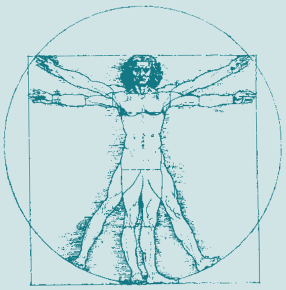
Research Update



HUMAN CENTERED

S Y S T E M S

The Human Centered Systems Research Program addresses human performance-related issues that affect highway system design. Current human centered research focuses on Highway Safety and Intelligent Transportation Systems (ITS).

Human centered research products include driver performance models, highway system design guidelines, and handbooks based upon empirical human performance data collected in the laboratory and in controlled, on-the-road tests.

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway
Research Center
6300 Georgetown Pike
McLean, Virginia 22101-2296

Development of Prototype Driver Models for Highway Design

Introduction

One of the high-priority research areas of the Federal Highway Administration (FHWA) is the development of the Interactive Highway Safety Design Model (IHSDM). The goal of the IHSDM research program is to develop a systematic approach that will allow highway designers to explicitly consider the safety implications of design decisions from the planning stage through the final design stage.

The present highway design process assumes that compliance with design policy assures an acceptable, albeit unspecified, level of safety. This assumption is overly simplistic in today’s highway development environment, in which citizens demand more context-sensitive design with broader application of the flexibility afforded by design policy and in which tort liability remains a constant concern. Assuring safety cost effective design decisions in this environment requires better safety evaluation tools than are currently available.

In an attempt to marshal available knowledge about safety into a more useful form for highway planners and designers, FHWA is developing IHSDM, a suite of evaluation tools for assessing the safety implications of geometric design decisions. IHSDM’s evaluation capabilities will help planners and designers maximize the safety benefits of highway projects within the constraints of cost, environmental and other considerations. A small increase in the safety cost effectiveness of individual highway projects, when accumulated across the tens of billions of dollars invested in highway improvements each year, can contribute significantly to FHWA’s strategic safety objective to reduce the number of highway-related fatalities and serious injuries by 20 percent in 10 years.

The development of IHSDM is a long-term, multi-year activity. The initial development efforts are restricted to two-lane rural highways—the largest single class of highways in the U.S., representing approximately two-thirds of all Federal-aid highways. Release of the full model for two-lane rural highways is scheduled for 2002. A subsequent phase of IHSDM development will add the capability to evaluate multi-lane design alternatives.

As currently envisioned, the IHSDM will consist of five modules, or components (as shown in Figure 1 on the following page). These five modules are:

- Policy Review Module—will verify compliance with highway design policies. The module will identify design elements not in compliance with policy and explain the policy violated. In response to this information, the user may either correct any deficiency or prepare a design exception. To aid in evaluating the safety implications of these alternatives, the module will prompt the user to conduct further analyses with other IHSDM modules.

- Accident Analysis Module—will consist of three models, which: (1) estimate the number and severity of crashes on specified roadway segments; (2) provide a

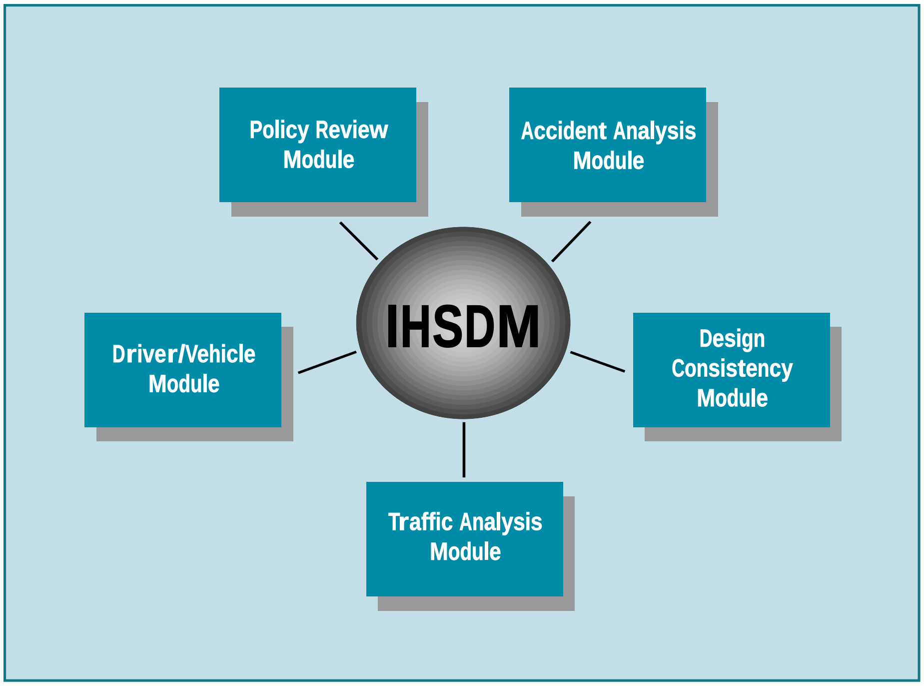


Figure 1. The five modules of IHSDM.

benefit/cost analysis of alternative roadside designs; and (3) use an expert system approach to evaluate intersection design alternatives, identify geometric elements that may impact safety, and suggest countermeasures.

- Design Consistency Module—will provide information on the extent to which a roadway design conforms with drivers' expectations. The primary mechanism for assessing design consistency is a speed-profile model that estimates 85th percentile speeds at each point along a roadway. Potential consistency problems for which alinement elements will be flagged include: large differences between the assumed design speed and estimated 85th percentile speed, and large changes in 85th percentile speeds between successive alinement elements.

- Traffic Analysis Module—will use traffic simulation models to estimate the operational effects of road designs under current and projected traffic flows. The Traffic Analysis Module will provide information on travel time, delay, interaction effects between vehicles, traffic conflicts and other safety surrogate measures.

- Driver/Vehicle Module—will consist of a Driver Performance Model (DPM) linked to a Vehicle Dynamics Model, and will allow consideration of driver (human) performance issues and data in the process of designing and evaluating safe highways. In the Module, as in reality, driver performance is influenced by cues from the roadway/vehicle system (i.e., drivers modify their behavior based on feedback from the vehicle and the roadway), and vehicle performance is, in turn, affected by driver behavior/performance. This Module will permit the designer, or reviewer, to model drivers with various characteristics driving any of the AASHTO design vehicles through the design alternatives under different control strategies in the absence of other traffic. Conditions which could result in loss of vehicle control will be identified using measures of skid and rollover potential. In the initial version of IHSDM, the DPM will provide the Vehicle Dynamics Model with speed selection, speed control, path selection, and path control information.

The focus of this update is the driver-centered research being performed to support IHSDM. This research includes the development of the Driver Performance Model, and modifications to the Traffic Analysis Module to improve its representation of driver behavior in traffic.

Initial Driver-Centered Research Efforts

In March 1995, two FHWA contracts were awarded to develop specifications for the DPM. The results of these efforts include descriptions of system and hardware requirements, variables to be used and their definitions, input/output specifications for the model and each of its proposed components, and candidates for the algorithms to be used/developed for proposed components of the model. The research required to develop the driver performance databases for use with the DPM was also specified. The results of these efforts were key to formulating current development efforts.

Current Driver-Centered Research Efforts

FHWA's current efforts are focused on using the specifications developed in the initial effort to build the DPM, and improving driver representation in IHSDM's Traffic Module. The objectives of this current effort are:

- To develop, test, validate, and deliver a functioning prototype Driver/Vehicle Module that will permit the designer, or design reviewer, to model humans driving any of the AASHTO design vehicles through the various design alternatives under different control strategies and identify conditions that could result in loss of vehicle control.

- To develop and implement specific modifications to be made to TWOPAS, the traffic model of IHSDM's Traffic Analysis Module, to improve the module's representation of driver behavior in traffic.

Driver Performance Model (DPM)

A flow chart describing the information flow within the planned DPM is shown in figure 2. It can be seen that the model has six major functional components:

The **Perception** component translates the Physical Description of the Driving Environment into Estimates of Vehicle States (such as speed, lateral and longitudinal acceleration, lane position and yaw rate) and Roadway Characteristics and other relevant variables needed by the decision and control modules.

The **Speed Decision** component computes the driver's desired speed or acceleration/deceleration (Desired Speed Profile), which is transmitted to the **Speed Control** component where accelerator and brake pedal actions are generated (Vehicle Control Inputs) to regulate speed about the desired profile.

The **Path Decision** component computes the desired path offset from lane center when cutting the corner of a curve (Desired Path Profile), and the **Path Control** component generates steering wheel movements (Vehicle Control Inputs) to regulate this lateral lane placement about the desired profile.

The **Attention** component provides the proportion of the modeled driver's attention available for each of the other five components. A driver's attentional capacity is shared among the speed decision, path decision, speed control and path control activities, and potential degradations in performance can occur if mental demand exceeds this capacity.

Major Input/Output Data Sets are shown in ellipses and the flow of information between the components is shown by the arrows, the solid arrows indicating the flow of dynamic information, and broken

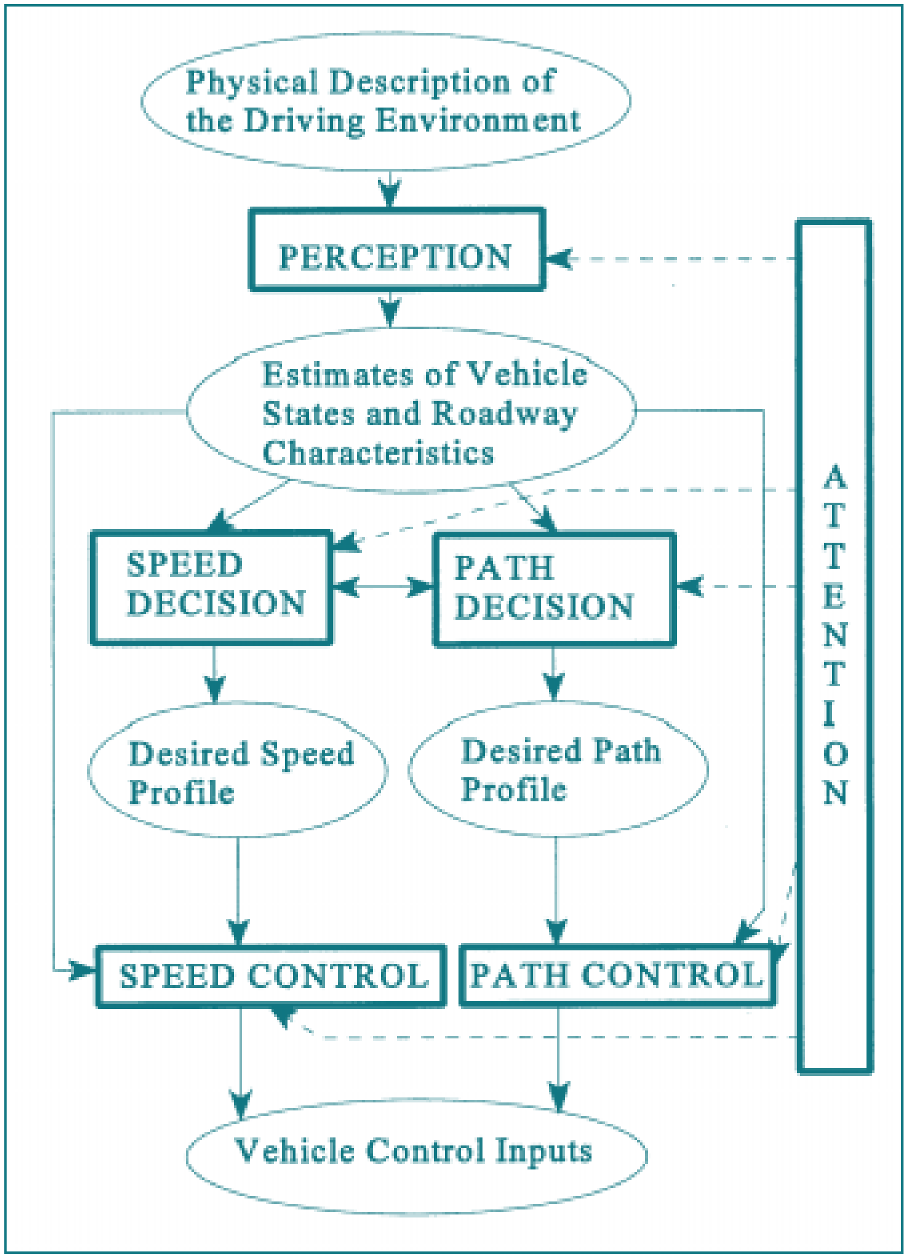


Figure 2 . Information flow in the driver performance model.

arrows indicating the flow of static information.

TWOPAS

TWOPAS is a microscopic traffic simulation model for two-lane highways. As outlined above, one of the objectives of this effort is to make specific modifications to TWOPAS to improve the model's representation of driver behavior in traffic. The approach designed to address this objective includes:

- Reviewing current driver representation in TWOPAS.
- Identifying and prioritizing specific modifications to be made to TWOPAS.
- Identifying and performing research to support high-priority modifications.
- Implementing the modifications in TWOPAS and performing testing and validation.

Preliminary results of the early tasks identified the following candidate modifications:

- Addition of the effects of narrow lanes/shoulders on speed selection.
- Addition of slow vehicle turnouts.
- Use of paved shoulders by slower vehicles.
- Addition of turning traffic in driveways and intersections.
- Addition of continuous two-way left-turn lanes.
- Automatic determination of reduced-speed zones.
- Automatic determination of downgrades where trucks reduce their speeds.
- Elimination of the need for the user to specify desired speeds.

These candidate improvements will be prioritized by the FHWA IHSDM development team and a group of 30 engineers who have familiarity with TWOPAS or similar design tools.

Initial IHSDM development efforts are focused on two-lane highways.

For More Information

For more information, contact Joseph Moyer, Engineering Research Psychologist, HRDS, (202) 493-3370 or Mark Robinson, Traffic Engineer, SAIC, (202) 493-3384.