DRIVER PERFORMANCE DATA ACQUISITION SYSTEM
FOR ERGONOMICS RESEARCH*

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A portable ergonomics data acquisition system consisting of state-of-the-art hardware is being designed. It will be employed to record driver, vehicle, and environment parameter data from a wide range of vehicles and trucks. The system will be unobtrusive to the driver and inconspicuous to the outside world. It will have three modes of data gathering and provide for extended periods of data collection. Modularity, flexibility, and cost will be key drivers in the development effort. The ergonomics data acquisition system project is being conducted in two phases—a feasibility study and a development, construction, and validation phase.

BACKGROUND

The United States (U.S.) Department of Transportation's National Highway Traffic Safety Administration (NHTSA) envisions many future situations in which the effectiveness and consequences of new intelligent vehicle-highway systems technologies will need to be studied in actual production vehicles. Such studies will enable evaluations in vehicles which are familiar to drivers. These studies would be further enhanced by the availability of an instrumentation package that can be easily installed in these vehicles to enable specific vehicle configurations of interest (e.g., pedal placement and head-up displays) to be evaluated, thereby increasing the variety of vehicle options (incorporating advanced technology) that are available for study. Ideally, an approach is needed that would allow data collection from a variety of vehicle models and types, and would address the issue of driver familiarity.

Such an approach is embodied in the concept of a portable ergonomics data acquisition system that could be installed in a wide range of vehicles within a relatively short period of time. As a universally adaptable system, it would provide researchers with the ability to manually input data (e.g., weather conditions and critical incidents) as well as directly record information on driver, vehicle, roadway, and environment parameters. Furthermore, it would enable the measurement of driver performance in the driver's own vehicle, thereby ensuring vehicle familiarity.
addition, it would be possible to measure driver performance in relation to any vehicle design characteristic at relatively little expense and effort, and would make it easy to update existing models of driver/vehicle behavior to reflect performance characteristics in vehicles of current manufacture. The availability of such information will lead to improved problem identification in crash avoidance research, as well as provide NHTSA with the capability to readily answer questions related to vehicle design characteristics not otherwise available. For example, on-the-road evaluation of new technologies such as head-up displays could be carried out in a driver's own vehicle under a variety of traffic and roadway conditions. In addition, such a system has the potential to measure driver performance as it relates to the location of surrounding vehicles. This would allow the study of how drivers interact with other vehicles in their immediate vicinity.

THE RESEARCH PROGRAM

Oak Ridge National Laboratory (ORNL) is conducting a research program for NHTSA oriented towards the development of a driver performance data acquisition system for ergonomics research.

Requirements/Constraints

The development effort is being driven by a number of requirements and/or constraints which are described below.

Parameters and measures. The ergonomics data acquisition system will be capable of gathering over fifty driver, vehicle, and environment parameters and measures. Driver related variables consist of driver control actions (e.g., accelerator/throttle, brake pedal, and steering), equipment status (e.g., cellular telephone, cruise control, and hand location), and physiological measures (e.g., fidget index/gross body movement, blood pressure, and body temperature). Vehicle parameters include, for example, acceleration, headway, lane keeping, pitch, roll, and yaw. Environment considerations consist, for instance, of ambient illumination, road gradient, wind direction, and congestion, mix, and proximity of traffic.

Off-the-shelf and state-of-the-art. The data acquisition system will be comprised of both off-the-shelf hardware and software, and state-of-the-art technology. ORNL will procure most of the system required equipment; some of the hardware and software will have to be designed and developed.

Portability. The data acquisition system will be portable. It will be capable of being installed on a particular vehicle within a relatively short time frame. The system will be able to be subsequently removed and placed within another vehicle in a small amount of time.
Automobiles and trucks. The ergonomics data acquisition system will be designed so that it can be installed within virtually any passenger vehicle (i.e., a large variety of automobiles and trucks made in the U.S.). It will be able to be mounted within vehicles of all three domestic vendors (General Motors, Ford, and Chrysler) and across a wide range of vehicle types (i.e., compact, intermediate, and large automobiles, vans, and small, mid-size and large trucks).

Unobtrusiveness and inconspicuousness. The data acquisition system will be unobtrusive to the driver. Placement of hardware within the vehicle will not obstruct the driver's primary task of driving. Instrumentation and cables/wires connecting different pieces of the system will be hidden, well out of the view of the driver. The system will also be inconspicuous to the outside world. Antennas, sensors, and cameras will be situated on the exterior of the vehicle so that they cannot be seen by other drivers. As far as possible, the vehicle will look like any other vehicle on the road.

Modularity and flexibility. The data acquisition system will be modularly designed; that is to say, the system will permit installation of only those data collection capabilities required for a particular study. An individual will not have to instrument the vehicle with the entire system in order to collect or record a subset of parameters. The data acquisition system will also be designed so that it has the flexibility to accommodate new data acquisition and sensor technologies as the state-of-the-art changes.

Three modes of data collection. The ergonomics data acquisition system will have three modes of data collection. The first will consist of recording parameter data on-board the vehicle via a laptop computer. This mode will also provide backup capability in the case of radio link failure or signal corruption during transmission. The second mode will be comprised of radio telemetry. The radio telemetry link will be used to transmit data from the vehicle to a base station during use at a test track. The third includes satellite transmission equipment. Satellite transmission will be employed to transmit data from a vehicle in an open road situation, somewhere in the U.S., to a base station a few to many hundreds of miles away.

Extended periods of recording data and cost. The data acquisition system will collect parameter data over two extremes of time - from as little as 20 minutes up to 6 months. The system will be designed with cost as a main consideration. Technical capabilities - cost tradeoff analyses will be performed for each piece of the data acquisition system.

Phases of the Research

Phase I. The ergonomics data acquisition system is being developed and implemented in two phases. A research requirements
and engineering design study is the initial step in determining the feasibility of, and requirements for, designing and fabricating a data acquisition system. The principal objectives of phase I of this effort are to:

- Identify driver, vehicle, roadway, and environment parameters that should be measured, the relationship of those measures to safety, and their priority, and define the minimum set of parameters that would be necessary.
- Identify state-of-the-art hardware/software to support development of the ergonomics data acquisition system.
- Identify the most cost effective and efficient data acquisition/transmission architecture.
- Identify the analysis techniques that would be used to integrate, analyze, evaluate, and interpret the data in relation to safety issues.
- Make a determination of whether it would be practical, productive, and technically feasible to fabricate an ergonomics data acquisition system capable of measuring the desired driver, vehicle, roadway, and environmental parameters.
- Determine the cost of one or more alternative configurations of the ergonomics data acquisition system.

Phase II. If it is determined by NHTSA that the construction of an ergonomics data acquisition system is feasible at an acceptable cost, the second phase of the program will be initiated. The objectives of phase II would be to:

- Construct a prototype data acquisition system.
- Develop a research plan for evaluating the prototype system.
- Evaluate the data acquisition system with regard to: its ability to reliably measure the parameters of interest; the reliability of the hardware and software; the ability to install a system on a variety of vehicle types within an acceptable time frame; and the ability for the system to collect data under a variety of operational conditions.