



FEDERAL AVIATION ADMINISTRATION
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- From: General Aviation Human Factors Program Manager, AAR-100
To: General Aviation Human Factors TCRG, (POCs: Frank Bick, ACE-111 and Jeff Holland ACE-111W)
- Subj: Electronic Primary and Multi-function Flight Displays for GA; Certification Criteria and Usability Assessments
- Ref: (a) General Aviation TCRG recommendation, ranked number 5 (09/17/02, GA TCRG minutes)
(b) General Aviation TCRG requirement entitled “Electronic Primary and Multi-function Flight Displays for GA; Certification criteria and usability assessments”, (AAR-100 Program Management requirement identification number 931).
1. There is an interest within both the FAA and standards-writing organizations in developing uniform guidelines and standards for both the design and the certification of Primary Flight Displays (PFDs) that contain terrain depictions as a background to attitude and guidance symbology, references (a) and (b). The “Electronic Primary and Multi-function Flight Displays for GA; Certification criteria and usability assessments” requirement states:

“The intent of this research requirement is to identify factors salient to the design and certification of primary flight displays and multi-function displays that may contain terrain representations and flight guidance cues and to quantify their effects upon pilot performance (flight technical error, procedural performance, terrain awareness, usability). The questions involve not only anticipated certification submissions, but also the displays already acquired and being installed for the Capstone program. The breadth of the requirement is intended to include any platform or means for presenting this information in the cockpit” (reference b).

This requires the identification of both the perceptual (displays) and usability (controls) factors that affect pilot performance (including flight control, execution of procedures, maintenance of terrain awareness), particularly where degradation of

performance has workload and/or safety implications. The issue involves both the displays presently in use in the Capstone program and a number of current and anticipated applications for display certification, and the effort is intended to include any cockpit display platform used as a means for presenting this type of information.

2. The project will be divided into two tasks:

- a) Task 1 will involve the examination of a number of display factors expected to affect pilot performance that should be addressed by the certification process. Not all of the listed issues will necessarily be addressed by empirical research, particularly where there are extant data relevant to the question. Issues to be examined will include but not be limited to: Depiction of horizon and guidance information, independent from the terrain, to guarantee its availability to the pilot; terrain format (solid, wire-frame, etc.) and presence/absence; indications in extreme attitudes (aiding recovery) and during failures; point of regard (viewing vector) and field of view; use of pitch ladders; color-coding schemes; comparison with baseline standard instrumentation; substitution of other display enhancements for HITS-format guidance when terrain depiction is present; fixed-field versus movable-field displays; asymmetric horizontal and vertical field-of-view compression or expansion schemes (minification/magnification). A summary of extant data will be prepared and empirical research will be used, where practical, to obtain those data not available in the literature.
- b) Task 2 will involve an examination of the impact of Capstone (Phase II) avionics on the flight operations in the Juneau area, with specific attention to training requirements/adequacy, usability, and overall effectiveness. This is an extension/continuation of evaluations conducted under Phase I of the Capstone effort and will include systems from each phase. Continuing evaluations will include the impact of national implementation of the Capstone systems. Issues to be assessed include the use of the equipment in single-pilot operations and use of the equipment by pilots of varying experience levels. Flight operations examined will include those conducted under IFR and VFR. An assessment of the multi-function flight display will include flight planning operations and changing flight plans in flight. Use and effectiveness of these displays under unusual (failure) conditions will also be assessed. Identification of specific problem areas will be fed back into Task 1.

3. The project will be a three-year effort. The project will be executed as follows:

I. Year I

a. Task 1

- i. Kick-off Meeting: Frank Bick (ACE-111), Jeff Holland (ACE-115W), General Aviation TCRG members (via telcon), and the CAMI Principle Investigator will meet at CAMI to verify that the project's objectives, goals, and milestones, and the present priorities of research topics that have come out of recent MEOTs and meetings with ACOs, as presented in this document, are still accurate as of the date of initiation of the project. Topics (see Task 1 paragraph) beyond those already identified as high priority will be prioritized for subsequent examination.
- ii. Referencing: A summary of extant data will be generated at the outset of the effort to determine which of the standing questions can be addressed by existing documentation, including research reports, guidelines, and standards (CFRs, RTCA MOPS, SAE G-10 ARDs and ARPs, etc.).
- iii. Experiments: Phase 1 experimentation will involve recovery from unusual attitudes as a task and the depiction of pitch symbology (reference lines and numeric indices) as an independent variable. Also to be examined will be the effect of the disparity between the zero-pitch line and the terrain horizon, as seen at higher aircraft altitudes, on pilot performance when no specific instruction is given in the interpretation of this feature (issues identified at recent MEOT as important). Phase 2 will examine variations in "vertical compression" of the terrain and pilots' ability to recognize potentially hazardous terrain features as a function of manipulations of the vertical scale factor (also identified in recent MEOT as an important variable). Phase 2 is expected to begin in Year 1 and run into Year 2.
- iv. Software and Hardware Development: CAMI's flight test simulators will be configured to address the proposed research questions. The BGARS will have both the Chelton display systems and the CAMI HMD¹ systems interfaced with software modified to allow the manipulation of the variables of interest on one or the other of the systems. Additionally, the HMD will be used in conjunction with the

¹ The HMD per se is NOT being used. The HMD computer system, however, IS being used as it contains the terrain database that is identical to the one being used in the AGARS for the out-the-window scene (this has been explained previously in our conversations concerning this requirement). Thus, we are using this computer system, which has functioning interfaces with the AGARS and the BGARS for passing 6-dof information and flight parameters like airspeed, as an expedient way to generate a PFD with terrain depiction that can be used on either simulator. The actual display device is a 12-inch LCD that was used in the recently completed NEXRAD study (e-mail from Dennis Beringer to William Krebs, 7/9/03).

AGARS to provide higher fidelity for the unknown-attitude recovery trials through the presence of controls providing dynamic force feedback.

b. Task 2

- i. Kick-off Meeting: General Aviation TCRG members and their designated points of contact and CAMI Principle Investigator will interact via teleconference or meeting at CAMI to verify that the tasks and scheduling, as presented in this document, are still accurate as of the date of initiation of the effort.
 - ii. Tasks: Tasks for first year involve a review and evaluation of training modules for the Capstone Phase II equipment, and an integration effort of the Phase II avionics into the CAMI research simulation facilities.
- c. Quarterly (December, March, June, September) research progress status reports: Informal e-mail reports from the human factors program manager to Frank Bick and Jeff Holland (General Aviation TCRG representatives).
- d. Annual Report: Researcher will submit an annual report using AAR-100's Productivity Report website <http://www.hf.faa.gov/report/>
- e. Task 1: Summary report. A summary report of the findings of the review of research publications, guidelines, and standards will be submitted to the sponsor points of contact.

II. Year II

a. Task 1

- i. Tasks: Phase 2, vertical compression of terrain, will be continued in Year 2 and additional tasks, either from the existing prioritized list or those found critical during ongoing certification efforts, will be added in consultation with sponsor points of contact.

b. Task 2

- i. Tasks: Development and execution of an experiment to test IFR flight activities using the Capstone Phase II avionics. Focus of the experiment will be on training requirements and usability for IFR procedures. Second task will be the planning and execution of interviews of pilots flying Phase II avionics in the Juneau area.

Focus of the interviews will be on a review of training effectiveness, usability issues, and common-use practices of the avionics under normal flight business conditions.

- c. Quarterly (December, March, June, September) research progress status reports: Informal e-mail reports from human factors program manager to Frank Bick and Jeff Holland (General Aviation TCRG representatives).
- d. Annual Report: Researcher will submit an annual report using AAR-100's Productivity Report website <http://www.hf.faa.gov/report/>
- e. Research reports: Reports appearing either in the open literature or as OAM reports will be submitted to the sponsor points of contact for review.

III. Year III

- a. Task 1
 - i. Tasks: Any remaining questions deemed unresolved by the sponsor points of contact, either from the original list or from additional experience with certification applications, will be addressed during the third year.
 - ii. Review meeting: General Aviation TCRG members and the sponsor points of contact and the Principle Investigator for CAMI will meet at CAMI to review the state of knowledge at the beginning of Year 3 and to determine how best to address any remaining certification needs at that time.
- b. Task 2
 - i. Tasks: Development and execution of an experiment to test VFR flight activities using the Capstone Phase II avionics. Focus of the experiment will be on training requirements and usability for VFR procedures.
- c. Quarterly (December, March, June, September) research progress status reports: Informal e-mail reports from the human factors program manager to Frank Bick and Jeff Holland (General Aviation TCRG representatives).
- d. Annual Report: Resarcher will submit an annual report using AAR-100's Productivity Report website <http://www.hf.faa.gov/report/>

- e. Research reports: Reports appearing either in the open literature or as OAM reports will be submitted to the sponsor points of contact for review.

4. Deliverables:

Year I:

Task 1: Summary of variables relevant to the design and certification of PFDs depicting perspective-view terrain (Q4, FY 2004).

Task 2: (1) Review and evaluation of flight training modules – Q2, FY'04, (2) Integration of Capstone Phase II avionics into CAMI simulators – Q4, FY '04.

Year II

Task 1: Research reports on experimental findings and recommendations (Q4, 2004).

Task 2: Phase II IFR usability experiment – Q2, FY '04. Capstone pilot interviews – Q4, FY '04.

Year III

Task 2: Phase II VFR usability experiment – Q2, FY '05.

5. Schedule:

Year I Tasks: FY04

Task 1:

- Modify HMD software for Phase 1 (Q4)
- Modify HMD software for Phase 2 (Q4)
- Modify Chelton hardware for BGARS installation (Q4)
- Initiate literature review (Q3)
- Initiate experimentation for Phase 1 (Q4)
- Deliver review summary (Q4)
- Initiate experimentation for Phase 2 (Q4)

Task 2: (see deliverables)

Year II Tasks: FY05

Task 1:

- Analyze/report results for Phase 1 (Q1)
- Analyze report results for Phase 2 (Q2)
- Configure AGARS for validation of Phase 1 (Q1)

Initiate validation experiment in AGARS (Q1)
Report results of AGARS validation (Q2)
Design additional experimentation as required (Q2)
Initiate additional experimentation (Q3)
Report additional experimentation (Q4)
Task 2: (see deliverables)

Year III Tasks: FY06
TBD by General Aviation TCRG

William K. Krebs