U.S. Department of Transportation
Federal Aviation Administration

Aeromedical Research Resume
Research Project Description Subtask for FY00

1. Title: Optimizing Human Performance	***2. Sponsoring Organization/Focal Point (FP)*** ARX-1; J. Staples AAM-1; J. Jordan, M.D. ARX-20; S. Pansky (FP) AAR-100; L. Cole	***3. Originator Name, Organization, Phone :*** 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-00-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 by 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 using 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. Models of ATC performance, as well as objective metrics of cognitive performance, will be applied in 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 enhance cognitive performance in training. Findings from research on expertise will be tested in the ATC domain using TRACON SATORI.

ATC Teamwork and Collaborative Decision Making. This research will provide a framework for measuring the degree to which various NAS modernization technologies, such as DSR, URET, Data Link, and others, affect the coordination between the R-side and D-side positions in the enroute environment.

Examination of Causal Factors Related to Decision Making. This project is targeted at reducing OEDs through the understanding of causal factors. Specifically, it will examine the association between OEDs and variables influencing decision making. Future research will examine other human factors related variables (e.g. shift work and fatigue) 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
FAA Staff Years	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 goals of baselining current performance and mechanisms, as well as identifying 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 decision making in operational errors/deviations, and 4) shift work and fatigue.

Understanding Expert ATC Performance: Skills and abilities required for ATC 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. TRACON SATORI will be used as one tool to begin to answer how ATCSs utilize the required cognitive skills and abilities to do their jobs. Our research approach will build on the available human factors research in areas of expertise, decision making, and memory. An emphasis will be placed on identifying the variables/conditions associated with the development of and utilization of expertise in the ATC domain. Because the post-strike ATC work force is aging, the research will include a focus on how age and expertise impact ATC performance.

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 Decision Making: 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 is developing a new automated final report form that will be distributed to the field. Current projects include

assessment of data fields to further improve the data collection and analysis efforts. As part of this effort, the utility of the Human Factors Analysis and Classification System (HFACS) will be evaluated for air traffic applications. In addition, efforts will focus on transitioning illustrative re-creations of OEDs to the

classroom training of Quality Assurance specialists. This research area will also be directed toward the analyses of causal factors related to situational awareness for applications to training.

Shift Work and Fatigue: Research on 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 Appropriations 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). The advantages of these schedules include the fact that 4 of 5 days are worked during normal waking hours, minimizing exposure to night shifts. 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. These schedules can result in a pattern of partial sleep loss and 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, as well as circadian rhythms and neuroendocrine changes for individuals working counterclockwise, rapidly rotating shift schedules. The efficacy of napping as a fatigue countermeasure was investigated in a laboratory study. In addition, coping strategy workshops and a brochure were developed for educational purposes. During the period of this ARR, a survey of shift schedules at 131 facilities and data collection on a laboratory-based bright lights study were completed. At the request of Congress, a facilities-wide comprehensive survey of air traffic control personnel will be conducted to determine the extent of fatigue among the workforce and the effect of current shift patterns and rotation practices. This requirement necessitated replacing a study regarding the implementation of fatigue counter measures with a field-based fatigue assessment study to validate survey findings. Also, as a result of the Congressional request, the development of a risk assessment model was postponed until conclusion of the survey and field study. Finally, a survey of the AF workforce was added to maximize the advantages of being geared up to survey ATCSs.

(2) Statement of Work subtasks:

Task 1. Understanding Expert 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 applied to baselining the current system.

Task 2. ATC Teamwork and Collaborative Decision Making.

This is an integrated program of research that encompasses laboratory assessments, training evaluation, and baseline/field studies. Laboratory assessments will be used to examine how changes in aircraft density affect R-side and D-side coordination via the communication exchanges between the two positions. This information will be provided for use in the design of R-side and D-side team training being developed at the Academy. Once developed, the training will be evaluated based on its effectiveness in reducing the negative impact that new technologies are projected to initially have on the coordination between the R-side and D-side positions. Finally, baseline/field assessments will be used to track the implementation of new technologies as they relate to R-side and D-side coordination in

the enroute environment. These field assessments will require targeting a given facility prior to the introduction of a specific technology that will potentially affect R-side and D-side coordination. Ideally, this research requires collecting baseline assessments at three points in time prior to technology implementation and three points in time after implementation.

Task 3. Examination of Causal Factors Related to Decision Making.

The FAA OEDs database will be examined for the association between OEDs and variables influencing decision making. An evaluation of goodness-of-fit will be made between the information collected by the existing data collection form and taxonomies such as HFACS. Missing and redundant information will be identified. Researchers will collaborate in the development of the new action plan with Eurocontrol. Information regarding the analysis, results, and conclusions from the application of the HFACS taxonomy to the analysis of operational errors will be exchanged. In addition, researchers will participate in the technical information meeting planned for the UK during the spring of 2000.

Task 4. Shift Work Countermeasures Implementation (Field, Laboratory, and Survey).

This research is designed to baseline the performance of ATCSs working unique shift schedules and demonstrate the effectiveness of specific countermeasures for preventing shift work-related fatigue. In addition, the Airway Facilities workforce will receive a shiftwork survey to assess the extent of fatigue in their work environments. Five studies are planned to survey and assess fatigue in the field and assess alternate shift schedules and countermeasures 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 programs 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:

Task 1: Understanding Expert ATC Performance	
1.1 Design study	COMPLETED
1.2 Conduct Study	FY00 Q1
1.3 Complete report and provide briefing of results	FY00 Q3
Task 2: ATC Team Performance/Collaborative Decision Making	
<u>Team Performance</u>	
2.1a Complete laboratory data collection on the effects that aircraft density has on R-side and D-side coordination via the communication exchanges between the two positions.	FY00 Q2
2.2a Complete team training program evaluation design	FY00 Q3
2.3a Complete data analysis of laboratory data	FY00 Q4
2.4a Complete evaluation of initial team training curriculum	FY01 Q1
2.5a Complete baseline assessment at an enroute facility	
Time 1 assessment	FY01 Q2
Time 2 assessment	FY01 Q3
Time 3 assessment	FY01 Q4
<u>Collaborative Decision Making for Future Systems</u>	
2.1b Conduct study	FY00 Q4
2.2b Complete report and provide briefing of results	FY01 Q2
Task 3: Causal Factors OE/D Reporting System	

Design of Reporting Form	
3.1a Design method for change over	
3.2a User Survey-1	COMPLETED
3.3a Data Reduction-1	COMPLETED
3.4a Complete Beta Version Debugging	COMPLETED
3.5a Conduct Beta Evaluation	COMPLETED
3.6a Deliver Final Form to AAT-200	COMPLETED
3.7a User Survey 2	FY99 Q4
3.8a Data Analysis	FY00 Q2
3.9a Complete Draft Report Study	FY00 Q3
	FY00 Q4
Causal Factors OE/D Reporting System	
3.1b Complete Literature Review	
3.2b Draft Report Completed	FY00 Q2
3.3b Design and Conduct Study	FY00 Q2
3.4b Conduct Analysis	FY00 Q3
3.5b Provide briefing of results	FY00 Q4
3.6b Beta Version Phase 2 Completed	FY01 Q2
	FY01 Q4
Causal Factors Analysis	
3.1c Development of QA training materials	
3.2c Analyze OED data using HFACS	COMPLETED
3.3c Compare and contrast HFACS data with that obtained using EUROCONTROL System	FY00 Q1 FY00 Q2
3.4c Draft Report Complete	FY00 Q4
Task 4. Shift Work Countermeasures Implementation (Field, Laboratory, and Survey).	
Bright Lights as a Countermeasure (Laboratory)	
4.1a Protocol	
4.2a Collect Data	COMPLETED
4.3a Draft Report	COMPLETED
4.4a Final Report	COMPLETED
	FY00 Q2
Shiftwork Survey of ATC Facilities	
4.1b Design study	
4.2b Scientific Steering Group Summit	COMPLETED
4.3b Finalize Protocol	COMPLETED
4.4b Collect Data	COMPLETED
4.5b Analyze Data	FY00 Q1
4.6b Complete report and provide briefing of results	FY00 Q3
	FY00 Q4
ATC Fatigue Assessment (Field)	
4.1c Design Study	
4.2c Collect Data	COMPLETED
4.3c Analyze Data	FY00 Q3
4.4c Draft Report	FY01 Q2
4.5c Complete report and provide briefing of results	FY01 Q3
	FY01 Q4
Shiftwork Survey of Airway Facilities	
4.1d Design study	
4.2d Collect Data	COMPLETED
4.3d Analyze Data	FY00 Q2
4.4d Draft Report	FY00 Q4
4.5d Complete report and provide briefing of results	FY01 Q1
	FY01 Q3

Shift Rotation Study (Laboratory)	
4.1e Design Study	COMPLETED
4.2e Collect Data	FY00 Q4
4.3e Analyze Data	FY01 Q2
4.4e Draft Report	FY01 Q3
4.5e Complete report and provide briefing of results	FY01 Q4

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 not anticipated for conduct of the laboratory and field studies. 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."

ATS Human Factors Research Project Description for FY-00 (RPD 586) "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."

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 1998 FAA Appropriations recommended continuing and expanding the important work done at the Civil Aeromedical Institute regarding fatigue in the controller workforce. For 1999, the Committee provided funding for a comprehensive survey of air traffic controller personnel to determine the extent of fatigue among the workforce and the effects of current shift work patterns and rotation practices, as well as to continue the work done at CAMI on 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, and (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 FAA 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 HF researcher 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. Finally, technological advances achieved under HRR-500 (1998) will be implemented in the laboratory-based research on this task. 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. Research associated with R/D side coordination and collaborative decision-making will involve collaboration with scientists at the William J. Hughes Technical Center and with personnel at the FAA Academy.

22. Special Facility Requirements:

CAMI facilities were supplemented through contractual arrangement with the USAF Armstrong Laboratory at Brooks AFB to enhance electrophysiological measurement capabilities to investigate the efficacy of fatigue countermeasures.

***23. Approvals (Signature Authority)*:**	***Project Revalidation***	***Performing Organization***
_____	_____	
John Staples, Director, Plans and Performance Program, (ARX-1)	*Date*	William E. Collins, Ph.D. Director, FAA Civil Aeromedical Institute, AAM-3
_____	_____	_____
Jon L. Jordan, M.D. Federal Air Surgeon (AAM-1)	*Date*	*Date*