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UMTRI's partners in the FOT are Automotive Distance Control Systems (ADC) GmbH, Haugen Associates, and the Michigan Department of Transportation. The Volpe National Transportation Systems Center is the independent evaluator.

16. Abstract

This interim document reports on a cooperative agreement between NHTSA and UMTRI entitled Intelligent Cruise Control (ICC) Field Operational Test (FOT). The overarching goal of the work is to characterize safety and comfort issues that are fundamental to human interactions with an automatic headway keeping system.

This report (1) summarizes the status of the FOT and (2) presents preliminary results and findings deriving from the testing activities now in progress. It describes the work done to prepare and instrument a fleet of 10 passenger cars with infrared ranging sensors, headway control algorithms, and driver interface units as needed to provide an adaptive cruise control (ACC) functionality. The vehicles have been given to lay-drivers to use for two weeks as their personal cars.

Based upon data from 35 drivers, objective and subjective results support the following preliminary observations:

- ACC driving is reported to be comfortable and is perceived as stress-relieving.
- The kinesthetic sensation of ACC-induced deceleration was often cited by drivers as a vigilance-enhancing cue, perhaps implying a safety benefit.
- Drivers appear to learn how to use ACC quickly and to converge on a strategy that meshes with their driving style .
- The data contain a natural type of "bias" by which manual driving appears riskier than ACC driving in part because denser, more conflict-laden, traffic induces drivers to turn the ACC system OFF.
- Under virtually all conditions in which ACC is engaged, drivers choose (and the system provides) headway distances that are greater than those seen when the same person drives manually.
- ACC driving results in fewer "near approaches" to the preceding vehicle than does manual driving.
- Headway-keeping behavior differs markedly with driver age. Younger drivers are typically more aggressive, operating at shorter headways.
- Given the properties of the ACC system being studied, a minimal impact on the accident record would be expected from observations to date. A major element of this expectation derives from the drivers' choice to use ACC only in rather benign traffic environments.

When completed, the FOT is expected to present findings based on results from over 100 drivers / participants.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

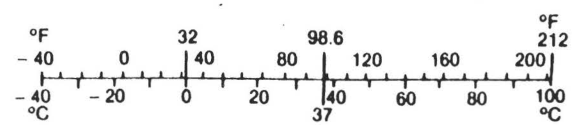
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimetres	mm
ft	feet	0.305	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
		AREA		
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.093	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometres squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.028	metres cubed	m^3
yd^3	cubic yards	0.765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperatuie	5(F-32)/9	Celcius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
		AREA		
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometres squared	0.386	square miles	mi^2
		VOLUME		
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F



* SI is the symbol for the International System of Measurement

(Revised April 1989)

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EXECUTIVE SUMMARY

This document provides an interim reporting on the Field Operational Test (FOT) of a driver assistance innovation called Adaptive (or Intelligent) Cruise Control (ACC). The test is being conducted by the University of Michigan Transportation Research Institute (UMTRI) under sponsorship by NHTSA, in partnership with the ACC sensor supplier, ADC, which is a joint venture of the Leica and TEMIC companies, and with Haugen Associates and the Michigan Dept. of Transportation.

The ACC system is incorporated into a fleet of ten passenger cars, each employing a grille-mounted sensor that detects vehicles ahead and controls both the speed and headway of the test vehicle so that the driver can proceed through moderate freeway traffic without adjusting cruise buttons or touching the throttle or brake. The field test places the ACC-equipped vehicles in the hands of randomly-invited citizens for use as their personal car for two weeks. (Later in the project, some drivers will also be given the vehicle for a total of five weeks.) Thus, the vehicles are put into naturalistic use, without constraining where the person drives, or when, or how. Each driver is also free to choose between operating manually or with conventional cruise control during the first week and between manual or ACC driving during the second (or subsequent) weeks.

Given this basic test approach, the overarching goal is to characterize the issues that are fundamental to human interaction with an automatic headway keeping system. Although only one system design is being fielded, it is hoped that the results will be generically instructive. Clearly, the issues in question cover the safe and convenient operation of the vehicle as well as potential impacts on traffic flow, fuel economy, and so forth.

The ACC system under study here can be described in terms of the sensor, the controller, and the driver's interface. The sensor is an infrared device that measures distance and the rate of closure to vehicles in the lane ahead, steering its sensing beam to the right or left as needed to follow lane curvature. The controller acts on the sensory data to modulate the throttle and also downshift the transmission as required to satisfy the driver-selected minimum for headway or spacing to a vehicle ahead. Since brakes are not incorporated into this ACC system, the vehicle has only modest deceleration available for controlling headway—a characteristic that is believed to figure strongly in the field experience reported here. The driver selects among three minimum headway buttons

ranging from "closer" to "farther" and otherwise operates the ACC system through the normal cruise control buttons located on the face of the steering wheel.

The ACC systems have been fitted into 1996 Chrysler Concorde sedans. The vehicles each employ a complex instrumentation package that operates untended in the vehicle's trunk. The package collects a broad array of quantitative data from the driving process and stores selected clips of video from a forward-looking camera.

The experimental design involves a sampling of normal drivers according to age, and prior cruise control usage. Although more than 100 persons will drive the test vehicles before the project is concluded, this report presents data drawn from the first 35 subjects. The table below summarizes the scope of usage covered by this first group of drivers ("CCC" in the table refers to the usage of Conventional Cruise Control). Approximately 26% of the mileage was covered with ACC control actually engaged ("Eng.," in the table) out of a total of 26,000 miles.

No. of Drivers: 35	All Trips	CCC Off	CCC Used	ACC Off	ACC Used
Trips	2659	916	325	938	480
Distance, miles	26,225.6	3,449.9	8,059.5	3,178.0	11,538.2
Dist. Not Eng., miles	15,656.1	3,449.9	4,405.6	3,178.0	4,622.7
Dist. Eng., miles	10,569.5	NA	3,653.9	NA	6,915.6
Duration, hours	723.6	146.0	181.0	139.2	257.3

Because some eighty variables are sampled continuously at 10 cycles per second, a data record of tremendous proportions is being amassed. Only a high level scan of these data, compiled mostly as histograms, is presented and discussed in this interim report. Supplementing the quantitative data, participating drivers have also given subjective assessments of ACC driving through response to a debriefing questionnaire and through participation in focus groups. Together, the subjective and objective results support the following preliminary observations:

1) ACC driving is reported to be comfortable and is perceived as stress-relieving, especially on long trips.

2) Drivers are comfortable using this ACC system under some traffic environments in which conventional cruise control would have been disengaged.

3) ACC operation did not pose any obvious safety threat to either the driver of the equipped vehicle or to others nearby. The kinesthetic sensation of ACC-induced deceleration was often cited by drivers as a vigilance-enhancing cue, perhaps implying a safety benefit. A few anecdotes of relaxed visual attention to the road ahead were also

reported, however, presumably as the driver adapted to the perceived benefit of the deceleration cue.

4) Drivers appear to learn how to use ACC quickly. As exposure time grows, the individual readily converges on preferred ACC headway settings as well as an operating strategy that meshes with his or her driving style .

5) Because the choice of control mode closely correlates with prevailing traffic conditions and road type, the data contain a natural type of bias by which manual driving appears riskier than ACC driving in large part because denser, more conflict-laden, traffic induces drivers to turn the ACC system off. A simple attempt to dis-aggregate the data so that ACC driving is compared with manual driving only under comparable conditions is reported here, but more sophisticated means are being pursued.

6) Under virtually all conditions in which ACC is engaged, however, drivers choose (and the system provides) headway distances that are greater than those seen when the same person drives manually. Some drivers have recognized this difference in their own behavior and have cited it as a perceived benefit of the system.

7) Related to this observation, ACC driving results in fewer “near approaches” to the preceding vehicle than does manual driving. Continuously monitored values of time-to-collision are markedly longer under ACC control.

8) Headway-keeping behavior differs markedly with driver age. Younger drivers are typically more aggressive, traveling generally faster than the average traffic around them and operating at shorter headways. Some drivers in this more aggressive category perceive that ACC control impedes their normal pattern of driving such that they may tend not to use it.

9) Drivers select set speed values under ACC control rather like they do under conventional cruise control—that is, nearly matching the prevailing speed of traffic. This may be one aspect of driver behavior that adapts with increasing ACC experience.

10) Given the properties of the ACC system being studied, a minimal impact on the accident record would follow from observations to date. A major element of this expectation derives from the drivers' choice to use ACC only in rather benign traffic environments.

11) This ACC system would likely also have a minimal impact on traffic operations, mostly because it becomes turned off when traffic approaches the density levels at which highway capacity is challenged.

The field test has yet to collect approximately 70% of its data. Included in the remaining testing is the coverage of some 24 drivers operating the vehicle for a total of five weeks each. Data processing will be expanded beyond the histogram domain, with heavy emphasis upon time-related phenomena, especially that of driver intervention upon the ACC-engaged state of operation. Possible extensions to the field test are also under consideration, particularly with braking incorporated into the ACC controller. Such an extension would address the higher levels of deceleration capability that are expected to appear on marketed vehicles over the next few years.

1. INTRODUCTION AND BACKGROUND

1.1 Introduction to the Report

This document constitutes an interim report on a cooperative agreement between NHTSA and UMTRI concerning a field operational test (FOT) of intelligent cruise control (ICC). The ICC systems employed in this study are known as and referred to as *adaptive cruise control* (ACC) by the partners in the FOT. UMTRI's partners in the FOT are Automotive Distance Control Systems (ADC) GmbH (a joint business venture of Leica and Temic to develop and market advanced distance control technology), Haugen Associates, and the Michigan Department of Transportation.

Per the U.S. DOT's requirements for FOTs, the program also involves an independent evaluation led by personnel from the Volpe National Transportation Systems Center (a part of the U.S. DOT). Volpe is aided in their evaluation effort by their subcontractor, Science Applications International Corporation (SAIC). Although there is an open exchange of test data, plans, and ideas between the partner's group and the independent evaluator's group, this report is entirely the responsibility of UMTRI and its partners.

The material presented here has been prepared by UMTRI to provide NHTSA with an understanding of the conduct and preliminary findings of the field operational test (FOT). To that end, this interim report summarizes the status of the FOT and presents preliminary results and findings deriving from the testing activities now in progress.

Although a particular ACC system is undergoing testing in this project, it is intended that this report characterize issues that to the maximum extent possible are fundamental to human interaction with an automatic headway-keeping system. Nevertheless it is clear that specific features of the fielded system have directly determined various details in the human use of the FOT vehicles.

Each of the ten field-test vehicles involves a 1996 Chrysler Concorde sedan that was purchased and modified to incorporate an ACC functionality. The vehicles were equipped with Leica ODIN 4 infrared ranging sensors. These prototype sensors are part of an electronics package that provides range and range-rate information in a form that is convenient for use in assembling and evaluating an ACC system. Based upon this framework developed by Leica, a headway control algorithm was created by UMTRI and installed in the vehicles.

A communication network has been developed so that the conventional cruise control system existing on the vehicle can be used as a velocity controller that responds to commands from the headway controller. This network also includes communication with the transmission controller in the vehicle so that a transmission downshift from fourth to third gear can be used to extend the control authority of the ACC system, thereby increasing the deceleration capability of the system without using the vehicle's braking system. In addition the vehicles have been extensively instrumented to collect data on driving performance and the driving environment. All of these systems and features have been functioning in the field operational tests that began in July 1996.

The preliminary results presented here portray the driving experience of 35 lay driver/participants who operated one of the ten ACC-equipped passenger cars. These drivers operated a vehicle for one week without ACC and the next week with ACC available. These two week periods of operation took place in the driver/participants natural driving environment sometime in the period from July through December 1996.

The results and findings presented in this report use the set of data from the 35 driver/participants to address questions associated with the following operational issues:

- the nature of speed and headway keeping behavior of drivers with and without an ACC system
- when, where and how drivers will use ACC
- driver's ability to adapt to different driving situations while using ACC
- concerns with ACC operation
- the levels of comfort and convenience and safety drivers associate with ACC
- the performance of a current state of the art ACC system

The data also provide a starting point for an expanded evaluation of ACC by Volpe and SAIC evaluators as well as by UMTRI and DOT researchers.

Further information and expansion on the preliminary results and findings are provided in section 4 of the main body of the report.

The main body of the report starts by presenting general background information concerning ACC systems and the control of speed and headway. (See section 2.) The tasks performed to prepare and instrument the vehicles for the tests are described in section 3. Section 3 presents information on the system for gathering and processing data as well as for archiving data in a form that is useful for future analyses and for responding to queries concerning new ideas. The current status of the project is characterized in section 3.6 by presenting data concerning the number of trips and miles traveled under various control and operating conditions.

In section 4, preliminary results and findings are presented and supported by evidence based upon the data obtained so far. The concluding section (section 5) of the report does three things. It summarizes the preliminary findings, it describes the anticipated amount of information to be obtained and its significance once the project is completed, and it postulates where this work is going and what might be done next.

1.2 Background on the FOT Project

1.2.1 Project Basis

Intelligent, or adaptive, cruise control systems (ICC or ACC) are under active development by car companies and their suppliers throughout the world. Such systems, which automatically control headway or range to a vehicle in front, are intended to become the next logical upgrade of conventional cruise control (CCC). However, validation of the comfort, convenience and safety implications (positive and negative) of such systems has heretofore not been undertaken using normal consumers as test subjects.

This project is a field operational test (FOT) which will ultimately involve more than 100 such test subjects. FOT's are intended to serve as the transition between research and development and the full-scale deployment of ITS technologies. The tests permit an evaluation of how well newly developed ITS technologies work under real operating conditions and assess the benefits and public support for the product or system.

1.2.2 Project Objectives

The general goal of this project is to characterize issues that are fundamental to human interaction with an automatic headway-keeping system. The extent to which this goal is realized clearly depends upon the extent to which results from using this particular ACC system can be generalized to other ACC systems.

In addressing this overall goal, the field operational test is expected to:

- evaluate the extent to which ACC systems will be safe and satisfying when used by the public

- consider the influences of key system properties such that the results can help in finalizing the design of production systems
- identify design and performance issues that call for further development, market research, industry recommended practices, or public policy
- contribute to the evolutionary process leading to the deployment of ACC systems as a user service
- develop an understanding of how the functionality provided by ACC systems contributes to the safety and comfort of real driving
- qualify how drivers use and appraise the functional properties provided by ACC systems
- develop an appreciation for the public issues and societal benefits to transportation associated with ACC systems

(The focus of this interim report is on the operational issues given in section 1.1.)

1.2.3 Project Approach

Figure 1 provides a conceptual overview of the FOT. As illustrated in the figure, the work done to provide a test system has involved acquiring system elements, assembling ACC systems and installing them in the test vehicles, designing and building a data acquisition system, and arranging for a pool of drivers.

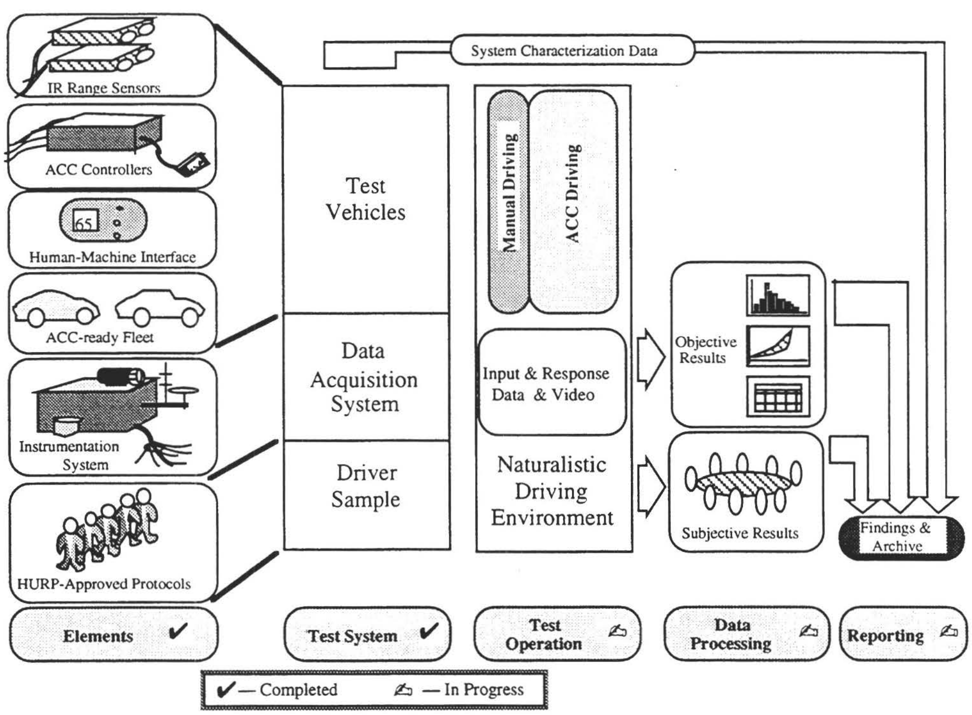


Figure 1. FOT Conceptual overview

Key elements of the project approach are:

- use of infrared-based ACC sensors and associated electronic systems which are engineering prototypes designed by Leica of Switzerland and provided under contract by ADC, a joint venture of Leica and TEMIC
- development and installation of headway control algorithms and communication links as needed to provide ACC functionality in the 10 test vehicles
- development and installation of human-machine interface as needed to provide ACC functionality in the 10 test vehicles
- development and installation of a data acquisition system (DAS) providing quantitative data regarding various driving performance measures along with measures of the driving environment (including video and GPS data)
- selection of test subjects through cooperation with the Michigan Secretary of State office, filling specific cells of subjects for age and CCC system level of familiarity. The basis for use of test subjects is meeting requirements of NHTSA Human Use Research Project (HURP) protocols
- familiarization training whereby drivers undergo training with UMTRI human factors personnel and then drive the test cars unaccompanied for periods of either two or five weeks (the first week of test car use is restricted to manual driving to provide a basis for comparison with the later ACC driving)
- data acquisition providing quantitative data regarding various driver performance parameters both at the end of each trip via cellular phone and when the vehicle is returned to UMTRI to change drivers
- driver qualitative data, obtained through survey questionnaires, debriefings and focus group meetings

1.2.4 ACC System; Sensing, Control, and Application Hardware

The ACC system includes headway sensors, an EBOX and a VAC, each of which is described below. (This hardware is supplied by Leica AG.)

Leica ODIN4 Headway Sensors

Two separate sensors, a sweep sensor and a cut-in sensor, are installed in the Chrysler grill area. The sensor respective coverage areas are illustrated in Figure 2.

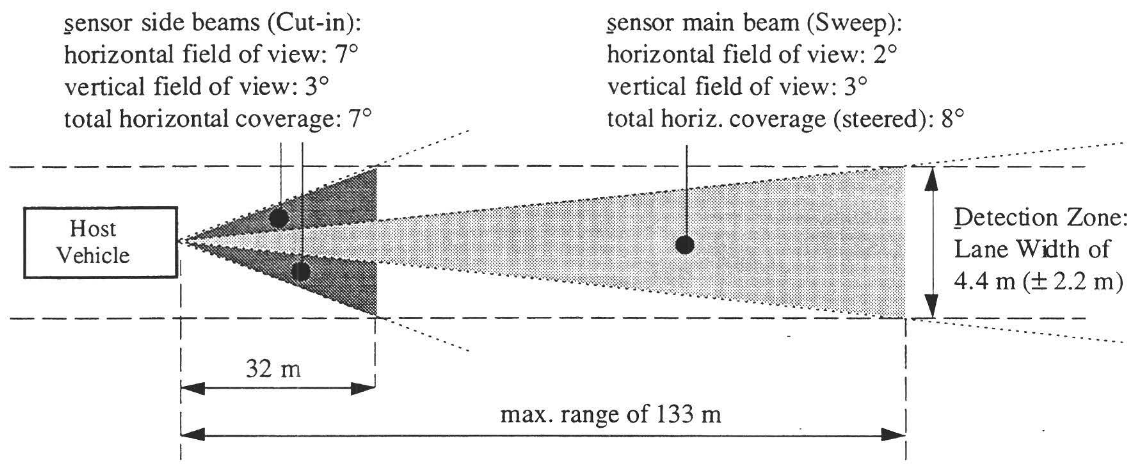


Figure 2. ODIN4 Sensors coverage areas

- The sweep sensor is a steered laser beam which is directed left or right by a solid state gyro which dynamically responds to road curvature. This sensor detects targets in the far field (6 to 150 meters).
- The cut-in sensor has a fixed beam and limited range, being used to sense vehicles that might cut-in close to the front of a test vehicle (0 to 30 meters).
- Both sensors operate by transmitting pulses of infrared light energy at a wavelength of 850 nanometers and a frequency of 10,000 pulses per second. The time of flight for an echo pulse to be received is used to determine range and range rate to a target vehicle.

EBOX

The EBOX contains the solid state gyro; the system power supply; electrical interfaces to the sensors; an external power supply; a Leica diagnostic connection; and CAN bus and RS232 interfaces.

Vehicle Application Controller (VAC)

The VAC contains software code and algorithms, including the UMTRI code and algorithms, used to provide the ACC control functions.

1.2.5 ACC Functional Description

In short, the ACC system provides the following functional operations:

- Establish and maintain a desired range if there is a preceding target vehicle with three driver-selectable headway settings — nominally 1.0, 1.4 or 2.0 seconds.

- Automatically accelerate and decelerate smoothly to maintain desired headway; automatically accelerate to set speed when a target disappears.
- Establish and maintain a desired speed (set speed) if there is no preceding target.
- Alert the driver to the existence of a perceived target; and to the operating status of the ACC.
- Decelerate the car when necessary, using throttle reduction; provide added deceleration by transmission downshifting if needed.
- Ignore targets that have a velocity less than 0.3 of the speed of the ACC vehicle to eliminate false alarms from fixed objects.
- Minimize missed targets that have poor reflective characteristics or unusual geometry.
- Provide a concern button for use by the driver to denote any ambiguous or dangerous driving situations. (The data acquisition system saves 30 seconds of video data prior to the time the concern button was pushed to capture pictures of the incident.)

2. TECHNICAL BACKGROUND

In this project an approach that uses speed to control headway is employed. Figure 3 provides a sketch showing the basic motion variables that are used in the headway controller. The following fundamental quantities are needed to describe headway and speed control:

V_p — velocity of the preceding vehicle

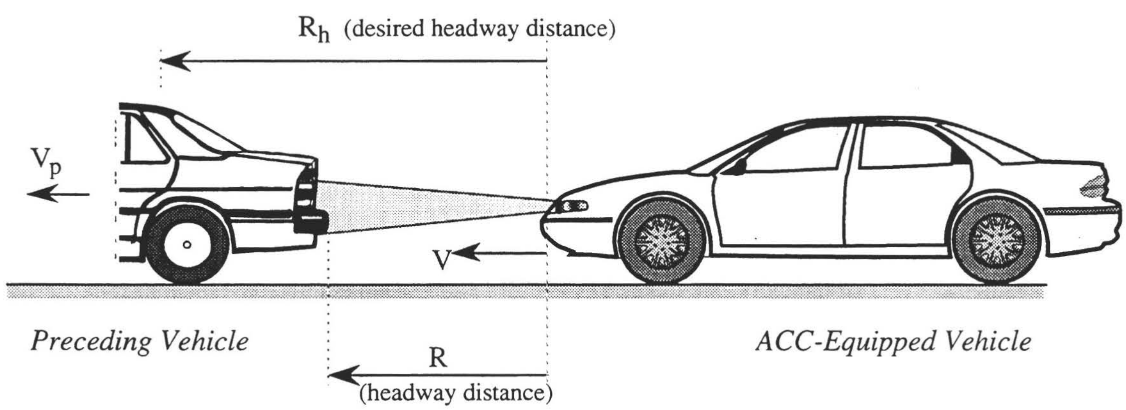
V — velocity of the ACC-equipped vehicle

R — range from the ACC-equipped vehicle to the preceding vehicle

R_h — desired range from the ACC-equipped vehicle to the preceding vehicle (In the situation shown in Figure 3, the ACC-equipped vehicle is closer to the preceding vehicle than the desired range.)

dR/dt — range-rate, the relative velocity between the vehicles (Range rate is also denoted by RDot in this report.)

Knowledge of these quantities plus the accelerations of these vehicles allows a complete kinematic analysis of the relative motion between the following and preceding vehicles.



$$dR/dt = \dot{R} = V_p - V$$

Figure 3. Headway control

The range versus rate range diagram (Figure 4) is useful for explaining the concepts behind the headway control algorithm employed in the ACC system used in the FOT. Conceptually, the control objective is to perform headway control in accordance with the following equation:

$$T \cdot {}^{dR}\!/_{dt} + R - R_h = 0 \qquad (1)$$

where the coefficient T determines the closing rate.

The equation for the control objective appears as a straight line in the range-rate/range diagram. See the line labeled "dynamics line for headway control" in Figure 4. The slope of that line, –T, serves as a control-design parameter.

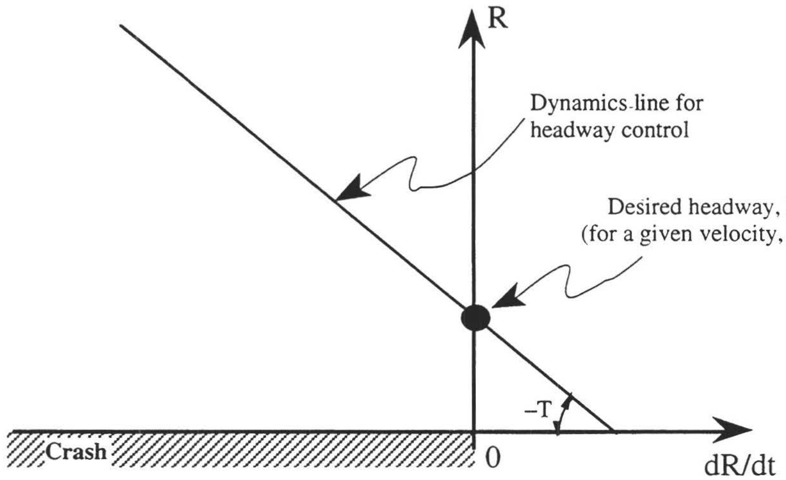


Figure 4. Range rate versus range

The point at $R = R_h$ and $dR/dt = 0$ is the ultimate objective for the ACC equipped vehicle. The desired headway at steady following is a linear function of V_p, the velocity of the preceding vehicle; viz.,

$$R_h = V_p \cdot T_h \tag{2}$$

where T_h is the desired headway time, which is a control system parameter. (In the ACC system used in the FOT, the driver can change T_h. See section 3.1.6.)

The headway distance varies with velocity, thereby providing a fixed margin in time for the system or the driver to react to changes in the speed of the preceding vehicle. The underlying concept here is similar to that which is behind the commonly used advice, "Allow one car length for each ten miles per hour of speed."

The speed of the preceding vehicle is given by:

$$V_p = dR/dt + V \tag{3}$$

using equation (3), measurements of V, R, and dR/dt are sufficient to evaluate the terms in equations (1) and (2). This means that the difference between the desired control state and our current situation, expressed as an error (e) in velocity is as follows:

$$e = dR/dt + \frac{(R - R_h)}{T} \tag{4}$$

where the quantities on the right side of the equation are evaluated using inputs from the sensors and the values of the control parameters, T and T_h.

For a vehicle with a cruise-control system, there is already an existing velocity-control system. To make a headway and speed control, one needs to send a velocity command (V_c) to the cruise-control unit, so that the desired headway will be attained and maintained. The general idea is that if the vehicle is too far away, one must speed up, and if the vehicle is too close, one must slow down.

As in sliding control methodology [1], equation (1) may be considered as a "sliding surface" towards which the controller attempts to converge, while equation (4) describes the prevailing error at any given time. Considering equations (3) and (4) together, the error is minimized to zero when the vehicle speed becomes:

$$V = V_p + \frac{(R - R_h)}{T} \tag{5}$$

This velocity value can be viewed as the desired speed for the ACC-equipped vehicle, or the velocity command (V_c) to achieve the desired headway (R_h); viz.,

$$V_c = V_p + \frac{(R - R_h)}{T} \tag{6}$$

Equation (6) is the basis for a simple design method for extending (or adapting) a speed controller to include an outer control loop that achieves a headway control function.

A major consideration with such an approach is the amount of control authority. If, for example, the ACC-equipped vehicle travels at 70 mph and the prevailing conditions call for a commanded speed (V_c) of 60 mph, the vehicle can only decelerate so fast before the control authority saturates (its coastdown deceleration). During the time that $V \neq V_c$ the error is also not zero, and the expression given by equation (1) is not satisfied. In graphical terms, we cannot follow the straight line (the control objective) in Figure 4 when the deceleration (or acceleration) has been saturated at the system's maximum control authority. The further we get from the control objective line, the more critical our situation becomes from a headway-keeping standpoint, and hence the more urgent our response should be.

From the discussion above, it appears that one might divide the range versus range-rate space portrayed in Figure 4 into zones based on response urgency, or in other words, based on deceleration levels that are required to attain certain headway clearances (and to avoid a crash).

A trajectory of constant deceleration (a) in the range versus range-rate space is described by:

$$R = R_a + \frac{\left(\frac{dR}{dt}\right)^2}{2 \cdot a} \tag{7}$$

Equation (7) describes a parabola that intersects the vertical axis (range) at some point R_a (see Figure 5). This point can be viewed as a design factor which may vary from some arbitrary headway threshold all the way down to zero, when crash avoidance is the objective. The higher the parabola's deceleration rate is, the more "flat" the parabola becomes.

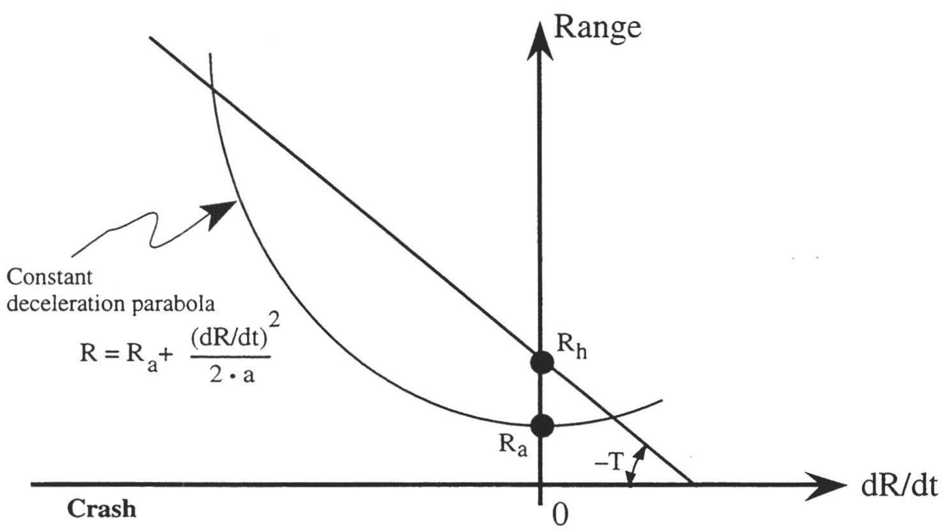


Figure 5. Constant deceleration parabola

With regards to the particular control algorithm employed in the FOT vehicles, the design value of constant deceleration (a) used was 0.05 g. This value corresponds to the Concorde's coastdown deceleration on a flat road at highway speeds. As long as the range and range-rate data from the sensors are above the parabola, the vehicle uses only coastdown to decelerate. However, if the sensor data are below the parabola, then even with full coastdown authority the ACC-equipped vehicle will end up closer than R_a to the preceding vehicle. In order to avoid that situation, higher deceleration rate (that is, control authority) is needed.

The software of the electronic transmission controllers in the ten test vehicles have been modified in cooperation with Chrysler. This modification allows the control algorithm to command a single transmission downshift. By downshifting, a deceleration rate of about 0.07 g can be obtained. This added deceleration (compared to 0.05 g by coastdown only) provides for a higher control authority. With the more flat parabola that is associated with higher deceleration, the range/range-rate trajectory might get back above the parabola and eventually achieve a headway range that is above R_a, or even closer to the objective R_h.

A depiction of the architecture of this ACC system that uses throttle and transmission algorithms to control speed and headway is shown in Figure 6. The figure shows the sensor's range and range-rate signals as inputs to the control system. The velocity of the ACC-equipped vehicle serves as the feedback signal used in an outer control loop and in two inner loops: one inner loop for throttle actuation and the other inner loop for transmission downshift actuation.

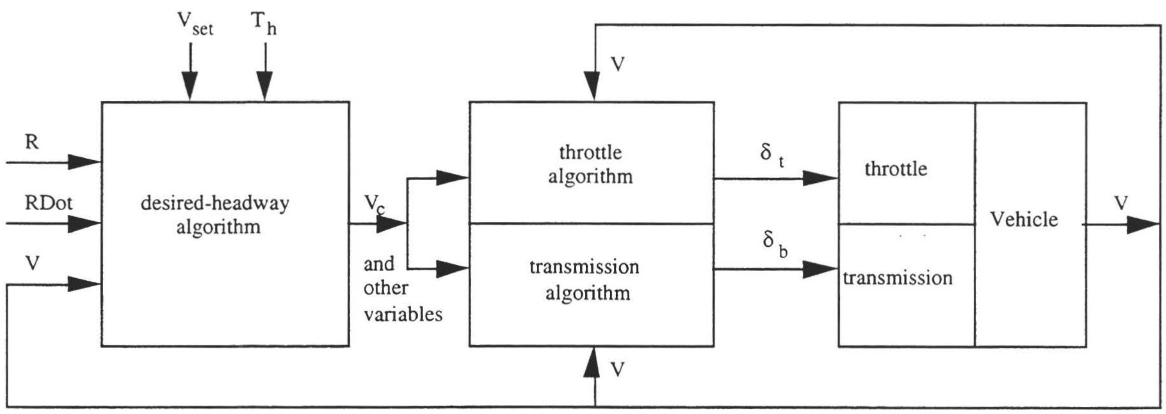


Figure 6. Control architecture for FOT ACC system

The control concept is based upon an overall goal for the ACC system. This goal is expressed by equation (1). At any given time, the system's state relative to that goal is given by the error in equation (4). When the goal is obtained, the error becomes zero.

In order to better explain the control idea, its basic generalized form is illustrated in Figure 7. The outer loop (which includes the inner loop as a special actuation loop) involves a "planner" element that looks at the sensed information, including the velocity of the vehicle and the external quantities R and RDot and decides what "command" to give to the "controller." The controller uses this command to generate control signals that cause the vehicle to respond in a manner that is consistent with the goal.

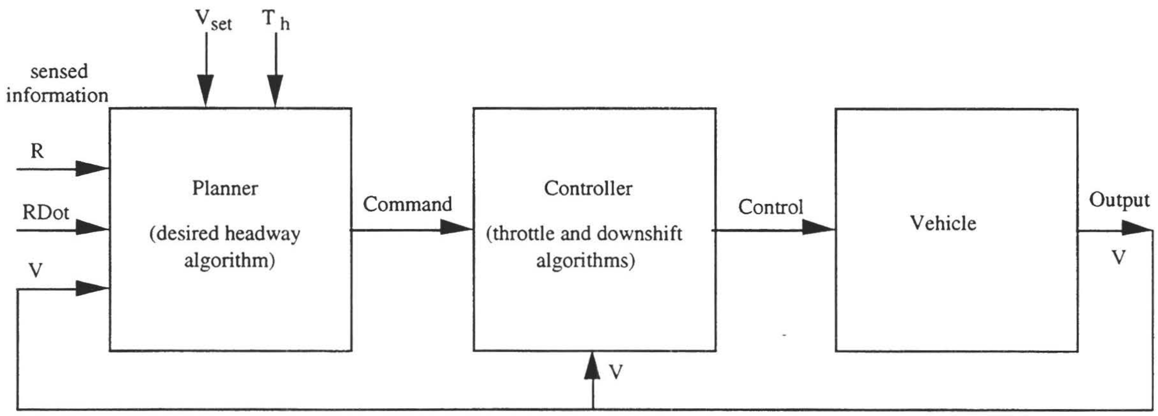


Figure 7. Control architecture with a planner

Throughout the above discussion, the variable T_h, which is the desired headway time for following, has been shown to hold a prime importance. Clearly, it is a variable whose value greatly depends upon individual preferences. The design of the ACC system employed in this FOT allows the driver to select one of three possible values for that variable. The functional structure of the system is depicted in a block-diagram form in Figure 8.

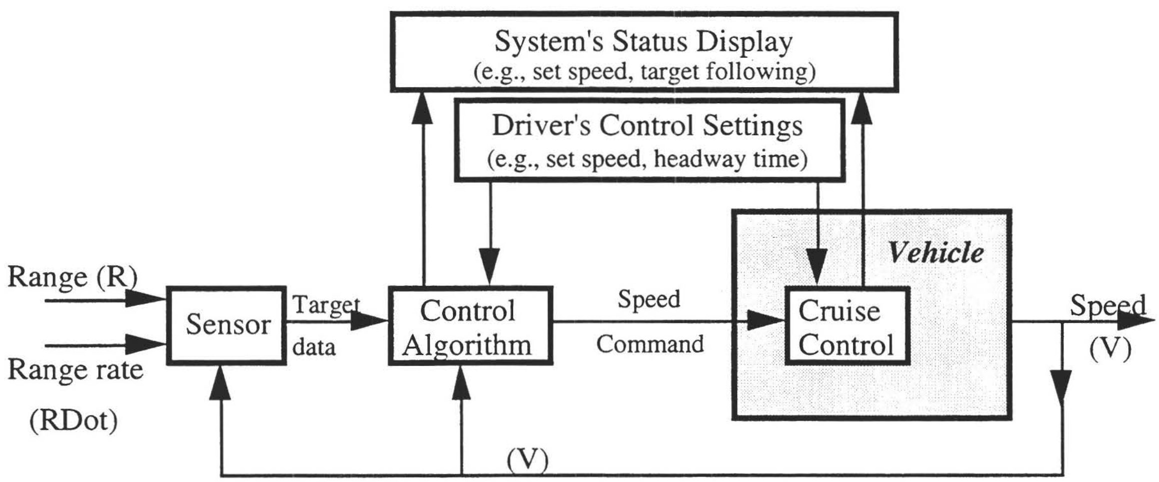


Figure 8. ACC System structure

In this design the driver can also provide other inputs that are essential to the operation of the ACC system: engaging/disengaging the system, setting speed, or pressing the brake. At the same time the system provides the driver with feedback about its operating status: what the set speed is, what its activation state is, and whether targets are tracked. It is evident from the participants' responses so far, that such feedback (though it may come in many different forms) is desirable.

3. PROJECT STATUS

Table 1 lists the tasks and milestones for the FOT project. It indicates those tasks that have been completed, tasks that are in progress, and tasks that have not started yet. As indicated, the field operational test (task 10) is underway. Preparations for conducting the test have been completed.

With regards to the sequence of milestones listed in Table 1, this interim report is the first deliverable describing results and findings from the FOT. The interim report provides a preview of the type of data and findings that are expected to appear in the final report.

Table 1. Tasks and milestones

No.	Name	Status
Tasks		
1	Startup	Completed
2	Develop test definition and project plan	Completed
3a	Design instrumentation package	Completed
3b	Build instrumentation package	Completed
3c	Install instrumentation package	Completed
4	Plan field operational test	Completed
5	Conduct pilot testing	Completed
6	Develop data processing system	In progress
7	Characterize system	Completed
8	Prepare test fleet	Completed
9	Apply for Field-test human-use approval	Completed
10	Conduct field operational test	In progress
11	Process test data	In progress
12	Write final report and archive data	Not started yet
Milestones		
1	Kick-off briefing	Accomplished
2	Test definition & Project plan	Accomplished
3	Operational test plan	Accomplished
4	Pilot test Briefing	Accomplished
5	Interim operational test report	Met by this report
6	Field Operational Test briefing	Not accomplished yet
7	Final technical briefing	Not accomplished yet
8	A video summary of FOT	Not accomplished yet
9	Equipped test vehicles to NHTSA	Not accomplished yet
10	Non-proprietary ACC software to NHTSA	Not accomplished yet
11	Final report	Not accomplished yet

3.1 Pre-Testing Tasks

3.1.1 Vehicle Purchase

The vehicles procured for this project are '96 Chrysler Concordes (see Figure 9). The Chrysler Concorde is a five-passenger sedan which belongs to the family of Chrysler LH-platform cars. This family also includes the Dodge Intrepid, Eagle Vision, Chrysler New Yorker and Chrysler LHS. The New Yorker and LHS have bigger trunks and C-shaped C-pillars, but other than these features they are mechanically similar to the other cars.

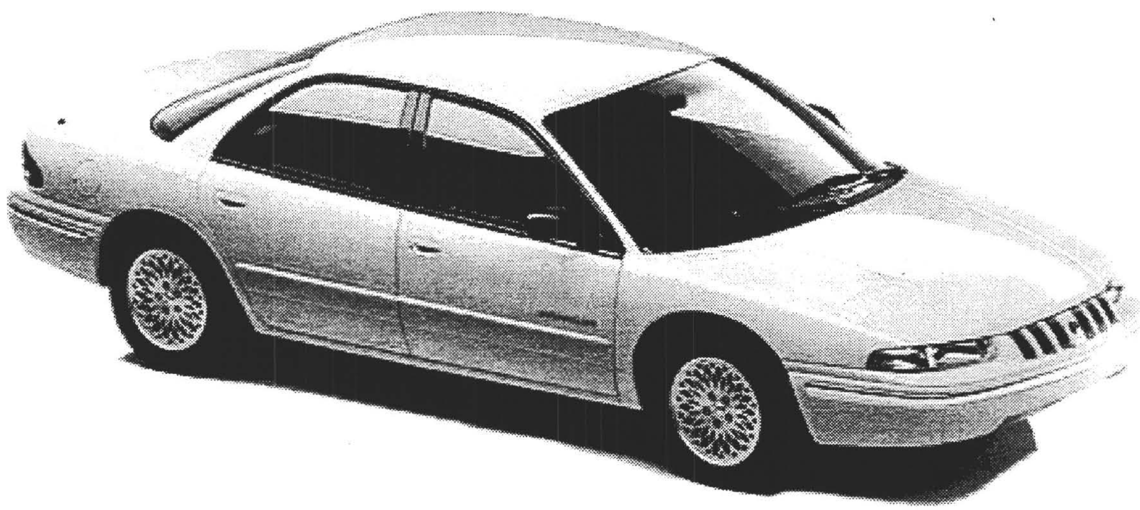


Figure 9. Chrysler Concorde

The primary motivation for using the Chrysler Concorde as the FOT vehicle platform is based on Leica's existing experience with integrating an ACC system onto the Chrysler LH platform. Early experience indicated that a careful tailoring of the ACC application to the selected vehicle must be made if good performance is to be ensured. Tailoring requires suitability of the electronics interface and matching of the control system parameters to the longitudinal response properties of the vehicle. As the provider of the ACC system, Leica had already integrated ACC onto the Chrysler LH platform. This fact was found to be most helpful during the pretesting task of designing the system's installation.

Following are highlights from the vehicle's specification which also served as guidelines when procuring the cars:

1. Model — 1996 Chrysler Concorde LX, option package 26C.
2. Engine —3.5-liter (215 CID) 24-valve V6, 214 hp, 221 lb-ft.

3. Transmission — Four-Speed Automatic Transaxle with overdrive, electronically controlled.
4. Brakes — power-assisted, 4-wheel disc antilock system.
5. Steering — Variable assist, speed-sensitive rack-and-pinion power steering with tilt steering column.
6. Suspensions — Front: Independent system with gas-charged (MacPherson-type) struts and double ball-joint stabilizer bar, Rear: Independent multilink suspension.
7. Mirrors — Inside mirror has a power anti-glare system, both external mirrors are remotely controlled and heated.
8. Dual Air Bags — Driver and front-seat passenger are both protected by an air bag supplemental restraint system.
9. Rear Defroster — Electric heating elements fused to the glass of the rear window.
10. Trunk — Low-Liftover edge of open trunk, and large cargo space to accommodate both luggage and data collection equipment.
11. Other equipment — Factory installed seat belts for all passengers, cruise control, power windows and locks, and air conditioning. Antitheft alarm was installed separately.

3.1.2 Pilot Testing and Human Use Approval

Since ACC has not yet reached the maturity of commercial products, the test systems must be treated as engineering prototypes. Thus, the ACC implementation in our test vehicles, and the protocols for its use, were subjected to careful preliminary testing before operational testing began.

Two phases of pilot testing were performed: supervised and unsupervised. Six lay persons were included in each of the two pilot testing phases. In the supervised testing phase participants received the standard instruction and were accompanied on a 2.5 hour route through metropolitan Detroit on interstate and state highways. During supervised testing ACC was always available to the participants. The overall scope of issues for full operational testing was scrutinized, including the performance of the ACC system, functioning of the instrumentation and remote data recovery system, the quality of the recovered data, and details of participant recruitment and orientation methods.

The application that sought approval for the use of human participants in supervised pilot testing was submitted early in the contract period. Approval was received from the Human Use Review Panel (HURP), NHTSA, USDOT on the 27th of February, 1996. An application seeking additional approval from the University of Michigan was submitted to the Human Subjects in Research Review Committee (HSRRC), Institutional Review Board Behavioral Sciences Committee. Approval from the University was also received in late February 1996.

The second phase of pilot testing (unsupervised) was similar to the operational test conditions, in that participants were not accompanied by researchers and they possessed the research vehicle for two days. Again, participants received the standard instruction. The application that sought approval for the use of human participants in unsupervised pilot testing was approved by the Human Use Review Panel (HURP), NHTSA, USDOT in April, 1996. An application seeking additional approval from the University of Michigan was submitted to the Human Subjects in Research Review Committee (HSRRC), Institutional Review Board Behavioral Sciences Committee. Approval from the University was received May 14, 1996. This approval also addressed full scale operational testing.

3.1.3 Experimental Design

The sample of participating drivers was selected according to a design that stratified the population by age and by prior use of conventional cruise control. An essential element of the design was that each driver's operation with ACC will be compared with the same individual's driving in the "manual" mode of operation.

The experimental design was based, in part, on findings from the FOCAS project [5]. Specifically, the independent variables of participant age and conventional-cruise-control usage were previously found to influence both objective and subjective dependent measures.

The operational test procedures and the associated data acquisition system have been designed with the following independent variables in mind:

- driver
- road type
- traffic situation
- weather
- time of day

Only the driver category of independent variables (age and conventional-cruise-control usage) is treated in the context of a controlled experimental design. The other variables are uncontrolled in the sense that they represent whatever situations the driver encounters in his or her normal driving pattern. The independent variables include three levels of participant age (20-30, 40-50, 60-70 years) and two levels of conventional-cruise-control usage (rarely/never use, frequently use). The gender of participants is being balanced.

Participants were recruited with the assistance of the Michigan Secretary of State (Michigan's driving license bureau). A random sample of 3,000 drivers was drawn from the population of licensed drivers in eight counties in South Eastern Michigan. Potential participants identified from the Department of State records were contacted through U.S. mail to solicit their participation in the field operational test. Interested persons were asked to contact UMTRI. All information obtained through the Department of State records was treated with strict confidentially.

Individuals who contacted UMTRI by telephone with an interest in participation received a brief overview of the field test from a research assistant. Potential participants were further informed of any benefits or risks associated with participation. If individuals found the conditions of participation to be generally agreeable, and after a series of questions were asked, a specific date and time was arranged for the participant to visit UMTRI for orientation and training.

Following a prepared ACC orientation accompanied by a research professional, each driver/participant first operates the assigned vehicle in a manual mode for one week, thereby affording within-subject comparisons as the basic experimental control. In the manual mode, data from the ranging sensor and other transducers is collected continuously to capture the individual's normal car-following behavior, but ACC is initially disabled. The same participant then operates the vehicle for a period of one week to one month with the ACC functionality available. Use of the test vehicles by anyone other than the selected individuals is prohibited.

Consenting drivers operate the test vehicle in an unsupervised manner, simply pursuing their normal trip-taking behavior using our test vehicle as a substitute for their personal vehicle. Objective data in digital form is recovered periodically throughout the day from each test vehicle using cellular modem. Qualitative (subjective) information is recovered using questionnaires, direct interviews, and focus groups.

Continual monitoring of the remotely-collected data permits tracking the ACC usage and determination of the possible need for administrative intervention (for example, if the ACC system is not being used by the subject at all.) The objective data is processed to derive suitable measures of the convenience and safety-related aspects of ACC operation, relative to the manual driving behavior of each test participant.

The primary emphasis in the experimental design is on relatively long exposures of individual lay drivers and upon a sampling scheme that roughly mirrors the population of registered drivers, but with simple stratification that reflects variables previously seen to interact with the manual-versus-ACC driving paradigm.

3.1.4 Instrumentation and Data Handling

The on-board instrumentation package was designed, built, and installed in three main development phases:

1. Define Requirements —The essential objective data needs of the project versus practical car data recording limits were defined. Also, subjective data collection methodology was defined to include items such as predrive surveys; in-car logs; postdrive surveys; and focus group meetings.
2. Pilot Instrumentation Package — An instrumentation package per the defined requirements was designed and installed in a car. The instrumentation design was verified and modified as needed in the pilot test program before being finalized for the full 10 car test fleet.
3. Fleet Instrument Packages — The pilot instrumentation design was finalized and modified based on the pilot testing program. Once the design was completed, identical-data-acquisition system packages were built and installed in all 10 cars and performance verified prior to the operational test program.

During each trip, data from the various transducers is collected using the instrumentation package. Whenever a trip is completed, some of the data that were collected is summarized and transmitted to UMTRI via the cellular modem. The complete set of data acquired during the vehicle's operation by a particular driver is downloaded at UMTRI when the vehicle is returned.

The instrumentation package is described in the "Test Definition and Project Plan" document [2]. There are two computer systems in the package. One system is for the prioritized recording of video data. The other does the on-line processing of the basic data from the Leica sensor, the control algorithm, the automotive electronics bus, the man-machine interface, and the GPS.

A detailed description of the cellular communication and GPS systems is provided later in section 3.4.

Data collection within the instrumentation package proceeds in simultaneous formats, as follows:

- time history sampling of primary and derived variables at 10 Hz in floating point form for continuous variables and in binary (true/false) form for logical variables (these data are stored on the disk drive that is part of the basic data computer (the main computer))
- capture of event-related video episodes, each of 30 seconds duration (this function entails a disk management routine that ensures saving only the most important video episodes on a disk that becomes full. The system provides for storage of 160 video episodes at 10 frames per second)
- capture of time-related video exposures, each of 2.5 seconds duration
- real-time processing of data variables to provide histograms and counts of pertinent events (these data are communicated at the end of each trip to a cellular modem/server at UMTRI)

The computers on-board each vehicle not only control the gathering of data but they also do on-line data processing. The main computer calculates the derived floating point and logical variables, and it sorts the time history data into bins in order to form floating point and logical histograms.

Several stages exist for the processing of test data, namely: (1) validation of data integrity and system operation; (2) interpretation of field data; and, (3) quantification of system performance.

UMTRI staff can recognize (via transmissions from the cellular modem) many of the problems or limitations that have arisen during any trip from the moment of starting the engine until the ignition is turned off.

In summary, the results of the study are derived from comparisons of headway control performance between normal (manual) driving and driving with the ACC system in operation. These comparisons are done from several perspectives involving :

- Safety
  - — available reaction time (headway time margin)
  - — time to impact
  - — deceleration needed to avoid impact
  - — scores in evaluating time margin or deceleration margin for following
  - — subjective evaluation of safety
- Convenience
  - — physical and mental work in activating the controls

— needed level of precision and timing in activating the controls

— subjective ratings of ease of use and control effort

- Comfort

  — smoothness of transitions (jerk) and levels of acceleration

  — subjective ratings of user friendliness

  — drivers feelings related to safety margins and range maintenance

  — level of comfort with the vigilance demands of ACC supervision

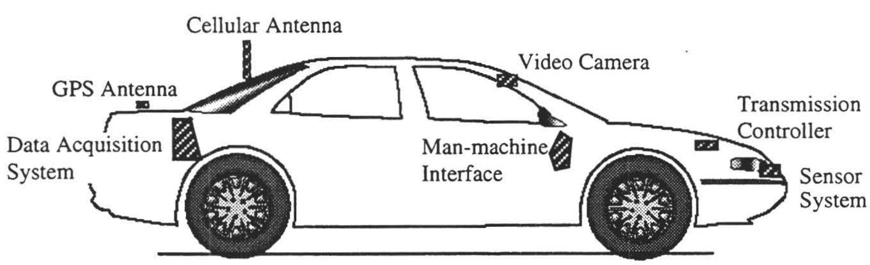
3.1.6 Vehicle Preparation

The vehicle preparation task involved the installation, modification and checkout of seven different systems on-board each test vehicle. Figure 10 shows the seven systems and their locations on each test vehicle. Many of the systems shown involved substantial preassembly before they could be installed. Also of significance was the installation and routing of a wire harness that provided power and data connectivity between the different systems. Figure 10 also includes a list of the major tasks for the vehicle preparation process. A total of 37 tasks were identified. The sequence of the tasks was optimized to help avoid repeated disassembly and modification of the vehicle components and existing subsystems.

❑ 1. Fab, assemble, and check instr. chassis
❑ 2. Fab chassis cover plate
❑ 3. Fab cover plate attachment
❑ 4. Fab GPS antenna backplate
❑ 5. Fab board & box for brake lamp mod

❑ 6. Fab MMI mod board
❑ 7. Modify Leica's MMI controller box
❑ 8. Stuff & assemble MMI display
❑ 9. Build up camera ass'y

❑ 10. Fab cut-in Plexiglas cover
❑ 11. Fab sensor foam inserts



❑ 12. Add supplemental wiring
❑ 13. Install connectors on wiring
❑ 14. Dress wiring
❑ 15. Install brake lamp mod box
❑ 16. Mount cellular antenna
❑ 17. Mount GPS antenna
❑ 18. Install & connect instr. chassis
❑ 19. Re-install seat belts & back seat
❑ 37. Mod. trunk carpet

❑ 20. Remove dashboard
❑ 21. Install concern button
❑ 22. Wire concern button
❑ 23. Defeat "Rec" air button
❑ 24. Install MMI controller
❑ 25. Install MMI display and hood
❑ 26. Install MMI cover & labels
❑ 27. Install buzzer
❑ 28. Dress wires, attach connectors
❑ 29. Position and install camera

❑ 30. Fuse and attach battery connections
❑ 31. Mod Chrysler's trans. connector
❑ 32. Install wire to Chrysler's trans. controller
❑ 33. Shrink-wrap sensor connectors
❑ 34. Align sensors; modify mounting as needed
❑ 35. Install sensor foam inserts
❑ 36. Install cut-in Plexiglas cover

Figure 10. Vehicle preparation checklist

Sensors System

With the sensors, Leica provided an installation kit which includes an adjustable mounting. Once the sensor is firmly clamped into this mounting, it is possible to adjust its orientation using several adjustment means. Installing the sensors in the vehicle involved modifying the adjustable mounting, affixing it to the vehicle's front bumper, and modifying the grill to accommodate the sensors. All the sensor-mounting activities have been carried out by UMTRI.

The adjustable mounting includes a subframe onto which the sensor is attached. This subframe can be slid up or down, and it can also be pitched and yawed. To accommodate installation in the grill between the bumper and the cooling radiator, it was necessary to modify some parts of the adjustable mounting. Special brackets were fabricated and welded to the bumper frame, and the modified adjustable mountings were bolted onto these brackets.

Special openings were cut in the grill to accommodate the sensors. Also, provisions were made to allow access to the adjustment screws of the mountings without any parts removal. The installed sensors are shown in Figure 11. The transmitter and receiver of the sweep sensor are shown on the driver's side of the grill; those of the cut-in sensor are shown on the passenger's side of the grill.

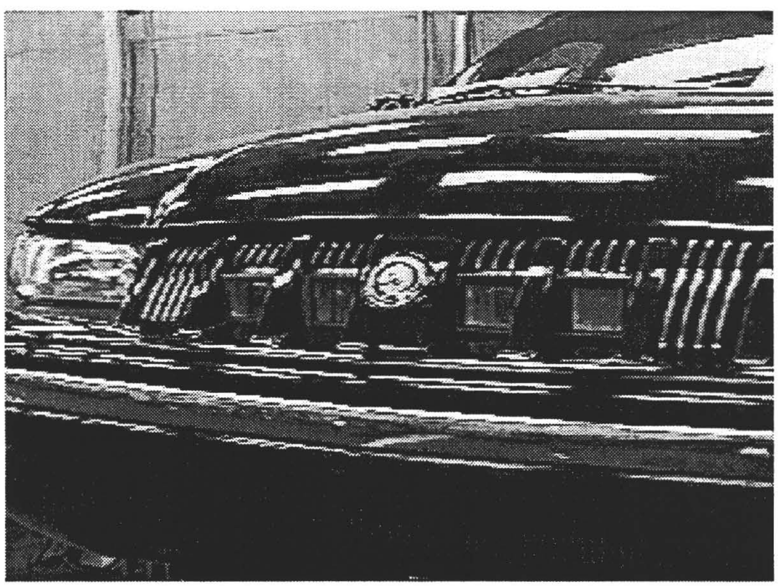


Figure 11. Sensors installed in the grill

Video Camera

The CCD video camera is mounted on the inside of the windshield, behind the rear-view mirror (see Figure 12). It has a wide-angle forward view, and it continuously digitizes and stores captured video to internal buffers in the video computer of the DAS.

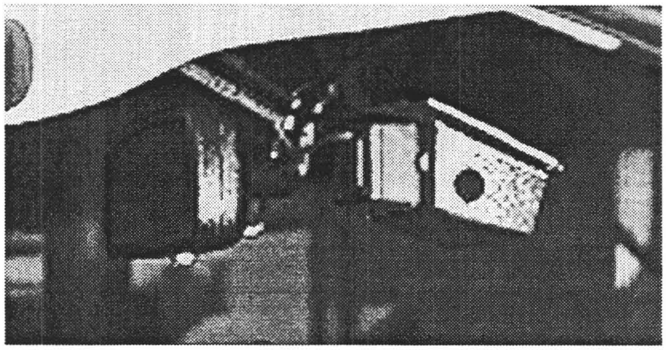


Figure 12. Forward-looking CCD camera

Man-Machine Interface

An integral part of the ACC system is the driver interface. The interface used for conventional cruise control was maintained in its OEM configuration and incorporated into the control of the ACC system. However, several new elements were added in order to accommodate use of the ACC system. The driver interface is illustrated in Figure 13.

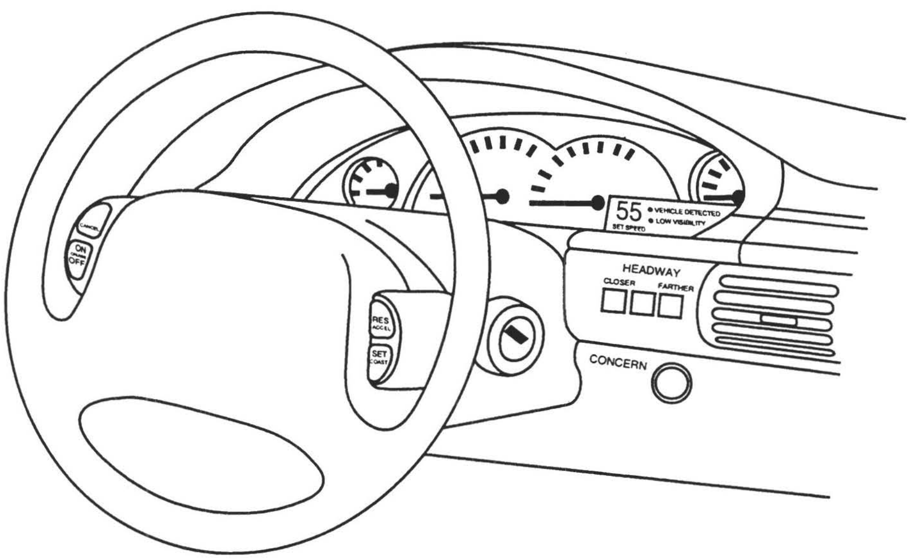


Figure 13. Chrysler Concorde instrument panel with ACC controls and displays

The items included in the headway controller's driver interface include a display for presenting the set speed to the driver, a light accompanied by an audible tone for indicating when visibility is poor, and a light for indicating when the ACC system has recognized a preceding vehicle. In addition there is a set of switches for the driver to use in selecting headway time (labeled as "HEADWAY" in Figure 13). The right button labeled "Farther", the left button labeled "Closer", and the center button unlabeled. By pushing these buttons the driver can select nominal headway times of 2.0, 1.0, and 1.4 seconds, respectively.

Data Acquisition System

The entire data acquisition system (DAS) is mounted in the vehicle's trunk compartment adjacent to the rear surface of the rear passenger seat. The system is mounted in a chassis which houses the primary and video processor subsystems and associated peripherals. The chassis also supports the VAC and E-box for the headway control system as well as the cellular communication equipment. A structure of Dow blue Styrofoam (R-10.8) with insulated cover encloses the electronics and provides a thermally stabilized environment. This covering is modified to suit the particular demands of each seasonal temperature cycle. The covering also protects the equipment from damage or meddling by the participants. The structure consumes about a third of the trunk, however it does not interfere with access to the spare tire. Figure 14 below shows the DAS chassis in the trunk (without the covering).

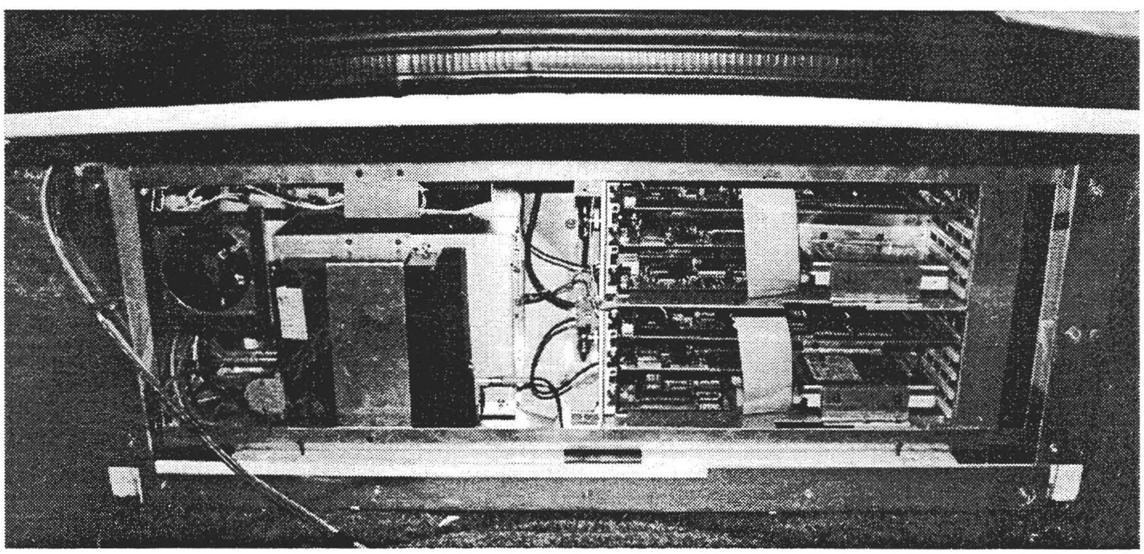


Figure 14. DAS Chassis mounted in the vehicle's trunk

Primary components that are contained within the chassis are DAS processor subsystem, video DAS processor subsystem (subsystems includes disk drives, power supplies, and I/O support cards), GPS receiver, cellular modem transceiver, environmental controller, 12V battery, power delivery system, and Leica's VAC and E-box subsystems. A detailed description of the cellular communication and GPS systems is provided later in section 3.4.

Following the installation and preparation, each vehicle was given a final verification checkout. This checkout consisted of the following tasks:

- power-up check
- ACC communications check
- MMI communication check (LED & buttons algorithm)
- ACC functional check
- cellular data transfer
- alarm installed and functioning
- verify equipment tracking sheet
- mileage run-in

Transmission Controller

Using a special-purpose tool (DRB-2) provided by Chrysler, UMTRI personnel modified the software of the electronic transmission controllers in the ten test vehicles. This modification was needed to allow the transmission to downshift by a command from the control algorithm (see technical discussion in section 2).

3.2 Vehicle and System Maintenance

Maintenance and monitoring of the test fleet, from both the automotive and the system operation aspects, are vital to the success and safety of the field operational test. The high mileage that these cars are expected to accumulate, and the experimental system that is installed in them, demand careful monitoring. The likelihood that drivers will treat these cars as "rentals," combined with the complexity of the system, make the maintenance task challenging.

The headway sensors used in this project are prototype sensors. As such, certain inspections and maintenance activities are required to be performed periodically to maintain the sensors' operative status. Part of the routine maintenance activities was dedicated to the sensors. These activities included sensors alignment and sensors inspection (by means of both software and hardware). As a result of sensor inspection, additional maintenance activities often ensue.

Vehicle and system maintenance encompass efforts by UMTRI staff, and work performed by an authorized Chrysler service shop. The maintenance task is carried out through three sub-tasks, as follows:

- on-line system monitoring — This is accomplished with diagnostic tools incorporated into the system software and the data processing. This form of monitoring ensures (within feasible limits) proper system operation, and that UMTRI is automatically notified (via the cellular modem) of any problems or limitations that have arisen. This maintenance feature depends upon monitoring the data transmitted to UMTRI by cellular phone during the operational test.
- home-base inspection — Each time a test vehicle is brought back to UMTRI between subjects, it is thoroughly checked and prepared prior to delivering it to the next participant. A comprehensive checklist has been prepared and evaluated. This checklist covers items such as:
  - safety, readiness, and functionality of all automotive systems
  - ensuring content of driver equipment (e.g., emergency tools, maps, etc.)
  - ensuring content of documentation (e.g., instructions, insurance, etc.)
  - data acquisition system (e.g., downloading, integrity, resetting, etc.)
  - ACC system functionality per specs, and alignment of the sensors
- OEM maintenance — Needed repairs and periodic maintenance per the manufacturer-recommended schedule will be performed by an authorized Chrysler service shop in Ann Arbor, Michigan. From the standpoint of service, the test fleet is quite unique. That is, expensive equipment items and new wiring have been installed throughout the vehicle, and OEM equipment has been modified (e.g., wired access to the engine controller, new transmission software, etc.). For these reasons, we have arranged for one dedicated point of Chrysler service—a dealer who will assign dedicated maintenance personnel who are acquainted with the special nature of our vehicles. The intention is these vehicles will be serviced only by the selected dealer unless road emergencies necessitate other arrangements.

3.3 System Characterization Procedures

Tests to characterize the performance of the overall system are conducted by UMTRI engineers on public roads covering a broad set of operating scenarios. Each test elicits a certain response that can serve as a meaningful description of system properties. Data is collected using the same data-acquisition package as is installed in each car for operational testing. Test variables that are controlled include the host vehicle speed, lead vehicle speed, state of the control system, and relatively simple steering and braking maneuvers. In each test, the properties of the system are characterized independent of human behavioral variables. A comprehensive description of the characterization-tests procedure is provided in Appendix A, which also includes example plots of test results.

Each of the test measurements is conducted with negligible road grade and head wind. Further, some of the tests require that a *Co-op Vehicle* is engaged to execute preplanned interactive movements between the host vehicle and a preceding vehicle. In these cases, the co-op vehicle is simply another passenger car driven by a collaborating staff member.

3.4 Data Acquisition System

Figure 15 shows a block diagram of the data acquisition system. It consists of five subsystems:

- power, interface, and control
- main computer
- GPS
- cellular communications
- video computer

The main computer system collects and records data from the headway control system, the vehicle (via the headway control system), and the GPS system. The data are organized by trip (ignition on to ignition off). The main computer system also performs on-line data processing to generate derived channels, histograms, summary counts, and video episode triggers.

The video computer system continuously samples output from a windshield mounted camera and saves 2.5-second exposures every five minutes and 30-second episodes when triggered by the main system.

After the ignition is turned off, the main system sends a summary trip file to the UMTRI server using the cellular communications system. When a car returns to UMTRI, the on-board Ethernet network is connected to the building network and the numerical and video data is transferred to the project server.

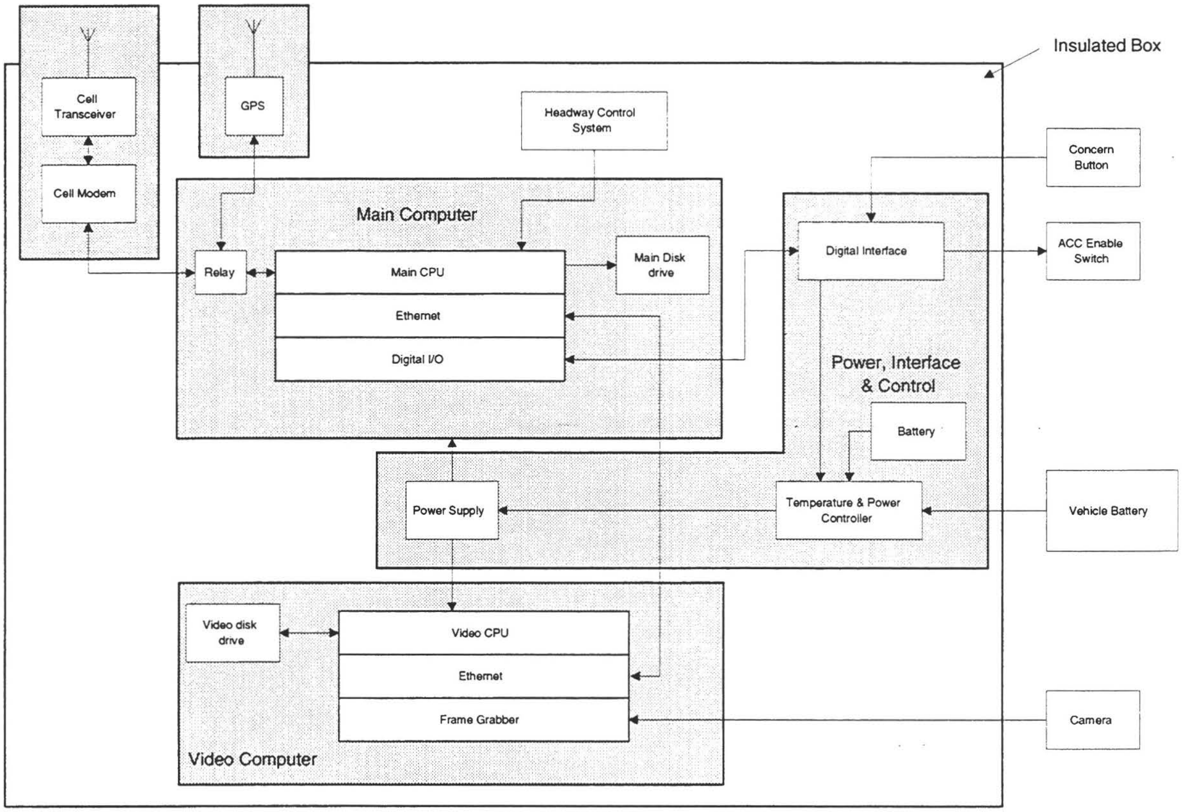


Figure 15. Data acquisition system hardware

3.4.1 Power, Interface and Control

The power, interface, and control subsystem provides power sequencing of the various components and closed-loop heating or cooling of the chassis. It includes:

- two triple-output (5, +-12 volt) ac-dc converters for the computers
- 9-volt regulator for camera power
- 3-volt lithium battery for the GPS battery-backup RAM
- three 12-volt 17.5 amp-hour lead acid batteries
- microcontroller with 11 channel 10-bit A/D and 12 digital inputs/outputs
- circulation and exhaust fans
- 50-watt heater
- three temperature sensors

The microcontroller continuously monitors the chassis and camera temperatures, battery voltages, and state of the ignition switch and updates histograms of these variables in nonvolatile memory (EEPROM). The histograms are downloaded and inspected via a RS232 serial line when the participant returns the vehicle.

The vehicle power system and the chassis batteries are connected only when the ignition is on. Power for heating and cooling of the system comes from the three chassis batteries. The camera temperature is maintained above -5 degrees C by turning it on (self-heating). If the temperature of the chassis goes below 4 degrees C, a 50-watt heating element and a circulation fan are activated. The microcontroller ceases closed-loop heating when the battery voltage drops below 10.0 volts. This assures that the chassis can be powered up when the next ignition-on event occurs. If the chassis temperature is out of operating range (2 to 50 degrees C), the microcontroller does not turn the computers on and logs a missed trip in its EEPROM.

3.4.2 Main Computer

The Main Computer includes:

- a 5-slot passive backplane and chassis
- an IBM-AT compatible CPU card with 90 MHz Pentium processor, 8 MB RAM, two serial ports, printer port, and hard disk controller
- 1.6 GB disk drive
- Ethernet network adapter
- digital I/O expansion card

Figure 16 shows how the system operates. When the vehicle is started, the interface and control system activates the main system, which turns on the GPS and video systems. The GPS system sends (via a RS-232 serial line) encoded position and velocity packets every time it computes a new position. The main system decodes these packets, calculates a grade estimation and heading from the velocity information, and stores the time, latitude, longitude, altitude, grade, and heading to a position file. The GPS time at power-up is used to set the main and video computer clocks.

The headway controller sends (via a second RS-232 serial line) an encoded packet of information every 0.1 seconds. The main system decodes this packet and extracts the appropriate sensor and vehicle information channels. Derived channels are then calculated and selected information is logged to a time-history file. Some logical channels are logged to a transition file. Each transition-file record indicates a channel number, the time of the false-to-true transition, and the duration that the signal was true. An episode-processing task monitors the incoming and calculated channels for the occurrence of significant episodes (e.g., ACC overrides, near encounters, concern button presses, etc.). When an episode is detected, the main system logs it to the transition file and sends a message (via Ethernet network) to the video system. Transition counts, histograms, errors, and other trip summary information are logged to a trip log at the end of each trip.

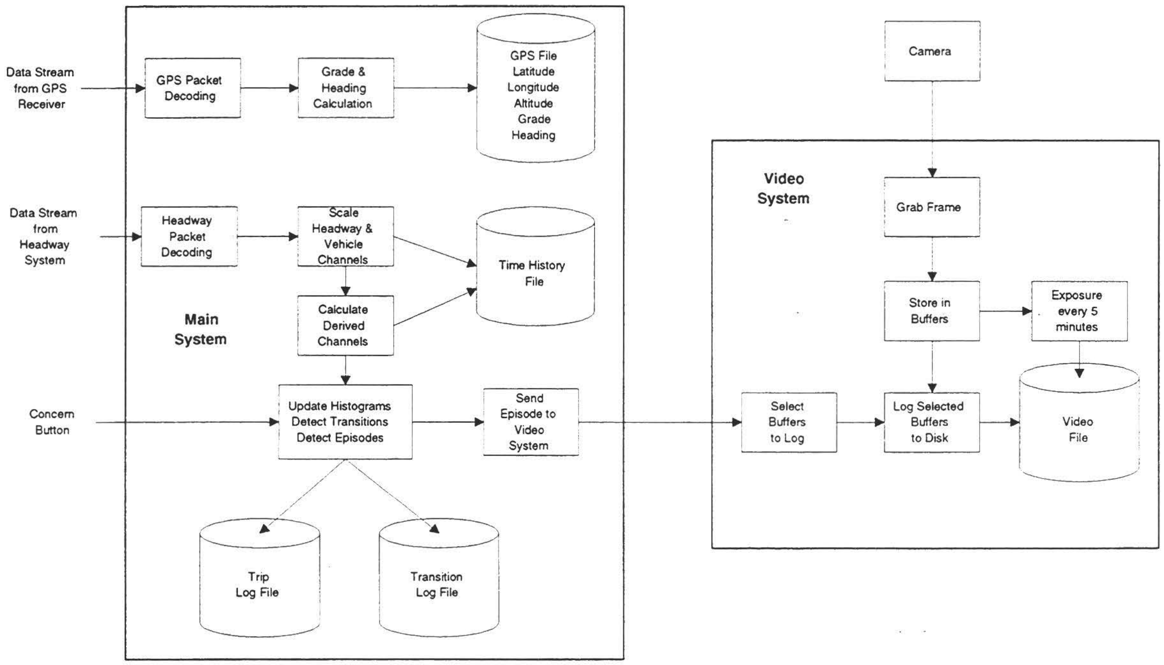


Figure 16. Data acquisition system operation

The video system continuously digitizes and stores captured video to internal buffers. When a message from the main system occurs, the video system selects a number of buffers (representing a time period that captures the event) and records these buffers to disk.

When a trip ends, the main system turns off the GPS and video systems and activates the cellular system. The trip log files are then transferred to the UMTRI server using standard Internet protocols (FTP, TCP/IP, and PPP). Then the main computer signals the microcontroller which turns the computer off.

3.4.3 GPS

The GPS system uses a Trimble six-channel receiver model SVeeSix-CM3 (which tracks up to eight satellites) with real-time clock and active antenna that is mounted on the center of the trunk lid. The receiver stores the almanac, ephemeris, and configuration data in battery-backup RAM. This minimizes the time from power-up to first computed position. If the receiver has been powered down for less than four hours, the saved data is considered valid and the acquisition time is typically less than 30 seconds. If more than four hours, the time to first fix is around 40 seconds.

The main computer communicates with the receiver via a 9600 baud RS232 serial line using the Trimble Standard Interface Protocol (TSIP). TSIP is a binary packet protocol that permits full control of the receiver's operating parameters and output format. Table 2 shows the packets that are automatically sent by the receiver and processed by the data acquisition software. The main computer causes the receiver to operate in 3D-manual and overdetermined modes. Position and velocity packets are sent twice a second as long as at least four satellites are visible. Reacquisition time for a momentary satellite loss is typically under 2 seconds. The over-determined 3D solution (which smoothes the position output and minimizes discontinuities caused by constellation changes) requires five or six visible satellites.

Table 2. GPS Packet information

Packet Type	Description
Health	Satellite tracking status and operational health of the receiver
Time	GPS time reported in weeks since January 6, 1980 and seconds since Sunday morning at midnight of the current week
Position	Single precision position in Latitude-Longitude-Altitude (LLA) coordinates
Velocity	Single precision velocity in East-North-Up (ENU) coordinates

3.4.4 Cellular Communications

The cellular communications system consists of an AT&T KeepInTouch 14.4 Kbps cellular modem that uses the Enhanced Throughput Cellular protocol, a Motorola 3 watt transceiver, and a window-mount antenna. The main acquisition and communications programs maintain a list of trip files to be transmitted to the UMTRI server. When a trip is over, the system executes a connection script that initializes the modem (which usually connects at rates of 4800, 7200, or 9600 baud), dials the phone, and logs in to the server with a PPP account name and password. If the call is not answered (busy cellular system or server) a second attempt is made. Files are transferred using FTP until either all the files in the list have been sent or five minutes has lapsed since the driver turned of the ignition. The system then executes a disconnect script and turns itself off.

3.4.5 Video Computer

The Video Computer includes:

- a 5-slot passive backplane and chassis

- an IBM-AT compatible CPU card with 90 MHz Pentium processor, 32 MB RAM, two serial ports, printer port, and hard disk controller
- 2.1 GB disk drive
- Ethernet network adapter
- CX100 Frame Grabber

The CX100 frame grabber is programmed to capture an image of 486 rows by 512 pixels in NTSC high resolution mode. Each image frame contains two interlaced fields (243 rows by 512 pixels) as shown in Figure 17.

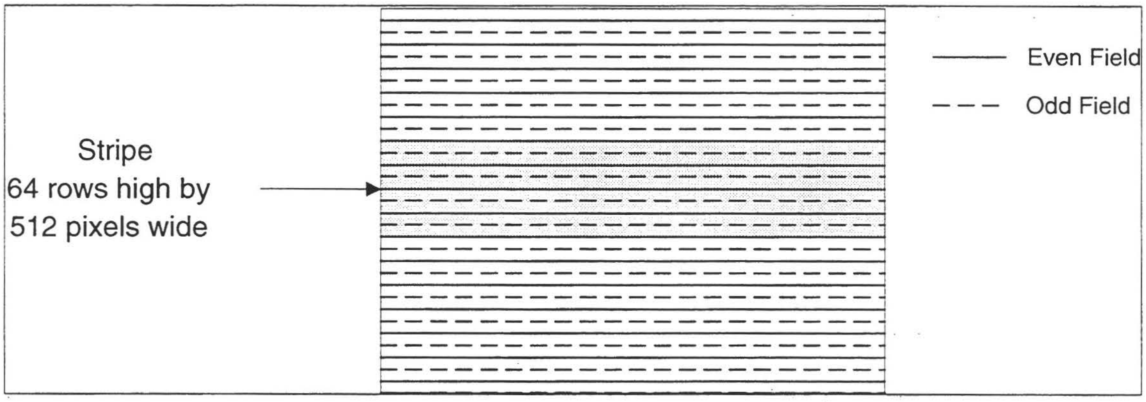


Figure 17. Video image frame structure

The video software samples a stripe from the even field, which is 64 rows by 512 pixels, every six frames, or 0.1 seconds. The stripe is marked with a date/time stamp derived from the system clock which reflects the time the stripe was copied into a stripe buffer (not the time the frame grabber digitized the field) and stored in a stripe buffer selected from a pool of 600 buffers.

The system maintains a circular list of the last 300 stripes. At 5-minute intervals, an exposure task wakes up and saves the last 25 stripes (2.5 seconds) to a file (819,200 bytes). The system hard disk contains 420 contiguous preallocated exposure files labeled from "1.exp" to "420.exp". The files are created once and never deleted, which minimizes write time and prevents the disk from becoming fragmented. They are overwritten in sequential order and a current list of file and driver-trip information is stored in a directory file called "director.exp".

When the main system detects an episode, it sends a message that contains the episode type, driver number, trip number, date/time stamp, and the importance of the episode (a number between 0.0 and 1.0). The video system copies the list of the last 300 buffers and increments the buffer use counts so they will not be returned to the "available" or "free" pool until they are written to disk. The episode is scheduled to be recorded after a 15-second wait period. If another more important episode occurs during this period, the previously scheduled one is deleted and the new one is scheduled. Thus cascaded triggers that are close in time generate only one video episode. The system hard disk contains 160 contiguous pre-allocated episode files (9,830,400 bytes each) labeled from "1.epi" to "160.epi". Table 3 shows the nine types of episodes that vie for this file space.

Table 3. Episode types

Episode Type	Minimum	Maximum
Concern button	50	50
Manual Brake Intervention - 1st week	10	50
Manual Near Encounter - 1st week	10	50
Cruise Brake Intervention	10	50
Cruise Near Encounter	10	50
Manual Brake Intervention - 2nd week	20	50
Manual Near Encounter - 2nd week	20	50
ACC Brake Intervention	20	50
ACC Near Encounter	20	50

The episodes files are filled in order from 1 to 160 as long as the number of each type is less than its maximum. Once all of the files are filled, a set of preemption rules applies. The current list of episodes is stored in a directory file called "director.epi".

The exposures and episode binary files are converted to "QuickTime movies," which can be played on Macintoshes or PCs running Windows (3.1, 95, or NT). The images are doubled in height to recapture the original aspect ratio (only the even rows are contained in the sample) and compressed. The resulting exposure movies are 200 to 350 K bytes in size. The longer episodes are from 3.5 to 4 Megabytes. The first frame of each movie is a title frame showing the driver number, trip number, date/time of the trigger or exposure, and the importance. Subsequent frames display the frame number and frame timestamp at the bottom. Figure 18 shows a frame from an exposure movie.

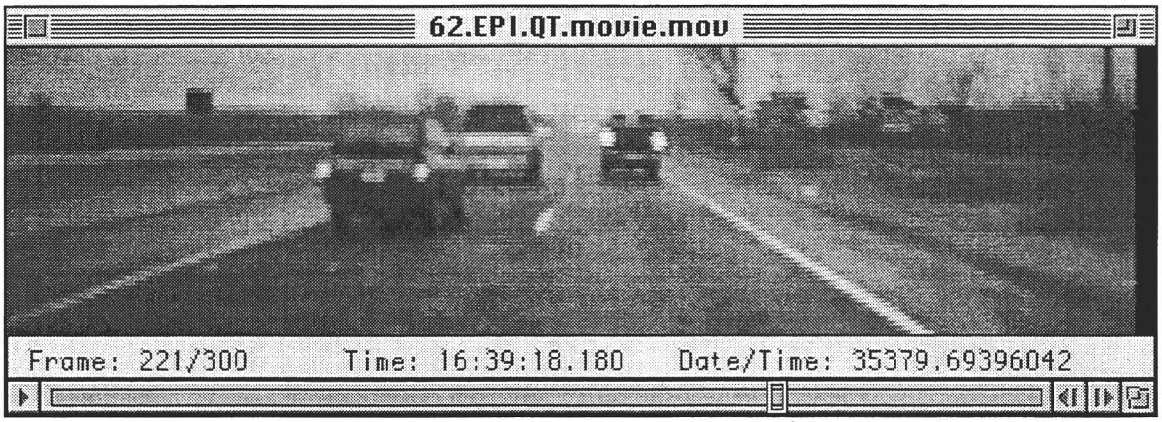


Figure 18. Snapshot from an exposure movie

3.5 Data Processing Procedures

This section outlines the data flow and current data processing for the FOT. There are many stages of data processing in this project. They range from the simple calculation of derived signals in real-time, on-board the test vehicle's data acquisition system (DAS), to the storage of files in a database format that allows flexible query generation and inter-connectedness of the data.

On average a subject will take 76 trips, drive 828 miles, and spend 21 hours in the FOT vehicle during the twelve day test period. From a data-processing perspective, an average driver generates around 300 numerical data files with a total file storage size of 115 Megabytes (MB). Likewise, the typical driver generates approximately 310 video files with a total file size of 794 MB. This means to-date the study has collected over 23,000 numerical and video data files that constitute nearly 34.5 Gigabytes (GB) of information.

This process is very computationally and network intensive. The end goal is to deliver a portable and very concise numerical and video history of the driving experience of each FOT driver. Figure 19 shows the general flow of the numerical and video data. The following sections discuss this figure starting with the primary and derived data channels. Then the on-line processing of these channels to make histograms is discussed. This is followed by a discussion on file types, databases and video files, and finally the permanent storage of the data on CD-ROM.

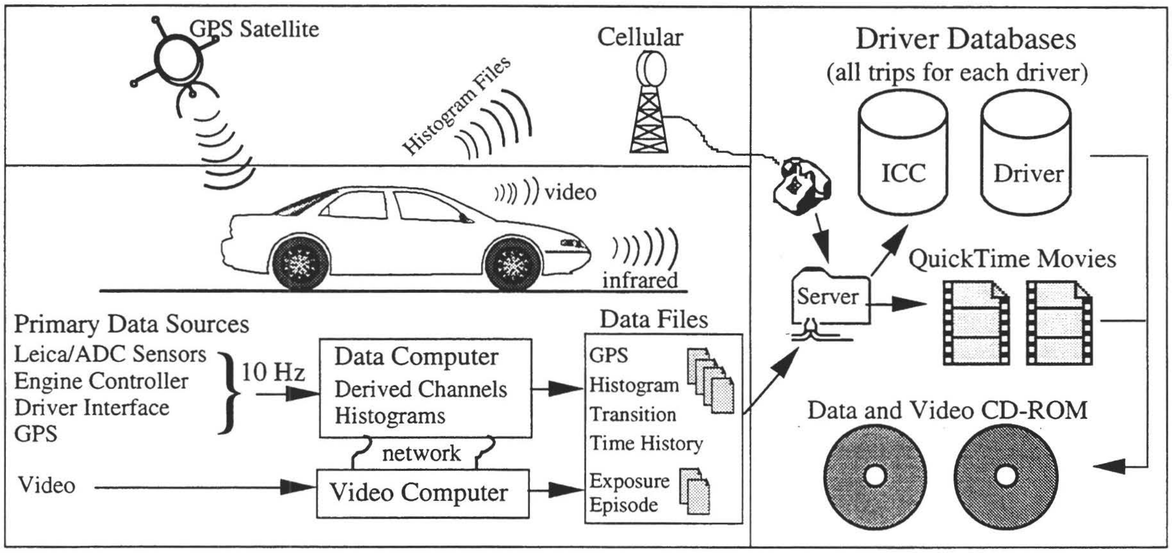


Figure 19. Data processing and flow for the field operational test.

3.5.1 On-board Data Processing

The DAS installed on the FOT vehicles is designed to collect, process and store both numerical and video data files using two on-board computers. The data are collected and stored on trip-by-trip basis. A trip is defined as the time between turning on and off the test vehicle's ignition. The rate of data sampling for the DAS is 10 Hz. The discussion below focuses first on the numerical side of the data processing. The video data processing is explained later in this section.

Primary and Derived Channels

The numerical data flow starts with the collection of 32 primary signals from various sources on-board each FOT vehicle. These sources are shown on the left in Figure 19 and include the Leica/ADC infrared sensors, the vehicle's engine control unit, the video camera, the GPS, and the driver/vehicle interface. A list of the 32 primary signals is given in Table 4. This table shows the name, type, description, and units of each signal. It also has a column called Logged. This column indicates if the signal is permanently stored on the computers internal hard disk[1].

---

[1] Some of the logical signals are stored in a more compact format than that used for time histories. This format is explained later in this section under Transition Files. The following nomenclature is used in the column "Logged", to indicate which file the data is logged into: "H" – time history; "G" – GPS history, "T" – transition table

Table 4. Primary channels

Name	Type	Description	Units	Logged
ACC Mode	Integer	0=off, 1=standby, 2=cruise, 3=headway		H
Accel	Logical	True if accel button is pressed		T
AccEnable	Logical	True after 1st week		
Altitude	Float	Altitude	m	G
Backscatter	Float	Backscatter (0 to 1023)		H
Blinded	Logical	True if ODIN 4 blinded bit is on		
Brake	Logical	True if brake pedal is pressed		H
Cancel	Logical	True if cancel button is pressed		T
CC_ACC On	Logical	True if cruise or ACC switch is on		
Cleaning	Logical	True if ODIN 4 cleaning bit is on		
Coast	Logical	True if coast button is pressed		T
Concern	Logical	True if concern button is pressed		T
CurveRadius	Float	Curve radius	ft	
Date/Time	Double	Days since 12/30/1899 + fraction of day	days	H
Downshift	Logical	True if controller requests downshift		T
East Velocity	Float	East velocity, + for east	m/sec	
Headway Time	Float	Selected headway time	sec	
HeadwaySwitch	Integer	headway switches , 1,2, or 4		
Latitude	Float	Latitude, + for north	radians	G
Longitude	Float	Longitude, + for east	radians	G
NewTarget	Logical	True for .3 sec with new target		H
North Velocity	Float	North velocity, + for north	m/sec	
Range	Float	Distance to target	ft	H
RDot	Float	Rate of change of range	ft/sec	H
ReducedRange	Logical	True if ODIN 4 reduced range bit is on		
Resume	Logical	True if resume button is pressed		T
Set	Logical	True if set button is pressed		T
Throttle	Float	Throttle percent		H
Tracking	Logical	True when tracking a target		H
Up Velocity	Float	Up velocity, + for up	m/sec	
ValidTarget	Logical	Target and velocity filter		H
VCommand	Float	Velocity commanded by controller	ft/sec	H
Velocity	Float	Vehicle velocity	ft/sec	H
Vset	Float	Cruise speed set by driver	ft/sec	H

The numerical data processing begins as these primary channels are read into the memory of the DAS. The computer then calculates what are called *derived channels*. These channels are combinations and manipulations of the primary signals. Examples of derived channels include: V_p (Velocity of the preceding vehicle), road grade, distance, near, following, etc. There are 66 derived channels. The 31 floating-point derived channels are given in Table 5. The remaining 35 are logical channels and are listed in Table 6. Both tables show the name of the derived signal, a description (which includes its derivation), units, and whether it is logged or saved in the data computers memory.

Table 5. Floating point derived channels

Name	Description	Units	Logged
AvgBackScatter	1 second moving Avg of BackScatter		
AvgDNearEncounter	4 second moving Avg of DNearEncounter	g's	
AvgVDot	4 second moving Avg of -VDot	g's	
CDot	Derivative of DegreeOfCurvature	deg/sec	H
D	$RDot^2$ / (2•(Range- 0.7 • Vp)•32.2)	g's	
DecelAvoid	$RDot^2$ / (2•Range•32.2)	g's	H
DegreeOfCurvature	5728.996 / CurveRadius	Deg	H
Distance	Integral of velocity	miles	H
DistanceEngaged	Integral of velocity while engaged	miles	
DNearEncounter	$RDot^2$ / (2•(Range - .3•Vp)•32.2)	g's	
DScore	if DScoreRegion then DScore= (D-.03) / .47; if TScoreRegion then DScore= 1		H
EngMaxAvgDNear	Maximum value of AvgDNear while EngNearEncounter is true	g's	
EngMaxAvgVDot	Maximum value of AvgVDot while EngBrakeIntervention is true	g's	
Flow	Velocity / (Range+L)	veh/sec	
Grade(GPS)	UpVelocity / sqrt($NorthVelocity^2$ + $EastVelocity^2$)		G
Heading	Heading angle calculated from NorthVelocity and EastVelocity	deg	G
HeadwayTimeMargin	Range / Velocity	sec	H
Hinderance	Velocity / VSet		
ManMaxAvgDNear	Maximum value of AvgDNear while ManNearEncounter is true	g's	
ManMaxAvgVDot	Maximum value of AvgVDot while ManBrakeIntervention is true	g's	
RangeCheck	.7 • Vp + $RDot^2$ / (2•.5•32.2)	ft	
RangeNear	.5 • Vp +RDot ^{2} / (2•.1•32.2)	ft	
Rpt03	Range - $RDot^2$ / (2•.03•32.2)	ft	
Thpt03	Rpt03/Vp if RDot < 0 or Range/Vp if RDot >= 0	sec	H
TimetoImpact	-Range / RDot	sec	H
TrackingError	TimeConstant • RDot + Range - Th•Vp	ft	
TScore	if TScoreRegion then TScore= (.7-Th0) / .7		H
Vdot	derivative of Velocity / 32.2	g's	H
VehicleResp	VCommand - Velocity	fps	
Vp	Velocity + RDot	fps	H
VpDot	derivative of Vp / 32.2	g's	H

Table 6. Logical derived channels

Name	Description	Logged
AccBi	15-sec oneshot - AccEnable AND EngBrakeIntervention	T
AccFollowing	Following AND .9Rh < Range <1.1Rh	H
AccNe	15-sec oneshot - AccEnable AND EngNearEncounter	T
AccTracking	AccMode > 2	
AlwaysTrue	Always True	
BackscatterWarn	Backscatter > min	H
CccBi	15-sec oneshot - NOT(AccEnable) AND EngBrakeIntervention	T
CccNe	15-sec oneshot - NOT(AccEnable) AND EngNearEncounter	T
Closing	NOT(Near) AND RDot <-5	H
Cutin	Range < RangeNear AND RDot >0	H
DScoreRegion	ValidTargetVgt35 AND RDot <= 0 AND Range > RangeCheck	
Engaged	AccMode > 1	T
EngBrakeIntervention	15-sec oneshot - Brake AND Vgt50 AND AverageVDot > .05 AND WasEngaged	
EngNearEncounter	15-sec oneshot - ValidTargetVgt50 AND AverageDNear > .05 AND WasEngaged	
Following	NOT(Near OR Cutin) AND -5 <= RDot <= 5	H
HeadwayLong	True if long headway switch is pressed	T
HeadwayMedium	True if medium headway switch is pressed	T
HeadwayShort	True if short headway switch is pressed	T
LDegOfCurvature	|DegreeOfCurvature| > 3 AND V>50	
LVpDot	VpDot < -.05g's	
Man1Bi	15-sec oneshot - NOT(AccEnable) AND ManBrakeIntervention	T
Man1Ne	15-sec oneshot - NOT(AccEnable) AND ManNearEncounter	T
Man2Bi	15-sec oneshot - AccEnable AND ManBrakeIntervention	T
Man2Ne	15-sec oneshot - AccEnable AND ManNearEncounter	T
ManBrakeIntervention	15-sec oneshot - Brake AND Vgt50 AND AvgVDot > .05 AND NOT WasEngaged	
ManNearEncounter	15-sec oneshot - ValidTargetVgt50 AND AverageDNear > .05 AND NOT WasEngage	
Near	Range < RangeNear AND RDot <0	H
Separating	NOT(Cutin) AND RDot > 5	H
Stopped	Velocity <3	
TScoreRegion	ValidTargetVgt35 AND RDot <= 0 AND Range <= RangeCheck	
ValidTargetVgt35	ValidTarget AND V>35	
ValidTargetVgt50	ValidTarget AND V>50	
Vgt35	Velocity > 35	
Vgt50	Velocity > 50	
WasEngaged	True if enaged within the last 15 seconds	

Floating Point Histograms

During each trip some of the primary and derived floating-point channels are made into histograms by the on-board computer. The counting and binning for the histograms is done *on-the-fly* as the signals are derived and processed. Table 7 shows the twenty-seven floating-point histograms that are currently being made and permanently stored. If data for a particular histogram is collected continuously during a trip, its enabling channel is listed as Always True. For other histograms the enabling channel is either a primary or derived logical channel and it must be *hi* or true in order for counting to occur in that particular histogram. For example, the Throttle histogram is only loaded when the enabling channel, Velocity > 30 mph is true.

Table 7. Floating point histograms

Name	Source Channel	Enabling Channel	Sorting Channel
BackScatterFhist	Backscatter	Vgt35	None
CDotFhist	CDot	Vgt35	Engaged
DecelAvoidFhist	DecelAvoid	ValidTargetVgt35	Engaged
DegOfCurvatureFhist	DegreeOfCurvature	Vgt35	Engaged
DScoreFhist	Dscore	DScoreRegion	Engaged
FlowFhist	Flow	ValidTargetVgt50	Engaged
HindranceFhist	Hindrance	Engaged	None
HtmFhist	HeadwayTimeMarg	Following	Engaged
RangeFhist	Range	ValidTarget	Vgt35
RangeFollowingFhist	Range	Following	Engaged
RangeVgt35FhistV	Range	ValidTargetVgt35	Engaged
RDotFhist	RDot	ValidTarget	Vgt35
RDotVgt35Fhist	RDot	ValidTargetVgt35	Engaged
Thpt03Fhist	Thpt03	ValidTargetVgt35	Engaged
ThrottleFhist	Throttle	Vgt35	Engaged
TimeToImpactFhist	TimeToImpact	ValidTargetVgt35	Engaged
TrackingErrorFhist	TrackingError	AccTracking	None
TScoreFhist	TScore	TScoreRegion	Engaged
VCommandFhist	VCommand	Vgt35	Engaged
VDotFhist	VDot	Always True	Vgt35
VDotVgt35Fhist	VDot	Vgt35	Engaged
VehnessFhist	VehicleResp	Engaged	AccTracking
VelocityFhist	Velcoity	Always True	None
VelocityVgt35Fhist	Vgt35	Vgt35	Engaged
VpDotFhist	VpDot	ValidTargetVgt35	Engaged
VpFhist	Vp	ValidTargetVgt35	Engaged
VSetFhist	VSet	Engaged	None

As shown in Table 7, most histograms have a sorting channel. The sorting channel separates the counts into two histograms depending on the state of the sorting channel variable. For example, the sorting channel for the Throttle histogram is the Engaged logical channel. When this channel is true, i.e., the velocity of the test vehicle is being controlled by either conventional or adaptive cruise control, one set of bins for the Throttle histogram is filled. If the driver turns the cruise control off, then engaged is false, and the other set of bins for the throttle histogram is filled. (Of course, in this example the vehicle must maintain a speed greater than 30 mph for either set of bins to be filled because the enabling channel is Velocity > 30 mph). In short, there are really two histograms when a sorting channel is used.

One two-dimensional histogram is processed by the DAS. This is a normalized Range, Range-Rate histogram. The normalizing channel is the speed of the preceding vehicle (V_p). The histogram is enabled by the ValidTargetVgt50 logical channel and is sorted by the Engaged channel.

Besides creating histograms, the DAS also calculates three statistical figures for each histogram. These figures are the most-likely-value (which histogram bin has the greatest number of counts), the mean and the variance, where the later two are defined as follows:

$$mean = \bar{x} = \sum_{i=1}^{nbins} (x_i \cdot n_i) / \sum_{i=1}^{nbins} (n_i) \tag{9}$$

and

$$variance = \sum_{i=1}^{nbins} (\bar{x}_i - x_i)^2 \cdot n_i / (\sum_{i=1}^{nbins} n_i) - 1 \tag{10}$$

where:

$\bar{x}$ = mean,

$nbins$ = number of bins,

n_i = count in each bin, and

x_i = value of the bin center

Logical Histograms

There are twenty logical histograms recorded by the DAS for each trip of each test vehicle. Table 8 shows the names, source channels, enabling channels and sorting channels for these histograms. Unlike the floating-point histograms, the logical histograms all have five bins. The first bin records the number of transitions (count of false to true changes) for the logical source channel. The second and third bins contain the number of counts that the source channel was true and false, respectively. The fourth and fifth bins contain the number of counts that corresponds to the longest consecutive time that the source channel was true and false, respectively. The enabling and sorting channels have the same meaning as in the floating-point histograms.

Table 8. Logical histograms

Name	Source Channel	Enabling Channel	Sorting Channel
AccFollowingLhist	AccFollowing	ValidTargetVgt35	Engaged
AccTrackingLhist	AccTracking	Engaged	None
BackscatterWarnLhist	BackscatterWarn	Vgt35	Vgt35
BlindedLhist	Blinded	Vgt35	Engaged
BrakeLhist	Brake	Vgt35	WasEngaged
CleaningLhist	Cleaning	Vgt35	Engaged
ClosingLhist	Closing	ValidTargetVgt35	Engaged
CutinLhist	Cutin	ValidTargetVgt35	Engaged
DScoreRegionLhist	DScoreRegion	ValidTargetVgt35	Engaged
FollowingLhist	Following	ValidTargetVgt35	Engaged
LVpDotLhist	LVpDot	ValidTargetVgt35	Engaged
NearLhist	Near	ValidTargetVgt35	Engaged
NewTargetLhist	NewTarget	Vgt35	Engaged
ReducedRangeLhist	ReducedRange	Vgt35	Engaged
SeparatingLhist	Separating	ValidTargetVgt35	Engaged
TrackingLhist	Tracking	Vgt35	Engaged
TScoreRegionLhist	TScoreRegion	ValidTargetVgt35	Engaged
ValidTargetLhist	ValidTarget	AlwaysTrue	Engaged
ValidTargetVgt35Lhist	ValidTarget	Vgt35	Engaged
ValidTargetVgt45Lhist	ValidTarget	Vgt45	Engaged

3.5.2 Data File Formats

For each trip, the DAS records and saves six different file formats. Four of these contain the numerical information for the trip and the other two contain the video information. A short description of each file formats follows.

- *GPS Files* - The GPS data is written in a time-history format to the DAS hard-disk. The channels of this file include: time, latitude, longitude, altitude, grade, heading. These data are written to the file at 0.5 Hz. Typically, these files are 60KB in size. In addition to logging a complete record of the test vehicle's position, start and end lateral, longitudinal and altitude GPS coordinates for each trip are saved in a more accessible format within the histogram file type.
- *Histogram files* - The data for all the floating-point and derived histograms are saved in the histogram files. These files are between 11 and 15 KB. The histogram files

also contains a trip summary table. The contents of the table are listed in Table 9 below. Unlike the other DAS files, the histogram files are transferred to UMTRI at the end of each trip via the cellular phone that is built into the DAS system. These files are then monitored as they are received to identify problems with the test equipment or anomalous results. Test drivers can then be contacted and appropriate measures taken to correct the problem.

- *Transition files* - The transition file format is a concise way of tracking logical events that occur relatively infrequently, such as cruise-control button pushes by the driver. Instead of recording these events in a time-history format (which can consume large amounts of disk storage space) a table containing the event name, its start time and duration is constructed. Using this information, a time-history of the logical variable can be re-created if necessary. Transition files are typically less than 1 KB in size. (These variables are denoted by a "T" in the logged column of the tables above.)
- *Time-History files* - With the exception of the video files, the time-history files constitute the bulk of the data storage and archive. There are thirty-five channels in each time history file (denoted by an "H" in the logged column of the tables above). For an average trip a time history file is 1.3 MB.
- *Video files* - There are two types of video files: exposure and episode. Episodes are the capture of event-related video of 30 seconds duration. A total of 10 event types have been formulated, each yielding a criterion upon which decisions are made automatically for recording a concurrent clip of video data onto the video-storage hard disk. These files are 9.8 MB in size. Exposure files provide a brief video sample recorded every 10 minutes[2] regardless of the operational state. This information is used to derive a regular spot-record of the highway and traffic conditions. These files are 0.8 MB in size.

---

[2] The sampling interval has been lowered to 5 minutes following an analysis of the trip summary information for the drivers to date. This will give a more complete picture of the driving environment for each trip and make better use of the storage capability of the hard disk on the video DAS.

Table 9. Trip table fields and descriptions

Field Name	Description
AccBi	Count of brake interventions while ACC is engaged
Accel	Count of Accel button hits
AccEnable	Switch indicating if ACC or CCC is enabled
AccNe	Count of near encounters while ACC is engaged
AccOn	Count of ACC button hits
Blinded	Count of blinded transitions
Brake	Count of brake pedal applications
Cancel	Count of cancel button hits
CccBi	Count of brake interventions while CCC is engaged
CccNe	Count of near encounters while CCC is engaged
Cleaning	Count of cleaning transitions
Coast	Count of Coast button hits
Concern	Count of concern button hits
Distance	Distance travelled during the trip, miles
DistanceEngaged	Distance travelled with the cruise control is engaged, miles
DownShift	Count of down shift transitions
DriverID	Driver identification number
Duration	Duration of the trip, minutes
EcuError	Count of ECU error transitions
EndAltitude	Altitude of the end of the trip
EndLatitude	Geographical latitude of the end of the trip
EndLongitude	Geographical longitude of the end of the trip
EndTime	End time of trip, days since 12/30/1899 + fraction of day
Engaged	Count of ACC engaged transitions
FileError	Count of File system error transitions
GpsError	Count of GPS error transitions
Man1Bi	Count of manual brake interventions while CCC is enabled
Man1Ne	Count of near encounters while CCC is enabled
Man2Bi	Count of manual brake interventions while ACC is enabled
Man2Ne	Count of Near encounters while ACC is enabled
NetworkError	Count of network error transitions
NewTarget	Count of new target transitions
OdinError	Count of Odin error transitions
ReducedRange	Count of reduced range transitions
Resume	Count of Resume button hits
Set	Count of Set button hits
StartAltitude	Altitude of the start of the trip
StartLatitude	Geographical latitude of the start of the trip
StartLongitude	Geographical longitude of the start of the trip
StartTime	Start time of trip, days since 12/30/1899 + fraction of day
Stopped	Count of vehicle stops transitions
SystemError	Count of System error transitions
Tracking	Count of tracking transitions
TripID	Trip identification number
VacError	Count of Vac error transitions
ValidTarget	Count of valid target transitions
Version	DAS software version number
Vgt50	Count of velocity greater than 50 mph transitions

3.5.3 Database and CD-ROM storage

An ultimate purpose of the data-gathering and processing activities is to build a database that can be used to study manual and ACC control of speed and headway. As illustrated in Figure 19, the database system for each driver is composed of two databases called the "ICC" Database and "Driver" Database. The "ICC" Database contains all the histogram and trip summary information. The "Driver" Database contains the transition, GPS, and time-history information. A third aggregate "ICC Master" Database is also being created. It contains all the information stored in each of the driver's "ICC" Databases. Interrogations and communications amongst these data bases are made possible by coding each section of data by driver, then trip , and then type of data. Each set of databases for each driver is being written to CD-ROM for permanent archive and data exchange. The two types of video files are also being saved in a compact format and written to CD-ROM.

3.6 Project Status as Characterized by Amount and Type of Driving in the FOT

The results and findings included in this report cover 35 of the 38 drivers that have participated in the study as of January 1997. The data from three drivers were excluded from the study for the following reasons: a) driver 2 had to return the test vehicle after only driving for approximately 5 miles, b) driver 16 had an equipment failure half way through the test period, and c) driver 28 returned the car due to a faulty head lamp switch.

Table 10 below shows a summary of the total number of trips, miles (miles are separated into distance not engaged or manual driving and distance engaged or CCC and ACC engaged driving) and duration, in hours, for the 35 valid drivers. The columns of the table show statistics for all trips, for trips with no cruise control used (CCC Off and ACC Off) and for trips in which the cruise control was turned on at least once during the trip (CCC Used and ACC Used).

Table 10. Summary of distance and time, all trips

No. of Drivers: 35	All Trips	CCC Off	CCC Used	ACC Off	ACC Used
Trips	2659	916	325	938	480
Distance, miles	26,225.6	3,449.9	8,059.5	3,178.0	11,538.2
Dist. Not Eng., miles	15,656.1	3,449.9	4,405.6	3,178.0	4,622.7
Dist. Eng., miles	10,569.5	NA	3,653.9	NA	6,915.6
Duration, hours	723.6	146.0	181.0	139.2	257.3

A total of 2,659 trips have been taken by the 35 drivers. Of the total trips, 1,241 (47 percent) were taken during the first week while CCC was enabled and 1,418 were taken during the second week while ACC was enabled. Of the first week trips 325 had the CCC engaged at least once during the trip, while 916 trips were driven completely in manual mode. Similarly, of the second week trips 480 had ACC engaged at least once during the trip, while 938 were driven completely in manual mode.

There were 155 more trips taken with ACC engaged as compared to the number of trips with CCC engaged. This represents a 47 percent increase in the number of trips in which ACC was used over CCC. Part of this difference is due to a bias in the amount of time for ACC enabled trips. (An effort is made to make the time equal for both cruise-control modes, but it is not always possible, so generally there is a bias toward having more time with ACC enabled.) However, because the number of manual-only trips are roughly the same for both time periods, the influence of this difference is probably small. More likely, the increase in ACC trips is due to two other reasons: a) the novelty effect of ACC (Drivers want to try the new technology even if they are not regular users of CCC.), and b) in driving situations where drivers would not normally use CCC, they will use ACC because of its added convenience of headway control.

This difference is also shown in the number of miles driven in the three different modes. For the study to date, a total of 26,225 miles were driven by the 35 valid test drivers. Of this total, 15,656 miles were driven in manual mode (distance not engaged). These miles are divided equally between the first week with CCC enabled (7,856 miles) and the second week with ACC enabled (7,800 miles). However, the distance engaged miles show an 89 percent increase in the number of miles driven with ACC engaged (6,915 miles) versus CCC engaged (3,653 miles).

Table 11 shows the same information as Table 10 except the numbers have been normalized by the total number of drivers (the notation "Trips/Drivers" means trips per driver). The table shows that the average driver takes 76 trips and travels 749 total miles during the two-week test period. Of the total miles, 447 were driven in manual mode and 302 were in a cruise-control-engaged mode.

Table 11. Normalized summary of distance and time, all trips

No. of Drivers: 35	All Trips	CCC Off	CCC Used	ACC Off	ACC Used
Trips/Driver	76.0	26.2	9.3	26.8	13.7
Distance/Driver	749.3	98.6	230.3	90.8	329.7
Dist. Not Eng./Driver	447.3	98.6	125.9	90.8	132.1
Dist. Eng./Driver	302.0	0.0	104.4	0.0	197.6
Duration/Driver	20.7	4.2	5.2	4.0	7.4

Table 12 shows a summary of the number of cruise-control button pushes that the average driver made during the two week test period. Not surprisingly, the number of times a typical driver simply turned the cruise control system on is greater for the ACC enabled period (19.6) than it is for the CCC enabled period (13.6). This increase (44 percent) is in line with the corresponding increase in the number of ACC versus CCC trips shown in Table 11.

Table 12 also shows the number of Set- and Resume-button hits per driver. Drivers use these buttons to change the vehicle control mode from manual to cruise engaged. However, these counts can be misleading when used this way because there are conditions when the driver can request the cruise to engage but, due to other reasons, like forward velocity being below the cutoff threshold, the cruise system (CCC and ACC) will not engage. For a more accurate account of the number of time the driver successfully engaged the system see the Engaged/Driver counts in Table 13.

Table 12. Summary of cruise-control buttons activations

No. of Drivers: 35	All Trips	CCC Off	CCC Used	ACC Off	ACC Used
Ccc-AccOn/Driver	33.2	NA	13.6	NA	19.6
Set/Driver	45.8	NA	20.0	NA	25.8
Coast/Driver	85.6	NA	42.3	NA	43.3
Resume/Driver	27.3	NA	10.6	NA	16.7
Accel/Driver	81.0	NA	28.6	NA	52.5
Cancel/Driver	11.1	NA	5.0	NA	5.9

Table 12 also shows the number of Coast, Accel, and Cancel button pushes per driver. For All Trips drivers tend to use both Coast and Accel buttons equally (85.6 Coast button hits versus 81.0 Accel button hits per driver). However, the distribution of usage in CCC and ACC driving is quite different for the two buttons. The Coast button is used equally in both CCC Used and ACC Used modes (42.3 and 43.3, respectively). Whereas, the Accel button is used approximately 84 percent more in the ACC Used trips

(28.6 for CCC Used and 52.5 for ACC Used). A clear explanation for this difference is difficult to discern. However, it may by attributable to drivers choosing to increase their set speed to take advantage of and challenge the headway control functionality of the ACC system.

Table 13 shows the number of brake applications per mile for the first 35 valid drivers. For All Trips there has been 2.4 brake applications per mile. For the trips when CCC and ACC were engaged this rate drops to 1.4 and 1.3, respectively. The number of downshifts per driver is applicable only when the ACC system is engaged. On average there were 40.0 downshifts per driver. The ACC control algorithm commands a transmission downshift when it has determined that the maximum available amount of deceleration is necessary.

Table 13. Summary of some driver / system control and status variables

No. of Drivers: 35	All Trips	CCC Off	CCC Used	ACC Off	ACC Used
Brake/mile	2.4	5.3	1.4	5.6	1.3
DownShift/Driver	40.0	NA	NA	NA	40.0
Engaged/Driver	64.1	NA	26.0	NA	38.1
Concern/Driver	2.1	0.1	0.3	0.0	1.7
Vgt50/Driver	208.9	39.3	60.0	30.6	79.0

The number of times the system was engaged per driver is shown in Table 13. If these counts are normalized by the number of miles engaged for the two cruise-control modes, then the average CCC engagement lasted for 4.0 miles while the average ACC engagement was 5.2 miles (a 30 percent increase). The table also shows the number of Concern button hits per driver and the number of times the vehicle speed transitioned above 50 mph (Vgt50) per driver for the four different trip categories. Not surprisingly, the trips when CCC and ACC were engaged show a significantly higher rate of transitions above the 50 mph threshold as compared to trips without any CCC or ACC engagement.

The final table (Table 14) in this section describes the number of brake interventions and near encounters per mile for manual driving during the first week (Man1), manual driving during the second week (Man2), CCC engaged driving and ACC engaged driving. (The definition of a near encounter and a brake intervention can be found in Table 6 ("Logical derived channels"). The data show a higher rate of near encounters per mile (0.049 versus 0.060; 22 percent increase) and brake interventions per mile (0.105 versus 0.120; 14 percent increase) when comparing the first and second week manual driving, respectively. However, when comparing CCC engaged near encounters per mile (0.034) to ACC engaged near encounters per mile (0.033) the rates are virtually identical. This is also true for CCC brake interventions per mile (0.054) and ACC brake interventions per mile (0.057).

Table 14. Summary of brake-interventions and near-encounters

No. of Drivers: 35	All Trips	CCC Off	CCC Used	ACC Off	ACC Used
Man1Bi/Mile	0.105	0.091	0.115	NA	NA
Man1Ne/Mile	0.049	0.049	0.048	NA	NA
CccBi/Mile	0.054	NA	0.054	NA	NA
CccNe/Mile	0.034	NA	0.034	NA	NA
Man2Bi/Mile	0.120	NA	NA	0.108	0.128
Man2Ne/Mile	0.060	NA	NA	0.065	0.056
AccBi/Mile	0.057	NA	NA	NA	0.057
AccNe/Mile	0.033	NA	NA	NA	0.033

The results and findings presented next in section 4 are based on the amount and types of driving described and characterized in this section.

4. INTERIM RESULTS AND FINDINGS

This section presents interim results from the FOT, in terms of both objective data (in Section 4.1) as compiled mostly in the form of histograms, and subjective results (in Section 4.2) as obtained from questionnaires. Preliminary findings are derived from these interim results by processing them, examining them, and interpreting their meaning. Section 4.3 addresses possible interpretations concerning societal issues by commenting on safety, traffic, and fuel flow.

4.1 Results and Findings From Quantitative Data

This discussion of the quantitative results is organized around trying to answer the following five questions:

1. How does ACC driving differ from manual or CCC driving if we consider all trips that were taken?
2. How do driving conditions influence driver choice among manual, CCC, and ACC modes of control?
3. How does driver age influence:
   1) the time gap between the ACC vehicle and the preceding vehicle, and
   2) the choice of control mode (ACC, MAN, or CCC)?
4. How do results for individuals differ from the aggregated results?
5. How well does this ACC system perform its functions?

Questions 1, 3, and 4 are associated with the operational issues concerning the nature of the speed and headway-keeping behavior of drivers (see section 1.1). Question 2 pertains to operational issues concerning when, where, and how drivers will use ACC. Question 5 addresses the performance of the current state-of-the-art ACC system.

The answers presented here are based upon information transmitted to UMTRI from the test vehicles via cellular phone at the end of each trip (where a trip is from ignition on to ignition off). This information is in the form of histograms for logical (two-level, yes/no) variables and for floating-point ("continuous" digital scale) variables as described in Section 3.5.

The notion of using the counts in each bin of the histograms to obtain information approximating probabilities plays a key role in understanding how the quantitative data have been processed/examined to respond to the questions posed here. In order to interpret these histograms it is convenient to think of them as if they were conditional probability density functions, since the count in each particular "bin" of the histogram (where a bin covers a small portion of the total range of the selected variable) divided by the total count summed over all of the bins in the histogram expresses the likelihood, or the probability, that the value of the variable at any moment falls within that particular bin. (The idea is cumbersome to state but simple to visualize once it is understood. Further material defining the ideas involved is presented in Appendix B.)

Appendix B explains how the histogram data has been processed to approximate the probability of certain events. These events and the associated probability symbols are of two types: (1) P(A|B) — the conditional probability of event A (i.e., set A is true) given that event B is true, and (2) Pd(A|B) — a conditional probability density function for the variable A. In this case, Pd(A|B) is the total result of computing P(Ai|A) for each of the Ai bins constituting A when B is true.

Putting aside abstract considerations, the point is that counts in the histograms have been used to estimate the chance / likelihood of sets and subsets of data chosen to aid in developing answers to the questions posed.

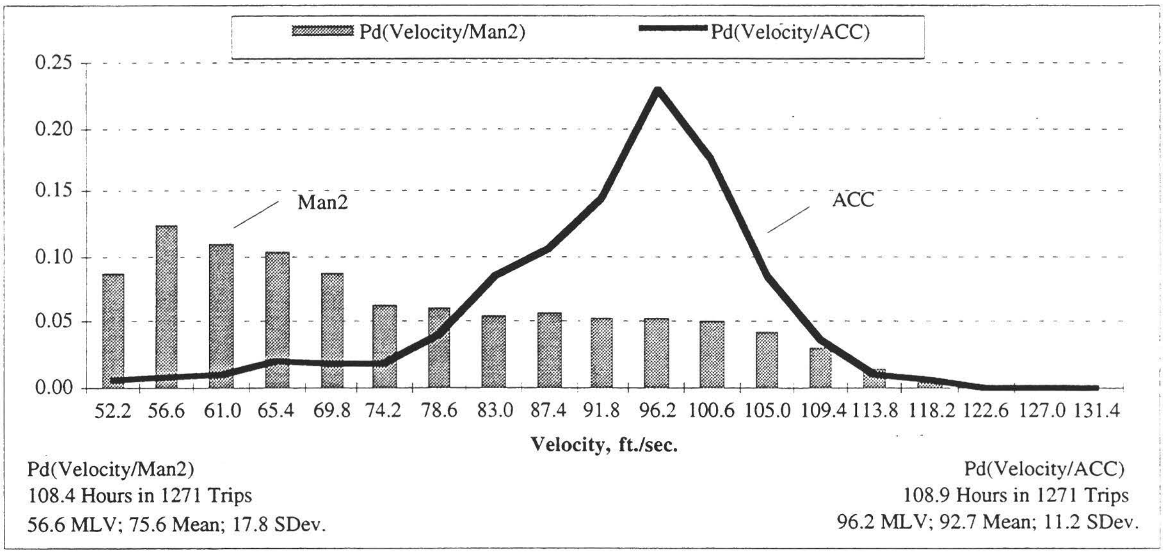
4.1.1 How does ACC driving differ from MAN or CCC driving?

This first question is intended for addressing the field test data at the broadest level. That is, when we look at all the data together, what are the macro characteristics of the driving activity appearing under each of the three forms of control? To address this question, consider applying the P(A|B) operator to the histograms for velocity and range obtained during manual, CCC, and ACC driving using the aggregated results for all drivers and all trips. We will consider further disaggregation (subsetting of the data) in later sections.

ACC versus Manual Results — Aggregated Data on Velocity

We can compare ACC versus manual modes of control by considering the data gathered during the second week with each driver, when only the ACC or manual modes of control were available. For this discussion, we will let ACC represent the set of results for ACC driving and let manual represent the set of results for manual driving. To compare ACC driving with manual driving, we will compare the approximate probability density functions corresponding to the velocity V by examining Pd(V|ACC) and Pd(V|MAN) as given in Figure 20.

This figure (and much of the other data representations in this report) covers speeds 35 mph and above because cruise-control systems are typically built with a lower bound on velocity near 35 mph. Thus, both the manual and ACC data have been restricted to this same range for purposes of comparison. The figure clearly indicates that ACC driving is only likely at highway speeds while manual driving is biased toward low speeds but is otherwise broadly distributed across the range.



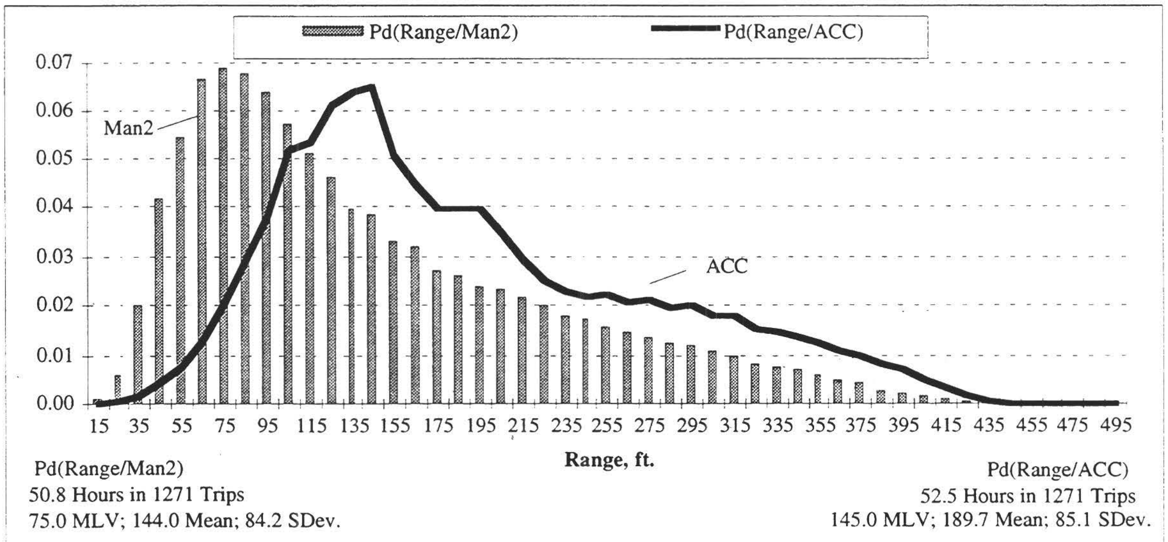
(MLV means Most Likely Value)

Figure 20. Probability density of velocity in ACC versus manual

Perhaps these results are what one might expect. They are interesting mainly because they prompt a following question that recognizes the contextual basis for driver choice in selecting the control mode to be used, namely: When do drivers choose to use ACC? It is quite apparent that any presentation of the fully-aggregated data will show that ACC driving differs from that of manual driving in a similar manner that manual freeway driving differs from manual driving on, say, an urban arterial network. To the extent that driving on limited access freeways is safer per mile of travel than is all driving, one would hypothesize that ACC operation will be safer than all manual driving, even if all the micro factors of longitudinal control with ACC versus manual systems were identical. Although these matters will be reexamined later, even the most casual look at the full data set makes it clear that drivers choose to use this ACC system predominantly in the higher-speed driving environments (which, in turn, tend to emphasize limited access highways in the data).

ACC versus Manual Results — Aggregated Data on Range & Time Gap

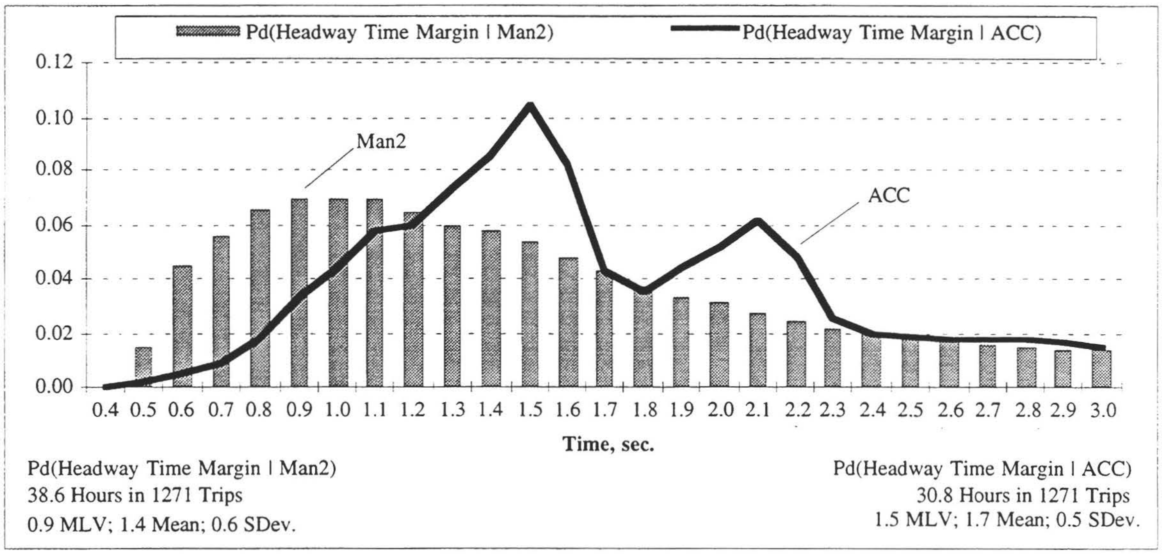
With regard to range, Figure 21 shows that ACC driving is characterized by longer ranges than those associated with manual driving. The figure is based on all drivers and all trips over 0.1 miles during the second week. Manual driving is characterized by fairly high likelihood of short headway range while ACC driving is characterized by little chance that headway range will be less than 65 ft. To the extent that short headway range represents a risky situation with respect to rear-end crashes, ACC driving could be said to pose lower levels of this particular form of risk than does manual driving.



(MLV means Most Likely Value)

Figure 21. Probability density of range in ACC versus manual

A second look at the headway contrasts is provided in Figure 22. Here we see all of the ACC versus manual driving data presented in terms of the headway time gap, whereby the range, R, has been divided by host vehicle's velocity, V. While the ACC histogram now reveals predominant spikes near the time gap selections of 1.4 and 2.1 seconds, the overall appearance still shows that ACC operation involves longer headway clearances than does manual operation (above 35 mph).



(MLV means Most Likely Value)

Figure 22. Probability density of headway time margin in ACC versus manual

There appear to be two reasons why ACC driving has longer headways than manual driving, namely:

1) The ACC controller operates the vehicle at longer time gaps than drivers employ under manual control (even though the driver can choose from among ACC headway times of 1.0, 1.4 , or 2.0 seconds).
2) Drivers choose the manual mode of control under the conditions of road type and traffic density that more or less necessitate close-headway operations.

To support the first point, it is helpful to examine and compare the data shown in Figure 23 and Figure 24 that have been specially gathered and presented to make two-variable histograms involving range and range-rate values measured at the same time. The data used in these histograms are normalized (divided by) the velocity of the preceding vehicle, V_p. The quantity R/V_p has the units of time and represents the time gap between the ACC vehicle and the preceding vehicle when steady following prevails, with $V \approx V_p$. Figure 23 shows the results when ACC is in use. We see that the time gap is very well controlled, with peaks near the headway time settings of 1.0, 1.4, and 2.0 seconds. In addition the likelihood of operation in the near corner of the diagram defined by short time gaps and large, negative, closing rates is very small. The profile of ACC driving is dominated by the highly likely narrowly distributed, peaks associated with the controller's objectives. In contrast, Figure 24 shows that manual driving is more broadly distributed across range values. Further, the likelihood of operating at short time gaps and substantial negative range rate is much larger than it is for ACC driving.

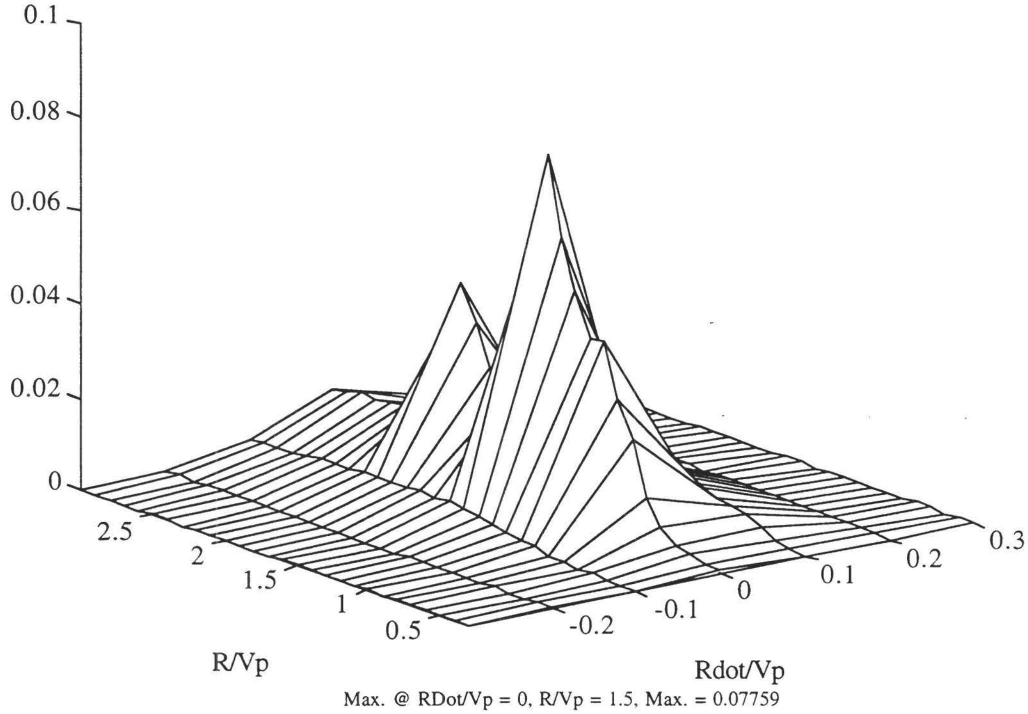


Figure 23. Probability density of normalized range and range rate in ACC driving

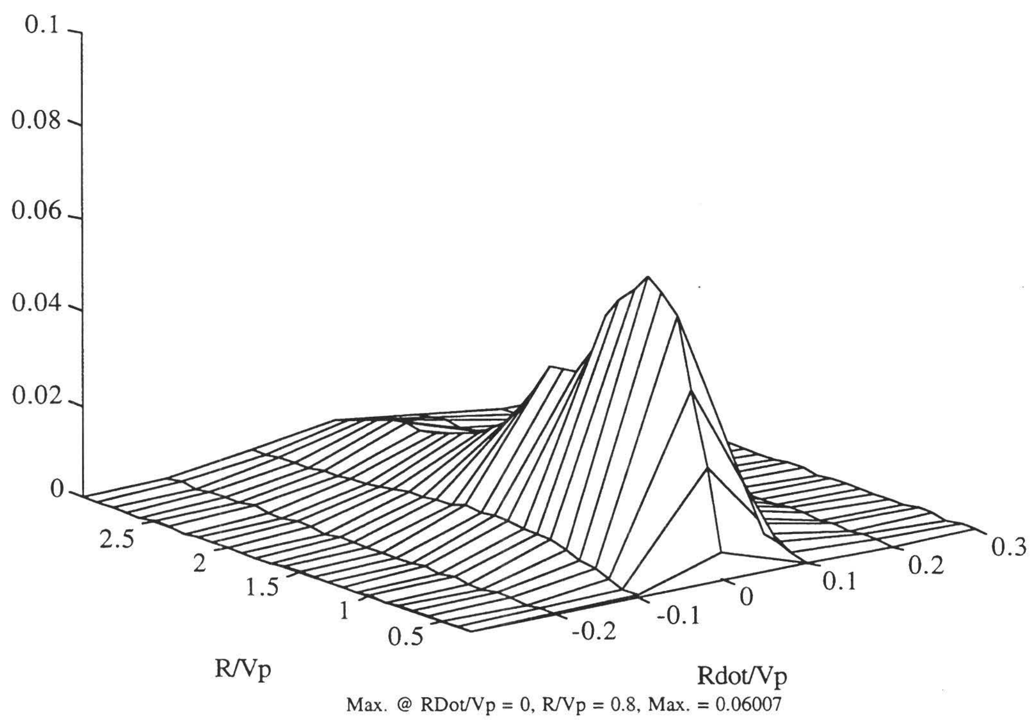


Figure 24. Probability density of normalized range and range rate in manual driving

Results similar to these have been obtained previously in the FOCAS project [5]. However, in that case, driving was restricted to quite uniform operating conditions with each driver operating both manually and with ACC over the same sections of freeway at approximately the same level of traffic. The data presented in Figure 23 and Figure 24, by contrast, were obtained in the wide open, naturalistic driving context by which each driver/participant went wherever they wanted, by whatever route, in whatever traffic as prevailed during the trips they chose to take. Notwithstanding these uncontrolled conditions, however, the FOT data are strikingly similar to those obtained when the driving environment was confined to the specific freeway test loop employed in the FOCAS study.

The second point concerning drivers choice of control mode will be addressed in more detail in the next section, but it is not surprising to find that people prefer to drive manually rather than trust a controller when it appears that braking may be needed. In addition, the FOT drivers have been carefully instructed to perform as the supervisor of ACC driving, being always prepared to brake when braking is needed. Accordingly, the system transitions to the manual control state whenever a headway-compromising conflict emerges. This in turn causes any short headway experience immediately following an ACC disengagement event to be registered as MAN data, as soon as brake pedal movement, for example, causes the brake switch to make. This means that data are recorded as manual driving whenever the driver has become uncomfortable with, and taken supervisory action in response to, an emerging headway conflict using the ACC system.

ACC versus Manual Results — Aggregated Data on Regions of Proximity

For purposes of examining different types of driving situations (regimes), the range-versus range rate space has been divided into the five regions shown labeled in Figure 25 as “closing”, “following”, “separating”, “near”, and “cut-in”. Definitions of these regions are presented in mathematical terms in Table 15. From a pragmatic point of view the boundaries between these regions have been chosen to separate different types of driving regimes. A prominent feature on Figure 25 is the parabola that has been chosen to separate short range conflict situations from the operations appearing at longer range. This parabola intercepts the range axis at a point that corresponds to a time gap of 0.5 seconds. The shape of the parabola corresponds to a deceleration of 0.1 g. The region below this boundary is divided into “near” and “cut-in” regions depending upon whether range rate (RDot) is negative (R is decreasing) or positive (R is increasing). Above the parabola the space is divided into three regions that also depend upon range rate. If range rate is between -5 ft/sec and +5 ft/sec, the subject vehicle is deemed to be following the preceding vehicle with little difference in relative velocity (range rate). The region to the left of following is called closing because in this region the subject vehicle is overtaking the preceding vehicle. The upper right region is called separating because the preceding vehicle is going faster than the subject vehicle thereby causing the vehicles to separate. Clearly, since measures of R and RDot are collected only when the sensor sees a valid target ahead, none of the five regions is satisfied when no valid target exists. The aggregated data taken from manual and ACC driving show that valid targets are detected (and thus tallied as occupying one of the five regions) approximately 52% of the time, regardless of the type of driving.

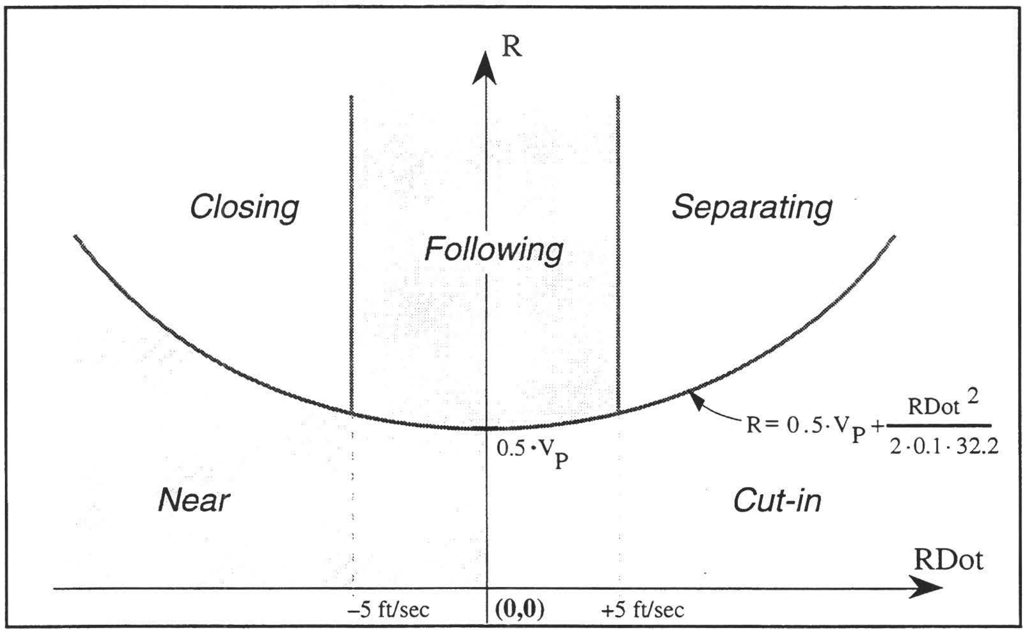


Figure 25. Driving situation (regimes) in the range-range rate space

Table 15. Definitions of driving regimes

$$R_b = 0.5 \cdot V_p + \frac{RDot^2}{2 \cdot 0.1 \cdot 32.2} \quad ft$$

$$RDot - b = -5 \ {}^{ft}/_{sec}$$

$$RDot + b = +5 \ {}^{ft}/_{sec}$$

$$Near \equiv [R \leq R_b \ \text{ AND } \ RDot \leq 0]$$

$$Cutin \equiv [R \leq R_b \ \text{ AND } \ RDot > 0]$$

$$Closing \equiv [R > R_b \ \text{ AND } \ RDot \leq RDot - b]$$

$$Following \equiv [R > R_b \ \text{ AND } \ RDot - b < RDot < RDot + b]$$

$$Separating \equiv [R > R_b \ \text{ AND } \ RDot \geq RDot + b]$$

The logical histogram of these tallies in Figure 26 express the probability of vehicle operation in each of the five regions discussed above, for manual and ACC modes of driving. Examination of the figure indicates that the great bulk of the time (with a valid target ahead) is spent at relatively long range, in either the closing, following, or separating regions of operation. The probability of operating in the near or cut-in regions is of the order of a few percent.

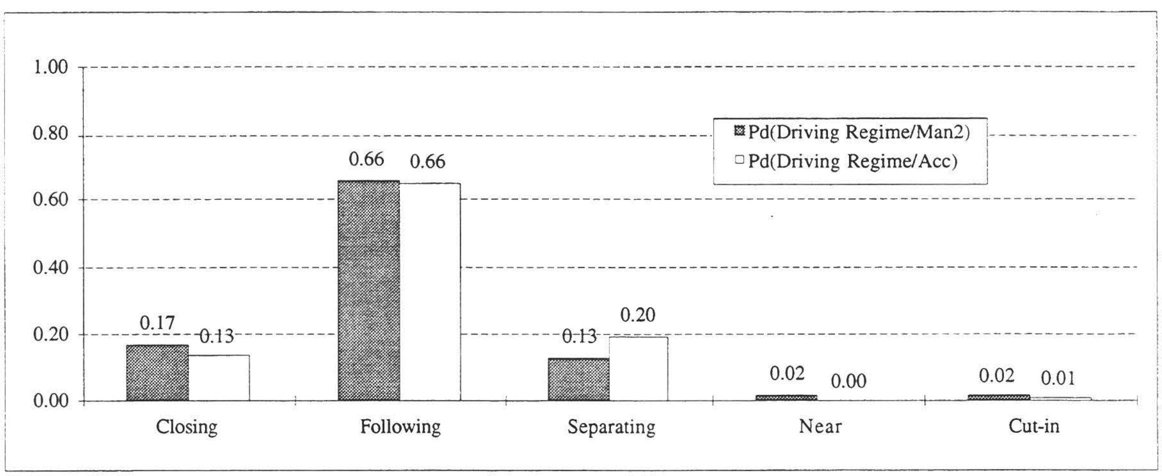


Figure 26. Probability density of operating within various driving regimes (2nd week)

Substantial differences between ACC and manual driving are noted in the near and the separating regions. Clearly, Figure 26 shows that the near region is generally avoided in either the manual or ACC control modes, but even more so with ACC since the system, by design, seeks time gaps that are substantially larger than the 0.5 second value at which the near-region's parabola reaches its minimum. A detailed look at these contrasting data indicates that of the total time spent in the near region during the second week of each subject's use of the vehicle, the ACC controller was engaged 1/8th of the time and the manual mode was in operation 7/8ths of the time.

Regarding the separating region, we note that since the ACC system does not aggressively chase vehicles that are going faster than itself, there is a relatively high probability of sustaining a positive RDot and dwelling in the separating region for substantial periods of time as a faster vehicle gradually recedes at long range. If we compute the conditional probabilities of ACC and manual control, given the separating region of operation, we find that the manual mode prevailed with a 0.38 probability and the ACC mode prevailed with a 0.62 probability.

The characteristics of the controller also explain why the likelihood of operating in the cut-in region is similar for both modes of control since vehicles that cut-in after a pass (by far the most common type of cut-in scenario) are going faster than either the ACC or the manually-controlled vehicle. Apparently, cut-in activity, overall, occurs with approximately the same frequency in either mode of control. More study of this issue is needed, however, with the aid of detailed examination of the transitions from one region to the next. Although it is recognized that merge or cut-in activity at entrance and exit ramps can influence the occurrence of either the near or the cut-in region operations, the overall frequency of such transients is thought to be so low as not to have significantly registered in the breakdown of data in Figure 26.

CCC versus Manual Results — Aggregated Data on Regions of Proximity

Shown in Figure 27, conventional cruise control (CCC) is compared with manual operation (during the first week of driving) in terms of the distribution among the five R versus RDot regions. The results show, again, that near and cut-in regions are only infrequently entered and that the majority of the operational time is spent at longer range in the closing, following, and separating regions. Interestingly, when compared with the ACC results shown earlier, the CCC mode of operation has a much higher occurrence in the separating region and substantially less time spent following (within the +/- 5 ft/sec window about zero RDot.) One would hypothesize on this result that drivers choose a higher value of set speed, given the traffic, when operating ACC than when operating in the CCC mode.

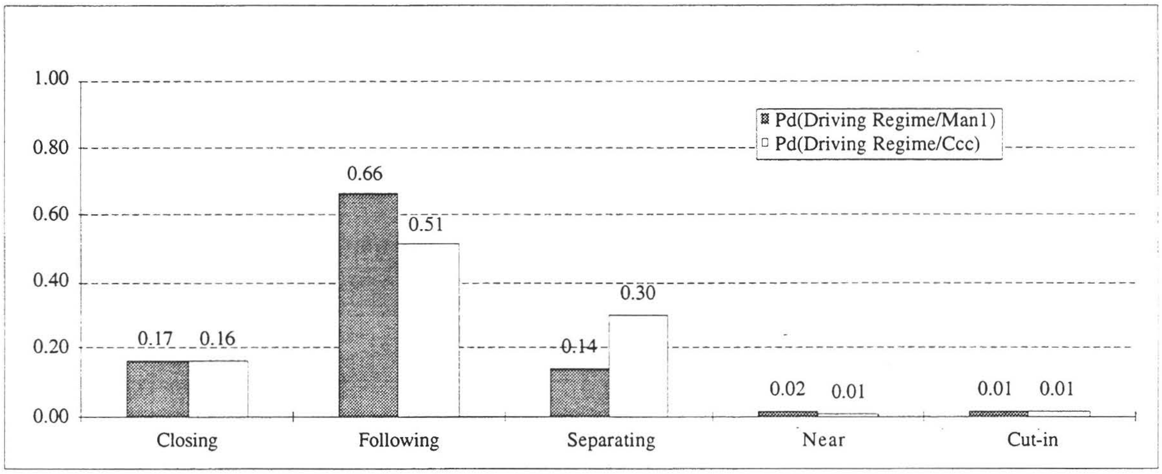
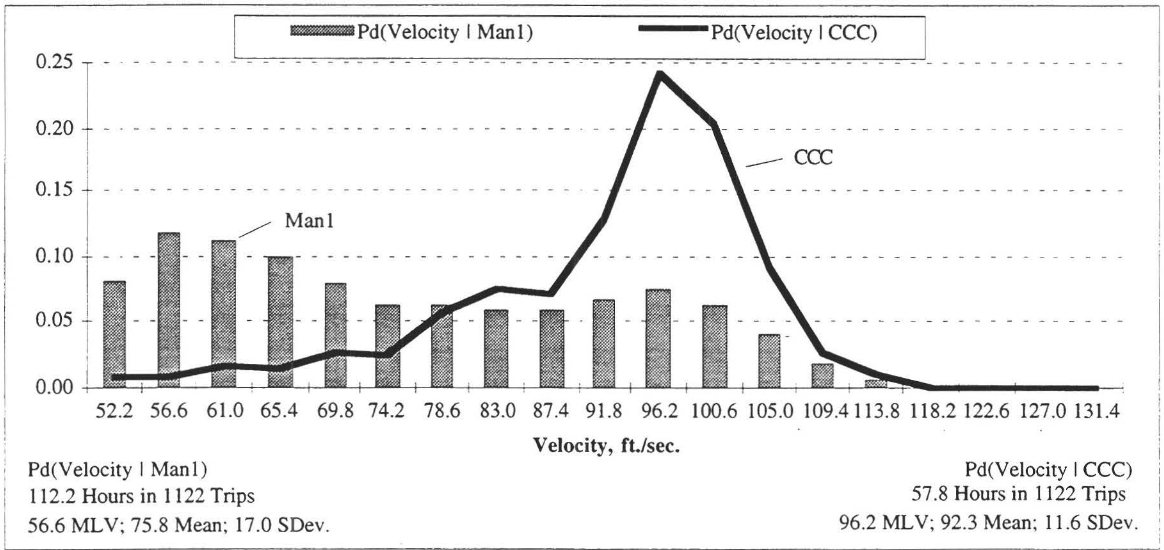


Figure 27. Probability density of operating within various driving regimes (1st week)

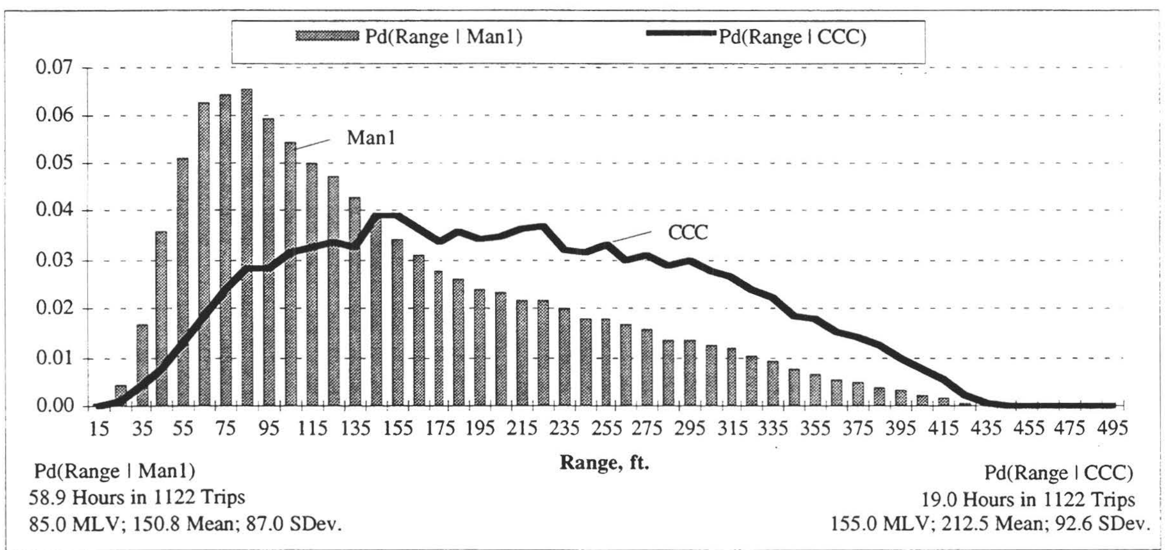
CCC versus Manual Results — Aggregated Data on Speed and Headway

Shown in Figure 28, Figure 29, and Figure 30 are corresponding comparisons between CCC and manual operations, as gathered from first-week data in terms of the velocity, range, and time-gap histograms. The velocity data in Figure 28 show that manual operation spreads down into the lower-speed regime while CCC is clearly used in high-speed environments. The range data in Figure 29 show that while the CCC operation does extend down into very short headway values, it does not compete with the downward bias in headway distributions that characterize manual driving. Indeed, CCC range values are rather flatly distributed, while manual values are sharply concentrated toward the left. Figure 30 shows that when range is normalized with the host vehicle velocity, V, the contrast between manual and CCC headways, expressed at time gaps, is less pronounced. This result further confirms that drivers are more attentive to time gaps than to distance, per se, and that the large skew toward short headway range values seen in the MAN1 data in Figure 29 is explained largely by the low speeds prevalent in much of the manual driving.



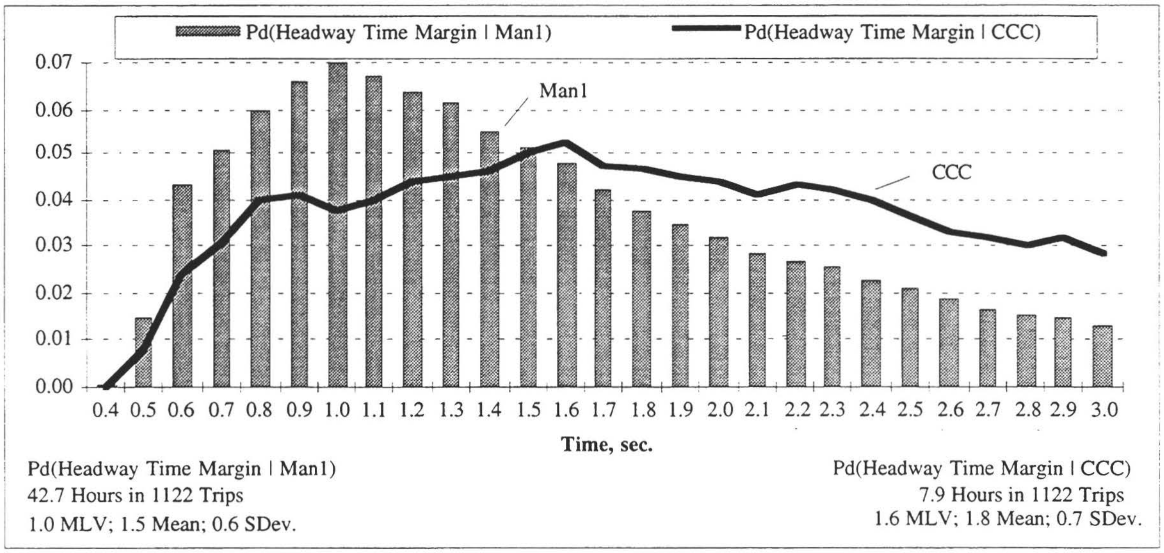
(MLV means Most Likely Value)

Figure 28. Probability density of velocity in manual versus CCC



(MLV means Most Likely Value)

Figure 29. Probability density of range in manual versus CCC



(MLV means Most Likely Value)

Figure 30. Probability density of headway time margin in manual versus CCC

Figure 31 and Figure 32 present two-dimensional, normalized, histograms of range and range-rate contrasting the manual and CCC results aggregated across all first-week driving. The CCC histogram spreads out over a very wide span of range values, but otherwise exhibits very nearly the same content in the critical-near corner (i.e., the negative $RDot/V_p$ regime, with short values of R/V_p) of the diagram as does the manual result. Clearly, CCC operations are as "headway-blind" a means of longitudinal control as one could envision.

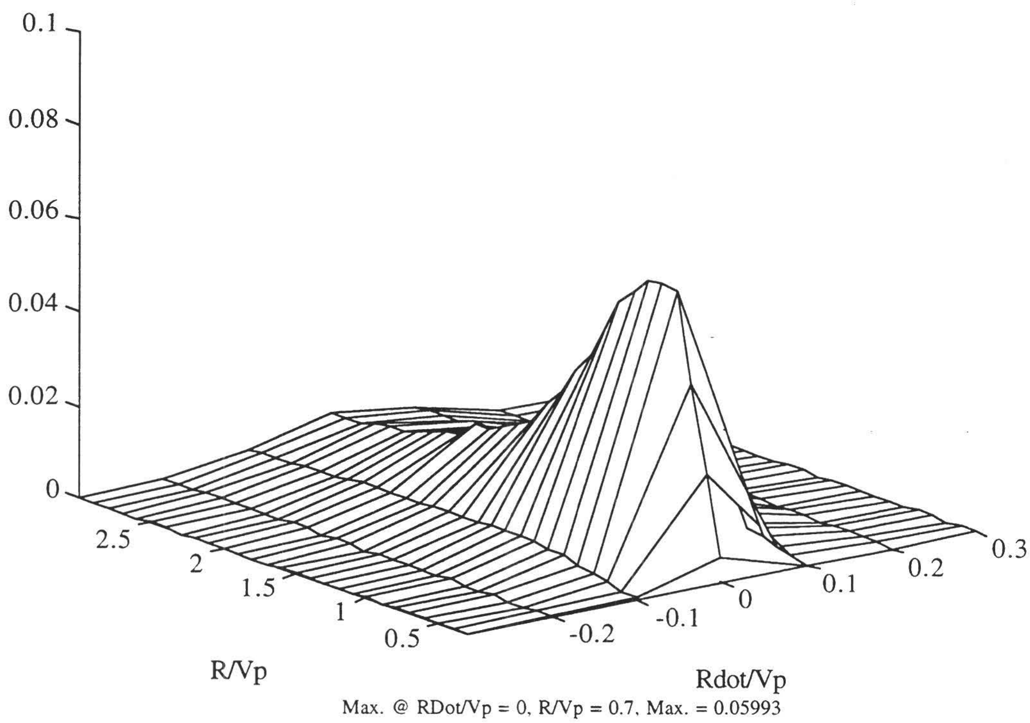


Figure 31. Probability density of normalized range and range rate in manual driving

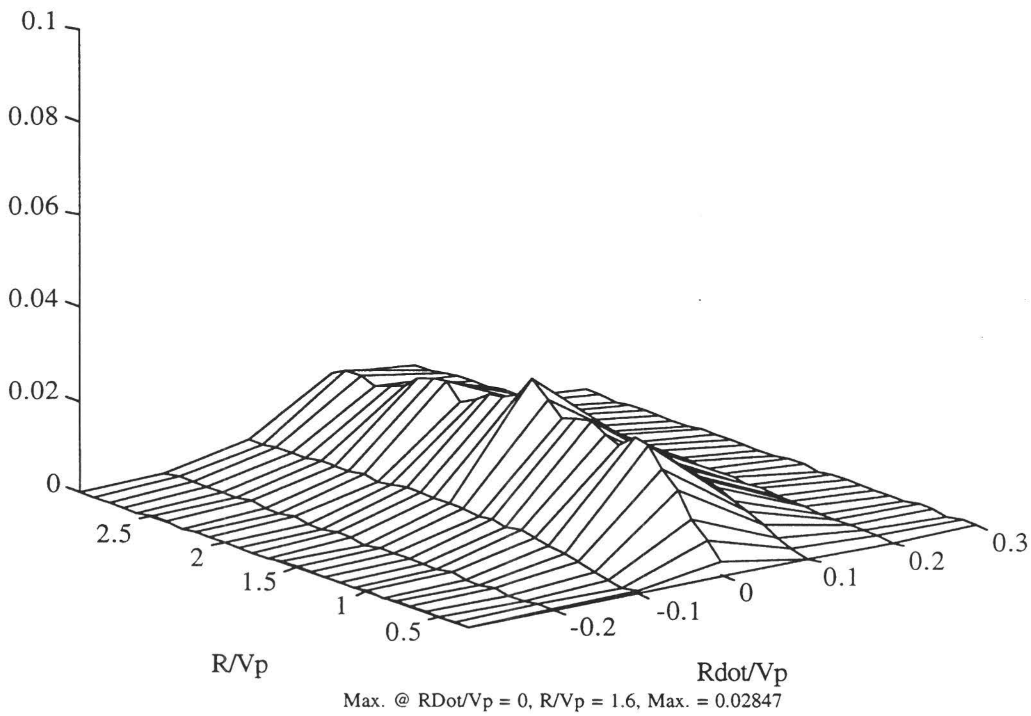


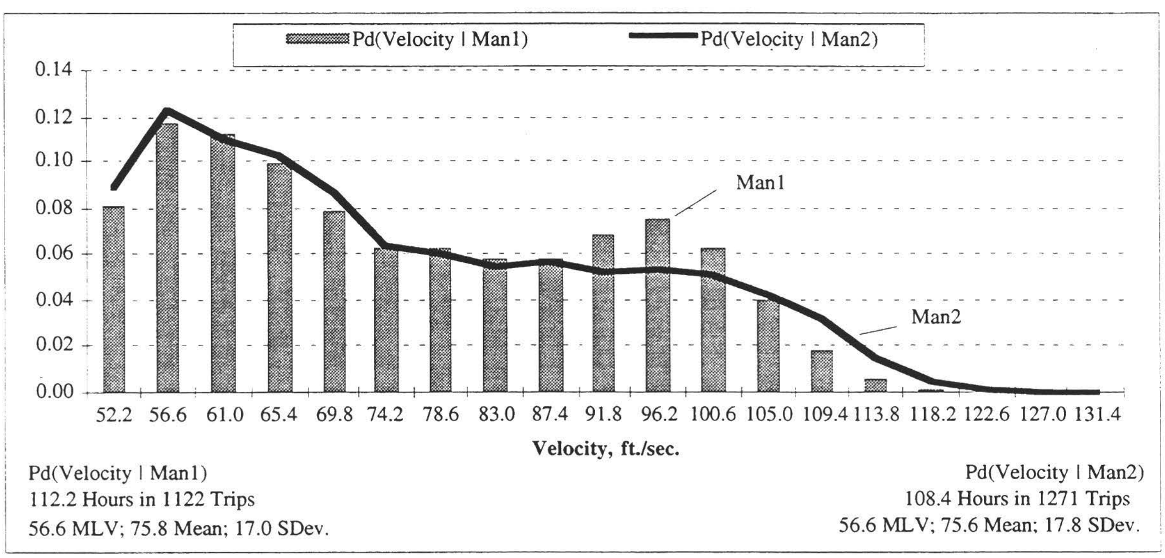
Figure 32. Probability density of normalized range and range rate in CCC driving

Manual Driving Only, Comparing Velocity and Headway Results From Week One versus Week Two

Because it is useful to compare ACC operations (which occurred only in the second week) with CCC operations (which occurred only in the first week), it was deemed valuable to compare the manual data gathered during each of the two respective weeks as a cross-check for nominal similarity of driving conditions. Thus, aggregated (that is, essentially all) MAN1 and aggregated MAN2 data are considered here as one (albeit not fully conclusive) illustration of the similarity. The comparison also supports later a combination of both weeks of manual data into one set, simply to improve its statistical power.

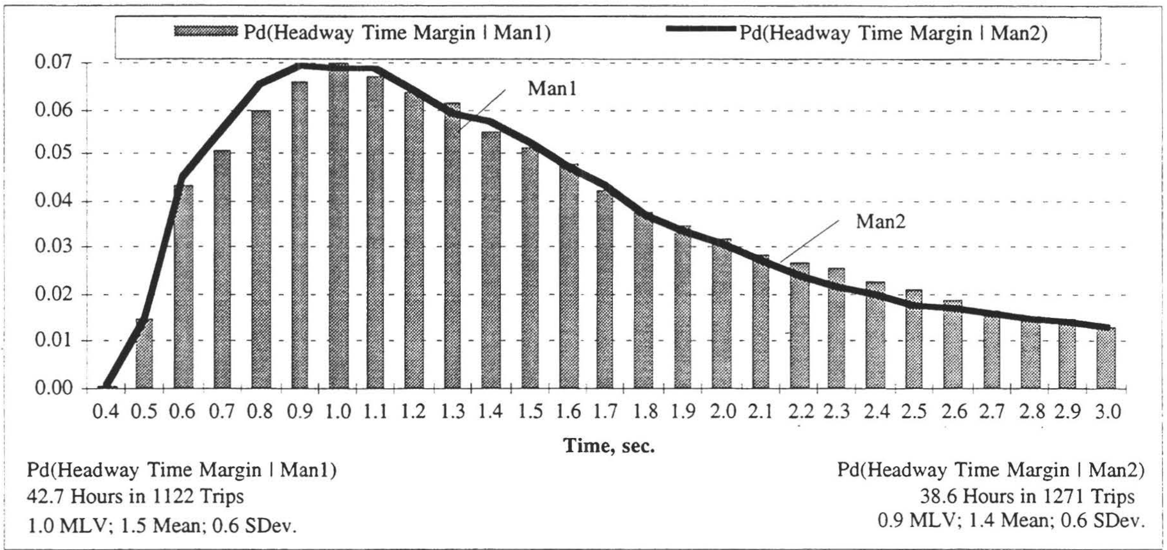
Shown in Figure 33 is a histogram of velocity covered under MAN1 and MAN2 episodes of driving. The figure shows very great similarity in the speed distributions (above 35 mph) covered driving manually during the two weeks, although the second week did appear to involve a modestly higher incidence of second-week operation at the high end of the velocity spectrum.

Shown in Figure 34 is a histogram of the time gap, again showing a high degree of similarity in the headway distributions between the two weeks. We conclude on a preliminary basis, at least, that manual operation during both weeks was quite the same and thus there is some degree of encouragement that comparison of the first- and second-week experiences with control in either the CCC or ACC modes will pertain to more or less comparable types of driving.



(MLV means Most Likely Value)

Figure 33. Probability density of velocity in manual: 1st week versus 2nd week

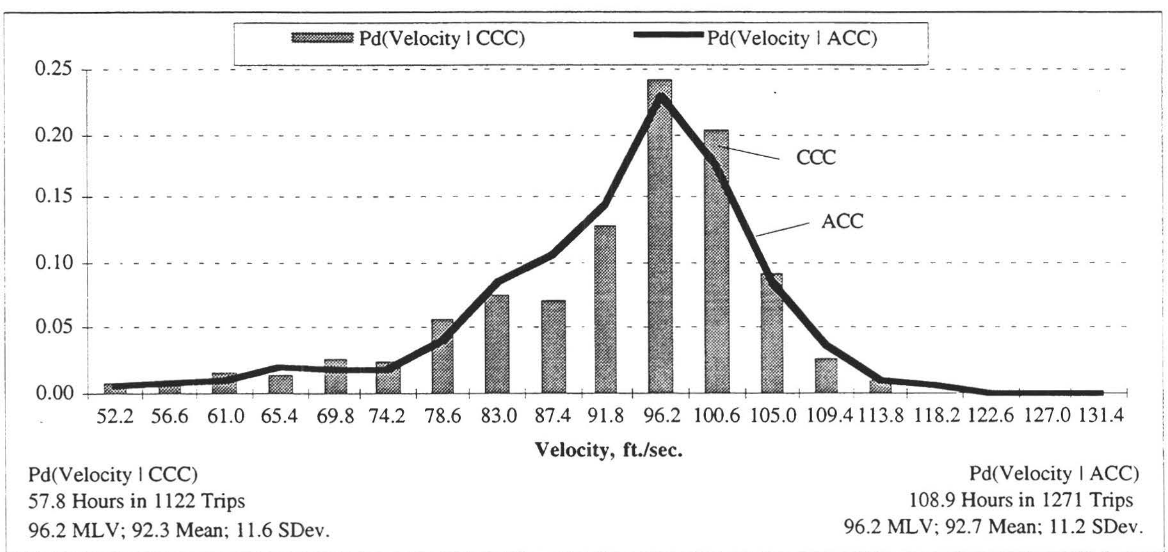


(MLV means Most Likely Value)

Figure 34. Probability density of headway time margin in manual: 1st week versus 2nd week

ACC versus CCC — Aggregated Data on Speed and Headway

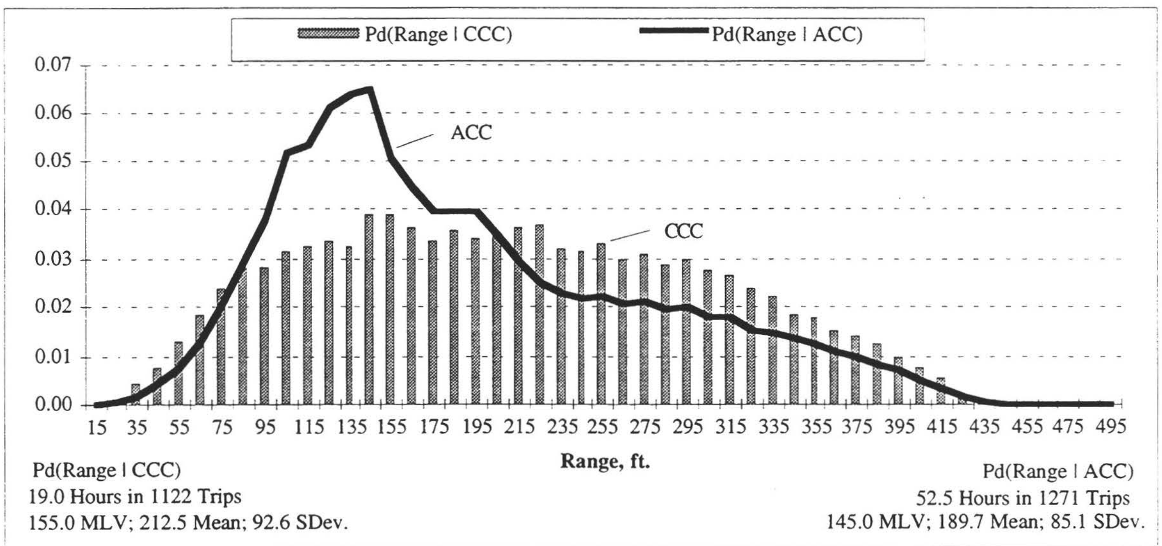
Shown in Figure 35 is a comparison of velocity histograms characterizing ACC and CCC operations. The data suggest that both forms of cruise control were utilized in comparable speed environments, with means being almost identical at 63 mph (92.4 ft./sec.) and with virtually identical distributions.



(MLV means Most Likely Value)

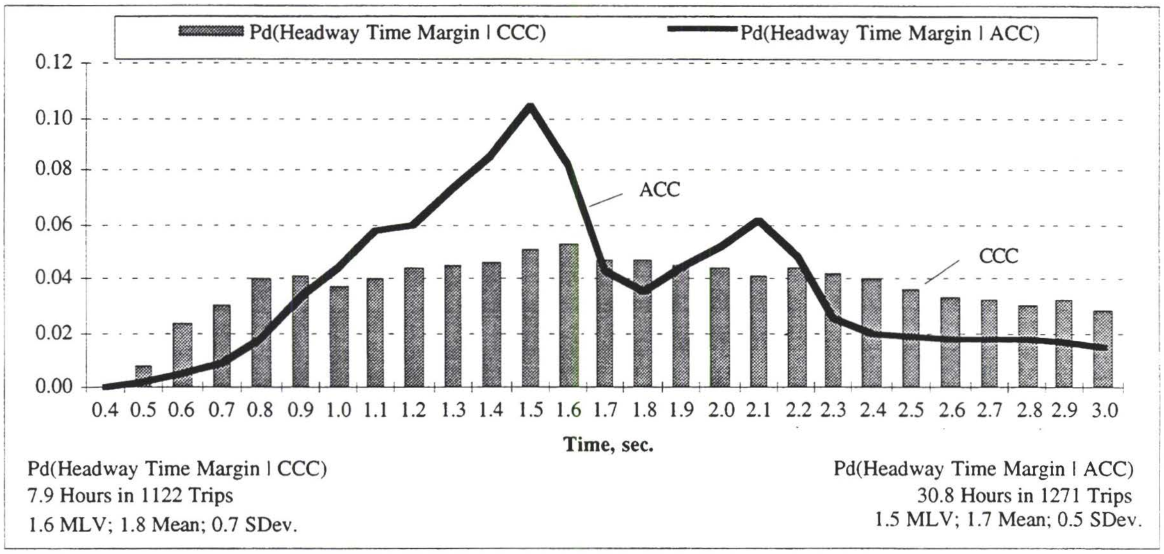
Figure 35. Probability density of velocity in ACC versus CCC

By way of contrast, the range (distance) and headway (time) histograms in Figure 36 and Figure 37 show that the patterns of headway keeping under CCC and ACC modalities differ markedly, as expected. Namely, the ACC controller seeks to modulate headway in the following mode of operation around the driver-selected times of 1.0, 1.4, and 2.0 seconds while the CCC controller is oblivious of headway and simply slews through the range spectrum while either overtaking and separating from vehicles ahead. On the very short end of the headway scale, CCC operations show a substantially higher incidence of time gaps below 0.9 seconds or so. Even though the ACC controller does indeed overshoot its minimum time gap settings depending upon the closure conditions, or braking ahead, the driver does seem to permit CCC to close into substantially shorter distances than are encountered with ACC.



(MLV means Most Likely Value)

Figure 36. Probability density of range in ACC versus CCC



(MLV means Most Likely Value)

Figure 37. Probability density of headway time margin in ACC versus CCC

4.1.2 How do driving conditions influence driver choice among manual, CCC, and ACC modes of control?

In this section we address the evidence in the data that driver choice between manual and the available cruise-control mode (CCC in first week, ACC in second week) is determined by the prevailing conditions of the trip. In this sense, the conditions that are candidates for investigation are limited to characteristics that were measured during the field test. And at this particular stage of the project, data describing the roadway itself (surface street, freeway, etc.) or the traffic (density, flow, erratic congestion, etc.) or the ambient weather (rain, snow, etc.) are unavailable, or yet to be analyzed. Later processing of GPS data or manual identification of conditions from video exposure data may serve to enhance the list of available conditions that could be examined.

Nevertheless, it is very clear that drivers are making a conscious choice of control mode, based apparently upon their perceptions of the suitability of the driving environment for each mode and perhaps the value to be derived from operating a selected mode in the prevailing environment. In this section we will present the relationship between certain variables and the choice of control mode for the sake of both a) presenting results that reveal the mode choice as a function of condition variables and b) deducing a means of filtering the full set of data to select just those trips which offer reasonably uniform conditions under which to compare driving under ACC, CCC and manual modes of operation. Put simply, we wish to filter the trip selections so as to avoid comparing, for example, ACC driving at 60 mph on a busy freeway with manual driving at 30 mph on a residential street.

ACC and CCC Mode Choice as a Function of Average Trip Velocity

Shown in Figure 38 is a presentation of the fraction of all first week and second week trips that included the engagement of CCC and ACC modes of control, respectively, as a function of the average trip velocity. For example, at a trip average velocity of 40 mph in the first week, CCC was engaged (at least temporarily) in 60% of the trips. We see in a general sense that the probability of choosing the available cruise-control mode (CCC or ACC) rises more or less steadily with average trip speed and reaches approximately a 90% level of probability when average speed exceeds approximately 55 mph. Of course, this observation seems reasonable since the only trips whose average speed can attain a 55 mph value (from ignition on to ignition off) are those in which the driver operates predominantly on a freeway or another high-speed roadway upon which the CCC or ACC functions offer their premium utility. Later in this section we indicate a selection of 30 mph as the minimum average speed to be used in filtering for trips in which ACC can be compared with the other modes of control.

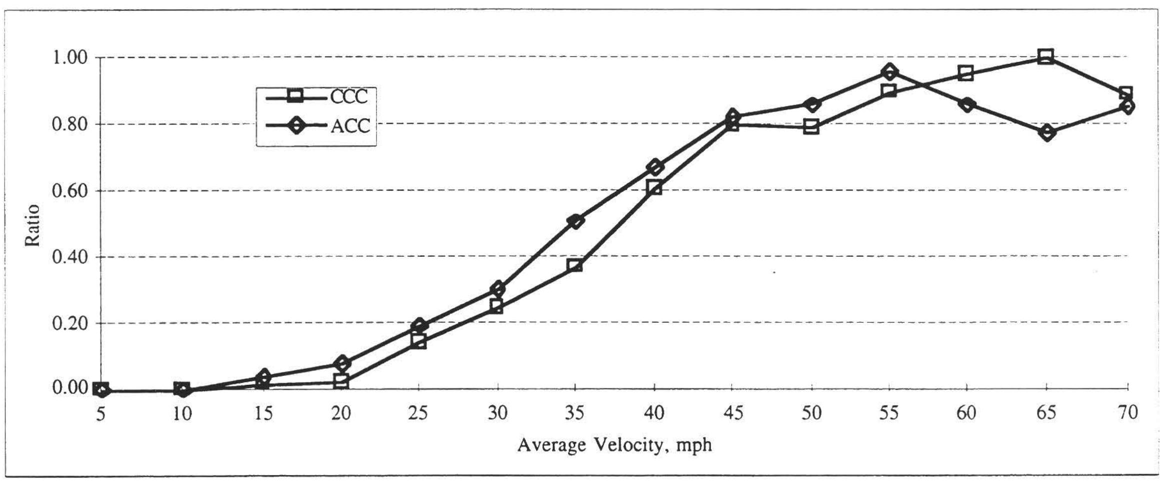


Figure 38. Utility of CCC and ACC as a function of velocity

ACC and CCC Mode Choice as a Function of Trip Length

Shown in Figure 39 is a presentation of the fraction of all first week and second week trips that included the engagement of CCC and ACC modes of control, respectively, as a function of the trip length. For example, at a trip length of 25 miles in the first week, CCC was engaged (at least temporarily) in 62% of the trips. We see in a general sense that the probability of choosing the available cruise-control mode (CCC or ACC) rises strongly up to trip lengths of 15 miles or more and then sustains an elevated probability in the 60 to 100% range. The relative scarcity of trips falling into bins at 50, 55, and 60 mile lengths seems to account for the erratic nature of the data in that zone. The probabilities of CCC selection at 70% and ACC selection at 87% that show up in the "end bins", at 65+ miles, appear to provide a more reliable indicator of the mode choices that were made, asymptotically, on longer trips.

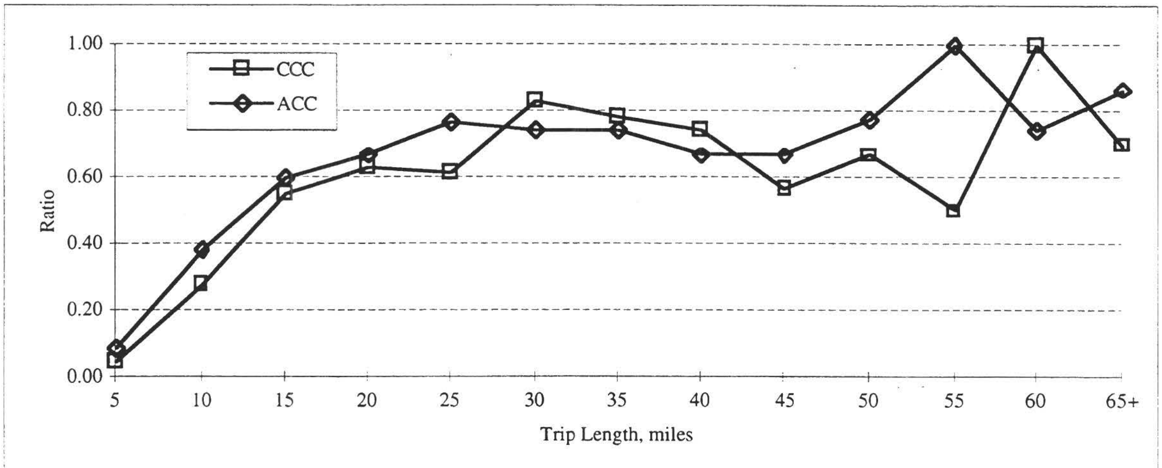


Figure 39. Utility of CCC and ACC as a function of trip length

Another look at the trip length data is shown in Figure 40. This figure presents the average distance actually engaged in the CCC or ACC control modes, respectively, as a function of trip length. This presentation addresses the lurking question, "How valuable is the indication that was shown earlier (for example, in Figure 39) of percent of trips in which the cruise mode was selected at least momentarily during the trip?" The data in Figure 40 show that once a cruise mode has been selected, it typically prevails for half or more of the trip. Thus, incidences of ACC and CCC engagement do not typically occur on a sporadic basis without being retained for a substantial episode of usage. Further, the extent of retained engagement of ACC is generally greater than that of CCC for a given length of trip. This latter observation would seem to be in line with the claim of ACC that, once engaged, it largely frees the driver of the need to intervene, thus yielding more sustained periods of engagement. On the basis of the presented data showing the relationship between trip length and control-mode choice, we have identified 10 miles as the minimum trip length for selecting trips in which ACC can be compared with the other modes of control.

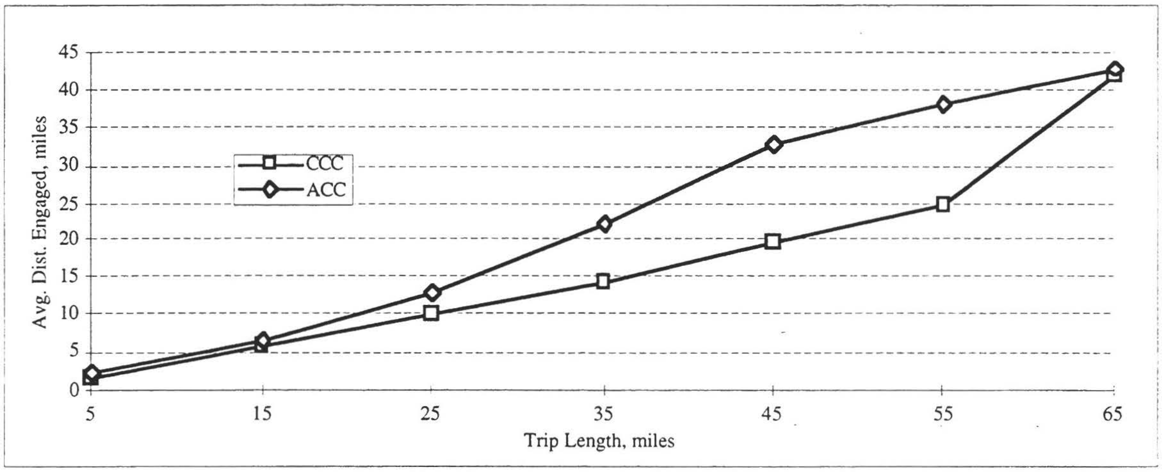


Figure 40. Distance CCC and ACC were engaged as a function of trip length

ACC and CCC Mode Choice as a Function of Time of Day

Figure 41 shows the probability of the driver choosing the CCC(first week) or ACC (second week) mode of control over the manual option at some point during the trip, as a function of time of day. The data show that the most probable times of cruise selection, with either CCC or ACC, are in the early morning and late evening or night. Apparently the daytime travel is so saturated with relatively short manually-driven trips that the incidence of cruise selection is lower in probability overall. Because a rather little amount of data were gathered during the early morning and night hours of the day, it is not currently attractive to filter trip selections on the basis of the time of day.

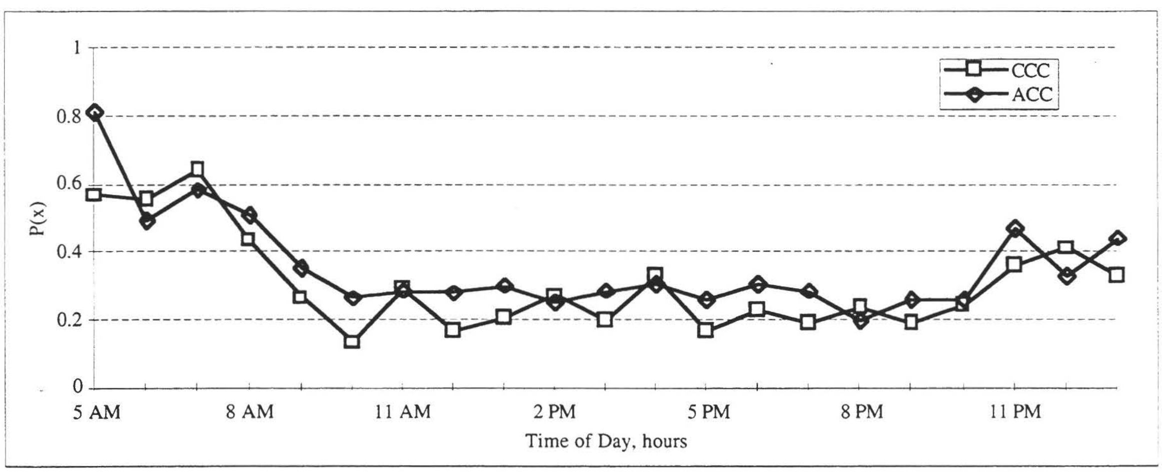


Figure 41. Utility of CCC and ACC as a function of time of day

ACC and CCC Mode Choice as a Function of Day of Week

Figure 42 presents the probability of the driver choice of the CCC or ACC mode over that of manual driving as a function of the day of the week. While, in general, the data all lie in the 20 to 40% band of probability throughout the week, we do note that a greater probability of ACC choice on Wednesdays may have resulted from this novel function first becoming enabled on each vehicle around the middle of the second of week of each person's usage. Thus, Wednesday may only appear as the typical day on which most subjects first had a chance to drive on their own in the ACC mode. The data suggest that it is not currently attractive to filter trip selections for evaluating ACC on the basis of the day of the week.

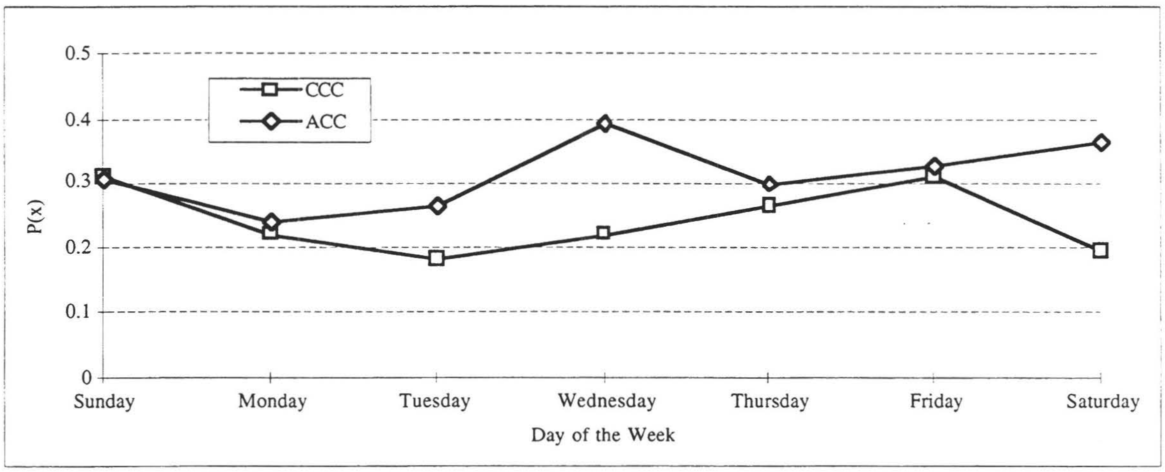
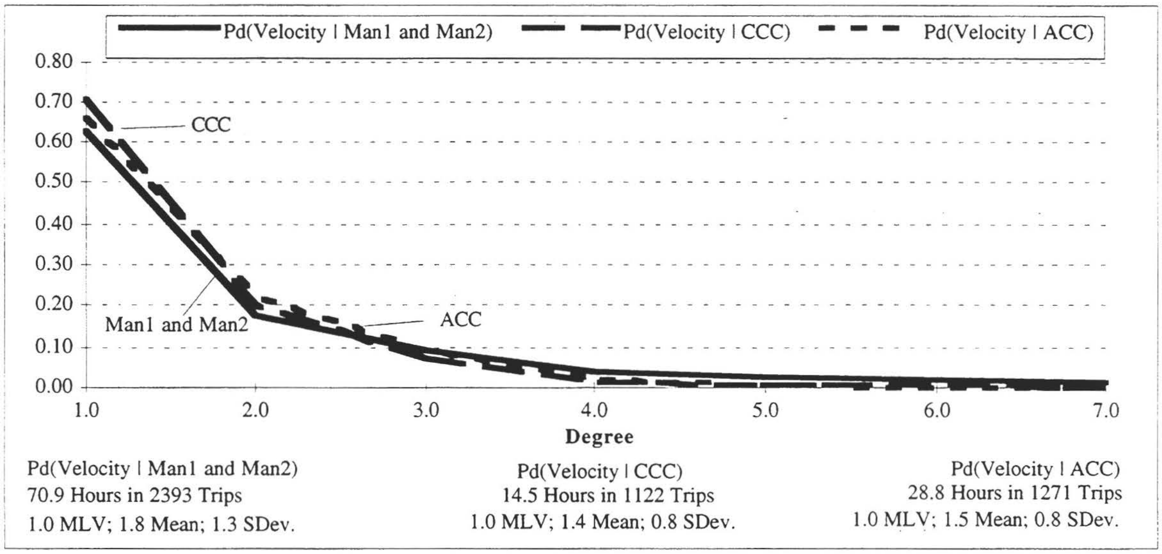


Figure 42. Utility of CCC and ACC as a function of day of the week

ACC and CCC Mode Choice as a Function of Roadway Curvature

One surrogate for identifying the type of road lies in the quantitative data on instantaneous curvature of the roadway (expressed in U.S. highway engineering format as the number of degrees of arc per 100 feet of circumferential distance). These data are obtained on board the test vehicle by a computed scaling of the ratio of yaw rate to velocity. Shown in Figure 43 is the probability density diagram for the "degree of curvature" encountered while operating in each of the three control modes. Assuming that only the manual mode of operation is chosen when driving on city streets and around the tightly curved (higher degree) road segments characteristic of local roads, the data showing a considerably greater extent of manual driving in the 4 and 5 degree curvature regimes seems reasonable. Conversely, the CCC and ACC modes of control are distributed overwhelmingly onto roads of 3 degree curvature (approximately 2,000 ft radius) and less, which characterize limited access highways and other high-speed facilities. Since tighter curvature tends to constrain speed rather naturally, however, a further filtering of trips according to the curvature data is seen as more or less redundant with the choice of average trip speed as a filter variable, as mentioned above.



(MLV means Most Likely Value)

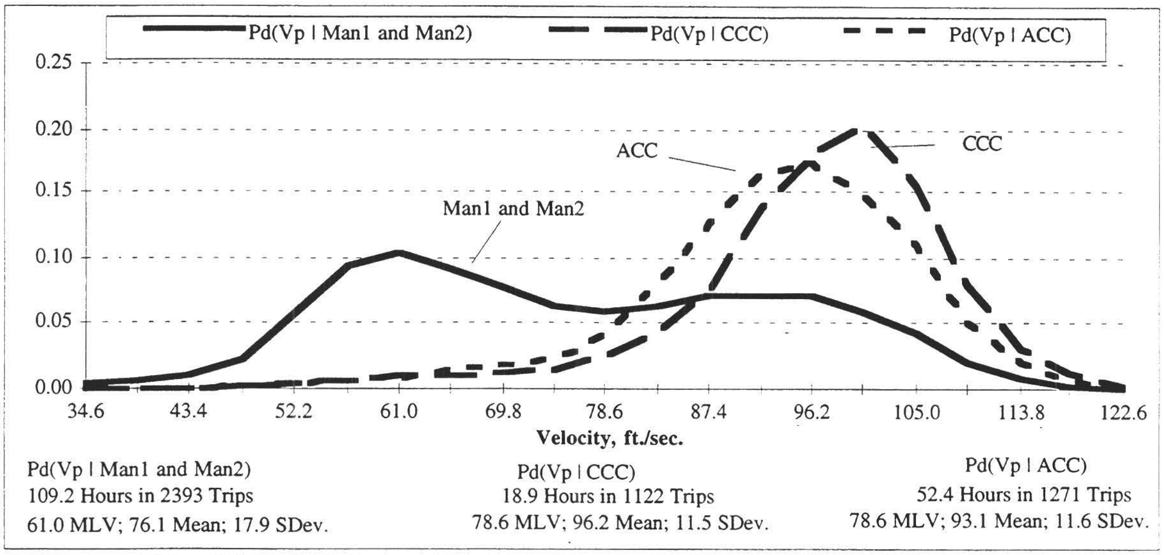
Figure 43. Utility of CCC and ACC as a function of roadway curvature

ACC and CCC Mode Choice as a Function of Preceding Vehicle's Speed and Acceleration

Another interesting exposure variable that is directly or indirectly associated with the choice of control mode is the speed, V_p, of the preceding vehicle. This variable and its derivative were examined as constituting an important aspect of the driving condition, but were not considered as a means of screening trips for the evaluation of ACC.

Although there is a very close connection between the host vehicle speed and the speed of any target vehicle detected ahead, the V_p value and its derivative are considered to be virtually independent of the host speed. Thus the preceding vehicle serves to characterize traffic in the sense of a probe device that, on the average, should approximate the speed selections, and longitudinal accelerations, of others in the traffic stream.

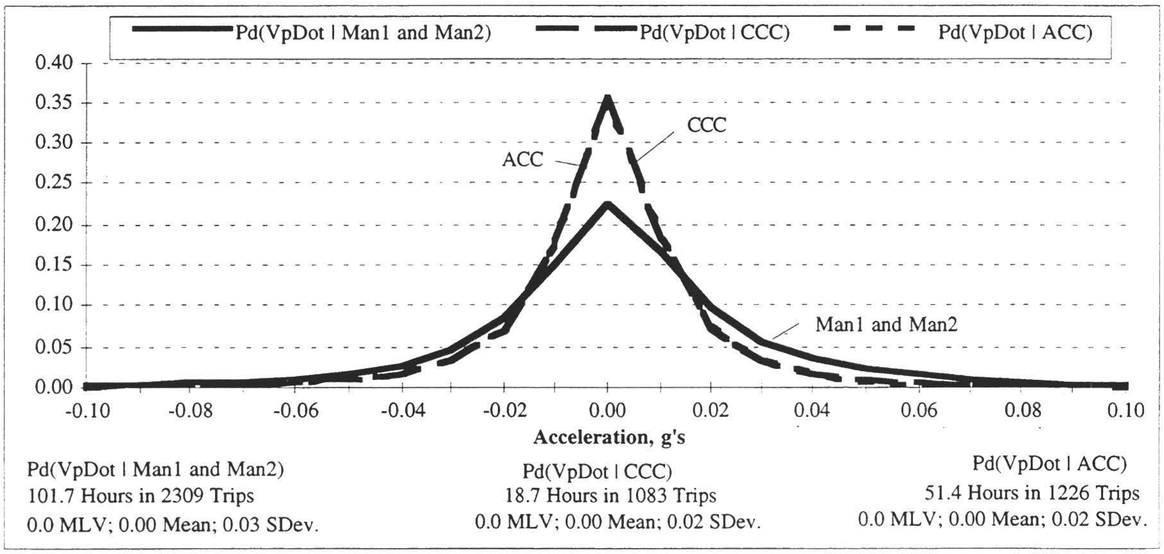
Shown in Figure 44 is the histogram of V_p as seen while the host vehicle was in each of the respective modes of control. We find these speed data to be comparable to those based upon the speed, V, of the host vehicle itself, shown earlier in section 4.1.1.



(MLV means Most Likely Value)

Figure 44. Histogram of preceding vehicle's velocity in various control modes

Of more interest, however, is the corresponding histogram, in Figure 45, showing the acceleration behavior, VpDot, for the preceding vehicle. This variable is of special pertinence to the task of headway keeping since it reveals the nature of disturbances that act to either shorten the headway gap or open it up. We see, for example, that preceding vehicles encountered during manual driving exceed a deceleration level of -0.05g approximately 5 times more frequently (i.e., comparing the included areas under the respective histograms to the left of -0.05g) than do vehicles encountered while driving under either ACC or CCC control. Clearly, the $V_p$dot condition posed by the traffic level and road type constitutes another of the many factors judged by drivers when they choose the appropriate mode of control. And, of course, it is well recognized that the freeway environment, and other high-speed roads, are generally characterized by very low levels of longitudinal acceleration. When they become congested such that more harsh stopping and starting transients prevail, the driver will have typically abandoned either of the cruise modes in favor of manual operation (although, of course, neither of the cruise modes is available below 30 mph, anyway.)



(MLV means Most Likely Value)

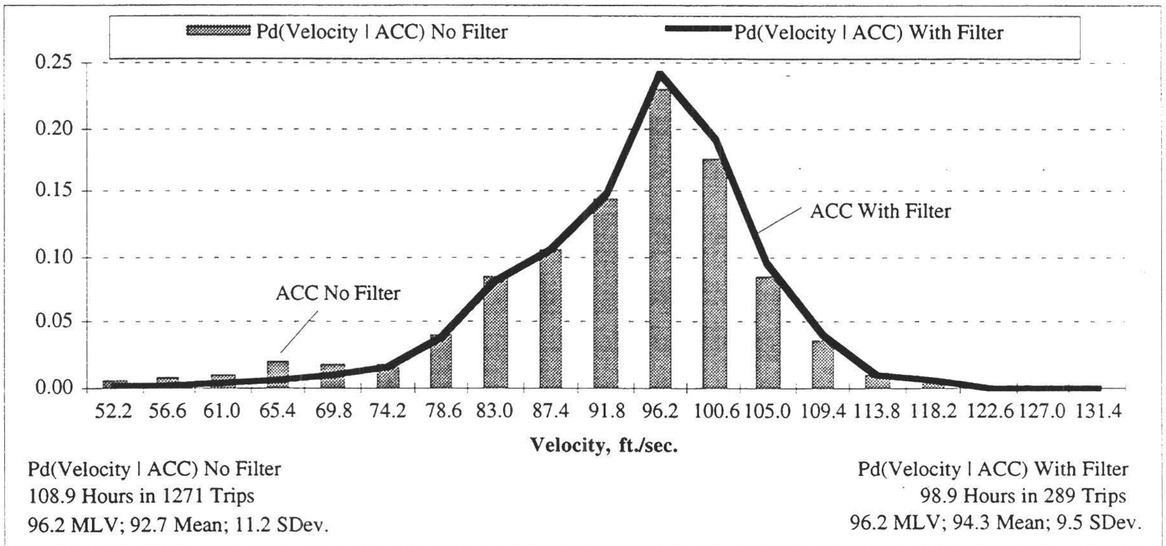
Figure 45. Histogram of preceding vehicle's acceleration in various control modes

4.1.3 What is the Influence of a Trip Filter on Basic Results?

In order to compare ACC operations with manual driving under nominally comparable conditions, trips were sub-selected to include only those whose average velocity exceeded 30 mph and whose trip length exceeded 10 miles. This screening filter retains a mere 22% of all the manual-only trips, but approximately 63% of the manual driving time. In ACC driving, only 28% of the ACC trips made it through the filter, but they represent 91% of all the ACC driving time. Even by these crude measures, then, we confirm that the filter removes much of the driving data in order to retain only those trips whose operating conditions are like those seen in most of the ACC driving. Thus, the short, relatively low-speed trips that were very numerous have provided rather little that can be used in studying the driver's experience with ACC. Note, also, that the large number of ACC trips that were removed by the filter, without significantly reducing the total amount of ACC driving time, reveals that our subjects were frequently trying to use ACC in very brief episodes, presumably as a curiosity while they were on a brief stretch of freeway or other road facility.

ACC Operations With and Without a Trip Filter

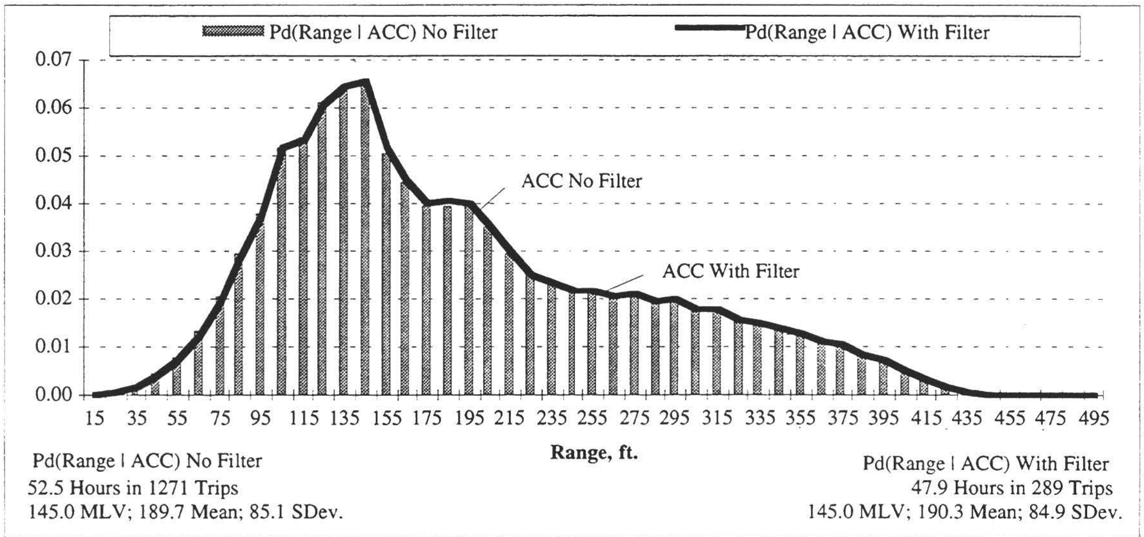
Shown in Figure 46 is the velocity histogram for ACC operations with and without the trip filter. Such charts are useful for assessing the impact of the selected trip filter, itself. The gray bars show all the ACC data (i.e., without filtering according to trip characteristics) while the solid line depicts the distribution from only the longer (>10 miles) and faster (>30 mph average speed) trips. These results indicate that the filtered trips are rather representative of the velocity distributions occurring in all ACC trips, albeit clipping out most of the narrow "tail" to the left, which pertains to driving below approximately 70 ft/sec.



(MLV means Most Likely Value)

Figure 46. Velocity histogram for ACC, with and without trip filter

Figure 47 compares the distance, or range, histograms for ACC operation in all the trips (gray bars) versus the filtered trips (solid line). Again, the filtered ACC trips appear virtually indistinguishable from the unfiltered ones. Dividing range by velocity to examine the headway times, we see in Figure 48 that the two graphs are still almost indistinguishable from one another. Of course, a simple reflection on the nature of this ACC controller would suggest that range-related histograms, which are compiled only while ACC is continuously engaged, should be largely insensitive to the trip conditions since the controller does indeed control that variable with substantial precision (see Section 4.1.6).



(MLV means Most Likely Value)

Figure 47. Range histogram for ACC, with and without trip filter

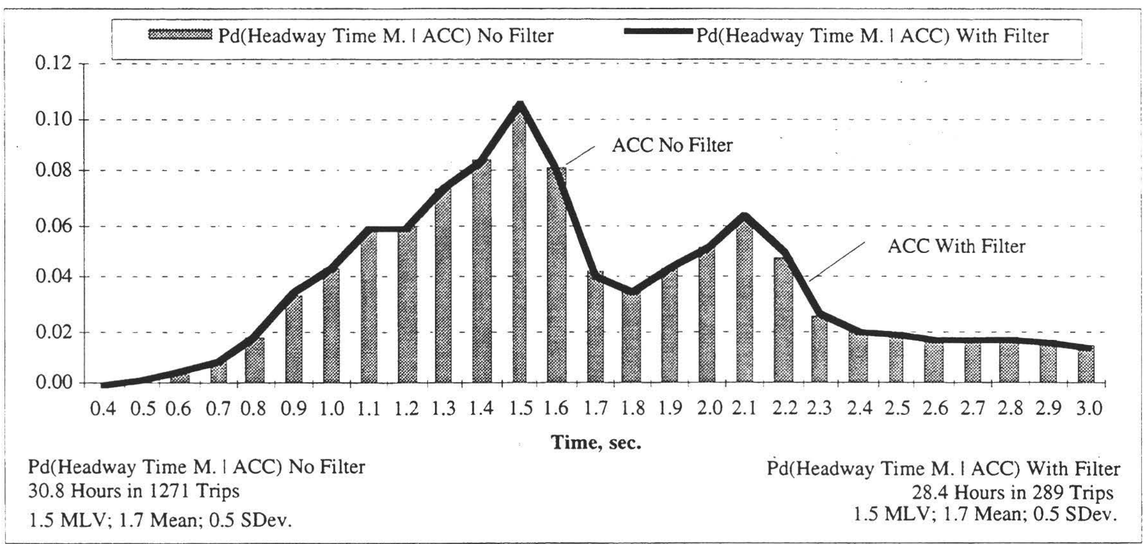


Figure 48. Headway Time Margin histogram for ACC, with and without trip filter

Manual Operations With and Without a Trip Filter

Shown in Figure 49 are the unfiltered (gray bars) versus the filtered (solid line) velocity histograms for manual driving. In this case, as intended, the filter serves to remove trips characterized by lower speed operation—conditions in which ACC usage has been seen to be very infrequent. Together with the observation, above, that the filtered trips do a good job of representing virtually all ACC operations, the data in Figure 49 further confirm the reasonableness of this simple filter approach since the filtered manual control trips show an upward shift in their velocity histogram.

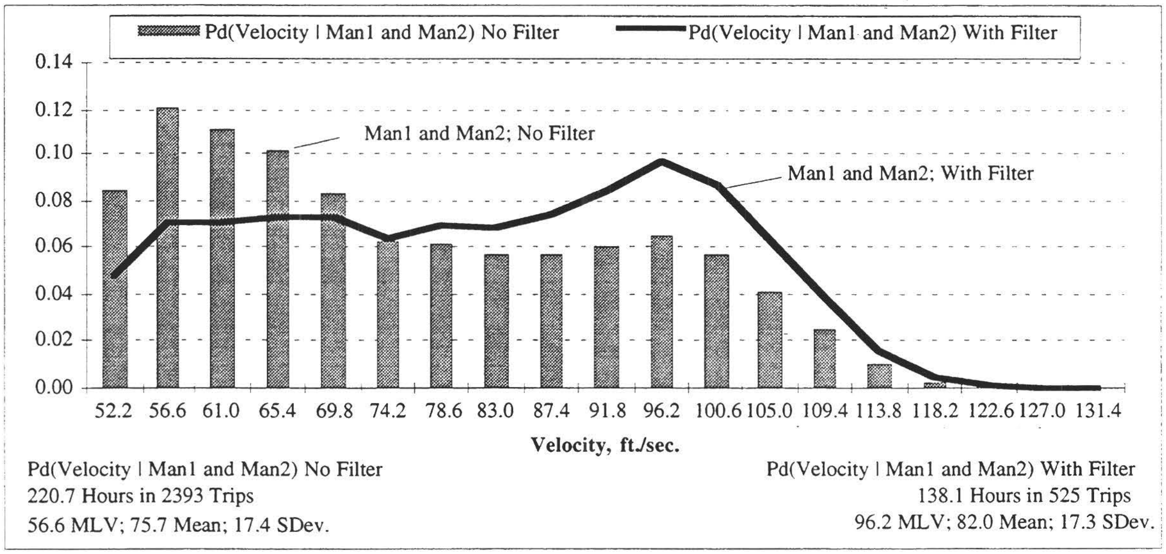
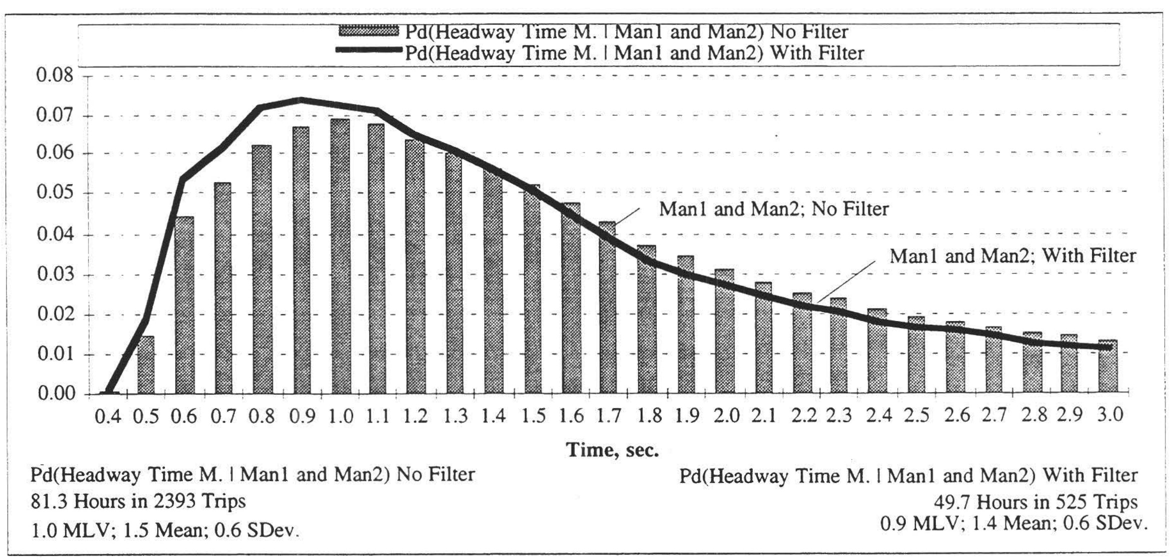


Figure 49. Velocity histogram for manual, with and without trip filter

Shown in Figure 50 are the unfiltered and filtered histograms for headway time in the manual mode of operation. Although a rather small redistribution of the results was affected by the trip filter, the direction of the change due to trip filtering can simply be called a puzzle at this point. That is, further investigation is needed to determine if a downward trend in headway time typically accompanies increasing speed in manual driving (as implied by the data which were filtered for speed and trip length.) More attention to this issue will be given as the project proceeds.



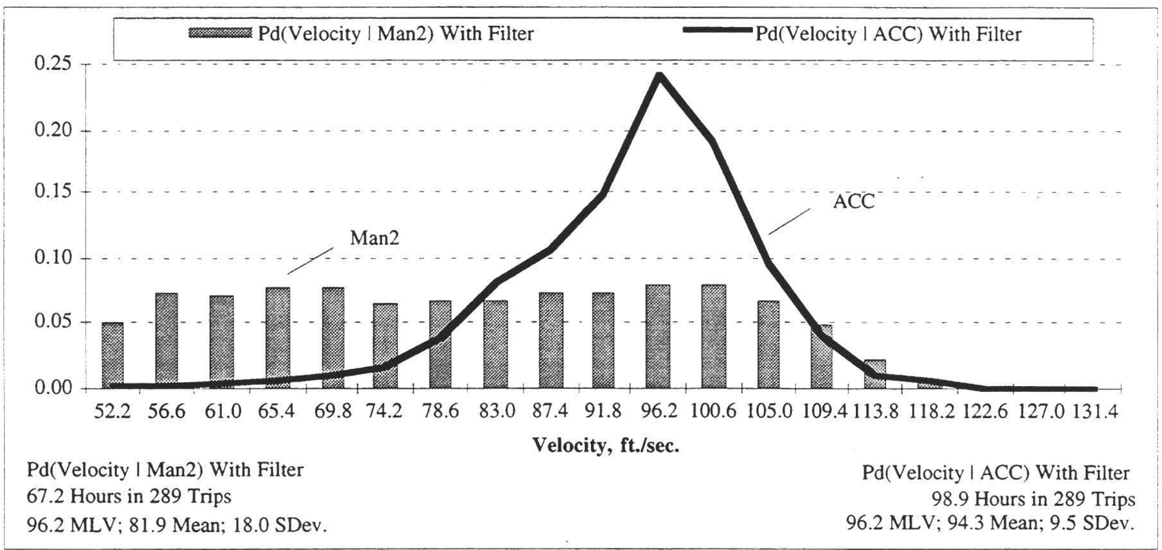
(MLV means Most Likely Value)

Figure 50. Headway Time Margin histogram for manual, with and without trip filter

In the remainder of this section, the trip filter described above will be employed to compare manual and ACC operations.

Manual versus ACC Operations Velocity Data Using the Trip Filter

Shown in Figure 51 is a comparison of the velocity histograms obtained during manual versus ACC driving from the filtered trips, only. The data are rather similar to those shown earlier, in section 4.1.1, for all trips (Figure 20, in particular) except that both the manual and ACC data show a reduced presence of low-speed (below 70 ft/sec) operation. The data, as filtered for only longer and higher-speed trips, suggest that ACC is used as a speed controller over a rather narrow range of speeds whose most likely value is around 94 ft/sec (64 mph).

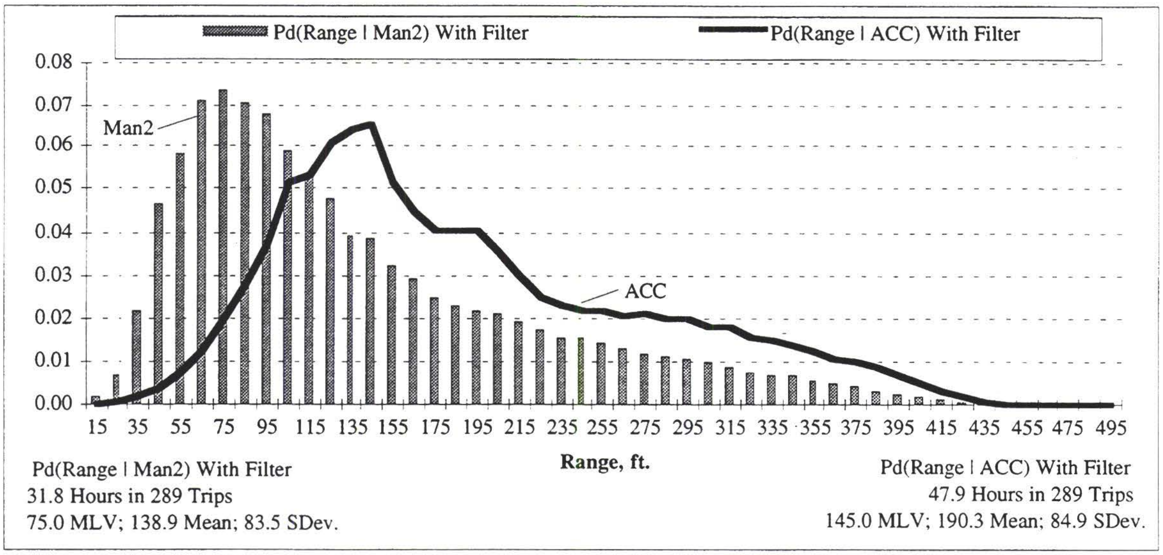


(MLV means Most Likely Value)

Figure 51. Probability density of velocity in ACC versus manual, with trip filter

Manual versus ACC Operations Range Data Using the Trip Filter

The range data obtained by trip-filtering on manual and ACC operations are shown in Figure 52. Although again the results appear very much like those that were shown comparing ACC versus manual driving from all trips in section 4.1.1 (see Figure 21), the mean value for manual driving has moved more to the left, toward shorter ranges, with the trip filter employed than did the overall distribution of manual results. Nevertheless, it would be fair to say that a negligible change in the comparison of ACC versus manual range values has occurred due to the trip filter.



(MLV means Most Likely Value)

Figure 52. Probability density of range in ACC versus manual, with trip filter

Normalizing range by velocity to obtain headway time margins in Figure 53, we observe that while the filtered-trip comparisons, ACC versus manual are, again, almost identical to those from all trips, the mean time gap from manual driving has moved about 6% to the left, yielding modestly more contrast between the two modes of control.

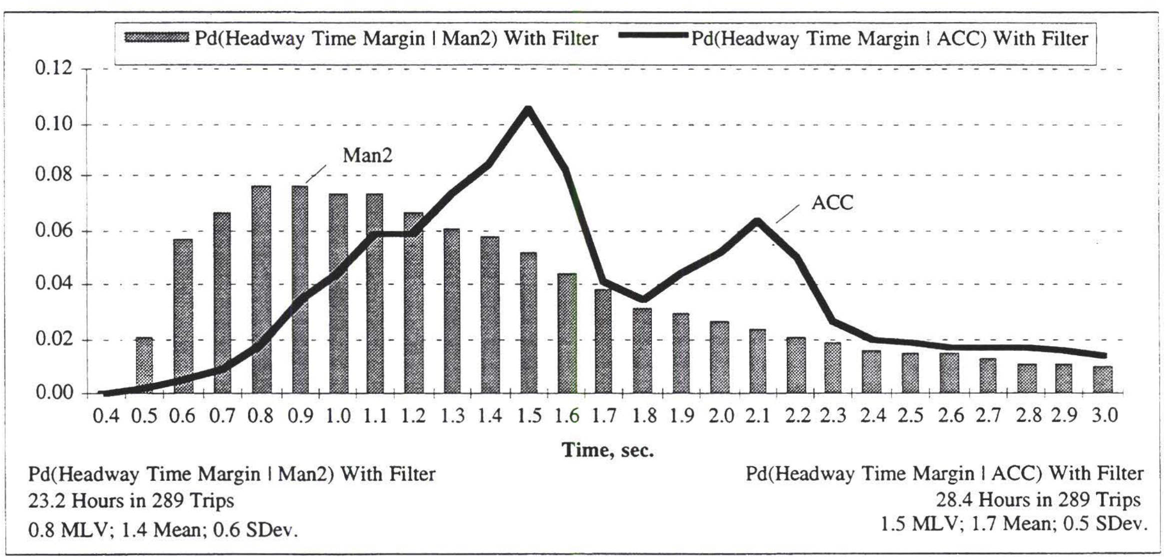


Figure 53. Probability density of headway time margin in ACC versus manual, with trip filter

Figure 54 and Figure 55 illustrate the two-dimensional histograms from ACC and manual driving modes, in the filtered trips, only. These figures are virtually indistinguishable from those shown earlier (Figure 23 and Figure 24) for all trips.

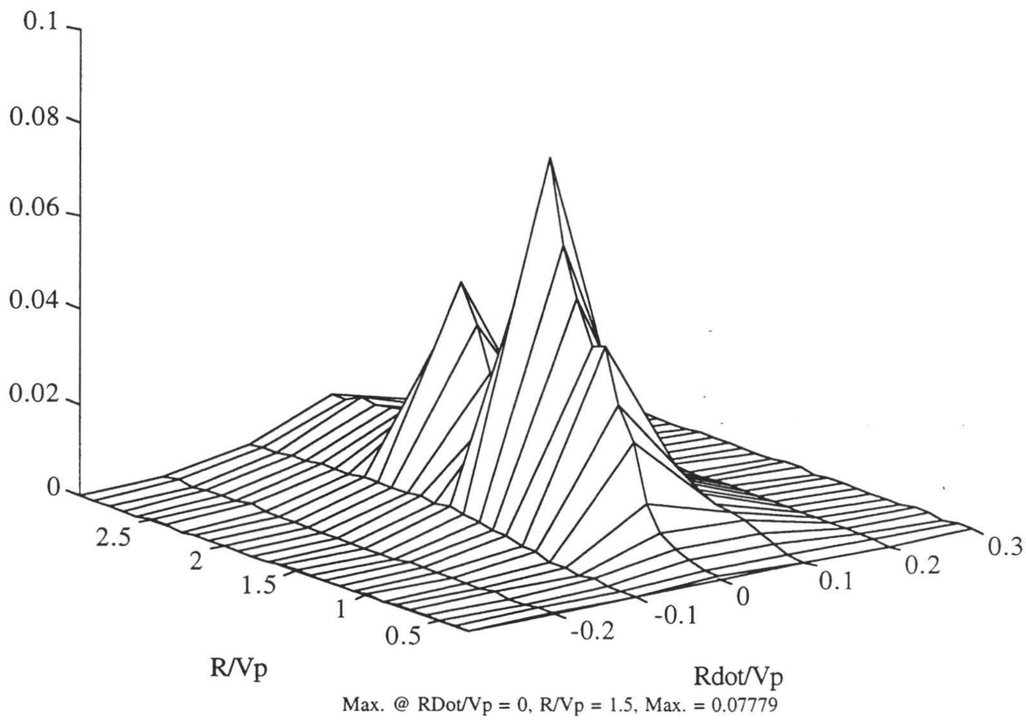


Figure 54. Probability density of normalized range and range rate in ACC driving, with trip filter

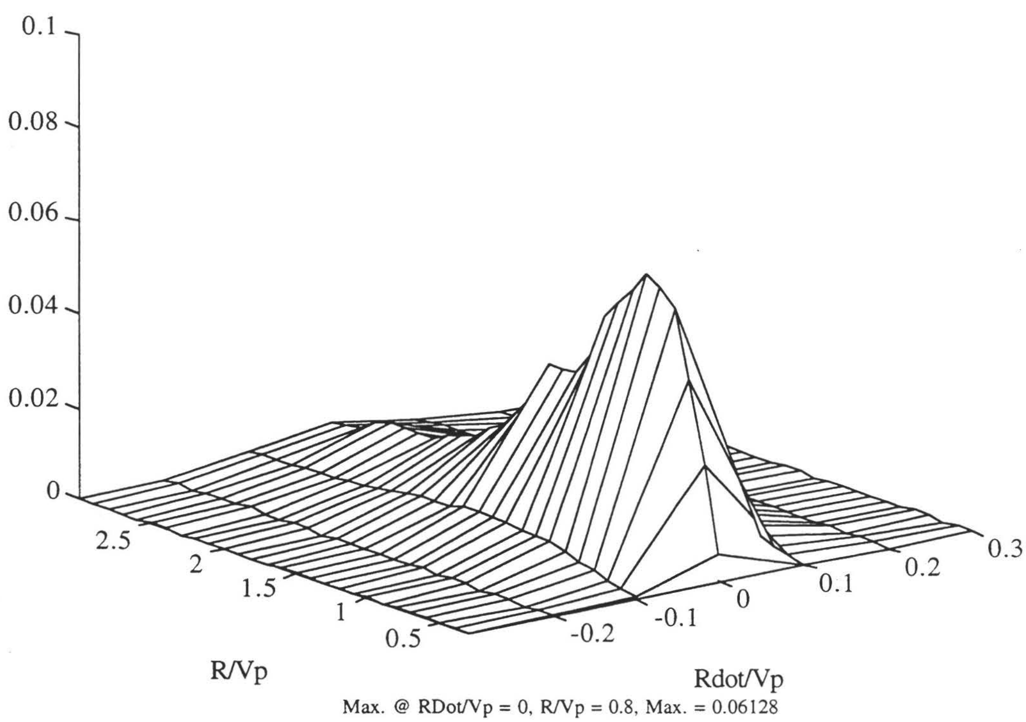


Figure 55. Probability density of normalized range and range rate in ACC driving, with trip filter

Finally, Figure 56 illustrates the results for five proximity regions defined earlier. The data compare the distributions of total probability of landing each of the five regions, given that a target has been acquired, under ACC and manual operations. These results, obtained from the filtered trips, only, are also virtually indistinguishable from those presented earlier, from all trips.

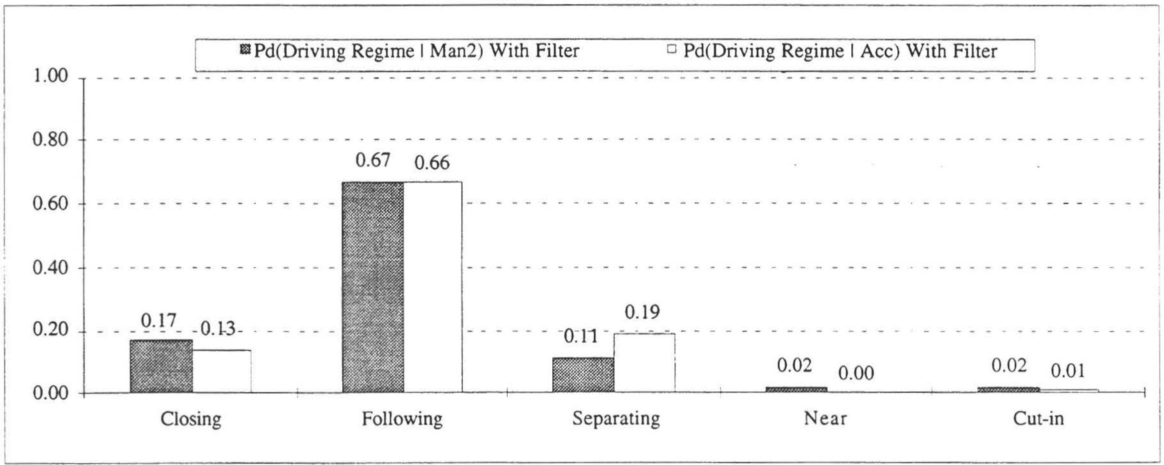


Figure 56. Probability density of operating within various driving regimes (2nd week), with trip filter

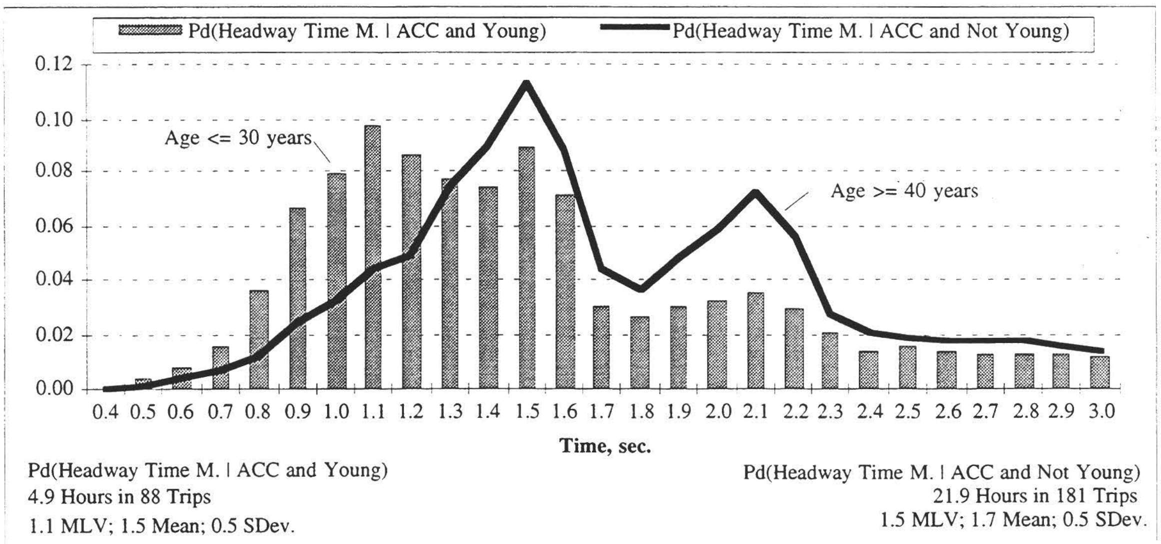
Altogether, these illustrations obtained using the described filtering for only longer and higher-speed trips have shown ACC versus manual comparisons differ from the "all-trip" results only in terms of the speed of manual driving. But since this substantial change in manual speeds in the filtered trips was not also accompanied by a significant change in either manual range values or in headway times, the filtering exercise has not shown itself to have been a needed discrimination mechanism. Nevertheless, the remainder of the results shown in successive sections of this report have employed the trip filter since the logic of its selection seems right (even though it is not possible to show quite what difference it makes). An extension of the exposure concepts and further attempts to identify "biases" in ACC versus manual driving that warrant trip filtering will be pursued during the remaining portion of the project.

4.1.4 How does driver age influence the results?

Previous research into ACC driving has shown that driver age distinctively relates to speed and headway-keeping behavior. Since ACC as an automotive product would be driven by persons across the full spectrum of licensed drivers, it is important that its safe and convenient operation under the age-determined variations in driving style be confirmed.

ACC Driving Young versus Older Drivers

Shown in Figure 57 is the comparison of headway times obtained by young (20-30 yrs.) versus older (>40 yrs.) drivers. The younger drivers (gray bars) apparently choose the 1.0-second headway time as their most popular selection among the three headway selections, with the 1.4-second choice as a close second. The older drivers (solid line) have a tendency to select the two longer headway settings, with the 1.4-second value being most likely. The data confirm that driver usage of ACC distinctly differentiates older from younger age groups, as had been expected from prior work.



(MLV means Most Likely Value)

Figure 57. Probability density of headway time margin in ACC driving, young versus old drivers

Shown in Figure 58 and Figure 59 are the two-dimensional histograms presenting the combined range and range-rate data comparing young ACC drivers with older ACC drivers. The younger drivers in Figure 58 not only come closer to the vehicle ahead, but they approach with higher values of range-rate as well, presumably as a result (to be confirmed later in the study) of having chosen higher set speeds such that higher rates of overtaking occur.

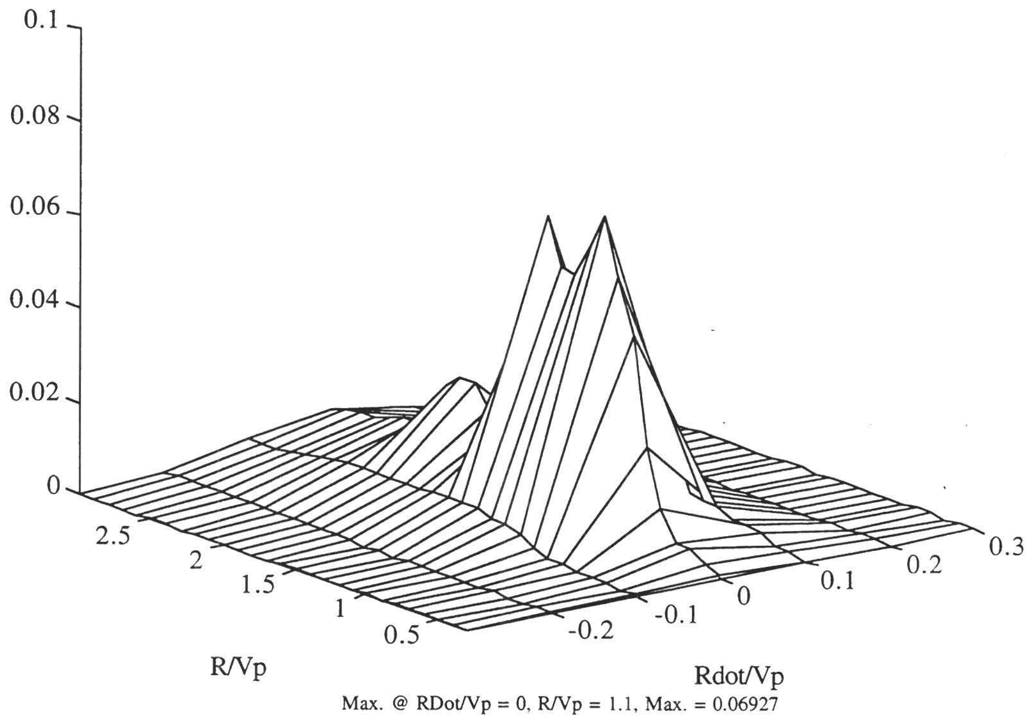


Figure 58. Probability density of normalized range and range rate in ACC driving, young drivers

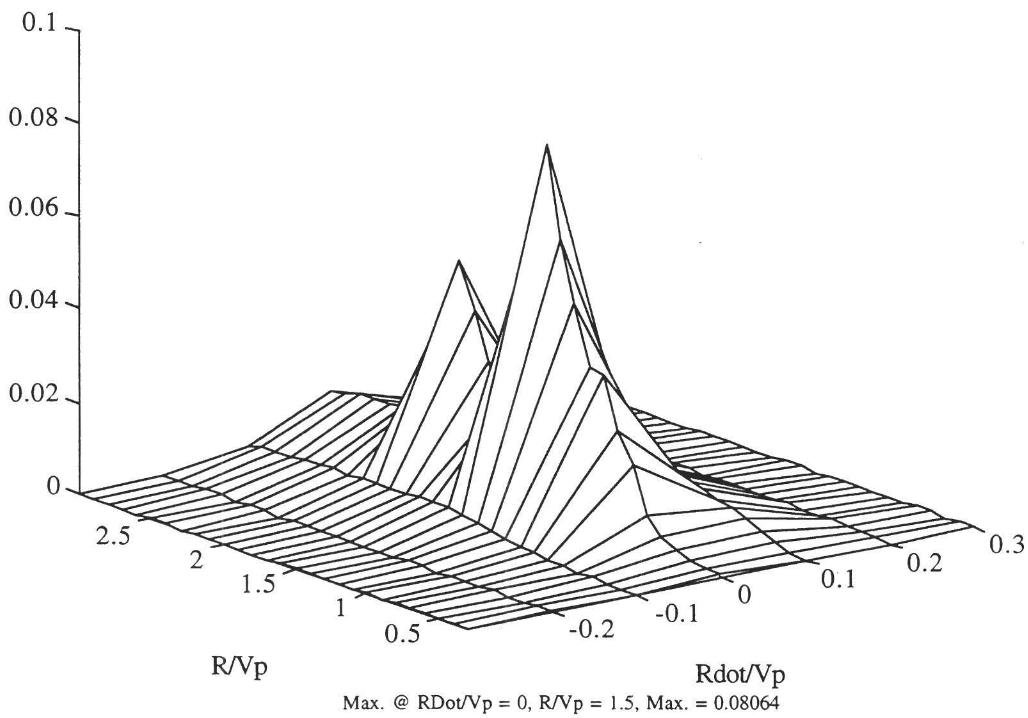


Figure 59. Probability density of normalized range and range rate in ACC driving, old drivers

A comparison of young versus older drivers in terms of the five proximity regions covered during ACC driving may be obtained by examining Figure 60 and Figure 61. The comparison shows that age has only a rather minor influence on the distribution of coverage, overall. Interestingly, however, the younger group shows a greater tendency to occupy the higher-conflict regions of "near" and "closing" than do the older drivers. This is probably because the younger drivers tend to use higher set speed than the older drivers do.

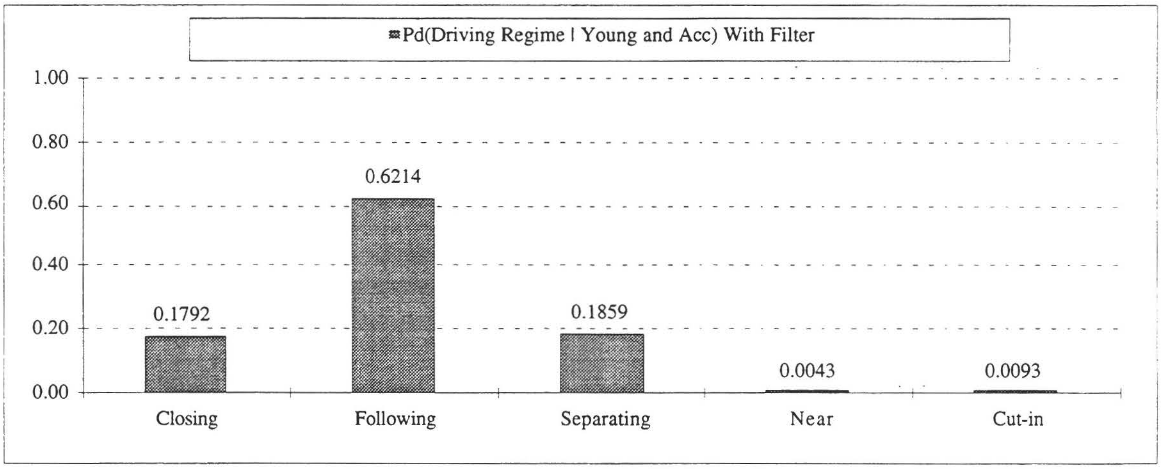


Figure 60. Probability of operating within various driving regime in ACC driving, young drivers

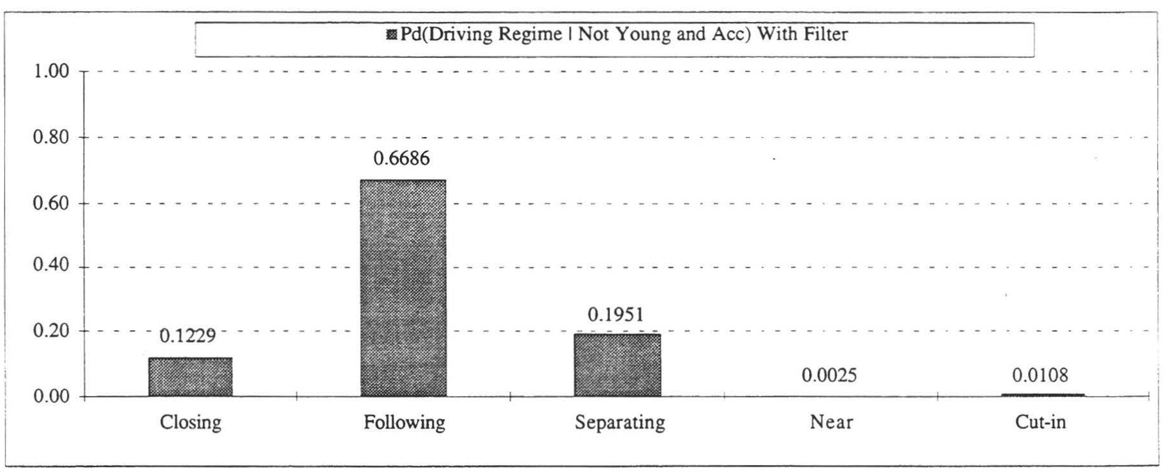
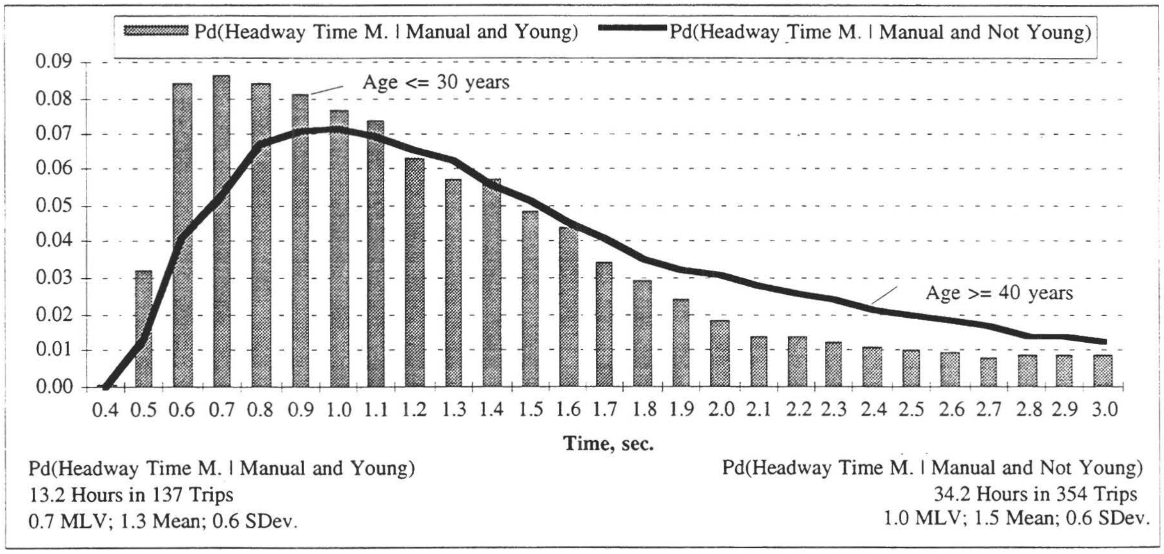


Figure 61. Probability of operating within various driving regime in ACC driving, middle-aged and old drivers

Manual Driving Young versus Older Drivers

Shown in Figure 62, the headway times for young and older drivers operating in the manual mode are compared. As expected, the young driver (gray bars) show a headway time histogram that is biased more to the left and which includes a large (approximately 40%) probability of operating within a value of 1.0 seconds.



(MLV means Most Likely Value)

Figure 62. Probability density of headway time margin in manual driving, young versus middle-aged and old drivers

Figure 63 and Figure 64 show two-dimensional R and RDot histograms showing, in turn, young and older drivers operating under manual control. Although the data taken with young drivers is much more concentrated into the short-range end of the spectrum, it must be acknowledged that the older group also shows substantial occupation of both the short-range and negative-RDot portions of the space.

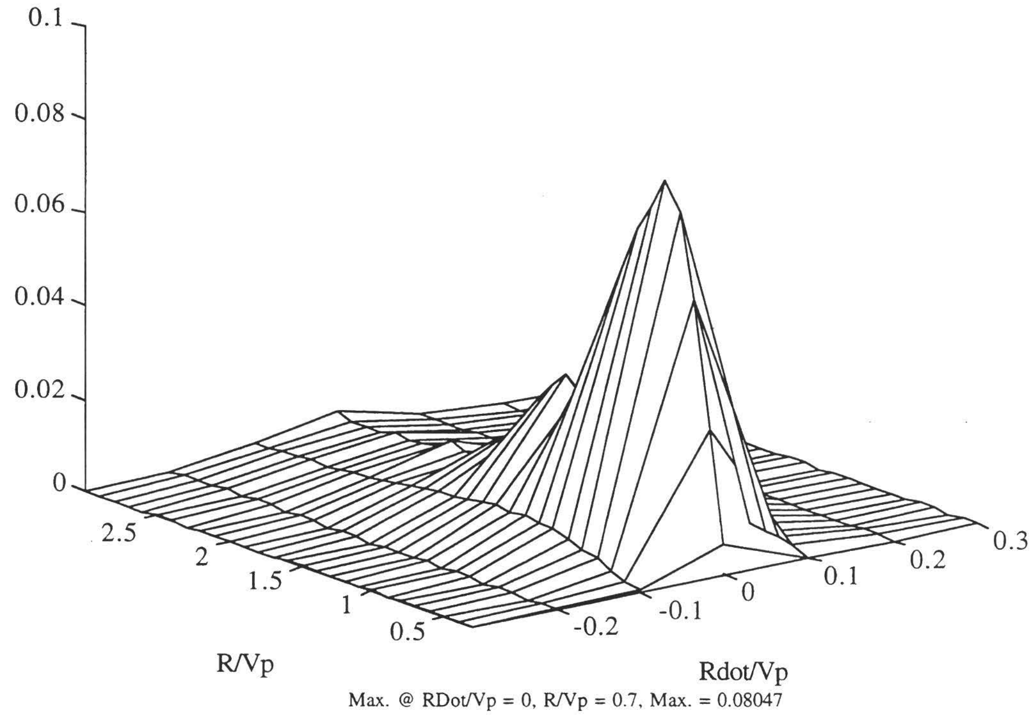


Figure 63. Probability density of normalized range and range rate in manual driving, young drivers

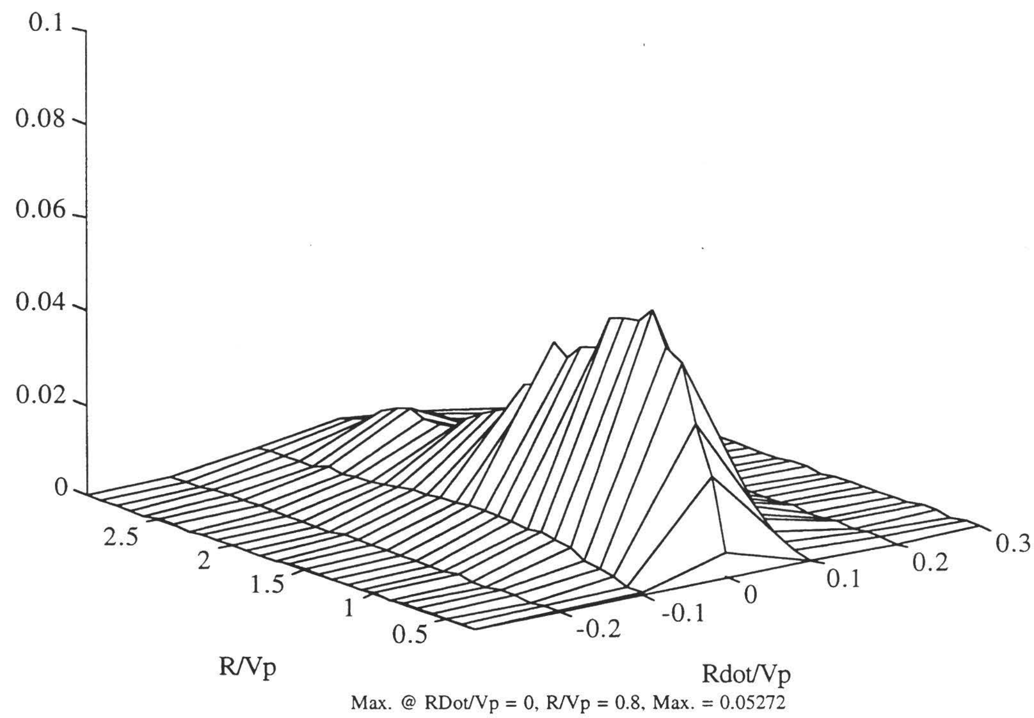


Figure 64. Probability density of normalized range and range rate in manual driving, old drivers

Figure 65 and Figure 66 presents a comparison of young versus older driver operations for manual driving across the five proximity regions. We see that while the overall distributions are very similar, the younger group is substantially more likely to occupy the "near" region, but nearly equivalently the "cut-in" region. Although the reader may tend to dismiss the differences in light of the overall small size of the near and cut-in probabilities, we should mention again that these areas are of special interest for their implication of conflicts that could portend near-miss or even rear-end crash possibilities.

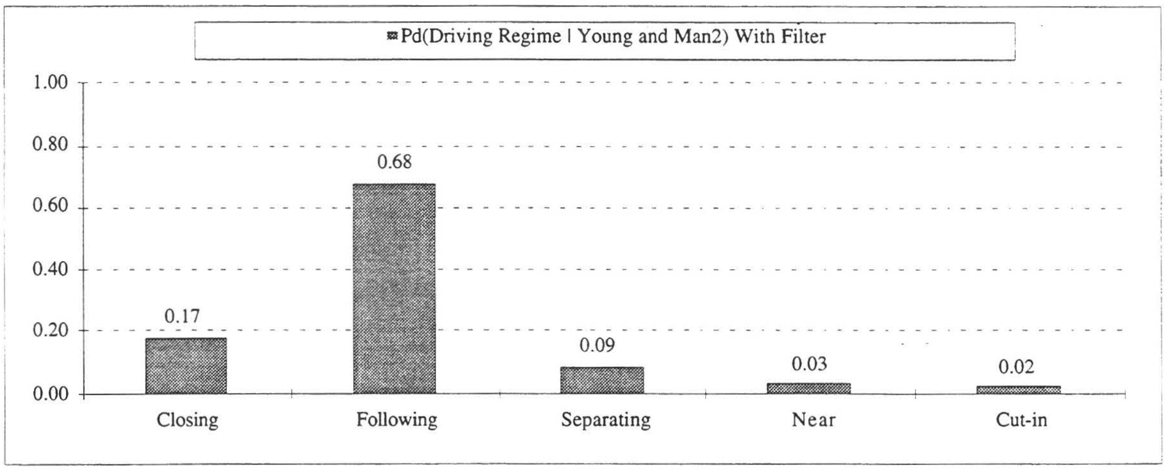


Figure 65. Probability of operating within various driving regime in manual driving, young drivers

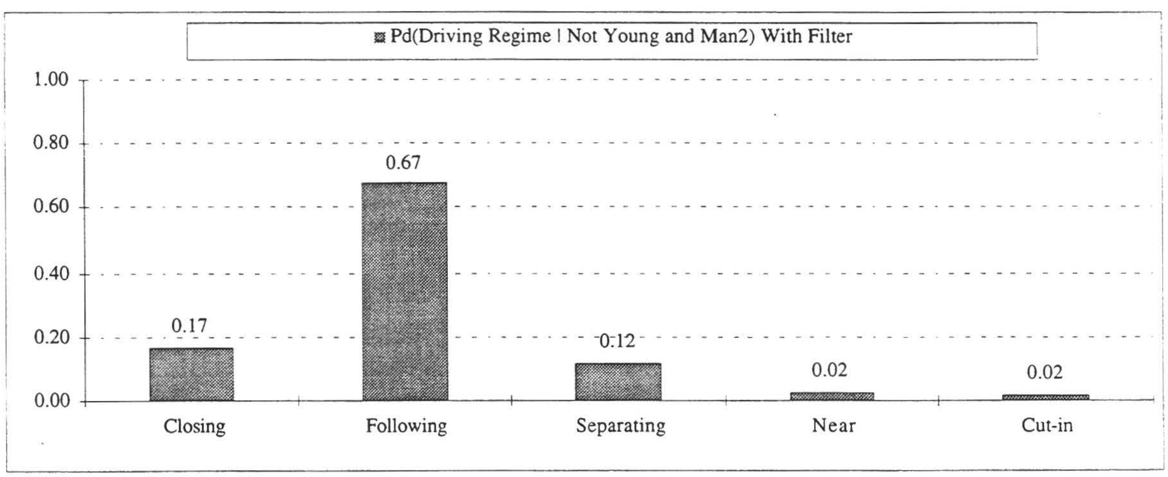


Figure 66. Probability of operating within various driving regime in manual driving, middle-aged and old drivers

ACC versus Manual for Young Drivers and for Older Drivers

By comparing Figure 60 and Figure 65, we see that the tendency for young drivers to be in the near region of the proximity space is greatly reduced. In addition, by comparing Figure 61 and Figure 66, we see also that the tendency for the other drivers (middle-aged and older) to be in the near region is greatly reduced. These results support the proposition that an ACC can provide a safety benefit by reducing the incidence of operation in the near region.

4.1.5 How do results for individuals differ from the aggregated results?

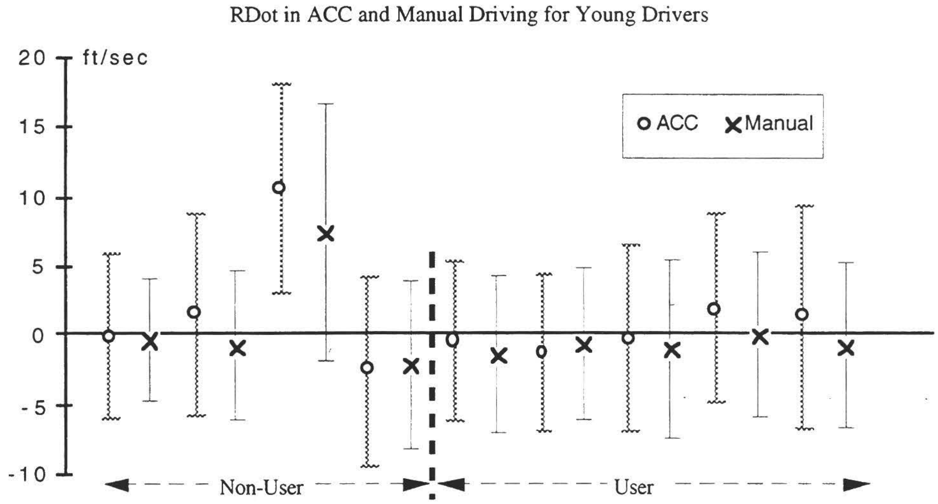
Appendix D provides a set of tables covering all drivers and all variables. Examining certain variables, and comparing them among drivers, can provide an assessment of differences between the individual and the aggregate results. The figures in this section depict the mean value of the variable being discussed, with error bars indicating plus/minus one standard deviation. Each figure is divided into three plots by the three age groups, and each plot groups the drivers by their familiarity with cruise control. The order of the drivers along the x-axis (within the grouping described above) is by their number as it appears under the column "No." in the tables in Appendix D.

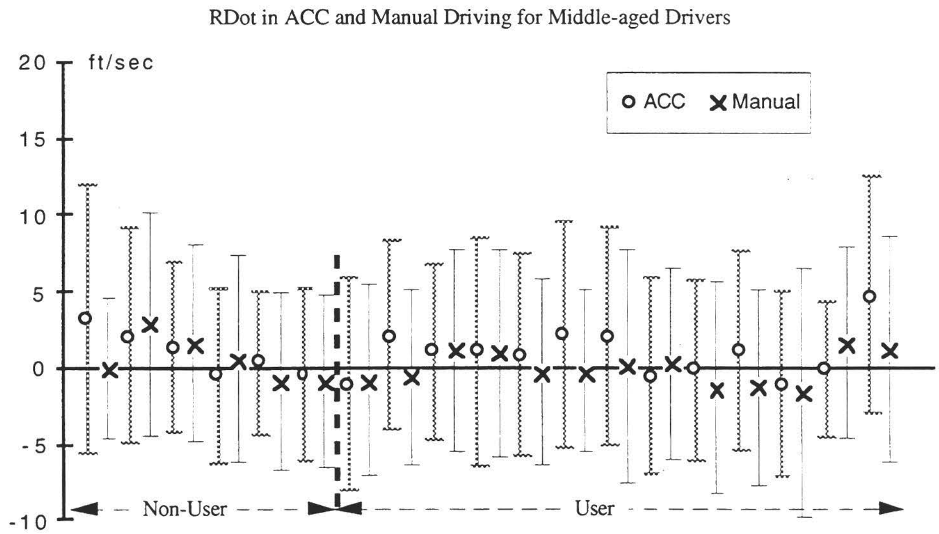
Examination of Relative Velocity (RDot)

The relative velocity RDot is a good indicator for identifying drivers who tend to drive more slowly than the speed of the other vehicles on the same road. This pertains primarily to manual driving but it can be observed in ACC driving as well. Examination of the data presented in Figure 67 shows that driver number 3 in the set of 35 drivers is an example of a slow driver.

Based on this and past experience, it seems that about 1 in 35 drivers tends to drive at a much slower speed than the speed of the other drivers on the same road. This slow driver is an outlier whose results are different from the other drivers and consequently different from the aggregate of the data for all drivers. The very slow driver does not overtake other vehicles and most of the vehicles picked up by the slow vehicle's sensor are separating from it. In this case the slow driver is an extraordinary 10 ft/sec slower on the average in manual driving and an even larger 14 ft/sec slower on the average in ACC driving. This slow speed in ACC driving is done by selecting a very low set speed. The setting of a low set speed is what a driver can do using CCC to avoid having to brake and use the CCC controls. In ACC it means that the headway controller has almost nothing to do and the vehicle is operating as if it were using CCC.

Examination of the data and logical reasoning indicates that negative range rates do occur but it is difficult and unlikely that a driver can, or will be able to, have an average RDot that is less than -2 ft/sec. This means that it is difficult to travel more than 2 ft/sec faster than the other vehicles. Even if a driver goes fast and manages to avoid the slower moving vehicles, the driver will encounter other vehicles that are going approximately at the same speed.





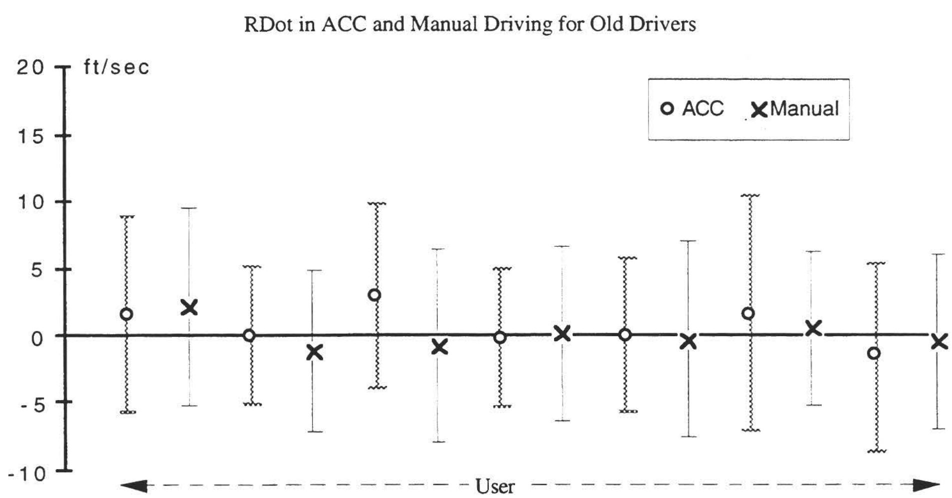


Figure 67. RDot in ACC and manual driving separated by age group

Evidence supporting the proposition that it is not likely that an individual driver will sustain a relative velocity that is negative (closing in on the preceding vehicle) is illustrated in Figure 67 where one can see that the average value of RDot is very close to 0 (except for driver number 3). The RDot average is close to zero and within ±2 ft/sec for nearly all of the drivers that have participated in the FOT so far.

As indicated by the ACC results presented in Figure 67, RDot average for ACC driving is often greater than zero but seldom less than zero (as one might expect given that the ACC system slows the vehicle to the speed of the vehicle ahead).

The conclusion here is that the data for RDot is good for identifying outliers, but aside from this most drivers tend to incur similar levels of RDot. Since the RDot aspects of the driving performance of most individual drivers is much like that of the others, the aggregate and individual performances are quite similar with respect to RDot.

Examination of Velocity

The three primary variables used to evaluate headway control are range, range rate (RDot), and velocity. The difference between the velocity of the preceding vehicle and the ACC vehicle is RDot. Nevertheless, RDot tends to be more informative than velocity (V) because RDot takes into account the speed of the preceding vehicle. Examination of the data given in Figure 68 shows that with a few exceptions most drivers tend to use ACC at approximately the same speed somewhere in the range of typical highway speeds.

Driver 3, of course, stands out but not as noticeably as driver 3 did in the examination of RDot. Other drivers also have relatively slow average velocities in manual driving due to the driving environment they encounter in their use of the car, but they keep up with the other cars on the road so that RDot average is approximately near zero.

The one thing that is apparent from the data in Figure 68 is that manual driving for every driver is slower on average than ACC driving. This agrees with the results for the aggregated data (as of course it would have to). In the aggregated data the histograms show that ACC driving is more common at higher speeds and that low speeds are associated with higher likelihood of manual driving.

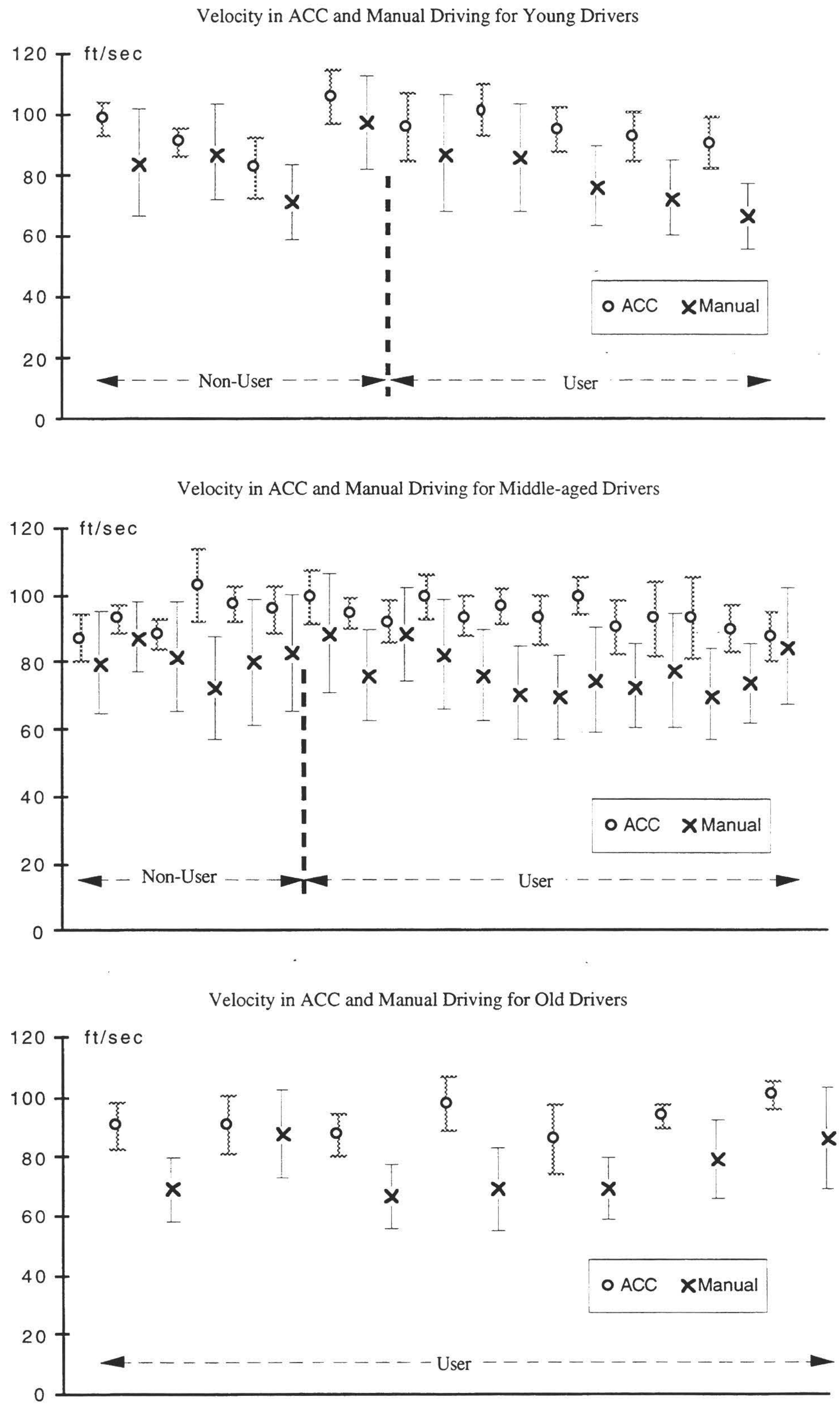


Figure 68. Velocity in ACC and manual driving separated by age group

Examination of Headway Range

Because the subjective results are gathered from each individual, they are in a way like the disaggregated results for the objective data. The opinion of driver 3 counts as much as that of any other driver even though driver 3 may have had very little experience with the headway-control system in operation. With only a few exceptions, the average range during manual driving is less than that attained during ACC driving. See Figure 69. This is in keeping with previous aggregated results. However there is a fairly wide dispersion of the headway ranges that different drivers choose to use. Also the standard deviations in range for all drivers are large, varying from approximately 60 to 100 feet. Different drivers differ considerably in the headway they choose to use.

Examination of Headway Time Margin

Headway time margin is equal to range divided by velocity (R/V). In a sense, dividing by velocity tends to bring the results for range into a common denominator of time. From a physical standpoint, headway time margin is the time available for the driver to match the deceleration maneuver of the preceding vehicle and still avoid a crash. As can be seen in Figure 70, the younger drivers tend to average short headway time margins just over 1 second with one standard deviation being well below one second. This difference between young and older drivers is discussed in Section 4.1.4.

Further interpretation of the individual driver data for headway time margin can be derived by examining Table 16. This table is extracted from Appendix D which provides a set of tables covering all drivers and all variables. Table 16 indicates that for most drivers the distribution of headway time margin is very skewed. The most likely value (MLV) is approximately one standard deviation below the mean for many drivers when they drive manually. It is interesting to note that only two of the 35 drivers have a MLV over 2 seconds, while 13 drivers have an MLV less than one second.

Naturally, the results for ACC driving indicate MLV near the headway times corresponding to the “closer”, unmarked, and “further” headway control buttons available in the driver interface of the ACC system.

Similar to the results for range, but perhaps easier to interpret, headway time margin for each individual is an indicator of that person's driving style. People with different behavior with respect to headway time margin will have different views as to how headway is to be controlled.

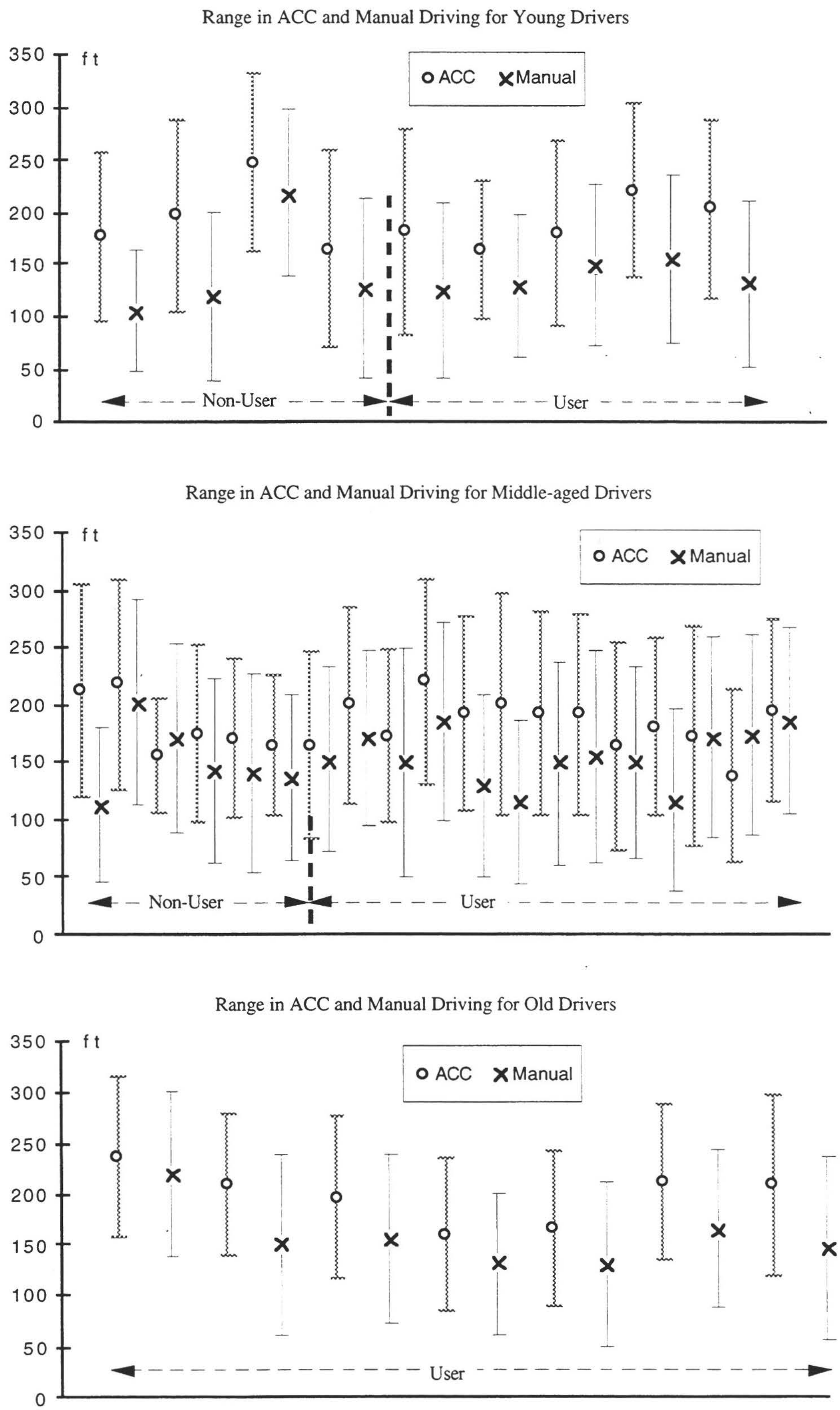


Figure 69. Range in ACC and manual driving separated by age group

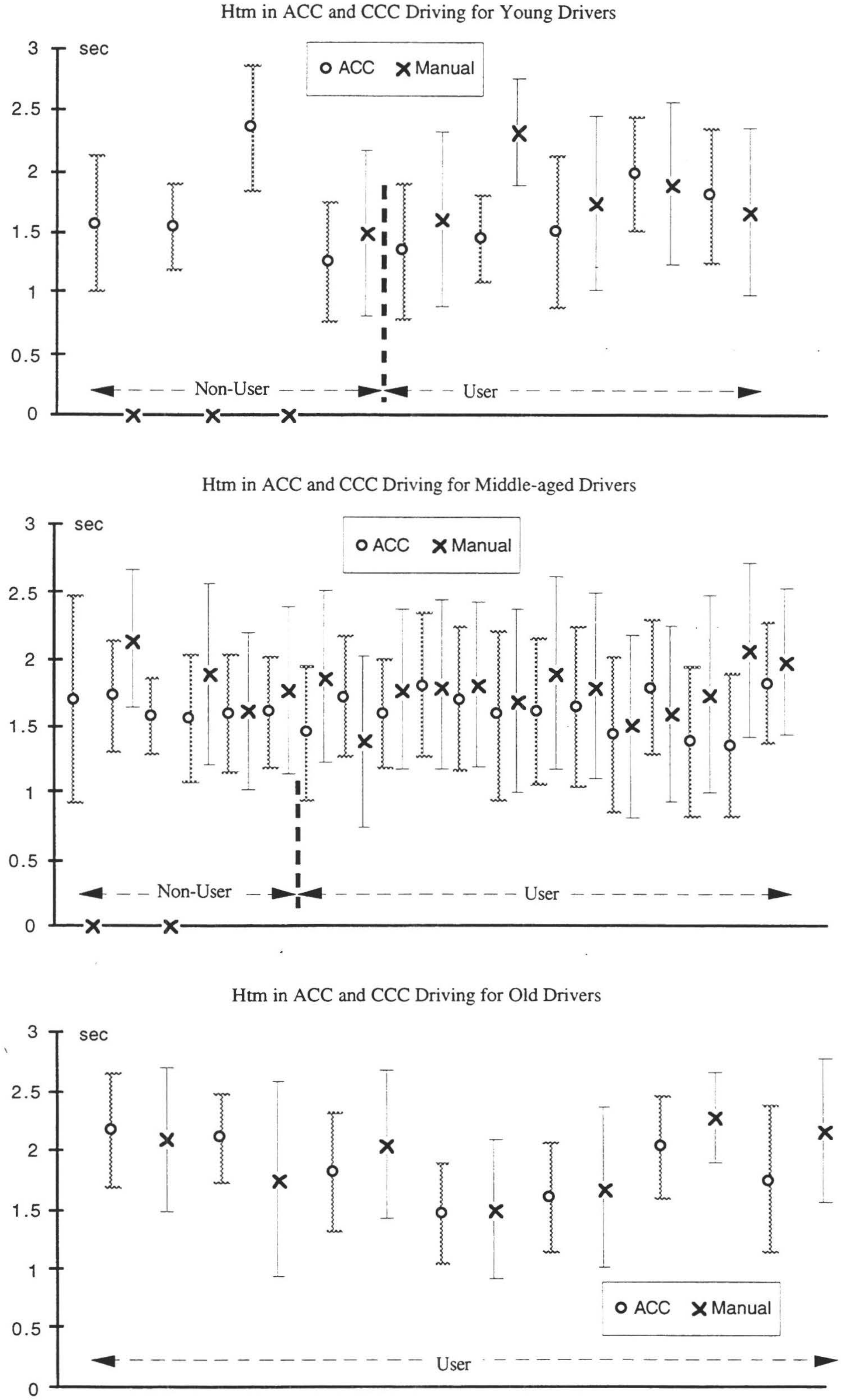


Figure 70. Headway time margin in ACC and manual driving separated by age group

Table 16. Individual driver data of headway time margin

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count	Mean	StDev	MLV	Trips	Count
						Manual Driving					***ACC Driving***				
1	Htm	27	20-30	0	F	1.1681443	0.4975232	0.8	5	20731	1.5641183	0.5552279	1.5	5	19227
2	Htm	31	20-30	0	F	1.1743975	0.5500697	0.6	13	71919	1.5386374	0.3606367	1.6	9	2275
3	Htm	38	20-30	0	F	2.3733153	0.4477507	2.5	8	1870	2.359113	0.5164097	3	6	1827
4	Htm	4	20-30	0	M	1.0827788	0.5032789	0.7	27	148670	1.2471877	0.485299	1.1	20	53944
5	Htm	10	20-30	1	F	1.1806717	0.5865881	0.6	24	78310	1.3411504	0.564909	1.1	11	9232
6	Htm	15	20-30	1	F	1.3167459	0.4654576	1.1	7	57799	1.440516	0.3590814	1.5	5	42235
7	Htm	30	20-30	1	F	1.5383257	0.5359594	1.4	15	29886	1.5027409	0.6222135	1.2	9	12478
8	Htm	33	20-30	1	M	1.6638677	0.6086803	1.4	31	53227	1.9761555	0.460899	2	18	27583
9	Htm	37	20-30	1	M	1.4295965	0.6203053	1.2	7	11846	1.7958928	0.5517941	1.6	5	6428
10	Htm	1	40-50	0	F	1.2139962	0.5648585	0.8	10	116524	1.6898156	0.7668481	0.8	5	2278
11	Htm	23	40-50	0	F	1.7302394	0.624849	1.5	14	14372	1.7174224	0.4106176	1.5	6	9683
12	Htm	25	40-50	0	F	1.6376431	0.6063775	1.2	7	34896	1.5655613	0.2895653	1.5	3	3046
13	Htm	26	40-50	0	F	1.6196811	0.6163087	1.2	8	25832	1.5490224	0.4837442	1.5	3	23634
14	Htm	29	40-50	0	F	1.4371287	0.6231943	1.3	12	63883	1.5864946	0.4377215	1.5	6	23872
15	Htm	34	40-50	0	M	1.3904135	0.5731566	0.9	29	146612	1.6070911	0.4130346	1.5	14	22366
16	Htm	5	40-50	1	F	1.4387633	0.5962915	1.1	19	76663	1.4441496	0.4970225	1.1	9	9008
17	Htm	6	40-50	1	F	1.8658797	0.5676932	1.4	9	20923	1.7148893	0.4601921	1.5	5	25300
18	Htm	8	40-50	1	F	1.168294	0.5400451	0.8	16	72469	1.5931658	0.4029096	1.5	6	47087
19	Htm	9	40-50	1	F	1.778699	0.637	1.3	29	73710	1.8036171	0.5413188	1.5	17	58196
20	Htm	12	40-50	1	F	1.3405977	0.6294698	1	20	36859	1.6933026	0.5347083	1.5	10	22860
21	Htm	21	40-50	1	F	1.2815429	0.5566132	0.8	20	61554	1.5752298	0.6261303	1.1	13	43839
22	Htm	24	40-50	1	F	1.5755169	0.6267019	1.4	8	14169	1.6065556	0.5418142	1.5	6	60240
23	Htm	36	40-50	1	F	1.3199224	0.6279711	0.7	10	24254	1.6368883	0.5975167	1.3	6	34309
24	Htm	3	40-50	1	M	1.5410914	0.6502171	0.8	14	22737	1.4317827	0.5768778	1.1	7	13715
25	Htm	14	40-50	1	M	1.274195	0.5554318	0.9	21	66630	1.7839853	0.5008026	2	13	50890
26	Htm	17	40-50	1	M	1.7039578	0.7254274	1.1	12	5205	1.3755842	0.5628204	0.9	6	11681
27	Htm	22	40-50	1	M	1.6577847	0.5983183	1.6	4	16783	1.3483157	0.5379818	1.1	1	18762
28	Htm	35	40-50	1	M	1.7113351	0.5873117	1.6	13	53268	1.8129628	0.4558271	1.5	5	18831
29	Htm	13	60-70	1	F	2.2296224	0.5123361	2.2	14	22510	2.161881	0.4819218	2.1	9	24190
30	Htm	7	60-70	1	M	1.3757585	0.6166781	0.8	17	193227	2.0997944	0.3650901	2.1	11	92857
31	Htm	11	60-70	1	M	1.6503994	0.5623149	1.3	32	29040	1.8175492	0.4922452	2.1	12	68687
32	Htm	18	60-70	1	M	1.5897008	0.5842963	1.6	11	18817	1.46083	0.4224178	1.5	7	92167
33	Htm	19	60-70	1	M	1.3711808	0.5370734	1.4	25	30490	1.5975021	0.4603993	1.5	13	40593
34	Htm	20	60-70	1	M	1.7464041	0.5430589	1.7	5	39419	2.0209816	0.4204375	2.1	4	19746
35	Htm	32	60-70	1	M	1.3485503	0.5971186	0.9	9	33734	1.7518723	0.61507	1.3	4	7904

Incidence of Driving in the Near Region of the Proximity Space

The near region is that region of the proximity space that is next to a crash at R = 0 and RDot < 0. Table 17 presents the probability for each driver that that driver will operate in the near region. For ACC driving, the probability of being in the near region is 0.01 or less for all drivers. For manual drivers, there are drivers with a probability of being in the near region exceeding 0.04. In particular these are drivers 2, 5, and 25 as listed in the tables. Examination of Table 16 indicates that these drivers all have headway time margins less than one second. In fact, there appears to be a good correlation between a short MLV for headway time margin and a relatively high probability of operating in the near region (as one might anticipate).

In general the individual data can be used to identify those drivers that have a tendency to drive manually at short headway time and come relatively close to the preceding vehicle. However, for all drivers the use of ACC greatly reduces the likelihood of driving in the near region.

Table 17. Individual driver's probability for operation in the "Near" region

No.	Measure	ID	Age	User	Sex	Transition	Probability	True	False	Trips	Transition	Probability	True	False	Trips
						Manual Driving					***ACC Driving***				
1	Near	27	20-30	0	F	14	0.011	251	22531	5	17	0.006	166	28471	5
2	Near	31	20-30	0	F	308	0.046	4401	90446	13	1	0.000	2	5001	9
3	Near	38	20-30	0	F	4	0.002	20	9759	8	0	0.000	0	18370	6
4	Near	4	20-30	0	M	305	0.036	7651	203106	27	35	0.010	790	80816	20
5	Near	10	20-30	1	F	211	0.054	6246	108911	24	5	0.002	26	15757	11
6	Near	15	20-30	1	F	78	0.011	758	71072	7	13	0.004	220	59830	5
7	Near	30	20-30	1	F	32	0.006	238	38056	15	4	0.002	48	21376	9
8	Near	33	20-30	1	M	109	0.011	793	71204	31	7	0.000	17	59737	18
9	Near	37	20-30	1	M	30	0.017	266	14991	7	7	0.002	29	14469	5
10	Near	1	40-50	0	F	133	0.029	4196	139898	10	1	0.001	4	6113	5
11	Near	23	40-50	0	F	20	0.004	109	29738	14	10	0.001	25	25474	6
12	Near	25	40-50	0	F	9	0.002	109	52357	7	0	0.000	0	3819	3
13	Near	26	40-50	0	F	23	0.007	229	31804	8	9	0.002	71	33589	3
14	Near	29	40-50	0	F	105	0.025	2328	89915	12	4	0.001	26	32077	6
15	Near	34	40-50	0	M	142	0.008	1574	189779	29	15	0.004	137	31230	14
16	Near	5	40-50	1	F	104	0.010	1106	111697	19	7	0.006	83	13581	9
17	Near	6	40-50	1	F	15	0.002	56	25892	9	2	0.000	5	43474	5
18	Near	8	40-50	1	F	69	0.015	1687	111620	16	6	0.000	32	66272	6
19	Near	9	40-50	1	F	94	0.007	886	122858	29	40	0.003	329	119648	17
20	Near	12	40-50	1	F	80	0.016	815	48828	20	4	0.001	22	39820	10
21	Near	21	40-50	1	F	96	0.020	1253	61484	20	19	0.002	147	94424	13
22	Near	24	40-50	1	F	33	0.021	406	18696	8	28	0.003	323	112285	6
23	Near	36	40-50	1	F	75	0.023	970	41394	10	18	0.003	151	52593	6
24	Near	3	40-50	1	M	84	0.030	1114	36116	14	7	0.007	147	20661	7
25	Near	14	40-50	1	M	214	0.063	4552	67502	21	46	0.007	624	85234	13
26	Near	17	40-50	1	M	28	0.030	296	9483	12	8	0.004	68	18721	6
27	Near	22	40-50	1	M	4	0.003	76	28760	4	4	0.004	90	25002	1
28	Near	35	40-50	1	M	42	0.003	260	95125	13	9	0.001	43	36999	5
29	Near	13	60-70	1	F	47	0.004	217	48614	14	56	0.006	306	53020	9
30	Near	7	60-70	1	M	242	0.019	5515	280208	17	20	0.002	248	136203	11
31	Near	11	60-70	1	M	44	0.011	407	37859	32	17	0.001	115	115837	12
32	Near	18	60-70	1	M	31	0.011	259	22930	11	64	0.003	372	128533	7
33	Near	19	60-70	1	M	64	0.025	1014	39830	25	17	0.002	150	59928	13
34	Near	20	60-70	1	M	30	0.004	198	55999	5	14	0.002	76	45734	4
35	Near	32	60-70	1	M	89	0.031	1577	49389	9	3	0.000	6	14003	4

4.1.6 How well does this ACC system perform its functions?

The ACC system is a controller that closes an inner loop on vehicle velocity and, when a target vehicle is detected ahead, also commands velocity in such a way as to close an additional outer loop on range. When operating in the headway control mode of ACC engagement, the commanded speed, V_c, is computed to satisfy the linear range versus range-rate relationship lying on the so-called *dynamics line* described earlier in section 2. We can examine the nominal performance of the ACC controller by considering how close the vehicle response matches that which would lie precisely on the dynamics line. Response, in this context, is characterized by instantaneous "errors" such that the range value lies a measured distance above or below the line and such that velocity corresponds to a range rate that is to the right or the left of the line.

Quality of the ACC System as a Velocity Controller

When there is no target vehicle ahead, the speed control performance of the test vehicle is simply determined by the OEM cruise-control system provided with the Chrysler Concorde. When the ACC system operates in the headway-control mode, however, we are interested to determine its velocity-control performance as the system modulates throttle and transmission shift commands to converge toward the selected nominal headway condition. The quality of velocity control during headway-constrained operations is presented in Figure 71 in terms of the velocity error (V_c - V), shown in the black bars. For comparison, the figure also shows the (V_c - V) measure in gray for the speed-control mode of ACC operations, when there is no target within range.

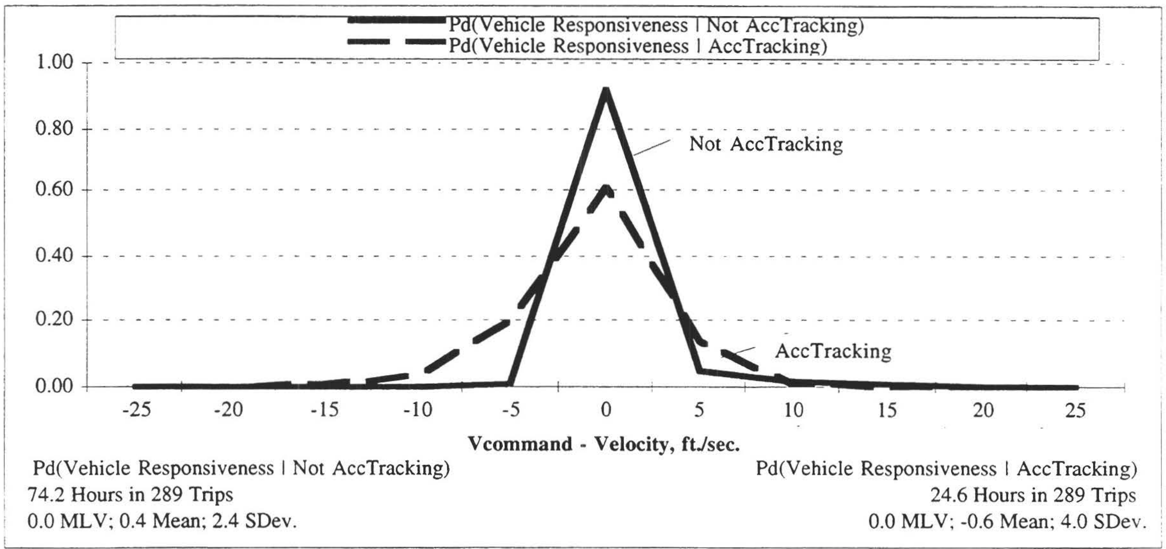


Figure 71. Vehicle responsiveness in headway mode versus speed-control mode

We see that the speed error is controlled around the zero value (i.e., within +/- 2.5 ft/sec of the commanded speed) approximately 92% of the time when in the simple speed-control mode and only about 61% of the time when in the headway ("ACC Tracking") mode of control. The ACC headway controller appears to spend approximately 39% of the time outside of this band, with some skew toward negative-polarity (i.e., approaching-type) errors when overtaking another vehicle. Clearly, the occurrence of cut-in, approach from higher speed, and braking-ahead transients serves to cultivate instantaneous velocity errors that look rather substantial, although the subjective reactions of the driver-participants do not imply that these variations are problematical.

Quality of the ACC System as a Range Controller

The quality of the range control is expressed in terms of the difference between the instantaneous range value, R, and the corresponding range value lying directly on the dynamics line, for the prevailing value of RDot. Shown in Figure 72, the probability density diagram of "Tracking Error" is presented between the values of -30 ft and +30 ft of distance error, bracketed by so-called *end bins* which reveal the respective probabilities of values at or below -35 ft and at or above +35 ft.

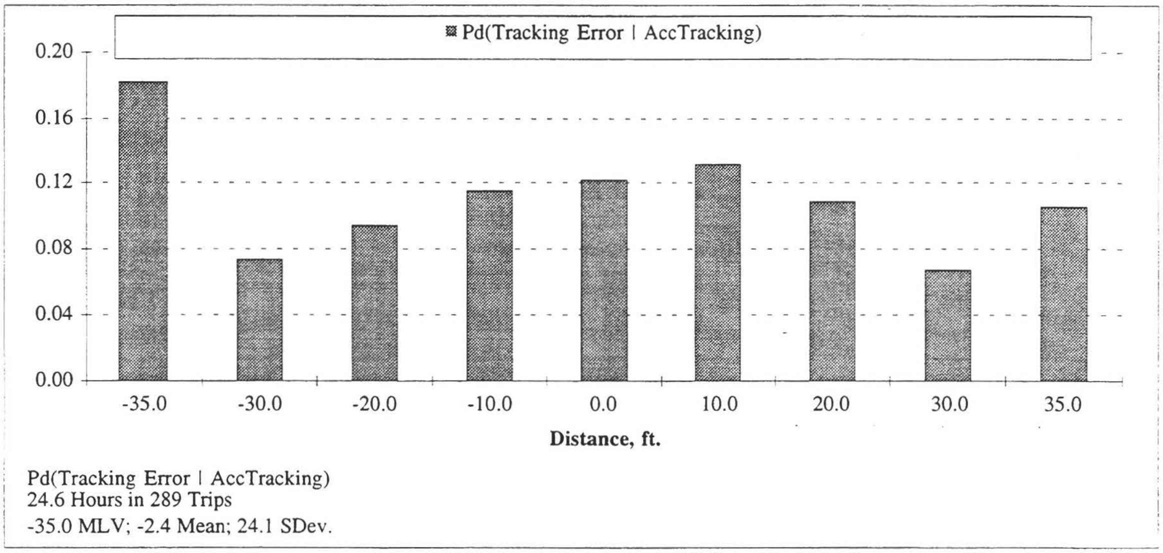


Figure 72. Probability density of range tracking error

It may at first seem surprising that 18% of the time the tracking errors are at or below -35 feet. Indeed, the general pattern of the data from +10 feet through -30 ft suggests that the left-side end bin contains negative distance errors that are substantially larger than -35 feet. If these errors were occurring while range rate was near zero, they would amount to wholesale undershoots of the driver-selected value of headway time, implying a good deal of headway conflict. But the fundamental dynamics of the problem are such that large negative values in tracking error will occur early in the process of closing on a slower-moving vehicle from long range. In such transients, the R-versus-RDot trajectory will drop substantially below the dynamics line after it first crosses it, especially if the overtaking velocity is initially large—for example -10 mph and greater. As the vehicle slows down, the tracking error subsides and often goes to zero before reaching the zero RDot condition. Thus, it is possible in a given closing transient to swing through instantaneous tracking errors as large as, say, 70 feet below the dynamics line and still arrive at RDot=0 with no undershoot of the target headway value.

The figure also shows that substantial positive values of tracking error occur, including some from the not-infrequent case when others cut-in at a positive value of RDot and subscribe growing values of positive distance until the system falls out of the headway control mode and proceeds toward its set speed.

Further study of the performance of the ACC system as a controller require processing of time history data. However, the results in the next section (section 4.2) indicate that drivers are comfortable with the performance of this system. Perhaps this is because the system controls headway-time margin (R/V) with little overshoot. An example time history for headway-time margin is shown in Figure 73. (This figure is from one of the characterization tests described in Appendix A.) Examination of the figure shows that the ACC vehicle closes in on the preceding vehicle in a smooth manner with almost no hunting or oscillation.

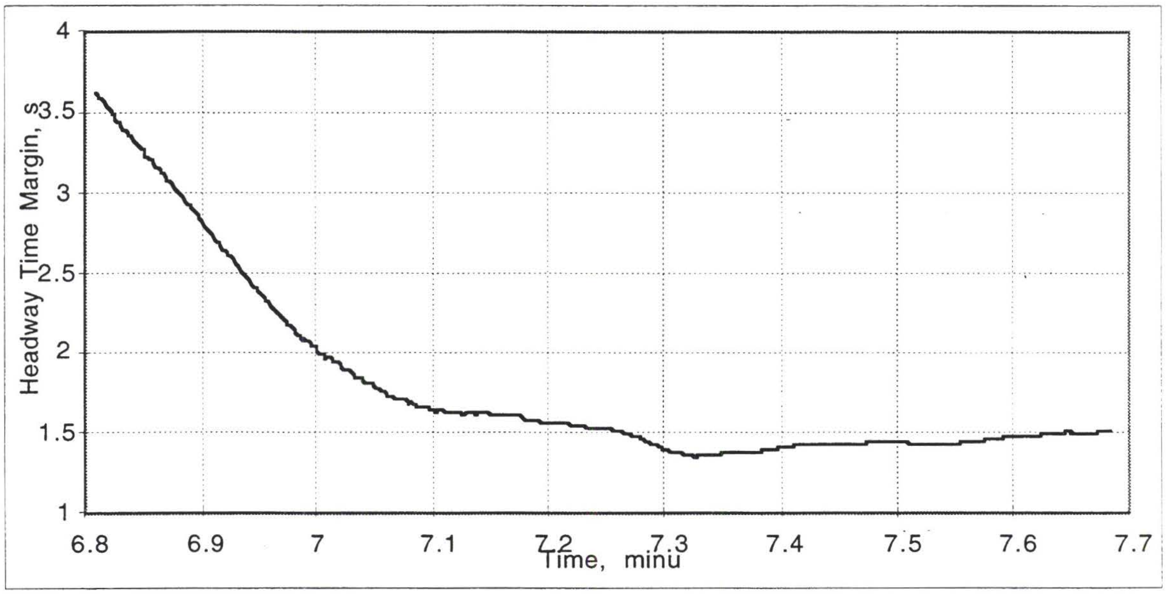


Figure 73. Headway-time margin data recorded in a characterization test

4.2 Results and Findings from Subjective Data

The subjective results and findings presented here pertain to operational issues concerning (1) the levels of comfort, convenience, and safety drivers associate with ACC, (2) driver concerns with ACC operation, and (3) the driver's ability to adapt to different driving situations while using ACC (see section 1.1).

The recovery of subjective results was completed when a participant returned the research vehicle to UMTRI. Subjective data in the form of a questionnaire was obtained from each participant. In addition, each participant was de-briefed by a researcher in order to gauge the participant's reaction to the research vehicle, ACC system, and experimental protocol. At this time participants were reminded that focus groups will be held, and an attempt was made to schedule the participant's attendance at the first available focus group. Participants in the field test were not required to attend focus groups, but their attendance was urged. The focus group setting also provided for open and earnest discussion among participants, permitting them to share ideas and concerns related to ACC.

Log books, which had been given to each participant to record significant events, were retrieved when the research vehicle was returned. A researcher examined the comments made in the log book as the participant completed the questionnaire. All entries into the log book were discussed with the participants.

4.2.1 Questionnaire Results

The complete list of the questions in the questionnaire is provided in Appendix C. For each question, statistics regarding the participants' answers are provided. This section includes excerpts from the appendix, grouped by topics that the questionnaire addresses.

Comfort and Convenience: In general, participants have rated the ACC system highly with relation to driving comfort. Most participants, 31 of 36, reported feeling comfortable using the system in one day or less. The remaining five participants reported feeling comfortable using the system after a few days (see questions 1 and 2 in Table 18). However, participants reported that they would become more comfortable with the system were they given additional time to use it (see question 4 in Table 18). The ACC system was also favorably rated on several other dimensions (see questions 6 through 10 in Table 18). When asked to rank the three possible modes of operation on the basis of comfort participants ranked the use of ACC first, followed by conventional cruise control and manual control (see question 11 in Table 18). Similar results were observed when participants were asked to rank the three modes of operation on the basis of convenience (see two items of question 11 in Table 18).

Table 18. Summary of comfort and convenience questions

Question	Answer	
1. How comfortable did you feel driving the car using the ACC system?	**Rating**	1 to 7 (most comf.)
	Mean	6.0 (s = 1.6)
2. How long did it take you to be comfortable using the ACC system?	15 after an hour or less 16 after first day 5 after a few days (none needed more) (none were never comfortable)	
4. How likely is it that you would have become more comfortable using the ACC system given more time?	**Rating**	1 to 7 (most likely)
	Mean	5.2 (s = 2.3)
6. How comfortable were you using the ACC system in the rain or snow? *(Note: 3 never experienced rain or snow)*	**Rating**	1 to 7 (most comf.)
	Mean	5.2 (s = 1.5)
7. How comfortable were you using conventional cruise control in the rain or snow?	**Rating**	1 to 7 (most comf.)
	Mean	5.1 (s = 1.6)
8. How comfortable were you using the ACC system on hilly roads?	**Rating**	1 to 7 (most comf.)
	Mean	5.6 (s = 1.5)
9. How comfortable were you using the ACC system on winding roads?	**Rating**	1 to 7 (most comf.)
	Mean	5.5 (s = 1.6)
10. How comfortable would you feel if your child, spouse, parents or other loved ones drove a vehicle equipped with ACC?	**Rating**	1 to 7 (most comf.)
	Mean	6.0 (s = 1.5)
11. Compare three operation modes (Manual, Conventional Cruise, ACC) for comfort	**Rank**	1 to 3 (least comfort)
	Mean	2.8 (Manual, s=.5) 2.0 (Conv. Cruise, s=.5) 1.2 (ACC, s=.5)
Compare three operation modes (Manual, Conventional Cruise, ACC) for convenience	**Rank**	1 to 3 (least convenient)
	Mean	2.9 (Manual, s=.4) 1.9 (Conv. Cruise, s=.4) 1.2 (ACC, s=.5)

Safety: With regards to safety, participants have reported the ACC system to be safe to use (see Question 28 in Table 19), and that use of the system may actually increase driving safety (see Question 29 in Table 19). When asked to rank the three possible modes of operation on the basis of safety participants ranked the use of manual control first, followed closely by ACC (see Question 11 in Table 19). Participants also reported driving most cautiously when using ACC relative to conventional cruise control and manual control (see Question 14 in Table 19), without experiencing "unsafe" following distances (see Question 25 in Table 19). In addition, very few system failures were reported (see Questions 34 and 35 in Table 19). Finally, participants reported being both aware and responsive to surrounding traffic when using the ACC system (see Questions 18 and 19 in Table 19).

Table 19. Summary of safety questions

Question	Answer	
11. Compare three operation modes (Manual, Conventional Cruise, ACC)	**Rank**	1 to 3 (least safety)
	Mean	1.5 (Manual, s=.8) 2.6 (Conv. Cruise, s=.6) 1.8 (ACC, s=.6)
14. Under which mode of operation do you drive most cautiously?	**Rank**	1 to 3 (least cautious)
	Mean	2.1 (Manual, s=1.0) 2.0 (Conv. Cruise, s=.6) 1.8 (ACC, s=.9)
18. Driving the ACC system, compared to manual driving, did you find yourself more or less aware of the actions of vehicles around you?	**Rating**	1 to 7 (most aware)
	Mean	5.8 (s = 1.3)
19. Driving the ACC system, compared to manual driving, did you find yourself more or less responsive to actions of vehicles around you?	**Rating**	1 to 7 (most responsive)
	Mean	5.3 (s = 1.5)
25. How often, if ever, did you experience "unsafe" following distances when using the ACC system?	**Rating**	1 to 7 (least frequent)
	Mean	6.3 (s = 1.0)
28. How safe did you feel using the ACC system?	**Rating**	1 to 7 (very safe)
	Mean	6.4 (s = .9)
29. Do you think ACC is going to increase driving safety?	**Rating**	1 to 7 (strongly agree)
	Mean	5.8 (s = 1.3)
34. While using the ACC system, how often, if ever, did the system fail to detect a preceding vehicle?	**Rating**	1 to 7 (never)
	Mean	6.2 (s = 1.0)
35. While using the ACC system, how often, if ever, did the system produce false alarms (i.e., detect a vehicle when none existed)?	**Rating**	1 to 7 (never)
	Mean	6.4 (s = .7)

Willingness to Purchase: When asked to provide an overall ranking of the three modes of operation for personal use, participants ranked ACC first with conventional cruise control and manual control following a distant second and third (see Question 38 in Table 20). Participants also reported being very willing to purchase an ACC system in their next new car (see Question 39 in Table 20), but were frequently reluctant to provide an amount they would be willing to pay (see Question 40 in Table 20). Participants were also willing to rent an ACC equipped vehicle (see Question 41 in Table 20).

Table 20. Summary of questions regarding willingness to purchase

Question	Answer	
38. Rank, in order of preference, the following modes of operation for personal use	**Rank**	1 to 3 (least desirable)
	Mean	2.5 (Manual, s=.8) 2.2 (Conv. Cruise, s=.7) 1.4 (ACC, s=.6)
39. Would you be willing buy an ACC system in your next new vehicle?	**Rating**	1 to 7 (very willing)
	Mean	6.5 (s = .9)
40. Approximately how much would you be willing to spend for this feature in a new vehicle?	**Rating**	
	Mean	$410 (s = $333)
41. Would you be willing to rent a vehicle equipped with an ACC system when you travel?	**Rating**	1 to 7 (very willing)
	Mean	6.7 (s = .7)

Comparison with an Objective Measure: Participants were asked to compare the modes of operation in which they drove the fastest (see Question 12 in Table 21). The result of the ranking for conventional cruise control and ACC use were identical. Interestingly, the objective measure of mean velocity for the two different control modes was nearly identical (with a conventional cruise control mean of 92.62 ft/sec and an ACC mean of 92.90 ft/sec).

Table 21. Summary of questions regarding comparison with an objective measure

Question	Answer	
12. In general, under what mode of operation did you feel like you drove fastest?	**Rank**	1 to 3 (slowest)
	Mean	1.4 (Manual, s=.6) 2.3 (Conv. Cruise, s=.7) 2.3 (ACC, s=.7)

4.2.2 Log Entries and Participant Debriefing

Upon return of the research vehicles, the log books were reviewed and participants were debriefed after they completed the questionnaire. The issues discussed in the debriefing were largely the result of comments written by the participants in the log books (some very detailed), as well as comments written in the margins of the questionnaire. All entries into the log books, comments written into the questionnaire margins, and notes made by the researcher during the debriefing are being transcribed for future evaluation.

4.2.3 Focus Group

Three sessions of focus group have been held to date, with a total of 15 participants in attendance. These sessions are video taped, as well as audio taped, and transcriptions are being prepared. In each of the three sessions the same 17 questions have been asked. While the responses vary considerably, the overall response to having experienced the ACC system has been very favorable. Because of the limited number of participants to date in the focus group sessions, no detailed summary is provided here. However, current indications are that additional useful information on driver views and experience will be obtained when the responses to the following 17 questions are considered.

Q1: In what situations was adaptive cruise control most useful?

- Consider traffic density, road type, and weather conditions.
- What features of adaptive cruise control did you find most beneficial?

Q2: When was the adaptive cruise control system least useful?

- Consider traffic density, road type, and weather conditions
- What additional features would you like to have with adaptive cruise control?

Q3: How convenient did you find using adaptive cruise control?

- Was it difficult to learn to operate?

Q4: How similar to your own driving behavior do you think the adaptive cruise control system operated?

- If the system was different, how did it differ from your driving behavior?

Q5: Did you feel comfortable with the headway distances available for use?

- Should they have been longer or shorter?
- Should there have been more levels?

Q6: Where the controls and display for the ACC system easy to use and easy to see.

- Were there other types of information you would like displayed?
- Where else might you place the controls/display?

Q7: What impact did adaptive cruise control have on your sense of comfort?

- Consider traffic density, road type, and weather conditions

Q8: Did the system ever make you feel too comfortable?

- Did you feel that you might fall asleep easily?

Q9: Did the system ever track false targets (i.e. cars in adjacent lanes)?

- Briefly explain the conditions under which this occurred.

Q10: Did the system ever track phantom targets (i.e. vehicles that did not exist)?

- Briefly explain the conditions under which this occurred.

Q11: Was there ever a situation when you didn't understand whether or not the system was working properly?

- Briefly explain.
- If so, what was your strategy?

Q12: What do you think of the adaptive cruise control system's rate of acceleration:

- when passing?
- when closing a gap?

Q13: What do you think of the adaptive cruise control system's rate of deceleration:

- in response to slower moving vehicles?
- in response to "cut-ins"?

Q14: When a difference in vehicle speeds required you to use the brake, was it difficult to learn when braking was required?

- Would an audible tone (warning) be useful?

Q15: What impact did adaptive cruise control have on your sense of safety?

- Consider traffic density, road type, and weather conditions
- Did you feel more or less safe driving with ACC as compared to manual driving?

Q16: When driving with ACC engaged, were you ever disturbed by an event involving a stopped vehicle -- and the fact that the ACC system does not respond to stopped objects?

- Do you feel the system should respond to stopped objects

Q17: Would a greater degree of ACC deceleration, using the brake system, have been helpful for dealing with a wider range of traffic situations?

4.3 Implications of Results for the Traffic System as a Whole

In this section, test results are examined for their preliminary (and fairly obvious) implications on the performance of the traffic system as a whole. The questions of system safety, traffic throughput, and fuel usage are addressed. This information provides a starting point for an expanded evaluation of ACC.

Implications for Safety

Although the overall Field Operational Test is configured to emphasize safety-related questions, the data processing to date can only give limited address to this subject.

First, the subjective responses by the driver/participants, reported in section 4.2, strongly suggest that from the drivers' perceptions of safety, no significant new risks were posed by the ACC system tested here. Or, stating it more rigorously, the perceptions acquired here during a limited, novelty-laden, phase of driving confirm that no significant safety hazards presented themselves. It is recognized, however that subtle but powerful safety issues may emerge only after developing long-term adaptation of driving behavior, a richer matrix of driving conditions, and perhaps the appearance of low-probability traffic conflicts and anomalies.

At this preliminary stage of FOT experience, we note the following properties of the system that might relate to safety (more details regarding these observations are provided later in this section):

- no crashes with ACC engaged
- no reported near-miss events
- no complaints of a proximate-hazard concern
- measured headway time (H_{tm}) with ACC is larger than H_{tm} without ACC
- relatively pleased responses despite an approximate variation of 10% in H_{tm}
- some comments revealing relaxed vigilance
- no significant note of problems encountered with stopped vehicles
- most complained about a sluggish resume acceleration (though it may have some safety implications, it is not a production feature)
- Hindrance (V/V_{set}) is virtually 1.0 in the current data (people seem to use the system almost exactly like CCC).

Quantitative data do provide some supplemental evidence of safety-related distributions. Shown in Figure 74, for example, the probability distribution of the "DecelAvoid" variable is shown for both manual and ACC-engaged operations for the filtered (i.e., trip length > 10 miles, avg. speed > 30 mph) set of trips. The DecelAvoid measure expresses the minimum value of deceleration needed at any moment to resolve the current headway conflict, whenever a target vehicle is detected ahead. The data show probability distributions dominated by values near zero (actually, below 0.0075 g's). Comparing the probability values for ACC and manual modes of control at this lowest g-level bar, we note that ACC shows a probability of 0.97 compared to 0.935 for manual driving. The remaining probabilities falling at higher g levels (e.g., 1.00 - 0.97 = 0.03 for ACC and 1.00 - 0.935 = 0.065 for manual) make it clear that the combination of driver choice of ACC-suitable conditions and the sustained control activity of the ACC system avail it a much more benign conflict environment than with manual driving.

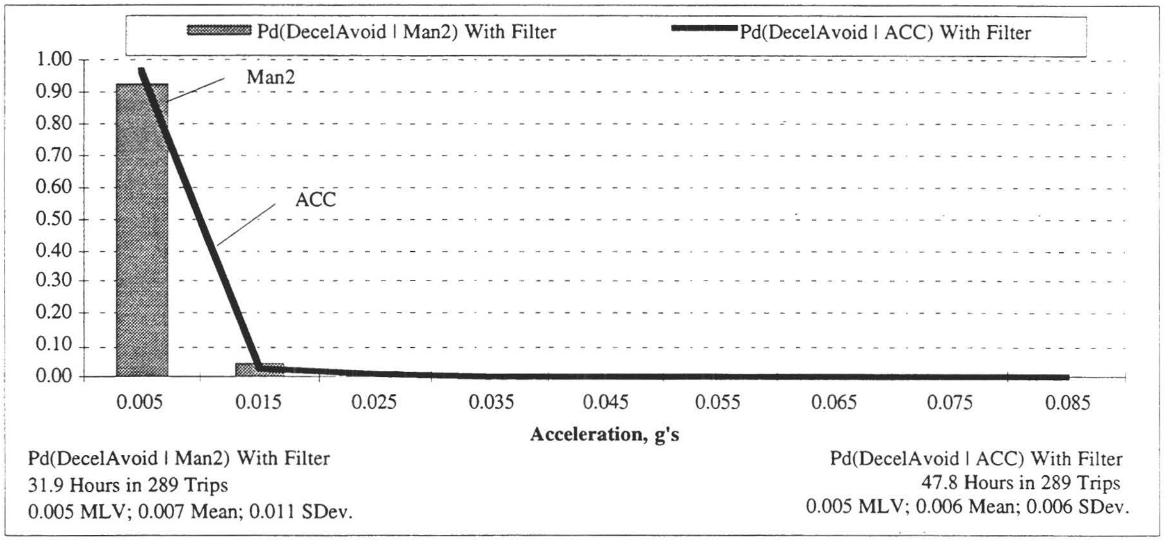


Figure 74. Probability density of Decel-to-Avoid in manual and ACC driving

Moreover, deceleration levels above approximately 0.05 g's appear in much less than one-half of one percent of travel time during these higher speed trips. Thus, we see again the remarkably low incidence of elevated deceleration levels appearing normally on freeways. On the one hand, this finding seems to help explain much of the satisfaction that drivers report with an ACC system that is limited to a 0.07g level of authority. At the same time, it speaks a sobering caution for automatic systems designed to deliver much higher levels of deceleration, for example the 1/4-g levels targeted by pending ACC systems in Europe. That is, the occurrence of 1/4-g braking on a freeway is so rare that its automatic actuation must be done only when warranted by a very high confidence level that the rare, but necessary, response is indeed called for.

Distributions of time-to-impact computed for manual and ACC driving when targets were detected ahead, are compared in Figure 75. We first see that values below 3 seconds occur less than 1% of the time. Further, manual operations result in almost twice the incidence of times-to-impact that are within 8 seconds. While, again, this contrast results from both the drivers' appraisal of conditions suitable for ACC operation and from the controller's performance within those conditions, the net outcome is that ACC operates with less of the conflict that connotes impact risk.

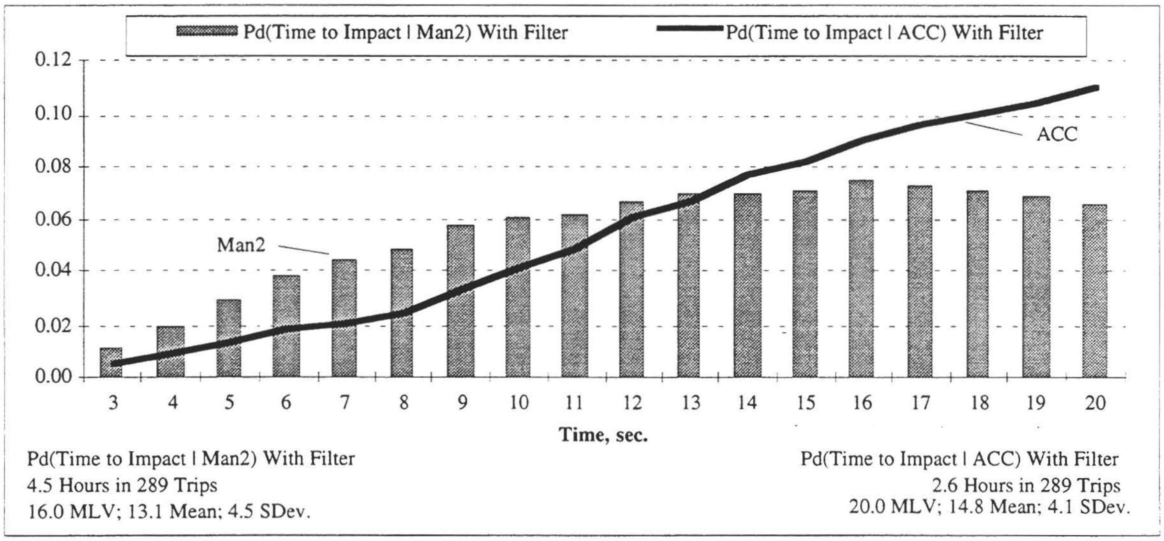


Figure 75. Probability density of Time-to-Impact in manual and ACC driving

Clearly, much more needs to be done to examine the safety implications of this field operational test. It is expected that more instruction will come from subjects operating the vehicle for 5-week periods and from the careful examination of results in the time domain, as found in the serial stream of data by the detection of transitions in control state.

Implications for Traffic Flow

At any given moment in any local traffic environment of southeastern Michigan, only a single ACC-equipped vehicle is likely to have been present, if any. Thus, no macro detection of traffic during this test could possibly have captured the implications of ACC operation for the traffic flow that may prevail in the future, at high penetrations of ACC vehicles. Accordingly, we must suggest various traffic-impact inferences from piecemeal observations of the immediate experience of the individual equipped vehicle.

In this section, a few differing views of the driving experience are presented as they appear to address some traffic-related variables. In the end, of course, we hope to discern the possible impact of ACC operations on the throughput capacity of freeways at moderate to heavy levels of loading. At the light end of the traffic loading spectrum, the traffic will be expected to move at rated (regulated) speeds, or above, notwithstanding the presence or absence of ACC. At the other, very congested, end of the spectrum, ACC is assumed not to be chosen as a control mode because of the high levels of conflict which seem to induce manual-only operation.

Shown in Figure 76 is the bottom-line illustration of apparent traffic throughput impact, based upon the filtered trips. The figure presents the so-called Flow variable computed continuously within the instrumentation package and stored as the Flow histogram. The Flow variable is defined by the ratio, V/(R + L), where V and R represent the host velocity and range variables addressed many times previously and L represents the nominal length of the passenger car. The Flow measure is expressed as the number of vehicles per second passing a given point on the highway and is computed only when a target vehicle has been detected ahead.

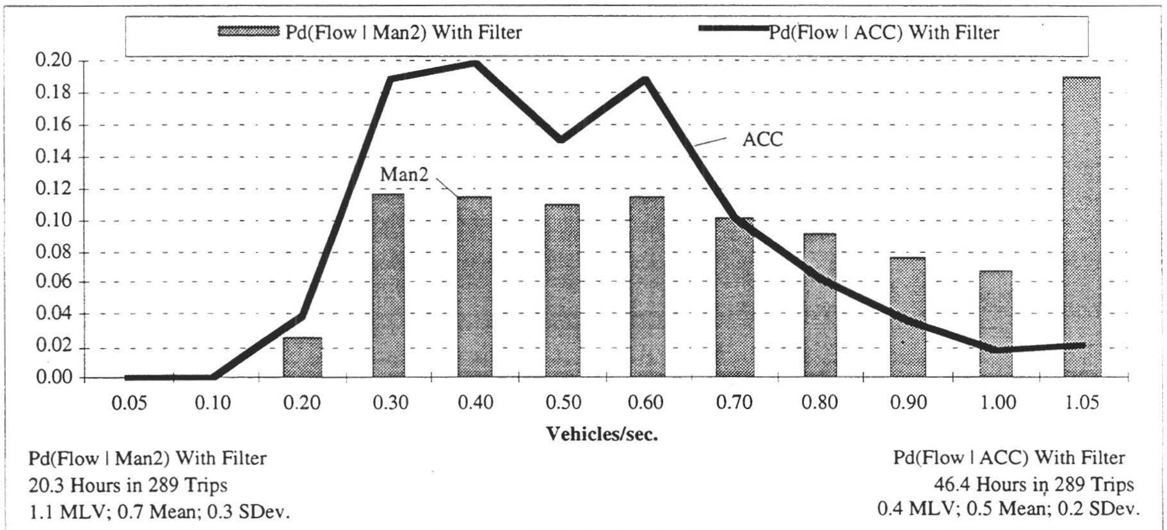


Figure 76. Probability density of Flow in manual and ACC driving

Figure 76 shows that the ACC system exhibits generally lower values of the Flow variable than are accrued under manual driving. The mean values of Flow under the ACC and manual modes of control are 0.52 and 0.59, respectively. Clearly, most of the contrast between the Flow measures under the two modes of control is attributed to the large (18%) block of manual results lying in the "end bin" at 1.05 vehicles/second and above. This result appears to be due to the short values of headway range that were often employed during manual driving.

While the data appear at first blush to imply a negative impact of the ACC function on highway capacity, the apparent preference for ACC usage under traffic conditions that are rather free-flowing suggests that no impact on heavier, capacity-determining, traffic flow would be encountered because the system would be turned off. Recapitulating results presented earlier in the report to make this point, Figure 77 shows again that ACC is used almost exclusively when traffic speeds (i.e., Vp values) are higher, above 80 ft/second or so. Thus, it would appear that the longer range values kept during ACC operation, as shown again in Figure 78, are associated with high-speed, relatively free-flowing traffic for which the capacity limitations of the highway are more or less moot.

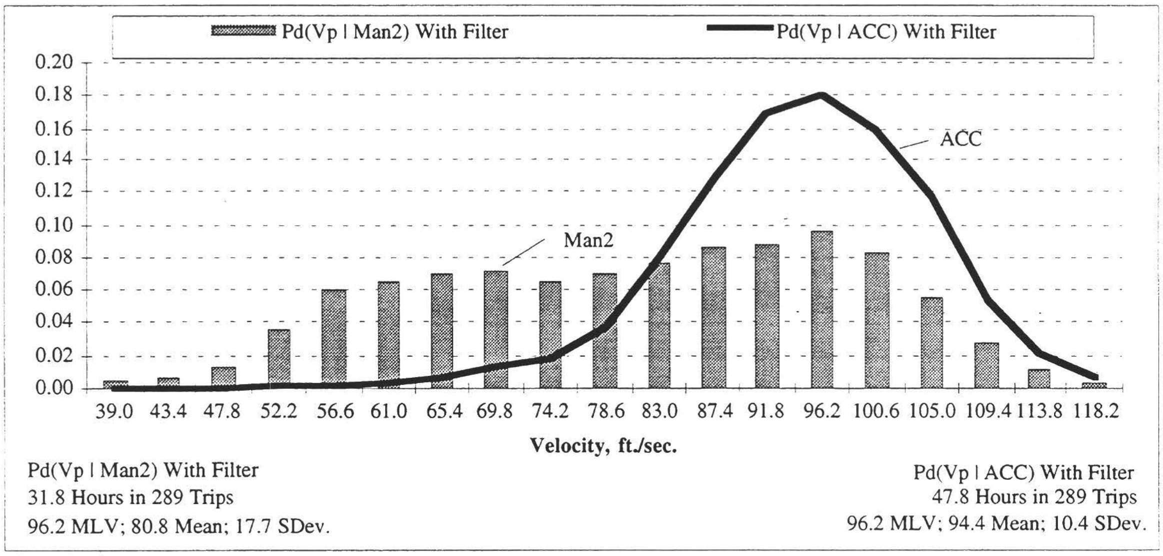


Figure 77. Probability density of traffic speed (V_p) in manual and ACC driving

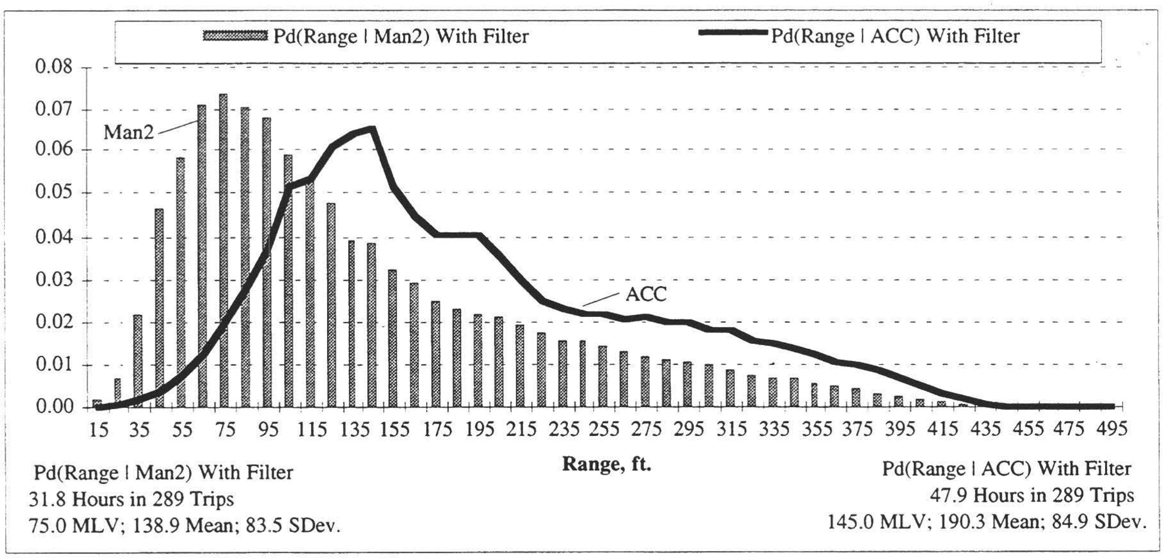


Figure 78. Probability density of Range in manual and ACC driving

Manual driving, on the other hand, includes much more operation at the reduced travel speeds (Figure 77) and shorter range values (Figure 78) that appear commonly in quite congested traffic. Thus, it appears, that the driver/participants in this field test opted to control the vehicle manually in virtually all of the high-conflict situations in which the ultimate capacity of the highway becomes an issue.

As an associated traffic issue, Figure 79 presents the so-called "Hindrance" measure for both conventional cruise (CCC) and ACC operations. This measure expresses the ratio of the host vehicle velocity, V, to the set speed, Vset. With ACC engaged, the ratio of these values indicates how much the prevailing traffic conditions have impeded the driver from continuously sustaining the set speed value due to headway control.

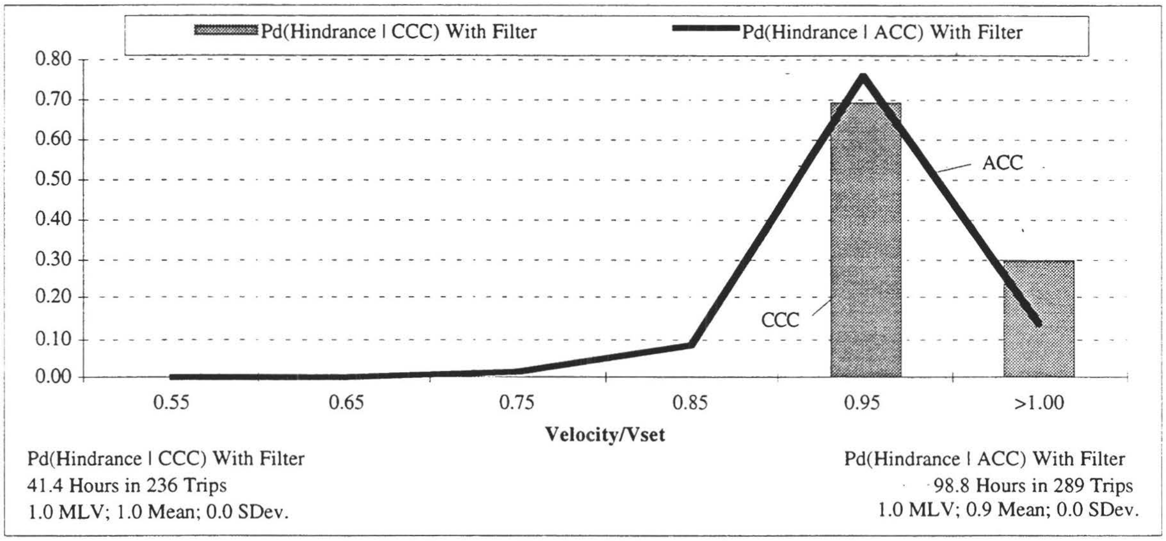


Figure 79. Probability density of Hindrance in manual and ACC driving

We see that the ACC system spends approximately 75% of the time at approximately 95% of its Vset value. This result seems to be partially explained by the testimony of many participants that they tend to select Vset values rather near to the prevailing speed of traffic, thus not significantly falling below Vset even when they encounter a headway-control episode due to a vehicle ahead. Such a pattern of Vset selections is noted to be very nearly mirrored to the learned practice of selecting set speeds with conventional cruise control. That is, CCC is simply unusable in the presence of other traffic unless one adjusts the set speed to virtually match that of nearby traffic.

Considering the CCC data in the figure, the results falling below a hindrance value of 1.0 are something of a puzzle since the system is only a speed controller. Thus, the 68% of all CCC time spent around the hindrance value of 95% can only depict control error of some sort, as if the system has a bias for negative errors relative to the Vset value. Closer examination of this result will be given later in the study.

Implications for Fuel Usage

Shown in Figure 80 is a plot of the longitudinal acceleration histogram for the host vehicle in both the manual and the ACC-engaged conditions. The data show that the ACC system keeps more than 85% of its positive and negative accelerations within 0.01 g's or less, while manual operations result in only about 56% of all travel within the same band. Since the implied speed fluctuations are opposed by speed-squared aerodynamic drag and other nonlinear losses, they imply reduced fuel economy. Accordingly, the preliminary results imply that ACC driving should cause fuel usage to decline relative to manual driving.

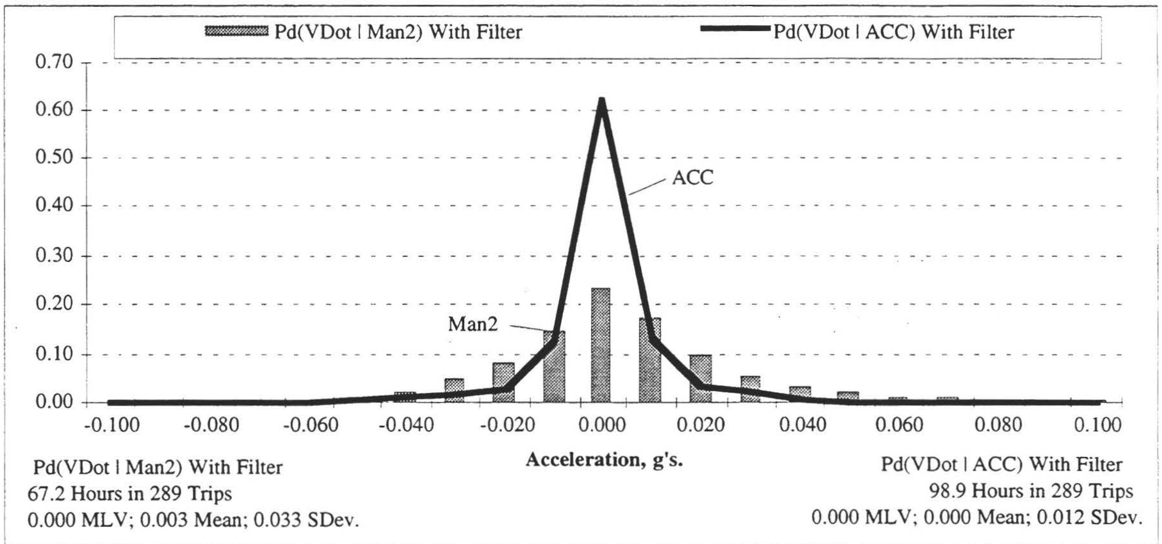


Figure 80. Probability density of Acceleration in manual and ACC driving

5. CONCLUDING STATEMENTS

5.1 Summary of Preliminary findings.

At this stage of the Field Operational Test, all the various systems are performing successfully. The cars run. The sensors work well but they are prototypes that require maintenance and attention, so sensor checking is needed to keep the vehicles in proper working order. The data acquisition system, although complex, with two computers and video, GPS, and cellular phone equipment as well as data storage and processing functions has performed well. The control algorithms, which are quite simple, perform reliably and the drivers indicate that they find the ACC system to be comfortable and convenient to use.

The preliminary results from the initial FOT experience indicate that drivers tend to enjoy driving with ACC. For the most part they find it comfortable and convenient. It seems to reduce stress, particularly on longer trips. The objective data indicate that the ACC system causes drivers to travel at longer clearance gaps than those they use when driving manually. This appears to be not only because the ACC maintains longer headways but also because drivers do not choose to use ACC when they see driving conditions that compel them to use short headways. (This tendency to drive manually when there is competition for gap space on the highway is even more apparent for conventional cruise control.) For ACC, the net effect is that risky driving situations involving short headways are much more likely to occur during manual driving than they are to occur during ACC driving. In addition the ACC system slows the vehicle when a slower preceding vehicle is encountered, thereby drawing the driver's attention to the forward scene and thereby contributing to the driver's feeling of comfort and safety.

An interesting finding with respect to driver age is that drivers from different age groups tend to prefer different amounts of clearance time to the preceding vehicle. This ACC system provides the driver with the means for selecting farther, closer, or an intermediate headway clearance. These settings correspond to 2.0, 1.0, and 1.4 seconds of clearance time, respectively. Given these choices, the younger drivers tended to use 1.0 and 1.4 seconds of headway with almost no use of 2.0 seconds of headway clearance while the older drivers almost never used 1.0 seconds of headway and they have a preference for 1.4 or 2.0 seconds. Apparently an adjustable headway clearance feature will aid in encompassing the preferences of the driving population.

With regard to the difference between ACC driving and manual driving, the preliminary results indicate that:

- Drivers tend to do riskier, more demanding driving at short headway in the manual mode of headway control.
- They use the ACC system when they can travel at highway speeds without frequent interruption.
- Drivers select set speeds at the speed they wish to travel thereby operating much like they would with conventional cruise control when there is not a slower moving preceding vehicle.
- Younger drivers tend to use shorter headway time selections than older drivers do when using ACC. (This fits with the behavior of these age groups when driving manually.)
- The incidence of near approaches to preceding vehicles is much less when ACC is used. (This is because drivers tend to drive closer manually and also because drivers do not tend to use ACC when they anticipate that close headway may be likely.)

The results so far support the following propositions:

- To the extent that remaining further from the preceding vehicle is safety beneficial, ACC driving will be safer than manual driving is now.
- Since drivers do not use ACC when the situation is risky, or when they want to take risks, ACC might not have much influence on the accident record (or traffic flow for that matter).

However, there is the possibility that ACC will provide more uniform headway and speed control and thereby facilitate greater flow at capacity. There is also the possibility that ACC will provide the driver with a deceleration cue that will reduce the incidence of rear-end collisions in which the driver is inattentive.

Drivers find the ACC system easy to use, and they are comfortable using it. They seem to understand what the ACC system does and when they will enjoy using it.

5.2 Anticipated Amount of Information and Its Significance.

The current projection for the total number of drivers participating in the study is 108. This sample size is based upon the following assumptions:

- At least eight vehicles will be fully operational for the duration of the field operational test.
- The turnaround of cars from one participant to the next will not exceed two working days.
- Data collection will continue up to, and including, the first week of September 1997.

On March 18, 1997, data collection for the first 47 drivers is expected to be completed. Of these, 46 drivers are two-week exposures and 1 is a five-week exposure. Beginning with the week of March 9, 1997, and ending the first week in September 1997, and assuming eight operational cars, there are 200 car weeks (25 weeks times eight vehicles). We are currently projecting that at the end of the project there will be data on 14 drivers per combination of age group (20 to 30, 40 to 50, 60 to 70) and cruise-control usage (user, nonuser), balanced for gender, for the two-week exposure group. In the five-week exposure group the projected number of participants is eight in each of the three age groups (balanced for gender). Cruise-control usage is not an independent variable in the five-week exposure group. This would result in a total sample size of 108 drivers (84 drivers with two-week exposures and 24 drivers with five-week exposures).

Later on we will perform further analysis of the expected statistical power of our data. Currently we believe that the number of driver/participants in each cell of our experimental design will be adequate to produce statistically reliable results at the end of the field testing.

Extrapolating from the information for 35 drivers as given in Section 3.6, we will have approximately three times as much information at the end of testing as that used in preparing this report. This means approximately 8,000 trips, 80,000 miles, and 2,200 hours of driving by 108 different people. (These estimates are probably low because there were no five-week participants in the original 35 drivers.)

However, there will be much more information to report since we have just begun to process the data. We have not yet gone into the time history information nor the transition tables. The database on matters related to headway control will be extensive and unique. There will be a CD ROM containing the measured data for each driver and another CD ROM containing the video data for each driver (in total 216 CD ROMs for 108 drivers). In addition, there will be a database of approximately 150 megabytes containing the histograms, transition tables, and other information as transmitted by cellular phone for all drivers. Clearly, a great deal of skill and understanding will be needed to grasp and communicate the meaning of this data. In that regard, this interim report represents a significant step in learning how to process and interpret the data that are now and will be in front of us in the future.

5.3 Where This Is All Going and What Might Be Done Next.

The equipped vehicles will be deployed in operational testing to the maximum extent supportable by the project team. On the one hand, we feel that the histogram-based results reported to date are unlikely to change as more test subjects are added, since driving behaviors and the range of operating conditions have been more or less circumscribed already. On the other hand, the final report is expected to contain a) more statistical power for defining low-probability driving phenomena, b) substantive evidence of the extent of driver adaptation to ACC over four continuous weeks of usage, c) extensive examination of time-domain events (as a complement to the time-independent histogram data), and d) various enhancements of the overall data such as through reverse-geocoded road-type designations and other expansions in the database.

Relative to item (a), above, the remainder of the FOT will involve approximately 2.5 times as much ACC driving exposure as was accrued to date. Thus a large increase in statistical power of the data is pending.

Relative to (b) the engagement of 24 drivers operating the vehicle for five weeks should provide a good opportunity for the novelty effect to subside and for at least suggesting the trends of adaptation, if anything measurable exists. In this regard, it is recognized that a potential relaxation in the driver's vigilance with extended use of ACC is of special interest.

Relative to item (c), it is expected that the process of driver intervention on ACC can be examined in detail beginning with event-identifiers that exist in the so-called transition tables of the dataset. Transitions out of the ACC control mode due to braking or due to activation of the "Cancel" button are all associated with specific time points in the 10Hz-recorded time histories. Extensive study of the mode-transitions is expected to provide a dynamic profile of the driver as an ACC-intervener (i.e., the role by which the driver acts to supervise ACC operation and provide the "outermost loop" of vehicle headway protection.)

Relative to (d), data enhancement to include road-type coding is underway and will be implemented for all travel in southeastern Michigan. Travel outside of that zone will not be reverse geocoded within this study. The road-type coding should help, for example, in isolating manual versus ACC comparisons to freeways, rural two-lane roads, or other defined types of facilities in which significant ACC usage has appeared. Other enhancements may also become attractive such as rebinning of selected histograms and the computation of additional or modified variables derived from measured raw data.

As possible extensions to the field test, it is recognized that a major need exists to explore naturalistic operation of ACC systems that are braking-assisted. In this regard, we note that the worldwide auto industry is tending toward systems having a deceleration authority in the range of 0.2 g's—in contrast to the nominal 0.07 g level of authority that attends our current throttle- and downshift-controlled system. In a complementary NHTSA-sponsored study that is proceeding through the summer and fall of 1997, UMTRI will be conducting preliminary testing of such a braking-assisted ACC package using another 1996 Chrysler Concorde that incorporates a so-called *smart booster* device for brake-by-wire control. Should the pilot testing of this system show it to be suitable for operation by lay drivers in unaccompanied testing, a supplemental phase of ACC field operational testing would seem to be in order.

It may also be attractive to continue employing the current FOT test cars for much longer exposure periods or perhaps under a more focused study of a certain subset of the driving population. The value of any such extensions may become apparent as the remainder of the FOT data are gathered and processed.

6. REFERENCES

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APPENDIX A

System Characterization Procedure

The tests described in this appendix have been used to provide a preliminary checkout of the control functionality of the prototype ACC system being used in this field operational test. The purpose of these tests is not to measure the specific performance of the ACC sensors per se. Rather, it is to characterize the entire prototype system which includes the sensors, control algorithm, and vehicle platform.

The tests are controlled in reference to the speed of the preceding vehicle. It is desired that the speed of the preceding vehicle be approximately 66 mph or 60 mph in certain tests. In addition, other vehicles should not intervene between the ACC vehicle and the preceding vehicle. If the tests are done without a cooperative preceding vehicle (a confederate vehicle), it will be necessary to accept the speed of an arbitrarily picked preceding vehicle encountered on the highway.

The tests are intended to be useful even if they are performed on normal grades and curves as encountered on limited-access highways. However, curvature and grade will influence quantitative measures of performance to the extent that straight level sections of roadway are desired when consistent numerical results are needed.

The approach employed here for characterizing the ACC system is based upon identifying generic, fundamental tasks that the system may be expected to perform. These tasks are related to the following operational situations:

- closing-in on a preceding vehicle from a long range
- changing to a new headway in response to changing the system's headway setting
- responding to a close approach to a preceding vehicle

This set does not cover all aspects of ACC driving. However, it covers important situations and it provides a good basis for checking the performance of the existing ACC systems.

In order to check and evaluate system performance in these types of situations it is necessary to define (1) the input (essentially the behavior of the preceding vehicle), (2) the initial conditions for starting the test, (3) the conditions that apply during a test run, and (4) the performance signatures and measures used to characterize system performance.

The inputs to these tests are the speed of the preceding vehicle. The results of the tests are based upon measurements of range, range rate, velocity, transmission shift commands, and velocity commands resident within the ACC system. The primary data signals (and their measured equivalents) that are used in performing and evaluating the test results were described in section 2, and illustrated in Figure 3 in the main body of the report. Also, R versus RDot plots are useful for interpreting results [4].

In addition, the computed quantity "Headway Time Margin", symbolized as H_{tm}, is useful for interpreting results. The equation for H_{tm} is:

$$H_{tm} = \frac{R}{V} \tag{A-1}$$

In steady following with $V = V_p$, H_{tm} should be equal to the headway time (T_h) used in the headway controller. H_{tm} represents the reaction time within which the following driver would need to match any deceleration profile of the preceding vehicle in order to avoid a crash. The goal of the headway control system is viewed as trying to cause H_{tm} to approach T_h.

Sensor and velocity information is inherent and essential to the performance of this system. Therefore, these data are treated as "measured", to emphasize the potential difference between the real data and that which the sensors report and the algorithm uses for calculations. (Symbols with a subscript "m" identify those variables.)

The following types of tests have been used to characterize basic functional aspects of the system.

A.1 Test 1: Closing-in on a Preceding Vehicle

This test examines the transition from (a) operating in a manner similar to that of a conventional cruise control, to (b) operating in a headway-control mode. When the preceding vehicle is first detected, the ACC vehicle is using V_{set} and not range and range-rate to determine its speed. However, as the ACC vehicle closes in, the headway-control feature is automatically activated. The ACC system slows the vehicle to match the speed of the preceding vehicle and maintains a distance determined by the preselected headway time.

Input
- V_p = 60 mph (88 ft/s, 26.8 m/s)

Initial conditions for the ACC vehicle
- V = 70 mph (103 ft/s, 31.3 m/s)

- V_{set} =70 mph
- T_h = 1.4 s (implies 123 ft at 60 mph, 37.5 m at 96.6 kph)
- R > about 350 ft (107 m)

Run conditions: Starting from appropriate initial conditions operate the ACC system until a following condition ($V = V_p$ and $R = 1.4\ V_p$) is established.

Example results: Typical results for this test are shown in Figure A-1 and Figure A-2. The process of slowing from the ACC vehicle's initial velocity to V_p is relatively long (30 to 60 seconds). Figure A-1 is a phase plane plot of range versus range rate for this test. Time is not directly shown in this plot, however the direction of increasing time is shown using arrowheads.

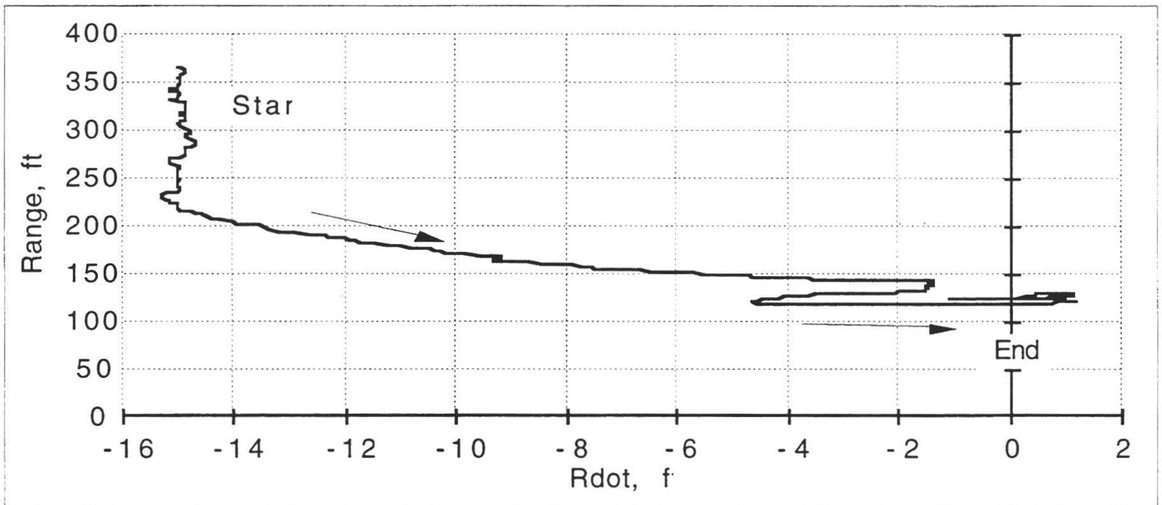

Figure A-1. Range versus Range-Rate, closing from long range

In closing from long range, R decreases as expected. RDot is the derivative of R, and hence is negative for decreasing range.

Figure A-2 is a plot of headway time margin, H_{tm}, versus time during this test. At the beginning of the sequence, before the system starts to respond to the preceding vehicle, the vehicles are separated by more than 3.5 seconds, and H_{tm} decreases linearly. At about H_{tm} = 2.3 seconds, the time history of H_{tm} curves to approach somewhat exponentially to the selected headway time T_h = 1.4 s. Typical variations in speed and grade will cause headway time margin H_{tm} to be within 10 percent of T_h when nominally steady following conditions are reached. Furthermore, the system tends to operate at 1.5 s rather than 1.4 s. (In practice, the actual headway times are best described as 1.1, 1.5, and 2.1 seconds.)

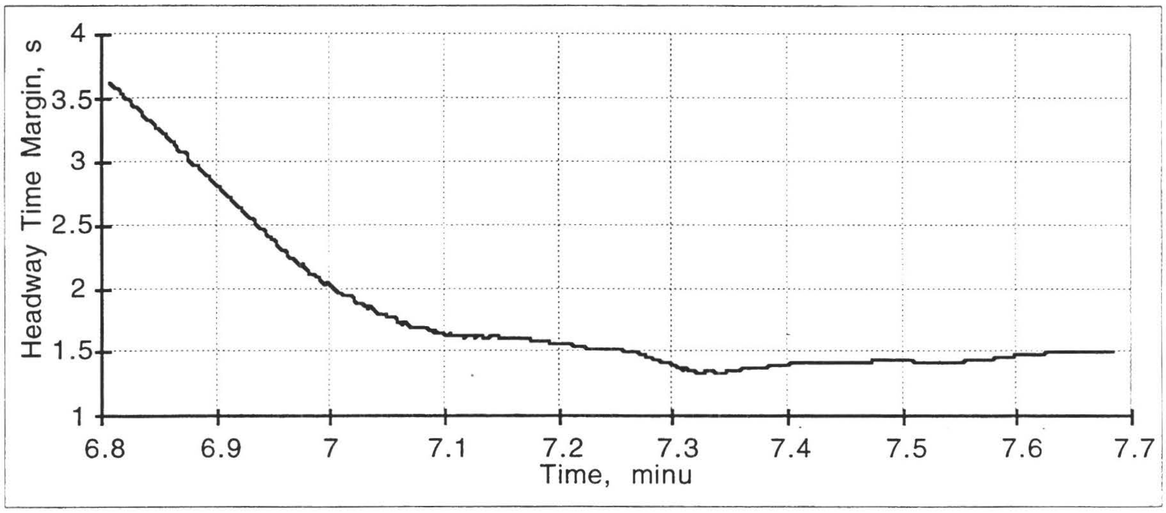

Figure A-2. Headway Time Margin (H_{tm}) versus time, closing from long range

A.2 Test 2: Changing to a new headway

The purpose of this test is to see how the ACC vehicle responds when headway is adjusted. The vehicle being tested has three settings for headway time: 1.0, 1.4, and 2.0 seconds (see section 3.1.6 in the main body of the report). These settings cover the range of headway used by drivers who tend to travel at the speed of adjacent traffic [6]. The test cases (A through C below) pertain to changes between these levels of headway time.

Case A

Input

- V_p = 66 mph (97 ft/s, 29.5 m/s)
- T_h = 2.0 s

Initial conditions

- V = 66 mph
- V_{set} = 70 mph (103 ft/s, 31.3 m/s)
- $R = T_h V_p$ = 194 ft (59.2 m) for 66 mph

Run conditions: Follow the preceding vehicle for several seconds. (That is, with $V = V_p$ and $R = 2.0\ V_p$.) Change the T_h button setting from 2.0 to 1.0 s. This test should cause the vehicle to change to a shorter range of approximately 97 ft.

Example results: Figure A-3 is a plot of range versus range rate for this test. The range decreases to satisfy the lower T_h selection. Since the velocity of the preceding vehicle is nominally constant, the relative acceleration represents the acceleration of the following ACC vehicle. For this test, the highest closure rate is approximately -6 ft/s (-1.8 m/s) and the total change in range is approximately 120 ft (36m).

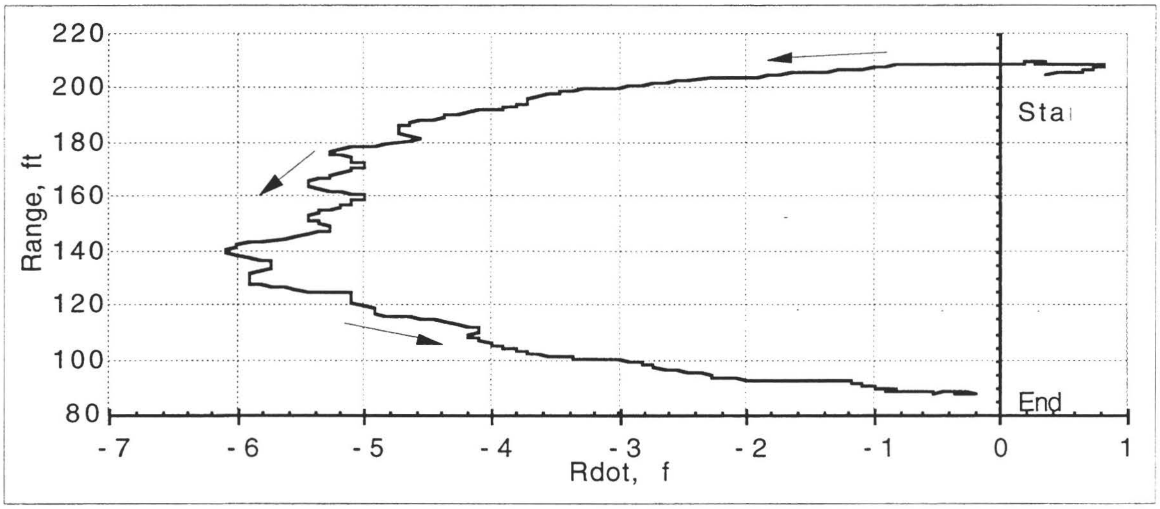

Figure A-3. Range versus Range-Rate, changing from $T_h = 2.0$ to 1.0 s

Figure A-4 shows the headway time margin (see equation (A-1)). The headway time margin changes fairly linearly during the transient with a slope of approximately 3.14 s/minute for this test.

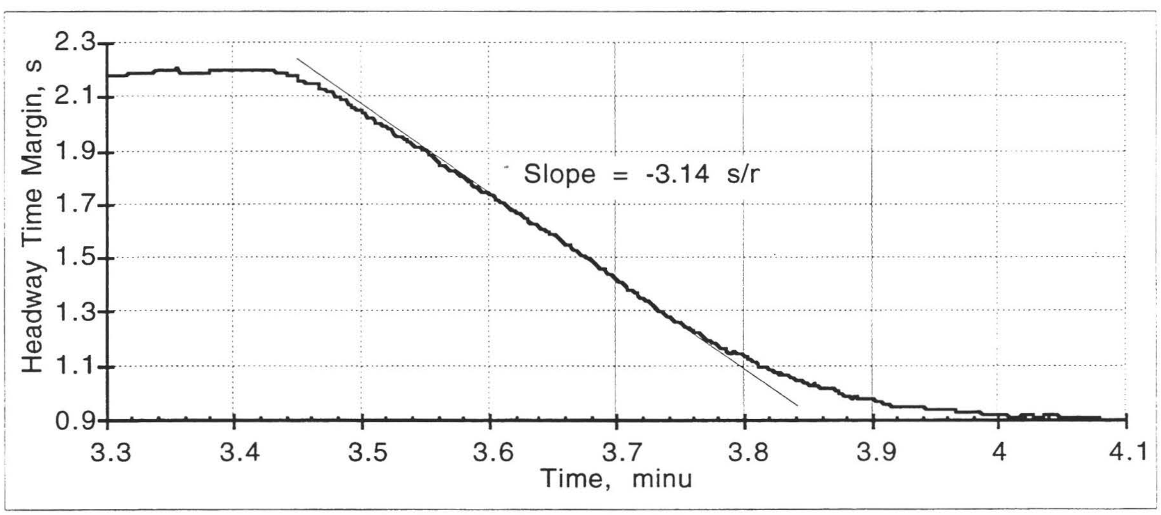

Figure A-4. Headway Time Margin (H_{tm}) versus time, changing from $T_h = 2.0$ to 1.0 s

Case B

(This case is the inverse of case A: initial T_h is 1.0 s and final T_h is 2.0 s)

Input

- $V_p = 66$ mph (97 ft/s, 29.5 m/s)

- $T_h = 2.0$ s, from $T_h = 1.0$ s initially

Initial conditions

- V = 66 mph
- V_{set} = 70 mph (103 ft/s, 31.3 m/s)
- $R = T_h V_p$ = 97 ft (29.6 m) for $T_h = 1.0$ s initially

Run conditions: The same general idea as in case A, except this case causes the vehicle to change from a short to a longer range.

Example results: Figure A-5 presents the range versus range-rate diagram for this example. The maximum range-rate is 8 ft/sec. This means that the ACC vehicle slows down considerably as it widens the headway range by approximately 100 ft (30.5 m) in this case. Examination of the data for cases A and B indicates that this system increased headway (from $T_h = 1.0$ to 2.0 s) in approximately 1/3 less time than it required to shorten headway by the same increment (compare Figure A-4 and Figure A-6 as well as Figure A-3 and Figure A-5).

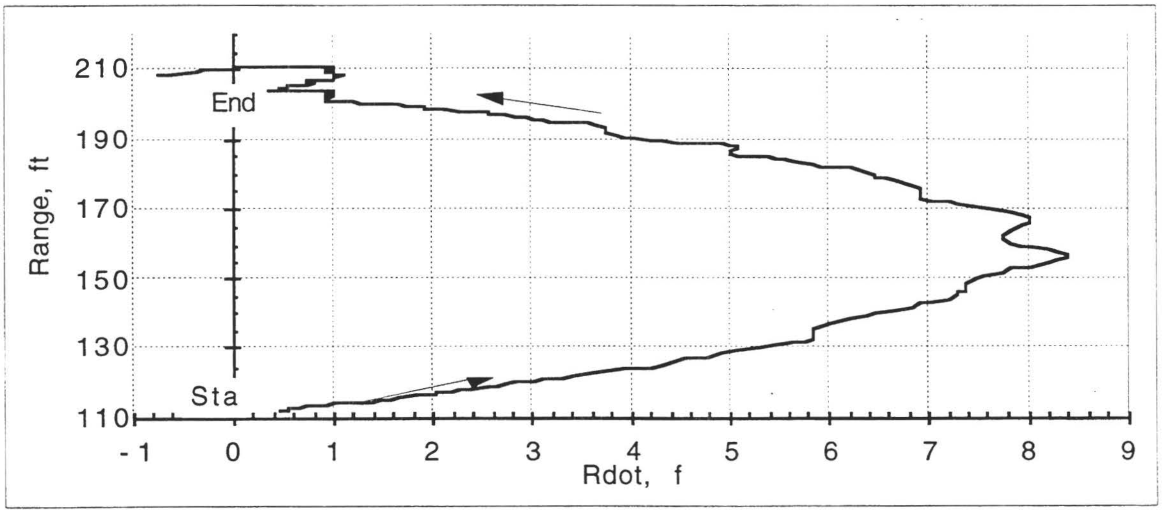

Figure A-5. Range versus Range-Rate, changing from $T_h = 1.0$ to 2.0 s

Examination of Figure A-6 indicates that the maximum slope of the headway time margin is approximately 6.3 sec/minute, or in other words, the slew rate employed in increasing headway time is about twice as fast as that employed in decreasing headway time.

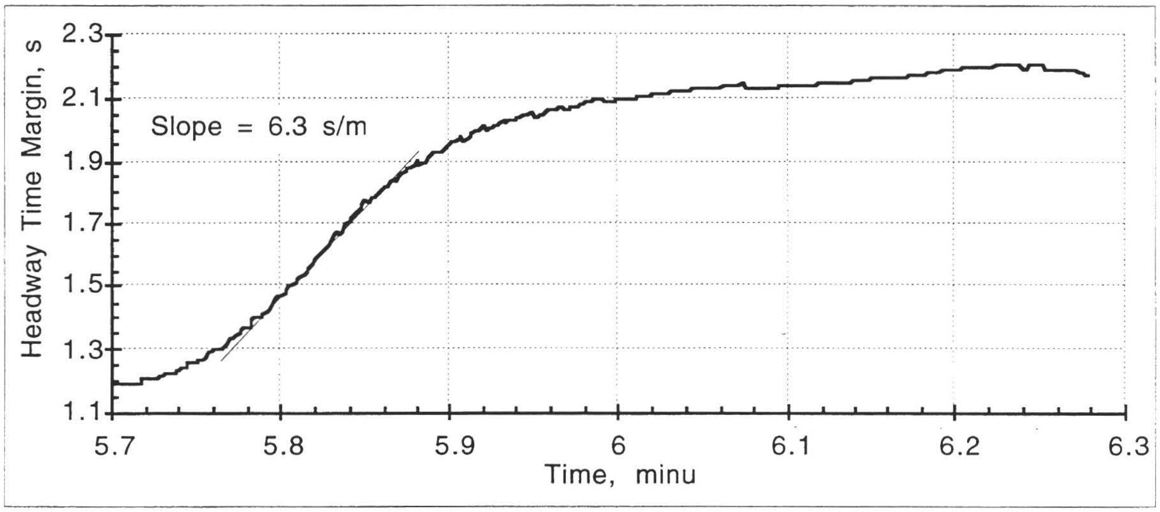

Figure A-6. Headway Time Margin (H_{tm}) versus time, changing from T_h = 1.0 to 2.0 s

Case C

(This case is similar to case A, only that final T_h is 1.4 s)

A.3 Test 3: Manually accelerating

The purpose of this test is to exercise the accelerator pedal override capability as well as to check the ability of the system to correct for a moderately-near encounter. This test may cause the control system to downshift the transmission while the driver is accelerating the ACC vehicle. Nevertheless, once the accelerator pedal is released by the driver, the ACC vehicle should slow down towards a proper following condition in a manner that is characteristic of the operation of this headway control system.

Input:

- V_p = 60 mph

Initial conditions for the ACC vehicle:

- V = 60 mph
- V_{set} = 70 mph
- T_h = 1.4 s (implies T_h V_p = 123 ft)
- The ACC vehicle should be following. (V = V_p and R = 1.4 V_p)

Run Conditions: The driver of the ACC vehicle is to accelerate and partially overtake the preceding vehicle. When the range gets to approximately 2/3 of the original gap, the driver of the following vehicle is to release the accelerator pedal. The test is continued until steady-state following is reestablished or until the driver brakes. (This test could be viewed as an aborted passing maneuver but it is probably better to view it as a means to simulate a near encounter. In practical operation, near encounters can happen for many reasons including merges or other events that cause the sensor to pick up a preceding vehicle for the first time at close range.)

Example results: Data for range versus range-rate are presented in Figure A-7. These data show that the trajectory in the range versus range-rate space is nearly a closed loop. (Ideally it would be a closed loop.) The minimum RDotm is approximately –12 ft/s and the maximum is about 8 ft/s. The minimum range is close to 50 ft.

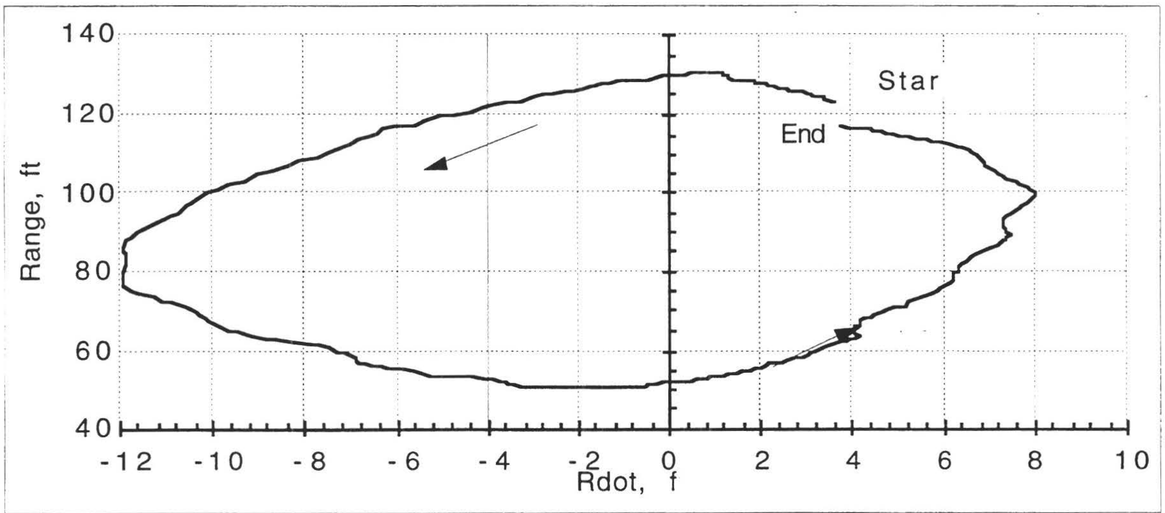

Figure A-7. Range versus Range-Rate, manually accelerating

Figure A-8 shows that the headway time margin goes from about 1.5 seconds to a low of about 0.6 seconds and then back to about 1.4 seconds in this test. This is all done in approximately 0.45 minutes (27 seconds).

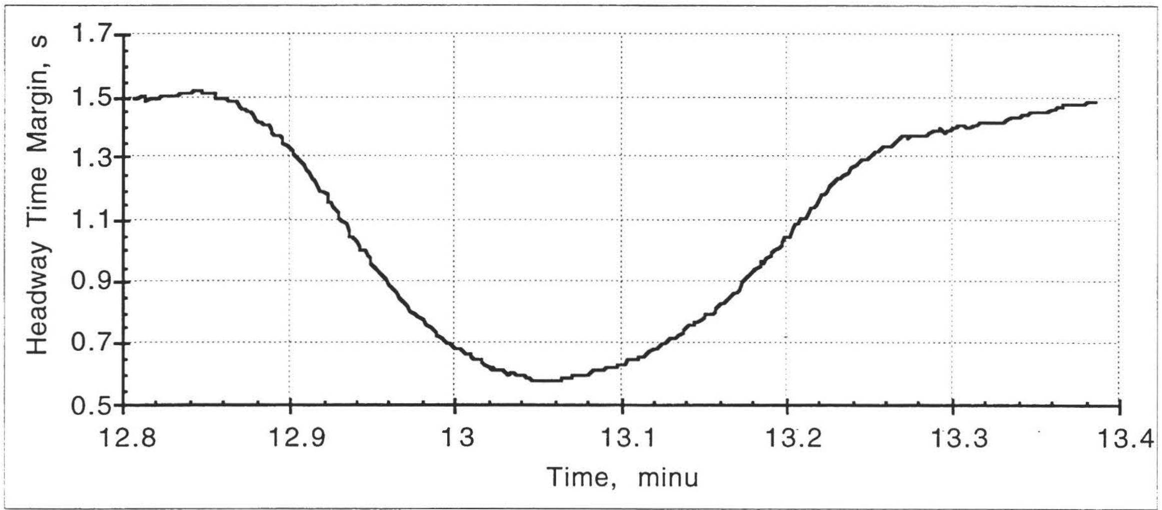

Figure A-8. Headway Time Margin versus time, manually accelerating

The test scenarios presented in this appendix serve as a practicable means for characterizing and periodically reconfirming the performance of the ACC vehicles in the field operational test. They provide performance signatures that can be examined to quantify features that serve as performance measures for ACC vehicles. Since the test conditions do not control for grade and traffic condition, the results will differ from time to time and place to place. Nevertheless, since the functionality of adaptive cruise control does not depend upon high levels of performance from a control system perspective, the results of these tests are sufficient to answer basic questions concerning the control algorithms such as: Does the vehicle slow down when it should? Does the vehicle speed up as it should? Does headway time adjust as it should?

From the characterization tests that were performed, it appears that this ACC system reaches selected headway times with a resolution of approximately ten percent. The system is able to correct for disturbances in speed or range-rate that cause range-rate to reach a closing rate of approximately 10 mph (–15 ft/s, –4.5 m/s). The system is also able to keep the headway time margin above 0.6 seconds in the sudden encounters involved in these tests. Changes in headway time are achieved smoothly with little overshoot or undershoot. When closing in from long range, the ACC system starts to adjust speed at 200 to 300 feet away. And finally, the ACC system downshifts when it needs to achieve a higher deceleration than that available from the natural retardation of the vehicle.

Clearly there are many driving situations that could be tested. The tests described here and an additional test that involves (1) a decelerating preceding vehicle, and (2) a preceding vehicle that suddenly appears in the path of the ACC vehicle, are presented in

[7]. However, tests that involve braking or cut-in are difficult to perform, and could upset other drivers. Such tests were performed as part of the early characterization of the test vehicles, however, they are not part of the current routine checks. The 3 types of tests described in this appendix have been used routinely to check ACC functionality before a test vehicle is released to a participant driver.

APPENDIX B

Methodology of Approximating Probability from Histograms

This appendix explains how the histogram data have been processed. It also defines and symbolizes certain operations associated with the process.

The basic data portrayed in the histograms are counts of how often the data falls within a defined subset (sometimes referred to as a "bin") of a larger set of data made up of two or more bins. The ratio of the counts within a particular bin to the total number of counts in all of the bins corresponding to a given variable is an approximation to the chance, likelihood, or probability that the variable takes on a value within that particular bin. Consider a two-column, n-row array of data aij as represented in Table B-1.

Table B-1. Hypothetical data for two histograms: one for R when E is true and one for R when E is false

variable \ sort	E	not E	P (E I Ri)	P (Ri I E)
R1	a11	a12	a11 / (a11+a12)	a11 / Si (ai1)
R2	a21	a22	a21 / (a21+a22)	a21 / Si (ai1)
R3	a31	a32	a31 / (a31+a32)	a31 / Si (ai1)
- - -	- - -	- - -	- - -	- - -
Ri	ai1	ai2	ai1 / (ai1+ai2)	ai1 / Si (ai1)
- - -	- - -	- - -	- - -	- - -
Rn	an1	an2	an1 / (an1+an2)	an1 / Si (ai1)

The counts in the bins of these two histograms are represented by ai1 from i = 1 to n when E is true and by ai2 from i = 1 to n when E is false. R is a variable binned into n bins ("Ri" stands for its ith bin). (Although R stands for range in the main body of the report, as shown in Figure 3, in this discussion R may represent any variable that has been sampled and sorted to make a histogram.) The symbol E stands for a logical variable that is either true or false. For example, in most applications E represents "engaged" which means that the counts for various values of R (that is the counts corresponding to each Ri) were obtained when the system was engaged (CCC driving on the first week, or ACC on the second week). "Not E" means that the data is for manual driving. In this sense the logical variable E stands for a variable that is used in a sorting operation to split the data into histograms that are very useful for comparing ACC driving with manual driving or CCC driving with manual driving.

The column labeled "P (E | Ri)" is like the conditional probability for being engaged given that row i (that is, R falls in the Ri bin) is true. This approximate probability is used, for example, to answer questions like: If a trip is approximately 10 miles long, what is the chance that the ACC system would be engaged during that trip? For answering this example question, the variable listed in the first column represents the length of trips and the entries in the second column are the counts of trips in various length categories (bins) when the control system is engaged. The fourth column, labeled P (E | Ri), gives the approximate probabilities for all lengths of trips. The answer to the example question will be found in the fourth column in the row corresponding to trips that are approximately 10 miles long.

The last column is an approximation to the probability density function for R when E is true. (Although not illustrated, the probability density function for R when E is not true is defined similarly using ai2 in place of ai1.) The symbol "Si (ai1)" represents the sum of all the counts for all of the bins constituting R. By plotting and comparing, P(Ri | E) with P(Ri | not E), one can compare ACC driving with manual driving with respect to the variable R.

This discussion is tedious but fundamental. It may be easier to understand after examining the results presented later. The ideas behind having a sample space as defined in probability theory may be useful for visualizing the reasoning. We are simply counting the number of members (samples) in various subsets and using these counts to estimate probabilities and conditional probabilities.

The symbol P(· | ·) may be viewed as an operator that performs the operation as defined above on the sets indicated as inputs to the operator. For example P(E | Ri) is the fraction of the set Ri for which E is true. The symbol P(Ri | R) would mean the fraction of the complete set R for which R falls in the Ri bin. This is cumbersome when there are many bins (i is large) and may be shortened to Pd(R | E) to indicate an approximation to the probability density function for R when E is true.

In general, when we are addressing questions of the form "When is ACC likely to be used?", we will be comparing P(E | Si) with P(notE | Si) for various values of i across the set S. In contrast Pd(S | E) is used to answer questions concerning performance with respect to the variable represented by the subset of S defined by E being true. For example if R represents the set of range counts for the range variable, one can examine Pd(R | E) to determine the chance that range will be short given that the ACC system is in operation.

APPENDIX C

Adaptive Cruise Control System Questionnaire and Evaluation

1. How comfortable did you feel driving the car using the ACC system?

1	2	3	4	5	6	7
Very Uncomfortable						Very Comfortable

Mean = 6.0 ***Stdev. = 1.6***

2. How long did it take you to become comfortable using the ACC system?

I was:

_*15*__ comfortable using the ACC system after one hour or less.

_16__ comfortable using the system after the first day.

_ 5__ comfortable using the system after a few days.

_ 0__ comfortable using the system after the first week.

_ 0__ never comfortable using the ACC system.

3. How easy did you find it was to drive using the ACC system?

1	2	3	4	5	6	7
Very Difficult						Very Easy

Mean = 6.4 ***Stdev. = .9***

Briefly describe the types of situations or driving environments where ACC was easiest to use:

4. How likely is it that you would have become more comfortable using the ACC system given more time?

1	2	3	4	5	6	7
Very Unlikely						Very Likely

Mean = 5.2 ***Stdev. = 2.3***

5. How comfortable were you physically (your posture, legs, feet, etc.) when driving using the ACC system in comparison with your usual mode of driving?

1	2	3	4	5	6	7
Less Comfortable						More Comfortable

Mean = 5.6 ***Stdev. = 1.3***

6. How comfortable were you using the ACC system in the rain or snow?

1	2	3	4	5	6	7	0
Very Uncomfortable						Very Comfortable	Did Not Experience

Mean = 5.2 ***Stdev. = 1.5*** ***Count of Zeros = 3***

7. How comfortable are you using conventional cruise control in rain or snow?

1	2	3	4	5	6	7	0
Very Uncomfortable						Very Comfortable	Did Not Experience

Mean = 5.1 ***Stdev. = 1.6*** ***Count of Zeros = 0***

8. How comfortable were you using the ACC system on hilly roads?

1	2	3	4	5	6	7	0
Very Uncomfortable						Very Comfortable	Did Not Experience

Mean =5.6 ***Stdev. = 1.5*** ***Count of Zeros =8***

9. How comfortable were you using the ACC system on winding roads?

1	2	3	4	5	6	7	0
Very Uncomfortable						Very Comfortable	Did Not Experience

Mean = 5.5 ***Stdev. = 1.6*** ***Count of Zeros = 7***

10. How comfortable would you feel if your child, spouse, parents or other loved ones drove a vehicle equipped with ACC?

1	2	3	4	5	6	7
Very Uncomfortable						Very Comfortable

Mean = 6.0 ***Stdev. = 1.5***

11. For the following categories, please compare the three modes of operation (Manual control, Conventional Cruise Control, and ACC), and rank them based on your preference. Use (1) to indicate your most preferred and (3) to indicate your least preferred.

		Manual Control	Conventional Cruise	ACC
Safety		____	____	____
	Mean	***1.5***	***2.6***	***1.8***
	Stdev.	***.8***	***.6***	***.6***
Comfort		____	____	____
	Mean	***2.8***	***2.0***	***1.2***
	Stdev.	***.5***	***.5***	***.5***
Convenience		____	____	____
	Mean	***2.9***	***1.9***	***1.2***
	Stdev.	***.4***	***.4***	***.5***
Driving Enjoyment		____	____	____
	Mean	***2.8***	***2.0***	***1.2***
	Stdev.	***.5***	***.5***	***.5***

Please rank the modes of operation, using the numbers (1) to (3), to answer the following questions:

12. In general, under what mode of operation did you feel like you drove fastest? (1 = fastest, 3 = slowest)

	_____Manual Control	_____Conventional Cruise Control	_____ACC
Mean	***1.4***	***2.3***	***2.3***
Stdev.	***.6***	***.7***	***.7***

13. Which mode of operation required you to apply the brakes most often? (1 = least braking, 3 = most braking)

	_____Manual Control	_____Conventional Cruise Control	_____ACC
Mean	***2.0***	***2.3***	***1.7***
Stdev.	***.9***	***.6***	***.9***

14. Under which mode of operation do you drive most cautiously? (1 = most cautiously, 3 = least cautiously)

	_____Manual Control	_____Conventional Cruise Control	_____ACC
Mean	***2.1***	***2.0***	***1.8***
Stdev.	***1.0***	***.6***	***.9***

15. What did you think of the rate of deceleration provided by the ACC system when following other vehicles?

1	2	3	4	5	6	7
Too Slow						Too Fast

Mean = 3.5 ***Stdev. = 1.3***

16. What did you think of the acceleration provided by the ACC system when pulling into an adjacent lane to pass other vehicles?

1	2	3	4	5	6	7
Too Slow						Too Fast

Mean = 3.5 ***Stdev. = 1.4***

17. How consistent did you maintain your speed when using the ACC system, as compared to driving manually?

1	2	3	4	5	6	7
Very Inconsistent						Very Consistent

Mean = 6.2 ***Stdev. = 1.2***

18. When using the ACC system, as compared to driving manually, did you find yourself more or less aware of the actions of vehicles around you?

1	2	3	4	5	6	7
Very Unaware						Very Aware

Mean = 5.8 ***Stdev. = 1.3***

19. When using the ACC system, as compared to driving manually, did you find yourself more or less responsive to the actions of vehicles around you?

1	2	3	4	5	6	7
Very Unresponsive						Very Responsive

Mean = 5.3 ***Stdev. = 1.5***

20. When using the ACC system, did you ever feel you didn't understand what the system was doing, what was taking place, or how the ACC system might behave?

1	2	3	4	5	6	7
Very Frequently						Very Infrequently

Mean = 6.1 ***Stdev. = 1.1***

21. How easy or difficult did you find it to maintain a safe distance to the preceding vehicle using each of the following modes of operation?

	1	2	3	4	5	6	7
Manual Control	1 Very Difficult	2	3	4	5	6	7 Very Easy
Mean = 4.7	***Stdev. = 2.2***						
Conventional Cruise	1 Very Difficult	2	3	4	5	6	7 Very Easy
Mean = 3.7	***Stdev. = 1.7***						
ACC	1 Very Difficult	2	3	4	5	6	7 Very Easy
Mean = 6.2	***Stdev. = 1.2***						

22. How comfortable did you feel with your ability to change lanes (to pass other cars) using each of the following modes of operation?

	1	2	3	4	5	6	7
Manual Control	1 Very Uncomfortable	2	3	4	5	6	7 Very Comfortable
Mean = 6.1	***Stdev. = 1.8***						
Conventional Cruise	1 Very Uncomfortable	2	3	4	5	6	7 Very Comfortable
Mean = 4.9	***Stdev. = 1.9***						
ACC	1 Very Uncomfortable	2	3	4	5	6	7 Very Comfortable
Mean = 5.6	***Stdev. = 1.7***						

23. How did using the ACC system affect your speed, relative to neighboring vehicles, when driving in the following traffic environments?

When using ACC on freeways and expressways, I drove:

1	2	3	4	5	6	7	0
Slower						Faster	Didn't Use

Mean = 4.6 ***Stdev. = 1.6*** ***Count of Zeros = 0***

When using ACC on two-lane rural highways, I drove:

1	2	3	4	5	6	7	0
Slower						Faster	Didn't Use

Mean =4.0 ***Stdev. = 1.3*** ***Count of Zeros = 5***

When using ACC on major arterial streets, I drove:

1	2	3	4	5	6	7	0
Slower						Faster	Didn't Use

Mean =3.9 ***Stdev. = 1.3*** ***Count of Zeros = 10***

When using ACC in heavy traffic, I drove:

1	2	3	4	5	6	7	0
Slower						Faster	Didn't Use

Mean = 3.5 ***Stdev. = 1.5*** ***Count of Zeros = 4***

When using ACC in medium traffic, I drove:

1	2	3	4	5	6	7	0
Slower						Faster	Didn't Use

Mean =4.3 ***Stdev. = 1.0*** ***Count of Zeros = 0***

When using ACC in light traffic, I drove:

1	2	3	4	5	6	7	0
Slower						Faster	Didn't Use

Mean = 5.3 ***Stdev. = 1.1*** ***Count of Zeros = 0***

24. How did using the ACC system affect your headway (following distance), as compared to manual control, when driving in the following traffic environments?

When using ACC on freeways and expressways, I drove:

1	2	3	4	5	6	7	0
Closer						Farther	Didn't Use

Mean = 4.5 ***Stdev. = 1.6*** ***Count of Zeros = 0***

When using ACC on two-lane rural highways, I drove:

1	2	3	4	5	6	7	0
Closer						Farther	Didn't Use

Mean = 4.3 ***Stdev. = 1.4*** ***Count of Zeros = 4***

When using ACC on major arterial streets, I drove:

1	2	3	4	5	6	7	0
Closer						Farther	Didn't Use

Mean = 4.6 ***Stdev. = 1.6*** ***Count of Zeros = 9***

When using ACC in heavy traffic, I drove:

1	2	3	4	5	6	7	0
Closer						Farther	Didn't Use

Mean = 6.0 ***Stdev. = 1.8*** ***Count of Zeros = 3***

When using ACC in medium traffic, I drove:

1	2	3	4	5	6	7	0
Closer						Farther	Didn't Use

Mean = 4.4 ***Stdev. = 1.6*** ***Count of Zeros = 0***

When using ACC in light traffic, I drove:

1	2	3	4	5	6	7	0
Closer						Farther	Didn't Use

Mean = 4.1 ***Stdev. = 1.8*** ***Count of Zeros = 0***

25. How often, if ever, did you experience "unsafe" following distances when using the ACC system?

1	2	3	4	5	6	7
Very Frequently						Very Infrequently

Mean = 6.3 ***Stdev. = 1.0***

Briefly explain how this may have occurred:

26. Do you feel the headway adjustment feature useful?

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

Mean = 6.1 ***Stdev. = 1.4***

Briefly explain your strategy for adjusting the headway (i.e., when you changed it, and why):

27. For the following questions, please rank the mode of operation you are most likely to use. (1 = most likely to use, 3 = least likely to use.)

In which mode of operation were you more likely to drive on the highway, interstate, state route, or turnpike? (1 = most likely to use, 3 = least likely to use.)

	_____Manual Control	_____Conventional Cruise Control	_____ACC
Mean	***2.9***	***2.1***	***1.0***
Stdev.	***.3***	***.3***	***.0***

In which mode of operation were you most likely to drive on two lane rural roads? (1 = most likely to use, 3 = least likely to use.)

	_____Manual Control	_____Conventional Cruise Control	_____ACC
Mean	***2.4***	***2.2***	***1.4***
Stdev.	***.9***	***.6***	***.6***

In which mode of operation were you most likely to drive on major arterial streets? (1 = most likely to use, 3 = least likely to use.)

	_____Manual Control	_____Conventional Cruise Control	_____ACC
Mean	***1.3***	***2.6***	***2.2***
Stdev.	***.7***	***.5***	***.7***

28. How safe did you feel using the ACC system?

1	2	3	4	5	6	7
Very Unsafe						Very Safe

Mean = 6.4 ***Stdev. = .9***

29. Do you think ACC is going to increase driving safety?

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

Mean = 5.8 ***Stdev. = 1.3***

30. While driving using ACC, did you ever feel overly confident?

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

Mean = 3.6 ***Stdev. = 2.2***

31. Did you feel more comfortable performing additional tasks, (e.g., adjusting the heater or the radio) while using the ACC system as compared to driving under manual control?

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

Mean = 5.0 ***Stdev. = 1.7***

32. Did you find the ACC system functions distracting (e.g., automatic acceleration and deceleration)?

1	2	3	4	5	6	7
Very Distracting						Not At All Distracting

Mean = 6.5 ***Stdev. = 1.2***

33. Did you find the ACC system components distracting (e.g., status lights, control buttons)?

1	2	3	4	5	6	7
Very Distracting						Not At All Distracting

Mean = 6.2 ***Stdev. = 1.3***

34. While using the ACC system, how often, if ever, did the system fail to detect a preceding vehicle?

1	2	3	4	5	6	7
Always						Never

Mean = 6.2 ***Stdev. = 1.0***

35. While using the ACC system, how often, if ever, did the system produce false alarms (i.e., reported the presence of a vehicle when none existed)?

1	2	3	4	5	6	7
Always						Never

Mean = 6.4 ***Stdev. = .7***

36. How easy or difficult do you feel it will be to market a vehicle equipped with an Adaptive Cruise Control (ACC) System?

1	2	3	4	5	6	7
Very Difficult						Very Easy

Mean = 6.4 ***Stdev. = .9***

37. How comfortable would you feel if ACC systems replaced conventional cruise control?

1	2	3	4	5	6	7
Very Uncomfortable						Very Comfortable

Mean = 6.5 ***Stdev. = .9***

38. Please rank, in order of preference, the following modes of operation for personal use. (1 = most desirable, 3 = least desirable)

	_____Manual Control	_____Conventional Cruise Control	_____ACC
Mean	***2.5***	***2.2***	***1.4***
Stdev.	***.8***	***.7***	***.6***

39. Would you be willing buy an ACC system in your next new vehicle?

1	2	3	4	5	6	7
Very Unwilling						Very Willing

Mean = 6.5 ***Stdev. = .9***

40. Approximately how much would you be willing to spend for this feature in a new vehicle?

$____________

Mean = $410 ***Stdev. = $333***

41. Would you be willing to rent a vehicle equipped with an ACC system when you travel?

1	2	3	4	5	6	7
Very Unwilling						Very Willing

Mean = 6.7 ***Stdev. = .7***

42. In general, how does driving using the ACC system compare to driving with conventional cruise control?

Reduced work load was cited most often as a benefit of the ACC system over conventional cruise control (16 participants). Participants also mentioned that they were more alert and more cognizant of surrounding traffic driving with adaptive cruise control (2 participants).

43. Can you suggest any changes or modifications to the ACC system that might improve it?

Five participants suggested faster acceleration for passing. Also suggested were providing nighttime illumination of the OEM cruise control buttons and faster acceleration and deceleration rates (2 participants).

44. Did you come close to having any accidents that you feel were related to using the ACC system?

When asked if they had come close to having any accidents related to using the ACC system, response of all participants was "No". One participant mentioned that if he had not been an alert person, he could have been involved in an accident.

APPENDIX D

Summary of Data Measurements for all Drivers

Logical Measures Summary

ACC Driving

No.	Measure	ID	Age	User	Sex	Transitions	Probability	True	False	Trips
1	Closing	27	20-30	0	F	88	0.149	4255	24382	5
2	Closing	31	20-30	0	F	15	0.180	899	4104	9
3	Closing	38	20-30	0	F	24	0.023	428	17942	6
4	Closing	4	20-30	0	M	196	0.242	19720	61886	20
5	Closing	10	20-30	1	F	51	0.182	2868	12915	11
6	Closing	15	20-30	1	F	328	0.188	11281	48769	5
7	Closing	30	20-30	1	F	67	0.200	4280	17144	9
8	Closing	33	20-30	1	M	253	0.137	8169	51585	18
9	Closing	37	20-30	1	M	113	0.191	2771	11727	5
10	Closing	1	40-50	0	F	17	0.158	967	5150	5
11	Closing	23	40-50	0	F	83	0.119	3043	22456	6
12	Closing	25	40-50	0	F	4	0.070	267	3552	3
13	Closing	26	40-50	0	F	98	0.143	4813	28847	3
14	Closing	29	40-50	0	F	70	0.096	3082	29021	6
15	Closing	34	40-50	0	M	219	0.151	4737	26630	14
16	Closing	5	40-50	1	F	65	0.199	2721	10943	9
17	Closing	6	40-50	1	F	83	0.066	2889	40590	5
18	Closing	8	40-50	1	F	86	0.081	5365	60939	6
19	Closing	9	40-50	1	F	404	0.163	19499	100478	17
20	Closing	12	40-50	1	F	108	0.147	5838	34004	10
21	Closing	21	40-50	1	F	423	0.134	12709	81862	13
22	Closing	24	40-50	1	F	442	0.108	12215	100393	6
23	Closing	36	40-50	1	F	276	0.179	9442	43302	6
24	Closing	3	40-50	1	M	43	0.136	2838	17970	7
25	Closing	14	40-50	1	M	347	0.138	11814	74044	13
26	Closing	17	40-50	1	M	105	0.187	3516	15273	6
27	Closing	22	40-50	1	M	55	0.124	3115	21977	1
28	Closing	35	40-50	1	M	68	0.040	1485	35557	5
29	Closing	13	60-70	1	F	205	0.122	6502	46824	9
30	Closing	7	60-70	1	M	304	0.110	15022	121429	11
31	Closing	11	60-70	1	M	140	0.045	5230	110722	12
32	Closing	18	60-70	1	M	598	0.132	17068	111837	7
33	Closing	19	60-70	1	M	223	0.134	8030	52048	13
34	Closing	20	60-70	1	M	176	0.188	8593	37217	4
35	Closing	32	60-70	1	M	127	0.245	3430	10579	4
1	Cutin	27	20-30	0	F	15	0.013	381	28256	5
2	Cutin	31	20-30	0	F	3	0.013	63	4940	9
3	Cutin	38	20-30	0	F	47	0.026	485	17885	6
4	Cutin	4	20-30	0	M	21	0.006	522	81084	20

No.	Measure	ID	Age	User	Sex	Transitions	Probability	True	False	Trips
5	Cutin	10	20-30	1	F	6	0.006	102	15681	11
6	Cutin	15	20-30	1	F	23	0.007	429	59621	5
7	Cutin	30	20-30	1	F	10	0.011	226	21198	9
8	Cutin	33	20-30	1	M	43	0.008	487	59267	18
9	Cutin	37	20-30	1	M	7	0.010	142	14356	5
10	Cutin	1	40-50	0	F	14	0.018	108	6009	5
11	Cutin	23	40-50	0	F	19	0.009	234	25265	6
12	Cutin	25	40-50	0	F	1	0.005	18	3801	3
13	Cutin	26	40-50	0	F	7	0.004	150	33510	3
14	Cutin	29	40-50	0	F	9	0.004	140	31963	6
15	Cutin	34	40-50	0	M	17	0.009	278	31089	14
16	Cutin	5	40-50	1	F	6	0.011	157	13507	9
17	Cutin	6	40-50	1	F	18	0.007	320	43159	5
18	Cutin	8	40-50	1	F	32	0.005	307	65997	6
19	Cutin	9	40-50	1	F	72	0.010	1144	118833	17
20	Cutin	12	40-50	1	F	17	0.008	327	39515	10
21	Cutin	21	40-50	1	F	87	0.013	1225	93346	13
22	Cutin	24	40-50	1	F	100	0.013	1422	111186	6
23	Cutin	36	40-50	1	F	22	0.007	372	52372	6
24	Cutin	3	40-50	1	M	8	0.008	166	20642	7
25	Cutin	14	40-50	1	M	58	0.019	1591	84267	13
26	Cutin	17	40-50	1	M	8	0.006	104	18685	6
27	Cutin	22	40-50	1	M	7	0.008	211	24881	1
28	Cutin	35	40-50	1	M	73	0.026	957	36085	5
29	Cutin	13	60-70	1	F	134	0.021	1126	52200	9
30	Cutin	7	60-70	1	M	32	0.003	425	136026	11
31	Cutin	11	60-70	1	M	120	0.013	1525	114427	12
32	Cutin	18	60-70	1	M	117	0.012	1573	127332	7
33	Cutin	19	60-70	1	M	23	0.010	576	59502	13
34	Cutin	20	60-70	1	M	56	0.017	765	45045	4
35	Cutin	32	60-70	1	M	8	0.009	132	13877	4
1	Following	27	20-30	0	F	135	0.710	20323	8314	5
2	Following	31	20-30	0	F	40	0.518	2593	2410	9
3	Following	38	20-30	0	F	127	0.182	3337	15033	6
4	Following	4	20-30	0	M	263	0.683	55700	25906	20
5	Following	10	20-30	1	F	83	0.672	10612	5171	11
6	Following	15	20-30	1	F	484	0.716	42974	17076	5
7	Following	30	20-30	1	F	152	0.637	13657	7767	9
8	Following	33	20-30	1	M	633	0.549	32806	26948	18
9	Following	37	20-30	1	M	214	0.524	7595	6903	5
10	Following	1	40-50	0	F	35	0.479	2932	3185	5
11	Following	23	40-50	0	F	254	0.569	14503	10996	6
12	Following	25	40-50	0	F	5	0.798	3046	773	3
13	Following	26	40-50	0	F	154	0.730	24567	9093	3
14	Following	29	40-50	0	F	136	0.783	25122	6981	6
15	Following	34	40-50	0	M	375	0.734	23011	8356	14
16	Following	5	40-50	1	F	87	0.692	9452	4212	9
17	Following	6	40-50	1	F	178	0.674	29286	14193	5
18	Following	8	40-50	1	F	161	0.758	50291	16013	6
19	Following	9	40-50	1	F	773	0.583	69953	50024	17
20	Following	12	40-50	1	F	232	0.652	25975	13867	10
21	Following	21	40-50	1	F	890	0.558	52778	41793	13
22	Following	24	40-50	1	F	975	0.619	69654	42954	6

No.	Measure	ID	Age	User	Sex	Transitions	Probability	True	False	Trips
23	Following	36	40-50	1	F	458	0.699	36846	15898	6
24	Following	3	40-50	1	M	70	0.710	14777	6031	7
25	Following	14	40-50	1	M	704	0.634	54426	31432	13
26	Following	17	40-50	1	M	169	0.705	13249	5540	6
27	Following	22	40-50	1	M	96	0.771	19354	5738	1
28	Following	35	40-50	1	M	205	0.575	21288	15754	5
29	Following	13	60-70	1	F	329	0.621	33097	20229	9
30	Following	7	60-70	1	M	543	0.770	105128	31323	11
31	Following	11	60-70	1	M	382	0.672	77872	38080	12
32	Following	18	60-70	1	M	1051	0.743	95837	33068	7
33	Following	19	60-70	1	M	364	0.730	43850	16228	13
34	Following	20	60-70	1	M	299	0.501	22939	22871	4
35	Following	32	60-70	1	M	164	0.628	8792	5217	4
1	Near	27	20-30	0	F	17	0.006	166	28471	5
2	Near	31	20-30	0	F	1	0.000	2	5001	9
3	Near	38	20-30	0	F	0	0.000	0	18370	6
4	Near	4	20-30	0	M	35	0.010	790	80816	20
5	Near	10	20-30	1	F	5	0.002	26	15757	11
6	Near	15	20-30	1	F	13	0.004	220	59830	5
7	Near	30	20-30	1	F	4	0.002	48	21376	9
8	Near	33	20-30	1	M	7	0.000	17	59737	18
9	Near	37	20-30	1	M	7	0.002	29	14469	5
10	Near	1	40-50	0	F	1	0.001	4	6113	5
11	Near	23	40-50	0	F	10	0.001	25	25474	6
12	Near	25	40-50	0	F	0	0.000	0	3819	3
13	Near	26	40-50	0	F	9	0.002	71	33589	3
14	Near	29	40-50	0	F	4	0.001	26	32077	6
15	Near	34	40-50	0	M	15	0.004	137	31230	14
16	Near	5	40-50	1	F	7	0.006	83	13581	9
17	Near	6	40-50	1	F	2	0.000	5	43474	5
18	Near	8	40-50	1	F	6	0.000	32	66272	6
19	Near	9	40-50	1	F	40	0.003	329	119648	17
20	Near	12	40-50	1	F	4	0.001	22	39820	10
21	Near	21	40-50	1	F	19	0.002	147	94424	13
22	Near	24	40-50	1	F	28	0.003	323	112285	6
23	Near	36	40-50	1	F	18	0.003	151	52593	6
24	Near	3	40-50	1	M	7	0.007	147	20661	7
25	Near	14	40-50	1	M	46	0.007	624	85234	13
26	Near	17	40-50	1	M	8	0.004	68	18721	6
27	Near	22	40-50	1	M	4	0.004	90	25002	1
28	Near	35	40-50	1	M	9	0.001	43	36999	5
29	Near	13	60-70	1	F	56	0.006	306	53020	9
30	Near	7	60-70	1	M	20	0.002	248	136203	11
31	Near	11	60-70	1	M	17	0.001	115	115837	12
32	Near	18	60-70	1	M	64	0.003	372	128533	7
33	Near	19	60-70	1	M	17	0.002	150	59928	13
34	Near	20	60-70	1	M	14	0.002	76	45734	4
35	Near	32	60-70	1	M	3	0.000	6	14003	4
1	Separating	27	20-30	0	F	75	0.123	3512	25125	5
2	Separating	31	20-30	0	F	22	0.289	1446	3557	9
3	Separating	38	20-30	0	F	149	0.769	14120	4250	6
4	Separating	4	20-30	0	M	105	0.060	4874	76732	20
5	Separating	10	20-30	1	F	44	0.138	2175	13608	11

No.	Measure	ID	Age	User	Sex	Transitions	Probability	True	False	Trips
6	Separating	15	20-30	1	F	191	0.086	5146	54904	5
7	Separating	30	20-30	1	F	99	0.150	3213	18211	9
8	Separating	33	20-30	1	M	459	0.306	18275	41479	18
9	Separating	37	20-30	1	M	126	0.273	3961	10537	5
10	Separating	1	40-50	0	F	39	0.344	2106	4011	5
11	Separating	23	40-50	0	F	205	0.302	7694	17805	6
12	Separating	25	40-50	0	F	3	0.128	488	3331	3
13	Separating	26	40-50	0	F	84	0.121	4059	29601	3
14	Separating	29	40-50	0	F	90	0.116	3733	28370	6
15	Separating	34	40-50	0	M	178	0.102	3204	28163	14
16	Separating	5	40-50	1	F	32	0.092	1251	12413	9
17	Separating	6	40-50	1	F	143	0.253	10979	32500	5
18	Separating	8	40-50	1	F	102	0.155	10309	55995	6
19	Separating	9	40-50	1	F	523	0.242	29052	90925	17
20	Separating	12	40-50	1	F	148	0.193	7680	32162	10
21	Separating	21	40-50	1	F	581	0.293	27712	66859	13
22	Separating	24	40-50	1	F	669	0.257	28994	83614	6
23	Separating	36	40-50	1	F	230	0.112	5933	46811	6
24	Separating	3	40-50	1	M	38	0.138	2880	17928	7
25	Separating	14	40-50	1	M	456	0.203	17403	68455	13
26	Separating	17	40-50	1	M	84	0.099	1852	16937	6
27	Separating	22	40-50	1	M	45	0.093	2322	22770	1
28	Separating	35	40-50	1	M	213	0.358	13269	23773	5
29	Separating	13	60-70	1	F	272	0.231	12295	41031	9
30	Separating	7	60-70	1	M	291	0.115	15628	120823	11
31	Separating	11	60-70	1	M	361	0.269	31210	84742	12
32	Separating	18	60-70	1	M	551	0.109	14055	114850	7
33	Separating	19	60-70	1	M	193	0.124	7472	52606	13
34	Separating	20	60-70	1	M	230	0.293	13437	32373	4
35	Separating	32	60-70	1	M	57	0.118	1649	12360	4

CCC Driving

1	Closing	27	20-30	0	F		0			0
2	Closing	31	20-30	0	F	0	0	0	0	4
3	Closing	38	20-30	0	F	9	0.110	93	753	2
4	Closing	4	20-30	0	M	131	0.292	11073	26872	7
5	Closing	10	20-30	1	F	118	0.202	7840	30975	13
6	Closing	15	20-30	1	F	13	0.258	581	1668	2
7	Closing	30	20-30	1	F	179	0.148	3696	21288	6
8	Closing	33	20-30	1	M	96	0.101	1831	16369	13
9	Closing	37	20-30	1	M	8	0.192	642	2706	2
10	Closing	1	40-50	0	F	0	0	0	0	5
11	Closing	23	40-50	0	F	47	0.068	957	13124	8
12	Closing	25	40-50	0	F	0	0	0	0	4
13	Closing	26	40-50	0	F	87	0.124	2274	16094	5
14	Closing	29	40-50	0	F	19	0.089	496	5071	6
15	Closing	34	40-50	0	M	365	0.291	13516	32980	15
16	Closing	5	40-50	1	F	32	0.273	2535	6743	10
17	Closing	6	40-50	1	F	13	0.071	267	3512	4
18	Closing	8	40-50	1	F	54	0.155	4385	23989	10
19	Closing	9	40-50	1	F	45	0.050	1395	26628	12
20	Closing	12	40-50	1	F	45	0.157	1961	10545	10

No.	Measure	ID	Age	User	Sex	Transitions	Probability	True	False	Trips
21	Closing	21	40-50	1	F	91	0.155	3440	18785	7
22	Closing	24	40-50	1	F	71	0.115	2057	15785	2
23	Closing	36	40-50	1	F	50	0.151	1455	8163	4
24	Closing	3	40-50	1	M	36	0.198	2046	8267	7
25	Closing	14	40-50	1	M	221	0.206	9299	35897	8
26	Closing	17	40-50	1	M	46	0.117	1786	13489	6
27	Closing	22	40-50	1	M	25	0.099	1100	10067	3
28	Closing	35	40-50	1	M	273	0.202	7124	28138	8
29	Closing	13	60-70	1	F	96	0.063	1785	26538	5
30	Closing	7	60-70	1	M	44	0.524	4675	4249	6
31	Closing	11	60-70	1	M	109	0.079	5400	63042	20
32	Closing	18	60-70	1	M	78	0.188	1633	7043	4
33	Closing	19	60-70	1	M	164	0.146	4647	27219	12
34	Closing	20	60-70	1	M	7	0.027	139	4950	1
35	Closing	32	60-70	1	M	34	0.317	1876	4051	5
1	Cutin	27	20-30	0	F		0			0
2	Cutin	31	20-30	0	F	0	0	0	0	4
3	Cutin	38	20-30	0	F	0	0.000	0	846	2
4	Cutin	4	20-30	0	M	30	0.030	1153	36792	7
5	Cutin	10	20-30	1	F	21	0.013	514	38301	13
6	Cutin	15	20-30	1	F	1	0.008	19	2230	2
7	Cutin	30	20-30	1	F	15	0.009	225	24759	6
8	Cutin	33	20-30	1	M	17	0.012	222	17978	13
9	Cutin	37	20-30	1	M	0	0.000	0	3348	2
10	Cutin	1	40-50	0	F	0	0	0	0	5
11	Cutin	23	40-50	0	F	9	0.003	44	14037	8
12	Cutin	25	40-50	0	F	0	0	0	0	4
13	Cutin	26	40-50	0	F	27	0.035	646	17722	5
14	Cutin	29	40-50	0	F	5	0.011	60	5507	6
15	Cutin	34	40-50	0	M	20	0.005	231	46265	15
16	Cutin	5	40-50	1	F	5	0.022	206	9072	10
17	Cutin	6	40-50	1	F	4	0.015	57	3722	4
18	Cutin	8	40-50	1	F	7	0.004	127	28247	10
19	Cutin	9	40-50	1	F	40	0.018	506	27517	12
20	Cutin	12	40-50	1	F	10	0.010	125	12381	10
21	Cutin	21	40-50	1	F	14	0.016	360	21865	7
22	Cutin	24	40-50	1	F	24	0.015	267	17575	2
23	Cutin	36	40-50	1	F	8	0.014	139	9479	4
24	Cutin	3	40-50	1	M	15	0.025	254	10059	7
25	Cutin	14	40-50	1	M	35	0.011	498	44698	8
26	Cutin	17	40-50	1	M	22	0.019	285	14990	6
27	Cutin	22	40-50	1	M	18	0.029	319	10848	3
28	Cutin	35	40-50	1	M	14	0.006	220	35042	8
29	Cutin	13	60-70	1	F	28	0.012	328	27995	5
30	Cutin	7	60-70	1	M	5	0.016	143	8781	6
31	Cutin	11	60-70	1	M	81	0.014	947	67495	20
32	Cutin	18	60-70	1	M	11	0.013	117	8559	4
33	Cutin	19	60-70	1	M	40	0.016	510	31356	12
34	Cutin	20	60-70	1	M	5	0.021	105	4984	1
35	Cutin	32	60-70	1	M	7	0.008	47	5880	5
1	Following	27	20-30	0	F		0			0
2	Following	31	20-30	0	F	0	0	0	0	4
3	Following	38	20-30	0	F	27	0.752	636	210	2

No.	Measure	ID	Age	User	Sex	Transitions	Probability	True	False	Trips
4	Following	4	20-30	0	M	180	0.545	20662	17283	7
5	Following	10	20-30	1	F	194	0.584	22672	16143	13
6	Following	15	20-30	1	F	30	0.551	1240	1009	2
7	Following	30	20-30	1	F	332	0.532	13279	11705	6
8	Following	33	20-30	1	M	192	0.701	12765	5435	13
9	Following	37	20-30	1	M	19	0.269	900	2448	2
10	Following	1	40-50	0	F	0	0	0	0	5
11	Following	23	40-50	0	F	144	0.396	5582	8499	8
12	Following	25	40-50	0	F	0	0	0	0	4
13	Following	26	40-50	0	F	160	0.472	8664	9704	5
14	Following	29	40-50	0	F	27	0.665	3700	1867	6
15	Following	34	40-50	0	M	549	0.534	24823	21673	15
16	Following	5	40-50	1	F	44	0.513	4763	4515	10
17	Following	6	40-50	1	F	20	0.331	1250	2529	4
18	Following	8	40-50	1	F	85	0.702	19922	8452	10
19	Following	9	40-50	1	F	164	0.304	8514	19509	12
20	Following	12	40-50	1	F	97	0.633	7913	4593	10
21	Following	21	40-50	1	F	216	0.632	14051	8174	7
22	Following	24	40-50	1	F	140	0.267	4769	13073	2
23	Following	36	40-50	1	F	137	0.506	4865	4753	4
24	Following	3	40-50	1	M	57	0.435	4491	5822	7
25	Following	14	40-50	1	M	370	0.576	26018	19178	8
26	Following	17	40-50	1	M	154	0.552	8430	6845	6
27	Following	22	40-50	1	M	55	0.431	4812	6355	3
28	Following	35	40-50	1	M	403	0.618	21778	13484	8
29	Following	13	60-70	1	F	219	0.521	14744	13579	5
30	Following	7	60-70	1	M	52	0.159	1419	7505	6
31	Following	11	60-70	1	M	363	0.392	26797	41645	20
32	Following	18	60-70	1	M	119	0.560	4857	3819	4
33	Following	19	60-70	1	M	410	0.405	12896	18970	12
34	Following	20	60-70	1	M	16	0.497	2527	2562	1
35	Following	32	60-70	1	M	55	0.529	3135	2792	5
1	Near	27	20-30	0	F		0			0
2	Near	31	20-30	0	F	0	0	0	0	4
3	Near	38	20-30	0	F	0	0.000	0	846	2
4	Near	4	20-30	0	M	54	0.053	2001	35944	7
5	Near	10	20-30	1	F	20	0.007	253	38562	13
6	Near	15	20-30	1	F	0	0.000	0	2249	2
7	Near	30	20-30	1	F	3	0.000	10	24974	6
8	Near	33	20-30	1	M	6	0.002	40	18160	13
9	Near	37	20-30	1	M	1	0.003	9	3339	2
10	Near	1	40-50	0	F	0	0	0	0	5
11	Near	23	40-50	0	F	1	0.000	3	14078	8
12	Near	25	40-50	0	F	0	0	0	0	4
13	Near	26	40-50	0	F	5	0.003	53	18315	5
14	Near	29	40-50	0	F	1	0.000	2	5565	6
15	Near	34	40-50	0	M	17	0.006	259	46237	15
16	Near	5	40-50	1	F	4	0.002	19	9259	10
17	Near	6	40-50	1	F	1	0.000	1	3778	4
18	Near	8	40-50	1	F	4	0.003	96	28278	10
19	Near	9	40-50	1	F	6	0.002	48	27975	12
20	Near	12	40-50	1	F	6	0.002	30	12476	10
21	Near	21	40-50	1	F	11	0.006	142	22083	7

No.	Measure	ID	Age	User	Sex	Transitions	Probability	True	False	Trips
22	Near	24	40-50	1	F	6	0.012	212	17630	2
23	Near	36	40-50	1	F	1	0.000	4	9614	4
24	Near	3	40-50	1	M	10	0.046	471	9842	7
25	Near	14	40-50	1	M	35	0.014	652	44544	8
26	Near	17	40-50	1	M	17	0.012	187	15088	6
27	Near	22	40-50	1	M	4	0.001	16	11151	3
28	Near	35	40-50	1	M	10	0.001	37	35225	8
29	Near	13	60-70	1	F	5	0.001	16	28307	5
30	Near	7	60-70	1	M	12	0.024	212	8712	6
31	Near	11	60-70	1	M	13	0.002	157	68285	20
32	Near	18	60-70	1	M	10	0.005	45	8631	4
33	Near	19	60-70	1	M	13	0.003	108	31758	12
34	Near	20	60-70	1	M	0	0.000	0	5089	1
35	Near	32	60-70	1	M	3	0.008	47	5880	5
1	Separating	27	20-30	0	F		0			0
2	Separating	31	20-30	0	F	0	0	0	0	4
3	Separating	38	20-30	0	F	19	0.138	117	729	2
4	Separating	4	20-30	0	M	53	0.081	3056	34889	7
5	Separating	10	20-30	1	F	115	0.194	7536	31279	13
6	Separating	15	20-30	1	F	23	0.182	409	1840	2
7	Separating	30	20-30	1	F	189	0.311	7774	17210	6
8	Separating	33	20-30	1	M	124	0.184	3342	14858	13
9	Separating	37	20-30	1	M	18	0.537	1797	1551	2
10	Separating	1	40-50	0	F	0	0	0	0	5
11	Separating	23	40-50	0	F	120	0.532	7495	6586	8
12	Separating	25	40-50	0	F	0	0	0	0	4
13	Separating	26	40-50	0	F	117	0.366	6731	11637	5
14	Separating	29	40-50	0	F	16	0.235	1309	4258	6
15	Separating	34	40-50	0	M	256	0.165	7667	38829	15
16	Separating	5	40-50	1	F	28	0.189	1755	7523	10
17	Separating	6	40-50	1	F	26	0.583	2204	1575	4
18	Separating	8	40-50	1	F	43	0.135	3844	24530	10
19	Separating	9	40-50	1	F	179	0.627	17560	10463	12
20	Separating	12	40-50	1	F	62	0.198	2477	10029	10
21	Separating	21	40-50	1	F	150	0.190	4232	17993	7
22	Separating	24	40-50	1	F	110	0.591	10537	7305	2
23	Separating	36	40-50	1	F	100	0.328	3155	6463	4
24	Separating	3	40-50	1	M	34	0.296	3051	7262	7
25	Separating	14	40-50	1	M	195	0.193	8729	36467	8
26	Separating	17	40-50	1	M	128	0.300	4587	10688	6
27	Separating	22	40-50	1	M	56	0.441	4920	6247	3
28	Separating	35	40-50	1	M	195	0.173	6103	29159	8
29	Separating	13	60-70	1	F	161	0.404	11450	16873	5
30	Separating	7	60-70	1	M	24	0.277	2475	6449	6
31	Separating	11	60-70	1	M	390	0.513	35141	33301	20
32	Separating	18	60-70	1	M	69	0.233	2024	6652	4
33	Separating	19	60-70	1	M	311	0.430	13705	18161	12
34	Separating	20	60-70	1	M	18	0.455	2318	2771	1
35	Separating	32	60-70	1	M	25	0.139	822	5105	5

No.	Measure	ID	Age	User	Sex	Transitions	Probability	True	False	Trips

Manual (MAN) Driving

No.	Measure	ID	Age	User	Sex	Transitions	Probability	True	False	Trips
1	Closing	27	20-30	0	F	68	0.107	2447	20335	5
2	Closing	31	20-30	0	F	444	0.141	13415	81432	13
3	Closing	38	20-30	0	F	31	0.078	758	9021	8
4	Closing	4	20-30	0	M	658	0.211	44559	166198	27
5	Closing	10	20-30	1	F	394	0.181	20792	94365	24
6	Closing	15	20-30	1	F	433	0.156	11183	60647	7
7	Closing	30	20-30	1	F	262	0.201	7684	30610	15
8	Closing	33	20-30	1	M	382	0.142	10199	61798	31
9	Closing	37	20-30	1	M	116	0.158	2408	12849	7
10	Closing	1	40-50	0	F	334	0.089	12839	131255	10
11	Closing	23	40-50	0	F	119	0.108	3231	26616	14
12	Closing	25	40-50	0	F	167	0.114	5991	46475	7
13	Closing	26	40-50	0	F	114	0.140	4488	27545	8
14	Closing	29	40-50	0	F	427	0.199	18378	73865	12
15	Closing	34	40-50	0	M	1180	0.173	33122	158231	29
16	Closing	5	40-50	1	F	483	0.197	22262	90541	19
17	Closing	6	40-50	1	F	84	0.160	4141	21807	9
18	Closing	8	40-50	1	F	229	0.131	14826	98481	16
19	Closing	9	40-50	1	F	479	0.140	17349	106395	29
20	Closing	12	40-50	1	F	161	0.157	7784	41859	20
21	Closing	21	40-50	1	F	248	0.127	7968	54769	20
22	Closing	24	40-50	1	F	116	0.178	3400	15702	8
23	Closing	36	40-50	1	F	227	0.139	5898	36466	10
24	Closing	3	40-50	1	M	190	0.233	8685	28545	14
25	Closing	14	40-50	1	M	440	0.182	13093	58961	21
26	Closing	17	40-50	1	M	87	0.294	2872	6907	12
27	Closing	22	40-50	1	M	74	0.104	3011	25825	4
28	Closing	35	40-50	1	M	587	0.152	14486	80899	13
29	Closing	13	60-70	1	F	256	0.111	5442	43389	14
30	Closing	7	60-70	1	M	878	0.193	55068	230655	17
31	Closing	11	60-70	1	M	175	0.203	7758	30508	32
32	Closing	18	60-70	1	M	142	0.150	3468	19721	11
33	Closing	19	60-70	1	M	234	0.170	6925	33919	25
34	Closing	20	60-70	1	M	243	0.124	6972	49225	5
35	Closing	32	60-70	1	M	293	0.178	9090	41876	9
1	Cutin	27	20-30	0	F	8	0.014	319	22463	5
2	Cutin	31	20-30	0	F	253	0.038	3571	91276	13
3	Cutin	38	20-30	0	F	30	0.044	434	9345	8
4	Cutin	4	20-30	0	M	168	0.021	4521	206236	27
5	Cutin	10	20-30	1	F	172	0.042	4830	110327	24
6	Cutin	15	20-30	1	F	72	0.014	976	70854	7
7	Cutin	30	20-30	1	F	25	0.009	346	37948	15
8	Cutin	33	20-30	1	M	71	0.008	569	71428	31
9	Cutin	37	20-30	1	M	25	0.020	298	14959	7
10	Cutin	1	40-50	0	F	134	0.021	3022	141072	10
11	Cutin	23	40-50	0	F	35	0.012	354	29493	14
12	Cutin	25	40-50	0	F	29	0.008	406	52060	7
13	Cutin	26	40-50	0	F	31	0.021	685	31348	8
14	Cutin	29	40-50	0	F	79	0.016	1478	90765	12
15	Cutin	34	40-50	0	M	86	0.005	994	190359	29

No.	Measure	ID	Age	User	Sex	Transitions	Probability	True	False	Trips
16	Cutin	5	40-50	1	F	69	0.011	1187	111616	19
17	Cutin	6	40-50	1	F	11	0.004	105	25843	9
18	Cutin	8	40-50	1	F	84	0.019	2151	111156	16
19	Cutin	9	40-50	1	F	77	0.008	1030	122714	29
20	Cutin	12	40-50	1	F	55	0.013	642	49001	20
21	Cutin	21	40-50	1	F	87	0.031	1921	60816	20
22	Cutin	24	40-50	1	F	31	0.039	738	18364	8
23	Cutin	36	40-50	1	F	65	0.030	1263	41101	10
24	Cutin	3	40-50	1	M	58	0.022	826	36404	14
25	Cutin	14	40-50	1	M	140	0.044	3190	68864	21
26	Cutin	17	40-50	1	M	12	0.026	259	9520	12
27	Cutin	22	40-50	1	M	13	0.008	223	28613	4
28	Cutin	35	40-50	1	M	80	0.009	853	94532	13
29	Cutin	13	60-70	1	F	109	0.019	932	47899	14
30	Cutin	7	60-70	1	M	135	0.012	3404	282319	17
31	Cutin	11	60-70	1	M	17	0.010	383	37883	32
32	Cutin	18	60-70	1	M	38	0.025	574	22615	11
33	Cutin	19	60-70	1	M	64	0.024	987	39857	25
34	Cutin	20	60-70	1	M	26	0.006	336	55861	5
35	Cutin	32	60-70	1	M	75	0.026	1330	49636	9
1	Following	27	20-30	0	F	118	0.798	18179	4603	5
2	Following	31	20-30	0	F	935	0.695	65888	28959	13
3	Following	38	20-30	0	F	113	0.316	3088	6691	8
4	Following	4	20-30	0	M	1004	0.689	145113	65644	27
5	Following	10	20-30	1	F	771	0.659	75860	39297	24
6	Following	15	20-30	1	F	748	0.723	51969	19861	7
7	Following	30	20-30	1	F	446	0.672	25731	12563	15
8	Following	33	20-30	1	M	802	0.702	50527	21470	31
9	Following	37	20-30	1	M	200	0.706	10764	4493	7
10	Following	1	40-50	0	F	728	0.779	112275	31819	10
11	Following	23	40-50	0	F	282	0.536	16000	13847	14
12	Following	25	40-50	0	F	354	0.650	34102	18364	7
13	Following	26	40-50	0	F	200	0.673	21571	10462	8
14	Following	29	40-50	0	F	710	0.654	60364	31879	12
15	Following	34	40-50	0	M	1870	0.733	140196	51157	29
16	Following	5	40-50	1	F	745	0.664	74932	37871	19
17	Following	6	40-50	1	F	135	0.725	18812	7136	9
18	Following	8	40-50	1	F	453	0.616	69846	43461	16
19	Following	9	40-50	1	F	877	0.631	78116	45628	29
20	Following	12	40-50	1	F	308	0.697	34589	15054	20
21	Following	21	40-50	1	F	507	0.741	46501	16236	20
22	Following	24	40-50	1	F	229	0.583	11134	7968	8
23	Following	36	40-50	1	F	514	0.645	27314	15050	10
24	Following	3	40-50	1	M	296	0.610	22701	14529	14
25	Following	14	40-50	1	M	739	0.625	45069	26985	21
26	Following	17	40-50	1	M	136	0.491	4803	4976	12
27	Following	22	40-50	1	M	160	0.643	18543	10293	4
28	Following	35	40-50	1	M	1172	0.596	56844	38541	13
29	Following	13	60-70	1	F	456	0.604	29494	19337	14
30	Following	7	60-70	1	M	1339	0.685	195765	89958	17
31	Following	11	60-70	1	M	269	0.630	24100	14166	32
32	Following	18	60-70	1	M	265	0.664	15406	7783	11
33	Following	19	60-70	1	M	434	0.643	26248	14596	25

No.	Measure	ID	Age	User	Sex	Transitions	Probability	True	False	Trips
34	Following	20	60-70	1	M	406	0.701	39374	16823	5
35	Following	32	60-70	1	M	573	0.644	32816	18150	9
1	Near	27	20-30	0	F	14	0.011	251	22531	5
2	Near	31	20-30	0	F	308	0.046	4401	90446	13
3	Near	38	20-30	0	F	4	0.002	20	9759	8
4	Near	4	20-30	0	M	305	0.036	7651	203106	27
5	Near	10	20-30	1	F	211	0.054	6246	108911	24
6	Near	15	20-30	1	F	78	0.011	758	71072	7
7	Near	30	20-30	1	F	32	0.006	238	38056	15
8	Near	33	20-30	1	M	109	0.011	793	71204	31
9	Near	37	20-30	1	M	30	0.017	266	14991	7
10	Near	1	40-50	0	F	133	0.029	4196	139898	10
11	Near	23	40-50	0	F	20	0.004	109	29738	14
12	Near	25	40-50	0	F	9	0.002	109	52357	7
13	Near	26	40-50	0	F	23	0.007	229	31804	8
14	Near	29	40-50	0	F	105	0.025	2328	89915	12
15	Near	34	40-50	0	M	142	0.008	1574	189779	29
16	Near	5	40-50	1	F	104	0.010	1106	111697	19
17	Near	6	40-50	1	F	15	0.002	56	25892	9
18	Near	8	40-50	1	F	69	0.015	1687	111620	16
19	Near	9	40-50	1	F	94	0.007	886	122858	29
20	Near	12	40-50	1	F	80	0.016	815	48828	20
21	Near	21	40-50	1	F	96	0.020	1253	61484	20
22	Near	24	40-50	1	F	33	0.021	406	18696	8
23	Near	36	40-50	1	F	75	0.023	970	41394	10
24	Near	3	40-50	1	M	84	0.030	1114	36116	14
25	Near	14	40-50	1	M	214	0.063	4552	67502	21
26	Near	17	40-50	1	M	28	0.030	296	9483	12
27	Near	22	40-50	1	M	4	0.003	76	28760	4
28	Near	35	40-50	1	M	42	0.003	260	95125	13
29	Near	13	60-70	1	F	47	0.004	217	48614	14
30	Near	7	60-70	1	M	242	0.019	5515	280208	17
31	Near	11	60-70	1	M	44	0.011	407	37859	32
32	Near	18	60-70	1	M	31	0.011	259	22930	11
33	Near	19	60-70	1	M	64	0.025	1014	39830	25
34	Near	20	60-70	1	M	30	0.004	198	55999	5
35	Near	32	60-70	1	M	89	0.031	1577	49389	9
1	Separating	27	20-30	0	F	55	0.070	1586	21196	5
2	Separating	31	20-30	0	F	366	0.080	7572	87275	13
3	Separating	38	20-30	0	F	135	0.560	5479	4300	8
4	Separating	4	20-30	0	M	251	0.042	8913	201844	27
5	Separating	10	20-30	1	F	249	0.065	7429	107728	24
6	Separating	15	20-30	1	F	339	0.097	6944	64886	7
7	Separating	30	20-30	1	F	218	0.112	4295	33999	15
8	Separating	33	20-30	1	M	480	0.138	9909	62088	31
9	Separating	37	20-30	1	M	96	0.100	1521	13736	7
10	Separating	1	40-50	0	F	306	0.082	11762	132332	10
11	Separating	23	40-50	0	F	214	0.340	10153	19694	14
12	Separating	25	40-50	0	F	262	0.226	11858	40608	7
13	Separating	26	40-50	0	F	141	0.158	5060	26973	8
14	Separating	29	40-50	0	F	306	0.105	9695	82548	12
15	Separating	34	40-50	0	M	830	0.081	15467	175886	29
16	Separating	5	40-50	1	F	370	0.118	13316	99487	19

No.	Measure	ID	Age	User	Sex	Transitions	Probability	True	False	Trips
17	Separating	6	40-50	1	F	72	0.109	2834	23114	9
18	Separating	8	40-50	1	F	216	0.219	24797	88510	16
19	Separating	9	40-50	1	F	570	0.213	26363	97381	29
20	Separating	12	40-50	1	F	165	0.117	5813	43830	20
21	Separating	21	40-50	1	F	250	0.081	5094	57643	20
22	Separating	24	40-50	1	F	111	0.179	3424	15678	8
23	Separating	36	40-50	1	F	295	0.163	6919	35445	10
24	Separating	3	40-50	1	M	129	0.105	3904	33326	14
25	Separating	14	40-50	1	M	294	0.085	6150	65904	21
26	Separating	17	40-50	1	M	70	0.158	1549	8230	12
27	Separating	22	40-50	1	M	122	0.242	6983	21853	4
28	Separating	35	40-50	1	M	749	0.241	22942	72443	13
29	Separating	13	60-70	1	F	336	0.261	12746	36085	14
30	Separating	7	60-70	1	M	580	0.091	25971	259752	17
31	Separating	11	60-70	1	M	159	0.147	5618	32648	32
32	Separating	18	60-70	1	M	148	0.150	3482	19707	11
33	Separating	19	60-70	1	M	226	0.139	5670	35174	25
34	Separating	20	60-70	1	M	236	0.166	9317	46880	5
35	Separating	32	60-70	1	M	275	0.121	6153	44813	9

Floating-Point Measures Summary

ACC Driving

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
1	DecelAvoid	27	20-30	0	F	0.0058276	0.0066116	0.005	5	28637
2	DecelAvoid	31	20-30	0	F	0.00507	0.0026329	0.005	9	5003
3	DecelAvoid	38	20-30	0	F	0.0051257	0.0020896	0.005	6	18370
4	DecelAvoid	4	20-30	0	M	0.0072676	0.0101393	0.005	20	81606
5	DecelAvoid	10	20-30	1	F	0.0054399	0.0027575	0.005	11	15776
6	DecelAvoid	15	20-30	1	F	0.0058194	0.0044873	0.005	5	60047
7	DecelAvoid	30	20-30	1	F	0.0058024	0.0039147	0.005	9	21424
8	DecelAvoid	33	20-30	1	M	0.0053131	0.0029638	0.005	18	59751
9	DecelAvoid	37	20-30	1	M	0.0057194	0.0050259	0.005	5	14498
10	DecelAvoid	1	40-50	0	F	0.0053975	0.002915	0.005	5	6113
11	DecelAvoid	23	40-50	0	F	0.0053324	0.0029742	0.005	6	21662
12	DecelAvoid	25	40-50	0	F	0.0050236	0.0004849	0.005	3	3819
13	DecelAvoid	26	40-50	0	F	0.0058306	0.0047388	0.005	3	33652
14	DecelAvoid	29	40-50	0	F	0.0051922	0.0022291	0.005	6	32103
15	DecelAvoid	34	40-50	0	M	0.0057525	0.0058932	0.005	14	31364
16	DecelAvoid	5	40-50	1	F	0.0061681	0.0052944	0.005	9	13663
17	DecelAvoid	6	40-50	1	F	0.0052286	0.0022644	0.005	5	43479
18	DecelAvoid	8	40-50	1	F	0.0051683	0.0018113	0.005	6	66304
19	DecelAvoid	9	40-50	1	F	0.0057201	0.005324	0.005	17	119942
20	DecelAvoid	12	40-50	1	F	0.0054282	0.0031099	0.005	10	39838
21	DecelAvoid	21	40-50	1	F	0.0054263	0.0035609	0.005	13	94566
22	DecelAvoid	24	40-50	1	F	0.0054667	0.00418	0.005	6	112601
23	DecelAvoid	36	40-50	1	F	0.0057357	0.0054004	0.005	6	52738
24	DecelAvoid	3	40-50	1	M	0.005896	0.0060693	0.005	7	20804
25	DecelAvoid	14	40-50	1	M	0.0058542	0.0060232	0.005	13	85834

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
26	DecelAvoid	17	40-50	1	M	0.0061098	0.0075228	0.005	6	18787
27	DecelAvoid	22	40-50	1	M	0.00512	0.0019615	0.005	1	25092
28	DecelAvoid	35	40-50	1	M	0.0052349	0.0045852	0.005	5	37042
29	DecelAvoid	13	60-70	1	F	0.0060713	0.0104844	0.005	9	53283
30	DecelAvoid	7	60-70	1	M	0.0054247	0.0032508	0.005	11	136444
31	DecelAvoid	11	60-70	1	M	0.0052286	0.0031069	0.005	12	115940
32	DecelAvoid	18	60-70	1	M	0.0056223	0.0056261	0.005	7	128837
33	DecelAvoid	19	60-70	1	M	0.0056108	0.0063752	0.005	13	60073
34	DecelAvoid	20	60-70	1	M	0.0057253	0.0050211	0.005	4	45801
35	DecelAvoid	32	60-70	1	M	0.0059501	0.0046528	0.005	4	14009
1	Flow	27	20-30	0	F	0.585988	0.212896	0.6	5	28572
2	Flow	31	20-30	0	F	0.4931341	0.1802535	0.6	9	5003
3	Flow	38	20-30	0	F	0.3811713	0.1655446	0.3	6	18031
4	Flow	4	20-30	0	M	0.6606283	0.2389451	0.8	20	77543
5	Flow	10	20-30	1	F	0.6142825	0.2456958	0.8	11	15722
6	Flow	15	20-30	1	F	0.6116616	0.1671113	0.6	5	59289
7	Flow	30	20-30	1	F	0.5746714	0.2206863	0.3	9	21377
8	Flow	33	20-30	1	M	0.4408212	0.163038	0.4	18	58608
9	Flow	37	20-30	1	M	0.4753721	0.1980116	0.3	5	14041
10	Flow	1	40-50	0	F	0.4632892	0.2396623	0.3	5	5211
11	Flow	23	40-50	0	F	0.4543963	0.1671811	0.3	6	25499
12	Flow	25	40-50	0	F	0.5634722	0.1288924	0.6	3	3819
13	Flow	26	40-50	0	F	0.5862416	0.1907925	0.6	3	33285
14	Flow	29	40-50	0	F	0.5720274	0.1662844	0.6	6	32051
15	Flow	34	40-50	0	M	0.565055	0.1541052	0.6	14	30754
16	Flow	5	40-50	1	F	0.6180145	0.2125204	0.6	9	13664
17	Flow	6	40-50	1	F	0.4974367	0.1693638	0.6	5	43479
18	Flow	8	40-50	1	F	0.5397161	0.159225	0.6	6	66268
19	Flow	9	40-50	1	F	0.4775335	0.1803657	0.3	17	119284
20	Flow	12	40-50	1	F	0.5055135	0.1823531	0.6	10	38887
21	Flow	21	40-50	1	F	0.5228988	0.2277036	0.3	13	93457
22	Flow	24	40-50	1	F	0.5206525	0.2106263	0.3	6	111633
23	Flow	36	40-50	1	F	0.549327	0.2067088	0.3	6	52744
24	Flow	3	40-50	1	M	0.604984	0.236116	0.7	7	20375
25	Flow	14	40-50	1	M	0.5154738	0.1822184	0.4	13	77166
26	Flow	17	40-50	1	M	0.6150295	0.2413341	0.3	6	17113
27	Flow	22	40-50	1	M	0.6616474	0.2136482	0.7	1	24220
28	Flow	35	40-50	1	M	0.47345	0.1765437	0.4	5	35290
29	Flow	13	60-70	1	F	0.399168	0.149844	0.3	9	52936
30	Flow	7	60-70	1	M	0.4223626	0.1321371	0.4	11	126908
31	Flow	11	60-70	1	M	0.4771218	0.1848716	0.4	12	111333
32	Flow	18	60-70	1	M	0.6092471	0.1865661	0.6	7	125331
33	Flow	19	60-70	1	M	0.5471601	0.1894475	0.6	13	50951
34	Flow	20	60-70	1	M	0.4456296	0.1617976	0.4	4	45648
35	Flow	32	60-70	1	M	0.5131451	0.1955662	0.3	4	14009
1	Htm	27	20-30	0	F	1.5641183	0.5552279	1.5	5	19227
2	Htm	31	20-30	0	F	1.5386374	0.3606367	1.6	9	2275
3	Htm	38	20-30	0	F	2.359113	0.5164097	3	6	1827
4	Htm	4	20-30	0	M	1.2471877	0.485299	1.1	20	53944
5	Htm	10	20-30	1	F	1.3411504	0.564909	1.1	11	9232
6	Htm	15	20-30	1	F	1.440516	0.3590814	1.5	5	42235
7	Htm	30	20-30	1	F	1.5027409	0.6222135	1.2	9	12478
8	Htm	33	20-30	1	M	1.9761555	0.460899	2	18	27583

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
9	Htm	37	20-30	1	M	1.7958928	0.5517941	1.6	5	6428
10	Htm	1	40-50	0	F	1.6898156	0.7668481	0.8	5	2278
11	Htm	23	40-50	0	F	1.7174224	0.4106176	1.5	6	9683
12	Htm	25	40-50	0	F	1.5655613	0.2895653	1.5	3	3046
13	Htm	26	40-50	0	F	1.5490224	0.4837442	1.5	3	23634
14	Htm	29	40-50	0	F	1.5864946	0.4377215	1.5	6	23872
15	Htm	34	40-50	0	M	1.6070911	0.4130346	1.5	14	22366
16	Htm	5	40-50	1	F	1.4441496	0.4970225	1.1	9	9008
17	Htm	6	40-50	1	F	1.7148893	0.4601921	1.5	5	25300
18	Htm	8	40-50	1	F	1.5931658	0.4029096	1.5	6	47087
19	Htm	9	40-50	1	F	1.8036171	0.5413188	1.5	17	58196
20	Htm	12	40-50	1	F	1.6933026	0.5347083	1.5	10	22860
21	Htm	21	40-50	1	F	1.5752298	0.6261303	1.1	13	43839
22	Htm	24	40-50	1	F	1.6065556	0.5418142	1.5	6	60240
23	Htm	36	40-50	1	F	1.6368883	0.5975167	1.3	6	34309
24	Htm	3	40-50	1	M	1.4317827	0.5768778	1.1	7	13715
25	Htm	14	40-50	1	M	1.7839853	0.5008026	2	13	50890
26	Htm	17	40-50	1	M	1.3755842	0.5628204	0.9	6	11681
27	Htm	22	40-50	1	M	1.3483157	0.5379818	1.1	1	18762
28	Htm	35	40-50	1	M	1.8129628	0.4558271	1.5	5	18831
29	Htm	13	60-70	1	F	2.161881	0.4819218	2.1	9	24190
30	Htm	7	60-70	1	M	2.0997944	0.3650901	2.1	11	92857
31	Htm	11	60-70	1	M	1.8175492	0.4922452	2.1	12	68687
32	Htm	18	60-70	1	M	1.46083	0.4224178	1.5	7	92167
33	Htm	19	60-70	1	M	1.5975021	0.4603993	1.5	13	40593
34	Htm	20	60-70	1	M	2.0209816	0.4204375	2.1	4	19746
35	Htm	32	60-70	1	M	1.7518723	0.61507	1.3	4	7904
1	RangeVgt35	27	20-30	0	F	177.38503	80.0355	155	5	28637
2	RangeVgt35	31	20-30	0	F	197.42503	91.470558	135	9	5002
3	RangeVgt35	38	20-30	0	F	247.96298	84.282524	255	6	18370
4	RangeVgt35	4	20-30	0	M	164.12355	93.834549	105	20	81602
5	RangeVgt35	10	20-30	1	F	181.61026	97.18557	105	11	15780
6	RangeVgt35	15	20-30	1	F	163.82915	66.058281	155	5	60050
7	RangeVgt35	30	20-30	1	F	179.45668	88.340302	115	9	21424
8	RangeVgt35	33	20-30	1	M	220.07129	83.206429	195	18	59754
9	RangeVgt35	37	20-30	1	M	204.03574	85.105629	135	5	14498
10	RangeVgt35	1	40-50	0	F	212.44482	92.629951	105	5	6117
11	RangeVgt35	23	40-50	0	F	217.58755	91.170494	135	6	25499
12	RangeVgt35	25	40-50	0	F	155.61011	49.903725	145	3	3819
13	RangeVgt35	26	40-50	0	F	174.88681	77.127884	145	3	33660
14	RangeVgt35	29	40-50	0	F	170.93964	68.969833	145	6	32103
15	RangeVgt35	34	40-50	0	M	163.85963	61.031509	125	14	31367
16	RangeVgt35	5	40-50	1	F	164.57333	82.062195	115	9	13664
17	RangeVgt35	6	40-50	1	F	199.20847	85.332336	125	5	43479
18	RangeVgt35	8	40-50	1	F	173.08563	75.327888	135	6	66304
19	RangeVgt35	9	40-50	1	F	220.25719	89.378708	145	17	119945
20	RangeVgt35	12	40-50	1	F	192.97777	84.598152	145	10	39842
21	RangeVgt35	21	40-50	1	F	199.33488	96.726387	105	13	94571
22	RangeVgt35	24	40-50	1	F	192.27806	87.864639	115	6	112608
23	RangeVgt35	36	40-50	1	F	192.08554	86.447693	115	6	52744
24	RangeVgt35	3	40-50	1	M	163.47784	89.38076	95	7	20806
25	RangeVgt35	14	40-50	1	M	181.3735	77.789131	125	13	85857
26	RangeVgt35	17	40-50	1	M	173.30806	96.360397	85	6	18789

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
27	RangeVgt35	22	40-50	1	M	137.58768	74.617638	105	1	25092
28	RangeVgt35	35	40-50	1	M	194.86232	78.363068	195	5	37042
29	RangeVgt35	13	60-70	1	F	237.09897	78.515984	225	9	53326
30	RangeVgt35	7	60-70	1	M	209.45135	70.697685	205	11	136451
31	RangeVgt35	11	60-70	1	M	196.24506	80.710449	195	12	115952
32	RangeVgt35	18	60-70	1	M	160.34592	74.853989	145	7	128898
33	RangeVgt35	19	60-70	1	M	165.19576	76.539284	145	13	60076
34	RangeVgt35	20	60-70	1	M	212.06418	77.109909	175	4	45810
35	RangeVgt35	32	60-70	1	M	208.33357	88.469734	115	4	14009
1	RDotVgt35	27	20-30	0	F	-0.1383217	5.864028	0	5	28600
2	RDotVgt35	31	20-30	0	F	1.5715731	7.1959982	0	9	4939
3	RDotVgt35	38	20-30	0	F	10.553715	7.5832682	14	6	18291
4	RDotVgt35	4	20-30	0	M	-2.5681744	6.7198019	0	20	81123
5	RDotVgt35	10	20-30	1	F	-0.4848869	5.7320485	0	11	15781
6	RDotVgt35	15	20-30	1	F	-1.2485468	5.6456962	0	5	60041
7	RDotVgt35	30	20-30	1	F	-0.2374527	6.6588922	2	9	21419
8	RDotVgt35	33	20-30	1	M	1.8711601	6.8439145	0	18	59702
9	RDotVgt35	37	20-30	1	M	1.2679657	8.0736055	0	5	14472
10	RDotVgt35	1	40-50	0	F	3.196033	8.8309698	4	5	6050
11	RDotVgt35	23	40-50	0	F	2.0886962	7.0229511	0	6	25390
12	RDotVgt35	25	40-50	0	F	1.3762765	5.5205293	0	3	3819
13	RDotVgt35	26	40-50	0	F	-0.4715021	5.7383227	0	3	33599
14	RDotVgt35	29	40-50	0	F	0.3891831	4.6922097	0	6	32098
15	RDotVgt35	34	40-50	0	M	-0.4343825	5.6920476	0	14	31295
16	RDotVgt35	5	40-50	1	F	-1.149597	6.9545088	0	9	13650
17	RDotVgt35	6	40-50	1	F	2.090127	6.2075377	0	5	43472
18	RDotVgt35	8	40-50	1	F	1.0568678	5.7896905	0	6	66294
19	RDotVgt35	9	40-50	1	F	0.9673344	7.4420967	0	17	119698
20	RDotVgt35	12	40-50	1	F	0.786863	6.5533509	0	10	39796
21	RDotVgt35	21	40-50	1	F	2.1401606	7.3999023	0	13	94406
22	RDotVgt35	24	40-50	1	F	2.0664425	7.1006184	0	6	112398
23	RDotVgt35	36	40-50	1	F	-0.5829313	6.3260603	0	6	52658
24	RDotVgt35	3	40-50	1	M	-0.2084678	5.9282875	0	7	20761
25	RDotVgt35	14	40-50	1	M	0.9708378	6.5234737	0	13	85693
26	RDotVgt35	17	40-50	1	M	-1.2015806	6.0681014	0	6	18727
27	RDotVgt35	22	40-50	1	M	-0.1650725	4.5327721	0	1	25092
28	RDotVgt35	35	40-50	1	M	4.6864185	7.7743402	0	5	36756
29	RDotVgt35	13	60-70	1	F	1.6125362	7.2126417	0	9	52201
30	RDotVgt35	7	60-70	1	M	-0.0190325	5.1238708	0	11	136398
31	RDotVgt35	11	60-70	1	M	2.9250951	6.7466187	0	12	115720
32	RDotVgt35	18	60-70	1	M	-0.1920359	5.1589508	0	7	128226
33	RDotVgt35	19	60-70	1	M	0.0064742	5.5991898	0	13	59930
34	RDotVgt35	20	60-70	1	M	1.6503125	8.685607	0	4	45595
35	RDotVgt35	32	60-70	1	M	-1.592746	6.9641666	0	4	14006
1	Throttle	27	20-30	0	F	9.0717592	3.9595404	9.5	5	39779
2	Throttle	31	20-30	0	F	7.3643217	2.6767023	7.5	9	8557
3	Throttle	38	20-30	0	F	6.9959912	3.1884098	6.5	6	53386
4	Throttle	4	20-30	0	M	10.5233	5.5008755	9.5	20	232186
5	Throttle	10	20-30	1	F	8.8568239	4.1808095	6.5	11	30707
6	Throttle	15	20-30	1	F	10.042867	5.5960398	7.5	5	65517
7	Throttle	30	20-30	1	F	8.1465616	3.3340394	7.5	9	53602
8	Throttle	33	20-30	1	M	8.2560225	3.3344026	7.5	18	155248
9	Throttle	37	20-30	1	M	7.406477	3.1383333	6.5	5	33874

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
10	Throttle	1	40-50	0	F	7.56182	4.0302153	7.5	5	10660
11	Throttle	23	40-50	0	F	8.2811537	3.3777907	7.5	6	38150
12	Throttle	25	40-50	0	F	8.7162304	4.1422482	7.5	3	5582
13	Throttle	26	40-50	0	F	9.6161785	3.5855939	8.5	3	47117
14	Throttle	29	40-50	0	F	8.7527332	3.4573765	7.5	6	37688
15	Throttle	34	40-50	0	M	8.9353828	3.6885626	8.5	14	41823
16	Throttle	5	40-50	1	F	9.4696951	4.4165835	8.5	9	27487
17	Throttle	6	40-50	1	F	7.8770943	3.263149	7.5	5	66315
18	Throttle	8	40-50	1	F	7.4247866	3.2082195	6.5	6	97762
19	Throttle	9	40-50	1	F	8.5456934	3.0568397	8.5	17	317877
20	Throttle	12	40-50	1	F	8.1082211	3.5984697	7.5	10	73715
21	Throttle	21	40-50	1	F	8.5183783	3.3108621	8.5	13	246048
22	Throttle	24	40-50	1	F	7.510056	3.6819777	6.5	6	174320
23	Throttle	36	40-50	1	F	9.6784725	3.6120067	8.5	6	73619
24	Throttle	3	40-50	1	M	7.8126597	3.7934675	6.5	7	30522
25	Throttle	14	40-50	1	M	8.2859573	3.7277646	7.5	13	104582
26	Throttle	17	40-50	1	M	8.8574066	4.1321783	7.5	6	41138
27	Throttle	22	40-50	1	M	8.8793068	3.9678042	7.5	1	25718
28	Throttle	35	40-50	1	M	7.0867033	3.0506842	7.5	5	53095
29	Throttle	13	60-70	1	F	7.787529	3.3376679	7.5	9	187661
30	Throttle	7	60-70	1	M	8.1162767	4.9491897	5.5	11	246292
31	Throttle	11	60-70	1	M	6.8827133	3.3542035	6.5	12	290852
32	Throttle	18	60-70	1	M	8.6451054	3.5732877	8.5	7	179759
33	Throttle	19	60-70	1	M	6.7254825	3.0761583	6.5	13	101081
34	Throttle	20	60-70	1	M	8.596714	3.0014482	7.5	4	164103
35	Throttle	32	60-70	1	M	9.2138243	3.207674	8.5	4	29122
1	TimeToImpact	27	20-30	0	F	20.111795	1.9086818	20.5	5	28637
2	TimeToImpact	31	20-30	0	F	20.402859	0.6048235	20.5	9	5003
3	TimeToImpact	38	20-30	0	F	20.464235	0.5920151	20.5	6	18370
4	TimeToImpact	4	20-30	0	M	19.634481	2.6345441	20.5	20	81606
5	TimeToImpact	10	20-30	1	F	20.181587	1.5482067	20.5	11	15783
6	TimeToImpact	15	20-30	1	F	20.023638	1.9806794	20.5	5	60050
7	TimeToImpact	30	20-30	1	F	19.960348	1.9897401	20.5	9	21424
8	TimeToImpact	33	20-30	1	M	20.353525	1.0000981	20.5	18	59754
9	TimeToImpact	37	20-30	1	M	20.15078	1.5774239	20.5	5	14498
10	TimeToImpact	1	40-50	0	F	20.217999	1.3926632	20.5	5	6117
11	TimeToImpact	23	40-50	0	F	20.356731	0.9214852	20.5	6	21662
12	TimeToImpact	25	40-50	0	F	20.384001	0.7901323	20.5	3	3819
13	TimeToImpact	26	40-50	0	F	20.095232	1.8038855	20.5	3	33660
14	TimeToImpact	29	40-50	0	F	20.343269	1.0049355	20.5	6	32103
15	TimeToImpact	34	40-50	0	M	20.097124	1.8080456	20.5	14	31367
16	TimeToImpact	5	40-50	1	F	19.807377	2.3199019	20.5	9	13664
17	TimeToImpact	6	40-50	1	F	20.375952	0.9822847	20.5	5	43479
18	TimeToImpact	8	40-50	1	F	20.36792	0.9415488	20.5	6	66304
19	TimeToImpact	9	40-50	1	F	20.218155	1.5644799	20.5	17	119977
20	TimeToImpact	12	40-50	1	F	20.250929	1.4210531	20.5	10	39842
21	TimeToImpact	21	40-50	1	F	20.235046	1.4315495	20.5	13	94571
22	TimeToImpact	24	40-50	1	F	20.226595	1.5318942	20.5	6	112608
23	TimeToImpact	36	40-50	1	F	20.145344	1.6381216	20.5	6	52744
24	TimeToImpact	3	40-50	1	M	19.861639	2.3216364	20.5	7	20808
25	TimeToImpact	14	40-50	1	M	20.00626	2.2312589	20.5	13	85858
26	TimeToImpact	17	40-50	1	M	19.978338	2.0725758	20.5	6	18789
27	TimeToImpact	22	40-50	1	M	20.110931	1.6402274	20.5	1	25092

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
28	TimeToImpact	35	40-50	1	M	20.399925	0.9979328	20.5	5	37042
29	TimeToImpact	13	60-70	1	F	20.224751	1.7060982	20.5	9	53326
30	TimeToImpact	7	60-70	1	M	20.224909	1.5728557	20.5	11	136451
31	TimeToImpact	11	60-70	1	M	20.381084	1.0580232	20.5	12	115952
32	TimeToImpact	18	60-70	1	M	20.130762	1.740398	20.5	7	128905
33	TimeToImpact	19	60-70	1	M	20.233696	1.545146	20.5	13	60078
34	TimeToImpact	20	60-70	1	M	20.238758	1.3553736	20.5	4	45810
35	TimeToImpact	32	60-70	1	M	20.092548	1.6028147	20.5	4	14009
1	VDotVgt35	27	20-30	0	F	7.681E-05	0.013615	0	5	41924
2	VDotVgt35	31	20-30	0	F	-5.299E-05	0.0104288	0	9	8869
3	VDotVgt35	38	20-30	0	F	0.0011458	0.010521	0	6	55176
4	VDotVgt35	4	20-30	0	M	-0.0002811	0.0124204	0	20	244374
5	VDotVgt35	10	20-30	1	F	0.0002295	0.0115958	0	11	32063
6	VDotVgt35	15	20-30	1	F	0.0003256	0.0182192	0	5	73122
7	VDotVgt35	30	20-30	1	F	-4.414E-05	0.0105041	0	9	55499
8	VDotVgt35	33	20-30	1	M	-6.615E-05	0.0103455	0	18	162951
9	VDotVgt35	37	20-30	1	M	-0.0005317	0.010313	0	5	35377
10	VDotVgt35	1	40-50	0	F	-0.0001505	0.0113996	0	5	11431
11	VDotVgt35	23	40-50	0	F	-0.0002707	0.0094488	0	6	39230
12	VDotVgt35	25	40-50	0	F	-0.0001956	0.0091288	0	3	5727
13	VDotVgt35	26	40-50	0	F	0.0004	0.0149433	0	3	51201
14	VDotVgt35	29	40-50	0	F	-0.000582	0.0129365	0	6	39981
15	VDotVgt35	34	40-50	0	M	-0.0008388	0.0154583	0	14	46267
16	VDotVgt35	5	40-50	1	F	-0.000111	0.0150974	0	9	30173
17	VDotVgt35	6	40-50	1	F	-0.0001841	0.0091216	0	5	68675
18	VDotVgt35	8	40-50	1	F	-0.0002353	0.0100589	0	6	101003
19	VDotVgt35	9	40-50	1	F	1.434E-06	0.0093266	0	17	327805
20	VDotVgt35	12	40-50	1	F	0.0002032	0.0118749	0	10	77156
21	VDotVgt35	21	40-50	1	F	0.000168	0.0089343	0	13	252479
22	VDotVgt35	24	40-50	1	F	4.959E-05	0.0123461	0	6	182908
23	VDotVgt35	36	40-50	1	F	-2.611E-05	0.0118782	0	6	76213
24	VDotVgt35	3	40-50	1	M	-0.0001542	0.0148121	0	7	33209
25	VDotVgt35	14	40-50	1	M	0.0004906	0.01659	0	13	116790
26	VDotVgt35	17	40-50	1	M	0.0014442	0.0141065	0	6	42986
27	VDotVgt35	22	40-50	1	M	-1.754E-05	0.0161058	0	1	27359
28	VDotVgt35	35	40-50	1	M	-0.0001499	0.0107776	0	5	55226
29	VDotVgt35	13	60-70	1	F	5.537E-05	0.0095326	0	9	194689
30	VDotVgt35	7	60-70	1	M	0.0001215	0.0127446	0	11	266167
31	VDotVgt35	11	60-70	1	M	4.927E-05	0.0085006	0	12	300367
32	VDotVgt35	18	60-70	1	M	6.802E-05	0.0135288	0	7	193321
33	VDotVgt35	19	60-70	1	M	8.887E-05	0.0132888	0	13	109375
34	VDotVgt35	20	60-70	1	M	-8.378E-05	0.0092701	0	4	169488
35	VDotVgt35	32	60-70	1	M	-0.0004997	0.0107953	0	4	30256
1	VelocityVgt35	27	20-30	0	F	98.698692	5.5290208	100.6	5	41924
2	VelocityVgt35	31	20-30	0	F	90.991348	4.7305403	91.8	9	8869
3	VelocityVgt35	38	20-30	0	F	82.183609	10.094069	83	6	55178
4	VelocityVgt35	4	20-30	0	M	105.73221	8.9695292	109.4	20	244394
5	VelocityVgt35	10	20-30	1	F	95.935425	10.994463	96.2	11	32064
6	VelocityVgt35	15	20-30	1	F	101.59984	8.3552399	109.4	5	73122
7	VelocityVgt35	30	20-30	1	F	94.921982	7.3521152	100.6	9	55564
8	VelocityVgt35	33	20-30	1	M	92.399048	8.3446226	96.2	18	162956
9	VelocityVgt35	37	20-30	1	M	90.556129	8.1321764	96.2	5	35377
10	VelocityVgt35	1	40-50	0	F	87.053192	7.0895324	91.8	5	11431

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
11	VelocityVgt35	23	40-50	0	F	92.802704	3.8253069	91.8	6	39230
12	VelocityVgt35	25	40-50	0	F	88.115273	4.3558464	91.8	3	5727
13	VelocityVgt35	26	40-50	0	F	102.69298	10.699137	109.4	3	51203
14	VelocityVgt35	29	40-50	0	F	97.499168	5.3430958	100.6	6	39981
15	VelocityVgt35	34	40-50	0	M	95.450897	7.0312252	100.6	14	46267
16	VelocityVgt35	5	40-50	1	F	99.414009	7.957798	105	9	30229
17	VelocityVgt35	6	40-50	1	F	94.289505	4.6886954	96.2	5	68675
18	VelocityVgt35	8	40-50	1	F	91.850876	6.1057816	96.2	6	101003
19	VelocityVgt35	9	40-50	1	F	99.230019	6.6274643	100.6	17	327807
20	VelocityVgt35	12	40-50	1	F	93.430122	6.1716571	96.2	10	77156
21	VelocityVgt35	21	40-50	1	F	96.401886	4.999577	96.2	13	252479
22	VelocityVgt35	24	40-50	1	F	92.52813	7.0338078	96.2	6	182933
23	VelocityVgt35	36	40-50	1	F	99.34021	5.6677341	105	6	76213
24	VelocityVgt35	3	40-50	1	M	90.288643	7.7411265	96.2	7	33209
25	VelocityVgt35	14	40-50	1	M	92.687721	10.95365	100.6	13	116790
26	VelocityVgt35	17	40-50	1	M	93.010155	12.074444	100.6	6	43009
27	VelocityVgt35	22	40-50	1	M	89.749962	6.8688192	91.8	1	27359
28	VelocityVgt35	35	40-50	1	M	87.552338	7.2921786	91.8	5	55226
29	VelocityVgt35	13	60-70	1	F	90.559837	7.6202188	87.4	9	194703
30	VelocityVgt35	7	60-70	1	M	90.705368	9.8775291	83	11	266167
31	VelocityVgt35	11	60-70	1	M	87.350868	7.4434447	91.8	12	300377
32	VelocityVgt35	18	60-70	1	M	97.660789	8.9773226	105	7	193321
33	VelocityVgt35	19	60-70	1	M	85.779488	11.535664	96.2	13	109436
34	VelocityVgt35	20	60-70	1	M	93.866608	3.8599954	96.2	4	169488
35	VelocityVgt35	32	60-70	1	M	100.88839	4.9149437	100.6	4	30256

CCC Driving

1	DecelAvoid	27	20-30	0	F	0	0	0	0	0
2	DecelAvoid	31	20-30	0	F	0	0	0	4	0
3	DecelAvoid	38	20-30	0	F	0.005	0	0.005	2	846
4	DecelAvoid	4	20-30	0	M	0.0079364	0.0093012	0.005	7	37945
5	DecelAvoid	10	20-30	1	F	0.0057662	0.0041492	0.005	13	38815
6	DecelAvoid	15	20-30	1	F	0.0060182	0.0040552	0.005	2	2249
7	DecelAvoid	30	20-30	1	F	0.005285	0.0022544	0.005	6	24984
8	DecelAvoid	33	20-30	1	M	0.0052984	0.0037069	0.005	13	18200
9	DecelAvoid	37	20-30	1	M	0.0065502	0.0074638	0.005	2	3348
10	DecelAvoid	1	40-50	0	F	0	0	0	5	0
11	DecelAvoid	23	40-50	0	F	0.0050973	0.0016763	0.005	8	14081
12	DecelAvoid	25	40-50	0	F	0	0	0	4	0
13	DecelAvoid	26	40-50	0	F	0.0052036	0.0023315	0.005	5	18368
14	DecelAvoid	29	40-50	0	F	0.0052946	0.0035341	0.005	6	5567
15	DecelAvoid	34	40-50	0	M	0.0062482	0.0050662	0.005	15	46492
16	DecelAvoid	5	40-50	1	F	0.0062557	0.0058462	0.005	10	9278
17	DecelAvoid	6	40-50	1	F	0.0051958	0.0023719	0.005	4	3779
18	DecelAvoid	8	40-50	1	F	0.0053098	0.002821	0.005	10	28372
19	DecelAvoid	9	40-50	1	F	0.0053651	0.0039055	0.005	12	28019
20	DecelAvoid	12	40-50	1	F	0.0052575	0.0041998	0.005	10	12506
21	DecelAvoid	21	40-50	1	F	0.0056281	0.0037398	0.005	7	22225
22	DecelAvoid	24	40-50	1	F	0.0053644	0.0043168	0.005	2	17840
23	DecelAvoid	36	40-50	1	F	0.005287	0.0021196	0.005	4	9618
24	DecelAvoid	3	40-50	1	M	0.0064297	0.0075616	0.005	7	10303
25	DecelAvoid	14	40-50	1	M	0.0058501	0.0041065	0.005	8	45195

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
26	DecelAvoid	17	40-50	1	M	0.0054803	0.0041498	0.005	6	15260
27	DecelAvoid	22	40-50	1	M	0.0053072	0.0023573	0.005	3	11167
28	DecelAvoid	35	40-50	1	M	0.0056562	0.0043947	0.005	8	35262
29	DecelAvoid	13	60-70	1	F	0.005136	0.0026601	0.005	5	28319
30	DecelAvoid	7	60-70	1	M	0.007965	0.0099879	0.005	6	8924
31	DecelAvoid	11	60-70	1	M	0.0057329	0.0067324	0.005	20	68426
32	DecelAvoid	18	60-70	1	M	0.0058541	0.0057535	0.005	4	8676
33	DecelAvoid	19	60-70	1	M	0.005767	0.0048029	0.005	12	31866
34	DecelAvoid	20	60-70	1	M	0.0050039	0.0001982	0.005	1	5089
35	DecelAvoid	32	60-70	1	M	0.0068053	0.0058396	0.005	5	5927
1	Flow	27	20-30	0	F	0	0	0	0	0
2	Flow	31	20-30	0	F	0	0	0	4	0
3	Flow	38	20-30	0	F	0.2413088	0.0492893	0.2	2	489
4	Flow	4	20-30	0	M	0.6182725	0.285403	0.3	7	37945
5	Flow	10	20-30	1	F	0.5737467	0.2612445	0.3	13	38538
6	Flow	15	20-30	1	F	0.4104935	0.148326	0.3	2	2249
7	Flow	30	20-30	1	F	0.4730748	0.2306943	0.3	6	24984
8	Flow	33	20-30	1	M	0.4984627	0.2237727	0.3	13	17758
9	Flow	37	20-30	1	M	0.4354059	0.221836	0.3	2	2919
10	Flow	1	40-50	0	F	0	0	0	5	0
11	Flow	23	40-50	0	F	0.3958845	0.1559438	0.3	8	14081
12	Flow	25	40-50	0	F	0	0	0	4	0
13	Flow	26	40-50	0	F	0.5230346	0.2283321	0.4	5	18368
14	Flow	29	40-50	0	F	0.5730735	0.217829	0.5	6	5567
15	Flow	34	40-50	0	M	0.5131076	0.2141873	0.3	15	46473
16	Flow	5	40-50	1	F	0.4756953	0.2250242	0.3	10	9278
17	Flow	6	40-50	1	F	0.4715533	0.2432694	0.3	4	3779
18	Flow	8	40-50	1	F	0.4972263	0.2162414	0.3	10	28374
19	Flow	9	40-50	1	F	0.4501545	0.2116737	0.3	12	27833
20	Flow	12	40-50	1	F	0.4653087	0.2027641	0.3	10	12506
21	Flow	21	40-50	1	F	0.5285934	0.2482402	0.3	7	20830
22	Flow	24	40-50	1	F	0.4430305	0.2111337	0.3	2	17842
23	Flow	36	40-50	1	F	0.4988303	0.2370882	0.3	4	9618
24	Flow	3	40-50	1	M	0.5500849	0.2720421	0.3	7	10013
25	Flow	14	40-50	1	M	0.569312	0.2513254	0.3	8	42409
26	Flow	17	40-50	1	M	0.5420687	0.2595153	0.3	6	15275
27	Flow	22	40-50	1	M	0.4462971	0.209374	0.3	3	11167
28	Flow	35	40-50	1	M	0.4554279	0.1718552	0.4	8	35262
29	Flow	13	60-70	1	F	0.4016275	0.1740898	0.3	5	28050
30	Flow	7	60-70	1	M	0.4956466	0.2564867	0.3	6	8924
31	Flow	11	60-70	1	M	0.4355232	0.1950898	0.3	20	60490
32	Flow	18	60-70	1	M	0.580331	0.24528	0.4	4	7794
33	Flow	19	60-70	1	M	0.5034994	0.2271939	0.3	12	31634
34	Flow	20	60-70	1	M	0.378307	0.133545	0.3	1	4672
35	Flow	32	60-70	1	M	0.4538046	0.2018191	0.3	5	5927
1	Htm	27	20-30	0	F	0	0	0	0	0
2	Htm	31	20-30	0	F	0	0	0	4	0
3	Htm	38	20-30	0	F	0	0	0	2	0
4	Htm	4	20-30	0	M	1.4854507	0.6854606	0.6	7	18097
5	Htm	10	20-30	1	F	1.5978109	0.7160982	0.7	13	19690
6	Htm	15	20-30	1	F	2.3072746	0.4313396	1.9	2	1031
7	Htm	30	20-30	1	F	1.7184544	0.7173714	1.3	6	9174
8	Htm	33	20-30	1	M	1.8893671	0.6650476	2.3	13	10599

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
9	Htm	37	20-30	1	M	1.6570997	0.6888145	2	2	662
10	Htm	1	40-50	0	F	0	0	0	5	0
11	Htm	23	40-50	0	F	2.1322119	0.5159776	1.6	8	3775
12	Htm	25	40-50	0	F	0	0	0	4	0
13	Htm	26	40-50	0	F	1.8782663	0.6687672	1.9	5	7661
14	Htm	29	40-50	0	F	1.6029409	0.5858234	0.8	6	3638
15	Htm	34	40-50	0	M	1.7521718	0.6220151	1.5	15	22286
16	Htm	5	40-50	1	F	1.858832	0.6394804	2.1	10	3459
17	Htm	6	40-50	1	F	1.3732328	0.6454837	1.5	4	863
18	Htm	8	40-50	1	F	1.7556261	0.6011381	1.6	10	16832
19	Htm	9	40-50	1	F	1.787871	0.626148	1.5	12	6571
20	Htm	12	40-50	1	F	1.7936909	0.6055948	1.6	10	6007
21	Htm	21	40-50	1	F	1.674237	0.689723	1.6	7	10942
22	Htm	24	40-50	1	F	1.8833988	0.7264974	2.5	2	3319
23	Htm	36	40-50	1	F	1.7887272	0.6924222	2	4	3983
24	Htm	3	40-50	1	M	1.4875174	0.6916736	0.6	7	3605
25	Htm	14	40-50	1	M	1.5736594	0.6614075	0.9	8	22919
26	Htm	17	40-50	1	M	1.7292026	0.737016	1.1	6	6883
27	Htm	22	40-50	1	M	2.0603178	0.6531168	2.5	3	3586
28	Htm	35	40-50	1	M	1.9679135	0.5520352	2.1	8	18475
29	Htm	13	60-70	1	F	2.0816581	0.6105667	2.4	5	8696
30	Htm	7	60-70	1	M	1.7472515	0.8245722	3	6	855
31	Htm	11	60-70	1	M	2.0425255	0.6272566	2.3	20	20296
32	Htm	18	60-70	1	M	1.4871832	0.5800712	0.9	4	4221
33	Htm	19	60-70	1	M	1.6682543	0.6760102	1.2	12	10918
34	Htm	20	60-70	1	M	2.27104	0.3716047	2.3	1	1654
35	Htm	32	60-70	1	M	2.156842	0.6132579	2.9	5	2375
1	RangeVgt35	27	20-30	0	F	0	0	0	0	0
2	RangeVgt35	31	20-30	0	F	0	0	0	4	0
3	RangeVgt35	38	20-30	0	F	300.30734	35.278606	285	2	846
4	RangeVgt35	4	20-30	0	M	188.24022	106.50376	65	7	37945
5	RangeVgt35	10	20-30	1	F	197.42278	96.281113	95	13	38815
6	RangeVgt35	15	20-30	1	F	256.12048	74.969078	205	2	2249
7	RangeVgt35	30	20-30	1	F	228.47423	95.989716	305	6	24984
8	RangeVgt35	33	20-30	1	M	209.61797	85.928864	215	13	18192
9	RangeVgt35	37	20-30	1	M	239.81482	100.30426	355	2	3348
10	RangeVgt35	1	40-50	0	F	0	0	0	5	0
11	RangeVgt35	23	40-50	0	F	248.07791	85.66394	145	8	14081
12	RangeVgt35	25	40-50	0	F	0	0	0	4	0
13	RangeVgt35	26	40-50	0	F	201.73781	84.347076	185	5	18368
14	RangeVgt35	29	40-50	0	F	180.28291	78.882698	125	6	5567
15	RangeVgt35	34	40-50	0	M	210.85535	88.163216	145	15	46496
16	RangeVgt35	5	40-50	1	F	238.33693	95.670135	205	10	9278
17	RangeVgt35	6	40-50	1	F	234.11882	105.51064	145	4	3779
18	RangeVgt35	8	40-50	1	F	213.2505	90.52433	155	10	28374
19	RangeVgt35	9	40-50	1	F	232.53416	92.634048	145	12	28023
20	RangeVgt35	12	40-50	1	F	218.63716	91.792847	115	10	12441
21	RangeVgt35	21	40-50	1	F	203.56198	92.035568	105	7	22225
22	RangeVgt35	24	40-50	1	F	228.87512	89.919304	225	2	17842
23	RangeVgt35	36	40-50	1	F	225.10397	92.022713	205	4	9618
24	RangeVgt35	3	40-50	1	M	194.12732	98.780457	145	7	10313
25	RangeVgt35	14	40-50	1	M	182.84959	90.08416	85	8	45196
26	RangeVgt35	17	40-50	1	M	199.79077	94.212608	195	6	15223

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
27	RangeVgt35	22	40-50	1	M	220.30313	89.152359	225	3	11167
28	RangeVgt35	35	40-50	1	M	230.86325	78.103615	215	8	35262
29	RangeVgt35	13	60-70	1	F	245.05124	82.806763	225	5	28302
30	RangeVgt35	7	60-70	1	M	223.70686	105.29757	225	6	8924
31	RangeVgt35	11	60-70	1	M	227.41631	85.726837	225	20	68431
32	RangeVgt35	18	60-70	1	M	178.73962	91.964821	125	4	8672
33	RangeVgt35	19	60-70	1	M	207.68217	91.963409	125	12	31866
34	RangeVgt35	20	60-70	1	M	257.53882	79.283096	265	1	5089
35	RangeVgt35	32	60-70	1	M	243.66544	86.205635	295	5	5927
1	RDotVgt35	27	20-30	0	F	0	0	0	0	0
2	RDotVgt35	31	20-30	0	F	0	0	0	4	0
3	RDotVgt35	38	20-30	0	F	0.8770686	3.8321614	0	2	846
4	RDotVgt35	4	20-30	0	M	-3.2759075	7.6084614	2	7	37904
5	RDotVgt35	10	20-30	1	F	-0.0187335	6.7442231	2	13	38754
6	RDotVgt35	15	20-30	1	F	0.0293464	7.7751441	0	2	2249
7	RDotVgt35	30	20-30	1	F	1.8890936	7.2170596	0	6	24958
8	RDotVgt35	33	20-30	1	M	0.8261446	5.6161251	-2	13	18084
9	RDotVgt35	37	20-30	1	M	3.230123	8.6916723	8	2	3333
10	RDotVgt35	1	40-50	0	F	0	0	0	5	0
11	RDotVgt35	23	40-50	0	F	5.3230987	7.0052586	6	8	14070
12	RDotVgt35	25	40-50	0	F	0	0	0	4	0
13	RDotVgt35	26	40-50	0	F	3.7492893	7.5126495	4	5	18292
14	RDotVgt35	29	40-50	0	F	1.4961365	6.8331661	-2	6	5565
15	RDotVgt35	34	40-50	0	M	-1.612842	7.6502314	-2	15	46379
16	RDotVgt35	5	40-50	1	F	-1.2268559	7.2825508	-2	10	9160
17	RDotVgt35	6	40-50	1	F	6.738152	7.1168742	4	4	3777
18	RDotVgt35	8	40-50	1	F	0.1354582	6.2497993	0	10	28363
19	RDotVgt35	9	40-50	1	F	6.799212	7.1248488	8	12	27925
20	RDotVgt35	12	40-50	1	F	0.7015439	5.9686341	4	10	12501
21	RDotVgt35	21	40-50	1	F	0.8806736	7.0231109	2	7	22208
22	RDotVgt35	24	40-50	1	F	5.9818172	8.6546412	8	2	17819
23	RDotVgt35	36	40-50	1	F	2.0499167	6.6485662	4	4	9616
24	RDotVgt35	3	40-50	1	M	0.5762545	7.6109128	0	7	10183
25	RDotVgt35	14	40-50	1	M	-0.1360668	6.5592604	0	8	45169
26	RDotVgt35	17	40-50	1	M	2.2684572	6.826273	0	6	15265
27	RDotVgt35	22	40-50	1	M	5.6361675	8.8971519	4	3	11115
28	RDotVgt35	35	40-50	1	M	-0.2502062	6.9123182	0	8	35155
29	RDotVgt35	13	60-70	1	F	4.9093032	7.1113801	2	5	28281
30	RDotVgt35	7	60-70	1	M	-2.459563	9.2922039	-8	6	8878
31	RDotVgt35	11	60-70	1	M	5.3436236	7.9552374	6	20	68156
32	RDotVgt35	18	60-70	1	M	1.1146821	7.3808274	2	4	8650
33	RDotVgt35	19	60-70	1	M	3.6212831	8.2355089	6	12	31781
34	RDotVgt35	20	60-70	1	M	5.875	7.2980976	2	1	5072
35	RDotVgt35	32	60-70	1	M	-2.2567909	7.5371189	-4	5	5927
1	Throttle	27	20-30	0	F	0	0	0	0	0
2	Throttle	31	20-30	0	F	0	0	0	4	0
3	Throttle	38	20-30	0	F	5.3259969	3.215842	4.5	2	3862
4	Throttle	4	20-30	0	M	9.0289574	3.5491042	9.5	7	104878
5	Throttle	10	20-30	1	F	8.5455675	3.2587166	8.5	13	69435
6	Throttle	15	20-30	1	F	7.2733092	2.1734014	7.5	2	5545
7	Throttle	30	20-30	1	F	8.8167582	3.702718	7.5	6	64251
8	Throttle	33	20-30	1	M	7.7146087	3.1562195	7.5	13	40497
9	Throttle	37	20-30	1	M	7.0235667	3.4592359	8.5	2	12157

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
10	Throttle	1	40-50	0	F	0	0	0	5	0
11	Throttle	23	40-50	0	F	7.2958093	2.6860583	6.5	8	23243
12	Throttle	25	40-50	0	F	0	0	0	4	0
13	Throttle	26	40-50	0	F	8.6894932	3.6989453	8.5	5	39136
14	Throttle	29	40-50	0	F	8.0482388	3.5257936	5.5	6	7183
15	Throttle	34	40-50	0	M	9.0198574	3.1982429	8.5	15	243057
16	Throttle	5	40-50	1	F	8.8841085	3.5891223	7.5	10	22629
17	Throttle	6	40-50	1	F	7.2100291	2.6331604	7.5	4	7887
18	Throttle	8	40-50	1	F	8.0191183	3.4230824	7.5	10	94780
19	Throttle	9	40-50	1	F	7.446104	2.0954561	7.5	12	79208
20	Throttle	12	40-50	1	F	7.302494	3.3032494	7.5	10	31918
21	Throttle	21	40-50	1	F	7.5982661	3.8629661	5.5	7	36737
22	Throttle	24	40-50	1	F	7.2930608	3.3584123	6.5	2	39543
23	Throttle	36	40-50	1	F	9.0626106	2.3052728	9.5	4	18567
24	Throttle	3	40-50	1	M	7.4984179	3.5908115	7.5	7	26549
25	Throttle	14	40-50	1	M	7.7455721	3.1583428	7.5	8	70916
26	Throttle	17	40-50	1	M	7.805057	3.5589917	6.5	6	34564
27	Throttle	22	40-50	1	M	6.980041	3.0771587	7.5	3	22496
28	Throttle	35	40-50	1	M	8.8449669	2.7500446	8.5	8	147991
29	Throttle	13	60-70	1	F	7.7351947	3.5537441	7.5	5	139867
30	Throttle	7	60-70	1	M	8.5329313	3.1505401	8.5	6	29941
31	Throttle	11	60-70	1	M	6.470552	3.4479251	6.5	20	346914
32	Throttle	18	60-70	1	M	7.4437146	4.2685847	7.5	4	17056
33	Throttle	19	60-70	1	M	7.0775437	3.0520775	6.5	12	97558
34	Throttle	20	60-70	1	M	6.2490606	2.254879	6.5	1	12242
35	Throttle	32	60-70	1	M	8.9536896	3.1199517	8.5	5	14338
1	TimeToImpact	27	20-30	0	F	0	0	0	0	0
2	TimeToImpact	31	20-30	0	F	0	0	0	4	0
3	TimeToImpact	38	20-30	0	F	20.5	0	20.5	2	846
4	TimeToImpact	4	20-30	0	M	18.983133	3.5270731	20.5	7	37945
5	TimeToImpact	10	20-30	1	F	19.816179	2.3007219	20.5	13	38815
6	TimeToImpact	15	20-30	1	F	19.809248	2.5469058	20.5	2	2249
7	TimeToImpact	30	20-30	1	F	20.309839	1.1684992	20.5	6	24984
8	TimeToImpact	33	20-30	1	M	20.327692	1.1605108	20.5	13	18200
9	TimeToImpact	37	20-30	1	M	19.741188	2.5074427	20.5	2	3348
10	TimeToImpact	1	40-50	0	F	0	0	0	5	0
11	TimeToImpact	23	40-50	0	F	20.439671	0.6796818	20.5	8	14081
12	TimeToImpact	25	40-50	0	F	0	0	0	4	0
13	TimeToImpact	26	40-50	0	F	20.288763	1.2931695	20.5	5	18368
14	TimeToImpact	29	40-50	0	F	20.304653	1.2249143	20.5	6	5567
15	TimeToImpact	34	40-50	0	M	19.74514	2.3570104	20.5	15	46496
16	TimeToImpact	5	40-50	1	F	19.885212	2.212424	20.5	10	9278
17	TimeToImpact	6	40-50	1	F	20.353401	0.901044	20.5	4	3779
18	TimeToImpact	8	40-50	1	F	20.286266	1.1318165	20.5	10	28374
19	TimeToImpact	9	40-50	1	F	20.353691	1.1230284	20.5	12	28023
20	TimeToImpact	12	40-50	1	F	20.2939	1.3331207	20.5	10	12506
21	TimeToImpact	21	40-50	1	F	20.056738	1.8577343	20.5	7	22225
22	TimeToImpact	24	40-50	1	F	20.167891	1.6524392	20.5	2	17842
23	TimeToImpact	36	40-50	1	F	20.265232	1.2736641	20.5	4	9618
24	TimeToImpact	3	40-50	1	M	19.553379	2.7710836	20.5	7	10313
25	TimeToImpact	14	40-50	1	M	19.823347	2.4256194	20.5	8	45196
26	TimeToImpact	17	40-50	1	M	19.947004	2.2630742	20.5	6	15275
27	TimeToImpact	22	40-50	1	M	20.206993	1.5503312	20.5	3	11167

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
28	TimeToImpact	35	40-50	1	M	20.230743	1.4150785	20.5	8	35262
29	TimeToImpact	13	60-70	1	F	20.464464	0.5836552	20.5	5	28323
30	TimeToImpact	7	60-70	1	M	18.752186	3.7613695	20.5	6	8924
31	TimeToImpact	11	60-70	1	M	20.265415	1.514078	20.5	20	68442
32	TimeToImpact	18	60-70	1	M	19.709024	2.5890522	20.5	4	8676
33	TimeToImpact	19	60-70	1	M	20.025654	2.0632308	20.5	12	31866
34	TimeToImpact	20	60-70	1	M	20.5	0	20.5	1	5089
35	TimeToImpact	32	60-70	1	M	19.384174	3.0242224	20.5	5	5927
1	VDotVgt35	27	20-30	0	F	0	0	0	0	0
2	VDotVgt35	31	20-30	0	F	0	0	0	4	0
3	VDotVgt35	38	20-30	0	F	0.0006549	0.0105988	0	2	4138
4	VDotVgt35	4	20-30	0	M	-0.0001604	0.0082553	0	7	108223
5	VDotVgt35	10	20-30	1	F	0.0002023	0.0075748	0	13	70083
6	VDotVgt35	15	20-30	1	F	7.212E-06	0.0049012	0	2	5546
7	VDotVgt35	30	20-30	1	F	0.0009145	0.0086305	0	6	64833
8	VDotVgt35	33	20-30	1	M	0.0002726	0.0087691	0	13	41337
9	VDotVgt35	37	20-30	1	M	0.0005062	0.0077487	0	2	12308
10	VDotVgt35	1	40-50	0	F	0	0	0	5	0
11	VDotVgt35	23	40-50	0	F	6.002E-06	0.0056926	0	8	23324
12	VDotVgt35	25	40-50	0	F	0	0	0	4	0
13	VDotVgt35	26	40-50	0	F	0.0012128	0.0091782	0	5	39321
14	VDotVgt35	29	40-50	0	F	0.0003377	0.00843	0	6	7225
15	VDotVgt35	34	40-50	0	M	0.0001776	0.0067009	0	15	244673
16	VDotVgt35	5	40-50	1	F	0.0003782	0.0070973	0	10	22816
17	VDotVgt35	6	40-50	1	F	-0.0003697	0.006767	0	4	8033
18	VDotVgt35	8	40-50	1	F	0.0001388	0.0071164	0	10	95939
19	VDotVgt35	9	40-50	1	F	-3.058E-05	0.0053012	0	12	79453
20	VDotVgt35	12	40-50	1	F	0.0008758	0.0091371	0	10	32255
21	VDotVgt35	21	40-50	1	F	0.0007129	0.0103695	0	7	37692
22	VDotVgt35	24	40-50	1	F	4.923E-05	0.0085119	0	2	40419
23	VDotVgt35	36	40-50	1	F	0.0005671	0.0063389	0	4	18639
24	VDotVgt35	3	40-50	1	M	0.0002677	0.0093579	0	7	27271
25	VDotVgt35	14	40-50	1	M	0.0004679	0.0087897	0	8	72753
26	VDotVgt35	17	40-50	1	M	0.0001021	0.0075836	0	6	35169
27	VDotVgt35	22	40-50	1	M	0.0001938	0.0069331	0	3	22545
28	VDotVgt35	35	40-50	1	M	8.27E-05	0.0063105	0	8	148739
29	VDotVgt35	13	60-70	1	F	0.0002262	0.0070899	0	5	141927
30	VDotVgt35	7	60-70	1	M	-0.0001611	0.0053663	0	6	30112
31	VDotVgt35	11	60-70	1	M	0.0004406	0.0074199	0	20	352132
32	VDotVgt35	18	60-70	1	M	0.0017143	0.0137154	0	4	17891
33	VDotVgt35	19	60-70	1	M	0.0004	0.0084037	0	12	98591
34	VDotVgt35	20	60-70	1	M	0.0009561	0.008944	0	1	12248
35	VDotVgt35	32	60-70	1	M	-6.436E-05	0.0077028	0	5	14449
1	VelocityVgt35	27	20-30	0	F	0	0	0	0	0
2	VelocityVgt35	31	20-30	0	F	0	0	0	4	0
3	VelocityVgt35	38	20-30	0	F	71.73098	2.5051222	69.8	2	4138
4	VelocityVgt35	4	20-30	0	M	105.43571	5.3064494	105	7	108225
5	VelocityVgt35	10	20-30	1	F	100.22186	7.1309757	100.6	13	70084
6	VelocityVgt35	15	20-30	1	F	101.34893	1.653756	100.6	2	5546
7	VelocityVgt35	30	20-30	1	F	95.417229	5.5135736	96.2	6	64862
8	VelocityVgt35	33	20-30	1	M	88.429291	11.469817	96.2	13	41337
9	VelocityVgt35	37	20-30	1	M	90.312477	15.096983	96.2	2	12308
10	VelocityVgt35	1	40-50	0	F	0	0	0	5	0

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
11	VelocityVgt35	23	40-50	0	F	92.4748	1.6626846	91.8	8	23324
12	VelocityVgt35	25	40-50	0	F	0	0	0	4	0
13	VelocityVgt35	26	40-50	0	F	96.33786	7.6991653	100.6	5	39321
14	VelocityVgt35	29	40-50	0	F	98.465469	4.9015164	96.2	6	7225
15	VelocityVgt35	34	40-50	0	M	99.590324	5.9102511	100.6	15	244673
16	VelocityVgt35	5	40-50	1	F	104.44036	5.5922961	105	10	22816
17	VelocityVgt35	6	40-50	1	F	95.387695	2.5298259	96.2	4	8033
18	VelocityVgt35	8	40-50	1	F	94.418098	6.4520378	91.8	10	95939
19	VelocityVgt35	9	40-50	1	F	93.597923	7.1124616	96.2	12	79453
20	VelocityVgt35	12	40-50	1	F	89.503113	6.9852233	91.8	10	32269
21	VelocityVgt35	21	40-50	1	F	91.529449	10.872342	96.2	7	37698
22	VelocityVgt35	24	40-50	1	F	91.439568	3.4294488	91.8	2	40419
23	VelocityVgt35	36	40-50	1	F	99.042442	5.3209252	96.2	4	18639
24	VelocityVgt35	3	40-50	1	M	90.475212	11.091756	96.2	7	27271
25	VelocityVgt35	14	40-50	1	M	94.319832	9.2722206	100.6	8	72753
26	VelocityVgt35	17	40-50	1	M	94.278183	7.0298886	100.6	6	35169
27	VelocityVgt35	22	40-50	1	M	88.086983	3.0367389	87.4	3	22545
28	VelocityVgt35	35	40-50	1	M	101.11789	4.5048389	100.6	8	148739
29	VelocityVgt35	13	60-70	1	F	90.217598	6.6449647	96.2	5	141927
30	VelocityVgt35	7	60-70	1	M	95.87722	4.4822268	96.2	6	30112
31	VelocityVgt35	11	60-70	1	M	82.608688	10.258309	83	20	352139
32	VelocityVgt35	18	60-70	1	M	88.317574	11.224687	96.2	4	17891
33	VelocityVgt35	19	60-70	1	M	90.866554	10.19067	96.2	12	98601
34	VelocityVgt35	20	60-70	1	M	89.951698	10.758062	96.2	1	12248
35	VelocityVgt35	32	60-70	1	M	99.167236	6.4959311	100.6	5	14449

Manual (MAN) Driving

1	DecelAvoid	27	20-30	0	F	0.0060796	0.0079107	0.005	5	22778
2	DecelAvoid	31	20-30	0	F	0.0063568	0.0076422	0.005	13	94834
3	DecelAvoid	38	20-30	0	F	0.0060062	0.0070682	0.005	8	9779
4	DecelAvoid	4	20-30	0	M	0.0073344	0.0107936	0.005	27	210694
5	DecelAvoid	10	20-30	1	F	0.0067383	0.0090657	0.005	24	115123
6	DecelAvoid	15	20-30	1	F	0.0061695	0.0074609	0.005	7	71818
7	DecelAvoid	30	20-30	1	F	0.0069249	0.0095174	0.005	15	38278
8	DecelAvoid	33	20-30	1	M	0.00644	0.0096154	0.005	31	71945
9	DecelAvoid	37	20-30	1	M	0.0071656	0.0112599	0.005	7	15257
10	DecelAvoid	1	40-50	0	F	0.0058483	0.0065096	0.005	10	144084
11	DecelAvoid	23	40-50	0	F	0.0054934	0.005755	0.005	14	29773
12	DecelAvoid	25	40-50	0	F	0.0054889	0.00456	0.005	7	52466
13	DecelAvoid	26	40-50	0	F	0.0065355	0.0081779	0.005	8	32002
14	DecelAvoid	29	40-50	0	F	0.0064521	0.008358	0.005	12	92238
15	DecelAvoid	34	40-50	0	M	0.0063794	0.0078365	0.005	29	191338
16	DecelAvoid	5	40-50	1	F	0.0066157	0.0083145	0.005	19	112777
17	DecelAvoid	6	40-50	1	F	0.006426	0.0091518	0.005	9	25946
18	DecelAvoid	8	40-50	1	F	0.005848	0.0060131	0.005	16	113289
19	DecelAvoid	9	40-50	1	F	0.0063464	0.0087975	0.005	29	123698
20	DecelAvoid	12	40-50	1	F	0.0065047	0.0086112	0.005	20	49612
21	DecelAvoid	21	40-50	1	F	0.0063095	0.0078061	0.005	20	62724
22	DecelAvoid	24	40-50	1	F	0.0073984	0.0114218	0.005	8	19100
23	DecelAvoid	36	40-50	1	F	0.0067722	0.0103874	0.005	10	42343
24	DecelAvoid	3	40-50	1	M	0.0086366	0.0141612	0.005	14	37200
25	DecelAvoid	14	40-50	1	M	0.0087365	0.0146903	0.005	21	72009

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
26	DecelAvoid	17	40-50	1	M	0.0092182	0.0146586	0.005	12	9772
27	DecelAvoid	22	40-50	1	M	0.0056555	0.0054735	0.005	4	28834
28	DecelAvoid	35	40-50	1	M	0.006061	0.0072337	0.005	13	95362
29	DecelAvoid	13	60-70	1	F	0.0062119	0.00977	0.005	14	48823
30	DecelAvoid	7	60-70	1	M	0.0065107	0.0081921	0.005	17	285636
31	DecelAvoid	11	60-70	1	M	0.0080041	0.0133445	0.005	32	38244
32	DecelAvoid	18	60-70	1	M	0.0072951	0.012263	0.005	11	23180
33	DecelAvoid	19	60-70	1	M	0.0078114	0.0134117	0.005	25	40816
34	DecelAvoid	20	60-70	1	M	0.0058535	0.0067739	0.005	5	56190
35	DecelAvoid	32	60-70	1	M	0.0064223	0.0075128	0.005	9	50958
1	Flow	27	20-30	0	F	0.8112816	0.2310599	1.05	5	15964
2	Flow	31	20-30	0	F	0.7538167	0.2667972	1.05	13	79860
3	Flow	38	20-30	0	F	0.4300185	0.2092865	0.3	8	6471
4	Flow	4	20-30	0	M	0.7604152	0.2734184	1.05	27	182286
5	Flow	10	20-30	1	F	0.7869797	0.2767195	1.05	24	86465
6	Flow	15	20-30	1	F	0.6798011	0.2242244	0.6	7	48515
7	Flow	30	20-30	1	F	0.5833562	0.2412905	0.5	15	21819
8	Flow	33	20-30	1	M	0.5654413	0.2416185	0.3	31	31118
9	Flow	37	20-30	1	M	0.7346597	0.2691534	1.05	7	2865
10	Flow	1	40-50	0	F	0.8050581	0.2437656	1.05	10	98583
11	Flow	23	40-50	0	F	0.49604	0.2245996	0.3	14	28649
12	Flow	25	40-50	0	F	0.5544236	0.2197786	0.4	7	35017
13	Flow	26	40-50	0	F	0.5951958	0.2435446	0.4	8	14987
14	Flow	29	40-50	0	F	0.6247402	0.2695855	0.3	12	47542
15	Flow	34	40-50	0	M	0.693019	0.2363817	0.7	29	132667
16	Flow	5	40-50	1	F	0.6521645	0.2480376	0.4	19	85934
17	Flow	6	40-50	1	F	0.5130718	0.1996484	0.4	9	13510
18	Flow	8	40-50	1	F	0.6810717	0.2926322	1.05	16	96134
19	Flow	9	40-50	1	F	0.5108176	0.2302587	0.3	29	78922
20	Flow	12	40-50	1	F	0.7133679	0.2783417	1.05	20	26470
21	Flow	21	40-50	1	F	0.7525139	0.2518695	1.05	20	27566
22	Flow	24	40-50	1	F	0.6865993	0.3014509	1.05	8	6190
23	Flow	36	40-50	1	F	0.6712254	0.2749494	1.05	10	21731
24	Flow	3	40-50	1	M	0.594028	0.2742177	0.3	14	16276
25	Flow	14	40-50	1	M	0.6636599	0.2613841	1.05	21	37083
26	Flow	17	40-50	1	M	0.7563006	0.2820051	1.05	12	2960
27	Flow	22	40-50	1	M	0.5047945	0.2304285	0.3	4	13599
28	Flow	35	40-50	1	M	0.525024	0.2096266	0.3	13	68714
29	Flow	13	60-70	1	F	0.3623146	0.1580509	0.3	14	20155
30	Flow	7	60-70	1	M	0.6564192	0.2706145	1.05	17	231594
31	Flow	11	60-70	1	M	0.558697	0.2880241	0.3	32	11205
32	Flow	18	60-70	1	M	0.7129275	0.2472508	1.05	11	9387
33	Flow	19	60-70	1	M	0.6108995	0.2833998	1.05	25	15441
34	Flow	20	60-70	1	M	0.5119776	0.2029622	0.5	5	34598
35	Flow	32	60-70	1	M	0.6664476	0.2750422	1.05	9	38814
1	Htm	27	20-30	0	F	1.1681443	0.4975232	0.8	5	20731
2	Htm	31	20-30	0	F	1.1743975	0.5500697	0.6	13	71919
3	Htm	38	20-30	0	F	2.3733153	0.4477507	2.5	8	1870
4	Htm	4	20-30	0	M	1.0827788	0.5032789	0.7	27	148670
5	Htm	10	20-30	1	F	1.1806717	0.5865881	0.6	24	78310
6	Htm	15	20-30	1	F	1.3167459	0.4654576	1.1	7	57799
7	Htm	30	20-30	1	F	1.5383257	0.5359594	1.4	15	29886
8	Htm	33	20-30	1	M	1.6638677	0.6086803	1.4	31	53227

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
9	Htm	37	20-30	1	M	1.4295965	0.6203053	1.2	7	11846
10	Htm	1	40-50	0	F	1.2139962	0.5648585	0.8	10	116524
11	Htm	23	40-50	0	F	1.7302394	0.624849	1.5	14	14372
12	Htm	25	40-50	0	F	1.6376431	0.6063775	1.2	7	34896
13	Htm	26	40-50	0	F	1.6196811	0.6163087	1.2	8	25832
14	Htm	29	40-50	0	F	1.4371287	0.6231943	1.3	12	63883
15	Htm	34	40-50	0	M	1.3904135	0.5731566	0.9	29	146612
16	Htm	5	40-50	1	F	1.4387633	0.5962915	1.1	19	76663
17	Htm	6	40-50	1	F	1.8658797	0.5676932	1.4	9	20923
18	Htm	8	40-50	1	F	1.168294	0.5400451	0.8	16	72469
19	Htm	9	40-50	1	F	1.778699	0.637	1.3	29	73710
20	Htm	12	40-50	1	F	1.3405977	0.6294698	1	20	36859
21	Htm	21	40-50	1	F	1.2815429	0.5566132	0.8	20	61554
22	Htm	24	40-50	1	F	1.5755169	0.6267019	1.4	8	14169
23	Htm	36	40-50	1	F	1.3199224	0.6279711	0.7	10	24254
24	Htm	3	40-50	1	M	1.5410914	0.6502171	0.8	14	22737
25	Htm	14	40-50	1	M	1.274195	0.5554318	0.9	21	66630
26	Htm	17	40-50	1	M	1.7039578	0.7254274	1.1	12	5205
27	Htm	22	40-50	1	M	1.6577847	0.5983183	1.6	4	16783
28	Htm	35	40-50	1	M	1.7113351	0.5873117	1.6	13	53268
29	Htm	13	60-70	1	F	2.2296224	0.5123361	2.2	14	22510
30	Htm	7	60-70	1	M	1.3757585	0.6166781	0.8	17	193227
31	Htm	11	60-70	1	M	1.6503994	0.5623149	1.3	32	29040
32	Htm	18	60-70	1	M	1.5897008	0.5842963	1.6	11	18817
33	Htm	19	60-70	1	M	1.3711808	0.5370734	1.4	25	30490
34	Htm	20	60-70	1	M	1.7464041	0.5430589	1.7	5	39419
35	Htm	32	60-70	1	M	1.3485503	0.5971186	0.9	9	33734
1	RangeVgt35	27	20-30	0	F	104.87578	58.053505	75	5	22782
2	RangeVgt35	31	20-30	0	F	119.62429	80.37429	45	13	94847
3	RangeVgt35	38	20-30	0	F	216.45618	78.666962	215	8	9779
4	RangeVgt35	4	20-30	0	M	126.47215	85.926079	65	27	210722
5	RangeVgt35	10	20-30	1	F	124.93279	84.475159	65	24	115157
6	RangeVgt35	15	20-30	1	F	127.60162	67.79055	105	7	71790
7	RangeVgt35	30	20-30	1	F	148.23923	76.192055	95	15	38293
8	RangeVgt35	33	20-30	1	M	153.7791	80.027145	105	31	71971
9	RangeVgt35	37	20-30	1	M	131.3407	78.900658	75	7	15257
10	RangeVgt35	1	40-50	0	F	112.20647	66.403801	65	10	144094
11	RangeVgt35	23	40-50	0	F	200.98453	89.458115	155	14	29847
12	RangeVgt35	25	40-50	0	F	169.46938	81.708855	105	7	52466
13	RangeVgt35	26	40-50	0	F	141.62099	80.124825	65	8	32033
14	RangeVgt35	29	40-50	0	F	140.84126	86.1539	85	12	92242
15	RangeVgt35	34	40-50	0	M	135.63527	72.763054	85	29	191350
16	RangeVgt35	5	40-50	1	F	151.14569	80.279655	95	19	112690
17	RangeVgt35	6	40-50	1	F	170.05396	74.54982	125	9	25948
18	RangeVgt35	8	40-50	1	F	148.89993	99.198242	65	16	113300
19	RangeVgt35	9	40-50	1	F	184.77101	86.573151	145	29	123616
20	RangeVgt35	12	40-50	1	F	128.2189	79.384377	65	20	49374
21	RangeVgt35	21	40-50	1	F	115.28819	70.946999	65	20	62735
22	RangeVgt35	24	40-50	1	F	148.6394	88.885796	75	8	19102
23	RangeVgt35	36	40-50	1	F	154.13274	93.123756	55	10	42363
24	RangeVgt35	3	40-50	1	M	148.13927	82.983009	75	14	37222
25	RangeVgt35	14	40-50	1	M	115.50796	78.800476	45	21	71975
26	RangeVgt35	17	40-50	1	M	171.0172	87.274292	145	12	9772

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
27	RangeVgt35	22	40-50	1	M	172.74969	87.18103	115	4	28836
28	RangeVgt35	35	40-50	1	M	184.56908	81.969276	135	13	95385
29	RangeVgt35	13	60-70	1	F	218.08463	80.193726	195	14	48813
30	RangeVgt35	7	60-70	1	M	150.16908	88.432472	85	17	285602
31	RangeVgt35	11	60-70	1	M	154.52086	84.091194	95	32	38256
32	RangeVgt35	18	60-70	1	M	131.11221	69.488144	75	11	23188
33	RangeVgt35	19	60-70	1	M	129.79018	81.399551	75	25	40844
34	RangeVgt35	20	60-70	1	M	164.30049	77.458382	115	5	56197
35	RangeVgt35	32	60-70	1	M	146.41153	90.331879	85	9	50966
1	RDotVgt35	27	20-30	0	F	-0.4859065	4.4279571	0	5	22741
2	RDotVgt35	31	20-30	0	F	-0.8483298	5.3838377	0	13	94633
3	RDotVgt35	38	20-30	0	F	7.2545323	9.2092876	4	8	9653
4	RDotVgt35	4	20-30	0	M	-2.2499285	5.9180636	0	27	209532
5	RDotVgt35	10	20-30	1	F	-1.5356501	5.6696053	0	24	114642
6	RDotVgt35	15	20-30	1	F	-0.7346517	5.419692	0	7	71702
7	RDotVgt35	30	20-30	1	F	-1.1160372	6.4042244	0	15	38074
8	RDotVgt35	33	20-30	1	M	-0.1242798	5.9120522	0	31	71677
9	RDotVgt35	37	20-30	1	M	-0.8482331	5.9347157	0	7	15168
10	RDotVgt35	1	40-50	0	F	-0.0926043	4.6243386	0	10	143665
11	RDotVgt35	23	40-50	0	F	2.7261074	7.2566032	0	14	29800
12	RDotVgt35	25	40-50	0	F	1.4581597	6.4576321	2	7	52318
13	RDotVgt35	26	40-50	0	F	0.4032207	6.7794557	0	8	31794
14	RDotVgt35	29	40-50	0	F	-1.0546848	5.7884736	0	12	91872
15	RDotVgt35	34	40-50	0	M	-1.0272269	5.6153808	0	29	190914
16	RDotVgt35	5	40-50	1	F	-0.9814907	6.3116083	0	19	112484
17	RDotVgt35	6	40-50	1	F	-0.7165834	5.7548904	-2	9	25803
18	RDotVgt35	8	40-50	1	F	0.972771	6.622304	0	16	112931
19	RDotVgt35	9	40-50	1	F	0.8841322	6.771224	2	29	123149
20	RDotVgt35	12	40-50	1	F	-0.4411134	6.061595	0	20	49434
21	RDotVgt35	21	40-50	1	F	-0.4004667	5.2556496	0	20	62562
22	RDotVgt35	24	40-50	1	F	-0.0253698	7.6425009	0	8	18999
23	RDotVgt35	36	40-50	1	F	0.1456806	6.2910504	0	10	42147
24	RDotVgt35	3	40-50	1	M	-1.4525839	6.9891391	2	14	36612
25	RDotVgt35	14	40-50	1	M	-1.3414559	6.4291821	0	21	71652
26	RDotVgt35	17	40-50	1	M	-1.7477739	8.1801805	2	12	9658
27	RDotVgt35	22	40-50	1	M	1.5029891	6.3021283	0	4	28772
28	RDotVgt35	35	40-50	1	M	1.0596775	7.4000826	0	13	95061
29	RDotVgt35	13	60-70	1	F	2.099829	7.3837667	0	14	47962
30	RDotVgt35	7	60-70	1	M	-1.2615135	5.9603558	0	17	284926
31	RDotVgt35	11	60-70	1	M	-0.8308804	7.1590657	2	32	37914
32	RDotVgt35	18	60-70	1	M	0.0478202	6.4852805	2	11	22961
33	RDotVgt35	19	60-70	1	M	-0.369925	7.1752844	0	25	40419
34	RDotVgt35	20	60-70	1	M	0.4442186	5.7546363	2	5	56094
35	RDotVgt35	32	60-70	1	M	-0.5443389	6.5121136	0	9	50847
1	Throttle	27	20-30	0	F	11.039543	6.3694901	9.5	5	21053
2	Throttle	31	20-30	0	F	9.8751755	4.6654224	7.5	13	99023
3	Throttle	38	20-30	0	F	8.113842	4.5036864	7.5	8	28131
4	Throttle	4	20-30	0	M	10.685386	5.9293742	9.5	27	480987
5	Throttle	10	20-30	1	F	10.785212	6.2184548	7.5	24	125079
6	Throttle	15	20-30	1	F	12.114389	7.0622516	8.5	7	69080
7	Throttle	30	20-30	1	F	11.994503	7.5893559	9.5	15	68952
8	Throttle	33	20-30	1	M	7.7278185	5.0015793	5.5	31	208552
9	Throttle	37	20-30	1	M	7.8937192	6.17588	4.5	7	20921

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
10	Throttle	1	40-50	0	F	9.3586874	6.7170019	3.5	10	120881
11	Throttle	23	40-50	0	F	8.0957737	4.6165247	6.5	14	50541
12	Throttle	25	40-50	0	F	8.7737865	4.9977856	6.5	7	53896
13	Throttle	26	40-50	0	F	8.105073	4.8011794	6.5	8	43760
14	Throttle	29	40-50	0	F	8.4073992	4.884644	7.5	12	108563
15	Throttle	34	40-50	0	M	8.6952791	4.7298431	7.5	29	232616
16	Throttle	5	40-50	1	F	11.425511	7.159605	8.5	19	130261
17	Throttle	6	40-50	1	F	8.6734304	5.803926	7.5	9	40264
18	Throttle	8	40-50	1	F	10.35801	5.405365	7.5	16	240419
19	Throttle	9	40-50	1	F	8.2591639	4.4349709	7.5	29	236007
20	Throttle	12	40-50	1	F	9.3069019	6.0280099	6.5	20	69659
21	Throttle	21	40-50	1	F	8.2982082	6.15062	5.5	20	66851
22	Throttle	24	40-50	1	F	9.2744875	6.7509108	4.5	8	21919
23	Throttle	36	40-50	1	F	8.7098227	5.4289732	5.5	10	61228
24	Throttle	3	40-50	1	M	8.712328	5.8299651	6.5	14	62088
25	Throttle	14	40-50	1	M	10.673214	5.6887646	7.5	21	65468
26	Throttle	17	40-50	1	M	9.0996208	5.9394035	6.5	12	20066
27	Throttle	22	40-50	1	M	6.1705365	3.4658604	4.5	4	48579
28	Throttle	35	40-50	1	M	8.9256668	4.3077145	7.5	13	166769
29	Throttle	13	60-70	1	F	7.3985806	4.6964598	5.5	14	117719
30	Throttle	7	60-70	1	M	8.9288673	5.0568089	7.5	17	492943
31	Throttle	11	60-70	1	M	8.5050478	6.1605706	4.5	32	92520
32	Throttle	18	60-70	1	M	9.59935	6.7864189	3.5	11	22768
33	Throttle	19	60-70	1	M	8.9532871	6.4568806	6.5	25	102348
34	Throttle	20	60-70	1	M	7.9442887	4.1364665	7.5	5	82111
35	Throttle	32	60-70	1	M	9.7486801	5.6748767	6.5	9	64758
1	TimeToImpact	27	20-30	0	F	19.606071	2.8365202	20.5	5	22782
2	TimeToImpact	31	20-30	0	F	19.464058	3.0508158	20.5	13	94847
3	TimeToImpact	38	20-30	0	F	20.182484	1.7850058	20.5	8	9779
4	TimeToImpact	4	20-30	0	M	19.233221	3.3038969	20.5	27	210757
5	TimeToImpact	10	20-30	1	F	19.394623	3.1300011	20.5	24	115157
6	TimeToImpact	15	20-30	1	F	19.652485	2.7035425	20.5	7	71830
7	TimeToImpact	30	20-30	1	F	19.490547	2.9599013	20.5	15	38294
8	TimeToImpact	33	20-30	1	M	19.79443	2.5941138	20.5	31	71997
9	TimeToImpact	37	20-30	1	M	19.347841	3.3377049	20.5	7	15257
10	TimeToImpact	1	40-50	0	F	19.775122	2.5022562	20.5	10	144094
11	TimeToImpact	23	40-50	0	F	20.291037	1.4230138	20.5	14	29778
12	TimeToImpact	25	40-50	0	F	20.134363	1.7262917	20.5	7	52466
13	TimeToImpact	26	40-50	0	F	19.640261	2.8219478	20.5	8	32033
14	TimeToImpact	29	40-50	0	F	19.419462	3.0631964	20.5	12	92243
15	TimeToImpact	34	40-50	0	M	19.580976	2.8208544	20.5	29	191353
16	TimeToImpact	5	40-50	1	F	19.565119	2.9106424	20.5	19	112803
17	TimeToImpact	6	40-50	1	F	19.901148	2.2854202	20.5	9	25948
18	TimeToImpact	8	40-50	1	F	19.959503	2.1117587	20.5	16	113307
19	TimeToImpact	9	40-50	1	F	19.924692	2.358357	20.5	29	123744
20	TimeToImpact	12	40-50	1	F	19.471012	3.0726297	20.5	20	49643
21	TimeToImpact	21	40-50	1	F	19.605049	2.8284183	20.5	20	62737
22	TimeToImpact	24	40-50	1	F	19.320621	3.3219137	20.5	8	19102
23	TimeToImpact	36	40-50	1	F	19.577696	2.9648802	20.5	10	42364
24	TimeToImpact	3	40-50	1	M	18.722563	4.1518002	20.5	14	37230
25	TimeToImpact	14	40-50	1	M	18.237232	4.682951	20.5	21	72054
26	TimeToImpact	17	40-50	1	M	18.449535	4.2697611	20.5	12	9779
27	TimeToImpact	22	40-50	1	M	20.057653	1.9932424	20.5	4	28836

No.	Measure	ID	Age	User	Sex	Mean	StDev	MLV	Trips	Count
28	TimeToImpact	35	40-50	1	M	20.019831	2.072505	20.5	13	95385
29	TimeToImpact	13	60-70	1	F	20.166636	1.8609236	20.5	14	48831
30	TimeToImpact	7	60-70	1	M	19.54117	2.9131145	20.5	17	285723
31	TimeToImpact	11	60-70	1	M	19.154446	3.4973202	20.5	32	38266
32	TimeToImpact	18	60-70	1	M	19.403252	3.3719664	20.5	11	23189
33	TimeToImpact	19	60-70	1	M	19.096672	3.6252165	20.5	25	40844
34	TimeToImpact	20	60-70	1	M	20.016655	2.0835028	20.5	5	56197
35	TimeToImpact	32	60-70	1	M	19.451496	3.0141516	20.5	9	50966
1	VDotVgt35	27	20-30	0	F	0.0028228	0.0328962	0	5	27218
2	VDotVgt35	31	20-30	0	F	0.0026507	0.0260428	0	13	122797
3	VDotVgt35	38	20-30	0	F	0.0025999	0.028422	0	8	36725
4	VDotVgt35	4	20-30	0	M	0.001317	0.0222174	0	27	557464
5	VDotVgt35	10	20-30	1	F	0.0031752	0.0288135	0	24	161776
6	VDotVgt35	15	20-30	1	F	0.0021642	0.030005	0	7	99836
7	VDotVgt35	30	20-30	1	F	0.0013309	0.0347451	0	15	101782
8	VDotVgt35	33	20-30	1	M	0.0018868	0.0248613	0	31	249596
9	VDotVgt35	37	20-30	1	M	0.0032194	0.0306599	0	7	27893
10	VDotVgt35	1	40-50	0	F	0.0035647	0.0270547	0	10	163171
11	VDotVgt35	23	40-50	0	F	0.0004667	0.0209647	0	14	56144
12	VDotVgt35	25	40-50	0	F	0.0015147	0.0214836	0	7	70825
13	VDotVgt35	26	40-50	0	F	0.0034372	0.0303949	0	8	58874
14	VDotVgt35	29	40-50	0	F	0.0032415	0.0260966	0	12	130953
15	VDotVgt35	34	40-50	0	M	0.0021175	0.0242187	0	29	285573
16	VDotVgt35	5	40-50	1	F	0.0022961	0.0287472	0	19	173204
17	VDotVgt35	6	40-50	1	F	0.0030887	0.0269418	0	9	51987
18	VDotVgt35	8	40-50	1	F	0.0008566	0.0214299	0	16	301101
19	VDotVgt35	9	40-50	1	F	0.0019297	0.0226117	0	29	276835
20	VDotVgt35	12	40-50	1	F	0.0031943	0.0293334	0	20	92839
21	VDotVgt35	21	40-50	1	F	0.003949	0.0307465	0	20	92659
22	VDotVgt35	24	40-50	1	F	0.0043923	0.0329027	0.01	8	30961
23	VDotVgt35	36	40-50	1	F	0.0034337	0.0293266	0	10	75644
24	VDotVgt35	3	40-50	1	M	0.0059771	0.0317669	0	14	79328
25	VDotVgt35	14	40-50	1	M	0.0055543	0.0328121	0	21	94699
26	VDotVgt35	17	40-50	1	M	0.0037362	0.0340789	0	12	26979
27	VDotVgt35	22	40-50	1	M	0.0014954	0.0216527	0	4	55966
28	VDotVgt35	35	40-50	1	M	0.0013956	0.022212	0	13	208851
29	VDotVgt35	13	60-70	1	F	0.0014907	0.0231375	0	14	157852
30	VDotVgt35	7	60-70	1	M	0.0010057	0.0199839	0	17	554945
31	VDotVgt35	11	60-70	1	M	0.0031244	0.0310622	0	32	130382
32	VDotVgt35	18	60-70	1	M	0.0058161	0.0351925	0	11	34150
33	VDotVgt35	19	60-70	1	M	0.0038767	0.0316657	0	25	130462
34	VDotVgt35	20	60-70	1	M	0.0015678	0.0210916	0	5	95529
35	VDotVgt35	32	60-70	1	M	0.002465	0.0265694	0	9	80214
1	VelocityVgt35	27	20-30	0	F	83.866745	17.51894	100.6	5	27829
2	VelocityVgt35	31	20-30	0	F	87.053856	15.598654	96.2	13	123952
3	VelocityVgt35	38	20-30	0	F	70.652023	12.241424	78.6	8	36929
4	VelocityVgt35	4	20-30	0	M	96.96756	15.179663	109.4	27	565147
5	VelocityVgt35	10	20-30	1	F	86.723999	19.106552	105	24	165981
6	VelocityVgt35	15	20-30	1	F	85.553596	17.830275	100.6	7	101881
7	VelocityVgt35	30	20-30	1	F	76.254906	13.052567	87.4	15	108020
8	VelocityVgt35	33	20-30	1	M	72.21508	11.993179	69.8	31	253282
9	VelocityVgt35	37	20-30	1	M	66.367279	10.965623	61	7	29381
10	VelocityVgt35	1	40-50	0	F	79.439232	15.377257	91.8	10	165481