



Evaluating self-analysis as a strategy for learning crew resource management (CRM) in undergraduate flight training
by Guy Mario Smith

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education
Montana State University
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Abstract:

Crew Resource Management (CRM) is training in crew coordination and teamwork. CRM was added to airline programs in the late 1970's because it became evident that human performance was a significant contributor to aviation accidents. In pilot preparatory programs, emphasis is usually placed on individual performance and crew skills are not addressed until airline training. College aviation programs are in a unique position to include CRM training in the curriculum to meet industry demands for pilots with a high degree of competence in interpersonal skills. CRM training is usually a student's first exposure to crew operations, requiring the college to modify airline training procedures to create meaningful learning for inexperienced pilots. Modern simulators have transformed airline training because full-mission simulation or Line-Oriented Flight Training (LOFT) allows airline training departments to reproduce the line, or operational, environment in the simulator. Research with airline pilots has found that LOFT was most effective for teaching CRM and that LOFT was best when airline crews debriefed themselves using self-analysis to evaluate their CRM performance. The study sought to determine if undergraduate flight students could effectively learn CRM skills by using self-analysis of LOFT as a debriefing strategy, despite their inexperience with crew operations. Eight men and two women, paired into five flight crews, completed CRM and LOFT training. Self-analysis was randomly inserted into their training using an alternating treatments research design. Crew effectiveness was assessed by measurements of crew attitudes, observations by trained observers, crew reflections on their performance, and communications analysis. It was found that at least one self-analysis session was effective for each crew and overall gains were noted for two of the five crews. Self-analysis was effective when crews had the prerequisite technical skills and was ineffective if technical skills were lacking or if the scenario was too complex. Results suggest that self-analysis should not be applied universally in undergraduate flight training, but it is a valuable supplementary strategy to focus attention on personalities, roles, team dynamics, or specific CRM skills.

EVALUATING SELF-ANALYSIS AS A STRATEGY FOR LEARNING
CREW RESOURCE MANAGEMENT (CRM) IN
UNDERGRADUATE FLIGHT TRAINING

by

Guy Mario Smith

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Doctor of Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

April, 1994

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ABSTRACT

Crew Resource Management (CRM) is training in crew coordination and teamwork. CRM was added to airline programs in the late 1970's because it became evident that human performance was a significant contributor to aviation accidents. In pilot preparatory programs, emphasis is usually placed on individual performance and crew skills are not addressed until airline training. College aviation programs are in a unique position to include CRM training in the curriculum to meet industry demands for pilots with a high degree of competence in interpersonal skills. CRM training is usually a student's first exposure to crew operations, requiring the college to modify airline training procedures to create meaningful learning for inexperienced pilots. Modern simulators have transformed airline training because full-mission simulation or Line-Oriented Flight Training (LOFT) allows airline training departments to reproduce the line, or operational, environment in the simulator. Research with airline pilots has found that LOFT was most effective for teaching CRM and that LOFT was best when airline crews debriefed themselves using self-analysis to evaluate their CRM performance. The study sought to determine if undergraduate flight students could effectively learn CRM skills by using self-analysis of LOFT as a debriefing strategy, despite their inexperience with crew operations. Eight men and two women, paired into five flight crews, completed CRM and LOFT training. Self-analysis was randomly inserted into their training using an alternating treatments research design. Crew effectiveness was assessed by measurements of crew attitudes, observations by trained observers, crew reflections on their performance, and communications analysis. It was found that at least one self-analysis session was effective for each crew and overall gains were noted for two of the five crews. Self-analysis was effective when crews had the prerequisite technical skills and was ineffective if technical skills were lacking or if the scenario was too complex. Results suggest that self-analysis should not be applied universally in undergraduate flight training, but it is a valuable supplementary strategy to focus attention on personalities, roles, team dynamics, or specific CRM skills.

CHAPTER 1

INTRODUCTION

Modern aircraft, loaded with computers and automation, demand highly trained pilots with finely tuned motor skills, the ability to follow involved procedures, and an extensive information base. As technology places additional demands on pilot skills and airmanship, the milieu of cognitive, behavioral, social, and organizational psychology requires more pilot education in interpersonal and teamwork skills. Statistics on the causes of accidents from 1959 to 1989 indicate that flight crew actions were causal in more than 70% of worldwide accidents in the public transport sector (Helmreich & Foushee, 1993). Recognition that human performance is as vital to aircraft operations as technical proficiency caused airlines to regard team skills as a vital part of the pilot selection and training process. The ideal airline candidate is a technical expert and a master of teamwork. For most of this century, however, pilot selection and training was based on technical proficiency alone. Airlines recognized this deficiency and have made substantial investments into human factors research, resulting in the development of advanced aircrew training programs such as Crew Resource Management (CRM).

It is argued that CRM is advanced training, not appropriate for beginning students who should concentrate on "stick and rudder" skills. Others contend that

teamwork is an indispensable pilot skill and that it is a disservice to students to postpone crew training until they reach the airlines (Trollip & Jensen, 1991). European "ab initio" programs, where nonpilots are taught from the beginning to be airline pilots, have successfully included CRM in initial flight training for years (Nash, 1992). College aviation programs are in a unique position to develop effective CRM training for initial flight students.

In 1993, the Federal Aviation Administration (FAA) published three guidelines for an effective CRM program for airlines operating under Federal Aviation Regulations (FAR) Parts 121 and 135:

1. The course content should emphasize the CRM skills.
2. Students should experience and practice these skills.
3. Students should get feedback on their CRM performance.

To apply these guidelines to undergraduate flight students, a "content" model, concerned with transmitting information and skills, was insufficient. An experiential or "process" model, concerned with providing resources to help learners acquire CRM skills, was required. Moreover, to evaluate the outcomes of this model, the primary effectiveness measure had to be "performance." There are numerous CRM instructional methods to choose from. Of the 16 listed in Sams (1987), the most effective for airline pilots was Line-Oriented Flight Training (LOFT), an experiential-learning method in which flight crews fly a complete scenario in a high fidelity simulator in real time. Airlines have achieved striking results with LOFT, but systematic research is necessary to ensure that LOFT is

equally effective for teaching CRM to undergraduate students. For most undergraduates, LOFT training is their first exposure to nonroutine, high-stress, high-workload, and emergency situations which require teamwork.

Self-analysis of LOFT, in which the debriefing is lead by the crew themselves, has been a highly effective technique for improving CRM performance in airline pilots (Butler, 1993). Self-analysis is a discovery-learning strategy based on the Theory of Objective Self-Awareness (Duval & Wicklund, 1972), which proposes that self-focusing stimuli often force objective appraisals of oneself that may lead to attitude and behavior changes. For college crews, self-analysis could give powerful insights into their CRM performance, offsetting some of their inexperience (Duval, Duval, & Mulilis, 1992).

To expand technical skills into higher-order CRM skills, students must be actively involved in each stage of the learning process (Bonwell & Eison, 1991). Active-learning theory implied that learning CRM in a classroom was not sufficient; students had to gain practical experience with the CRM skills in a crew setting. Active-learning strategies, especially LOFT and self-analysis, were employed in a college CRM training program which progressed through three distinct phases: learning sessions where CRM skills were introduced, practice sessions where CRM skills were exercised, and feedback sessions where behaviors were reinforced or corrected.

Purpose Statement

The purpose of this study was to determine if undergraduate flight students could learn Crew Resource Management (CRM) through self-analysis of Line-Oriented Flight Training (LOFT) despite their inexperience with crew operations.

Significance of the Study

This study concerns CRM and LOFT training at the undergraduate level with flight students who have no experience with crew procedures. It cannot be assumed that any of the results gathered from airline pilots are applicable to college flight students because of the vast differences in their technical and crew experiences. When designing CRM training for undergraduate flight students, many of the issues already explored by airline researchers should be re-examined. This study was limited in scope to only one facet of teaching strategies: Could undergraduate flight students learn CRM through self-analysis of LOFT despite their inexperience with crew operations?

The philosophy underlying CRM training is that heightened awareness of CRM skills will produce tangible behavior change in cockpit performance. The fact is that these principles and techniques are being "preached as the gospel" without much research dealing with the evaluation or relative efficacy of such programs (Foushee & Helmreich, 1988). Beyond the goal of developing awareness of teamwork skills, the bottom line is that continued research is necessary to ensure

that CRM and LOFT training are applicable to aviation safety (Lofaro, 1990).

Awareness of CRM skills can be taught in the classroom and knowledge can be assessed. But, if the goal is to teach students how to use CRM skills and to evaluate their effectiveness, students must actually fly. LOFT allows undergraduate flight students to experience the crew environment many years before envisioned.

Validation of the effectiveness of LOFT in crew coordination and resource management requires proof that it produces the desired outcomes: increased teamwork, reduced pilot errors, and ultimately enhanced safety. "The critical research task becomes the determination of the relative effectiveness of different instructional techniques and the development of more effective ones" (Foushee & Helmreich, 1988, p. 224). There is already evidence that personality and attitudes are linked to pilot performance, including crew management (Cook, 1991).

Whereas personality traits are considered stabilized and only marginally affected by training, crew attitudes are less stable and are responsive to change through training and experiences. Therefore, if CRM training and especially LOFT are to be effective in changing pilot's attitudes, they must have a positive effect on actual cockpit management and flight performance. Group investigations generally concentrate on attitudes, on output, or on performance factors. They commonly ignore the process variables linking the training program to the outcomes (Foushee & Helmreich, 1988).

Measuring attitudes is only an indirect assessment of effectiveness. "The effect of crew attitudes on process variables and line performance remain issues in

need of further investigation" (Gregorich, Helmreich, & Wilhelm, 1990). An important question is whether changes in attitude as a result of CRM training actually result in increased crew effectiveness. Irwin (1991) notes that it is difficult to examine this link in air transport environments because organizations rarely permit the acquisition of the types of data needed for investigation. However, with college flight students, there are fewer apprehensions that performance information could threaten their status as airline pilots (Foushee & Helmreich, 1988). The issue of assessment may be addressed in this environment where it is acceptable to gather attitude and behavioral data at an individual level.

Airlines struggle with the problem of CRM failures, those crew members who are unable or unwilling to adopt CRM concepts. "What do individual crew members and organizations do when confronted with the individual who represents a continuing threat to safety because of poor resource management practices?" (Helmreich & Wilhelm, 1989). CRM training and evaluation at the undergraduate level could help to revise the career choices of untrainable students and provide an input into their career selection process. Once linkages between attitudes, effectiveness, and performance are better understood, selection of students for airline training can be based on superior rankings in these areas. Traditional approaches to psychological screening have focused on "selecting out" those few individuals who showed signs of psychopathology (Gregorich, Helmreich, Wilhelm, & Chidester, 1989). Equivalent measures could be taken towards "selecting in" individuals who demonstrate superior performance in undergraduate CRM and LOFT training.

Research Questions

1. Does self-analysis of LOFT change undergraduate flight students' attitudes as measured by the Cockpit Management Attitudes Questionnaire (CMAQ)?
2. Does self-analysis of LOFT change undergraduate flight crews' effectiveness as measured by the LINE/LOS Checklist?
3. Does self-analysis of LOFT change undergraduate flight crews' reactions to CRM training as measured by the CRM Survey?
4. Does self-analysis of LOFT change undergraduate flight crews' performance of CRM skills as measured by Communications Analysis?
5. Are there factors or circumstances that strengthen or inhibit the learning of CRM skills by self-analysis?

General Procedures

The research was essentially five single-subject experiments, each conducted with one flight crew composed of two undergraduate students. The performance of each crew was analyzed independently, similar to case study research. Due to the small number of students involved, comparisons between crews was only speculative and non-inferential.

Each crew received five lessons in CRM with each lesson focusing on a specific CRM skill. CRM lessons were taught using active learning strategies which required students to be actively involved in each stage of the learning process

(Bonwell & Eison, 1991). Each lesson progressed through three distinct phases: a learning session where the CRM skill was introduced, a practice session where the CRM skill was exercised in the LOFT simulator, and a debriefing session where specific behaviors were reinforced or corrected. Learning and practice sessions were the same throughout the five lessons, but two distinctly different debriefing methods were employed. When conventional or traditional debriefing was used, the instructor provided the majority of the input while the students were basically passive recipients (Butler, 1993). When self-analysis debriefing was used, the crew themselves conducted the debriefing, and the instructor monitored the discovery-learning process (Butler, 1993). The crews were alternately exposed to conventional debriefing and self-analysis debriefing; multiple measurements were made after each lesson to determine if changes in effectiveness could be attributed to self-analysis debriefing.

Delimitations

Due to the size of the population, generalizability to any other population cannot be made. In this aspect, the study has the characteristics of a case study in that it attempts to describe outcomes in depth. According to Guba (1978), generalizability in a case study is left up to the reader who analyzes the findings of the reported case and generalizes to his own context, if appropriate.

Guba and Lincoln (1981) note a limitation of case studies that also pertains to single-subject designs: "Case studies can oversimplify or exaggerate a situation,

leading the reader to erroneous conclusions about the actual state of affairs" (p. 377). In this study, no global conclusions about the overall effectiveness of self-analysis can be drawn.

Because the number of participants was small, the quantitative data from the CMAQ, the LINE/LOS Checklist, the CRM Survey, and the Communications Analysis could not produce statistically significant results. Qualitative data from open-ended questions asking students what they had learned during CRM sessions were used to reinforce or diminish the findings.

Cockpits may have more diverse methods for communication than many other arenas. Due to the nature of information present and to the specialized training of pilots, crews can significantly interact in ways other than verbal such as gestures, pointing, body language, and adjusting instruments. Due to the nature of the data collection devices (videotapes and audio backup tapes), communications analysis ignored all non-verbal crew communications. However, significant non-verbal communications were noted in the instructor field notes.

A Frasca 142 two-place flight simulator was used for student LOFT training to emulate a typical two-place multi-engine aircraft. A limitation of the Frasca 142 simulator is that it does not provide displays and controls on the right side of the cockpit, requiring the co-pilot to share instruments with the pilot and occasionally to reach in front of the pilot to manipulate controls. In a typical aircraft of this type, the co-pilot would have some displays and controls on the right side of the cockpit, and the pilots would be able to swap flying duties. This limitation might

have affected decision making because some of the normal crew options were not available.

Definition of Terms

Ab initio Pilot Training: Pilot training programs that teach airline procedures from the beginning of training (Trollip & Jensen, 1991, pp. 9-15).

Active Learning: Instructional strategies that get students involved in doing things and thinking about what they are doing. To be actively involved, students must engage in higher-order thinking tasks such as analysis, synthesis, and evaluation (Bonwell & Eison, 1991).

Baseline Training: Conventional or traditional debriefing that was immediate, quantifiable, and objective where the instructors provided the majority of the input and students were basically passive recipients (Butler, 1993). Performance effectiveness after conventional debriefing provided the baseline measurements for this study.

Captain: The pilot designated to have overall responsibility for the flight crew actions and for the safety of the flight (Campbell & Bagshaw, 1991, p. 143). The Captain is often identified as the Pilot-in-Command or the Aircraft Commander. Normally the Captain sits in the left seat of an airplane's cockpit. X

Cooperative Learning: The instructional use of small groups so that students work together to maximize their own and each other's learning (Johnson, Johnson, & Smith, 1991). X

Co-pilot: The pilot designated to assist the Captain in flight deck responsibilities. Also known as the First Officer. Normally the co-pilot sits in the right seat of an airplane's cockpit. X

Crew Resource Management (CRM): The process of managing all resources for the benefit of flying an airplane safely. These resources may be on or off the airplane and include both humans and mechanical systems (Trollip & Jensen, 1991, p. G-3). The effective use of available human, technical, and information sources (Lauber & Foushee, 1983). In earlier literature, CRM meant Cockpit Resource Management. X

Crew: The essential people required to operate an aircraft. For this study, a crew consists of a Captain (left-seat pilot) and a Co-pilot (right-seat pilot) who share the flying duties. X

General Aviation: That portion of civil aviation which encompasses all facets of aviation except scheduled airlines and large aircraft commercial operators (AOPA, 1991).

Human Factors: The technology concerned to optimize the relationships between people and their activities by the systematic application of human sciences, integrated within the framework of system engineering (Edwards, 1988, p. 9). It is the study of how people interact with their environments (Trollip & Jensen, 1991, pp. 1-2).

Interpersonal Skills: The ability to work effectively as a team member and to build cooperative effort within a team as a leader (Butler, 1991).

Line: An aviation industry term that encompasses the total operational environment distinct from the training environment (Hawkins, 1987).

Line-Oriented Flight Training (LOFT): A flight training scenario in which flight crews fly a complete trip in a high-fidelity simulator. These flights are made in real time, and no intervention is made by the instructor regardless of the actions of the crew. LOFT is often an integral part of or a supplement to Crew Resource Management (CRM) training (Foushee & Helmreich, 1988, p. 221).

Line-Oriented Simulation (LOS): Same meaning as Line-Oriented Flight Training (LOFT). The term was developed to emphasize that the training occurred in a simulator and not in a line flight.

Mission-Oriented Simulator Training (MOST): The military counterpart of Line-Oriented Flight Training (Caro, 1988).

SHEL Model: The interrelationship between the three types of system resource (Software, Hardware, and Liveware) and their Environment (Edwards, 1988, p. 12).

Technical Skills: A pilot's knowledge of aircraft systems and an understanding of and proficiency in skills involving piloting procedures and techniques (Butler, 1991).

CHAPTER 2

LITERATURE REVIEW

Crew Resource Management (CRM)

Hawkins (1987) defines Crew Resource Management as the management and utilization of all the people, equipment, and information available on the aircraft. The concept originated from two conclusions: (a) that some accidents occur because the resources available are not adequately used, and (b) that sufficient resources were available to avoid the accident if they had been utilized in the optimum way.

Edwards (1972) developed a conceptual model that delineates the four types of resources available to the cockpit crew:

1. Software: Collection of documents which include rules, regulations, laws, orders, standard operating procedures, customs, practices, and habits.
2. Hardware: Physical property - the aircraft itself as well as terminals, vehicles, equipment, materials, and so forth.
3. Environment: Physical, economic, political, and social factors that affect the crew from outside the airplane.

4. Liveware: Humans involved - flight and cabin crew, passengers, controllers, aircraft and baggage handlers, and dispatchers.

These four system resources interact with each other; the relationships between them are represented in the model by their initial letters (SHEL) (Edwards, 1988).

Crew Resource Management is concerned with interactions between all four of these resources. The Liveware (Human) interactions, called "teamwork," constitute almost the entirety of CRM training courses, because successful interactions between other resources hinge on teamwork. Two central issues in implementing effective teamwork training are: (a) the specific skills (content) to be learned, and (b) the learning methodology (strategy) to gain the needed behavioral changes (Telfer & Biggs, 1988).

CRM Skills

A quality CRM program should identify the specific interpersonal skills that will be taught and evaluated. These group interaction (or teamwork) skills are distinctly different from the personal skills and technical skills that constitute the subject matter of undergraduate flight training. In CRM, students learn the dynamics of group interaction and how group members communicate with each other in order to coordinate their individual actions. Bolman (1979) proposes a "Theory of the Situation" which shows how various forces interact with each other in an attempt to gain an awareness of the situation. The following definitions are offered for the elements of this model:

1. Theory of the Situation: What you assume to be true, based on your perception of the facts you have at any point in time.
2. Reality: The situation as it is in the "real world" - often not fully known until after the fact.
3. Theory in Use: Your predictable behavior in a given situation that has been developed since birth.
4. Espoused Theory: Your account or explanation of your behavior.
5. Theory in Practice: The set of skills, knowledge, and experience you call upon according to your theory of the situation (Trollip & Jensen, 1991, pp. 9-17).

If the flight crew's assumptions are correct, safe flight decisions are likely; but if a discrepancy exists between their theory of the situation and reality, danger exists. Most CRM accidents, according to Trollip and Jensen (1991), are a result of these discrepancies going unrecognized and magnified under stress. Proper interactions (teamwork skills) are the tools for handling these discrepancies.

In discussions of teamwork, the concept of synergy among flight crew members is an important factor. Synergy is combined action, the notion that two, three, or more crew members working together in a sound way can produce a more effective solution to a problem than any one person (Telfer & Biggs, 1988).

Interaction and communication is the key to synergism which is best achieved when five concepts (inquiry, advocacy, listening, conflict resolution, and critique) are used by all individuals within the team (Trollip & Jensen, 1991). Other authors discuss

synergy using different terms such as "information flow" (Foushee & Helmreich, 1988) and "information sharing" (Stone, 1988) as crucial variables of teamwork. Stone (1988) stresses division of duties between pilots, information sharing, and communication of intentions as essential teamwork skills. Foushee and Helmreich (1988) link information flow with two other indispensable teamwork variables: feedback and acknowledgement of information provided by other crew members.

The first attempts to identify the essential content elements of a CRM curriculum came from Blake and Mouton, who in 1982 customized their Managerial Grid Theory to CRM as a means of understanding teamwork dynamics in the cockpit. They identified five elements of teamwork: inquiry, advocacy, conflict resolution, critique, and decision making. In 1985, a group of 13 aviation professionals compiled a more extensive list of 20 teamwork skills that they considered vital to CRM training:

1. listening
2. communication
3. assertiveness
4. awareness of the situation
5. ability to deal with conflict
6. problem solving
7. problem definition
8. priority and analysis
9. open-mindedness
10. personality awareness
11. managing distractions
12. fatigue management
13. use of checklists
14. decision making
15. pattern recognition
16. crew incapacitation recognition
17. workload assessment

18. division of attention
19. stress management
20. ability to critique. (Telfer & Biggs, 1988, p. 139)

Individual airlines developed their own training programs, each listing teamwork skills that constitute the essential elements of their individualized CRM program.

A typical offering is the list of principles of flight resource management developed by American Airlines. They include:

1. appropriate delegation of tasks and assignment of responsibilities,
2. establishment of a logical order of priorities,
3. continuous monitoring and cross checking of essential instruments and systems,
4. careful assessment of problems and avoidance of preoccupation with minor ones,
5. utilization of all available data to conduct an operation,
6. clear communication among crew members of all plans and intentions, and
7. assurance of sound leadership by the pilot in command. (Telfer & Biggs, 1988, p. 139)

Perhaps the most definitive list, though not a complete one, comes from Federal Aviation Administration (1993) which defines seven teamwork skills which should be acquired:

1. Communication
2. Situational Awareness
3. Problem Solving, Decision Making, Judgement
4. Team Management
5. Stress Management
6. Team Review
7. Interpersonal Skills

In the Line Operational Simulations Advisory Circular, AC 120-35B, the Federal Aviation Administration in cooperation with the Air Transport Association

formulated a taxonomy for CRM skills (FAA, 1992). Three main clusters of CRM skills were defined as: (a) Communication Processes and Decision Behavior, (b) Team Building and Maintenance, and (c) Workload Management and Situational Awareness. The clusters were broken down further into subcomponents as follows:

1. Communication Processes and Decision Behavior

Briefing (conduct and quality)

Inquiry/Assertion/Advocacy

Crew self-critique (decisions and actions)

Conflict resolution

Communications/Decisions

2. Team Building and Maintenance

Leadership, followership, and concern for tasks

Interpersonal relationships/Group climate

3. Workload Management and Situational Awareness

Preparation/Planning/Vigilance

Workload distribution/Distracton avoidance

In this study, these teamwork skills will be considered the essential content elements of any CRM curriculum regardless of the delivery method or proposed learning strategy.

CRM Learning Strategies

X

Methods for teaching and learning CRM are also varied, and many useful strategies have been developed. The Blake and Mouton (1982) CRM Grid Model defined two phases of training:

1. Phase I: A home study program that provides a common language for use in applying succeeding phases of the program, and
2. Phase II: A structured learning process in a seminar environment where crews analyze how they react to various leadership styles and how their own behavior can affect operational outcomes.

To extend the training into the flight environment and to optimize teamwork and cockpit behavior, the use of critique and feedback was added to the Grid Model (Telfer & Biggs, 1988). United Airlines developed the first formal airline CRM training program in 1979, and later adopted the Grid Model as a teaching strategy. As programs developed, many techniques evolved from both professional training groups and the airlines. The following strategies were incorporated into CRM training programs: classroom lectures, group exercises, seminars, personality assessments, feedback techniques, role-playing, case studies, and interpersonal encounter drills (Foushee & Helmreich, 1988).

Line-Oriented Flight Training (LOFT). One strategy that has developed harmoniously with CRM and has now been widely adopted is LOFT. It is the instruction, and sometimes testing, of flight crews as a team rather than as

individuals. Hawkins (1987) credits the development of LOFT to the realization that individual proficiency is not sufficient when the skill must be practiced in a group activity where personality and situational factors interact to create overall performance. Training programs should not concentrate on changing attitudes alone; it is critical to reinforce changes in attitude by providing opportunities, such as LOFT, to place new attitudes into practice (Helmreich, Foushee, Benson, & Russini, 1986). Helmreich (1984) considers the most effective CRM learning strategy to be presentations of CRM skills, followed by behavioral exercises such as LOFT.

LOFT scenarios are flights flown in a mission-oriented simulator with a full crew complement. They are flown in real time, and no intervention is made by the instructors regardless of the actions of the crew (Foushee & Helmreich, 1988). As crews are faced with routine as well as nonroutine, emergency, and judgement situations, they use CRM principles to bring the flight to a successful conclusion. The strength of LOFT training is that it combines CRM principles with vital performance and judgement skills in a single learning environment. The findings suggest that more emphasis should be placed on task behavior in CRM training (Cook, 1991). Using LOFT to evaluate the outcomes of a CRM training program requires the program to focus on task behavior and crew performance.

Massey (1990) outlines the procedures used: as part of the CRM training program, LOFT exercises are flown in a simulator and the exercise is videotaped for debriefing after the LOFT has been flown. The crew debriefs itself in

cooperation with the flight instructor; then the tape is erased by the crew to ensure that it is used only for training and not for evaluation or employment decisions.

LOFT is recognized as a valid method for teaching CRM, but it is not an essential strategy element of CRM training; many smaller airlines, which cannot afford simulators, conduct CRM training programs without LOFT exercises (Massey, 1990). The Federal Aviation Administration (1993) acknowledges that there are many approaches and learning strategies useful in CRM training. They list certain features that are necessary for effective CRM programs:

1. The program should focus on the functioning of crews as intact teams.
2. The program should provide opportunities for crew members to practice the skills that are necessary to be good team leaders and members.
3. The program should help crew members learn that how they behave during normal, routine circumstances can have a powerful impact on how well a crew functions during high workload, stressful situations.

Since the Federal Aviation Administration (1993) presents federal guidelines for developing, implementing, and evaluating a CRM training program, these three principles are considered the essential strategy elements for all CRM training programs, including undergraduate flight training.

Behavior Modification Model

The predecessor to this study was a CRM course that was taught according to the Behavior Modification Model. The first challenge was to modify CRM training for the inexperienced pilot and to develop effective strategies which cultivate CRM skills early in a pilot's career. A college CRM course was developed based on guidelines established for FAR Parts 121 and 135 (FAA, 1993). The objective was to give these students realistic CRM and crew training despite their inexperience. The Behavior Modification Model was chosen because the overall goal of CRM training is to modify behavior. It was evident that operant conditioning is a powerful tool for behavior modification; it reinforces desired behaviors and immediately corrects adverse behaviors. In this model, three phases were repeatedly utilized to reinforce learning:

1. learning sessions where CRM skills were introduced,
2. practice sessions where CRM skills were exercised, and
3. debriefing sessions where feedback was used to reinforce or correct behaviors.

Most current undergraduate flight training concentrates on technical skills: the knowledge base, procedural activities, and motor activities required to fly an airplane. These individual technical skills must be paired with crew-related skills to ensure safe flight (FAA, 1993). In learning sessions, students attained awareness of CRM skills through a variety of methods. The objective was for the students to

identify CRM skills, to define them operationally, and to recognize their own positive or negative utilization of them.

Awareness of CRM skills was not sufficient to change behavior; students had to perform them in an operational environment. Simulator LOFT provided a viable opportunity to practice CRM skills in a learning environment. In LOFT, a realistic flight simulator and highly structured scenarios were used to reflect real-world line operations. The flights were flown in real-time with no external assistance except what would be supplied by Air Traffic Control (ATC) (Foushee & Helmreich, 1988). Simulator sessions were videotaped for use in debriefing sessions.

Feedback is the essence of behavior modification; it is the reinforcer of positive skills and the correction tool for negative behavior. Feedback can come from the crew members themselves in the form of self- or peer-critique, from videotapes, or from third-party evaluators. Feedback is most effective if it is immediate, quantifiable, and objective (Butler, 1992). In the behavior modification model, the debrief was scheduled immediately following a LOFT simulation, they were interactive between students and instructors, and observations were confirmed by field notes, plotter data, and videotapes.

The behavior modification model had significant limitations because it dealt only with manifest behaviors without inquiry into personality, attitudes, learning processes, common sense, or judgement (Butler, 1992). Most of the shortcomings of the behavior modification model occurred in debriefing sessions:

1. Students focused on technical skills rather than CRM skills.
2. Errors were emphasized rather than positive performance.
3. Constructive feedback caused students to act defensively.
4. Videotapes centered on technical skills, particularly errors.
5. Students tended to passively observe videotapes.

For these reasons, the behavior modification model had only limited success as a learning strategy for an undergraduate CRM program. Technical and crew errors are expected to occur in LOFT training at this level; LOFT training is most effective when errors are tolerated without penalty (Hawkins, 1987). The limited success of the behavior modification model made it clear that a different strategy was needed. Though the guiding principles appeared sound, another model for debriefing was explored.

Discovery-Learning Model

Discovery-learning was chosen as an alternative to the behavior modification model for this study. Discovery-learning is a model where the learner is placed in the environment which is structured to allow the learner to manipulate it, to learn its limits, and to apply concepts to other situations and environments (Butler, 1992). Numerous aircrew learning contexts have been surveyed by Butler and simulator LOFT appears to be the best environment for discovery-learning. If the reduction of human factor errors in the cockpit is the goal, then CRM skills should be discovered by individuals rather than poured out from a fountain of knowledge.

Formal CRM training and LOFT are designed not only to instruct but also to encourage each pilot to examine his/her own management skills and to implement other CRM techniques that may seem even more effective (Butler, 1991).

Theoretical or Conceptual Framework

The innovative learning method (treatment) employed in this study was a discovery-learning strategy called self-analysis. Self-analysis is a LOFT debriefing strategy that was compared to conventional (behavior modification) debriefing to determine if effectiveness could be improved by self-analysis. When self-analysis was in effect, students analyzed videotapes of their own LOFT simulator flights, concentrating on their performance of CRM skills. From a theoretical viewpoint, this approach may very well produce some tangible changes in attitudes and behavior (Foushee & Helmreich, 1988). The Theory of Objective Self-Awareness (Duval & Wicklund, 1972) professes to explain numerous behaviors falling within the domain of human performance. The theory assumes that self-focusing stimuli often forces objective appraisals of oneself that may lead to attitude and behavior changes (Wicklund, 1975). The theory draws heavily from Piaget's (1966) Cognitive Theory and Festinger's (1957) Cognitive Dissonance Theory. According to Festinger, if a person is led to focus on discrepant cognitive elements, dissonance reduction will result. Other researchers, Jones and Nisbett (1971), proposed that two people, the actor and the observer, will offer two different explanations of the actor's behavior; the actor explains his behavior based on environmental

contingencies, but the passive observer is likely to interpret it based on the actor's personality. Duval and Wicklund (1972) have made the actor and the observer the same person, by making the actor an observer of himself, and found greater attribution to self when the actor is turned into a self-observer.

Wicklund (1975) explains how the Theory of Objective Self-Awareness works: The initial reaction to self-focused attention is self-evaluation, which can be favorable or unfavorable, depending on the nature of the discrepancy noted. It is assumed that discrepancies in this context are mostly negative. There are two possible reactions to a negative discrepancy in addition to the self-evaluation: to avoid the self-focusing stimuli, or to create an objective self-awareness that will result in attempted discrepancy reduction. If escape from the self-focusing stimuli is not possible, discrepancy reduction will follow.

Wicklund's (1975) research has demonstrated changes in both attitude and performance, specifically, both lowering and raising of aggression, improved rate of performance on simple tasks, dissonance reduction, and conformity. Wicklund and Brehm (1976) reported a meta-analysis of research projects that show positive results for objective self-awareness in distinct fields such as marketing, interpersonal persuasion, politics, religion, disconfirmation of cherished beliefs, clinical psychology, marriage, smoking, and gambling.

In a study by Gibbons and Wicklund (1982) the result of self-directed attention on prosocial behavior was examined; they concluded that self-focus and prosocial behavior are closely related to one another only to the extent that the

individual is "self-reflective." Recently, Duval, Duval, and Mulilis (1992) examined factors that determine the decision to withdraw or to progress towards discrepancy reduction after an objective self-awareness. They drew heavily on the work of Carver and Scheier (1981) who assume that the decision to match or withdraw is determined by outcome expectancy favorability. Combining the two theories, Duval et al. (1992) assessed the match or withdraw response in relationships to the magnitude of the discrepancy. They confirmed that larger discrepancies lead to withdrawal more than to discrepancy reduction. More importantly, they found that the objective self-awareness group, who believed they were making rapid progress towards discrepancy reduction, clearly evidenced greater efforts to match their behavior and attitudes to the standard, even if the initial discrepancy was very large.

Objective self-awareness theory has implications for the present study. The goal of the study is to determine if self-analysis can shape attitudes and increase performance of CRM skills. It should be noted that a possible result of a negative self-awareness stimuli is withdrawal from the self-analysis situation; however, if escape from the self-focusing stimuli is made very difficult, discrepancy reduction should follow. The Gibbons and Wicklund (1982) study shows that self-awareness is not sufficient to produce results; the students need time and incentive to engage in "self reflection" in order to observe significant results. The article by Duval et al. (1992) showed that evidence of progress towards discrepancy reduction can motivate students to continue their efforts to learn and practice the CRM principles, even if they perceive that their errors are numerous or severe. The

implication is that undergraduate flight students can learn CRM through self-analysis despite their lack of experience in crew operations.

Learning Strategy - Cooperative Learning

As in the behavior modification model, learning sessions should provide awareness of the CRM skills. In the discovery-learning model, however, learning becomes an active process, removed from the classroom setting and placed in the crew context (Bonwell & Eison, 1991). One active learning method is the Cooperative Learning procedure called "Jigsaw" (Johnson, Johnson, & Smith, 1991). Each student is individually responsible for a number of readings or assignments. When both are prepared, they are scheduled for a learning session to interchange information with each other by sharing their readings, discussing case studies, analyzing accident reports, and writing team response papers. Students are responsible for their own learning, and the instructor becomes a facilitator and a learning resource.

Practice Strategy - LOFT

In the discovery-learning model, simulator LOFT is the focal point of training as it was in the behavior modification model. Simulator scenarios deliberately focus on CRM skills such as crew communication, situational awareness, judgement, decision making, and leadership skills. Faced with routine as well as nonroutine, emergency, and judgement situations, crews must use CRM skills to bring the flight to a successful conclusion. Situations are subjective and

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usually do not have a "right" or "wrong" outcome; instead, students discover for themselves the relationships between CRM skills, safety and error. In the discovery-learning process, students experience both success and error in the LOFT simulator.

Ruffell-Smith (1979) in a simulation study provided strong evidence for the importance of experiencing group performance, finding that crew interactions were significantly related to safety. He found that most problems were related to breakdowns in crew coordination, not to a lack of technical knowledge and skill. "High-error" crews experienced difficulties in the areas of communication, crew interaction, and integration.

Several studies delineate group processes that jeopardize safety. Caro (1988) identifies safety factors such as aircrew preoccupation with minor mechanical problems, failure to delegate tasks and assign responsibilities, failure to set priorities, failure to communicate intent and plans, failure to utilize available data, and inadequate monitoring of other crew member's performance. Focusing on the vital area of communication, Campbell and Bagshaw (1991) list communication blocks that impact safe flight: pre-occupation, resentment, status differential, and strongly held opinions. Foushee and Helmreich (1988) discuss a malady some refer to as "Captainitis," a situation where a Captain does not achieve the full potential of the crew because of ego or lack of leadership. All of these factors are behaviors that can be experienced tangibly in LOFT simulations.

Hawkins (1987) warns that there are some factors that probably will not be affected by CRM or LOFT training. Personality traits and the effects of domestic stress, fatigue, circadian rhythm disturbance, drugs or medication will probably change very little with LOFT training. Also, LOFT training will not put an end to errors in information processing, eliminate visual illusions, or do away with design-induced error.

Debriefing Strategy - Self-Analysis

Instead of having instructors debrief students after LOFT training, discovery-learning allows pilots to examine their own performance and to analyze the CRM skills they have learned (Butler, 1991). Recognizing that college crews may need assistance in analyzing their LOFT performance, self-analysis of LOFT Training was developed. It is a discovery-learning strategy that provides focusing tools and specific learning tasks to support the self-analysis.

Though the use of videotapes had shortcomings in the behavior modification model, they still provide the most objective criteria for self-analysis (Hawkins, 1987). In self-analysis of LOFT, two strategies enable videotapes to be used for discovery: learning tools and learning tasks. The learning tools and the learning task transform the debrief session from "watching videotapes" to an "active learning process" that focuses on CRM skills, places the locus of control within the students, and emphasizes positive use of CRM skills rather than focusing on errors (FAA, 1992).

Evaluating Effectiveness

The concept of effectiveness implies demonstrated proficiency or evaluation of performance. Measurements of teamwork skills are not only evaluations of the effectiveness of the CRM training program, but also assessments of the performance of crew members. Presently, in the airline community, the training associated with CRM and the simulator experience associated with LOFT are entirely nonpunitive and current philosophy encourages them to remain that way (Foushee & Helmreich, 1988). Especially since LOFT training has expectations of errors, this kind of training is effective only in a situation where errors are allowed to occur without penalizing the trainees (Hawkins, 1987). There remains a definite separation between training and evaluation at this juncture, however, there is a logical extension into required demonstration of proficiency in crew resource management. Should this occur, there is an expected outcry from pilots who have apprehensions that performance in this area could be used as a condition of gaining or maintaining a license to operate in multipilot aircraft (Foushee & Helmreich, 1988).

In situations where a high level of teamwork is required, the individual skills of team members are often not enough to assure effective performance of the group (Jones, 1974). Group performance criteria has received relatively little attention in the aviation research and training communities until recently; this heightened awareness has been stimulated, unfortunately, by a number of tragic

accidents relating to flight crew performance. Accidents such as these have prompted some researchers to believe that the "group effectiveness problem" cannot be solved in the near future (Foushee & Helmreich, 1988). But those claiming that CRM training and LOFT scenarios are ineffective tend to overlook evidence from two accidents in which both Captains credited their crew's CRM training for reducing loss of life (Cook, 1991).

CRM training assessment requires more defined techniques to assess the direct or indirect effects of training programs on the outcomes they wish to produce. Unfortunately, current knowledge is not advanced enough to establish absolute standards of measurement (Gregorich & Wilhelm, 1993). Training programs are currently assessed using multiple measures which provides less ambiguous assessment of program elements and outcomes as well as more reliable and more interpretable findings (Helmreich & Wilhelm, 1987). Rather than using a single instrument to measure effectiveness, the crew effectiveness research methodology emphasizes the assessment of crew performance via converging sources of data (Chidester, Kanki, & Helmreich, 1989). Helmreich (1991) lists six methodological approaches that can be used to measure crew effectiveness. Four of these are within the scope of undergraduate flight training and are addressed in the research questions of this study:

1. Survey data on crew member attitudes as indicators of culture and training effects: The CMAQ.
2. Systematic observation of crew behavior: The LINE/LOS Checklist.

3. Survey data on crew reactions to LOFT: The CRM Survey.
4. Micro-coding of communications: Communications Analysis.

Each of the above evaluation methods measure a different aspect of effectiveness. Reliability can be maximized by establishing that the evaluation methods converge on a global measure of effectiveness (Chidester, Kanki, & Helmreich, 1989).

Attitudes

The thrust of CRM training is crew dynamics and the target of CRM evaluation is crew effectiveness. Under aircrew team dynamics, Vandermark (1989) lists three vital components: personality, attitude, and communication. Similarly, when discussing crew effectiveness, Gregorich, Helmreich, Wilhelm, and Chidester (1989) state that it is largely determined by technical skills, attitudes, and personality characteristics. *Personality* and *attitudes* must be considered both as objectives of crew dynamics training and as measures of crew effectiveness.

Personality, which Helmreich (1983a) calls *traits* are deep-seated dispositions to behave in a certain way (Vandermark, 1989). They are acquired relatively early in life and are stable and resistant to change (Helmreich, 1983a). Personality must be a factor in the selection of pilots, but it is "unrealistic to believe that training can effect lasting changes in personality" (Helmreich, 1983a, p. 7). There is considerable evidence that personality traits are directly linked to flight deck performance. If these traits are the major determinant, then the best strategy

would be to concentrate on selection and not to worry about teaching old dogs new tricks (Helmreich, 1984).

Attitudes, on the other hand, are less stable characteristics that are learned patterns of responding (Helmreich, 1983a). They can be acquired at any time during the lifespan and are relatively open to modification through intellectual or emotional appeals. Though both personality and attitudes affect crew performance, the data show that they are relatively independent (Helmreich, 1983b). This independence suggests that CRM training can reshape attitudes through intellectual or emotional appeals and that CRM assessments can use attitudes as a measure of actual performance (Helmreich, 1984).

Examining the link between attitudes and performance, Helmreich (1983a) concluded, "Effecting change in management attitudes can produce marked changes in behavior and can improve the effectiveness and safety of flight personnel" (p. 10). Another study (Helmreich, Foushee, Benson, & Russini, 1986) established a direct linkage between self-reported attitudes and independent evaluations of performance. Measuring attitudes provides an indirect approach to assessing the potential effectiveness of resource management.

While research shows significant positive increases in attitudes resulting from CRM training, ten to fourteen percent of the individuals tested were either unaffected by the training or showed a negative result of training with attitudes "boomeranging" in the direction opposite of that intended. Helmreich and Wilhelm (1989) pinpoint personality factors and group dynamics as the critical determinants

of the direction of the change in attitudes. Studies revealing the "boomerang effect" were done with airline pilots, but it is reasonable to consider that it could be present in undergraduate students as well.

Training designed to instill or enhance the desired attitudes in flight crew members is now commonplace in both commercial and military aviation. To evaluate the effectiveness of such training, the CMAQ (see Appendix A) was designed as an index for measuring attitudes (Helmreich, 1984). "The items on the survey were chosen to tap issues that are conceptually and/or empirically related to cockpit resource management" (Helmreich, 1984, p. 585). It has three functions in CRM training: providing an evaluative pre- and post-training snapshot of attitudes, identifying individual areas that may need special attention, and evaluating the impact of CRM training (Gregorich, Helmreich, & Wilhelm, 1990).

Systematic Observation of Crew Behavior

The overall objective of LOFT is to improve total flight crew performance, meaning that, in parallel with technical skills, crew coordination and communication skills must be both learned and assessed (FAA, 1992). Traditional evaluation of pilot performance concentrates on assessing individual technical skills. However, considering that crew coordination problems have played a significant role in more than half of aviation's accidents and incidents (Gregorich, Helmreich, & Wilhelm, 1990), evaluation of individual flying skills is not enough.

Detailed data on the cognitive and interpersonal skills of crew members are needed (Helmreich, Wilhelm, Kello, Taggart, & Butler, 1991).

Consensus seems to be against using LOFT as an evaluation tool primarily because pilots perceive that any formal evaluation includes the risk of decertification, regardless of assurances to the contrary (Butler, 1992). Yet there is a need to reinforce and evaluate the impact of training in CRM (Helmreich, Wilhelm, Kello et al., 1991). Otherwise, most crew performance data come from reports where things end badly, the formal investigations of accidents and serious incidents. Helmreich, Wilhelm, Kello et al. (1991) maintain that a better understanding of crew effectiveness could be obtained from analysis of situations where crews performed successfully.

In order to evaluate the overall effectiveness of CRM/LOFT training, a joint research project between the National Aeronautics and Space Administration (NASA) Ames Research Lab and the University of Texas developed the NASA/UT LINE/LOS Checklist (see Appendix C). The LINE/LOS Checklist was designed to provide accurate systematic data on crew performance including the positive aspects (Helmreich, Wilhelm, Kello et al., 1991). It defines eight specific *crew effectiveness markers* and two global ratings that are each made specific by a set of behavioral indicators. Research data indicate that the use of behavioral markers to help evaluators classify observed behavior greatly increases the reliability of observations (Helmreich & Wilhelm, 1991).

An issue of concern is whether reliable judgements of CRM behaviors can be made with the LINE/LOS Checklist through the observation of only one flight segment. It is the subjective feeling of Helmreich and Wilhelm (1991) that first impressions of crew interaction are sufficiently clear that single observations are suitable for analysis.

Survey Data on Crew Reactions

Whereas the LINE/LOS Checklist is an evaluation of performance by observers, flight crews can report their own reactions to the training in a self-report sheet called the CRM Survey (see Appendix D). The questionnaire asks questions regarding familiarity with the scenario, its value for technical and crew coordination training, the effectiveness of the instructor and debriefing, workload imposed, and evaluation of team performance and use of CRM concepts (Helmreich, 1991).

Survey data from more than 20,000 flight crew members showed overwhelming acceptance of CRM training with the vast majority of pilots endorsing the training as both relevant and useful (Helmreich & Wilhelm, 1991). A similar pattern was found in a survey from more than 8,000 participants in LOFT exercises where crew members overwhelmingly felt that LOFT was important and useful training, and that it had value for technical training as well as training in CRM skills. Clearly, acceptance of the training program is a necessary but not sufficient indicator of its effectiveness, but if the crew members do not perceive the

training to be useful, the result may be increased awareness of CRM concepts but little change in observable behavior (Helmreich & Foushee, 1993).

Communications Analysis

Another approach to evaluation of crew performance follows a research tradition known as ethnography and involves a trained observer making extensive notes on the actions of crews during extended observations (Helmreich & Wilhelm, 1991). They agree that this type of data provides an extremely rich record of the characteristics of particular crews and is an invaluable research technique. The drawbacks that Helmreich and Wilhelm note is that it is labor intensive, it requires detailed content coding, and it is limited to a small sample of crews. However, it provides more detailed data than any of the other evaluation measures.

Effective crew coordination depends on verbal communication to transmit and receive information; the foundation for achieving effective teamwork in the cockpit resides within the information transfer process (Kanki, 1991). In order to understand these group process issues, researchers are implementing ethnographic methods using communications-based research that analyzes the information transfer process in the cockpit.

Kanki (1991) describes five studies that used a variety of techniques to analyze the speech records from actual line flights or LOFT simulators. In each case the basic data are the verbatim transcripts of interactive speech sequences that are coded according to a particular classification system. "Each coding system is

tailored to meet the needs of a particular research/theoretical focus as it relates to communication/information transfer process" (Kanki, 1991, p. 247).

There are four phases of the research that apply to all the studies in Kanki (1991): designing the data source, transcribing the speech record, coding according to a model, and analyzing the data. Table 1 is a summary of these phases.

Table 1. Group Process Communication Research.

<p><u>I</u> <u>Design Phase</u></p> <ul style="list-style-type: none"> . Data source (e.g., field versus simulation study) . Level of analysis (macro/micro) . Define critical contrasts
<p><u>II</u> <u>Transcribing Phase</u></p> <ul style="list-style-type: none"> . Identify portion of videotaped records to be transcribed . Transcribe verbal data in real-time sequences . Demarcating critical events and flight phases
<p><u>III</u> <u>Coding Phase</u></p> <ul style="list-style-type: none"> . Speech act sequences . Problem solving functions . Managerial functions . Information model . Standard versus nonstandard terminology
<p><u>IV</u> <u>Analysis Phase</u></p> <ul style="list-style-type: none"> . Identify communication and other group process patterns that relate to input and/or outcome variables
<p>(Kanki, 1991, p. 251)</p>

Kanki (1991) calls the coding phase the most crucial and creative because the research question must be translated into a discriminating coding system by which all speech will be characterized. Several studies describe a variety of coding

strategies, each aimed at uncovering important differences in communication patterns. The majority of researchers begin with a primary coding strategy developed by Foushee and Manos (1981) in which each communication act is assigned to one of 18 communications categories (see Appendix E). Secondary codes are often assigned to the same speech acts to uncover important communications patterns relating to the research question. For example, Kanki, Palmer and Veinott (1991) created a secondary code of speech sequences to determine initiators and responders in cockpit communications.

Communications Analysis has potential to be far more than an assessment tool. It can provide direct, objective evidence to crew members on their communications and their effectiveness in crew coordination. Mostly, it provides an opportunity to forsake the negative aspects of evaluation and to concentrate on positive skills reinforcement. One of the reasons we lack a full understanding of effective crew performance is that the database on crew performance is built on accident or serious incidents. We would have a better understanding of crew effectiveness if we could analyze crew behavior in those situations where the crews were particularly effective (Helmreich, Wilhelm, Kello et al., 1991).

CRM and LOFT in Undergraduate Flight Training

CRM and LOFT are usually considered to be advanced training programs for experienced airline crews. Some undergraduate programs offer a CRM seminar for upper division flight students, but combining it with LOFT training is rare. Very

few research projects have been conducted with undergraduate crews using both LOFT and CRM. Ross, Slotten, and Yeazel's (1990) study incorporates a "LOFT" scenario into an initial (undergraduate) flight training program. Since it uses only single-pilot crews, there are no cockpit interactions involved; it is individual performance training and does not evaluate the learning of CRM principles.

The best models for LOFT training in undergraduate programs come from team training included as part of *ab initio* training (Trollip & Jensen, 1991). These programs break away from the strong emphasis on individual performance typical of primary flight training. From the beginning of their flying careers, *ab initio* students fly as part of a team, initially with an instructor in the right seat and a second student in the back seat who is also an active participant in the flight. "By encouraging teamwork and constructive criticism from the beginning, students build a habit of cooperation rather than competition" (Trollip & Jensen, 1991, pp. 9-15).

In a CRM training program for Air Traffic Control (ATC) Specialists at Hampton University, Weisman (1991) found that teamwork skills and individual competence can be developed in an undergraduate student simultaneously. She recommends that a prototype CRM curriculum be developed for undergraduate programs to be used with all of the aviation specialties, including pilots.

The military has been the traditional source of airline pilots for years. Defense cutbacks will reduce the number of military pilots available to U.S. airlines in the future. General Aviation, where pilots build flight hours by flight instructing and flying charters and light cargo, is emerging as the principal source of

journeyman pilots. General Aviation creates a group of pilots with entry skills that are more diverse than the typical expertise of military pilots. Airline standards cannot broaden to accommodate such differences; new technology and automation demand greater technical competence than ever, and crew resource management introduces additional standards for pilots to master.

College aviation programs are in a unique position to fulfill these requirements. Because colleges have more educational requirements than other General Aviation programs, college flight training is a broader, more diverse education. Colleges influence their students for several years longer than most flight schools allowing time to integrate interpersonal skills into "airmanship" and "professionalism" technical training. Some experts uphold that CRM is too advanced for undergraduate flight training; others contend that it is wrong to defer crew training until a pilot reaches the airlines (Trollip & Jensen, 1991). Perhaps, the strongest argument in favor of including CRM in initial flight training is that it is successfully being taught in European *ab initio* programs (Nash, 1992).

CHAPTER 3

METHODOLOGY

Research Objectives

Beginning with the premise that self-analysis of LOFT is the most effective way for airline pilots to learn CRM, the purpose of this study was to determine if undergraduate flight students can learn CRM through self-analysis of LOFT despite their inexperience with crew operations. "Performance" was selected as the measure of effectiveness. The Cooperative Learning sessions and LOFT practice sessions were common to all crews, but debriefing sessions (conventional or self-analysis) were uniquely distinctive so that differences in CRM performance could be measured:

Research Design

The design for this research was an alternating treatments design (Gay, 1992), a type of single-subject design. In the alternating treatments design the subject is alternately exposed to a nontreatment (baseline) and a treatment phase, and performance is repeatedly measured in each phase. In this research, the treatment (self-analysis debriefing) was alternated with the baseline (conventional

debriefing). Repeated measurements of attitudes, effectiveness, performance, and self-reporting were made to determine if changes were a function of self-analysis.

Single-Subject Designs

The single-subject design is a variation of the time-series design (Gay, 1992) or the longitudinal time design (Kerlinger, 1973) in which each subject serves as his or her own control. Single-subject designs, sometimes called single-case designs, are studies of the effect of interventions on an individual (Best & Kahn, 1989), but they can also be applied when several individuals are considered as one group, such as a flight crew (Gay, 1992). Most experimental research that compares treatments requires a traditional group comparison design; however, a single-case design may be more appropriate if there are not enough subjects of a given kind to permit the formulation of two equivalent groups (Gay, 1992). Single-subject design differs from case study research in the degree of experimental control (Borg & Gall, 1989); case studies rely heavily on qualitative data and the researcher's subjective impressions whereas single-subject design is an experimental method that is typically concerned with manipulation of a treatment in order to draw inferences about the effectiveness of the treatment (Cohen & Manion, 1985). Single-subject research requires careful assessment, repeated observation or measurements, and conscientious applications of the treatment (Best & Kahn, 1989).

A-B-A-B and Multiple Baseline Designs

The characteristics of single-subject research are discussed in terms of A-B-A-B designs which determine the effects of an intervention by alternating the baseline condition (the A phase) with the intervention condition (the B phase) (Kazdin, 1982). Kazdin states that the effects of the intervention are clear if performance improves during the first intervention phase, reverts back to baseline levels when the intervention is removed, and improves again when the intervention is recommenced at the second intervention phase.

Sometimes the effects of the treatment may not disappear when the treatment is removed. Actually, in many cases, as in this research, it is highly desirable if they do not. Multiple baseline design allows for conditions other than the naturally occurring target behavior as a control for assessing treatment effects (Borg & Gall, 1989). They are used whenever a treatment can be withdrawn but when the effects of the treatment carry over into the second baseline phase and a return to original baseline conditions is difficult or impossible (Gay, 1992). In this research, a multiple baseline design was used; instead of collecting one target behavior for one crew in one setting, several behaviors were collected for each crew in each of the LOFT simulations.

Alternating Treatments Design

Alternating treatments design is a special application of either the A-B-A-B design or the multiple baseline design; it is a relatively rapid alternation of

treatments for a single subject (Gay, 1992). "The design currently represents the only valid approach to assessing the relative effectiveness of two (or more) treatments, within a single-subject context" (p. 346). The design allows for the comparison of two or more treatments without controlling for possible order effects. Treatments can be alternated for each session or they can be randomly assigned to sessions (Best & Kahn, 1989). Additionally, the design may be used to alternate between treatment and no-treatment without having to establish a baseline (Gay, 1992). In this study, the alternation was between treatment and no-treatment for each LOFT scenario. For each crew, the first LOFT scenario was randomly assigned to either conventional debriefing (no-treatment) or to self-analysis debriefing (treatment).

Analytical Techniques

In single-subject designs, statistical analysis is rarely used (Best & Kahn, 1989; Borg & Gall, 1989). One criticism is that inferential statistics are not compatible with the logic of the single-subject experiment; another is that inferential statistics assume that observations are independent of each other which is seldom satisfied in single-subject designs. In single-subject designs, data analysis typically involves visual inspection and graphical analysis of the results (Gay, 1992).

Single-subject designs have their roots in clinical psychology. For single-subject designs, Gay (1992) maintains that the primary criterion of treatment effectiveness is clinical significance of the results rather than statistical significance.

Clinical significance means that the treatment must produce meaningful outcomes in performance, not just mathematically significant results.

To tabulate the graphical results, a summary method of classifying individual results to show magnitude and direction of a change was employed (Irwin, 1991).

Difference scores between observations were computed for each factor and subjects were placed into one of seven groups:

<u>Symbol</u>	<u>Amount of Change</u>
- - -	those observations decreasing more than two standard deviations since the last observation.
- -	those observations decreasing between one and two standard deviations since the last observation.
-	those observations decreasing less than one standard deviation since the last observation.
nc	those observations that have not changed since the last observation.
+	those observations increasing less than one standard deviation since the last observation.
+ +	those observations increasing between one and two standard deviations since the last observation.
+ + +	those observations increasing more than two standard deviations since the last observation.

When alternating between self-analysis and conventional debriefing, an effectiveness measure was considered to favor self-analysis if it showed gains for a self-analysis session that was higher than the previous conventional debriefing session. For example, if a self-analysis measurement showed that performance increased more than two standard deviations since the previous conventional session, it would be classified as "+ + +" signifying that one measurement indicated that self-analysis session was more effective than the conventional debriefing session.

Replication is a vital part of all research and especially single-subject research since initial findings are generally based on one or a small number of subjects (Gay, 1992). Three types of replication are: direct, systematic, and clinical. In this study, direct replication was used by the same investigator with different subjects (different crews) in a specific setting (the same LOFT scenarios).

Population and Site Description

The study was conducted at Rocky Mountain College (RMC) in Billings, Montana. RMC is a four-year, private, liberal arts college with an aviation department which offers two undergraduate degree programs in aviation: Aeronautical Science and Airway Science. RMC is an institutional member of the University Aviation Association (UAA). The LOFT training was conducted at the college's Flight Simulator Laboratory in a Frasca Model 142 ground trainer.

Research Subjects

A two credit course in CRM and LOFT was offered at RMC in Spring, 1993. The course prerequisites required students to be juniors or seniors, to possess a Commercial Pilot Certificate and to be finished with multi-engine ground instruction. Twelve students were enrolled. Prior to any CRM instruction, each student completed a locally-developed questionnaire to document pilot experience, education, and exposure to CRM (see Appendix B). Students received an individual orientation session in the Frasca 142 simulator and were separately evaluated on their flying skills. The Flying Skills Test score was used to assign individuals to crews so that the technical skill level of each crew was balanced. Of the twelve, nine were fully qualified to participate in the study; two were unqualified and were excluded; and one was marginally qualified (Ed) but had acceptable technical skills and was included to produce an even number for crew assignments. None of the students had previous experience with CRM or LOFT. Table 2 (with pseudonyms) summarizes their background and scores on the Flying Skills Test. Eight men and two women were teamed as follows:

One crew with above-average skills (Alex/Art).

Two crews with average skills (Betty/Bob, Carl/Cathy).

One crew with mixed skills (Dan/Dave).

One crew with below-average skills (Ed/Eric).

Each crew completed five sessions of CRM and LOFT training; they had two self-analysis debriefing sessions randomly inserted into their schedule.

Table 2. Summary of Students' Background and Skills.

	Pilot	Ratings	Year	Instru- ment Hours	Multi- Engine Hours	Total Hours	Skills Test
Alex	Comm.	Instructor Single-Engine Multi-Engine Instrument	Jr.	100	320	630	8
Art	Priv.	Single-Engine Instrument	Jr.	33	0	168	8
Betty	Priv.	Single-Engine Instrument	Sr.	36	0	206	6
Bob	Comm.	Single-Engine Multi-Engine Instrument	Sr.	58	23	218	7
Carl	Priv.	Single-Engine Instrument	Jr.	39	2	194	7
Cathy	Comm.	Single-Engine Instrument	Jr.	32	0	252	6
Dan	Comm.	Single-Engine Seaplane Instrument	Jr.	56	0	1015	8
Dave	Priv.	Single-Engine Instrument	Sr.	33	0	166	4
Ed	Priv.	Single-Engine	Jr.	19	0	128	5
Eric	Priv.	Single-Engine Instrument	Sr.	41	0	199	3
	Skills Test: 10, 9, 8 = above average technical skills 7, 6 = average technical skills 5, 4, 3 = below average technical skills 2, 1, 0 = unsatisfactory technical skills						

Research Setting

Though airline LOFT training tends to use multimillion dollar simulators with a six-axis motion system, wrap-around visual representation, sound effects, and high-fidelity re-creation of operational parameters; it is possible that lower-fidelity simulation using video recording of behavior might provide much of the needed training at a lower cost (Foushee & Helmreich, 1988). In General Aviation, it is not necessary to reach the level of fidelity required by the airlines; it is crucial to identify and simulate only those cues that are necessary and sufficient for the high transfer of learning (Campbell & Bagshaw, 1991). The Frasca 142 twin engine simulator is designed to support the requirements of advanced collegiate flight training providing the handling and performance characteristics similar to that of a typical light, twin-engine General Aviation airplane (Frasca, 1986). It is possible to conduct controlled studies of group process variables in this type of simulator with confidence that the results are strongly representative of the real world (Foushee & Helmreich, 1988).

The communication system in the Frasca 142 was modified for LOFT training to provide the following:

1. Monitoring of radio communications by the simulator instructor,
2. monitoring of both radio and internal communications by the researcher,
3. video-recording that includes both radio and internal communications,
and

4. backup audio recording that includes both radio and internal communications.

Simulator Procedures

Before the simulator flights, students were provided with complete preflight information including the scenario, flight planning information, en route and approach charts, and a printout of the current and forecasted weather. The crews had an opportunity to ask the instructors questions and to clarify any requirements. From the time they entered the simulator room, they were considered to be operational flight crews and no assistance was given except that which is normally provided by Air Traffic Control. Simulator sessions were videotaped from start to finish with an audio tape backup. Researchers agree that videotaping markedly increases the impact of LOFT training (Foushee & Helmreich, 1988; Hawkins, 1987; O'Hare & Roscoe, 1990). The researcher and simulator instructor took extensive collaborative field notes to record significant events, to support the videotape data, and to provide objective criteria for evaluation.

The LOFT Scenarios

The LOFT scenarios were based on Federal Aviation Regulations (FAR) Part 91 and 135 operations requiring Commercial Pilot skills. Instrument flight rules (IFR) were required throughout. No scenario forced students to choose a solution that would violate regulations. Flights took place in the United States inter-mountain Northwest, a unique area that requires extreme vigilance because of

mountainous terrain and intermittent radar coverage. To preclude rehearsal errors, unfamiliar airports and routes were chosen. Flights were designed to last 45 minutes, including 15 minutes of normal workload followed by an occurrence triggering a high-workload phase.

LOFT 1 was designed as a crew training flight because it was their first crew experience. The scenario required normal crew interactions for instrument flight; there were no critical occurrences. There were two similar legs allowing each student the opportunity to fly as Captain. Two crews (Alex/Art and Carl/Cathy) received self-analysis debriefing.

LOFT 2 was a communications flight concentrating on advocacy. The scenario was a medical support flight that was requested to divert by an urgent request for blood replacements. It required crew interaction and radio communication to choose a divert airport that was above weather minimums and that could deliver the required blood. Self-analysis debriefing was used for Betty/Bob, Dan/Dave and Ed/Eric.

LOFT 3 was a decision-making flight focusing on prioritizing and analyzing alternatives. The crew was on a long distance flight which encountered arrival deadlines, departure delays, and unsuitable weather at the destination. It required consideration of operational commitments, weather complications, and fuel constraints. Self-analysis debriefing was used for Alex/Art and Carl/Cathy.

LOFT 4 was designed as a situational awareness flight emphasizing situation monitoring and cross-checking. While transporting high-priority medical supplies,

minor mechanical difficulties progressively developed into a total loss of electrical power. The scenario required attentive monitoring of the aircraft's capabilities and awareness of external factors: weather, operational requirements, navigation capabilities, and alternatives. Communication with Air Traffic Control (ATC) and radar services were lost about 30 minutes after takeoff. Self-analysis debriefing was used for Betty/Bob, Dan/Dave, and Ed/Eric.

LOFT 5 was a team management flight highlighting workload assessment and management. The crew was exposed to operations in a high-density (Class "B" airspace) environment where the weather was unsuitable for their destination but was above minimums for several nearby alternates. They lost communication with Air Traffic Control requiring crew interaction and leadership skills to select a course of action from a large number of alternatives. Because of the complex airspace, marginal weather, and faulty radios, LOFT 5 became known as the "LOFT from Hell!"

Procedures for Training and Evaluation

Individual Orientation to the Simulator. All of the participants had previously flown the Frasca 142 simulator in various configurations. To assure that they were entirely familiar with every display and control before any CRM training or evaluation began, every person was individually instructed in the configuration used throughout the study. An oral debrief was given and errors were corrected to ensure 100% comprehension of the simulator displays and controls.

Evaluation of Flying Skills and Assignment to Crews. Before any crew training or evaluation began, each student was given an Evaluation of Individual Flying Skills. This evaluation was used to assign individuals to crews so that the level of experience in each crew was balanced. They were assigned to perform 10 instrument flying tasks which were graded as "Pass" or "Fail." Their performance in these tasks was used to match students of equal technical skill level.

Learning Procedures: Cooperative Learning. It was important to establish that the full content domain was addressed and that appropriate knowledge about the CRM skills (FAA, 1992) was imparted to each crew. The theoretical content was mastered by a Cooperative Learning procedure called "Jigsaw" (Johnson, Johnson, & Smith, 1991). Students individually read assigned material and then shared information with their crew member by discussing case studies, analyzing accident reports, and writing team response papers. The instructor acted as a resource person and evaluated learning by observation and oral quizzing.

Practice Procedures: LOFT. After learning about the CRM skills, students practiced them in the LOFT simulator flights where they were required to actively use the learned CRM skills in an operational environment. LOFTs were flown in real-time without interruption or assistance and were videotaped from start to finish.

Debriefing Procedures: Conventional. Debriefing sessions were periods to provide feedback to the crew on performance of CRM skills in the simulator. Two distinct debriefing methods were used: conventional and self-analysis.

Conventional debriefing was NOT an active-learning strategy; feedback was immediate, quantifiable, and objective, and the instructors provided the majority of the input (Butler, 1993). Performance effectiveness after conventional debriefing provided the baseline measurements for this study.

Debriefing Procedures: Self-Analysis. LOFT simulators were videotaped; a verbatim transcript of the tape was prepared; and the transcription was coded by Communications Analysis. The alternating treatments design required two sessions of self-analysis debriefing for each crew. When a crew was scheduled for self-analysis debriefing, they did not debrief immediately after the simulator session, but they waited until the transcription and communication analysis of the videotape was complete, usually within two days. Guided by learning tools (the videotape, the transcription, and the communication analysis), the crew objectively evaluated their own performance. They were instructed to do a specific learning task (to highlight the transcript whenever they used one of the CRM skills). They were challenged to count the number of positive CRM skills that occurred in a half hour of simulator time. Their attention was solidly focused on CRM skills, and they were encouraged to avoid any discussion of fault or blame.

All self-analysis sessions were videotaped for data collection. Crews mostly ignored the video recorder, but there were occasions when it noticeably detracted from the openness of the self-analysis discussion. The instructor visited the debriefing room intermittently to personally observe and to answer questions, but he usually deferred to the self-analysis process.

These self-analysis debriefs constituted the "treatment" in this study and were the keystone events of this research. A unique feature of this self-analysis training was that the verbatim transcripts and the Communications Analysis strengthened the crew's examination of the videotapes and fostered more effective self-analysis (Hawkins, 1987).

Data Collection Methods

The Cockpit Management Attitudes Questionnaire (CMAQ)

Aviator's attitudes are typically measured before and after CRM training with the CMAQ (Helmreich, Wilhelm, & Gregorich, 1988). Appendix A contains the revised version of the CMAQ (Gregorich, Helmreich, & Wilhelm, 1990) used in this study. On the CMAQ, students express the extent that they agree with a series of statements on a five-point Likert-type scale where 5 signifies strong agreement and 1 signifies strong disagreement with the statement (Gregorich & Wilhelm, 1993). The CMAQ measures three attitude clusters that are either conceptually or empirically related to CRM (Gregorich, Helmreich, & Wilhelm, 1990):

1. Communication and Coordination (COMCOOR): eleven statements that measure a pilot's beliefs about appropriate degrees of interpersonal awareness, communication, and coordination in cockpit operations.
2. Command Responsibility (COMRES): four statements which measure a belief in the appropriateness of shared responsibilities of crew members as opposed to the wholly dominant Captain.
3. Recognition of Stressor Effects (RSE): four statements that denote an individual's appreciation for the debilitating effects of situational stressors on performance.

Besides being used in a pretest - posttest manner to assess training induced changes in attitude, the CMAQ can further be used as an indirect measure of crew performance. Helmreich, Foushee, Benson, & Russini (1986) established a linkage between self-reported attitudes and independent evaluations of performance, thus attitudes provide an approach to assessing effective crew resource management.

Validity of Attitude Measurements. Content validity involves establishing that the items on the CMAQ representatively sample the domain of aviator's attitudes (Brown, 1983). Distinctions are drawn between personality traits which are viewed to be relatively stable and attitudes which are considered to be receptive to training. Helmreich (1984) found that there were non-significant correlations between personality traits, measured by the Personal Attributes Questionnaire (Helmreich, Spence & Holahan, 1979), and attitudes, measured by the CMAQ.

Criterion-related validity involves establishing an empirical relationship between test scores and some external measure (Brown, 1983). In related research with the same battery, few significant correlations were found between personality and attitudes (Helmreich, Spence, & Holahan, 1979). The available evidence supports the conclusion that cockpit management attitudes measured by the CMAQ are relatively independent of personality attributes.

Construct validity is the degree to which a test measures the psychological trait or characteristic it is designed to measure (Brown, 1983). In a factor analysis using data provided by crew members from three commercial airlines, Gregorich, Helmreich, and Wilhelm (1990) investigated the exogenous variables, organization and history effects and established that the three clusters (COMCOOR, COMRES, and RSE) were stable and exhibited strong correlations across samples. In a study of six airlines, Helmreich and Wilhelm (1991) found a consistent gain in attitudes, suggesting that the CMAQ has construct validity because crews do relate the concepts being taught to specific attitudes.

The CMAQ has been revised so that all items would have predictive validity, the degree to which the test can predict how an individual will perform in a future situation (Helmreich, Wilhelm, & Gregorich, 1988). Using this revised version, studies have typically demonstrated significant positive shifts in attitudes as a result of training impact (Helmreich & Foushee, 1993).

Though the CMAQ may be a valid test for airline pilots, there is no data to establish it as a valid test of the attitudes of undergraduate flight students. This is

evident when considering the individual items on the CMAQ which assume that the pilots have prior experience in crew operations. In the pretest, particularly, untrained college students can only imagine how they would function in a crew operation.

Reliability of Attitude Measurements. The factor-analytic study of Gregorich, Helmreich, and Wilhelm (1990) exhibited strong correlations across the three samples demonstrating reliability of the CMAQ. They conclude that the CMAQ is a reliable test because their data suggest the existence of three stable factors that exhibit strong correlations across samples. Gregorich (1993) used a sample of 1191 crew members from a major air carrier to compute reliability coefficients for the three attitude clusters. The reliability coefficient is the correlation between scores from two administrations of the test to the same sample of people (Brown, 1983). For Communication and Coordination the pre-training and post-training reliability coefficients were .63 and .71, respectively. Corresponding reliability coefficients for Command Responsibility were .38 and .42 and for Recognition of Stressor Effects were .50 and .64. A consistent pattern of intercorrelations established the internal reliability of each attitude dimension.

Validity and Reliability of the CMAQ as a Measure of Performance. Aside from attitude stability, validation of the effects of attitudes on performance is meager (Gregorich, 1993). Two investigations using expert ratings of performance in line operations have provided some validation that attitudes measured by the

CMAQ are predictors of crew performance (Helmreich, Foushee, Benson, & Russini, 1986; Helmreich, Wilhelm, Gregorich, & Chidester, 1990). Because the linkage between attitudes and performance is less than perfect, the CMAQ should be used with other performance data in a multiple measures design to measure outcomes or to determine whether training programs such as CRM are effective (Helmreich & Foushee, 1993).

CMAQ Methodology. The CMAQ was completed by each crew member individually as a pretest-posttest evaluation of the entire program. It was also completed by each crew (scored by consensus) after each LOFT session as a measure of the effectiveness of the debriefing strategy employed (conventional or self-analysis). Though the CMAQ is designed as an individual instrument, consensus scoring of one form by two crew members was used in order that the attitude/performance relationship could be based on an aircrew score (Simon, Pawlik, & Bronkhorst, 1991).

Individual Background Data. Section II of the CMAQ (Background Information) was designed for airline pilots to document their airline and military experience. The questions were not appropriate for undergraduate students, so a modified questionnaire was developed to collect background information on the students and to document their pilot experience, education, and exposure to CRM, (see CMAQ Personal Questionnaire, Appendix B).

The LINE/LOS Checklist

The LINE/LOS Checklist (see Appendix C) is an instrument for evaluating crew performance of CRM skills on the line and in Line-Oriented Simulations (Helmreich, Wilhelm, Kello et al., 1991). The LINE/LOS Checklist is used by instructors in LOFT and by other line evaluators to evaluate the performance of full crews rather than the skills or behavior of a particular crew member. The instrument taps multiple dimensions of performance and utilizes interval scales, providing a greater range of variation than binary, pass-fail ratings (Helmreich & Wilhelm, 1987).

The LINE/LOS Checklist consists of eight Crew Effectiveness Markers and two Global Ratings. The Crew Effectiveness Markers were factored into three conceptual groupings that are indicators of crew performance (Helmreich & Wilhelm, 1991; FAA, 1993):

GROUP 1: Communications Processes/Decision Behavior.

GROUP 2: Team Building and Maintenance.

GROUP 3: Workload Management and Situational Awareness.

The two global ratings are:

GLOBAL RATING 1: Overall Technical Proficiency.

GLOBAL RATING 2: Overall Crew Effectiveness.

Validity of the LINE/LOS Checklist. Under a grant from the National Aeronautics and Space Administration (NASA), Dr. Robert Helmreich at the

University of Texas (UT) compiled a significantly large database on the effectiveness of CRM training. Through this research, he developed the behavioral markers for the NASA/UT LINE/LOS Checklist to be used in the evaluation of CRM skills of cockpit crews. Through accurate and systematic data collection that included more than 15,000 completed LINE/LOS Checklists, the NASA/UT Crew Performance Project established the LINE/LOS Checklist to be a valid measure of effectiveness of crew performance (Helmreich & Wilhelm, 1991). Current CRM training programs are built on the principles developed in the NASA/UT studies. The Federal Aviation Administration has issued an advisory circular (FAA, 1993) which specifies the three clusters of the LINE/LOS Checklist as the basic CRM skills that should be taught and evaluated in each CRM program of instruction (Driskell & Adams, 1992)

Reliability of the LINE/LOS Checklist. To establish reliability of the LINE/LOS Checklist, the NASA/UT Crew Performance Project used multiple observers to rate a large number of crews and compared results (Helmreich & Wilhelm, 1991). There was general consensus on the ends of the rating scales (1 and 5 ratings) with some variability in the middle of the rating range. Differences in trained observer ratings of the same crew seldom exceeded 1 point on a 5-point scale. The research data show that the use of behavioral markers to evaluate CRM performance greatly increases the reliability of the observations (Gregorich & Wilhelm, 1993).

LINE/LOS Checklist Methodology. During the LOFT exercise, comprehensive field notes were independently taken by two instructors. The LINE/LOS Checklist was scored immediately following each LOFT by the instructors using the Evaluator/LOS Instructor Reference Manual (Helmreich, Wilhelm, Kello et al., 1991) as a guide. Each behavior marker was deliberated until a consensus score could be agreed upon by both instructors. Conscientious efforts were made to evaluate the crew as undergraduate flight students and not as airline pilots. Deliberations included the performance of technical skills, but each behavioral marker was considered on its own merit independent of evaluations in other areas. The LINE/LOS Checklist was used as a measure of crew effectiveness for this study.

The CRM Survey

Typically, efforts to evaluate training programs have included a student's evaluation of the curricula and instruction. The CRM Survey (see Appendix D) was designed as a team consensus instrument to measure crew opinions about their LOFT experience. Since simulator training is expensive and excellence in training is the objective, evaluating the training should include input from the viewpoint of the crew member (Wilhelm, 1991). The CRM Survey includes a section where crew members can contribute feedback and information about what they found most useful about the training and what they feel might be done to increase the

usefulness of the training. Responses on the CRM Survey have been factored into six categories (Wilhelm, 1991) to obtain student's views on:

1. Value of LOFT as a training technique
2. Quality of the LOFT scenario
3. Workload imposed by the LOFT scenario
4. LOFT instructor ratings
5. Self-evaluation of the crew's overall performance
6. Self-report on their use of CRM skills

Validity of the CRM Survey. The self-evaluations of training provided by the CRM Survey cannot be considered valid evidence for training effectiveness because of low correlations between self-reports and behavior (Helmreich & Wilhelm, 1987). The enthusiastic endorsement of a training program by participants does not mean that their performance will change in any significant way. Its validity is also suspect because there is a significant degree of variation in acceptance of CRM training found in self-report evaluations (Helmreich & Wilhelm, 1989). Whereas the CRM survey may not be a valid measure of the effectiveness of self-analysis, it has strong construct validity as a measure of the crew's acceptance of self-analysis training and their evaluation of its relevance and usefulness (Helmreich & Foushee, 1993). Though "buy-ons" and measures of student motivation are not sufficient evidence of a program's success, it is unlikely

that behavior changes will occur without these expressions of motivation and agreement (Helmreich & Wilhelm, 1987).

Reliability of the CRM Survey. The CRM Survey is a very reliable measure of training effectiveness at the extreme ends of the scale, both negative and positive. If the participants reported that a program had little value, it was reasonable to conclude that it had not achieved its goals (Helmreich & Wilhelm, 1989). Also, good instructor ratings correlated highly with good scenario ratings, with good CRM behaviors, and with overall ratings of LOFT as a training technique (Wilhelm, 1991).

The most important aspect of the CRM Survey is that it provides input data directly from the viewpoint of the program participants. It increases the reliability of the multiple measures assessment because it may provide converging data that will support other data sources (Gregorich & Wilhelm, 1993).

Methodology of the CRM Survey. The crew completed the CRM Survey as soon as conventional or self-analysis debriefing was complete. They were given the survey together in the debriefing room and were asked to complete it together before leaving. They were instructed on the concept of consensus so that the survey would truly be a crew response rather than the opinion of a singular individual. They were allowed to be absolutely straightforward and were assured that the results would have no effect on their grades.

Communications Analysis

Communication has dozens of functions, but this research concentrates only on communication as a means to effectively accomplish a task. Evaluation of crew communications can be used to determine how crew communications relate to performance. Listening to the communications during a flight provides indicators whether the crew is performing functionally or if problems are occurring (Kanki & Palmer, 1993). Past research has shown that cockpit communications patterns are related to flight crew performance (Foushee, Lauber, Baetge, & Acomb, 1986; Foushee & Manos, 1981).

The procedure used to analyze within-cockpit communications was adapted from the Foushee and Manos (1981) procedure that coded each statement by the Captain or First Officer into one of 20 categories of communication (see Appendix E). Although it would have been desirable to analyze all 20 categories, only four that have been empirically related to performance were used as measures of crew effectiveness:

1. Total Communications: The sum of all types of verbal communication by the Captain and First Officer, including radio communications.
2. Commands by the Captain: Specific assignment of responsibility by the Captain to the First Officer.
3. Acknowledgements by the First Officer: Verbal recognition of the Captain's command, inquiry, or observation.

4. Observations by Both Crew Members: Remarks aimed at orienting the other pilot to some aspect of flight status.

Validity of Communications Analysis. Prior studies (Foushee & Manos, 1981; Kanki, Lozito, & Foushee, 1987) have shown communication patterns to be linked to quality of crew performance. Foushee and Manos (1981) found that more effective crew performance was associated with more task-related talk, more commands, and more acknowledgements. Kanki, Lozito, and Foushee (1987) found that more effective crews made greater use of command-acknowledgement sequences initiated by Captains while less effective crews used more question-response sequences initiated by First Officers.

Several studies link the performance of crews with the four patterns of communication used in this investigation. Commands by the Captain appear to have a coordinating effect on crew performance because of their strong influence on subordinate crew member's actions (Foushee, Lauber, Baetge, & Acomb, 1986; Foushee & Manos, 1981; Kanki, Lozito, & Foushee, 1987). Acknowledgements by the First Officer to the communications of the Captain were associated with fewer crew performance errors and with a stronger personal interaction process (Foushee, Lauber, Baetge, & Acomb, 1986; Foushee & Manos, 1981; Kanki, Lozito, & Foushee, 1987). Observations by crew members, particularly by the First Officer, were significantly related to effective crew performance (Foushee, Lauber, Baetge, & Acomb, 1986; Foushee & Manos, 1981; Kanki, Lozito, & Foushee, 1987).

Increased total communications are considered an indicator of crew effectiveness because there is a tendency for crews who do not perform well to communicate less (Foushee, Lauber, Baetge, & Acomb, 1986; Foushee & Manos, 1981).

Reliability of Communications Analysis. Using a procedure adapted from Foushee and Manos (1981), cockpit communications for a period of exactly 30 minutes were transcribed, and each statement was coded into one of 20 categories. Two coders, working independently, coded all of the tapes. A point-by-point comparison of their coding established an interrater reliability of 81%. To further refine reliability, the coders jointly reviewed each differently-coded statement, debating their position until a consensus code was reached.

Communications Analysis Methodology. LOFT flights were designed to last at least 45 minutes with about 15 minutes of normal workload followed by a high-workload phase. In order to make comparisons between LOFTs, communications for each LOFT were analyzed for a timed 30-minute segment that began when a planned event triggered the high-workload phase of the flight. The variable, Total Communication, was the numerical sum of all of the Captain's communications and the First Officer's communications that were spoken during that exact period. Each crew member's total communication was further sorted into the 20 categories designed by Foushee and Manos (1981). The three categories which were analyzed in this study were Commands (by the Captain), Acknowledgements (by the First Officer), and Observations (by both crew members). These three

variables were analyzed as a percentage of the total communication rather than as individual frequencies.

Qualitative Data: Lessons-Learned

Learning criteria in LOFT has received almost no attention; research has predominantly focused on crew behaviors (Gregorich & Wilhelm, 1993). In an effort to measure what was learned by individual crews, open-ended questions asked students what lessons they had discovered during the learning, practice, and debriefing sessions. The Lessons-Learned (see Appendix F) was a self-evaluation generated by each crew after their debriefing session. Students reflected on the entire experience, listed their lessons-learned relating them to a specific CRM skill, and specified the source of learning for each lesson. The lessons-learned were classified into five categories that defined the cockpit behaviors that resulted from the training program:

1. Communication
2. Decision Making
3. Situational Awareness
4. Team Building
5. Technical

The sources of learning were sorted into six categories that defined where the crew derived the lesson from:

1. Debrief
2. Instructor
3. LOFT
4. Preflight
5. Readings
6. Self-analysis

The Lessons-Learned documents are sources of qualitative data to evaluate the student's learning experience. The task was not criteria-based, rather it was a formative learning task. Crews were encouraged to concentrate their lessons-learned on CRM skills rather than the technical and proficiency aspects of the flight. The lessons-learned were included in the study as descriptive evidence of the effectiveness of the CRM training program.

Supplementary or Supportive Data

Excerpts from their transcripts illustrated a finding or demonstrated the level of sophistication that a crew achieved in integrating CRM principles into cockpit dialogue. The quality of the communications is a good indication of the extent that the crew has internalized the CRM skills.

The researcher and the simulator instructor took extensive field notes throughout the study especially during the LOFT practice sessions and the self-analysis debriefing sessions. Where appropriate, these notes were included in the study to clarify or document a finding.

CHAPTER 4

ANALYSIS OF DATA

Alex/Art

The Alex/Art crew was well matched in technical skills, but mismatched in experience. Art was a low-time private pilot while Alex was an active flight instructor. Alex struggled with role definition throughout the training program because he thought of himself as a flight instructor, but the course expected him to perform in a team, sometimes even as the junior crew member. Whenever Alex was First Officer, there were occasions when he would instruct rather than assist, for example, in LOFT 5:

FO: More flaps?
CAP: Oh! Yup! 40.
FO: You need more than that. (laugh)
CAP: (laugh) We need ... just dive!
FO: Be ready to bring power in at the bottom.

When Alex was Captain, the struggle with role definition was different. Art had a tendency to regard himself as subordinate to Alex and deferred to Alex's decisions even if he differed. They discussed these relationships in their self-analysis sessions and addressed them in their Lessons-Learned:

Learned that just because of different experience levels, that one pilot should not assume the more experienced does not make mistakes. (LOFT 1)

Captains must delegate authority, assign tasks, during emergency and normal operations. (LOFT 4)

Both crew members became aware of role definition challenges in their self-analysis sessions and role issues were an important part of their self-analysis deliberations. It was apparent from their crew interactions in subsequent LOFTs that they worked hard to resolve role differences. Consequently, they achieved many positive results. Their final set of Lessons-Learned after LOFT 5 revealed their insights on role issues:

Crew members need to work together on decisions.

Someone needs to take control and be a leader.

Delegate duties of flying and option review.

The Captain needs to take more control in emergency situations.

Table 3 shows substantial gains in both self-analysis sessions.

In the crew CMAQ, none of the attitude scores showed differences, except Recognition of Stressor Effects. Thus, little insight into self analysis was gained from their CMAQ. Lack of any variation indicates that the crew probably responded mechanically with remembered scores. One exception was a dramatic gain in Recognition of Stressor Effects following LOFT 5, a particularly difficult LOFT for them. They apparently departed from their methodical scoring of the

Table 3. Alex/Art Evaluation Results.

Alex/Art	1st Self-Analysis LOFT 2	2nd Self-Analysis LOFT 4
CAPTAIN/FIRST OFFICER	Alex/Art	Alex/Art
CMAQ		
Communication and Coordination	nc	nc
Command Responsibility	nc	nc
Recognition of Stressor Effects	-	nc
LINE/LOS CHECKLIST		
Communications/Decision Behavior	+	-
Team Building and Maintenance	-	+
Workload Mgmt/Situational Awareness	nc	nc
Overall Technical Proficiency	+	++
Overall Crew Effectiveness	nc	++
CRM SURVEY		
Training Value of LOFT	---	nc
Scenario Quality	+++	+
Workload Imposed	++	++
Instructor Rating	++	--
Self-Evaluation of Performance	+	+
Self-Report on CRM Skills	nc	-
COMMUNICATIONS ANALYSIS		
Total Communications	+++	+
Commands (by Capt)	+	+++
Acknowledgements (by FO)	+	++
Observations (Capt & FO)	++	+
Key: Standard deviations since the last observation: --- = <-2, -- = -1<-2, - = 0<-1, nc = no change, + = 0>1, ++ = 1>2, +++ = 2>3		

CMAQ to express a notable change in their understanding of flying abilities during stressful flight situations.

The LINE/LOS Checklist showed moderate gains for the crew in the first four LOFTs. Overall Technical Proficiency showed strongest gains, consistent with the crew's high technical ability and their expressed concern for "looking good." They progressed steadily through both self-analysis sessions up to LOFT 4. One effectiveness group, Communication Process and Decision Behavior, decreased in LOFT 4 because they had decided, possibly from self-analysis, that limited communications were the key to effectiveness. In LOFT 4, there were long periods of non-communication when the crew should have been sharing information, assimilating circumstances, and deciding between alternatives.

In LOFT 5 the crew made some bad decisions which threatened the safety of the flight. The consequence was decreased performance in every category of the LINE/LOS Checklist. These declines were supported by the increased Recognition of Stressor Effects in the CMAQ and by the crew's CRM Survey self-evaluation scores. Complacency did not appear to be the key to their setback, because this crew was involved, dedicated, and expressed a preflight ambition to "be the best." Self-analysis was not a factor in their declines in LOFT 5. Also, Art was Captain in both LOFT 3, where they were very successful, and in LOFT 5, where they had difficulties, indicating that Captain was not the determining factor. LOFT 5 was a complex scenario, but it should have been within the ability level of this crew. Two plausible reasons for their decline were that the scenario was too

complex or that the crew's continuing struggle with role definition interfered with their ability to improve in LOFT 5.

The CRM Survey showed that self-analysis increased their workload but resulted in scenarios of higher quality. Self-analysis instructor ratings decreased in the second session, indicating that more instructor inputs were desired. A suggestion for improvement read:

Possibly more actual teaching of CRM skills rather than self-taught, trial-and-error teaching. (Survey, LOFT 2)

It appears that self-analysis challenged this crew but influenced their technical skills more than CRM behavior.

Their Communications Analysis showed gains in all four categories in both sessions the strongest evidence that self-analysis motivated this crew. The data suggest that the crew focused on communications in their sessions, though they reported concentrating on team building. The result supports the CRM principle that communications is instrumental toward achieving other CRM skills (Kanki & Palmer, 1993).

In their Lessons-Learned, Alex/Art focused on Team Building, though the subject was not formally taught until LOFT 5. They recorded that their main learning sources were LOFT, readings, and self-analysis. It appears that self-analysis challenged this crew and made an important contribution to their learning. The Lessons-Learned that Alex/Art attributed to self-analysis were:

Lesson 1: Communication

Understand or question - departure procedure from Livingston when First Officer asked the Captain if he was using Navigation # 2.

Lesson 2: Decision Making

Learned to analyze the questions and to know what our answer means.

Lesson 3: Situational Awareness

Briefings are important for each phase of the flight -- failing to discuss departure procedures from Livingston.

Lesson 4: Situational Awareness

Knowledge of job description - both doing jobs of single pilots, not allowing specific job applications.

Lesson 5: Situational Awareness

There is a time and place for each action, a particular action should not interrupt a previous action.

Lesson 6: Team Building and Maintenance

Assumption is bad - assuming that the Captain always knows what's going on.

Lesson 7: Team Building and Maintenance

Need to learn how to do own job, double check other without doing his job. Flight flown as two IFR pilots in same airplane.

Lesson 8: Team Building and Maintenance

Need to not assume both people are on the same track, that one knows what the other one is thinking.

Lesson 9: Team Building and Maintenance

Learned that, just because of different experience levels, one pilot should not assume the more experienced does not make mistakes.

Lesson 10: Team Building and Maintenance

Alex was flight instructor again (sometimes).

Lesson 11: Team Building and Maintenance

Art was not making decisions (sometimes).

These Lessons-Learned, particularly those that addressed Team Building and Maintenance, revealed that self-analysis made the crew fully aware of the role issues and that they made earnest efforts to manage them. It appears that discovery-learning in self-analysis made these lessons more tolerable than if they came from an instructor. Self-analysis may be more effective for learning about personality matters or about private concerns that involve individual differences.

Betty/Bob

The Betty/Bob crew had great difficulty accepting the training environment. They were very aware that they were in a research project, though they did not know the research question or how the data would be analyzed. It was necessary to remind them, especially Bob, to disregard the research and to concentrate on learning. The crew also had difficulty accepting the realism of the simulator. When something occurred, they would sometimes conclude that the simulator malfunctioned or that the instructors were "trying to pull something." They did not seem capable of "suspending reality" and treating the simulator sessions as line flights. Instead they focused on training aspects which often do not occur in the LOFT environment:

When we make a mistake, the LOFT session should terminate, because at that point or soon after, CRM is kind of ignored, and we find ourselves thinking back to our own training and skill. (CRM Survey, LOFT 2)

Crew dynamics may have influenced this crew's learning ability more than methods or strategy. Bob was confident and capable and tended to be dominant in most situations. He was not overtly sexist, but occasionally his manner or speech inferred that Betty was a "girl" rather than a crew member. Betty was equally capable but was more acquiescent. She responded professionally to him, but her body language and responses exhibited sensitivity. Evidently, their crew dynamics were more manifest to the instructors than to the crew, and it was apparently not an important topic in their self-analysis sessions. Table 4 shows the changes in effectiveness measures for Betty/Bob.

In the crew CMAQ, only losses in attitude corresponded with self-analysis. Declines in attitude after self-analysis sessions were contrary to observations and were not confirmed by findings from other instruments in the first self-analysis session (LOFT 3). This crew appeared to be very enthusiastic about self-analysis and claimed to gain significantly from it. The crew CMAQ more closely resembles Bob's individual CMAQ indicating that his attitudes probably had more leverage in the consensus process.

In LOFT 2 there was a noticeable change in crew dynamics manifested in body language and noted by instructor field notes:

0818 Betty is just flying -- where is the thinking?

0828 Bob, you just agreed she could go to 7,000 feet without thinking about it or discussing it.

Table 4. Betty/Bob Evaluation Results.

Betty/Bob	1st Self-Analysis LOFT 3	2nd Self-Analysis LOFT 5
CAPTAIN/FIRST OFFICER	Bob/Betty	Betty/Bob
CMAQ		
Communication and Coordination	--	--
Command Responsibility	+	--
Recognition of Stressor Effects	-	---
LINE/LOS CHECKLIST		
Communications/Decision Behavior	+++	--
Team Building and Maintenance	+++	--
Workload Mgmt/Situational Awareness	+++	-
Overall Technical Proficiency	++	--
Overall Crew Effectiveness	+++	-
CRM SURVEY		
Training Value of LOFT	nc	---
Scenario Quality	++	--
Workload Imposed	nc	nc
Instructor Rating	--	--
Self-Evaluation of Performance	++	--
Self-Report on CRM Skills	+++	-
COMMUNICATIONS ANALYSIS		
Total Communications	-	+++
Commands (by Capt)	+++	--
Acknowledgements (by FO)	--	+
Observations (Capt & FO)	+++	++
Key: Standard deviations since the last observation: --- = <-2, -- = -1<-2, - = 0<-1, nc = no change, + = 0>1, ++ = 1>2, +++ = 2>3		

0830 What are you doing, Betty? Share the "big picture."

0839 Hello, Bob, are you there? Would you like a martini and a more comfortable seat in First Class?

In the beginning, impaired crew dynamics were evident to the instructors but did not show in the effectiveness measures. Every item on the Line/LOS Checklist and three CRM Survey items showed strong gains after the first self-analysis session. It appeared that crew dynamics was not a concern. However, in LOFT 4, impaired crew dynamics again were noted by both instructors and were manifested in the crew's Lessons-Learned:

Do not assume that your partner knows what you mean.

Recognize problems. Don't fixate on them -- fly the plane.

Share decision making. Don't let Captain override the crew.

Their poor performance after the second self-analysis session did not relate to Captain, self-analysis, or other responses on the CRM Survey. Their decline may be attributable to the complexity of the scenario, but inferior crew dynamics was still detectable in their comments:

The need for CRM skills was not practiced. We used a lot of non-verbal communication and that was a mistake. (CRM Survey)

First Officer learned to wait for Captain decisions or make verbal suggestions before taking action. (Lessons-Learned)

In the second self-analysis session, the Communications Analysis shows gains, contrary to the other measures of effectiveness. Gains in communications skills suggest that the crew may have been processing their crew dynamics issue and

that self-analysis was starting to work. Their poor performance in LOFT 5 could have been more attributable to the difficulty level of the scenario than to interpersonal disparities. However, reduction in Commands by Captain Betty correlate with other results, signifying that she may not have been completely in charge of the situation.

In their Lessons-Learned, Betty/Bob concentrated on Communication and Situational Awareness. None of their self-analysis Lessons-Learned addressed Team Building and Maintenance and only three of their Lessons-Learned from conventional debriefing concerned teamwork issues:

Coordinate better crew coordination during emergencies and missed approach.

Learned to not take the simulator for granted -- that it is more like an actual airplane.

Share decision making. Don't let Captain override the crew.

The crew primarily learned from flying the LOFT with only five of their 50 lessons-learned coming from self-analysis. The lessons-learned that Betty/Bob attributed to self-analysis were:

Lesson 1: Communication
Use complete sentences so that we understand each other.

Lesson 2: Communication
Limit talking to ourselves.

Lesson 3: Communication
Use complete sentences, explaining what you mean (hot engine or generator).

Lesson 4: Situational Awareness

Scan even more often - should have picked up failure earlier.

Lesson 5: Situational Awareness

Look carefully at alternate approaches to determine what's available.

Their self-analysis Lessons-Learned indicate that crew dynamics was not discussed in their self-analysis sessions. These data suggest that the crew was presumably unaware of the dynamics issues. In this regard, it is reasonable to conclude that self-analysis was not effective in illuminating the personality characteristics and human relations skills that influenced the performance of this crew.

Carl/Cathy

The Carl/Cathy crew was equally matched in skills and were compatible in personality, performing well as a male/female crew. They were preoccupied with the technical aspects of flying which limited their absorption of CRM skills. They struggled with the basics of crew coordination. They had difficulty deciding who was to talk on radios or how to do checklists. They confused preflight planning (technical) with preflight briefing (CRM), giving the impression that they were unprepared for the flights. Table 5 shows the changes in effectiveness for Carl/Cathy.

The crew CMAQ does not show that self-analysis was effective for this crew. They continually struggled with Command Responsibility, experiencing difficulty deciding the basics of crew flight, such as who was to talk on radios or how to do

Table 5. Carl/Cathy Evaluation Results.

Carl/Cathy	1st Self-Analysis LOFT 2	2nd Self-Analysis LOFT 4
CAPTAIN/FIRST OFFICER	Cathy/Carl	Cathy/Carl
CMAQ		
Communication and Coordination	--	+
Command Responsibility	--	--
Recognition of Stressor Effects	---	--
LINE/LOS CHECKLIST		
Communications/Decision Behavior	--	+++
Team Building and Maintenance	--	+++
Workload Mgmt/Situational Awareness	--	+++
Overall Technical Proficiency	--	+++
Overall Crew Effectiveness	--	++
CRM SURVEY		
Training Value of LOFT	nc	---
Scenario Quality	++	++
Workload Imposed	++	+
Instructor Rating	nc	--
Self-Evaluation of Performance	--	--
Self-Report on CRM Skills	++	nc
COMMUNICATIONS ANALYSIS		
Total Communications	+++	-
Commands (by Capt)	-	+++
Acknowledgements (by FO)	nc	--
Observations (Capt & FO)	+	-
Key: Standard deviations since the last observation: --- = <-2, -- = -1<-2, - = 0<-1, nc = no change, + = 0>1, ++ = 1>2, +++ = 2>3		

checklists. Their Recognition of Stressor Effects steadily decreased because they were preoccupied with the technical aspects of flying and had little time to reflect on their CRM skills.

The LINE/LOS Checklist showed negative results for the first self-analysis session but strong gains were registered for the second one. In the first self-analysis session the crew was concentrating on technical errors, not CRM. Instructor field notes reflect this:

0806 Two separate people in the cockpit, not a crew yet.

0856 Cathy, you're the Captain, but you're asking Carl questions as if he had all the answers.

The crew was making efforts but did not know what to do. Self-analysis did not provide any answers; they needed a role model. To assist them, the instructor decided to deviate from self-analysis procedures because this was primarily a training activity and the learning needs of the students took precedence over the a priori research design. Thus, their second self-analysis session was closely monitored by the instructor who facilitated the self-analysis, keeping them away from technical discussions. It became a guided self-analysis session which manifested strong gains in the LINE/LOS Checklist scores. The gains did not continue into LOFT 5 which was apparently an unmanageable challenge for both their technical and CRM skills.

In the CRM Survey, the crew recorded an increase in CRM skills in the first self-analysis session, contrary to the results of the LINE/LOS Checklist. Gains they

perceived were probably in technical performance confirming that the crew was unable to discern between technical and CRM skills at that point. In the second self-analysis session the crew reported that they sensed the workload had increased and instructor helpfulness decreased during the guided self-analysis session. Their low Self-Evaluation of Performance and Self-Report on CRM Skills did not agree with the results of the LINE/LOS Checklist which showed strong gains for guided self-analysis.

In the first self-analysis session Communications Analysis showed a notable increase in total communications, usually an indication of increased performance. Foushee and Manos (1981) warn that more communication among flight crew members does not necessarily translate into better performance. In the second self-analysis session, increased commands by the Captain does support the results of the LINE/LOS Checklist, evidence that guided self-analysis was an effective learning method.

Crews were briefed that Lessons-Learned should not address technical skills, but nevertheless many of Carl/Cathy's comments addressed technical lessons:

Should trim out the aircraft; lack of trim leads to unfavorable flight attitudes. (LOFT 1)

Learned to be aware of 1 minute legs in the holding pattern. (LOFT 2)

Don't use out-of-date charts. (LOFT 4)

It was evident that the crew did not distinguish between technical and CRM skills. The crew reported that their Lessons-Learned focused on Situational Awareness.

They learned mostly from instructor debriefings, LOFT, and self-analysis. The

Lessons-Learned that Carl/Cathy credited to self-analysis were:

Lesson 1: Communication

Learned what advocacy was. Carl explained to Cathy that we could descend after intercepting the localizer.

Lesson 2: Communication

Learned when to declare minimum fuel.

Lesson 3: Communication

Using more standard phraseology. Leave the crap outside.

Lesson 4: Decision Making

If not sure, don't be afraid to ask questions.

Lesson 5: Decision Making

Learned to take into consideration all available airports in the area.

Lesson 6: Situational Awareness

Learned to be vigilant. Being on top of things such as engine instrument checking.

Lesson 7: Situational Awareness

Learned not to focus on one problem.

Lesson 8: Situational Awareness

Double check approaches: 9,000 feet instead of 10,000 feet.

Lesson 9: Situational Awareness

In heavy workload situations, First Officer should talk on radios.

Lesson 10: Team Building and Maintenance

Both crew members should copy the clearances.

Lesson 11: Technical

Carl learned to scan better because of his erratic attitude situations.

Lesson 12: Technical

Learned to figure out holding patterns before entering one.

Lesson 13: Technical

To slow down the situation, for instance, slowing the plane.

Numerous Lessons-Learned documented by Carl/Cathy are of a technical nature even when they pertain to a CRM skill. This finding suggests that CRM skills are higher-order skills that can only be mastered when the crew has acquired a high level of technical expertise in individual flying skills.

Dan/Dave

The Dan/Dave crew was the only crew mismatched in skills; Dan's skills were above-average, and Dave's skills were below-average. This combination, especially when Dan was Captain, produced the best overall gains in effectiveness. They worked hard in self-analysis sessions and appeared to make excellent discoveries. They openly expressed their dislike for self-analysis and preferred to integrate the instructor into the discussion. Table 6 shows the changes in effectiveness measures for Dan/Dave.

The crew CMAQ shows very little evidence that self-analysis was an effective learning environment for this crew. The gains in Recognition of Stressor Effects that occurred in LOFT 5 are probably more characteristic of the difficulty of that scenario than of self-analysis.

The LINE/LOS Checklist results made a persuasive case for self-analysis. Gains were achieved in all global scores except in Overall Technical Proficiency in both self-analysis sessions regardless of who was Captain. The crew was definitely

Table 6. Dan/Dave Evaluation Results.

Dan/Dave	1st Self-Analysis LOFT 3	2nd Self-Analysis LOFT 5
CAPTAIN/FIRST OFFICER	Dave/Dan	Dan/Dave
CMAQ		
Communication and Coordination	nc	--
Command Responsibility	nc	nc
Recognition of Stressor Effects	nc	++
LINE/LOS CHECKLIST		
Communications/Decision Behavior	+	++
Team Building and Maintenance	++	++
Workload Mgmt/Situational Awareness	++	++
Overall Technical Proficiency	--	++
Overall Crew Effectiveness	+	+++
CRM SURVEY		
Training Value of LOFT	nc	nc
Scenario Quality	nc	nc
Workload Imposed	++	--
Instructor Rating	-	--
Self-Evaluation of Performance	++	++
Self-Report on CRM Skills	++	---
COMMUNICATIONS ANALYSIS		
Total Communications	-	--
Commands (by Capt)	---	-
Acknowledgements (by FO)	++	-
Observations (Capt & FO)	+++	+
Key: Standard deviations since the last observation: --- = <-2, -- = -1<-2, - = 0<-1, nc = no change, + = 0>1, ++ = 1>2, +++ = 2>3		

more technically efficient when Dan, the more experienced pilot, was Captain because they concentrated more on CRM skills. When Dave was Captain, they were more susceptible to technical problems, but Dan usually advocated his concerns strongly enough to keep the crew from making poor decisions. Unlike the other four crews, they were not overwhelmed in LOFT 5 and established considerable gains in every crew effectiveness marker. From another viewpoint, however, the LINE/LOS Checklist basically stands alone in support of self-analysis in the second session. It is possible that the evaluators were unknowingly inflating the evaluation of Dan/Dave because their performance in LOFT 5 was superior to the other crews. Conceivably, Dan/Dave did well in the LINE/LOS Checklist only in comparison to the others, but the remaining effectiveness measurements indicated that their gains were not substantiated. Dan/Dave were the last crew to fly LOFT 5.

The crew's preference for the conventional debriefing method is reflected in their CRM Survey where the Instructor Rating dropped for both self-analysis sessions. However, the crew's Self-Evaluation of Performance for both self-analysis sessions and their Self-Report on CRM Skills for session one showed positive effects for self-analysis despite their dislike of the method.

Two variables in the Communications Analysis supported gains during the first session of self-analysis. They seemed to work particularly hard on increasing observations, keeping each other well informed. Communications Analysis did not give evidence of the gains for self-analysis that were shown in the LINE/LOS Checklist in the second session of self-analysis.

In the Lessons-Learned, this crew documented a large variety of lessons-learned in Communications, Decision Making, Situational Awareness, and Team Building. Their learning sources were predominately LOFT and self-analysis, indicating that they felt self-analysis was an effective learning agent for them. The lessons-learned that Dan/Dave attributed to self-analysis were:

Lesson 1: Communication

Inquiry - making sure that both people understand when the other person speaks.

Lesson 2: Communication

Advocacy - when "Missoula" was said instead of "Butte," while in communication with Salt Lake Center.

Lesson 3: Communication

Assertiveness - turned around right after losing second generator.

Lesson 4: Communication

Checklist - went to the flight manual to verify generator emergency procedures.

Lesson 5: Communication

Advocacy - both tried to state our ideas on where to go.

Lesson 6: Decision Making

Decision making is important.

Lesson 7: Decision Making

Problem solving - reading approach plates correctly.

Lesson 8: Decision Making

Problem solving/assessment - where, when, how to get the blood.

Lesson 9: Decision Making

Problem solving, workload management, dealt with cylinder head temperature problems.

Lesson 10: Decision Making

Problem assessment. Saw left generator fail and worked together to reduce overload on right generator.

Lesson 11: Decision Making

Tried to use other resources to solve another problem -- knob to turn off the ADF.

Lesson 12: Decision Making

Exploring possibilities about where to go in our situation.

Lesson 13: Situational Awareness

Avoiding fixation - we kept trying to make the weather better, when we knew we couldn't get into Butte.

Lesson 14: Situational Awareness

Stress management - laughing at weather that we knew we couldn't get into.

Lesson 15: Situational Awareness

Double check - repeating pertinent information.

Lesson 16: Situational Awareness

Double-check each other. System checking and monitoring.

Lesson 17: Situational Awareness

Fixated on knob for ADF.

Lesson 18: Situational Awareness

Situational awareness, decided to go to 11,000 feet from 12,000 after going to East heading.

Lesson 19: Team Building and Maintenance

Cockpit crew coordination - readying approach plates, etc. for Captain.

Lesson 20: Team Building and Maintenance

Leadership - directing cockpit components, communication, what happens next, etc.

The Lessons-Learned by the Dan/Dave crew had variety; they displayed willingness to experiment in the LOFT simulator. Their lessons-learned were

driven by practicality because they reflected on how to make the CRM lesson work for them. They applied theory in practice, looking for a new tool that would work. Perhaps they functioned most like an airline crew because both students considered Dan to be the senior crew member no matter what seat he occupied. There was never a question of who was in charge and who made the major decisions for the crew. On the other hand, Dan always endeavored to get an input from Dave, particularly when Dave was Captain.

Ed/Eric

The Ed/Eric crew had a very positive attitude; they were dedicated and conscientious and were very anxious to learn. Both had excellent academic records, yet their technical performance was below-average. The evaluation process documents a laborious journey from textbook knowledge to a practical (technical or CRM) skill. For example, their Lessons-Learned show their struggle with checklist management:

Standardization needed with regards to use of checklists in the cockpit. (LOFT 1)

Need to work more on the "do-list" and the "checklist" concept. (LOFT 2)

Still haven't established the "do-list" and "checklist." (LOFT 3)

"Do-list" and "checklist" still need more work. (LOFT 4)

"Do-list" and "checklist" needs a hell of a lot more work. (LOFT 5)

Table 7 shows the changes in effectiveness measures for Ed/Eric.

Table 7. Ed/Eric Evaluation Results.

Ed/Eric	1st Self-Analysis LOFT 3	2nd Self-Analysis LOFT 5
CAPTAIN/FIRST OFFICER	Ed/Eric	Eric/Ed
CMAQ		
Communication and Coordination	++	+
Command Responsibility	--	+
Recognition of Stressor Effects	-	---
LINE/LOS CHECKLIST		
Communications/Decision Behavior	+	--
Team Building and Maintenance	++	--
Workload Mgmt/Situational Awareness	+	--
Overall Technical Proficiency	+	--
Overall Crew Effectiveness	+	--
CRM SURVEY		
Training Value of LOFT	nc	nc
Scenario Quality	++	---
Workload Imposed	++	nc
Instructor Rating	-	---
Self-Evaluation of Performance	-	---
Self-Report on CRM Skills	-	--
COMMUNICATIONS ANALYSIS		
Total Communications	---	--
Commands (by Capt)	++	---
Acknowledgements (by FO)	+++	-
Observations (Capt & FO)	+++	-
Key: Standard deviations since the last observation: --- = <-2, -- = -1<-2, - = 0<-1, nc = no change, + = 0>1, ++ = 1>2, +++ = 2>3		

The crew CMAQ showed positive results for the first self-analysis session in communication and coordination, indicating that self-analysis influenced their learning of interpersonal awareness, communication, and crew coordination. The crew became aware of communications deficiencies in the first self-analysis session; subsequently communication became the nucleus of CRM for them.

The LINE/LOS Checklist showed very moderate gains attributable to self-analysis except in Team Building and Maintenance for the first session. The crew did not use CRM in LOFT 3 because they were fully engaged by the technical requirements of the flight. Their performance declined as the difficulty increased in subsequent LOFTs. Since they concentrated their energy on communication and judgement processes, they were unable to manage the additional demands of situational awareness (LOFT 4) and team processes (LOFT 5). LOFT 4 and LOFT 5 both involved "lost communications" with air traffic control, a stumbling block for Ed/Eric. They had a conceptual understanding of "lost communications" procedures, but were unable to transfer their knowledge into appropriate action.

The CRM Survey Report for the first self-analysis session showed that the crew perceived an increase in the scenario quality and in the workload imposed, but they did not sense any gains in performance or use of CRM skills over conventional debriefing. Their perception of progress apparently declined when they encountered explicit feedback in self-analysis. Their negative entries in the second self-analysis session probably reflected that the crew was "over their head" in a scenario that was too difficult for their skill level.

Communications Analysis substantiated the results of the other effectiveness measures for this crew. After the first self-analysis session, the crew's concentration on cockpit communication generated considerable progress in communication effectiveness measures. The Communications Analysis also confirmed their lack of progress in LOFT 5.

The Lessons-Learned for Ed/Eric focused on Communication and Team Building. They reported that the majority of their lessons were learned from LOFT, but seven of their Lessons-Learned were attributed to self-analysis. The Lessons-Learned that Ed/Eric credited to self-analysis were:

Lesson 1: Communication

Need to listen to one another and not cut in on each other.

Lesson 2: Communication

Too much extraneous talking, need to concentrate on the "sterile cockpit."

Lesson 3: Communication

During the problem solving, need to work on "thinking first." Still too much communication to oneself out loud.

Lesson 4: Communication

Advocacy is very important part of CRM!

Lesson 5: Communication

"Do" list and "check" list still need more work.

Lesson 6: Communication

Sterile cockpit and extraneous conversation needs more work. (Has improved though).

Lesson 7: Situational Awareness

Situational awareness needs some more improvement (not recognizing temperature gauge).

The Lessons-Learned document that Ed/Eric were considerably preoccupied with cockpit communication skills. The self-analysis sessions made them acutely aware of the confusion persisting in their communications. They became aware of interrupting each other's thoughts, extraneous talking, thinking out loud, and incomplete or interrupted communication. Being aware is the first step, but not the solution. This crew, more than any other, needed more time and less complicated scenarios so they could continue to make progress in effective communications. They were not ready for the advanced CRM skills that were introduced in LOFT 4 and LOFT 5.

Similar to the situation of Alex/Art, it appears that discovery-learning in self-analysis made the communications issues more visible to Ed/Eric than if they came from an instructor. Self-analysis may be more effective for learning about personal communications habits that are not readily apparent from other sources.

Summary

Summary of Findings

Due to the small number of students involved, comparisons between crews were only speculative and non-inferential. Table 8 provides a summary statement of the results for each measurement instrument, stating whether or not it supports the hypothesis that self-analysis was an effective learning strategy for each crew. It was compiled by graphical analysis and visual inspection of the data; by combining the magnitude and direction of change for each factor, a global appraisal was

Table 8. Summary: Effectiveness of Self-Analysis.

SELF-ANALYSIS SESSION	CMAQ	LINE/LOS	SURVEY	LESSONS-LEARNED	COMM ANALYSIS
1st Alex/Art	No	No	[Yes]	N/A	Yes
2nd Alex/Art	No	[Yes]	[No]	Yes	[Yes]
1st Betty/Bob	No	Yes	[Yes]	N/A	[Yes]
2nd Betty/Bob	No	No	No	No	[Yes]
1st Carl/Cathy	No	No	[Yes]	N/A	[Yes]
2nd Carl/Cathy*	No	Yes	[No]	Yes	[Yes]
1st Dan/Dave	No	[Yes]	[Yes]	N/A	[Yes]
2nd Dan/Dave	Neutral	Yes	[No]	Yes	No
1st Ed/Eric	[No]	[Yes]	[Yes]	N/A	[Yes]
2nd Ed/Eric	No	No	No	No	No
Yes = Supports that self-analysis is effective. No = Does not support that self-analysis is effective. [Yes] = Mostly Yes. [No] = Mostly No. N/A = Not Applicable. * = Guided self-analysis.					

produced for the entire instrument. Only significant changes, observations that changed more than one standard deviation since the last observation, were considered in computing the global evaluation. The results were considered to definitely support self-analysis only if all factors of an instrument showed gains. Conversely, if all factors showed losses, the results were judged to definitely not

support self-analysis. Often, the data were not definitive, but the factors could be judged to be mostly supportive or mostly non-supportive of self-analysis as an effective learning strategy for that crew.

Individually, the instruments gave a different response to the effectiveness question. Using multiple instruments to measure effectiveness took advantage of varying sources of data. Reliability was maximized by collecting data from each source and estimating the correlations among the sources (Chidester, Kanki, & Helmreich, 1989). There was not absolute correlation between data sources; instead they converged on an answer that reflected the variability in learning styles of these students.

Summary of Lessons-Learned

The final assignment for the crew at the end of each CRM session was to complete the Lessons-Learned worksheet (see Appendix F). The worksheet details ten CRM lessons that the crew learned during that session. Though it is artificial that each crew should learn exactly ten CRM lessons in a session, the worksheet was designed to stimulate extended reflection on the learning process.

Consequently, each crew wrote exactly 50 lessons-learned in the course. These were later analyzed and categorized into the four CRM skills that were taught. Though directions were explicit that crews should write only about CRM lessons-learned, several wrote about technical lessons-learned, indicating that they did not thoroughly distinguish between CRM skills and technical skills.

The crews were also asked to name the source of learning for each lesson-learned. Without exception, LOFT proved to be a valuable learning source. This clearly indicated that these students learned CRM by doing it. Self-analysis was a helpful learning source for three crews, indicating that it also had value. The strongest support for self-analysis came from Dan/Dave who frankly acknowledged that they did not like self-analysis but attributed 40% of their learning to it. For the 50 lessons-learned by each crew, Table 9 shows the skills that were learned and the sources of learning for those skills.

Table 9. Summary of Lessons-Learned.

Lessons-Learned						
Crew	Comm- nication	Decision Making	Sit. Aware	Team Building	Tech	Total
A/A	8	10	10	22	0	50
B/B	14	9	21	3	3	50
C/C	9	6	16	5	14	50
D/D	9	18	12	11	0	50
E/E	24	4	9	13	0	50
Where Learned						
Crew	Debrief	Instructor	LOFT	Preflight	Rdgs	Self- analysis
A/A	3	0	27	0	9	11
B/B	3	2	35	1	4	5
C/C	15	0	20	2	0	13
D/D	0	1	28	0	1	20
E/E	0	6	34	0	3	7

Each crew focused their lessons-learned on a specific CRM skill, and four crews had a CRM skill they neglected:

<u>CREW</u>	<u>FOCUSED ON</u>	<u>NEGLECTED</u>
Alex/Art	Team Building	None
Betty/Bob	Situational Awareness	Team Building
Carl/Cathy	Situational Awareness	Team Building
Dan/Dave	Decision Making	Communication
Ed/Eric	Communication	Decision Making

All of the CRM skills were not taught in the beginning of training; instead they were introduced in the following sequence: Communications (LOFT 2), Decision Making (LOFT 3), Situational Awareness (LOFT 4), and Team Building (LOFT 5). It would be logical for Communications and Decision Making to have more references in the lessons-learned and for Situational Awareness and Team Building to be neglected. Crews with lower technical ability (Dan/Dave and Ed/Eric) neglected one of the earlier lessons of Communications or Decision Making. Crews with more technical ability (Alex/Art, Betty/Bob, and Carl/Cathy) were able to focus on Situational Awareness and Team Building, though these CRM skills were taught towards the end of the curriculum.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

ConclusionsThe Cockpit Management Attitudes
Questionnaire (CMAQ)

Research Question #1: Does self-analysis of LOFT change undergraduate flight students' attitudes, as measured by the CMAQ.

For every crew, the CMAQ indicated only slight variability and provided essentially no evidence for effectiveness of self-analysis. Two crews showed nominal increases for isolated CMAQ variables in self-analysis sessions, and these gains supported results from other measurement instruments. Relationships between attitudes and performance have been validated for airline crews (Helmreich, Foushee, Benson, & Russini, 1986), but the instrument may be unsuitable for undergraduates because they lack crew experience on which to base attitudes. Also, the CMAQ was taken by a crew as a consensus measure of crew attitude, though it was designed as an individual instrument. A "crew attitude" may not even exist. It is also conceivable that the CMAQ showed small variations because it was completed so often (every two weeks) and crews remembered

previous responses. Thus, for several reasons, the CMAQ did not render an acceptable measure of self-analysis effectiveness.

The LINE/LOS Checklist

Research Question #2: Does self-analysis of LOFT change undergraduate flight crews' effectiveness, as measured by the LINE/LOS Checklist?

In the first self-analysis session, only one crew showed decisive gains in the LINE/LOS Checklist, two crews showed modest gains, and two crews showed no gains at all. In the second self-analysis session, two crews showed considerable gains, one crew showed moderate gains, and two crews showed no gains at all. The LINE/LOS Checklist is consistent with other measures when the crew's performance is either superior or substandard. It did not discriminate well for crews with intermediate performance.

The LINE/LOS Checklist was probably the most objective measure of effectiveness because it required systematic data collection of CRM skills distinct from technical performance. Consensus grading compelled justification for every grade and reduced the possibility of grading by instinct, crew reputation, or preferred results. Of all the measurements taken, the LINE/LOS Checklist is the best summary of the study. It shows three significant gains and three limited gains for the ten self-analysis sessions.

The CRM Survey

Research Question #3: Does self-analysis of LOFT change undergraduate flight crews' reactions to CRM training, as measured by the CRM Survey.

The CRM Survey was designed as a self-analysis instrument. In the CRM Survey, none of the crews rated self-analysis highly as a training technique. One factor in the survey, Self-Report on CRM Skills, is probably the most direct measure of self-analysis. Three of the five crews showed a step increase in this factor after the first application of self-analysis, but none reported gains in the second session. It appears that crews became more discerning and critical as they gained awareness of the CRM skills.

For self-analysis sessions, two other trends were evident in the survey:

1. Instructor Ratings declined. Four crews rated the instructor lower in self-analysis sessions showing that self-analysis was harder than having the instructor give the answers. Instructor ratings were markedly higher for baseline sessions noting that instructor "knowledge and helpfulness" were decidedly missing in the self-analysis sessions.

2. Workload Imposed increased. Three crews said that self-analysis was more work; two said it was about the same as baseline training. Crews apparently preferred conventional debriefing with the instructor; the extra work was perceived as a negative feature of self-analysis.

Communications Analysis

Research Question #4: Does self-analysis of LOFT change undergraduate flight crews' performance of CRM skills, as measured by Communications Analysis?

Multiple measures of effectiveness were used because each data source has its strengths and weaknesses. A data source has merit if it consistently validates or disproves the results from other measures. In Communications Analysis, frequencies are an equivocal measure of effectiveness because communication must be interpreted within a task, environment, or interpersonal context (Kanki & Palmer, 1993). In this study, three of the four communications categories confirmed results of other measures. However, Total Communications was not consistent as a measure of effectiveness. It appears that well-intentioned crews, in an effort to practice communications skills, "talked" more but "communicated" less.

When a crew was scheduled for self-analysis debriefing, they did not debrief immediately after the simulator session but waited until the transcript and communication analysis of the LOFT videotape were complete. This process was expedited, but there was usually a two-day delay between the simulator session and the self-analysis debrief. This unfortunate detainment allowed the crews to lose some of the intensity and emotions of the LOFT simulator, even though all the details were still available through the videotape and transcript. It is possible that the affective results of self-analysis would be different if the debriefings were

immediate as they were in the conventional debriefings. The conventional debriefings were not delayed for two days after the simulator session, because feedback is best if it is immediate (Butler, 1993).

CRM and Technical Skills

Research Question #5: Are there factors or circumstances that strengthen or inhibit the learning of CRM skills by self-analysis?

Throughout this research, the focus was on CRM skills, leaving the impression that CRM skills are superior to or more desirable than technical skills. A high degree of technical proficiency is essential for safe and efficient flight operations (FAA, 1993). In this research, crews with lower technical ability had considerable difficulty learning CRM skills, confirming the conventional wisdom that mature technical skills are the foundation for developing CRM skills. Assessment of technical skills prior to CRM training was essential; however, a higher qualifying grade on the technical skills test should have been established, excluding more individuals.

Women Pilots

Research Question #5: Are there factors or circumstances that strengthen or inhibit the learning of CRM skills by self-analysis?

The two women pilots that participated in the study were as professional and competent as the men, supporting the reality that women belong in aviation and

should be encouraged to participate equally with men in all domains of the industry. This study confirmed that all pilots should be treated equally; if even suspicions of discriminatory or preferential behavior are raised, the issue must be confronted. In the case of Betty/Bob, the learning needs of the students should have taken precedence over the research design and the crew dynamics issues should have been discussed and resolved. Sexist behavior by women or men, students or instructors, must be addressed and eliminated as soon as it is discovered.

Scenarios

Research Question #5: Are there factors or circumstances that strengthen or inhibit the learning of CRM skills by self-analysis?

The objective of LOFT is to provide crew members with the opportunity to practice both technical and CRM skills in a realistic scenario. The scenarios for this research were created, field-tested, and evaluated by experienced aviators based on perceived skills of commercial pilots. "Realistic and reasonable" for designers may not be viable for the students. In retrospect, two unanticipated factors may have influenced the results: students needed more low-workload time in all scenarios, and LOFT 4 and LOFT 5 were too difficult for most of the crews. With the exception of Dan/Dave, overall technical performance in LOFT 5 was deficient, making it difficult to determine if outcomes were attributable to self-analysis or to the scenario itself. Undergraduate flight students in a CRM class are

uniquely different from airline pilots reporting for initial or recurrent CRM training. For many, it is likely that CRM training was their first exposure to situations where they were required to coordinate their activities with another person. An effective CRM curriculum for them might require less content material and more simplified scenarios to accommodate for their inexperience.

In the LOFT, no scenario required students to choose a solution that violated Federal Aviation Regulations (FARs). However, in the 25 flights, two crews deliberately chose to violate FARs, both while in "lost communication" situations. All five crews had some difficulty with "lost communication" which they encountered in LOFT 4 and LOFT 5, and these scenarios were particularly difficult, especially for the less skilled. They all seemed comfortable with textbook answers but had difficulty transferring the knowledge to appropriate action when they were denied assistance or feedback. LOFT requires higher-order thinking, just as life's situations do. This may be one of the strongest arguments in favor of including LOFT in undergraduate programs.

Role Definition and Crew Dynamics

Research Question #5: Are there factors or circumstances that strengthen or inhibit the learning of CRM skills by self-analysis?

Reflecting on the crews that struggled with role definition and crew dynamics reveals an important difference between airline CRM training and undergraduate training. Airline crews are expected to have such issues resolved

beforehand, but these contentions are natural learning encounters for college students. The outcome for Alex/Art was positive because self-analysis made them aware of the role definition problem and they struggled with it, though it was not totally resolved. On the other hand, self-analysis did not expose the crew dynamics issue to Betty/Bob, so it was not addressed forthrightly and the outcome is uncertain. It may have been more appropriate if I had temporarily relinquished my role as researcher and reverted to my role as educator to examine the crew dynamics issues with Betty/Bob so they could resolve it.

Self-Analysis Skills

Research Question #5: Are there factors or circumstances that strengthen or inhibit the learning of CRM skills by self-analysis?

The expectation of the research was that crews would know how to direct their own thinking and learning processes in self-analysis sessions. This assumes that they have previously developed skills in metacognitive strategies and reflective learning. Metacognition refers to reflecting on and regulation of one's own thinking (Flavell, 1981). Reflective learning in a self-analysis setting means being aware of and expertise in the use of interpersonal skills (Telfer & Biggs, 1988). The structure and guidelines of self-analysis require students to use "higher-order" learning skills such as analysis, synthesis, and evaluation (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956).

The findings indicate that some of the expectations of self-analysis were not realized because students lacked training and experience with metacognitive or "higher-order" learning processes. Specifically, some crews exhibited deficiency in the skills of self-disclosure or expressing feelings and emotions (Betty/Bob), attending and listening (Ed/Eric), and placing legitimate demands on each other (Carl/Cathy). All of the crews showed inadequacies in the skills of self-critique and confronting others. The learning sessions of the course concentrated on four CRM skills (Communication, Situational Awareness, Decision Making, and Team Building) which prepared them for the skills required in the LOFT scenarios, but were probably not adequate preparation for the task of self-analysis. Even if crews had mastered the interpersonal skills directed at the structured environment of the cockpit, it is not assured that they would be able to apply them in the group climate established in a self-analysis session. Flavell (1981) identified three metacognitive abilities that a learner must achieve in order to exercise "higher-order" learning, i.e., a self-knowledge about personal cognitive processes, an insight into the requirements for successful completion of the task, and adeptness with the strategies of achieving goals in the learning process. Without specific training and experience in metacognitive processes and reflective learning, the undergraduate students in this study probably were not highly skilled in self-analysis processes.

Communications Analysis and Transcripts

Research Question #5: Are there factors or circumstances that strengthen or inhibit the learning of CRM skills by self-analysis?

One limitation of the self-analysis method was that verbatim transcriptions were expensive and time-consuming to produce. In order to have similar segments of transcript for communications analysis, exactly 30 minutes of communication from each LOFT was transcribed. Though these lengthy transcripts were valuable learning tools, they were too extended and often overloaded the students with work. Ten or fifteen minutes of transcribed communication would have been sufficient to keep a crew diligently involved in self-analysis training for over an hour.

Expenses can be decreased significantly by limiting transcriptions to segments where CRM skills are specifically required by the scenario. The segments can be selected by the instructor and customized for the specific needs of a crew. Graduate students or work study students can learn to do transcripts and they cost significantly less than professional transcribers. My transcriber for this research was a graduate student who was a skilled typist but had no experience with transcriptions. She became a wizard at the task, averaging 2.3 hours to transcribe 15 minutes of a LOFT.

Summary of Conclusions

The research has some practical implications for the design and conduct of flight training in general. None of the crews rated self-analysis highly, indicating that crews preferred conventional debriefing to self-analysis. Substantial evidence weighed against self-analysis as a stand-alone strategy for undergraduate flight students. The results are characteristic of initial flight students who are accustomed to more guidance and rely heavily on feedback from instructors to evaluate their performance. However, there are sufficient data supportive of self-analysis, especially for some crews, that it should not be completely rejected. Though airline strategies are not necessarily applicable to undergraduate flight students, airline research shows that debriefings handled in a "teacher-tell" manner are less effective than discussions led by the crew themselves with the instructor and the videotape as resources for the self-critique (Butler, 1993).

Self-analysis seems to be more effective as a supplemental strategy to be employed by an instructor when certain conditions exist. Further research is needed to determine the circumstances such as personalities, team dynamics, or experience that would make it successful. Self-analysis may be more effective for learning about personality matters or about individual differences (Alex/Art). It also appears that self-analysis may facilitate understanding of communications issues (Ed/Eric).

In general, the first exposure to self-analysis was more effective than the second. This conclusion is partially explained by the complexity of the scenarios in the second self-analysis session (LOFT 4 or LOFT 5) which caused a decrease in performance. The data show a step increase in many of the effectiveness measures after the first application of self-analysis that is not as apparent after the second application. If the students considered self-analysis techniques to be worthwhile and useful, they presumably would continue to use them even for conventional debriefing sessions, thereby decreasing the effect of second or subsequent applications of self-analysis.

The crew's assessment of self-analysis as a learning tool matched the data in the LINE/LOS Checklist in four out of five cases. The crews were apparently aware of the requirements for effective CRM skills and were able to judge their performance according to valid criteria. Their self-evaluation on the CRM Survey showed that three crews were able to discriminate between technical performance and performance of CRM skills. This, in itself, is a measure of their understanding of the subject matter as it relates to performance criteria.

The effectiveness of self-analysis is strongly influenced by individual technical ability and by the complexity of the scenarios. Self-analysis may also become more effective as students accumulate experiences with crew operations and with self-critique. Butler (1993) supports the concept that learning to perform operational review and analysis establishes a platform for effective post-LOFT discussion that consists of more than technical issues. In the beginning of this

course, students had no experience base, but after several sessions they had ample exposure to several CRM skills. As the course progressed, their self-evaluations became more discerning, their lessons-learned became more discriminating, and their cockpit communication reflected active practice of the CRM skills.

Recommendations

Improving Self-Analysis

After reflecting on the procedures used for self-analysis in this study, I recommend changes in the design that might improve the study. Instead of forming crews with students of equal skill, I would use mismatched crews, similar to Dan/Dave, so that one person obviously had seniority in the crew. I would not swap roles between Captain and First Officer but would organize the crews so that the more experienced pilot was always the Captain. I would considerably reduce the complexity of the scenarios and even tailor scenarios to match the learning pace of individual crews. I would decrease the length of the self-analysis sessions to about one hour and would provide fewer pages of transcript for analysis. I would allot more time for learning effective communication skills and would discriminate between communications skills needed in self-analysis sessions and cockpit communications skills. I would have a higher standard for admission into the course, denying admission to anyone whose technical skills score was less than six.

Metacognitive Learning

Smith (1982) explored metacognition, the concept of learning how to learn, and concluded: "A central task of learning how to learn is developing awareness of oneself as a learner" (p. 57). This requires that the learner engage in reflection on his own learning process such as an inventory of learning styles. Flavell (1981) identified two other metacognitive skills that a learner must achieve in order to engage in "higher-order" learning activities such as self-analysis, i.e., an insight into the requirements of the task and adeptness with "higher order" learning strategies. I recommend training and experience in metacognitive processes and reflective learning before undergraduate students embark on self-analysis. This could be a supplementary course in interpersonal skills which includes the skills of self-disclosure, self-critique, expression of feelings and emotions, attending and listening, accurate empathetic understanding, genuineness and respect, challenging, confrontation and immediacy (Egan, 1976). The minimum preparation for self-analysis should be a module on metacognition that furnishes the students with skills required for effective self-analysis: self-awareness, an insight into the learning task, and proficiency with interpersonal skills such as self-critique, attending and listening, and confrontation (Flavell, 1981).

Guided Self-Analysis

Because one crew centered on technical discussions, a variant of self-analysis was employed; the instructor closely monitored the session and

participated in the exchange. It became a guided self-analysis session and produced strong gains in the LINE/LOS Checklist. Based on the outcomes from this flight, I recommend using a facilitated approach to self-analysis, a teaching strategy that combines self-analysis and conventional debriefing. This strategy theoretically employs the benefits of self-analysis and standard debriefings, providing a very powerful debrief method for undergraduate crews. Research with this design might be more complex because it would be difficult to discriminate between guided self-analysis and conventional debriefing.

Role Models

Participants in this study were sometimes frustrated because they did not always know "the right way" to do things. They were given readings, particularly sections of airline operations manuals, but they were not always able to apply theory to practice in the LOFT. Self-analysis did not help either, unless they knew beforehand what to do. It became clear that these students needed a standard for their comparison. They needed to imitate a Captain or First Officer, a role model with considerable experience in crew operations to demonstrate effective crew performance. In this study, the only role model a student experienced was another student. I recommend a research design where a self-analysis session is preceded by an exposure to role model crew members who illustrate effective crew performance. Students could observe role models on videotapes or role plays, but

the best training would be achieved by flying a LOFT scenario with a pilot experienced in crew operations.

For Further Research

Crews in this study experienced that the cockpit can be a confining and sometimes emotional environment and that male/female relationships can add CRM issues that must be considered. Further research is needed to understand perceptions of male dominance, male/female dynamics, and the seniority of Captains regardless of age, sex, and often skill. These issues are compelling reasons why CRM should be included in initial flight training to educate men and women of the appropriate paradigm: men and women are equal; performance, not gender, is the decisive factor.

Preferably students should randomly be assigned to flight crews, but diversity of experience and differences in technical ability of these students dictated that they should be assigned to crews by technical ability rather than randomly. Ability grouping where experienced pilots were teamed together left at least one crew that was too inexperienced to handle the complexities of some scenarios. The data show that excellent gains in effectiveness were achieved by the crew that had mixed skills (Dan/Dave). Further research should consider forming crews using one pilot with high skills and one with lower skills, allowing for greater heterogeneity of the crews.

Each learning session focused on a new CRM skill using the Cooperative Learning procedure called "Jigsaw" (Johnson, Johnson, & Smith, 1991). Students individually studied material about that particular CRM skill and then shared their learning with the other crew member. It is uncertain whether one exposure to each CRM skill is sufficient for thorough learning. LOFT engages the students in such higher-order thinking tasks as analysis, synthesis, and evaluation (Bonwell & Eison, 1991). Future CRM programs could attempt a longer program of study so that each CRM skill could be discussed several times at different levels of comprehension.

In self-analysis sessions, crews evaluated their own performance in a secluded room using videotapes and transcripts that were not shared with other crews. It was suggested that group analysis of LOFT videotapes and transcripts might be a valuable learning method. Admitting that much could be learned from serious group analysis of another crew's successes and mistakes, I envision possible negative outcomes such as frivolity, crew embarrassment, or individual mockery if the scrutinized crew members are classmates. Further research might consider if it is worthwhile for the entire group to analyze videotapes and transcripts from LOFTs performed by unfamiliar crew members.

Training requirements compelled students to exchange roles between Captain and First Officer for each scenario. The significance of role changing for the research was that crew performance could vary with the Captain. Assigning one crew member to be Captain for the entire study would have been better for

research; however, it is unethical in an educational environment because students require exposure to both paradigms. An alternative approach would be to teach CRM in two semesters with beginner students flying First Officer and experienced ones flying Captain. A potential benefit is that experienced students could be a role model for novice students. Further research could determine if a student with one semester of LOFT experience is an adequate role model.

Future research should recognize that college students need acclimation to crew operations; scenarios should be uncomplicated and should include significant low-workload periods. Undergraduate flight students require high stress, high workload, and emergency experiences that stimulate the use of CRM skills, but their level of experience dictates that scenarios should not be overwhelming. Guidelines and scenarios developed for airline pilots may be too complex for undergraduate flight students.

REFERENCES CITED

- AOPA's Aviation USA. (1991). Frederick, MD: Aircraft Owners and Pilots Association.
- Best, J. W., & Kahn, J. V. (1989). Research in education (6th ed.). Englewood Cliffs, NJ: Prentice-Hall.
- Blake, R. R., & Mouton, J. S. (1982). Cockpit resource management. Denver, CO: Scientific Methods, Inc.
- Bloom, B. S., Englehart, M. B., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). Taxonomy of educational objectives: The classification of educational goals. Handbook 1: The cognitive domain. New York: Longman.
- Bolman, L. (1979). Theory of the situation. Boston: Harvard University School of Education.
- Bonwell, C. C., & Eison, J. A. (1991). Active learning: Creating excitement in the classroom. ASHE-ERIC Higher Education Report No. 1. Washington, DC: The George Washington University, School of Education and Human Development.
- Borg, W. R., & Gall, M. D. (1989). Educational research: An introduction (5th ed.). New York: Longman.
- Brown, F. G. (1983). Principles of educational and psychological testing. New York: Holt, Rinehart, and Winston.
- Butler, R. E. (1991). CRM, LOFT, and Bernard Shaw: Flight crew evaluator training workshop presentation (NASA/ University of Texas Technical Manual 91-3). Moffett Field, CA: NASA-Ames Research Center.
- Butler, R. E. (1992). AOP Committee: LOFT design focus group report (Report of ATA LOFT Design Focus Group Meeting, February 6, 1992; NASA/University of Texas Crew Performance Project). Austin, TX: University of Texas.
- Butler, R. E. (1993). LOFT: Full-mission simulation as crew resource management training. In E. L. Weiner, R. L. Helmreich, & B. G. Kanki (Eds.), Cockpit resource management (pp. 231-259). San Diego: Academic Press.
- Campbell, R. D., & Bagshaw, M. (1991). Human performance and limitations in aviation. Oxford: Blackwell Scientific Publications, Inc.

- Caro, P. W. (1988). Flight training and simulation. In E. L. Weiner, & D. C. Nagel (Eds.), Human factors in aviation (pp. 229-262). New York: Academic Press.
- Carver, C. S., & Scheier, M. F. (1981). Attention and self-regulation: A control theory approach to human behavior. New York: Springer-Verlag.
- Chidester, T. R., Kanki, B. G., & Helmreich, R. L. (1989). Performance evaluation in full-mission simulation: Methodological advances and research challenges. In R. S. Jensen (Ed.), Proceedings of the Fifth International Symposium on Aviation Psychology (pp.16-21). Columbus, OH: Ohio State University Press.
- Cohen, L., & Manion, L. (1985). Research methods in education (2nd ed.). London: Croom Helm.
- Cook, G. N. (1991). Cockpit resource management training: Are current instructional methods likely to be successful? The Journal of Aviation/Aerospace Education and Research. 1(3), 26-35.
- Driskell, J. E., & Adams, R. J. (1992). Crew resource management: An introductory handbook (NTIS no. PB93-101525). Springfield, VA: National Technical Information Service.
- Duval, S., & Wicklund, R. A. (1972). A theory of objective self awareness. New York: Academic Press.
- Duval, T. S., Duval, V. H., & Mulilis, J. P. (1992). Effects of self-focus, discrepancy between self and standard, and outcome expectancy favorability on the tendency to match self to standard or to withdraw. Journal of Personality and Social Psychology, 62(2), 340-348.
- Edwards, E. (1972). Man and machine: Systems for safety. In Proceedings of British Airline Pilots Association Technical Symposium. (p. 21-36). London: British Airline Pilots Association.
- Edwards, E. (1988). Introductory overview. In E. L. Weiner, & D. C. Nagel (Eds.), Human factors in aviation (pp. 3-26). New York: Academic Press.
- Egan, G. (1976). Interpersonal living: A skills/contract approach to human relations training in groups. Monterey, CA: Wadsworth.

- Federal Aviation Administration. (1992). Line operational simulation advisory circular (AC no. 120-35B). Washington, DC: U.S. Department of Transportation.
- Federal Aviation Administration. (1993). Cockpit resource management training (AC no. 120-51A). Washington, DC: U.S. Department of Transportation.
- Festinger, L. (1957). A theory of cognitive dissonance. Stanford, CA: Stanford University Press.
- Flavell, J. H. (1981). Cognitive monitoring. In W. P. Dickson (Ed.), Children's oral communication skills. New York: Academic Press.
- Foushee, H. C., & Helmreich, R. L. (1988). Group interaction and flight crew performance. In E. L. Weiner, & D. C. Nagel (Eds.), Human factors in aviation (pp. 189-228). New York: Academic Press.
- Foushee, H. C., & Manos, K. L. (1981). Information transfer within the cockpit. In C. E. Billings and E. S. Cheaney (Eds.), Information transfer problems in the aviation system (NASA Technical Paper 1875). Moffett Field, CA: NASA Ames Research Center.
- Foushee, H. C., Lauber, J. K., Baetge, M. M., & Acomb, D. B. (1986). Crew factors in flight operations: III. The operational significance of exposure to short-haul air transport operations (NASA Technical Memorandum 88322). Moffett Field, CA: NASA Ames Research Center.
- Frasca model 142 fact sheet. (1986). Urbana, IL: Frasca International, Inc.
- Gay, L. R. (1992). Educational research: Competencies for analysis and application (4th ed.). New York: Macmillan.
- Gibbons, F. X., & Wicklund, R. A. (1982). Self-focused attention and helping behavior. Journal of Personality and Social Psychology, *43*(3), 462-474.
- Gregorich, S. E. (1993). The dynamics of CRM attitude change: Attitude stability. In R. S. Jensen (Ed.), Proceedings of the Seventh International Symposium on Aviation Psychology (pp. 509-512). Columbus, OH: Ohio State University Press.
- Gregorich, S. E., Helmreich, R. L., & Wilhelm, J. A. (1990). The structure of cockpit management attitudes. Journal of Applied Psychology, *75*(6), 682-690.

- Gregorich, S. E., Helmreich, R. L., Wilhelm, J. A., & Chidester, T. (1989). Personality based clusters as predictors of aviator attitudes and performance. In R. S. Jensen (Ed.), Proceedings of the Fifth International Symposium on Aviation Psychology (pp. 686-691). Columbus, OH: Ohio State University Press.
- Gregorich, S. E., & Wilhelm, J. A. (1993). Crew Resource Management Training Assessment. In E. L. Wiener, R. L. Helmreich, & B. G. Kanki (Eds.), Cockpit Resource Management (pp. 173-198). San Diego: Academic Press.
- Guba, E. G. (1978). Toward a methodology of naturalistic inquiry in educational evaluation. Los Angeles: Center for the study of Evaluation, UCLA Graduate School of Education.
- Guba, E. G. & Lincoln, Y. S. (1981). Effective evaluation: Improving the usefulness of evaluation results through responsive and naturalistic approaches. San Francisco: Jossey-Bass.
- Helmreich, R. L. (1983a, October). What changes and what endures: The capabilities and limitations of training and selection. Paper presented at the Irish Air Line Pilots/AER Lingus Flight Operations Symposium, Dublin, Ireland.
- Helmreich, R. L. (1983b). Cockpit management attitudes. Paper presented at the Second International Symposium on Aviation Psychology, Ohio State University. Columbus, OH.
- Helmreich, R. L. (1984). Cockpit Management Attitudes. Human Factors, 26(5), 583-589.
- Helmreich, R. L. (1989). Evaluating the effectiveness of cockpit resource management training. In Proceedings of the Second Conference on Human Error Avoidance Techniques (pp. 17-22). Warrendale, PA: Society of Automotive Engineers.
- Helmreich, R. L. (1991). Strategies for the study of flight crew behavior. In R. S. Jensen (Ed.), Proceedings of the Sixth International Symposium on Aviation Psychology (pp. 338-343). Columbus, OH: Ohio State University Press.
- Helmreich, R. L., & Foushee, H. C. (1993). Why crew resource management? In E. L. Wiener, R. L. Helmreich, & B. G. Kanki (Eds.), Cockpit resource management (pp. 3-45). San Diego: Academic Press.

- Helmreich, R. L., Foushee, H. C., Benson, R., & Russini, W. (1986). Cockpit resource management: Exploring the attitude-performance linkage. Aviation, Space, and Environmental Medicine, *57*, 1198-1200.
- Helmreich, R. L., Spence, J. T., & Holahan, C. K. (1979). Psychological androgyny and sex-role attitudes: A test of two hypotheses. Journal of Personality and Social Psychology, *37*, 1631-1644.
- Helmreich, R. L., & Wilhelm, J. A. (1987). Evaluating cockpit resource management training. In R. S. Jensen (Ed.), Proceedings of the Fourth International Symposium on Aviation Psychology (pp. 440-446). Columbus, OH: Ohio State University Press.
- Helmreich, R. L., & Wilhelm, J. A. (1989). When training boomerangs: Negative outcomes associated with Cockpit Resource Management programs. In R. S. Jensen (Ed.), Proceedings of the Fifth International Symposium on Aviation Psychology (pp. 692-697). Columbus, OH: Ohio State University Press.
- Helmreich, R. L., & Wilhelm, J. A. (1991). Methodological issues in the use of the LINE/LOS Checklist and Behavioral Markers: Notes for evaluators. (NASA/University of Texas Technical Memorandum 91-1). Austin, TX: University of Texas.
- Helmreich, R. L., Wilhelm, J. A., & Gregorich, S. E. (1988). Revised version of the Cockpit Management Attitudes Questionnaire (CMAQ) and CRM Seminar Evaluation Form (NASA/University of Texas Technical Report 88-3). Austin, TX: University of Texas.
- Helmreich, R. L., Wilhelm, J. A., Gregorich, S. E., & Chidester, T. (1990). Preliminary results from the evaluation of cockpit resource management training: Performance ratings of flight crews. Aviation, Space, and Environmental Medicine, *61*, 576-579.
- Helmreich, R. L., Wilhelm, J. A., Kello, J. E., Taggart, W. R., & Butler, R. E. (1991). Reinforcing and evaluating crew resource management: Evaluator/LOS instructor reference manual (NASA/ University of Texas Technical Manual 90-2, Revision 1). Austin, TX: University of Texas.
- Hawkins, F. H. (1987). Human factors in flight. Brookfield, VT: Gower Publishing Company.

- Irwin, C. M. (1991). The impact of initial and recurrent cockpit resource management training on attitudes. In R. S. Jensen (Ed.), Proceedings of the Sixth International Symposium on Aviation Psychology (pp. 344-349). Columbus, OH: Ohio State University Press.
- Johnson, D. W., Johnson, R. T., & Smith, K. A. (1991). Cooperative learning: Increasing college faculty instructional productivity. ASHE-ERIC Higher Education Report No. 4. Washington, DC: The George Washington University, School of Education and Human Development.
- Jones, M. B. (1974). Regressing group on individual effectiveness. Organizational Behavior and Human Performance, 11, 426-451.
- Jones, E. E., & Nisbett, R. E. (1971). The actor and the observer: Divergent perceptions of the causes of behavior. New York: General Learning Press.
- Kanki, B. G. (1991). Session overview: Information transfer and crew performance. In R. S. Jensen (Ed.), Proceedings of the Sixth International Symposium on Aviation Psychology (pp. 247-252). Columbus, OH: Ohio State University Press.
- Kanki, B. G., & Palmer, M. T. (1993). Communication and crew resource management. In E. L. Weiner, R. L. Helmreich, & B. G. Kanki (Eds.), Cockpit resource management (pp. 99-136). San Diego: Academic Press.
- Kanki, B. G., Palmer, M. T., & Veinott, E. (1991). Communication variations related to leader personality. In R. S. Jensen (Ed.), Proceedings of the Sixth International Symposium on Aviation Psychology (pp. 253-259). Columbus, OH: Ohio State University Press.
- Kanki, B. G., Lozito, S., & Foushee, H. C. (1987). Communication indexes of crew coordination. In R. S. Jensen (Ed.), Proceedings of the Fourth International Symposium on Aviation Psychology (pp. 406-412). Columbus, OH: Ohio State University Press.
- Kazdin, A. C. (1982). Single-case research designs. New York: Oxford University Press.
- Kerlinger, F. N. (1973). Foundations of behavioral research (2nd ed.). New York: Holt, Rinehart and Winston.

- Lauber, J. K., & Foushee, H. C. (1983, October). Line-oriented flight training. In The Flight Operations Symposium. Irish Air Line Pilot's Association/AER Lingus, Dublin, Ireland.
- Lofaro, R. J. (1990). Cockpit resource management: Research, development, status. Airworthy Aviator, 1(3), 1, 8.
- Massey, D. (1990). CRM: Teaching crew interaction. Career Pilot, 10, 13-17.
- Nash, T. (1992). LOFT: Where is it going? Civil Aviation Training, 3(1), 26-30.
- O'Hare, D., & Roscoe, S. (1990). Flight deck performance: The human factor. Ames, IA: Iowa State University Press.
- Piaget, J. (1966). Judgement and reasoning in the child. Totowa, NJ: Littlefield, Adams.
- Ross, L. E., Slotten, P. W., & Yeazel, L. M. (1990). Pilots' evaluation of the usefulness of full mission IFR simulator flights for general aviation pilot training. The Journal of Aviation/Aerospace Education and Research. 1(2), 16-25.
- Ruffell-Smith, H. P. (1979). A simulator study of the interaction of pilot workload with errors, vigilance, and decisions (NASA Technical Memorandum 78482). Moffett Field, CA: NASA-Ames Research Center.
- Sams, T. L. (1987). Cockpit resource management concepts and training strategies: Developing an analysis of training needs. In R. S. Jensen (Ed.), Proceedings of the Fourth International Symposium on Aviation Psychology (pp. 360-371). Columbus, OH: Ohio State University Press.
- Simon, R., Pawlik, E. A., & Bronkhorst, T. M. (1991). Aircrew coordination for Army helicopters: An exploration of the attitude-behavior-performance relationship. In R. S. Jensen (Ed.), Proceedings of the Sixth International Symposium on Aviation Psychology (pp. 290-295). Columbus, OH: Ohio State University Press.
- Smith, R. M. (1982). Learning how to learn. Chicago: Follett Publishing.
- Stone, R. B. (1988). Airline Pilots' perspective. In E. L. Weiner, & D. C. Nagel (Eds.), Human factors in aviation (pp. 189-228). New York: Academic Press.

- Telfer, R., & Biggs, J. (1988). The psychology of flight training. Ames, IA: Iowa State University Press.
- Trollip, S. R., & Jensen, R. S. (1991). Human factors for general aviation. Englewood, CO: Jeppesen Sanderson.
- Vandermark, M. J. (1989). Aircrew Team Dynamics: A comprehensive crew management program for America West Airline's pilots and flight attendants. In R. S. Jensen (Ed.), Proceedings of the Fifth International Symposium on Aviation Psychology (pp. 640-645). Columbus, OH: Ohio State University Press.
- Weisman, G. (1991). A new partnership in CRM training. ICAO Journal, 9, 10-12.
- Wicklund, R. A. (1975). Objective self-awareness. In L. Berkowitz (Ed.), Advances in experimental social psychology (Vol. 8). New York: Academic Press.
- Wicklund, R. A., & Brehm, J. W. (1976). Perspectives on cognitive dissonance. Hillsdale, NJ: Lawrence Erlbaum, Associates.
- Wilhelm, J. (1991). Crew member and instructor evaluations of Line Oriented Flight Training. In R. S. Jensen (Ed.), Proceedings of the Sixth International Symposium on Aviation Psychology (pp. 362-367). Columbus, OH: Ohio State University Press.

APPENDICES

Appendix A

The Cockpit Management Attitudes Questionnaire (CMAQ)

Cockpit Management Attitudes Questionnaire

As part of NASA sponsored research, we are collecting data on attitudes about flightdeck management in commercial operations. You will greatly assist our research if you complete the survey. All data are strictly confidential. Please answer by writing beside each item the letter that best reflects your personal attitude. Choose the letter from the scale below.

- | A | B | **Scale** | D | E |
|----------------------|----------------------|--------------|-------------------|-------------------|
| Disagree
Strongly | Disagree
Slightly | C
Neutral | Agree
Slightly | Agree
Strongly |
| ___ 1. | | | | |
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| ___ 2. | | | | |
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| ___ 3. | | | | |
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| ___ 4. | | | | |
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| ___ 12. | | | | |
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| ___ 21. | | | | |
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| ___ 22. | | | | |
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| ___ 23. | | | | |
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| ___ 24. | | | | |
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| ___ 25. | | | | |

Please go on to the next page

II. Background Information**Airline Experience:**

Year of birth _____ Years in 121 ops _____ Years in 135 ops _____

Sex (M or F) _____ Years with present organization _____ Nationality _____

Status and Position: Complete both status and position. Check those that apply. (If you are a new hire, or are in upgrade or transition training fill in the appropriate item, then complete status and position in reference to your old aircraft/position.)

_____ New hire training for _____ position in _____ aircraft
 _____ Upgrade training to _____ position
 _____ Transition training to _____ aircraft

Status:**Position:**

_____ Line pilot	_____ Captain
_____ Instructor (pilot or FE)	_____ First Officer
_____ Line check (pilot or FE)	_____ Flight Engineer (S/O)
_____ Management	_____ Staff
_____ Other (specify) _____	

Years in present position: _____ Flight hours in present position _____

Current aircraft: _____ Hours in current aircraft _____

Total airline flight hours (all airlines, aircraft and positions) _____

Military Experience:

Aircraft flown _____ Position(s) _____

Years in military flying _____ Total military flight hours _____

Other Civilian Pilot Experience:

Aircraft flown _____ Position(s) _____

Nature of flying (ex: pleasure, cargo, FBO, etc.) _____

Years in other civilian operations _____

Total civilian non-airline flight hours _____

This completes the questionnaire. Thanks for your help!

Appendix B
Background Questionnaire

BACKGROUND QUESTIONNAIRE

Name: _____ Date: _____

(NOTE: ALL RESPONSES WILL BE HANDLED ANONYMOUSLY)

1) Do you now hold, or have you ever held the following FAA Pilot Certificates:

- | | |
|--|--|
| <input type="checkbox"/> Recreational | <input type="checkbox"/> Cert. Flight Instructor |
| <input type="checkbox"/> Private | <input type="checkbox"/> Cert. Instr. Instructor |
| <input type="checkbox"/> Commercial | <input type="checkbox"/> Multi-Engine Instructor |
| <input type="checkbox"/> Air Transport Pilot | |

2) Do you now hold, or have you ever held the following FAA Ratings:

- | | |
|---|---|
| <input type="checkbox"/> Single-Engine Land | <input type="checkbox"/> Glider |
| <input type="checkbox"/> Single-Engine Sea | <input type="checkbox"/> Lighter-than-air |
| <input type="checkbox"/> Multi-Engine Land | <input type="checkbox"/> Helicopter |
| <input type="checkbox"/> Multi-Engine Sea | <input type="checkbox"/> Instrument |

3) Have you ever had formal (classroom) ground school in the following:

- | | |
|--|--|
| <input type="checkbox"/> Private Pilot | <input type="checkbox"/> Cert. Flight Instructor |
| <input type="checkbox"/> Commercial Pilot | <input type="checkbox"/> Cert. Instr. Instructor |
| <input type="checkbox"/> Air Transport Pilot | <input type="checkbox"/> Multi-Engine Instructor |
| <input type="checkbox"/> Glider Pilot | <input type="checkbox"/> Instrument Rating |
| <input type="checkbox"/> Balloon Pilot | <input type="checkbox"/> Seaplane Rating |
| <input type="checkbox"/> Helicopter Pilot | <input type="checkbox"/> Multi-Engine Rating |

7) Briefly state your goals and ambitions in aviation.

8) PERSONAL INFORMATION:

a) Year of Birth: _____

b) Sex: M F

c) Home State: _____

d) Family Background (Circle One): RURAL, URBAN, SUBURBAN

e) Check all that apply:

- Freshman
- Sophomore
- Junior
- Senior
- Graduate

- Full-time student
- Part-time Student
- Aeronautical Science Major
- Airway Science Major
- Other Major: _____

f) Minor: _____

g) Do you work while attending college? Yes No

If Yes, ___ Full Time? or ___ Part Time?

Work Description: _____

- 9) Have you had any previous experience with Cockpit Resource Management (CRM)? Yes No.

If Yes, Explain briefly: _____

- 10) Have you had any previous experience with Line-Oriented Flight Training (LOFT)? Yes No.

If Yes, Explain briefly: _____

Appendix C
The LINE/LOS Checklist

NASA/UT Crew Performance Indicators

1. Briefing (conduct and quality). The effective briefing will be operationally thorough, interesting, and will address coordination, planning, and problems. [Although primarily a Captain responsibility, other crewmembers may add significantly to planning and definition of potential problem areas.]

Evaluation Scale

1	2	3	4	5
Poor Performance Significantly Below Expectations	Minimally Acceptable Performance Improvement Needed	Satisfactory or Standard Performance	Very Good, Above Average Performance	Exceptional Performance Significantly Above Standard

Crew Performance Markers

Scoring

(Bold, Italicized Markers apply to Advanced Technology Flightdecks)

	a.	establishes environment for open/interactive communications (e.g., calls for questions or comments, answers questions directly, listens with patience, does not interrupt or "talk over", does not rush through the briefing, makes eye contact as appropriate).
	b.	is interactive, 2-way, and emphasizes the importance of questions, critique and the offering of information
	c.	establishes "team concept" (e.g., uses "we" language, encourages all to participate and help with the flight)
	d.	covers pertinent safety and operational issues
	e.	identifies potential problems such as weather, delays, and abnormal system operations
	f.	provides guidelines for crew actions -- division of labor and crew workload addressed
	g.	includes cabin crew as part of team in the briefing, as appropriate
	h.	Sets expectations for how deviations from S.O.P. are to be handled
	<i>i.</i>	<i>establishes guidelines for the operation of automated systems (i.e. when system will be disabled, programming actions that must be verbalized and acknowledged)</i>
	<i>j.</i>	<i>specifies PF and PNF duties and responsibilities with regard to Automated Systems</i>

Overall Rating

None/Poor 1

2

3

4

5 Excellent

Comments:

NASA/UT Crew Performance Indicators

2. Inquiry/Advocacy/Assertion practiced. This rating assesses the extent to which crewmembers advocate the course of action they feel best, even when it involves conflict and disagreements with others.

Evaluation Scale

1	2	3	4	5
Poor Performance Significantly Below Expectations	Minimally Acceptable Performance Improvement Needed	Satisfactory or Standard Performance	Very Good, Above Average Performance	Exceptional Performance Significantly Above Standard

Scoring

Crew Performance Markers

(Bold, Italicized Markers apply to Advanced Technology Flightdecks)

	a.	crewmembers speak up, and state their information with appropriate persistence, until there is some clear resolution and decision
	b.	"challenge and response" environment developed
	c.	questions are encouraged, and are answered openly and nondefensively.
	d.	crewmembers are encouraged to ask questions regarding crew actions and decisions
	e.	crewmembers seek information and direction from others when necessary
	f.	<i>crewmembers question status and programming of Automated Systems to verify situational awareness</i>

Overall Rating

None/Poor 1

2

3

4

5 Excellent

Comments:

NASA/UT Crew Performance Indicators

3. **Crew self-critique (decisions and actions).** This item evaluates the extent to which crewmembers, conduct and participate in a debriefing, operational review, and critique of activities, which includes the product, the process, and the people involved. Critique can, and should, occur during an activity, and/or after completion of the activity.

Evaluation Scale

1 Poor Performance Significantly Below Expectations	2 Minimally Acceptable Performance Improvement Needed	3 Satisfactory or Standard Performance	4 Very Good, Above Average Performance	5 Exceptional Performance Significantly Above Standard
---	--	--	---	--

Crew Performance Markers

Scoring

(Bold, Italicized Markers apply to Advanced Technology Flightdecks)

	a.	given at appropriate times, both low and high workload
	b.	deals with positive as well as negative aspects of crew performance during flight
	c.	interactively involves the whole crew
	d.	made a positive learning experience -- feedback is specific, objective, based on observable behavior, and given constructively.
	e.	critique is accepted objectively and nondefensively.
	f.	

Overall Rating

None/Poor 1

2

3

4

5 Excellent

Comments:

NASA/UT Crew Performance Indicators

4. **Communications/Decisions.** This rating reflects the extent to which free and open communication is practiced. It includes the extent to which crewmembers provide necessary information at the appropriate time (for example, initiating checklists, alerting others to developing problems). Active participation in decision making process encouraged and practiced. Questioning of actions and decisions is proper. Decisions made are clearly communicated and acknowledged.

Evaluation Scale

1 Poor Performance Significantly Below Expectations	2 Minimally Acceptable Performance Improvement Needed	3 Satisfactory or Standard Performance	4 Very Good, Above Average Performance	5 Exceptional Performance Significantly Above Standard
---	--	--	---	--

Crew Performance Markers

Scoring

(Bold, Italicized Markers apply to Advanced Technology Flightdecks)

	a.	operational decisions are clearly stated to other crewmembers
	b.	crewmembers acknowledge understanding of decisions made
	c.	"bottom lines" are established and communicated for safety of operations
	d.	the "big picture" and the gameplan are shared within the team including flight attendants and others
	e.	crewmembers are encouraged to state their own ideas, opinions, and recommendations
	f.	effort is made to provide an atmosphere conducive to open and free communications
	g.	<i>entries and changes to Automated Systems' parameters are verbalized and acknowledged</i>

Overall Rating

None/Poor 1

2

3

4

5 Excellent

Comments:

NASA/UT Crew Performance Indicators

5. Leadership-Followership/Concern for tasks. This rating evaluates the extent to which appropriate leadership and followership is practiced. It reflects the extent to which the crew is concerned with the effective accomplishment of necessary tasks.

Evaluation Scale

1 Poor Performance Significantly Below Expectations	2 Minimally Acceptable Performance Improvement Needed	3 Satisfactory or Standard Performance	4 Very Good, Above Average Performance	5 Exceptional Performance Significantly Above Standard
---	--	--	---	--

Crew Performance Markers

Scoring

(Bold, Italicized Markers apply to Advanced Technology Flightdecks)

	a.	utilizes all available resources to accomplish job at hand
	b.	coordinates flightdeck activities to establish proper balance between authority and assertiveness
	c.	acts decisively when the situation requires
	d.	demonstrates desire to achieve most effective possible operation
	e.	recognizes need to maintain adherence to SOPs
	f.	ensures that group climate is appropriate to operational situation (i.e. social conversation in low workload conditions but not high)
	g.	recognizes effects of stress and fatigue on performance
	h.	manages time available for task accomplishment
	<i>i.</i>	<i>recognizes and deal with demands on resources posed by operation of Automated Systems</i>
	<i>j.</i>	<i>disengages Automated Systems operation when programming demands could reduce situational awareness or create work overloads</i>

Overall Rating

None/Poor	1	2	3	4	5	Excellent
Comments:						

NASA/UT Crew Performance Indicators

6. **Interpersonal relationships/Group climate.** This evaluation reflects the quality of observed interpersonal relationships among and the overall *climate* of the flightdeck. This is independent of demonstrated concern with accomplishment of required tasks.

Evaluation Scale

1 Poor Performance Significantly Below Expectations	2 Minimally Acceptable Performance Improvement Needed	3 Satisfactory or Standard Performance	4 Very Good, Above Average Performance	5 Exceptional Performance Significantly Above Standard
---	--	--	---	--

Crew Performance Markers

Scoring

(Bold, Italicized Markers apply to Advanced Technology Flightdecks)

a.	crewmembers remain calm under stressful conditions
b.	shows sensitivity and ability to adapt to other crewmembers' personalities and personal characteristics
c.	recognizes symptoms of psychological stress and fatigue in self and others (e.g., note when a crewmember is not communicating, and draw him/her back into the team; recognize when they are experiencing "tunnel vision", and seek help from the team)
d.	"tone" in the cockpit is friendly, relaxed, supportive
e.	during times of low communication, crewmembers check in with each other to see how they are doing

Overall Rating

None/Poor 1

2

3

4

5 Excellent

Comments:

NASA/UT Crew Performance Indicators

7. **Preparation/Planning/Vigilance.** This rating indicates the extent to which crews anticipate contingencies and actions that may be required. Excellent crews are always "ahead of the curve" while poor crews continually play catch up. Vigilant crews devote appropriate attention to required tasks and respond immediately to new information. *A crew indulging in casual social conversation during periods of low workload is not necessarily lacking in vigilance if flight duties are being discharged properly.*

Evaluation Scale

1 Poor Performance Significantly Below Expectations	2 Minimally Acceptable Performance Improvement Needed	3 Satisfactory or Standard Performance	4 Very Good, Above Average Performance	5 Exceptional Performance Significantly Above Standard
---	--	--	---	--

Crew Performance Markers

Scoring

(Bold, Italicized Markers apply to Advanced Technology Flightdecks)

	a.	demonstrates and expresses situational awareness -- the "model" of what is happening is shared within the crew
	b.	monitoring of all instruments and communications, sharing relevant information with the rest of the crew
	c.	monitor climatic and traffic conditions, sharing relevant information with the rest of the crew
	d.	avoids "tunnel vision" of stress-- stating or asking for the "big picture"
	e.	is aware of factors such as stress that can reduce vigilance -- thus, monitoring the performance of other crew members
	f.	stays "ahead of curve" in preparing for expected or contingency situations (including approaches, weather, etc.)
	g.	verbally insures that cockpit and cabin crew are aware of plans
	h.	includes all appropriate crewmembers in planning process
	<i>i.</i>	<i>plans for sufficient time prior to maneuvers for programming of Flight Management Computer</i>
	<i>j.</i>	<i>ensures that all crewmembers are aware of status and changes in FMS parameters</i>

Overall Rating

None/Poor	1	2	3	4	5	Excellent
Comments:						

NASA/UT Crew Performance Indicators

8. **Workload distributed/Distractions avoided.** This is a rating of time and workload management. It reflects how well the crew managed to distribute the tasks and avoid overloading individuals. It also considers the ability of the crew to avoid being distracted from essential activities and how work is prioritized.

Evaluation Scale

1	2	3	4	5
Poor Performance Significantly Below Expectations	Minimally Acceptable Performance Improvement Needed	Satisfactory or Standard Performance	Very Good, Above Average Performance	Exceptional Performance Significantly Above Standard

Crew Performance Markers

Scoring

(Bold, Italicized Markers apply to Advanced Technology Flightdecks)

	a.	crewmembers report and admit work overloads
	b.	action is taken to distribute tasks to maximize efficiency
	c.	workload distribution is clearly communicated and acknowledged
	d.	makes sure that non-operational factors such as social interaction do not interfere with necessary task duties
	e.	communicates the work priorities clearly to the crew.
	f.	makes sure that secondary operational tasks (i.e. dealing with passenger needs, company communications) are prioritized so as to allow sufficient resources for dealing effectively with primary flight duties
	g.	recognizes and report overloads in others
	h.	<i>crewmembers recognize potential distractions posed by Automated Systems and take appropriate preventive action, including disengaging</i>

Overall Rating

None/Poor 1

2

3

4

5 Excellent

Comments:

Cluster D. Overall Technical proficiency

Item 9. Overall Technical Proficiency. This is a rating of how well the crew as a unit discharged the technical aspects of the flight. It reflects awareness that a high degree of technical proficiency is essential for safe and efficient operations. Demonstrated mastery of CRM concepts cannot overcome a lack of proficiency. Similarly, high technical proficiency cannot guarantee safe operations in the absence of effective crew coordination. This rating can be thought of as a more fine grained evaluation of the *technical* performance of a crew than the typical "S" or "U" employed in a Line Check or other evaluation. A "5" represents an unusual demonstration of proficiency while a "1" would reflect seriously substandard behavior. Refer to the scale definitions in the previous section.

**Behavioral Indicators for
Overall Technical Proficiency**

(Bold, Italicized Indicators apply to Advanced Technology Flightdecks)

1. adheres to FAR's and ATC requirements, and follows company established procedures including checklist management and standard call-outs.
2. observes and effectively manages sterile cockpit environment .
3. demonstrates a high level of basic (stick and rudder) flying skills .
4. required briefings include all pertinent safety and operational issues as defined in the AOM and FOM.
5. demonstrates knowledge of aircraft systems and normal, abnormal, and emergency procedures

Item 10. Overall CREW effectiveness. This item is a composite, global judgment of the crew's performance taking into account *both* demonstrated technical proficiency and the CRM concepts assessed above. To receive a "5", a crew must be at least at the midpoint ("3") on Item 9 and must show clearly above average performance on a number of CRM items with no "1"s. A crew rated "1" overall might receive this on the basis of low technical proficiency that threatens the conduct of the flight or on the basis of low ratings on one or more critical CRM items. Reference to the definition of the scale will help in determining this judgement.

NASA/UT LINE/LOS CHECKLIST

I. FLIGHT AND EQUIPMENT INFORMATION

Airline _____ Date (Mo,Yr) _____ RATER ID.

LOFT LOE SPOT LINE CHECK (S or U) Line Observation

Scenario ID Pilot flying: CA FO

ROUTING A/C Type & Series HOURS OBSERVED # LEGS OBSERVED

Demographics	Captain	First Officer	Flight Engineer
Completed Initial CRM (Y, N, or ?)	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>
Number of CRM Recurrent Sessions	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>
Number of LOS/LOFT Sessions	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>
Crewmember Domicile	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>
Flight Hours in this Aircraft	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>
Flight Hours in this Position	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>
Approximate Age	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>	<input style="width: 50px; height: 20px;" type="text"/>

II. CREW EFFECTIVENESS MARKERS

- | | | | | | | | |
|---|-----------|---|---|---|---|---|-----------|
| 1. Briefings (conduct and quality) | None/Poor | 1 | 2 | 3 | 4 | 5 | Excellent |
| 2. Inquiry/Assertion/Advocacy | None/Poor | 1 | 2 | 3 | 4 | 5 | Excellent |
| 3. Crew self-critique (decisions and actions) | None/Poor | 1 | 2 | 3 | 4 | 5 | Excellent |
| 4. Communications/Decisions | Poor | 1 | 2 | 3 | 4 | 5 | Excellent |
| 5. Leadership-Followership/Concern for tasks | Poor | 1 | 2 | 3 | 4 | 5 | Excellent |
| 6. Interpersonal relationships/Group climate | Poor | 1 | 2 | 3 | 4 | 5 | Excellent |
| 7. Preparation/Planning/Vigilance | Poor | 1 | 2 | 3 | 4 | 5 | Excellent |
| 8. Workload distributed/Distractions avoided | Poor | 1 | 2 | 3 | 4 | 5 | Excellent |
| 9. Overall TECHNICAL proficiency | Poor | 1 | 2 | 3 | 4 | 5 | Excellent |
| 10. Overall CREW effectiveness | Poor | 1 | 2 | 3 | 4 | 5 | Excellent |

III. SUPPLEMENTARY INFORMATION:

11. Environmental workload Low 1 2 3 4 5 High

Other conditions which significantly influenced the flight (include weather, ATC, pre-existing mechanicals, in-flight abnormal events, IOE, extra crewmembers, etc.). Describe below.

IV. SPECIAL CIRCUMSTANCES: This section provides data on non-standard situations or behaviors that may influence crew performance. If conflicts occur, rate how effectively they were resolved.

12. Severity of abnormal or emergency situation Low 1 2 3 4 5 High

13. Conflict resolution Poor 1 2 3 4 5 Excellent

In some cases the actions of a particular crewmember may be particularly significant to the outcome of the flight. In cases where this happens, enter the relevant item number from above, check the position of the crewmember involved, and circle the rating assigned.

 Poor 1 2 3 4 5 Excellent
 Item No. Captain First Officer Engineer

 Poor 1 2 3 4 5 Excellent
 Item No. Captain First Officer Engineer

 Poor 1 2 3 4 5 Excellent
 Item No. Captain First Officer Engineer

 Poor 1 2 3 4 5 Excellent
 Item No. Captain First Officer Engineer

V. COMMENTS: Describe abnormal or emergency conditions, conflicts, or individual behaviors rated in Section II. Also comment on extreme (1 or 5) ratings from Section II.

Item #

Comments

Appendix D
The CRM Survey

Please fill out this short survey to give us your opinion about the usefulness of LOFT in general and of the LOFT scenarios you have just completed. This survey is part of the NASA-sponsored research evaluating the impact of Cockpit Resource Management training. The questionnaire is anonymous and will be used to develop summary statistics and recommendations regarding CRM and LOFT. Please place the completed form in the envelope provided and place it in Company mail.

Aircraft _____ LOFT from _____ to _____

Inflight problem _____

Position: ___ CA ___ FO ___ FE Completed CRM Seminar? ___ YES ___ NO

How many LOFT sessions have you completed before today? _____

1. Were you aware of the nature of the scenario and problem in this LOFT?

- _____ No information about any aspect of it.
 _____ Slight familiarity with problem and scenario.
 _____ Considerable familiarity with problem and scenario.
 _____ Detailed information on problem and scenario.

1a. If you indicated some awareness of the scenario, please check the statement below which is closest to your opinion.

- _____ This awareness greatly reduced the training value.
 _____ This awareness slightly reduced the training value.
 _____ This awareness had no effect on the training value.

2. How realistic was the scenario? (Circle a number on the scale)

Unrealistic in every way	1 2 3 4 5 6 7	Realistic in every way
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3. How difficult was the scenario?

Extremely easy	1 2 3 4 5 6 7	Extremely difficult
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4. How well did your crew perform the mission?

Extremely poor	1 2 3 4 5 6 7	Extremely well
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5. How well did you personally perform?

Extremely poor 1 2 3 4 5 6 7 Extremely well

6. Overall, how would you rate the value of this LOFT session for crew coordination training?

Completely useless 1 2 3 4 5 6 7 Completely useful

7. Overall, how would you rate the technical training value of this LOFT session?

Completely useless 1 2 3 4 5 6 7 Completely useful

8. Overall, how much have you learned in this simulation that you will actually use on the line?

Absolutely nothing 1 2 3 4 5 6 7 A tremendous amount

Use a number from the following scale to indicate your level of agreement with each of the following statements. Write the number in the space to the left of the statement.

1	2	3	4	5	6	7
Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

- ___ 9. Our crew really worked as a team.
- ___ 10. During the LOFT we spent far too much time talking or arguing.
- ___ 11. Dealing with members of the crew left me feeling irritated and frustrated.
- ___ 12. Our crew practiced inquiry/questioning.
- ___ 13. The Captain made most of the decisions about our flight without involving other crewmembers.
- ___ 14. Our crew practiced advocacy/assertion.
- ___ 15. Our crew shared responsibility for its leadership.
- ___ 16. Our crew practiced self-critique of decisions and actions.

- ___ 17. Our LOFT instructor was knowledgeable and helpful.
- ___ 18. The debriefing following the LOFT was highly useful for all crewmembers.
- ___ 19. The videotape of the LOFT provided important feedback to the crew.
- ___ 20. Overall, LOFT is an extremely useful training technique.

Please describe what you found most useful about the LOFT.

Please describe anything that you feel might be done to increase the usefulness of LOFT.

Appendix E
Communications Analysis

COMMUNICATIONS ANALYSIS CODES

1. Commands/Command Decisions
2. Observations/Supplying Unsolicited Information
3. Suggestions
4. Statements of Intent
5. Inquiries/Requests for Clarification/Requests
6. Agreements
7. Disagreements
8. Acknowledgements
9. Answers supplying information
10. Response uncertainty
11. Tension release
12. Frustration/anger/derisive remarks/surprise
13. Embarrassment
14. Repeats
15. Checklist
16. Non-task related
17. Non-codeable
18. ATC communications
19. Talking to self aloud
20. Incomplete/interrupted communication

Foushee, H. C. & Manos, K. L. (1981). Information transfer within the cockpit. In C. E. Billings and E. S. Cheaney (Eds.) Information transfer problems in the aviation system. (NASA Technical Paper 1875). Moffett Field, CA: NASA Ames Research Center.

Foushee, H. C., Lauber, J. K., Baetge, M. M., & Acomb, D. B. (1986). Crew factors in flight operations: III. The operational significance of exposure to short-haul air transport operations. (NASA Technical Memorandum 88322). Moffett Field, CA: NASA Ames Research Center.

Appendix F
Lessons-Learned

Lessons-Learned

Names: _____ & _____

Lesson: _____

We learned that from: _____

Lesson: _____

We learned that from: _____

Lesson: _____

We learned that from: _____

Lesson: _____

We learned that from: _____

Lesson: _____

We learned that from: _____

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