Aeromedical Research Resume
Research Project Description Subtask for FY99

U.S. Department of Transportation
Federal Aviation Administration

1. Title:	2. Sponsoring Organization/Focal Point (FP)	3. Originator Name, Organization, Phone : AAM-510 (405) 954-6828
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5. Parent RPI Number: Flight Deck Human Factors	**6. Subtask Number:** AM-A-98-HRR-510	**7. Completion Date:** September 1999
8. Parent MNS: 187	**9. RPI Manager Name, Organization, Phone:** David J. Schroeder, Ph.D. AAM-500, FAA Civil Aeromedical Institute (405) 954-6825	

10. Research Objective(s):

This ARR details a plan for the conduct of human factors research in response to regulation and certification (AVR) requirements. Additionally, this ARR supports the objectives of AAR-100's general aviation human factors program. A primary objective is to develop and test interventions, which will mitigate or eliminate root causes of general aviation pilot "errors" and thereby achieve a reduction of general aviation accidents and incidents. Human factors information and data gained via that objective will provide a sound scientific basis for the FAA and the GA Industry Coalition to develop and execute certification and rule making initiatives which will result in gains in general aviation safety. Specifically, the research is designed to: (1) assess the impact of various human factors variables on pilot performance under specified flight regimes; (2) identify aircraft system designs and environments which tend to induce errors and degrade pilot performance and develop pilot/aircraft interface design guidelines; (3) support standards and certification efforts by collecting empirical pilot performance data upon which to base regulatory and aircraft systems certification decisions; (4) provide support for developing advisory circulars and other informational materials for educational purposes; (5) investigate the effects of fatigue on pilot performance and (6) investigate the impact of advanced, high-technology equipment on GA cockpit systems design on pilot performance and training (Joint FAA-NASA Advanced General Aviation Transport Experiments (AGATE) program).

11. Technical Summary:

This ARR includes a multi-task approach to meeting the research objectives noted above. For the most part, these tasks will involve laboratory research and simulation to investigate specific factors and conditions, which are felt to impact GA pilot performance. The primary research tools in conducting this research will be CAMI's two GA flight simulators: the Advanced General Aviation Research Simulator (AGARS) and the Basic General Aviation Research Simulator (BGARS). Research protocols, scenarios, and flight regimes will be configured to emulate the flight environment critical to the human factors research question under study. Recommendations are to be provided based on empirical pilot performance data obtained from high-fidelity real-time simulation. Wherever appropriate, pilot-subject response data will be presented in the form of probability functions, performance curves, and other graphic and probabilistic data presentation, which will support Agency actions. Where appropriate, human engineering design recommendations will be offered, based on study results, which may serve to improve the pilot-aircraft system interface, mitigate pilot error, and enhance flight safety.

12. Resources Requirements:	FY-98	FY-99	FY-00
FAA Staff Years	8.0	10.0	10.0

13. Description of Work:

(1) Brief Background

This ARR was initiated in FY'94 with an investigation of performance enhancements attainable through use of an integrated horizontal situation indicator (HSI) in place of separated non-integrated instrumentation (directional gyro and VOR head). Results were documented in several articles in the open literature and in OAM Technical Reports DOT/FAA/AM-96-15 of April, 1996, and DOT/FAA/AM-96-16 of May, 1996. Work has also been completed in developing certification criteria for autopilot / autotrim autonav systems, on providing inputs on the flight systems and training work packages for AGATE, in examining criteria for airborne GPS-derived map and displays, in defining design criteria for HUDs, and in documenting pilot hearing thresholds. Continuing support for the AGATE program (system development and testing & evaluation) is supported within the tasks in this ARR.

(2) Statement of Work

This is a multiple-task ARR and includes tasks with several component phases or stages where there is a transition of attention to follow-on issues and problems as a function of the degree of success of earlier efforts. Tasks that were included in earlier versions of this ARR have since been completed and final products and documentation have been provided. Two additional tasks have been identified in coordination with AIR, assessing root causes of human error in accidents and defining standardized human/system performance criteria for system certification, that were not sufficiently developed to include in this document as complete tasks. These will be developed in '99 for inclusion as tasks in later ARRs.

General Hypothesis: that the cockpit flight systems innovations designed and/or tested will produce statistically significant gains in one or more measures of pilot performance and contribute significantly to value-added assessments.

Task 1 - Pilot visual performance with integrated head-up displays. This task is in response to both the appearance of noncollimated head-up displays (HUDs) as available add-on avionics for general aviation aircraft and in consideration of the uses of HUDs for the AGATE aircraft. The two subtasks of this task are (1) conducting a task analysis wherein candidate tasks for HUD implementation are identified for further experimental examination and (2) assessing the impact of noncollimated HUDs on visual scan patterns and target detections. First, it is of interest that a determination of GA flight tasks amenable to HUD aiding be completed. Some tasks are likely to benefit more from HUD presentation of data than do others. For example, maintaining cruise altitude may not be as germane a task for HUD use as would flying an approach. It is also of interest to determine if there are tasks that are performed in VMC that can benefit from HUD presentation, particularly if this presentation allows the pilot to conduct surveillance of surrounding airspace more effectively. Second, HUDs that appear in commercial transport aircraft are collimated with the intent of drawing the pilot's accommodation (visual focus) out toward optical infinity. Even with such optical systems it has been demonstrated that the pilot's focus tends to drift inward toward the dark focus distance (generally about 1 meter), causing distant objects to lose resolution and clarity and in some cases to fail to be detected. Some new devices being introduced for the general aviation market are not collimated, having an apparent distance of something close to 1 meter or less depending upon the distance from the pilot's eye position to the mounting position of the HUD combining glass. Inasmuch as objects at this distance tend to serve as accommodation traps, this situation is likely to force visual accommodation inward much more than collimated HUDs, producing substantial misaccommodation to distant objects. An additional hazard is the reduction of the visual scan as attention is focused on the HUD, particularly as present devices present alphanumeric data but no gyro horizon information.

Pilot subjects will perform full-mission scenarios containing flight tasks selected from the task analysis that represent those most likely and least likely to benefit from a HUD presentation. Conditions of no HUD,HUD present but not illuminated, and HUD illuminated in a high-fidelity external visual environment (AGARS) will be included. This combination of conditions has been used in previous research involving collimated displays.

Comparative analyses will be used to determine if any substantial degradation in visual search is concurrent with presence and/or use of the HUD and which of the selected tasks benefit most from a HUD presentation. This task was initiated in FY'98 and will continue into FY'99.

Task 2: GPS Design Evaluation. GPS navigation units have become widely available recently, many of these being of the hand-held or the add-on variety. The appearance of these devices, while a significant aid to navigation, has produced several concerns. Those that are not integrated into the aircraft panel in a meaningful fashion have the potential of distracting pilot attention and disrupting the usual scan, particularly if the display is used for momentary guidance (course tracking). Additionally, the small low-contrast displays seen on most units, particularly those attempting to present moving map displays, are difficult to read at normal cockpit viewing distances. In a number of cases it is evident that engineering conveniences have been design determiners rather than the application of fundamental human factors principles. The structure of the software interface is also of concern, particularly where the menu structure is such that it complicates "navigation" through the control hierarchy of the unit. This task is designed to examine to what degree established human factors principles are being applied to GPS navigation operator interfaces and to define any additional or specific guidelines applicable to the design and use of such systems.

This investigation will use actual representative GPS units as well as simulated GPS displays interfaced to and driven by the BGARS and the AGARS for initial evaluation of characteristics of displays and control interfaces and menu structures. This will be accomplished by examination of an integrated GPS display modifiable by the experimenter within which key parameters will be examined relating to display characteristics and control interface structure. The first series of studies (menu structures: display formatting) in the series, a usability investigation of the Magellan EC-10X GPS and examinations of display formatting to support the nearest-airport function, were completed. Continuing experimentation will focus more on issues of display integration, minimum functional requirements, and interface standardization.

Task 3: **Cockpit Auditory and Visual Alarms**. Each new technological innovation installed in the aircraft cockpit with an alarm or warning mode requires a thorough understanding of how a flight crewmember will interface with the system being guarded. This information is important to the FAA fulfilling its responsibility for certification. Although standard human factors principles can be applied in these instances, such standards are often inadequate for complex interface design situations. Hence, pilot-aircraft interface design standards need to be developed and tested under a variety of operating circumstances. This project contributes to the development of standards through simulation studies and tests under realistic flight protocols and through the assessment of baseline hearing abilities in pilots and nonpilots, both in quiet and in engine-noise environments. This project is focused initially on alarms and malfunction warning systems for autopilot/autotrim systems and de-icing malfunction warning mechanisms. Other alarm issues include the design of aural/visual signals for (a) data-link uplink in which sender and level of urgency (L-N-H) must be coded; and (b) pilot alerts to prevent controlled-flight-into-terrain (CFIT). Results will provide baseline performance data for developing standards to support certification of new cockpit systems. The assessment of pilot hearing threshold profiles has been completed and reported in the open literature. Additional support for this task is through funded grant research at the University of Illinois (see Task 4).

Task 4 - Flight Systems Development for AGATE. The focus of AGATE is to bring advanced technology into the general aviation cockpit with the goals of enabling all-weather autonomous operations, improving pilots' situational awareness, and reducing training and skill maintenance times and expense. Support of AGATE will be realized through participation in multiple working groups, with each of these activities constituting a project as follows: (4.1) primary flight displays; (4.2) primary flight controls; (4.3) multi-function displays (weather/traffic); (4.4) navigation displays; and (4.5) interface devices. A human factors workshop for members of the flight systems and training work packages was staged in May, 1996 and published as Technical Memorandum AAM-500-96-12.

A manifestation of advanced-technology display systems is the "glass cockpit"; the extensive use of CRTs to present multi-function graphical displays to the pilot. One of the aims of the program is to facilitate the migration of glass-cockpit technology from commercial and corporate aircraft into the general aviation fleet, using developed and proven technologies where appropriate and developing new ones where necessary. Inasmuch as a number of the systems currently available for the cockpit display of data (maps, tracking indices, alpha-numerics) do not necessarily conform fully to established human factors standards, it is necessary to evaluate the limits of the display technologies being used and the guidelines available for the creation of these systems in the light of human factors design principles and criteria (as called for in section 3.1.5 in the work package summary for the AGATE; "Human Factors Evaluations of Candidate System Specifications"). The focus is on both primary flight displays and data displays used for other than continuous flight control (3.2).

The present plan for these tasks is that CAMI will participate with the AGATE flight systems work group in the examination of candidate display formats and control-interface configurations. CAMI's rapid prototyping capability and ability to export candidate designs to AGARS for in-flight evaluation will be employed. Final appraisal of candidate designs will be based on empirical data collected in AGARS. These performance evaluations will then be used, in conjunction with other criteria, to select the formats and designs to be recommended for the AGATE aircraft cockpit. The primary flight display evaluation will have been completed in FY'98.

Additional support for this task is through two research grants. The New Mexico State University is providing baseline analytical data on present cockpit information requirements and those anticipated for the "free flight" environment ("The source, priority, and organization of elements of information accessed by pilots in various phases of flight") as an aid in developing cockpit displays, communications requirements, and datalink parameters. The University of Illinois at Urbana-Champaign is providing empirical data on baseline pilot performance for IMC and VMC pilotage for comparison with augmented data sources, displays, and means of pilot self-determination of routing. The investigation will also examine the effects of data reliability on pilot resolution of conflict.

Task 5 - Intelligent Systems Development for AGATE. With the advent of advanced technology for the AGATE cockpit, there is a need to explore ways of managing that technology (or enabling the pilot to manage the technology) through the use of intelligent pilot assistant software applications. Intelligent pilot assistants have the potential to aid general aviation pilots who may experience serious cognitive overload during certain mission phases. The goal of this task is to create a capability to develop and test various intelligent pilot assistant packages, designed to aid the pilot in the performance of designated tasks, that are relevant to the AGATE aircraft. When developed, this capability would be used to create and evaluate any number of intelligent pilot assistant packages.

The approach to this task shall be first to develop a list of function/tasks to be aided, along with concepts regarding level of authority for each pilot assistant package, and circumstances of its use. The results of this analysis will provide input for developing a capability to create and test various intelligent pilot assistant packages relevant to the AGATE aircraft. This capability will allow the identification of system requirements for each package including: 1) the data that are required for the system to function; 2) where and how the necessary data will be obtained; 3) how often the data need to be updated; 4) what kinds of data should be displayed; 5) how the data should be displayed; and 6) how the pilot will interact with the system. The current plan for development and evaluation of intelligent pilot assistant packages is to coordinate efforts with Rockwell International. Testing of packages can be accomplished using CAMI's BGARS. Eventually, a Cockpit Automation Prototyping System (CAPS) will be constructed for development, evaluation, and refinement of intelligent pilot assistant packages. CAPS will allow identification of system requirements for each package and will allow testing of each package using CAMI's advanced flight simulation. Additional support for this task is provided through the grant research described in Task 4.

Task 6 - Instructional Systems Development for AGATE. This task involves providing support and direction to the AGATE Training Systems Technology Work Package. The goals of this work package are to provide human-centered, training-related design recommendations to the other AGATE work groups, and to develop and demonstrate new approaches to training that: 1) encompass the new and advanced technology of the AGATE airplane, and 2) create a training environment that is more efficient and less expensive for the student. Research to support these goals is still being identified by the work package. However, involvement with this task will likely include literature searches and reviews to support the development of design recommendations, and experiments to evaluate new approaches to training.

Task 7: Cockpit Display Data-linked Information. Investigate the impact of increasing degrees of automated information transfer on GA and commuter flight environments. Identify innovations involving display/control design and layout, symbology, color usage, display modes, and display dimensionality which will improve air-to-air and air-to-ground transfer of information to and from the pilot. As part of this task, investigate the various properties of data-linked information transfer with respect to sequence, format considerations, display integration, confirmatory actions, and authority sharing issues, among others, for general aviation applications. Work already completed using B-727 and B-747-400 simulators on optimal location of the data-link display and keypad will be considered. Implications of VHF datalink and ADS-B communication systems will also be considered. Coordination with the AGATE project will need to be carried-out along with consideration of ICAO and RTCA recommendations. Use of multi-function displays involving time-sharing of information presentation will be included. This study is scheduled to be conducted on BGARS which will require the preparation of experimental displays and formats to simulate uplink/downlink of digital data transmission along with controls to support confirmatory and data entry actions. Additional support for this task is provided by the grant research described in Task 4.

Task 8 - Fatigue in Single Pilot Business Flying (AGARS). This task will benefit from the products of ARR-500 to identify innovative methods and instrumentation for real-time sensing of pilot loss-of-alertness and fatigue effects. The Piper Malibu configuration of AGARS will be used to simulate a high-performance, single engine aircraft platform to measure levels of fatigue and loss of alertness induced by a pilot/business person's day. The protocol will involve approximately a 12-hour day in which the pilot departs home airport around 0700, flies a 4-hour mission to a meeting in another city, attends the meeting, and departs around 1700 and arrives back at home airport around 2100. Research objectives include (1) determining if significant fatigue effects and performance impairment are found as a result of the business flying protocol; (2) determining whether fatigue assessment methods developed earlier demonstrate a reliable sensitivity to the effects of fatigue in the simulation; and (3) determining whether the instrumentation used for real-time sensing of loss-of-alertness and fatigue effects functions reliably and whether the alerting provision effectively stimulates the pilot to take appropriate countermeasures. The results of this study will indicate (1) degree of impairment in pilot performance as a result of long, business flying days, and (2) provide guidance in how to design, install, and use real-time sensing devices for protecting the pilot against performance impairment due to fatigue effects.

Task 9 - Fatigue Effects in Regional Airlines Operations (AGARS). In 1995, 1,546 Part 135 regional aircraft flew 3,033,773 hours at a cost of 11 accidents with a rate of .43 accidents per 100,000 flight hours as compared to Part 121, where the accident rate was .27 per 100,000 flight hours. FAR Part 119, which applies the regulatory requirements of Part 121 to regional aircraft now operating under Part 135, created a higher safety standard by requiring changes in flight crew qualifications, cabin safety equipment and materials, airplane performance requirements, aircraft dispatching, and maintenance. However, the regional airline operational environment still differs from the operational environment of "long-haul" carriers, and these important differences seemingly affect regional airline safety, as is evidenced in the difference in accident rates. For example, regional airlines fly into smaller airports, spend proportionately more time in IMC conditions, encounter terminal area traffic densities more frequently, and fly a higher number of take-offs and landings per day. Fatigue issues pertaining to high workload, long workdays, and irregular, unpredictable schedules, as frequently involved in operations of regional airlines, will be investigated using appropriate fatigue and performance assessment methods in a simulated cockpit operational environment.

Further, level of pilot experience in regional airlines is on average less than for Part 121. In 1994, the NTSB reported that these factors might combine in an interactive fashion to increase the risk of critical mistakes that could jeopardize the safety of flight. Human factors research is needed that discerns the exact nature and effects of these factors on pilot performance, and identifies high-payoff approaches for reducing risk and managing uncertainty in regional airline operational environments. In particular, pilot-in-the-loop simulations of regional airline operational contexts can provide pilot performance data that meet these objectives. Such simulations would (1) address the impact of automation on crew task performance; (2) reveal the effects of mission duration and evolution on crew fatigue levels; (3) identify pilot error and strategies to mitigate such error; (4) allow for more optimal integration of the dispatcher function; (5) test fatigue countermeasures; (6) provide pilot performance data that complement current agency efforts to certify aircraft for use in supercooled large droplet (SLD) icing environments; and (7) clarify the implications of "free flight" on the regional airline operational environment and pilot performance.

Findings from the earlier study on GA pilot fatigue will be incorporated in the design and conduct of this study. The primary research tool will be AGARS configured as a twin turboprop commuter aircraft. Objectives include (1) determining the level and onset of fatigue effects as a function of commuter airline missions; (2) testing the value of fatigue assessment methods employed in earlier studies; and (3) assessing the usefulness and cockpit practicality of real-time, loss-of-alertness sensing instrumentation and efficacy of recommended aircrew countermeasures.

Decision making regarding the execution of this task and establishment of milestones is dependent upon the outcome of pending rulemaking and additional review of requirements.

Task 10 - Use of PCATDs for maintaining instrument flight currency. The use of PC-based Aviation Training Devices (PCATDs) has recently been approved, via Advisory Circular 61-126, as an acceptable means of providing some of the training required for the instrument rating. It has been demonstrated, however, that a major problem seen amongst pilots is the effective retention of flying skills in the time following initial certification. Research results have indicated that spaced instructional interventions can be used to maintain flight skills and that those skills that deteriorate most rapidly are generally procedural in nature. The possible use of affordable simulation to provide some of these instructional interventions has the benefits of increasing the availability of instrument flight practice, decreasing the cost of the associated training, and reducing the hazard exposure of both the trainee and other individuals in the nearby environment. The research will involve the comparison of four groups of pilots over time to determine the effectiveness of different training/recurrency interventions: a control group with no practice or instrument flying between pretest and posttest, a second control group which practices in the aircraft, an experimental group receiving practice time in a conventional aviation training device, and an experimental group receiving practice on a PC-based device (one that has been approved for use in instrument training). Performance will be assessed for 12 flight tasks and will be correlated with flight training experience and currency variables. Results will be used to recommend appropriate use of the PCATDs in the maintenance of instrument flying skills. Research was initiated in FY'98 and will continue in FY'99.

Task 11 - Development and implementation of specialized assessment procedures and questionnaire probes for enhancing performance. FAA personnel involved in aviation regulation and certification provide a critical link with flight operations in determining the overall level of safety maintained within the National Airspace System (NAS). Optimal performance is determined in part by the overall quality of the selection and training programs, the procedures and available work tools available and other aspects of the overall corporate climate. With NAS modernization there will be a need to develop new procedures and technological approaches to accomplishing various job tasks. Information can also be gathered from general aviation pilots and others regarding their perceptions of various changes. This research task is designed to develop specialized assessment procedures and questionnaire probes that will provide baseline data for assessing employee and pilot views of safety-related issues, training, and performance. That information will, in turn, be used to assess the effectiveness of new technologies and procedures in optimizing performance and enhancing the overall corporate culture, including information gathered as part of the biennial FAA employee attitude survey (EAS). Work has been ongoing related to the EAS, the AFS/CAPS assessments,
and efforts to support the transition to a paperless office in the Aircraft Registry.

14. Intended End Products/Deliverables:

Efforts on this ARR will result in products which will be delivered through such media as advisory circulars (AC's); DOT/FAA/CAMI informational pamphlets distributed to the GA community; educational materials provided to FAA safety counselors for distribution and presentation; guidelines for certification and rule making; equipment design specifications provided to GA equipment manufacturers (most notably AGATE industry partners); general human engineering guidelines for the design and integration of GA cockpit instrumentation; and so forth. Results of scientific studies will be documented in technical reports and memoranda, and reported to sponsors at project review meetings, with a selected number being presented at professional meetings and submitted for publication in the scientific literature.

15. Schedule/Milestones:

Task 1 - Pilot Visual Performance with Head-Up Displays - AGARS

1.1 Experimental design completed; protocols developed, analyses specified 99Q1

1.2 Simulation scenarios designed; preliminary experiments conducted	99Q2
1.3 Full-mission simulations conducted in AGARS	99Q3
1.4 Data reduced/statistical analyses completed; draft report completed	99Q4
Task 2 - GPS Design Characteristics Study	
2.1 Develop/implement new simulator interface software & GPS scenarios	ongoing
2.2 Pretest data collection	
2.3 Collect/analyze primary data	
2.4 Report findings, recommendations	
Task 3 - Auditory and Visual Alarms Study	
3.1 Design Phase 3 Study	99Q1
3.2 Reconfigure AGARS (hardware/software)	99Q1
3.3 Collect pretest data	99Q2
3.4 Collect/analyze primary flight data	99Q3
3.5 Report findings, recommendations	99Q4
Task 4 - Flight Systems Development for AGATE	
4.1 Design and evaluation inputs to primary flight displays	Ongoing
4.2 Design and evaluation inputs to primary flight controls	(as required)
4.3 Design and evaluation of multi-function displays (CNS; weather; terrain)	
4.4 Design support of pilot control/display interface devices	
Task 5 - Intelligent Systems Development for AGATE	
5.1 Function-based areas of potential application	Ongoing
5.2 Current/projected AI technology	(as required)
5.3 Cockpit Automation Prototyping System	
5.4 Concept Test and Evaluation	
Task 6 - Instructional Systems Development for AGATE	
6.1 Create Instructional Systems Development guidelines	completed
6.2 Develop AGATE Profiles	completed
6.3 Develop Training Requirements	ongoing
6.4 Prepare instructional program plan	
6.5 Install and Test Program	

Task 7 - Cockpit Display of Data-Linked Information	
7.1 Design Study	completed
7.2 Reconfigure BGARS; develop supporting displays	completed
7.3 Develop simulation software	completed
7.4 Collect/analyze data	99Q1
7.5 Report findings; make recommendations	99Q2
Task 8 - Fatigue in Single Pilot Business Flying	
8.1 Integration and test of loss-of-alertness sensors	99Q2
8.2 Develop protocol - OKC to ABQ and return	99Q3
8.3 Determine nature of impairment, countermeasures	99Q4

Task 9 - Human Factors in Regional Airlines Operations - Commuters - AGARS
9.1 Develop specifications for twin turbo-prop aircraft upgrade
9.2 Develop Regional Airlines human factors research program
9.3 Develop commuter aircraft simulator capability
9.4 Investigate fatigue in commuter flight crew flight/duty scheduling

Task 10 - Use of PCATDs for maintaining instrument flight currency

10.1	Complete standardization of instrument check scale	completed
10.2	Complete testing of recent grads and pilots w/o recent experience	completed
10.3	Begin experimental testing	completed
10.4	Complete experimental testing	99Q3
10.5	Complete data analyses	99Q3
10.6	Submit final report	99Q4

Task 11 -	Development of specialized assessment tools	ongoing
11.1	Determine task procedural and technical requirements	(as required)
11.2	Develop procedures/tools for assessing baseline data relative to task	
11.3	Collect baseline data	
11.4	Analyze and report data	

16. Procurement Strategy/Acquisition Approach/Technology Transfer:

Technology transfer to the general aviation equipment community will be accomplished through such organizations as GAMA, SAMA, AOPA, through the AGATE, and through circulars and other media to the GA pilot community. It is anticipated that additional hardware/software support will be required to upgrade AGARS. Procurements will support the AGATE program and plans to upgrade the device to support other aero model configurations at an estimated cost of $154K.

17. Justification/History:

NTSB civil aviation accident data for 1995 indicate that of the total of 2,188 accidents, 2,066 or 94% were associated with general aviation. Of the total number of accidents, 438 were fatal with general aviation accounting for 408 or 93%. Total fatalities for 1995 were 961 with 732 or 76% attributable to general aviation. Note that general aviation includes all aviation operations with the exception of air carrier and the military. (Information was taken from the NTSB Annual Review of Aircraft Accident Data, 1995 Preliminary Data.) General aviation, due to its relatively high accident and fatality rates, offers a potentially high return on investment of R&D resources because of the larger potential payoff in increased aviation safety from interventions that serve to reduce those rates.

It has been estimated that over 80% of the 2,066 accidents noted above within the general aviation community (1653 accidents) can be attributed to some form of pilot error. General aviation pilot "errors" may be precipitated by any number of causal factors including inappropriate decision-making, poor judgment, inappropriate attitudes toward flying, lack of the necessary skill level required for a particular set of flying conditions, or lack of knowledge of weather, procedures, rules or regulations. Such "errors" could also be due to impairment induced by fatigue, drugs, alcohol, stress, hypoxia, preoccupation, or other stressors. In addition to those potential causal factors, general aviation accidents and incidents can also be attributed to confusing navigational charts, poorly conceived airspace restrictions, lack of standardization between aircraft, poorly designed cockpit interfaces including controls and displays, confusing avionics input and output entries, and new technology to which the general aviation pilot must adapt. This ARR is dedicated to developing and testing interventions that will serve to reduce the root causes of general aviation pilot "errors" and thereby achieve a reduction of general aviation accidents and incidents. Some of these interventions will arise from the application of emerging technology through AGATE. Supporting justification for this project area also can be found in Public Law 100-591, the Aviation Safety Research Act of 1988, and the Federal Air Surgeon's Annual Program Guidance Policy Statement, 1992-1993 which supports research on the impact of recent changes in the cockpit environment on pilot performance and assessment of pilot attributes required to perform safety in current and future advanced cockpits. The National Plan for Civil Aviation Human Factors also stresses the urgency of fully integrated human factors research. These activities are also in response to the report of the Gore Commission and its call for interventions to reduce the aircraft accident rate, and are in support of the Flight 2000 initiative.

18. Issues:

Human subjects will be used and will be informed of the tasks to be required. No drugs or alcohol are to be used in the research. A description of the research protocol and subject consent form will be submitted to the CAMI Institutional Review Board for approval. Support will also be provided for the "ATS concept of operations for the National Airspace System in 2005."

19. Transition Strategy:

Transition of R&D findings from the ARR will be accomplished through existing FAA structures within the Flight Standards organization, GA safety counselors, and Aircraft Certification. Other transitions will be accomplished through representation at general aviation industry expositions and technical meetings and through the NASA AGATE program. Transition will also be facilitated by continued coordination with the General Aviation Coalition and continued participation with the four working groups currently operating within that organization.

20. Impact of Funding Deferral:

Deferred funding of this project would likely result in significant delays in understanding the contribution of the specified avionics devices and situations to aircraft accidents and incidents. Deferral would also significantly restrict or prohibit participation in the AGATE and compromise application of human factors standards and criteria to the developing avionics and control systems. This would translate into a continuance of general aviation accidents at an unabated rate (2,066 in 1995), many of which involve fatalities (408 in 1995), and the accompanying loss of life and property damage. One can not discount the indirect costs to society related to subsequent insurance claims, lost wages and productivity, as well as litigation and investigatory costs to the agency.

21. R&D Teaming Arrangements:

The HFRL will collaborate with other federal laboratories and university research centers important to the accomplishment of stated research objectives. In particular, coordination will be maintained with the NASA general aviation program currently being managed at NASA Langley. Continued coordination and participation will be maintained with the General Aviation Coalition composed of FAA-AFS, AOPA, GAMA, SAMA, EAA, and NBAA. The goals of these programs and organizations are shared by this ARR and include aviation safety, product innovation and competitiveness, air facilities capacity and access, and affordability of innovations by the GA pilot community. Additional support for Tasks 2, 3, 4, 5, 7, and 10 will be obtained through grants to the New Mexico State University, the University of Illinois Aviation Research Laboratory, and other institutions. Teaming with the CAMI Accident Investigation Research team (AAM-600) will be pursued where appropriate.

22. Special Facility Requirements:

The General Aviation Flight Simulation Research Facility at CAMI including both AGARS and BGARS will be used in the performance of most experimental tasks.

23. Approvals (Signature Authority):	***Project Revalidation***	***Performing Organization***
____________________ Nancy Lane Special Assistant to the Director Aircraft Certfication Service (AIR-3)	____________ Date	____________________ William E. Collins, Ph.D. Director, FAA Civil Aeromedical Institute, AAM-3
____________________ Jon L. Jordan, M.D. Federal Air Surgeon, AAM-1	____________ Date	