U.S. Department of Transportation
Federal Aviation Administration

Aeromedical Research Resume
Research Project Description Subtask for FY99

1. Title:	2. Sponsoring Organization/Focal Point (FP)	3. Originator Name, Organization, Phone :
Optimizing Human Performance	ARX-1; J. Staples AAM-1; J. Jordan, M.D. AAR-100; L. Cole (FP)	Pamela Della Rocco, Ph.D. Julia Pounds, Ph.D. Larry Bailey, Ph.D. AAM-510, (405) 954-6833
		4. Origination Date: October 1998
5. Parent RPD Number: ATS Human Factors	6. Subtask Number: AM-B-99-HRR-518	7. Completion Date: September 2002
8. Parent MNS: 176/179	9. RPD Manager Name, Organization, Phone: David J. Schroeder, Ph.D. AAM-500, FAA Civil Aeromedical Institute (405) 954-6825	

10. Research Objective(s):

The purpose of this research is to optimize performance of operational personnel through gaining a better understanding of the individual, situational and work-related factors that influence performance capabilities. In the equation of the human-machine interface, this research focuses on the human side. The objectives are to 1) broaden our understanding of the role of cognitive factors and expertise as they influence ATC performance, team performance and collaborative decision making, human factors of operational errors, and fatigue and environmental stressors; and 2) to utilize the knowledge to optimize human performance. The research will baseline current performance, investigate cognitive and behavioral mechanisms underlying the performance and identify factors which lead to performance decrements and errors. The findings will be used to develop improved human factors approaches to procedures, training and guidelines.

11. Technical Summary:

The research is designed to result in baseline performance metrics for current equipment, policies and procedures through conduct of both laboratory and field studies. From those, strategies for maximizing performance will be developed. This research is focused in the following four areas:

Understanding Expert ATC Performance. This project will apply techniques from research on expertise to the ATC domain. Models of ATC performance, as well as objective metrics of cognitive performance will be developed from this research. The objective measures will be applied to baselining performance in the current system and providing a knowledge-base for optimizing transition to future systems. In addition, we will identify opportunities to enchance cognitive performance in training.

Baseline assessment of ATC teamwork and collaborative decision making. This subtask will focus on developing baseline information on coordinated decision making for the R-side and D-side controllers in the en route environment and for terminal radar approach controllers.

Examination of Causal Factors Related to Situational Awareness. This project is targeted at reducing OEDs through the understanding of causal factors. Specifically, it will examine the OEDs database for the association between OEDs and factors of situational awareness. Future research will examine other human factors (e.g. shift work) related variables to OEDs.

Shift Work and Fatigue. This research is designed to evaluate the effectiveness of specific countermeasures for preventing shift work-related fatigue. The interaction of fatigue with age will be investigated. To assess the degree to which the unique shift rotations affect optimum performance, field and laboratory studies are proposed, including a survey of facilities.

12. Resources Requirements:

	FY 99	FY00	FY01	FY 02

FAA Staff Years	7.0	7.0	7.0	7.0

13. Description of Work:

Brief Background This research consolidates projects in several areas. Each area investigates aspects of human performance with the goal to baseline current performance and mechanisms, as well as to identify strategies, which can be directly applied to optimizing performance of ATS personnel in current and future systems. The work is responsive to calls for research to "increase our understanding of the human factors of emerging technologies, changing human roles and responsibilities and evolving procedures to help optimize human performance" (RPD 586 Human Factors). The research is designed to result in performance metrics, a baseline for performance with current equipment and policies.

This research is focused in four areas: 1) understanding expert ATC performance; 2) baseline assessment of ATC teamwork and collaborative decision making; 3) examination of causal factors related to situational awareness in operational errors/deviations and 4) shift work and fatigue.

Understanding Expert ATC Performance: Skills and abilities required for both ATC and AF are primarily cognitive. As the job evolves, through automation of many job tasks, it is critical that we understand the evolution in terms of changing cognitive requirements. How do ATCSs utilize the required cognitive skills and abilities to do their jobs, and how do we measure them? Our research approach will build on the available human factors research in areas of situational awareness and memory. An emphasis will be placed on identifying the factors/conditions associated with the development of and utilization of expertise in the ATC domain. Age is a factor in successful performance in ATC and the post-strike ATC work force is aging. The research will include a focus on how age-related changes impact expert ATC performance. It will build upon previous work in expertise to develop an ATC performance metric, baseline cognitive performance in current jobs, and maximize transitioning to future jobs using cognitive performance analysis.

Baseline assessment of ATC teamwork and collaborative decision making: In transitioning to future systems, it is critical to understand team interactions, specifically collaborative decision making. The National Research Council, other scientists and recent reviews have focused considerable attention on the importance of teamwork in controller performance. With the advent of the NAS modernization, technological change will continue as an ongoing process through the next decade. Proposed changes may greatly influence requirements for teaming. Often, there exists only a limited amount of baseline performance data with which to compare performance before and after the change. Moreover, there is a limited amount of available baseline performance data to judge the impact of various NAS modernization-training initiatives on job performance. Thus, a second focus of the research in this ARR is on the topic of teamwork. The work in this area will be to baseline team performance and collaborative decision making in current systems, as well as examine future systems, such as DSR and STARS. Tools developed in this task, as well as the findings will be applicable to team training on collaborative decision making.

Examination of Causal Factors Related to Situational Awareness: An ongoing element of the CAMI ATC human factors research program, is concerned with gaining a better understanding of how individual and situational factors influence the occurrence of operational errors/deviations (OEDs). Initial work has involved application of human factors principles to the data collection process with the goal of improving data quality and reducing the workload required of OED investigators. Toward these ends, CAMI has developed a new automated final report form that will be distributed to the field. In addition, causal factors related to situational awareness were incorporated into the OED final report. Current projects include assessment of other data fields to further improve the data collection and analysis efforts. In addition, projects focus on transitioning illustrative re-creations of OEDs to the classroom training of Quality Assurance specialists. This research area will focus on the analyses of causal factors related to situational awareness for applications to training.

Shift Work and Fatigue: Research in fatigue and environmental stressors has been ongoing for several years. The research is responsive to the Department of Transportation and Related Agencies Appropriations Bill 1998 Senate and 1999 House of Representatives Committee Reports. The focus of

the research has been on the unique, counterclockwise rotating shift schedules worked by ATCSs. Air Traffic Control Specialists are faced with shift work throughout their career. Shift work has been demonstrated to create stress and health problems in some shift workers. The sources of stress include fatigue, circadian rhythm disruption, and disruption of social interactions due to working odd hours. There is some evidence that at about age 40, shift work could become even more problematic. ATCSs work unique counterclockwise, quick-rotating schedules (2-2-1 or variations). These are phase advancing schedules that require employees to work progressively earlier shifts during the work week. The advantages to this shift include the fact that 4 of 5 days are worked during normal waking hours. Only the mid-night shift occurs when the circadian clock would have scheduled sleep. Thus, exposure to the night shift is minimized. However, the rotation can result in a pattern of partial sleep loss over the course of a week and also requires employees to attempt to sleep when the circadian clock would otherwise expect them to be awake, resulting in degraded quality of sleep toward the end of the week. Problems with the shift have been manifested in previous studies in reports of sleepiness on the night shift, as well as marked sleepiness on the drive home after the night shift. When ATCSs are not required to work a night shift, they frequently maintain schedules that rotate counterclockwise from afternoon to early morning shifts or work straight early morning shifts. Either of these two schedules can also result in a pattern of partial sleep loss/degraded sleep quality over the course of the week. Despite these problems, many ATCSs report that they want to retain the counterclockwise schedules because they receive nearly 80 hours off work between work weeks. The prevailing attitude of shift work researchers is that shift schedules should rotate clockwise. There are few data to support this recommendation, however. Age and shift work is a critical area to explore as a large proportion of the current, post-strike ATCS work force will be aging. The research presented here is part of a systematic approach to developing solutions for shift work problems in the ATC environment.

Research over the past few years has resulted in a set of studies baselining ATCS sleep/wake patterns, performance, health patterns, as well as circadian rhythms and neuroendocrine changes for individuals working counterclockwise, rapidly rotating shift schedules. In addition, coping strategy workshops and a brochure were developed for educational purposes. At the request of Air Traffic Services (ATS-200), two projects were added to this task. The first was a request to survey schedules used in ATC facilities and the second was to explore the feasibility of developing the findings from these studies into a risk assessment model for air traffic decision making. The second is development of a risk assessment model. The model will integrate information about workload, traffic complexity, fatigue, and shift work factors to provide an estimate of risk. This study will be developed collaboratively between the Behavioral Stressors and Advanced Automation Research Program within CAMI. SATORI will be explored for modeling proposed designs. A contract will be sought for consultation and collaboration with nationally renowned experts in workload and risk assessment. In addition, a facilities-wide comprehensive survey of air traffic control personnel may be conducted to determine the extent of fatigue among the workforce and the effect of current shift patterns and rotation practices.

(2) Statement of Work subtasks:

A. Understanding Ex(pert ATC Performance. This project will apply techniques from research on expertise to the ATC domain. The study will apply a tool for describing human expertise using statistical properties of decisions. Objective measures of ATC cognitive performance, as well as models of performance will be developed and applied to baselining the current system.

B. Baseline assessment of ATC teamwork and collaborative decision making. This subtask will focus on developing baseline information on coordinated decision making for the R-side and D-side controllers in the en route environment and for terminal radar approach controllers.

C. Examination of Causal Factors Related to Situational Awareness. The FAA OEDs database will be examined for the association between OEDs and factors of situational awareness.

D. Shift Work Countermeasures Implementation (Field and Laboratory). This research is designed to baseline the performance of ATCS working unique shift schedules and demonstrate the

effectiveness of specific countermeasures for preventing shift work-related fatigue. Four studies are planned to assess specific countermeasures in the field and assess alternate shift schedules in the laboratory.

14. Intended End Products/Deliverables:

Guidelines for improved procedures and training will result from the baselining studies in this research. In-service training program and a multimedia CD-ROM to teach coping strategies for adaptation to shift work will result. Reports and briefings will offer data-based guidance for management decision making affecting the organization and work environment of FAA personnel. OAM technical reports and briefings will document the utilization and effectiveness of fatigue countermeasures in the operational environment.

15. Schedule/Milestones:

Study A1 Understanding Expert ATC Performance	FY 99
A1.1 Conduct study	Q4
	FY00
A1.2 Complete report and provide briefing of results	Q2
Study B1 Baseline Team Performance/Collaborative Decision Making	FY99
B1.1 Develop baseline measures	Q2
B1.2 Conduct study	Q4
	FY00
B1.3 Complete report and provide briefing of results	Q2
Study B2 Identify Collaborative Decision Making for Future Systems	FY00
B2.1 Conduct study	Q4
	FY01
B2.2 Complete report and provide briefing of results	Q2
Study C1 Examination of Causal Factors Related to Situational Awareness	FY99
C1.1 Conduct study	Q3
	FY00
C1.2 Complete report and provide briefing of results	Q2
Study D1 Fatigue Countermeasures Implementation (Field)	FY99
D1.1 Conduct study	Q3
	FY00
D1.2 Complete report and provide briefing of results	Q2
Study D2 Fatigue Shift Rotation Laboratory Study	FY00
D2.1 Conduct study	Q3
	FY01
D2.2 Complete report and provide briefing of results	Q2

	FY99
Study D3 Survey of ATC Facilities	Q4
D3.1 Conduct Study	FY00
	Q4
D3.2 Complete report and provide briefing of results	
	FY99
Study D4 Development of a Risk Assessment Model	Q1
D4.1 Prototype Model Developed	Q4
D4.2 Revised model available	
	FY98
Study D5 Bright Lights as a Countermeasure	Q3
D5.1 Protocol	FY99
	Q4
D5.2 Collect data	FY00
	Q2
D5.3 Final report	

16. Procurement Strategy/Acquisition Approach/Technology Transfer:

Technology transfer and analytic capability will be made available through the scientific media and existing FAA structures. Acquisition of equipment (in excess of $5,000) for measurement of fatigue and performance is anticipated for conduct of the laboratory and field studies. First, it is anticipated that additional wrist activity monitors will be acquired to provide adequate coverage of volunteers in field and laboratory studies ($20,000). Additional specialized equipment will be needed for assessment of baseline performance related to the cognitive and team decision making tasks ($76,000)

17. Justification/History:

Public Law 100-591, the Aviation Safety Research Act of 1988 calls for CAMI to conduct research "to develop a better understanding of the relationship between human factors and aviation accidents and between human factors and air safety, to enhance....performance."

RPD 586 Human Factors “Increase understanding of the human factors of emerging technologies, changing human roles and responsibilities, and evolving procedures to help optimize human performance. Develop and enhance measures of human performance and increase understanding of factors which can lead to performance decrement.”

NAS Architecture v3.0 Human Performance Metrics and Baselines

RPD 586 Human Factors: Performance Goal 3: “From 1998 to 2003 provide continually refined human performance baseline measures for use in the evaluation of implementation of new systems and their associated pre-planned product improvements.”

RPD 586 Human Factors Key Product Decision Support System and Collaborative Decision Making “Baseline of human performance levels associated with current decision processes proposed for support by DSSs.”

The National Plan for Civil Aviation Human Factors (March 1995), defines the requirements for a human performance assessment research thrust to develop information needed to improve safety and productivity. As part of that effort additional research is needed to "...reduce the effects of fatigue and circadian dysrhythmia on controllers, mechanics, and flight deck and cabin crews."

In their Department of Transportation and Related Agencies Appropriations Bill 1998 committee report (S6602), the Senate Appropriations Committee encouraged the FAA “to follow up with further research into the fatigue-related effects of the current ‘2-2-1’ shift rotation policy for air traffic controllers. A recent study by the Civil Aeromedical Institute raised issues of sleep deprivation and performance loss which, in the Committee’s opinion, warrant immediate research attention by the agency.”

The House Appropriations Subcommittee Report for 1999 FAA Appropriations recommended continuing and expanding the important work done at the Civil Aeromedical Institute regarding fatigue in the

controller workforce.

This research is responsive to the ARS Human Factors Research Requirements for FY 1998 number 11 entitled “Relationship among performance and shift work, fatigue and situation awareness.”

18. Issues:
Human resource impact is the primary focus of this research. All products, briefings, and outcomes in this initiative impact directly on human resource effectiveness and efficiency. Improved safety and work force performance should result due to (a) improved adaptation of workers to shift work environments (b) more effective understanding of the cognitive skills and abilities required for maximum performance, (c) increased understanding of causal factors of operational errors, (d) data on the dynamics of team decision making. Human subjects will be used. A description of the research protocols and subject consent forms will be submitted to the CAMI Institutional Review Board for approval.

19. Transition Strategy: Transfer of these data findings to the field will be accomplished through briefings to field facility managers, groups of controllers, and FAA Headquarters managers; and published technical reports in the scientific literature to encourage continued development of research on related issues. Forums will include ARTCCs, Air Traffic Control Towers, and Airway Facility Sector offices in which employees must provide staffing for 24 hours. In addition, an educational CD-ROM for ATCSs will be developed and distributed to ATC facilities.

20. Impact of Funding Deferral: Rising costs due to strained labor relations, higher job turnover, and reduced productivity due to the fallout of poor work environments. Implementation of manpower, personnel, and training policies that might not serve to advance organizational effectiveness, or that might be only partially successful, or that might be more costly to implement without guidance on what to anticipate from employees.

21. R&D Teaming Arrangements: CAMI works closely with cognizant management teams throughout the agency. There are no competing in-house labs conducting this work. CAMI collaborates with other federal laboratories and centers of excellence when such collaboration will further mission objectives. Specifically, collaboration with the USAF Armstrong Laboratory and the Japanese was established, as well as a long term collaboration with the Biomedical Research Applications Laboratory at the U.S. Army Aeromedical Research Laboratory. Collaboration with the NASA Fatigue Countermeasures program for air carrier pilots has been active since the inception of this project. In addition, the laboratory collaborates with the U.S. Coast Guard Research and Development Center. Work on expert ATC performance will be conducted through collaboration with the Kansas State University. Finally, technological advances achieved under HRR-500 (1998) will be implemented in the laboratory-based research on this task.

22. Special Facility Requirements: CAMI facilities will be supplemented through contractual arrangement with the USAF Armstrong Laboratory at Brooks AFB to enhance electrophysiological measurement capabilities to investigate the efficacy of fatigue countermeasures and benefit from their AWACS simulation capabilities.

23. Approvals (Signature Authority):

Project Validation

_____ _____
Date

John Staples,
Director, Plans and Performance Program, (ARX-1)

_____ _____
Date

Jon L. Jordan, M.D.
Federal Air Surgeon (AAM-1)

Performing Organization

William E. Collins, Ph.D.
Director, FAA Civil Aeromedical Institute, AAM-3

_____
Date