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April 17th, 2006

From: General Aviation Human Factors Program Manager, ATO-P R&D Human Factors
To: General Aviation TCRG

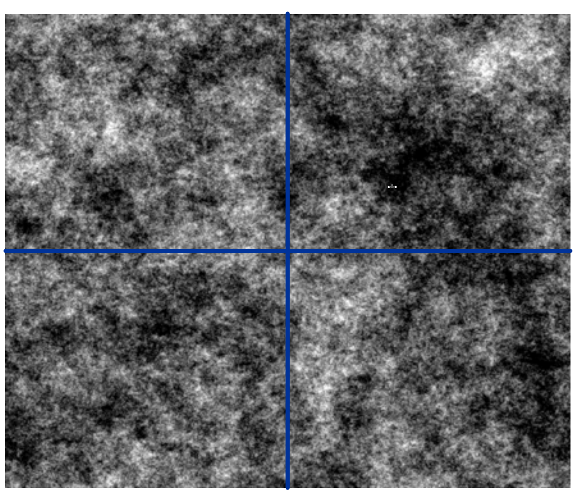
Subj: GENERAL AVIATION HUMAN FACTORS SECOND QUARTER '06 REPORT

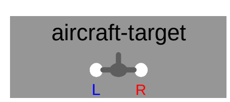
Ref: General aviation human factors execution plans (http://www.hf.faa.gov/gafunded.htm)

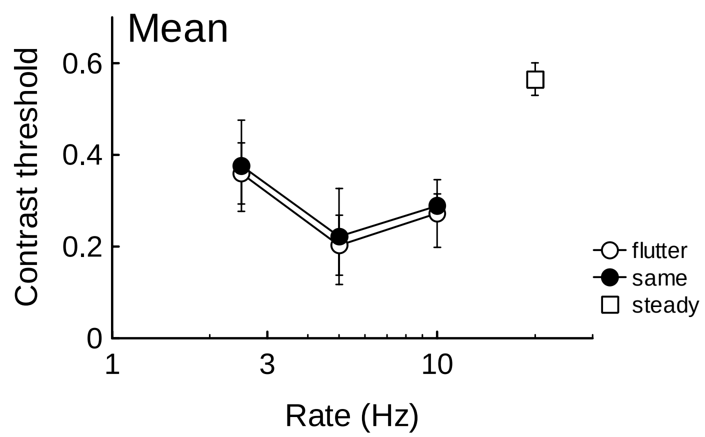
1) Each project is listed below.

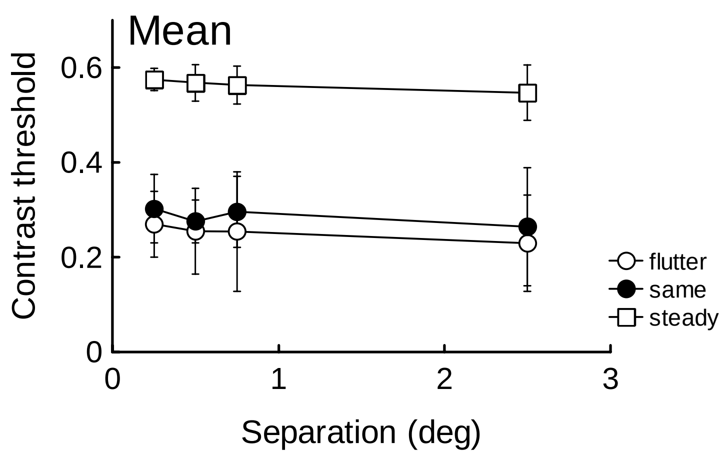
a) Visibility in the Aviation Environment – The researcher has made further development of training presentation product. This product will be a traveling oral presentation on visibility in the Aviation environment. The presentation will incorporate concepts conclusions from the studies conducted under this grant. A preliminary version of the presentation has been given at EAA's AirVenture in Oshkosh (2004). The talk was well received and the Oshkosh event coordinator invited the researcher to return and present again this year.

The researcher is continuing to evaluate current detection models for application to the flight environment. In some of these experiments the researcher evaluates the effectiveness of different temporal modes of wingtip lighting. The left figure below shows the background image composed of spatial noise. The right figure shows one possible target (shown larger than actual) to be detected on the background. The study found that for the parameters encompassing realistic aircraft situations, flashing synchronous lights and flashing asynchronous lights were about equally effective and increased detection better than steady wingtip lights. In addition to collecting data varying in flicker rate and light separation (shown below) we also measure the effect by varying the relative phase of the flicker and by measuring reaction time (not shown).









In addition to data on detection of strobe sequences the researcher also has collected extensive data on predicted versus actual detection performance using several current models of detection. These studies have suggest that Masking models such as proposed by Ahumada et al. may predict detection sufficiently for use in the aviation environment. Future tests will evaluate this prediction.

Interactive Training - The researcher has developed a sample problem sets for our interactive program to instruct pilots on detection and recognition of the altitude direction of motion and distance of targets. These sample problem sets include separate training for distance, relative altitude, and direction of flight. There is a final test set that combines all of these trained judgments. It is hoped that the use of this training aid will improve pilot judgment and detection performance. The researcher is in the process of testing this prediction. The plan will be to include this test as one of the initial detection experiments in the flight simulator.

Flat light - The researcher is continuing to develop experiments that will objectively measure performance under simulated flat light conditions.

Educational Presentation Product - The researcher continued to develop a presentation designed to educate pilots on the problems of visibility and strategies for optimizing vision in the cockpit. A preliminary version of this product was presented at Oshkosh (EAA's Air

Venture) last year as a pilot forum and was very well received. Because of the positive feedback from this event, the National Association of Flight Instructors (NAFI) and EAA have invited the researcher to present the forum again this year. The researcher hopes to also present the completed version of this talk at EAA's Sun'n'Fun Fly-in at Lakeland Florida in spring 2007.

ATO-P R&D HF General Aviation Program Manager in cooperation with AFS-800 granted a six month no-cost extension to insure delivery of the final products.

b) <u>Migration of HFACS database to a web-based interface</u>

The HFACS on-line production site is now available. This site allows users to query aviation accidents from 1990 to 2004 that have been coded by SMEs using the HFACS taxonomy. All enrolled users were notified and provided access to the site (see Figure 1). Several employees across the FAA have been granted access including the FAA's FAASTeam. Additionally, the training site is currently in use by the pilot and mechanic SMEs. The SMEs are coding accidents from 2003 that have been previously coded via the paper and pencil method as a training exercise and to examine the site's utility and feasibility regarding coding on-line. Future aviation accidents will be coded via the on-line method.

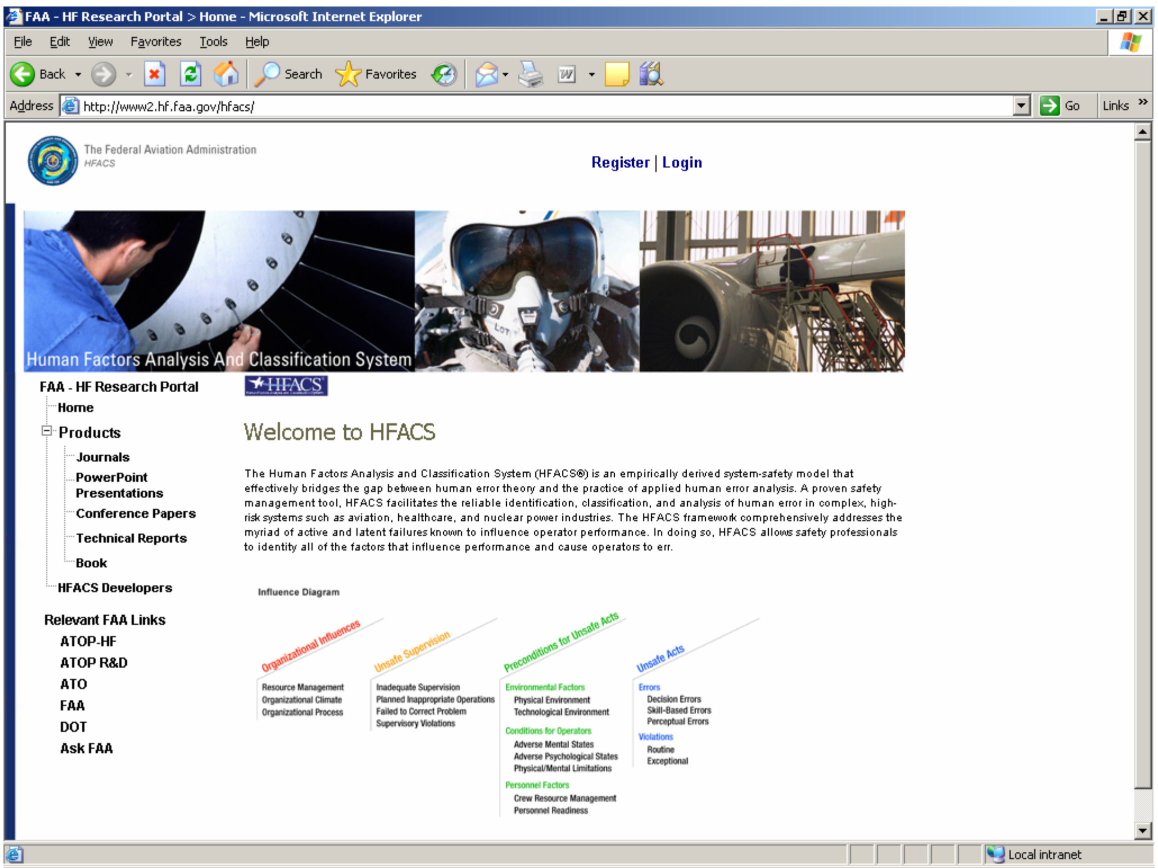


Figure 1. Login Screen for HFACS Online Query System

Project is complete

c) <u>Flight Deck Technologies and Procedures, Discriminability Assessment of Proposed Traffic Symbol Set</u> **-** Two experiments have been done to further evaluate the usefulness of the current metric. The first experiment was a very minor alteration in the methodology of the Volpe experiment [1] to see whether there was any effect of some minor variables that are not accounted for by the model. The second experiment was done with the same modifications and the same symbol set, but with color set to yellow so that there would be more confusions with these same patterns and the confusions would be in the pattern domain only. The following sections describe the experiments and show the data, but we have yet to analyze the data.

Replication Experiment: No symbol rotation, non-masking fixation mark, no post-symbol mask, and symbol duration = 250 msec.

The symbols were only presented in their upright form as shown on the response screen. The duration of the presented stimulus was decreased from 500 msec to 250 msec, as in the original experiment. The fixation cross (horizontal and vertical white (255, 255, 255) 400 by 2 pixel lines) was replaced by four L-shaped marks (L=12 pixels, W=1 pixel, Level = 255) at the vertices of a one inch square (larger than the largest symbol), a separation of 31.8 arc min at a distance of 273cm.

In this new replication, four subjects participated. One of them did three runs (two runs of 3 sessions (20 min each) and a run of 2 sessions) in different days, two subjects (two sessions) and a final subject (one run of 3 sessions). In the previously reported replication experiment [1], the confusion matrix showed that the information transmitted per symbol was 3.7 bits, corresponding to 13 errorless symbols. The new confusion matrix is shown in Table 1.1.

	9	**14**	**19**	**1**	**2**	**5**	**6**	**10**	**11**	**15**	**16**	**4**	**8**	**12**	**17**	**18**	**7**	**13**	**3**
9	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	132	14	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1
19	0	23	122	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	90	57	0	1	2	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	13	134	0	1	2	0	0	0	0	0	0	0	0	0	0	0
5	0	2	0	3	0	112	32	0	0	1	0	0	0	0	0	0	0	0	0
6	0	5	1	1	1	10	131	0	0	1	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	53	97	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	9	141	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	96	54	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	21	128	0	0	0	1	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	149	1	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	150	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	135	0	0	0	8	7
17	0	0	1	0	0	0	0	0	0	0	0	0	0	0	121	16	6	5	1
18	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	107	11	27	4
7	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	15	120	4	10
13	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	4	122	19
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	2	10	135

Table 1.1: Replication Data Confusion matrix (No rotation symbols, T =250msec)

For each symbol pair, the information transmitted from that pair of symbols to all responses wass computed and the results of the Volpe experiment and this new replication are shown in Table 1.2 and Table 1.3 respectively.

pink
19

14	0.10

cyan

	2	**5**	**6**
1	0.25	0.74	0.65
2		0.78	0.43
5			0.45

green

	11	**15**	**16**
10	0.22	0.81	0.76
11		0.76	0.72
15			0.05

yellow

	8	**12**	**17**	**18**	**7**	**13**	**3**
4	0.81	1.00	1.00	1.00	1.00	1.00	1.00
8		1.00	1.00	1.00	1.00	1.00	1.00
12			0.51	0.68	0.69	0.52	0.38
17				0.41	0.39	0.30	0.58
18					0.27	0.13	0.57
7						0.14	0.43
13							0.35

Table 1.2: Information transmitted in bits per symbol for all same-color pairs in the Volpe experiment.

pink

	19
14	0.46

cyan

	2	**5**	**6**
1	0.23	0.91	0.92
2		0.94	0.93
5			0.41

green

	11	**15**	**16**
10	0.10	1.00	1.00
11		1.00	1.00
15			0.20

yellow

	8	**12**	**17**	**18**	**7**	**13**	**3**
4	0.97	1.00	1.00	1.00	1.00	0.99	1.00
8		1.00	1.00	1.00	1.00	0.97	1.00
12			0.94	0.85	0.91	0.78	0.81
17				0.64	0.73	0.80	0.84
18					0.50	0.48	0.75
7						0.69	0.72
13							0.52

Table 1.3: Information transmitted in bits per symbol for all same-color pairs in the replicated experiment with no rotation symbols and stimulus duration of 250msec (as in the original experiment).

Yellow Symbol Experiment - In this experiment, all the symbols were yellow to evaluate the effect of increased spatial pattern confusion and to allow size confusions to be made without color cues to disambiguate them (Figure 1). Confusion matrices were obtained from five subjects (3 subjects did 3 sessions and the other two did 2 sessions). The values in the combined matrix are shown in Table 2.1.

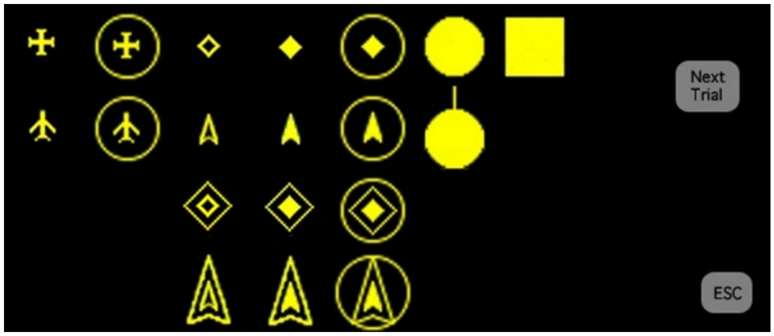


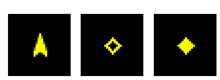
Figure 1: Symbols used in all-yellow Replication.

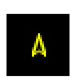
The information transmitted from the following pair of symbols to all responses is computed and the results are shown in Table 2.2.

	9	14	19	1	2	5	6	10	11	15	16	4	8	12	17	18	7	13	3
9	140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	120	3	4	11	0	0	0	0	0	0	0	0	0	0	0	0	2	0
19	0	38	90	2	3	0	6	0	0	0	0	0	0	0	0	1	0	0	0
1	0	10	0	109	20	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2	0	8	1	15	112	0	1	0	0	0	0	0	0	0	0	0	0	0	3
5	1	5	3	5	3	101	22	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	5	2	22	6	90	0	0	0	0	0	0	13	0	0	2	0	0
10	0	0	0	0	0	0	0	87	53	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	23	116	0	0	0	0	1	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	112	24	0	0	0	2	0	1	1	0
16	0	0	0	0	0	0	0	0	0	21	98	0	0	0	8	1	8	2	2
4	0	0	0	0	0	0	0	0	0	0	0	139	1	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	140	0	0	0	0	0	0
12	0	0	0	0	0	0	0	3	9	0	0	0	0	125	0	0	0	0	3
17	0	0	0	0	0	0	0	0	0	1	1	0	0	1	129	2	0	6	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	106	11	21	1
7	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	106	12	21
13	0	0	0	0	0	0	0	0	0	0	0	1	0	0	11	0	7	103	18
3	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	1	11	125

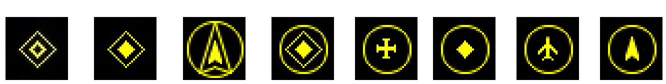
Table 2.1: Replication Data Confusion matrix (All yellow symbols)

	19
14	0.4255





	2	5	6
1	0.40	0.80	0.80
2		0.80	0.62
5			0.50



	15	16	12	17	18	7	13	3
15	0.00	0.34	1.00	0.88	0.96	0.93	0.93	0.97

16	0.34	-0.00	0.98	0.76	0.86	0.76	0.79	0.90
12	1.00	0.98	0	0.97	0.96	0.95	0.96	0.89
17	0.88	0.76	0.97	0	0.87	0.93	0.68	0.94
18	0.96	0.86	0.96	0.87	0	0.68	0.63	0.85
7	0.93	0.76	0.95	0.93	0.68	0.00	0.53	0.58
13	0.93	0.79	0.96	0.68	0.63	0.53	0	0.52
3	0.97	0.90	0.88	0.94	0.85	0.58	0.52	0.00

Table 2.2: Information transmitted in bits per symbol for all same-color pairs in the replicated experiment with no rotation symbols and stimulus duration of 250msec (as in the original experiment).

Rotation - The Radon transform is being investigated as a possible way of incorporating rotation into the model [2].

References

1. Ahumada, A., Trujillo San-Martin, M. and Gille J., "Symbol discriminability models for improved flight displays", B. E. Rogowitz and T. N. Pappas, eds., Human Vision and Electronic Imaging XI, SPIE Proc., 2006.
2. Kadyrov, A. and Petrou, M., "The Trace transform as a tool to invariant feature construction", Proc. Of Pattern Recognition, Vol. 2, 16-20, pp. 1037-1039, 1998.

This effort is cost shared with NASA Ames. All available information indicates the project is on track.

d) <u>FITS - Proficiency Standards for Technically Advanced Aircraft</u> – Researcher has completed the first draft of the text for the TAA Flying Handbook. In addition, the first draft contains all 125 color illustrations. The handbook also contains five flights in a technically advanced aircraft have been scripted to allow pilot reviewers to read sections in the handbook and then practice what they've learned in flight. Comments received from these pilot reviewers will be used to prepare the next major revision of the handbook in FY06Q3.

Sample illustration from the *Technically Advanced Aircraft Flying Handbook*

All indications indicate that this project is on track to complete the milestones as planned. Completion date will be September 2006.

e) Unmanned Aircraft Operator Qualification and Training Requirements

The draft final report is being reviewed by UAS Program Office. The goal is to complete the final report by FY06Q4.

f) General Aviation Private Pilot Survey / Initial Certified Flight Instructor – Airplane Survey/ Designated Pilot Examiner Program Assessment - During the second quarter of 2006, Dr. Hackworth delivered the DPE survey results to AFS-800, ASW-200, and AFS-640. The survey included 39 items asking DPEs about their PTS practices. Additionally, respondents were asked to provide written comments with regard to any survey items. The delivery included an overall summary report with transcribed written comments and individual reports for each region with the exception of the Alaskan region, which did not meet the minimum reporting requirement of 8 respondents

CAMI personnel distributed the survey to 848 DPES in early November, 2005 and received a total of 557 (66%) returned surveys. Our population of interest was DPEs who had given at least one ASEL practical test in the 12 months prior to the survey. Of the 557 respondents, 17 did not meet this qualification, and therefore were not included in the results leaving 540 DPEs. This sample comprised experienced examiners whereby over 64% indicated that they had been a DPE for at least 11 years. DPEs conducted an average of 30 first-time Private Pilot ASEL tests with 59% indicating that at least 81% of their first-time applicants passed. Nearly 99% reported using a written plan of action when conducting a practical test. The majority of respondents were positive regarding the FSDO to which they reported with 80% remarking that they were provided clear and concise information when needed.

More information will be available soon as we are drafting an Office of Aerospace Medicine Technical report summarizing the results from the survey.

In addition, the overall results from the ASEL GA survey distribution November to January 2006 were summarized and delivered to AFS-800, ASW-200, and AFS-640. CAMI personnel distributed 4,216 surveys to pilots who were newly certificated on or after August 1, 2005. Returned surveys were screened to include only pilots who were tested by a DPE and who reported no previous ASEL practical test failures leaving 1,112 surveys (26% response rate) for reporting purposes. Source of training for pilots was split across pilot schools (43%) and instructors (57%). The majority of pilots were positive about the quality of flight instruction they received with over 80% giving high marks. When commenting upon their practical test experience, the majority (over 95%) reported that they were tested on stalls (power-on and power-off), spin awareness (82%), aeronautical decision making (85%), and in-flight collision avoidance (82%).

More information will be available soon as we are drafting an Office of Aerospace Medicine Technical report summarizing the results from the survey. CAMI personnel will continue collecting GA ASEL survey data until mid-August ’06.

All indications indicate that this project is on track to complete the milestones as planned.

g) A New Approach to Aviation Accident/Incident Prevention/Mitigation - At the request of AFS-800, all MU-2 accidents with corresponding HFACS codes were identified and analyzed. A brief summary of the human error elements associated with these accidents was provided to AFS-800.

CAMI personnel have begun identifying all general aviation accidents that have occurred since 1990 where VFR flight into IMC was identified as a factor within the accident.

Drs. Hackworth, Chidester, and Schroeder reviewed a grant proposal aimed at evaluating FAA and industry initiatives that have been developed to address VFR into IMC general aviation accidents. The Tech Center has advised that the Cooperative Agreement has been awarded. We are awaiting Clemson confirmation that work has begun.

The grant proposal's clearance was delayed until the end of this quarter which will postpone the scheduled start by Clemson personnel until FY06 Third Quarter. This has the potential to subsequently delay all future FY06 deliverables.

h) Aviation Safety Inspector Training for Technically Advanced Aircraft - Classes scheduled for March at Middle Tennessee State University and University of North Dakota were postponed, due to the need to complete course curricula documentation. Embry-Riddle Aeronautical University (ERAU) had developed and implemented the TAA course, but the instructor manual was deemed not sufficient to begin training at additional locations. Course documentation has been completed and approved by UND, and their first class will begin April 4th. The schedule at MTSU has yet to be determined. Following discussions with Brian Dunlop, CAMI personnel have concluded that an ongoing survey at ERAU will be more productive in the coming quarter than surveying at UND and MTSU. We will be able to rapidly increase survey sample size at ERAU and provide feedback on the course.

Drs. Chidester, Knecht, and Hackworth have concluded that the End-of-Course examination for the pre-requisite study course would be a sufficient measure of knowledge of TAA characteristics to allow assessment of course effectiveness. However, the exam has not been administered in a way that allows that assessment to be accomplished. Determining course impact requires either testing and retesting of participating ASIs (comparing ASI scores on an exam before and after completing the course) or comparing their post-training scores to a sample of other, untrained ASIs. All ASIs who have completed or will complete the training in the next quarter received the pre-requisite materials before completing the exam. Those who have completed training did not take the exam again after completing the evaluation course. So, test-retest analyses are not possible at this point. Following discussions with Brian Dunlop, we propose to rely on the ASIs' self-assessment items on the survey in order to accomplish the deliverable, "Submit a report detailing results from a survey evaluating ASIs' understanding of advanced avionics." This will not provide a formal evaluation of course impact on knowledge, which we propose to defer to AFS-530 formal evaluations, but will give an indication of the value of the prerequisite and qualification courses in assisting participating ASIs to perform their duties in TAAs. CAMI personnel propose to survey a series of courses at ERAU to increase survey sample size and report the results as scheduled.

Due to the postponement of several classes, the researchers are awaiting AFS-800 guidance to define new objectives for the project.

i) ASRS Weather Callback - The Aviation Safety Reporting System (ASRS) weather incident questionnaire was administered to pilots previously identified as having reported weatherrelated incidents. Since the last quarterly report, ASRS has delivered the planned 100 responses. Analysis has begun, and a preliminary cluster analysis completed. Cluster analysis is an analytical technique which identifies groups of pilots having similar response patterns, and is used to explore complex data sets where normal multivariate techniques fail. The common characteristics of these "clusters" can then, hopefully, be understood. Dr. Knecht has discussed these analyses with AFS-800 (POC is Mike Lenz) as they have progressed, receiving good suggestions for further exploration, possible explanatory insights, and written acknowledgement and encouragement. What remains on this project is to now develop a logical "story" explaining each cluster that emerged from the analysis. Once a full set of coherent stories emerges, this will be developed into a technical report.

All indications indicate that this project is now on track to complete the milestones. Completion date will be September 2006.

j) <u>Ultra-Fine Grained Analysis of General Aviation Accidents 1990-present</u>

This requirement has been combined with the "A New Approach to Aviation Accident/Incident Prevention/Mitigation" requirement.

k) <u>Low Visibility and Visual Detection: Design and Development of a Visibility Analysis Tool</u> - The overall objective for this fiscal year is to provide the FAA with two user-friendly software tools that 1) provides quantitative information on the impact of Air Traffic Control Tower (ATCT) height and placement on aircraft visibility (the FAA Vis tool), and 2) provides quantitative information on the available time that a unmanned aerial vehicle (UAV) operator would have to respond to a potential conflict with other manned and unmanned aircraft (the See-And-Avoid tool). The technical approach that ARL Sensors and Electron Devices Directorate (SEDD) will utilize is to team with the U.S. Army's Night Vision and Electronics Sensor Directorate (NVESD) to complete the development and functional testing of the FAA Vis and the See-And-Avoid software tools (developed and enhanced for the FAA by ARL and NVESD in FY04 and FY05), and to calibrate these tools by experimentally determining the field-of-view (FOV) search-time equations, the target (aircraft) *discrimination* difficulty criteria, and *characteristic* target (aircraft) dimensions, through execution of two human perception (HP) experiments/tests. The first HP experiment will be a "time-limited search" experiment designed to yield FOV search time equations as well as aircraft *detection* difficulty criteria (N_{50} for *detection*) and appropriate *characteristic* target (aircraft) dimensions. The general approach will be to collect high-contrast, high-resolution, visible-band digital images of several scale-model aircraft from several perspectives, and high-resolution, visible-band images of real (natural) sky backgrounds, for use in the HP experiment. The HP experiment will measure human response time and *detection* accuracy to displayed images containing variably-*sized* aircraft images synthetically placed into real sky backgrounds at random locations in the FOV. The second experiment will be a classic HP experiment designed to yield both *recognition* and *identification* difficulty criteria (N_{50} for *recognition* and *identification*), and the proper *characteristic* dimensions for *aircraft*. The approach for the second experiment will also utilize high-resolution, visible-band digital images of several scale-model aircraft synthetically placed into either a real (natural) background, e.g., an airport runway scene as viewed from an ATCT, or a homogeneous synthetic background. This second experiment will measure the ability of human observers to *recognize* and *identify* aircraft images synthetically placed into a selected background image with a range of spatial *blurs* applied to the displayed images. The use of scale-model aircraft will significantly reduce both the cost and timelines of these experiments relative to using actual-size aircraft, and should yield more consistent results through better control of experimental conditions. The sets of imagery generated from these experiments will be made available to NASA-Ames researchers for use in an experiment aimed at independently determining task difficulty criteria (N_{50}'s) for *aircraft* using their Standard-Observer-Model-based methodology.

Tasks/Status:

1. Complete the development and functional testing of the enhanced version of FAA Vis and the baseline version of the See-And-Avoid software tools.

   Status: The enhanced desktop version of the FAA Vis tool and the baseline version of the See-And-Avoid software tool have been completed and tested. The only remaining activities under this task are to: 1) add additional rain and fog aerosol modeling capabilities to the MODTRAN atmospheric attenuation calculation sections of the two desktop software tools (when the new MODTRAN interface program becomes available from Ontar Corp. – see below), and 2) add additional camera/sensor input files/selections to the See-And-Avoid tool, as requested by the FAA.

2. Work w/ FAA IT specialists to migrate the current desktop versions of the FAA Vis and the See-And-Avoid software tools to the FAA's Website environment. (This will require negotiations and licensing of the MODTRAN components of these tools with Ontar Corp.)

   Status: The enhanced desktop version of the FAA Vis tool and the baseline version of the See-And-Avoid software tool have been migrated to the FAA's Website environment. Negotiations for the licensing of the MODTRAN components of these tools have recently been finalized; the MODTRAN components of the subject tools can now be activated. Furthermore, negotiations for the addition of several rain and fog aerosol models to the presently available set of MODTRAN atmospheric attenuation aerosol models have been completed; an upgraded MODTRAN interface program has recently been developed by Ontar Corp. and is presently being tested. The expanded aerosol modeling capability is expected to be available by mid-June '06.

3. Execute the "time-limited-search" HP experiment for *aircraft* described above.

   Status: Because of unexpected delays in completing tasks 1 & 2 above and unexpected delays in receipt of FY06 funding, work on this task has just recently started. However, in order remain on track for completing and documenting both experiments (tasks 3, 4 & 5) by the end of the fiscal year, we have revised our approach to include a document-as-we-go process and adjusted the performance schedule (see below) accordingly. ARL and NVESD personnel have had preliminary discussions on the design of the "time-limited-search" experiment and have started an experiment design document. This document will be sent to the FAA and NASA-Ames for review and comment in approximately two weeks. The design document will include (among several items) a list of the set of scale-model aircraft that we propose to use in this experiment. (Expected completion date: Jun '06)

4. Execute the *recognition* and *identification* HP experiment for *aircraft* described above.

   Status: Work has not formally started on this task. (Expected completion date: Sep '06)

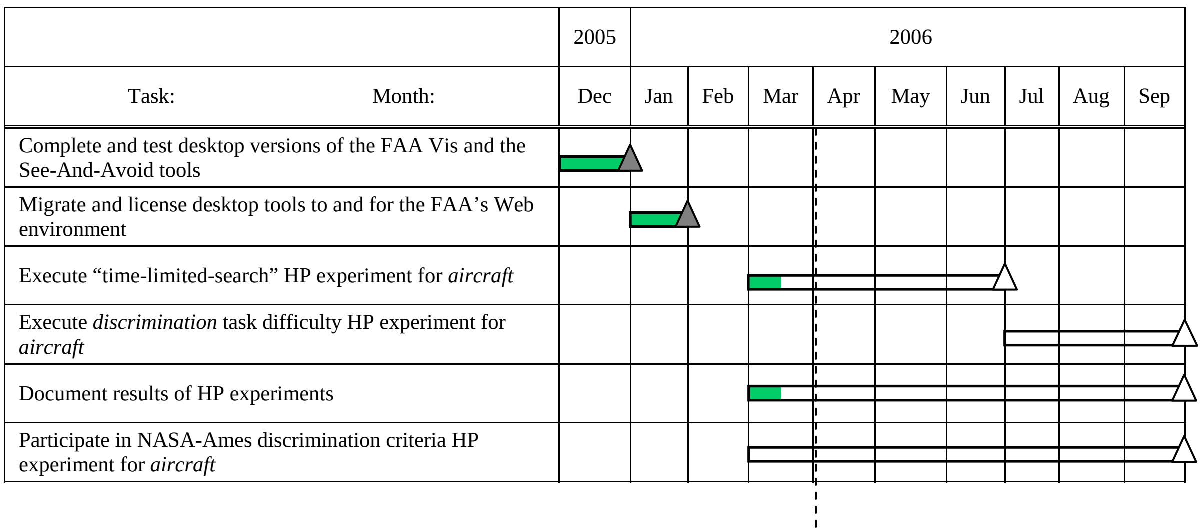
5. Document the results of both HP experiments.

   Status: Work has just started on this task in the form of an experiment design document for the "time-limited-search" experiment. (Expected completion date: Sep '06)

6. Participate with NASA-Ames in the design and execution of a Standard-Observer-based experiment to determine *discrimination* criteria for *aircraft*.

Status: As reported previously, we have had several conversations with NASA-Ames (Dr. Andrew Watson) regarding their preliminary results of simulating human target *identification* performance using the Spatial Standard Observer (SSO) model on ground vehicle targets, and on plans to perform a similar experiment on *aircraft* target imagery obtained as part of this research. ARL and NVESD researchers plan and look forward to feedback from NASA-Ames on the experiment design document(s), and to continued collaboration with the NASA-Ames and FAA researchers as this research year progresses.

Schedule: Shown below is the revised schedule for the IAA tasks funded for FY06, along with the estimated progress to date.



Period of Performance: The starting date for this work is December 2005 and the approximate completion date is September 2006.

This effort is cost shared with Army Research Lab and US Army CECOM NVESD.

l) An Assessment of the Effectiveness of Unmanned Aircraft Control Systems - The schedule for this task called for a completion of the control architecture inventory during the second quarter of 2006. The inventory was completed in February and given to the UAS Program Office for review. Four research questions were addressed by the research. They were:

a. What kinds of control architectures are currently being used in commercial applications?

For horizontal and vertical control of the aircraft, the research identified four kinds of control architectures. The lowest level imposes direct control of the aircraft surfaces through the use of a joystick. The highest level imposes control of the aircraft through the use of programmed waypoints that determine the location and altitude of the aircraft at a given point in time. Waypoint programming is accomplished through a "point and click" computer interface. Two intermediate levels of control allow the command of either bank angle/turn rate or heading and either vertical speed or altitude. Intermediate levels of control use physical controls for some systems such as a joystick or knob, or a computer interface that either requires a pull-down menu selection or interaction with a virtual control using a computer pointing device such as a mouse or trackball. All of the systems inventoried allowed waypoint control of the aircraft. Those that allowed direct control of aircraft surfaces only did so using an external line-of-sight pilot that handled takeoffs and landings only. There is a trend to eliminate the use of external pilots in favor of automated takeoff and landing systems.

b. What is a common control architecture for controlling UA through direct line-of-sight?

Direct line-of-sight control is most commonly accomplished using an interface similar or identical to a radio-controlled hobbyist control box. Some systems (e.g., Aerostar) have a modified control box that commands bank and vertical speed rather than controlling the aircraft surfaces directly. Only 3 of the 15 systems inventoried use direct line-of-sight control. Other systems, such as the Bell Eagle Eye, have a control box available for testing the movement of aircraft surfaces but it is not used during normal flight.

c. How do different control systems (i.e., stick, menu, knobs, etc.) affect the pilot regarding basic flight and navigation parameters?

The analysis of control levels that was accomplished in this research suggests that the manner in which flight commands are input is not as important as the level of the command that is input. Lower levels of control provide more immediate ability to change aircraft attitude but require more integration by the pilot to achieve a particular flight goal. Higher levels of control require less integration but do not allow immediate access to lower level control needs. For example, a control system that allows direct input of vertical speed means various values of vertical speed can be achieved but requires the pilot to monitor changes in altitude to establish a particular altitude goal. In other words, the pilot has to fly the aircraft to an altitude using changes in vertical speed. On the other hand, a control system that allows direct input of altitude does not require the pilot to fly the aircraft to that altitude but also does not allow a range of vertical speeds to be input. Higher levels of control make flying the aircraft easier but restrict the flight options available.

d. *Is there a lowest level of flight control that can be mandated for certain systems? In other words, what level of automation should be required for UA systems?*

Previous research indicates that the performance level control joystick, which commands bank angle and vertical speed, is more effective than the direct control of aircraft surfaces. There is no need to allow control inputs below this level of control because there is no need to perform aerobatic maneuvers with these aircraft and because of the benefits to the pilot due to not requiring the integration of lower levels of inputs (see the report for more details).Whether control at this level is accomplished using a joystick or some other method is not relevant. The question of whether higher levels of control should be allowed as a minimum level depends on the type of flight activities anticipated for the system.

A draft report was submitted to sponsor February 28th, 2006. I'm waiting for feedback from sponsor.

William K. Krebs, Ph.D.