The Peripheral Visual Cue Assessment Facility at Ames Research Center

Richard F. Haines

Man-Vehicle Systems Research Division
Ames Research Center - NASA
Moffett Field, California 94035

Introduction:

A great deal of time and effort have been expended over the years to gain a better understandmg of what extra-cockpit visual information pilots use to initiate manual control inputs. This effort has been expended in flight simulators as well as in flight and has provided some valuable insights into various subject areas discussed in detail elsewhere (AGARD, 1981). In both simulators outfitted with advanced, computer-generated scenes and actual aircraft there is usually a rich array of constantly moving optical information from which the observer must extract relevant information in order to carry out his various tasks. Because of the amount and complexity of this array of information it is extremely difficult to know precisely which cue or set of cues led to which response. Similarly, because flight vectors may be considered in terms of their various linear, orthogonal components (e.g., glide slope is a resultant of forward velocity and descent rate) there is a natural confounding interaction that takes place. Warren and Owen (1982) and Owen et al. (1981) have commented on this matter at some length. The Peripheral Visual Cue Assessment Facility (PVCAL) was established to study various responses to controlled dynamic stimuli that could be considered as visual analogs of some real-world counterpart such as the horizon. Careful stimulus control permits specific responses to be traced to specific stimulus dynamics.

Another basic objective for establishing this facility was to be able to quantify the ability of the visual system to assess various kinds of stimulus motion. A major emphasis is upon the peripheral visual field, however, since the author believes that this area has been sorely neglected yet very probably plays an important role in a pilot's assessment of where he is in space, where he is going, how fast he is travelling, and what angular and linear rates of movement are taking place. The facility was designed to be able to carry out carefully controlled psychophysical vision research over a wide angular range.

The Peripheral Visual Cue Assessment Facility:

This facility comprises three separate collimated optical display units driven by an Evans and Sutherland picture system II. A PDP 11/60 digital computer is used to derive the specific motion dynamics of interest for the picture system. Figure 1 presents a block diagram of the major systems. Data from the response panel is output via a disc to a printer and plotter. The response panel permits each observer to initiate each trial.

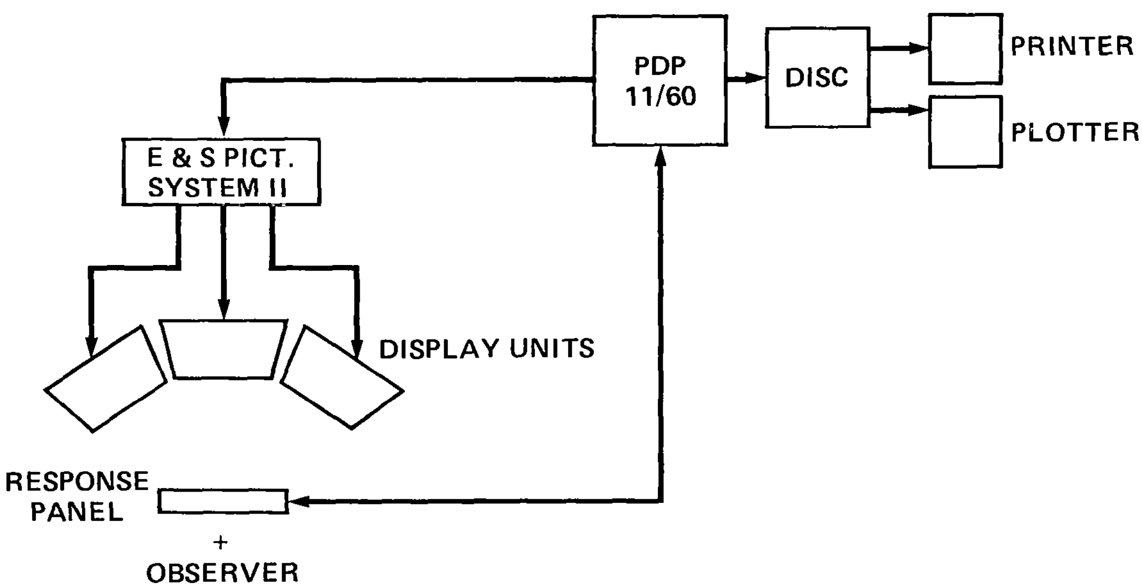

Figure 1. Block diagram of major systems.

Figure 2 illustrates the spatial relationships existing among the three 25-inch focal length mirror-beam splitter optical display units in plan view. Each unit incorporates a 25-inch (diagonal) Zytron stroke monitor.

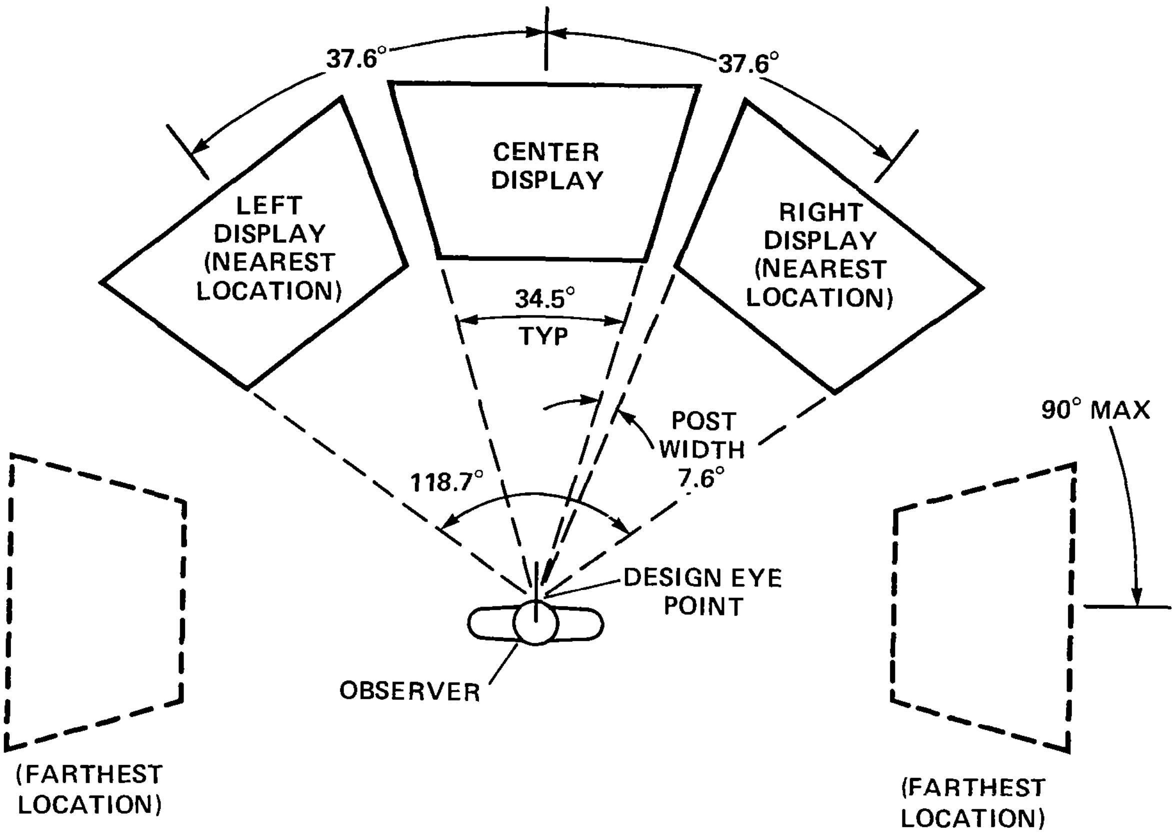

Figure 2. *Illustration of display layout/angles.*

Referring to Figure 2, each display unit subtends a total (binocular) field of view (FOV) of 34.5 deg (0.602 rad) in width with a minimum post width between displays of 7.6 deg (0.132 rad). With the three displays located next to each other a total horizontal angle of 118.7 deg (2.072 rad) is subtended. The measured instantaneous FOV width of each display is 31.7 deg (0.553 rad). The vertical angle subtended by each unit is 21.9 deg (0.382 rad). The right-hand display can be repositioned as far as 90 deg (1.570 rad) to the right (left-hand unit similarly to the left) through the use of rigid pivotal "radius bars" attaching the two side displays to the observer's seat. This pivot point lies directly beneath the design eye point (DEP) of the three displays. The optical focal distance of the stimulus line(s) was found to be at apparent optical infinity (-0.01 diopter) within the central 80 percent of each display's FOV as measured with a precision dioptometer located at the DEP. A Hilger-Watts No. 2 Microptic theodolite was used to measure all angles. A single, stroke-drawn line subtends an angle of 0.033 deg (0.58 mrad) width at the DEP.

Concerning stimulus luminance and contrasts within the FOV, the stroke-written line(s) has an eight bit intensity resolution with an independent contrast adjustment. Initial calibrations have shown that stimulus intensities ranging from about 0.1 to 3.7 $\log_{10}$ units neutral density above the eye's absolute, central visual field light threshold are attainable. In order to provide an illuminance upon the front of the three displays that is approximately equivalent to twilight, two 20 watt tungsten incandescent lamps are mounted in front of and to each side of the observer. Light shields prevent illumination from falling on the observer; it is necessary to maintain the observer in darkness in order to prevent reflections from being seen in the spherical mirrors of the displays. The contrast of black diffuse metal surrounding frames and the dynamic display area can be adjusted between zero and 0.66 where contrast is defined as surround (metal frame) luminance minus display area luminance divided by display area luminance.

Use of an optical display system using mirror-beam splitter collimation requires strict control of ambient illuminance to prevent unwanted static and dynamic reflections. This is no small task; the observer's region should be kept in relative darkness during testing.

Figure 3 is a photograph of the three display units. It was taken just behind and to the right of the DEP (defined by the plumb bob). An aircraft seat that may be adjusted both fore and aft as well as vertically is used to place the eyes at the DEP.

Figure 3. Photograph of three collimating display units.

Painted panels (diffuse black) are located beneath each beam splitter glass to prevent nearby objects from becoming visible. The observer's response panel is seen below and to the right of the plumb bob (white rectangular panel). All areas between and around the three display units are masked with black cloth.

Located beneath the center beam splitter is a low light level TV camera aimed at the observer's face. This device makes it possible to monitor head and eye location during testing. A padded head rest is used to maintain a stable head position. A preliminary investigation has found that the eyes may be as much as 2.5 cm above or 2.5 cm below the DEP without significantly influencing angular judgments of pitch displacement of a simulated earth horizon.

Several initial studies have been conducted to date and the equipment and computer programs have been found to afford highly flexible control of the dynamic stimuli in the spatial and temporal domains.

References:

AGARD, Advisory Group for Aerospace Research and Development, Characteristics of Flight Simulator Visual Systems, Advisory Report No. 164, May 1981.

Owen, D.H., R. Warren, R.S. Jensen, S.J. Mangold, and L.J. Hettinger, Optical information for detecting loss in one's own forward speed. Acta Psychologica, vol. 48, Pp. 203-213, 1981.

Warren, R., and D.H. Owen, Functional optical invariants: a new methodology for aviation research. Aviation, Space, and Environmental Medicine. vol. 53, no. 10, Pp. 977-983, 1982.