U.S. Department of Transportation
Federal Aviation Administration

Aeromedical Research Resume
Research Project Description Subtask for FY02

1. Title: Flight Deck Human Factors	***2. Sponsoring Organization/Focal Point (FP)*** AIR-3; J. Jones AAM-1; J. Jordan, M.D. AAR-100; W. Krebs, Ph.D. AAR-100; T. McCloy, Ph.D.	***3. Originator Name, Organization, Phone :*** AAM-500 (405)954-6826/6827 Scott Shappell, Ph.D. Dennis Beringer, Ph.D. Thomas Nesthus, Ph.D. Kevin Williams, Ph.D. ***4. Origination Date***: July 1999
5. Parent RPI Number: Flight Deck Human Factors	***6. Subtask Number:*** AM-A-02-HRR-521	***7. Completion Date:*** September 2003
8. Parent MNS: 187	***9. RPI Manager Name, Organization, Phone:*** David J. Schroeder, Ph.D. AAM-500, FAA Civil Aerospace Medical Institute (405) 954-6825	

10. Research Objective(s):

This ARR details a plan for the conduct of human factors research in response to the requirements of regulation and certification (AVR). A primary objective is to develop and test interventions, which will mitigate or eliminate causes of general aviation pilot "errors" and thereby achieve a reduction in aviation accidents and incidents. Human factors information and data gained via that objective will provide a scientific basis for the FAA to develop and implement certification and rule making initiatives that will enhance aviation safety. Specifically, the research is designed to: (1) prevent and/or mitigate causal factors associated with controlled flight into terrain (CFIT), (2) reduce weather-related and maneuvering flight accidents, (3) identify statistical trends among human causes of aviation accidents and incidents, (4) support flight standards and certification efforts by collecting empirical pilot performance data to support regulatory and aircraft systems certification decisions concerning aircraft systems; 5) provide summaries of human factors data required for the certification of emerging technologies and equipment; and (6) provide needed data for advisory circulars and other informational materials for educational purposes.

11. Technical Summary:

This ARR presents a multi-task approach to meeting the research requirements as defined by the AVR Human Factors Technical Community Representative Group (TCRG). Many of these tasks will involve laboratory research and simulation to investigate specific factors and conditions, which are felt to impact pilot performance. Other tasks will require database analyses and survey-style inquiries. The primary research tools for conducting the simulator-based research will be CAMI’s two general aviation (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 will 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 presentations, which will support Agency actions. Human engineering design and/or instructional system design recommendations will be offered to improve the pilot-aircraft system interface, mitigate pilot error, expedite training, and enhance flight safety.

12. Resources Requirements:	FY-00	FY-01	FY-02
FAA Staff Years	15.0	15.0	15.0

13. Description of Work:

(1) Brief Background

This research is an outgrowth of several research requirements generated and prioritized by the appropriate AVR TCRGs. CAMI was identified as the provider for research on all General Aviation requirements, as well as selected requirements associated with the Flight Technology and Procedures subgroup. A brief overview of the FY02 requirements follows:

***Task 1: Controlled flight into terrain (CFIT)/Terrain Displays*.**
CFIT accidents have been cited as one of the leading causes of fatalities in aviation, in particular general aviation. Unfortunately, little is known about the specific human causal factors associated with these accidents. What is needed is a better understanding of the types of human causal factors associated with CFIT accidents along with any trend information so that the impact of selected interventions can be tracked. This need has been partially addressed by the CFIT Joint Safety Analysis Team (JSAT) which identified several human casual factors associated with CFIT accidents and developed 55 intervention strategies to mitigate the causes. One of the most effective strategies identified by the team was the installation and use of horizontal and vertical situation awareness displays. However, the quality of these displays and their effectiveness in the general aviation sector remains to be determined. Research in this area will be aimed at validating the findings of the CFIT JSAT and assessing the intervention and mitigation strategies the committee identified.

***Task 2. Reduction of Weather-Related and Maneuvering Flight Accidents*.**
Weather and maneuvering flight accidents continue to plague general aviation. Typically, each of these factors accounts for about one-quarter of the approximately 400 fatal GA accidents each year. Recently, a JSAT addressed the problem of weather-related accidents and produced an extensive analysis of the problem and potential prevention/mitigation strategies. The proposed solutions involve a mix of aircraft and air traffic systems, procedural changes, and human factors interventions and training. However, to successfully implement these solutions and to ensure that they truly have an impact on the safety of GA, a research program that addresses a broad range of human factors issues is required. Research in this area will: (1) identify those human factors associated with maneuvering flight accidents and flight into instrument meteorological conditions by pilots unprepared for such conditions, (2) develop interventions that will address the human factors identified above to reduce the frequency of weather-related and maneuvering flight GA accidents, and (3) develop and implement techniques to validate proposed interventions to ensure their acceptance, utilization, and effectiveness in the target population.

***Task 3. Safe Flight 21, Human Factors GA Safety*.**
The Safe Flight 21 program is a government/industry effort to explore the use of Automatic Dependent Surveillance-Broadcast (ADS-B) and other Free Flight Phase I technologies. Safe Flight 21 initiatives accelerate efforts to improve aviation safety and efficiency through a multi-year introduction of current and emerging concepts and technologies. The technologies include: 1) Automatic Dependent Surveillance-Broadcast (ADS-B) and Traffic Information Service-Broadcast (TIS-B) to enable pilots of equipped aircraft to “see and avoid” each other through the use of a multi-function display (MFD); 2) A terrain database in the onboard computer software that displays terrain advisory information on the MFD; and 3) Data link of weather, NOTAMs, PIREPs, and the status of special use airspace as provided by Flight Information Services (FIS) on the MFD. There are two geographical areas where Safe Flight 21 operational evaluations are being conducted. One is in Alaska and the other is in the Ohio River Valley (ORV). The goal of the Alaska Capstone initiative is to improve aviation safety, capacity, and efficiency in Alaska through the introduction of new surveillance and navigation technologies that will enhance a pilot’s abilities to cope with weather, terrain hazards, and potential traffic conflicts. Similarly, the goal of the ORV project is to provide an operational evaluation of an integrated ADS-B environment that will support free flight operational enhancements. The Alaska Capstone and ORV activities will provide improved aviation

capabilities for equipped aircraft and vehicles in the evaluation area and an infrastructure from which to gather data necessary to make the best possible decisions when implementing the future National Airspace System (NAS) architecture. Both the Capstone and ORV evaluations will provide answers to technical and cost/benefit questions that are needed to enable decision-makers in the FAA and industry to make key technology choices in support of communication, navigation, and surveillance activities in the cockpit.

Task 4. Weather displays research.
Certification specialists who must evaluate new weather displays are in need of guidance material and assistance regarding the current state of the art in weather display research. Specifically, a literature and product review is needed that includes existing design conventions. Pilot opinions regarding problems with existing weather display systems the relative importance (ranking) of various weather-related data that can be displayed. Research in this area will lead to a “best practices” for flight deck weather display design and contribute to current MOPS and TSOs, as well as advisory circulars.

***Task 5. Causal Factors of Accidents and Incidents Attributed to Human Error*.**
Human error continues to be the predominant cause of aviation accidents and incidents. However, the investigation and analysis of human factors remains qualitative and elusive. What is needed is a standardized methodology for conducting accident investigation and analysis of human error associated with aviation accidents and incidents. Only then will it be possible to examine human error trends in accident and incident databases, and to track the efficacy of intervention and mitigation strategies. One candidate system in use today within the U.S. military, the Human Factors Analysis and Classification System (HFACS), has proven useful in identifying human and causal factors associated with aviation accidents and incidents as well as the post hoc analysis of existing accident databases. Recently HFACS has been applied to U.S. commercial and GA accidents, revealing significant findings. For instance, HFACS has revealed that skill-based errors are associated with roughly 80% of GA accidents followed by violations, decision errors, and perceptual errors. What is needed however, is a finer grained analysis of these four error forms. This task will focus on a better understanding of these four error forms as they relate to GA accidents as well as the preconditions for the unsafe acts committed by aircrew as described within the HFACS framework.

***Task 6. General Aviation Training*.**
Previous studies suggest that if the GA accident rate is to be meaningfully effected in the near-term, improved airman training represents one of the best intervention strategies given that new aircraft systems and capabilities often take several years to implement. Research efforts conducted under this task are aimed at: (1) identifying those areas of GA training in need of improvement, (2) ensuring that GA pilots are trained to fully utilize the capabilities of new aircraft systems as they retrofit and transition to those new systems, (3) ensuring that human centered approaches are considered in the development of new GA aircraft systems and that training systems are based on human factors principles, (4) supporting the development of appropriate airmen evaluation and certification methods in consideration of new and emerging technologies, and (5) reducing the time and cost of ab initio airman certification while extending the amount of instrument training provided to all pilot applicants.

***Task 7. Loss of Primary Flight Instruments during IMC*.**
Most single-engine GA airplanes are not equipped with redundant attitude or heading indicators and loss of information from these instruments during IFR flight, constitutes a genuine emergency. The emergency situation may be exacerbated by the fact that most vacuum-powered instruments in General Aviation airplanes do not alert pilots when their indications become unreliable. When these instruments or their vacuum sources fail, they often fail slowly and many pilots continue to follow their indications longer than they would if an abrupt failure were to occur. Once a failure is detected, the pilot must transition to partial-panel flight, ignoring the failed instruments. Although partial-panel training is required for certification and partial-panel skills must be demonstrated during practical tests, many pilots are not prepared for in-flight instrument failure. Research under this task will empirically determine the extent to which the loss of primary flight instruments can be attributed to GA accidents.

Task 8. Pilot Field-of-Vision/Head Down Time.

This requirement is in response to several lines of inquiry, all relating to pilot visual performance. Of primary interest, is the development of certification criteria for highway-in-the-sky (HITS) and other emerging display technologies. Three concerns are present for these displays. First, there is interest in the effective field of view within the GA cockpit and where it is allowable to place head-down displays. The functional field of view literature needs updating to produce usable limits (for certification) for the placement of both primary flight displays (PFDs) and multi-function displays (MFDs). Second, many emerging displays are thought to be quite compelling, and there is concern that pilots may spend too much time fixated upon this particular PFD to the exclusion of other instrumentation and out-the-window scanning. Third, head-up displays have been suggested as a means of reducing the proportion of time that the pilot spends head-down, but, again, preliminary data indicate that despite the physical positioning, scanning is greatly reduced with cognitive fixations on the HUD. This “cognitive capture” has been demonstrated to negatively affect processing of features (other aircraft, etc.) in the real world. In addition to the HUD, devices are now becoming available that allow unrestricted access to overlaid synthetic imagery throughout the pilot's visual field. Indeed, the NRC of Canada has already flight-tested one such device intended for civilian use. These head-mounted see-through display systems (HMDs) will additionally present their own unique problems in terms of contrast, hysteresis (display lag), and cognitive and perceptual capture. Research associated with this task will examine the human factors associated with these displays and devices.

Task 9. Multi-Function Display (MFD) / Controls.

FAA Technical Standard Order (TSO) C113 on multi-function displays is out of date and is in need of revisions based on current technology and information requirements. The SAE group tasked to develop the new document requires a thorough review of the MFD literature. What is needed is guidance in areas where not enough is known (e.g. requests for a combined system with TCAS and ADS-B traffic alerts). Specifically, this research task will address: 1) What happens when you have red traffic on top of red terrain, on top of red weather; 2) What should the FAA approve or certify for use; and 3) What happens when you have TCAS and ADS-B alerts being indicated simultaneously- what should our certification requirements be? Other issues include clutter/declutter, color usage, use of display for primary flight information, reversion, emergency annunciations, and display switching as well as the prioritization of displayed data relative to operational mode, and phase of flight.

Task 10. Flight Training Devices

With advances in automation and computer technology the proliferation of flight training devices (both conventional and PC-based) has reached new levels. Current regulations that govern how Flight Training Devices (FTDs) are rated within the FAA are antiquated and in need of updating. Currently FTDs are rated on a 0 to 8 scale with 8 being the most sophisticated. The level at which an FTD is rated is particularly important when the amount of credit FTDs can be given for traditional in-flight qualifications is considered. This research task consists of three phases: (1) The identification of all current FTD and Personal Computer Aviation Training Devices (PCATDs) currently in use or on the market; (2) The capabilities of each of these FTDs; and (3) the amount of credit in lieu of actual flight time toward currency requirements that can be offered for each device.

Task 11. Flight-Deck Alerting.

The characteristics of flightdeck alerting systems have been a concern of aircraft safety engineers for some time. For instance, in 1981, the FAA sponsored an "Aircraft Alerting Systems Standardization Study." However, since publishing the 1981 study, several changes have occurred in the aviation industry (e.g., proliferation of automation and the development of more sophisticated computer techniques). Research in this area will provide an update of the 1981 study that would include both U.S. and European technological advancements.

(2) Statement of Work

This is a multiple-task ARR and includes tasks with several component phases dependent upon the success of earlier efforts. Components of tasks that were completed as part of a previous ARR are noted.

Task 1 – CFIT/Terrain Displays

Manufacturers have been developing and marketing horizontal and vertical situation awareness displays for some time. The quality of the displays varies significantly. However, with the recent development of less expensive and higher quality color displays, there has been a significant increase in the quantity and sophistication of these systems. Unfortunately, the designs seem to be driven more by intuition, supposition, and marketability than by data. The effectiveness of some of these systems to prevent CFIT accidents is therefore questionable. Consequently, research needs to be conducted to determine the minimal amount and type of information that should be presented to develop adequate situation awareness to avert CFIT-related accidents. While the CFIT JSAT/JSIT has identified some key issues, a comprehensive investigation of all CFIT accidents over the last several years remains to be conducted. Some issues that remain to be examined when considering new terrain and weather displays:

- Horizontal Situation Displays vs. Vertical Situation Displays vs. Both
- Benefits/Detriments for 2-D & 3-D Displays
- Minimum Display Size
- Minimum Level of Detail and Quality of Terrain Depiction
- Type and Form of Displayed Position-Terrain Information
- Color Application Philosophy (e.g., darker colors for lower elevations)
- Desired Visual/Audio Alerts
- Most Appropriate and Effective Cues to Alerting Pilot of an Impending Situation
- Methods of Operation
- Appropriate Use of Such Systems

Task 2 – Reduction of Weather-Related and Maneuvering Flight Accidents

Flight Standards (AFS-800) requires that a program of research be established to: a) identify the human factors associated with maneuvering flight accidents and flight into instrument meteorological conditions (IMC); b) develop interventions that will reduce the frequency of GA accidents attributable to weather and maneuvering flight GA accidents; and c) develop and implement techniques that validate proposed interventions to ensure their acceptance, utilization, and effectiveness in the user population. To address these requirements, the following tasks have been identified:

- Systematically examine the human errors associated with weather-related accidents
- Investigate pilot knowledge of weather dynamics and create a CBI evaluation and training system
- Perform research on weather-related decision-making, hazard recognition, and risk taking by pilots
- Analyze differences in problem solving, develop risk perception measures, and evaluate temporal positioning of in-flight events on pilot behavior

Task 3 – Safe Flight 21, Human Factors GA Safety

To insure that all Safe Flight 21 activities have a consequential impact on GA safety, a human factors GA safety team was formed. The HF GA Safety Team (Team) will be involved in several activities in support of Capstone and OpEval projects. These activities are listed below.

- Developing criteria for the human factor evaluation of candidate avionics for Capstone II
- Constructing interview questions, observation flight criteria, proficiency evaluation criteria, and developing the format for the pilot focus group discussions
- Conducting pilot interviews, random observation flights, focus group discussions, and proficiency evaluations (subgroup) in Bethel and Southeast Alaska to support Capstone I.

Conducting a usability study for Capstone I and Capstone II avionics to identify 1) how usable the avionics are for single pilot operations, 2) issues associated with display attributes, performance and workload, situational awareness, head-down time, ergonomics, tactile response, alerting, and benefits/detriments of the avionics, 3) training requirements for the avionics, 4) the effect of pilot experience (total flight time and level of GPS experience) on the use of the avionics, and 5) issues associated with datalink applications being considered within the continental U.S.

Task 4 – Weather displays research.

Aircraft Certification (AIR-130) requires that a program of research be established to identify and perform research that is necessary for the development of FAA/AVR technical standards and advisory circulars for weather displays. The objective of the present task is to 1) provide the FAA with the guidelines (minima) to ensure that certification standards are able to adequately and efficiently evaluate the complex weather display avionics systems that are currently commercially available, and 2) provide insight into the human factors issues and bottlenecks that may arise in future weather display avionics systems. The following tasks have been identified to address these objectives:

- Develop measures for evaluating weather products and weather displays
- Review weather display literature and weather display systems
- Provide a survey of human factors issues associated with existing weather display systems
- Collect pilot-performance and preference data to identify "best practices" for the design of weather display systems and the hierarchy of data importance by phase of flight
- Conduct a weather displays usability assessment
- Perform a Functional Allocation of Issues and Tradeoffs (FAIT) analysis of weather display avionics in the cockpit

As a part of the usability assessment efforts, a generic usability assessment capability will be developed to assist in the certification of future generations of cockpit avionics.

Task 5 – Causal Factors of Accidents and Incidents Attributed to Human Error (with the University of Illinois and NASA Langley)

The overall objective of this tasking is to provide a better methodology for acquiring, recording, and analyzing the human factors aspects of aircraft accidents (including General Aviation). Accurate information concerning human factors provides aeromedical researchers and operational field management with critical trend information necessary for the development of accident prevention programs. Such a program, would reach the aviation community through pilot training materials, Advisory Circulars, and/or changes in the Federal Aviation Regulations based on the accident data.

The application of the Human Factors Analysis and Classification System (HFACS) to Department of Defense (DoD) aviation accidents has afforded them the ability to develop objective, data-driven accident/incident intervention and mitigation strategies. HFACS provides a framework for understanding the "big picture," as it highlights important human factors safety issues and their inter-relationships and helps target the need for specific intervention strategies. The framework has also been used to develop innovative accident/incident investigation methods that have enhanced both the quantity and quality of the human factors information gathered during investigations.

The first two years of this effort have yielded unique insight into the human causal factors associated with civilian aviation, in particular general aviation. As a result, AFS-800 and major safety committees associated with *SafeFlight 21* such as the General Aviation Data Improvement Team (GADIT) and the Aeronautical Decision Making Joint Safety Action Team (ADM JSAT) have requested several additional analyses. With this in mind, this task will provide:

- An analysis of all commercial and general aviation accidents occurring between 1990-98
- An assessment of the inter-rater reliability of HFACS within civilian aviation
- A comparative analysis of 14 CFR Part 91 (General Aviation) fatal and non-fatal accidents
- An in-depth analysis of selected unsafe acts (e.g., skill-based and decision errors) as identified using HFACS
- A comparison of general aviation accidents regionally to identify differences in the pattern of human causal factors throughout the continental U.S., Alaska, and Hawaii

Task 6 – General Aviation Training

Multifunctional displays (MFD's) will, in the near future, begin to replace current navigational display systems commonly in use in today's GA cockpit. While there is promise that these displays will increase safety by increasing situation awareness, there is also the possibility that a new level of complexity will be introduced in the cockpit that will have a negative impact on general aviation. Lessons learned from the introduction of GPS systems to the GA cockpit suggest that there are possible trade-offs between the

Increased navigational capability provided by new technology and the increased complexity that must be handled by the pilot/user of the system. In addition, a lack of a standard user-interface and other interface design shortcomings for GPS units has caused problems for pilots operating those units. With the advent of MFD's much, if not all, of the functionality of the GPS systems will be migrated to these new displays. Research is required to study the training requirements that these new systems will impose on the GA pilot. Such research will allow the development of minimum training standards for these systems. This research will also enable the beginning of a user-interface standardization process for these new systems that will allow system developers to avoid the problems encountered with the introduction of GPS systems.

Task 7 – Pilot Field of Vision Capabilities/Head-Down Time

The activities to be performed in assessing the impacts of these technologies and determining requirements to adequately support optimal pilot performance will include: 1) a review and evaluation of guidelines and standards relating to the effective field of view with supplemental experimentation where data are lacking, (2) conducting task analyses wherein candidate tasks for primary flight display (PFD) (whether head-down or head up) implementation are identified for further experimental examination to compare baseline head-down visual behavior with that using advanced display formats and (3) assessing the impact of HUD presentation of these display formats on the visual scan pattern and target detection. First, it is important that a determination of GA flight tasks that can be aided by these display formats be completed. Some tasks are likely to benefit more from graphical perspective presentation of data than do others, and study results are expected to provide data for the SAE G-10 subcommittee on graphical perspective displays. For example, maintaining cruise altitude may not be as germane a task for PFD use as would flying an approach. It is also important to determine if there are tasks that are performed in VMC that can benefit from an integrated PFD presentation, particularly if this presentation allows the pilot to perform the tasks with less effort/training and to conduct surveillance of surrounding airspace more effectively. Examination of the human factors issues relevant to the certification issues will use pilot subjects performing full-mission scenarios. These scenarios will contain flight tasks selected from the task analyses that represent tasks most likely and least likely to benefit from a HUD presentation. Comparative analyses will be used to determine if any substantial degradation in visual search is concurrent with the presence and/or use of the HUD/HDD and which of the selected tasks benefit most from each type of presentation.

Task 8– Loss of Primary Flight Instruments during IMC

Most GA airplanes are not equipped with redundant attitude or heading indicators. Consequently, the loss of information from these instruments during IFR flight constitutes a genuine emergency. The emergency situation may be exacerbated by the fact that most vacuum-powered instruments in GA airplanes do not alert pilots when their indications become unreliable. When these instruments or their vacuum sources fail, they often do so slowly. Not surprising then, many pilots continue to follow their indications longer than they would if an abrupt failure were to occur. Even if the failure is detected, the pilot must transition to partial-panel flight, and ignore the failed instruments. Notably, there is some evidence that partial-panel instrument flying skills has become considerably reduced, and that it is not uncommon for a Certified Flight Instructor, Instruments, (CFII) to give an examination that does not include partial panel work. To address this issue, a joint research effort is being conducted with the AOPA Air Safety Foundation. Specifically, CAMI, in conjunction with AOPA will collect simulator and aircraft data to further define the limits of pilot performance under these conditions and to examine what interventions may have a positive influence on pilot performance.

Task 9 – Multi-Function Display (MFD) / Controls

The avionics market is now replete with multi-function units offering a variety of functions, not necessarily standardized upon any common set of human factors criteria. The appearance of these devices, while a significant aid to navigation and flight planning, 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 pilot's visual scan, particularly if the display is used for momentary guidance (course tracking). Although the trend is toward increasingly larger and more capable displays, engineering conveniences are still often 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 provide guidance for the evaluation and certification of MFDs and, as such, guidelines for the design of MFDs and the systems with which they will be integrated. The goals are to provide summaries of guidelines and standards to the sponsors for use in certification, provide design guidance to the manufacturers (through GAMA documents), and provide evaluative support as new classes of devices appear that require certification consideration.

Task 10 – Flight Training Devices

The advisory circular for flight simulators and flight training devices was developed several years ago and with the advent of modern computer technology is in need of updating. The majority of this task is being addressed within AFS-205; however, the lower end flight training devices (those assigned level 0-3) have received little attention in the previous advisory circular. AFS-800 has requested that research be conducted to examine the types and capabilities of these lower-end Flight Training Devices (FTDs). Additional efforts will be directed at determining the extent to which these lower end FTDs can be used for flight hour credit during initial and recurrent qualifications.

Task 11 – Flight-deck Alerting

Each 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 in 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, particularly in a multi-task environment. Additionally, the standards must be applicable to system-wide solutions where a number of after-market installations may need to have their auditory warnings integrated in a cohesive and consistent fashion. This project contributes to the development of standards through simulation studies and tests under realistic flight protocols. Baseline hearing abilities in pilots and non-pilots were documented under this project in 1999, and earlier efforts examined pilot response to malfunction warning systems for autopilot/autotrim systems. Present concerns involve 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.

Task XX – Special Assessments

Occasionally, CAMI scientists are requested to provide assistance or investigate questions for the Agency regarding Aviation Human Factors. For instance, in FY00, CAMI scientists were requested to provide: 1) data analyses relating accidents to the Age 60 rule; 2) support for the Turbulence JSAT; and 3) data analysis and consultative support for the Runway Incursion Program. Because these “special assessments” cannot be planned or predicted, this task remains open ended and funding will be assessed on a case-by-case basis.

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/SATS 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, reported to sponsors at project review meetings, presented at professional meetings, and submitted for publication in the scientific literature.

15. Schedule/Milestones:

Task 1: CFIT/Terrain Displays

Subtask 1. Analysis of existing displays	TBD
1.1a Acquire existing CFIT displays	
1.1b Integrate displays with AGARS	
1.1c Develop experimental protocol	
1.1d Conduct experiment and analyze results	
1.1e Complete report and provide briefings	

Task 2: Reduction of Weather-Related and Maneuvering Flight GA Accidents

Subtask 1. Perform research on weather-related decision-making, hazard recognition and risk taking by pilots (University of Illinois)	TBD
Subtask 2. Analyze differences in problem solving, develop risk perception measures, and evaluate temporal positioning of in-flight events on pilot behavior (University of Otago)	TBD

Task 3: Safe Flight 21, Human Factors GA Safety

Subtask 1. Develop criteria for the HF evaluation of candidate avionics for Capstone II (S.E. Alaska)	FY02, Q1
Subtask 2. Assist the University of Alaska in the writing of interview questions, observation flight criteria, proficiency evaluation criteria, and in developing the format for the pilot focus group discussions for Capstone I.	FY02, Q1
Subtask 3. Assist the University of Alaska in the SE Alaska data collection in the same manner as the data mining effort in Bethel.	FY03, Q4
Subtask 4. Conduct a usability study for Capstone I avionics.	FY02, Q2
Subtask 5. Conduct a usability study for Capstone II avionics.	FY03, Q1

Task 4: Weather displays research

Subtask 1. Usability Assessment of Commercially Available Weather Displays	
4.1a Acquire access to commercially available weather displays	FY02, Q1
4.1b Testing, evaluation and interviews	FY02, Q2
4.1c Literature review	FY02, Q3
4.1d Final draft of technical document	FY02, Q4
4.1e Develop generic usability capability	FY02, Q4
Subtask 2. FAIT Analysis of Weather Display Avionics	
4.2a Complete characteristics list	FY02, Q1
4.2b Calculate influence and sensitivity scores for each characteristic	FY02, Q2
4.2c Scenario generation identifying trade-off and /or error situations	FY02, Q3
4.2d Final draft of technical document	FY02, Q4

Subtask 3. Ranking of weather-related display data with phase of flight	
4.3a Questionnaire data collection	FY01, Q4
4.3b Data analysis	FY02, Q1
4.3c Preliminary report and briefings	FY02, Q1
4.3d Final report	FY02, Q2
Task 5: Causal Factors of Accidents and Incidents Attributed to Human Error	
Subtask 1. HFACS Analysis of GA CFIT Accident Data	
5.1a HFACS analysis of GA CFIT JSAT accident database	Completed
5.2b HFACS analysis of remaining FY90-98 GA CFIT accidents	Completed
5.3c Report on GA CFIT accidents	FY02, Q1
Subtask 2. HFACS Analysis of Scheduled Commercial Part 121 and Part 135 Accident Data	
5.2a Report on scheduled commercial Part 121 and 135 accident data	Completed
5.2b Delivery of data and results to NASA Langley	Completed
Subtask 3. HFACS Analysis of GA accidents	
5.3a HFACS analysis of fatal GA accidents and subset of non-fatal GA accidents (FY90-98)	Completed
5.3b Report and briefings to AAR-100, AFS-800, ADM JSAT, GA Data Improvement Team, and delivery of results to NASA Langley	Completed
5.3c HFACS analysis of remaining GA accidents (FY90-98)	FY02, Q2
5.3d Final report of GA analysis	FY02, Q3
Subtask 4. Analysis of Skill-based Errors and Decision Errors (with University of Illinois)	TBD
Task 6: General Aviation Training	
Subtask 1. Multifunction display training (with Embry-Riddle Aeronautical University and Ohio State University)	
6.1a Acquire and develop existing MFD functionality	FY01, Q1
6.1b Develop experimental protocol for MFD training study	FY01, Q1
6.1c Modify MFD functionality to conform to protocol	FY01, Q2
6.1d Conduct experiment	FY01, Q3
6.1e Analyze results	FY01, Q3
6.1f Complete report and provide briefings	FY01, Q4
Task 7 – Pilot Field of Vision Capabilities/Head-Down Time	
7.1 Background literature search completed; additional data requirements defined	FY01, Q1
7.2 Simulation scenarios designed; scenarios tested/verified; pretest complete	FY01, Q2
7.3 Simulator data collected in AGARS	FY01, Q3
7.4 Data reduced/statistical analyses completed	FY01, Q4
7.5 Final report completed and recommendations submitted	FY01, Q4
7.6 Define HFD issues and develop experimental design	FY02, Q1
7.7 Configure AGARS for HMD use and construct experimental scenarios	FY02, Q1
7.8 Collect data	FY02, Q2
7.9 Analyze results	FY02, Q3
7.10 Complete report and provide briefings	FY02, Q4

Task 8 – Loss of Primary Flight Instruments during IMC

8.1 Instrument aircraft (ASF) and develop simulator scenarios (CAMI)	Completed
8.2 Conduct pretest in aircraft and simulator	Completed
8.3 Collect data (simulator)	Completed
8.4 Collect data (aircraft)	FY02, Q1
8.5 Reduce data and conduct statistical analyses	FY02, Q1
8.6 Final report completed and recommendations submitted	FY02, Q2

Task 9 - Multi-Function Display (MFD)/Controls

9.1 Summarize guideline and standard documents	Ongoing
9.2 Prepare summaries for AIR	
9.3 Evaluate impacts of new classes of devices (simulator)	

Task 10 – Flight Training Devices

Subtask 1. Examination of Current Flight Training Devices

10.1 Survey of existing flight training devices	FY02, Q4
10.2 Examination of the capabilities of flight training devices	FY02, Q4
10.3 Comparison of Personal Computer Training Devices, Flight Training Devices and Aircraft during Instrument Proficiency Checks (with University of Illinois)	TBD

Task 11 - Flight-deck Alerting

11.1 Review guidelines, standards, and relevant literature	FY02, Q1
11.2 Summarize findings into recommendations	FY02, Q2
11.3 Final report completed and recommendations submitted	FY02, Q2

Task XX – Special Assessments

XX.1 Upon request	TBD

16. Procurement Strategy/Acquisition Approach/Technology Transfer:

Technology transfer to the general aviation equipment and training communities will be accomplished through such organizations as GAMA, SAMA, AOPA, through the SATS, 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 in support of this specific research. Procurements to upgrade the device to fully support aero model configurations and performance monitoring subsystems will cost an estimated $1OOK.

This ARR is dedicated to developing and testing interventions that will serve to reduce the underlying 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 SATS. 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 pilot impact of recent changes in the cockpit environment 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 Safe Flight 2000 initiative.

17. Justification/History:

A review of civil aviation accident data from 2000 revealed that of the 1,975 accidents reported, 1,835 or 93% were associated with general aviation. Furthermore, of the 365 civil aviation fatalities that occurred in 2000, 341 or 93% were attributed to general aviation. It makes sense that due to its relatively high accident and fatality rate, increases in general aviation safety will benefit enormously from interventions that serve to reduce those rates. Simply put, there is potentially more return on investment of research and development dollars in general aviation because of the larger potential payoff in increased aviation safety.

It has been estimated that over 80% of the accidents noted above within the general aviation community can be attributed to some form of pilot error. GA 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, GA 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 GA pilot must adapt.

This ARR is dedicated to developing and testing interventions that will serve to reduce the root causes of GA pilot "errors" and thereby achieve a reduction of GA accidents and incidents. 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 pilot impact of recent changes in the cockpit environment and assessment of pilot attributes required to perform safely 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 Safe Flight 2000 initiative. Finally, the entire program was developed in conjunction with the GA and Flight Technology TCRGs.

18. Issues:

Human subjects will be used and, as such, each 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 FAA 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 and Aircraft Certification Services. Other transitions will be accomplished through representation at GA industry expositions and technical meetings and through the NASA AGATE, SATS, and AWIN programs. Transition will also be facilitated by continued coordination with the General Aviation Coalition and 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. This would translate into a continuance of general aviation accidents at an unabated rate (1,907 in 1998), many of which involve fatalities (361 in 1998), and the accompanying loss of life and property damage. One cannot discount the indirect costs to society related to subsequent insurance claims, lost wages and productivity, and litigation, as well as investigatory costs to the agency. Deferral would also significantly restrict or prohibit participation in the SATS and other programs and compromise application of human factors standards and criteria to the developing avionics and control systems.

21. R&D Teaming Arrangements:

CAMI 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 this plan 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 will be obtained through grants to the Arizona State University, the University of Illinois Aviation Research Laboratory, and other institutions.

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):	***Performing Organization***
______________________ Jon L. Jordan, M.D., AAM-1 Date ______________________ James Jones, AIR-3 Date	______________________ Melchor Antunano, M.D. Date Director, FAA Civil Aerospace Medical Institute, AAM-3