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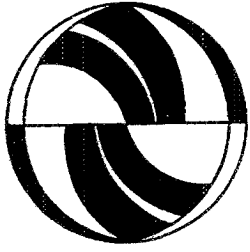
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Behavior in Response to ATIS**

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## **INTERACTIVE SIMULATION FOR MODELING DYNAMIC DRIVER BEHAVIOR IN RESPONSE TO ATIS**

**Jeffrey L. Adler, Michael G. McNally, and Wilfred W. Recker**

### **ABSTRACT**

It has been contended that in-laboratory experimentation with interactive microcomputer simulation can substitute for the lack of real-world applications and provide a useful approach to data collection and driver behavior analysis. With the rapid development but limited real-world deployment of Advanced Traveler Information Systems, interactive simulation has quickly grown in popularity among researchers studying dynamic driver behavior. This paper discusses the development and implementation of FASTCARS (Freeway and Arterial Street Traffic Conflict Arousal and Resolution Simulator), an interactive microcomputer-based animated simulator designed for in-laboratory experimentation to assist in the estimation and calibration of predictive models of driver behavior under the influence of real-time information.



## **INTRODUCTION**

When studying route choice and travel decisions, simulation can be a productive method to isolate choice components and obtain subjective estimations of choice factors (Bovy and Stern, 1990). The role of a good simulator is to recreate real-world scenarios and elicit from participants responses that are similar to those expected under real-world conditions. This ability to model choice is based on how effective a simulator can translate real-world situations and the manner that physical elements of the real world that play an active role in the choice process are represented.

As interest in ATIS has increased, several research efforts have been undertaken to analyze the impacts of real-time traffic condition information on dynamic driver behavior. Because there have been relatively few advanced information technology systems implemented in the real-world, many researchers have turned to using computer-based interactive simulation rather than relying on field studies. Unlike standard revealed preference studies that would require drivers to answer hypothetical questions about technologies they have not yet experienced, interactive simulation provides the opportunity to recreate ATIS technologies in-laboratory and study revealed behavior within a controlled environment. Recent research efforts relying on microsimulation to study driver behavior under ATIS include Bonsall and Parry (1991), Ayland and Bright (1991), Koutsopoulos et al., (1993), Chen and Mahmassani (1993), and Vaughn et al., (1993).

## **FASTCARS DRIVING SIMULATOR**

FASTCARS is an interactive computer-based simulator that has been developed for in-laboratory experimentation to gather data for estimating and calibrating predictive models of driver behavior under conditions of real-time





information. It was developed with Turbo Pascal and designed to run on a 386-series personal computer running at least 33 MHz and equipped with VGA graphics and a voice adapter.

FASTCARS is not a pure driving simulator but rather simulates real-time travel decision making. FASTCARS presents an environment to study temporal and spatial factors, such as perceptions of speed and volume, time lapse, network familiarity, information acquisition, and travel goal specification and evaluation, which are the basic decision-making processes directly impacting driver behavioral choice. Its purpose is not to study driving ability, but rather to focus on the decision-making aspects of trip making, including goal specification, route choice, information search, and diversion.

The advantages of using FASTCARS over other data collection methods to study driver behavior are realized through the program's flexibility and completeness. The program encompasses the entire driving process from pre-trip planning through arrival at the destination. Players are required to make a broad range of choices including goal specification, route and lane changes, and whether or not to use available information technologies. Furthermore, many system variables, such as network conditions and information content, can be altered to represent different driving conditions. These features allow FASTCARS to replicate and model many of the decisions common to the trip-making process.

The central element of FASTCARS is its ability to simulate travel along a traffic network and to represent basic travel characteristics, such as variations in travel speed, lane changing, and road changing involving both freeway and arterial street networks. Additionally, the program was designed to model temporal factors that impact travel choice, including delays caused by congestion and incidents, and traffic signals. The following sections detail how FASTCARS emulates pre-trip and enroute

travel behavior. For more detail on how networks are developed and used in FASTCARS, please refer to Adler et al., (1992).

### **MODELING PRE-TRIP PLANNING**

There are network-specific decisions that must be made "pre-trip": destination, departure time, and initial route choice. The former two choices are actual inputs to the FASTCARS program, the latter is reflected by a player's selected route to be traversed. Destination and departure time choices can be selected by, or alternatively predetermined for, the player.

The final pre-trip choice to be made consists of specifying travel objectives for the trip. Real-time decisions are made with respect to the perception of goal attainment; during post-trip evaluation drivers focus on how successful they were in meeting their goals. Correspondingly, goal specification and analysis is a central element of FASTCARS and is incorporated into the scoring system to analyze the actions and responses of participants.

It is known that several factors influence route choice including drivers knowledge of alternate routes, specific route attributes, and driver preferences. As such, FASTCARS models travel performance and route selection through a multiobjective goal set. Each player is rated according to relative success in maximizing utility over a goal set consisting of five predetermined goals. The five goals that are considered are: (1) arrive at destination 20 minutes early, (2) minimize travel time, (3) minimize number of stop lights encountered, (4) minimize number of road changes, and (5) minimize trip distance. To capture individual behavioral differences and preferences among players, each player is permitted to assign a set of subjective weights totaling 100 to the goal set. At the end of the program, each goal is scored from 0 (worst) to 100 (best) based on the player's ability to achieve these goals.

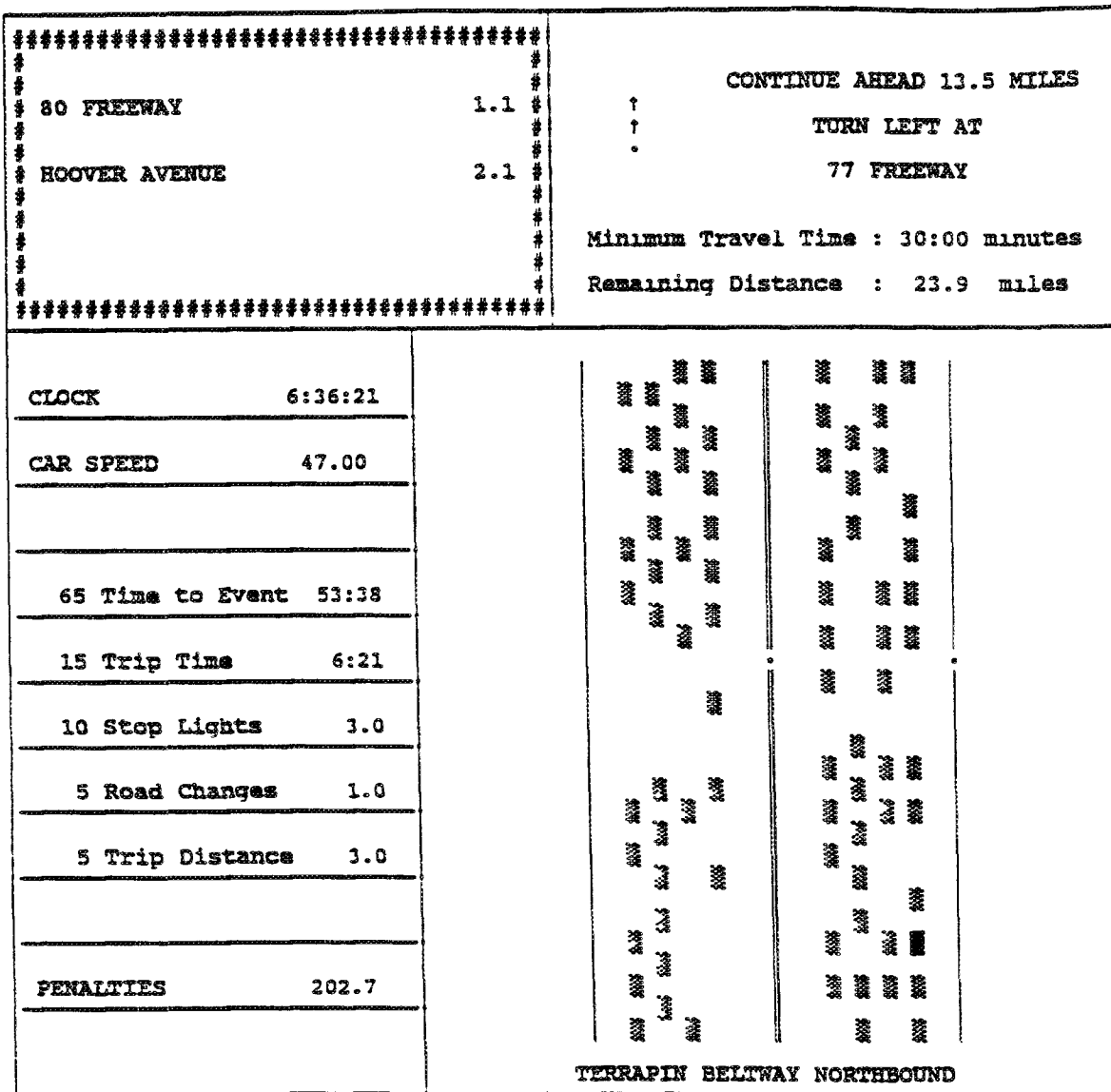


With 100 points in goal weights and a maximum achievement value of 100 per goal, the maximum possible score a player can receive is 10,000 points.

### **EMULATING ENROUTE TRAVEL BEHAVIOR**

Once the initial route has been selected and the goal set established, the travel sequence begins. FASTCARS models travel on a link-by-link basis, ignoring system-wide traffic and focusing on traffic around the player. Play is conducted on a visual display depicted in Figure 1. This display has four components: the network viewer, the control panel, road-side information viewer, and the in-vehicle navigator.

FIGURE 1. FASTCARS Visual Display



## **Network Viewer**

The lower right-hand box, the largest section of the display, is the network viewer. Players are provided with a bird's eye view of a one mile stretch of a road section. Cars are displayed as small rectangles moving in lanes. The player's vehicle, or cursor car, is shown as the solid rectangle. At the bottom of the road section, the current road is labeled. Cars move by lane, each lane has a specific speed, and generally, lanes to the left have higher speeds.

Players control two basic car movements, lane changing and road changing. Lane changes are initiated by a single keystroke. The cursor car turns into an arrow indicating direction of desired lane change. After a calculated lane-switch delay that accounts for travel conditions, the cursor is moved to the desired lane.

Road changes are available when the viewer displays a cross street. Available turning movements are indicated by arrows on either end of the cross street. The name of the cross street and turning direction is indicated next to the street. When a driver wants to make a turn, two steps must be followed. First, the driver must move to the correct lane. All turns from freeways are made from the rightmost lane. On surface streets, however, right turns are made from the rightmost lane, left turns from the leftmost lane. Second, the driver indicates the turning direction with a single keystroke. The cross street changes color and the arrow indicator blinks. When the cursor car intersects the cross street, it is guided automatically through the turn. If the cursor car is still in the wrong lane when the cross street is reached, the turn will not be executed.

The cursor car is moved to the next road section when it executes a successful turn, passes an intersection without turning, or when it reaches the halfway point on the display. There are a set of next display markers along the roadway to inform drivers when the display will be reset. Surface streets are distinguishable by traffic

signals and generally lower speeds. Signals have set timings and on the red cycle, cars caught behind the stop line will queue and wait for the green cycle.

### **Control Panel**

The control panel, on the lower left of the window, displays important system information. At the top of the display are the current simulation time and cursor car speed. Below that, the set of five goals are listed. To the left of each goal is the player's selected goal weights; to the right is the accumulated score for each goal weight. These scores will be normalized at the end of the program to values between 0 and 100.

### **Emulating ATIS**

FASTCARS is equipped to emulate three types of advanced traveler information systems: variable message signs (VMS), highway advisory radio (HAR), and in-vehicle shortest time navigation system (IVNS). These were selected on the basis of their diversity of presentation and message content.

In the simulation, variable message signs are displayed at certain freeway locations to provide drivers with brief reports on the local traffic conditions on the current link. At points where messages are selected to be displayed, the program searches several miles ahead on the current freeway to gather data on the traffic conditions that are scheduled to be encountered. Based on the downstream condition, there are four possible message categories to be displayed. "Freeway Clear", "Minor Freeway Congestion", "Major Freeway Congestion", "Incident Ahead". The program uses simple heuristics to decide which message is to be displayed and then posts each message in the upper left-hand window on the visual display.

Highway Advisory Radio is the second information technology simulated. FASTCARS utilizes a Voice Adapter which allows players to activate pre-recorded radio messages containing relevant information on highway conditions and on the availability and accessibility of alternate routes. In the current version of FASTCARS, incident probabilities and speed distributions are assigned to network links. Before beginning data collection, a series of network profiles that distribute incidents on the network may be generated. Based on these network files, HAR files can also be prepared. At the start of the game, the simulator randomly selects a network profile and set of HAR files to be used.

In-vehicle navigation systems offer drivers a direct source for finding the shortest path to their destination. Through a computerized system, IVNS typically gathers real-time information and instructs the driver where to turn. With IVNS, drivers do not receive traffic information nor do they have to make any predictions or calculations - they merely follow directions. The benefit of IVNS is that drivers who are unfamiliar with the network can adhere to the advice and take a shorter time path to the destination. It does not, however, relate explicit traffic conditions; the best path may still be along a congested corridor.

FASTCARS emulates IVNS with a prototype in-vehicle navigator that gathers travel time information. The navigator is displayed in the top right corner of the visual display. When a new link is entered, FASTCARS calculates the shortest time path to the destination. This information is used to display in-vehicle navigation information. While activated, the navigator displays three pieces of guidance information based on the calculated shortest path: (1) suggested action for next intersection or freeway exit, (2) expected shortest travel time to the destination, and (3) distance from the current location to the destination via shortest time path.



## **FASTCARS APPLICATION**

FASTCARS has been used to collect data on driver behavioral choice (Adler et al., 1993). Several data analysis efforts have been conducted in parallel including category analyses, estimation of discrete choice models, and experiments with structural equation techniques. Preliminary analyses on diversion behavior show that several factors impact enroute diversion behavior including network experience, familiarity with potential alternate routes, visual information gathered from Variable Message Signs, and changes in travel speed.

Further results from these analyses and other studies will be used as part of the Advanced Traffic Management System Testbed Research Program being conducted at UC Irvine. Part of this effort is to assess the effectiveness of and traveler response to various advanced traveler information systems under a broad range of implementation conditions. The data that was collected will also be useful in the efforts to develop a real-time simulation capability that can operate on-line to predict dynamic response under an integrated freeway-arterial ATMS/ATIS system. Predicting optimal or equilibrium assignment and effecting optimal real-time feedback control between freeway and arterial systems is dependent on driver behavior and response.

## **FUTURE STUDY AND ENHANCEMENTS**

The flexibility of FASTCARS allows it to potentially be used for a variety of travel-related purposes. With minor adaptations, FASTCARS could be implemented to study various types of trip making, including commuter and special event travel. More challenging tasks are to expand the program to include a wider range of pre-trip options such as departure time choice and acquiring real-time information. An enhanced graphical display is being considered to improve the map display and the in-

vehicle navigation system. Future versions will have a next-generation IVNS system that provides more direct interface with the driver.

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## REFERENCES

Adler, J.L., Recker, W.W., and McNally, M.G. (1993). "In-Laboratory Experiments to Analyze Enroute Driver Behavior Under ATIS", Presented at the 72nd Annual Meeting of the Transportation Research Board, Washington, D.C.

Adler, J.L., Recker, W.W., and McNally, M.G. (1992). "A Conflict Model and Interactive Simulator (FASTCARS) For Predicting Enroute Assessment and Adjustment Behavior in Response to Real-Time Traffic Condition Information", Presented at the 71st Annual Meeting of the Transportation Research Board, Washington, D.C.

Ayland, N. and Bright, J. (1991). "Real-Time Responses to Invehicle IVHS Technologies - A European Evaluation", Presented at the Transportation Research Board 70th Annual Meeting, Washington, D.C.

Bonsall, P.W. and Parry, T., (1991). "Using an Interactive Route-Choice Simulator to Investigate Drivers' Compliance with Route Guidance Advice", Transportation Research Record 1036, pp. 59-68.

Bovy, P.H.L. and Stern, E., (1990). Route Choice: Wayfinding in Transport Networks, Kluwer Academic Publishers, The Netherlands.

Chen, P. and Mahmassani, H.S. (1993). "A Dynamic Interactive Simulator for the study of Commuter Behavior under Real-Time Traffic Information Supply Strategies." Presented at the 72nd annual meeting of the Transportation Research Board, Washington, D.C.

Leiser, D., and Stern, E., (1988). "Determinants of Subjective Time Estimates in Simulated Urban Driving", Transportation Research A, Vol 22, pp.175-182.

Koutsopoulos, H., Lotan, T., and Yang, Q. (1993). "A Driving Simulator and its Application for Modeling Route Choice in the Presence of Information." Presented at the 72nd annual meeting of the Transportation Research Board, Washington, D.C.

Vaughn, K.M., Abdel-Aty, M.A., Kitamura, R., and Jovanis, P.P. (1993). "Experimental Analysis and Modeling of Sequential Route Choice Behavior under ATIS in a Simplistic Traffic Network." Presented at the 72nd annual meeting of the Transportation Research Board, Washington, D.C.