U.S. Department of Transportation
Federal Aviation Administration

Aeromedical Research Resume
Research Project Description Subtask for FY01

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. ARX-20; S. Pansky (FP) AAR-100; P. Krois, Ph.D.	AAM-510, (405) 954-4082 Thomas Nesthus, Ph.D. Julia Pounds, Ph.D. Larry Bailey, Ph.D.
		4. Origination Date: October 1998
5. Parent RPD Number: 586	6. Subtask Number: AM-B-01-HRR-518	7. Completion Date: September 2002
8. Parent MNS: ATS Human Factors	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 individual, situational, and work-related factors that influence performance. The objectives are to 1) broaden our understanding of the role of cognitive factors and expertise as they influence ATC performance, team performance, 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 performance, and identify factors which lead to performance decrements and errors. The findings will be used to develop improved human factor approaches to procedures, training, and guidelines.

11. Technical Summary:

This research is designed to identify baseline performance metrics for current equipment, policies, and procedures using both laboratory and field studies. From this work, strategies for maximizing performance will be developed. The research to be conducted 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. The objective measures will be used to baseline performance in the current system and provide a knowledge base for optimizing the transition to future systems. In addition, opportunities to enhance cognitive performance in training will be identified. Findings from research on expertise will also be tested in the ATC domain using TRACON SATORI.

ATC Teamwork, Communication, and Coordinated 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 communication and coordination between the R-side and D-side positions in the enroute environment.

Examination of Human Causal Factors Related to Decision-Making. This project is targeted at reducing Operational Errors (OEs) through a better understanding of the human causal factors attributed to them. Specifically, models of human error will be used to identify underlying human error trends in existing OEs and develop putative intervention and mitigation strategies. In addition, work has begun to enhance the quality of human factors data obtained during OE investigations by incorporating human factors principles in the investigation of OEs and the reporting form.

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 also be investigated. To assess the degree to which the unique shift rotations affect optimum performance, three studies are planned, including a survey of all controllers, a field study of selected ATC sites, and a laboratory study.

12. Resource Requirements:

	FY01	FY01
FAA Staff Years	7.0	7.0

13. Description of Work:

(1) Brief Background

This research consolidates projects in several areas. Each area investigates aspects of human performance with the goals of baselining current performance levels, 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 coordinated decision making, 3) examination of causal factors related to operational errors/deviations, and 4) fatigue associated with shift work.

Understanding Expert ATC Performance: Transitions of enhanced capabilities pose shifts in task-load and performance that need to be assessed in order to provide recommendations to mitigate performance degradation including defining better interface designs and improving training and procedures. 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. SATORI will be used as one tool to assess 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 and utilization of expertise in the ATC domain. Because the post-strike ATC work force is aging, the research will also include a focus on how age and expertise impact ATC performance.

ATC Teamwork, Communication, and Coordinated Decision-Making: When transitioning to future systems, it is critical to understand team interactions, specifically coordinated 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 NAS modernization, technological change will continue as an ongoing process through the next decade. Proposed changes may greatly influence requirements for teaming. However, 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. Specifically, the work in this area will baseline team performance and collaborative decision making in current systems, as well as examine future systems, such as URET and data link. 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. Work will continue in support of the harmonized FAA/Eurocontrol approach to the management and reduction of error in ATM (Action Plan 12).

Shift Work and Fatigue: Research on fatigue and environmental stressors has been ongoing for several years. However, the present work is responsive to the 1998 Senate's Department of Transportation and Related Agencies Appropriations Bill and the1999 House of Representatives, Appropriations Committee Reports. The focus of the research has been on the unique, counterclockwise rotating shift schedules worked by ATCSs. It is well known that shift work can create stress and health problems in some shift workers. For example, fatigue, circadian rhythm disruption, and disruptions of social interactions have all been associated with shift work. There is even 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 are 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 between work weeks. Nevertheless, the prevailing attitude of shift work researchers is that shift schedules should rotate clockwise, even though few data support this recommendation. What is required is a comprehensive examination of shift work related fatigue in the ATCS workforce, as well as a comprehensive examination of the forward and backward 2-2-1 schedule commonly worked.

(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 baseline the current system.

Task 2. ATC Teamwork, Communication, and Coordinated 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 used in the design of R-side and D-side team training. Once developed, the training will be evaluated based on its effectiveness in reducing the negative impact that new technologies are projected to 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 Operational Error and Deviation (OED) database will be examined to identify the association between OEDs and variables influencing decision-making. Missing and redundant information will be identified. In addition, researchers will continue to collaborate in the execution 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. Furthermore, researchers will participate in the technical information meeting planned to complete Work Package 1 and initiate Work Package 2 of the Joint FAA/Eurocontrol Action Plan, in December 2000 and May 2001.

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

This research is designed to baseline the performances of ATCSs working unique shift schedules and demonstrate the effectiveness of specific countermeasures for preventing shift work-related fatigue. Four 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 baseline studies in this research. In-service training programs and a multimedia CD-ROM to teach coping strategies for adaptation to shift work will result. In addition, OAM technical reports and briefings will document the utilization and effectiveness of fatigue countermeasures in the operational environment. Reports and briefings will also offer data-based guidance for management decision-making affecting the organization and work environment of FAA personnel. Finally, methods and tools for improved investigation and reporting of OE/D events to improve data-driven development of skills enhancements and automation recommendations.

15. Schedule/Milestones:

Task 1: Understanding Expert ATC Performance	
1.1 Complete report and provide briefing of results	Completed
Task 2: ATC Team Performance/Collaborative Decision Making	
<u>Team Performance</u>	
2.1a 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	Completed
2.2a Data analysis of laboratory data	Completed
2.3a Complete report on team performance/collaborative decision making	FY01, Q1
<u>Team Configuration Study: Joint Program of Research with Tech Center</u>	
2.1b Laboratory data collection on the effect of team configuration on controller-to-controller communication and coordination. Three team configurations will be assessed: (1) alone as a radar controller, (2) as a two-person team consisting of a Radar Controller (R-side) and a Data Controller (D-side), and (3) as a three-person team of two R-side controllers being assisted by one D-side controller.	FY01, Q1
2.2b Laboratory analysis	FY01, Q2
2.3b Complete report on team configuration	FY01, Q3
<u>The Effect of Controller Team Configuration & the Use of Decision Support Automation: Joint Program of Research with Tech Center</u>	
2.1c Laboratory data collection on how team configuration and decision support technologies affect controller-to-controller communication and coordination. This study builds on the results of task 2.1b	FY01, Q3
2.2c Laboratory analysis	FY01, Q4
2.3c Complete report on controller team configuration and the use of decision support automation	FY02, Q1
Task 3: Causal Factors OE/D Reporting System	
<u>Design of Reporting Form</u>	
3.1a Design method for change over	Completed
3.2a User Survey-1	Completed
3.3a Conduct Beta Evaluation	Completed
3.4a Deliver Final Form to AAT-200	Completed
3.5a Usability Study	FY00, Q4
3.6a Complete Report on reporting form	FY01, Q1
<u>Causal Factors OE/D Analysis and Reporting System</u>	
3.1b Complete Literature Review	Completed
3.2b Conduct Analysis	FY00, Q4
3.3b Provide recommendations to AAT-200 for revising the content of the OE/D final report	FY01, Q1

3.4b Provide AAT-200 a method for identifying variables relevant to reducing separation errors	FY01, Q3
3.5b Provide reporting tool for data collection and analysis of human and latent system errors	FY02, Q2
Task 4: Shift Work Countermeasures Implementation (field, Laboratory, and Survey).	
Bright Lights as a Countermeasure (USAF Armstrong Laboratory at Brooks AFB)	
4.1a Complete Report	FY00, Q4
Shift Work Survey of ATC Facilities	
4.1b Complete report and provide briefing of results	FY00, Q4
ATC Fatigue Assessment (Field)	
4.1c Conduct pilot study at Pittsburgh Tower	Completed
4.2c Conduct study at ARRTC locations	FY01, Q1
4.3c Complete report and provide briefing of results	FY01, Q4
Shift Rotation Study (Laboratory)	
4.1d Collect Data	FY00, Q3 and Q4
4.2d Analyze Data	FY01, Q2
4.3d Draft Report	FY01, Q3
4.4d 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 to conduct 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."

Likewise, the ATS Human Factors Research Project Description for FY-00 (RPD 586) states that an "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." Specifically, RPD 586 Human Factors: Performance Goal 3 states that, "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." Furthermore, RPD 586 Human Factors Key Product Decision Support System and Collaborative Decision Making calls for the "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." With this in mind, 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. Finally, this research is also 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:

Deferral of funding for proposed projects will result in a general reduction in the quality of the work environment, which could result in reduced operational efficiency, increased job turnover, or increased strain in labor relations and reduced organizational effectiveness. Without the availability of a solid scientific basis for developing interventions designed to optimize performance, proposed interventions are likely to be less successful and more costly. This will be especially true with regard to the development of countermeasures proposed to effectively reduce the fatigue experienced by air traffic personnel required to maintain the safety and efficiency of the NAS during 24-hour operations.

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 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 and the University of Illinois. 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):			***Performing Organization***
_____		***Name***	William E. Collins, Ph.D.
John Staples, ARX-1	***Date***	***Title***	Director, FAA, Civil Aeromedical Institute, AAM-3
_____			
Jon L. Jordan, M.D., AAM-1	***Date***	***Date***	