FEDERAL AVIATION ADMINISTRATION
AAR-100 (Room 907)
800 Independence Avenue, S.W.
Washington, D.C. 20591

Tel: 202-267-8758
Fax: 202-267-5797
william.krebs@faa.gov

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From: Vertical Flight Human Factors Program Manager, AAR-100
To: Vertical Flight TCRG

Subj: VERTICAL FLIGHT HUMAN FACTORS FIRST QUARTER '04 REPORT

Ref: Vertical flight human factors execution plans (http://www.hf.faa.gov/vffunded.htm)

1) Each project is listed below.

   a) Night Vision Goggle Lighting Requirement

The funded three tasks under this agreement have been successfully completed and one Night Vision Imaging System (NVIS) lighting evaluation kit was delivered to the FAA and has received a favorable review. The research conducted to find an acceptable, objective method of assessing NVIS radiance was reported at the FAA research conference in Reno earlier this year. This method simply measured the amount of NVG light output with the cockpit lighting "on" and "off". If the light output increased by too much when the cockpit lighting was turned "on" then the lighting was considered to be unacceptable. Although the results obtained in this study appeard to be reasonably good it is believed the method can be developed further by providing a slightly different set of instructions to the subjects. In the original study the subjects were told to direct the NVG with the light meter attached out the simulated cockpit window. However, this meant that for some of the conditions and readings the illuminated cockpit instrument panel area might be within the field of view of the NVGs and thus become part of the measurement. If the subject/evaluator directs the NVG field of view out the windscreen such that no part of the instrument panel lighting is included in the reading then we should obtain a cleaner indication of potential interference with vision out of the cockpit.

To conduct a reduced version of the previously completed study using the modified directions to the subject/evaluator. This would provide FAA evaluators an objective tool/measurement of NVIS lighting incompatiblity that they could compare to their current vision-based assessment. It is most likely that the vision-based assessment would always be necessary so that specific reflection issues or light leaks could be addressed and corrected; but the objective NVG light output measurement could serve as a supportive procedure. In addition, it is expected that AFRL/HECV personnel will test the NVG light output procedure in an actual cockpit environment, probably at AATC, Tucson, AZ.

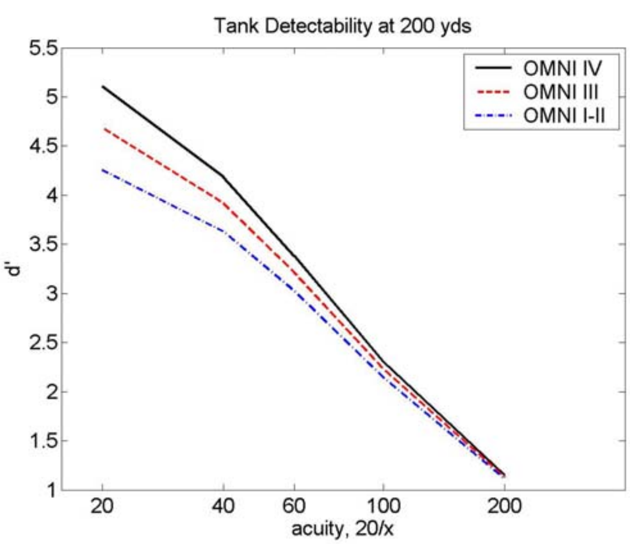
Project completed. Depending upon FY04 funding amount, AAR-100 will cost-share with Wright Patterson Air Force Base Armstrong Laboratory to validate field tool.

b) Night Vision Goggle Resolution Requirement

RTCA 196 Minimum Operational Performance Standards document outlined numerous issues that the Federal Aviation Administration must consider if civilian pilots are authorized to use Night Vision Goggles (NVGs). A high priority issue identified by the RTCA 196 committee was NVG resolution – what are the effects of degraded visual acuity on NVG detectability ("Minimum visual acuity (VA) requirements" and "Pilot vision requirements for NVG operations" from Simpson, Turpin, and Gardner, 2001, report entitled "Human Factors Issues for Civil Aviation use of Night Vision Goggles")?

The researcher developed a human performance Image Discrimination Model (Ahumada, 1996; Ahumada & Beard, 1996, 1997; Rohaly, Ahumada & Watson, 1997) to predict an observer's ability to discriminate between two images – image with a designated target and identical image with target subtracted. The model includes both the human observer and night vision goggle sensor performance characteristics to predict observers' ability to detect a target. The model written in Matlab can be downloaded to allow users to manipulate the model by importing two scenes to predict observers' detectability.

To predict the effects of degraded visual acuity while using various NVGs, the image discrimination model was modified to include observer's acuity. The Matlab acuity program predicts an observers' detectability of a target with different levels of visual acuity for the three different night vision goggle tubes. The figure below illustrates an observer's detectability of a tank positioned 200 yards from the observer.



no tank

tank

An observer's sensitivity (d') in detecting a tank positioned 200 yards from an observer possessing different levels of visual acuity while viewing through three different night vision goggle tubes. The larger the d' value indicates the observer is more sensitivity in detecting the tank.

To predict observers' ability to detect other objects, load image files into the Matlab Image discrimination Model or the acuity software applications. If you have any further questions regarding the software code, please contact Drs. Ahumada (NASA Ames) or Landy (New York University).

Project completed.

c) Simultaneous Non-interfering Operations - Quantify VFR Navigation Performance.

NASA Ames (Eye Tracking Task): Researcher obtained digitized flight data from University of Tennessee Space Institute then transferred the data to NASA computers. The flight data GPS recordings were decoded, audio utterance detection software was written, and video de-interlacing software was written. Expected FY04 deliverables include: (1) visualization of gaze direction rendered on scene camera video (Q2 FY04), (2) construction of cockpit model and development of registration software (Q3 FY04), and all flight data analyzed (Q4 FY04).

Naval Postgraduate School (Virtual Model Task):

Task 1. Initial construction of simulation environment
Task 1 Deliverables: Virtual terrain and surrounding areas, simple flight models and interfaces

Task 1 Progress: Complete.

Task 2. Coordinate with TBD group who will be responsible for developing test plan and collecting helicopter flight data. We will provide eye tracker requirements and obtain information about the test location
Task 2 Deliverables: Requirements specification for eye tracking device

Task 2 Progress: Complete.

Task 3. Build eye tracker for helicopter data collection
Task 3 Deliverables: Eye tracking device, Pilot test data

Task 3 Progress: Complete.

Task 4. Record eye movement data in helicopter
Task 4 Deliverables: Complete actual flight data set, analysis, model of pilot performance to be used in subsequent tasks

Task 4 Progress: Complete.

Task 5. Complete simulation environment
Task 5 Deliverables: Complete model and simulation environment, interfaces, flight models, and radio communications

Task 5 Progress: The basic terrain model has been complete for some time now. However, we have had significant difficulties refining the model to the point where it is usable for a navigation task transfer study. The current technique uses a lower resolution standard to create the basic model (terrain skin with satellite imagery.) Cultural features are then created and added. Because of their higher resolutions these models tend to have greater contrast with their surrounding environment than their real-world counterparts. This tends to create navigation 'sweet spots' – areas of obviously higher visual detail. Increasing the overall detail of the basic model negatively impacts performance. Reducing the detail of the inset models can make them indistinguishable so that they cannot be used as landmarks. We believe we have a new approach that will resolve these difficulties. There are some new tools available that should allow us to "carve" roads into the terrain and add surface detail as needed. We expect the model to be completed by March 2004. We have a working flight dynamics model that has been integrated with the flight controls and distributed rendering system. We originally had planned to emulate the cockpit environment with LCD panels representing the cockpit gauges. This has progressed well and is on track; however we have found an improvement on this we would like to incorporate in the final system. Since this study is extremely reliant on pilot's scan, realistic physical gauges may be preferable. We are investigating the feasibility of a system using physical gauges. We have a functional out-the-window display system (our CAVE) that we intended to use for this project. However, we are not satisfied with the brightness of the displays and may switch to a front projected system which will be much brighter and easier to calibrate since the mirrors will no longer be needed.

Task 6. Replicate actual flight study in simulated environment
Task 6 Deliverables: Complete virtual flight data set and analysis, validated simulation model

Task 6 Progress: Complete.

Task 7. Conduct simulation using multiple SNI scenarios provided by Dr. Krebs
Task 7 Deliverables: Human performance and modeling data

Task 7 Progress: Not started. Planned for March 04.

Task 8. Complete analysis and write report
Task 8 Deliverables: Report specifying the minimal RNP value for various SNI scenarios

Task 8 Progress: Not started. Follows task 7.

Work in Progress:

- Complete model of Tullahoma, Tennessee area – specifically texture features, roads, and cultural data.
- Complete cockpit apparatus
- Complete CAVE reconstruction (we may not do this if it will adversely impact the schedule)

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

d) Rotocraft Precision Visual Flight Rules Simultaneous Non-Interfering Human Factors Project.

Mr. Hickok, Principle Investigator and Project Supervisor, was met in Tullahoma, Tennessee by Mr. McConkey, Senior Engineer/Technical Director, and began efforts for data collection flight testing on September 28th, 2003. The University of Tennessee Space Institute (UTSI) had the final installations completed in accordance with requirements established during the second systems integration and installation trip, which took place on August 25th (reported on previously). Much of the September 28th was spent going over final details involving installations of systems, software, checklists, and much effort was initiated for devising a better means for calibrating each subject pilot's head and eye reference position for NASA AMES head and eye tracking data. (See Appendix A for final solutions of the calibration process).

The first subject pilot arrived on Monday, September 29th for a day-only flight schedule. This allowed for a slow-paced effort with the involvement by all test personnel as observers during the entire days events, and a full critique at the end of the day by all test team personnel.

Mr. Hickok remained onsite through Wednesday and departed Thursday after participating with and observing the test team and flight test process for both day and night data collection flights, and single data collection-sortie daily routines (plus 1 familiarization flight) and 3 data collection-sortie daily routines (plus 2 familiarization flights/2 pilot-days). During these first few days the head and eye tracker calibration process was finalized and documented, test team procedures finalized and documented as checklists to be used prior to and after each flight, pilot briefings (conducted by the project pilot) monitored, and validation that the data collection system was fully operational. The final documentation 'packages' for each subject pilot were finalized, and included the following:

- NASA AMES Human Research Consent Form (presented to and signed by each subject pilot)
- Appendix E of Flight Test Plan completed (PVFR Subject Pilot – Pre-Test Questionnaire) documenting pilots background and experience.
- Appendix F of Flight Test Plan completed (Subject Pilot Post-Test Questionnaire) completed after flight/s.
- PVFR/SNI Evaluation Pilot – Pre-Test Questionnaire and pilot contact information.
- PVFR Observer Log (Flight Test Engineer and UTSI Test Control Form.
- Subject pilot expense and travel report.

The only scheduling problem encountered occurred late on September 30th when the subject pilot scheduled to participate the next day, October 1st, called and cancelled. Mr. Hickok had originally scheduled 10 subject pilots and included 2 alternate subject pilots; with 1 subject pilot located within driving distance of Tullahoma, and the other alternate pilot/police officer located near New York City. The alternate pilot (A-1) was called in and the vacant pilot slot filled without further difficulties. Mr. Hickok also decided that he would arrange for the second alternate pilot's participation or risk the police officer encountering a schedule conflict (previous discussions included advance scheduling requirements). Schedules were accommodated and travel plans finalized for the second alternate pilot (A-2) participation during the second week of testing.

Mr. McConkey assumed onsite lead on Thursday October 2nd, and completed the final data collection flight on the evening of October 9th, 2003. Flight tests were originally scheduled to require two separate 2-week flight test periods, with the first flights conducted in October 2003, and the final data collection flights to be conducted in January 2004. The completion of all data collection flights in October 2003 establishes the PVFR project three months ahead of schedule.

Leading to the successful completion of all data collection flight testing in October 2003 were the highly successful systems integration and installation trips conducted during the weeks of July 28th and August 25th (both have been previously reported as post trip reports) and the outstanding support provided by FAA, UTSI, and NASA, during those pre-test efforts and post-trip follow up actions. These test flight activities required the installation of the aircraft GPS receive w/interface cables for laptop recording of pertinent data, the Ashtech truth system, and the head and eye tracking system recorder/control unit, and numerous cameras, into a test aircraft to constitute the complete data collection system. While cancellations and missed flights are sometimes caused when similar integrated data collection systems encounter failures during flight testing, there were no flights missed during October's PVFR flight schedules due to failure of the data collection system.

Phase One and Phase Two are now complete and we are working on flight test data merging and reduction (i.e. post-processing), which is included under Phase

Three of the project plan. Phase Three was scheduled to begin in March 2004. Reporting on specific Tasks is provided below:

Phase One Tasks:

Task 3.1.1 through 3.1.2 (Flight Test Plan): Final Flight Test Plan dated September 14th, 2003, was accepted by FAA. While this deliverable was finalized 3 months later than the original schedule pending final FAA approval the project is currently 3 months ahead of schedule.

Task 3.1.3 (Site Selection/Test Routes): Test route complete/data base coding complete/charting complete and all are documented in final Flight Test Plan for examination.

Task 3.1.4 and 3.1.5 (Data Collection/System Evaluations/System Evaluation): Complete and documented in final Flight Test Plan for examination (see test plan for pictures and full description) and 3.1.5. reported separately after each systems integration and installation 'pre-test' trips.

Task 3.1.6 (Test Aircraft/Subject Pilots/Equipment): Complete. Test aircraft specifics are documented in final Flight Test Plan for examination. Subject pilots were chosen from volunteers who responded to a multi-month canvassing effort to locate interested pilots who also met the test requirements. IFR and VFR only rated helicopter pilots were needed; both high and low time. The final subject pool and specifics per each pilot will be reported in detail in the final report under Phase Three, however the lowest time subject pilot has less than 200 hours and the highest pilot 7,500 hours. As will become reported in the final report after complete human factors and data post processing analysis is completed, total flight hours is by far not the single most important qualifier or indicator of how a pilot can be expected to perform while flying a PVFR-SNI sortie. IFR training that reinforces and establishes initial instrument scanning techniques, and of great importance, familiarity with navigation using GPS, will likely be highlighted as key elements in regards to pilot performance. *A final note on subject pilots: 2 Navy pilots were not made available as previously hoped and anticipated as per the final test plan. Mr. Hickok did have each subject pilot respond as to their willingness and availability to become a subject pilot at the Naval Postgraduate School's simulation flights. Those names will be provided, along with all other data, to the Postgraduate school, and will hopefully fulfill the desired goal of quantification of simulation against flights conducted in the actual aircraft.*

Task 3.1.9 (Coordination with NPS and NASA): This is a continuing task repeated throughout all the Phases One –Three of the test project and is ongoing.

Tasks 3.2, 3.3, 3.6 & 3.5, 3.7, 4.0 (Management and Reporting): This is a continuing task repeated throughout all the Phases One –Three of the test project and is ongoing.

Task 3.1.4 (Systems Installation/Integration into the test aircraft): Completed.

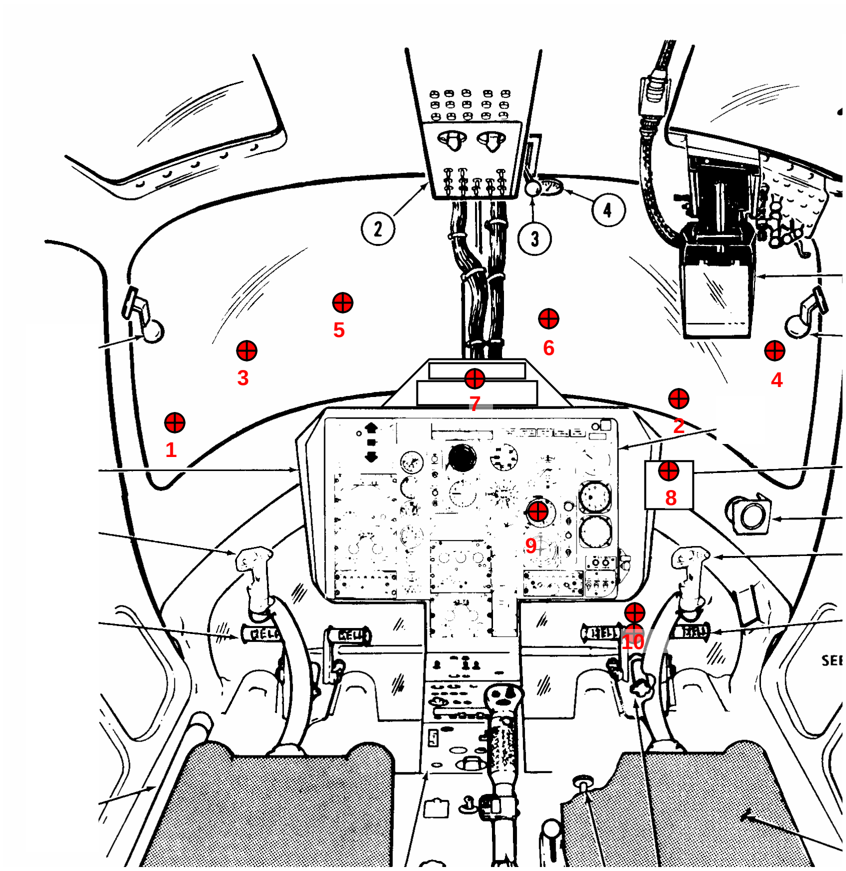
Tasks 3.1.7-1.8, 1.13-1.14 (Conduct Flight Tests). Completed.

Task 3.1.7-1.8 (Flight Test Data Merge & Reduction): In progress/ongoing. The following bullet version outlines these efforts currently underway:

- Record-by-record analysis of TSPI and Bendix KLN89B data records to identify all anomalous records and identify cause of problem.
- Develop strategies, algorithms, and software modules to time-merge TSPI and KLN89B data records (strategies involve handling of missing or anomalous data records)
- Develop algorithms and software modules to compute navigation system errors in along track and cross track direction (record-by-record comparison of KLN89B and TSPI data resolved in along-track and cross-track directions)
- Develop strategies, algorithms and software modules to parse the track data for each flight into segments (20 straight and 19 turning segments)
- Develop algorithms and software modules to calculate flight technical error (FTE) in each of the straight and turning segments
- Develop software modules to aggregate error statistics for each straight and turning segment
- Develop software modules to aggregate error statistics for each complete flight
- Develop software modules to aggregate error statistics for all 14 data flights (by flight segment and by entire flight)
- Correlate data from pilot questionnaires with statistical data to identify potential effects of pilot experience (flight hours, aircraft flown, type of flying, GPS experience, etc.)
- Analyze processed data and describe findings in draft test report

Origination of head and eye tracker calibration baseline measurements

Methodology description: Ten/numbered calibration points were established and round (orange) stickers applied to the inside of the windscreen, chin bubble, and several instruments in the panel. Points were established and numbered in a manner to progress sequentially, and alternated from the left side of the cockpit to the right, and down the instrument panel to the chin bubble. Measurements were completed for two people (a short pilot with low seat position, and subject pilot #2, who has a tall seat position) to determine the bridge of the nose (center between both eyes) down from the overhead greenhouse while seated in the pilot’s seat. The distance from the bridge of the nose was then measured to each of the ten calibration points using a cloth tape ruler (measurements made in feet and inches). The angle down/up from the bridge of the nose was then measured to each of the ten calibration points using a clinometer and recorded in both degrees and percentage (45^0=100%). A spreadsheet was developed using these origination baseline measurements for individual subject pilot calibrations prior and after each data collection flight. This process required only the measurement for each subject pilot's head/eye down from greenhouse for entry into the spreadsheet prior and after each flight. (Calibration process for individual subject pilots and each data flight is explained later herein in section 2.)

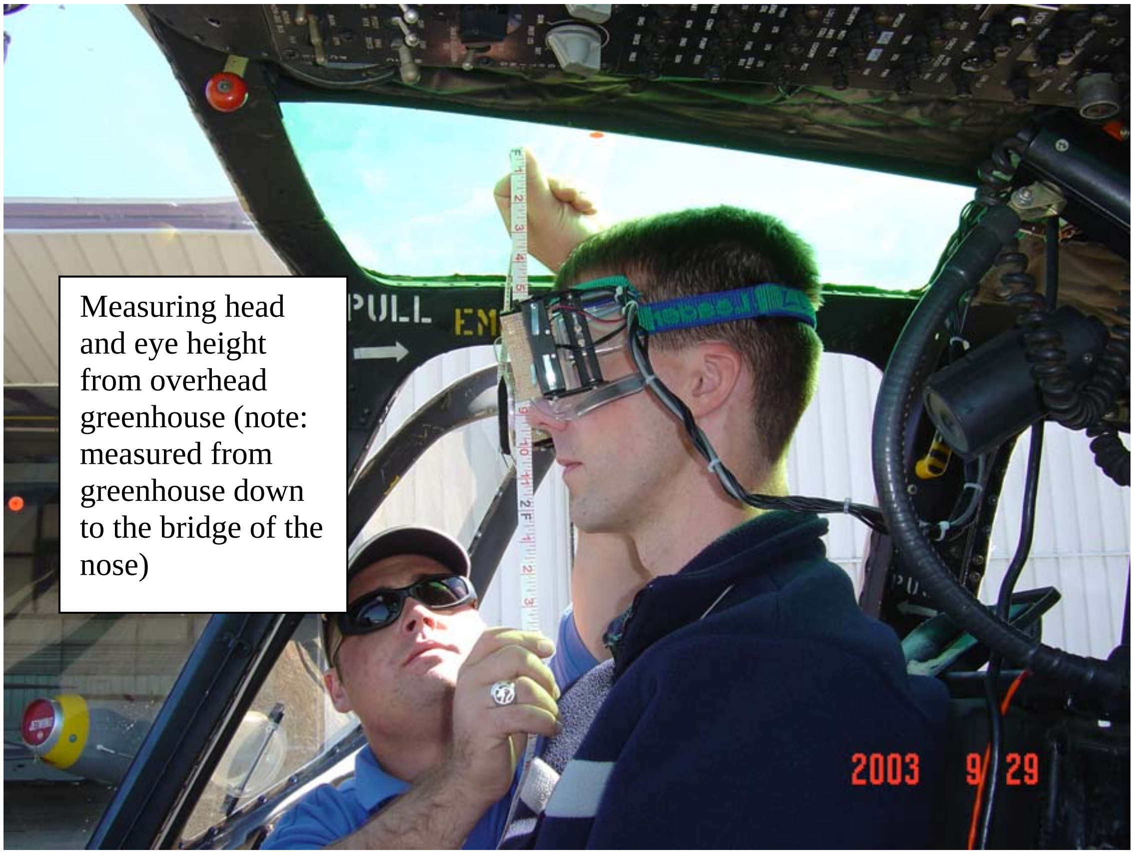


Head & Eye Tracker Calibration Points

1. looking outside left/lower copilot windscreen
2. looking outside center/lower pilot windscreen
3. looking outside center copilot windscreen
4. looking outside right/center pilot windscreen
5. looking outside right/upper copilot windscreen
6. looking outside left/upper pilot windscreen
7. looking at GPS receiver
8. looking at OBS
9. looking at heading indicator
10. looking outside down through pilot chin bubble.

Calibration process used for individual subject pilots prior and after each data collection flight.

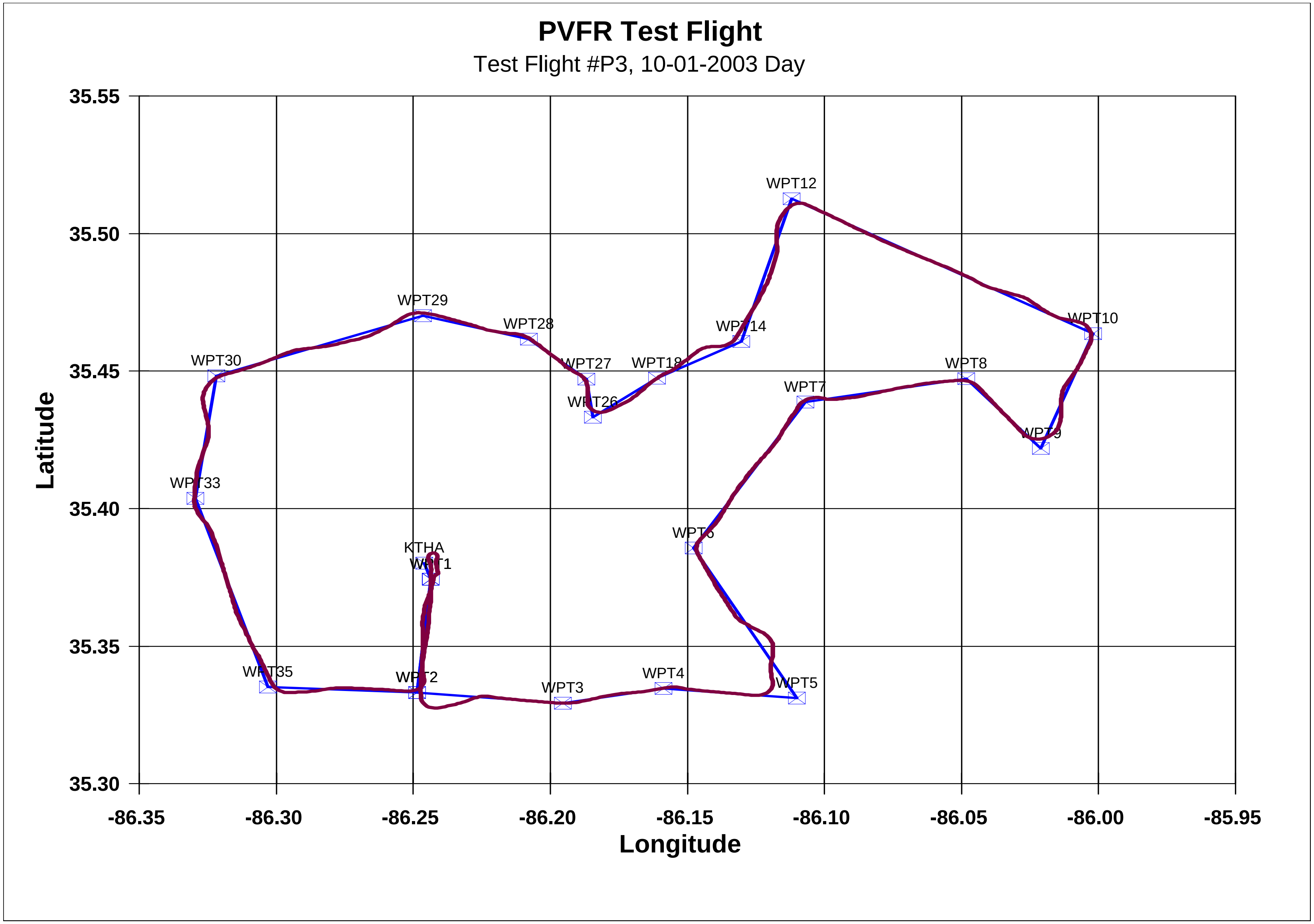
Methodology and Description: The subject pilot (wearing headgear) was seated in the pilot's seat to obtain measurement of head and eye from greenhouse. The recorder was started to make adjustments to the headgear-eye camera and centering of the eyeball using the monitor in the recorder. After the eye camera was properly adjusted, the director's slate (filled out with details for the data collection flight) was placed in full view of the headgear camera, and 'clapped' shut to enable time sync of the audio recording with the video during post processing. The pilot was asked to point at each calibration point in sequential order, and remain looking directly at the calibration point for 5 seconds. After pointing at and remaining looking at calibration points 7, 8, and 9, for 5 seconds, the pilot was asked to rotate his head in a circular pattern, while keeping his eyes on the calibration point. The calibration process was recorded on NASA's head and eye tracker tape preceding each data collection flight for use by NASA during data post processing. This calibration process was duplicated at the end of the flight immediately prior to shutting down the aircraft.



Measuring head and eye height from overhead greenhouse (note: measured from greenhouse down to the bridge of the nose)

Subject Pilot Flight Tracks (Plotted)

Note: These are the raw data plots recorded from the aircraft receiver and should not be regarded as a standalone indication of pilot performance. While these data plots provide an illustration of each flight, they represent only 1 of the 15 data collection parameters recorded in accordance with Table 8 of the Flight Test Plan. Post processing of data against the Ashtech truth system, incorporation of human factors elements using subject pilot experience profiles and post flight questionnaires, and correlation with NASA AMES post processed head and eye tracker data are ongoing efforts.



PVFR Test Flight
Test Flight #P3, 10-01-2003 Day
Latitude
Longitude
35.55
35.50
35.45
35.40
35.35
35.30
-86.35
-86.30
-86.25
-86.20
-86.15
-86.10
-86.05
-86.00
-85.95
WPT12
WPT29
WPT28
WPT10
WPT30
WPT27
WPT18
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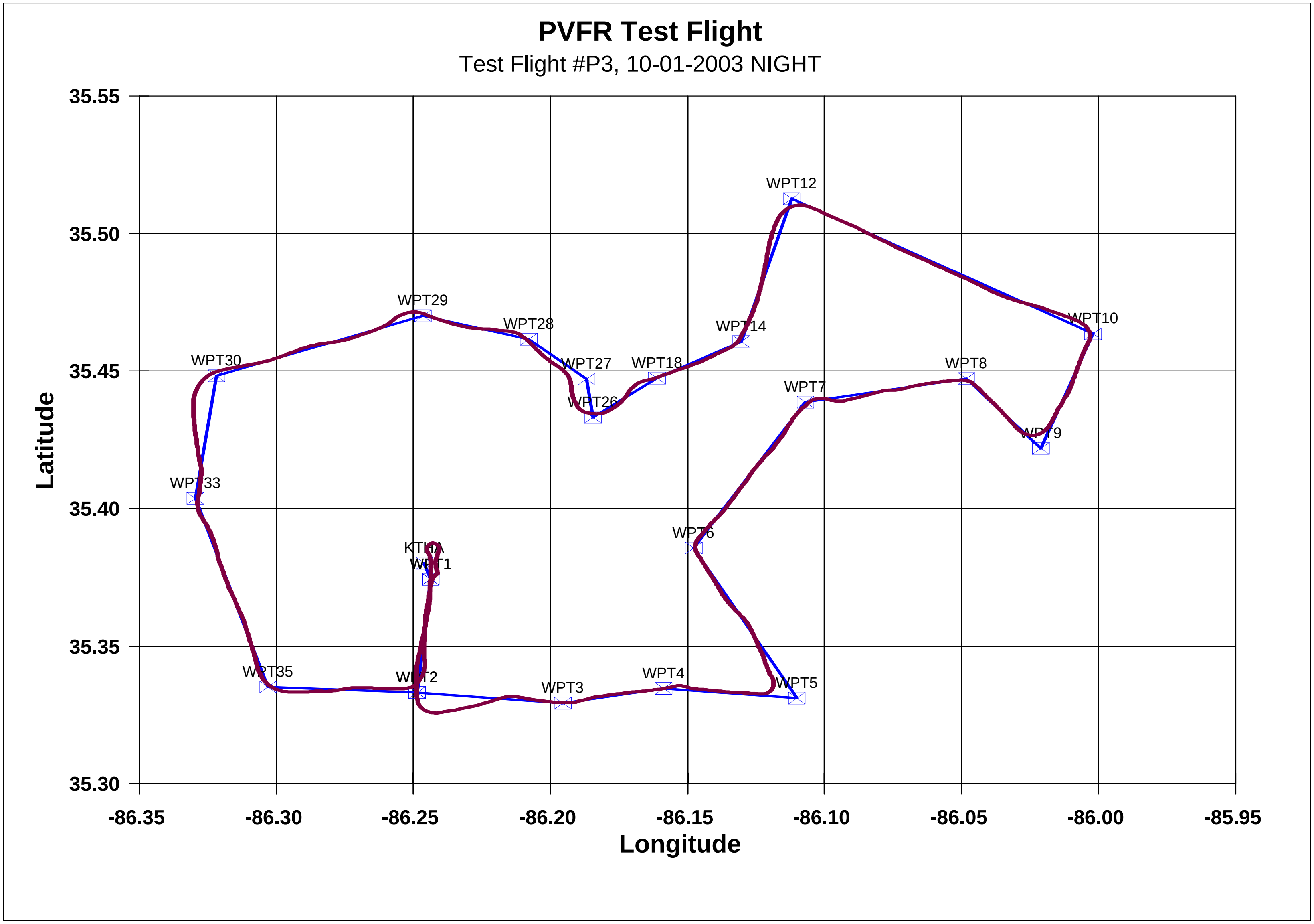
WPT3
WPT4
WPT5


PVFR Test Flight
Test Flight #P3, 10-01-2003 NIGHT
Latitude
Longitude
35.55
35.50
35.45
35.40
35.35
35.30
-86.35
-86.30
-86.25
-86.20
-86.15
-86.10
-86.05
-86.00
-85.95
WPT12
WPT29
WPT28
WPT14
WPT10
WPT30
WPT27
WPT18
WPT8
WPT7
WPT26
WPT9
WPT33
WPT6
KTHA
WPT1
WPT35
WPT2
WPT3
WPT4
WPT5

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

William K. Krebs