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From: General Aviation Human Factors Program Manager, AAR-100
To: General Aviation TCRG

Subj: GENERAL AVIATION HUMAN FACTORS SECOND QUARTER '03 REPORT

Ref: (a) General aviation human factors execution plans

1) Per reference (a), the second quarter 2003 report for each general aviation human factors projects are listed below.

   a) Human Error and General Aviation Accidents: A Comprehensive, Fine-Grained Analysis using HFACS.

      CAMI and University of Illinois researchers continue to analyze data to address the five questions outlined in the execution plan. None of the questions have been completed this quarter.

      Due to the projected 30% reduction in funds for the general aviation research program, this project was reduced 29%. Although the researcher will not be able to hire a post-doctoral student to help with the analyses, the researchers claim that the proposed deliverables and milestones will still be met.

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

   b) Comparison of the Effectiveness of a Personal Computer Aviation Training Device, a Flight Training Device and an Airplane in Conducting Instrument Proficiency Checks.

      During quarter 2, 44 pilots have been scheduled for all types of sessions. A total of 6 pilots completed IPC#1 and 6 pilots completed IPC#2, thereby completing the study. The following table shows the totals for Q2 as of March 31,2003:

**Quarter Session Runs**

| Air-fam* | PCATD-fam* | Frasca-fam* | IPC#1 | IPC#2 | P-Training | F-Training | A-Training | All types: | # of Subjects Started |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 8 | 6 | 6 | 6 | 6 | 5 | 0 | 44 | 5 |

In terms of the total number of subjects who have started the study, 62 of 71 started are continuing or have completed the study. Of these 62 subjects started, 44 have completed the study. There are 64 subjects yet to be scheduled. As of March 31, 336 sessions have been scheduled. A total of 49 pilots have completed IPC#1 and 44 pilots have completed IPC#2, thereby completing the study. The following table shows the session totals as of March 31,2003:

**Total Session Runs**

| Air-fam* | PCATD-fam* | Frasca-fam* | IPC#1 | IPC#2 | P-Training | F-Training | A-Training | All types: | # of Subjects Started |
|---|---|---|---|---|---|---|---|---|---|
| 57 | 59 | 57 | 49 | 44 | 29 | 44 | 1 | 336 | 71 |

During the past quarter the project scope and budget has been reduced (recommendation by the General Aviation Technical Community Representative Group – 1/16/03 meeting minutes). A revised budget and revised proposal was submitted as follows: for FY 2003, $99,440 from February 26, 2003 through September 30,2003 and for FY 2004 of $65,775 from October1, 2003 through February 26, 2004 for a total of $165,215. This represents a budget reduction of $293,848. The principal change was in the number of subjects per group which was reduced from 35 per group to 25 per group. This represents a reduction in total subjects from 105 to 75.

*All indications indicate that this project is on track and will be completed in FY04.*

c) Credit for Instrument Rating in a Flight Training Device or Personal Computer

i. Phase I: Survey UAA, Part 61, and Part 141 institutions. Report submitted to AAR-100 on December 31st, 2002.

*Project completed.*

ii. Phase II: Capabilities of FTDs/PCATDs. The number of targeted schools has been increased to 178 based on information gathered for the Phase I continuation effort. Of the initial 151 schools that were sent a survey 45 schools have responded. From January through mid-March, approximately 471 follow-up telephone calls were made to the 151 schools that were sent a survey - 140 initial follow-up calls, 120 second follow-up calls, 100 third follow-up calls, 80 calls make to calls to clarify data, and 31 surveys faxed per request of the school.

To increase survey return rate, Mike Henry (AFS-800) wrote a letter of endorsement to be included in the follow-up mailing to the 123 (106 schools from first mailing plus 27 additional schools) schools that did not respond on the first mailing. As of March 26th, seven surveys were received; bringing the total number of respondents to 52. The target number is 105 schools.

*Indications are that there are minor risks to the activity being completed as planned. A contract extension was awarded to extend the grant to May 31st to improve survey return rate.*

iii. Phase III: Transfer of Training Effectiveness of a Flight Training Device (FTD). No new data was collected during quarter 2. The table below lists the current subject totals for the study.

Lesson 45 Statistics (Fall, 2002)

| | Airplane Only | PCATD 5.00 | Frasca 5.00 | Frasca 10.00 | Frasca 15.00 | Frasca 20.00 |
|---|---|---|---|---|---|---|
| Number of Students | 7 | 6 | 6 | 6 | 7 | 6 |
| % First Flight Pass Rate | 42.86 (N=3) | 83.33 (N=5) | 66.67 (N=4) | 66.67 (N=4) | 85.71 (N=6) | 33.33 (N=2) |
| % Second Flight Pass Rate | 100.00 (N=4) | 100.00 (N=1) | 100.00 (N=2) | 100.00 (N=2) | 0.00 (N=0) | 100.00 (N=4) |
| Students Recommended 102 | 0 | 0 | 1 | 1 | 1 | 1 |
| Total Dual to Completion | 20.74 (N=7) | 18.70 (N=6) | 18.37 (N=6) | 18.85 (N=6) | 19.88 (N=6) | 17.58 (N=6) |
| Variance Total Dual to Completion | 7.90 | 3.06 | 6.90 | 12.80 | 3.03 | 11.58 |

Note: This lesson is the final check ride for AVI 130.

This quarter 30 AVI 130 Basic Instruments students started the project for the spring semester. Forty students enrolled in AVI 140, Advanced Instruments for the spring semester.

An interim six-month report was submitted to AAR-100. Please point to http://www.hf.faa.gov/docs/508/docs/FTDPhaseIIIinterim022703.pdf

*Indications are that this activity is on track.*

d) Developing And Validating Criteria for Constraining False & Nuisance Alerts For Cockpit Display Of Traffic Information Avionics. Review of the literature pertaining to unaided human performance in conflict prediction is complete. This literature review was conducted to support the hypotheses laid out in the original project proposal and to provide a foundation for the experimental work within the project. The results are summarized below:

**A**. Effects of stimulus configurations on relative judgment (RJ) accuracy in Law et al. (1993)

- When the two objects were moving at the same velocity and one of the objects was closer to the contact point (i.e., the closer target was the first to arrive), the subjects generally made the correct choices using the rule of "the closer object was the first to arrive." When the two objects were moving at different speeds expressed as the ratio of the two velocities, subjects still tended to use the "closer arrives first" rule even when the closer object would have arrived first only in half of the trials, suggesting that they placed too much weight in their judgment in distance relative to speed.

- The performance accuracy decreased as the relative velocity of the two increased (from 1:1 to 1.5:1 to 2:1 velocity ratio) due mainly to the distance-over-speed bias.

- As the arrival-time differential (ATD) between the two objects increased, the RJ accuracy also increased.

- The effect of ATD was attenuated in the 2:1 velocity ratio condition.

- Configuration had a significant effect on performance, with the parallel tracks (except Configuration 3) being the easiest, oblique ones more difficult, and the perpendicular ones being the most difficult, a finding for the most part consistent with Remington et al. (2000) regarding how the angle of convergence influenced response time and accuracy in controllers' conflict detection.

- There is also a significant interaction between configuration and velocity ratio, where the effect of relative velocity was attenuated in the more difficult configurations and the effect of configuration attenuated in the 1.5:1 and 2:1 velocity ratio conditions.

**B**. Effects of factors on time to collision (TTC) estimation accuracy in 3-D TTC estimation tasks as summarized by Hancock and Manser (1998):

- Higher velocity of the approaching target results in more accurate estimation of TTC than slower velocity (McLeod & Ross, 1983; Schiff, Oldak, & Shah, 1992).

- Longer periods of view time before the disappearance of the target is associated with better estimation of TTC (McLeod & Ross, 1983; Schiff & Oldak, 1990; Caird & Hancock, 1994).

- Greater viewing distance before the disappearance of the target is associated with better estimation of TTC, even when the viewing time was held constant (Tresilian, 1991).

- Males perform better than females when estimating TTC (McLeod & Ross, 1983; Schiff et al., 1992; Caird & Hancock, 1994).

- Estimates of TTC are more accurate when the target is approaching the observer on a head-on collision course as compared to other angles of approach (Manser & Hancock, 1996).

- Importantly, TTC is typically under-estimated in a progressive fashion, with increase in actual TTC (Carel, 1961; Caird & Handcock, 1994; Cavallo & Laurent, 1988; McLeod & Ross, 1983; Schiff & Detwiler, 1979).

**C.** Effects of factors on TTC estimate accuracy for a single object moving on a 2-D display

- Over-estimation of TTC and therefore under-estimation of object speed (Slater-Hammel, 1955). (Note the conflicting result with 6) in the 3-D TTC estimation literature.)

- Over-estimation of TTC for fast-moving object but under-estimation for slower object (Bonnet & Kolehmainen, 1970; Ellingstad, 1967). As with findings by Law et al. (1993), this would suggest the dominant role of distance, since a faster object would be farther away than a slower object from the destination, if both were to contact it at the same time.

- Slower velocity leads to greater TTC estimation errors (Peterken et al., 1991).

- Longer occlusion time (Peterken et al., 1991) or distance (Slater-Hammel, 1955) resulted in longer TTC estimate.

- Occlusion distance or time had a greater effect on TTC estimation than viewing distance or time (Peterken et al., 1991).

**D**. Effects of factors on TTC estimate accuracy for two objects moving on a 2-D display (Kimball, 1970; Kimball et al., 1973)

- TTC estimates were underestimated at slower velocities and overestimated for faster velocities.

- TTC estimates were more accurate at faster velocities than at slower velocities.

- TTC estimates were more accurate at 30° than at 90° of convergence angle.

- ATC experience did not improve performance.

- TTC estimates were better when the two objects were at the same speed than when they were different.

**E.** Effects of some variables on conflict detection and time prediction performance (relative judgment) on 2-D displays are summarized in the table below:

| | **Variable** | **Effect on Performance** |
|---|---|---|
| a. | Increase in arrival-time differential (ATD) between two objects | Increase in RJ accuracy (Law et al., 1993) |
| b. | Increase in TTC | Increase in RT for conflict detection (Remington et al., 2000) |
| c. | Dominance (closer/slower vs. faster/further arrives first) | Subjects chose a closer/slower object as arriving earlier even when it arrives later than a faster/farther object for a RJ task, suggesting distance dominance over speed (Law et al., 1993) |
| d. | Increase in angle of convergence | Increase in RT for trajectory prediction (Ellis, 1982; Smith et al., 1984), conflict detection and “commission error” (Remington et al., 2000); Reduction in RJ accuracy (Law et al., 1993); Reduction in TTC estimation accuracy (Kimball, 1970) |
| e. | Increase in relative velocity (velocity ratio) between two objects | Reduction in RJ accuracy (when the closer/slower object arrives at the destination later than the farther/faster object) (Law et al., 1993); Reduction in TTC estimate accuracy for two objects (Kimball et al., 1973) |
| f. | ATD x relative velocity interaction | Effect of ATD on RJ accuracy was attenuated in a high relative velocity condition (Law et al., 1993) |
| g. | Angle of convergence x relative velocity interaction | Relative velocity effect on RJ accuracy was attenuated in the more difficult (larger angle) conditions and effect of angle was attenuated in the higher relative velocity conditions (Law et al., 1993) |
| h. | Angle of convergence x time-to-conflict interaction | Effect of convergence angle on conflict detection RT was amplified with long conflict time (Remington et al., 2000) |
| i. | Increase in absolute velocity | Increase in TTC estimate accuracy for single object (Peterken et al., 1991); Increase in TTC estimate accuracy for two objects (Kimball, 1970; Kimball et al., 1973); Under-estimation of velocity and thus over-estimation of TTC for a faster-moving object, but over-estimation of speed and thus under-estimation of TTC for slower object (Bonnet & Kolehmainen, 1970; Ellingstad, |

| | | |
|---|---|---|
| | | 1967; Kimball, 1970) |
| j. | Increase in prediction distance | Increase in estimated TTC for single object (Slater-Hammel, 1955) |
| k. | Increase in prediction time | Increase in estimated TTC for single object (Peterken et al., 1991) |
| l. | Dominant influence (distance vs. time) | Time dominance over distance influencing TTC estimate (Peterken et al., 1991) |

Most of the work on the project during the second quarter focused on the development of experimental design and protocols to develop a cognitive model of the features of unaided conflict prediction, that is, pilot prediction made without the aid of intelligent automation. This model will reveal the pilot vulnerabilities that are in greatest need of automation support and suggest design solutions to provide such support. The specific goals of the experiments are (1) to examine how different geometric variables will influence unaided conflict detection with the CDTI using estimate accuracy of distance to closest point of approach (DCPA), orientation at the closest point of approach (OCPA), and time to the closest point of approach (TCPA), (2) to identify the features that make unaided conflict detection difficult or easy, (3) to identify biases that affect performance (e.g., distance-over-speed bias) in Experiment 1. Experiment 2 will further examine (4) how correct automation can improve performance via conflict predictor and (5) how different types automation imperfections (e.g., due to heading or speed change of the intruder) will influence performance.

*Indications are that this activity is on track.*

e) Low Visibility and Visual Detection. Grant was awarded on April 1st, 2003. The researcher will begin work this spring.

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