QUARTERLY REPORT

1. **Contract Number:** DAMD17-91-C-1081
2. **Report Date:** 3 November 1994
3. **Reporting Period:** 16 May 1994 to 14 September 1994
4. **Principal Investigator:** Dr. Thomas Harding
5. **Telephone:** (205) 598-6389, FAX (205) 598-9256
6. **Institution:** UES, Inc.
   4401 Dayton-Xenia Road
   Dayton, Ohio 45432
7. **Project Title:** Development of Data Packages on the Human Visual Response with Electro-optical Displays
8. **Current staff, with percent effort of each on project:**

NAME	TITLE	HOURS	% OF EFFORT
Dr. Thomas Harding	Project Director	605	88%
Dr. Victor Klymenko	Research Psychologist	631.5	92%
Mr. Howard H. Beasley	Electronics Technician	589	86%
Mr. John S. Martin	Electro-optics Technician	653.5	95%

688 hours were available this reporting period not including holidays. The above hours are the actual hours worked (sick leave and annual leave have been subtracted).

9. **Contract expenditures to date:**

Personnel	$748,072.08	Equipment & Supplies	$ 6,544.01
Travel	11,986.32	Other	6,836.43
		TOTAL*	$773,438.84

* Does not include facilities capital and G&A expense.

10. Comments on administrative and logistics matters:

None

11. Scientific Progress:

<u>Physical Measurements</u>

Efforts were devoted to completing most of the prescribed physical measurements on the IHADSS and initiating a series of detailed physical measurements on the Honeywell prototype aviation head mounted display which uses miniature LCD flat panel displays. In addition all of the necessary psychophysical investigations required of this contract were completed. The results of the psychophysical investigations were prepared for publication.

<u>IHADSS Measurements</u>

The field of view measurements on the IHADSS were completed. Field of view was measured by rotating the IHADSS about a point that was fixed at the center of the exit pupil. By ray tracing, it can be demonstrated that the image displayed by the IHADSS is contained within a cone whose apex is at the exit pupil and extends out into space. By measuring luminance within this cone, we were able to measure the extent of the formed image and the field of view. The tests that have been completed will be documented in a paper titled "Physical and Psychophysical Evaluation of the Integrated Helmet and Display Sighting System." Efforts to measure the static and dynamic MTFs of the IHADSS were cut short due to the arrival of the Honeywell prototype system (see below).

<u>Honeywell Prototype Aviator System</u>

The Honeywell prototype HMD system uses two miniature LCD flat panel displays. The image from the flat panel displays are reflected twice prior to reaching the eye. During this process a nearly parallel ray system is formed and the image is combined with light emanating from the front of the system. In the majority of tests performed on the Honeywell system, the headband was removed and the display housing was mounted to a crosspiece which was clamped to a rotating stage. The stage rotated about a center which was set equal to the approximate inner surface of the front mirror.

Spectral Output. The spectral characteristics of the prototype were measured using a Photo Research SpectraScan 740 spectrophotometer. The right side of the display has a distinctive yellow tint to it compared to the right side's green tint. The right sides spectral output shows side band enhancement in the red region of the spectrum which confirms the visual yellow tint.

Both sides have spectrums that peak at 544 nm. which is identical to the spectra of the P-43 and P-53 phosphors used in many aircraft displays.

Luminance Output. The Honeywell prototype display can be driven by standard VGA (640 X 480 pixel) video drivers. Microsoft Windows was configured to run under standard VGA and through application software specified 256 gray shades to correspond with the prototype displays 8 bit video address space. Using a paint program with a linear LUT, the luminance of a large patch over the digital range of 0 to 255 with an average increment of 7.5 (increments of 7 and 8 were exchanged to produce the average increment) was measured. The left side has a greater extended range compared to that of the right side. The luminance curves were highly non-linear showing a general acceleration until near saturation. Ambient temperature was found to have a dramatic effect upon luminance output, and therefore measurements were made under conditions of near constant room temperature (72^{o}).

Luminance Uniformity and Contrast Ratios. Luminance uniformity was measured at nine positions and a notable variation was observed for each side. Some systematic variations were noted, for example, lower screen positions had greater luminance output than higher screen positions. This variation may be due to the light guide affect inherent in liquid crystal displays. Contrast ratios were measured using bipartite squares where half the square was set to a steady luminance of 255 and the other half was set to a steady luminance of 0. The squares measured approximately 40 pixels by 30 pixels. The photometers 0.25 degree aperture was placed clearly within one side of the bipartite field. The contrast ratios showed variation which followed the variation seen in our uniformity measurements.

Spatiotemporal MTF: The ability to evaluate the spatiotemporal MTF of CRTs and flat panel displays has been hampered due to the lack of a reliable method to directly interface with CRTs and/or flat panels and due to unreliable software tools required to generate spatiotemporal patterns for physical evaluation. To measure the spatiotemporal MTF using both drifting sine wave gratings and phase alternating gratings, an existing visual stimulator (VisionWorks) was used and successfully modified the video drivers of the system so that it had the capability of interfacing with any display. The system has built-in features that make it highly desirable for physical evaluations.

Autoscanning System for EO Display Evaluation: An exhaustive search of the industry was conducted to locate an autoscanning system that is capable of measuring luminance uniformity, spectral uniformity, pixel conformity, spatiotemporal frequency response, and other measures. The autofocusing system utilizes a CCD video camera as a detector head which is mounted to an X-Y-Z system equipped with micropositioners. The detector is photometrically calibrated and comes with a spatial calibration system. Necessary software and hardware tools come with the system to include a complete data analysis package and its own software language for developing user specified test programs. A successful procurement documentation was prepared for the Government resulting in a $15,000 savings over the specified system price.

Physical Evaluation Publications:

Verona, R.W., Beasley, H. H., Martin, J.S., Klymenko, V., and Rash, C. E. 1994. Dynamic sine wave response measurements of CRT displays using sinusoidal counterphase modulation. SPIE Proceedings, Vol. 2218, Helmet- and Head-Mounted Displays and Symbology Design Requirements, 105-114. Orlando, FL: SPIE-The International Society for Optical Engineering. [also appeared as U.S. Army Aeromedical Research Laboratory, Reprint Report 94-22.]

Beasley H.H., Martin, J.S., Klymenko, V., Harding, T.H., Verona, R.W., and Rash, C.E. 1994. Characterization of low luminance static and dynamic modulation transfer function curves for P-1, P-43, and P-53 phosphors. U.S. Army Aeromedical Research Laboratory, Report 94-xx.

Harding, H.T., Beasley H.H., Martin, J.S., Rash, C.E., Rabin, J., and McLean, W.E. 1994 Physical and psychophysical evaluation of integrated helmet and display sighting system (IHADSS) Imagery. USAARL Lab Report 95-xx. (In preparation)

Harding, H.T., Klymenko, V., Beasley H.H., Martin, J.S., and Rash, C.E. 1994. Modulation transfer function of essentially non-linear CRTs may not always provide the best human factors assessment. USAARL Lab Report 95-XX. (In preparation)

Martin, J.S., Beasley, H. H., Verona, R. W. and Rash C. E. 1994. Semiautomated methodology for measurement of field-of-view, magnification, and distortion of night vision devices as defined in MIL-A-49425(CR). USAARL Lab Report 94-25.

Psychophysical Measurements:

A protocol was submitted to the Scientific Review Committee titled "Visual Performance Effects of Horizontal and Vertical Binocular Misalignment." Based on the review it was revised, resubmitted and accepted. In binocular HMDs it is important to know how accurate the calibration of the two images needs to be because of cost, time and other factors. Perfect alignment of the images in a binocular HMD is not practical due to optical, electronic and other factors. The protocol reviewed the literature on binocular alignment and suggested ways of psychophysically testing the performance effects of misalignment allowing one to specify the binocular tolerance requirements. Previous work failed to find any objective measure and only found subjective measures--eyestrain etc. Replication was completed by informally testing ourselves: results showed no difference in performance measures for a psychophysical task--reaction time and percent correct target detection--, however we did find subjective differences--more visual discomfort for greater degrees of misalignment. Despite the number of variations tried--visual angle of target, speed of target, etc.--it appears the visual system can tolerate a surprisingly large amount of image misalignment in terms of performance, but it is very uncomfortable--headaches, eyestrain, even image blurring. Phoria and retinal slip (fixation disparity) pre- and post-tests were tried for the stimulus misalignment session and no large systematic (reliable) differences were found. The visual system appears to be very adaptable. This is a tough problem and would require more investigation to find an objective psychophysical measure which càn specify tolerance levels at the lower levels of misalignment which cause visual discomfort--well below obvious visual effects such as diplopia. The visual system can compensate for levels of misalignment which should cause decrements of long term performance. A short test, 15 minutes a session, did not investigate the longer term effects due to fatigue and eyestrain. The software developed for this protocol is available to the lab to test longer term (e.g. fatigue) effects in the future should this be deemed important.

Psychophysical Publications:

Klymenko, V., Verona, R.W., Beasley H.H., Martin, J.S., and McLean, W.E. 1994. Factors affecting the visual fragmentation of the field-of-view in partial binocular overlap displays, U.S. Army Aeromedical Research Laboratory, Report 94-29.;

Klymenko, V., Verona, R.W., Beasley H.H., Martin, J.S., and McLean, W.E. (1994) The effect of binocular overlap mode on contrast thresholds across the field-of-view as a function of spatial and temporal frequency, U.S. Army Aeromedical Research Laboratory, Report 95-xx.;

Klymenko, V., Verona, R.W., Martin, J.S., Beasley, H.H. and McLean, W.E. (1994) Factors affecting the perception of luning in monocular regions of partial binocular overlap displays, U.S. Army Aeromedical Research Laboratory, Report 95-xx.

Klymenko, V., Verona, R.W., Beasley H.H. and Martin, J.S. and McLean W.E. (1994) Visual perception in the field-of-view of partial binocular overlap helmet-mounted displays, U.S. Army Aeromedical Research Laboratory, Report 95-xx.

Klymenko, V., Verona, R.W., Beasley H.H. and Martin, J.S. (1994) Convergent and divergent viewing affect luning, visual thresholds, and field-of-view fragmentation in partial binocular overlap helmet-mounted displays, SPIE Proceedings, Vol. 2218, Helmet- and Head-Mounted Displays and Symbology Design Requirements, 82-96. Orlando, FL: SPIE-The International Society for Optical Engineering.

Klymenko, V., Verona, R.W., Beasley H.H., Martin, J.S., and McLean, W.E. (under review) Visual field-of-view fragmentation in the partial binocular overlap helmet-mounted display design, The International Journal of Aviation Psychology.

Klymenko, V., Martin, J.S., and Rash, C.E. (in process of submission) Helmet-mounted displays: Past, present and future. U.S. Army Aviation Digest.

Klymenko, V., Martin, J.S. and Rash, C. E. (1995) Human factors evaluation of visual field-of-view effects of partial binocular overlap designs in helmet-mounted displays. American Helicopter Society, Annual Meeting. Fort Worth, TX.

Milestones:

Efforts next quarter will focus on completing the physical evaluation of the Honeywell prototype system and completing the spatiotemporal evaluation of the IHADSS. Assessment of figures-of-merit for flat panel display evaluation will be completed.