Peripheral Vision Horizon Display Testing in RF-4C Aircraft

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1. The USAF Test Pilot School (TPS) is currently responsible for testing the Peripheral Vision Horizon Display (PVHD) installed in an RF-4C aircraft (SN 68-7744). The primary objective of this program is to assess the capability of the PVHD (sometimes called the Laser Horizon) to provide peripheral attitude cues to the pilot. These peripheral cues are expected to reduce the likelihood/severity of spatial disorientation episodes and to improve performance during precise attitude tasks in Instrument Meterological Conditions (IMC).

2. The PVHD being tested by the TPS is an evolution of a previous design by Dr Richard Malcolm which was tested by TPS Classes 80A and 80B. The previous system used a Xerox arc lamp installed in a UV-18 aircraft. Although the results from those tests were generally inconclusive, the basic design concept was considered to have merit if the displayed horizon line could be made thinner, brighter and overall more distinct. A laser-generated horizon line was the logical choice for improving the quality of the display. This new system was subsequently installed in the RF-4C as well as in other aircraft (e.g., NASA T-37, Calspan NT-33 and Single Seat Night Attack (SSNA) A-10).

3. The basic concept of the PVHD is that it should provide an unconscious attitude cue to the pilot through his peripheral vision sensing system.

Ideally, once the pilot has become acclimated to the PVHD as a valid cue, he should be less susceptible to spatial disorientation. Additionally, this subconscious attitude cue should reduce the amount of concentration required on the aircraft Attitide Indicator (AI), thus freeing him to concentrate more on other performance instruments. The end result should be improved performance during unusual attitude recoveries and precision instrument tasks (i.e., instrument approaches). It must be emphasized, however, that the PVHD is not designed as an alternate/substitute attitude indicator, but merely as an aid to attitude reference.

4. To help determine the validity of the PVHD concept, the TPS was tasked to install the system in the rear cockpit (R/C/P) of an RF-4C aircraft. The laser projector is mounted on the lower edge of the canopy, aft of the pilot's right shoulder. The control box is located low on the center console, directly in front of the control stick. This particular aircraft is modified with an onboard Aydin Vector Data Acquisition System (DAS) as well as with data telemetry capability. The R/C/P of the RF-4C was chosen for two reasons. First, the R/C/P can be totally blacked out by use of an instrument hood and specially designed blackout panels. Second, the instrument crosscheck in the R/C/P is extremely poor in terms of human factors criteria, especially when performing an Instrument Landing System (ILS) approach. The ID-249 ILS glide slope and localizer indicator is located remotely on the instrument panel which forces the pilot's attention away from the AI in order to monitor localizer and glide scope deviations. This makes the RF-4C R/C/P an ideal natural test bed for assessing the ability of the PVHD to improve attitude awareness and thus ILS approach performance.

5. The PVHD test plan for the RF-4C was designed to assess three primary areas: (1) ability of the system to reduce spatial disorientation, (2) ability of the system to aid the pilot in recovering from unusual attitudes, and (3) improvement in pilot performance during ILS approaches. To reduce some of the "learning curve" effects, only F-4 instructor pilots will be utilized as project pilots because of their experience in flying instrument approaches from the R/C/P. So far, only two data and two orientation flights have been flown. The test plan calls for approximately 15 sorties (18 flying hours) to be divided among three to five pilots. No attempt has been made however to ascertain at just what point the PVHD becomes accepted as a valid input to the pilot's peripheral senses. The test plan calls for measurement of the pilot's performance from the very outset, both during unusual attitude recoveries and ILS approaches. Consideration is now being given to revising the test plan to allow for an adaptation period. Only the last one or two flights would be data flights. The emphasis would then be on showing degraded performance without the PVHD, rather than trying to assess arbitrary improved performance with the PVHD (arbitrary in that adaptation may not have occurred, especially during the first flight or two).

6. Initially, specific maneuvers were designed to help create distinct types of spatial disorientation: Somatogravic, somatogyral and combinations of the two. The first four flights of the PVHD revealed that although valid in theory, the maneuvers were not very successful in flight in generating the desired spatial disorientation. Somatogravic effects (false perception of climbing/diving during accelerations/decelerations) were the most difficult to create. Somatogyral effects (or the "Leans") seemed to be the

easiest to create. Since the "Leans" are one of the most commonly occurring forms of spatial disorientation, further test missions will concentrate on creating these effects repeatedly in order to assess the functionality of the PVHD. Hopefully, as testing progresses, it will become increasingly difficult to generate the "Leans" in the project pilot as the influence of the PVHD becomes more accepted by his subconscious. Additionally, the project pilot should display quicker reaction to and recovery from the unusual attitude resulting from this particular maneuver.

7. To assess the ability of the PVHD to improve pilot performance during instrument approaches, a self-setup ILS pattern has been devised. From a fixed starting point, the project pilot will fly a standard pattern to intercept the localizer and glide slope and fly the approach through the missed approach. The aircraft's DAS has been specially modified to include glide slope and localizer deviation as recorded parameters along with airspeed, altitude, heading, pitch and bank angles, and other standard parameters. Deviations from localizer and glide slope will be totalled and a mean deviation per unit time will be determined for comparative purposes. It is expected that improved performance will be experienced by using the PVHD and will be indicated by lower mean values of localizer and glide slope deviation. Originally, an optional, increased workload task was conceived, to be used if a normal ILS was not providing a sufficient workload for the project pilot. However, in the few sorties already completed, it was a unanimous opinion that the ILS, by itself, is more than a sufficient workload and does not require any additional tasks to saturate the pilot.

8. Although only two data flights have been flown so far, a number of

problem areas have surfaced. The most predominant problem is that of the display itself. The line is extremely wavy, not sharp and distinct as desired and expected. Although it has ten discrete brightness levels, the display is too dim for effective use in any form of daylight. Additionally, the sky pointer is not distinct at lower brightness levels. Geometric considerations prevent the line from being projected across the entire instrument panel and it can be partially obscured by only a slight movement to the right by the pilot. The system's controls are difficult to reach and the brightness control has no discrete setting corresponding to each level of brightness. Other problems include the lack of complete darkness in the R/C/P due to the absence of a blackout panel directly behind the front pilot's seat. Although the project pilot cannot see any horizon or outside references, there is enough stray light transmitted through this area so as to reduce the effect of complete darkness/IMC. Additionally, sunlight changes due to aircraft motion provide limited motion/orientation cues and thus reduce the effectiveness of any maneuvers to create spatial disorientation. All project pilots so far agree that the most easily recognized motion on the PVHD was roll, and that pitch motion was barely discernible at all, regardless of the scale selected (the pilot can select a 1:1, 2:1, or 3:1 scale factor for pitch sensitivity - 3:1 implies that one degree of PVHD movement in pitch equals three degrees of actual aircraft pitch attitude change). Also, there tended to be a "pendulum effect" in roll if the display was repositioned in pitch at other than its center; i.e., the display rolled about a point other than the intersection of the horizon line and the sky pointer.

9. Currently, the major effort at the TPS is to eliminate the non-aesthetic

horizon display. It appears to be due, in part, to noise from the aircraft electrical bus. Nonetheless, it is felt that unless the display is corrected to appear sharp and distinct as expected of a laser, subconscious adaptation to the PVHD system may be prolonged or, in fact, may never occur. Although other tests have shown that the quality of the image does not necessarily affect the mind's ability to perceive motion, image quality may affect the mind's acceptance of the validity of the input, thus inhibiting adaptation to the PVHD. An additional blackout panel will be made in order to create the desired environment and eliminate distractions from stray light. It must be remembered that the present configuration in the RF-4C is by no means necessarily the final configuration. This test is merely one means of attempting to verify or refute the validity of the PVHD concept and provide some degree of quantitative (and qualitative) evidence to support the conclusions. Also, it must be borne in mind when assessing the PVHD system that its only intended use is as an aid to attitude orientation, not as a substitute attitude indicator. Any attempt to refine the PVHD to the level of an attitude indicator necessarily disregards the basic design premise. That is, the PVHD is to be sensed by the pilot's peripheral sensing system thereby providing him a subconscious awareness of his attitude. This, in turn, relieves the pilot's workload and allows him more time for concentration on other cockpit instruments. The R/C/P of the RF-4C is an excellent natural environment in which to obtain quantitative and qualitative data for assessing the validity of the PVHD concept.