Journal of Aviation/Aerospace Education & Research

Volume 5
Number 2 *JAAER Winter 1995*

Article 2

Winter 1995

Cockpit Resource Management Training: Are Current Instructional Methods Likely to be Successful?

Gerald N. Cook

COCKPIT RESOURCE MANAGEMENT TRAINING: ARE CURRENT INSTRUCTIONAL METHODS LIKELY TO BE SUCCESSFUL?

Gerald N. Cook

Editor's Note: This article originally appeared in the Spring 1991 issue. It is reprinted due to its continuing value and timeliness.

Investigators and members of the National Transportation Safety Board attribute the cause of the majority of airline accidents and incidents to pilot error. In an effort to address this problem, many airlines have developed training programs for pilots aimed at improving teamwork and decision making in the cockpit. Much of this training, generally termed cockpit resource management (CRM), has leadership style assessment and modification through group exercise as its foundation. Though cockpit resource management training has been widely embraced in the aviation industry, its effectiveness in improving flight safety has yet to be demonstrated. An argument is advanced that the current approach to this training is not likely to be effective. Other approaches are suggested.

INTRODUCTION

With the advent of the jet age in 1958, commercial air travel accident rates began a precipitous decline (Sears, 1989), but by the early 1970s the decline leveled off and has remained low but nearly constant. Because of jet aircraft systems' reliability and redundancy, accidents due primarily to mechanical failure are rare. The human system failure, the pilot, is the causal factor in more than 70% of commercial airline accidents (Lautman and Gallimore, 1987).

Researchers at the National Aeronautics and Space Administration (NASA) in the early 1970s began studying ways to further improve airline safety and concluded that the root causes of pilot error accidents must be addressed if the accident rate were to be further lowered. At the same time, flight operations managers at United Airlines came to similar conclusions from their investigations at United and other airlines. One accident, which has since become a classic in the study of pilot error, galvanized support for a different type of training for United's pilots. This new approach to pilot training, now commonly termed cockpit resource management (CRM), has been adopted by many airlines in an effort to further improve airline safety.

This paper explores the foundations of CRM training and its prospects for success.

CRASH OF UNITED FLIGHT 173

In December 1978, United Flight 173, a DC-8 aircraft on a scheduled passenger flight from Denver to Portland, Ore., crashed after the crew delayed their approach and landing to work on an unsafe landing gear indication. The flight was routine until the gear extension was accompanied by a loud thump, abnormal vibration, aircraft yaw, and a red warning light for the right main landing gear. Following established procedure for this abnormality, the flight engineer confirmed all main landing gear were down and locked by a visual inspection system designed for that purpose.

Some 28 minutes after reporting the gear problem to Portland air traffic controllers, the captain contacted United's dispatch and maintenance center controllers to discuss the problem. All agreed that the appropriate procedures had been completed. The conversation ended approximately 30 minutes before the aircraft crashed. For the remainder of the flight, the captain's main concern seems to have been to allow the flight attendants time to prepare the cabin for an emergency landing.

During that time, both the first officer and flight engineer made several oblique and unassertive references to the increasingly critical fuel situation. So oblivious was the captain to those comments that when the first of four engines quit and the first officer said, "We're losing an engine," the captain asked, "Why?" The crew managed to keep the remaining three engines running for another seven minutes; the DC-8 crashed six miles from the runway after the fuel was exhausted and all engines flamed-out (NTSB, 1979).

For many, the crash exemplified what was wrong with airline pilots and their approach to teamwork in the cockpit. Foushee and Helmreich (1988) have argued that both traditional pilot selection and training are, in part, responsible for these deficiencies. They point out that many airlines have long favored the military single-seat fighter pilot for hiring, the type immortalized by Tom Wolfe (1979) as having *the right stuff.*

"Most of us are familiar with the common stereotype of the pilot as a fearless, self-sufficient, technically qualified, and slightly egotistical individual, whose job description calls for the defiance of death on a regular basis" (Foushee and Helmreich, 1988 p. 191). Pilots who have this background and self-image are unlikely to function well in the multi-pilot crew when there is a need for teamwork and group decision processes. Although Foushee and Helmreich may have overestimated the extent to which this personality type is evident in airline cockpits, some of the attitudes they refer to are common (Helmreich, 1984).

DEVELOPMENT OF LABORATORY EDUCATION FOR PILOTS

At the time of the accident, some United managers were participating in a training program provided by Scientific Methods Inc., the organizational development firm founded by Robert Blake and Jane Mouton. These managers were quick to note the similarity in the problems of business management addressed by this training and those involved in the crash of United 173. Accordingly, Scientific Methods was asked to develop a similar program for United's pilots (Oberle, 1990). Although United was not the first airline to carry out management training for pilots, its initial commitment to CRM training was the greatest, making United the industry leader in this area.

Laboratory Education in Business

Blake and Mouton were the developers of the Managerial Grid for assessing leadership styles and were early proponents of laboratory education in business. Intensive group experience education, known variously as T-group, encounter group, sensitivity training, and laboratory education, was developed and used extensively in many companies for the two decades after World War II (Kaplan, 1986).

In the earliest stages, managers from different companies or work areas were assembled in training groups but not provided with any specific direction or given any explicit task. The role of the educator or facilitator was not to provide structure but rather to encourage the group members to identify and communicate their feelings about the group, its work as it evolved, and its members. This feedback was considered the most important product of the process (Argyris, 1964). The objective was to develop an ability for "openness" that the manager could then use on the job. Later developments included the use of interactive work groups and the introduction of a series of more structured tasks for the group to perform.

Current methods for the management team-building aspect of organizational development are direct results of initial work in laboratory education (Lewis, 1975). Regardless of the training method advocated, scholars and practitioners believed that controlling, autocratic leadership styles, to the exclusion of relationships in the group, were counterproductive (Horstein, Heilman, Mone, & Tartell, 1987).

Laboratory education was intended to heighten sensitivity to the importance of relationships. Underlying teamwork values were the free flow of valid information, a spirit of inquiry, nondefensiveness, and collaboration. These qualities seemed the perfect prescription for avoiding accidents like the Portland crash.

CRM Training at United Airlines

The United CRM program uses the Managerial Grid as the basis for examining individual leadership style. The Managerial Grid allows for various management styles to be depicted on a coordinate system where the X axis measures concern for production or task behavior with the Y axis showing concern for people or relationship behavior.

The course introduction states that when the grid is

https://commons.erau.edu/jaaer/vol5/iss2/2
DOI: https://doi.org/10.15394/jaaer.1995.1145

"understood it provides a comparative basis for seeing teamwork and how individuals contribute to it or prevent it from occurring by the way in which they interact with one another" (Scientific Methods, 1988, p. 3). This emphasis is necessary because "well-educated and technically proficient crew members ... rarely understand what makes people tick" (Scientific Methods, 1988, p. 2). Yet the skills in working with other crew members are essential to "reaching informed, strategically sound decisions and taking action accordingly" (Scientific Methods, 1988, p. 1).

Objectives of the course are five: (a) gain insight into one's own style of action, (b) set standards for advocacy and inquiry based on openness and candor, (c) learn effective use of the captain's authority and crew member leadership, (d) develop principles of synergistic teamwork, and (e) understand the impact of external forces on cockpit behavior.

Small teams of pilots work together intensely for three and a half days on a series of projects. This teamwork allows participants to develop skills in inquiry, advocacy, conflict solving, decision making, and critiqueing. The developers say these skills will not be taught but will develop through group interaction. At the end of the session, team members evaluate each other's strengths and weaknesses. This sometimes harsh evaluation by peers is intended to promote reflection and lead to a change of attitude and behavior.

CRM Training at Other Airlines

Cockpit resource management training, though not yet required by regulation, has been introduced in some form at most major airlines. Many programs are patterned after United's course and most programs use some form of leadership style assessment and group feedback.

EFFICACY

Despite wide acceptance by the airline industry and 10 years experience in CRM training, there is no conclusive evidence this training is effective in improving flight safety. Certainly pilot-error accidents continue to occur. Nevertheless, an accident is such a low frequency occurrence that a short-term change in the accident rate will not be statistically significant in proving the efficacy of training.

Some anecdotal evidence, however, has been offered. United, which had not had a hull-loss accident since beginning its training program in 1979, suffered two accidents in 1989. One, a Boeing 747 on climb out of Honolulu lost a forward cargo door resulting in serious flight control problems and several passengers being sucked through the gaping hole in the fuselage.

The second accident occurred when the center engine of a DC-10 aircraft exploded in flight, resulting in severe control problems and a spectacular televised crash landing at Sioux City, Iowa. Both captains credited their crews' CRM training for reducing the loss of life in these accidents (Langer, 1990). Still, this testimony is not considered hard statistical evidence and the vested interest of United Airlines must be acknowledged.

Helmreich (1984) has argued that CRM training programs may be effective in changing pilot attitudes but are unlikely to affect underlying personalities. Further, there is evidence that personality is linked to pilot performance, including cockpit management. If personality is the predominant determinant of cockpit management behavior, then airline managers should concentrate on pilot selection rather than on training and allow cockpit management to gradually improve with the retirement of those pilots with inappropriate personality traits.

In research at one airline, however, Helmreich has found that attitudes toward cockpit management differ significantly by pilot position, that is, captain, first officer, second officer. Because personality traits were not similarly linked to position, it would seem that personality traits and attitudes toward cockpit management are independent. In subsequent research at the same carrier, a significant correlation between attitudes and flight deck performance in cockpit management was found (Helmreich, Foushee, Benson, & Russini, 1986).

CRM training has been shown to have a positive influence on pilot attitudes both as measured by pilots' subjective evaluation of the usefulness of the training and by psychological testing administered pre- and post-training (Helmreich, Chidester, Foushee, Gregorich, & Wilhelm, 1989). If CRM training is effective in changing pilots' attitudes, it should have a positive effect on actual cockpit management.

Helmreich and his colleagues reported preliminary results indicating CRM training does translate to improved cockpit management behaviors in actual and simulated flight (Helmreich, Wilhelm, Gregorich, & Chidester, 1990).

The researchers face several methodological problems.

Perhaps the greatest difficulty is in obtaining consistency of evaluation from the pilots measuring cockpit management performance.

Although the degree of efficacy is yet to be determined, the Federal Aviation Administration (FAA) (1989), sufficiently convinced that CRM training will be effective in improving safety, has proposed such training for all airline pilots.

CRITICISMS

There has been no research on the best pedagogical methods for CRM training.

This lack of evidence notwithstanding, there are reasons to question whether programs that place heavy emphasis on leadership style assessment, feedback, and introspection are likely to be effective in improving airline safety.

These questions involve (a) the underlying analysis of the causes of pilot error accidents, (b) the dissimilarity in the working roles of airline pilots and business managers, and (c) the history of ineffectiveness of laboratory training in business.

Questionable Analysis

Though not ignoring other combinations of task and relationship attitudes and behaviors, much current CRM thinking emphasizes the problem combination of the autocratic, task-oriented captain and the timid, unassertive subordinate crewmembers as in the case of the crew of United 173.

Thus, much of the emphasis is on the concern for people or the relationships dimension of management style. Data suggests that many pilot-error accidents involve failures in areas that are the domain of traditional pilot training programs. In a study of fatal air carrier accidents worldwide from 1977 through 1988, Sears (1989) found that deviations from standard operating procedures were a significant factor in 37%.

Table 1
The Significant Accident Causes and Their Percentage of Presence in 93 Major Accidents

33%	Pilot deviated from basic operation procedures.
26%	Inadequate crosscheck by 2nd crew member.
*9%	Crews not conditioned for proper response during abnormal conditions.
*6%	Pilot did not recognize the need for go-around.
4%	Pilot incapacitation.
*4%	Inadequate piloting skills.
3%	Crew errors during training flights.
*3%	Pilot not trained to respond promptly to GPWS command.
*3%	Pilot unable to execute safe landing or go-around when runway sighting is lost below MDA or DH.
3%	Operational procedures did not require use of available approach aids.
*3%	Captain inexperienced in aircraft type.

Source: The Boeing Airliner April/June 1987

* Factors suggesting a lack of technical knowledge and/or basic flying skills in the author's opinion.

Training and practice of standard operating procedures for both normal and abnormal situations are a large part of traditional pilot training. In its investigation of two recent accidents resulting from the failure of the flight crews to properly set flaps for takeoff (Northwest at Detroit and Delta at Dallas), the National Transportation Safety Board (NTSB) (1988, 1989) found in both cases the captains failed to maintain cockpit discipline and follow standard operating procedures.

In another study conducted at Boeing Aircraft, Lautman and Gallimore (1987) found that 12% of all commercial aircraft operators accounted for 90% of all accidents. Although the study was not scientifically based, a series of interviews showed that standardization and cockpit discipline were common elements of those operators with the best safety records.

In an early study, Sears (1986) found a lack of technical knowledge and/or basic flying skills to be a contributing factor in approximately 30% of air carrier accidents (**Table 1**).

These findings suggest that more emphasis should be

https://commons.erau.edu/jaaer/vol5/iss2/2
DOI: https://doi.org/10.15394/jaaer.1995.1145

placed on task behavior in CRM training.

Dissimilarity of Pilot and Management Teams

To the extent that the importance of relationships also should be emphasized in CRM training, there is reason to question whether group exercises are an effective means of doing so. Since laboratory education was designed to address the problems of openness in management teams and CRM training draws directly on this foundation, significant differences between the work of management and pilot teams may invalidate assumptions about the transferability of the training.

Both by tradition and federal law, an airline captain has absolute authority over the operation of his/her crew and the aircraft. A manager has similar responsibilities though perhaps more limited authority. For most situations the similarity ends here. For all normal flying situations, procedures for aircraft operations are highly developed, specific in detail, and intended to be precisely followed. The same is true for all abnormal conditions that have been anticipated. Traditional pilot training emphasizes rote learning and practicing of these procedures. In contrast, high-level management teams operate in a world of much less certainty, in longer time horizons, and in environments over which management has little control.

Lewis (1975) delineates the conditions most favorable for the operation of integrated management teams most likely to benefit from team development training. Among those conditions are: (a) An external environment that is highly variable and/or changing rapidly; (b) an organization that is young and/or undergoing major change, resulting in fluid structure, few operating policies and procedures, and emerging role definitions; (c) technology that is relatively new and/or developing rapidly; and (d) a tendency toward frequent use of project management, temporary task forces, and/or ad hoc problem-solving groups to augment conventional organizational structures.

These conditions are not characteristic of the airline pilot's job and, by extension, team building may be inappropriate. To the contrary, Argyris (1964) acknowledges that directive style leadership is appropriate for routine decisions and extreme emergencies. These, in fact, are exactly the working conditions faced by airline pilots. A well-known adage among pilots characterizes their job as hours and hours of boredom interspersed with moments of sheer terror.

Continuity is an additional significant difference between management teams and airline crews. Though management team members can be expected to take some time to get to know one another, develop working relationships, and then work together for an extended period, it is common for airline pilots to meet for the first time and one hour later to have to function as a highly integrated team performing a complex task. At larger airlines, it is also common for a crew to work together for one month and then possibly never again. Such teamwork can be accomplished only by adherence to detailed standard operating procedures.

Effectiveness of Laboratory Training in Business

Laboratory training programs for management, which are the basis for many CRM programs, eventually proved disappointing even to their advocates. Chris Argyris (1979), who championed the cause of laboratory education for many years, eventually concluded "there may be factors endemic to the theory and practice of the laboratory education that act to inhibit transferability" (p. 197). Kaplan (1986) concludes that laboratory training failed for two reasons: (a) some participants were hurt in the process and their working relations damaged, and (b) those who felt positive about the process were generally unable to apply what they had learned in the training. There is evidence that both of these problems are results of current CRM training.

Although reporting a positive shift in attitudes by most pilots participating in CRM programs, Helmreich et al. (1989) have found a negative reaction in about 15% of those trained. The data indicate those pilots reacting most negatively are low in both task and relationships on the grid measurement system. These are the pilots judged to be most in need of improvement.

Although the developers of the United CRM program deny it, elements of T-group and sensitivity training are certainly involved (Public Broadcasting System, 1986). During a sales presentation of the course to this author, the Scientific Methods representative explained with apparent satisfaction how he had witnessed senior captains and, in one instance, a chief pilot, break down and cry before the group during the final evaluation.

As Jack Gordon (1989) sees it, this "personality shredding is a pretty fair description of what went on in some sensitivity training sessions, and that at least a few people were seriously wounded" (p. 29).

Problems can occur elsewhere even when training does not involve such direct feedback as was characteristic of early sensitivity training. Following the breakup of AT&T, Pacific Bell instituted a corporate-wide program called Leadership Development. The company's director of training noted that the program "was a long way from sensitivity training" (Gordon, 1989, p. 38). Nonetheless, following complaints by some employees and an investigation by the California Public Utilities Commission, the program was dropped. These results could have been expected. In an early article advocating T-group training, Argyris (1964) cautions that individuals who are highly defensive should not be involved in the training.

The second reason cited by Kaplan for the failure of laboratory education is that even when participants had a positive reaction, they frequently had difficulty applying what they had learned once they returned to the job. Given this difficulty, positive effects are short-lived. Similar criticisms have been leveled at CRM training. Walker and Youngblood (1989) note: "Some of the existing programs rely heavily on self-analysis without emphasis on actually working together or giving skills to use while working in the cockpit. While self-analysis may give some personal insight into individual styles of management, it does not deal with how to apply skills to working better with other crew members" (p. 56). The difficulty stems from an emphasis on attitudes and motivations rather than on behaviors. To be effective, training programs must identify behaviors that are objective, observable, and measurable (Luthans, Maciag, & Rosenkrantz, 1983, cited in Kirkpatrick, 1988). Most CRM programs fail to define the cockpit behaviors that should result from the training program.

NEW APPROACHES TO CRM TRAINING

Current approaches of CRM training have been questioned by others. John Lauber in his presentation to the Annual Airline Operations Forum, *Airline Safety in a transitional era* (November, 1988), stated his concern that "some of us have fallen into the dangerous waters of hot tub harmony. What I mean by this is that I see signs of too much emphasis on interpersonal relationships in some of the approaches to cockpit resource management, and not enough emphasis on command and leadership skills." Doug Schwartz of FlightSafety International describes an evolution from first-generation CRM programs, which emphasized open communication, teamwork, and advocacy, to training that will provide specific and measurable cockpit behaviors (Hughes, 1989).

The foregoing criticism is not intended to suggest leadership style analysis has no place in pilot education. In fact, an appreciation of the various leadership styles can provide valuable insights into pilots.

Given evidence that such attempts have not been successful in business settings, and in the absence of explicitly defined behaviors to be used in the cockpit, the question is what amount of scarce training time should be spent in an attempt to modify existing pilot attitudes and leadership styles.

There are other elements of CRM training, some old and some more recently developed, that promise to be effective.

Standard Operating Procedures

First, the importance of strict adherence to existing standard operating procedures must be emphasized. Case study of accidents, particularly when video recreations are available, should be effective. Strong flight operations management support is critical to the development of norms requiring the use of standard procedures.

Safety Monitor

Procedures can be developed that delegate the role of safety monitor to the non-flying pilot, who should be responsible for challenging any deviation from standard procedure in much the same way that a challenge to a deviation from a stabilized approach profile is now required.

There are circumstances when deviation from standard procedure is appropriate, but the reasons for such a deviation must first be fully established and explained to the crew. The safety monitor also would bring to the attention of the flying pilot information

https://commons.erau.edu/jaaer/vol5/iss2/2
DOI: https://doi.org/10.15394/jaaer.1995.1145

Table 2
Error Chain Elements

1. Ambiguity
2. Fixation and/or Preoccupation
3. Confusion or Empty Feeling
4. No one flying the aircraft
5. No one looking out window
6. Use of undocumented procedure
7. Violating minimums and/or limitations
8. Unresolved discrepancy
9. Failure to meet targets
10. Departure from standard operating procedure
11. Communication failure

Source: Schwartz (1989)

critical to the safe operation of the aircraft (Bolman, 1979).

Error Chain

Most accidents result from a unique series of events and errors, no one of which may be uncommon or, in isolation, would lead to an accident (Sears, 1986). If this "error chain" could be detected and broken while in progress, accidents could be avoided. FlightSafety has developed a list of clues that may point to an error chain in progress (**Table 2**) (Schwartz, 1989).

Decision Processes

Although decision making is frequently mentioned in CRM training, the actual process is seldom more than superficially explored. It seems an assumption has been made that if sufficient openness in the cockpit can be instilled, good decisions will certainly follow. Many decisions in aviation are highly structured and programmable, consequently detailed procedures exist for most mechanical problems. But pilots also occasionally face non-programmable decisions that are left to pilot judgment. The aviation community has generally felt that pilot judgment is either innate in good pilots or acquired over time, but were not a proper subject of formal training (Buch & Diehl, 1984).

This attitude is in contrast to business management training, which devotes considerable effort to developing business judgment. Understanding the classical decision model and practice in its application to aviation problems can be effective.

CONCLUSION

CRM is not the only avenue being explored to improve the safety of air travel. The newest generation of commercial aircraft make extensive use of computers to automate functions that previously required pilot control. Though the introduction of high levels of automation presents new cockpit management problems (Wiener, 1989), there is reason to believe that these newer aircraft will be safer. Because pilot error continues to a major contributor to commercial aircraft accidents, work to improve the human system holds the greatest promise for improving airline safety. Formal CRM training is more than 10 years old and has been adopted by most airlines. Preliminary research results indicate the training is effective in improving cockpit management behaviors. There is no research on the relative effectiveness of various approaches to CRM training, but there are reasons to question whether approaches that emphasize assessment and modification of leadership styles through group exercises will be effective. Until research results are available, CRM training should de-emphasize the study of leadership styles so that other promising approaches to training can be included.□

Gerald N. Cook is a Boeing 737 captain for Air South in Columbia, S.C. With a Master of Science in management and a Bachelor of Science in aviation technology, both from Purdue University, Captain Cook is currently pursuing a Doctorate in Business Administration at Nova University, Fort Lauderdale, Fla.

REFERENCES

Argyris, C. (1964). T-groups for organizational effectiveness. *Harvard Business Review, 42*, 60-74.

Argyris, C. (1979). Reflecting on laboratory education from a theory of action perspective. *Journal of Applied Behavioral Science*, 1979, *15*, 296-310.

Bolman, L. (1979). Aviation accidents and the 'theory of the situation'. In G. E. Cooper, M. D. White, & J. K. Lauber (Eds.), *Resource Management on the Flight Deck, Proceedings of a NASA/Industry Workshop* (pp. 31-57). San Francisco, CA. National Aeronautics and Space Administration publication 2120.

Buch, G., & Diehl, A. (1984). An investigation of the effectiveness of pilot judgement training. *Human Factors, 26*(5), 557-564.

Federal Aviation Administration. (1989). *Cockpit resource management training*. (AC no. 120-51). Washington, DC

Foushee, C., & Helmreich, R. L. (1988). Group interaction and flight crew performance. In E. L. Wiener & D. C. Nagel (Eds.), *Human Factors in Aviation* (pp. 189-225). San Diego: Academic Press.

Gordon, J. (1989). Where's the line between training and intrusion? *Training, 26*(3), 27-39.

Helmreich, R. L. (1984). Cockpit management attitudes. *Human Factors, 26*(5), 583-589.

Helmreich, R. L., Chidester, T. R., Foushee, H. C., Gregorich, S., & Wilhelm, J. A. (1989). *How effective is cockpit resource management training? Issues in evaluating the impact of programs to enhance crew coordination.* (Draft, NASA/UT Technical report 89-2). Moffett Field, CA: NASA-Ames Research Center.

Helmreich, R. L., Foushee, H. C., Benson, R., & Russini, W. (1986). Cockpit resource management: Exploring the attitude-performance linkage. *Aviation, Space, and Environmental Medicine*, 1198-1200.

Helmreich, R. L., Wilhelm, J. A., Gregorich, S. E., & Chidester, T. R. (1990). Preliminary results from the evaluation of cockpit resource management training: Performance ratings of flightcrews. *Aviation, Space, and Environmental Medicine, 61*, 576-579.

Hornstein, H. A., Heilman, M. E., Mone, E., & Tartell, R. (1987). Responding to contingent leadership behavior. *Organizational Dynamics, 15*(4), 56-65.

Hughes, D. (1989, October 16). New approaches to pilot training stress human factors, coordination. *Aviation Week and Space Technology*, pp. 86-87.

Kaplan, R. E. (1986). Is openness passe? *Human Relations, 39*(3), 229-243.

Kirkpatrick, D. L. (1988). *How to manage change effectively*. San Francisco: Jossey-Bass.

Langer, H. A. (1990, April). *Human performance research laboratory dedication*. Paper presented at the dedication of the Human Performance Research Laboratory dedication, NASA Ames Research Center, CA.

Lauber, J. K. (1988, November). *Airline safety in a transitional era*. Keynote address at the annual airline operations forum of the Air Transport Association, Williamsburg, VA.

Lautman, L., & Gallimore, P. (1987, April-June). Control of crew-caused accidents. *The Boeing Airliner*.

Lewis, J. W. (1975). Management team development: Will it work for you? *Personnel, 52*, 11-25.

Luthans, F., Maciag, W. S., & Rosenkrantz, S. A. (1983, March-April). O.B. mod: Meeting the productivity challenge with human resources management. *Personnel*, pp. 28-36.

National Transportation Safety Board. (1979). Aircraft accident report. United Airlines, Inc. McDonnell-Douglas DC-8-61, N8082U, Portland, OR, December 28, 1978 (Report No. NTSB-AAR-79-7). Washington, DC: Author.

National Transportation Safety Board. (1988). Aircraft accident report. Northwest Airlines, Inc. McDonnell-Douglas MC-9-82, N312RC, Detroit Metropolitan Wayne County Airport, Romulus, MI, August 16, 1987 (Report No. NTSB-AAR-88-05). Washington, DC: Author.

National Transportation Safety Board. (1989). Aircraft accident report, Delta Air Lines, Inc. Boeing 727-232, N473DA,

https://commons.erau.edu/jaaer/vol5/iss2/2
DOI: https://doi.org/10.15394/jaaer.1995.1145

Dallas-Ft. Worth International Airport, TX, August 31, 1988 (Report No. NTSB/AAR-89/04). Washington, DC: Author.

Oberle, J. (1990). Teamwork in the cockpit. *Training, 27*(2), 34-38.

Public Broadcasting System. (1987). *Why airplanes crash* (TV documentary). [Interview with M. Voltz, United Air Lines]. Boston, MA: WGBH.

Schwartz, D. (1989, April). *Training for situational awareness*. Paper presented at the fifth international symposium on aviation psychology, Columbus, OH.

Scientific Methods Inc. (1988). *Cockpit Resource Management* (Unpublished report). Austin, TX: Author.

Sears, R. L. (1986). *A new look at accident contributions and the implications of operational and training procedures*. Unpublished report. Boeing Commercial Airplane Company.

Sears, R. L. (1989, February). *Prevention strategies for the crew-caused accident*. Paper presented at the second Egyptian Aircraft Accident Investigation and Prevention Annual Seminar, Cairo, Egypt.

Walker, S., & Youngblood, H. (1989). A review of CRM training within the Alaska Air Group and its application accident investigation. *Proceedings of the Nineteenth International Seminar of the International Society of Air Safety Investigators, 23*(4), p. 56. Vancouver, British Columbia, Canada.

Wiener, E. L. (1989). *The human factors of advanced technology ("glass cockpit") transport aircraft*, (NASA contract report 177528). Moffett Field, CA: NASA Ames Research Center.

Wolfe, T. (1979). *The right stuff*. New York: Farrar, Straus & Giroux.□