The First Head Up Display Introduced by General Motors

Technical Paper

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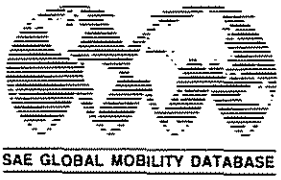

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ABSTRACT

The first production configured head up display (HUD) was introduced in the United States in the 1988 Oldsmobile Cutlass Supreme Indianapolis 500 Pace Car Parade Convertibles. The design and performance of this HUD uses a vacuum fluorescent display tube (VFD) and reflective optics, including the standard production windshield as the final element,and produces a virtual image of a digital speedometer and selected telltales just above the hood line in the driver's central vision area at approximately front bumper range. The unit's functional and physical design minimize modification of existing instrument panel structures and interfaces while providing essential features and performance for consumer satisfaction. Human factors engineering contributed to this application; supporting studies and simulation efforts are summarized to substantiate the design decisions.

A Head Up Display (HUD) is an instrument which allows the driver of a vehicle to view key driving/status data superimposed on the visual field through the windshield rather than requiring looking down at the instrument panel for necessary or useful information. The HUD feature has come into widespread use in the aircraft industry over the past 20 years and is suited for adaptation to today's modern automobiles.

The basic automotive HUD concept is illustrated in Figure 1. There are two ways in which the HUD can facilitate the driving task: First, with key driving data such as vehicle speed as part of the HUD image, the driver can keep his eyes looking toward the road ahead while accessing and responding to the information; in addition, his eyes remain adapted to the ambient light level in his primary visual field. Secondly, with the image focused to appear two or more meters forward of the driver, the need to re-accommodate from the road to the image is reduced.

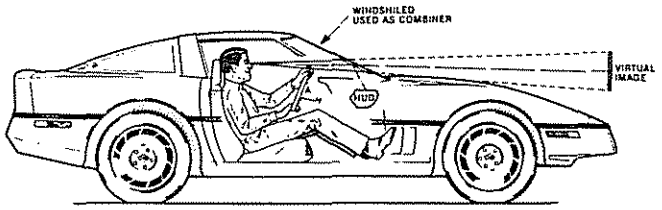

Figure 1 - Basic Automotive HUD Concept

The first production-configured automotive HUD introduced in the U.S. was developed by a General Motors team from Oldsmobile,CPC-Advanced Vehicle Engineering, Delco Electronics and Hughes Aircraft Co. Its design was guided by human factors considerations such as those mentioned above and its implementation was based on technology derived from HUDs used in the world's foremost fighter aircraft. This pioneering HUD system was engineered specifically for the 1988 Oldsmobile Cutlass Supreme Indianapolis 500 Pace Cars and limited edition Parade Convertibles. This advanced technology feature is ideally suited to the Cutlass Supreme since it matches well the innovations in design and styling of this new family of mid-size, front wheel drive coupes. Based on the response to this introductory system, it is expected that HUDs will find widespread acceptance in the automotive market as they have in the aerospace industry.

REFLECTIVE AUTOMOTIVE HUD CONCEPT

Head Up displays are used routinely by pilots of military and commercial aircraft to perform very complex and difficult tasks which require cognizance of auxiliary information in the context of the visual field. An obvious advantage of HUD over in-cockpit,panel-mounted instruments and displays is that the pilots can maintain visual contact with airspace and/or targets while monitoring information (without looking down) that is needed for effective control of the vehicle and/or weapon systems to accomplish the desired mission objectives. While the detailed tasks, missions, and environments of automobile drivers and pilots are different, they nevertheless have much in common, not the least of which is the need, or desire, to maintain continuous visual contact with the real world. It is therefore not surprising that drivers react very positively to HUD-equipped vehicles, particularly if the HUDs are carefully designed for the driving task. As in airborne systems, the right information should be presented in the proper location with clarity, in natural, easily interpretable formats. Unlike airborne systems, automotive HUDs are not used as sighting, tracking or comprehensive system monitoring/control devices; therefore, high accuracy and voluminous information content, which account for much of the complexity and cost of airborne systems, are not critical in automotive applications. Clearly the design of a cost- effective automotive HUD is not a simple adaptation of an airborne design, but a carefully tailored application of aerospace technology and experience to the specific needs of drivers and the automotive environment. The HUD described herein and illustrated conceptually in Fig. 2 is such a design.

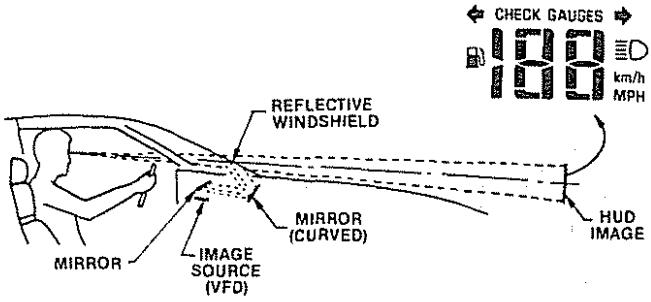

Figure 2 - Pace Car HUD Optical Schematic Diagram

Human factors analysis, preliminary design studies, and evaluation of early engineering models led to the conclusion that, for optimum utility, the HUD image should be simple and located in the lower central region of the driver's visual field. Also, the image should be at a range greater than two meters from the driver's nominal eye position, preferably at, or just forward of the front bumper, where re-accommodation time can be reduced. This contrasts with windshield-reflected instruments which have no optical power and place the image off axis at relatively close range where typical drivers will need greater re-accommodation and divert their attention from the visual field time.

Numerous design alternatives were considered, including; refractive, diffractive and reflective optics, integral combiners and various windshield combined treatments, VFD, LED and LCD display devices, integral, separate and shared electronics, absorption - and diversion type glare traps, spherical and aspheric imaging elements, large optical apertures and small apertures with manual tilt control. After careful consideration of the various tradeoffs, the reflective HUD concept was selected for the Pace Car HUD, which is classified as a secondary instrument; this concept is characterized as follows:

1. A high-brightness VFD with discrete segmented graphics is used as the image "source".

2. Image content is limited to a digital speedometer (3 digits) and units of measure (English/Metric) along with selected telltales (turn/hazard arrows, headlight high beam on indicator, low fuel indicator and provisions for a "check gages" summary advisory message); graphics style,composition and image size are consistent with easy legibility, Figure 8.

3. A virtual image of the VFD graphics is produced at front bumper range using a relatively small aperture, folded reflective optical system with manual tilt control to suit driver position preference, a flat window with a louver-type absorptive glare trap, and the unmodified production windshield as the combining glass.

4. A complete set of electronics is included in the unit (power supplies, signal processing, VFD drivers and dimming circuits), making HUD operation totally independent of, and redundant with, the instrument cluster.

5. The HUD unit and auxiliary components (dimming control module, mounting brackets and wiring harness components) are packaged in and on the top pad of the instrument panel to minimize vehicle integration impact.

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