

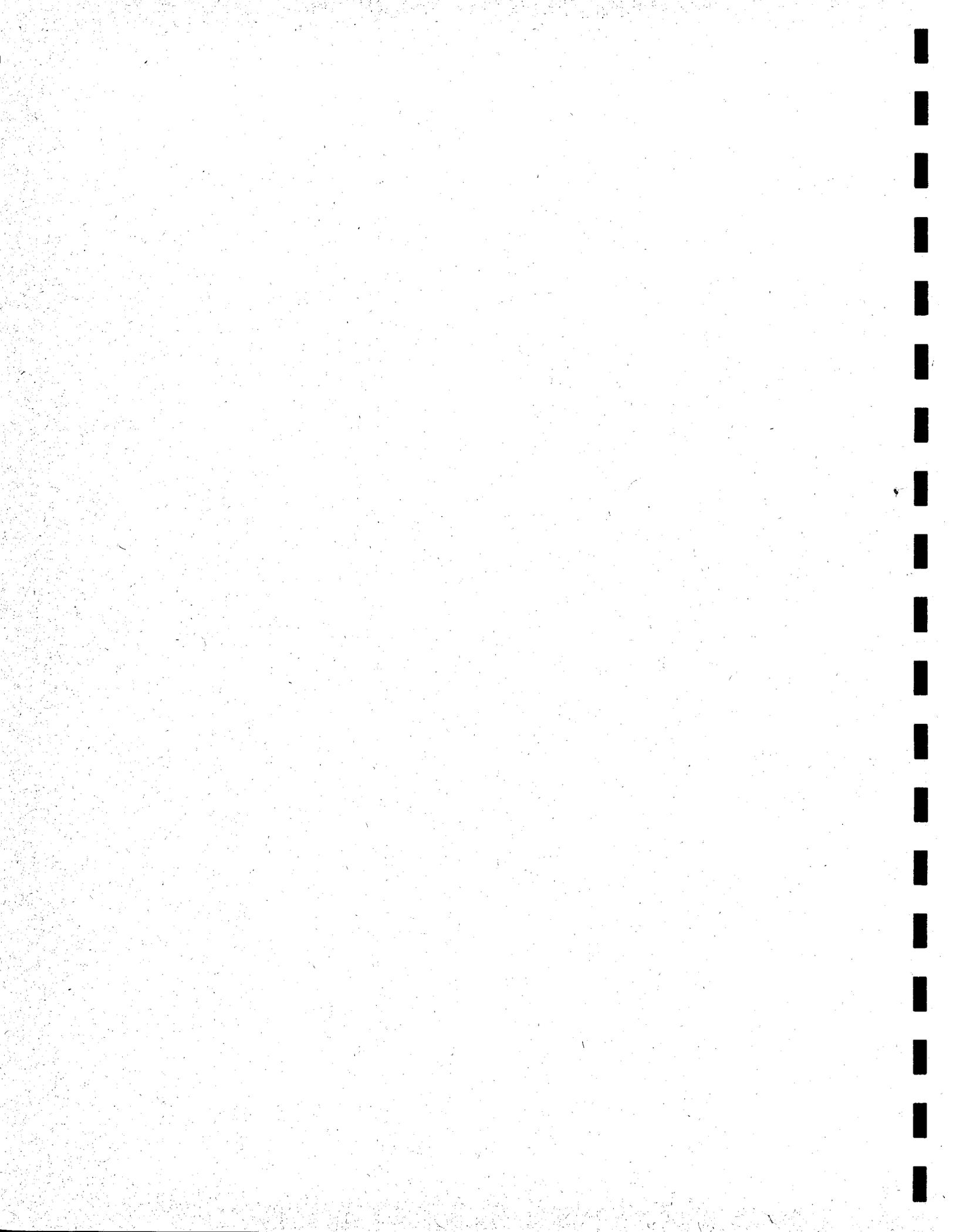


SAFETRUCK

Safetruck: Sensing and Control to Enhance Vehicle Safety

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 PB99-134629	2.	3. Recipient's Accession No.	
4. Title and Subtitle Safetruck: Sensing and Control to Enhance Vehicle Safety		5. Report Date December 1997	
7. Author(s) Lee Alexander Vassilios Morellas Sundeep Bajikar Ted Morris Heon-Min Lim Max Donath		6.	
9. Performing Organization Name and Address University of Minnesota Department of Mechanical Engineering 111 Church Street, S. E. Minneapolis, MN 55455		8. Performing Organization Report No. 10. Project/Task/Work Unit No.	
12. Sponsoring Organization Name and Address Minnesota Department of Transportation 395 John Ireland Boulevard Mail Stop 330 St. Paul, Minnesota 55155		11. Contract (C) or Grant (G) No. (C) 74708 TOC # 2	
15. Supplementary Notes		13. Type of Report and Period Covered Final Report 1997	
16. Abstract (Limit: 200 words) <p>This report summarizes the work performed during the 18-month period ending in December 1997. Researchers investigated the use of differential global positioning systems (GPS), inertial measurement, and other sensing technologies as the basis of a system that would prevent crashes. Such a system attempts to control the vehicle if it leaves the lane because the driver is incapacitated.</p> <p>The report includes in its appendices related work on driver fatigue and a bibliography on the effect of drugs and alcohol on driving behavior. The long-term goal of this research involves development of a "driver-centered" vehicle control system capable of providing lane-keeping feedback to the driver, and, if necessary, of imposing aggressive intervention strategies to take over control of the vehicle, steer it to a safe position on the shoulder, and stop it.</p> <p>This research also targets the development of "driver assistive" technologies--such as Heads Up Display and torque feedback supplied by the steering wheel--which provide information to the driver without necessarily requiring computer control of the vehicle. The highlight achievement during this funding period has been the successful demonstration of a GPS-based automated lane-keeping mode of a tractor-trailer on the Minnesota Road Research Project (Mn/ROAD) test track. The report concludes with a strategy for pursuing future deployment.</p>		14. Sponsoring Agency Code	
17. Document Analysis/Descriptors truck safety GPS preventing lane departures driver fatigue automated lane-keeping		18. Availability Statement No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161	
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 105	22. Price



**SAFETRUCK:
Sensing and Control to Enhance Vehicle Safety**

Final Report

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December, 1997

Published by

Minnesota Department of Transportation
Office of Research Services
First Floor, MS 330
395 John Ireland Boulevard
St. Paul, MN 55155

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Acknowledgments

We would like to thank Craig Shankwitz for his input at the initial stages of this project. Pat Simpkins was very helpful with the image processing algorithms used for evaluating the Differential Global Positioning System (DGPS) performance. Alec Gorjestani's role in the DGPS evaluation should also be acknowledged.

Thanks are due to Minnesota Department of Transportation (Mn/DOT) personnel including Dave Gorg and the Surveying and Mapping Section and Dixon Hoyle of the U.S. Geodetic Survey for providing us with valuable background information and continued support. We would especially like to thank Jack Herndon and others at Minnesota Road Research Facilities (Mn/ROAD) for their flexibility and assistance with the experiments. Dave Johnson of the Mn/DOT Office of Research Administration (as chair of our technical advisory panel) has always been helpful in reviewing many of our work plans, documents and reports.

This project was partially supported by Mn/DOT, and the Center for Advanced Manufacturing, Design and Control and the Center for Transportation Studies, both at the University of Minnesota, and the Federal Highway Administration of the U.S. Department of Transportation.

We would like to thank Navistar International Transportation Co. (in particular Jack Gemender), for their assistance with the acquisition of the truck, Don Krantz of MTS Systems, Inc. for his assistance with various subsystem design issues, and Sid Bennett of Andrew (now KVH Industries) and Tom Ford of NovAtel for technical assistance regarding their sensors.



Executive Summary

The SAFETRUCK program is developing and evaluating methodologies to reduce highway accidents. Our focus is presently on trucks traveling on rural roads. This technology also applies to snowplows and other vehicles which need to be out on the road under unfavorable weather conditions.

We have specifically addressed lane departure based crashes which are associated with driver behavior, e.g., driver boredom, inattention, fatigue, intoxication. We are working on both driver assistive technologies which reduce driver stress and help maintain vigilance, and on intervention strategies when the driver has lost control. In many situations, alarms and warning devices can be ineffective due to their short term effects. We have designed (based on a high accuracy Differential GPS-Novatel's RT20 system) and experimentally demonstrated for the first time (on a Navistar 9400 Tractor-Trailer vehicle) a prototype system which can take over lane keeping functions from the driver based on real time Global Positioning System (GPS) vehicle position sensing. This automated lane keeping serves as a backup in case the driver is not reacting appropriately. If loss of control by the driver is detected, the vehicle would be steered over to the next appropriate shoulder and brought to a safe stop. This human-centered steering controller can also provide haptic feedback to the driver to help keep the vehicle in the lane. (Related work on driver fatigue and a bibliography on the effect of drugs and alcohol on driving behavior are included in Appendices.)

We are working on implementing and integrating the "Virtual Bumper" concept into our current SAFETRUCK architecture. The main concept behind the virtual bumper is the notion of a "personal space" around the vehicle. When an obstacle or other vehicle intrudes into this space, a "virtual" spring and/or damper is "compressed" which results in a "force" or "torque"

which is applied through the steering, throttle and braking subsystems to effect a change in the host vehicle's motion. Since there is no physical contact and since these effects are computed based on sensed incursions, one can in effect continuously adapt the shape of the virtual bumper and the nature of the resulting "forces" on the vehicle. Simulations of these algorithms have demonstrated successful collision avoidance in a number of scenarios. Details are presented in a sister report entitled "The Virtual Bumper - A Control Based Collision Avoidance System for Highway Vehicles".

We have also focused on driver assistive technologies such as a Heads-Ups Displays (HUD) which intuitively provide feedback to the driver when normal perception is limited. We are developing these technologies for drivers that must be on the road even when conditions warrant otherwise. This is particularly the case for snowplows and for police and emergency vehicles operating under low visibility conditions due to adverse weather, i.e., driving through blizzards, driving on snow covered highways, etc. We have developed an initial laboratory prototype which projects lane boundaries (adjusted for driver head position and other geometric parameters specific to a given vehicle) on to the windshield using a HUD so that the driver can continue to steer in as natural a manner as possible even with limited. This system is based on the use of the same high accuracy DGPS-based sensing system described above. Evaluation of the above HUD prototype and of radar sensors which provide information as to obstacles and other vehicles on the road has started and will be the subject of subsequent reports.

CHAPTER 1

Introduction

This report summarizes the research work performed during the 18 month period ending in December, 1997 under the SAFETRUCK Program designation. The primary objective of our work has been to investigate the use of Differential Global Positioning System (DGPS), inertial measurement and other sensing technologies as the basis of a system which would prevent crashes due to lane departure in case the driver is incapacitated. Our long term goal is to develop a "driver centered" vehicle control system capable of providing lane-keeping feedback to the driver, and if necessary, impose aggressive intervention strategies that take over control of the vehicle and steer it to a safe position on the shoulder and stop it. Our research also targets the development of "driver assistive" technologies (such as a Heads Up Display and torque feedback provided by the steering wheel) which provide information about departure from the lane or about encroaching vehicles. These tools represent a means for providing sensory information to the driver without necessarily requiring computer control of the vehicle. The results of this ongoing research will improve the safety of driving under poor visibility conditions and on rural roads where driver fatigue is a significant issue. The incremental approach that we are pursuing is directed at minimizing the infrastructure investments needed for final implementation of these safety oriented technologies. In the following sections, we summarize the work performed and the objectives which have been met during the 1996-97 funding period. We conclude with a strategy for pursuing deployment in the future.



CHAPTER 2

Experiments with Computer Control of the Tractor-Trailer Testbed

2.1 Preview Based Control of a Tractor Trailer Using DGPS

In order to reduce the number of road departure accidents caused by fatigue and driver inattention, we have been investigating intervention strategies during critical situations, part of a human centered approach to lateral vehicle control. Alarms and warning devices are for the most part ineffective since their effects on a fatigued driver are only short term. We have designed and demonstrated a system which can take over lane keeping functions from the driver based on real time Global Positioning System(GPS) vehicle position sensing. This automated lane keeping serves as a backup in case the driver is not reacting appropriately. If loss of control by the driver is detected, the vehicle would be steered over to the next appropriate shoulder and brought to a safe stop.

We are using a preview based controller implemented on a Navistar 9400 series tractor-trailer comprised of a "pursuit" algorithm which steers the vehicle towards goal points on the road, stored in the form of a digital map. This map which represents the roadway's geometry (including lane characteristics and details regarding shoulders) is generated by previously recording the corresponding DGPS coordinates of the road.

A Novatel RT-20 second generation DGPS system is the primary sensor modality for providing feedback of the vehicle's position and orientation with respect to a global coordinate system (in

our case the State Plane Coordinate System) with a yaw rate gyro providing additional feedback.

Heading error and yaw rate are used to control the truck's steering control subsystem.

This lateral control system, the first system using DGPS for truck lane keeping on a standard road, has been successfully demonstrated through field experiments at the Minnesota Department of Transportation's Mn/ROAD (Minnesota Road Research Facilities) research facility.

Two papers were prepared and presented at the IEEE Conference on ITS (Boston, MA) in November, 1997. One documents our experiments evaluating the DGPS accuracy during truck motion (see Appendix A for a copy of the paper); while the other documents the control algorithms and the results of our experiments on lateral steering control of the truck using preview (see Appendix B for a copy).

2.2 Enhancements to the original VMEBUS based control system

We are pursuing two control prototypes. The first and older system is based on VMEBUS communication between multiple 68040 based (Motorola VME147) processors. This system has been the baseline unit for all computation, data acquisition and control for our tractor-trailer experiments.

Our real time embedded software is based on VXWORKS. We have begun to develop a less expensive alternative based on the PC platform. Developments on both these platforms are described below. More details on the VMEBUS based platform has been described in previous reports and publications.

We continued to improve the safety, performance and reliability of the original DGPS based steering controller in the Navistar 9400 truck tractor (Fig. 2.1, 2.2) that is our experimental testbed.

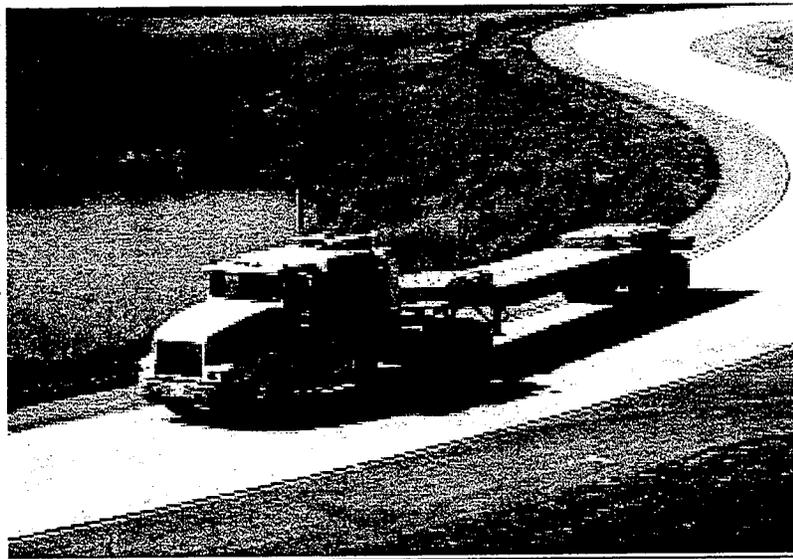


Figure 2.1. The Navistar 9400 Truck used for all our lane keeping experiments

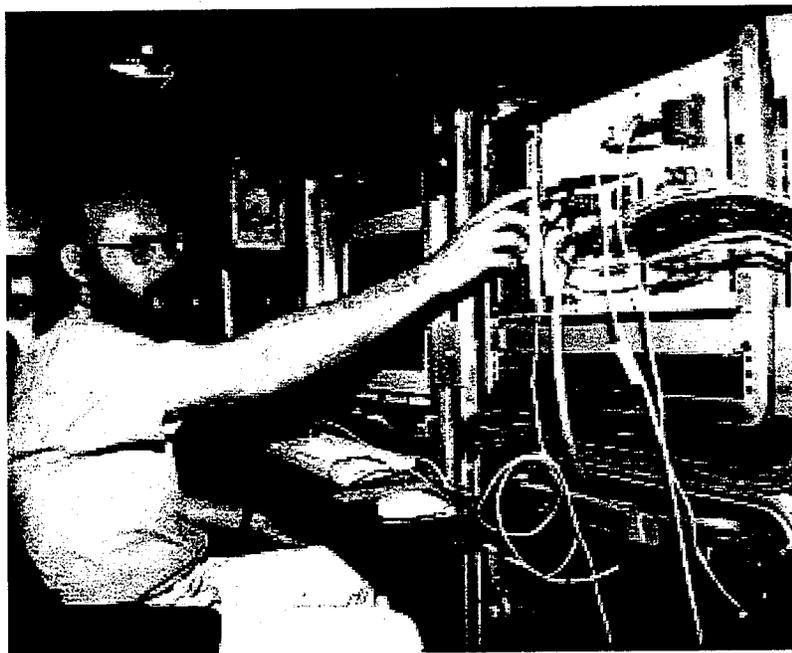


Figure 2.2 Computers in the truck's sleeper cab

The steering control system was successfully designed so that a human can drive in tandem with the controller. Torque feedback to the driver's hands, through the steering wheel, provides a sensation that helps center the truck in its lane. A direct drive torque motor design that we incorporated directly into the steering shaft made it possible to allow the driver to "backdrive" the actuator, and thereby directly feel the steering system's behavior. (see Figure 2.3a and 2.3b) This direct link between the driver and the steering control system is a critical part of our driver assisted lanekeeping system, which can either work with the driver, or can take over complete lateral control of the truck, if necessary. Providing the driver with a combined position/torque feedback sensation that is used to improve manual control is often referred to as haptic feedback.

During the 18 month of this funding period, we made a number of changes to increase the reliability and performance of the steering control system. These changes included the following:

1. Installed a new mounting platform on the truck cab roof for the GPS antenna. (Fig. 2.4)
This platform facilitated the installation of a choke ring which helped to eliminate multipath reception.



Figure 2.3a

Original steering shaft on the semi-tractor.

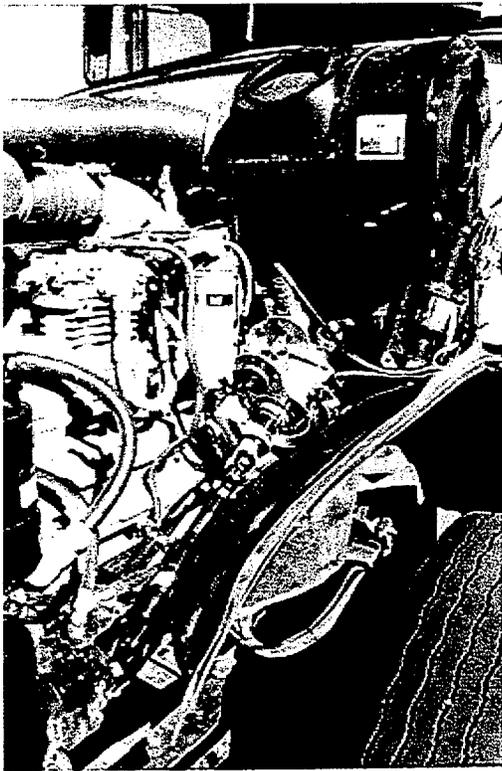


Figure 2.3b

Modified steering subsystem on the semi-tractor. The direct driver torque motor was designed around the existing steering system, so that it would not affect other components (e.g. seals in the hydraulic power steering unit). The torque motor's weight is supported by the frame rail of the truck and not by the shaft. The double U-joint designed into the shaft also allows some 'float' between the cab and the vehicle frame.



Figure 2.4 Close-up of cab showing GPS antenna mounted inside a choke centered on a mounting platform on top of the sleeper. The antenna for receiving DGPS corrections is mounted on the rear corner of the sleeper cab.

2. Changed the steering system design and increased the resolution of the steering position sensor. The steering control software was modified accordingly to accommodate the higher steering resolution.
3. Installed and tested two new 16-bit fiber optic rate gyros measuring vehicle yaw and roll. We then modified the steering controller so that it included a yaw rate term from one of the gyros. The addition of this term along with the increased resolution of the steering sensor stabilized the steering system well enough that we can now steer automatically on slippery ice and snow covered road surfaces. Earlier versions of the steering controller (April to June, 1997) without the gyro term exhibited a lateral oscillation with a period of about 5 seconds and an amplitude of approximately three feet on dry surfaces that tended to increase in amplitude when the track was slippery. This oscillation has been

successfully removed. Good lateral control was achieved successfully on snow and ice, but due to the unusual warm and dry 1997-1998 winter, additional experiments demonstrating control performance on snow and ice could not be performed. (This was not part of our original work plan anyway.)

4. Retuned the controller algorithms which resulted in a considerable improvement of the lane keeping performance of the truck on straight sections of roadway. The system was capable of autonomous driving at speeds up to 55 mph on straight roads. The maximum speed was limited only by the length of straight-aways and the road curvature on the Mn/ROAD low volume test track (see Figs. 2.5, 2.6, 2.7) without the noticeable oscillation which occurred in earlier experiments.

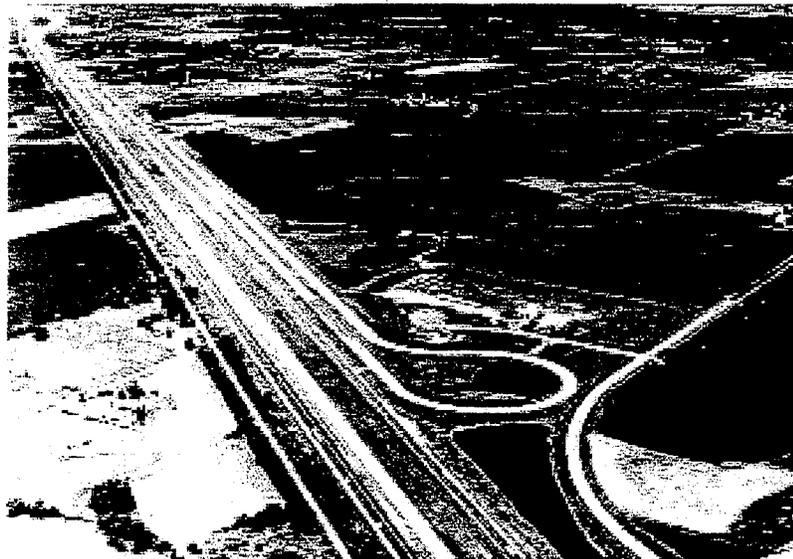


Figure 2.5 The “dog bone” shaped low volume test road used for our experiments. The research building is located just above the lower curve of the test track.

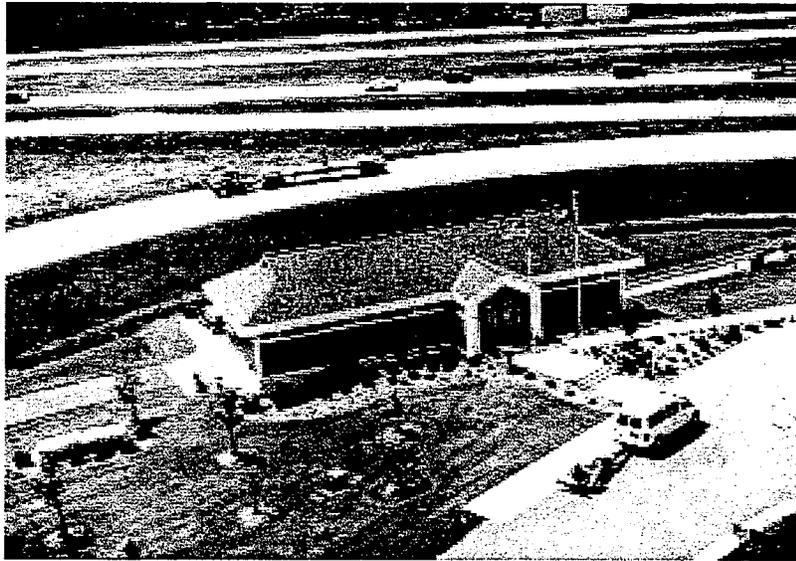


Figure 2.6 Research building at MnROAD test facility. The GPS antenna used for generating a correction signal is mounted on the roof peak on the far right (can be barely seen to the left of the flag on the right flagpole).



Figure 2.7 A view of the road curvature at the northwest end of the track.

5. Developed, integrated and successfully tested a new version of the truck's steering software that adjusted, in real time, the look-ahead distance and the gyro gains of the preview controller according to the curvature of the upcoming road segment. This modification significantly reduced the lateral errors on the curves that were observed in the past. The performance of our preview based controller compares very well with human driving where lateral errors of the same magnitude were recorded (worst case around 25 cm). Details and results are described in Appendix B.

Two safety related improvements were the addition of a securely attached seat with a seatbelt for the workstation operator in the rear cab of the truck, and the removal of all power electronics (a large 24 volt splitter and two 120 volt inverters) from the cab to separate enclosed aluminum cabinets located behind the cab.

During the course of the year we verified the robustness of the SAFETRUCK system by scheduling numerous demonstrations of SAFETRUCK's autonomous lane keeping behavior to interested parties (many of them from out of state or from other countries) while operating at different speeds and under various weather conditions including driving on snow covered roads. We also were able to demonstrate that the control system works well while the Navistar is pulling a loaded semitrailer.

2.3 Development of a new PC based control system

To demonstrate that the GPS based vehicle control systems will run on less expensive (and more rugged) hardware we implemented a second system that uses a PC (i.e. based on an "IBM PC" compatible computer) and off the shelf I/O cards to control the truck. PC compatible computers

are available in a number of configurations from standard desktops and laptops to the very compact STD and PC-104 busses that are becoming a standard in industrial control applications. Software developed on one of these platforms is readily ported to another since they all share the same basic hardware architecture. A PC based system can be installed in another vehicle (a snowplow for instance) much more readily than the larger multiprocessor VME bus system that is presently installed in the sleeper of the Navistar. We have been able to successfully control the truck using a PC as small as a 20 MHz 80386 with an 80387 numeric coprocessor and have implemented the initial versions of both lateral (steering) and longitudinal (throttle and braking) controllers on such a platform. A schematic of the PC based system is shown in Figure 2.8.

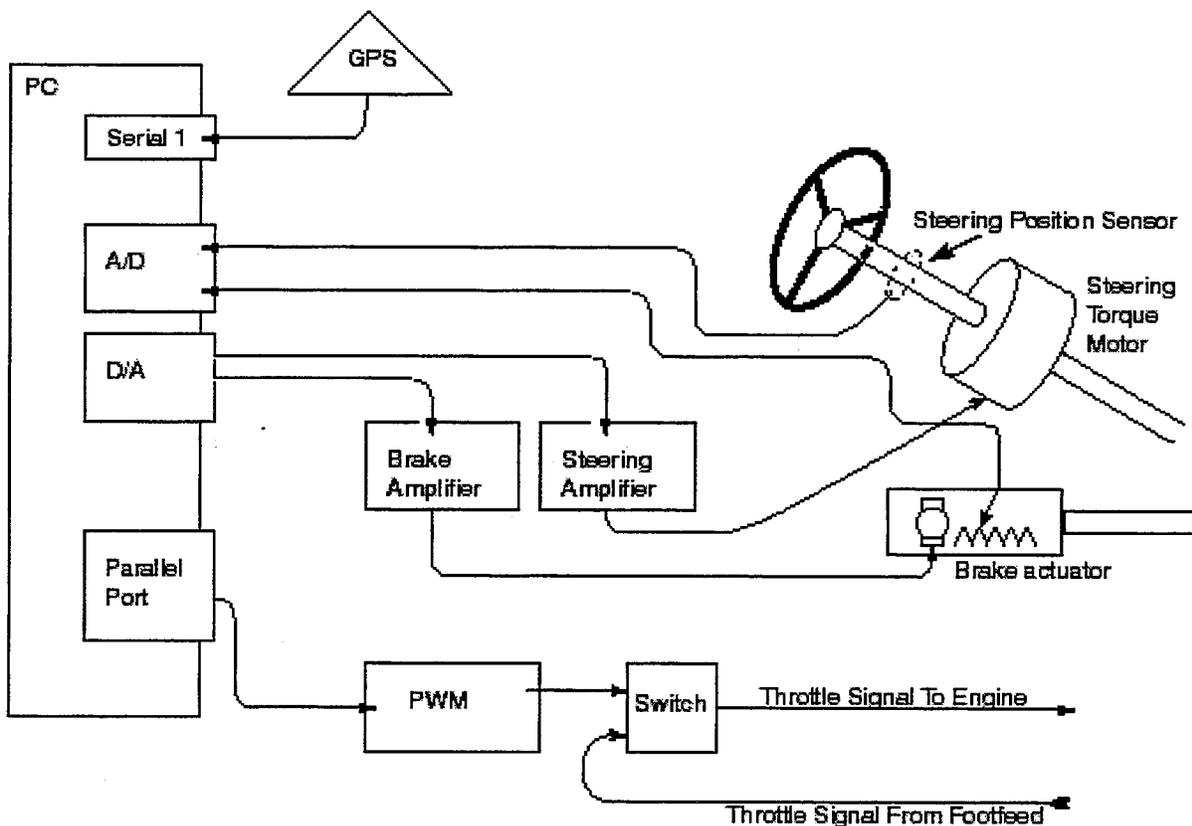


Figure 2.8 An overall schematic of the current SAFETRUCK PC based control system.

We experimented with a "look down" lateral controller using the PC based system (as opposed to the "look ahead" or "pursuit algorithm" presently used with the VME system) and found that we could use a digitally filtered history of the steering position to dampen a slow back and forth oscillation that we experience when we do not use the yaw rate gyro that is used on the VME system for the same purpose. There is a tradeoff however: the "look down" controller gains must be adjusted to a level that makes the system more sensitive to noise in the GPS signal than the VME system using the "pursuit algorithm". Work will continue on both systems to improve stability in the presence of noise and in response to rapidly changing lateral commands.

Two graphs indicating speed and actuator position vs. time illustrate the performance of the longitudinal controller and are shown in Figure 2.9. Presently both the throttle and brake actuators have software limits placed on the positions to which they can travel. The throttle has been limited to 50% (more than enough for a 400 hp engine in an unloaded truck on a closed test track). The brakes have various limits that depend on the current velocity. For example, it takes considerable braking action to keep the truck at a standstill against the pull of the idling engine when the automatic transmission shifts itself down into first gear, so the limit is increased at very slow speeds. The brake actuator has a certain amount of "stiction" that makes it resistant to precise positioning with a smooth input signal. We found it responded better to the sharp step commands shown in the lower graph of Figure 2.9.

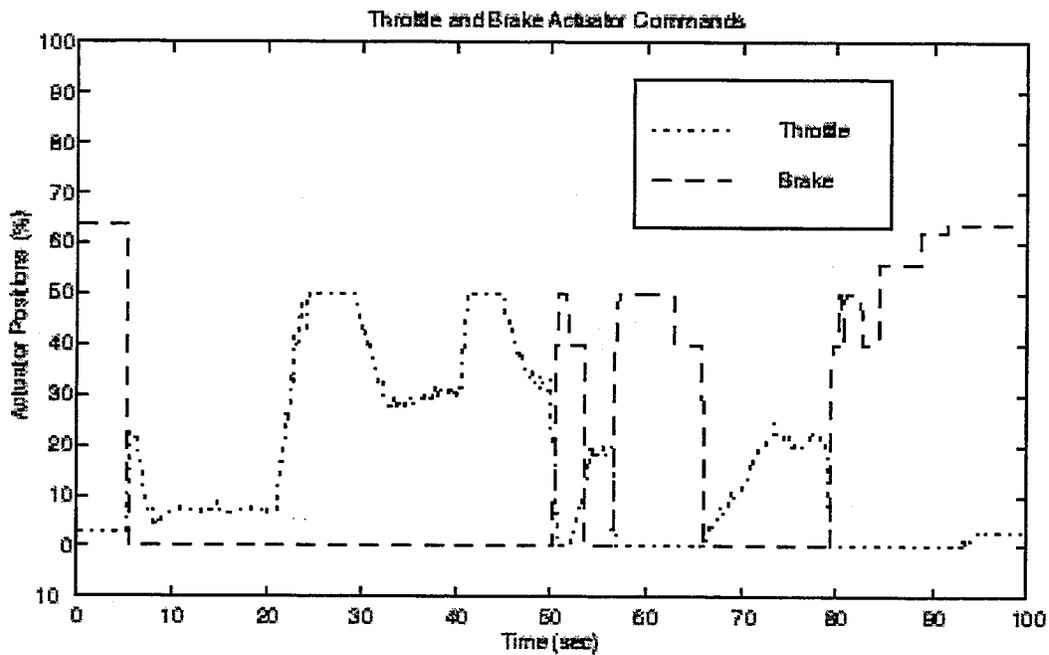
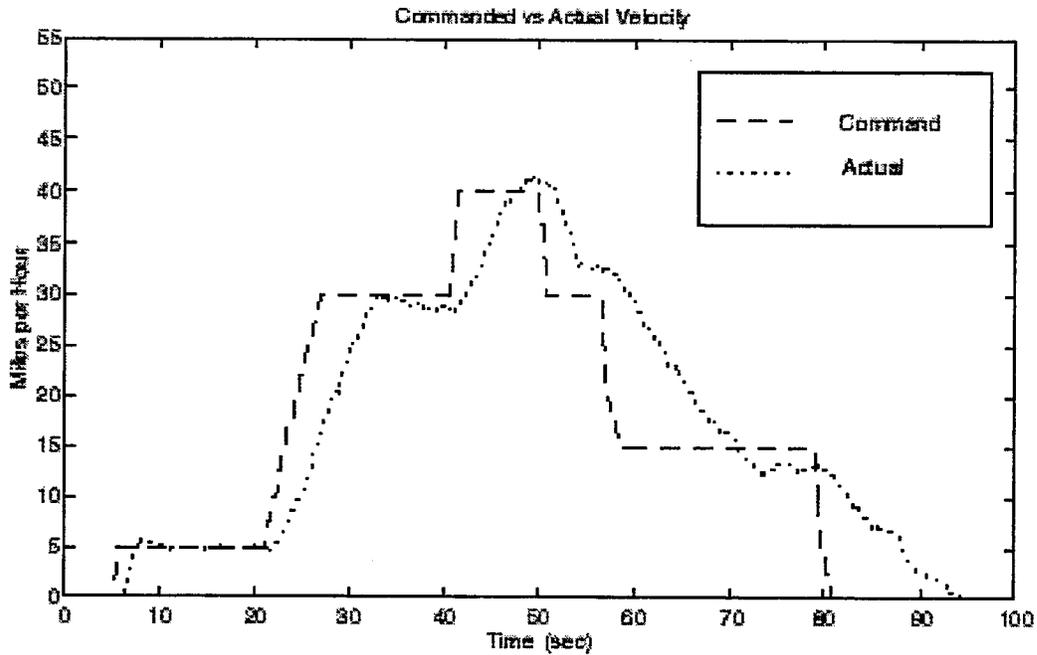


Figure 2.9 Graphs showing the response of the SAFETRUCK and its PC based longitudinal controller to a commanded velocity profile. The upper figure shows the commanded velocity and the resulting actual truck velocity as measured by the GPS receiver (5 Hz). The lower figure shows the corresponding throttle and brake positions that were set by our controller.

2.4 Evaluation of In-Vehicle GPS-Based Lane Position Sensing For Preventing Road Departure

Determining a vehicle's lateral position in a highway lane is important for many applications - preventing run-off-the-road accidents, determining erratic driving behavior based on vehicle motion, providing feedback to the driver under low visibility conditions, etc. We developed a systematic method for quantifying the dynamic performance of Differential GPS, in particular, the Novatel RT-20 DGPS unit. This is achieved by using an image processing approach.

Novatel's RT-20 Double Differencing Carrier Phase Measurement System is specified to achieve real-time positioning performance of better than 20 cm nominal accuracy. In a paper that we presented at the IEEE Conference on ITS, held in Boston in November, 1997 (included in Appendix A), we documented the experimental conditions and the results from a series of dynamic tests carried out on the RT-20 to verify its actual accuracy while on a moving vehicle. The approach that we adopted incorporates synchronized data acquisition using two separate computer systems, and experimental verification of the computational latency of the RT-20. We co-aligned a digital camera with the GPS antenna on the truck, so that accurately located square templates on the road could be imaged while the truck drove around the MnROAD low volume test track. These templates (based on floor tiles) were positioned at survey nails adjacent to the road and were precisely oriented along the North axis. The image processing scheme achieved high accuracy by taking advantage of subpixel resolution in the image processing algorithm. Since the axis of the GPS antenna was aligned with the center of the digital camera's imaging pixel field, errors could be calculated by accurately locating the position and orientation of the tiles in the image. These images were acquired at precisely 30 frames per second.

Synchronization was needed in order to align the 5 Hz of GPS signal acquisition with the acquired images. The details are described in the paper.

The image processing algorithms (not described in the paper due to page limitations in the conference proceedings) that were used to calculate the dynamic error performance specifications for the DGPS included (in order):

- Thresholded image.
- Edge Detection: Used 2nd derivative filter based on Laplace of Gaussian (LoG) Filter - (7x7 Kernel).
- Verified the presence of an edge using a 1st degree Sobel filter.
- Used a modified Hough Transform based on the magnitudes of a 1st degree filter to find the most dominant lines which framed the tile template.
- Found the intersection of lines to identify the corners of the tile.
- Calculated the orientation of the tile and the offset of the designated tile corner from the image center.

Our results indicated that the RT-20 system exhibited a mean error of 2.03 cm in the lateral direction, and 3.16 cm in the longitudinal direction (note that both lateral and longitudinal are with respect to the moving truck) while moving at speeds ranging from 15 mph through 40 mph. The corresponding error standard deviations were 1.98 cm and 34.87 cm respectively. Our main interest was in the lateral positioning performance of the RT-20, which turned out to be very good. Furthermore, we believe that the longitudinal error standard deviation exhibited by the RT-20 can be further reduced by using an algorithm that eliminates the outlier data points.

2.5 Experiments with loss of GPS signal lock

We verified the effect of GPS signal drop outs (for example when going under overpasses) on the performance of the truck's lane keeping. We looked into the new GPS dual frequency receiver technology, in which position accuracy reaches the desired specifications within 2 to 3 minutes after loss of satellite lock (rather than the 20+ minutes of our present system). We also made modifications to the Kalman filter software. The Kalman filter will provide an optimal estimate of the position of the truck in the presence of uncertain, noise in the GPS signal and in the Inertial Navigation System sensors. Testing of the Kalman filters was postponed to a later phase of the project.

We are planning experiments and a demonstration of SAFETRUCK on actual highways, rather than the MnRoad test track. These efforts to evaluate appropriate inertial measurement systems and dual frequency GPS receivers will continue in the next phase of our work.

We are in the process of examining sites for a new dual frequency DGPS base station within range of the Mn/ROAD facility.

CHAPTER 3

Human-Driver Interfaces for Steering and Road Departure Prevention

3.1 Virtual Rumble Strip

We developed and demonstrated the concept of a virtual rumble strip to warn drivers of lane departures. In this mode, instead of trying to autonomously steer the truck in the lane the navigation sensing subsystem watches for a specified lateral deviation outside of the current driving lane. The control system (i.e. the torque motor) then oscillates the steering wheel as if the truck was driving over a rumble strip embedded in the pavement.

3.2 Literature Review

In order to understand the role of lane keeping and intervention when a driver has lost control, we performed a review of the literature on the sensing methodologies for determining driver fitness. This review focused on fatigue and was completed in October, 1996. The review, developed as a presentation is included as Appendix C. A list of references follows the documented presentation. In order to evaluate other potential applications of our technology, an additional search of the literature was performed. The resulting extended bibliography (i.e. including abstracts) on driving behavior while under the influence of alcohol or drugs is attached as Appendix D.

3.3 Heads Up Display

We worked on the development and testing of a heads up display prototype (see Fig. 3.1) for providing a driver with lane boundaries when visibility is poor (for example under the white out

conditions experienced by a snowplow driver during a snowstorm). In particular, the work performed included the following:

- Ported the Heads Up Display (HUD) software developed earlier on an SGI based machine to a PC based (Windows 95 - 32 bit) computer. (The software was based on the Microsoft Visual C++ object oriented environment).
- Integrated a steering wheel/throttle/brake pedal system into the PC based HUD software for laboratory simulation, demonstration and evaluation of the HUD.
- Implemented 3-D road data structure in order to facilitate traveling on hilly roads.
- Redesigned the system and reduced the size of various subsystems so that they can be readily installed into the truck's cab, including the scan converter and power adapter.
- Evaluated commercially available GPS navigation systems e.g., DeLorme GPS and Street Atlas, in order to determine how accompanying digital maps can be used and integrated into our system.
- Modified software to accommodate inputs from a steering wheel and throttle/brake set to the HUD system. These simulated human steering wheel control (as opposed to the previously used keyboard inputs).

- Completed the calibration of the virtual focusing mechanism of the HUD system which resulted in projecting clear road images on the combiner glass, focused about 20 ft. out in front of the combiner. (See Figs. 3.2a, b, c)
- Developed a serial driver for the PC that successfully reads GPS coordinates in real time from the NovAtel RT-20 GPS receiver system.
- Installed the HUD system inside the truck. This installation consisted of a fixture to mount the HUD projector and combiner in the truck's cab so that the fixture adjusts to the driver's height. (See Fig. 3.3)
- Developed an automatic steering control simulator for demonstrating the HUD system in the laboratory or in a stationary truck. This newer version of the software included a simple vehicle dynamic model. This eliminated the need for real time steering and acceleration inputs when doing stationary demonstrations and experiments.
- Increased the computational speed of the perspective projection algorithm.
- Performed several demonstrations of the HUD system at the ITS America Conference (May 30 - Jun. 4, 1997, Washington DC), at the National Automated Highway Systems Consortium Demonstration in San Diego (Aug. 7-11) and at the 1997 Fall Maintenance Expo in Anoka (Oct. 1-2).

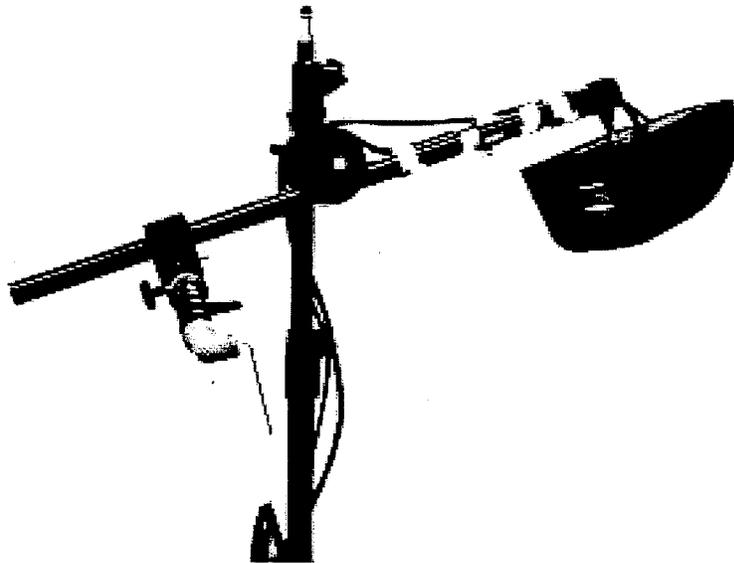


Figure 3.1 Heads up Display (Delco DataView) after-market unit. Projector on right is normally mounted to vehicle cab ceiling. Combiner is supported on left.

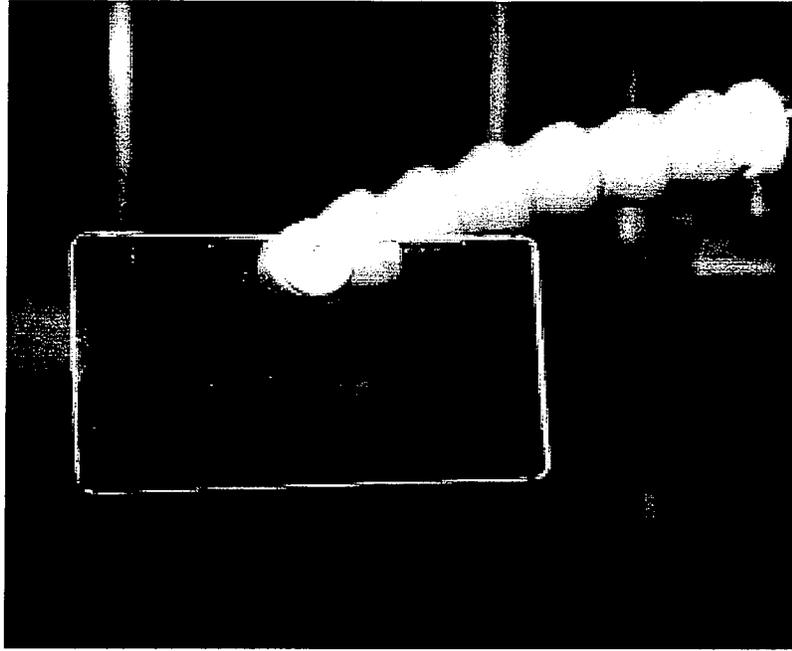


Figure 3.2 a. Heads Up Display Combiner when camera lens focus is on combiner and using flash. (Note that lane boundaries are barely visible because of flash.)

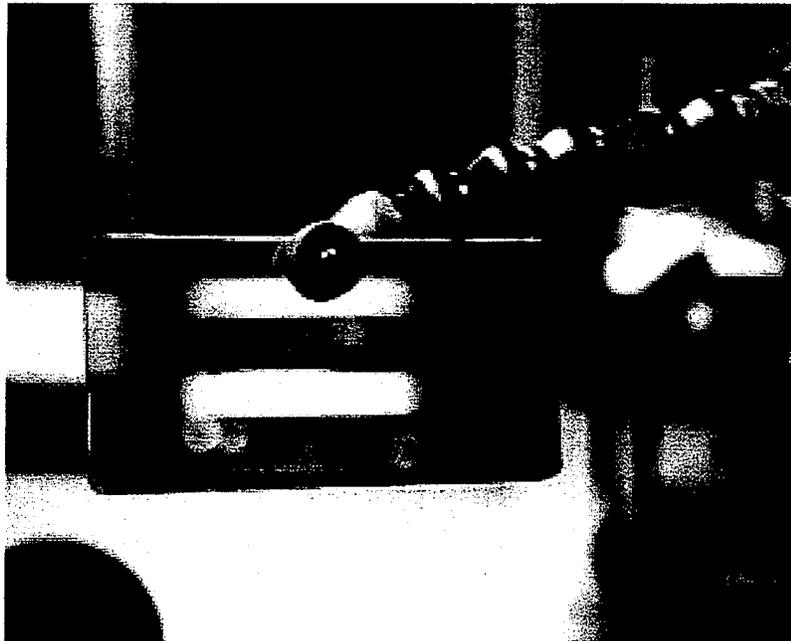


Figure 3.2 b Heads Up Display Combiner when camera lens focus is on combiner. No flash used. (Note that lane boundaries are out of focus when camera lens is focused on combiner).

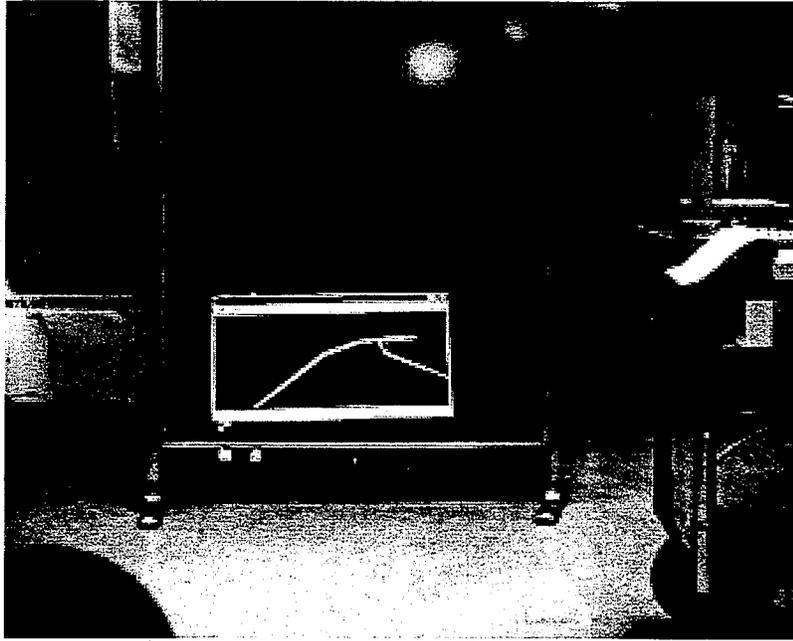


Figure 3.2 c Heads Up Display image of lane boundaries when focus of camera lens is 20 ft. out. (Combiner is barely visible. Combiner support is out of focus.)



Figure 3.3 HUD projector mounted in cab with combiner mounted over the steering wheel in the driver's field of view.

CHAPTER 4

COLLISION AVOIDANCE WARNING AND CONTROL STRATEGIES

We have developed a new collision avoidance strategy, the 'virtual bumper' and tested it in simulation for vehicles operating on highways. The virtual bumper is a 2-dimensional control strategy that provides both steering and throttle/braking actuation to maneuver a vehicle in a dynamic environment in order to avoid obstacles and other vehicles. This algorithm has its roots in impedance control and is integrated with a heuristic-based system. We developed this concept to be capable of responding to both normal and emergency driving conditions. Under all circumstances, the vehicle dynamic limits are incorporated in order to ensure that the control commands are within safe levels. The virtual bumper will attempt to avoid a collision and will at least, minimize the magnitude of an unavoidable collision (collision mitigation). This approach like all others, cannot guarantee that a collision will be avoided.

The virtual bumper is implemented using two separate impedance control loops. One loop is the longitudinal impedance control loop and controls the velocity of the host. This loop acts to maintain the desired headway to target vehicles ahead, as well as to provide emergency braking. The other loop is the lateral impedance control loop with a set of heuristics integrated into its feedback loop. This loop is responsible for maintaining lateral spacing between the host and adjacent target vehicles as well as performing lane change maneuvers. The heuristics provide a mechanism for deciding which is the desired lane for travel and controls the lane change maneuver for both normal and emergency driving conditions. When these loops execute in parallel, the host is provided with control that steers and accelerates/brakes the vehicle to avoid collisions (or at least mitigate the effect of a collision).

Most of the work done to date on control strategies for highway vehicles has been developed in a traditional simulation environment. In order to expedite development, the virtual bumper is developed in a real-time simulation environment. In this simulation environment, the control software executes on a control computer running a real-time operating system, and controls the modeled dynamic behavior of the vehicle under test. Models, which characterize the actual behavior of each sensor, interact with objects represented by solid models in the graphically simulated environment.

This type of simulation allows us to evaluate much more than the virtual bumper algorithm. For example, with this approach we are able to evaluate sensor latency issues, controller bandwidth requirements, process timing issues, etc. In addition, when the simulation testing is completed, this software is debugged and ready for implementation on the real vehicle. This form of simulation allows us to move rapidly towards real world implementation.

For this first investigation of the virtual bumper, objects in the environment are sensed using an array of radar range sensors. We introduce a methodology for evaluating the sensor placement on a vehicle driving in a highway environment. This approach involves a graphical tool which characterizes the ability of a given sensor configuration to meet our sensing requirements. We then use an iteration process to determine the final sensor configuration -- an array of fourteen radar units.

To test the functionality of the virtual bumper, several driving scenarios were evaluated. The scenarios consider both normal driving situations as well as emergency driving conditions. The

normal driving scenarios demonstrated that the control algorithm operates the vehicle similar to the way a human would. This is important because a comfortable and predictable (i.e. intuitive) system response is required for achieving driver acceptance. The emergency scenarios demonstrated that the strategy is capable of reacting appropriately while maintaining safe acceleration/deceleration levels for the vehicle. This evaluation has shown that the virtual bumper can provide safe vehicle control for a broad range of driving situations.

We prepared an extensive report that documents the virtual bumper control strategy design and the simulation results. This report is published separately under the title, "The Virtual Bumper – A Control Based Collision Avoidance System for Highway Vehicles."



Chapter 5

Outreach Activities

The first successful public demonstration of the SAFETRUCK vehicle navigating the MnROAD low volume test road occurred at the April 10-11, 1997, meeting of the Automated Vehicle Controls and Safety Systems (AVCSS) Committee of ITS America, held in the Twin Cities.

We have reported on our work in a number of settings. The following have been presented and published:

Morellas, V., Morris, T., Alexander L., and Donath, M. " Preview Based Control of Tractor Trailer Using DGPS for Preventing Road Departure Accidents", Proceedings of the **IEEE Conference on Intelligent Transportation Systems, ITSC'97**, Boston, MA, 1997.

Bajikar, S., Gorjestani, A., Simpkins, P., and Donath, M., "Evaluation of In-Vehicle GPS-Based Lane Position Sensing for Preventing Road Departure", Proceedings of the **IEEE Conference on Intelligent Transportation Systems, ITSC'97**, Boston, MA, 1997.

Schiller, B., "The Virtual Bumper - A Control Based Collision Avoidance System for Highway Vehicles", **M.Sc. Thesis, University of Minnesota**, October 1997. A Mn/DOT report (slightly modified) under the same title has also been submitted.

We won second place in *GPS World's* 1997 Showcase Applications Contest (July 1997). A brief description of our work appeared in the August 1997 issue of *GPS World*.

KARE 11 TV devoted a segment of its 10:00 o'clock news program on September 9th, 1997, to our work relating to the SAFETRUCK and HUD system.

Our work was cited in a number of national publications. Reference to our work appeared in:

- Larson, R. "An Ideal Candidate", *Traffic Technology International*, Feb/Mar, 1997, pp. 80-84.
- "Researchers Using GPS for Crash Avoidance", *ITS World*, Sept/Oct, 1997. pp. 20-21.

CHAPTER 6

Conclusions

We have for several years been pursuing safety as a top priority in our research and development efforts towards enhanced driver assistive systems for heavy vehicles, both for the tractor trailer and most recently for a snowplow.

We are focused on improving the safety of rural roads. Crashes on rural roads, especially 2-lane roads, account for a disproportionate number of fatalities and severe injuries compared to crashes in urban areas and on urban and rural freeways in Minnesota. A third of the crashes on Minnesota rural roads occur due to inadvertent lane departure, often because of driver fatigue. Even though only about 50% of the vehicle miles traveled are on rural roads, a strikingly consistent 70+ percent of fatal crashes in Minnesota occur on these roads. These numbers are representative of many states and are not unique to Minnesota. All agree that most accidents are due to human error. We feel that a focus on technologies that assist the driver will reap the greatest gains in the shortest term.

For northern tier states, solutions for vehicles traveling on rural roads must be compatible with their northern climate: extreme cold temperatures; large and rapid temperature swings; and, heavy and blowing snow along with the action of snowplows on the road surface. Lane stripes deteriorate so quickly that they must be repainted every year in urban areas and every two years in rural parts of the state. These conditions limit the likelihood that infrastructure-dependent solutions (especially, those with forms of sensing that must be applied on or in pavement) will be deployed quickly and broadly enough to take advantage of the potentially impressive safety

benefits possible in the near term (5 to 10 years). For the above reasons, much of our research to date (described in this report) has involved the use of differentially-corrected GPS as the tool for vehicle guidance. Our research and demonstrations to date have demonstrated for the first time that DGPS can be used for lane keeping. Much however remains to be done.

We estimate that the complexity and cost of in-vehicle systems to support any of the currently proposed road sensing systems will be approximately the same. The key for realization of the potential safety benefits will be deployability of both the in-vehicle and infrastructure elements. To address the majority of road miles where our worst safety problems exist, we believe deployment of base stations to provide differential corrections for GPS signals is more feasible in the near term than other alternatives. This is certainly true for those portions of the country that are not mountainous, and when other applications of DGPS can be used to leverage the installations costs of base stations.

Over the one million mile and/or ten year operational life of a maintenance or commercial vehicle, there are many more accidents per truck than per passenger car (through no fault of the professional truck driver, who often has a safer driving record and more experience). An investment in safety technology by the maintenance agency or a truck operator can be amortized over a longer period than the same investment by a car owner and represents a smaller fraction of the cost of the vehicle. As such, we feel that snow plow and commercial freight operators are likely to be the first users of such technologies. Furthermore, professional truck drivers represent a more homogeneous group for testing and evaluating technologies

Since truck manufacturers are integrators and acquire technologies as needed to meet the individual customer's requirements, they are more likely to take advantage of new developments by other suppliers and are not constrained to only consider technologies that can be scaled to very high manufacturing volume. The American truck manufacturing industry is fragmented into eight players with margins inadequate to directly support much internal investment in R & D. As such, they are more receptive to trying concepts that can be shown to be effective and viable. However, given their size and market, they are averse to risk. As such, the trucking industry represents a market where government leadership is needed to help establish industry wide collaborative organizations which are capable of integrating and performing objective evaluations of new technology which may reap significant near-term benefits.

The benefits are not insignificant for the rest of the driving public. Statistics show that the victims of truck accidents are often not the truck drivers themselves. Rather, over 85% of associated fatalities are the people around the truck, not in it.

Poor visibility conditions cause a large percentage of crashes each year. The inability to see road boundaries, obstacles, and other vehicles on the road is especially of concern during the winter. Snowplow drivers in particular are affected because they must often drive when visibility is poor, when roads are snow covered and lanes are, therefore, hard to discern. There are serious safety and economic repercussions if snowplows can't do their jobs. By focusing attention on technologies that help the snow plow operator, we help the rest of the driving public, whether it is by keeping the roads open to the movement of people or freight, or by facilitating the passage of emergency vehicles.

We feel that technologies which improve truck safety and serve to assist the driver will most likely come to market first and therefore will lead the rest of the industry to improvements. Efforts to develop and deploy these technologies will be enhanced by public investment. Mn/DOT operates about 800 snow plows statewide. The number of snow plows in Minnesota is many times more when county, city and private fleets are considered. The number of snow plows in North America are many times more than what exists in Minnesota when other snow belt states and Canada are considered. If new technologies can be demonstrated as credible, then this vehicle base might be large enough to support additional private investment in heavy vehicle technology development. If these same technologies are transferable to the commercial vehicle fleet and small vehicles, and if prices drop, the potential safety benefits can be multiplied dramatically.

It is our belief that public support of technologies to enhance snow plow safety and productivity make them a prime target for early deployment, testing and evaluation. The safety and productivity gains due to these cross-cutting technologies apply equally as well to commercial vehicle fleets. Once proven on snow plow platforms, they are likely to migrate to the commercial vehicle platforms. As the market size increases, prices will eventually drop so that they become cost-effective for transit fleets and eventually for private automobiles.

APPENDIX A

Evaluation of In-Vehicle GPS-Based Lane Position Sensing for Preventing Road Departure Accidents

**(This is a copy of the paper, which was presented and appeared in the Proceedings of the
IEEE Conference on ITS, Boston, November, 1997. References are included.)**



Evaluation of In-Vehicle GPS-Based Lane Position Sensing for Preventing Road Departure

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Abstract—

Determining a vehicle's lateral position in a highway lane is important for many applications - preventing run-off-the-road accidents, determining erratic driving behavior based on vehicle motion, providing feedback to the driver under low visibility conditions, etc. We present a systematic method for quantifying the dynamic performance of Differential GPS, in particular, the Novatel RT-20 DGPS unit. This is achieved by using an image processing approach.

Novatel's RT-20 Double Differencing Carrier Phase Measurement System is specified to achieve real-time positioning performance of better than 20 cm nominal accuracy. This paper documents the results from a series of dynamic tests carried out on the RT-20 to verify its actual accuracy while on a moving vehicle. The approach adopted here incorporates synchronized data acquisition using two separate computer systems, and experimental verification of the computational latency of the RT-20. The image processing scheme used for this analysis achieved high accuracy by taking advantage of sub-pixel resolution in the image processing algorithm.

Our results indicate that the RT-20 system exhibited a mean error of 2.03 cm in the lateral direction, and 3.16 cm in the longitudinal direction (note that both lateral and longitudinal are with respect to the moving truck) while moving at speeds ranging from 15 mph through 40 mph. The corresponding error standard deviations were 1.98 cm and 34.87 cm respectively. Our main interest is in the lateral positioning performance of the RT-20, which turns out to be very good. Furthermore, we believe that the longitudinal error standard deviation exhibited by the RT-20 can be reduced further by using an algorithm that eliminates the outlier data points.

I. BACKGROUND

The University of Minnesota, in conjunction with the Minnesota Department of Transportation, is investigating means for reducing roadway departure incidents typically associated with driver fatigue. As part of this program, we are working on highway lane sensing strategies that can robustly operate under road and weather conditions typical of northern climates, and guidance systems that are capable of aggressive intervention, i.e. take over vehicle control in case the driver of the vehicle becomes incapacitated for whatever reason.

The methodology and experiments described here, represent the second phase of our efforts towards characterizing the NovAtel RT-20 differential GPS (DGPS) receiver for real-time dynamic positioning. Furthermore, we intend to use this or other DGPS in conjunction with inertial measurement for evaluating the ability of radar to detect obstacles under regular and adverse weather conditions. Recently, we also demonstrated the feasibility of using DGPS position information for projecting lane boundaries to the

driver using a Heads-Up Display (projected on the front wind-shield) as an approach towards aiding driver perception of road edges and helping the driver make "informed" maneuvering decisions under poor visibility conditions.

The measurement methods for evaluating the dynamic accuracy of this or other DGPS are equally applicable towards characterizing many other lateral position sensing systems (eg. magnetic tape, vision based systems etc.). We begin with a description of our experiment design, and then give a detailed account of the evaluation results for the NovAtel RT-20 Differential GPS.

In the first phase of DGPS evaluation [1], we found that the Novatel RT-20 exhibited reasonably low error levels despite the fact that our experimental design at that time did not feature absolute synchronous data acquisition. However, even in a non-synchronous data acquisition mode, we are able to use the RT-20 as a principal lane-keeping sensor [5]. We re-designed our experimental setup to allow for time-stamped synchronous data collection. The results obtained in this second phase of DGPS evaluation show that the DGPS performs better than previously reported [4]. We are now working on modifying our controller to use the more efficient mode of data collection described further in this paper.

This paper also features a discussion on the internal latency of the RT-20, and presents our approach used for experimental measurement of the RT-20's internal latency.

II. EXPERIMENTAL DESIGN

The ground truth used for all these experiments was the set of pre-surveyed location coordinates in the State Plane system (referred to later as survey-nails), lining the Mn/Road research facility's low volume test road. Figure 1 illustrates the Mn/Road pavement test road and the survey-nails along the track. We ran several experimen-

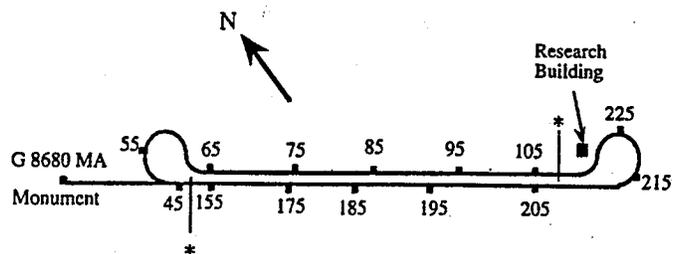


Fig. 1. Mn/Road Test Facility (Wright County, MN) showing survey-nail locations (from Bodor et al [1]).

tal runs using survey-nails numbered 194 through 179 (in that order while travelling in the North-West direction) for the experiments described here. White ceramic tiles measuring 12"x12" (accurate to within 0.1 mm) were placed at each survey-nail such that one corner of each tile was located exactly at the survey-nail. The tile corners that were placed exactly on the survey nails were marked for later reference during the image processing. The tiles were aligned with the South-North axis in order to verify the orientation angle made by the truck during the runs. The white tiles provided a good contrast against the color and texture of the road for image processing. Figure 2 depicts the principle of relative measurement used in our evaluation. DGPS specified positions were compared with those of the pre-surveyed survey-nails in image processing, and error offsets were generated. This is described in section 4. We aligned a CCD camera with high shutter speed (1/4000 sec) directly below the GPS receiver antenna and mounted them as a unit about a foot off the side of the truck (see Figure 3). A computer-controlled time-stamp VCR (JVC BR-S822 DXU) recorded the images of the tile from the camera and encoded each frame with a time-stamp.

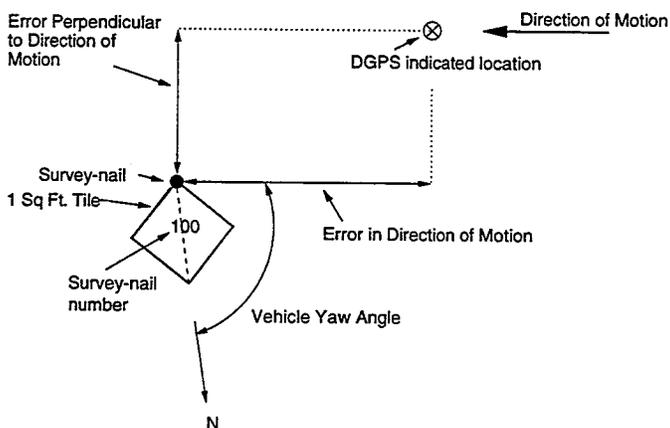


Fig. 2. Calculation of Dynamic Errors based on Tile Images

The real-time accuracy of this VCR was specified to be no worse than 1.8 seconds per hour (about 1 part in 2000). We used two separate computer systems to accomplish the synchronized data collection, which was the most important feature of these experiments. A PC laptop (C1) running the Novatel WinSat software was used to record the data logs sent out by the RT-20 over the COM 1 serial port. While position data was logged regularly at a rate of 5 Hz, GPS time-stamp data was logged in response to triggers supplied by the second computing system, viz. a Motorola MVME 147 embedded processor running VxWorks (C2). During each run, C2 sent out "mark pulses" at regular intervals of 200 ms (frequency of 5Hz) to the "mark input" of the RT-20 system. For each pulse sent out, C2 recorded the corresponding time-stamp from the VCR and the rate gyro data, while C1 recorded the GPS time-stamp sent out by the RT-20, and also the other data logs specified at startup. Figure 4 shows the signal timing diagram that was used as a reference in the present experimental design. The

first row illustrates the "mark pulse" (specified by Novatel Communications Ltd.). The second row shows the mark time log referenced as the "MKTA GPS time-stamp signal" corresponding to the instant of detection of the falling edge of the "mark pulse" by the RT-20, that is sent out to C1. Row 3 shows the P20A position data signals as bands of pulses packed together in sets regularly spaced at 200 ms. The next two rows show the VCR time stamp data (corresponding to the falling edge of the mark pulse), and the gyro data, that are recorded (by C2) after the "mark pulse" is sent out by C2. Figure 5 illustrates the interconnections between the different pieces of hardware used in the setup. Note that for the present set of survey nails, it was not necessary to use the rate gyro data for computing any geometrical compensations.

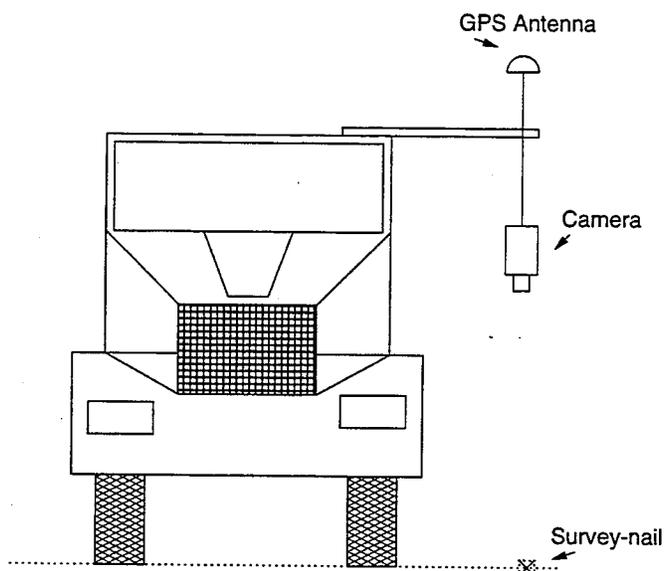


Fig. 3. Measurement Setup for Evaluating the DGPS

Attempts were first made to extract the GPS computed data from the RT-20 using one of the available built-in transputer links, based on the idea that such an approach might possibly eliminate the delay involved in serial data acquisition. However we ran into complications with the availability of a necessary synchronizing clock signal accurate to within 40 ns, and developing a custom interface using a link adapter. Further research revealed that the primary cause for the quoted 70 ms nominal latency in the data log was the high processing overhead on the transputer, and as such, "faster" data acquisition would not change the basic latency.

III. EXPERIMENTAL PROCEDURE

Two discrete sets of experiments were conducted. One for the actual GPS data collection with the RT-20 for accuracy testing, and the other set for examining the latency in the data log transmitted by the RT-20 over its serial port.

A. GPS Data Collection

Eight runs were made along the portion of the Mn-Road track identified earlier, at speeds ranging from 15

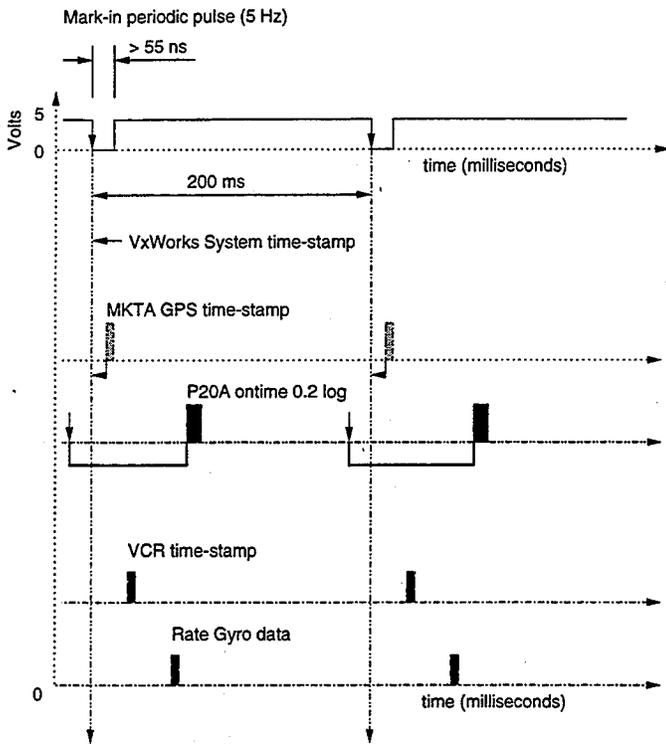


Fig. 4. RT-20 signal timing diagram

mph through 40 mph. These runs were done one after the other spanning over 2 hours. Before starting the first run, enough time (approximately 45 minutes) was allowed for the RT-20 to converge to an accurate solution. We used the P20A position data log along with the MKTA GPS time-stamp data log at 9600 baud and monitored the differential correction flag to ensure that differential correction signals were being received.

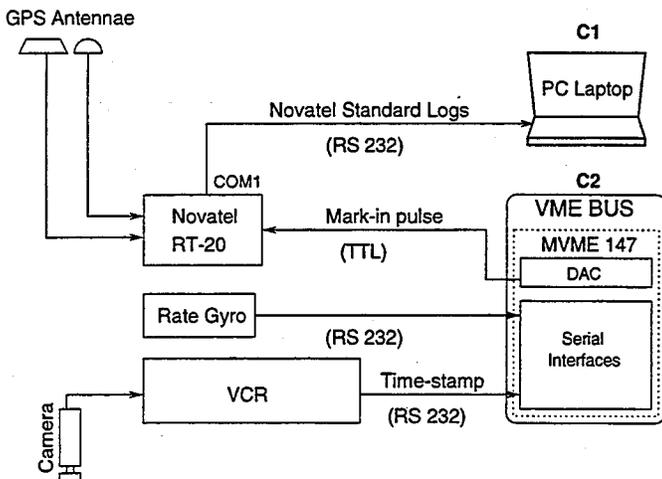


Fig. 5. Data acquisition setup

B. Latency Measurement

We define the computational latency of a GPS position data log transmitted over either the COM1 or COM2 by the RT-20 unit as the time period between the instant

at which a measurement in space corresponding to a transmission was made, and the instant at which the serial transmission began. Note that the computational latency together with the data acquisition delay (time required for the data to travel on the serial line to the host data acquisition computer) comprises the total latency associated with a given data log.

With technical guidance from NovAtel, we were able to measure the latency of the RT-20 using signals that are available at the output connectors of the unit. We used

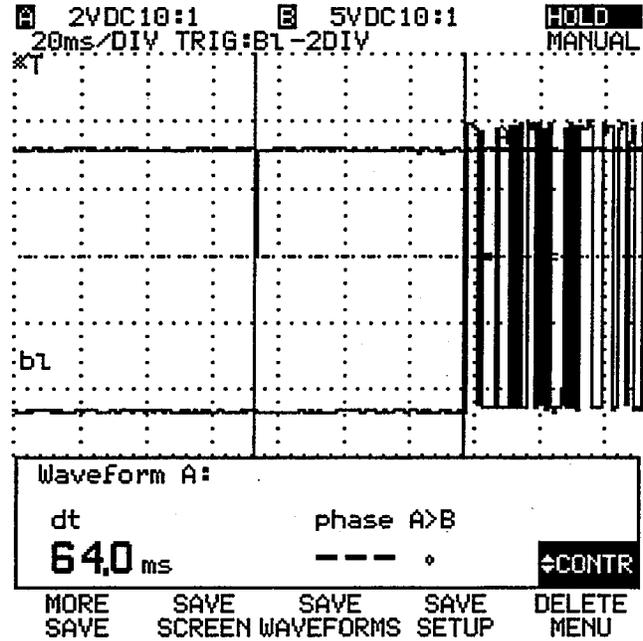


Fig. 6. Image of scope meter screen used for Latency Measurement. 'dt' is the time measured between the two cursors = 64ms. The first vertical line represents the first cursor, it overlaps with the "Measurement made" signal which is a single falling spike. The second vertical line to the right of the first represents the second cursor, it is placed at the first rising edge of the data transmission signal from the RT-20.

the following signals:

- "Measurement made" signal = Pin 3 on the DB 9 connector marked as I/O on the RT-20 unit.
- Ground for "measurement made" signal = Pins 6,7,8 on the I/O DB 9 connector.
- Serial data was acquired over the COM1 line (DB 9: Pin 3).
- Ground for the serial data was provided on COM1 line (DB 9: Pin 5).

All measurements were made with a scopemeter (Fluke 105B Scopemeter Series II) which had provision for freezing the display of waveforms to be measured; this helped us make accurate measurements using the provided cursors. Figure 6 shows a sample latency measurement setup on the screen of the scope meter. The time-phase difference between the "measurement made" signal and the first appearance of the serial data is the computational latency (shown as 64 ms in Figure 6).

IV. DATA PROCESSING

We processed only those GPS data that had a corresponding reference measurement (based on a tile image stored by the VCR at that time instant) against which to determine its absolute accuracy. Subsequent steps involved the conversion of position coordinates provided by GPS (in degrees latitude, longitude) to State Plane coordinates, the determination of the error offsets using the data from the images, and conversion of final errors back to the truck (i.e. the local travelling) coordinate system. Since this experimental design used GPS time-stamps to achieve record matching in the time domain, the position estimates provided by the P20A RT-20 log were interpolated based on their time-stamps, and the corresponding time stamps provided by the MKTA RT-20 log. Each P20A log captures the time at which satellite data was received and the position solution computation began. The MKTA time-stamp captures the GPS-time that is aligned with the VCR frame time-stamp. We use the MKTA time-stamp to interpolate the position stored in two consecutive P20A logs. Thus for every VCR frame, we have a corresponding GPS specified position. Image processing of the VCR frame results in the identification of the true position of the truck at that instant. This is then compared with the GPS specified position, and the error is determined.

A. Image Processing

The Image Processing Subsystem (IPS) consisting of a group of appropriate algorithms, was developed in order to extract the error "offsets" from the images of tiles. The images were first digitized from the video cassette taped on the JVC VCR, using a Silicon Graphics workstation. Each image (Figure 7 shows a sample video image) was then processed using the IPS. The IPS is briefly described below.

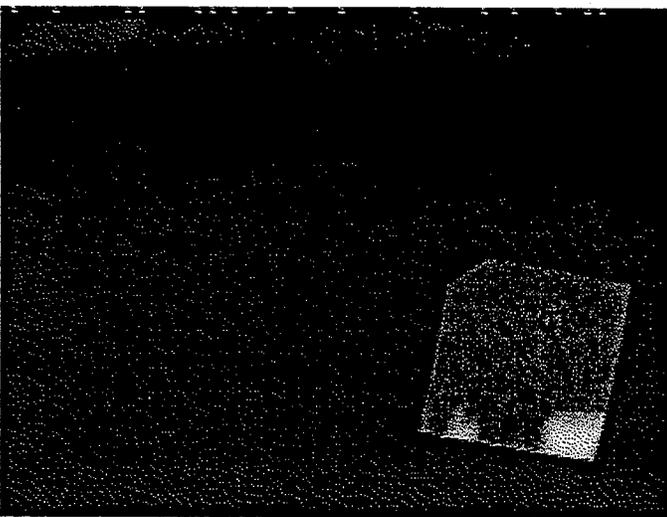


Fig. 7. Sample Video Image of a Tile (located at Survey Nail number 97). Arrow points to the Survey Nail, and is aligned along North-South i.e. arrow points in the North direction.

General Description of the IPS : After the image file name is specified, the IPS loads up the image. This is

followed by specifying the location of the "mask" window (of pre-determined size dependent on the true size of the tile) such that the mask surrounds the tile in the image. Separate routines then perform the edge detection (using a Laplacian of Gaussian Kernel), and line fitting (using the Hough Transform) operations on the tile. Next the program prompts for an identification of the tile corner 'C' at which the survey-nail was located. This is done manually based on visual recognition of a marking on the corner of the tile. This could have been automated but the time for developing the code was limited. The IPS proceeds to compute the error offsets (which from the IPS point of view are the coordinates of the corner 'C' w.r.t the center of the image) and the orientation angle of the truck (which is the angle made by the marked diagonal of the tile with the horizontal image axis in the clockwise direction). The IPS then creates a new record in the data file "info.asc" for the processed image and writes all the relevant computation results described in the previous section.

Other items are briefly described below:-

- Input parameters to the IPS include the true tile size (e.g. 12"), and the name of the image file containing that tile.
- The Image file name and the position of the mask (approximately centered over the tile in the image) are manually entered.
- The processing time per image is about 15 seconds.
- The Resolution of all the images processed was based on NTSC (640 x 480 pixels).
- The IPS generates results with sub-pixel level accuracy.
- A dynamic calibration is performed based on the true tile size for every image. Dimensionless scale factors ScX and ScY (in the X and the Y directions respectively) are returned in the record for that image in the output data file. The offsets (in the X and the Y directions) reported by the IPS in the output file are divided by ScX and ScY respectively to get the values of the offsets in actual units (inches).

V. RESULTS AND DISCUSSION

Figures 8 and 9 show the lateral and longitudinal errors that we determined in the RT-20 position solution. The mean lateral error was found to be -2.03 cm, while the mean longitudinal error was -3.16 cm. The corresponding error standard deviations were 1.98 cm, and 34.87 cm respectively. We collected 91 data samples from 8 runs over the portion of the track indicated earlier. This represents a statistical level of confidence of 99 percent.

Note that the longitudinal errors in this case do not need to be compensated for latency. Synchronization and record matching for data processing are both done on the basis of GPS time-stamps, which indicate the exact time at which the signals were captured from the GPS satellite, to which the finally computed GPS data correspond. It is not necessary to know when the computations were actually completed (start-time + latency) inside the RT-20; because in this experimental design, we do not "synchronize" based

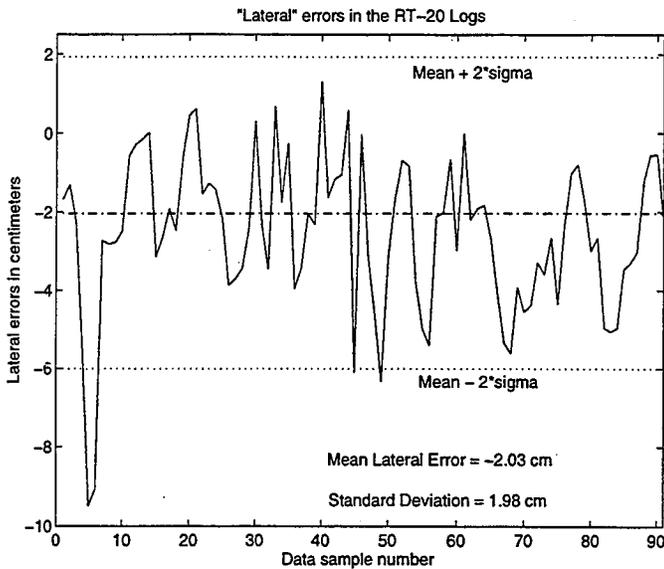


Fig. 8. "Lateral" Errors in the RT-20 Position Solution (for eight runs from Survey Nail number 194 to Survey Nail number 179 at speeds ranging from 15 mph to 40 mph)

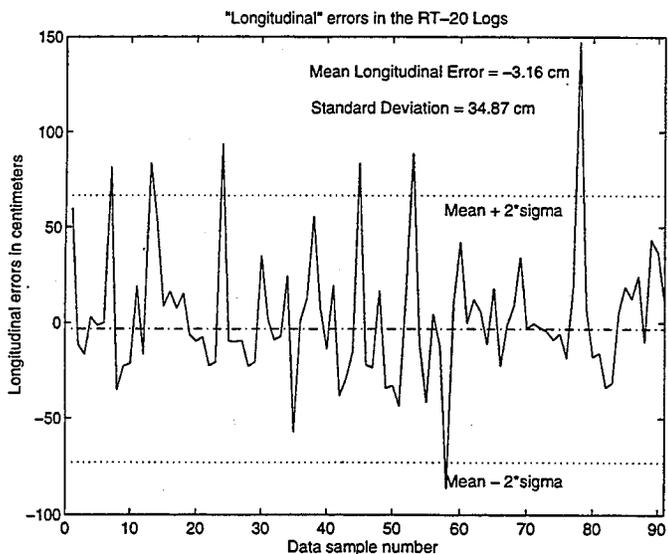


Fig. 9. "Latency Compensated" Longitudinal Errors in the RT-20 Position Solution (for ten runs from Survey Nail number 87 to Survey Nail number 105 at three different speeds)

on the data acquisition, but rather on the initial capture trigger data and its time-stamp.

Several groups have evaluated DGPS for applications requiring significant dynamic accuracy requirements. Studies such as that at SRI [2] categorize GPS performance based upon the convergence algorithms used. According to the information presented in that study, GPS receivers using the narrow correlator technology equipped with robust floating point ambiguity resolution techniques should exhibit dynamic accuracies at the 10 cm level. It seems that the Novatel RT-20 does much better than 10 cm if appropriately used.

The method presented here can be applied to the accuracy measurement of a variety of other sensors also. For

example, if a rate gyro is to be tested, we can use the angle information derived from image processing to compute the rate of angle change, and compare with the measurement provided by the rate gyro.

In closing, it is important to note that the methods and the analysis of the Novatel RT-20 was motivated by the following two concerns:

1. The need to evaluate the performance of high accuracy, high bandwidth lateral position sensing technologies (DGPS, magnetic striping/magnetometer methods etc.) for a variety of applications including driver-assistive vehicle control systems [5].
2. The need for sensors that can provide instantaneous real-time position information used for an augmented display (such as a Heads-Up-Display) that would project the future course of the road on the windshield for navigational assistance under poor visibility conditions.

Our interest is clearly in the lateral positioning performance of the RT-20, which turns out to be very good. However, we think it is important to also investigate the causes for the large residual error standard deviations in the longitudinal direction, so that we can directly use the RT-20 or other similar systems, for evaluating other types of sensors, such as radar.

One of the issues that will ultimately limit the RT-20's use is a loss in satellite lock. If it takes a long time to re-converge every time that we go under an overpass, then other sensors will have to be used and evaluated, e.g., a dual frequency GPS receiver such as the Novatel RT-2 which recovers within a minute after a complete loss of lock. Furthermore, we have found that going under overpasses does not always lead to a loss of lock. Reasonable performance can often be maintained. One solution to the satellite loss of lock problem is to put a receiver at the front and back of the truck, and synchronize the two of them. This study has also not evaluated the multipath rejection capabilities of the unit, a subject for further study.

ACKNOWLEDGEMENTS

The work presented here would not have been possible without the assistance of Lee Alexander. We would like to thank Mn/DOT personnel for their assistance, including Dave Johnson of the Office of Research Administration, Dave Gorg of the Surveying/Mapping Section and Jack Herndon of Mn/ROAD. This project was partially supported by the Minnesota Department of Transportation, the Center for Advanced Manufacturing Design and Control, the ITS Institute and the Center for Transportation Studies at the University of Minnesota, and the U.S. Department of Transportation.

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APPENDIX B

Preview Based Control of a Tractor Trailer Using DGPS for Preventing Road Departure Accidents

**(This is a copy of the paper, which was presented and appeared in the Proceedings of the
IEEE Conference on ITS, Boston, November, 1997. References are included.)**



Preview Based Control of a Tractor Trailer Using DGPS for Preventing Road Departure Accidents

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Abstract—

In order to reduce the number of road departure accidents caused by fatigue and driver inattention, we are investigating intervention strategies during critical situations, part of a human centered approach to lateral vehicle control. Alarms and warning devices are for the most part ineffective since their effects on a fatigued driver are only short term. We have designed and integrated a system which monitors the vehicle/driver's behavior noninvasively and takes over control if and when the driver does not react appropriately. During such an event, the vehicle would be steered over to the next appropriate shoulder and brought to a safe stop.

We are using a preview based controller implemented on a Navistar 9400 series tractor-trailer comprised of a "pursuit" algorithm which steers the vehicle towards goal points on the road, stored in the form of a digital map. This map which represents the roadway's geometry (including lane characteristics and details regarding shoulders) is generated by previously recording the corresponding DGPS coordinates of the road.

A Novatel RT-20 second generation DGPS system is the primary sensor modality for providing feedback of the vehicle's position and orientation with respect to a global coordinate system (in our case the State Plane Coordinate System) with a yaw rate gyro providing additional feedback. Heading error and yaw rate are used to control the truck's steering control subsystem.

This lateral control system, the first system using DGPS for truck lane keeping on a standard road, has been successfully demonstrated through field experiments at the Minnesota Department of Transportation's Mn/ROAD research facility. In this paper, we focus on the computer control of steering.

I. INTRODUCTION

In cooperation with the Minnesota Department of Transportation (Mn/DOT), we are working to reduce road departure accidents by investigating emerging sensing and control technologies as they apply to trucks. Eighty nine (89%) percent of the roads in Minnesota are rural. Even though these rural roads carry fifty three (53%) percent of the Vehicle Miles Travelled (VMT), seventy two (72%) percent of highway fatalities occur on such roads. Run-off-the road accidents in particular, represent a significant portion (over 30%) of all vehicle accidents and highway fatalities in Minnesota and nationwide [1]. Our goal is to prevent such accidents by taking over vehicle control if loss of manual control is imminent. This project, part of the SAFETRUCK program in Minnesota, is one of several underway investigating a virtual bumper for collision avoidance, heads up displays, radar sensors, etc., whose goal is to evaluate safety oriented technologies that can assist the driver.

Our strategy for road departure prevention differs from

other approaches in that no matter what the cause of imminent road departure i.e., driver fatigue, illness, intoxication, inattention, etc., our system intervenes and steers the vehicle to the next appropriate shoulder and brings it to a safe stop. Visual or audible warning systems may be incorporated into the driver's dreams and as such may not ultimately work for the seriously fatigued individual. Our system, which includes embedded real time processors, a suite of sensors and a direct drive steering unit constantly monitors the vehicle/driver's behavior noninvasively and takes over control, if and when the driver is not responding in a normal manner. Therefore, the basis of our approach is the active coexistence of manual driving and a back up system capable of automatic steering.

The steering system first applies a resistive torque to prevent lane departure (unless the turn signal is activated), with this torque increasing as the offset from lane center increases. Subsequently, a "virtual" rumble strip excites the steering wheel through a vibratory torque to remind the driver through tactile feedback of imminent lane departure. If the "aberrant" behavior persists, as determined by any one or more indicators such as steering wheel angle vs steering wheel angular rate [6], eye blink/shape characteristics, vehicle lateral position [7], then the system will actively steer the vehicle off the road and safely park it on the shoulder. Many researchers are interested in the factors which predict fatigue and their effectiveness at indicating loss of control. This is not the subject of this paper. Our emphasis here is on the response if the predictors indicate loss of control.

Our focus has been on heavy vehicles, because they represent the first likely use of the technology. Given the longer life of trucks (at least a million miles on the road over a typical span of ten years), it has been shown that the accident rate during the life of a vehicle is higher for a truck than for an automobile (1.99 vs 0.76 accidents/vehicle life). Thus the technology is far more likely to be needed and one has the added benefit of a longer period to amortize its cost. An additional argument for considering trucks is the fact that accident severity is much larger for trucks due to their higher inertia. Furthermore, in the event of an accident, it is the non-truck occupant who is most affected (87% fatalities and 75% of non-fatal injuries).

The RALPH system developed at Carnegie Mellon University [2] and the Crewman's Associate for Path Control (CAPC) system of the University of Michigan [4] rely on a time-to-lane crossing (TLC) algorithm to warn the driver

of imminent road departures. TLC represents the time until the vehicle crosses one of the road boundaries under the assumption that its speed and steering wheel angle remains unchanged. TLC has long been known to be an important factor in human driving behavior [8], [9]. LeBlanc and his co-workers [4] indicate that integrating active intervention into the CAPC system to provide lateral control is in order. They go on to say that their intervention strategy when implemented will be based on differential braking rather than on steering control. In our approach, the steering system "co-drives" with the driver at all times. This strategy may be contrasted with other autonomous road-following systems which remove the driver completely from the steering loop. These systems are engaged in *either* autonomous or manual driving modes e.g., for platooning at high speeds, but do not work in tandem [3].

One of the important features which distinguishes our system from others is its use of Differential Global Positioning Sensing (DGPS). To the best of our knowledge, this is the first steering control system which uses DGPS for lane keeping on a standard road¹. Given the widespread demand for highly accurate correction signals, more and more sources of these signals are becoming available throughout the country. In fact, a network of radio transmitted correction signals are already commercially available across wide areas of Minnesota and Iowa in order to provide the agricultural community with signals for their combines, spreaders and other moving machinery.

Our methodology uses preview based control, implemented as a "pursuit" algorithm which steers towards goal points on the road, stored in the form of a digital map. This map represents the roadway's geometry (including lane parameters and details regarding shoulders) and is generated by previously recording the corresponding DGPS coordinates of the road. Such maps could be stored on a CD-ROM and would be made available for different regions of the country, not unlike traditional maps. Current DGPS readings received as the vehicle moves, are compared to goal points on the digital map and along with yaw rate measurements of the vehicle, provided by a yaw gyro, are used to generate a steering command to the low-level steering PD controller. Our system constantly monitors the controlled heading angle error. Computer initiated intervention is felt by the driver only when the error exceeds certain limits. We will show by examples how the gyro term in the preview based controller and the size of the preview distance as a function of the road curvature affect truck's performance measured by the absolute lateral error.

In the following, we will describe the hardware and the control software organization. We will then present experimental results of automatic steering of the truck at various speeds and at geometrically different road sections.

II. THE SAFETRUCK VEHICLE

Our system has been tested on a Navistar 9400 series sleeper cab at the Mn/ROAD research laboratory. This

¹Note, that the system to be described here is the simplest of a set of various controllers which we plan on testing in the future.

pavement technology research facility is located 40 miles northwest of the Twin Cities. It is used to study the effects of vehicle loadings and weather conditions on a variety of pavement structures and types. Mn/ROAD includes a 3.9 Km, two lane low volume road with a racetrack-like configuration; two S-link turn reversals exist at each end (right/left/right or left/right/left).

A. The Differential Global Positioning System (DGPS)

The primary sensor modality of the SAFETRUCK is Novatel's RT-20 global positioning system. The RT-20 DGPS receiver provides the X, Y state plane coordinates of the truck at a rate of 5Hz. One GPS antenna and a differential correction antenna are mounted on top of the truck. The differential correction antenna continuously receives correcting signals from a GPS receiver mounted on the roof of a nearby research building.

The reasons for choosing GPS over other sensing technologies are its off-the-shelf, real-time, high accuracy and its ever expanding commercial use, which tends to drive its cost down. The static and kinematic accuracy of the system has been verified experimentally to be within 5cm in the direction perpendicular to the vehicle motion [5]. In addition to this, GPS systems can perform equally well under unfavorable weather conditions, i.e., snow-covered highways, white out conditions, heavy rain and fog, etc. This is an important issue when applying this technology to environments with unpredictable and quickly changing weather conditions such as those that prevail in Minnesota.

Like most systems, GPS-based position sensing has drawbacks as well. There may be occasions in which satellite signals are lost, e.g., when driving under overpasses. In order to compensate for this type of limitation, an Inertial Measurement Unit (IMU) is used.

It is important to note that in addition to using the GPS generated data, the experimental results which will be described in the following sections, were obtained by using a fiber optic 16 bit angular rate gyro (AUTOGYRO Navigator, from Andrew Corporation) used for determining yaw rate.

B. The Steering Sub-system

The steering actuator system consists of a torque motor concentric with the steering wheel shaft operating in a direct drive mode. It is capable of applying up to 40 ft-lb of torque. The steering sub-system was designed "around" the existing one. Its design allows the human driver to always be in command. That is, the human driver can overpower the steering motor when he or she wishes to do so. The steering wheel angle encoder used for feedback has a resolution of 1.4°.

C. The Embedded and Host Computer Systems

A portable Unix-based computer (Sparc-laptop) serves as the host computer which is used for code development and cross compilation. Three MVME147 Motorola single board computers communicate across the VME bus and

form the core of an embedded multi-processing environment. An off-the-shelf o+r board with various modules provide channels for A/D and D/A conversion, as well as I/O for counters and incremental encoders. Other boards mounted on the VME bus provide serial and parallel communication ports for interfacing various systems e.g., serial connections to the DGPS system.

Two uninterruptable power supplies (UPS) with their auxiliary batteries and inverters provide the required electric power to all computers and hardware components. The embedded processors run the VxWorks real time operating system chosen for its multi-tasking capabilities. A hierarchy of watchdog processors were integrated into the system to provide safe default switching conditions [10].

The description of our methodology which includes a pursuit algorithm as part of a preview-based steering controller follows in the next section.

III. ROAD DEPARTURE PREVENTION USING PREVIEW BASED CONTROL

As indicated in the introduction, an important component of our methodology is the availability of a digital map of the road on which automatic steering takes place. We create such digital maps by collecting DGPS data of the road to be traversed by the truck. Figure 1 shows the DGPS recording obtained for the southeast part of the Mn/ROAD low volume test track. The reason for focusing on this particular roadway section is due to fact that its ends denote the boundaries of two "washboard" gravel road sections which we generally wish to avoid. Once a digital map is created, we develop a series of linear segments which interpolate the DGPS data. One should note that the number of line segments for a particular road section may vary depending on the length and curvature of the segments. We have chosen (based on performance criteria) to set the length of the line segments at 3 m. The use of splines or other means to interpolate the DGPS data is another alternative which can be used to further improve system performance. This post-processing of DGPS data generates a map containing the goal points for steering the truck. All tests presented here were performed on the section from A to E. The locations denoted by B, C and D represent curvature transitions. The curvature geometry (which has a tighter radius than normal highways) limits our speeds on the curves, but represents a more difficult challenge.

A. Preview Based Lateral Control Using a Pursuit Algorithm

The idea of a pursuit algorithm for preview based lateral control is relatively simple. The pursuit algorithm examines goal points at a specified distance ahead of the vehicle. Once the goal point is found, the heading angle error is calculated. The angle between the tangents of the desired and of the actual heading is called the *Heading Angle Error*. The look ahead distance parameter can be adjusted to any value. In early field experiments, we set the look ahead distance to be 30 m on both the linear and curved

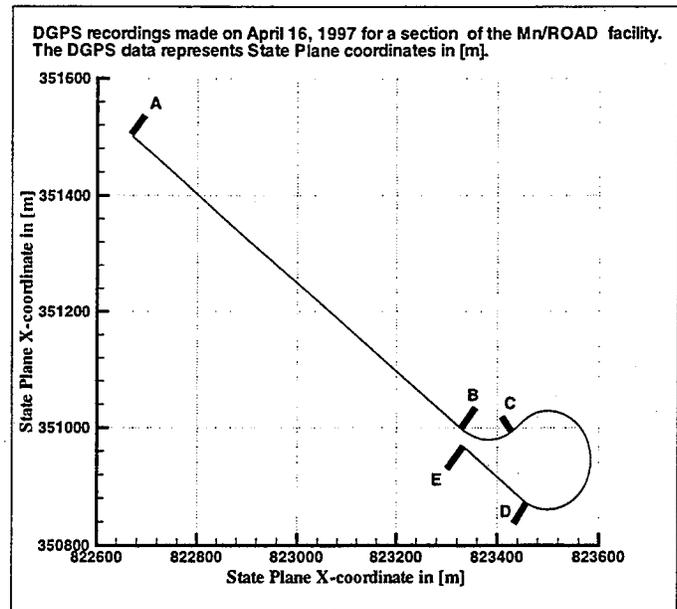


Fig. 1. DGPS recordings for a section of the Mn/ROAD Low Volume test road.

TABLE I
NOMENCLATURE FOR THE INTEGRATED PREVIEW BASED STEERING CONTROLLER.

<i>Nomenclature</i>	
s	: Laplace Operator
γ	: Desired Steered Wheel Angle
α	: Truck's Yaw Angle
α_d	: Desired Heading Angle
$\Delta\alpha$: Heading Angle Error
$\delta\phi$: Steering Wheel Angle Error

segments of the road. However, there is a trade off to consider when choosing this parameter. The greater the look ahead distance the smoother the driving on straightaways (which becomes a factor at higher speeds), but the greater the lateral errors on curved road sections.

The larger lateral error on a curve when using a longer look ahead distance is a result of the algorithm steering towards a point farther around the curve. The vehicle moves to the inside of the curve in the same manner that a long trailer tracks to the inside of a curve when towed by a tractor that remains in the center of its lane. The version of preview control described here incorporates a mechanism which adaptively changes the look ahead distance depending on the road curvature (we use a greater look ahead distance for linear segments and a shorter look ahead distance for curved road segments). This modification results in relatively small lateral deviations around the curves.

Figure 2 illustrates the structure of the controller. The nomenclature is listed in Table I. The preview based controller produces a steered wheel angle command γ given by $\gamma = K_e\Delta\alpha - K_g\dot{\alpha}$. The first term of the preview controller is provided by the pursuit algorithm which computes the desired heading direction towards which we wish

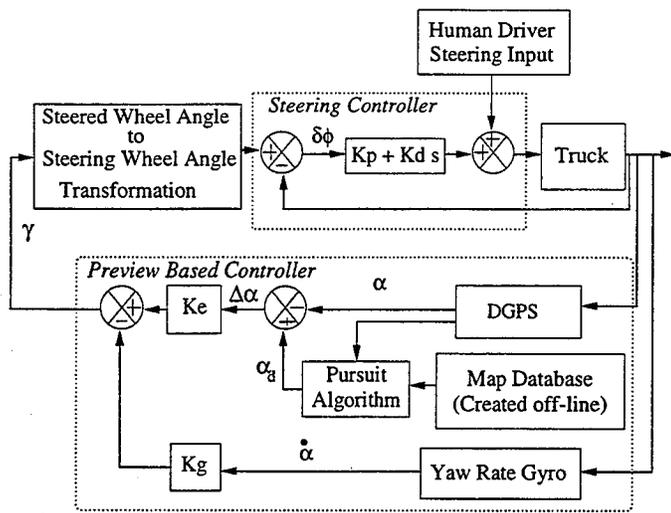


Fig. 2. The preview based steering controller using DGPS. The truck's yaw angle is the same as the actual heading angle.

the truck to drive. The actual heading or yaw angle of the truck is calculated by using the DGPS data and is then subtracted from the desired heading to determine the heading angle error $\Delta\alpha$. This quantity is multiplied by a gain K_e to produce a steered wheel command. With only this type of preview ($K_e \neq 0, K_g = 0$), the performance of the truck during automatic steering exhibits considerable oscillations which would make any passenger nervous especially at higher speeds (35 mph and up). To eliminate this problem, we used an expanded version of preview control ($K_e \neq 0, K_g \neq 0$) shown in Figure 2. The second term is formed by multiplying the yaw rate of the truck, $\dot{\alpha}$ (provided by the yaw rate gyro), with a gain K_g . This new steered wheel command $\gamma = K_e\Delta\alpha - K_g\dot{\alpha}$ eliminates the considerable oscillatory behavior enabling the computer to steer the truck smoothly at tested speeds up to 55 mph². Finally, a steering controller tracks the steered wheel commanded inputs after they are transformed into steering wheel angle commands. This schematic explicitly shows how the human driver enters the loop and interacts with the controller.

IV. EXPERIMENTAL RESULTS

The experimental results which are discussed in this section correspond to driving tests performed under computer steering control for the section of the Mn/ROAD facility shown in Figure 1. The experimental data focuses on the absolute value of the lateral deviation (i.e., the lateral error) from the desired path for several successively better controllers where the gyro gain and the preview distance were varied on the linear and curved sections of the road. Runs at different speeds were also performed. All data was collected at 100 Hz. One should also keep in mind that the data shown for each experimental test were stored in buffers of approximately the same size.

Figure 3 shows the absolute value of the deviation from

²We believe that higher speeds are possible but were limited by the test road limitations.

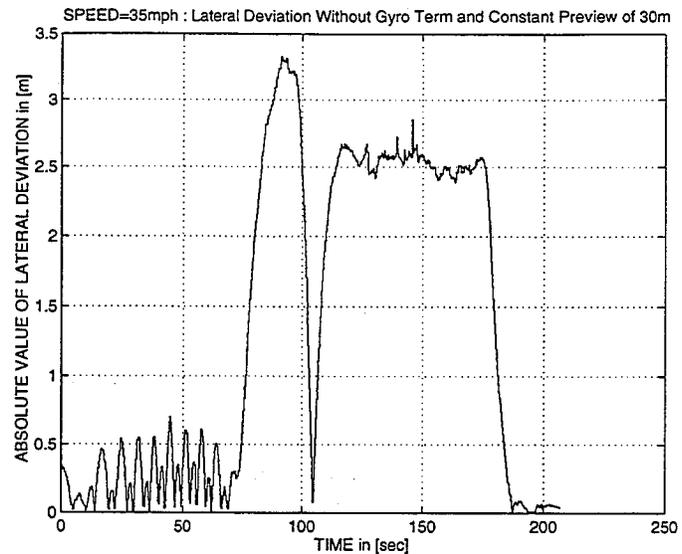


Fig. 3. Absolute value of lateral error *without* including the yaw rate gyro component ($K_g \neq 0$) in the preview based controller. The preview distance is kept at 30 m on *both* the linear and curved segments of the road. Truck's speed is 35 mph on the straightaways and 15 mph on the curves. Milestones along road (approx.): B:70 sec, C:105 sec, D:185 sec.

the desired trajectory for the case where the gyro term is *not* included in the preview controller. The speed was kept at 35 mph on the straightaways and 15 mph on the curves. Preview was kept constant throughout at 30 m. Figure 3 clearly shows that the maximum absolute lateral error on the straightaway segment (AB) of Figure 1 can get as high as ~ 70 cm. This oscillatory behavior is uncomfortable and is felt by the passengers when steering at higher speeds (greater than 30 mph). On the curved segment (BC) the absolute lateral error almost reaches 3.5 m and on the following segment (CD) about 2.5 m. This type of preview control ($K_g = 0$) represents the worst performance and is used here as a baseline for the significant improvements to be demonstrated in the following controllers.

To quantify the effect of preview, another experimental run was performed where the preview distance was set at 30 m on the straightaways and only 10m on the curves. As in the previous case, gyro information was *not* included in the preview controller ($K_g = 0$). Figure 4 shows a considerable reduction of the lateral deviation on the curves. The worst case maximum lateral deviation during the linear segment (AB) (represented by data from 0 to 55 sec) occurs for a brief moment at ~ 75 cm approximately the same as in the previous experiment, while the lateral deviation on the curved segments (BC) and (CD) was reduced to an average of about 15 cm with the worst error of 30 cm occurring when steering from a left to a right turn (transition at C, from the BC section to the CD section).

The third preview based steering controller adds the yaw rate gyro term into the preview based controller. Note that different preview distances are used for the linear and curved road segments. The preview distance was set to 30 m and to 10 m for the straight and curved road sections

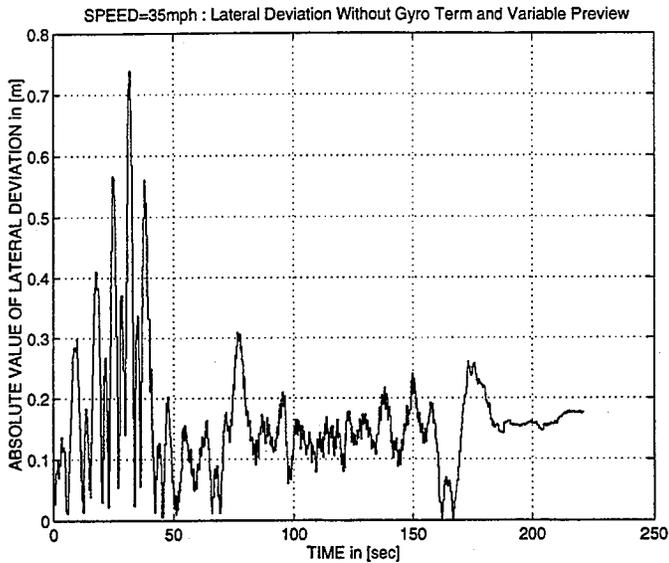


Fig. 4. Absolute value of lateral error *without* gyro feedback ($K_g = 0$) and using variable preview distance (30 m for the linear and 10 m for the curved road segments). The speed was kept at 35 mph on straightaways and 12mph on the curves. Milestones along road (approx.): B:55 sec, C:75 sec, D:165 sec.

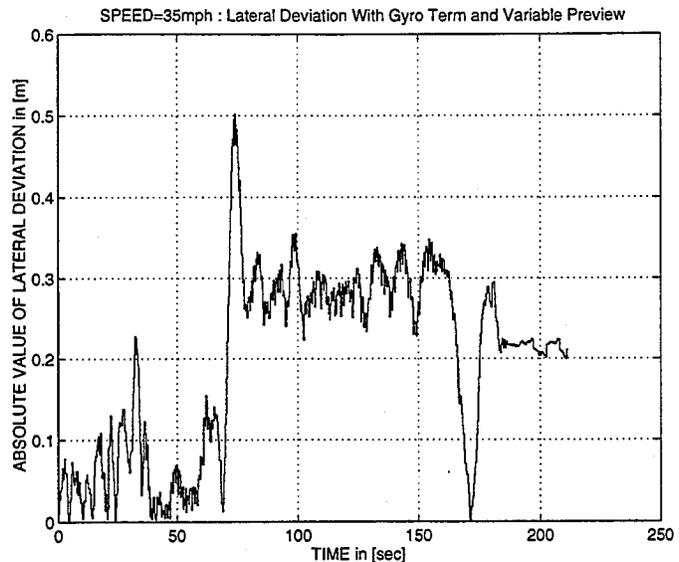


Fig. 5. Absolute value of lateral error with gyro feedback ($K_g \neq 0$) and using variable preview distance (30 m for the linear and 10 m for the curved road segments). The speed was kept at 35 mph on straightaways and 12mph on the curves. Milestones along road (approx.): B:55 sec, C:75 sec, D:170 sec.

respectively. One may observe in Figure 5 that the absolute lateral path error is decreased on the straightaway segment (AB) to better than 20 cm. However, the error increases on the curved segments (BC) and (CD), up to a momentary 50 cm in the worst case. Note that on straightaways the system performance compares very well with that of human driving, where lateral errors of the same magnitude have been recorded (Figure 6). These results represent a typical run for a professional driver paying careful attention to the driving task and without any assistive devices.

The next experiment (Figure 7) is similar to the previous one (Figure 5) with the only difference being that the computer steers the vehicle while travelling at a higher speed of 45 mph on the straightaway section (AB) and 12mph on the curved segments (BC) and (CD). Once more, gyro information and variable preview is incorporated in the preview based controller. This result demonstrates that the steering behavior is repeatable at higher speeds.

We can improve the performance of the system further by including the gyro term *only* on the straightaways while keeping variable preview for the linear and curved sections as we did earlier. Figure 8 shows the resulting improvement. Note that in this experiment one cannot discern from the graph data when the transition from the linear segment (AB) to the curved segment (BC) occurs. The lateral deviation error is kept below 27 cm on the straightaway segment (AB) and the first curved segment (BC) (from 0 to 100 sec) and averages around 15 cm for the curved section (CD—from 100 sec to 180 sec). The worst case error reaches a maximum (at the inflection point C) of 32 cm. One should keep in mind that the sampling period of the data presented in all the graphs is 100 Hz. The lateral deviation described by the previously mentioned maximum was not felt by the either the driver or the passengers.

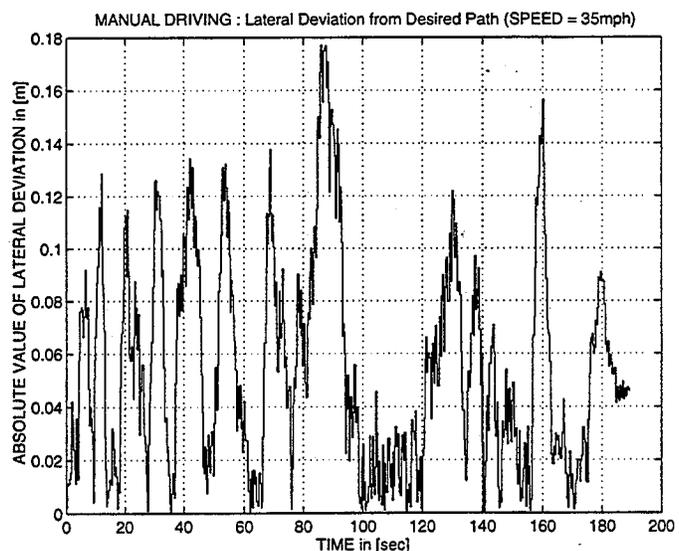


Fig. 6. Absolute value of lateral deviation during manual driving. The speed was kept at 35 mph on straightaways and 12 mph on the curves. Milestones along road (approx.): B:60 sec, C:80 sec, D:160 sec.

In the last of the field experiments described here, we show how preventing road departure can be achieved. In this experiment, the human driver overpowers the steering motor and intentionally veers the vehicle over to the adjacent lane. This intentional human steering input simulates the situation in which a driver, either due to fatigue, inattention or other causes swerves from his own lane to an adjacent lane. Were the system to operate as a back up safety subsystem, then the computer steering input would overpower the human steering. The intentional human *disturbance* takes place on the linear segment of the road (AB).

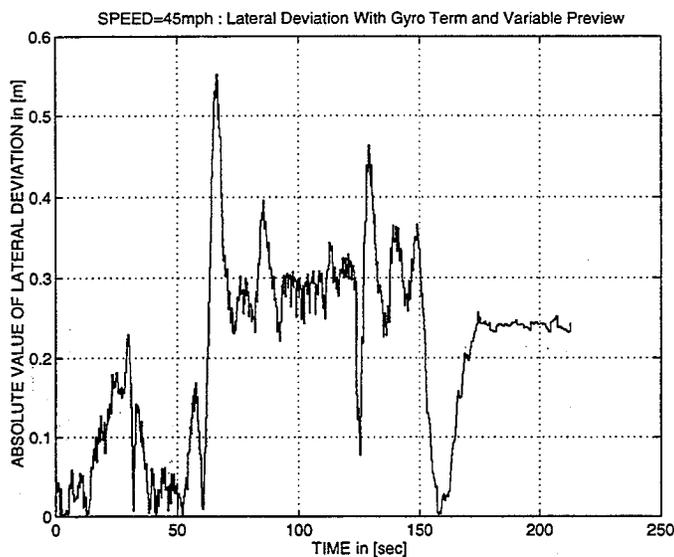


Fig. 7. Absolute value of lateral error when including the yaw rate gyro component ($K_g \neq 0$) in the preview controller. The preview distance was kept at 30 m for the linear and at 10 m for the curved road segments. The speed was kept at 45mph on straightaways and 12 mph on the curves. Milestones along road (approx.): B:55 sec, C:70 sec, D:160 sec.

This is depicted in Figure 9 by the sharp change in the lateral error which starts at about 25 sec into the experiment. As Figure 9 shows, the steering controller is able to drive the truck back on to the lane in which it was supposed to be. Again, the speed of the truck was kept at 35 mph.

V. DISCUSSION AND CLOSING REMARKS

In this paper, we presented a preview-based control strategy to prevent road departure of heavy vehicles by using primarily DGPS sensing.

The preview used was heading angle error information and information about the yaw rate of the truck. We showed through examples how the yaw gyro gains and the size of preview distance for the linear and curved road segments affect the truck's performance as measured by its absolute lateral error. We demonstrated, through field experiments using a Navistar 9400 truck, that this controller was successful and also comfortable for the driver and passengers. It must be noted that *no* information about the dynamics of the truck was incorporated into our system. Due to the "simplicity" of the controller which does not need information about the truck's dynamics, we believe that the experimental results presented in this paper set minimum performance standards for subsequent versions of more sophisticated controllers. In this respect, our system differs from others in which dynamic models of the vehicle have been part of the lane keeping strategy ([11], [12]).

We have also developed a dynamic model of the truck which we have verified experimentally [13]. In the next phase, we plan on using this dynamic model to implement a Kalman Filter for two reasons. First, it will help to improve the dynamic performance of the truck on slip-

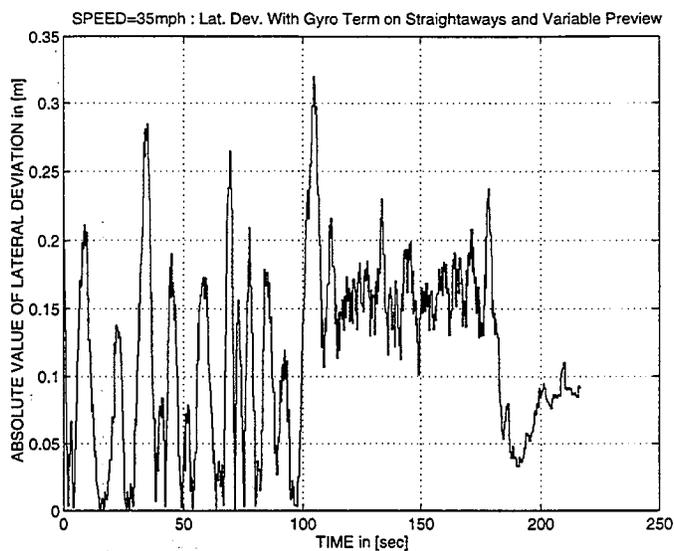


Fig. 8. Absolute value of lateral error when the yaw rate gyro component is included only on the straightaways. Variable preview is used as before. The speed was kept at 35 mph on straightaways and 12 mph on the curves. Milestones along road (approx.): C:100 sec, D:180 sec.

pery roads. Second, it will improve the performance in cases when we briefly lose satellite signals e.g., when going under overpasses, and we must rely on inertial measurements. Computer-based brake and throttle control is being presently integrated into the overall system. This is part of the next phase of our work.

In closing, we believe that our current approach and experimental testbed provides us a basis for testing and evaluating the performance of continuously evolving controllers for operating under various weather and road conditions.

ACKNOWLEDGMENTS

We would like to thank Mn/DOT personnel for their assistance, including Dave Johnson of the Office of Research Administration, Dave Gorg of the Surveying/Mapping Section and Jack Herndon of Mn/ROAD. This project was partially supported by the Minnesota Department of Transportation, the Center for Advanced Manufacturing Design and Control, the ITS Institute and the Center for Transportation Studies at the University of Minnesota, and the U.S. Department of Transportation.

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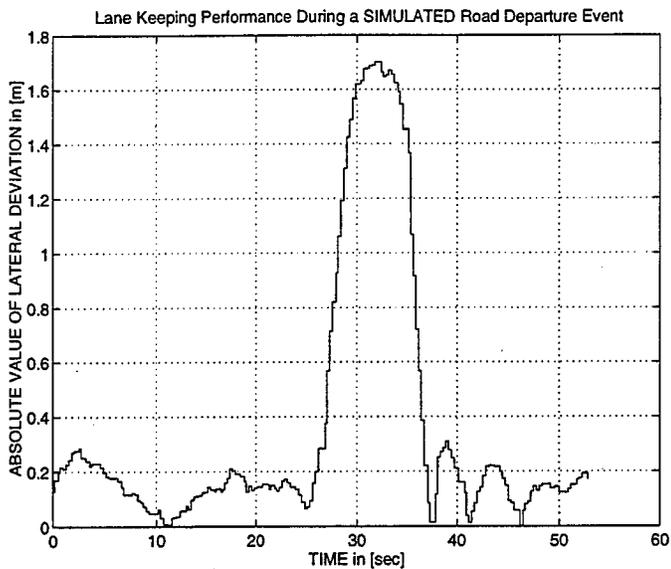


Fig. 9. The response to an intentional road departure event. The steering controller is able to pull the vehicle back to the correct lane after an "unplanned" shift out of the lane. This experiment was performed on a segment of the straightaway section AB. Speed was 35 mph.

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APPENDIX C

In-Vehicle Sensing for Driver Fitness Monitoring: A Review

(References follow review)

Prepared

October, 1996



Asleep at the Wheel

- A study by the National Transportation Safety Board looked at every accident in eight states where drivers of heavy trucks were fatally injured (182 accidents).
- "Fatigue and fatigue-drug interactions were involved in more fatalities in this study than alcohol and drugs alone."
- Only 10 percent of the truck drivers killed were under the influence of alcohol or other drugs.
- Yet driving logs and coworker reports indicate that 31 percent (57 of 182) of the drivers were fatigued.

"Fatigue, Alcohol, Other Drugs and Medical Factors in Fatal-To-The-Driver Heavy Truck Crashes", Vol. 1

National Transportation Safety Board
Washington, DC, Feb. 1990

Fatigue Kills

- In one study, the Association of Professional Sleep Societies reports that falling asleep at the wheel causes up to 6,500 fatalities yearly.
- That's up to 13 percent of all crash related U.S. deaths.
- "Fatigue is an underestimated cause of accidents."
Prof. Martin C. Moore-Ede
Director, Institute of Circadian Physiology
Harvard Medical School
- Many truck drivers take driving tired for granted.

• Moore-Ede has asked rooms full of truck drivers if they have ever fallen asleep behind the wheel.

• "Almost all of them raise their hands."

The Numbers

- Of 6.3 million crashes covered annually in Police Accident Reports (PAR), approximately 100,000 crashes per year (1.6% of 6.3 million) were associated with drowsiness.
- 71,000 of these involved non-fatal injuries.
- The Fatal Accident Reporting System (FARS) indicated that 3.6% of all fatal crashes were related to drowsy driving.
- However, drowsiness' role in accidents may be largely underestimated due to unreported off-roadway crashes and lack of verification.

*- Based on NHTSA's estimates for 5 yr. period (89-93),
Knipling and Wang, 1995*

Truck Drivers Logs Often Inaccurate

- Based on backtracking the driver's activity to determine the presence of fatigue, 221 accidents in 6 western states were studied.
- Fatigue was found to be the probable/primary cause of 41% (90 of 221) and a contributory cause in an additional 18% (40 crashes) of heavy truck accidents.

"A Report on the Determination and Evaluation of the Role of Fatigue in Heavy Truck Accidents"
Prepared for the AAA Foundation for Traffic Safety, Falls Church, VA, October, 1985.

Who is affected?

- Data from the NHTSA General Estimates System (GES) and the Fatal Accident Reporting System (FARS) statistics for 1989-1993 indicate that:
 - 37% of fatalities and 20% of non-fatal injuries associated with truck driver drowsiness crashes occurred to individuals outside the truck.
- Combination-unit truck crashes *in general* result predominantly in fatalities and injuries to individuals outside the truck (e.g. occupants of other vehicles or pedestrians).
 - For all combination-unit truck crashes, 87% of associated fatalities and 75% of non-fatal injuries occurred to non-truck occupants.

Ron R. Knipling and J.- S. Wang,
*"Crashes and Fatalities Related to Driver
Drowsiness/Fatigue"*
Research Note, NHTSA, Nov. 1994

First Conviction of Trucking Executive

- First successful criminal prosecution of trucker who doctored driver's log ... known in some parts of the country as 'joke books'.
 - Mark Gunther, Gunther's Leasing Transport Inc., Hanover, MD
 - Employees told to drive up to 20 hrs. to meet promised schedules. (Rules require drivers to take 8 hrs off after spending 10 hrs behind the wheel.)
 - Fined \$171,000. and sentenced to 30 months in federal prison by U.S. District Court Judge William Nickerson, Baltimore, MD

Journal of Commerce, October 8, 1996

HOURS OF SERVICE

WHAT IS RIGHT?

Monitoring Fitness-for-Duty

- A variety of systems exist for pre-drive or interval screening (e.g. ReadyShift® II from Evaluation Systems Inc., San Diego, CA).
- All require extra effort or time on the part of the driver.
- Prefer approach that requires no additional involvement by driver, that provides for continuous monitoring, can handle driver variability and is non-invasive.
- Many have tried to develop measures based on monitoring the driver and vehicle/road characteristics while driving (e.g. Smart Truk® is under development by Evaluation Systems Inc., San Diego, CA) .
- Few have documented their work in a manner that can be reproduced.

ReadyShift® II

ReadyShift® II Input Controls

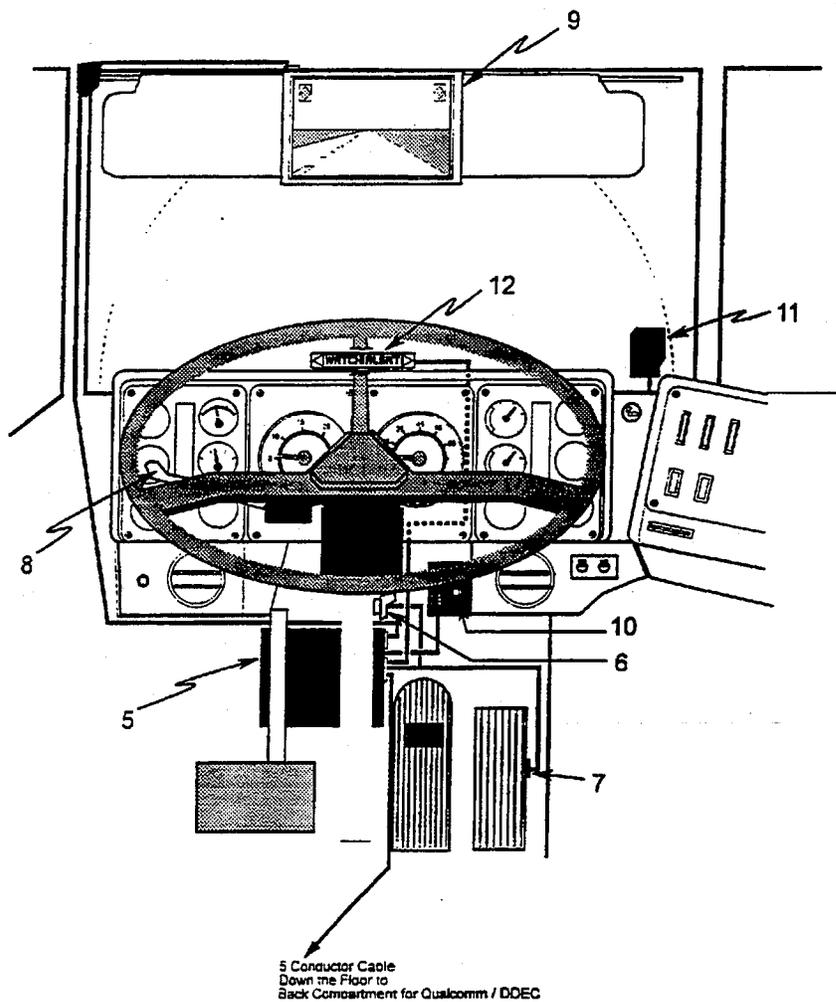


Figure 2. The *ReadyShift®II* and *Smart Truk®* components in a truck cab, viewed from the driver's seat. Key: 5, embedded computer; 6, steering wheel sensor; 7, pedal sensor; 8, turn signal (connector at base); 9, *ReadyShift®II* display panel; 10, control panel; 11, *Smart Truk®* CCD camera; 12, *Smart Truk®* display panel.

Drowsiness Indicators

- In most comprehensive study to date, Wierwille et al. used sleep deprived drivers in driving simulator (late 70's mid-sized sedan) to isolate parameters that would detect drowsiness onset.
- Key determinants:
 - Driver eye closure, blink characteristics.
 - Lateral position of vehicle, vehicle yaw characteristics.
 - Steering wheel characteristics.

Wierwille et al. *"Research on Vehicle Based Driver Status/Performance Monitoring; Development, Validation and Refinement of Algorithms for Detection of Driver Drowsiness"*
Virginia Polytechnic Institute and State University,
NHTSA Report No. DOT HS 808 247, Dec. 1994.

Testing on the Road

- Wierwille results to be evaluated on two trucks in \$1.2 million 2 year study by CMRI funded by NHTSA (with partial support by Volvo/GMC and National Private Truck Council).
 - Sensors to be installed:
 - Advanced Micro Devices micromachined accelerometer to measure lateral acceleration (range: 0 - 1 g, bandpass from 0 to 7 Hz)
 - Steering wheel angular position and velocity.
 - Vehicle speed
 - Lateral vehicle position within lane based on vision data (Assistware Technology).
 - Head position along 3 coordinate axes with 1 mm. resolution (Safety Concepts Inc., Sante Fe, NM)
 - Eye blink sensor (MTI Research, Chelmsford, MA)
 - Tests to begin in 1997.
 - Will use audio alarms plus peppermint scent delivery system.
-

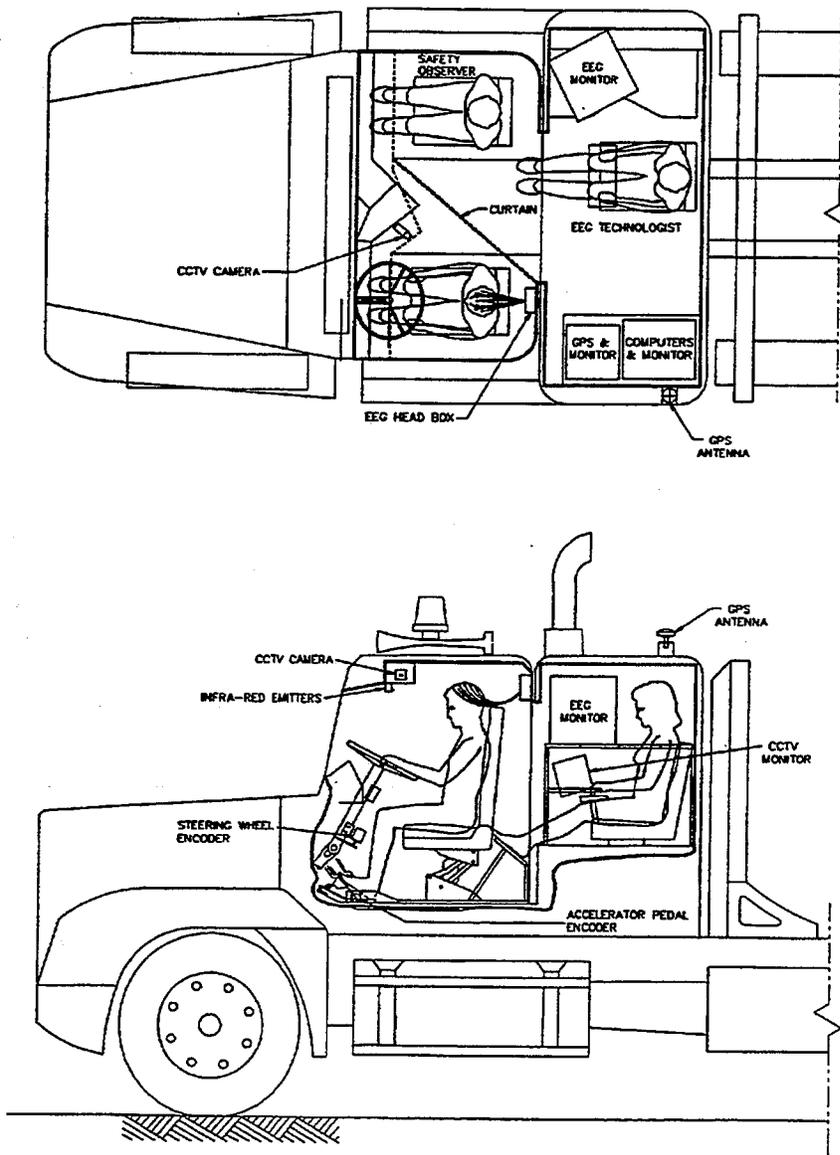
MTI Research Inc.

- Eyelashes/eyelids motion interrupts light beam.
 - LED to photodiode path from bridge to temple.
 - IR transmission of data to receiver in cab.
 - First units priced from \$100-200. Possibly \$400-500 if more exotic processing desired.
 - Blink closure (% closed) parameters are output.
 - Commercial version will output analog voltage proportional to "fatigue."
 - LED bar graph - additional LED's will turn on as fatigue "increases."
 - Considering audio alarm.
 - For people who don't wear glasses, will use off-the-shelf safety glasses without the lenses.
-

Vehicle Based Measures Tested on Sleep Deprived Truck Drivers

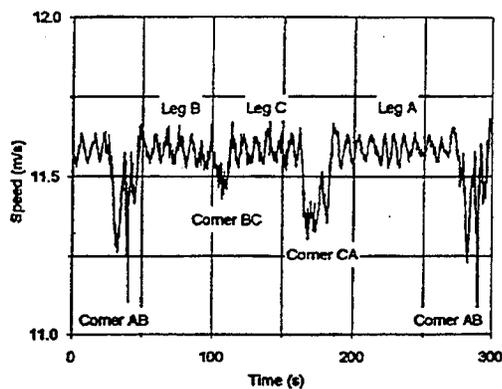
- MacInnis Engineering Associates Ltd., Vancouver, BC conducted a series of tests using 17 sleep deprived drivers on a 1994 Freightliner conventional tractor with integral sleeper (funded by Insurance Corp. of British Columbia).
 - Parameters evaluated (primarily vehicle dependent):
 - Vehicle speed
 - Steering wheel angle and angular velocity
 - Accelerator pedal angle (θ) and angular velocity (ω)
 - Driver EEG and heart rate (ECG)
 - Clinical assessment of driver fatigue (video of driver's face and shoulders)
 - Vehicle lateral lane position, and
 - Car following distance.
 - Pace vehicle was used to maintain a constant velocity of 40 km/hr (11.1 m/s)
 - The 2.9 km triangular track consisted of an unused runway and taxiway of a local airport.
-

MacInnis Study (1994)

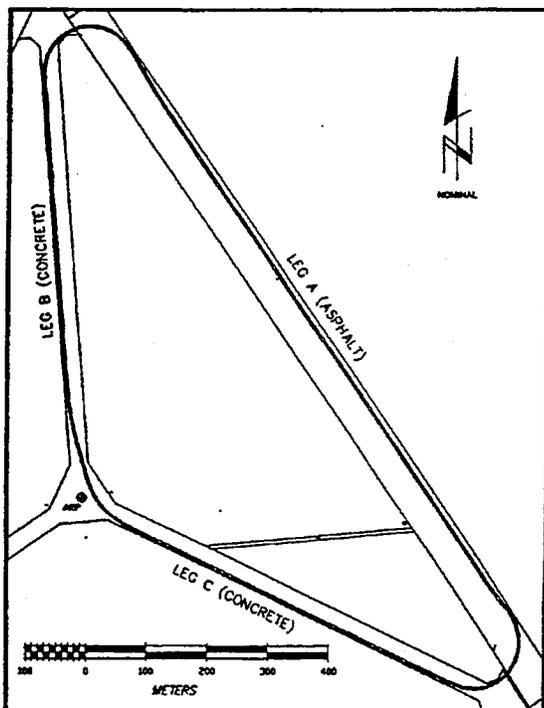


Layout of Freightliner Interior

MacInnis Study (1994)



Pace Vehicle Cruise Control Speed Variations

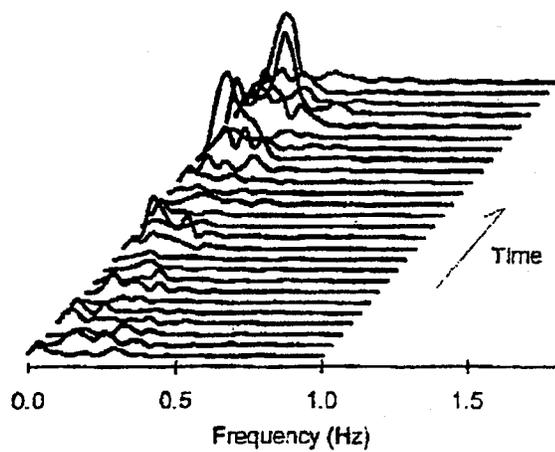


Test Track Layout

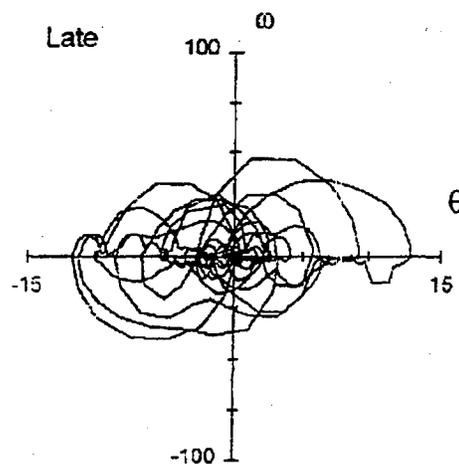
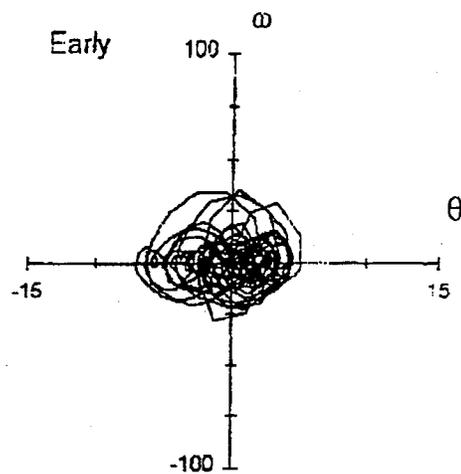
MacInnis Study (1994)

- **Fatigue is best measured indirectly by sensing:**
 - Lane maintenance output (measures driver's ability to both sense and respond to the road environment), or
 - Steering wheel input (only measures how a driver responds to the road environment, NOT what the driver is responding to).
- Lane breaching is the ultimate result of inattention.
- However, a lane breach usually occurs after the driver is fatigued - may be too late.
- Must be able to decipher actual lane breaches from ordinary events, such as lane changes, overtaking maneuvers and highway exit ramps.

MacInnis Study (1994)



Changes in steering behavior in the frequency domain



Sample Phase Plots from Driver 8
Showing Steering Behavior and Control Ellipse
of $-7.5 \leq \theta \leq 7.5^\circ$ and $-50 \leq \omega \leq 50$ °/s

Eaton Vorad Real Time Fitness Monitoring

United States Patent

Patent Number:

5,465,079

Bouchard et al.

Date of Patent:

Nov. 7, 1995

[54] **METHOD AND APPARATUS FOR
DETERMINING DRIVER FITNESS IN REAL
TIME**

[75] **Inventors: Paul J. Bouchard, San Diego; Jerry
D. Woll, Poway; Bryan D. Woll,
Laguna Niguel; Jimmie R. Asbury, San
Diego, all of Calif.**

[73] **Assignee: Vorad Safety Systems, Inc., San
Diego, Calif.**

[21] **Appl. No.: 106,407**

[22] **Filed: Aug. 13, 1993**

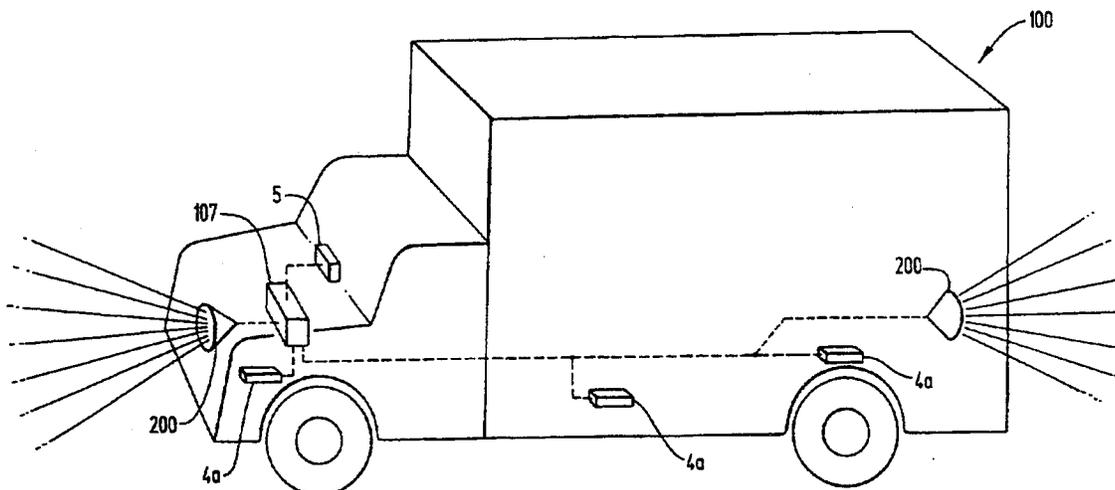


FIG. 1

RALPH

- **RALPH (Rapidly Adapting Lateral Position Handler)** developed by Dean Pomerleau and Todd Jochem (from Carnegie Mellon University and AssistWare Technology)
- **Uses road images with perspective correction to determine road curvature.**
- **Was used to automatically steer a van from Washington DC to San Diego, CA for 98% of the 2850 mile journey.**
- **Maintained average speed of 63 mph during conditions including bright sunlight, dusk, rainfall and at night.**
- **Problems; freshly paved road with no markings, driving into sun and driving through cities.**
- **May be useful as a fatigue warning system.**

Eye Tracking

- Non-intrusive eye tracking.
- Optically track face, head and eye movements
- Systems developed independently by:
 - Northrup Grumman Corp. (Pico Rivera, CA), and
 - University of Minnesota (Prof. Papanikolopoulos)
- IR used to provide lighting at night.

Other Studies

- Yamamoto, Hirata and Higuchi (Mitsubishi, 1994) used fuzzy logic criteria based on:
 - monotony of the road (calculated from turn signal, braking and shift lever activity),
 - the amount of meandering, and
 - the amount of corrective steering.
- Kaneda et al (1994) used image processing technology to assess fatigue from facial image records.
- A French team (Faidy et al., 1992) determined that hand grasping pressure on the steering wheel (6 sensors) and seating pressure (8 sensors) were correlated with fatigue.

In-Vehicle Sensing for Driver Fitness Monitoring: A Review

References

"Fatigue, alcohol, other drugs, and medical factors in fatal-to-the-driver heavy truck crashes."
Volume 1, Report #NTSB/SS-90/01, NTIS # PB90-917002, National Transportation Safety Board, Washington, D.C. February, 1990

"Alcohol and other Drugs in Transportation: Research Needs for the Next Decade,"
Transportation Research Circular 3408, Transportation Research Board, National Research Council, June 1993.

"A Report on the Determination and Evaluation of the Role of Fatigue in Heavy Truck Accidents"
Prepared for the AAA Foundation for Traffic Safety, Falls Church, VA, October, 1985.

Paul J. Bouchard, Jerry D. Wall, Bryan D. Woll, Jimmie Asbury
Method and Apparatus for Determining Driver Fitness in Real Time"
U. S. Patent #5,465,079, Nov. 7, 1995.

M. Burns

"Alcohol And Drug Effects On Performance"

Transportation Research Circular. 1993/06. (408) pp 49-60, 1993

Transportation Research Board, 2101 Constitution Avenue, NW, Washington, DC, 20418, USA

Abstract: A number of difficult questions underlie the topic of performance impairment by alcohol and drugs. This paper addresses some of these questions. It begins with a discussion of "Research Directions: Who Needs It?" Among the answers to that question, the following are examined: law enforcement; the criminal justice system; the workplace; legislators and regulatory agencies; and citizens. A second question addressed is "Research Directions: What Do We Know Already?" Examined in this context are the literature documenting the body of knowledge about alcohol and drugs, and the substances, specifically alcohol, marijuana, cocaine, narcotic analgesics, and prescription drugs. In conclusion, it is pointed out that the body of knowledge in 1992 about alcohol and drug effects on performance varies by substance from extensive and/or adequate to scattered and incomplete, having grown sporadically, without design, in response to a mixed bag of "needs to know." It is concluded that a consensus recommendation for research will not be easily reached, and that perhaps the objective should be a direction and a strategy to facilitate more systematic research.

Arun Chatterjee, Ernest Cadotte, Nick Stamatiadis, Harry Sink, Mohan Venigalla, Greg Gaides
"Driver-Related Factors Involved with Truck Accidents"
Final Report, University of Tennessee Transportation Center, Knoxville, TN, January, 1994.

Arun Chatterjee, David Clark, Stephen Rutner, Harry Sink, Nick Stamatiadis
"Intermodal Freight Transportation and Highway Safety"
Final Report, University of Tennessee Transportation Center, Knoxville, TN, March, 1995.

J.P. Faidy; Y. Mevel; P. Siarry; B. Cointot; A. Coblentz

"The Detection Of Alertness Level Drop At The Wheel: Study Of New Behavioural Parameters And Associated Sensors"

Proc. of the XXIV Fisita Congress, - **Safety, The Vehicle And The Road**, Volume 2 (IMechE No C389/254 And Fisita No 925221). pp. 33-7, Institution Of Mechanical Engineers, London, United Kingdom, 1992

Abstract: This paper presents the results of joint research between PSA, ECP and LAA. This research was carried out to link various behavioral parameters (wheel angle, driver attitude,...) with drowsiness at the wheel. An experimental car has been equipped with several sensors; chosen sensors characterize the main contact regions between the car and the driver, without causing any constraint or discomfort for the driver. To find effective correlations between behavioral signals and the onset of driver's drowsiness at the wheel, experimental tests were conducted, in a first step, in static condition, with six drivers, who were submitted to simulated driving conditions. During each test, driver's physiological signals (EEG and EOG) and above-mentioned behavioral signals were simultaneously recorded. The initial results have proved it is possible to predict the onset of driver's drowsiness, through the use of multiple sensors. Other tests, involving more drivers in more realistic driving conditions, are still necessary in order to exhibit a general and reliable device. (A) For the covering abstract see IRRD 869205.

F.A. Holloway

"Low-Dose Alcohol Effects On Human Behavior And Performance"

Alcohol, Drugs and Driving. 1995/01. 11(1), pp 39-56

Abstract: This literature survey reviews the effects of alcohol on human behavior and performance, especially low alcohol dose effects. This review consisted of 155 empirical studies dating from 1985 to mid-1993, using the alcohol effect schema of Kruger. Several general conclusions that were largely in agreement with previous reviews on this topic were reached. First, sensitivity to the subjective intoxicating effects of alcohol was greater than that for all other performance classes and appeared to display a "threshold" with respect to blood alcohol concentration (BAC), rather than the linear relation evident in performance data. Second, sensitivity to performance impairment in "controlled" performance and simulator tasks was greater than that for psychophysical function or "automatic" performance. Finally, a variety of task-, subject-, and environmental-characteristics or conditions were found to mediate the magnitude and sensitivity to alcohol effects, particularly at lower doses. This review concluded that since alcohol sensitivity can vary from time to time, person to person, and situation to situation, the setting of a "safe" BAC will always be arbitrary, being based on a low, but non-zero, incidence of effects below that level.

David J. King, Gunter P. Siegmund, Darcy T. Montgomery

"Outfitting a Freightliner Tractor for Measuring Driver Fatigue and Vehicle Kinematics During Closed-Track Testing"

SAE Paper #942326, 1994.

One of several papers written by Maclnnis Engineering staff describing their work on sleep deprived drivers.

R. R. Knipling; W. W. Wierwille,

"Vehicle-Based Drowsy Driver Detection: Current Status And Future Prospects"

Moving Toward Deployment. Proceedings of the IVHS AMERICA 1994 Annual Meeting, pp 245-256 , Atlanta, Georgia. 1994.

Abstract: Driver drowsiness is a major, though elusive, cause of traffic crashes. As part of its IVHS/human factors program, The National Highway Traffic Safety Administration (NHTSA) is supporting research to develop in-vehicle systems to continuously monitor driver alertness and performance. Scientific support for the feasibility of this countermeasure concept is provided by research showing that: Drowsy drivers typically do not "drop off" instantaneously. Drowsiness can be detected with reasonable accuracy by monitoring driving performance measures such as "drift-and-jerk" steering and fluctuations in vehicle lateral lane position. The use of direct, unobtrusive driver psychophysiological monitoring (e.g., eye closure) could enhance drowsiness detection significantly. The use of secondary/subsidiary auditory tasks (e.g., auditory recognition tasks presented to the driver via recorded voice) could further enhance detection accuracy.

Ron R. Knipling and J.- S. Wang,

"Crashes and Fatalities Related to Driver Drowsiness/Fatigue"

Research Note, NHTSA, Nov. 1994

Ron R. Knipling, J.- S. Wang, Joseph N. Kaniathra

"Current NHTSA Drowsy Driver R&D"

Proceedings of the Fifteenth International Technical Conference on the Enhanced Safety of Vehicles (ESV), Melbourne, Australia, May, 1996.

James C. Miller, M.C. Cook

"Fitness for Duty"

Draft Interim Report (Task G. FHWA Contract DTFH61-93-C-00088), Evaluation Systems Inc., ESI-TR-96-01, February, 1996.

Dean Pomerleau, Todd Jochem

"Rapidly Adapting Machine Vision for Automated Vehicle Steering "

IEEE Expert, pp. 19-27, April, 1996.

Gunter P. Siegmund, David J. King, David K. Mumford

"Correlation of Steering Behavior with Heavy-Truck Driver Fatigue"

SAE Paper #961683, 1996.

One of several papers written by MacInnis Engineering staff describing their work on sleep deprived drivers.

Gunter P. Siegmund, David J. King, David K. Mumford

"Correlation of Heavy-Truck Driver Fatigue with Vehicle-Based Control Measures"

SAE Paper #952594, 1995.

One of several papers written by MacInnis Engineering staff describing their work on sleep deprived drivers.

Mark Shuman

"Asleep at the Wheel"

Traffic Safety, pp. 6-9, January/February, 1992

Willem B. Verwey,

"SAVE - System for Effective Assessment of the Driver State and Vehicle Control in Emergency Situations"

Transport Telematics project No. TR 1047, TNO, The Netherlands.

Wierwille-WW; Wreggit-SS; Kirn-CL; Ellsworth-LA; Fairbanks-RJ

"Research On Vehicle-Based Driver Status/Performance Monitoring: Development, Validation, And Refinement Of Algorithms For Detection Of Driver Drowsiness,"

NHTSA Report No. DOT HS 808 247, National Highway Traffic Safety Administration, Washington, DC, December, 1994.

Abstract: The report summarizes the results of a 3-year research project to develop reliable algorithms for the detection of motor vehicle driver impairment due to drowsiness. These algorithms are based on driving performance measures that can potentially be committed on-board a vehicle during highway driving, such as measures of steering wheel movements and lane tracking. A principal objective of such algorithms is that they correlate highly with, and thus are indicative of, psychophysiological measures of driver alertness/fatigue. Additional objectives are that developed algorithms produce low false alarm rates, that there should be minimal encumbering of (interface with) the driver, and that the algorithms should be suitable for later field testing. The report describes driving simulation and other studies performed to develop, validate, and refine such algorithms.

K. Yamamoto, Yukie Hirata

"Estimate of Driver's Alertness Level using Fuzzy Method"

SAE paper #942321, 1994.



APPENDIX D

Extended Bibliography On Driver Behavior While Under the Influence of Alcohol or Drugs

Please note that the numbering system used at the top of each page is non-consecutive because irrelevant reports were removed. The 33 citations come from several sources: NTIS, TRIS, MEDLINE and Aerospace Database, acquired through a DIALOG search. As a result, the formats are not quite consistent. This computerized literature search was performed in October, 1996.



26/5/1 (Item 1 from file: 6)DIALOG(R)File 6:NTIS Comp. & distr. 1996 NTIS,
US Dept. Of Commerce. All rts. reserve.

TITLE: Profile Analysis of After-Effects Experienced During Exposure to Several Virtual Reality Environments

AUTHOR(S): Kennedy, R. S. ; Jones, M. B. ; Lilienthal, M. G. ; Harm, D. L. National Aeronautics and Space Administration, Houston, TX. Lyndon B. Johnson Space Center. Corp. Source Codes: 019042004; ND185000

May 94 9p Languages: English Journal Announcement: GRAI9424; STAR3212
In AGARD, Virtual Interfaces: Research and Applications 9 p. NTIS Prices: (Order as N94-37261/2, PC A09/MF A02) Country of Publication: United States

ABSTRACT:

Motion sickness symptoms are an unwanted by-product of exposure to virtual environments. This problem is not new and was reported in the early flight simulators and experiments on ego motions and vection. The cardinal symptom of motion sickness is, of course, vomiting, but this symptom is ordinarily preceded by a variety of other symptoms. In his classic studies of motion sickness conducted before and during World War II, G. R. Wendt introduced a three point scale to score motion sickness beyond a vomit/no vomit dichotomy. Later, Navy scientists developed a Motion Sickness Questionnaire (MSQ), originally for use in a slowly rotating room. In the last 20 years the MSQ has been used in a series of studies of air, sea, and space sickness. Only recently, however, has it been appreciated that symptom patterns in the MSQ are not uniform but vary with the way sickness is induced. In seasickness, for example, nausea is the most prominent symptom. In Navy simulators, however, the most common symptom is eye strain, especially when cathode ray tubes are employed in the simulation. The latter result was obtained in a survey of over 1,500 pilot exposures. Using this database, Essex scientists conducted a factor analysis of the MSQ. We found that signs and symptoms of motion sickness fell mainly into three clusters: 1) oculomotor disturbance, 2) nausea and related neurovegetative problems, and 3) disorientation, ataxia, and vertigo. We have since rescored the MSQ results obtained in Navy simulators in terms of these three components. We have also compared these and other profiles obtained from three different virtual reality systems to profiles obtained in sea sickness, space sickness, and alcohol intoxication. We will show examples of these various profiles and point out similarities and differences among them which indicate aspects of what might be called 'virtual-reality sickness'.

Descriptors: *Dichotomies; *Exposure; *Flight simulators; *Motion sickness; *Nausea; *Signs and symptoms; *Space adaptation syndrome; *Virtual reality; *Vomiting; *Warfare; Alcohols; Ataxia; Cathode ray tubes; Data bases; Disorientation; Factor analysis; Intoxication; Vertigo
Identifiers: NTISNASA

Section Headings: 51F (Aeronautics and Aerodynamics--Test Facilities and Equipment); 57W (Medicine and Biology--Stress Physiology); 62GE (Computers, Control, and Information Theory--General); 95D (Biomedical Technology and Human Factors Engineering--Human Factors Engineering)

26/5/10 (Item 10 from file: 6)DIALOG(R)File 6:NTISComp. & distr. 1996 NTIS,
US Dept. of Commerce. All rts. reserv.1292262 NTIS Accession Number: PB88-118708/XAB

TITLE: Dagen-Efter-Effekter av Alkohol pa Koerfoermagan i Simulerad Bilkoerning
(Hang-over Effects of Alcohol on Driver Performance in Simulated Driving)

AUTHOR(S): Toernros, J. ; Laurell, H.
Statens Vaeg-och Trafikinstitut, Linkoeping (Sweden) (National Swedish Road and Traffic
Research Institute).

Corp. Source Codes: 041613000 Report No.: VTI-314 1987 27p Languages: Swedish
Journal Announcement: GRAI8804

Text in Swedish.

NTIS Prices: PC E03/MF A01 Country of Publication: Sweden

ABSTRACT:

The purpose of the present investigation was to study possible hang-over effects of alcohol on driver performance in a sophisticated driving simulator. The driving task was demanding and required the Ss to drive a 20km test distance in as short time as possible. The road had horizontal as well as vertical curves. The Ss participated in drinking parties which preceded each hang-over condition. Each S chose to drink one of four alternative beverages; whisky, vodka diluted in orange juice, wine-red or white, or export beer. Free and ample supply of food and beverages was provided. It appeared that performance was lowered in the morning when average BAC was just below 0.04%. Each S made another three test runs during the day, 2.5 hours apart. No performance decrement was found at these later occasions; however, after another night's sleep all effects were gone.

Descriptors: *Alcoholism; *Reflexes; *Motor vehicle operators; *Performance
evaluation; Psychological effects; Reaction time Identifiers: *Foreign technology;
*Alcoholic intoxication; *Alcohol drinking; *Driver intoxication; Drivers; NTISTFSOLO
Section Headings: 57R (Medicine and Biology--Psychophysiology); 92B(Behavior and
Society--Psychology); 85H (Transportation--Road Transportation)

26/5/20 (Item 7 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.634863

TITLE: ACUTE AND HANGOVER EFFECTS OF ALCOHOL ON SIMULATED DRIVING PERFORMANCE

AUTHOR(S): Tornos, J; Laurel, H

CORPORATE SOURCE: Bund gegen Alkohol im Strassenverkehr eV; Alsterchaussee 17; D-2000 Hamburg 13; West Germany

JOURNAL: Blutalkohol Vol: 23 Issue Number: 1: pp 24-30

PUBLICATION DATE: 910000

PUBLICATION YEAR: 1991

LANGUAGE: German

SUBFILE: HRIS ISSN: 00065250

AVAILABILITY: Bund gegen Alkohol im Strassenverkehr eV; Alsterchaussee 17; D-2000 Hamburg 13; West Germany

ORDER NUMBER: N/A

ABSTRACT:

Hangover effects from alcohol in simulated driving were studied. The task was to negotiate 20 km in as short a time as possible. The road had curves, horizontal and vertical, with ice friction at irregular intervals. It was found that in the acute intoxicated state driving performance was severely impaired. Performance was also impaired but to a much lesser degree, in the morning after the alcohol consumption when average BAC (blood alcohol concentration) was just below 40 mmg%. Later during the day no significant differences were demonstrated. After another night's sleep, all effects were gone.

DESCRIPTORS: ALCOHOLIC BEVERAGES; DRIVER PERFORMANCE;
DRIVING SIMULATION; DRIVER IMPAIRMENT; HIGHWAY CURVES; ICE;
INTOXICATION; BLOOD ALCOHOL LEVELS SUBJECT HEADING: H52 HUMAN
FACTORS; H51 SAFETY; I83 ACCIDENTS AND THE HUMAN FACTOR

26/5/21 (Item 8 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.631923

TITLE: EDUCATIONAL BIOFEEDBACK DRIVING SIMULATOR AS A DRINK-DRIVING PREVENTION STRATEGY

AUTHOR(S): HOWAT,P; ROBINSON, S; BINNS, C; PALMER, S; LANDAUER, A
CORPORATE SOURCE: ALCOHOL AND DRUG PROBLEMS ASSOCIATION OF NORTH AMERICA; C/O MICAP, BOX 10212; LANSING; MI 48901;
JOURNAL: Journal of alcohol and drug education Vol.: 37 Issue Number: 1 Pag: 7-14
PUBLICATION DATE: 910000
PUBLICATION YEAR: 1991
LANGUAGE: ENGLISH SUBFILE: IRRDSOURCE
ACCESSION NUMBER: 9212TR345EIRRD
DOCUMENT NUMBER: 853226
ISSN:0090-1482
REFERENCES: -DATA SOURCE: Transport Research Laboratory(TRL)

ABSTRACT:

An experimental driving simulator was used as the basis of a strategy to encourage a reduction in drink driving prevalence. Seventy-two male subjects were randomly allocated to either a control or study group, after being interviewed about their drink-driving behavior. The study group subjects (n=36) were tested on the EB Simulator after consuming ethanol sufficient to raise their blood alcohol level (BAL) to 0.08 percent on one occasion, and after consuming a placebo drink on a second occasion, followed by interviews about their drink-driving behavior. The control group (n=36) were only subjected to the interviews. At the end of the second EB Simulator test, the study group subjects were given information about how their performance was affected by alcohol, along with general counseling about drink driving risks. Both groups were interviewed 8 months later to ascertain differences in drink driving behavior. The results indicated that the study group subjects significantly decreased their drink driving compared to the control group. (A*)

DESCRIPTORS: DRIVING (VEH); SIMULATION; DRUNKENNESS;
INTERVIEW; EDUCATION; BLOOD ALCOHOL CONTENT; MAN; DRIVER; SKILL
(ROAD USER); USA

26/5/22 (Item 9 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.629197

TITLE: INTERACTION EFFECTS OF HYPNOTICS AND ALCOHOL ON DRIVING PERFORMANCE

AUTHOR(S): Laurell, H; Tornros, J.

CORPORATE SOURCE: International Assn for Accident & Traffic Medicine; IAATM Headquarters, P.O. Box 1644; S-75146 Uppsala; Sweden

JOURNAL: Journal of Traffic Medicine Vol: 19 Issue Number: 1 Page: pp 9-13

PUBLICATION DATE: 910000

PUBLICATION YEAR: 1991

LANGUAGE: English **SUBFILE:** HRIS **ISSN:** 03455564

AVAILABILITY: International Assn for Accident & Traffic Medicine; IAATM Headquarters, P.O. Box 1644; S-75146 Uppsala; Sweden

ORDER NUMBER: N/A **FIGURES:** Figs. **TABLES:** 1 Tab

REFERENCES: Refs.

ABSTRACT:

Twenty-four healthy volunteers, screened as moderate drinkers and not using drugs, were paid subjects in the study. The design was double-blind, randomized, cross-over. Medications were: 2 mg; flurazepam, 30 mg; triazolam, 0.5 mg; placebo. Each drug was ingested on four consecutive nights at bedtime. Nine hours after the fourth intake, performance testing was carried out. Immediately after, alcohol was ingested. When the blood alcohol concentration reached 0.05 percent, performance testing was repeated. The driving task was to negotiate a distance of 20 km as fast as possible in a sophisticated driving simulator. In the case of a crash, the driver had to wait for 20 seconds before driving could resume. It was found that performance was affected by drug intake whereas no drug x alcohol interaction was evident; performance was worse after flurazepam than after any of the other two active drugs, regardless whether alcohol had been consumed or not.

DESCRIPTORS: BLOOD ALCOHOL CONTENT; PHARMACOLOGIC EFFECT;
PLACEBO; DRIVER PERFORMANCE; INTERACTIONS; DRUG CAUSED ACCIDENTS;
FATIGUE(HUMAN); DRIVING SIMULATION RESEARCH SUBJECT HEADING: H52
HUMAN FACTORS; I83 ACCIDENTS AND THE HUMAN FACTOR; H51 SAFETY

26/5/23 (Item 10 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.624844

**TITLE: THE EFFECTS OF BLOOD ALCOHOL LEVELS ON DRIVING SIMULATOR,
COORDINATION, AND REACTION TIME TESTS IN A HIGH RISK POPULATION:
OBJECTIVE AND SUBJECTIVE MEASURES**

AUTHOR(S): Cox, DJ; Gressard, CF; Quillian, WC; Westerman, P; Gonder-Frederick, L
CORPORATE SOURCE: Virginia University; Charlottesville; VA; 22903; AAA Foundation
for Traffic Safety; 1730 M Street, NW, Suite 401 ; Washington; DC; 20036; Pag: 72p

PUBLICATION DATE: 920213

PUBLICATION YEAR: 1992

LANGUAGE: English **SUBFILE:** HRIS

BIBLIOGRAPHIC/DATA APPENDICES: 5 App.

AVAILABILITY: AAA Foundation for Traffic Safety; 1730 M Street, NW, Suite 401;
Washington; DC ; 20036

FIGURES: 8 Fig.

TABLES: 4 Tab.

REFERENCES: Refs.

ABSTRACT:

This study employed high risk drivers (college fraternity students) to investigate the following questions: 1) Is legal intoxication recognizable by such individuals? 2) Would legally intoxicated individuals choose to drive? 3) What component(s) of driving performance is/are impaired at raised blood alcohol levels (BALs)? 4) What specific driving skill(s) is/are impaired? and 5) Are there things one can do to help accurately detect legal intoxication and potential driving impairments? To assess perception of legal intoxication and willingness to drive, three different groups of subjects were evaluated: Legally Intoxicated ($\geq .10\%$ BAL), Elevated BAL (.04-.09% BAL), and Placebo ($<.04\%$ BAL). Additionally, the specific driving impairments associated with BALS of 0.08% or higher were analyzed. Finally, the abilities of different coordination and reaction time tests were evaluated to determine if such tests were able to differentiate between BALS $\geq 0.08\%$ and BALS $<0.04\%$. All tests were evaluated objectively and subjectively. To summarize results, subjects were accurate at recognizing legal intoxication, but a third of the legally intoxicated subjects were still willing to drive. When BAL was $\geq 0.08\%$, individuals objectively performed more poorly on various parameters of the driving simulation, coordination, and reaction time tests. At these same BALS, subjects rated all of these tests to be more difficult, and their performance to be less accurate and more impaired. Experience on the simulator did not influence subjects/ willingness to drive.

DESCRIPTORS: BLOOD ALCOHOL LEVEL; YOUNG DRIVERS; MALE
DRIVERS; PERFORMANCE TESTS; DRIVING SIMULATORS; DRIVER
PERFORMANCE; REACTION TIME; INTOXICATION; RECOGNITION; DECISION
MAKING; SUBJECTIVE ANALYSIS; OBJECTIVE ANALYSIS SUBJECT HEADING:
H52

HUMAN FACTORS; H51 SAFETY; I83 ACCIDENTS AND THE HUMAN FACTOR

26/5/24 (Item 11 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.624509

**TITLE: LOCUS OF CONTROL AND ALCOHOL PLACEBO EFFECTS ON
PERFORMANCE IN A DRIVING SIMULATOR**

AUTHOR(S): Breckenridge, RL; Dodd, MO
CORPORATE SOURCE: N/A; P.O. Box 9229; Missoula; MT; 59807;
JOURNAL: Perceptual and Motor Skills Vol: 72 Issue Number: 3 Pag: pp 751-756
PUBLICATION DATE: 910000
PUBLICATION YEAR: 1991
LANGUAGE: English
SUBFILE: HRIS ISSN: 00315125
AVAILABILITY: Perceptual and Motor Skills; P.O. Box 9229; Missoula; MT ;59807
ORDER NUMBER: N/A

ABSTRACT:

Performance in a driving simulator was evaluated as a function of locus of control, perceived alcohol ingestion (no alcohol versus a no-alcohol placebo), and sex. Using a pre-test/post-test design, an analysis of covariances was performed using the pre-test performance on a driving simulator as the covariate. There were 10 men and 10 women in each of 4 groups. As predicted, the external-scoring placebo subjects made more post-test errors than did the internal-scoring placebo group or either of the no-alcohol control groups. This indicated that the external-scoring placebo subjects were more affected by what they expected to happen than their actual physiological state warranted. A difference was also found in which external-scoring women made more errors than did any other group. This was an unexpected finding which, being inconsistent with previous findings involving sex, warrants further research.

DESCRIPTORS: ALCOHOLIC BEVERAGES; DRIVER PERFORMANCE;
DRIVING SIMULATORS; PLACEBO; SEX; PHYSIOLOGICAL ASPECTS SUBJECT
HEADING: H51 SAFETY; H52 HUMAN FACTORS; I83 ACCIDENTS AND
THE HUMAN FACTOR

26/5/27 (Item 14 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.615169

**TITLE: CURVE NEGOTIATION PERFORMANCE IN A DRIVING SIMULATOR AS A
FUNCTION OF CURVE GEOMETRY**

AUTHOR(S): Gawron, VJ; Ranney, TA

CORPORATE SOURCE: Butterworth Scientific Limited; Journals Division, P.O. Box 63,
Westbury House, Bury Street; Guildford, Surrey GU2 5BH; England

JOURNAL: Applied Ergonomics Vol: 21 Issue Number: 1 Pag: pp 33-38

PUBLICATION DATE: 900000

PUBLICATION YEAR: 1990

LANGUAGE: English **SUBFILE:** HRIS **ISSN:** 00036870

AVAILABILITY: Westbury Subscription Services; P.O. Box 101; Sevenoaks, Kent TN15 8PL;
England

ABSTRACT:

Driver performance on curves was investigated using a driving simulator. Between-trial factors were blood alcohol content level and type of driving scenario; within-session factors were edgeline width, type of curve warning sign, and curve type. 12 men drove continuously for two hours on each of the three nights. Curve entry speed increased as radius of curvature increased. Lateral position error was greatest on the curve with the smallest radius and least on the curve with the shortest length. Heading error first increased then decreased as curve radius increased. Results are attributed to the absence of lateral acceleration cues in the driving simulator.

DESCRIPTORS: DRIVER PERFORMANCE; DRIVING SIMULATION; BLOOD
ALCOHOL LEVEL; VEHICLE LATERAL PLACEMENT; HIGHWAY CURVES;
ALCOHOLIC BEVERAGES **SUBJECT HEADING:** H51, SAFETY; H52,HUMAN
FACTORS;
183, ACCIDENTS AND THE HUMAN FACTOR

26/5/28 (Item 15 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.607985

TITLE: PEER ATTITUDES, SEX, AND THE EFFECTS OF ALCOHOL ON SIMULATED
DRIVING PERFORMANCE

AUTHOR(S): Oek, TP; Kerschbaumer, DM

CORPORATE SOURCE: Dekker (Marcel), Incorporated; 270 Madison Avenue; New York;
NY; 10016;

JOURNAL: American Journal of Drug and Alcohol Abuse Vol: 16 Issue Number: 1-2

Pag: pp 135-146

PUBLICATION DATE: 900000

PUBLICATION YEAR: 1990

LANGUAGE: English SUBFILE: HRIS ISSN: 00952990

AVAILABILITY: Dekker (Marcel), Incorporated; 270 Madison Avenue; New York; NY; 10016

ABSTRACT:

This study presents an investigation of the effects of peer attitude, gender, and blood alcohol level on driving performance using a driving simulator. Subjects were randomly assigned to pro or against drinking driving conditions and tested at different blood alcohol levels. The results revealed that subjects when under the influence of alcohol in the for drinking-driving condition perceived themselves to be more capable than they actually were and drove increasingly faster and made more mistakes than subjects in the against-drinking-driving condition. Significant sex differences were observed only for performance on the driving simulator. Males in the main, engaged in more dangerous driving and risk taking in simulated driving conditions than females.

DESCRIPTORS: ALCOHOLIC BEVERAGES; DRIVING UNDER THE
INFLUENCE; DRINKING DRIVER; ATTITUDES (MENTAL); SEX; DRIVER
PERFORMANCE; BLOOD ALCOHOL LEVEL; DRIVING SIMULATORS SUBJECT
HEADING: H51, SAFETY; H52,HUMAN FACTORS

26/5/30 (Item 17 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.601383

TITLE: DRIVING SIMULATORS: A CLASSIFIED BIBLIOGRAPHY

EDITOR(S): Kronfol, R; Grimm, A

CORPORATE SOURCE: University of Michigan Transp Research Institute; 2901 Baxter Road;
Ann Arbor; MI; 48109-2150; **REPORT NUMBER:** UMTRI-90-9;HS-040 697 **Page:** 35p

PUBLICATION DATE: 900300

PUBLICATION YEAR: 1990

LANGUAGE: English **SUBFILE:** HSL; HRIS

AVAILABILITY: University of Michigan Transp Research Institute; 2901 Baxter Road ;
Ann Arbor; MI ; 48109-2150

DATA SOURCE: National Highway Traffic Safety Administration

ABSTRACT:

This bibliography contains 245 references to documents concerned with the application of or the design of driving simulators. The documents date from 1974 to the present and are arranged according to the following subject areas: Alcohol/Drugs; Design; Driver Education; Handicapped/Disabled; Human Performance; Human Stress/Fatigue; Risk Taking; Signs/Signals; and Vision. A Corporate Author Index is provided.

DESCRIPTORS: BIBLIOGRAPHIES; DRIVING SIMULATORS; DRIVING UNDER THE INFLUENCE; DRUG; DESIGN; DRIVER EDUCATION; HANDICAPPED INDIVIDUALS; DISABLED DRIVERS; DRIVER PERFORMANCE; STRESS (HUMAN); DRIVER FATIGUE; RISK TAKING; TRAFFIC SIGNS; SIGNALS; WARNING SYSTEMS; BRAKING LIGHTS; DRIVER VISION **SUBJECT HEADING:** H51, SAFETY; H52, HUMAN FACTORS;
183, ACCIDENTS AND THE HUMAN FACTOR

26/5/31 (Item 18 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.568184

TITLE: THE EFFECTS OF SPOT TREATMENTS ON PERFORMANCE IN A DRIVING
SIMULATOR UNDER SOBER AND ALCOHOL-DOSED CONDITIONS

AUTHOR(S): GAWRON, VJ; RANNEY, TA

JOURNAL: ACCIDENT ANALYSIS AND PREVENTION Vol: 22 Issue Number: 3

Pag: PP 263-279

PUBLICATION DATE: 900600

PUBLICATION YEAR: 1990

LANGUAGE: English SUBFILE: TLIB

SUPPLEMENTAL NOTES: VALERIE J. GAWRON AND THOMAS A. RANNEY

ILLUSTRATED INCLUDES BIBLIOGRAPHICAL REFERENCES

DATA SOURCE: UC, BERKELEY, INSTITUTE FOR TRANSPORTATION

STUDIES22214560

ABSTRACT:

No abstract provided.

DESCRIPTORS: DRINKING AND TRAFFIC ACCIDENTS; ALCOHOL;
PHYSIOLOGICAL EFFECT; AUTOMOBILE DRIVING SIMULATORS

26/5/34 (Item 21 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.493558

TITLE: DRUG EFFECTS ON HUMAN PERFORMANCE: NIDA RESEARCH PROGRAMS

AUTHOR(S): Walsh, JM

CORPORATE SOURCE: Brain Information Service; Brain Research Institute, California University, Los Angeles; Los Angeles; CA; 90024-1746;REPORT NUMBER: HS-040 258

JOURNAL: Alcohol, Drugs and Driving Vol: 3 Issue Number: 1 Pag: pp 31-35

PUBLICATION DATE: 870100

PUBLICATION YEAR: 1987

LANGUAGE: English SUBFILE: HSL; UMTRIS; ATRIS; RRIS; HRIS

ISSN: 08917086

AVAILABILITY: Brain Information Service; Brain Research Institute, California University, Los Angeles; Los Angeles; CA ; 90024-1746

REFERENCES: Refs.

DATA SOURCE: National Highway Traffic Safety Administration

ABSTRACT:

In 1986, approximately \$65 million was appropriated for drug abuse research in the U.S. These funds were allocated across a spectrum of basic biomedical studies, clinical and behavioral pharmacology, treatment and prevention research. Approximately \$9 million was targeted for marijuana research and more than \$6 million for cocaine. The portion of the program directly related to drug effects on human performance was roughly \$4 million or 6% of the total research dollars available. In an attempt to spend limited funds in a wise and efficient manner, the National Institute on Drug Abuse (NIDA) has identified four major areas of program importance in the area of human performance. These are (a) dose-response relationships and pharmacokinetics, (b) development of performance assessment batteries, (c) simulation and field studies, and (d) productivity in the work/school environment. The details of these important areas are discussed in this paper, which also includes highlights of NIDA's current research program and comments on the future research initiatives at NIDA.

DESCRIPTORS: DRUG; HUMANS; PERFORMANCE; RESEARCH;
NATIONAL INSTITUTE ON DRUG ABUSE; FUND ALLOCATIONS;
PHARMACOLOGIC EFFECT; DOSE-RESPONSE RELATIONSHIPS; TEST METHOD;
DRIVING SIMULATION; FLIGHT SIMULATORS; FIELD STUDIES; EPIDEMIOLOGY;
WORK ENVIRONMENT; SCHOOL; MARIHUANA; COCAINE SUBJECT HEADING:
H52,HUMAN FACTORS; H51, SAFETY; 183, ACCIDENTS AND THE HUMAN FACTOR;
U26,SAFETY & PRODUCT QUALITY

26/5/35 (Item 22 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.493027

**TITLE: A PROPOSED INVESTIGATION INTO DRUG IMPAIRMENT TESTING
METHODOLOGY.**

AUTHOR(S): Irving, A

CORPORATE SOURCE: CNS (Clinical Neuroscience) Publishers; 50 Ferry Street, Isle of
Dogs; London; England Pag: pp 99-109

JOURNAL: Medicine and road traffic safety

PUBLICATION DATE: 880000

PUBLICATION YEAR: 1988

LANGUAGE: English **SUBFILE:** HRIS;

IRRDSOURCE ACCESSION NUMBER: IRRD 819725 **ISBN:** 1-869868-02-1

AVAILABILITY: CNS (Clinical Neuroscience) Publishers; 50 Ferry Street, Isle of Dogs;
London; England

REFERENCES: Refs.

DATA SOURCE: Transport and Road Research Laboratory

ABSTRACT:

The author describes the scheduled program developed by the Transport and Road Research Laboratory (TRRL) to investigate the properties of the various types of test and testing procedures used to study the effects of certain key drug substances. The program is based on recommendations concerning a testing protocol published by the world health organization. Details are given of two interactive laboratory-based driving simulations -the moving-belt CCTV simulator (MBS) and the moving road (film) simulator (MRS) - and one non-interactive simulator -the hazard perception simulator -which are to be used in the program. Two additional laboratory tasks are to be utilized: an adaptive tracking task and a task involving compensatory tracking and vigilance. Two fully equipped closed test tracks at the laboratory are also to be used in the testing assessment programs. (TRRL)

DESCRIPTORS: CONFERENCE; DRUG; DRIVER PERFORMANCE; DRIVER;
UNITED KINGDOM; TEST; SIMULATION; EQUIPMENT; TEST METHOD;
LABORATORY TESTS; ATTENTION; REACTION; CINEMATOGRAPHY SUBJECT
HEADING: H51, SAFETY; H52,HUMAN FACTORS

26/5/36 (Item 23 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.493023

TITLE: THE PSYCHO PHARMACOLOGICAL APPROACH: EFFECTS OF
PSYCHOTROPIC DRUGS ON CAR HANDLING. MEDICINES AND ROAD
TRAFFIC SAFETY

AUTHOR(S): Hindmarch, I

CORPORATE SOURCE: CNS (Clinical Neuroscience) Publishers; 50 Ferry Street, Isle of
Dogs; London; ENGLAND PAG: pp 73-9

PUBLICATION DATE: 880000

PUBLICATION YEAR: 1988

LANGUAGE: English

SUBFILE: HRIS; IRRDSOURCE ACCESSION NUMBER: IRRD 819721

ISBN: 1-869868-02-1

AVAILABILITY: CNS (Clinical Neuroscience) Publishers; 50 Ferry Street, Isle of Dogs;
London; ENGLAND

REFERENCES: Refs.

DATA SOURCE: Transport and Road Research Laboratory

ABSTRACT:

The author describes three kinds of tests used over the last 15 years or so, to measure changes in behavior brought about by the administration of psychotropic drugs. All the tests are based on measuring different aspects of the processing of information which make up psychological performance. The tests are: (1) on the road tests which involve "slalom" steering and other activities. The methods used to study car handling on the road appear to have a low order of sensitivity; (2) car driving simulators; (3) laboratory analogues. (TRRL)

DESCRIPTORS: CONFERENCE; DRUG; DRIVER PERFORMANCE;
VEHICLE HANDLING; TEST; HIGHWAY; PSYCHOLOGICAL ASPECTS;
SIMULATION; EQUIPMENT; PSYCHOTROPIC AGENTS SUBJECT HEADING: H51,
SAFETY; H52,HUMAN FACTORS

26/5/37 (Item 24 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.492157

TITLE: SUBJECTIVE FACTORS RELATED TO FATIGUE

AUTHOR(S): Nelson, TM

CORPORATE SOURCE: Brain Information Service; Brain Research Institute, California
University, Los Angeles; Los Angeles; CA; 90024-1746;

REPORT NUMBER: HS-040 745

JOURNAL: Alcohol, Drugs and Driving Vol: 5 Issue Number: 3 Pag: pp 193-214

PUBLICATION DATE: 890700

PUBLICATION YEAR: 1989

LANGUAGE: English SUBFILE: HSL; HRIS ISSN: 08917086

AVAILABILITY: Brain Information Service; Brain Research INSTITUTE, California
University, Los Angeles; Los Angeles; CA ; 90024-1746

FIGURES: Figs.

TABLES: Tabs.

REFERENCES: Refs.

ABSTRACT:

This paper develops the concept of fatigue as a declarative state based upon self-perceptions of body distress, mood and performance. The significance of this approach is exemplified in results obtained from an extensive series of laboratory experiments using partial driving simulation. Several report how quantitative features of subjective experience can be used to predict the time at which drivers judge themselves incompetent to go on driving. A different experiment shows that blood alcohol reduces the time to fatigue and distorts the driver's interpretation of the symptoms of pre-fatigue symptoms without reducing awareness of them. In another study it is found that conditions of comfort can be combined with multiple rest pauses so as to delay the onset of fatigue. The paper concludes with an 18-point advisory about fatigue designed to serve the driving public.

DESCRIPTORS: DRIVER FATIGUE; HUMAN FACTOR; LABORATORY
STUDIES; DRIVING SIMULATION; ALCOHOLIC BEVERAGES SUBJECT HEADING:
H51, SAFETY; H52, HUMAN FACTORS; 183, ACCIDENTS AND THE HUMAN FACTOR

26/5/38 (Item 25 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.490822

TITLE: USE OF CONTROLLED SUBSTANCES AND HIGHWAY SAFETY: A REPORT TO CONGRESS. FINAL REPORT

AUTHOR(S): Compton, RP

CORPORATE SOURCE: National Highway Traffic Safety Administration; 400 7th Street, SW ; Washington; DC; 20590;

REPORT NUMBER: HS-807 261Pag: 45p

PUBLICATION DATE: 880300

PUBLICATION YEAR: 1988

LANGUAGE: English

SUBFILE: HSL

AVAILABILITY: National Highway Traffic Safety Administration; 400 7th Street, SW ; Washington; DC ; 20590

SUPPLEMENTAL NOTES: Prepared in Response to Section 3402: P.L. 99-570, October 27, 1986 Anti-Drug Abuse Act of 1986.

REFERENCES: Refs.

DATA SOURCE: National Highway Traffic Safety Administration

ABSTRACT:

This report reviews the relationship of drug use to highway safety. It identifies the information needed to determine the nature and magnitude of the drug and highway safety problem and reviews the major methodological problems. The report describes the best information on the incidence of drug usage by drivers involved in crashes, and summarizes the findings from research on the behavioral effects from drugs, and studies using driving simulators. General conclusions are presented on the role of drugs in highway safety.

DESCRIPTORS: DRUG; TRAFFIC ACCIDENT; HIGHWAY SAFETY; BEHAVIOR

26/5/40 (Item 27 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.483296

TITLE: THE EFFECT OF ALCOHOL DOSING ON DRIVING PERFORMANCE ON A
CLOSED COURSE AND IN A DRIVING SIMULATOR

AUTHOR(S): Gawron, VJ; Ranney, TA
JOURNAL: ERGONOMICS Vol: 31 Issue Number: 9 Pag: 1219-44
PUBLICATION DATE: 880000
PUBLICATION YEAR: 1988
LANGUAGE: English SUBFILE: HRIS; IRRD ISSN: 00140139
DATA SOURCE: Transport and Road Research Laboratory

ABSTRACT:

The effect of alcohol consumption on driving performance was examined in two studies. In the first, six subjects drove for two hours over a closed-loop, two-lane course. In the second, 12 subjects drove for two hours in a driving simulator. In both studies, target blood alcohol concentrations (BAC) were 0.00%, 0.07%, or 0.12%. Multiple measures of vehicle control, tracking and information processing were recorded. In general, the standard deviations of these measures increased as BAC increased. Differences in the results between the two studies were related to differences in facilities (i.e. Closed course vs driving simulator).

(a)DESCRIPTORS: DRUNKENNESS; SKILL (ROAD USER); DRIVING (VEH);
SIMULATION; PERCEPTION

26/5/41 (Item 28 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.480043

TITLE: EFFECT OF ALCOHOL CONSUMPTION ON RISK-TAKING WHILE DRIVING

AUTHOR(S): McMillen, DL; Wells-Parker, E

CORPORATE SOURCE: Pergamon Press, Incorporated; Maxwell House, Fairview Park;
Elmsford ; NY; 10523;

JOURNAL: Addictive Behaviors Vol: 12 Issue Number: 3 Pag: pp 241-247

PUBLICATION DATE: 870000

PUBLICATION YEAR: 1987

LANGUAGE: English

SUBFILE: HRIS; IRRDSOURCE ACCESSION NUMBER: IRRD 811299

ISSN: 03064603

AVAILABILITY: Pergamon Press, Incorporated; Maxwell House, Fairview Park; Elmsford ;
NY ; 10523

DATA SOURCE: Transport and Road Research Laboratory

ABSTRACT:

Using a cover story of the effects of alcohol on perceptual and motor abilities, three levels of alcohol consumed (high, moderate, and none) to determine their effects on risk taking while driving. Thirty-nine subjects were randomly assigned to six conditions. A driving simulation task was employed; dependent variables were cars passed and total time at high speed. Results indicated greater risk-taking, measured by cars passed and time spent at high speed, by subjects who believed they had consumed a moderate amount of alcohol. Actual amount of alcohol consumed produced no significant differences. (Author/TRRL)

DESCRIPTORS: DRUNKENNESS; ACCIDENT; VISION; BIOMECHANICS;
MUSCLE; RISK TAKING; SIMULATION; DRIVING (VEH) SUBJECT HEADING:
H52,HUMAN FACTORS; H51, SAFETY

26/5/42 (Item 29 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.472960

TITLE: MARIJUANA AND ALCOHOL: A DRIVER PERFORMANCE STUDY

AUTHOR(S): Biasotti, AA; Boland, P; Mallory, C; Peck, R; Reeve, VC
CORPORATE SOURCE: California Department of Justice; 1515 K Street, Suite 511 ;
Sacramento; CA; 95814; Pag: 187p
PUBLICATION DATE: 860900
PUBLICATION YEAR: 1986
LANGUAGE: English
SUBFILE: HRIS
AVAILABILITY: National Technical Information Service; 5285 Port Royal Road; Springfield;
VA ; 22161
ORDER NUMBER: PB87-172037/WTS
DATA SOURCE: National Technical Information Service

ABSTRACT:

Approximately 80 volunteer male marijuana and alcohol users received one of four experimental treatments: (1) marijuana, (2) alcohol, (3) marijuana and alcohol, or (4) double placebo. After consumption, each subject drove a vehicle over a test course which simulated a number of real-world driving conditions. Four post-drug runs were involved, separated by one-hour intervals. The subject's performance was rated by an in-car examiner, outside observers, and computerized vehicle measurements. Blood and urine specimens were extracted after each run to establish levels of tetrahydrocannabinol (THC), serum carboxy, and alcohol. A variety of multivariate statistical techniques were applied in evaluating treatment effects. Both marijuana and alcohol had significant effects on driving performance, and the effects were particularly detrimental under the both-drugs treatment. The effects of marijuana were more rapid than those of alcohol and somewhat less severe for most tasks.

DESCRIPTORS: DRIVING UNDER THE INFLUENCE; ETHYLALCOHOL;
MARIHUANA; DRIVER PERFORMANCE; DRIVING SIMULATION; PHYSIOLOGICAL
EFFECT; BLOOD ALCOHOL LEVEL SUBJECT HEADING: H52,HUMAN FACTORS;
H51, SAFETY; 183, ACCIDENTS AND THE HUMAN FACTOR

26/5/43 (Item 30 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.472617

**TITLE: DEVELOPMENT OF MODELS FOR ON-BOARD DETECTION OF DRIVER
IMPAIRMENT**

AUTHOR(S): Dingus, TA; Hardee, HL; Wierwille, WW
CORPORATE SOURCE: Pergamon Press Limited; Headington Hill Hall; Oxford OX3
0BW ; England **REPORT NUMBER:** HS-040 348
JOURNAL: Accident Analysis and Prevention Vol: 19 Issue Number: 4Pag: pp 271-283
PUBLICATION DATE: 870800
PUBLICATION YEAR: 1987
LANGUAGE: English **SUBFILE:** HSL; HRIS **ISSN:** 0001475
AVAILABILITY: Engineering Societies Library; 345 East 47th Street; New York; NY; 10017
TABLES: Tabs.
REFERENCES: Refs

ABSTRACT:

Two of the leading causes of automobile accidents are driver impairment due to alcohol and drowsiness. Apparently, a relatively large percentage of these accidents occur because drivers are unaware of the degree to which they are impaired. The purpose of this research was to develop models, utilizing changes in driver behavior, which could detect driver impairment due to alcohol, drowsiness, or the combination of alcohol and drowsiness, and which could be practically implemented in an automobile. A computer-controlled automobile simulator was used to simulate a nighttime highway driving scenario for 6 drivers who participated in each of four conditions; a control condition, an alcohol condition, a sleep-deprived condition, and a combined alcohol and sleep-deprived condition. The results indicated that a useful on-board drowsiness detection device is possible and practical for highway driving. The results also showed that on-board alcohol impairment detection may be possible at levels below the legal driving limit in most states (BAC 0.1%).

DESCRIPTORS: MODEL; ON BOARD; DRIVER IMPAIRMENT; ALCOHOLIC
BEVERAGES; DROWSINESS; DRIVER BEHAVIOR; NIGHT; DRIVING
SIMULATORS; BLOOD ALCOHOL LEVEL **SUBJECT HEADING:** H51, SAFETY;
183, ACCIDENTS AND THE HUMAN FACTOR

26/5/44 (Item 31 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.471917

**TITLE: PHYSICAL AND PSYCHOLOGICAL EFFECTS OF ALCOHOL AND OTHER
DRUGS ON DRIVERS**

AUTHOR(S): Blaschke, JD; Dennis, ME, III; Creasey, FT
CORPORATE SOURCE: Institute of Transportation Engineers; 525 School Street, SW, Suite
410; Washington; DC; 20024;
REPORT NUMBER: HS-040 264
JOURNAL: ITE Journal Vol: 57 Issue Number: 6 Pag: pp 33 -38
PUBLICATION DATE: 870600
PUBLICATION YEAR: 1987
LANGUAGE: English **SUBFILE:** HSL; UMTRIS; HRIS **ISSN:** 01628178
AVAILABILITY: Institute of Transportation Engineers; 525 School Street, SW, Suite 410;
Washington; DC ; 20024
FIGURES: Figs.
TABLES: Tabs.
REFERENCES: 29 Ref.

ABSTRACT:

Four primary topics concerning the effects of alcohol and other drugs on drivers are discussed: alcohol and drug-related accidents; research areas; alcohol and its effects; and other drugs and their effects. It is noted that more than 50% of all fatal accidents involve drinking. Research areas considered here were as follows: identification and analysis of accident rates and causation factors; laboratory task testing; driving simulation; and real driving conditions. Accident statistics are also discussed. It is pointed out that impairment of driving abilities that could result in traffic accidents occurs at blood alcohol concentration levels as low as 0.05%. It is also noted that the present laws on drunk driving could be misleading the public into thinking that drinking and driving is safer than it is.

DESCRIPTORS: PHYSIOLOGICAL EFFECT; PSYCHOLOGICAL EFFECTS; ALCOHOLIC
BEVERAGES; DRUG; DRIVER IMPAIRMENT; TRAFFIC ACCIDENT;
RESEARCH; FATAL ACCIDENTS; ACCIDENT RATE; ACCIDENT CAUSES;
LABORATORY TESTS; DRIVING SIMULATION; STATISTICS; LAW SUBJECT
HEADING: H52,HUMAN FACTORS; 183, ACCIDENTS AND THE HUMAN FACTOR;
U23,HUMAN RESOURCES MANAGEMENT

26/5/45 (Item 32 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.470439

TITLE: ALCOHOL, DRUGS AND TRAFFIC SAFETY. ROAD USERS AND TRAFFIC SAFETY

AUTHOR(S): Smiley, A; Brookhuis, KA

CORPORATE SOURCE: Van Gorcum & Comp BV; P.O. Box 43; Assen; Netherlands Pag: pp 83-104

PUBLICATION DATE: 870000

PUBLICATION YEAR: 1987

LANGUAGE: English

SUBFILE: HRIS; IRRDSOURCE ACCESSION NUMBER: IRRD 809414

ISBN:90-232-2316-0

AVAILABILITY: Van Gorcum & Comp BV; P.O. Box 43; Assen; Netherlands

REFERENCES: 57 Ref.

DATA SOURCE: Transport and Road Research Laboratory

ABSTRACT:

Traffic safety studies have clearly shown that the cause of the majority of traffic accidents is human error. A number of factors play a significant role in the production of human errors, one of which is the influence of alcohol and drugs, the topic of this chapter. In order to ascertain the effect of alcohol and drugs on traffic safety it is necessary to examine the problem from a number of perspectives. Epidemiological studies, laboratory tests of driving related skills, simulator studies and on-road studies each provide a vital part of the evidence establishing the role of any given substance to traffic safety. The relevance of each of these type of studies, their strengths and limitations, and some of the major issues and recent results in each of these areas are discussed. (TRRL)

DESCRIPTORS: ALCOHOLIC BEVERAGES; DRUG; TRAFFIC ACCIDENT;
ACCIDENT CAUSES; HUMAN FACTOR; EPIDEMIOLOGY; DRIVER PERFORMANCE;
DRIVING SIMULATION; LABORATORY TESTS SUBJECT HEADING: H51,SAFETY;
H52, HUMAN FACTORS

26/5/46 (Item 33 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.466729

TITLE: THE INTERACTION OF ALCOHOL AND FATIGUE ON DRIVER SIMULATOR PERFORMANCE

AUTHOR(S): Stein, AC; Allen, RW; Cook, ML

CORPORATE SOURCE: American Association for Automotive Medicine; 40 Second Avenue; Arlington Heights; IL; 60005;

JOURNAL: American Association for Auto Medicine Conf Proc Pag: pp 91-104

PUBLICATION DATE: 850000

PUBLICATION YEAR: 1985

LANGUAGE: English **SUBFILE:** HRIS; IRRDSOURCE **ACCESSION NUMBER:** 8602SWO08E.

AVAILABILITY: American Association for Automotive Medicine; 40 Second Avenue; Arlington Heights; IL; 60005

FIGURES: 11 Fig.

REFERENCES: 16 Ref.

DATA SOURCE: Transport and Road Research Laboratory Institute for Road Safety Research SWOV

ABSTRACT:

Interactive driving simulators have provided a safe and efficient mechanism for studying the effects of impairing agents on driving performance. Unfortunately, in the past simulators have been limited in their ability to test drivers for long periods of time. In this study the authors developed a methodology for testing drivers over a two hour time period; and for analyzing the possible effects that this long driving period had on driving performance. This paper presents the basic results of this portion of the study, and discusses the effects of alcohol and fatigue on driver performance variables which may lead to accident involvement. For the covering abstract of the conference see IRRD 287637. (Author/TRRL)

DESCRIPTORS: CONFERENCES; DRIVING UNDER THE INFLUENCE;
DRIVER FATIGUE; **DRIVING SIMULATORS;** **DRIVER PERFORMANCE SUBJECT**
HEADING: H51,SAFETY; H52, HUMAN FACTORS

26/5/47 (Item 34 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.463371

TITLE: MARIJUANA, COCAINE AND TRAFFIC SAFETY

Editor(s): Moskowitz, H

CORPORATE SOURCE: Brain Information Service; California University, Center for Health Science; Los Angeles; CA; 90024;

JOURNAL: Alcohol, Drugs and Driving Vol: 2 Issue Number: 3-4 Pag: 163p

PUBLICATION DATE: 860700

PUBLICATION YEAR: 1986

LANGUAGE: English SUBFILE: HRIS

AVAILABILITY: Brain Information Service; California University, Center for Health Service; Los Angeles; CA; 90024

FIGURES: Figs.

TABLES: Tabs.

REFERENCES: Refs.

ABSTRACT:

The papers are published that were presented at the symposium on Marijuana, Cocaine and Traffic Safety which was designed to assess whether these drugs represent a substantial danger to traffic safety and to clarify avenues for future research endeavors. The papers presented in this issue discuss marijuana; the papers discussing cocaine and other stimulants will be presented in the following issue. The papers presented are as follows: Problems and Methods in Studying Drug Crash Effects; Epidemiology of Road Accidents Involving Marijuana; Psychosocial Correlates of Marijuana Use in Adolescence and Young Adulthood: The Past as Prologue; Drug Concentrations and Traffic Safety; Pharmacokinetics and Metabolism of (delta sup 9) -Tetrahydrocannabinol: Relations to Effects in Man; Analytical Methodology for (delta sup 9)- Tetrahydrocannabinol and its Metabolites; Behavioral Interactions and the Effects of Marijuana; The Effects of Alcohol and Marijuana in Combination: A Review; Marijuana: On-Road and Driving Simulator Studies; The Effects of Marijuana and Alcohol on Actual Driving Performance; and Effects of Long Term Marijuana Use.

DESCRIPTORS: TRAFFIC SAFETY; MARIHUANA; COCAINE;
CONFERENCES; RESEARCH; EPIDEMIOLOGY; PSYCHOSOCIAL ASPECTS;
ADOLESCENT; YOUNG ADULTS; METABOLISM; ALCOHOLIC BEVERAGES;
BEHAVIOR; DRIVER PERFORMANCE; DRIVER BEHAVIOR SUBJECT HEADING:
H51,SAFETY; H52 HUMAN FACTORS; 183, ACCIDENTS AND THE HUMAN FACTOR

26/5/48 (Item 35 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.456339

TITLE: EFFECTS OF DRUGS ON DRIVING. DRIVING SIMULATOR TESTS OF
SECOBARBITAL, DIAZEPAM, MARIJUANA AND ALCOHOL

AUTHOR(S): Smiley, A; Moskowitz, HM; Ziedman, K

CORPORATE SOURCE: National Institute on Drug Abuse; 5600 Fishers Lane; Rockville;
MD; 20852;

REPORT NUMBER: HS-040 208

JOURNAL: Clinical and Behavior Pharmacology Research Report Pag: 21p

PUBLICATION DATE: 850000

PUBLICATION YEAR: 1985

LANGUAGE: English

SUBFILE: HSL; UMTRIS; HRIS; IRRDSOURCE ACCESSION NUMBER:IRRD 288346

IRRD DOCUMENT NUMBER: IRRD 288346

AVAILABILITY: National Institute on Drug Abuse; 5600 Fishers Lane, Rockville; MD; 20852

DATA SOURCE: Transport and Road Research Laboratory

ABSTRACT:

Secobarbital, diazepam, marijuana, and alcohol were all found to impair performance of a variety of simulated driving tasks. Drug levels tested for secobarbital and diazepam were therapeutic doses; the marijuana doses were considered moderate to strong by the subject population used; the alcohol effects were reported for levels up to and slightly above the legal limit. No clear-cut differences in the pattern of effects were found among the drugs tested. All drugs impaired perceptual-motor skills (e.g., tracking, speed, and headway control), perceptual tasks where response time and detection ability were measured, and decision making tasks. (Author/TRRL)

DESCRIPTORS: DRIVERS (VEHICLE); DRUG; ALCOHOLIC BEVERAGES;
PERCEPTION; SIMULATORS; REACTION TIME; TRAFFIC ACCIDENT;
TRANQUILIZERS; MARIHUANA; DRUG; DRIVER; SKILL (ROAD USER); DRIVING
(VEH); SIMULATION; TEST; DRUNKENNESS; PERCEPTION; REACTION TIME;
DECISION PROCESS SUBJECT HEADING: H52 HUMAN FACTORS; H51,SAFETY;
U26, SAFETY & PRODUCT QUALITY

26/5/49 (Item 36 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.420727

TITLE: THE EFFECTS OF PAVEMENT EDGELINES ON PERFORMANCE IN A
DRIVING SIMULATOR UNDER SOBER AND ALCOHOL-DOSED CONDITIONS

AUTHOR(S): RANNEY, TA; GAWRON, VJ

JOURNAL: HUMAN FACTORS Vol: 28 Issue Number: 5 Pag: PP 511-525

PUBLICATION DATE: 861000

PUBLICATION YEAR: 1986

LANGUAGE: ENGLISH

SUBFILE: TLIB

SUPPLEMENTAL NOTES: THOMAS A. RANNEY, VALERIE J. GAWRON

CHART BIBLIOGRAPHY: P. 525

DATA SOURCE: UC, BERKELEY, INSTITUTE FOR
TRANSPORTATION STUDIES 15273258

ABSTRACT:

No abstract provided.

DESCRIPTORS: AUTOMOBILE DRIVING SIMULATORS; DRINKING AND TRAFFIC
ACCIDENTS; ALCOHOL; PHYSIOLOGICAL EFFECT; ROAD MARKINGS

26/5/50 (Item 37 from file: 63)DIALOG(R)File 63:TRIS(c) format only 1996
Knight_Ridder Info. All rts. reserv.396752

TITLE: TRUCKS INVOLVED IN FATAL ACCIDENTS, 1980-82

(VERSION NOVEMBER 16, 1984)

AUTHOR(S): Carsten, O; Pettis, LC

CORPORATE SOURCE: Michigan University, Ann Arbor; Transportation Research Institute ;
Ann Arbor; MI; 48109; **REPORT NUMBER:** UMTRI-85-1 **Pag:** 113p

PUBLICATION DATE: 850100

PUBLICATION YEAR: 1985

LANGUAGE: English **SUBFILE:** HRIS

AVAILABILITY: National Technical Information Service; 5285 Port Royal Road; Springfield;
VA; 22161

ORDER NUMBER: PB85-169837/WTS

SUPPLEMENTAL NOTES: See Also PB84-183037.

ABSTRACT:

The study described in this report investigated the effect of alcohol and marijuana, alone and in combination, on driver performance and behavior in a fully interactive driving simulator. The simulator provided the driver a complex visual scene similar to a rural nighttime drive, and allowed the driver full control of steering and speed maneuvers. Performance and behavior data were collected during a 10-12 mile drive requirement about 15 minutes to complete. A variety of events were encountered during the drive, including curves, obstacles in the roadway, and winding roads. Accidents, tickets, and speed were recorded as traffic safety measures during the overall drive. Driver behavior, speed control, and steering performance were collected during each event to provide insight into the impairment mechanisms of alcohol and/or marijuana on the driver. Based on a large number of driver performance and behavior variables, alcohol was found to have a pervasive and significant impairing effect. Marijuana effects were minimal. A significant drug interaction effect was observed in simulator accidents.

DESCRIPTORS: TRAFFIC ACCIDENT ANALYSES; FATAL ACCIDENTS;
TRUCKS; VEHICLE CLASSIFICATION; HEAVY VEHICLE; TRACTOR SUBJECT
HEADING: H51,SAFETY; H52, HUMAN FACTORS; H53, VEHICLE CHARACTERISTICS;
181AHFB, ACCIDENT STATISTICS

26/5/51 (Item 1 from file: 155)DIALOG(R)File 155:MEDLINE(R)(c) format only 1996
Knight_Ridder Info. All rts. reserv.09404179 95334179

TITLE: Antidepressant drugs and psychomotor performance. A review.

AUTHOR: Volz HP; Sturm Y Psychiatric Department, Jena University, Germany.
JOURNAL: Neuropsychobiology (SWITZERLAND) 1995, 31 (3) p146-55, ISSN 0302-282X
Journal Code: NZM Languages: ENGLISH Document type: JOURNAL ARTICLE; REVIEW;
REVIEW, TUTORIAL JOURNAL ANNOUNCEMENT: 9510 Subfile: INDEX MEDICUS

Nearly all antidepressants are tested psychometrically in order to detect side effects of these drugs. Based on a review of the relevant published data on critical flicker fusion frequency measurements, simple reaction time, complex reaction time, tracking, tapping, and car driving simulation measurements, the underlying principles of the different effects of these drugs in healthy volunteers are discussed. It seems that essentially the sedative properties of a compound are important rather than e.g. specific reuptake inhibiting properties or the chemical structure. This finding is discussed in the light of the usefulness of these test procedures for detecting side effects. (92 Refs.) Tags: Animal; Human

Descriptors: *Antidepressive Agents--Adverse Effects--AE; *Psychomotor Performance—
Drug Effects--DE; Hypnotics and Sedatives CAS Registry No.: 0 (Antidepressive Agents);
0 (Hypnotics and Sedatives)

26/5/54 (Item 4 from file: 155)DIALOG(R)File 155:MEDLINE(R)(c) format only 1996
Knight_Ridder Info. All rts. reserv.08077024 92215024

TITLE: The older driver. Clinical assessment and injury prevention [see comments]

AUTHORS: Underwood M , Travelers Center on Aging, University of Connecticut Health Center, Farmington.

JOURNAL: Arch Intern Med (UNITED STATES) Apr. 1992, 152 (4) p735-40,
ISSN0003-9926

Journal Code:: 7FS Comment in Arch Intern Med 1992 Nov; 152(11):2347-8

Languages: ENGLISH Document type:: JOURNAL ARTICLE; REVIEW; REVIEW,
TUTORIAL JOURNAL ANNOUNCEMENT: 9207

Subfile: AIM; INDEX MEDICUS

ABSTRACT:

Continued increases in the number of older drivers during the next several decades will increase the importance of medical, ethical, and health policy issues related to driving privileges. Physicians have a critical role in examining patients for driving competence and in screening for impairments that increase the risk of motor vehicle injuries. Both age-related and disease-related factors may affect driving ability in older adults. Research related to the impact of chronic diseases, medications, visual problems, and various neurologic disorders should provide guidance to clinicians in the assessment of driving ability. Performance-based functional assessment, including the use of driving simulators and road tests, may provide information that is useful in the evaluation and rehabilitation of possibly impaired older drivers. Further research related to human, vehicular, and environmental factors and the development of intervention strategies for prevention of crashes and crash-related injuries will reduce the risk of injury and death in older adults. (5 Refs.)

Tags: Human Descriptors: *Accidents, Traffic--Prevention and Control--PC;
*Aged;*Automobile Driver Examination; Accidents, Traffic --Statistical and Numerical Data--SN; Aging--Physiology--PH; United States--Epidemiology--EP

26/5/63 (Item 13 from file: 155)DIALOG(R)File 155:MEDLINE(R)(c) format only 1996
Knight_Ridder Info. All rts. reserv.07088050 89390050

TITLE: The effects of alcohol, expectancy, and sensation seeking on driving risk taking.

AUTHORS: McMillen DL; Smith SM; Wells-Parker E Department of Psychology, Mississippi State University, Mississippi State 39762-6161.

JOURNAL: Addict Behav (ENGLAND) 1989, 14 (4) p477-83, ISSN 0306-4603

Journal Code: 2GW Languages: ENGLISH Document type: CLINICAL TRIAL; JOURNAL ARTICLE; RANDOMIZED CONTROLLED TRIAL

JOURNAL ANNOUNCEMENT: 8912

SUBFILE: INDEX MEDICUS

ABSTRACT:

Using a cover story of the effects of alcohol on perceptual and motorabilities, two levels of alcohol consumed (moderate and none), two levels of alcohol expectancy (moderate and none), and two levels of sensation seeking (high and low) were combined to determine their effect on risk taking in a driving simulator. Ninety-six subjects were randomly assigned to eight conditions. Dependent variables were lane changes-cars passed and time at maximum speed. Results on lane-changes-cars passed indicated greater risk-taking in driving by high sensation seekers. Interaction of alcohol expectancy and sensation seeking indicated high sensation seeker took more risks when they believed they had consumed alcohol. Low sensation seekers became more cautious in driving when they believed they had consumed alcohol. Alcohol consumed did not produce a significant main effect or interaction.

Tags: Female; Human; Male Descriptors: *Alcohol Drinking--Psychology--PX; *Alcoholic Intoxication--Psychology--PX; *Arousal--Drug Effects--DE; *Automobile Driving; *Risk-Taking--Drug Effects--DE; asset (Psychology); Adult; Dose-Response Relationship, Drug; Personality Tests

26/5/64 (Item 14 from file: 155)DIALOG(R)File 155:MEDLINE(R)(c) format only 1996
Knight_Ridder Info. All rts. reserv.06788372 89090372

TITLE: The pharmacodynamics of diphenhydramine-induced drowsiness and changes in mental performance.

AUTHORS: Gengo F; Gabos C; Miller JK Neuropharmacology Division, Dent Neurologic Institute, State University of New York, Buffalo.

JOURNAL: Clin Pharmacol The (UNITED STATES) Jan 1989, 45 (1) p15 -21,
ISSN0009-9236

Journal Code: DHR Languages: ENGLISH Document type: JOURNAL ARTICLE

JOURNAL ANNOUNCEMENT: 8904

SUBFILE: AIM; INDEX MEDICUS

ABSTRACT:

The time course of diphenhydramine concentrations and effects on both mental performance and subjective feelings of drowsiness were assessed in 15 healthy men. Subjects received single oral doses of diphenhydramine, 50mg, and placebo in this double-blind crossover study. Diphenhydramine plasma concentrations and central nervous system actions were assessed for 24 hours after each treatment. Cognitive impairment was assessed with an automobile driving simulator and digit symbol substitution scores, whereas drowsiness was self-assessed on a visual analog scale. Diphenhydramine produced significant feelings of drowsiness for up to 6 hours after the dose, whereas significant mental impairment was apparent for only 2 hours. Despite the difference in duration of these effects, drowsiness and mental impairment have parallel slopes when effects are related to diphenhydramine concentrations. These data suggest that although the apparent diphenhydramine concentration thresholds to produce drowsiness are lower (30.4 to 41.5 ng/ml) than those needed to produce mental impairment (58.2 to 74.4 ng/ml), these effects have profiles consistent with their being manifestations of the same pharmacologic effect.

Tags: Human; Male; Support, Non-U.S. Gov't Descriptors:

*Diphenhydramine--Pharmacology--PD; *Psychomotor Performance--Drug Effects--DE; *Sleep Stages--Drug Effects--DE; Adult; Diphenhydramine--Pharmacokinetics--PK; Reaction Time--Drug Effects--DE CAS Registry No.: 58-73-1 (Diphenhydramine)

26/5/68 (Item 18 from file: 155)DIALOG(R)File 155:MEDLINE(R)(c) format only 1996
Knight_Ridder Info. All rts. reserv.05882869 86183869

TITLE: Effects of long-term administration of buspirone and diazepam on driver steering control.

AUTHORS: Smiley A; Moskowitz H

JOURNAL: Am J Med (UNITED STATES) Mar 31 1986, 80 (3B) p22 -9,

ISSN 0002-9343

Journal Code: 3JU Languages: ENGLISH Document type: JOURNAL ARTICLE

JOURNAL ANNOUNCEMENT: 8607

SUBFILE: AIM; INDEX MEDICUS

ABSTRACT:

The effects of buspirone, diazepam, and placebo on tracking control were investigated over a nine-day period, using three groups of subjects, each with eight females and eight males. Subjects were tested using an interactive, computer-based driving simulator on days one, eight, and nine of the treatment period. On day nine, subjects received alcohol with their drug treatment. Measures of steering control were derived from car-driver transfer functions. Tracking performance was also measured. Diazepam was found to adversely affect steering control measures in comparison with placebo. This was true both after doses on the first as well as the eighth day of treatment. Thus, there was no evidence of behavioral tolerance to diazepam. In contrast, buspirone was not found to have any adverse effect on steering control; in fact, some evidence of improved tracking control was found. When alcohol was added to each treatment on the ninth day, differences between the drug treatment groups were less pronounced but in the same direction as on the first and eighth days.

Tags: Comparative Study; Female; Human; Male; Support, Non-U.S. Gov't Descriptors:
*Diazepam--Adverse Effects--AE; *Motor Skills--Drug Effects--DE; *Pyrimidines--Adverse Effects--AE; Administration, Oral; Adult; Alcohol, Ethyl--Pharmacology--PD; Automobiles; Drug Interactions; MMPI; Random Allocation CAS Registry No.: 0 (Pyrimidines); 36505-84-7 (Buspirone); 439-14-5 (Diazepam); 64-17-5 (Alcohol, Ethyl)

26/5/73 (Item 2 from file: 108)DIALOG(R)File 108: Aerospace Database(c) 1995
AIAA. All rts. reserv.1948449 A93-55929

TITLE: Motion and space sickness

AUTHORS: CRAMPTON, GEORGE H., ED. (Wright State Univ., Dayton, OH)
Boca Raton, FL, CRC Press, Inc., 1990, 459 p.
(For individual items see A93-55930 to A93-55949)

PUBLICATION Date: 1990

Report No.: ISBN 0-8493-4703-3

LANGUAGE: English

Country of Origin: United States

Country of PUBLICATION: United States

Document Type: COLLECTED WORK

Journal Announcement: IAA9324

ABSTRACT:

A collection of papers that address the major issues of motion and space sickness is presented. Attention is given to motion sickness and evolution, the central nervous connections involved in motion induced emesis, neurophysiology of motion sickness, the role of vestibular end organs in experimental motion sickness, neurochemistry and pharmacology of motion sickness in nonhuman species, endocrinology of space/motion sickness, animal models in motion sickness research, investigating motion sickness using the conditioned taste aversion paradigm, the accelerative stimulus for motion sickness, and physiology of motion sickness symptoms. Also discussed are prediction of motion sickness susceptibility, symptoms and signs of space motion sickness on Spacelab-1, adaptation of the stimulated stimulus rearrangement of weightlessness, statistical prediction of space motion sickness, simulator sickness, pharmacological counter measures against motion sickness, autogenic feedback training as a treatment for motion and space sickness, adaptation to nauseogenic motion stimuli and its application in the treatment of airsickness, motion sickness susceptibility and behavior, and motion sickness and human performance. (AIAA) Source of Abstract/Subfile: AIAA/TIS

Descriptors: *CENTRAL NERVOUS SYSTEM; *HUMAN PERFORMANCE;
*MOTION SICKNESS; *MOTION SICKNESS DRUGS; *NEUROPHYSIOLOGY;
*PHYSIOLOGICAL RESPONSES; *SIGNS AND SYMPTOMS; ADAPTATION;
BIOFEEDBACK; BIOLOGICAL EVOLUTION; FLIGHT SIMULATORS; MANNED
SPACE FLIGHT; NAUSEA; PRIMATES; SENSITIVITY; STIMULI; VESTIBULES;
VOMITING; WEIGHTLESSNESS Subject Classification: 7552 Aerospace Medicine (1975-)

