PERIPHERAL VISION HORIZON DISPLAY ON THE SINGLE SEAT NIGHT ATTACK A-10

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INTRODUCTION

The concept of the peripheral vision horizon display (PVHD) held promise for significant reduction in workload for the single seat night attack pilot. For this reason it was incorporated in the single seat night attack (SSNA) A-10. This paper presents a discussion of the implementation and results of the PVHD on the SSNA A-10. The paper will briefly discuss the SSNA program, then give a description of the part the PVHD played in the test and the results and conclusions of that effort.

SSNA A-10 PROGRAM

The SSNA A-10 program was an outgrowth of previous night attack testing on the A-10. In the late 70's Fairchild Republic Company conducted a company funded effort to create a night attack variant of the A-10 close air support aircraft. In this original concept an A-10A was modified to allow a second crewmember, and a night attack systems suite was developed for two-man operation. This aircraft underwent extensive company and Air Force testing and it was found that the aircraft had significant capability. However, the Air Force expressed interest in determining the capability of a single seat variant of the same night attack system. In 1982 the aircraft was modified to provide a highly integrated front cockpit with complete control of all aircraft systems. The rear cockpit was retained as a safety observer's station and for control of the aircraft instrumentation systems. The night attack systems aboard the aircraft included a FLIR with snap-look and narrow field-of-view which could be presented on the head-up display (HUD). A terrain following/terrain avoidance multi-mode radar included could also simultaneously provide a ground map or ground moving target indicator display. Navigation was aided by an inertial navigation system and progress could be monitored on an electronic moving map display. The system included a laser ranger and a radar altimeter. The AGM-65D imaging infrared Maverick missile was used as ordnance. A PVHD was installed on the right canopy rail of the front cockpit.

The SSNA test was primarily a workload study of the job of single seat, low level, night attack. The test was broken up into several phases. An avionics test phase was used to conduct a limited test of the aircraft systems. A training phase allowed the project pilots to get familiar with the SSNA systems. The heart of the project, the workload testing, was conducted in three phases. First, the workload associated with the basic tasks of night attack was investigated. In the second workload phase the basic tasks were combined to form realistic workload levels for the SSNA job. Lastly, simulated typical night attack profiles such as interdiction and close air support were flown. In all, over 30 sorties were flown under very dynamic conditions, low altitude, at night.

THE PVHD IN THE SSNA TEST

The PVHD system was introduced as part of the SSNA suite in response to two areas. First, the job of maintaining attitude awareness at low altitude at night is one of the major workload drivers of the SSNA mission. Stress, another facet of workload, was generated by concern over attitude awareness. It was hoped that the PVHD would alleviate some of the workload associated with maintaining attitude, and provide the pilot with a stress reducing confidence in his attitude awareness.

The SSNA test did not include a direct effort to determine the value of the PVHD system. Specific testing with the PVHD did include a system operation checkout and familiarization flight for each of the SSNA project pilots. In general the PVHD was treated as one of a number of systems upon which the pilot could rely to do his job. The PVHD was used at the pilot's discretion on the remaining SSNA workload missions.

RESULTS

The tests found that the PVHD did function as designed. There was adequate control of brightness to suit the night mission. The pitching and rolling response of the system was in agreement with the aircraft motion. The alerting feature at maximum travel activated properly. The 1 to 1 pitch scale factor was found to be suitable for the night attack mission.

Though the PVHD functioned properly, a number of problems were associated with the installation of the system. The design display area was located low on the main instrument panel. This area was selected because the upper area of the panel was occupied by two CRT multifunction displays (MFDs). The first problem was caused by the fact that the main instrument panel was built in two sections with the lower section slightly recessed from the upper. In addition, the PVHD was mounted about shoulder height on the canopy rail. As a result of this geometry, it was possible for the horizon line to be displayed just below the upper portion of the instrument panel in an area at the top of the lower section of the panel which was not directly in the pilot's line of sight. Unfortunately, although only a very small area was not visible to the pilot, this was the location where the horizon line would be displayed with the system initialized in the normal manner and the aircraft at nominal operating speeds. The next problem with this low display area was that substantial portions of the area were blocked from the pilot's vision by the stick and the pilot's arm. The pilot's peripheral vision of this area was also reduced by his oxygen mask. In effect, much of the display area was not in the pilot's peripheral vision. In an effort to overcome these problems associated with the low display area, the nominal position of the horizon line was moved to a position much higher in the pilot's peripheral vision in the middle of the upper instrument panel. There were problems associated with this location as well. The actual range of the PVHD motion could not be changed to accommodate this location. The problem was that although the nominal position could be displayed, the horizon line could only move a very limited distance up (pitch down direction) before it reached the limits of its travel. The actual display area in this upper location was limited in width because the beam could only be seen on a narrow HUD control panel located between the two MFDs in the upper instrument panel. The beam could not be seen on the surface of the MFDs. The geometry of the PVHD installation and the location of the right MFD put it in perfect position to cause a major reflection into the pilot's eyes of the laser beam when the upper display area was used. This bright red light was very distracting to the pilot. In summary, no suitable location could be found to present the PVHD horizon line in the SSNA cockpit.

The effect of these problems, associated with the installation of the PVHD, was that the desired benefits of the system were not accrued. Most pilots gave the system one or two flights, then deemed the problems to outweigh the value and turned the system off. This amount of exposure to the system was not felt to be adequate to arrive at any meaningful conclusions about the operational utility of the system.

The last result that will be discussed is not directly associated with the PVHD system. Though the majority of SSNA operations were conducted at night, frequently with overcast or no moon conditions, the pilots did not have a major problem with attitude orientation. This result is primarily attributed to the use of the FLIR presentation on the HUD. The HUD display was 16 degrees wide. Though not as wide as the desired use of the PVHD, this does extend significantly into the pilot's peripheral vision. (Future HUD displays will be even wider; e.g., the LANTIRN HUD, 30 degrees.) The FLIR provides a natural horizon which the HUD reinforces with the horizon line symbol. The FLIR picture also provides surface texture from which the pilot can gain peripheral cues of altitude, attitude, and translation. Testing is warranted to determine the necessity of a PVHD system given the availability of a HUD/FLIR combination.

CONCLUSIONS

The most obvious conclusion that can be drawn from the SSNA experience with the PVHD system is the difficulty in achieving a suitable installation in a fighter type cockpit. Innumerable major and minor problems seem to crop up to defeat the efforts of the design engineers to successfully install the PVHD.

As a result of compromises for the sake of installation, a less than desirable display area might seem necessary in order to use the PVHD. Though only common sense, it bears stating that a peripheral vision horizon display that is not in the pilot's peripheral vision does not have much utility.

The SSNA project pilots did not have significant problems with attitude awareness. This was attributed to the constant use by the pilots of the FLIR presentation on the HUD. The value of this FLIR/HUD combination in satisfying the needs for a PVHD should be investigated.

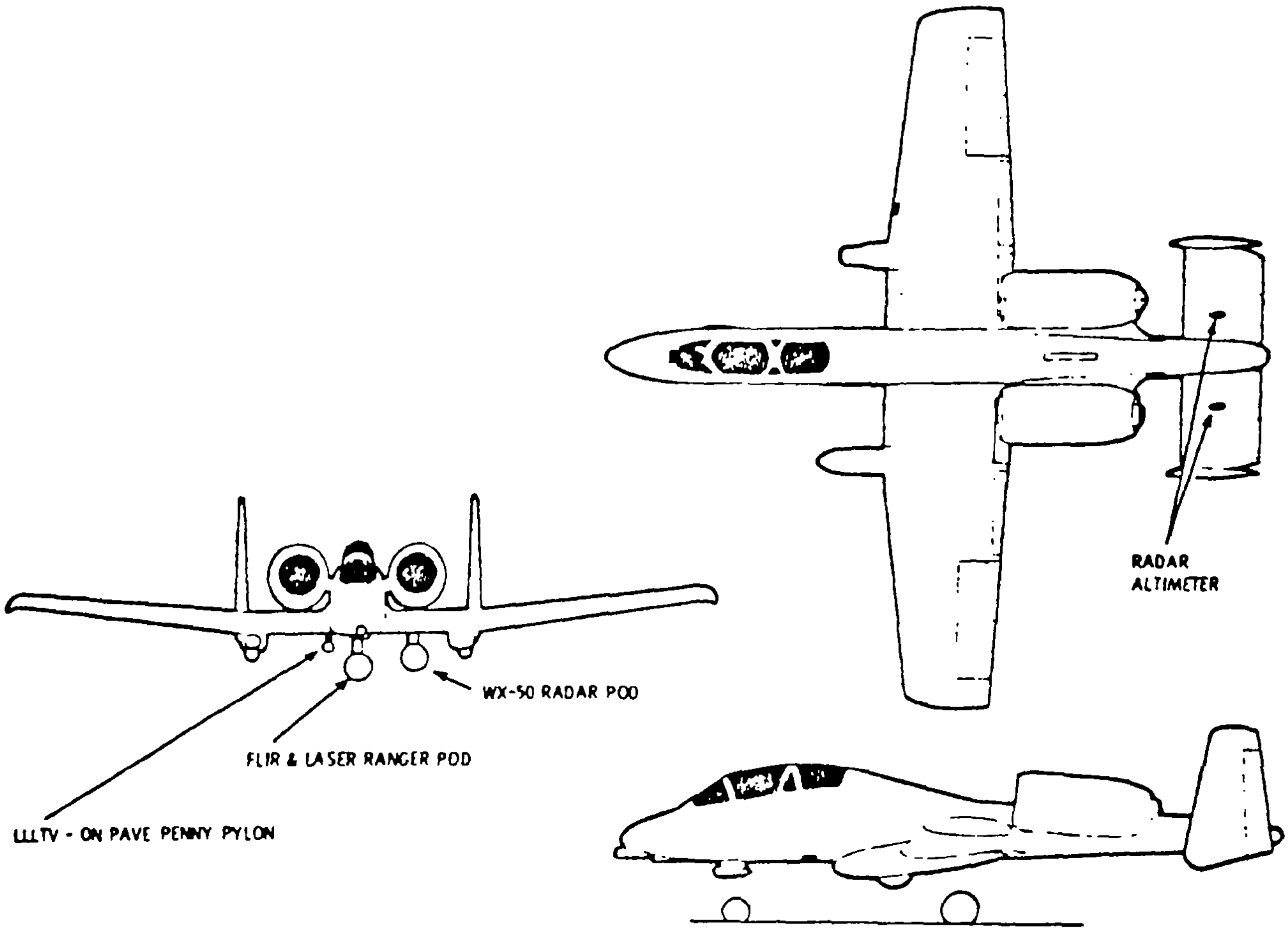

Figure 1
SSNA YA-10B EXTERNAL CONFIGURATION

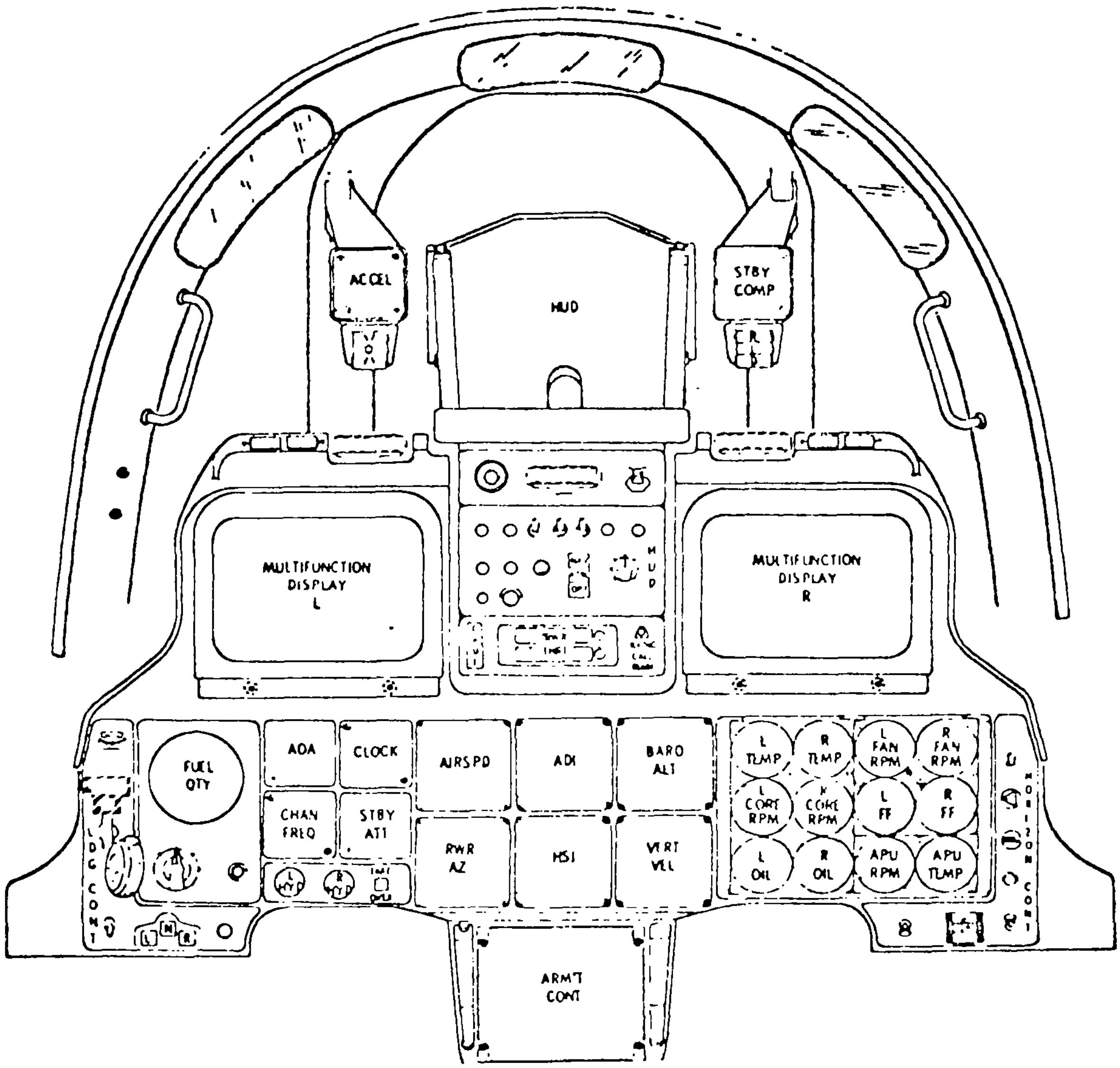

Figure 2
FRONT COCKPIT INSTRUMENT PANEL

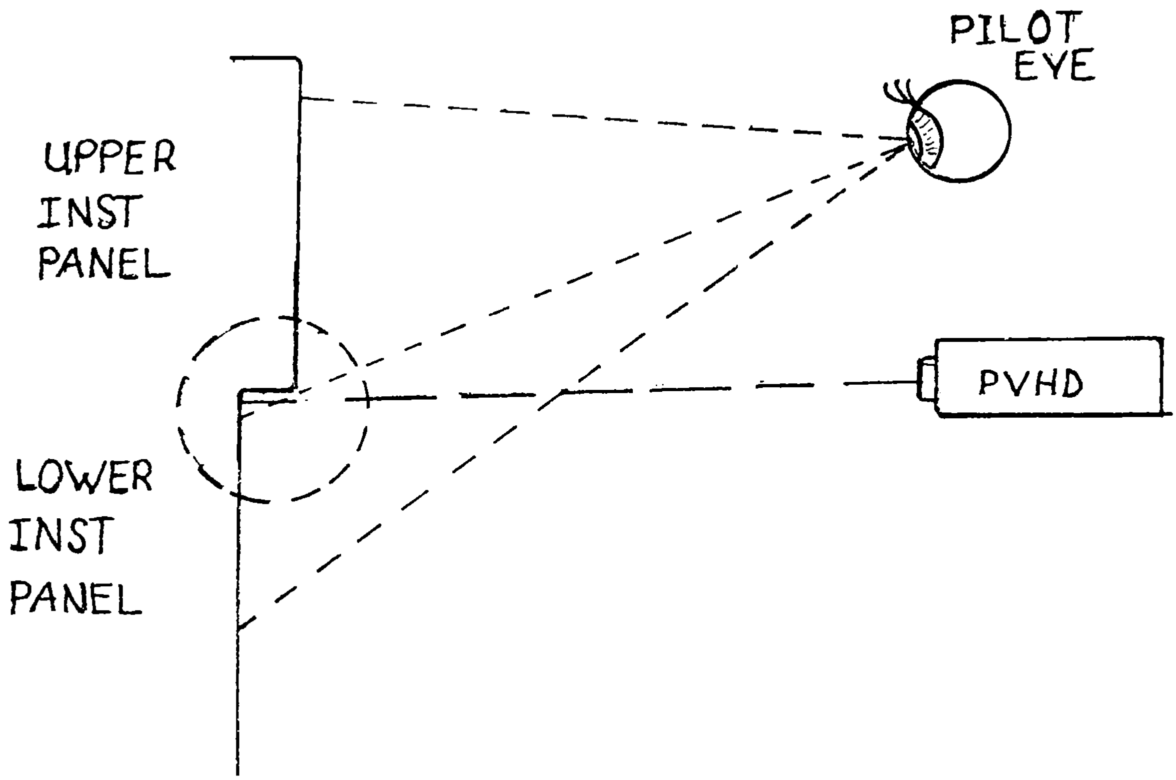

Figure 3
SHELF EFFECT

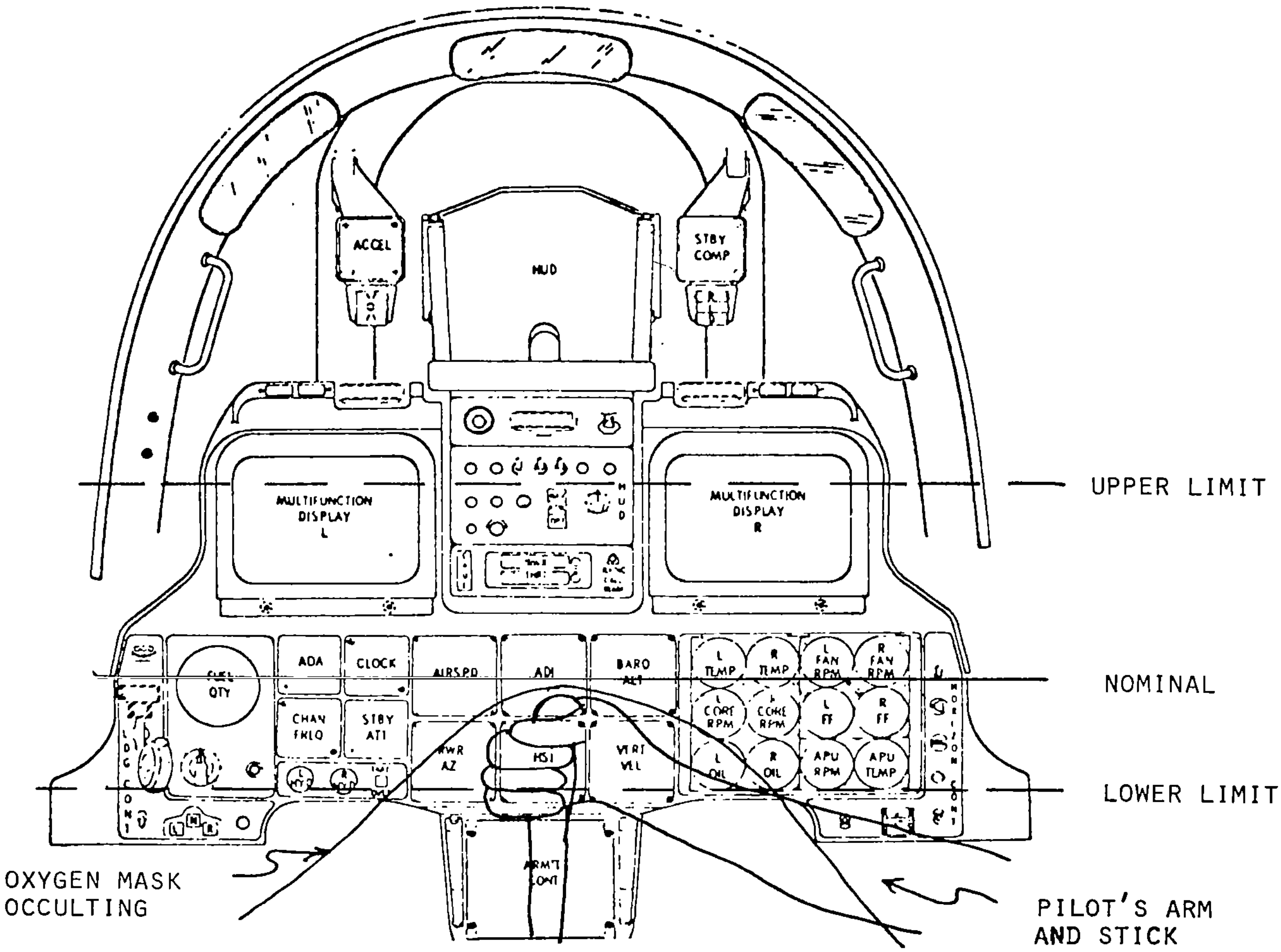

Figure 4
LOW PRESENTATION

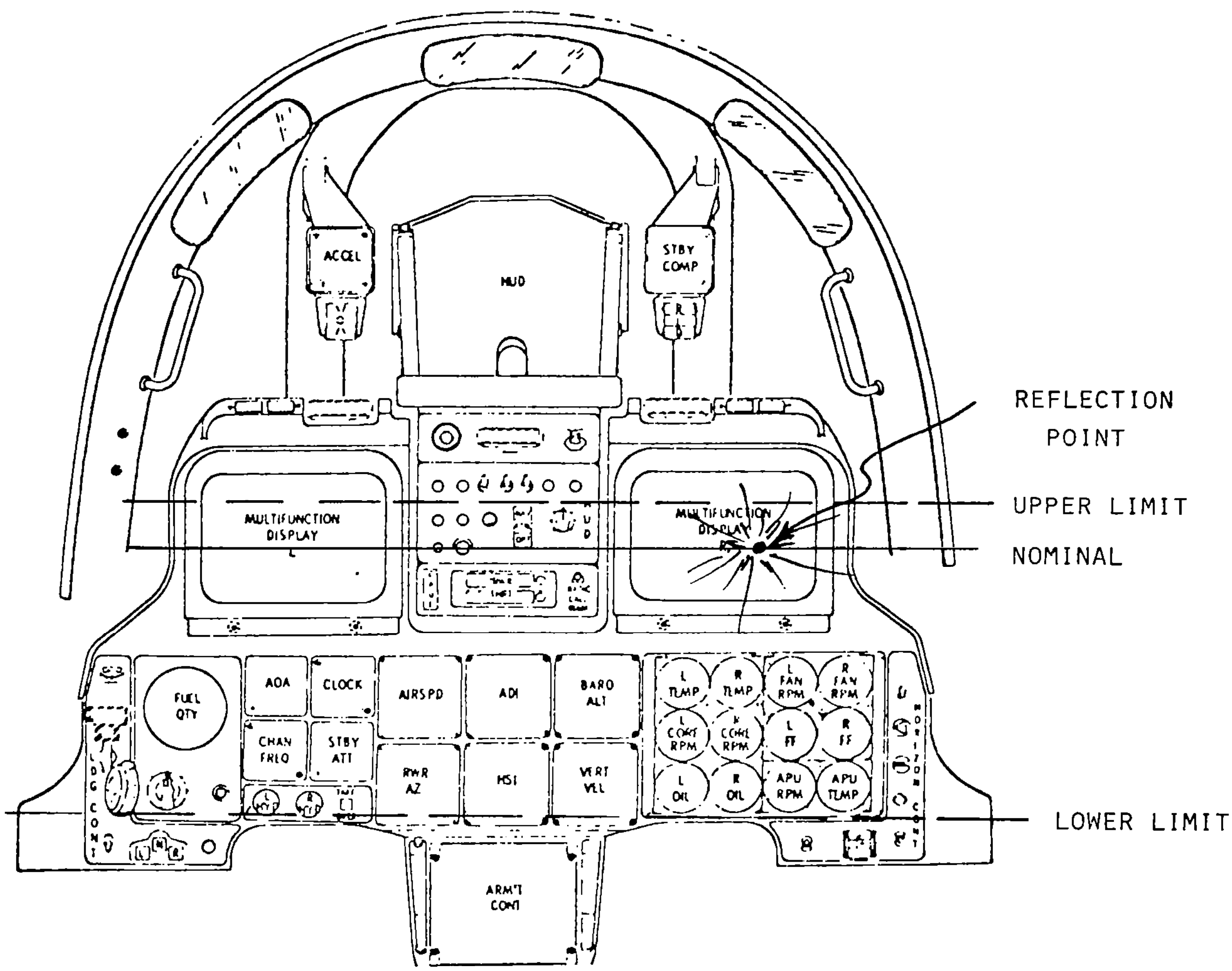

Figure 5
HIGH PRESENTATION