Air Carrier
Training
Research Review

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Air Carrier Training Research

The FAA Office of the Chief Scientist for Human Factors (AAR-100) directs an air carrier training research program centering on methods for effective pilot training and assessment. Semi-annual research reviews are conducted by this office. The following report summarizes the June 1997 review.

Introduction

Although basic technical and Crew Resource Management (CRM) concepts are widely accepted, much remains to be learned regarding the appropriate methods for effective training and valid and reliable assessment of training programs. The general research philosophy guiding efforts to improve training and assessment is that research must consider distinct segments of aviation training systems. Individuals comprising the crew, instructors who train and evaluate crews in the classroom, the simulator and on the line as well as the management personnel responsible for the safety climate of the carriers should all be considered. Additionally, this research must regard the variables important to Line Oriented Flight Training (LOFT) development, implementation and evaluation. Thus, this research centers on (1) crew training and assessment, (2) instructor training, (3) LOFT development strategies, and (4) organizational and systematic influences on pilot performance.

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Project Title: *Identification of Hard to Train CRM Skills*

Performing Agency: University of New Mexico, Albuquerque

Background: Traditionally, CRM training has focused on the high-level CRM concepts or elements of pilot performance. The training and assessment of high-level concepts is fraught with many problems. Among them, the validity of course content is questionable and the reliability and validity of CRM assessment has not been established. Prior research has shown that assessment of observable behaviors, rather than global concepts, especially within LOFT event sets, can improve the reliability of CRM assessment. Therefore, observable behaviors have provided a more meaningful and lower level of detail for the CRM assessment process. However, the research and operational community have not yet developed a comparable level of detail for the CRM training process. It is impractical to try to train observable behaviors. Thus, at present, it is likely that training would be on the global level but assessment could take place at the observable behavior level. This training paradigm, although improved from all CRM training activities being at the global level, still lacks the training vigor employed, for example, in technical training. An approach to solving this dilemma is to attempt to identify the knowledge, skills and abilities underlying CRM concepts and then to train at that level. Observable behaviors could be identified and assessed for skills in situation specific training events.

Project Description: This research project has been investigating two distinct segments of air carrier training, skill analysis and reliable performance assessment.

Work is being conducted with major carriers to identify the key CRM skills that can be trained systematically in crews undergoing transition and recurrent training. CRM concepts, or CRM knowledge, that are important across several air carriers were identified. These are the concepts that are less affected by individual corporate climate and should be the foundation of CRM knowledge at most US based air carriers. Additionally, a general framework for skill analysis was developed that incorporated an analysis methodology with skill categories that could have significant training implications for air carriers. The skill types under investigation are: 1) procedural skills, 2) representational skills, and 3) strategies. It may be possible to design skill training, employing this taxonomy. This idea will be explored in follow up research.

Work continues in the validation of methods that can be used by air carriers to identify and link CRM skills within their fleet-specific Advanced Qualification Program (AQP) databases. Currently, most carriers insert place holders similar to high-level CRM elements in their AQP databases, rather than enter detailed CRM skills. Once developed, these new methods will allow air carriers to systematically identify appropriate CRM skills and to link those skills with the observable behaviors presently used in the CRM assessment process.

Efforts to reliably assess pilot performance, during training, have traditionally been less than successful. During FY96 and FY97, this research team has been working with an air carrier to improve training assessment by designing rater training and new data collection systems. This work focuses on rater calibration, development of grade sheets, development of videos used in the calibration sessions, presentations to the instructors on the importance of quality data, collection and analysis of the calibration data, and reporting results. Several calibration studies have been completed and additional sessions are

planned. Thus far, the results of these calibration studies show (1) how minor changes in the wording of observed behaviors listed on gradesheets can have a significant effect on ratings, (2) large individual differences among raters, (3) higher inter-referent than inter-rater reliability, and (4) a significant increase in reliability when improvements to the calibration sessions were implemented (wording of the gradesheet, quality of the video, better briefing of the event sets). The frequency of the higher inter-referent reliability is important to note because there are differences among carriers in their views of whether a referent should be established and instructors trained to the referent or whether instructor's inter-rater reliability is adequate. AAR-100 is investigating this question further through work being done by George Mason University at several other carriers employing the inter-rater reliability methodology.

This team has begun work on the development of a PC-based system that will effectively present a complete calibration session to individual evaluators. Upon entering a pin, the system will 1) provide the evaluator with a prebriefing of the LOE that is to be presented; 2) display the gradesheet that is to be used; 3) present an audio/video of the first event set; 4) collect ratings to the event set and the observed behaviors; 5) continue to present and collect ratings for the entire LOFT or LOE; 6) analyze the evaluators ratings and present evaluator's performance relative to other evaluators and a referent score based on the fleet's qualification standards; 7) allow the evaluator to select any segment of the video and receive instructions as to what the qualification standards were and why a specific rating was deemed appropriate.

This project has produced a document describing what it means to have quality data, why quality data are necessary for training under AQP, and the methods for achieving quality in performance assessment. This document is intended for evaluators and instructor/evaluator supervisors and is available to industry.

This project is also examining the statistical properties of a large amount of maneuver validation data. The goal is to be able to identify statistically significant changes in maneuver validation performance across time in general, and more specifically in first-look performance.

Products: Skill training and assessment strategies incorporated into training guidelines; Instructor/evaluator training guidelines

Project Title: *Identifying Leadership and Followership Skills in CRM*

Performing Agency: Western Michigan University

Background: The University of New Mexico research described earlier will center on CRM components: Crew Communication, Crew Climate, Decision Making, and Workload Management. Western Michigan University will provide the CRM leadership component skill analysis information.

Historically, leadership has been viewed as a linear, one-way (i.e., downward) action with the primary aim of task accomplishment. This perspective has dominated the cockpit of air carriers. However, as the role of the modern cockpit crew changes, the skills required of the crew members change also. It is now thought that leadership is an activity that involves both leaders and followers as they interact to accomplish goals and that followership skills are as important as leadership skills to the safe and efficient performance of flight crews. It is unclear how to train leadership/followership as the skills underlying these concepts have not been identified.

Project description: This project will analyze cockpit performance to determine the behavioral components of leadership/followership skills. When these are identified, this research will provide training guidelines. This project will provide the skill analysis of cockpit leadership and be employed in the more general skill study at the University of New Mexico.

In phase I of this two-year project, a model of cockpit leadership was developed which guided the skill analysis. This model of effective and efficient cockpit operations points out that the crew must use many skills to deal effectively with environmental variables largely out of their control. These variables include the regulatory environment, the corporate environment, the market environment, and the physical environment. Analyses are being conducted based on the assumptions that (1) a minimum amount of leadership/followership is required to achieve a safe flight, (2) individuals constantly oscillate between leader and follower roles, and (3) weak leader or follower skills will be compensated for by other crew members. Preliminary analysis is complete and reveals that to deal effectively within the framework described in the model, crews must possess skills in: envisioning, modeling, receptiveness, influence, adaptability, and initiative. The analysis also showed that these skills are common to both leadership and followership.

During FY 96, data from a line audit at a major carrier revealed that the components described in the model are related to overall crew effectiveness. In general, the more severe an abnormal situation the less effective the crew was in exhibiting leadership/followership skills. Captains tended to be less likely to articulate a vision for the flight, meet company standards or obtain commitment from other crewmembers or be adaptable. Both Captains and First Officers were less likely to initiate actions in response to an operational deficiency when the severity of abnormals was high. When handling a complex situation, but not an abnormal, these crews displayed "outstanding" leadership/followership skills. These ratings were not dependent on position or time together as a crew.

The data also showed that Captains do, in fact, set the tone in the cockpit. When Captains articulated a vision for the flight the First Officer would initiate a response to an operational deficiency

without further direction from the Captain. When Captains exhibited good conduct and high standards, First Officers exhibited similar behavior. When Captains were receptive, First Officers were likewise receptive.

Maintaining vigilance during the flight seems to be dependent on each crew member at different phases. During predeparture, takeoff, climb and cruise, vigilance was related with the Captain's envisioning, modeling and receptiveness. However, during the descent and approach phases, vigilance was related to the First Officer's conduct and standards.

Workload and task distribution was dependent on the Captain's conduct, standards, and receptiveness. Establishing guidelines for automated systems for all phases of flight were related to the Captain's articulating a vision, conduct and standards (modeling), receptiveness and use of interpersonal skills to obtain commitment from others.

The next phase of this study is to determine the effects of leadership/followership skills on cockpit performance in LOE's and another major line audit. Data collection began January, 1997. When completed, guidelines for an integrated approach to training will be developed. It is likely that the skills identified in the preliminary analysis will be modified by future work.

Challenges facing the development of curriculum have been identified, and include the development of classroom exercises extending beyond role-playing, the creation of event sets that address critical leadership/followership skills, and addressing company philosophy and policy issues. During FY 97, curriculum has been developed for Alaska Airlines recurrent pilot training.

Products: Leadership/Followership training guidelines; curriculum materials for addressing leadership/followership awareness and skills training; and a web site for distribution of curriculum development materials.

Project Title: *Analysis of Cockpit Management System in Multiple Carrier Environments*

Performing Agency: George Mason University

Background: It is widely believed that CRM training can result in significant improvements in flightcrew performance and flight safety. Historically, it has been possible to assess the effects of CRM training on pilot attitudes regarding the general management of cockpit duties with self-reporting inventories administered pre- and post-CRM training. It is thought that a change in pilot attitude will result in a change in behavior in the cockpit. It has also been possible to subjectively evaluate the effects of CRM training on pilot performance in LOFT and on the Line by noting the differences in CRM performance between crews that have had CRM training and the crews that have not. Further, performance differences between air carriers and between fleets within one air carrier have been investigated. While this approach to assessment has contributed to the advancement of CRM, it is hampered by the practical constraints of self report and global measurement.

Project Description: This research project will help determine the most efficient method to train and assess CRM and whether conceivable performance differences pre- and post- CRM training can be empirically substantiated. This research project is being conducted with one regional carrier and one major carrier. This project focuses on the design and implementation of a prototype CRM training program based on a task analysis methodology. The research will evaluate the effects of this specific CRM training on the Line and LOFT performance of crews. This study also integrates CRM performance requirements or procedures into the standard operating procedures of the air carrier. CRM procedures are the implementation of specific calls, checks, and/or guidance into one or more of the following: normal checklists, Quick Reference Handbook, Abnormal/Emergency Procedures, Flight Standards Manual, and additional Job Aids. This can be viewed as translating critical CRM principles into CRM procedures.

In developing the prototype, advanced CRM course data from line operations, instructor comments and ratings, and findings from the NTSB commuter safety study were used as the basis for the CRM training course. These data were incorporated into a proceduralized management system specifically tailored to the needs of this regional carrier. This advanced CRM course is being given to pilots in the research fleet. Their performance in a LOE was assessed prior to this training and will be assessed after the training course is completed with an appropriate time lapse. The central focus of this research is to determine if a proceduralized system will increase pilot performance, thereby increasing safety. This research has thus far proceduralized: Team Management, Crew Communication, Decision Making, and Situation Awareness in the operational environment of the regional carrier.

The proceduralized CRM training course is complete, and has been given to flight crews. The Quick Reference Handbook has been rewritten to reflect proceduralized CRM. The normal procedures have been rewritten to incorporate the proceduralized CRM. Baseline performance data are being collected during LOEs and preliminary analyses are underway.

One analysis of the baseline performance data showed some interesting results. In the research process, it was necessary to train evaluators to collect data during the LOEs. The evaluators are line pilots working in the training center. One of the critical questions centered on whether the evaluator training was

successful and would result in reliable and valid CRM assessment. The analysis showed that the LOE assessment process, which was taught in the evaluator training, going from ratings of observable behaviors to technical and CRM ratings, to overall Pilot In Command (PIC), Second In Command (SIC) and Crew ratings for each event set was confirmed. Observable behavior ratings significantly contributed to both technical and CRM evaluations of each crew. This confirms that with appropriate training and calibration, evaluators can use specific, observable behaviors as the basis for judgments which should increase the objective component of CRM evaluation in an LOE and ensure more fair, unbiased evaluations of each pilot.

CRM ratings, across event sets, as well as technical ratings significantly contributed to the overall evaluation of PIC and SIC. This confirms that evaluators, when properly trained and calibrated, can consistently integrate CRM evaluation with technical performance to obtain overall evaluation of crew members on each event set. This is evidence that the LOE evaluation was reliably tapping CRM as well as technical performance. This is important because in the past there were questions as to whether CRM ratings were just a reflection of technical performance. It has been suggested that evaluators could not or would not rate CRM behavior as a separate performance domain, but part of the entire crew performance.

Additionally, the analysis showed that Captains and First Officers were evaluated differently. In evaluations of the entire LOE, CRM performance was more important than technical performance for the PIC, while technical performance was more important than CRM performance in rating the SIC. These differences in evaluations are congruent with holding the PIC more responsible for CRM as part of the Captain's role. These findings are also congruent with previous findings that Captains state that the most important feature of a good first officer is technical competence and First Officers state the most important feature of a good Captain is CRM competence.

Further analysis showed stronger relationships between Captain evaluation and crew performance than between First Officers and crew performance. This provided additional evidence that Captains are held more responsible for crew performance, particularly CRM performance. This empirically confirms that Captains are the focal point for CRM and crew performance and suggests additional training on establishing and maintaining CRM should be performed in upgrade training when a First Officer transitions to Captain.

LOE data were compared with the data from traditional proficiency check of specific maneuvers. The proficiency check evaluations could predict about 50% of the overall evaluations of PIC and SIC on the LOE. This confirms that the technical proficiency emphasized by the traditional check is relevant to LOE performance. However, the remaining 50% of the variance unique to the LOE confirms that the LOE is also tapping a distinct type of performance in addition to technical proficiency. More detailed evaluation of proficiency check assessments showed that only evaluations of the SIC do not predict LOE results. Additional analyses are required to better understand the role of rating SIC performance in proficiency checks.

Analysis of different event sets found significant differences in the performance of the targeted observable behaviors. For specific event sets, the targeted behaviors (e.g. specific briefings) were observed significantly less often. Isolation of performance problems across crews can be used to rationally and efficiently change pilot training. The lack of specific observable behaviors can be tied to specific instructional objectives using an instructional database such as the model AQP database. The database can

also be used to find the specific training components for these objectives that must be strengthened. This analysis shows that isolating poor performance across crews can be used to directly change relevant components of training.

During FY 96, work was initiated with several carriers to identify appropriate questions, data collection strategies, and statistical methods to analyze pilot performance data. This data collection system will allow carriers to evaluate their AQP training system effectiveness in many dimensions. The overall goal of this part of the project is to determine the appropriate data necessary to extend training intervals for AQP programs.

Also in FY 96, a formal workshop was developed for regional carriers to introduce the instructor/evaluator training methods used in this research project and to introduce the data analysis methodology. The workshop was attended by 50 air carrier representatives from 30 different carriers.

During FY97, data collection was completed and new LOE and associated forms for Year 3 were developed. IRR sessions for new LOE were conducted in May-June 1997. A second IRR workshop is being planned. The future work will center on developing and evaluating CRM training and future AQP data analysis.

Another area of this research is IRR Indoctrination Training for Instructor/Evaluators (I/E). The overall goal of this project is to assist a carrier with incorporating interrater reliability training strategies into existing instructor/evaluator (I/E) indoctrination training. This project involves: selecting and evaluating existing videotapes of crew performance to use as "gold" standards for the I/E indoctrination class; developing behaviorally-based grading sheets for the selected video tapes; and collecting and analyzing data from at least one I/E indoctrination class on the levels of agreement (i.e., interrater reliability) that emerge as a result of training. Results from this investigation will be summarized in an FAA technical report that documents the extent to which the I/E indoctrination class can be used to do the initial rater agreement training and to foster observational skills for LOFT debriefing.

Products: A cockpit management system; Research report on performance differences due to proceduralized CRM training; Industry papers on Inter-rater reliability training; Training data analysis software

Project Title: *Crew Resource Management: Design and Evaluation of Human Factors Training in Aviation.*

Performing Agency: The University of Texas, Austin

Background: This research consists of several projects that center on evaluating the impact of CRM and LOFT and developing methods to optimize training and performance evaluation. This research group has maintained an international, longitudinal database of pilot performance since the late 1980's. Prior findings from this work indicate that formal CRM programs combined with LOFT have a significant, measurable positive effect on crew behavior and attitudes and by inference on system safety. However, the data also indicate that all human factors problems in aviation have not been solved by the current CRM and LOFT programs. Specifically, the following negative outcomes have been documented through this research program:

(1) There is great variability in the impact of programs and in observed crew performance, even after implementation of CRM training. Incomplete acceptance of CRM concepts and practices by instructors and evaluators has been identified as one source of problems.

(2) In the absence of continuing reinforcement, behavior and attitudes regress almost to pre-training levels.

(3) LOFT programs in several organizations show great variability in execution and impact.

(4) Considerable controversy remains regarding the evaluation of individual and team performance, as required of organizations participating in the Advanced Qualification Program (AQP).

(5) There is an absence of reliable data on the human factors of incidents occurring in the aviation system.

(6) Recent investigations of major accidents, including air carrier crashes, have shown that organizational cultures have a profound impact on operations and on the effectiveness of human factors programs.

(7) Human Factors training and awareness in Air Traffic Control (ACT) has lagged behind programs in air carrier operations.

(8) Human Factors aspects of cockpit automation are not being addressed in most CRM/LOFT programs and have been identified as critical in a number of accidents.

Project Description: The research program is designed to build on current knowledge and to address the issues noted above. This research program has developed and maintains a massive longitudinal database on the effectiveness of CRM in the Aviation industry. Operational line and LOFT observation data comprise the database. Confidential data are entered into the database and reports are delivered to each participating carrier. This information is used to remedy the weaknesses apparent in the observations or to highlight

strengths. It is common practice for carriers to use these reports on which to base the following year's recurrent training. This research group disseminates research findings to scientific meetings and is widely published each year.

In addition to collecting line and LOFT data from a cross section of air carriers, work with Southwest Airlines and Conquest Airlines currently is underway to explore concepts and issues important to each carrier.

The research group is collecting data from many different air carrier cultures to determine the effects of culture on CRM performance. The goal is to develop training guidance for carriers employing cross-cultural cockpits or for carriers operating with non-Western cockpits.

Because flight deck automated systems can execute most control functions performed by pilots, the flight management computer has been likened to an "electronic crewmember." This view of automation has led to speculation that the manner in which crew members interact with the FMC may influence crew behavior and performance. The link between interpersonal flight management attitudes and performance in aviation suggests that attitudes regarding flight deck automation are likely to be related to pilots' use of automated systems and overall performance. This research project has collected data from more than 10,000 pilots from more than 10 cultures addressing attitudes towards automation. Analysis of these data showed significant fleet, organizational and national differences in both general attitudes regarding the conduct of the flight and attitudes regarding the use of flight deck automation. Currently, this research project is investigating these issues with an expanded methodology and will further explore the link between national differences in attitudes toward automation and a multi-dimensional model of national culture.

The research is correlating the behavioral markers developed under this project with a world wide accident database. This is being done in order to determine the influence of certain cockpit behaviors and accidents worldwide rather than just in the United States.

A large number of direct observations along with instructor and line check airmen comments have been analyzed regarding incidents that were successfully and safely resolved. These data can be used to develop training scenarios and are available to air carrier training departments.

A segment of the work done recently by this program was to analyze the particular CRM requirements of the regional carriers coming under Part 121 (NPRM 94-35) which requires CRM training for pilots, flight attendants, and dispatchers (rule issued December 14, 1995). This research suggests that regional CRM programs should focus on specific elements of the commuter environment. The programs must address low experience level and high turnover of both pilots and flight attendants. Also, pilots may be thrust into automated equipment without extended training in non-automated equipment which may affect trust in the automated systems. Also, these programs must address the environmental variables: high frequency, low altitude, turbulence and small airports.

One project of this research program focuses on the effectiveness of LOFT. The goal is to determine the key components for high quality LOFT. Thus, this research seeks to determine what set of LOFT attributes best predicts overall LOFT quality and to find the relative importance of each predictor. In

addressing this issue, scenarios were analyzed for appropriate workload, creative problem solving required, problem realism, and simulator mechanical condition. Briefings were analyzed for how the instructor integrated the crew into briefings, handled a review of CRM concepts, and conveyed enthusiasm. Scenario execution was also analyzed for simulator operation, flight attendant roles, adherence to script and radio calls. Debriefings were analyzed for crew involvement with self-appraisals, the comprehensiveness of the debrief, and the integration of technical and CRM skills. Findings showed that overall, the briefing and debriefing quality were the most important aspect of LOFT quality, followed by the quality of the scenario and then its execution. These findings will be made available to the Airline Transport Association subcommittee on LOFT development.

This research program investigated the role of group dynamics and performance in the Air Traffic Control system. This project was conducted with the Southwest Region to investigate the relationships between the behavior of organizations, work teams and individuals and three possible operational outcomes: loss of separation, acceptable performance (absence of remarkable event) or outstanding performance in the presence of increased challenge. Data from loss of separation events and acceptable performance events have been collected. Data from outstanding performance in increased challenge events are currently being collected. Analyses of the data to date indicate that differences between unremarkable outcomes and undesirable outcomes (loss of separation) rests on a combination of environmental challenge, interpersonal sensitivity, and information sharing present during an operational time frame. Undesirable outcomes are characterized more by the absence of desirable behaviors than by the presence of undesirable ones. Environmental challenge seems to force a decrease in interpersonal sensitivity and controllers report perceiving increased demands under these conditions. High levels of information sharing seem to moderate the effects of high environmental challenge and decreased sensitivity on operational outcomes. A technical report summarizing this study is in progress and should be distributed Spring 1997.

During FY 96, this research group conducted 3 line audits for major carriers. This work included the training of air carrier personnel to collect line data as well as the collection of line data by the researchers. The results were reported to the carriers, allowing them to address weaknesses or strengths highlighted on the audits.

The research group produced three doctoral dissertations: (1) "The role of group dynamics in error tolerant systems," (2)" Rising to the occasion: foundations, processes and outcomes of emergent leadership", and (3) " National culture and work attitudes in commercial aviation: A cross-cultural investigation."

Additionally, the research group produced fifteen academic papers on aviation crew issues. These papers and dissertations can be obtained from the Internet. For instruction on how to access these papers, call: Lou Montgomery (512) 480-9997.

During FY97, a fifth generation model of CRM was developed to be used in error management. This requires a new approach to training of instructor/evaluator groups, as well as development of new evaluation tools.

Research is also concentrating on validating the findings from the NTSB 1994 report on commercial aviation accidents using line audit data. This validation study will examine whether the accident causes

identified by the NTBS are observable in line operations.

Products: Reports to air carriers; Maintenance of International CRM/LOFT database; Information for Advisory Circulars and regulatory considerations for Flight Standards and industry training groups.

Project Title: *An Investigation of Training Issues Concerning the Advanced Qualification Program (AQP)*

Performing Agency: Battelle Memorial Institute, Columbus, Ohio

Background: In an attempt to encourage the use of innovative training programs, the FAA has proposed the concept of Advanced Qualification Program (AQP) training. Central to AQP is proficiency-based training. Under AQP, carriers who have applied for inclusion in the program can develop their own proficiency objectives which must address the range of conditions and contingencies that might be faced by pilots working within the carrier's operational domain. These proficiency objectives define the set of skills and tasks a pilot must be able to perform to be proficient on a given aircraft type within the carrier's operational domain. The goal is to ensure that the training program meets each carrier's specific requirements and does so in the most efficient way possible. Utilization of a strong analytical framework for developing a carrier's program helps to ensure that training is systematically oriented towards those objectives of greatest relevance to the individual carrier and also supports meaningful crew and program evaluation. One of the objectives of AQP is to provide seamless integration of CRM and technical skills within the curriculum to ensure that CRM skills are practiced together with all other flight skills and procedures as required by each flight situation. One goal of AQP is that CRM skills should be utilized as a normal and inherent part of aircraft operation little different from operating the automation or performing a proper checklist.

While AQP permits significant departures from the traditional FAR requirements for training and checking airmen, the price of that regulatory flexibility is a detailed front end analysis, the methodology for which is described in Advisory Circular (AC) 120-54. Accomplishing the analyses necessary to create AQP qualification standards has proven to be particularly challenging for participating air carriers. Training developers have had difficulty selecting an appropriate level of analysis detail, efficiently executing their analyses and determining how to incorporate cognitive and crew resource management considerations in a manner that will generate meaningful proficiency objectives, standards, and conditions. These difficulties stem in part from the fact that as a new program, AQP lacks concrete examples for reference purposes. The methodology was developed by the FAA on an a priority basis, with the explicit intention that it be refined subsequently as experience with the new programs accumulate. There was a need for a methodology that if faithfully followed would produce an effective AQP.

Project Description: The goals of this research project are to: (a) assess whether the Instructional Systems Design (ISD) process can be effectively used to develop a prototype AQP, including specification of the process that derives learning objectives from the task analysis, (b) determine whether the ISD methodology needs to be modified to best support AQP development, and (c) verify the modified ISD methodology that has been standardized through the development of a database comprised of templates and instructional guidance for developing an AQP.

The approach to integrating CRM into technical training adopted by this research utilizes ideas from several sources: (1) ISD methodology used for AQP curriculum development, (2) the event set approach developed by Carlow for the FAA, and (3) the situation assessment model being developed by Battelle for the Model AQP. Each of these sources provides a useful and unique perspective. The ISD methodology, as currently implemented, focuses on the technical skills, knowledge and procedures required to accomplish specified tasks and subtasks. The methodology is especially effective for activities that occur at predictable

times and in a standard order. The event set approach, in contrast, focuses on a selected sequence of situations which attempts to mimic real-world situations with all of the attendant complexity. The objective is to evaluate crew performance in situations that require both technical and CRM skills. This approach is currently used by many carriers to support line operational simulation. This research project's situation assessment model attempts to provide a cognitive perspective by focusing on those factors that influence a flight crew's assessment of a situation and subsequent management of available resources. In the past, there has been little continuity between the task-oriented front end analysis provided by the ISD methodology and the situation-oriented event set approach. This lack of continuity is exemplified by differences in types of CRM skills addressed by each approach. The ISD methodology is best suited to handle phase-specific skills, that is, those activities which are always performed by the crew for a given task or subtask. Traditional ISD's behavioral orientation supports its emphasis on the specific tasks and subtasks that must be performed to complete a job.

This task orientation does not support those aspects of the pilot's job which fall outside of the sequential tasks and subtasks found in a task list. Instead, the unique dynamics of the aviation environment necessitate a change in focus to the situation as a whole, including conditions under which a task or subtask must be performed (e.g. weather, aircraft system, failure) and the requirement to utilize phase-independent flight management skills either on a need basis or continuously to ensure that the flight is properly managed. Appropriate utilization of phase-independent skills depends upon crew judgment: accurate assessment of the requirements of the situation together with effective utilization of those skills and information sources most likely to be useful in that situation. This judgment depends upon an understanding of the situation as a whole, not simply the task in isolation.

This situational focus is the strength of the event set approach. An effective training program will enable flight crews to experience these situations so as to allow them the opportunity to practice the phase-independent skills required to cope with these situations.

Both the ISD and event-set methodologies bring important and unique perspectives to an AQP. Merging both into a coherent approach will support the development of a complete training program. One means by which this integration can occur is to place the focus of flight training on situations rather than tasks throughout the program rather than waiting until LOFT. A situational orientation throughout training helps to ensure that phase-specific and phase-independent technical and CRM skills are practiced in an integrated fashion. In addition, the situational orientation gives flight crews the opportunity to practice those skills involved with assessing situations.

This transition from the task focus of the ISD methodology to a situation orientation takes place in the Model AQP by means of the concept of an event. An event includes a specific task (i.e., a maneuver or set of procedures) together with the conditions (weather, malfunctioning aircraft system, etc.) under which the task is to be performed. To handle an event successfully requires that the crew quickly and accurately assess the situation, plan how to manage the event and utilize the technical and CRM skills appropriate for that event. In addition, the set of events included in the curriculum can be selected to ensure that important technical and CRM issues are addressed. Each event centers on a specific topic or theme. The flight training curriculum can be designed by strategically selecting and positioning events in accordance with these themes.

One of the strengths of the event concept is its applicability to both ground and flight training. Continuity throughout all parts of an AQP is a critical goal for the Model AQP project. Events can be used as the building blocks for both the ground and flight training curricula. For ground school, one of the goals of the Model AQP is to utilize scenario-based training in which students would be required to not only acquire new information but also learn how to apply that information to solving problems. Events are a natural tool for designing a scenario-based ground school curriculum. Similarly, events can serve as the individual units for FTD and simulator training. Finally, they will continue to serve as the building blocks for LOE scenario development.

The Model AQP, which has been targeted to regional carrier training, has been completed and is being used by approximately 20 carriers. During FY 96, two workshops were conducted to train air carrier personnel in the use of the model. During FY 97, appropriate updates and modifications to the model were accomplished.

AQP training and LOE evaluation is exceeding the objective of integrated crew training. Data analysis is providing critical information to focus training. AQP performance analysis is providing critical safety information to initiate changes in pilot training.

This model AQP has introduced several novel approaches to pilot training. In summary, this research project and the Model AQP views flight tasks, including CRM behaviors, as being either phase-specific or phase-independent. Also, this model proposes that pilot training should begin event training at the start of a program and not wait to the end to incorporate a set of individual tasks into the Line Operational Evaluations.

Products: Model AQP and research report delineating process, methodology and lessons learned. The Model has been delivered to many air carriers. During FY 97, modifications to the model were completed. The 2nd generation database included conversion to MSAccess with more powerful user information. AQP methodology enhancements were recommended which included task identification guidance, EO design guidance, and rapidly reconfigurable event sets. A performance/proficiency database was also created.

Project Title: *LOFT Debriefing Study*

Performing Agency: NASA Ames

Background: Training effectiveness of LOFT simulations is heavily influenced by the debriefing that occurs afterward. The LOFT simulation is a very busy, intense, and sometimes stressful experience. Thoughtful discussion after the experience is necessary in order for the crew to sort out and interpret what happened and to consolidate the lessons learned into long-term memory in a form that can be used later in actual line operations. The debriefing is a window on the entire CRM process. LOFT debriefings can demonstrate how well crews are able to analyze their performance along CRM dimensions. It is thought that in order to implement CRM effectively in day-to-day line operations, crews must have the skill and the habit of analyzing their own performance in terms of CRM.

Project Description: The purpose of this project is to determine which techniques are actually being used by LOFT instructors, how effective the techniques seem to be, the extent to which those techniques are consistent with FAA Advisory Circular guidelines, how practical the guidelines are for real-world training and what obstacles instructors encounter in trying to teach according to these guidelines.

Data have been collected from five major US air carriers. At each carrier, five to eleven instructors from different fleets made audiotapes of the debriefings they conducted. The audiotapes were transcribed and coded, generating a large database. The data from the first two carriers have been analyzed and results have been reported to the respective carriers. Data analysis from the other three carriers is in progress and will be completed in winter 1996.

Preliminary findings are as follows:

(1) Typically, the debriefing is scheduled after the practice of proficiency maneuvers, rather than immediately after the LOFT. Interposition of the proficiency maneuver practice constitutes an "interference experiment" that probably impedes the ability of the crew to remember what happened in the LOFT.

(2) The similarities among carriers are greater than differences in how they conduct LOFT and LOFT debriefings. There are large differences among individual instructors within carriers in facilitation effectiveness.

(3) Most instructors conscientiously attempt to elicit crew participation, but some unwittingly sabotage their own efforts with behaviors that discourage participation.

(4) Most instructors fail to make clear at the beginning of the debriefing the nature of the participation that they expect of the crew and do not explain why it is important that the crew take an active role.

(5) Although instructors have been told to facilitate crew self-debriefing, they have been given only very general advice on how to do this. Training departments should provide much more

explicit hands-on training in facilitation and should mentor new instructors as they start to facilitate.

(6) The content of the debriefing is strongly driven by the instructor's observations and questions, rather than the crew's self analysis.

(7) The crews are responsive to the instructors, but are more reactive than proactive.

(8) Most crews would probably have difficulty conducting a deeply analytical debriefing on their own, however they appear to be quite conversant with and accepting of CRM. With practice, they could develop debriefing skills and apply them routinely on the line.

The data and analysis have resulted in major carriers developing a list of do's and don'ts for facilitators. It is being used as the core of annual recurrent training for instructors.

A field test of debrief criteria is now underway by Northwest Airlines.

Further research will examine distractions and attention lapses in the cockpit. The question is "During multi-tasking performance, how do humans switch from one task to another effectively?" Cockpit attention problems include the failure to return to interrupted tasks, returning to the wrong place of a task, tunneling of attention, premature interpretation of situations, and inefficient task management. This research will analyze NTSB and ASRS reports, field observations, video from Orasanu/Prince project and experimental studies to develop techniques crews can use to manage attention effectively.

Products: CRM Debriefing training guidelines were distributed in February 1997. A handbook is being developed and will be distributed to carriers in January 1997. Training video produced with Delta Air Lines. Draft technical report of International Journal of Aviation Psychology.

Project Title: *The Development of Reliable and Valid Scenario Event Sets for Line Operational Evaluation, Based on Empirical Data.*

Performing Agency: NAWCTSD; University of Central Florida

Background: In practice, training and assessment of CRM takes place during LOFT. LOFT occurs in a full mission simulator and aircrews are required to fly scenarios that include specific CRM events, or event sets, which are designed to target CRM behaviors. Under AQP, CRM proficiency will be evaluated in the simulator during LOE. Therefore, the procedure by which CRM scenario event sets are developed will have an impact on the CRM assessment process. Quality event sets will need to be incorporated into LOE scenarios to ensure that an adequate number of CRM behaviors are elicited by an aircrew so that check pilots can make judgments regarding a crew's proficiency in CRM.

In theory, scenarios are designed in such a fashion as to require crews to demonstrate CRM skills. The FAA provides guidelines, Advisory Circular on LOFT, on the development of scenarios. However, little or no information is presented on how to develop scenarios that are of reasonable difficulty and that adequately distinguish between various crew performance levels. It has been suggested that crews should have more than one opportunity to display CRM skills of interest in order to validly assess the crew's level of performance. This point is not in any formal guidance from the FAA nor has this idea been tested in operational settings.

Scenario event sets can be thought of like items on a test. Therefore, scenario events could be, and perhaps should be, generated in a fashion similar to that of test development. Reliable and valid measurement of CRM skills will likely be achieved if two conditions exist in the measurement process. First, CRM event sets, embedded in scenarios, must possess reasonable levels of difficulty and effectively discriminate different levels of aircrew performance. Second, there must be multiple event sets that address each CRM skill assessed. In test development, reliability and validity are maximized by selecting the highest quality items and employing multiple items to measure a single variable of interest. For each item, data are collected on the item's difficulty and discriminability, and then the best items are selected based upon these indicators.

A unique aspect of this project is that several sources of safety data collected by the carrier are being used for event set design rather than subjective judgment of issues currently effecting the carrier.

Project Description: This research project will develop and test a methodology for establishing reliable and valid CRM event sets and determine the number of event sets required to measure CRM skills reliably.

Products: A series of reliable and valid CRM event sets that can be incorporated into any number of CRM scenarios for the purpose of LOE.

Project Title: *Rapidly Reconfigurable Event-Set Based Line-Oriented Evaluations (LOE) Generator*

Performing Agency: NAWCTSD; University of Central Florida

Background: Line-Oriented Evaluations (LOEs) are a methodology used in Advanced Qualification Programs (AQPs) to evaluate pilot training performance and establish trainee proficiency. LOEs consist of flight simulation scenarios that are developed by the training organization and approved by the FAA.

In the past, LOEs were developed and apprised individually. That is, each LOE was separately conceived, developed and tested by the training organization and individually reviewed and approved by the FAA. The development and approval of new LOEs was costly and time consuming. As a result, training organizations usually had only a limited number of LOEs available for evaluation, each of which were only approved for a limited time period. In some cases, this may have increased the risk of LOE scenarios being compromised within a training organization, thus reducing the validity and reliability of the scenarios.

One way to reduce the negative aspects of the previous LOE design process will be to develop a set of LOE event sets (modules) which upon FAA approval could be assembled by the training organization into a number of unique LOEs without requiring additional, specific approval of each individual LOE by the FAA.

This project will develop appropriate software to allow the reconfiguration of separate event sets into entire LOEs. This will require that the difficulty of each event set is established. This project was started in July, 1997. The requirements document has been written and approved. This is a three year effort.

Project Title: *Integrating CRM into Crew Procedures: Checklist Standardization*

Performing Agency: NASA AMES

Background: Non-compliance with checklists has become a potentially serious problem for air carriers and the FAA. In today's aviation system, procedural changes occur frequently and are instituted for a large variety of reasons: company mergers, changes in air traffic procedures, changes in airport environments, introduction of new technologies and new aircraft, etc. While one obvious goal is to maintain compliance and standardization of crew member performance, there must not be a sacrifice in the match between procedures and the operational realities in which the procedures are to be used. Not only must procedures reflect a reasonable match to technical task demands, they must reflect consistency with company and system requirements. Within an air carrier for example, philosophy, policies and procedures should be made consistent both within teams (within aircraft type) and across teams (across fleets within the company) to the extent that standardization is feasible. Since there are legitimate aircraft and mission differences across fleets, a means of evaluating the appropriate level of standardization must be developed and reviewed when changes are anticipated.

Project Description: The goal of this research project is to integrate CRM principles into crew roles and procedures in order to: 1) improve the match between current procedures and operational reality, and 2) develop a process for adapting procedures to anticipated changes.

The basic approach is to analyze procedures from a team perspective and to conduct a team task analysis in order to assess whether current procedures match the task flow including team processes. The integration of CRM principles into the task analysis provides the basis for reviewing and re-designing procedures. The development of standard methods and measures for evaluating procedure usage is important for assessing both current and proposed procedures. Measures used during the research process will be refined for validation purposes as well as eventual use in training.

The objectives of this research project are to develop a systematic approach to checklist standardization across all fleets, to develop guidelines for implementing and evaluating procedure changes that optimize: l) within company standardization, 2) compatibility with aircraft and operational differences and 3) procedures consistent with CRM principles. This research is in phase II and has thus far established company-wide philosophy and policy statements: Operations, Automation, Training, and Checklists. Also, methods for data collection have been identified and developed. Pilot feedback on proposed checklist changes has been completed. This project has been completed and the report and guidelines are being written.

Project Products: Guidelines for standardization of procedures.

Note: This project led to the following project described on the next page.

Project Title: *Operating Documents Human Factors Project*

Performing Agency: NASA; George Mason University

Background: The original project described on the preceding page was intended to develop a systematic approach to checklist standardization and to develop guidelines that would optimize within-company standardization for eight fleets, to insure compatibility with aircraft and operational differences and be consistent with CRM principles. This project considered the form of the checklist with respect to content, structure, logic, format, terminology, roles and usage. However, this approach was inadequate as checklists are part of the whole operating document system. It became apparent that operating documents must show internal consistency across fleets (aircraft types, and route structures), across departments (training, evaluation, safety, cabin crew, maintenance, etc.), and across documents (FOM, training documents, pilot's handbooks, company policies, etc.) Further, these documents must be externally consistent with regulations and manufacturers. Document systems must be consistent across philosophies, policies, procedures and practices. This concept is not in place in the air carrier industry.

This research team developed surveys and held workshops to bring together air carriers (including regionals and cargo), manufacturers, and the FAA to work on a better, more human centered approach to these documents. Two workshops have been held in FY 97. The most recent workshop was attended by 78 participants.

Based on the information provided on the surveys and in the workshops, guidelines will be written for the development of operating documents that will include: the Organization of Documents, Standardization of Documents, Usability of Documents, Developing and Maintaining Documents, and Transition to Electronic Media.

Products: Focus group presentations and guidelines document.

Project Title: *Team Situational Awareness*

Performing Agency: Naval Air Warfare Center, Orlando

Background: There is little question that situational awareness is critical for safe flight. Much research has centered on attempts to identify and quantify individual situational awareness. However, since cockpit crew performance depends heavily on team processes, it is necessary to determine exactly what aspects of individuals and the environment either enhance or degrade team situational awareness.

Project Description: This research project will identify a model of team situational awareness, develop effective instructional strategies to improve situational awareness training, develop situational awareness assessment tools, and develop guidelines for situational awareness scenario development.

During Phase I of this project, an initial framework for team situational awareness has been completed. This framework will serve as a basis for the team situational awareness model. Preliminary training guidelines based on this framework, which will be amended as the research progresses, follow:

(1) Tailor training to the experience level of the crew in terms of time in aircraft, time in position, and familiarity with locality. For example: Consider a newly hired first officer or flight engineer that is transitioning to or learning a new aircraft and flying out of a new area. It is important to ensure that the crew member is familiar with cockpit roles, the geographic area, and the aircraft equipment before expecting him/her to have the awareness to handle dynamic problem situations in that environment.

(2) Ensure job/task analysis provides information about the cognitive, perceptual and behavioral demands required for situational awareness. For example: A job analysis of a pilot who flies a highly automated or "glass cockpit" aircraft should solicit information particularly relevant to that environment, emphasizing factors such as information seeking from different sources, collation and interpretation of information from complicated displays, scan through the FMS, mode errors with the FMS, manual data entry task demands, and communications associated with the advanced technology.

(3) Include training which specifically focuses at the team level of situational awareness in addition to training which focuses on individual skill development. For example: individual skill development in situational awareness may include: providing information that increases the individual's knowledge base so that he/she knows when and what information to seek, helping in the development of planning skills so that he/she is better prepared for completing tasks within the flight, and providing tips that help free up time from basic tasks in the cockpit so that more attention may be paid to the situation. Team skill development in situational awareness should include team process skill training such as communication and leadership behaviors to enhance and maintain crew awareness.

(4) Based on the complexity of the situation, provide training which emphasizes adequate

information, demonstration, and active practice and feedback. All are needed to produce a behavioral change. For example: to enhance the overall training experience provided in a realistic LOFT scenario emphasizing situational awareness, the crew members should receive advanced preparation about the training objectives, including specific information on the skills to be trained and demonstrations or examples of effective and/or ineffective behaviors relevant to those skills. Providing general information about situational awareness concepts would be insufficient to expect the crew to obtain the full impact of LOFT. Crew members who are at a low experience level need to have specific information on the kind and timing of information transfer that will enhance crew situational awareness. Alerting them to the importance of communication, if they do not know what and when to communicate, would not prepare them to practice good communication skills in the LOFT session.

(5) Design training scenarios to be realistic and to elicit the desired cognitive, perceptual and behavioral task demands encompassing the situational awareness construct. For example: consider that including an unfamiliar event, such as icing for crews who have only flown in Florida, would require them to recognize the relevant cues, comprehend their meaning and project a course of action. A very different type of problem, such as a gradual change in an instrument due to a developing condition, may require perception, comprehension and projection as well, but the cognitive and behavioral demands related to this problem are very different from those imposed by icing conditions. Including both types of problems within a scenario would allow the trainee to exercise these different cognitive and behavioral skills and would help him/her learn to generalize the application of these skills across various problem situations.

(6) Conduct training which focuses on improving team or process skills related to situational awareness (e.g., planning, communication, leadership). For example: training focusing on communication skills related to situational awareness can include training that encourages the flow of the information that needs to be transmitted in the planning phase of the flight (e.g., what questions the Captain can ask to solicit information, what questions the First Officer should ask, what information should be covered with Flight Attendants). Situational awareness training can also include practice in the communications that are most effective (e.g., what information to provide to another crew member or when to communicate the information to the other).

(7) Include training which emphasizes developing accurate and appropriate knowledge structures for expectations related to situational awareness. For example: familiarizing crews with a specific airport's traffic flow prior to arrival increases their readiness to recognize an abnormal situation.

(8) Use realistic and dynamic scenarios to provide training on information seeking and processing, detecting anomalous information, prioritizing attention to cues especially when there is information that may be related to different problems, and taking appropriate actions based on cues. For example: design realistic scenarios with events requiring crew members to look for and use information, handle multiple cues, determine when information is signaling a problem or possible problem, and act on the information. Intermittent fluctuations of an instrument during a scenario require crew members to recognize the fluctuations and to diagnose the problem. This may include cross checking instruments, discussing among themselves, and seeking additional

information. Putting this event in the scenario at the time of moderately heavy workload or during another troubleshooting event gives crew members practice in dividing their attention and determining priorities.

(9) Design and develop performance measurement tools for the behaviors, knowledge and perceptions required for situational awareness. For example: a realistic scenario provides information about situational awareness behaviors; an observation scale can be developed for those behaviors. Tapping into the crew member's knowledge and perceptions may require asking questions, either during the scenario or after it is completed to determine if he/she saw the problem and understood its possible impact. For pilots with low experience levels, questions can be either a part of the scenario (e.g., ATC can question the crew members) or the scenario can be stopped briefly for questions to be asked.

(10) Measurement tools should measure individual situational awareness skills as well as team interactions related to situational awareness. For example: an observation scale can be designed that measures what individual team members contributed to the team situational awareness and what actions they performed independently that demonstrated their situational awareness. The same scale should include opportunities to document team interactions (e.g., planning, communications, and leadership) that helped the crew members gain and maintain team situational awareness.

(11) Situational awareness measurements of behaviors should include both outcome and process measurements. For example: outcome is the action taken by the crew in response to an event (e.g., the crew diverted to Airport A) and process is how they achieved the outcome (e.g., the Captain gathered information from others about the decision, crew members discussed the merits of each airport, the crew members noticed that the runway at Airport B was not adequate for their needs). Both are important to understanding performance.

(12) Include instructions and information about training objectives to instructors about each training method or tool. For example: write out the specific objectives to be accomplished at the top or on a cover sheet of scenario instructions. Include clear objective behaviors as part of the scenario goals. The instructor is then informed about how to use the measurement tool to re-enforce the training objectives.

(13) Link the measurement criteria to the scenario events and to the debrief plans, for consistency in training. For example: if a generic measurement instrument is used, prepare the raters to recognize and document specific examples observed in the scenarios that relate to the general behaviors on the rating form. It is likely that the raters will need thorough training so they can map the scenario events and behaviors observed to the rating form. Thus, in the debrief, crew members will know what specific actions they took and how those relate to general requirements for situational awareness.

(14) Multiple measurements over time are necessary to yield a good measurement of situational awareness; single measurements at one time are insufficient. For example: in a single LOFT

scenario, build a number of opportunities for crew members to demonstrate situational awareness (e.g., NOTAM information, ATC calls to other aircraft, PIREPs, subtle changes in instruments, weather, unexpected circumstances) and ensure that observers know when, where, and how to observe and document situational awareness actions. The same could be accomplished by using a number of small scenarios (each with opportunities to observe situational awareness) and then evaluating the aviator's situational awareness across the scenarios.

(15) Use specific feedback tools along with realistic and dynamic scenarios to provide feedback that is specific to the trainees on their situational awareness skill performance, reinforces the development and maintenance of relevant knowledge, and stresses adapting knowledge to meet situation demands. For example: give observers feedback forms with the specific situational awareness elements that were built into the scenario. Observers should use these forms to document behavior they see in the scenario. This is then used to give specific feedback on what the crew members did, how they did it, and the context of the behaviors. Explanation of the rationale for the feedback helps the crew members develop and add to their existing knowledge.

(16) Train instructors on making ratings and giving feedback. For example: this training can be done by providing information to the raters on situational awareness, showing them examples of the behaviors associated with situational awareness (so raters can be knowledgeable about the behaviors), giving them practice in rating those behaviors, and giving raters practice in providing feedback on specific situational awareness behaviors.

Phase II of this research project concentrates on other challenges. The goals will include making the methodology generic to airlines and aircraft, creating data exchange protocols with existing databases, creating intuitive and adaptable user-interfaces and validating the methodology under field conditions.

Products: The above guidelines have been expanded, are under review and will be distributed 11/97.

Project Title: *Training Pilot Not Flying (PNF) Back-up Skills*

Performing Agency: Naval Air Warfare Center, Orlando

Background: Regional airline Captains indicate that one of the greatest difficulties they experience is working with inexperienced or new First Officers who lack the skill to effectively provide back-up when serving as Pilot Not Flying (PNF) when it is needed. Since the complex environment of regional flying necessitates the coordination of the two crew members, it is critical that this issue be addressed.

Project Description: This research project will identify the knowledge, skills and attitudes necessary for PNFs to properly perform back-up duties. In conducting this research, (1) structured interviews with pilots from the regional airlines were conducted to inquire about effective and ineffective back-up behavior, (2) the 100 most recent submissions to the ASRS database were analyzed using the descriptors of "regional airlines" and (3) analysis of the recent NTSB report which reviewed flightcrew-involved major accidents of U.S. air carriers that occurred from 1978 through 1990 and which identified poor monitoring/challenging behavior on the part of the non-flying crewmember as a causal factor in seventy-six percent of these accidents. Combining information from these sources, three broad problem areas requiring additional training were identified: (1) First Officer or PNF assertiveness in ambiguous situations, (2) monitoring and challenging by the First Officer or PNF, and (3) proficiency in technical and communication procedures. Presently, a study is being conducted to test the training potential of several techniques for improving PNF back-up performance.

The direction of future research will be toward metacognitive training and CRM-/team-training. Metacognitive training is a viable addition to CRM and is particularly useful for teaching abstract, difficult to observe cognitive processes. Team training will allow the training of a good backup, and that behavioral training will not “boomerang.”

Products: “Identifying Critical Training Needs for Junior First Officers” was distributed 5/97.

Project Title: *Decision-Making and Judgment on the Flight Deck*

Performing Agency: NASA-Ames and the Naval Systems Warfare Center, Orlando

Background: The NTSB reports that in the four year period, 1983-1987, crew judgment and decision making was implicated in 47% of fatal accidents. The NTSB and ASRS cite many more reports where poor decision making was evident in many potentially serious incidents. Decision making is a component of most CRM courses and is encouraged by the FAA Advisory Circular 120-51, 1993. However, scientific research has not been available to support this training. Decision making in the dynamic, time-constrained cockpit environment does not mirror decision making in a static laboratory setting. Thus, findings from generic decision making research do not necessarily generalize to aviation settings.

Project Description: Decision making is an essential component of a Captain's expertise. The Captain is responsible for making the hard decision (for example: choosing where to divert after a system malfunction, when fuel is short and weather is deteriorating; determining how to cope with a passenger's medical emergency, evaluating whether to take-off with a placarded system given past experience with the projected weather and traffic at the destination). The Captain's judgment is most critical when conditions are ambiguous and no clear guidance is provided in manuals, checklists, or company policy.

This research project has been in progress for several years and has developed a model of factors that make flight decision efforts difficult, along with a taxonomy of decision problems. This model incorporates the nature of the problem, the time available to solve the problem and the risks associated with the options. This work was based on analyses of crews coping with abnormal and emergency events in full mission simulators and further supported by NTSB accident analyses and ASRS reports. For example, analyses revealed differences in the importance of risk and time pressure between Captains and First Officers. For Captains, risk was the most important variable in the decision strategy, while First Officers viewed time pressure as most important. As might be expected, experience does affect decision strategies. Experienced crew members are more sensitive to available decision time, better at handling uncertainty and have better prioritization of information needs. Based on these results it is suggested that to encourage effective decision strategies, crews are trained to: (1) understand and verify the problem, (2) assess time and risk, (3) not rush to judgment, (4) consider constraints and consequences of options so as not to oversimplify the problem, (5) use "worst case" instead of "best case" reasoning, (6) plan for contingencies, and (7) manage the situation by setting priorities, assigning tasks and using all available resources.

Presently, this research project is developing decision making training scenarios for major carriers to validate during recurrent training. This research project focuses on designing and validating assessment methods and scales for the decision making scenarios. This work also is developing training guidelines to manage risk in ambiguous situations, and assess LOS/LOFT and debriefing tools.

Products: Decision making training and assessment guidelines for air carriers to incorporate into their CRM training or into AQP will be published in 1998. Article written, “Stress and Naturalistic Decision Making: Strengthening the Weak Links.”

Project Title: *Pilot Training and Evaluation: Airplane Simulation Human Factors*

Performing Agency: Volpe Center

Background: Flight simulator technology has advanced significantly during the past decade, one result of which is that device capability has increased while cost declined. However, for regional airlines, cost continues to be an obstacle to flight simulator access, particularly for recurrent training. Currently, airplane FTD and simulator qualification criteria are contained in Advisory Circulars AC 120-40B and 45B/C and related documents. Changes both in the air carrier training environment and in the field of simulator technology demand a reassessment of these criteria. The shift in training philosophy from a time-based list of specific training events to the Advanced Qualification Program (AQP) training approach based on individual training needs requires that much of the training formerly performed in aircraft will move to the simulator. Considering the initiative that Part 135 carriers be held to the same safety standards as Part 121 carriers, the success of AQP depends on whether regional carriers will be able to afford simulators that are appropriate for training 121 proficiency using an AQP training approach. AAR-100 is undertaking an extensive investigation of the pilot cueing requirements to enhance affordability without degrading the standards or quality of performance for such equipment.

Project Description: An extensive literature review of the motion vs. non-motion studies for pilot training has been completed. The research study has been designed, an air carrier has been secured to conduct the research, the simulators have been programmed to collect the necessary data and the instructor pilots have been trained in data collection. Data collection will begin 10/97 and is expected to continue for approximately 1 year.

Products: Report on the necessity of motion for recurrent pilot training