands-on observation check sheets, discussion questions, and supplemental readings. The course materials include two audiotapes with a lecture and a panel discussion for each study unit.[14]

Each semiannual seminar consists of group discussions of the materials in two study units. Discussions are stimulated by viewing selected videotapes and conducting a detailed analysis of an NTSB accident report. Selected exercises and self-assessment instruments are included in certain study units such as the one on management style. People Express plans a LOFT mission following each workshop seminar. Given this semiannual cycle, a pilot will need three years to complete all 12 study units.[15]

SimuFlite Training International

SimuFlite Training International, based at the Dallas–Fort Worth Airport, developed FliteDeck Management (FDM) for training customers in CRM skills. Although this training is oriented towards corporate aviation, the company does some flight training for military units that fly similar aircraft. This course is a three-day interactive workshop. The three primary

methods of instruction are traditional lecture with videotape and slide presentations, seminars, and NTSB accident report study and analysis.[16]

The FDM workshop is offered as a stand-alone course, but many of the students continue in one of SimuFlite's flight programs where they have the opportunity to practice their FDM skills in the realistic cockpit environment of high-fidelity simulators. The last simulator mission in each of their flight programs is a videotaped LOFT scenario.

SimuFlite noted that the most successful pilots and flight crews shared critical attitudes and methods:

> 1. An intimate knowledge of [the] business.
>
> 2. An . . . embracing continual skepticism, a time-dependent situational awareness, and a conservative situational response.
>
> 3. The development and use of effective standard operating procedures.[17]

The SimuFlite course discusses the effect of eight "critical success elements" on these "critical success factors." The critical success elements are: policy and regulations, command authority, effective communication, planning, available resources, operating strategy, judgement and decision making, and work load performance.[18]

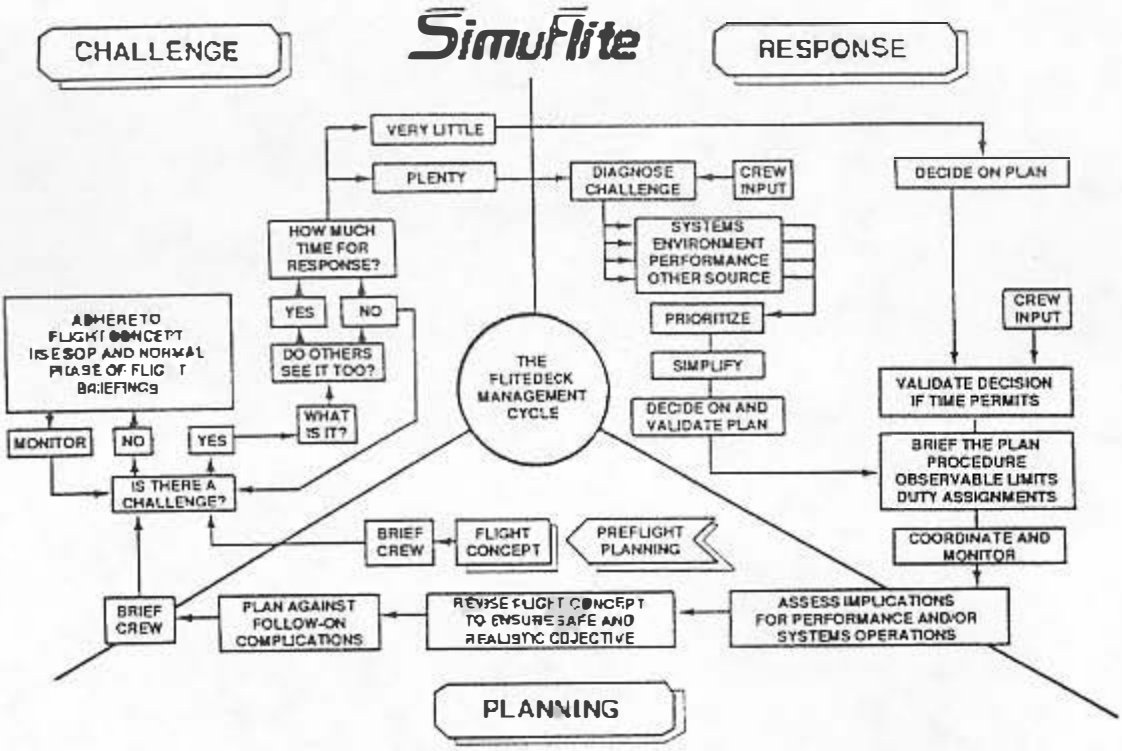
The unique feature of the SimuFlite program is the management cycle for planning. The SimuFlite FliteDeck Management Cycle is a systematically organized approach to aircrew problem solving (fig. 2).[19]

The planning cycle is set in motion after the pilot briefing, which describes the procedures to be used, sets observable limits, and includes specific duties for each crew member.[20] Replanning for contingencies and further briefings may be required. The cycle is completed as the crew begins monitoring events for new challenges.

FlightSafety International

FlightSafety International provides flight training for many customers, including the Air Force. The company has an extensive program for teaching cockpit resource management, called Cockpit Management Concepts (CMC). This program includes four elements: cockpit management courseware, line-oriented flight training, crew self-critique, and instructor critique. The course material may be presented in a two-and-a-half day Practical Cockpit Management Workshop or taught in four separate sections that allow the pilots more time to absorb what they learn. The instructional methods consist of group interaction in skill development exercises, role-playing, problem-solving exercises, and case studies of accidents.

The training focuses on situational awareness, defined as the "accurate perception of the factors and conditions that affect an aircraft and its flight crew during a defined period of time."[21] In more familiar terms, situational



Source: FliteDeck Management Seminar, A FliteDeck Management Skills Application WorkBook (Workbook used in part of FliteDeck Management Training course, 10–12 November 1988), SimuFlite Training International: Dallas-Ft Worth Airport, Texas, 01-2. Used with permission.

Figure 2. FliteDeck Management Cycle

awareness is thinking ahead of the aircraft. Crew situational awareness is not the sum total of the awareness of those in the crew, but is limited by that of the pilot in command.[22] Therefore, crew members must do everything possible to raise the aircraft commander's level of situational awareness. The aircraft commander also must recognize the contribution of other crew members and establish a cockpit environment where all crew members feel comfortable in voicing their concerns.[23]

FlightSafety has identified 10 clues to the loss of situational awareness:

- Ambiguity—Any time two or more sources of information do not agree. This can include instruments, gauges, people, manuals, senses, control positions that do not correspond with instrument indications, etc.
- Fixation or preoccupation—The focus of attention on any one item or event to the exclusion of all others. This may include any number of distractions that can draw attention away from the progress of the flight.
- Confusion—A sense of uncertainty, anxiety, or bafflement about a particular situation. This may be the result of falling behind the aircraft or lack of knowledge or experience.
- No one flying the aircraft—No one monitoring the current state or progress of the flight.

• No one looking out the window—Crew not performing visual lookout procedures.

• Use of an undocumented procedure—The use of a procedure (or procedures) that is not prescribed in approved flight manuals or checklists to deal with normal, abnormal, or emergency conditions.

• Violating minimums—Intentional or unintentional violation of (or intent to violate) defined minimum operating conditions or specifications, as prescribed by regulations or more restrictive flight operations manuals or directives. This includes weather conditions operating limitations, crew rest or duty limitations, approach minimums, and so forth.

• Unresolved discrepancy—Failure to resolve conflicts of opinion, information, changes in weather, or other conditions.

• Failure to meet targets—Failure of the flight or flight crew to attain and/or maintain identified targets. Targets include ETAs (estimated times of arrival), speeds, approach minimums, altitudes and headings, configuration requirements, plans, etc.

• Departure from standard operating procedure—Departure (or intent to depart) from prescribed standard operating procedure.[24]

CMC identifies five elements that contribute to situational awareness: experience and training, physical flying skills, spatial orientation, health and attitude, and cockpit management.[25] Cockpit management is the most neglected element in traditional pilot training. FlightSafety defines cockpit management as "the use and coordination of all the skills and resources available to the flight crew . . . the means by which a pilot might achieve and maintain situational awareness."[26]

The civilian CRM training programs I have described above parallel each other. I have highlighted some of the different approaches taken in a small sample of civilian CRM programs, but each one addresses the five critical elements of successful CRM training: leadership, interpersonal communications, situational awareness, problem solving, and critique. A more complete list and rank ordering of the most effective instructional methods and training media used by CRM programs appears in a study conducted by Capt T. L. Sams of American Airlines (appendix A).[27] The next chapter reviews Air Force adaptations of CRM training and highlights some of the differences in operational environments that must be considered in military applications.

Notes

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16. *FliteDeck Management Seminar: A FliteDeck Management Skills Application Workbook* (text for FliteDeck Management Training course, SimulFlite Training International, Dallas–Fort Worth Airport, 10–12 November 1988), 01-2.

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Chapter 4

Air Force Applications

The research that led to the development of cockpit resource management training programs sought to find the underlying causes of human error by flight crews. Data from civil aviation was easier to obtain because cockpit voice recorders in civilian cockpits provided a source of information not available in Air Force aircraft, and public access to information about Air Force air crashes is restricted. Even though the data is derived primarily from civilian sources, the basic elements of CRM training should apply equally well to military aircrews. The technical flying skills and general cockpit behaviors required of both airline and Air Force aircrews are similar despite differences in their missions and in the composition of the aircrews. These differences probably make CRM training more imperative for military aircrews. After comparing and contrasting civilian and Air Force aircrews, I conclude this chapter with a review of current Air Force applications of CRM training.

Operational Differences

Civilian air carriers have one mission, to carry passengers and air freight from one location to another. Civilian flights are generally routine flights in familiar areas and all ground requirements are handled by specialized company personnel.[1] In contrast, Air Force crews fly a variety of complex missions: tactical airlift, gunship, bombing, aerial refueling, reconnaissance, special operations, airdrop, and search and rescue among others. And they use many tactics to accomplish these missions, including high- and low-altitude deliveries and formation flying. Furthermore, Air Force aircrews must be prepared to deploy worldwide at a moment's notice to unfamiliar locations where ground support may not exist. Finally, Air Force aircraft commanders are responsible for many more activities than their civilian counterparts, such as mission planning, weight and balance, filing of flight plans, preflight checks, ground servicing, and cargo loading.[2]

In addition, the rank structure in the military can complicate relationships in the cockpit. Differences in rank can restrict voluntary communications, especially between a junior enlisted crew member and a senior officer. In some instances, "old head" senior noncommissioned officers may attempt to dominate a junior aircraft commander. Problems also arise when the aircraft commander is junior in rank to other crew members.[3]

Likewise, the Air Force aircraft commander must cope with formal bans on fraternization between officer and enlisted members of the aircrew. The normal Strategic Air Command tanker crew has one enlisted crew member, a boom operator. Aircrews of MAC's large transport aircraft usually have at least two enlisted crew members, a flight engineer and a loadmaster; they may have two or more of each. Aircraft commanders work closely with enlisted crew members on a daily basis and bear responsibility for their behavior even during off-duty periods. Officers must be sensitive to the needs and feelings of enlisted crew members and attempt to remove barriers to communications. The active participation of all crew members—officer and enlisted—is essential for optimum crew performance.[4]

This officer-enlisted relationship requires formality in the military cockpit. Hence, crew position titles—pilot, copilot, engineer, load—are used instead of first names. Increased discipline and formality are necessary when using interphone systems for communications, as required on Air Force tanker-transport aircraft because of high noise levels and remote crew member workstations. In airline cockpits where noise levels are low, crew members can use voice communications.[5]

To compound the situation even more, Air Force pilots on the average have less experience in the cockpit than their civilian counterparts. The typical Air Force pilot enters undergraduate pilot training with 40 hours' flying time and the typical aircraft commander will average approximately five years of service and 2,000–3,500 flying hours. The average airline "new hires" have 1,500–2,000 flying hours. By the time they upgrade to captain, they will have 10–15 years with the company and a total of 7,000–10,000 flying hours. This difference is compounded by the higher turnover rate in the Air Force. At the 8- to 11-year point approximately one half of the Air Force pilots resign, many of them to begin airline careers. In contrast, airline pilots may spend 30 years' flying for the same company.[6]

Air Force CRM Training Programs

Rank structure, social barriers, a lesser experience level, and the added complexities of the military mission combine to make aircrew coordination more difficult in Air Force cockpits. These operational differences between the civilian and military environments provide additional justification for providing Air Force crews with cockpit resource management training. CRM training will provide increased margins for flight safety in both civilian aviation and the Air Force. In addition, CRM has tremendous potential for increasing mission effectiveness of Air Force flight crews.

C-5 Aircrew Training System

Impressed by the favorable responses to the United Airlines CRM program, the Air Force required that CRM be included as part of the contractor-operated Aircrew Training System (ATS) purchased from United

Airlines Services Corporation for training C-5 crew members.[7] The CRM portion of the ATS is called aircrew coordination training (ACT). The implementation of ACT has recently been taken over by FlightSafety International. The stated purpose of this course is "to develop skills in interpersonal communication, situational awareness, and team leadership" and to "motivate the participants to incorporate crew coordination concepts and principles into their own operational environment."[8] Each class consists of 12–24 C-5 aircrew members—pilots, flight engineers, and loadmasters—who have completed initial qualification and are undergoing mission qualification.[9]

The ACT program begins with a precourse workbook that presents ACT concepts and principles and introduces the terminology used in subsequent discussions. Students then attend a two-day ACT workshop that consists of interactive lectures, group discussions, and group exercises. The group discussions are stimulated by showing videotapes that illustrate positive and negative examples of aircrew coordination based on actual flight incidents or accidents.[10] The effectiveness of the workshop depends on the ability of the instructor or facilitator to encourage open participation and discussion. Group discussions rely heavily on the sharing of experiences and expertise among the participants. In addition to the workshop, aircrew members must complete four specific scenarios in mission-oriented simulator training (MOST) each year.

The MOST mission in the C-5 simulator includes a two-hour prebrief, four hours in the simulator, and a one-hour critique. MOST scenarios are similar to civilian LOFT scenarios, except they simulate the military mission. The crew's actions during the four hours in the simulator are recorded on videotape. The instructor plays back portions of the videotape during the postmission critique, encouraging crew self-critique and emphasizing the principles of crew coordination.

1550th Combat Crew Training Wing

In September 1985 MAC's 1550th Combat Crew Training Wing (CCTW) at Kirtland AFB, New Mexico, developed one of the first cockpit resource management programs in the Air Force. The wing is responsible for initial qualification and refresher training for C-130 and heavy-lift helicopter aircrews. On the first day of initial ACT qualification, crews at the 1550th CCTW receive eight hours of academics, followed on the second day by a MOST mission. Annual recurrent training consists of a two-hour academic refresher course followed by a MOST mission.[11]

The academics include an introduction, group exercise, group discussions, and slide and videotape presentations of airline crashes. Discussions center around five key elements of crew coordination: inquiry, advocacy, conflict resolution, decision making, and critique. The course also stresses communications, leadership, and followership.[12]

The MOST mission is videotaped and portions are replayed during critique. MOST allows crew members to put their new knowledge to practice in a cockpit environment. Scenaitos are made as real as possible, with the instructor acting as an observer and taking notes to facilitate the postmission critique. Crews debrief themselves on the five elements of crew coordination and assess their own leadership styles.[13]

349th Military Airlift Wing

The 349th Military Airlift Wing (MAW), Travis AFB, California, is a C-5 reserve unit. The wing developed its own CRM program, called aircrew resource management (ARM), to emphasize the use of all resources and crew members, specifically the loadmasters—whose duty stations are not located in the cockpit. The crew on a C-5 may number seven but can grow to as many as 22.[14]

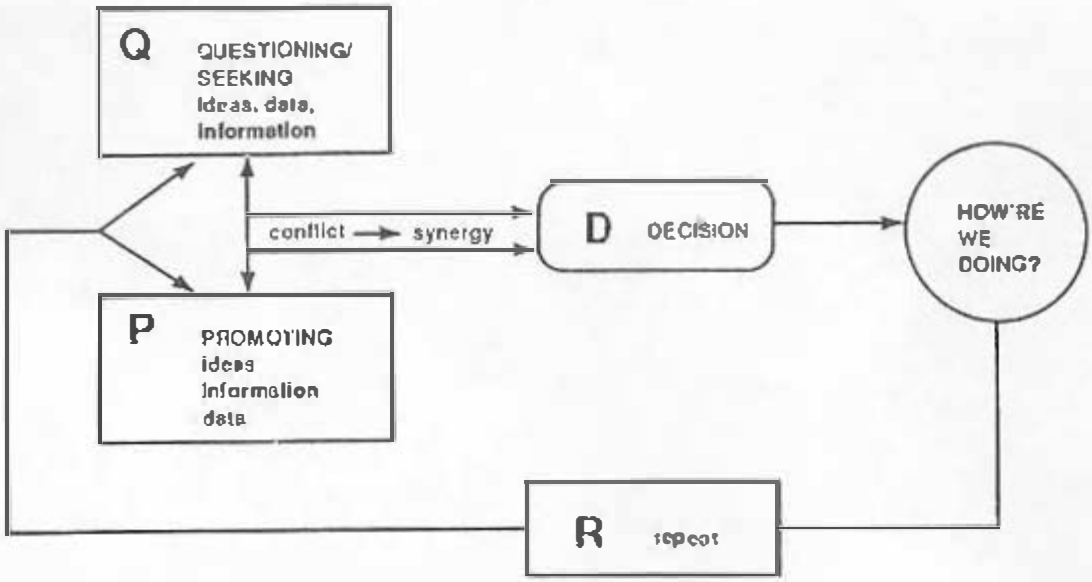
The ARM course begins with a nine-hour seminar for a typical C-5 crew, consisting of three pilots, three flight engineers, and four loadmasters. ARM emphasizes synergy: crew performance as a group is superior to the sum of the performances of each crew member taken independently. The first two objectives of the course are developing an understanding of synergy and learning a common language fordiscussing associated principles. The third objective, considered the heart of the program, involves learning and using the synergy formula (fig. 3) as a practical tool for effective problem solving and decision making in the aircraft.[15]

The process of seeking and promoting ideas often results in conflicts of opinion among crew members. As Lt Col Conrad Biegalski states, "In the act of working out the conflicts through a purification and refinement of data, the pilot-in-command is able to make a synergistic decision, one based on more data than was previously available to any single individual on the airplane."[16]

Before learning the formula, crews discuss communication skills, barriers to effective communications, and behavioral characteristics of individuals in a group problem-solving situation. The formula is then presented on three-by-five cards that crews may carry on the aircraft as a reference.[17] Role-playing exercises aim at having the students internalize the formula and develop skill in using it.

One of the unique features of the ARM seminar is the videotaping and replaying of the role-playing exercises. The objective is the same as videotaping of LOFT sessions in the simulator. The videotape role-play is accomplished by using chairs and a common bathroom plunger (simulated control column) in a classroom to simulate a cockpit. The students play roles as members of an aircrew in a strictly controlled scenario that introduces conflicts the crew must resolve. The videotape replay allows crews to observe and analyze the decision-making process and allows the seminar facilitators to provide better personal feedback.[18]

The Synergy Formula
(expanded)



Q stands for questioning, seeking, and searching for information, data, and ideas.

P stands for promoting, or advocating the information, data, ideas, needs, requirements, etc., which each member of the crew possesses.

D is the decision.

"How're We Doing" is a reminder to conduct an "immediate and ongoing in-flight review" of the problem solution.

R is a reminder to "repeat this process as many times as necessary."

Source: Maj John Y. Halliday, Lt Col Conrad S. Biegalski, and Maj Anthony Inzana, "CRM Training in the 349th Military Airlift Wing," *Cockpit Resource Management Training: Proceedings of a NASA-MAC Workshop*, ed. Henry W. Orlady and H. Clayton Foushee, conference publication 2455 (Moffett Field, Calif.: NASA, Ames Research Center, 1987), 152.

Figure 3. Synergy Formula

Time-limited group exercises are used during the seminar to emphasize the concept of synergy. The exercises are supported by case studies and role-playing. The seminar is followed and reinforced by mission-oriented simulator training.[19]

Surveys conducted by the 349th MAW indicate that "students developed a highly receptive and improving attitude toward the seminar format" in the areas emphasized.[20] When crew members who had not received the ARM training were asked if crew coordination had been improved, "80 percent of those untrained individuals felt they had observed better coordination and flight-deck atmosphere from those crewmembers who had undergone training."[21] The members of the 349th MAW credit much of their success to promotion of ARM goals by the entire unit, from the creation of an ARM staff that reports directly to the commander on the use of an ARM critique guide to debrief missions.

Military Airlift Command

The Military Airlift Command cosponsored the NASA-MAC conference on cockpit resource management in San Francisco, 6-8 May 1986.[22] Much of the material reported here first appeared in the proceedings of that conference. Subsequently, Headquarters Military Airlift Command published "Aircrew Coordination Training, A Military Airlift Command Workshop on Human Resource Management in the Aircraft," as a guide for developing standardized aircrew coordination training workshops at each MAC training unit.[23] This manual contains lesson outlines, reference materials, and suggested methods of instruction.

Aircrew coordination training includes the same elements found in most CRM courses: communications, situational awareness, leadership and followership, decision making, and mission analysis. The suggested methods of instruction include prework (self-study), group exercises, workshop seminars, tutoring, structured peer pressure, and mission-oriented simulator training. Each unit is encouraged to tailor the presentation of course materials as appropriate for their type of aircraft, mission, time, and facilities.[24]

Strategic Air Command

The Strategic Air Command (SAC) is currently in the process of contracting with a civilian firm to develop and implement cockpit resource management training for all of the command's weapon systems. SAC recognizes that its training is oriented towards technical knowledge and that training deficiencies exist in intracrew communications, situational awareness, team leadership and followership, problem solving, and decision making. The contracted CRM training will enhance aircrew coordination by correcting these deficiencies.[25]

The Air Force is already realizing the benefits to be gained from training its aircrews in the skills of cockpit resource management. Specialized undergraduate pilot training (SUPT) will allow the Air Training Command to provide the foundation for follow-on CRM training by the major commands. Two major commands, SAC and MAC, already have initiated CRM

training for their crews. The next chapter provides guidelines for implementing CRM training during SUPT.

Notes

1. Dale R. Cavanagh and Kenneth R. Williams, "The Application of CRM Training to Military Operations," in *Cockpit Resource Management Training: Proceedings of a NASA/MAC Workshop*, ed. Harry W. Orlady and H. Clayton Foushee, conference publication 2455 (Moffett Field, Calif.: NASA, Ames Research Center, 1987), 137.
2. Ibid.
3. Ibid., 136.
4. Ibid., 137.
5. Ibid., 138
6. Ibid., 138-39.
7. Ibid., 135.
8. *C-5 Aircrew Training System: Aircrew Coordination Training Workshop Student Guide* (Lakewood, Colo.: United Airlines Services Corp., 1987), 3.
9. Ibid., 4.
10. Ibid.
11. Capt Michael T. Fiedler, "CRM Training In the 1550th Combat Crew Training Wing," in Orlady and Foushee, 145.
12. Ibid.
13. Ibid., 146-47.
14. Maj John T. Halliday, Lt Col Conrad S. Blegelski, and Maj Anthony Inzana, "CRM Training in the 349th Military Airlift Wing," in Orlady and Foushee, 148.
15. Ibid., 149.
16. Ibid., 153.
17. Ibid., 151.
18. Ibid., 149.
19. Ibid.
20. Ibid., 155.
21. Ibid.
22. Orlady and Foushee, iv.
23. Lt Col Richard Moody et al., *Aircrew Coordination Training: A Military Airlift Command (MAC) Workshop on Human Resource Management in the Aircraft* (Scott AFB, Ill.: Headquarters Military Airlift Command, 1 May 1987), 1.
24. Ibid., 1-6.
25. Maj Jimmy C. Crook, *Cockpit Resource Management Statement of Work* (Offutt AFB, Nebr.: Headquarters Strategic Air Command [HQ SAC/DOTPI], 17 April 1989).

Chapter 5

Implementing Cockpit Resource Management Training in Specialized Undergraduate Pilot Training

In this study I show that civilian and military cockpit resource management training enhances aircrew coordination. Chapter 1 documents poor aircrew coordination as the major cause of aircraft accidents and identifies deficiencies in traditional pilot training that contribute to this lack of aircrew coordination. Chapter 2 describes cockpit resource management as a program for enhancing the many skills required for effective aircrew coordination. In chapters 3 and 4, I review training methods used in existing civilian and Air Force CRM programs. In this chapter, I summarize the steps the Air Training Command will need to take to initiate CRM training during specialized undergraduate pilot training. I then make program-specific recommendations for implementing cockpit resource management training in SUPT.

Organizational Support

Prof J. Richard Hackman of Harvard University observed that for the cockpit team to be successful, crew members must expand the team concept to include anyone in the organization who can affect the safety and efficiency of their flight.[1] Implementing a successful CRM training program in Air Training Command will require support at every level of the command, from the senior staff to squadron instructors.

For CRM training to produce lasting behavioral change, the attitudes developed through CRM training must be supported throughout the command by training, material resources, policies, and regulations. Air Training Command should "reinforce the view that crewmembers are responsible as a team for the safe conduct of a flight" by adjusting policies and regulations to reward effective crew performance as well as individual performance.[2] The implementation of the CRM training program should begin by "helping those who have authority and responsibility for the design, management, and regulation of crews learn how to create perfor-

mance environments that will actively support the kinds of behaviors and attitudes that are taught in CRM courses.[3]

Air Training Command should conduct briefings for its personnel to increase their awareness of CRM and how their support will contribute to the success of the program. The briefings should define CRM, provide an overview of CRM concepts, and outline the planned ATC cockpit resource management training program. Seminars may be used in conjunction with the CRM awareness briefings as an introductory program for designated staff personnel.

The next critical step is to train evaluators and instructors. Their critiques and in-flight evaluations of actual aircrew performance can make or break the program. Instructors and evaluators must receive intensive CRM training above and beyond that given to other crew members to develop the judgement to identify individual and crew problems correctly.

The next consideration is to ensure that student pilots understand and support the purpose and goals of cockpit resource management training. The concepts must be presented in terms familiar to the students, not in the jargon of the psychologist or educator in academia. Student background and experience, or lack thereof, should be considered in selecting training methods and media that will keep interest and motivation high. Appendix B outlines recommended phases for ATC's cockpit resource management training.

Training Integration

Most aircrew training programs teach cockpit resource management through three-day workshops followed by recurring semiannual or annual LOFT or MOST simulations. Workshops are economical when pilots must take time out from normal duties for training, especially if they have to travel to training locations. However, these workshops limit the time available for students to absorb and internalize what they have learned.

The Air Training Command, by totally integrating cockpit resource management with other training requirements during SUPT, can present CRM training in one- to two-hour blocks spread over several weeks rather than compressing it into a three-day workshop. This approach will give student pilots more time to internalize CRM concepts and skills. Integrating CRM training during SUPT, combined with the follow-on training pilots will receive in the MAJCOMs, will create a total training program that will reinforce CRM skills throughout a pilot's career.

In addition, the Air Training Command needs to integrate the emerging technologies of computer-based instruction and interactive videos into its CRM programs. Interactive video presentations can be easily integrated with existing training and will permit students to progress at their own rate. Interactive video allows students to choose among alternative courses of action and then see the consequences of their decisions played back on

video. These media will allow students to interact in realistic problem-solving scenarios and provide feedback on the effectiveness of their actions. This new technology can provide the advantages of interaction in a self-paced training environment and does not require a highly trained facilitator. Interactive video may be a particularly effective substitute for workshops when the experience level of the students is very low, as during SUPT.

Tanker-Transport Track

The current, single-track undergraduate pilot training (UPT) program utilizes a fighter-type aircraft, the T-38, for all advanced pilot training. However, because the T-38 airframe has "inherent design limitations, the present training . . . does not address many of the specific needs of the approximately 60 percent majority [of the UPT cadets] bound for multicrew, multiengine aircraft."[4] To correct this shortcoming, implementation of SUPT includes the acquisition of a tanker-transport training system (TTTS) aircraft. It will be a commercially available business jet modified to meet the operational training requirements of the tanker-transport track.[5] As Lt Gen John A. Shaud said, "The Tanker Transport Training System will permit ATC to train crew leadership in a multiengine aircraft system for the first time since we retired the World War II vintage B-25 in 1959."[6] He also noted that

> through the years, ATC has prepared aspiring aviators to make the most of their individual talents and skills. As we move into a new era in pilot training with the TTTS, we continue that process of refinement. This time, it means renewed emphasis on aviation's equivalent of team play—aircrew coordination.[7]

The TTTS aircraft and simulators will provide tanker-transport pilots with opportunities for advanced CRM skill development. Two student pilots will be flying with one instructor in the TTTS aircraft and simulator, which will require aircrew coordination as an integral part of every training sortie. Since an instructor will be at one set of controls most of the time, the students should have specific crew coordination duties that they must perform from the "jump seat." These duties should include reading checklists, clearing for conflicting traffic, aiding in situational awareness, and possibly operating radios. Although they should leave the teaching to the instructors, students should be encouraged to assert themselves if they see an unsafe situation developing. Student pilots in the tanker-transport track should practice CRM skills during planning, execution, and critique of simulator and aircraft missions.

Tanker-transport instructors should have prior experience flying tanker-transport aircraft. The Air Training Command's pilot instructor training (PIT) for tanker-transport track instructors should include a comprehensive CRM training program. Until ATC develops sufficient CRM expertise within

the command, instructors should attend a civilian-contracted CRM seminar or complete one of the MAC or SAC instructor courses.

The tanker-transport advanced track of SUPT should include a fully integrated, comprehensive course in cockpit resource management. In this paper I have provided the background information for developing and implementing such a course. Appendix C is a list of training tasks that should form the basis of a SUPT cockpit resource management training program.

Bomber-Fighter Track

As noted earlier, the design limitations of the T-38, which will provide training in the fighter-bomber track, do not afford the same opportunities as the TTTS aircraft for developing CRM skills. Nevertheless, pilots in the fighter-bomber track would benefit from a limited CRM program tailored to their needs. Leadership, communications, situational awareness, problem solving, and critique are important skills for all pilots.

The need for aircrew coordination training in multicrew aircraft is obvious. Because the B-52, as well as the B-1 and B-2, requires multiseat crews and because the crews on these aircraft fly complex missions, bomber pilots have even more to gain from CRM training than tanker-transport pilots. Moreover, since the increasingly complex nature of the enemy threat environment requires that fighters perform as teams in combating those threats, even single-seat fighter pilots have much to gain from CRM training. CRM training improves team performance. Skills in leadership, situational awareness, problem solving, interpersonal communications, and critique are as important, "with some modifications, to the pilots manning a flight of Tactical Air Command A-7's as it is to the pilots, flight engineers, and loadmasters crewing a C-5."[8]

An off-the-shelf version of a CRM training program is not recommended for pilots of single-seat aircraft. However, many of the training objectives should be modified and tailored to meet the unique requirements of those pilots. The fighter-bomber track should include a block of academic instruction on the basic elements of cockpit resource management. Training requirements for this course may be developed from a subset of the tanker-transport course. The content should be tailored to the specific bomber and fighter missions.

Undergraduate Navigator Training

Improving aircrew coordination requires enhancing the skills of all crew members. Air Training Command provides initial crew training to both pilots and navigators and, therefore, should provide cockpit resource management training in undergraduate navigator training (UNT) as well as

SUPT. Both the existing Military Airlift Command cockpit resource management training and the CRM program being developed for Strategic Air Command train navigators. Air Training Command can better meet the needs of the MAJCOMs by integrating CRM training into UNT curriculum.

Summary of Recommendations

Cockpit resource management training is an effective new approach to enhancing aircrew coordination, thus increasing the safety and mission effectiveness of Air Force flight crews. SUPT should include cockpit resource management training as a foundation on which the major commands can build according to their needs. CRM includes many training objectives that are valuable to tanker-transport pilots and all other aircrew members. In sum,

1. The advanced tanker-transport track of SUPT should include a fully integrated, comprehensive course in cockpit resource management.
2. The fighter-bomber track should include instruction in the basic elements of cockpit resource management.
3. Air Training Command should ensure that all ATC staff personnel receive briefings to increase their awareness of CRM and how their support contributes to the success of the program.
4. Instructors and evaluators should receive intensive CRM training above and beyond that given to other crew members, to develop the judgement to identify individual and crew problems correctly.
5. Air Training Command should review undergraduate navigator training for the feasibility of integrating CRM training objectives into the curriculum.

Notes

1. J. Richard Hackman, "Group-Level Issues in the Design and Training of Cockpit Crews," in *Cockpit Resource Management Training: Proceedings of a NASA/MAC Workshop*, ed. Harry W. Orlady and H. Clayton Foushee, conference publication 2455 (Moffett Field, Calif.: NASA, Ames Research Center, 1987), 23.
2. Ibid., 36.
3. Ibid., 38.
4. *Department of Defense 1989 Trainer Aircraft Masterplan* (Randolph AFB, Tex.: Headquarters Air Training Command, Directorate of Requirements, 1989), 8.
5. Ibid., 23.
6. Lt Gen John A. Shaud, "New Focus on Aircrew Coordination," *Flying Safety*, March 1988, 2.
7. Ibid.
8. Dale R. Cavanagh and Kenneth R. Williams, "The Application of CRM Training to Military Operations," in Orlady and Foushee, 135.

Appendix A

Appropriate Cockpit Resource Management Instructional Methods

Rank Order:

1. Line-oriented flight training (LOFT) and critique
2. Seminars based on CRM case studies
3. Increasing the Check Airman's role in promoting CRM
4. Giving individual or crew recognition for excellence in CRM
5. Interactive audiovisual tutorials
6. Instructor/Check Airman conferences
7. Contract training using CRM specialists
8. Classroom presentations and lectures
9. Emphasizing CRM through in-house media and publicity programs
10. Crew member conferences
11. Role-playing and game-based simulations
12. Distributing CRM hand-out materials
13. Interdepartmental visitations
14. Traditional slide/tape/video carrels
15. Home-study programs
16. Commercial correspondence course

Source: T. L. Sanz, "Cockpit Resource Management Concepts and Training Strategies: Developing an Analysis of Training Needs," in Proceedings, of the Fourth International Symposium on Aviation Psychology, ed. R. S. Jensen (Columbus, Ohio: Ohio State University, Department of Aviation, 27-30 April 1987), 384-87.

Appropriate Cockpit Resource Management Training Media

Rank Order:

1. Full-motion simulator
2. Video replay of flight simulator sessions
3. Video reenactments of CRM accidents/incidents
4. Reports: accident, incident, and ASRS
5. Nonmotion simulator
6. Company communications
7. Lectures, briefings, and guest speakers
8. NASA Publications ("Callback," etc.)
9. Videocassette instructional tapes
10. "Flight Safety Foundation Bulletins"
11. Computer terminals (PLATO, etc.)
12. Videotaped interviews with CRM experts
13. Slide-tape presentations and reenactments
14. Journal and periodical articles on CRM
15. Random access media presentation
16. Cockpit procedures trainer
17. Laser-disc systems
18. Actual aircraft training
19. Programmed instruction workbooks
20. Audio tape review material
21. Cockpit mock-up

Appendix B

Application of Training Techniques

Techniques	*Phase 1*	*Phase 2*	*Phase 3*
Attitude inventory	x	x	
Homestudy	x	x	
Guided observation	x	x	
Individualized prework	x	x	
Classroom instruction	x	x	
Interpersonalindices	x		x
Workshop/seminar	x	x	x
Case studies	x	x	x
Group exercises	x	x	x
Situational leadership	x	x	x
Panels		x	
Role-playing		x	x
Continuing training		x	x
Structured peer pressure			x
Part task training			x
Evaluation critique			x
LOFT/MOST			x

Phase 1: Introduction/motivation
Phase 2: Transmission of knowledge
Phase 3: Skill acquisition

Source: Adapted from Cockpit Resource Management Training: Proceedings of a NASA/MAC Workshop, 6-8 May 1986, ed. Harry W. Orlady and H. Clayton Foushee, conference publication 2455 (Moffett Field, Calif.: NASA Ames Research Center, 1987).

Appendix C

Specialized Undergraduate Pilot Training—Aircrew Coordination Training

Master Task Listing

I. Comprehend the impact of leadership on crew coordination.

A. Identify differences in leadership styles.

1. Cite examples of high concern for performance, low concern for people.
2. Cite examples of low concern for performance, low concern for people.
3. Cite examples of high concern for people, low concern for performance.
4. Cite examples of high concern for people, high concern for performance.

B. Identify behavioral characteristics of effective leadership.

C. Identify characteristics of your leadership style.

D. Comprehend the concept of "assertiveness balance."

1. State the impact of assertiveness on crew coordination.
2. Cite examples of poor assertive behavior.

E. Understand the concept of "team leadership."

1. Define the statutory authority of command.
2. Define and cite examples of designated leadership roles.
3. Define and cite examples of designated followership roles.
4. Define and cite examples of functional leadership roles.
5. Define and cite examples of functional followership roles.

II. Comprehend the effect of communications on crew coordination.

A. Define interpersonal communications.

1. Cite examples of verbal and nonverbal communications.
2. Identify responsibilities of senders and receivers.

B. Understand the effect on the message sender of the behavioral response by the message receiver.

1. Define and cite examples of confirmation.
2. Define and cite examples of rejection.
3. Define and cite examples of disconfirmation.

C. Identify barriers to effective communications.

1. Define and cite examples of semantic distortion.
2. Define and cite examples of status differential.
3. Define and cite examples of serial distortion.
4. Define and cite examples of information overload.
5. Define and cite examples of information underload.

D. Identify methods for overcoming barriers to communication.

1. Define and cite examples of effective listening.
2. Define and cite examples of constructive feedback.

III. Comprehend the relationship between situational awareness and crew coordination.

A. Explain the concept of situational awareness and its effect on aircrew performance.

1. Understand the effect of individual perceptions and reality on situational awareness.
2. Explain the relationship between individual and crew situational awareness.
3. Identify and assess environmental and situational conditions affecting situational awareness.

B. Recognize individual behaviors that degrade situational awareness.

1. State the effects of task overload on situational awareness.
2. State the effects of boredom on situational awareness.
3. State the effects of complacency on situational awareness.
4. State the effects of uncertainty on situational awareness.
5. State the effects of frustration and anger on situational awareness.
6. State the effects of fatigue and stress on situational awareness.
7. State the effects of cockpit distractions on situational awareness.

C. Recognize group behaviors that degrade situational awareness.

1. Explain and cite examples of the crew tendency to "press on regardless."
2. Explain and cite examples of the concept of "group think."
3. Explain and cite examples of the group behavior expressed by "not playing with a full deck."
4. Explain and cite examples of group behavior expressed as "too much too soon, too little too late."

IV. Identify techniques for improving mission preparation through effective crew coordination.

A. State the impact of thorough versus incomplete premission planning.

B. Identify elements of an effective aircrew briefing.

C. Identify and state the effect of effective premission critique.

V. Identify methods of effective resource management.

A. Identify all available resources and state their impact on aircrew performance.

B. State the impact of task overload on crew coordination.

C. State the impact of task underload on crew coordination.

D. Cite examples of the benefits of delegating responsibility.

E. State the impact of prioritizing tasks on crew coordination.

F. State the impact of situational awareness on resource management.

G. Identify techniques of effective monitoring of all aspects of aircraft and aircrew performance.

H. State the benefits of ongoing mission critique.

VI. Apply an effective problem-solving process.

A. State the effects of inquiry on the problem-solving process.

B. State the effects of advocacy on the problem-solving process.

C. Explain the impact of conflict resolution on the problem-solving process.

1. Describe the concept of *synergy* and its impact on the problem-solving process.

D. Describe the decision-making responsibilities of each crew member.

1. Comprehend the concept of judgement as "experience applied."

E. State the benefits of review and critique of the problem-solving and decision-making process.

Glossary

Advocacy—Obligation to speak out in support of an alternate course of action, and after a decision is made and accepted, to remain vigilant thereafter.

Confirmation—Acknowledging and accepting a message and its sender.

Conflict—An interpersonal event that arises when individual or group needs and goals are incompatible or when the parties perceive themselves in a win-or-lose situation.

Constructive feedback—A descriptive, specific, well-timed response that focuses on modifiable behavior, promotes openness and trust, and clarifies communications.

Decision making—The process of selecting a course of action from available options, based on information available at the time.

Designated leader or follower—The leader or follower established by tradition, social order, or appointment.

Disconfirmation—Ignoring the sender and the message entirely.

Discretionary behavior—That behavior and activity for which specific procedures are not established in existing regulations, directives, and technical publications.

Effective listening—Listening for the real substance of a message. You listen critically to hear what is said, and you listen creatively to hear what is meant, but not said.

Feedback—Response messages that clarify and ensure that meaning is transferred.

Functional follower—The person who defers to the person who has the most information or knowledge in a particular situation.

Functional leader—The person in charge as defined by the moment and the situation; the person who, momentarily and temporarily, has the most information or knowledge about the current situation.

Human factors—Any combination of human attributes, characteristics, or limitations that in any way affects the crew, airplane, environment, mission, and/or management relationship.

Information overload—A condition where too much information is available.

Information underload—A condition where too little information is available.

Inquiry—Questioning and investigating your perception of the current situation or what other crew members are doing; seeking information you do not have; concern for "what" is right, not "who" is right.

Operationally relevant communications—Those task-oriented interpersonal communications that are directly involved and related to command, control, and flight accomplishment.

Rejection—Acknowledging and accepting the sender of a message, but not its content.

Self-concept—The mental image you have of yourself; how people see themselves and their situation.

Self-esteem—Confidence and satisfaction with yourself.

Semantic distortion—A condition that occurs when either or both the speaker and the listener assume they understand what was said.

Serial distortion—A condition that occurs when the intended meaning of a message is changed as the message passes from person to person.

Situational awareness—A realization of what is going on at the moment in relation to what has gone on in the past and what may go on in the immediate future.

Status differential—A perception that your rating or position is unequal to the rating or position of other persons in a social order, class, or profession.

Synergy—The total performance of a crew working together is greater than the sum of the performances of all of the crew members working independently.

Team leadership—The distribution of influence in a particular situation between the leader and the followers in order to reach specific goals.

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