QUARTERLY REPORT

1. **Contract No.:** DAMD17-91-C-1081
2. **Report Date:** 30 November 1992
3. **Reporting Period:** 16 August 1992 through 15 November 1992
4. **Principal Investigator:** Dr. Robert W. Verona
5. **Telephone Number:** (205) 598-6389
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. Robert W. Verona	Engineering Psychologist	424	85%
Dr. Victor Klymenko	Research Psychophysicist	484	98%
Mr. Howard H. Beasley	Electronics Technician	424	85%
Mr. John S. Martin	Electro-optic Technician	490	99%

* 496 Hours were available during this reporting period not including holidays. The above hours are the actual hours worked (sick leave and vacation time have been subtracted).

9. **Contract expenditures to date:**

Personnel	$345,982.44	Equipment & Supplies	$3,557.89
Travel	$ 4,591.30	Other	$3,161.12
		TOTAL*	$357,292.75

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

10. Comments on administrative and logistical matters:

None.

11. Scientific Progress:

Physical Measurements:

The prototype electro–optical systems being charactered contain both image intensifiers (I^2s) and cathode ray tubes (CRTs). This quarter attention was focused on I^2 characterizations.

The efficacy of using a color television monitor with only the red color channel activated for I^2 performance measurements was investigated instead of a typical tungsten lamp with a 2856^{o}K color temperature. A tungsten lamp operated at a 2856^{o}K color temperature with an opal glass Lambertian diffusing window and variable intensity mechanism is typically used as the visible and near–infrared light source for I^2 performance measurements. The use of a color monitor as a substitute for the tungsten lamp was investigated, since the tungsten lamp has several undesirable characteristics. These characteristics include awkward intensity control, intensity and color temperature interaction, lack of modulation capability, and cumbersome size.

The light source used for I^2 performance measurements must be varied in intensity over four to five log units without changing its spectral distribution. Neutral density dye filters do not provide uniform attenuation over the visible and near–infrared spectrum. Neutral density metallic filters provide better attenuation uniformity across the spectrum, but are fragile and expensive. Fixed density filters must be augmented by another intensity attenuation method to achieve a fully adjustable intensity range when used with a lamp. Single or overlapping gradient metallic filters can be used to provide fine intensity control, but the output radiating area is reduced and/or the uniformity is compromised. Other methods of continuously varying intensity include varying the lamp aperture size and the lamp–to–aperture distance. Although effective, these approaches cause the light source to be large and bulky. Since a tungsten light source requires frequent lamp replacement and calibration, its large size becomes an even more significant handicap. Shipping and handling a large fragile light source is an expensive and time consuming process.

The I^2 device parameters being measured include: gain, objective resolution (MTF), and subjective resolution. These parameters are measured over a range of input light conditions from full moon to overcast starlight. The light source for these tests is normally a 2856^{o}K tungsten lamp. The same values can be obtained by using the red channel of a color monitor with its output levels set to the equivalent 2856^{o}K tungsten levels.

Two equations that express the relationship between the two sources, the color monitor and the tungsten lamp, were developed, one on a linear scale and another on a log scale. A linear regression through the points on a log–log plot produced the following relationship:

$$L_{monitor} = 10 \exp (0.71 + 1.02 \log L_{tungsten})$$

with a correlation coefficient equal to 1.0.

An alternative linear regression through the points on a linear plot produced the following relationship:

$$L_{monitor} = - 1.86 \times 10^{-6} + 4.45 L_{tungsten}$$

with a correlation coefficient equal to 0.999.

A detailed discussion of this experiment is contained in a draft report titled, "Use of a color monitor as a light source for image intensifier tube measurements," by R. W. Verona and J. Rabin. A joint technical report will be published when Dr. Rabin validates the subjective resolution comparison with human subjects.

The I^2 device field–of–view (FOV), magnification, and distortion were identified as device characterization requirements. A suggested measurement technique was included in the Aviator's Night Vision Imaging System (ANVIS) military specification, MIL–A–49425(CR), 1989. The technique with computer controlled positioners was implemented and software to perform the measurements more consistently and accurately was developed. Repeated measures on the same device demonstrated the reliability of the measures (+/–0.01 degree). Repeated measures on different devices demonstrated the validity of the measures. These measurements are comparable with measurements taken by other laboratories on the same devices.

Preparations have been made to take gain, objective resolution (MTF), FOV, magnification, and system distortion measurements on the various I^2 based systems planned for the hyperstereo assessment flight test scheduled for the next quarter.

Psychophysical Measurements:

In the last quarter, after a number of revisions incorporating comments from various members of the scientific community, the Scientific Review Committee (SRC) granted approval of the protocol, "Psychophysical Assessment of Visual Parameters in Electro–Optical Display Systems." In addition, the Human Use Committee (HUC) approved the protocol and the protocol was forwarded from USAARL to MRDC and the contract (DAMD17-91-C-1081) was modified accordingly.

The physical components of the visual perception laboratory have been completed, fine tuned and tested. The physical components are the computer graphics monitor, the optical table configuration and the subject booth with viewing binoculars. Procedures to align the mirrors and binoculars were implemented and practiced to ensure the correct physical calibration. In addition, procedures to modify alignment of mirrors and binoculars based on individual interpupillary distance (IPD) were also implemented and practiced. Magnification and focus of the binocular viewing system was measured. Using a diopterscope, the astigmatism of the system was measured and the focus settings were standardized.

The computer graphics software was modified and expanded. Graphic images are available now to aid in optical path alignment, focus calibration, as well as the measurement of subjects' vertical and horizontal visual phorias, which is the tendency of the observer's eyes to converge or diverge.

For the software controlling the experimental sessions, the following was done: A small amount of image convergence was added to the experimental displays to match the image focus distance to simulate the natural accommodation/convergence relationship. Four experimental paradigms are available now for collecting data on the effect of three display modes (convergent partial overlap v. divergent partial overlap v. complete binocular overlap). Three of the paradigms are converging operations measuring the effect of display mode on contrast, and the fourth measures the luning effect, a distracting perceptual effect induced by partial overlap displays.

The four paradigms and their naming conventions are as follows. First, Training, contrast matching procedure measures apparent contrast and acclimates subject to experimental setup; second, Method of Limits (actually a modified adjustment procedure), allows subject to set own contrast threshold; third, Staircase, measures contrast threshold by adjusting contrast based on correctness of subject responses to orientation of the probe pattern; and fourth, Luning, measures luning effect by recording percent of the time it is seen.

Additional changes, transparent to the subject, include the following. The output data file for each experimental session now includes descriptive statistics, cumulative mean values and standard deviations across blocks of trials. The immediate information available from this data file will allow for more efficient use of subjects. Different field of view grey level values were added to luning program to determine effect of grey level on luning. Training and Limits programs now have two corresponding positions per session and position indicators for each trial to increase subject/session efficiency. These software changes were based on data obtained by using the experimenters as subjects in practice sessions.

Administrative procedures for running subjects were implemented and practiced. These include the various documentation and forms needed such as subject instruction booklet, test administration booklet, consent forms etc. as well as data cataloging and hardcopy and softcopy data backup.

Recruitment of subjects has begun and data has been collected from two subjects in a number of experimental conditions. More are scheduled. Based on preliminary findings, an abstract, "Binocular Viewing Mode affects Spatio–Temporal Contrast Threshold," has been submitted to the May 1993 Annual Meeting of the Association for Research in Vision and Ophthalmology (ARVO). These preliminary findings have produced a tentative confidence for stating that, it appears that the divergent display mode is inferior to the convergent mode in that, at least for high spatial frequency probe stimuli near the monocular/binocular border, a higher contrast is needed to see it.

12. Milestones:

Measurement procedures for I^2 tubes and devices are being documented and will be released next quarter as a USAARL technical report. The technical report will also contain sample data from the tubes and devices that have been tested.

The focus will shift back to CRTs next quarter and the development of dynamic MTF procedures and software. Once satisfied with the results of the CRT dynamic tests, those procedures will be used to measure I^2 tube dynamic MTFs. A fast response miniature CRT is proposed for use as a dynamic light input stimulus for the I^2 tube/system. Moving test patterns can be generated electronically on the CRT and imaged on the I^2 tube's photocathode.

In the next quarter, psychophysical data will be collected and anlyzed, an ARVO presentation will be prepared and a report will be started. In addition, based on the preliminary findings, initiation of an abbreviated protocol for a more precise test of the effect of the monocular/binocular border on threshold is planned. Software development will continue for new perceptual and cognitive tests.