CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

Project Summary Report 0-4621-S
Project 0-4621: Optimum Level of Roadside Information to Reduce Driver Stress
Authors: Alexei Tsyganov, Randy Machemehl, Ahmed Qatan, Nick Warrenchuk
October 2005

PROJECT SUMMARY REPORT

Driver Responses to Urban Freeway Information Loads: A Summary

What We Did ...

Relationships between information flow, driver stress, driver performance, and accident experience have been hypothesized. This research project classifies urban freeways in Dallas, Houston, and San Antonio, Texas, regarding the intensity of information flow or information load presented to drivers. The classification process includes dividing the target freeways into homogenous sections so that numbers of lanes and traffic volumes are uniform within sections. A procedure for classifying sections regarding the intensity of information flow or load presented to drivers is described and applied to all subject urban freeway sections in the three selected cities.

Information load as described here includes information from traffic control features, adjacent traffic streams, and the vehicle itself, as well as background visual noise. Crash statistics for 1999, 2000, and 2001 were compared to information load rates to determine whether relationships between information loads and crash rates can be found. Test drivers experienced each of the 27 information load levels identified for the freeways in the three Texas cities as they negotiate selected driving routes. A portable data acquisition system records the driver's field of view, vehicle trajectory data (Figure 1), driver electro-cardiogram, and eye movements (Figure 2), as the drivers experience the real-world information flow situations.

What We Found ...

Significant relationships between information load levels and driver behavior were detected. Investigation of crash data for 1999, 2000, and 2001 for freeways in Houston, San Antonio, and Dallas indicates several correlations between crash frequencies and information loads. Increased signage on highways with two, three, and four lanes causes a growth in general accident frequency, with a simultaneous increase of multiple-vehicle collisions, and in some cases crash severity. Based on this, one might hypothesize that such conditions cause driver information overload. The data indicated that exceeding sign frequencies of 0.18 and 0.21 signs per second on

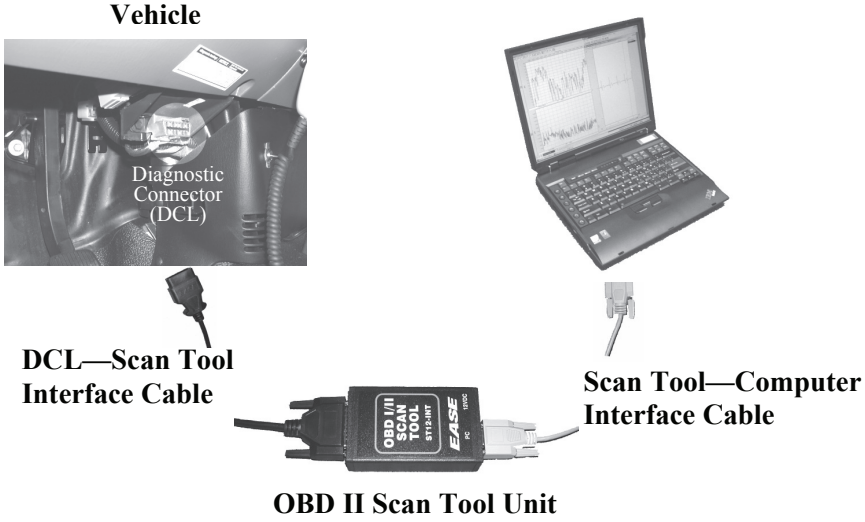

Figure 1. Vehicle diagnostic module

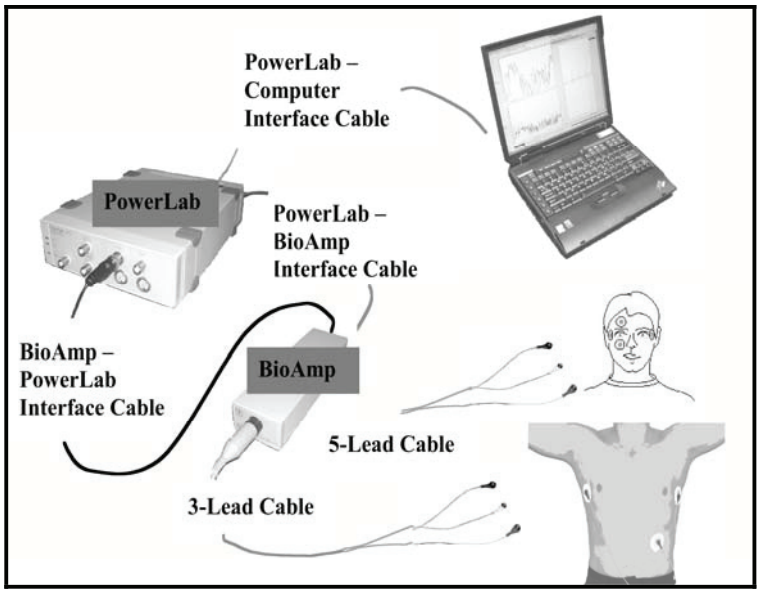

Figure 2. Biological module

freeways with two and three-four lanes, respectively, causes major impacts, and therefore such values can be assumed as threshold values for driver information overload.

Analyses indicated that freeway sections with five and six traffic lanes and lower sign frequencies are characterized by increased crash frequencies. This phenomenon supports the hypothesis that such traffic conditions may cause driver information underload and corresponds to sign frequency of 0.25 signs per second and less.

Additionally, test driving and associated driver behavior monitoring identified significant relationships between information load and driver behavior. Among these, the frequency of intense braking was found to increase significantly with increasing information load, as shown in Figure 3. Observations on freeways with up to four lanes per direction tended to show patterns of increasing intense braking with increasing information loads.

Similarly, test driver heart rates were found to increase with increasing information loads, particularly under heavy surrounding traffic scenarios, as shown in Figure 4. Again, similar patterns of increasing heart rate with increasing information load were observed for freeways having up to four lanes per direction.

The patterns of increasing driver heart rate, which may be synonymous with stress level, and increasing information loads were observed generally for all freeways having four or fewer lanes per direction. However, freeways with five or more lanes tended to show

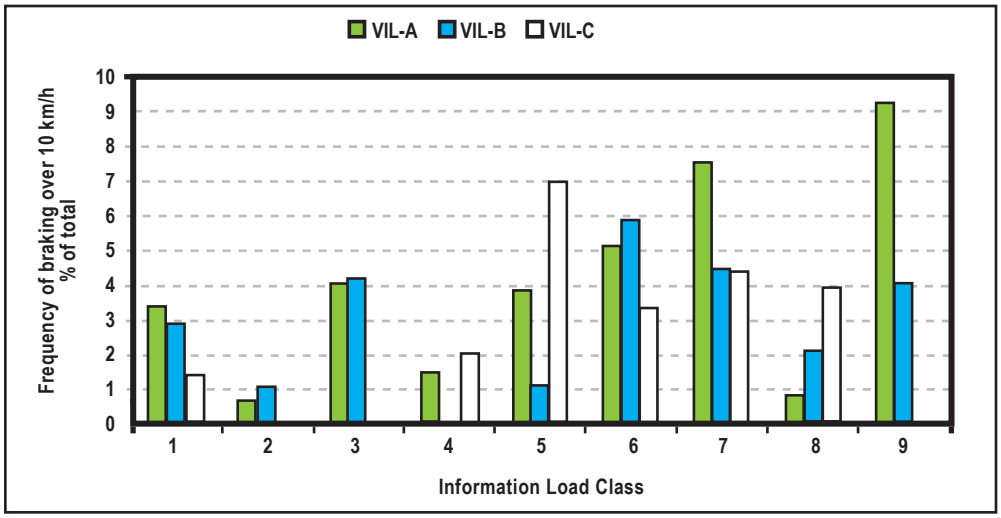

Figure 3. Frequency of intense braking versus information load for light, medium and heavy traffic interaction (VIL A, B and C)

an opposite pattern, with the highest information load levels appearing to be associated with the lowest driver stress levels. The absence of bars in the highest information load classes (information load classes 25-27) shown in Figure 5 indicates that driver heart rates never exceeded 115 percent of their non-driving rates.

Measurements of driver eye movements along with other simultaneous observations made during the test driving appear to indicate that when negotiating wide five- or six-lane freeways, drivers tend to search for additional guidance rather than feel overwhelmed by an information-rich environment.

The Researchers Recommend ...

Combining the findings leads one to conclude that the following sign frequencies correspond to optimal levels of driver performance, mental workload, and reduced driving stress:

- On two-lane freeways – from 0.16 to 0.20 signs per second (10-12 signs per mile for speed limit 60 mph).
- On three- and four-lane freeways – from 0.18 to 0.22 signs per second (11-13 signs per mile for speed limit 60 mph).
- On five- and six-lane freeways – from 0.25 to 0.29 signs per second (15-17 signs per mile for speed limit 60 mph).

A methodology for classifying urban freeways, based on the information load imposed upon drivers, was developed and implemented for Dallas, Houston, and San Antonio freeways. This methodology can be applied to freeways in any urban area to determine the current state of information load imposed upon urban freeway drivers.

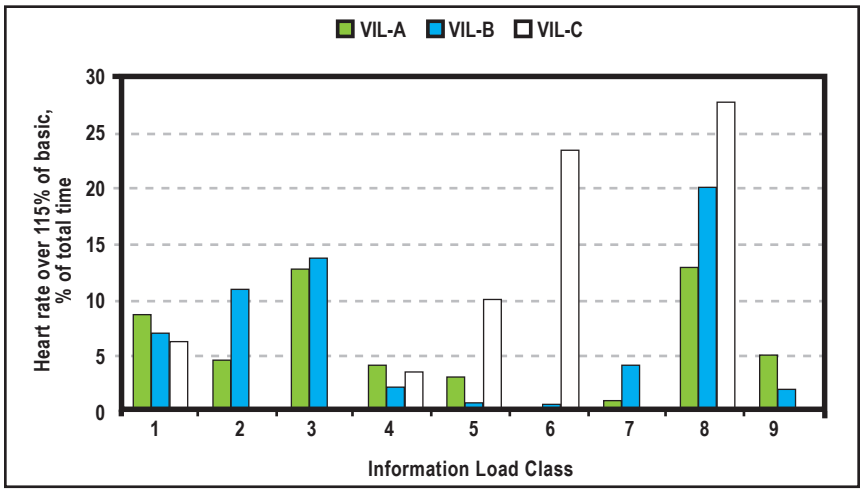

Figure 4. Frequency of driver heart rate exceeding 115% of the non-driving rate for light, medium and heavy traffic interaction (VIL A, B and C)

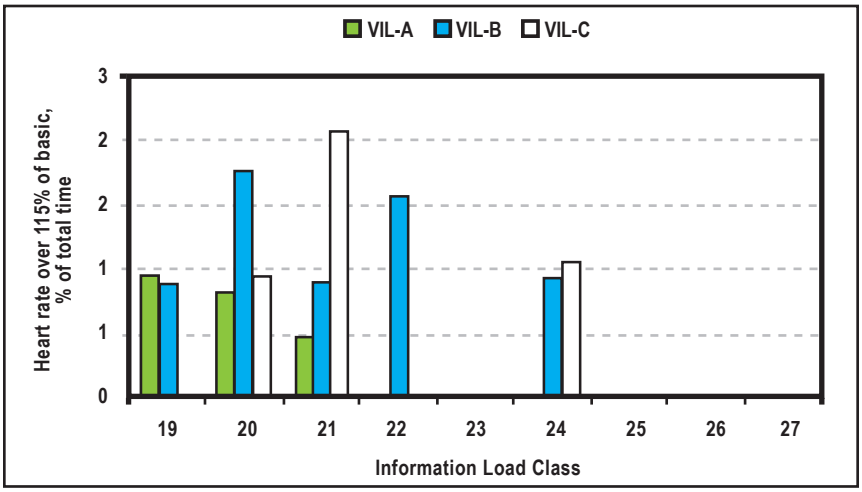

Figure 5. For five- and six-lane freeways, frequency of driver heart rate exceeding 115% of the non-driving rate for light, medium and heavy traffic interaction (VIL A, B and C)

For More Details...

Research Supervisor: Randy Machemehl, Ph.D., P.E., (512) 232-3107
email: rbm@mail.utexas.edu

TxDOT Project Director: Melanie Young, P.E., Dallas District, (214) 320-6229
email: myoung@dot.state.tx.us

TxDOT Research Engineer: Wade Odell, P.E., Research and Technology Implementation Office,
(512) 465-7403
email: wodell@dot.state.tx.us

The research is documented in the following reports:

0-4621-1 *Quantitative Description of Informational Dimensions of Urban Freeways*
0-4621-2 *Driver Responses to Urban Freeway Information Loads*

To obtain copies of a report: CTR Library, Center for Transportation Research,
(512) 232-3126, email: ctrlib@uts.cc.utexas.edu

Your Involvement Is Welcome!

Disclaimer

The University of Texas at Austin
Center for Transportation Research Library
3208 Red River #115
Austin, TX 78705-2650