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Crew Resource Management: A Literature Review

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CREW RESOURCE MANAGEMENT:
A LITERATURE REVIEW

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Crew Resource Management as an academic field of study has only been in existence for a relatively short period. However, because of its importance to the aviation community and the airlines in particular, there is a small but growing community of researcher and academicians that are specializing in its postulates. Despite the importance of research to the aviation industry and to aviation education, no comprehensive compendium of point specific literature exists. This void presents an obstacle for both researchers and practitioners in locating articles that may be relevant to their work. In addition, because of a narrow scope of many aviation education programs, researchers seeking information are often unaware of specificity's that address the totality of any particular program. Thus, the authors set out to identify a particular point specific niche of articles relating to a particular time segment of the unfolding Crew Resource Management Training field. Using descriptive research methodology and a systematic and thorough computer methodology, three hundred eighty-five citations were identified. These then were culled of duplication and a resultant sixty-six representative articles, with abstracts were found to coincide to the period of 1993 to 1998. These were further refined to key topics of a) the current status of CRM training and research, b) evolution of CRM concepts, c) measuring methods, and d) application of CRM.

The history of CRM, Crew Resource Management, or as originally titled, Cockpit Resource Management is relatively short by modern standards. Its history is almost as short as that of the Airline Deregulation Act, which occurred only one year prior to the commonly accepted beginnings of CRM. Most practitioners trace the early formation of CRM to a meeting held by the National Aeronautic and Space Administration entitled Resource Management on the Flightdeck (Cooper, White & Lauber, 1993).

Since that time many meeting, papers, research and training activities have created a natural time metamorphosis to occur that has as its Genesis the evolutionary process of valuable research and natural changes occurring with input. So pervasive has this metamorphosis become that Helmerich, Ashleigh and Wilhelm (1998) have defined an evolutionary period corresponding to five generations, each have an identified event corresponding to their introduction.

This natural change period has the most recent generation, the fifth, in its formative stages and is identified as the period of a search for a universal rationale. Underlying this fifth generation of CRM is the premise that human error is ubiquitous and inevitable, providing a valuable source of information (p.5). The aim of this fifth generation is the normalization of error and the development of strategies for managing error (Helmerich, 1997).

The fourth generation, the most complete, has been characterized by the requirement of major air carriers to make detailed analysis of training requirement for each type of aircraft in their fleets along with the development of programs addressing the issue of Crew Resource management in all aspects of training. The apparent prime mover, defining the fourth generation, was a program established to address all aspect of CRM, requiring air carriers to incorporate and integrate CRM programs into their technical training. The Federal Aviation Administration introduced a major change in the training and qualification of flight crews in 1990 with the initiation of its Advance qualification Program (Birnbach & Longridge, 1993).

Need for the Study

From January 1993 to January 1998, coincident with the fourth generation of CRM, there was a shift from conventional cockpits to highly automated ones (Scott, 1995). This called for a CRM training update. Also, during this period the Federal Aviation Administration (FAA) endorsed CRM training for commercial and commuter airlines in the U. S. The FAA stated that "CRM training has been conceived to

prevent aviation accidents by improving crew performance through better crew coordination" (FAA, 1995, P. 1). The shift from conventional cockpits to highly automated ones, and the fact that the FAA endorsed CRM training caused CRM training to grow, evolve, and gain popularity worldwide (Merritt & Helmreich, 1995).

Purpose of the Study

A review of CRM training literature and research failed to disclose any compilations of resource literature in this area. Thus, a need for the instant study was realized. Four closely related aviation field studies were found and their methodology became a focus for this study. In each a study of a particular field of resource management was undertaken and the establishment of annotated bibliography-citing reviews and articles reported the findings

The purpose of this study was to review and synthesize the literature and research on CRM training and to compile an annotated bibliography from January 1993 to January 1998. Because of the dramatic changes occurring in CRM training, the mid-1990's were a crucial period. This research made an attempt to capture and report these major changes. It also sought to compile a useful CRM reference tool that includes easy access to many significant CRM abstracts and authorities. The publication should be useful for aviation students, aviation employees, pilots, and other individuals who wish to learn about CRM, as well as gain access to recent CRM training research and developments.

Review of Similar Research

Duncanson (1994) reviewed the human factor literature on visual and auditory symbols. The purpose was to stimulate and prepare the ground in an effort to develop a set of standard symbols for use through Airway Facilities. Vidulich, Dominguez, Vogel and, McMillan (1994) compiled an annotated bibliography about situation awareness (SA, Effective use of CRM is one way to avoid or mitigate the effect of aircraft wake vortices). Hallock (1990) compiled abstracts of publications on aircraft wake vortices. The material was arranged alphabetically by authors(s) and then by month and year of publication. Experimental and theoretical articles were included and classified by formation, structure, motion, and the breakdown of vortices and their effect on penetration aircraft.

Van Patten and White (1992) reviewed the literature on high acceleration cockpits (HAC) over the past fifty-six years and organized this literature into twelve categories.

The research objectives of each of these undertakings was to assemble in one location a compendium of the pertinent, unduplicated literature pertaining to the subject matter.

RESEARCH METHODS

Description of Research Type

Document analysis, a specific kind of descriptive research, was used to conduct the study. As Best and Kahn (1993) explained, descriptive research focuses on conditions that exist:

When document analysis is used as a descriptive research, current documents and issues are the foci. The analysis is concerned with the explanation of the status of some phenomenon at a particular time or its development over a period of time. (p. 191)

Source of Data

A systematic and thorough computer search was conducted in order to identify data. The following databases and search engines were used: (a) Silverplatter: ERIC, Applied Science and Technology Abstracts, Geobase, Healthstar, Medline Express, NTIS, Business Periodicals, (b) CARL UnCover, © Dissertation Abstracts Online, (d) Illinet Online, (e) InfoTrac, (f) Ovid: PsycInfo, Current Contents, (g) First Search: WorldCat, ArticleFirst, ContentsFirst, ABI/Inform, GPO Monthly Catalog, Medline, PapersFirst, Periodical Abstracts, WilsonSelect, (h) World Wide Web: Hotbot, Alta Vista, Netscape & Yahoo.

For most database searches CRM is not available as an official descriptor. As a result the following keywords were used: "crew resource management, (crew resource management in title), (crm in title & human factors). The search covered the time period from January 1993 to January 1998.

Procedures

The LINKS computer terminals at Morris Library, Southern Illinois University at Carbondale provided access to the electronic databases and to the World Wide Web. The first round of searches identified 385 citations that were printed for ease of review. All citations published before 1993 were deleted, except for reference sources used herein. The next data items to be deleted were duplicate citations; citations, which mentioned CRM but which, were considered to be unimportant or insignificant. Additionally, items which covered an aspect of CRM already discussed by previous citations, such as introduction to CRM, definition of CRM, or the different airlines which integrate flight attendants into

their CRM training programs, were deleted.

The remaining 66 citations/abstracts were printed and downloaded to a floppy disk. Citations that did not provide an abstract were collected from the library shelves or ordered through inter-library loan. Five citations were non-circulating or unavailable from inter-library loan, and are listed alphabetically by title only with the rest of the abstracts.

The continuing 61 abstracts were ordered into three categories and are contained in Appendix A. A summery review derived from these abstracts is provided according to the following four categories: (a) Current status of CRM training and research, (b) Evolution of CRM concepts from January 1993 to January 1998, © Methods of measuring CRM skills, (d) Various applications of CRM.

ANALYSIS AND RESULTS

The 61 abstracts resulting from a search of electronic databases and the World Wide Web covers most aspects of CRM training. These abstracts are identified and reviewed according to the following four categories: (a) Current status of CRM training and research, (b) Evolution of CRM concepts from January 1993 to January 1998, © Methods of measuring CRM skills, (d) Various applications of CRM. The abstracts are also complied into an annotated bibliography and identified in alphabetical order of the author(s), not chronological order.

Current Status of CRM Training and Research

Mortag (1997) claimed that because of the importance of CRM training and skills, it is essential for universities which train pilots to integrate CRM concepts into the curriculum. He developed a syllabus for a course that infused CRM concepts into the Aviation Management University curriculum.

Federal Aviation Administration Advisory Circular No. 120-51B (1995) presented guidelines for developing, implementing, reinforcing, and assessing CRM training programs for flight crewmembers and other personnel essential to flight safety. It emphasized that by focusing on communication skills, teamwork, task allocation, and decision-making, CRM intends to increase the efficiency with which flight personnel perform.

The FAA suggested the following CRM curriculum topics:

(a) Communications processes and decision behavior. This topic includes internal and external influences on interpersonal communications. External factors include communication barriers such as rank, age, gender, decision-making skills, conflict resolution techniques, and the use of appropriate assertiveness and advocacy. Subtopics include briefings; inquiry, advocacy, assertion; crew self-critique; conflict resolution; communications and decision-making.

(b) Team building and maintenance. This topic includes interpersonal relationship and practices. Effective leadership, teamwork, and interpersonal relationships are key concepts to be stressed. Curricula can also include recognizing and dealing with diverse personalities and operating styles. Subtopics include: leadership, teamwork, concern for task; interpersonal relationship, group climate; workload management and situational awareness; preparation, planning, and vigilance; workload distribution, distraction avoidance; individual factors, and stress reduction (FAA, 1995).

The CRM training of today aims to broaden the influence of crewmembers on the flight deck in a positive way. Captains are advised to be receptive and open-minded without showing weakness in their authority. On the other hand, captains should not be too authoritative and should share command. Crewmembers must learn to be involved without losing an awareness of who is in charge (Parke, 1995). An optimal cockpit would have a strong group or team orientation and a relatively flat authority level that allows for easy communication from subordinates to superiors (Merritt & Helmreich 1996).

Transport Canada (1997) is a CRM training facilitator which claims that the key to success of a CRM training program is the mutual respect and confidence that is created among crew members which advances an environment that promotes openness, candor, and constructive criticism. The result is a more professional performance due to the harmony that is achieved in the cockpit; therefore, decreasing the risk of an accident or incident. Their course objectives include the following: (a) to gain a greater awareness of the concepts, (b) to discuss different philosophies and objectives of crew resource management training, © to enable participants' to utilize more crew resource management tools, and (d) to enhance participants' abilities to utilize their most valuable resource.

Delta Air Lines, United Airlines, Japan Air Lines, and South Korea's Asiana Airlines are refining their crew resource management programs to keep pilots motivated and the training concentrated on topics relevant to their operations. USAir, American Airlines, and their respective pilots and unions are using so-called partnership programs

with the FAA to focus on the causes of flight crew mistakes instead of punishing the pilots who commit the errors (Mckenna, 1996).

Douglas Aircraft Co. intends to fold CRM into their new advanced training curriculum. Conventional training procedures will be offered on the MD-95 and other Douglas models as the company continues its emphasis on tailoring flight crew training programs to meet the requirements and capabilities of its individual airline customers (Smith, 1996).

Beard, Salas and Prince (1995) presented guidelines for designing semi-structured role-playing to elicit crew resource management behaviors and provide feedback to trainees on their performance. They claim that role-playing provides targeted practice and feedback of specific behaviors at low cost, with the trade-off being the limited fidelity it provides.

The study "Guidelines for Simulator Scenario Development"(1993) asserted that the simulator is a valuable training aid, and that simulation provides realistic scenarios that can be used to train optimal pilot behavior in emergency situations. The study pointed out that U. S. Navy researchers have now extended existing guidelines for scenario development. These guidelines, with an emphasis on their use for CRM training, are presented to assist others who design scenarios. The guidelines are separated into five categories: scenario overview, objectives, realism, role of the facilitator, and technical tips.

On the other hand, the researchers (Baker, Prince, Shrestha, & Oser, 1993) claimed that role-playing has few realistic environmental cues to help crews behave as they do in the cockpit, and simulator scenarios are limited by the cost and availability of the simulators. The researchers provide inexpensive, tabletop computer-based simulations as CRM training media, and claim that reactions of the crew members taking part in the research were very positive both in their acceptance of the system in general and as a trainer for CRM skills.

In another effort to improve the quality of CRM training and save airlines and other potential users hundreds of thousands of dollars per year in the cost of developing new videos, training manuals, and other course materials, U. S. human factor specialists are setting up a crew resources management library. The library will archive a wide range of videotapes, manuals, and other training materials that airlines can share (Hughes, 1995).

The authors of "CRM for CRM" suggested that the airlines industry could save time and money by not "reinventing the wheel," and instead using a few well-chosen video presentations about CRM training. The

authors noted that a picture is worth a thousand words and that airlines should not develop "in-house" productions when similar products are already commercially available (Karlins, Koh, McCully, & Chan, 1996).

Current Status of CRM Training and Research

1. Baker, D., Prince, C., Shrestha, L., & Oser, R. (1993). Aviation computer games for crew resource management training. International Journal of Aviation Psychology, 3, 143-156.

Abstract: Suggests that methods for providing air crews with opportunities to practice crew resource management (CRM) skills have been limited to role plays in class and scenarios in operational flight trainers. There are drawbacks to both training methods; role-plays have few realistic environmental cues to help crews behave as they do in the cockpit, and the cost and availability of the simulators limit simulator-scenarios. Research using inexpensive, tabletop computer-based simulations as CRM training media was conducted with 112 male military aviators. Reactions of the crewmembers taking part in the research were very positive both in their acceptance of the system in general and as a trainer for CRM skills. (PsycINFO Database Copyright 1994 American Psychological Assn, all rights reserved).

2. Beard, L. R. , Salas, E. , & Prince, C. (1995). Enhancing transfer of training: Using role-play to foster teamwork in the cockpit. [On-line]. International Journal of Aviation Psychology, 5, 131-143. Abstract from: Ovid File: PsycINFO Item: 83-03121

Abstract: Discusses the use of role plays to provide practice and feedback for air crew team development training in the classroom and presents guidelines for designing semi-structured role plays to elicit crew resource management behaviors and for providing feedback to trainees on their performance. When compared with other training strategies, role play provides targeted practice and feedback of specific behaviors at low cost, with the trade-off being the limited fidelity it provides. (PsycINFO Database Copyright 1996 American Psychological Assn, all rights reserved).

3. Bradley, P. (1996, June). Advanced CRM. [On-Line]. Business and Commercial Aviation, 78, 62-66. Abstract from: Silverplatter File: Applied Sci and Tech Abs Item: 96041242

Abstract: Washington-Dulles-based regional airline Atlantic Coast Airlines and the Federal Aviation Administration are studying advanced crew resource management to improve crew performance. The objective of the program is to

supply all pilots with tools to aid them fly like the best pilots. Although the results of the program are still being examined, evidence from flight-crews already strongly suggests that it is working.

4. CRM training of Swiss Air. (1997) [On-line]. Availability: http://www/swissair-as. ch/crm/HADIndex. html

Swiss airlines implemented two-day, seminar-style courses. They emphasized topics dealing with experiences in flight safety, incident and accident evaluation. The focus is on the team-relevance of the individual's behavior in specific and critical situations. It is not simply flight phase-related issues that are addressed, but rather a broader spectrum of human behavioral dynamics: Topics: Communication, Conflict - task and chance, Human Behavior in Emergency. In a two four-day block basic instructor course, candidates get involved in CRM-specific training-issues before being trained as simulator and route instructors on their specific aircraft type.

5. Effects of crew resource management (CRM) training in airline maintenance: Results following three year's experience. (1995). [On-Line]. Abstract from: Silverplatter: File: NTIS Item: N96108592XSP

Abstract: An airline maintenance department undertook a CRM training program to change its safety and operating culture. In 2 ½ years this airline trained 2200 management staff and salaried professionals. Participants completed attitude surveys immediately before and after the training, as well as two months, six months, and one year afterward. On-site interviews were conducted to test and confirm the survey results. Comparing managers' attitudes immediately after their training with their pre-training attitudes showed significant improvement for three attitudes. A fourth attitude, assertiveness, improved significantly above the pre-training levels two months after training. The expected effect of the training on all four attitude scales did not change significantly thereafter. Participants' self-reported behaviors and interview comments confirmed their shift from passive to more active behaviors over time. Safety, efficiency, and dependability performance were measured before the onset of the training and for some 30 months afterward. Associations with subsequent performance were strongest with positive attitudes about sharing command (participation), assertiveness, and stress management when those attitudes were measured 2 and 12 months after the training. The two-month follow-up survey results were especially strong and indicate that active behaviors learned

from the CRM training consolidate and strengthen in the months immediately following training.

6. Eissfeldt, H. , Goeters, K. M. , Hoermann, H. J. , Maschke, P. , & Schiewe, A. Effective work in teams: Crew resource management training for pilots and air traffic controllers. [On-line]. Abstract from: Silverplatter File: NTIS Item: TIBB9503314XSP

Abstract: More than 60% of all accidents in commercial jet operation can be attributed to errors of the flight crew. The existing redundancy in the multi-crew cockpit is often not used to increase performance effectively. The crew-induced accidents show as causal factors deficiencies regarding the exchange of information, the interpersonal interaction, decision-making and stress resistance. Therefore, crew resource management courses train the behavioral potential with respect to communication, leadership and teamwork, judgment and decision-making as well as stress coping. This work summarizes the existing models and methods of training and gives recommendations concerning their optimization. In a special chapter the transfer of the concepts originally developed for cockpit personnel into air-traffic control is discussed. Peculiarities of this area are reported.

7. Federal Aviation Administration. (1995, September 8). AFS-210 crew resource management training (Advisory Circular No : 120-51B).

Abstract: This advisory circular (AC) presents guidelines for developing, implementing, reinforcing, and assessing Crew Resource Management (CRM) training programs for flight crewmembers and other personnel essential to flight safety. These programs are designed to become an integral part of training and operations. Guidelines are for reference by Federal Aviation Regulations (FAR) Parts 121 and 135 certificate holders to increase the efficiency with which flight personnel perform by focusing on communication skills, teamwork, task allocation, and decision-making.

8. FlightSafety International crew resource management training curriculum. (1997). [On-line]. Availability: http://www. flightsafety. com/crm. html

Abstract: FlightSafety International's claims that their CRM workshops use a variety of training techniques to make the experience interesting and effective. Training activities include: Accident and Incident Analysis, Videotape Cockpit Scenarios, Classroom Role Playing Exercises, Group Communications, Problem-Solving Activities, Interactive Workshop Discussions. They invite the public to browse

their web site.

9. Gayman, A. J. , Schopper, A. W. , Gentner, F. C. , Neumeier, M. C. , & Rankin, W. J. (1996, February). Review analysis: Crew resource management (CRM) anonymous reporting system (ARS) questionnaire evaluation. [On-line]. Abstract from: Silverplatter File: NTIS Item: CSERIACRA96003

Abstract: The purpose of this report is to furnish suggestions for improvement of the Air Mobility Command (AMC) Crew Resource Management (CRM) Anonymous Reporting System (ARS) reporting form based on current scientific literature. This report describes CRM dimensions and CRM evaluation techniques helpful in refining the AMC CRM ARS form. The AMC CRM ARS form is compared to research findings, and recommendations for revisions to the ARS form are provided. In summary, this report: reviews current literature regarding CRM; identifies concurrent CRM dimensions common to the Federal Aviation Administration (FAA), the US Air Force (USAF), and mainstream CRM literature; identifies applicable CRM rating methods; evaluates the current AMC CRM ARS reporting form using widely accepted CRM dimensions and rating methods; and presents recommendations for the improvement of the AMC CRM ARS reporting form.

10. Guidelines for simulator scenario development: Increasing hits and reducing misses in CRM/LOS scenarios. (1993). International Journal of Aviation Psychology. 3, 69-82.

Abstract: Simulator scenarios have been used to elicit air crew members' skills for research, training, and evaluation. These scenarios are associated with line-operational simulations (LOSs), line-oriented flight training, and line-operational evaluation. Although design guidelines published by the FAA and NASA include the essential information for scenario development, there is additional guidance needed by persons who are inexperienced in scenario design to help ensure that their scenarios will have value for their intended purpose. US Navy researchers have now augmented existing guidelines for scenario development. These guidelines, with an emphasis on their use for crew resource management (CRM) training, are presented to assist others who design scenarios. The guidelines are separated into 5 categories: scenario overview, objectives, realism, role of the facilitator, and technical tips. (PsycINFO Database Copyright 1993 American Psychological Assn, all rights reserved).

11. Hughes, D. (1995, June 12). CRM library to help

share data, save money. [On-line]. Aviation-Week-and-Space-Technology. 142, 161-163. Abstract from: Silverplatter File: Applied Sci & Tech Abs Item: 95040030

Abstract: Human factors specialists in the U. S. are setting up a cockpit resource management (CRM) library. The effort is designed to improve the quality of CRM training and save airlines and other potential users hundreds of thousands of dollars per year in the cost of developing new videos, training manuals, and other course materials.

12. Hunt, J. F. (1996). Designing instruction for human factors training in aviation. [On-line]. Abstract from: WWW·File: Http: //WWW. caar. db. erau. edu/crm/books

Abstract: This book provides an instructional resource for all who are responsible for designing, teaching or evaluating human factors issues in aviation training and educational programs. It brings together a range of insights and experiences structured to follow the underlying theories, through the use of technology, teaching, and assessment procedures. It also considers the specific needs of groups such as air traffic controllers and air accident investigators. The intended readership includes instructors, CRM facilitators, air traffic management, aviation and educational psychologists, and specialists in computer based training.

13. Karlins, M. , Koh, F. , McCully, L. , & Chan, C. T. (1996). CRM for CRM: Cockpit relevant movies for cockpit resource management. [On-line]. Availability: http://www. hf. faa. g. . . Mvideo/CRMvideo. htm

Abstract: It is true that a picture is worth a thousand words, then imagine how many hours of CRM lectures could be condensed with a few well-chosen video presentations! In fact, the use of films in CRM programs produces significant benefits beyond time conservation. By alerting the aviation community to this select group of films it is hoped that: (a) their use in CRM programs will increase; and (b) airlines will save time and money by not "reinventing the wheel": developing "in-house" productions when similar products are already commercially available.

14. Manningham, D. (1995, July). Managing the basics. Business and Commercial Aviation. 77, 66-69.

Abstract: The effective management of human resources, information, equipment, fuel and time is crucial to cockpit and flight safety. It is therefore vital that prior to making a flight, pilots and crew members should identify all available resources and be well-trained in the principles of crew resource management (CRM). CRM focuses on the development of five skills, namely information gathering,

frankly stating opinions, dispute resolution, decision making and constructive criticism.

15. McKenna, J. T. (1996, September 2). Carriers hone CRM programs. Aviation Week & Space Technology, 145, 146-149.
Abstract: Part of a special section on aerospace training. Carriers like Delta Airlines, United Airlines, Japan Airlines, and South Korea's Asiana are refining their crew resource management programs to keep pilots motivated and the training concentrated on topics relevant to their operations. Other airlines, led by USAir, American Airlines, and their respective pilots and unions are using so-called partnership programs with the FAA to focus on the causes of flight crew mistakes, instead of punishing the pilots who commit the errors.

16. Merritt, A., & Helmreich, L. R. (1996, April). Cultural issues in crew resource management. Austin, Texas: University of Texas at Austin, Department of Psychology Aerospace.
Abstract: Trainers and researchers are become increasingly more aware of the critical influence of national and organizational culture on the impact and effectiveness of Crew Resource Management (CRM) training. While some aspects of CRM are universally endorsed, e. g., briefings and coordination, large cultural differences have been observed in command styles, acknowledgment of stress, and attitudes toward the use of automation. For CRM training to be successful, it must be tailored to the organizational context. A new strategy to harmonize CRM with organizational and national culture is proposed.

17. Merritt, A., & Helmreich, L. R. (1995, April 25). CRM I hate it, what is it? Austin, Texas: University of Texas at Austin, Department of Psychology Aerospace.
Abstract: Crew Resource Management (CRM) is now mandated training in most parts of the world, yet many pilots and managers resist its introduction. What is needed is a universal justification for training and operational practices that cannot be denigrated or dismissed. They propose a model based on organizational recognition of the inevitability of error. If one can accept that human performance has limitations, and that errors are inevitable, then one can be logically persuaded that Crew Resource Management is a necessary and successful strategy for managing error. The CRM strategies required to avoid, trap, and mitigate the consequences of error must be operationally relevant, yet they can be culturally defined to fit the organizational and national cultures. Cross-cultural data on stress and fatigue are presented to highlight the influence of attitudes toward stress in a system dedicated to managing error.

18. Mortag, K. (1997). Development of a crew resource management training syllabus (Master research report, Southern Illinois University at Carbondale, 1997). [On-line]. Availability: First search File: WorldCat.
Abstract: The hiring practices of airlines are changing. New employees need strong interpersonal skills to adapt to CRM philosophy in training crews effectively for today's highly automated aircraft. Because of the changes in the airline industry training, it is essential for universities and colleges, whose mission it is to train pilots and prepare them for the work force, to integrate CRM concepts into their curriculums. The purpose of this study was to develop a syllabus, for a course to implement CRM concepts in the Aviation/Management curriculum.

19. Mudge, S. (1996, August). Repackaged CRM discussion of the June 1996 article, advanced CRM. [On-Line]. Business and Commercial Aviation, 79, 13-14.
Abstract from: Silverplatter: File Applied Sci and Tech Abs Item: 96051290
Abstract: In a discussion of the June 1996 article by Perry Bradley on "Advanced CRM", the writer presents some additional information on the advanced CRM course being developed by the Federal Aviation Administration at Atlantic Coast Airlines.

20. Parke, B. R. (1995, January). CRM update. [On-line]. Business and Commercial Aviation, 76, 70-76.
Abstract from: InfoTrac File: Business Index Item: A16565338
Abstract: Today, the aim of crew resource management (CRM) training is to broaden the influence of crewmembers on the flight deck in a positive way. Pilots are advised to be receptive and open-minded without signaling weakness in authority. Crewmembers learn to be involved without losing awareness of who is in charge. There are 4 steps in instituting CRM in flight departments: learning, using, teaching, and inspecting. A sign of the commitment of some corporate aviation flight departments to CRM principles is the fact that some managers evaluate new hires as to their sympathy for and understanding of CRM. Operators committed to CRM often cite examples of how the procedure has been used to great advantage in certain incidents.

7

21. Smith, C. B. (1996, September 2). Douglas plans to expand tailored training approach. Aviation Week & Space Technology, 145, 145-146.
Abstract: Douglas Aircraft Co. plans to broaden its pilot training program to include instruction early in the process that places greater emphasis on crew responses to aircraft problems. The initial Advanced Qualification Program training, which is expected to be introduced with the MD-95, is designed to focus early on crew interaction and the processes used to respond to aircraft problems. Crew resource management - which involves training in areas such as cockpit communications, stress management and team-building - will be folded into the new advanced training curriculum. Conventional training procedures also will be offered on the MD-95 and other Douglas models as the company continues its emphasis on tailoring flight crew training programs to meet the requirements and capabilities of its individual airline customers.

22. Sparaco, P. (1996, September 2). Airbus restructures CRM training. Aviation Week & Space Technology, 145, 133-137.
Abstract: Part of a special section on aerospace training. A wide-ranging effort by Airbus Industry to improve cockpit crew interaction with automated systems is concentrating more on practical know-how than on academic knowledge. The need for more refined training methods emerged slowly from in-service experience, which showed that automated transports had an excellent safety record, as well as a 99 percent dispatch reliability. The reasons for and format of Airbus's new crew resource management training are discussed.

23. Transport Canada. (1997, April, 20). Development of crew resource management training. [On-line]. Availability: http:// www. caar. db. erau. edu/crm/ resources/misc/trancan/trancan1. html
Abstract: This Crew Resource Management (CRM) course has been developed by Transport Canada. CRM is a concept involving three main elements: Indoctrination and awareness training, practice, feedback and recurrent training, continuing reinforcement. This CRM course and manual utilizes plain language in a non-technical format. Individual participation is imperative to gain maximum benefit from the course. The key to the success of a CRM program is the mutual respect and confidence that is created among crew members which fosters an environment that is conducive to openness, candor, and constructive critique. The result is a more professional performance due to the synergy that is achieved in the cockpit, thereby decreasing the risk of an accident or incident. Course Objectives: To gain a greater awareness of the concepts, philosophies and objectives of resource management training, to enable participants to utilize more resource management tools and to enhance participants' abilities to utilize their most valuable resource.

24. Turney, M. A. (1994). Women's learning and leadership styles: Impact on crew resource management. [On-line]. Abstract from: Silverplatter File: Eric Item: ED 377347
Abstract: With an increasing number of women becoming members of flight crews, the leadership styles of men and women are at issue. A study explored three basic questions: (1) How do male and female learning and leadership styles differ? (2) What barriers to gender integration and crew teamwork are perceived by pilot crewmembers? and (3) What recommendations can be made to support improved Crew Resource Management (CRM) training programs? A review of the literature revealed three important areas of research: women's learning styles, women's leadership characteristics, and recent research in CRM. The literature showed that men prefer debate-like learning situations, whereas women like to share and learn by interacting in a collegial manner. As leaders, women are often perceived as acting inappropriately if they put their professions first, or if they do not offer emotional support, according to the literature. The literature also found that women are better at communicating a skill that should be stressed in CRM programs. The study methodology included 19 interviews with airline, military, and corporate pilots of both genders in order to determine their perceptions concerning the research questions addressed in the study. After the interviews, three observations were made of CRM training sessions, using various male-female configurations of the training groups. Results of the interviews showed that women were reported to have different styles and that they suffered as crew members because of lack of understanding of gender differences on the part of both women and men and because of the "macho" pilot image. Based on the information that emerged from the study, there is a need to provide training for crewmembers regarding differences between men and women in learning and leadership styles. Suggestions were made for changes in CRM instructional design.

Evolution of CRM Concepts from January 1993 to January 1998

The need to avoid human error induced accidents serves as the impetus of CRM evolution. More and more airlines realize the importance of extending CRM training beyond the flight crew to include air traffic controllers, aircraft dispatchers, maintenance personnel, and even groups such as passenger service agents, mid, and upper-level managers, and special crisis teams like hijack and bomb-threat teams (FAA 1995).

Merritt and Helmreich (1996) claimed that trainers and researchers are becoming more aware of the critical influence of national and organizational culture on the impact and effectiveness of CRM training. While some aspects of CRM are universally endorsed, e.g., briefings and coordination, large cultural differences have been observed in command styles, acknowledgment of stress, and attitudes toward the use of automation. According to the authors, the key to CRM's success is accommodation of the organizational context.

Turney (1994) reported that the result of her study showed that women have different learning and leadership styles and that they suffered as crew members because of a lack of understanding of gender differences on the part of both women and men and because of the "macho" pilot image. Based on information that emerged from the study, she recommended providing training for crewmembers regarding differences between men and women in learning and leadership styles and offered suggestions of how to orient CRM towards women.

Wiener (1996), a leading human factors researcher, stated that the aviation industry has assumed that the highly automated cockpit of the 1990s would remove human error. However, operational experience suggests that automation simply changes the nature of the error, and possibly increase the severity of its consequences. Therefore, CRM remains an important tool in reducing aviation accidents.

Human fallibility causes most aviation accidents. Wilhelm, Hines and Helmreich (1996) reported some disturbing research findings about human fallibility in regards to CRM training. They detected some slippage in the attitude of line pilots about CRM, erosion of recurrent training over time, the failure of CRM to "take" in several "non-Western" cultures, the low impact in some U. S. airlines, highly variable recurrent training quality, and most importantly pilots' denial of personal vulnerability. Their recommendations were to revisit the basic concepts of

CRM training, and to use audit/assessment techniques to verify training and evaluation.

Evolution of CRM concepts from January 1993 to January 1998

25. Aarons, N. R. (1996, February). The information flow begins. [On-line]. Business-and-Commercial-Aviation, 78, 71-72. Abstract from: InfoTrac File: Business Index Item: A18033270

Abstract: American Airlines flight 965 crashed while approaching Cali, Colombia, on Dec. 20, 1995, killing 156 people. Preliminary analyses of flight data recordings and air traffic control communications revealed no untoward occurrences, except for extended conversations between non-flight personnel. The analyses suggest that poor situational awareness and crew resource management may have contributed to the accident

26. Admit it. Crew resource management as a component of airline pilot training. (1996) [On-line]. Flight International, 150, 3-4. Abstract from: InfoTrac File: Business Index Item: A18989582

Abstract: A recent accident involving a Birgenair Boeing 757 brings to light the inadequacy of current airlines pilot training standards in meeting the demands of the rapidly-changing aircraft and air traffic environment. The report on Birgenair accident confirmed that the pilots, despite having attained their full commercial licenses, were not equipped with the knowledge necessary in emergency situations. In this regard, pilots must be required to take up crew resource management training before they fly airplanes.

27. Anca, M. J., & Sarmiento, M. C. (1995). CRM is in the heart of Asia. Manila, Philippines: Philippine Airlines.

Abstract: This paper provides a socio-historical framework within which to view CRM in the Philippines, particularly the moral ethos and hierarchy of the Filipino family which directly bear and impinge upon organizational culture, especially upon the attitudes towards authority and consequently even our patterns of communication. Our short disaster-filled history as a people also explains our personal proclivities vis a vis Stress Management which is largely managed through Divine Intervention;a unique Higher Power as only Filipinos can know. The discussions shall highlight findings from the Flight Management Attitudes Questionnaire and LOFT surveys spanning two years of research in CRM/LOFT effectiveness in Philippine Airlines.

9

28. Aviation crew resource management web site. (1998) [On-line]. availability: http://www. py. utex. . . /helmreich/acrm. htm

Abstract: They are rapidly putting resources for CRM program developers on the web. Developers are free to use these materials as long as they properly reference our group. Crew resource management: past, present and future will contain a short history of CRM, including the seminal references -- it will then describe current regulations, include links to FAA file archives, and provide links to extensions of CRM in other domains such as medicine. (c) Implementing Successful CRM: this section contains material focusing on how to tailor a program to specific organization, how to measure the effectiveness of your CRM program, and how to provide ongoing reinforcement of CRM skills.

29. Bailey, L. L. , & Shaw, R. V. (1996, September). Flight inspection crew resource management training needs analysis. [On-line]. Abstract from: Silverplatter: File NTIS Item: ADA3166915XSP

Abstract: On October 26, 1993, there was a fatal crash of a Federal Aviation Administration (FAA) flight inspection aircraft. During the accident investigation, the National Transportation Safety Board (NTSB) cited ineffective crew resource management (CRM) as one of the causal factors and recommended CRM training for flight inspection aircrews. As part of the FAA's response to the NTSB recommendation, a CRM training needs analysis was conducted. Cluster analytic results of the identified training needs suggested three categories affecting crew performance: (1) technical skills, (2) crew coordination skills, and (3) the organization context in which flight inspection crews perform. Implications for CRM awareness training are discussed. The purpose of this report is to document the flight inspection CRM training needs that emerged from the analyses and to recommend steps for developing a flight

30. Barker, J. M. , Jr. Clothier, C. C. , Woody, J. R. , & McKinney, E. H. (1996). Crew resource management: A simulator study comparing fixed versus formed aircrew. Aviation, Space and Environmental Medicine, 67, 3-7.

Abstract: This research investigates the effect of crew formation policy on aircrew performance. The method used was a comparison of fixed aircrew to formed aircrews flying the same simulator mission scenario, which included an in-flight emergency. CRM behavioral data and error data were collected by trained observers for 17 crews, 9 fixed and 8 formed. The reported results showed that fixed crews committed more minor errors (4. 4 per mission), than

formed crews (2. 6 per mission). This can be expressed as t(14) = 2. 32, p = 0. 036. According to the results, no differences were found concerning major errors or CRM behavioral indicators. The researchers (Baker, Clothier, Woody, McKinney and Brown, 1994) concluded that the results suggest the possibility of a familiarity decline, where aircrew performance declines when crewmembers became too familiar with each other. This may affect flight safety.

31. Edward, H. P. (1997, April 14). Crew acted swiftly in FedEx DC-10 fire. [On-line]. Aviation Week & Space Technology, 146, 32-35. Abstract from: InfoTrac File: Business Index Item: A19327451

Abstract: Quick action by the flight crew and effective crew resource management were important factors in the safe landing of a burning Federal Express DC-10 in September 1996, according to reports issued by the National Safety Transportation Board. Safety board officials expect to conclude the investigation and issue a probable cause of the accident sometime in 1997. An account of the flight crew's response to the incident is provided.

32. Edward, H. P. (1996, May 20). CRM focus of FAA's commuter rule. [On-line]. Aviation-Week-and-Space-Technology, 144, 61-65. Abstract from : Silverplatter File: Applied Sci & Tech Abs Item: 96033590

Abstract: Upgraded pilot training and the increased use of flight simulators are major changes facing regional airline operators making the move to Part 121 standards, as required by the FAA's commuter rule. The new rule, intended to create a single level of safety throughout the American airline industry, becomes effective in March 1997. It requires aircraft that have ten or more passenger seats or that need two pilots to be re-certified to operate under the standards that govern major airlines and to implement CRM training. Though industry officials do not expect increased training expenses to become a key factor in the transition to Part 121 status, it will probably cost the regional airline operators between $250 million and $300 million to comply with the new training rules during the next ten years.

33. Edward, H. P. (1995, December 24). Eagle crash probe targets crew. Aviation Week & Space Technology, 142, 30-31.

Abstract: The NTSB's report on the Dec 13, 1994 crash of an American Eagle Jetstream Super 31 focuses on the captain's decision-making and CRM skills. The NTSB expects to determine a probable cause for the accident late

this summer.

34. Federal Aviation Administration. (1997). Human factors: FAA's guidance and oversight of pilot crew resource management training can be improved: Report to congressional requesters (Report No. GAO/RCED-98-7B-275381). Washington, DC: U. S. Government Printing Office.
Abstract: unavailable.

35. Fitzgerald, E. R. (1997, June). Call to action: We need a new safety engineering discipline. Professional Safety, 42, 41-44.
Abstract: Human error still plagues the safety of commercial aircraft. Although human factors and system safety engineering have made great strides in improving the design of modern aircraft, both fields need to be integrated into a new discipline. In addition, the behavioral sciences must be challenged to fully contribute in order to ensure that new aircraft designs fully account for human behavior.
To address human error in aviation, the US Federal Aviation Administration has prescribed crew resource management (CRM). Several accidents have proven that CRM can improve the level of safety in airline operations.

36. Hanson, M. A. (1996). Examining the feasibility of applying the critical incident technique to enhance crew resource management (CRM) training. Texas: Amstrong Laboratory.
Abstract: unavailable.

37. Helmreich, L. R. (1996, October 31). The evolution of crew resource management. Austin, Texas: University of Texas at Austin, Department of Psychology Aerospace.
Abstract: The roots of Crew Resource Management training in the United States are usually traced back to a workshop sponsored by the National Aeronautics and Space Administration (NASA) in 1979. This workshop, called Resource Management on the Flight-deck (Cooper, White & Lauber, 1980), was the outgrowth of NASA research into the causes of air transport accidents. The research presented at this meeting identified the human error aspects of the majority of air crashes as failures of interpersonal communications, decision making, and leadership. At this meeting, the label Cockpit Resource Management (CRM) was applied to the process of training crews to reduce "pilot error" by making better use of the human resources on the flight-deck. Many of the air carriers represented at this meeting left committed to developing new training programs to enhance the team aspects of flight operations. Since that time CRM training programs have proliferated in the United States and around the world. Approaches to CRM have also evolved in the years since the NASA meeting. The focus of this paper is on the generations of CRM training that reflect this evolution and on the problems that have been encountered in changing the attitudes and behavior of flight crews.

38. Jansen, A. (1996). Altus crew saves C-141 using crew resource management. [On-line]. Abstract from: FirstSearch File: Periodical Abstracts Item: N96108592XSP
Abstract: An air crew on a training flight from Altus AFB used crew resource management to save a C-141, when the cowling on the number four engine had separated from its attachment fasteners, causing it to buckle and bend severely in the airstream. They decided to take a right seat, three-engine, no-flap approach to landing.

39. Jensen S. R. (1996). Pilot judgement and crew resource management. [On-line]. Availability: http://www. amazon. com/exee/obidos/ISBN%D0291398049/theindustrymdca
Abstract: Human judgment error is now recognized as the major cause of aviation accidents. This volume provides a comprehensive discussion of how to reduce errors among pilots, with 14 chapters covering various theoretical approaches as well as such practical issues as crew resource management; stress, fatigue, and nutrition; and risk management. Contents: instruction to judgment error, judgment models, rational judgment, motivational judgment, can judgment be taught?, crew resource management, stress and relaxation, teaching pilot judgment, the assessment of pilot judgment, complacency, risk management in aviation, management factors in pilot judgment, special applications: ballooning and gliding.

40. LaSalle, R. (1995, October). CRM toolbox for pilots. [On-line]. Business-and-Commercial-Aviation, 77, 88-90. Abstract from: Silverplatter File: Applied Sci and Tech Abs Item: 95066039
Abstract: One way for flight-crew members to play an active role in implementing crew resource management (CRM) is to develop a set of standard CRM "tools" for use on the flight deck. Poor crew coordination and a lack of CRM are cited as contributing factors in aircraft accidents by several National Transportation Safety Board reports.

A verbal CRM tool-kit can be developed for pilots, the idea being to use a handful of standard verbal cues that automatically alert crew members to the need to improve crew coordination. If a situation develops, pilots can reach into their "toolbox" for a tool that starts the CRM process or keeps it going. The result should be better crew coordination and safer operations.

41. Manningham, D. (1996, July). Persecuted passengers. [On-line]. Business & Commercial Aviation, 79, 56-60. Abstract from: InfoTrac File: Business Index Item: A18591999
Abstract: A 747 pilot talks about the lessons he learned after the United Airlines plane he was supposed to fly experienced engine trouble and became stuck in a snow bank. He realizes that crew resource management is essential, during problem situations, to coordinate properly with airport, maintenance and airlines personnel, as well as passengers. He also learned that passengers express different reactions to delayed flights.

42. Merritt, A. , & Helmreich, L. R. (1995, November 20). CRM in 1995: where to from here? Austin, Texas: University of Texas at Austin, Department of Psychology Aerospace.
Abstract: Since its inception as a training intervention for American pilots, CRM has grown. No-one has foreseen how far CRM would progress in its brief history. CRM is now mandated training in many countries, for pilots and in some instances flight attendants, maintenance personnel, and dispatchers. There is a growing interest in this branch of Human Factors. CRM has pervaded a large sector of the aviation community. The article questions whether CRM may have been lost or at least confused in the burgeoning enthusiasm. Has CRM lost its meaning? Can there be a "one size fits all" CRM, and if so, what is it? Should CRM be customized for every new group? If so, how should the customization proceed? Do we have a clear CRM blueprint from which we can work? The factual history of the first 15 years of CRM is recounted. An architectural metaphor is adopted to understand the origins and development of CRM and to point the way to future research and development.

43. Muller, M. (1996). Training with a simulator--experiences in space flight. Langenbecks Arch Chir Suppl Kongressbd (BAD), 113, 53-56.
Abstract: High technology and automation have not been able to significantly improve flight safety within the last two decades. The main cause of aviation accidents was and is human error. Therefore, the most powerful tools to reduce risks in aviation deal with the human operator on the flight deck. Pilot selection, training and teamwork are of the utmost importance. The simulator is a valuable training aid. Simulation provides realistic scenarios that can be used to train optimal pilot behavior in emergency situations. Many complex abnormal situations can be only managed in teamwork. That is the reason why training programs for improved team behavior (crew resource management) are becoming more and more important.

44. Patterson, K. D. (1997). Barriers to communication in aviation: A foundation for crew resource management (Doctoral dissertation, Oklahoma state University, 1997). [On-line]. Availability: First search File: WorldCat.
Abstract: unavailable.

45. Reinhart, O. R. (1996, November). CRM is evolving. Aviation Week & Space Technology, 262, 60-64.
Abstract: Experts serving as panelists at the 6th crew resource management (CRM) workshop in Charlotte, NC, talked about the wide range of skills covered by the CRM concept. They stated that CRM is steadily evolving into an operational issue that must be addressed not only through classroom studies but through line-oriented flight training as well. They also discussed the importance of advanced CRM, which emphasizes behavior-focused intervention instead of attitude-focused intervention.

46. Reinhart, O. R. (1994, February). The human factors of CRM. BCA Magazine, 75, 25-28.
Abstract: This article is an introduction to CRM. CRM is an operational philosophy, a means of doing things, and like the generic term "safety", it is built around people working with people in unpredictable situations to ensure safe and productive performance. CRM is an ongoing, reinforced program for enhancing personal skills. The International Civil Aviation Organization (ICAO) defines CRM as ". . . the effective use of all available resources, i. e. equipment, procedures and people, to achieve safe and efficient flight operations. " The FAA uses the same definition and adds "CRM training has been conceived to prevent aviation accidents by improving crew performance through better crew coordination. " Again, like the concept of safety, CRM is difficult to be very specific about.

47. Smith, G. M. (1995). Evaluating self-analysis as a strategy for learning crew resource management (CRM) in undergraduate flight training. (Doctoral Dissertation, Montana State University, 1995). Dissertation Abstracts International, 55 (07), AAC 9428995.

Abstract: Smith, in his EDD dissertation, evaluated self-analysis as a strategy for learning CRM in undergraduate flight training. His study attempted to determine if undergraduate flight students could effectively learn CRM skills by using self-analysis of Line-Oriented Flight Training (LOFT) as a debriefing strategy, despite their inexperience with crew operations. The method used was to randomly insert self-analysis into the subjects training using an alternating research design. Crew effectiveness was assessed by measurements of crew attitudes, observations by trained observers, crew reflections on their performance, and communications analysis. The results showed that at least one self-analysis session was effective for each crew and overall gains were noted for two of the five crews. The researcher indicated that self-analysis was effective when crews had the prerequisite technical skills and ineffective if technical skills were lacking or if the scenario was too complex. The results suggests that self-analysis should not be applied universally in undergraduate flight training, but is a valuable supplementary strategy to focus attention on personalities, roles, team dynamics, or specific CRM skills.

48. Vollmar, P. J., Jr. (1997). Crew resource management in aviation. [On-line]. Availability: First search File: WorldCat.
Abstract: unavailable.

49. Wardlaw, S. A. (1995). Crew resource management development training for the non integrated flight crew of the Civil Air Patrol (Master dissertation, Oklahoma state University, 1995). [On-line]. Availability: First search File: WorldCat.
Abstract: unavailable.

50. What is CRM and where can I learn more about it? (1995). [On-line]. Business & Commercial Aviation, 76, 72-73. Abstract from: InfoTrac File: Business Index Item: A16565342
Abstract: Crew resource management is a new type of pilot-training program. CRM encourages the participation of crewmembers in ensuring the safety of a flight, and to prepare and train them to effectively respond to critical situation. The program delegates the pilot-in-command as the leader of the teams and the airlines crew including flight attendants as the members. It also recommends the involvement of air traffic control officials and people controlling ground stations in the decision-making process.

51. Wiener, L. E., Kanki, G. B., & Helmreich, L. R.

(1993). Cockpit resource management. Austin, Texas: University of Texas at Austin, Department of Psychology Aerospace.
Abstract: This text draws together material from a group of authors with backgrounds in academia, government, and private enterprise. They represent the diversity of the research, activities, and organizational experience of CRM. Discussed is the psychology of decision-making and general training issues. Intended readers are not only those who specifically want to know about CRM, but also those keen to find out about flight deck or avionics issues in general. Descriptions of specific communication practices help to achieve particular task goals. Examples of National Transportation Safety Board accident reports are brought and incident reports. Discussed: early communication research, functions of communication (informational, interpersonal /expressive, establishing predictable behavior, maintaining task attention and situation awareness, managerial/directive function). Discussed communication skills training within CRM.

52. Wiener, P. (1996). Crew resource management. University of Central Florida, Institute for Simulation.
Abstract: Wiener, a leading human factors researcher at the University of Miami at Coral Gables, Florida, states that many in the aviation industry have assumed that automation would remove human error, however, operational experience suggests that automation simply changes the nature of the error, and possibly increases the severity of its consequences. Therefore, CRM remains an important tool in reducing aviation accidents.

53. Wilhelm, A. J., & Helmreich, L. R. (1996, April). CRM and culture. Austin, Texas: University of Texas at Austin, Department of Psychology Aerospace.
Abstract: The multiple cultures that influence pilot behavior and the ability of cultures to deflect or enhance the impact of CRM training are described. A new, Fifth Generation model of CRM training based on the management of human error is presented. Organizational actions necessary to make the new approach to CRM work are delineated. A conceptual model of the relationships between national, professional, organizational, safety cultures, CRM and crew performance is postulated.

54. Wilhelm, A. J., Hines, W., & Helmreich, L. R. (1996, September 18). Issues in crew resource management and automation use. Austin, Texas: University of Texas at Austin, Department of Psychology

Aerospace.

Abstract: Historical Progress of CRM skills and objectives are detailed at a higher level of specificity. Specific behavioral goals, and objectives, by phase of flight, has made CRM more concrete and observable. The authors pointed out some disturbing research findings. After years of continuous improvement, the authors detected some backward movement: 1) some slippage in attitude of line pilots about CRM, 2) airman and organizational resistance to CRM, 3) erosion of recurrent training over time, 4) failures of CRM to "take" in several "non-Western" cultures, 5) low impact in some US airlines, 6) LOFT and recurrent training was highly variable in quality, 7) pilots denied personal vulnerability. Recommendations: Revisit the basic concepts of CRM in training, and use audit/assessment techniques to verify training and evaluation.

Methods of Measuring CRM Skills

A new challenge for CRM developers and training facilitators is how to measure CRM skills. According to Law and Sherman (1996), the measurement of CRM skills is a controversial task. Both the FAA and the European Union are calling for reliable measurement of CRM skills. However, empirical data regarding the reliability and validity of such assessment are questionable. Assessing the quality of crew briefings, planning, workload distribution, vigilance, and overall crew effectiveness requires CRM evaluators to make subjective judgments. Their paper discussed what it means to "reliably" measure crew behavior using trained observers.

Law and Sherman (1996) investigated the question of whether two independent evaluators observing the same crew would give them the same CRM ratings. They offered a practical index for measuring degree of agreement of CRM skill ratings during evaluator training. They also provided a strategy for studying and enhancing inter-rater agreement of CRM evaluators.

The FAA may mandate the Advanced Qualification Program (AQP) as a CRM skill measurement tool. The AQP spells out the specific skills in which an air transport pilot must be competent to perform safely and effectively. The AQP also integrates CRM training and measures pilots' performance in this area (Hughes, 1996).

Methods of Measuring CRM Skills

55. Hughes, D. (1996, January 16). FAA may make AQP mandatory. Aviation Week & Space Technology, 142, 27-

29.

Abstract: Recently the FAA's shift toward acceptance of the Advanced Qualification Program (AQP) training philosophy is helping U. S. carriers to develop more efficient and focused training programs. The AQP that may become mandatory by the FAA spells out the specific skills in which an air transport pilot must be competent to perform safely and effectively. AQP integrates CRM training and measures pilots performance in this area.

56. Law, J. R. , & Sherman, P. J. (1996). Do raters agree? Assessing inter-rater agreement in the evaluation of air crew resource management skills. Austin, Texas: University of Texas at Austin, Department of Psychology Aerospace.
Abstract: The measurement of CRM skills is a controversial task. Both the FAA and the European Union are calling for the reliable measurement of CRM skills, however, empirical data regarding the reliability and validity of such assessment are sparse. Assessing the quality of crew briefings, planning, workload distribution, vigilance, and overall crew effectiveness requires CRM evaluators to make an array of subjective judgments. Would two independent evaluators observing the same crew give them the same ratings? This paper first discusses what it means to "reliably" measure crew behavior using trained observers. The second section introduces a practical index for measuring the degree of agreement of CRM skill ratings during evaluator training. Finally, a strategy for studying and enhancing inter-rater agreement of CRM evaluators is discussed.

Various Applications of CRM

According to Bonney (1996), aviation CRM training can be applied to other organizations and industries because it is appropriate for team-driven work-groups in a dynamic work environment. For example, the UK's Royal Air Force and the Royal Australian Air Force are among the first in the world to adopt and modify CRM training to suit military needs. Military facilitators who have begun implementing CRM are optimistic it would have a significant impact on their operations (Leamount, 1995). US Air Force CRM Instruction (1994) mandated CRM training for all aircrew members. It noted that Naval aviation recognized a need for CRM training, but elected to call the training Aircrew Coordination Training (ATC).

According to the authors (Gayman, Gentner, Canaras, & Crissey, 1996), the application of CRM principles to tank

crews may increase mission effectiveness and operational safety. Several factors support the application of CRM principles to tank crews. These factors include increases in automation, the criticality of shared perceptions, possible information overload, and increasing requirements for team decision-making on the digital battlefield. They concluded that it is an appropriate time to develop a comprehensive strategy for the implementation of CRM tanks crew training.

In 1993 Howard, Gaba, Fish, and Yang have developed a course for physicians named Anesthesia Crisis Resource Management (ACRM) which is analogous to courses in aviation crew resource management (CRM). The rational is that anesthesiologists do not receive formal training in crisis management although they are expected to manage life-threatening crises at a moment's notice.

Finally, Flin (1995) reported about a crew resource management-training program for teams in the offshore oil industry. He stated that CRM courses are also being used in shipping, medicine, and the nuclear power industry. He described CRM application to the offshore oil industry, which includes control room operators and emergency command teams.

Various Applications of CRM

57. Bonney, J. (1996, November). High performance teams: Lessons from the cockpit. [On-line]. <u>Organizations & people, 3,</u> 34-38. Abstract from: InfoTrac File: Business Index Item: A188964336
Abstract: The airline industry's Crew Resource Management training program is designed to enhance management practices in the event of an emergency. It is applicable to other organizations and industries because it is appropriate for team-driven work-groups in a dynamic work environment. The McKinsey 7-S framework and flight performance models are described.

58. <u>Cockpit/crew resource management program, Air Force Instruction.</u> (1994). [On-line]. Availability: http://ott. sc. ist. u. . . 1_1/2_1/index. htm
Abstract: The Air Force requires CRM training for all aircrew members. Naval aviation recognized a need for CRM training, but chose to call the training Aircrew Coordination Training, (ATC). This report offers an introduction to crew resource management for the U. S. Air Force.

59. Collins, L. R. (1996, April). The solo crew: Flight resource management for the single pilot. [On-line]. <u>Flying, 123,</u> 92-94. Abstract from: WWW File: http://medusa. prod. . . . htm%22:/fstxt59. htm
Abstract: Airplanes with crews tend to have much better safety records than those flown by single pilots. This article discusses flight resource management techniques for use by the single pilot.

60. Flin, H. R. (1995, September). Crew resource management for teams in the offshore oil industry. [On-line]. <u>Journal of European Industrial Training, 19,</u> 23-27. Abstract from: InfoTrac File: Business Index Item: A17594252
Abstract: The international aviation industry uses a special form of human factors training with their flight deck crews and other teams called crew resource management (CRM). CRM is designed by psychologists and pilots to reduce errors and accidents and to improve emergency response capability by improving teamwork skills. Key topics include communication, decision making, assertiveness, and stress management. CRM courses are now being used in shipping, medicine, and the nuclear power industry. An outline of CRM is followed, and an application in the offshore oil industry with control room operators and emergency command teams is described.

61. Gayman, A. J. , Gentner, F. C. , Canaras, S. A. , & Crissey, M. J. (1996, December). Implications of crew resource management (CRM) training for tank. [On-line]. Abstract from: Silverplatter File: NTIS Item: ADA3235900XSP
Abstract: Mission effectiveness of US Army tank crews may be enhanced by applying principles of Crew Resource Management (CRM). A recent study of the US Army Safety Center Database identified a number of tank accidents, particularly during non-combat operations, that involved deficiencies in crew coordination. In addition, data from the Center for Army Lessons Learned indicates that CRM may play a role in fratricide accidents. In the late 1970s, findings of crew coordination problems in aviation accidents created the impetus for mandated CRM training for aircrews. The purpose of this paper is to explore evidence of tank CRM-related problems and investigate the possible applications of aviation-derived CRM training to tank crews. CSERIAC's analysis of crew coordination-related tank accidents suggests that the application of CRM principles to tank crews may increase mission effectiveness and operational safety. Several factors support the application of CRM principles to tank

15

crews. These factors include increases in automation, the criticality of shared perceptions, possible information overload, and increasing requirements for team decision making on the digital battlefield. Developing a comprehensive strategy to improve tank CRM appears to be timely. Although surface similarities of aircraft and armor crews imply that CRM training courses could be directly applied from the air cockpit to the ground vehicle, it is important to understand the differences between these two crew environments and to appreciate the unique CRM needs of tank crews.

62. Howard, S. K., Gaba, D. M., Fish, K. J., & Yang, G. (1993, September). Anesthesia crisis resource management training: Teaching anesthesiologists to handle critical incidents. Sarnquist Aviat Space Environ Med, 63, 763-770.
Abstract: The authors have developed a course in Anesthesia Crisis Resource Management (ACRM) analogous to courses in Crew (Cock-pit) Resource Management (CRM) conducted in commercial and military aviation. Anesthesiologists do not typically receive formal training in crisis management although they are called upon to manage life-threatening crises at a moment's notice. Two model demonstration courses in ACRM were conducted using a realistic anesthesia simulation system to test the feasibility and acceptance of this kind of training. Anesthesiologists received didactic instruction in dynamic decision-making, human performance issues in anesthesia, and in the principles of anesthesia crisis.

63. Learmount, D. (1996, June 12). Resource tuning. [On-line]. Flight International, 149, 33-35. Abstract from: InfoTrac File: Business Index Item: A18515480
Abstract: The crew resource management (CRM) concept has been successfully applied as a training method to improve flight deck efficiency in general aviation operations. CRM puts importance on human factors in performance. CRM trains pilots with varying backgrounds to work in harmony with each other. It also strengthens the link between abstract concepts and actual practice.

64. Learmount, D., Lopaz, R., & Phelan, P. (1995, August 16). Safety resource management. [On-line]. Flight International, 148, 33-37. Abstract from: InfoTrac File: Business Index Item: A17389725
Abstract: Crew resource management (CRM) is fast gaining popularity among military aviation flight-safety officials because of its contribution to accident reduction in the civil aviation arena. The UK's Royal Air Force and the Royal Australian Air Force are among the first in the world to adopt and modify the practice to suit military needs. Whether CRM will equally be effective in military aviation remains uncertain, but military officials who have begun implementing it are optimistic that it would have a significant impact on their operations.

65. Santiago, M., Jr. (1996, April 26). Application of crew resource management and line oriented flight training concepts to general aviation flight training. between them. Phoenix, Arizona: Arizona State University.
Abstract: This paper explores the major differences between airline style flight training and general aviation flight training with respect to Crew Resource Management (CRM) principals. It defines what CRM is and how it is currently applied through the use of Line Oriented Flight Training. The paper discusses the current discontinuity between the two broad aviation sectors with respect to the training philosophies, and attempts to explore ways of closing the aviation gap that outlines how solo pilots can gain the principles of CRM to improve flying proficiency and avoid accidents.

66. Turner, P. T. (1995, July 1). Cockpit resource management: The private pilot's guide. New York: McGraw-Hill.
Abstract: Cockpit Resource Management (CRM) has been used successfully by airlines and corporate flight departments to increase safety, but if you're a single-operator private or commercial pilot, chances are you know little about it. In this guide, you have a manual

CONCLUSION

The authors would like to say that the totality of Crew Resource Management publishing has been covered and that our goals of locating the best and the brightest of the stage four evolutionary process have been met. But, we recognize that the listings in this article do not include every scholarly article published during the sited time frame. Therefore, much remains to be accomplished if a compendium of CRM specific sources to come to fruition. This research article is only a beginning. It is hoped that this undertaking will act as an impetus to the development of more comprehensive listings towards the totality of the CRM topic. The newness and urgency of this field of study creates such a vacuum.□

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19

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21