



U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**



DOT HS 810 917

March 2008

Use of Advanced In-Vehicle Technology By Young and Older Early Adopters

Survey Results on Adaptive Cruise Control Systems



James W. Jenness, Neil D. Lerner, Steve Mazor, J. Scott Osberg, Brain C. Tefft

Prepared for:



Prepared by:



In cooperation with:



This publication is distributed by the U.S. Department of Transportation, National Highway Traffic Safety Administration, in the interest of information exchange. The opinions, findings and conclusions expressed in this publication are those of the author(s) and not necessarily those of the Department of Transportation or the National Highway Traffic Safety Administration. The United States Government assumes no liability for its content or use thereof. If trade or manufacturer's names or products are mentioned, it is because they are considered essential to the object of the publication and should not be construed as an endorsement. The United States Government does not endorse products or manufacturers.

1. Report No. DOT HS 810-917	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Use of Advanced In-Vehicle Technology by Young and Older Early Adopters. Survey Results on Adaptive Cruise Control Systems		5. Report Date March 2008	
		6. Performing Organization Code	
7. Authors James W. Jenness, Neil D. Lerner, Steve Mazor, J. Scott Osberg, and Brian C. Tefft		8. Performing Organization Report No.	
9. Performing Organization Name and Address Westat, Inc. Automobile Club of Southern California 1650 Research Blvd. 1577 So. Valley Vista Drive Rockville, MD 20850 Diamond Bar, CA 91765		10. Work Unit No. (TRAIS)	
		11. Contract or Grant No. DTNH22-05-D-01002	
12. Sponsoring Agency Name and Address USDOT/National Highway Traffic Safety Administration Office of Advanced Vehicle Safety Research, NVS-331 1200 New Jersey Ave SE. Washington, DC 20590 AAA Foundation for Traffic Safety 607 14 th Street NW. Suite 201 Washington, DC 20005		13. Type of Report and Period Covered Sept. 15, 2005 to Sept. 25, 2007	
		14. Sponsoring Agency Code	
15. Supplementary Notes COTR: Michael Perel			
16. Abstract This document describes the results of survey research undertaken by the Automobile Club of Southern California. Questionnaires (10,000) were mailed to insurance customers who own vehicles that may have adaptive cruise control (ACC) as standard or optional original equipment. Half of the questionnaires were mailed to vehicle owners who were younger than 65, and half of the questionnaires were mailed to owners who were 65 or older. Of the 1,659 questionnaires returned, 370 were from ACC owners. Follow-up telephone interviews were conducted with 17 ACC owners. Survey items addressed topics such as learning to use the system, behavioral adaptation, system effectiveness, and perceived safety of the system. Although most ACC owners would want to get their system again, many (72%) were not aware of manufacturers' warnings about system limitations. Some differences in responses between younger and older respondents were noted. Other response differences were related to vehicle manufacturer and experience with the vehicle (miles driven).			
17. Key Words human factors, adaptive cruise control, older drivers		18. Distribution Statement This report is free of charge from the NHTSA Web site at www.nhtsa.dot.gov	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 105	22. Price

TABLE OF CONTENTS

EXECUTIVE SUMMARY	1
PROJECT OVERVIEW: USE OF ADVANCED IN-VEHICLE TECHNOLOGY BY YOUNG AND OLDER EARLY ADOPTERS	5
Project Partners	5
Purpose.....	5
Project Scope	6
ADAPTIVE CRUISE CONTROL SYSTEMS	7
DEVELOPMENT OF SURVEY	8
Content areas.....	8
Telephone Interviews.....	10
Sampling	11
RESULTS	12
1. General Characteristics of Survey Respondents	12
Response rate	12
Age and gender	12
Physical conditions that make driving more difficult	12
Driving experience with currently owned vehicle	13
2. Desire to Have Adaptive Cruise Control	14
3. Learning to Use Adaptive Cruise Control.....	15
Differences in learning to use ACC based on vehicle manufacturer.....	15
Age differences in learning to use ACC.....	16
4. Behavioral Adaptation	16
Use of adaptive cruise control and conventional cruise control.....	16
Response to unexpected road hazards	17
ACC and following distance	17
Stress, lanes changes, and gap settings	19
Reliance on ACC system	21
5. Perceived Effectiveness	21
ACC locks onto a vehicle other than the vehicle immediately ahead	21
Respondents' perception that ACC helps them avoid collisions	23
Unexpected braking, acceleration, and shutting off ACC.....	25
Conditions where respondents avoid using ACC.....	28
6. User Interface and Usability	28
7. Safety	30
Perceived safety of ACC systems	30
Awareness of system limitations.....	32
Collision experience.....	33
8. Need for Improvements to Adaptive Cruise Control	33
9. Meeting the Needs of Older Drivers	34
SUMMARY AND DISCUSSION.....	35
Summary of Findings.....	35
Survey sample	35
Desire to have ACC	35
Learning to use ACC.....	35

Behavioral adaptation.....	35
Perceived effectiveness	36
User interface and usability.....	37
Safety	37
Need for improvements.....	37
Summary of comparisons by age group.....	37
Comparison to Previous Studies	38
Study Limitations.....	39
Implications	41
REFERENCES	42
APPENDIX A: FUNCTIONAL CHARACTERISTICS OF ADAPTIVE CRUISE CONTROL SYSTEMS	43
Audi Adaptive Cruise Control.....	43
BMW Active Cruise Control	45
Cadillac Adaptive Cruise Control	47
Infiniti Intelligent Cruise Control.....	49
Jaguar Adaptive Cruise Control	52
Lexus Dynamic Laser Cruise Control.....	53
Mercedes-Benz Distronic Adaptive Cruise Control.....	55
Toyota Dynamic Laser Cruise Control Operation	57
APPENDIX B: MAIL-OUT SURVEY INSTRUMENT AND RECRUITMENT LETTER.....	60
APPENDIX C: TABULATED SURVEY RESULTS FOR ADAPTIVE CRUISE CONTROL SYSTEMS	71
APPENDIX D: DISCUSSION GUIDE FOR TELEPHONE INTERVIEWS WITH OWNERS OF ADAPTIVE CRUISE CONTROL SYSTEMS	92
APPENDIX E: COMMENTS FROM TELEPHONE INTERVIEWEES WHO OWN ADAPTIVE CRUISE CONTROL	93

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Adaptive Cruise Control questionnaire: Content areas and associated items	8
2. Respondents who have ACC by gender and by experience with their vehicle	14
3. Respondents who would want adaptive cruise control if they purchased their same vehicle again.....	14
4. Response to unexpected road hazards with ACC engaged (by vehicle manufacturer)	17
5. How respondents would change their usual following distance if they no longer had ACC (by vehicle manufacturer)	19
6. ACC locks onto a vehicle other than the vehicle ahead (by vehicle manufacturer).....	22
7. Perceived effectiveness of ACC system for avoiding a collision in stop –and-go traffic (by experience level)	24
8. Perceived effectiveness of ACC system for avoiding a collision with a stopped car ahead (by experience level).....	24
9. ACC system brakes unexpectedly (by age group)	26
10. ACC system brakes unexpectedly (by vehicle manufacturer)	26
11. ACC system brakes abruptly or brakes hard (by vehicle manufacturer).....	27
12. ACC accelerates unexpectedly (by age group)	27
13. Forgot to turn off the system (by age group)	27
14. Confusion about ACC following distance setting by experience level.....	30

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Age and gender of respondents who have an ACC system.....	13
2. How younger and older respondents would change their usual following distance if they no longer had ACC.....	18
3. Younger and older respondents experience with ACC locking onto the wrong vehicle.....	23
4. Respondents who believe that their ACC system would help them to avoid a collision when following a vehicle in stop-and-go traffic and when encountering a stopped vehicle in the lane ahead	25
5. Perceived safety benefits of adaptive cruise control	31
6. Safety concerns about adaptive cruise control	32
A-1 Audi A8 Adaptive Cruise Control interface elements.....	44
A-2. BMW 5-Series Active Cruise Control interface elements	46
A-3 Cadillac Adaptive Cruise Control interface elements	48
A-4 Infinity Intelligent Cruise Control interface controls	49
A-5 Infinity Intelligent Cruise Control interface displays.....	50
A-6 Jaguar XK Adaptive Cruise Control interface elements	52
A-7 Lexus Dynamic Laser Cruise Control interface elements.....	54
A-8 Mercedes-Benz CLS-class Distronic interface elements	57
A-9 Toyota Dynamic Laser Cruise Control interface elements	59

EXECUTIVE SUMMARY

This report describes the analysis of survey data collected by AAA Foundation for Traffic Safety in cooperation with the Automobile Club of Southern California (ACSC). The survey was designed to assess drivers' experiences with adaptive cruise control systems (ACC). This technology is still relatively new to the U.S. passenger vehicle fleet and the purpose of the study was to learn about early adopters' experiences using these systems. Some specific areas of interest included drivers' desire to have the systems, perceived effectiveness and usability of the systems, and behavioral adaptations which may occur with system use. The overarching goal of the study was to learn more about the extent to which adaptive cruise control systems enhance or detract from safety, particularly with respect to the capabilities and limitations of older drivers.

Questionnaires were mailed to 10,000 ACSC insurance customers who might have ACC based on their vehicle model and model year. Approximately 17 percent of the questionnaires were returned including 370 (22%) from ACC owners. Thirty-nine percent of the respondents with ACC were 65 or older. Thirty percent of respondents with ACC were women. ACSC staff also conducted brief telephone interviews with 17 of the respondents to gather additional information about their experiences with ACC and their suggestions for system improvements.

Desire to have ACC

A majority (76%) of those who currently have ACC said that if they purchased their same vehicle again, they would want to get the technology again. Among those who do not currently have the technology, only 35 percent said that they would want to get ACC. The most common reasons cited for not purchasing ACC were related to availability on the specific vehicle that they purchased (54%) or that, "It never occurred to me to look for it when I purchased the vehicle" (54%).

Learning to use ACC

The most frequently cited methods for learning how to use ACC were the vehicle owner's manual and "on-road experience . . ." In fact, on-road experience was the only learning method selected by 15.5 percent of respondents.

Behavioral adaptation

Several items asked respondents who had ACC to compare their driving behavior when using ACC and conventional cruise control.

- Sixteen percent of respondents said that they were "always," "frequently," or "sometimes" confused about whether their ACC system or conventional cruise control system was operating.
- When asked how quickly they respond to unexpected road hazards when using ACC as compared to using conventional cruise control, 49 percent said that they respond in the same time, 24 percent said that they respond more quickly with ACC, and 9 percent said that they respond more slowly with ACC.

- Eleven percent of respondents said they usually have their ACC set to the shortest gap (following distance) and 24 percent said that they usually use the longest gap setting. Half of the respondents said that if they could not use ACC anymore they would usually keep the same gap between their vehicle and the vehicle ahead as they do now using ACC, but 26 percent said that they would keep a smaller gap and 23 percent said that they would keep a larger gap. Eight percent of respondents agreed with the statement that, “I tend to follow the vehicle ahead more closely when using ACC.”
- More than half of the respondents agreed that when they use ACC they tend to change lanes less frequently. Half of the respondents indicated that they change the amount of gap between their vehicle and the vehicle ahead as driving conditions change, and 18 percent agreed that they tend to set ACC to a shorter gap (closer following distance) in heavy traffic than in light traffic.
- Nearly half of the respondents agreed that using ACC relieves them of stress when driving.
- Most respondents said that their reliance on ACC had stayed about the same since that got it. Approximately 27 percent of respondents said that they rely on ACC more now, and nine percent said that they rely on it less.

Perceived effectiveness

Many ACC owners were not aware of the limitations of their system and overestimate its effectiveness at helping them to avoid collisions. In fact, 72 percent of respondents said that they were not aware of any manufacturer’s warnings or limitations about their ACC system. A large percentage of respondents thought that their ACC system would help them to avoid a collision in scenarios where the technology would likely not be effective. In fact, many respondents thought that their system would work fairly well or perfectly to help them avoid a collision when:

- 24 percent - Following a vehicle in stop-and-go traffic;
- 43 percent - Encountering a stopped vehicle in the lane ahead; and
- 27 percent - Following a vehicle on a curvy road.

Despite these results, 85 percent of the respondents said that they avoid using ACC in stop-and-go traffic, 61 percent avoid using it on curvy roads.

User interface and usability

Most respondents thought that it was easy to understand the lights/symbols, and sounds (if present) from their ACC system, and 75 to 78 percent said that they were, “not at all” confused about their ACC settings for speed and following distance. The likelihood of being confused about ACC settings decreased with experience level.

Safety

- Thirty-eight percent of ACC owners thought that using ACC made them safer drivers than using only conventional cruise control and 7 percent thought that it made them less safe. A majority (54 percent) thought that using ACC made them neither more nor less safe.

- Fourteen percent of ACC owners said that their ACC system had created new driving problems or safety concerns for them.
- Two respondents (out of 327) reported that they had unintentionally collided with something while they had their adaptive cruise control engaged, and 12 respondents (3.7%) reported having a collision or “close call” while driving another vehicle equipped with conventional cruise control because they expected the vehicle they were driving to automatically slow down.

Need for improvements

Approximately 30 percent of respondents reported a need for improvements, and the most frequent suggested areas for improvement of ACC systems were related to the occurrence of unsafe/uncomfortable reductions or increases in speed, and the area of coverage or sensitivity of the system.

Summary of comparisons by age group

There were few items on which the responses from older and younger respondents differed significantly with respect to their experiences using ACC. As compared to younger respondents, the older respondents:

- Were more likely to have learned how to operate their ACC system from the owner’s manual;
- Were more likely to say that they would increase their typical following distance if they could no longer use ACC;
- Were more likely to say that they never forgot to turn off their ACC system;
- Were less likely to say that their ACC system created new driving problems or safety concerns for them;
- Were less likely to agree that their ACC system sometimes locks onto a vehicle that is not immediately ahead of them;
- Experienced their ACC system slowing unexpectedly when there is no vehicle immediately ahead less frequently than did younger respondents; or
- Experienced their ACC system accelerating unexpectedly less frequently than did younger respondents.

Conclusions

The survey methodology used in this study provided insights into drivers’ understanding of the functional capabilities of ACC systems and it was effective at providing some information about how the systems may be impacting driver behavior. Certain limitations and implications of the study are discussed at the end of the report.

Most ACC owners said that they would want to get the system if they purchased the same vehicle again and many think that their systems make them safer drivers (as compared to using conventional cruise control). However, ACC owners tend to be unaware of manufacturer’s warnings and limitations of their system and they tend to overestimate their

system's effectiveness for preventing collisions in situations where ACC does not perform well for this purpose such as encountering a stopped vehicle in the lane ahead.

Relatively few significant differences were found between the responses of younger and older ACC owners. Younger respondents were more likely to have safety concerns about ACC and were more likely to report a need for system improvements.

PROJECT OVERVIEW: USE OF ADVANCED IN-VEHICLE TECHNOLOGY BY YOUNG AND OLDER EARLY ADOPTERS

This report describes survey research conducted with owners of adaptive cruise control systems. It is one of a series of reports that describe the work conducted under the overall project on the use of advanced in-vehicle technology by young and older early adopters.

Project Partners

This project was a collaborative effort between the National Highway Traffic Safety Administration and AAA Foundation for Traffic Safety (AAAFTS). AAAFTS joined with the Automobile Club of Southern California (ACSC) to administer mail-out surveys to individuals who were likely to own vehicles equipped with specific advanced in-vehicle technologies. NHTSA engaged Westat, Inc. to work with AAAFTS and ACSC to reduce the data from returned questionnaires, and perform statistical analyses of the results.

Purpose

The purpose of the project was to assess drivers' experiences with recently introduced in-vehicle technologies. Safety issues (either positive or negative) may be discovered or better understood from the experiences of early adopters before the technologies become widely deployed in the U.S. vehicle fleet. Some specific areas of interest included drivers' acceptance of the systems, perceived effectiveness and usability of the systems, and behavioral adaptations which may occur with system use. Another area of particular interest was the use of advanced in-vehicle technologies by older drivers. For the purposes of this study, drivers 65 or older are referred to as "older drivers," and drivers younger than 65 are referred to as "younger drivers."

Specific objectives were to:

- Determine driver acceptance and behavioral adaptation to advanced technology currently available in production automobiles.
- Determine how the use of the technology has affected the driving task from a safety point of view.
- Determine how acceptance and use of technology is influenced by system interface characteristics, operation, and performance.
- Assess drivers' ability to learn how to use the technology and integrate it into the driving task.
- Compare drivers' reactions to and understanding of different interface designs.
- Identify future research needs.

The overarching goal was to learn more about the extent to which advanced in-vehicle technologies enhance or detract from safety, particularly with respect to the capabilities and limitations of older drivers. It's possible that new technologies can assist older drivers to drive more safely with less stress, thus extending their safe driving years. It's also possible that, for some drivers, new in-vehicle technologies are misunderstood and misused in dangerous ways.

A major focus of the data analysis was to compare the responses of older drivers (65 or older) to those of younger drivers (younger than 65).

Project Scope

The project partners selected five in-vehicle technologies for investigation. Some of the factors considered in the choice of technologies were the research priorities of NHTSA and AAAFTS, the relative numbers of vehicle owners in the ACSC insurance database who could be expected to have each technology, and the potential to explore human factors and safety issues associated with each technology through survey methods. Five separate surveys were developed to cover:

- Backing aid systems (sensor-based systems);
- Rear-view video camera systems;
- High intensity discharge (HID) headlamps, and adaptive headlamps;
- Navigation systems; and
- Adaptive cruise control.

A total of 40,000 questionnaires were mailed to ACSC insured members who were invited to participate based on the known manufacturer, model, and model year of their vehicle and the likelihood that the vehicle would have one of the five specific in-vehicle technologies. The number of questionnaires mailed for each technology type is shown below:

Backing Aid Systems	5,000
Rear-View Camera	5,000
Advanced Headlamp Systems	10,000
Navigation Systems	10,000
<u>Adaptive Cruise Control</u>	<u>10,000</u>
Total questionnaires mailed	40,000

The results of these five surveys will be released in a series of reports covering the different in-vehicle technologies investigated. This report describes the results from the survey on adaptive cruise control systems.

ADAPTIVE CRUISE CONTROL SYSTEMS

Adaptive cruise control is an in-vehicle convenience feature designed to maintain a set speed and, when applicable, adjust the set speed to maintain a specified distance from a lead vehicle. When following another vehicle, the ACC system will automatically slow down or speed up in responses to changes in the lead vehicle's speed. The information given below about the functional characteristics of ACC systems and descriptions of specific ACC systems (Appendix A) was taken from an inventory of in-vehicle devices that was conducted as part of the current project and previous projects (Llaneras & Singer, 2002; Llaneras, Neurauter, Singer, & Jenness, 2005).

Only a few model lines include adaptive cruise control as standard equipment. These include the Cadillac XLR and the Mercedes-Benz SLR. Jaguar's XJ-Series (Super V8 and XJR) and Toyota's Sienna (XLE Limited) have certain trim levels that include ACC as standard equipment. In general, the technology for adaptive cruise control is found on expensive luxury sedans, although some of the entry-level models within luxury brands (BMW 3-Series) are beginning to offer this feature. ACC also can be found on other vehicle types such as minivans (Toyota Sienna XLE Limited) and sport utility vehicles (Infiniti FX35/45 and QX56, and Lexus RX330).

Manufacturers market ACC systems under several different names, including Adaptive Cruise Control, Active Cruise Control, Intelligent Cruise Control, Dynamic Cruise Control, and DISTRONIC Cruise Control, but despite the different names, the ACC systems are functionally similar. They operate at or above a speed threshold of 20 to 28 mph, and automatically disengage and warn the driver when the speed falls below this minimum operating value. Controls and displays allow drivers to input and view set speed and distance settings, and disengage the system using alternate methods including a brake tap. All systems provide a "vehicle detected" signal or icon, and have some type of approach warning (using both audible and visual cues) to indicate when driver intervention is required. However, ACC systems vary with regard to the location and placement of the controls and displays, maximum deceleration authority, range and levels of headway settings (the minimum headway settings appears to be at or above 1.0 second), use of warning symbols and sounds, and integration with conventional cruise control. Some systems provide unique features such as the ability to lock-out access to the ACC system when the windshield wipers are operating and provisions for warning drivers of forward obstacles even when the ACC system is disengaged. One system (equipped on the Cadillac XLR) automatically reduces the vehicle's speed in tight curves (irregardless of whether a lead vehicle is present).

Two critical characteristics of most ACC systems are that in many cases they do not react to stationary or slow moving vehicles and they may react to vehicles in other travel lanes, especially on curves. Vehicle owner's manuals typically include this information, but it may be included among several other warnings, making it less conspicuous.

Detailed descriptions of specific ACC systems found on vehicles manufactured by Audi, BMW, Cadillac, Infiniti, Jaguar, Lexus, Mercedes-Benz, and Toyota are given in Appendix A.

DEVELOPMENT OF SURVEY

Content areas

The mail-out questionnaire was developed through an iterative process that included several stages of review by project partners. Initial drafts of the questionnaires were based on NHTSA’s exploratory study of early adopters of in-vehicle technologies (Llaneras, 2006). Many new items were written to address the specific objectives of the current project such as determining driver acceptance and adaptation to the technologies and determining how use of the technology has affected safety of the driving task. Items were developed to address several key content areas, including:

- Background information about the vehicle owner – age, gender, experience with the vehicle, etc.;
- Desire to have the technology;
- Learning how to use the technology – sources of information, difficulty with learning;
- Behavioral adaptation to the technology – changes in driving behavior with the technology, how drivers rely on the technology;
- Perceived effectiveness of the technology – how well owners believe that the technology works under several specific scenarios and weather conditions
- User interface and usability – sounds, visual displays;
- Safety – overall opinion of the safety of the system, driving incidents related to the technology; and
- Need for improvements – owners’ suggestions for needed improvements regarding the technology and regarding the design of vehicles for older persons.

All of the questionnaire items are listed in Table 1. Items are grouped by their key topic area. Some items may apply to more than one topic area, but they are listed here only under their primary topic area.

Table 1. Adaptive Cruise Control questionnaire: Content areas and associated items

Background	1. Age 2. Gender 3. Do you have physical conditions which make driving more difficult? 4. Conventional cruise control systems allow you to maintain a constant vehicle speed without keeping your foot on the accelerator pedal. Some newer vehicles also have adaptive cruise control (ACC). ACC adjusts your vehicle speed automatically to maintain a constant gap (headway) between your vehicle and the vehicle ahead. Does your vehicle have adaptive cruise control? 4A. If no, then why not? 4B. If you purchased this same vehicle again would you want adaptive cruise control? (for those who do not currently have ACC) 6. Approximately how many miles have you personally driven this vehicle? 27. Have you recently stopped (given up) driving?
Desire to Have System	5. If you purchased this same vehicle again would you want adaptive cruise control? (for those who currently have ACC)
Learning	7. How did you learn to use your adaptive cruise control system? 9. Were there things that were especially difficult to learn about your adaptive cruise control system? 9A. If yes, please explain.

Behavioral Adaptation to System	<p>11. Does your vehicle have the option of using conventional cruise control without adaptive cruise control?</p> <p>11A. If yes how, frequently have you been confused about which system is operating?</p> <p>12. Compared to driving with cruise control off, how quickly do you notice and respond to unexpected road hazards when the adaptive cruise control is engaged (turned on)?</p> <p>13A. If you could not use adaptive cruise control any more how would your driving change?</p> <p>13B. If you could not use adaptive cruise control any more how much would you use conventional cruise control (constant speed control)?</p> <p>14C. Using adaptive cruise control relieves me of stress when driving (strongly disagree, disagree, neutral, agree, strongly agree, not applicable).</p> <p>14D. I tend to change lanes less frequently when using adaptive cruise control (strongly disagree, disagree, neutral, agree, strongly agree, not applicable).</p> <p>14E. I tend to follow the vehicle ahead more closely when using adaptive cruise control (strongly disagree, disagree, neutral, agree, strongly agree, not applicable).</p> <p>14F. I tend to set adaptive cruise control to a shorter gap (closer following distance) in heavy traffic than in light traffic (strongly disagree, disagree, neutral, agree, strongly agree, not applicable).</p> <p>17. Do you normally use the same gap (headway) setting or do you adjust the gap based on driving conditions?</p> <p>18. At what gap (headway) setting do you usually have the adaptive cruise control system set?</p> <p>23. How has your reliance on adaptive cruise control changed since you first drove the vehicle?</p>
Perceived Effectiveness	<p>10. Under what conditions do you avoid using the adaptive cruise control system?</p> <p>10A. Rain</p> <p>10B. Snow</p> <p>10C. At night</p> <p>10D. In congested, “stop-and-go” traffic</p> <p>10E. In heavy traffic that is flowing</p> <p>10F. On interstate highways</p> <p>10G. Freeways off ramps, or when exiting highways</p> <p>10H. On curvy roads</p> <p>10I. On neighborhood or city streets with traffic lights</p> <p>10J. Are there any other conditions where you avoid using the adaptive cruise control system?</p> <p>14G. My adaptive cruise control sometimes locks on to a vehicle other than the vehicle immediately in front of me (strongly disagree, disagree, neutral, agree, strongly agree, not applicable).</p> <p>15. Please rate how well your adaptive cruise control would assist you to avoid colliding with the vehicle in front of you under the following circumstances</p> <p>15A. You are following a vehicle in stop-and-go traffic.</p> <p>15B. You encounter a stopped car in your lane ahead.</p> <p>15C. You are following a vehicle on a curvy road.</p> <p>16. How often have you encountered each of these situations?</p> <p>16A. The adaptive cruise control system would slow unexpectedly when there was no vehicle immediately ahead of you.</p> <p>16B. The adaptive cruise control system would brake abruptly or brake hard causing the vehicle behind you to get uncomfortably close, or to brake hard.</p> <p>16C. The adaptive cruise control system would accelerate unexpectedly.</p> <p>16D. You forgot to turn off the system.</p> <p>16E. The system shut off unexpectedly.</p>
User Interface and Usability	<p>14A. The lights/symbols on the adaptive cruise control system are easy to understand (strongly disagree, disagree, neutral, agree, strongly agree, not applicable).</p> <p>14B. The sounds made by the adaptive cruise control system are easy to understand (strongly disagree, disagree, neutral, agree, strongly agree, not applicable).</p> <p>21. To what extent have you been confused about what speed the adaptive cruise control is set to?</p>

	22. To what extent have you been confused about what following distance the adaptive cruise control is set to?
Safety	8. Are you aware of any warnings or limitations about your adaptive cruise control system? 8A. If yes, please explain. 14H. More cars cut me off or pull in front of me when I am using adaptive cruise control (strongly disagree, disagree, neutral, agree, strongly agree, not applicable). 19. Since you have owned your vehicle with adaptive cruise control, have you driven any other vehicle equipped with only conventional cruise control and had a collision or a “close call” because you expected the vehicle you were driving to automatically slow down? 20. Does your adaptive cruise control system create any new driving problems or safety concerns for you? 20A. If yes, please explain. 24. Have you ever unintentionally collided with something when you had the adaptive cruise control system engaged (turned on)? 24A. If yes, please describe the situation 25. Overall, are you a safer driver using adaptive cruise control than you would be if you only used conventional cruise control?
Need for Improvements	26. Is there anything about the way the adaptive cruise control system works that you think should be improved or changed? 26A. If yes, please explain. 28. In general, do you believe that car manufacturers are doing enough to design vehicles to accommodate an aging population? 28A. If you answered “no” then what more do you believe could be done?

The questionnaire (see Appendix B) was designed so that all survey items and a cover letter could be printed double-sided on no more than five sheets of paper. Pilot tests were conducted to ensure comprehension of the questions and to ensure that the typical completion time for the questionnaire was less than 15 minutes. A second stage of pilot tests was conducted by mailing out 100 questionnaires to drivers insured through the Automobile Club of Southern California. This mail-out was used to get an indication of the expected response rate for the survey and to review the types of answers that respondents provided to ensure that each item was understandable.

Final questionnaires for the adaptive cruise control survey were mailed out during November 2006. A cover letter from ACSC was included that explained the purpose of the survey and invited the vehicle owner to participate. All vehicle owners who received questionnaires were asked to return the questionnaire even if they did not have the indicated technology on their vehicle. On the back of the cover letter, respondents were asked whether they would be willing to participate with ACSC in a brief phone interview about their vehicle. Those who were willing to do this were asked to write in their contact information. The cover letter and questionnaire are given in Appendix B. (The response frequencies for every item are tabulated in Appendix C.)

Telephone Interviews

A subset of survey respondents who gave their consent to be called was selected for telephone interviews. ACSC staff called system owners who indicated on the written questionnaire that they thought that their adaptive cruise control system should be improved, as a goal of the telephone interviews was to uncover any potential problems with the systems that were not addressed by items on the questionnaire. The telephone interviewers used a script to guide

the conversation (see Appendix D). Seventeen owners of adaptive cruise control systems were interviewed. The interviewees' comments are given in Appendix E. Selected comments from the telephone interviews also are included (*in italics*) in the Results section.

Sampling

Practical considerations, such as project budgets, variables available in the ACSC insurance database, and estimated questionnaire return rate contributed to the sampling plan. ACSC queried their database to identify a subset of customers who owned particular vehicle models (and model years) that have an ACC system as standard equipment or might have it as optional equipment. Note that the investigators could not determine in advance whether owners in the insurance database that owned vehicles with optional ACC had purchased these options, thus, some people who received the survey did not own a vehicle that actually had an ACC system.

Adaptive cruise control questionnaires (n = 10,000) were mailed to a random sample of these candidate system owners subject to the following constraints. Approximately 75 percent of the questionnaires were mailed to vehicle owners whose vehicle included the technology as a factory-installed standard feature and 25 percent of the questionnaires were mailed to owners of vehicles on which the technology was a factory-installed optional feature. An additional sampling requirement was that one-half of the questionnaires for each technology survey were mailed to vehicle owners 65 or older, and the other half were mailed to vehicle owners who were 25 to 64 years old. Respondents were not offered any monetary or other incentives for their voluntary participation.

RESULTS

Tabulated response frequencies for all survey items are shown in Appendix C. In this section, the results from the survey are described in more detail, along with selected quotations from follow-up telephone interviews. The complete set of quotations from the telephone interviews is given in Appendix E.

Nearly all respondents with adaptive cruise control systems (ACC) had vehicles from seven manufacturers in the 2002 to 2006 model years, and all ACC owners' data were used for the majority of the analyses reported here. However, due to the small sample size obtained for some vehicle manufacturers, we restricted comparisons between manufacturers to those with adequate data in our sample. Thus, only data from respondents who owned ACC systems on vehicles manufactured by BMW, Infiniti, Lexus, Mercedes-Benz, and Toyota were used in analyses that included vehicle manufacturer as an analysis variable. Unless noted, all comparisons between age groups involved respondents who were less than 65 years old (younger group) being compared to respondents who were 65 or older (older group).

1. General Characteristics of Survey Respondents

Response rate

Vehicle owners selected for the adaptive cruise control survey were instructed to return the questionnaire even if they did not have ACC on their vehicle. Approximately 16.6 percent ($n = 1,659$) of the 10,000 questionnaires mailed were returned, and 22.3 percent ($n = 370$) of those who returned the questionnaire reported having an ACC system.

Age and gender

Approximately 39 percent of the respondents with ACC were 65 or older. Figure 1 shows the number of respondents in each of six age categories who have ACC. The dark bar represents the number of men and the lighter bar represents the number of women. Overall, 30 percent of the respondents who reported owning an ACC system were women, however, the ratio of male to female ACC owners was significantly related to age group $\chi^2(5) = 30.1, p < .001$. There were more female respondents (65%) than male respondents (35%) with ACC in the youngest age group, but in the oldest two age groups only 17 to 21 percent of respondents with ACC were female.

Physical conditions that make driving more difficult

I have a bad back and it's difficult for me to turn to see what's beside my car. I would like the ability to know what's beside my car; I think some cars now have that capability. - (Male, 76)

Respondents were asked, (Q3): "Do you have any physical conditions which make driving more difficult?" The most commonly reported physical conditions were vision problems (6.3%), hearing problems (3.0%), and difficulty turning my head/neck (2.5%). Nearly 90 percent of all respondents reported that they have no physical conditions which make driving more difficult. Among those with ACC systems who answered this question, 84 percent of older ACC owners and 95 percent of younger ACC owners reported no physical conditions. This difference was statistically significant, $\chi^2(1) = 11.2, p < .001$. Approximately 11 percent of older respondents and four percent of younger respondents reported vision problems. This

difference also was statistically significant, $\chi^2(1) = 5.9, p < .05$. Other differences between younger and older ACC owners were not statistically significant for any of the other physical conditions shown in Appendix C although in some cases the frequencies were too small to perform a valid statistical comparison.

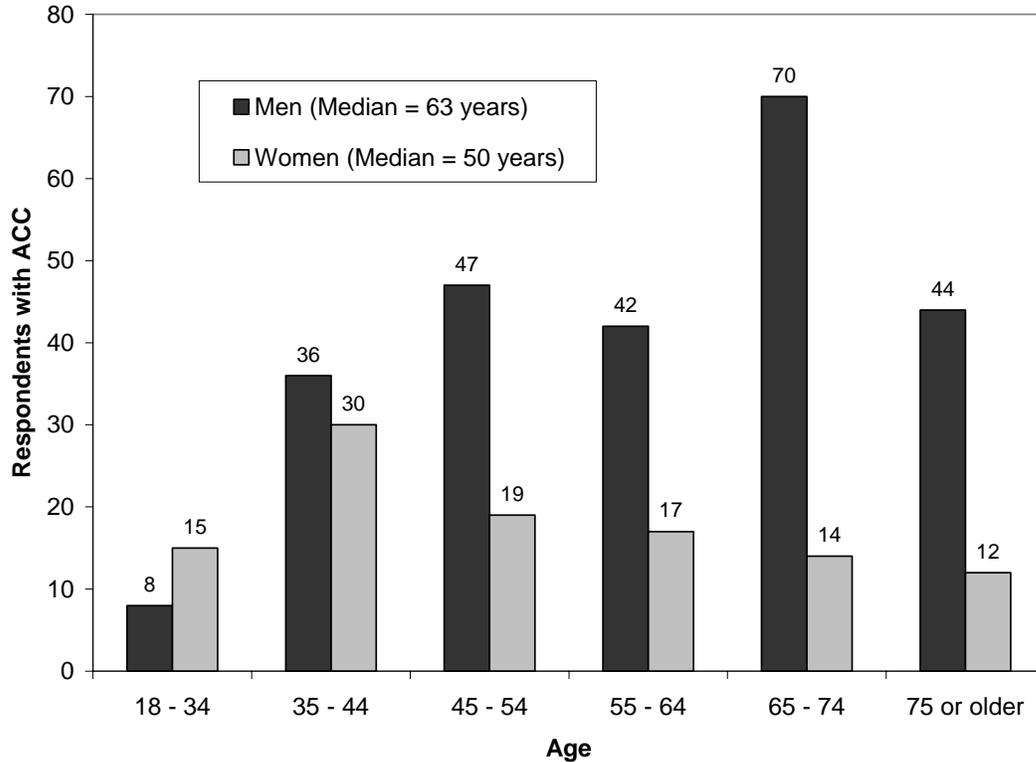


Figure 1. Age and gender of respondents who have an ACC system

Driving experience with currently owned vehicle

“I haven’t had any problems with the [ACC] system in twenty thousand miles of driving. We make a trip to the Midwest each summer and we rely on the adaptive cruise control since you can relax a little using it.”
 - (Male, 68)

ACC owners were asked to write-in the number of miles they had personally driven their vehicle. This item (Q6) was used as a surrogate measure of experience with the vehicle and its associated in-vehicle technologies. For analysis purposes, responses were grouped in mileage (experience) categories. Table 2 shows the distribution of experience levels for male and female ACC owners who responded to the survey. Although men appeared to be more likely than women to have higher levels of experience, the overall differences between the experience distributions for male and female ACC owners failed to reach statistical significance, $\chi^2(4) = 8.3, p = .08$.

Table 2. Respondents who have ACC by gender and by experience with their vehicle

Frequency Row Pct. (Col. Pct.)	Less than 5,000 Miles	5,000 to 9,999 Miles	10,000 to 19,999 Miles	20,000 to 29,999 Miles	30,000 or More Miles	Total
Male	26 11.16 (86.67)	36 15.45 (69.23)	66 28.33 (62.26)	41 17.60 (75.93)	64 27.47 (72.73)	233 (70.61)
Female	4 4.12 (13.33)	16 16.49 (30.77)	40 41.24 (37.74)	13 13.40 (24.07)	24 24.74 (27.27)	97 (29.39)
Total	30 9.09	52 15.76	106 32.12	54 16.36	88 26.67	330 100.00

Due to the small sample size, all subsequent analyses involving the relation between level of experience and other variables were performed by recoding the experience data into only three levels (0 to 9,999 miles; 10,000 to 29,000 miles; 30,000 or more miles).

Item Q27 asked ACC owners if they had recently stopped (given up) driving. Of the 322 respondents who answered this question, none reported that they had recently stopped driving.

2. *Desire to Have Adaptive Cruise Control*

Two identical questions on the ACC survey were targeted to respondents who currently have (Q5) or do not have (Q4B) the system: “If you purchased this same vehicle again would you want adaptive cruise control?” The response frequencies for these items were combined and are shown in Table 3. (Only those who indicated definitively that they either have ACC or do not have ACC on item Q4 were included in this analysis.) The pattern of responses depended significantly on whether or not the respondents currently have ACC, $\chi^2(2) = 191.8, p < .001$. Most respondents who have ACC appear to be satisfied with their systems because the majority of them would want to purchase their adaptive cruise control system again (76%), however only 34 percent of those without ACC said that they would want to get the system. As expected, a higher percentage of those without ACC said that they didn’t know as compared to those who have ACC.

Table 3. Respondents who would want adaptive cruise control if they purchased their same vehicle again

Frequency Row Pct.	Yes	No	Don’t Know	Total
Respondents who have ACC now	273 75.83	33 9.17	54 15.00	360 100.00
Respondents who do not have ACC	417 34.58	337 27.94	452 37.48	1206 100.00

Respondents who do not currently have ACC were asked why they didn’t have it (item Q4A). The two most common reasons cited for not having ACC were related to lack of knowledge about the system and availability of the system. More than half (54%) of the respondents indicated that, “It never occurred to me to look for one when I was buying the vehicle,” and a

similar percentage of respondents (54%) indicated that, “It was not an option on my vehicle.” Approximately 19 percent said that they didn’t need the system and 14 percent cited the cost of the system as a reason for not having ACC. Over 12 percent of respondents said that they wouldn’t trust the system to keep them from colliding with other vehicles. Relatively few respondents cited bundling with other unwanted options (7%) as a reason for not having an ACC system. The complete list of response frequencies for these items is shown in Appendix C.

3. Learning to Use Adaptive Cruise Control

“It didn’t take long to learn. I read the owner’s manual and experimented with it.” – (Male, 46)

“I did not get any training with the system, only a manual.” - (Male, 71)

“I feel the salesman should have trained me or provided a training video or something.” – (Male, 68)

Item Q7 asked respondents with ACC how they had learned to use the system. The most frequently reported learning methods were, “Vehicle owner’s manual” (67%), and “On road experience and practice (trial and error)” (54%). In fact, of the 354 respondents with ACC who answered item Q7, 15.5 percent indicated, “On-road experience . . .” as the only learning method that they used.

Five percent of respondents reported receiving help from a friend or relative and only 1 percent made use of “Information on the Internet.” Nearly 8 percent of respondents said that they have, “Not yet learned how to use the adaptive cruise control.” “Instructions from the dealership . . .” was cited as a learning method by 29 percent of respondents.

Only 9 percent of respondents thought that there were things that were especially difficult to learn about their ACC system (Q9).

Differences in learning to use ACC based on vehicle manufacturer

In general, differences in the methods used to learn about ACC did not depend strongly on vehicle manufacturer. Respondents’ learning methods were compared between the five most common vehicle manufacturers in the sample. The percentage of respondents who learned to use their ACC system from, “Instructions from the dealership” ranged from 22 percent of Toyota owners to 34 percent of Infiniti owners, however these differences were not statistically significant, $\chi^2(4) = 3.3, p = .51$. Similarly, the percentage of ACC owners who learned to use their ACC system by reading the owner’s manual ranged from 60 percent (Toyota) to 75 percent (Infiniti), but the differences were not statistically significant, $\chi^2(4) = 4.4, p = .36$. The percentage of ACC owners who learned to use their system by on-road experience ranged from 36 percent (BMW) to 64 percent (Toyota), however, due to the small sample size these differences also failed to reach statistical significance, $\chi^2(4) = 7.7, p = .10$. Sample sizes for the other learning methods listed in item Q7 were not sufficiently large to perform further statistical comparisons between vehicle manufacturers. Responses to item Q9 concerning the difficulty of learning about the ACC system were not significantly related to vehicle manufacturer, $\chi^2(4) = 2.4, p = .65$.

Age differences in learning to use ACC

Responses from younger and older ACC owners were compared for each of the learning methods listed in item Q7. The only statistically significant difference between age groups occurred for the use of the vehicle owner's manual. Older participants (73.7%) were more likely than younger participants (63.6%) to have used the vehicle owner's manual to learn how to use their ACC system, $\chi^2(1) = 3.9, p < .05$. Respondents were asked whether the owner's manual was easy to use, and more than 90 percent of all respondents said, "Yes." There was no significant difference between older and younger age groups in the percentage of respondents who found the owner's manual easy to use, $\chi^2(1) = 0.3, p = .56$. Older and younger respondents did not differ significantly in their responses to item Q9 concerning the difficulty of learning about their ACC system, $\chi^2(1) = 0.2, p = .62$.

4. Behavioral Adaptation

"I have changed my driving habits since I began using the ACC more often. I'm comfortable enough with the system that I will use in town where there is a long stretch between signals. It took me about two months to become fully used to the system since I don't drive every day." – (Male, 67)

"I don't think I have changed my driving habits using the system. I set the adaptive cruise control 5 mph above the speed limit and it works fine as traffic changes speed. It is such a fine system that I became comfortable with it within five minutes or so." – (Male, 87)

"I haven't really changed my driving habits and I'm still not comfortable with the system for the reasons I mentioned earlier. My wife refuses to use the ACC, she does not trust it." – (Male, 62)

Use of adaptive cruise control and conventional cruise control

Some drivers may have adaptive cruise control and conventional cruise control available to them on the same vehicle (or on different vehicles that they frequently drive). For example, the ACC systems on Lexus, Toyota, Infiniti, and Mercedes models allow the driver to set a fixed cruising speed without using the automatic speed adjustment function. Potentially, drivers could become confused about which system (or functions) they are using. When driving with conventional cruise control, the driver who is used to driving with adaptive cruise control may mistakenly assume that his vehicle will automatically slow down in response to the slowing of a lead vehicle. Respondents were asked (Q11) whether their vehicle provided the option of using conventional cruise control without adaptive cruise control. Forty-six percent of respondents said, "Yes," and 50 percent of respondents said, "No." Approximately 3 percent of respondents said that they didn't know. Those who have both conventional cruise control and adaptive cruise control were asked how frequently they have been confused about which system is operating (Q11). Due to the small sample size, responses were combined across some categories. Sixteen percent of these respondents said that they were either, "Always confused," "Frequently confused," or "Sometimes confused." Approximately 23 percent of respondents said that they were "Rarely confused," and 59 percent were "Never confused." Older and younger respondents had nearly identical

distributions of responses to item Q11, and the responses did not depend significantly on respondents' level of experience with their vehicle, $\chi^2(4) = 4.7, p = .32$.

Response to unexpected road hazards

Drivers were asked how quickly they respond to unexpected road hazards when their ACC is engaged as compared to when their ACC is off (Q12). Only 9 percent of respondents said that they respond more slowly when ACC is engaged, while 24 percent said that they respond more quickly. Approximately 49 percent said that they respond in the same time, and 18 percent said that they didn't know. The responses to this item depended significantly on the respondent's vehicle manufacturer, $\chi^2(12) = 25.7, p < .05$, as shown in Table 4. The top number in each cell of the table shows the number of respondents from a particular manufacturer (column heading) who gave the response listed in the row heading. The number in parentheses represents the column percentage (percentage of respondents who gave that response among those who had vehicles from the same manufacturer). Although the cell sizes are quite small, it appears that Toyota owners and BMW owners were more likely than Infiniti, Lexus, and Mercedes-Benz owners to say that they respond more slowly to unexpected road hazards when ACC is engaged. Mercedes-Benz owners were more likely to say that they respond more quickly with ACC engaged, and they were more likely to say that they don't know as compared to owners of vehicles from other manufacturers.

Table 4. Response to unexpected road hazards with ACC engaged (by vehicle manufacturer)

Frequency (Col. Pct.)	BMW	Infiniti	Lexus	Mercedes-Benz	Toyota	Total
More slowly	4 (16.67)	5 (6.67)	6 (5.22)	1 (3.33)	10 (12.50)	26 (8.02)
In the same time	12 (50.00)	48 (64.00)	50 (43.48)	9 (30.00)	40 (50.00)	159 (49.07)
More quickly	3 (12.50)	15 (20.00)	33 (28.70)	10 (33.33)	19 (23.75)	80 (24.69)
Don't know	5 (20.83)	7 (9.33)	26 (22.61)	10 (33.33)	11 (13.75)	59 (18.21)
Total	24	75	115	30	80	324
Row Pct.	7.41	23.15	35.49	9.26	24.69	100.00

The responses to Q12 did not depend significantly on the respondent's age group, $\chi^2(3) = 5.2, p = .16$ or level of vehicle experience, $\chi^2(6) = 9.14, p = .17$.

ACC and following distance

Item Q13A asked ACC owners how their driving behavior would change if they could not use ACC anymore. Half of the respondents (50%) said that they would usually keep the same gap between their vehicle and the vehicle ahead as they do now using ACC. A slightly higher percentage of respondents (26.5%) said that they would keep a smaller gap as compared to those who said they would keep a larger gap (23.4%).

The responses to this item (Q13A) did not depend significantly on respondents' level of experience with their vehicle, $\chi^2(4) = 4.6, p = .33$, however, the responses did differ significantly based on the respondent's age group, $\chi^2(2) = 7.6, p < .05$. Figure 2 shows how the responses for younger and older ACC owners differ. Younger respondents were more likely than older respondents to say that they would reduce their usual following distance (smaller gap) if they no longer had ACC. Older were more likely to say that they would increase their following distance (larger gap) without ACC.

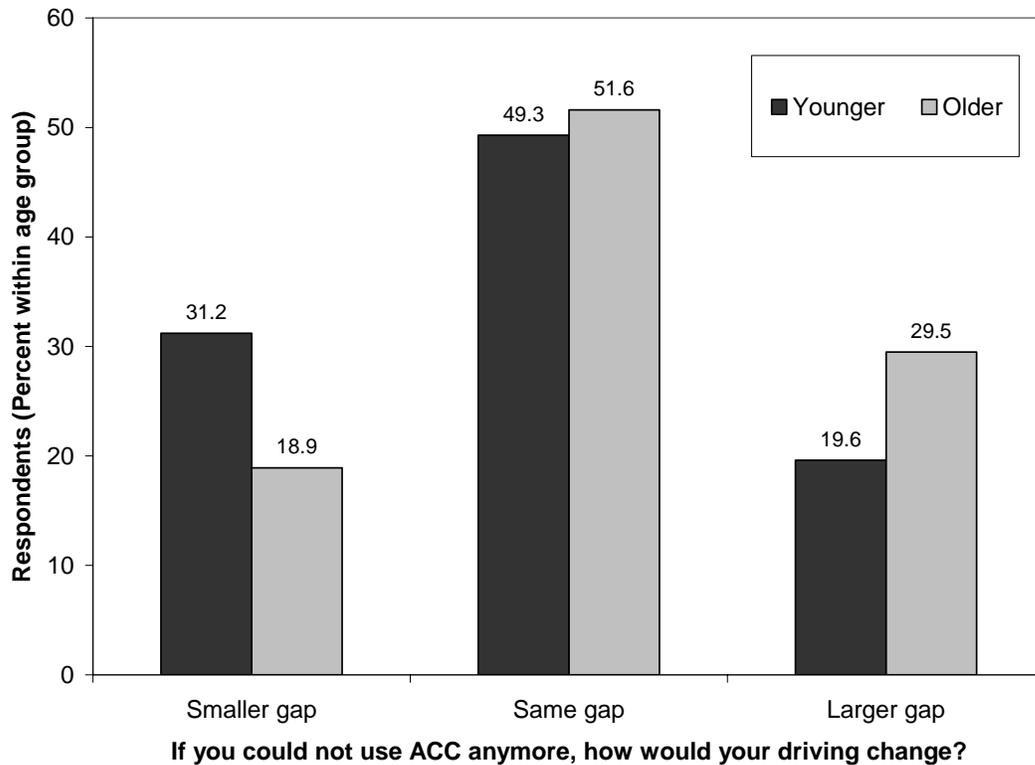


Figure 2. How younger and older respondents would change their usual following distance if they no longer had ACC.

The responses to item Q13A depended significantly on respondents' vehicle manufacturer, $\chi^2(8) = 37.7, p < .001$. Table 5 shows how the responses from owners of different vehicle makes differed. Mercedes-Benz owners were most likely to say that they would maintain a larger gap between vehicles if they couldn't use ACC anymore.

Table 5. How respondents would change their usual following distance if they no longer had ACC (by vehicle manufacturer)

Frequency (Col. Pct.)	BMW	Infiniti	Lexus	Mercedes-Benz	Toyota	Total
Smaller gap	2 (9.52)	24 (33.33)	24 (22.43)	3 (10.34)	27 (34.62)	80 (26.06)
Same gap	13 (61.90)	38 (52.78)	57 (53.27)	8 (27.59)	40 (51.28)	156 (50.81)
Larger gap	6 (28.57)	10 (13.89)	26 (24.30)	18 (62.07)	11 (14.10)	71 (23.13)
Total	21	72	107	29	78	307
Row Pct.	6.84	23.45	34.85	9.45	25.41	100.00

Following distance was also addressed by item Q14E. Respondents were asked how much they agreed with the statement, “I tend to follow the vehicle ahead more closely when using adaptive cruise control.” The response frequencies are given in Appendix C. Two-thirds of the respondents (66.9%) disagreed or strongly disagreed with this statement, and only 8 percent agreed or strongly agreed with the statement. The responses to this item did not depend significantly on age group, $\chi^2(5) = 5.8, p = .32$. Comparisons between manufacturers for this item were difficult due to the small sample size and the small number of respondents who agreed or strongly agreed. In order to compare the responses by vehicle manufacturer, the “Disagree” and “Strongly Disagree” responses were combined into a single category and the “Neutral,” “Agree,” and “Strongly Agree” responses were combined into a second single category. The “Not Applicable” responses (6.4%) were not included in this analysis. Of the data included, the percentage of respondents who disagreed or strongly disagreed varied from 63 percent (BMW) to 75 percent (Toyota), however these differences did not reach statistical significance, $\chi^2(4) = 1.8, p = .77$.

Item Q13B asked respondents how much they would use conventional cruise control if they could no longer use ACC. Most respondents (53%) indicated that they would use conventional cruise control as often as they use it now. Approximately 21.5 percent of respondents said that they would use conventional cruise control less often than they do now and only 7.6 percent said that they would use conventional cruise control more often than they do now. Ten percent said that they didn’t know. These results did not depend significantly on age group or vehicle experience.

Stress, lanes changes, and gap settings

Items Q14C, Q14D, Q14F, and Q14H asked respondents how much they agreed (or disagreed) with statements concerning the use of ACC and stress, frequency of lane changes, ACC settings for following distance in heavy versus light traffic, and propensity for other drivers to cut them off or pull in front of them. The complete response frequencies are shown in Appendix C.

Nearly half (48%) of the respondents agreed or strongly agreed that using ACC relieves them of stress when driving (Q14C) and more than half of the respondents (53%) agreed or strongly agreed that when they use ACC they tend to change lanes less frequently (Q14D). Responses

to the question about stress did not depend significantly on the respondent's level of experience with the vehicle, $\chi^2(10) = 4.2, p = .94$, nor did they depend significantly on the respondent's age group, $\chi^2(5) = 4.5, p = .48$. Responses to the item about lane changes also did not depend significantly on the respondent's level of experience, $\chi^2(10) = 8.3, p = .60$ or age group, $\chi^2(5) = 4.8, p = .44$.

Item Q14F asked respondents whether they agreed or disagreed with the statement, "I tend to set adaptive cruise control to a shorter gap (closer following distance) in heavy traffic than in light traffic." A substantial number of respondents (20%) selected, "Not Applicable" for this item, and 43 percent disagreed or strongly disagreed. Approximately 18 percent of respondents agreed or strongly agreed with the statement, indicating that they probably adjust their ACC following distance depending on traffic conditions. One likely reason for setting a shorter gap in heavy traffic is to avoid other cars pulling in front of them or cutting them off. In fact, 35 percent of respondents agreed or strongly agreed with the statement (Q14H), "When I use adaptive cruise control more cars cut me off or pull in front of me." Neither the responses to item Q14F nor the responses to item Q14H depended significantly on age group or level of experience.

Item Q17 asked respondents directly about adjusting their ACC gap setting, "Do you normally use the same gap (headway) setting or do you adjust the gap based on driving conditions?" Approximately 51 percent of respondents indicated, "I change the amount of gap between my vehicle and the vehicle ahead as driving conditions change." Nearly 28 percent said that they, "Always choose the same setting for the amount of gap between my vehicle and the vehicle ahead." The remaining respondents either didn't know how to change the gap setting on their ACC system (15%) or they said that their system doesn't allow changing the following distance (6%). Differences in responses based on age group failed to reach statistical significance, $\chi^2(3) = 6.4, p = .10$.

Although the overall distribution of responses to item Q17 did not depend significantly on level of experience with the vehicle, $\chi^2(6) = 7.4, p = .28$, the percentage of respondents who said that they didn't know how to change the gap setting on their ACC system decreased systematically with experience from 20.6 percent for those with less than 10,000 miles of experience to 14.5 percent for those with between 10,000 and 29,999 miles of experience, to 9.5 percent for those with 30,000 miles or more of experience. These data suggest that some ACC system owners may not learn all of the capabilities of their system until they have had a lot of driving experience with the vehicle.

Item Q18 asked respondents, "At what gap (headway) setting do you usually have the adaptive cruise control system set?" The largest number of respondents (37%) said that they select a medium setting, while 24 percent said that they use the longest setting and 11 percent said that they use the shortest setting. Many respondents (19.5%) said that they didn't know, and some (7.5%) said that their system doesn't allow changing the following distance. The results did not depend significantly on age group, $\chi^2(4) = 7.0, p = .14$, or on experience level, $\chi^2(8) = 7.8, p = .45$.

Reliance on ACC system

*“The system gives you a warning beep when someone cuts in front of your path in case you have a little highway hypnosis going on.”
– (Male, 67)*

“I find the system very useful in every-day traffic when the speed is constantly changing. I just set it and it does the work.” – (Male, 40)

“I have become dependent on the system in traffic; I allow the system to apply the brakes before [I do].” – (Male, 71)

Item Q23 asked respondents how their reliance on adaptive cruise control has changed since they first drove their vehicle. Most respondents (64%) indicated that their reliance has stayed about the same. Approximately 27 percent of respondents rely on ACC more now than they did in the beginning, and 9 percent rely on it less. The most common reasons that respondents gave for relying on the system more now were related to an increased level of knowledge, trust, or comfort with the system. The results did not depend significantly on age group, $\chi^2(2) = 4.5, p = .10$, or on experience level, $\chi^2(4) = 6.6, p = .16$.

5. Perceived Effectiveness

“The system on my Infiniti is very sensitive to semi-trucks in other lanes. When the highway curves it will lock onto trucks in other lanes and abruptly slow down. This happens in other than straight-line driving.” – (Male, 58)

*“When the road curves the system occasionally will pick up a car in a lane beside you. I would like a warning when it detects that situation.”
– (Male, 46)*

*“The system probably keeps a better distance between cars than I do.”
– (Male, 40)*

ACC locks onto a vehicle other than the vehicle immediately ahead

Several items assessed participants' perceptions about how well their ACC system worked in various conditions. Item Q14G asked respondents whether they agree or disagree that, “The adaptive cruise control sometimes locks on to a vehicle other than the vehicle immediately in front of me.” Although nearly 46 percent of participants disagreed or strongly disagreed with this statement, a substantial number (29%) agreed or strongly agreed, indicating that this problem may be fairly common.

The results for item Q14G were analyzed by vehicle manufacturer. Due to the small cell sizes for some responses, differences between vehicle manufacturers were assessed by recoding all “agree” and “strongly agree” responses into a single category. Similarly, all “disagree” and “strongly disagree” responses were combined into a single category. The results are shown in Table 6. Expressed in this way, the results from item Q14G differ significantly by vehicle manufacturer, $\chi^2(12) = 55.2, p < .001$. Infiniti owners had the highest percentage of respondents who agreed with the statement, and BMW owners had the lowest percentage of owners who agreed with the statement.

Table 6. ACC locks onto a vehicle other than the vehicle ahead (by vehicle manufacturer)

Frequency (Col. Pct.)	BMW	Infiniti	Lexus	Mercedes- Benz	Toyota	Total
Disagree / Strongly Disagree	15 (62.50)	22 (30.56)	50 (47.17)	11 (40.74)	43 (55.13)	141 (45.93)
Neutral	3 (12.50)	9 (12.50)	20 (18.87)	6 (22.22)	9 (11.54)	47 (15.31)
Agree / Strongly Agree	1 (4.17)	39 (54.17)	25 (23.58)	2 (7.41)	22 (28.21)	89 (28.99)
Not Applicable	5 (20.83)	2 (2.78)	11 (10.38)	8 (29.63)	4 (5.13)	30 (9.77)
Total Row Pct.	24 7.82	72 23.45	106 34.53	27 8.79	78 25.41	307 100.00

As shown in Figure 3, younger and older ACC owners responded somewhat differently to item Q14G, $\chi^2(5) = 12.3, p < .05$. Younger respondents were more likely than older respondents to agree that their ACC system sometimes locks onto a vehicle that is not immediately ahead of them.

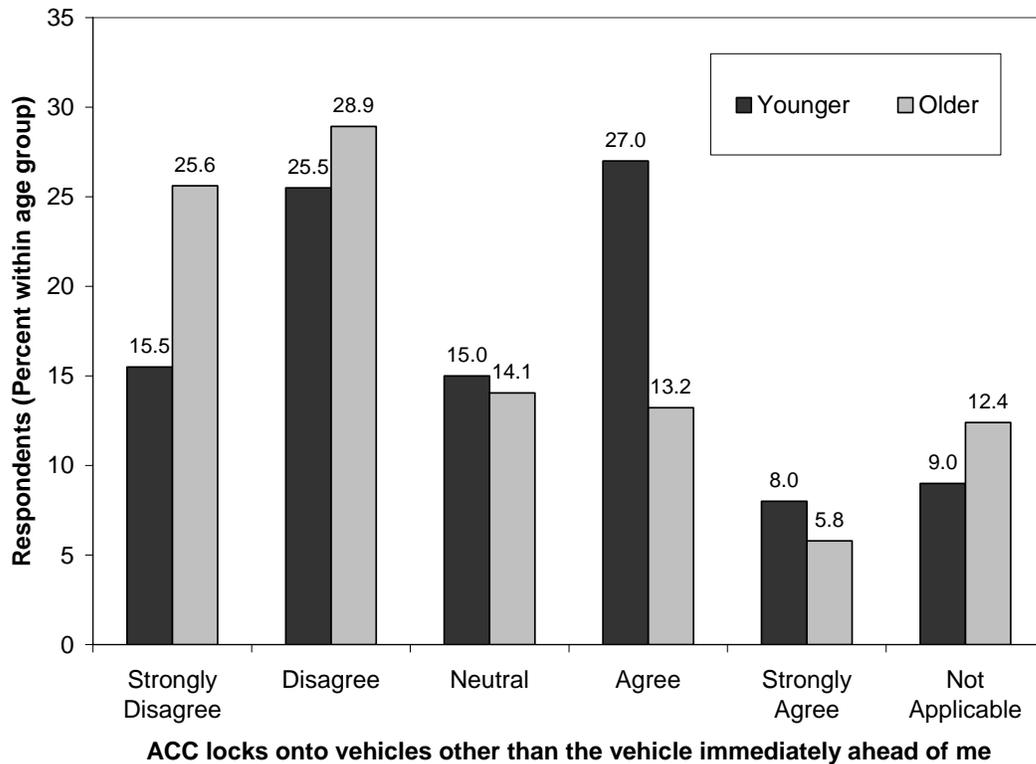


Figure 3. Younger and older respondents experience with ACC locking onto the wrong vehicle.

Respondents’ perception that ACC helps them avoid collisions

A series of three survey items asked respondents to judge how well their system would help them to avoid colliding in several different situations (Q15A – Q15C). These scenarios were written to cover circumstances where ACC is not likely to work well and they are usually included as warnings in the vehicle owner’s manual. Despite these warnings, many respondents indicated that their ACC system would work fairly well or perfectly to assist them to avoid colliding with the vehicle ahead in the following situations:

- 24 percent - Following a vehicle in stop-and-go traffic (Q15A)
- 43 percent – Encountering a stopped car in your lane ahead (Q15B)
- 27 percent – Following a vehicle on a curvy road (Q15C)

For all three situations, a large percentage of respondents (35 to 40%) said that they didn’t know. None of the results for items Q15A – Q15C depended significantly on the respondent’s age group, however, the results for Q15A depended significantly on the respondent’s level of experience with the vehicle, $\chi^2(8) = 18.5, p < .05$, as did the results for item Q15B, $\chi^2(8) = 17.3, p < .05$. The responses to item Q15C did not depend significantly on experience level, $\chi^2(8) = 9.4, p = .31$. The response frequencies for items Q15A and Q15B are shown in Table 7 and Table 8. Surprisingly, at higher levels of experience respondents are more likely to say that their system works “fairly well” or “perfectly” to help them avoid a collision in these situations (see Figure 4).

Table 7. Perceived effectiveness of ACC system for avoiding a collision in stop-and-go traffic (by experience level)

Frequency (Col. Pct.)	Less than 10,000 Miles	10,000 to 29,999 Miles	30,000 or More Miles	Total
Not at all	23 (30.67)	38 (25.85)	19 (22.09)	80 (25.97)
Poorly	13 (17.33)	8 (5.44)	13 (15.12)	34 (11.04)
Fairly well	11 (14.67)	24 (16.33)	22 (25.58)	57 (18.51)
Perfectly	3 (4.00)	9 (6.12)	7 (8.14)	19 (6.17)
Don't know	25 (33.33)	68 (46.26)	25 (29.07)	118 (38.31)
Total	75	147	86	330
Row Pct.	24.35	47.73	27.92	100.00

Table 8. Perceived effectiveness of ACC system for avoiding a collision with a stopped car ahead (by experience level)

Frequency (Col. Pct.)	Less than 10,000 Miles	10,000 to 29,999 Miles	30,000 or More Miles	Total
Not at all	14 (18.92)	22 (14.86)	7 (8.05)	43 (13.92)
Poorly	5 (6.76)	6 (4.05)	10 (11.49)	21 (6.80)
Fairly well	16 (21.62)	43 (29.05)	32 (36.78)	91 (29.45)
Perfectly	13 (17.57)	18 (12.16)	17 (19.54)	48 (15.53)
Don't know	26 (35.14)	59 (39.86)	21 (24.14)	106 (34.30)
Total	74	148	87	309
Row Pct.	23.95	47.90	28.16	100.00

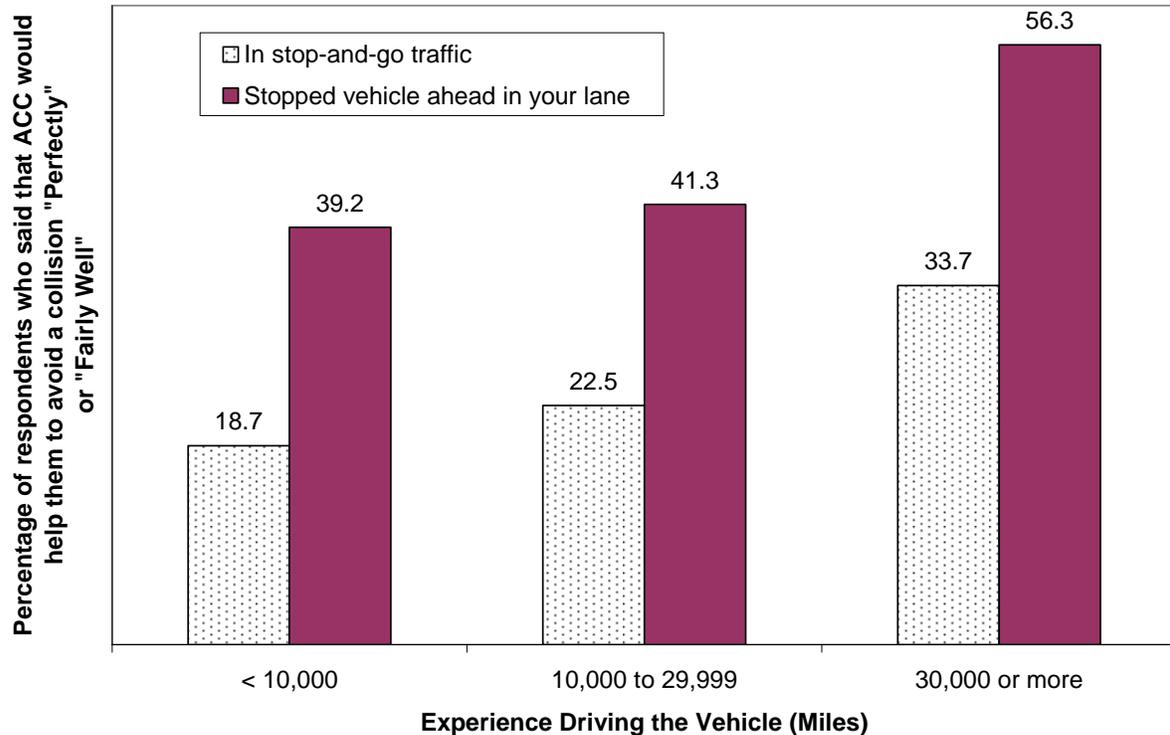


Figure 4. Respondents who believe that their ACC system would help them to avoid a collision when following a vehicle in stop-and-go traffic and when encountering a stopped vehicle in the lane ahead.

Unexpected braking, acceleration, and shutting off ACC

Item Q16 asked respondents how often they have encountered each of several unfavorable situations related to the operation of their ACC. The complete response frequencies are shown in Appendix C. For subsequent analyses, the response categories for, “Very often,” “Often,” and “Occasionally” were combined because of the small number of responses in these categories. For items Q16A to Q16E the number of respondents who reported experiencing each condition at least occasionally is listed below. The responses did not depend significantly on the respondent’s age group, level of experience with their vehicle, or vehicle manufacturer except where noted.

- 18.6 percent – “The adaptive cruise control system would slow unexpectedly when there is no vehicle immediately ahead” (Q16A). Older and younger respondents differed significantly in their responses to this item, $\chi^2(2) = 10.5, p < .01$. As compared to younger respondents, older respondents encountered this situation less often (Table 9). The responses also depended on the respondent’s vehicle manufacturer, $\chi^2(8) = 17.8, p < .05$. These results are shown in Table 10.
- 17.9 percent – “The adaptive cruise control system would brake abruptly or brake hard causing the vehicle behind to get uncomfortably close, or to brake hard” (Q16B). The responses depended on the respondent’s vehicle manufacturer, $\chi^2(8) = 18.0, p < .05$. These results are shown in Table 11.

- 16.3 percent – “The adaptive cruise control system would accelerate unexpectedly” (Q16C). Older and younger respondents differed significantly in their responses to this item, $\chi^2(2) = 9.0, p < .05$. As compared to younger respondents, older respondents encountered this situation less often (Table 12).
- 15.4 percent – “You forgot to turn off the system” (Q16D). Older and younger respondents differed significantly in their responses to this item, $\chi^2(2) = 7.6, p < .05$. As compared to older respondents, younger respondents were more likely to say that they rarely forgot to turn off their ACC system (Table 13).
- 9.3 percent – “The system shuts off unexpectedly” (Q16E).

Table 9. ACC system brakes unexpectedly (by age group)

Frequency (Col. Pct.)	Younger than 65	65 or Older	Total
Very often, often, or occasionally	45 (22.39)	15 (12.50)	60 (18.69)
Rarely	52 (25.87)	21 (17.50)	73 (22.74)
Never	104 (51.74)	84 (70.00)	188 (58.57)
Total Row Pct.	201 62.62	120 37.38	321 100.00

Table 10. ACC system brakes unexpectedly (by vehicle manufacturer)

Frequency (Col. Pct.)	BMW	Infiniti	Lexus	Mercedes-Benz	Toyota	Total
Very often, often, or occasionally	3 (13.04)	23 (31.08)	13 (12.38)	7 (26.92)	13 (16.67)	59 (19.28)
Rarely	5 (21.74)	21 (28.38)	22 (20.95)	3 (11.54)	17 (21.79)	68 (22.22)
Never	15 (65.22)	30 (40.54)	70 (66.67)	16 (61.54)	48 (61.54)	179 (58.50)
Total Row Pct.	23 7.52	72 24.18	105 34.31	26 8.50	78 25.49	306 100.00

Table 11. ACC system brakes abruptly or brakes hard (by vehicle manufacturer)

Frequency (Col. Pct.)	BMW	Infiniti	Lexus	Mercedes- Benz	Toyota	Total
Very often, often, or occasionally	1 (4.35)	17 (22.97)	14 (13.46)	3 (11.11)	20 (25.32)	55 (17.92)
Rarely	4 (17.39)	14 (18.92)	35 (33.65)	6 (22.22)	25 (31.65)	84 (27.36)
Never	18 (78.26)	43 (58.11)	55 (52.88)	18 (66.67)	34 (43.04)	168 (54.72)
Total	23	74	104	27	79	307
Row Pct.	7.49	24.10	33.88	8.79	25.73	100.00

Table 12. ACC accelerates unexpectedly (by age group)

Frequency (Col. Pct.)	Younger than 65	65 or Older	Total
Very often, often, or occasionally	40 (19.80)	13 (10.74)	53 (16.41)
Rarely	43 (21.29)	17 (14.05)	60 (18.58)
Never	119 (58.91)	91 (75.21)	210 (65.02)
Total	202	121	323
Row Pct.	62.54	37.46	100.00

Table 13. Forgot to turn off the system (by age group)

Frequency (Col. Pct.)	Younger than 65	65 or Older	Total
Very often, often, or occasionally	32 (15.84)	18 (15.00)	50 (15.53)
Rarely	54 (26.73)	17 (14.17)	71 (22.05)
Never	116 (57.43)	85 (70.83)	201 (62.42)
Total	202	120	322
Row Pct.	62.73	37.27	100.00

Conditions where respondents avoid using ACC

Item Q10 asked respondents, “Under what conditions do you avoid using the adaptive cruise control system?” The responses are listed below and ordered by the percentage of respondents who said avoid using ACC in that condition. Except as noted below, the responses did not depend significantly on experience level or age group.

- 85 percent – Congested, “stop-and-go” traffic
- 78 percent – On neighborhood streets
- 73 percent – Freeway off ramps, or when exiting highways. The percentage of respondents selecting this response varied with experience from 64 percent (<10,000 miles) to 77 percent for those with between 10,000 and 29,999 miles of driving experience, and also 77 percent for those with more than 30,000 miles of experience. This difference nearly reached our criterion ($\alpha = .05$) for statistical significance, $\chi^2(2) = 5.6, p = .06$.
- 61 percent – On curvy roads
- 58 percent – Rain
- 58 percent – In heavy traffic that is flowing
- 49 percent – Snow
- 22 percent – At night
- 9 percent – On interstate highways
- 6 percent – None of the above
- 6 percent – Other (The majority of those who said, “Other” indicated that they avoid using ACC in all conditions.)

6. User Interface and Usability

“Eliminate the longest distance or gap setting, I never use it. I would like to be able to engage the standard cruise control [more easily].” – (Male, 76)

“I would like a louder emergency alert instead of the softer beeping I now have with the ACC.”

A few questions on the survey asked about the ACC user interface and usability of the system. Items Q14A and Q14B asked respondents how much they agreed or disagreed with the following two statements:

Q14A – “It’s easy to understand the lights/symbols on the adaptive cruise control system.”

Q14B – “It’s easy to understand the sounds made by the adaptive cruise control system.”

In general, respondents tended to agree with these two statements, although many (28%) said that statement Q14B was not applicable to their system. Approximately 73 percent agreed (or strongly agreed) that the lights/symbols on their ACC system were easy to understand, and 49 percent agreed (or strongly agreed) that the sounds made by the system were easy to

understand. However, nearly 6 percent of respondents to item Q14A and 4 percent of the respondents to item Q14B disagreed (or strongly disagreed) with the statement. The complete set of response frequencies is given in Appendix C. Due to the small sample size for items Q14A and Q14B, the “agree” and “strongly agree” responses were pooled as “agree.” The “disagree” and “strongly disagree” responses were pooled as “disagree” and the “not applicable” responses were not included in the analyses. Thus, three response categories were compared (agree, neutral, and disagree) by age group, and by experience level. Neither the results for item Q14A nor the results for item Q14B depended significantly on the respondent’s age group or level of experience with their vehicle.

Items Q21 and Q22 asked respondents if they had been confused about the speed and following distance settings on their ACC system. Most respondents (78%) said that they were, “not at all confused” about their ACC setting for speed, and 75 percent of respondents were, “not at all confused” about their ACC setting for following distance. For subsequent analyses, the response categories of “extremely confused,” “very confused,” and “moderately confused” were combined. The combined responses did not depend significantly on age group for item Q21 and for Q22. For item Q22 (but not Q21) the responses depended significantly on the respondent’s level of experience, $\chi^2(4) = 11.3, p < .05$. These results are shown in Table 14. Although the sample sizes are small, the likelihood of being confused about ACC following distance settings clearly decreases with experience level.

Table 14. Confusion about ACC following distance setting by experience level

Frequency (Col. Pct.)	Less than 10,000 Miles	10,000 to 29,999 Miles	30,000 or More Miles	Total
Extremely, very, or moderately confused	15 (20.00)	15 (10.49)	4 (4.65)	34 (0.87)
Slightly confused	12 (16.00)	17 (11.89)	15 (17.44)	44 (14.47)
Not at all confused	48 (64.00)	111 (77.62)	67 (77.91)	226 (74.34)
Total Row Pct.	75 24.65	143 47.04	86 28.29	304 100.00

The percentage of respondents who said they were not at all confused about the ACC speed setting varied slightly by vehicle manufacturer from 81 percent (Toyota) to 75 percent (Infiniti, Mercedes-Benz). Similarly, the percentage of respondents who said they were not at all confused about the ACC following distance setting varied by vehicle manufacturer from 84 percent (Infiniti) to 71 percent (BMW, Lexus). These differences were not statistically significant in either case.

7. Safety

“I find [ACC] to be a great safety system in traffic because it can brake quickly when someone cuts in front of me.” – (Male, 76)

“I would like more assurance that it will work in emergencies. When I first got the car I was showing my daughter how the system worked at low speed and came very close to another car, I was going about twenty mph and had to hit the brakes hard. I never trusted the system after that.” – (Male, 74)

Perceived safety of ACC systems

ACC owners were asked (Q25), “Overall, are you a safer driver using adaptive cruise control than you would be if you only used conventional cruise control?” The responses are shown in Figure 5. The majority of respondents (54%) thought that using ACC made them neither more nor less safe. Approximately 38 percent of respondents thought that they were safer using ACC and 7 percent felt that ACC made them less safe. These responses did not depend significantly on the participant’s age group, $\chi^2(2) = 0.8, p = .66$ or level of experience with the vehicle, $\chi^2(4) = 2.8, p = .58$.

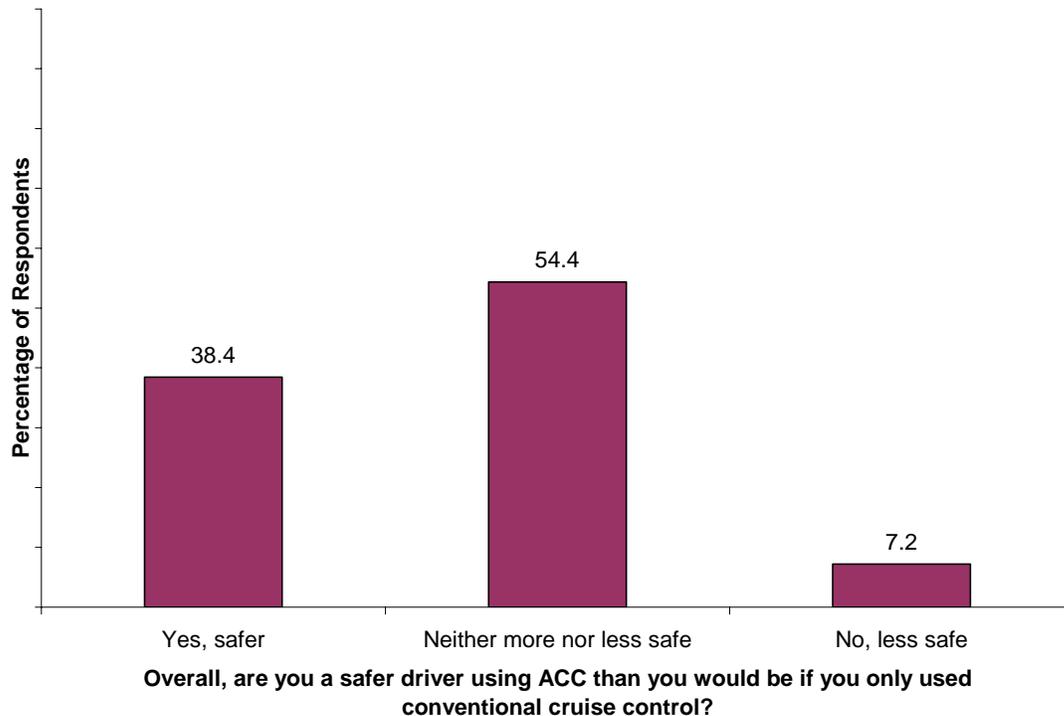


Figure 5. Perceived safety benefits of adaptive cruise control

Another closely related item asked (Q20), “Does your adaptive cruise control system create any new driving problems or safety concerns for you?” The responses to this item are shown in Figure 6. While the majority of respondents (86%) did not have any concerns, approximately 14 percent of ACC owners indicated that they did have some safety concerns. A follow up item asked respondents to explain their safety concerns. The resulting text strings were read by data coding staff and categorized according to meaning. The three most commonly mentioned concerns were, “sudden changes in speed,” “adapting to the change between non-cruise or conventional cruise control and ACC,” and “other vehicle merging.”

One respondent who answered, “Don’t know” for item Q20 was not included in the analyses by age group and by experience. The respondent’s level of experience with their vehicle was not significantly related to the responses for item Q20, $\chi^2(2) = 3.3, p = .20$ however, the responses did depend significantly on the respondent’s age group, $\chi^2(1) = 6.8, p < .01$. Younger respondents (18%) were more likely than older respondents (7.5%) to say that their ACC system created new driving problems or safety concerns for them.

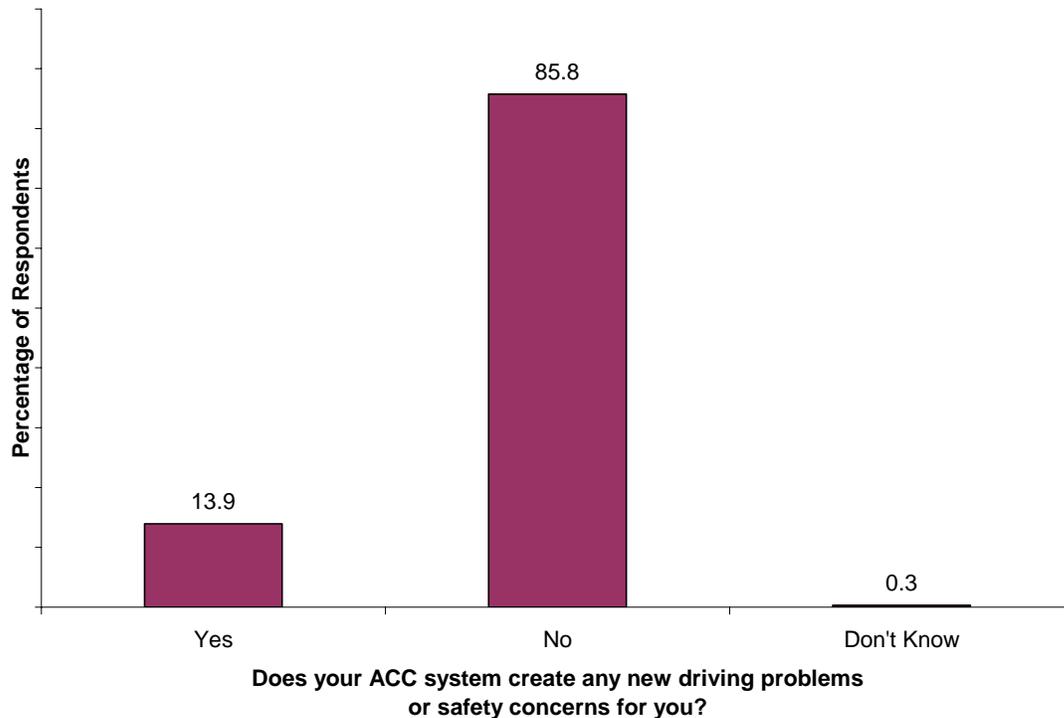


Figure 6. Safety concerns about adaptive cruise control

Awareness of system limitations

“My adaptive cruise control will pick up vehicles in another lane when the highway curves; I’m aware of that now.” – (Male, 67)

“I found out when I first got the system that it switches off in heavy rain when you turn the wipers on full.” - (Male, 75)

Although vehicle owner’s manuals typically list warnings and limitations regarding adaptive cruise control, 72 percent of ACC owners in the present survey said that they were not aware of any manufacturer’s warnings or limitations about their ACC system. Among those who were aware of warnings, the most commonly mentioned one was that the ACC system does not relieve the driver of responsibility to pay attention to road conditions. The complete set of response frequencies for this item is given in Appendix C. Awareness of warnings or limitations about ACC did not depend significantly on the respondent’s age group, $\chi^2(1) = 0.4, p = .55$, and did not depend significantly on the respondent’s level of experience, $\chi^2(2) = 0.6, p = .73$.

Items Q15A – Q15C, discussed above in the section on, “Perceived Effectiveness” asked respondents how well their ACC system would work to help them avoid colliding in three situations that are often listed in owner’s manual as warnings for ACC use. For example, many respondents (43%) said that their system would work fairly well or perfectly when encountering a stopped car in the lane ahead (Q15B). These responses indicate that many ACC owners are unaware of the limitations of their system or that the ACC warnings given in owner’s manuals are overly conservative about system performance and do not match user’s experiences.

Collision experience

Only two (0.6%) of the 327 ACC owners who responded to item Q24 said that they had ever unintentionally collided with something when they had their adaptive cruise control engaged. In both cases, the collision involved a stationary object. Thus, although 35 percent of respondents agreed or strongly agreed with the statement (Q14H), “When I use adaptive cruise control more cars cut me off or pull in front of me,” there is no evidence from this survey that this problem leads to collisions.

Item Q19 asked respondents, “Since you have owned your vehicle with adaptive cruise control, have you driven any other vehicle equipped with conventional cruise control and had a collision or a ‘close call’ because you expected the vehicle you were driving to automatically slow down?” Twelve respondents (3.7%) responded affirmatively to this question, indicating that some drivers may become over-reliant on the ACC system.

8. Need for Improvements to Adaptive Cruise Control

“On making a lane change, a wider view on the sensors might avoid the speed changes, when passing through the gap in coverage from the car in the lane you are leaving to the car in the lane you are moving into. That needs improving. The system also takes some time to react when someone cuts in front of you in your lane, it can come pretty close sometimes. Otherwise it’s a fantastic system.” – (Male, 87)

“Currently the system comes to an abrupt stop when another car cuts in front of me. If that vehicle then continues across my path into another lane the system then accelerates hard to catch up to the vehicle in front.” – (Male, 37)

“When going up a hill my car will get real close to the vehicle in front of me and then brake sharply when it’s too close. I would like to see that improved. Also the vertical detection range should be increased to detect raised vehicles.” – (Male, 46)

Respondents were asked whether there is anything about the way that their ACC system works that should be improved or changed (Q26). Approximately 30 percent of respondents reported a need for improvements, and 69 percent did not see a need for improvements. Two respondents (0.7%) who said that they didn’t know were not included in subsequent analyses. These responses to item Q26 did not depend significantly on the respondent’s age group, $\chi^2(4) = 2.6, p = .10$ or experience level, $\chi^2(2) = 2.0, p = .37$.

The two most frequently cited topic areas suggested for improvement were the occurrence of unsafe or uncomfortable reductions or increases in speed (mentioned by nearly 25 percent of respondents to this item) and the area of coverage or sensitivity of the system (mentioned by 35% of respondents). Other issues mentioned as needing improvement are given in Appendix C.

During the follow-up telephone interviews with 17 ACC owners, several respondents commented on hard braking and hard acceleration that occurs when a vehicle cuts into and then out of your lane. Some respondents thought that the available speed settings (i.e., 5 mph

increments) were too coarse, and wanted to be able to set speed at 1 or 2 mph increments. The complete set of telephone interview responses is given in Appendix E.

9. Meeting the Needs of Older Drivers

“I feel the control layout in some cars is confusing and could be hard for a senior to figure out.” – (Male, 45)

“I think the manufacturers are doing enough to accommodate seniors; I have memory settings on my seats and mirrors, and the gas pedal and brake pedal move in and out. The doors and tailgate are power, it has a rear-view video camera, etc.” – (Male, 67)

Respondents were asked whether they, “believe that car manufacturers are doing enough to design vehicles to accommodate an aging population” (Q28). Most of those responding said “Yes” to this question (71%). Among 322 ACC owners, 67 percent thought that vehicle manufacturers were doing enough. Among ACC owners who were less than 65 years old, 60 percent responded affirmatively to this question as compared to 76 percent of those who were 65 or older. This difference is statistically significant, $z = 3.14$, $p < .01$.

Differences in the responses to this item were noted between BMW, Infiniti, Mercedes-Benz, and Toyota owners with ACC however, these observed differences did not quite reach statistical significance, $\chi^2(4) = 9.2$, $p = .06$. The percentage of those responding “Yes” to item Q28 varied from 59 percent for Infiniti owners to 84 percent for Mercedes-Benz owners.

Those who answered, “No” to item Q28 were asked what more they believe could be done. The most common responses were to improve the user interface (displays and controls), improve visibility around the vehicle, and improve the vehicle’s safety features. The complete set of response frequencies is shown in Appendix C.

SUMMARY AND DISCUSSION

Summary of Findings

Questionnaires were mailed to vehicle owners who were possibly owners of adaptive cruise control systems in an effort to understand how these types of systems are influencing driver behavior (modifying behavior in potentially positive or negative ways) and to assess the extent to which early adopters of these systems understand the systems' performance capabilities and limitations. A majority of ACC owners think that their systems make them safer drivers (as compared to using conventional cruise control) and most said that they would want to get the system if they purchased the same vehicle again but many system owners were unaware of the limitations of their systems. Many respondents tended to overestimate their system's effectiveness in situations where ACC does not perform well such as encountering a stopped vehicle in the lane ahead.

Survey sample

Adaptive cruise control questionnaires mailed to 10,000 ACSC insurance customers who were identified as owning vehicle models likely to have ACC. Half of the questionnaires were mailed to vehicle owners who were younger than 65 and half of the questionnaires were mailed to owners who were 65 or older. Approximately 17 percent of the questionnaires were returned. Of the questionnaires returned, 370 (22%) were from ACC owners. Approximately 39 percent of the respondents with ACC were 65 or older. Thirty percent of respondents with ACC were women.

Desire to have ACC

A majority (76%) of those who currently have ACC said that if they purchased their same vehicle again, they would want to get the technology again. Among those who do not currently have the technology, only 35 percent said that they would want to get ACC if they purchased their same vehicle again. The most common reasons cited for not purchasing ACC were related to availability on the specific vehicle that they purchased (54%) or that, "It never occurred to me to look for it when I purchased the vehicle" (54%). Cost was cited as a reason by 14 percent of those who did not purchase an ACC system, and 12.5 percent indicated that, "I wouldn't trust it to keep me from colliding with other vehicles." Nineteen percent said that they don't need it.

Learning to use ACC

The most frequently cited methods for learning how to use ACC were the vehicle owner's manual and "On-road experience . . ." In fact, on-road experience was the only learning method selected by 15.5 percent of respondents.

Behavioral adaptation

Several items asked respondents who had ACC to compare their driving behavior when using ACC and conventional cruise control. Specific topics included driver's response to unexpected road hazards, following distance and gap settings, frequency of lane changes, and stress level.

- Sixteen percent of respondents said that they were “always,” “frequently,” or “sometimes” confused about whether their ACC system or conventional cruise control system was operating.
- When asked how quickly they respond to unexpected road hazards when using ACC as compared to using conventional cruise control, 49 percent said that they respond in the same time, 24 percent said that they respond more quickly with ACC, and nine percent said that they respond more slowly with ACC.
- Half of the respondents said that if they could not use ACC anymore they would usually keep the same gap between their vehicle and the vehicle ahead as they do now using ACC. Approximately 26 percent said that they would keep a smaller gap and 23 percent said that they would keep a larger gap. Mercedes-Benz owners were most likely to say that they would maintain a larger gap between vehicles if they couldn’t use ACC anymore. In response to another item, two-thirds of respondents disagreed with the statement that, “I tend to follow the vehicle ahead more closely when using ACC,” Only 8 percent agreed with this statement. Eleven percent of respondents said they usually have their ACC set to the shortest gap (following distance) and 24 percent said that they usually use the longest gap setting.
- More than half of the respondents agreed that when they use ACC they tend to change lanes less frequently, and half indicated that they change the amount of gap between their vehicles and the vehicle ahead as driving conditions change, however, only 18 percent agreed that they tend to set ACC to a shorter gap (closer following distance) in heavy traffic than in light traffic. A third of respondents agreed that when they use ACC, more cars cut them off or pull in front of them.
- Nearly half of the respondents agreed that using ACC relieves them of stress when driving.
- Most respondents said that their reliance on ACC has stayed about the same since that got it. Approximately 27 percent of respondents said that they rely on it more now, and nine percent said that they rely on it less.

Perceived effectiveness

Many ACC owners were not aware of the limitations of their system. In fact, 72 percent of respondents said that they were not aware of any manufacturer’s warnings or limitations about their ACC system. A large percentage of respondents thought that their ACC system would help them to avoid a collision in scenarios where the technology would likely not be effective. In fact, many respondents thought that their system would work fairly well or perfectly to help them avoid a collision when:

- 24 percent - Following a vehicle in stop-and-go traffic;
- 43 percent - Encountering a stopped vehicle in the lane ahead; and
- 27 percent - Following a vehicle on a curvy road.

Despite these results, 85 percent of the respondents said that they avoid using ACC in congested, “stop-and-go” traffic, and 61 percent avoid using it on curvy roads. Many respondents avoid using ACC on freeway exit ramps (73%), and on neighborhood or city

streets with traffic lights (78%), and approximately 58 percent of respondents avoid using ACC in flowing heavy traffic, and in rain.

User interface and usability

There were only a few questions on the survey which addressed the user interface of ACC systems. Most respondents thought that it was easy to understand the lights/symbols, and sounds (if present) from their ACC system, and 75 to 78 percent said that they were, “not at all” confused about their ACC settings for speed and following distance. The likelihood of being confused about following distance settings decreases with experience.

Safety

- Thirty-eight percent of ACC owners thought that using ACC made them a safer driver than using only conventional cruise control and 7 percent thought that it made them less safe. A majority (54%) thought that using ACC made them neither more nor less safe.
- Fourteen percent of ACC owners said that their ACC system had created new driving problems or safety concerns for them.
- Two respondents (out of 327) reported that they had unintentionally collided with something while they had their adaptive cruise control engaged, and 12 respondents (3.7%) reported having a collision or “close call” while driving another vehicle equipped with conventional cruise control because they expected the vehicle they were driving to automatically slow down.

Need for improvements

Respondents were asked whether there is anything about the way that their ACC system works that should be improved or changed. Approximately 30 percent of respondents reported a need for improvements.

- The most frequent suggested areas for improvement of ACC systems were related to the occurrence of unsafe/uncomfortable reductions or increases in speed, and the area of coverage or sensitivity of the system.
- In general, 71 percent of survey respondents thought that vehicle manufacturers are doing enough to design vehicles to accommodate an aging population.

Summary of comparisons by age group

Responses from system owners who were 65 or older were compared to those from system owners who were younger than 65. There were very few items on which the responses from older and younger respondents differed significantly. These differences are listed below.

As compared to younger respondents, the older respondents:

- Were more likely to reported having some physical condition physical which makes driving more difficult, especially vision problems;
- Were more likely to have learned how to operate their ACC system from the owner’s manual;

- Were more likely to say that they would increase their typical following distance if they could no longer use ACC;
- Were less likely to agree that their ACC system sometimes locks onto a vehicle that is not immediately ahead of them;
- Experienced their ACC system slowing unexpectedly when there is no vehicle immediately ahead less frequently than did younger respondents;
- Experienced their ACC system accelerating unexpectedly less frequently than did younger respondents;
- Were more likely to say that they never forgot to turn off their ACC system;
- Were less likely to say that their ACC system created new driving problems or safety concerns for them;
- Were more likely to believe that car manufacturers are doing enough to design vehicles to accommodate an aging population;

Comparison to Previous Studies

Several items on this survey were similar to items on a previous telephone interview survey sponsored by NHTSA (Llaneras, 2006). There was generally good qualitative agreement between the results of the present study and the previous study for items with similar content. However, direct quantitative item by item comparisons are difficult to interpret because the wording of questions and response choices differed between the two surveys. This section compares the results for a few examples of similar items.

The demographics of the participants on the previous survey were similar to those in the present study although Llaneras' sample was more geographically diverse than the present sample. The previous study included 150 vehicle owners who had ACC systems. Approximately 65 percent of the ACC owners were men. Nearly half (47%) of the respondents were older than 60.

In both surveys, the majority of respondents perceived their ACC to be effective and would purchase it again. However, some differences in responses to similar items were noted. For example, 84 percent of those in the Llaneras (2006) survey said that adaptive cruise control improves safety over conventional cruise control, while only 38 percent of the respondents in the present survey said that they were safer drivers using ACC than they would be if they only used conventional cruise control. This difference in results may be due to differences in the wording of the items and to the salience of an additional response category on the more recent paper survey ("Neither more nor less safe"). This response choice was selected by 54 percent of respondents.

Other similar items on the two surveys were related to driver's use of the ACC system and choice of vehicle following distance. In both surveys, most drivers reported using either the longest setting or a medium setting for following distance. Llaneras found that 19 percent of drivers usually use the shortest possible setting for following distance while in the present study only 11 percent of respondents said that they usually use the shortest possible setting. As a result of using ACC rather than conventional cruise control, 39 percent of drivers in the previous study reported that their typical following distance to a lead vehicle has increased

and 4 percent reported adopting shorter headways. In the present study, approximately 8 percent of respondents agreed or strongly agreed that they tend to follow the vehicle ahead more closely when using adaptive cruise control.

A key safety concern addressed by both surveys is the driver's misunderstanding of the ACC system's reaction to a stationary vehicle in the lane ahead. Typically, ACC systems will not detect stationary objects and vehicle owner's manuals have warnings about this. In the previous study (Llaneras, 2006) vehicle owners were asked, "If you encountered a stopped car in your lane ahead with the ACC system engaged, how do you think the system would react?" Only 1 percent of the respondents correctly reported that the system would not detect the stationary car. Approximately 63 percent of the respondent said that their ACC system would detect the car and start to brake, but that they would have to intervene to bring their vehicle to a complete stop. Twenty-three percent of respondents thought that their ACC system would detect the stationary car and then slow their own vehicle to a stop. Thirteen percent said that they didn't know. On the present survey, vehicle owners were asked to rate how well their ACC system would assist them to avoid colliding with the vehicle in front of them when the vehicle is stopped in their lane. Fifteen percent correctly responded, "Not at all," and an additional 7 percent said, "Poorly." Approximately 43 percent of respondents said that their system would work, "Perfectly" or "Fairly Well" in this situation and 35 percent said that they didn't know. The recent results may indicate that in the two years between surveys, more people were becoming aware of ACC system limitations. On the other hand, the present results clearly confirm Llaneras' finding that a large percentage of drivers are unaware of ACC system limitations.

The Automotive Collision Avoidance System field operation test (ACAS FOT), lead by General Motors in cooperation with the U.S. Department of Transportation evaluated both forward collision warning systems and adaptive cruise control systems (General Motors Corporation, 2005). In the ACAS FOT, younger drivers were more likely to set their ACC system for the minimum (short) headway, whereas older drivers were more likely to choose the maximum (long) headway setting. The tendency for younger drivers to prefer smaller gaps and for older drivers to prefer larger gaps is evident in the results found in the present study as well (see Figure 2). When respondents were asked how their driving would change if they no longer had ACC, younger respondents were more likely than older respondents to say that they would maintain smaller gaps, and older respondents were more likely than younger respondents to say that they would adopt longer gaps. One possible interpretation of these results is that using ACC actually prevents many younger drivers from adopting headways that are shorter than the minimum headway allowed by the system, and it encourages many older drivers to maintain shorter headways than they would use if they didn't have ACC.

Study Limitations

The survey methodology used in the present study was an effective way to assess a large number of drivers' perceptions about adaptive cruise control systems. It provided insights into drivers' understanding of the functional capabilities of the systems and it was also effective at providing information about how the systems may be impacting driver behavior. Given the various limitations of the method explained below, however, the results provided by this work should be confirmed by observational studies and experimental methods.

- Self-reports were obtained from mail-out questionnaires sent to a random sample of ACSC members who were possibly ACC owners (based on model of vehicle owned). There are some inherent weaknesses associated with this type of data. Self-reports can be unreliable, especially where respondents need to rely on memories of past events or where respondents may have certain expectancies about giving answers that they believe the researchers “want” to see, for example. Although each questionnaire was mailed to a specific vehicle owner to be answered about a specific vehicle, it is possible that other household members completed some questionnaires or that a respondent answered the questionnaire based on experience with a vehicle other than the one specified.
- In this study, no attempt was made to obtain a nationally representative sample. It is likely that ACSC members included in the survey differ in some ways from other vehicle owners who are not members of an automobile club, or from those who live in different areas of the country with different weather and traffic conditions. For example, items that addressed the perceived effectiveness of the technologies in snow or rain may get very different responses from vehicle owners living in colder climates. The limitations and characteristics of the sample obtained should be considered carefully if the results are generalized.
- The response rate for the ACC survey was 16.6 percent. This sample may not be representative of ACSC members because those who responded may have had different experiences with the technology as compared to those who did not respond. Future studies of this type should attempt to increase the response rate by converting non-responders to responders through methods such as a second or third mailing, through a telephone call, or by offering an incentive to participate.
- The sample included only 370 respondents who had ACC. The moderate sample size limited the statistical power of comparisons between sub-groups. Based on the high percentage of questionnaires returned from respondents who do not have ACC (77.8%), it appears that the strategy to target owners of vehicles likely to have ACC was only partially successful. Perhaps when ACC is offered as an optional feature, only a small percentage of customers choose to purchase it.
- Based on the data from the adaptive cruise control survey, certain changes over time in system usage, behavioral adaptations, system knowledge, and owners’ opinions may be inferred if they were significantly related to the level of experience with the system. However, level of experience was measured indirectly by asking respondents how many miles they had driven the vehicle, rather than asking them how much they had used the system. It is possible that there are large differences in cumulative system usage between drivers who have similar levels of experience with the vehicle. Also, this study used a cross-sectional approach as opposed to tracking individual drivers across time. That is, the survey yielded a range of driver experience levels allowing comparisons between these groups and providing a basis for interpreting how behavior and knowledge with these systems changed across time as cumulative usage of the system increased. A weakness of the cross sectional approach is that it is difficult to

make firm conclusions about the effects of experience over time for individuals. It is possible that drivers who tend to keep their vehicles longer (and therefore have more experience) are different in many ways from drivers who get a new vehicle every year. Another issue is that drivers with the higher levels of experience tend to have older vehicles possibly with earlier versions of the ACC technology. Future work should follow specific individuals across time to examine how system usage changes and behavioral adaptations develop.

Implications

- Educational efforts should be undertaken to improve vehicle owners' understanding of the limitations of their adaptive cruise control system. Relying on the owner's manual to communicate information about system limitations is not an effective strategy. Also, given the system limitations and consumers' tendency to overestimate their safety benefits, it may be helpful if ACC systems were marketed in ways that do not portray them as safety systems.
- Further research, including longitudinal research should be undertaken to understand how drivers modify their behavior resulting from the use of adaptive cruise control systems. The present survey suggests that some drivers may rely more on the ACC technology as they gain greater experience, and that those with more experience may overestimate the capabilities of the system. Besides providing information or training on ACC at the time of purchase, it may be effective to provide "refresher" warning information about ACC to drivers 6 to 12 months after the vehicle has been purchased.
- Although drivers find adaptive cruise control to be a useful feature, a substantial number of ACC owners would like system improvements, particularly with regard to overly hard acceleration and braking, locking on to vehicles outside of the immediate travel lane, performance on horizontal and vertical curves, and finer adjustment of speed settings. Manufacturers should consider designing more intelligent ACC systems that change speed less abruptly (when conditions allow) in order to better match users' expectations.

REFERENCES

- General Motors Corporation (2005). Automotive Collision Avoidance System Field Operational Test. Final Program Report. Report No. DOT HS 809 886. Washington, DC: National Highway Transportation Safety Administration.
- Llaneras, R. E. (2006). Exploratory study of early adopters, safety-related driving with advanced technologies. Report No. DOT HS 809 972. Washington, DC: National Highway Transportation Safety Administration.
- Llaneras, R.E., & Singer, J.P. (2002). Inventory of in-vehicle technology human factors design characteristics. Final Report under contract DTHH22-99-D-07005. Washington, DC: National Highway Transportation Safety Administration.
- Llaneras, E., Neurauter, L., Singer, J., & Jenness, J. (2005). Attachment 1: 2005 Inventory of In-Vehicle Devices & Interface Characteristics. In Jenness, J. (2005). Use of Advanced In-Vehicle Technology by Younger and Older Early Adopters Sub-Task 1 Report: Identification of technologies, vehicle makes and models, and information needs. NHTSA Report under contract DTNH22-05-D-01002. Washington, DC: National Highway Transportation Safety Administration.

APPENDIX A: FUNCTIONAL CHARACTERISTICS OF ADAPTIVE CRUISE CONTROL SYSTEMS

Appendix A contains descriptions of ACC systems from specific vehicle manufacturers. These descriptions were taken from an inventory of in-vehicle devices that was conducted as part of the current project and previous projects (Llaneras & Singer, 2002; Llaneras, Neurauter, Singer, & Jenness, 2005).

Audi Adaptive Cruise Control

Audi's Adaptive Cruise Control (ACC) is offered as optional equipment on all three trim levels of the A8 model line. Audi's ACC incorporates a radar sensor with a detection distance of 420 feet. The system operates between 20 mph and 95 mph, and will automatically turn off when the vehicle speed falls below 17 mph. There are four distance options, with following distances of 1, 1.3, 1.8, and 2.3 seconds. Unless a particular setting is stored in Audi's Multi Media Interface (MMI; an interface that allows the driver to control most vehicle functions and stored in driver-memory settings) the distance is automatically reset to 1.8 seconds upon starting the vehicle. If necessary, Audi's ACC can provide braking at 25 percent of the vehicle's maximum. All ACC controls are located on a control lever on the left side of the steering column. The system is activated by pulling the lever towards the driver (deactivated by pushing away), and the speed can be set by pressing the set button on the end of the lever inward. It should be noted that the Electronic Stabilization Program is automatically activated when the ACC system is turned on if not already active. The driver can also select the preferred distance setting using the slider switch from left to right or right to left to increase or decrease the following distance respectively.

The A8 provides more information and driver-feedback concerning ACC than any of the other systems discussed in this report. The Primary Display, denoted by the "A" in the A8 Display diagram (Figure A-1), presents the current ACC scenario of host vehicle, following distance, detected lead vehicle (if applicable), and any adjustments the system may be making. The set speed is also marked by a red LED. Warnings are presented in the primary display using the following guidelines: (1) Open Road – displays host vehicle and following distance bars in green; (2) Driving in traffic – displays, in green, a detected lead vehicle in addition to host vehicle and following distance bars; and (3) Request for driver to assume control – displays, in red, the detected lead vehicle and host vehicle with following distance bars. The latter message is accompanied by an audible gong, and warns the driver that the system is unable to decelerate enough to maintain the set following distance. This type of approach warning is only operational when the ACC system is engaged. The supplementary display, centered between the tachometer and speedometer (denoted by the "B"), can display supplemental ACC information if the driver desires (this display can also be used for basic vehicle monitoring and even as a secondary Navigation screen). Most notably, the supplementary display presents information to the driver regarding a lead vehicle. If a vehicle is not detected (open road) only a vehicle outline is displayed. Upon detection of a lead vehicle the vehicle image will turn grey (driving in traffic). Finally, a red vehicle is presented if driver intervention is required (request for driver to assume

control). A pointer is also used to convey the same information following the distance bar shown directly beneath the supplementary display. A message box (denoted by the “C”), contained in the instrument panel display, is used to convey information pertaining to changes made in following distance and warns the driver of any malfunctions or irregularities in the system.

The owner’s manual is quite comprehensive, suggesting when to use the ACC system, its limitations, and special driving situations. The manual warns the driver not to use the system in high-traffic environments (city), or on winding roads. It continues by suggesting that the system should also not be used when there is ice, gravel, fog, etc., and that the system be turned off when approaching highway exit ramps or construction zones. The last two pages cover special driving situations with text and diagrams, presenting limitations of the ACC system. In the end, 15 pages are devoted to familiarizing the driver with the ACC system, which includes four warning boxes, six tips, and one note (relates to damage of the vehicle).

A8 Controls



A8 Display



Figure A-1: Audi A8 Adaptive Cruise Control interface elements

BMW Active Cruise Control

BMW offers an optional Active Cruise Control system on their 3, 5, 6, and 7-Series vehicles. The following information is based on the 2005 5-Series owner's manual. The radar-based ACC system provides four different headway settings, with stalk-mounted controls for activating and setting headway distances. It should be noted, however, that the manual does not specify what these headway settings are. The system operates at speeds between 20-110 mph and automatically disengages when the vehicle's speed falls below 20 mph (drivers are notified of the disengagement via a gong sound and message in the Check Control). A graphic display, located between the speedometer and tachometer, provides system status and operational information, including the set speed and distance settings (Figure A-2). The system issues an alert to drivers when the braking capacity has been reached and intervention by the driver is required. This is communicated by both an audible and visual warning (the vehicle icon flashes and a chime sounds). The vehicle icon graphic illuminates and changes to yellow when the radar has detected a forward vehicle, providing an indication to drivers that the system has captured a target (only the headway setting is displayed if no vehicle is detected). The system also automatically activates the vehicle's brake lamps when decelerating as an added safety feature. One interesting aspect that the manual discusses is the complication of an ACC-equipped vehicle with a manual transmission. In addition to automatic deactivation when the speed falls below a threshold (20 mph), the system may deactivate if the engine is operating at "very high or very low engine speeds." Not surprisingly, ACC is only operable in gears 2 through 6. The manual includes approximately 6 pages dedicated to the system, but includes surprisingly little technical detail about the ACC system's capabilities (e.g., specific headway setting values, maximum braking authority, sensor detection range, etc.). The manual does dedicate half of one page to a basic description of ACC and its capabilities before discussing specifics. Numerous warnings (11) and system limitations are provided in the manual, including: notifications that the system is not intended as a collision warning device; situations when the system will deactivate or lose targets, conditions under which to avoid use, as well as the systems inability to detect slow or stopped vehicles or decrease the vehicle's speed under large differences in speed. As with conventional cruise control, the ACC system can be deactivated by applying pressure to the brake pedal.

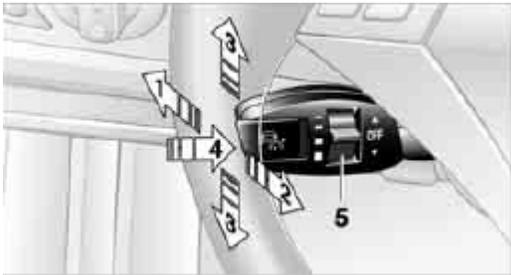
Controls	Display	
		
ACC Notification		
		
Headway Settings		
		
Warning Messages		
		

Figure A-2: BMW 5-Series Active Cruise Control interface elements

Cadillac Adaptive Cruise Control

Cadillac's Adaptive Cruise Control system is optional on the STS (V8 trim level) and standard on the XLR. The radar-based system operates at speeds above 25 mph, has a detection range of 328 feet, and is capable of applying 0.3 g (2.95m/sec²) of braking force in the XLR, and 0.25 g (2.45 m/sec²) in the STS. Controls for activating the system and setting a speed are located on a multifunction stalk-mounted control, while a separate steering-wheel-mounted control allows drivers to select one of six discrete distance settings ranging from 1- to 2-second headways. A head-up display (HUD) provides information on system status and operational settings, including set speed. Since much of the ACC system information is communicated via the HUD, the HUD must be on and properly adjusted in order for drivers to receive the information (the manual cautions drivers to ensure the HUD is on and adjusted, otherwise they may forget the set speed or miss critical information). Following distance is displayed using a graphic depicting two vehicles which move closer or farther apart based on the selected following distance (Figure A-3). A variety of icons are also presented on the HUD in addition to the main graphic display. For example, XLR drivers are notified that the ACC system has been activated by a graphic symbol displaying a vehicle and speedometer (uses the ISO symbol). The STS drivers are notified of ACC activation when the set speed is displayed. A "Vehicle Ahead" symbol depicting a car silhouette is displayed on the HUD in both vehicles to notify the driver that a lead vehicle has been detected by the system. Finally, an alert symbol is displayed in both vehicles when driver interaction is required (the symbol will flash and a warning beep sounds). This may occur under a range of conditions such as when the ACC system cannot apply sufficient braking, or the vehicle speed drops below 20 mph (in which case the system will automatically deactivate). There are differences in the layout of the HUD between both vehicles, but both present the same content.

Incidentally, the alert symbol used by this system is one of the symbols developed under the Crash Avoidance Metrics Partnership (CAMP) program, and considered for use as a forward collision warning icon. In this application, it is used to communicate a need for driver intervention for the ACC system (the owner's manual indicates the ACC system is "not a safety system").

The XLR and STS manuals devote approximately 13 pages to describing ACC system functions, controls, displays, and system limitations and capabilities. Eleven separate cautionary warning boxes are included in the ACC section of both manuals. Cautionary statements warn drivers of system limitations and operating characteristics, including: system's inability to respond to stopped (or slow moving) vehicles, pedestrians or animals; and the potential loss of targets in curves and low visibility conditions (rain, snow, fog). The manuals also graphically present several driving scenarios illustrating ACC system performance capabilities and limitations. This is currently the only system (of those reviewed) that uses a head-up display. The system activates the vehicle's brake lamps when ACC braking is applied. The ACC system automatically reduces the vehicle's speed in tight curves (irregardless of whether a lead vehicle is present); a "tight curve" message is displayed on the HUD to notify drivers.

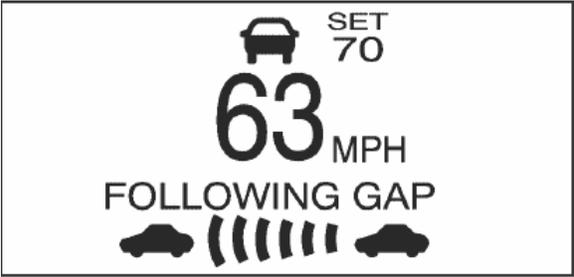
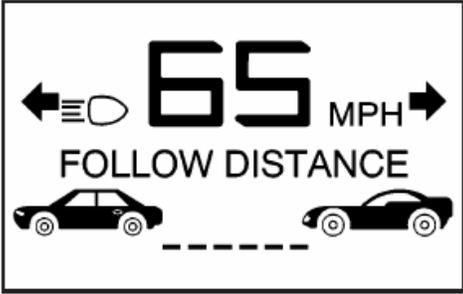
Cadillac STS & XLR Controls	
	
STS HUD	XLR HUD
	
STS Activation Icon	XLR Activation Icon
	
Shared Icons and Symbols	
	

Figure A-3: Cadillac Adaptive Cruise Control interface elements

Infiniti Intelligent Cruise Control

Infiniti offers its Intelligent Cruise Control (ICC) system as an optional feature on four of its model lines, the FX (FX35 & FX45; 2005), M (M35 & M45; 2006), Q45 (2005) and QX56 (2005). The system was introduced first in the Q45 for the 2002 model year. All systems are nearly identical across the Infiniti model line. All of the controls are located on the steering wheel, but all models offer a different design and layout of the controls except for the FX model line and the QX56 which share identical controls (Figure A-4). The Infiniti ICC uses lasers to detect objects with a range of 390 feet, operate at speeds between 25 mph and approximately 89/90 mph, and can provide up to 25 percent of the vehicles braking authority. The system automatically disengages when the vehicle speed falls below 20 mph (a warning chime sounds to indicate this to the driver). The system also issues various warnings to drivers under conditions requiring driver intervention or action. These warnings normally include a warning chime and various visual indicators, the configuration of which are used to communicate the particular type of problem (it may be difficult for drivers to quickly distinguish and interpret the various types of warning conditions). The steering wheel-mounted controls include buttons for activating the system, setting cruise speed, and setting following distances. Three discrete following distances are offered corresponding to short, middle, and long headways. All equipped Infiniti models use time headways of 1.02, 1.47, and 2.21 seconds. The system defaults to 2.21 seconds (long) each time the vehicle is started.

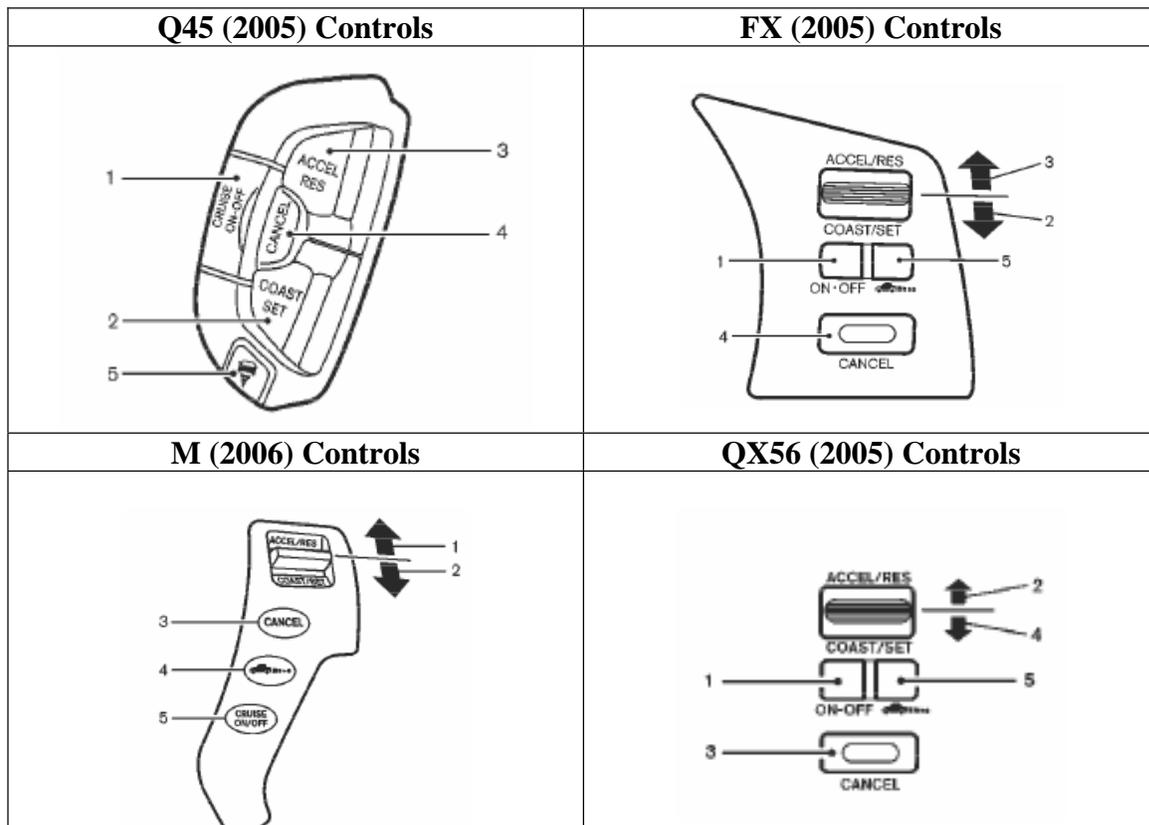


Figure A-4: Infiniti Intelligent Cruise Control interface controls

All models provide an in-dash (instrument panel) display to present system information, including set speed and distance settings using graphics. The displays across the four model lines (Figure A-5) provide functionally similar information (a vehicle detection indicator, set distance indicator, host vehicle indicator, a set speed, a system on/off indicator, and an ICC warning light). However, the specific graphics used to communicate this information and its format differs between the Q45 and the remaining models (FX, M, and QX56). The Q45 uses a

car icon (viewed from the rear) to denote the presence of a vehicle and series of distance bars located below the car icon to indicate set headway or following distance (the largest and closest bar includes an indicator to denote the host vehicle). The resulting graphical display provides an orientation which is consistent with the true underlying spatial relationship between the host car and the lead vehicle. The FX, M, and QX56 also use a car icon, but it depicts a profile view of the entire vehicle to denote a lead vehicle detected. A series of distance bars are also provided, but they are located to the right of the car icon (an indicator located to the right of the bars is used to represent the host vehicle). Unlike the Q45, this display format does not preserve the underlying spatial relationships between the host vehicle and lead vehicle (it requires some mental rotation of the image). The set speed indicator blinks when the vehicle speed exceeds the set speed.

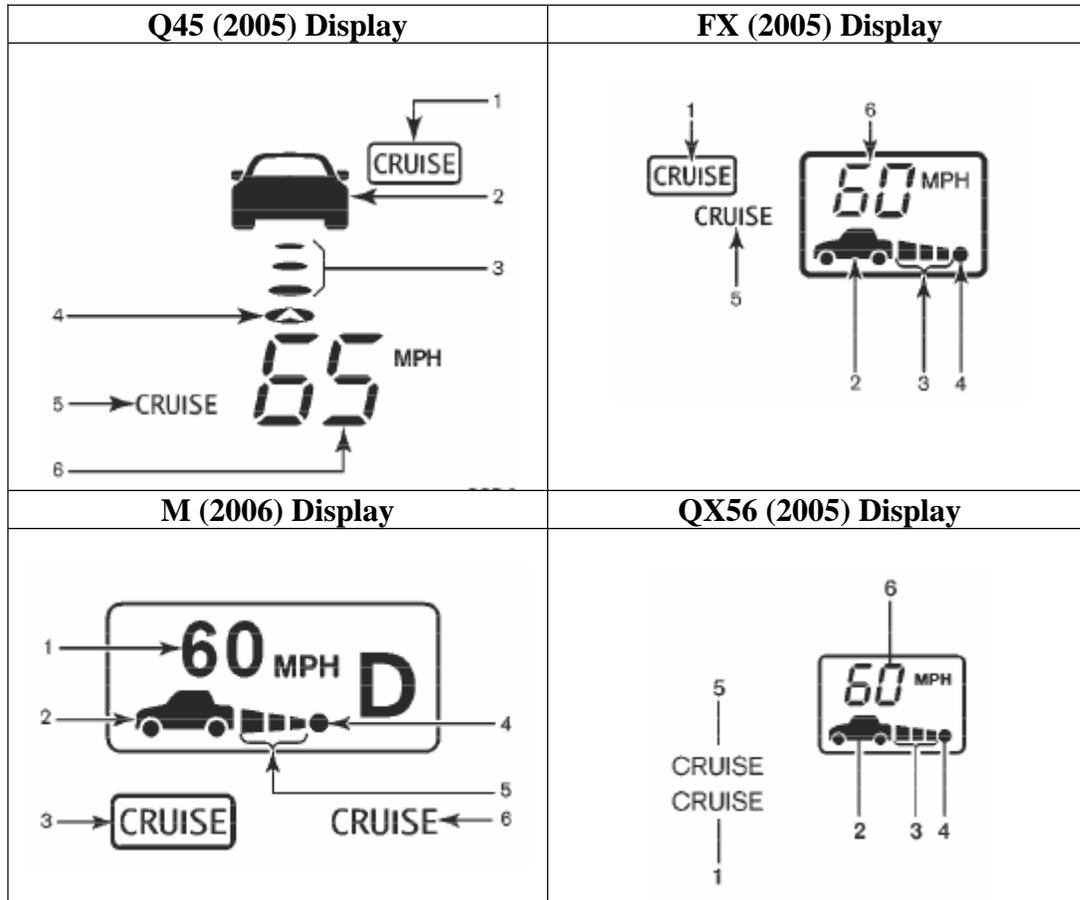


Figure A-5: Infinity Intelligent Cruise Control interface displays

The conventional cruise control is integrated along with the more capable Intelligent Cruise Control system. Drivers can select which system (or cruise mode) is activated based on how they press the on/off switch. Depressing the switch quickly activates the ICC, while pushing and holding the switch for longer than 1.5 seconds activates the conventional cruise control system. The display provides an indication as to which system is activated (the graphic portion of the display with set speed, following distance and car icon are not presented under conventional cruise control). Further, once a cruise control mode (either conventional or ICC) is selected, it cannot be changed unless the driver first turns the system off. The ICC system automatically disengages (or is locked-out) when the windshield wipers are set to the high intermittent, low, or high setting effectively preventing ACC use during rainy or some inclement weather conditions. Another safety feature common across all models offering the system, and seen in other ACC

systems, is the illumination of the vehicle's brake lamps whenever the ICC system performs braking (the brake pedal also automatically depresses). The Q45, FX, and M manuals devote approximately 18 pages to the ICC system, and the QX56 17 pages. All four manuals include numerous warning and cautionary messages to drivers. They include notification that the system is an aid and not a collision warning system; intended for straight, dry open roads with light traffic; system will not automatically stop the vehicle; and system may not detect the vehicle ahead under certain conditions (bad weather, sharp curves, strong direct light in front of the vehicle, etc.). The manuals also provide graphic illustrations of road and traffic situations where system performance may be degraded or reduced.

Jaguar Adaptive Cruise Control

The Jaguar XK’s radar-based Adaptive Cruise Control system (reviewed as part of the 2004 model year) operates at speeds between 20 and 110 mph; the system automatically deactivates at speeds below 18 mph. Six steering-wheel-mounted controls allow drivers to set time gap (using a rocker switch for increasing or decreasing following distance to one of four discrete settings), speed, resume set speed, and cancel to temporarily turn off the ACC without erasing system memory. An in-dash multifunction display message center (Figure A-6) is used to provide system status information including gap setting (when in follow mode), and set speed (when in cruise mode). A warning light (dummy light) on the instrument cluster illuminates when a lead vehicle has been detected and the system enters into “follow mode.” The system warns drivers when manual intervention is required (e.g., ACC predicts maximum braking level will not be sufficient); an audible warning sounds, a red warning light illuminates, and the message “DRIVER INTERVENTION” is displayed in the message center. The displays and message center are located on the lower portion of the speedometer. A unique system feature is the forward alert which warns drivers of objects ahead (through audible and visual signals only, no braking) even when the ACC system is not engaged. Drivers can adjust the sensitivity of the forward alert using the ACC gap setting controls, and can turn the feature on or off using a switch located on the lower left of the steering column (on the lower outboard knee bolster).

The ACC also system uses a master warning approach to highlight priority messages presented on the driver message center (using separate red and amber lights). The manual devotes 6 pages to the ACC system and is laid out with noticeably fewer warning than many other owners’ manuals; however, it does caution drivers against use when entering/exiting freeways, and warns drivers that the system is not a collision warning system and will not detect stationary or slow moving vehicles, pedestrians, or oncoming vehicles.

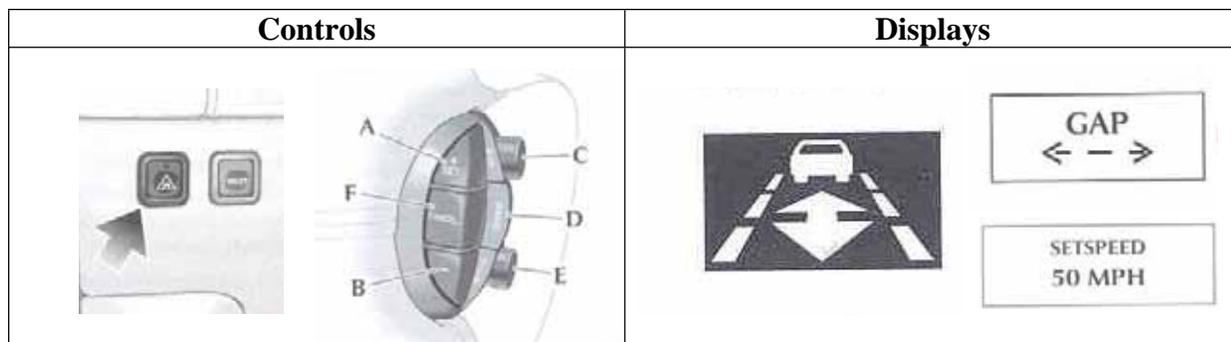


Figure A-6: Jaguar XK Adaptive Cruise Control interface elements

Lexus Dynamic Laser Cruise Control

Lexus offers two vehicles equipped with an optional Dynamic Laser Cruise Control system for 2005, the LS 430 and the RX 330 (the GS 300 and GS 430 can be equipped with Dynamic *Radar* Cruise Control). The laser-based system operates at speeds between 28 and 85 mph, and has a detection range of 400 feet. The system automatically disengages if the vehicle's speed falls below 25 mph (the driver is alerted via a warning tone). The system also disengages (or prevents activation) and notifies the driver when the windshield wipers are operated at low/high speed. The LS 430 manual also overviews other situations in which the system will automatically disengage (e.g., antilock system engages, sensor malfunction). Stalk-mounted system controls allow drivers to activate the system and input the desired cruise speed whereas steering wheel controls are used to set following distance. The stalk and steering wheel controls are different in both vehicles (Figure A-7). Both systems also feature an integrated conventional cruise control mode, as well as Adaptive Cruise Control. Drivers can select either conventional or dynamic laser cruise control by using the stalk-mounted control lever (pressing the main switch at the end of the lever engages the dynamic laser cruise; moving the lever towards the dash for longer than 1 second after pressing the main switch changes the mode to conventional cruise). The display in the LS 430 provides an indication of which operating mode has been selected (conventional or dynamic laser cruise, the display area is blank under conventional cruise). When dynamic laser cruise control is activated in the RX 330 the CRUISE icon is illuminated. Alternatively, the CRUISE and NORM icons are illuminated for the conventional cruise control. Once the dynamic laser cruise control has been activated and used, drivers cannot change into conventional cruise mode without first turning off the system; this guards against accidental changes in mode.

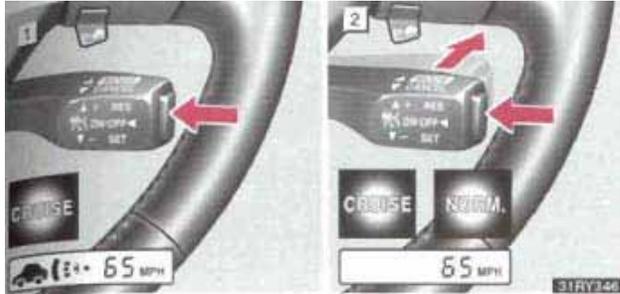
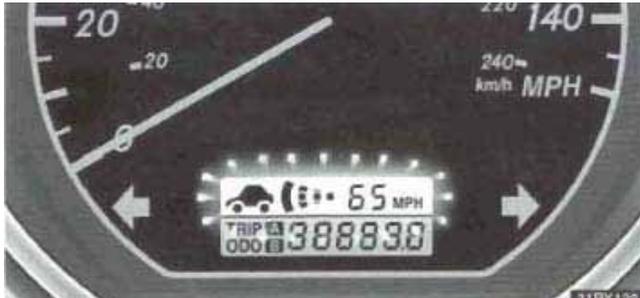
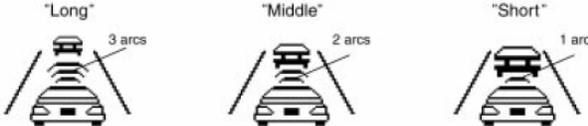
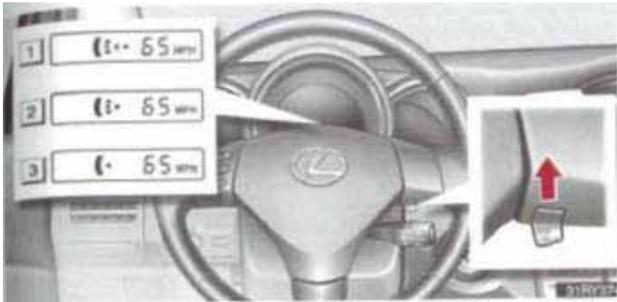
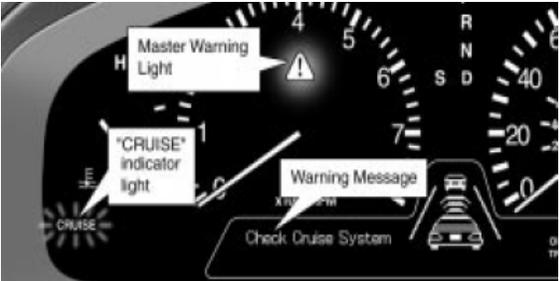
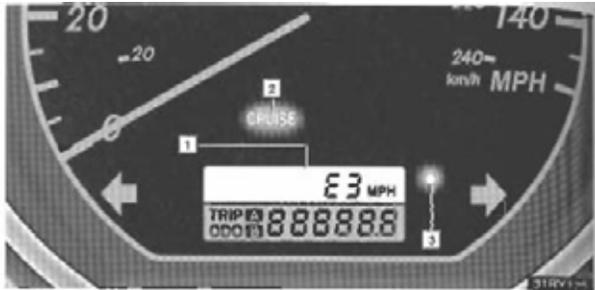
<p style="text-align: center;">LS 430 Controls</p> 	<p style="text-align: center;">RX 330 Controls</p> 
<p style="text-align: center;">LS 430 Display</p> 	<p style="text-align: center;">RX 330 Display</p> 
<p style="text-align: center;">LS 430 - Headway Setting Indicators</p> 	<p style="text-align: center;">RX 330 - Headway Setting Indicators</p> 
<p style="text-align: center;">LS 430 - Warning Indicators/Messages</p> 	<p style="text-align: center;">RX 330 - Warning Indicators/Messages</p> 

Figure A-7: Lexus Dynamic Laser Cruise Control interface elements

Drivers can select one of three discrete distance settings corresponding to 1.24-, 2.04-, and 3.03-second headways using the steering-wheel-mounted buttons. The system defaults to the longest distance setting (3.03 sec) whenever the dynamic laser cruise system is first activated. The LS 430 incorporates a multi-information display on the instrument panel that presents set speed,

detected vehicle, following distance, and various text messages regarding system status. The graphic display contains icons depicting the host vehicle as well as any detected lead vehicles, and preserves the spatial relationship through its vertical orientation. Whenever the system brakes to slow the vehicle, the vehicle's rear brake/stop lamps are illuminated in both vehicles; however, the brake lights of the icon representation of the host vehicle pictured in the display (LS 430) also illuminate as an additional cue to the driver that braking is occurring. The display in the RX 330 only presents the set speed, following distance, and a lead vehicle icon if it is within range. A variety of audible and visual warnings are provided by the systems. An approach warning, alerts drivers to situations where intervention (manual braking by the driver) is required (e.g., vehicle ahead decelerates rapidly causing inadequate braking). Under these conditions, the multi-informational display flashes and beeps. This feature is only active when the dynamic laser cruise control system is on (no alerts are provided if conventional cruise is active, or if the cruise system is off). If there is a system failure while the system is operating, the cruise indicator light on the instrument panel flashes, a master warning light illuminates, and a warning tone sounds. In addition, a text message is presented detailing the nature of the problem (e.g., clean radar, check cruise system, etc.) for the LS 430. The RX 330 displays error codes (E1, E2, or E3), the meanings of which are described in the owner's manual.

The RX 330 manual devotes 17 pages to the dynamic laser cruise control system. Most pages in the manual contain some form of warning or cautionary statement referencing system capabilities and limitations. Drivers are cautioned against using the system on freeway on/off ramps, bad weather, heavy traffic, roads with sharp curves, on slippery road surfaces, and hilling roads. Drivers are also cautioned to "pay special attention" to slow or stopped vehicles, and that under certain conditions (e.g., cut-ins with drastic speed differences) the system "will neither warn you nor decelerate." Many situations are graphically illustrated in the owner's manual.

Mercedes-Benz Distronic Adaptive Cruise Control

Mercedes-Benz has perhaps the most extensive line of ACC-equipped vehicles in the United States, offering Distronic in seven different vehicle models, including the E55, SLR, and all trim levels within the CLS, S, CL, and SL classes. Maybach, a luxury marques resurrected by DaimlerChrysler, also features the Mercedes-based Distronic cruise control as a no-cost option. The SLR is the only vehicle that includes Distronic as standard equipment. The following information is based on information obtained for the 2006 CLS-Class.

The radar-based system operates at speeds between 20-110 mph and is capable of providing up to 20 percent of the vehicle's braking power (maximum of 6.5 ft/s^2 , or 2 m/s^2). The brake pedal is also automatically depressed when braking is being performed by the system. Drivers can activate the system and program the set cruising speed using conventional steering column mounted controls. Advanced controls for setting following distance and turning on/off a distance warning function (discussed later) are located on the lower section of the center console, next to the shift lever. A thumbwheel is used to increase or decrease the distance setting, varying headway from between 1.0 and 2.0 seconds. Each end of the thumbwheel is labeled with an icon; moving the wheel forward decreases headway, while moving the wheel towards the back increases headway.

A multifunctional display, located in the instrument panel (inset within the speedometer), is used to provide system status information (Figure A-8). The speedometer presents both the set or desired speed programmed into the Distronic system, and the actual vehicle speed. The driver's set speed is displayed for about 5 seconds when the system is activated (or when a new set speed is entered); lighted segments on the speedometer continuously indicate the set speed. Additionally, if a lead vehicle is detected, segments will indicate the difference between the set speed and the speed of the detected vehicle. The multifunctional display graphically illustrates

both the desired headway (set following distance) and actual distance from lead vehicles. The graphic display uses car icons to represent detected lead vehicles as well as the host vehicle (both using car profiles); the display is horizontally oriented. If the system detects a situation in which a collision with a lead vehicle is likely (e.g., system is incapable of slowing the vehicle sufficiently and driver intervention is required), a warning is issued. The warning consists of an intermittent warning sound and illumination of a warning lamp (located in the instrument cluster); the warning terminates when the “necessary distance to the vehicle ahead is again established,” or when the driver depresses the brake pedal. This distance warning function is operational even if the Distronic system is deactivated, notifying the driver of collision threats resulting from stationary objects or slower moving vehicles. An over-ride switch is provided (located on the lower section of the center console) which allows drivers to turn-off the distance warning function. Drivers can assess the status of the distance warning function by an icon (loudspeaker symbol) located on the multi-functional display (the icon is illuminated when the system is active); the indicator lamp on the switch itself also illuminates when the distance warning function is on. Distronic can be deactivated by applying pressure to the brake pedal. If the vehicle speed falls below 20 mph the system automatically disengages and notifies the driver (signal sounds and the message “Distronic Off” is presented for 5 seconds on the multifunction display).

The owner’s manual for the CLS devotes approximately 12 pages to the Distronic system, and includes a variety of warnings and special informational items (15 specific warning notices/boxes, and 8 helpful hints segments). Drivers are advised that the system is intended as a convenience system; that it should not be used in fog, heavy rain, snow, or sleet; and that the system can be dangerous on winding roads or heavy traffic. Warnings that the system does not react to stationary objects is referenced repeatedly throughout the manual. Problem driving scenarios (e.g., turns and bends, offset driving, lane changing) are graphically illustrated in the manual to help drivers understand system performance capabilities and limitations.

Controls	
Display	
Symbols	

Figure A-8: Mercedes-Benz CLS-class Distronic interface elements

Toyota Dynamic Laser Cruise Control Operation

Currently, the Toyota Sienna is the only minivan offering Adaptive Cruise Control in the U.S. market; moreover, the system comes as standard equipment in the 2004 XLE Limited trim level. ACC is also offered as an option on the re-designed 2005 Avalon Limited. As with its more expensive counterpart, Lexus, Toyota's Dynamic Laser Cruise Control system uses laser-radar to detect objects out to a range of 400 ft., operates between speeds of 28 to 85 mph, offers drivers three discrete distance settings, and integrates conventional cruise control along with Adaptive Cruise Control. Like the Lexus system, it also prohibits use when the windshield wipers are operated on low or high settings (if the cruise control is engaged, the system automatically cancels when wipers are set to these positions). System controls are located on the steering wheel and on a conventional stalk off the steering column. The multi-axis, stalk-mounted control is used to input most system functions, including turning the system on and off, setting a cruising speed, and selecting the operational mode – either adaptive cruise control (“vehicle-to-vehicle distance control”) or conventional (“fixed speed”) mode. Drivers use the steering-wheel-mounted distance switch to select one of three following distances (long, middle, and short), corresponding to headways of approximately 3.03, 2.04, and 1.23 seconds. The graphic display,

located on the lower portion of the speedometer, represents these following distances (in addition to set speed) using bars and a car icon (Figure A-9). The graphic display used to depict following distance is oriented horizontally, similar to the Lexus RX 330.

Pressing the on/off button automatically activates the system in its advanced vehicle-to-vehicle distance control mode; an additional step is required to change to the conventional “fixed speed” mode (the lever must be pushed in the mode direction for longer than 1 second). Visual display indicators and elements are used to inform drivers about which mode has been selected. When ACC is engaged (vehicle-to-vehicle distance control mode), the graphic display presents a vehicle icon, distance bars, and set speed. Only set speed is presented when operating in conventional cruise mode. In addition, a dedicated indicator light labeled “NORM” is presented on the instrument cluster when operating in conventional cruise mode. Once the ACC mode has been used, drivers cannot change to conventional cruise mode without first turning off the system. However, drivers can change from conventional cruise mode to ACC mode directly without turning off the cruise system (requires pushing the lever in the mode direction for longer than 1 second).

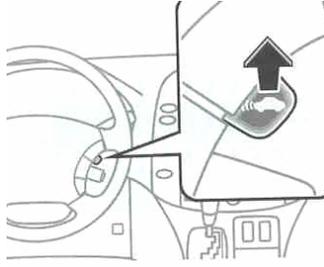
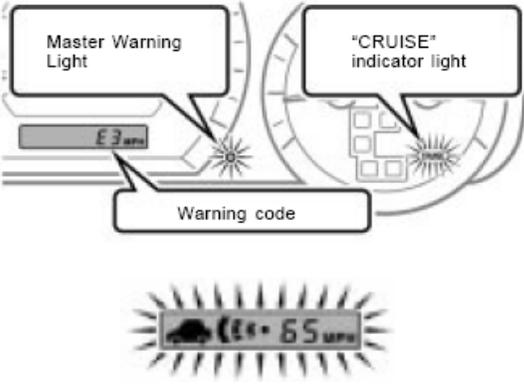
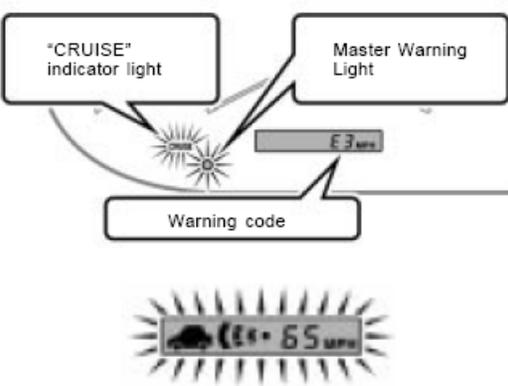
Controls – Sienna and Avalon		
		
Headway – Sienna and Avalon		
LONG	MIDDLE	SHORT
		
Display - Sienna	Display - Avalon	
		

Figure A-9: Toyota Dynamic Laser Cruise Control interface elements

When engaged, the system warns the driver (through an audible beep flashing display) when system braking is insufficient to handle the closing distance to the vehicle ahead, and manual braking by the driver is required. This approach warning is only active in vehicle-to-vehicle distance mode (does not function when using conventional cruise, or when the system is off). A master warning light is also used to indicate problems with the Dynamic Laser Cruise Control, as well as problems with other systems; warning codes are presented on a display to reference the specific problem. The manual includes numerous dialog boxes providing cautionary information and statements. Drivers are warned, for example, that the system may not issue a warning, nor decelerate under certain conditions such as a stopped lead vehicle.

APPENDIX B: MAIL-OUT SURVEY INSTRUMENT AND RECRUITMENT LETTER



1577 So. Valley Vista Drive
Diamond Bar, CA 91765

«First_Name» «Last_Name»
«Address»
«City», «State» «Zip»

Dear Member:

The Automobile Club of Southern California (AAA) is working on a major research project to reduce traffic crashes and injuries on our roadways. We need your help in this important study.

The goal of our study is to make recommendations to the automotive industry and government about the kinds of innovative equipment that should be put on vehicles to protect drivers and make our roads safer. The Club selected your name *at random* from the rolls of all Club members who are owners of recent model vehicles.

The car you own is likely to be equipped with the technology we are investigating. As an “early adopter” of this technology, your responses will be very valuable. Please take a few minutes to fill out the attached survey and mail it back in its pre-paid envelope. This survey covers:

- **Adaptive Cruise Control – A system that helps drivers by automatically controlling their speed based on the speed of the vehicle ahead.**

Please let us know, by filling out the attached questionnaire, whether your «Model_Yr» «Manufacturer», with Vehicle Identification Number «VIN» has an adaptive cruise control system and if so, what your experience has been with it.

Even if your vehicle does not have adaptive cruise control, you can still provide us with valuable input because you drive a recent model vehicle. Please fill out the first four questions and the last question as these will help us in understanding drivers’ purchasing decisions in regards to adaptive cruise control systems.

All information you provide is voluntary, strictly *confidential* and will be used *solely* for scientific purposes. (It will not affect your insurance rates or membership and will not be used for marketing purposes.)

Thank you in advance for your help with this project and for participating in its exciting opportunity to influence our next generation of motor vehicles.

Please complete the enclosed survey and return it in the postage paid envelope.

Thank you for your cooperation,

A handwritten signature in black ink, appearing to read "Steven D. Mazor".

Steven D. Mazor
Manager, Automotive Research Center
(909) 612-2560

(over)

OPTIONAL:

We are planning to follow up on this written questionnaire with more in-depth telephone interviews of some of the survey respondents. These interviews are expected to take up to 15 minutes. If you would be willing to participate in a follow up interview, please fill in the personal (optional) information below. We will only be contacting a limited number of respondents for follow ups. They will be selected randomly from those who volunteer. Not all volunteers will be contacted.

Would you like to participate in a telephone interview? *(circle one)* Yes No

If yes, please tell us:

Your name (optional) _____

Telephone number _____

Best time(s) of day to reach you at this number? *(circle all that apply)*

Morning Afternoon Evening

Thank you for completing the survey!

Please mail it back in the business reply envelope provided.

Automobile Club of Southern California

1577 So. Valley Vista Drive

Diamond Bar, CA 91765

Please tell us about yourself:

1. Age: ____ (you must be at least 18 years of age to participate)

2. Gender (circle one) Male Female

3. Do you have any physical conditions which make driving more difficult? (check boxes for all that apply)

- Vision problems
- Hearing problems
- Dexterity problems (e.g. arthritis).....
- Difficulty turning my head/neck
- Other (explain): _____
- None

4. Conventional cruise control systems allow you to maintain a constant vehicle speed without keeping your foot on the accelerator pedal. Some newer vehicles also have **adaptive cruise control (ACC)**. ACC adjusts your vehicle speed automatically to maintain a constant gap (headway) between your vehicle and the vehicle ahead. Does your vehicle have **adaptive cruise control**?

(circle one) Yes → Go to question 5 on next page

No → Answer questions 4a and 4b, then skip to question 28.

4a. If **no**, then why not? (check boxes for all that apply)

- Adaptive cruise control was not an option on my vehicle
- It never occurred to me to look for it when I purchased the vehicle.....
- I thought it would be a nuisance or distraction
- I wouldn't trust it to keep me from colliding with other vehicles.....
- I don't need it
- It was not worth the extra cost
- It was only available with other options that I didn't want.....
- I was not the person who decided to get this vehicle

4b. If you purchased this same vehicle again would you want adaptive cruise control? (circle one) Yes No Don't Know

Please skip to question 28.

5. **If you purchased this same vehicle again would you want adaptive cruise control?**
(circle one) Yes No Don't Know

6. **Approximately how many miles have you personally driven this vehicle?**
_____ miles

7. **How did you learn to use your adaptive cruise control system?**
(check boxes for all that apply)

- Instructions from the dealership, such as a video, brochure, or demonstration.....
- Vehicle owner's manual.....
- Was the owner's manual easy to use? Yes No
- Help from a friend or relative.....
- Information on the Internet
- On-road experience and practice (trial and error)
- I have not yet learned how to use the adaptive cruise control

8. **Are you aware of any manufacturer's warnings or limitations about your adaptive cruise control system?**
(circle one) Yes No

(If yes, please explain): _____

9. **Were there things that were especially difficult to learn about your adaptive cruise control system?**
(circle one) Yes No

(If yes, please explain): _____

10. Under what conditions do you avoid using the adaptive cruise control system?
(check boxes for all that apply)

- Rain
- Snow.....
- At night
- In congested, “stop-and-go” traffic
- In heavy traffic that is flowing.....
- On interstate highways.....
- Freeway off ramps, or when exiting highways
- On curvy roads
- On neighborhood or city streets with traffic lights
- Other (*please describe*): _____
- _____
- None of the above

11. Does your vehicle have the option of using conventional cruise control without adaptive cruise control? [Note: conventional cruise control provides constant speed control only and does not automatically adjust your speed.]

(circle one) Yes No

If yes, how frequently have you been confused about which system is operating?
(circle one)

- Always confused 1
- Frequently confused..... 2
- Sometimes confused 3
- Rarely confused..... 4
- Never confused 5

12. Compared to driving with cruise control off, how quickly do you notice and respond to unexpected road hazards when the adaptive cruise control is engaged (turned on)?
(circle one)

- I respond more slowly 1
- I respond in the same time 2
- I respond more quickly..... 3
- I don't know 4

13. A. If you could not use adaptive cruise control any more, how would your driving change? *(circle one)*

- I would usually keep a smaller gap between my vehicle and the vehicle ahead of me than I do now using ACC..... 1
- I would usually keep the same gap between my vehicle and the vehicle ahead of me than I do now using ACC..... 2
- I would usually keep a larger gap between my vehicle and the vehicle ahead of me as I do now using ACC 3

13. B. If you could not use adaptive cruise control any more, how much would you use conventional cruise control (constant speed control)? *(circle one)*

- I would not use conventional cruise control either 1
- I would use conventional cruise control less often than I do now 2
- I would use conventional cruise control as often as I do now 3
- I would use conventional cruise control more often than I do now 4
- I don't know..... 5

14. For each of the following statements, please indicate how much you agree or disagree. *(circle one response for each row)*

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable
A. The <u>lights/symbols</u> on the adaptive cruise control system are easy to understand.	1	2	3	4	5	NA
B. The <u>sounds</u> made by the adaptive cruise control system are easy to understand.	1	2	3	4	5	NA
C. Using adaptive cruise control relieves me of stress when driving.	1	2	3	4	5	NA
D. I tend to change lanes <u>less</u> frequently when using adaptive cruise control.	1	2	3	4	5	NA
E. I tend to follow the vehicle ahead more closely when using adaptive cruise control.	1	2	3	4	5	NA
F. I tend to set adaptive cruise control to a shorter gap (closer following distance) in heavy traffic than in light traffic.	1	2	3	4	5	NA
G. My adaptive cruise control sometimes locks on to a vehicle other than the vehicle immediately in front of me.	1	2	3	4	5	NA
H. More cars cut me off or pull in front of me when I am using adaptive cruise control.	1	2	3	4	5	NA

15. Please rate how well your adaptive cruise control would assist you to avoid colliding with the vehicle in front of you under the following circumstances.

(circle one response for each row)

	Not at all	Poorly	Fairly Well	Perfectly	Don't Know
A. You are following a vehicle in stop-and-go traffic.	1	2	3	4	DK
B. You encounter a stopped car in your lane ahead.	1	2	3	4	DK
C. You are following a vehicle on a curvy road.	1	2	3	4	DK

16. How often have you encountered each of these situations?

(circle one response for each row)

	Very Often	Often	Occasionally	Rarely	Never
A. The adaptive cruise control system would slow unexpectedly when there was no vehicle immediately ahead of you.	1	2	3	4	5
B. The adaptive cruise control system would brake abruptly or brake hard causing the vehicle behind you to get uncomfortably close, or to brake hard.	1	2	3	4	5
C. The adaptive cruise control system would accelerate unexpectedly.	1	2	3	4	5
D. You forgot to turn off the system.	1	2	3	4	5
E. The system shut itself off unexpectedly.	1	2	3	4	5

(over)

17. Do you normally use the same gap (headway) setting or do you adjust the gap based on driving conditions?

(circle one)

- I don't know how to change the amount of gap between my vehicle and the vehicle ahead 1
- I always choose the same setting for the amount of gap between my vehicle and the vehicle ahead..... 2
- I change the amount of gap between my vehicle and the vehicle ahead as driving conditions change..... 3
- My system doesn't allow changing the following distance 4

18. At what gap (headway) setting do you usually have the adaptive cruise control system set?

(circle one)

- At the shortest setting, which is as close to the lead vehicle as the system allows 1
- At a medium setting 2
- At the longest setting, which is as far from the lead vehicle as the system allows 3
- My system doesn't allow changing the following distance 4
- I don't know 5

19. Since you have owned your vehicle with adaptive cruise control, have you driven any other vehicle equipped with only conventional cruise control and had a collision or a "close call" because you expected the vehicle you were driving to automatically slow down?

(circle one) Yes No

20. Does your adaptive cruise control system create any new driving problems or safety concerns for you?

(circle one) Yes No

(If yes, please explain): _____

21. To what extent have you been confused about what speed the adaptive cruise control is set to?

(circle one)

- Extremely confused..... 1
- Very confused 2
- Moderately confused..... 3
- Slightly confused..... 4
- Not at all confused 5

22. To what extent have you been confused about what following distance the adaptive cruise control is set to?

(circle one)

- Extremely confused..... 1
- Very confused 2
- Moderately confused..... 3
- Slightly confused..... 4
- Not at all confused 5

23. How has your reliance on adaptive cruise control changed since you first drove the vehicle?

(circle one)

- I rely on it more now than I did in the beginning 1
Why? _____
- I rely on it less now than I did in the beginning..... 2
Why? _____
- My reliance has stayed about the same 3

24. Have you ever unintentionally collided with something when you had the adaptive cruise control system engaged (turned on)?

(circle one) Yes No

(If yes, please describe the situation):

(over)

25. Overall, are you a safer driver using adaptive cruise control than you would be if you only used conventional cruise control?

(circle one)

- Yes, safer..... 1
- Neither more nor less safe..... 2
- No, less safe 3

26. Is there anything about the way the adaptive cruise control system works that you think should be improved or changed?

(circle one) Yes No

(If yes, please explain): _____

27. Have you recently stopped (given up) driving?

(circle one) Yes No

(If yes, please explain why): _____

28. In general, do you believe that car manufacturers are doing enough to design vehicles to accommodate an aging population?

(circle one) Yes No

If you answered “no” then what more do you believe could be done?

(Explain): _____

Thank you for completing the survey!

Please mail it back in the business reply envelope provided.

*Automobile Club of Southern California
1577 So. Valley Vista Drive
Diamond Bar, CA 91765*

APPENDIX C: TABULATED SURVEY RESULTS FOR ADAPTIVE CRUISE CONTROL SYSTEMS

The following list shows the response frequencies for each item on the Adaptive Cruise Control survey. Counts shown are the number of respondents who selected a particular response. Note that some items on the questionnaire required the respondent to choose a single best response, while other items required the respondent to indicate all responses that apply. The responses to open-ended questions (write-in responses) have been coded into categories. Of the 10,000 questionnaires mailed out, 1,659 questionnaires were returned within three months and were included in the analyses. For each item, the response percentages shown are calculated based on a total count of responses, a sub-total count of valid responses, or the total number of respondents depending on which measure researchers believe is most appropriate for understanding the pattern of results. For items on which the participant was able to make multiple responses, percentages are based on the total number of respondents who selected at least one response to that question. For items where open-ended responses were solicited, the responses were read by data coding staff and classified into a small number of post-hoc categories. These categories are shown in *italics* in the response descriptions below.

Model year of vehicle				
Description	Count	Percentage	Count with Adaptive Cruise Control	Percentage with Adaptive Cruise Control
2001	2	0.12	1	0.27
2002	128	7.72	41	11.08
2003	280	16.88	52	14.05
2004	527	31.77	75	20.27
2005	492	29.66	161	43.51
2006	230	13.86	40	10.81
Total	1,659	100.00	370	100.00

Vehicle manufacturer				
Description	Count	Percentage	Count with Adaptive Cruise Control	Percentage with Adaptive Cruise Control
BMW	208	12.54	29	7.84
Cadillac	33	1.99	6	1.62
Infiniti	169	10.19	79	21.35
Jaguar	51	3.07	10	2.70
Lexus	751	45.27	129	34.86
Lincoln	1	0.06	0	0.00
Mercedes-Benz	315	18.99	32	8.65
Toyota	131	7.90	85	22.97
Total	1,659	100.00	370	100.00

Q1. Age (self-reported)

Description	Count	Percentage	Count with Adaptive Cruise Control	Percentage with Adaptive Cruise Control
18 - 34 years	66	4.06	23	6.32
35 - 44 years	198	12.18	68	18.68
45 - 54 years	284	17.48	67	18.41
55 - 64 years	315	19.38	60	16.48
65 - 74 years	444	27.32	88	24.18
75 years or older	318	19.58	58	15.93
Subtotal valid responses	1,625	100.00	364	100.00
Not ascertained	34		6	
Total	1,659		370	

Q2. Gender

Category	Description	Count	Percentage	Count with Adaptive Cruise Control	Percentage with Adaptive Cruise Control
1	Male	1,098	68.16	250	70.03
2	Female	513	31.84	107	29.97
	Subtotal valid responses	1,609	100.00	357	100.00
9	Not ascertained	48		13	
	Total	1,659		370	

Q3. Do you have any physical conditions which make driving more difficult?

Category	Description	Count	Percentage	Count with Adaptive Cruise Control	Percentage with Adaptive Cruise Control
1	Vision problems	87	6.31	21	6.73
2	Hearing problems	41	2.97	8	2.56
3	Dexterity problems (e.g. arthritis)	23	1.67	1	0.32
4	Difficulty turning my head/neck	35	2.54	4	1.28
5	Other conditions	13	0.94	3	0.96
6	None	1,232	89.34	282	90.38
	Subtotal valid responses	1,431		319	
	Total respondents	1,379	100.00	312	100.00
9	Not a	279			

Q3. Other physical condition (explain).

Category	Description	Count	Percentage	Count with Adaptive Cruise Control	Percentage with Adaptive Cruise Control
1	<i>Physically handicapped</i>	5	38.46	1	33.33
2	<i>Flexibility/degenerative disc/back problems</i>	3	23.08	0	0.00
3	<i>Physical body size(too short, tall, small, large)</i>	2	15.38	0	0.00
94	<i>Other</i>	2	15.38	2	66.67
	Subtotal valid responses	12		3	1
	Total respondents who responded "other" in Q3	13	100.00	3	100.00
96	<i>Text response not reported</i>	1	7.69	0	0.00

Q4. Conventional cruise control systems allow you to maintain a constant vehicle speed without keeping your foot on the accelerator pedal. Some newer vehicles also have adaptive cruise control (ACC). ACC adjusts your vehicle speed automatically to maintain a constant gap (headway) between your vehicle and the vehicle ahead. Does your vehicle have adaptive cruise control?

Category	Description	Count	Percentage
1	Yes	370	22.76
2	No	1,253	77.06
8	Don't know (written on form)	3	0.18
	Subtotal valid responses	1,626	100.00
9	Not ascertained	33	
	Total	1,659	

Q4a. If no, then why not?

Category	Description	Count	Percentage
1	Adaptive Cruise Control was not an option on my vehicle	663	54.34
2	It never occurred to me to look for it when I purchased the vehicle.	664	54.43
3	I thought it would be a nuisance or distraction.	61	5
4	I wouldn't trust it to keep me from colliding with other vehicles.	153	12.54
5	I don't need it.	235	19.26
6	It was not worth the extra cost.	171	14.02
7	It was only available with other options that I didn't want.	90	7.38
8	I was not the person who decided to get this vehicle.	61	5
	Subtotal valid responses	2,098	
	Total respondents	1,220	100.00

Q4b. If you purchased this same vehicle again would you want adaptive cruise control? (For vehicle owners who do not have adaptive cruise control)

Category	Description	Count	Percentage
1	Yes	423	34.33
2	No	344	27.92
8	Don't Know	465	37.74
	Subtotal valid responses	1,232	100.00
9	Not ascertained	425	
	Total	1,657	

Q5. If you purchased this same vehicle again would you want adaptive cruise control? (For vehicle owners who currently have adaptive cruise control)

Category	Description	Count	Percentage
1	Yes	273	75.00
2	No	33	9.07
8	Don't Know	58	15.93
	Subtotal valid responses	364	100.00
9	Not ascertained	1,295	
	Total	1,657	

Q6. Approximately how many miles have you personally driven this vehicle?

Category	Description	Count	Percentage
1	(<5,000 miles)	32	9.30
2	(5,000 to 9,999)	54	15.70
3	(10,000 to 19,999)	108	31.40
4	(20,000 to 29,999)	57	16.57
5	(30,000 to 39,999)	50	14.53
6	(40,000 to 49,999)	16	4.65
7	(50,000+)	25	7.85
	Subtotal valid responses	344	100.00
	Not ascertained	1,315	
	Total	1,659	

Q7. How did you learn to use your vehicle's adaptive cruise control system?

Category	Description	Count	Percentage
1	Instructions from the dealership, such as video, brochure, or demonstration	105	29.41
2	Vehicle owner's manual	240	67.22
3	Help from a friend or relative	18	5.04
4	Information on the Internet	4	1.12
5	On-road experience and practice (trial and error)	191	53.50
6	I have not yet learned how to use the adaptive cruise control	28	7.84
	Subtotal valid responses	586	
	Total respondents	357	100.00

Q7. Was the owners manual easy to use?

Category	Description	Count	Percentage
1	Yes	208	90.82
2	No	21	9.17
	Subtotal valid responses	229	100.00
9	Not ascertained	1,430	
	Total	1,659	

Q8. Are you aware of any warnings or limitations about your vehicle's adaptive cruise control system?

Category	Description	Count	Percentage
1	Yes	102	28.41
2	No	257	71.59
	Subtotal valid responses	359	100.00
9	Not ascertained	1,300	
	Total	1,659	

Q8. If yes, please explain.

Category	Description	Count	Percentage
1	<i>Does not relieve driver of responsibility to pay attention to road conditions</i>	24	23.53
2	<i>Do not use in adverse weather conditions</i>	19	18.63
3	<i>Do not use in adverse traffic conditions/slow speed</i>	14	13.73
4	<i>Don't use on curves/ramps/hills</i>	2	1.96
5	<i>Driver should be ready to apply brakes upon system failure</i>	7	6.86
94	<i>Other</i>	10	9.80
	Subtotal valid responses	76	
	Total respondents who answered "Yes" to Q8.	102	100.00
95	Response did not pertain to the question	3	2.97
96	Text response not reported	30	29.70

Q9. Were there things that were especially difficult to learn about your vehicle's adaptive cruise control system?

Category	Description	Count	Percentage
1	Yes	31	9.06
2	No	310	90.64
	Subtotal valid responses	342	100.00
8	Don't Know (written on form)	1	0.29
9	Not ascertained	1,317	
	Total	1,659	

Q9. If yes, please explain.

Category	Description	Count	Percentage
1	<i>Sudden change of driver's vehicle speed</i>	8	25.00
2	<i>Trusting ACC</i>	5	15.63
3	<i>ACC responses on turns/curves</i>	2	6.45
4	<i>Sensors pick up vehicles in other lanes</i>	2	6.25
5	<i>Setting distance and/or speed</i>	9	28.13
94	<i>Other</i>	5	15.63
	Subtotal valid responses	31	
	Total respondents who answered "Yes" to Q9.	31	100.00
95	Response did not pertain to the question	2	6.25

Q10. Under what conditions do you avoid using the adaptive cruise control system?

Category	Description	Count	Percentage
1	Rain	206	58.52
2	Snow	174	49.43
3	At night	77	21.88
4	In congested, "stop-and-go" traffic	300	85.22
5	In heavy traffic that is flowing	205	58.24
6	On interstate highways	32	9.09
7	Freeway off ramps, or when exiting highways	257	73.01
8	On curvy roads	215	61.08
9	On neighborhood or city streets with traffic lights	276	78.41
94	Other	20	5.68
	None of the above	22	6.25
	Subtotal valid responses	1,784	
	Total respondents	352	100.00

Q10. Other, please describe

Category	Description	Count	Percentage
1	<i>All conditions</i>	13	65.00
2	<i>Ice/slippery roadways</i>	1	5.00
3	<i>Hills</i>	0	0.00
94	<i>Other</i>	4	20.00
95	Response did not pertain to question	1	5.00
96	Text response not reported	1	5.00
	Subtotal valid responses	19	100.00
	Total	20	

Q11. Does your vehicle have the option of using conventional cruise control without adaptive cruise control? (Note: conventional cruise control provides constant speed control only and does not automatically adjust your speed.)

Category	Description	Count	Percentage
1	Yes	155	46.41
2	No	168	50.30
8	Don't know (written on form)	11	3.29
	Subtotal valid responses	334	100.00
9	Not ascertained	1,325	
	Total	1,659	

Q11. If yes, how frequently have you been confused about which system is operating?

Category	Description	Count	Percentage
1	Always confused	9	5.81
2	Frequently confused	3	1.94
3	Sometimes confused	13	8.39
4	Rarely confused	36	23.22
5	Never confused	92	59.35
94	Other	0	0.00
	Subtotal valid responses	153	
	Total respondents who answered "Yes" to Q11.	155	100.00

Q12. Compared to driving with cruise control off, how quickly do you notice and respond to unexpected road hazards when the adaptive cruise control is engaged (turned on)?

Category	Description	Count	Percentage
1	I respond more slowly	30	8.80
2	I respond in the same time	166	48.68
3	I respond more quickly	82	24.05
4	I don't know	63	18.48
	Subtotal valid responses	341	100.00
9	Not ascertained	1,318	
	Total	1,659	

Q13A. If you could not use your adaptive cruise control any more, how would your driving change?

Category	Description	Count	Percentage
1	I would usually keep a smaller gap between my vehicle and the vehicle ahead of me than I do now using ACC	85	26.47
2	I would usually keep the same gap between my vehicle and the vehicle ahead of me than I do now using ACC	161	50.16
3	I would usually keep a larger gap between my vehicle and the vehicle ahead of me as I do now using ACC	75	23.36
	Subtotal valid responses	321	100.00
	Total respondents	1,659	
9	Not ascertained	1,338	

Q13B. If you could not use your adaptive cruise control any more, how much would you use conventional cruise control (constant speed control)

Category	Description	Count	Percentage
1	I would not use conventional cruise control either	25	7.57
2	I would use conventional cruise control less often than I do now	71	21.52
3	I would use conventional cruise control as often as I do now	175	53.03
4	I would use conventional cruise control more often than I do now	25	7.58
5	I don't know	34	10.30
	Subtotal valid responses	330	100.00
9	Not ascertained	1,329	
	Total	1,659	

Q14. For each of the following statements on the left, please indicate how much you agree or disagree.

Q14a. The lights/symbols on the adaptive cruise control system are easy to understand.

Category	Description	Count	Percentage
1	Strongly disagree	4	1.23
2	Disagree	15	4.62
3	Neutral	54	16.62
4	Agree	128	39.39
5	Strongly agree	108	33.23
	Not applicable	14	4.31
	Subtotal valid responses	325	100.00
8	Don't Know (written on form)	2	0.62
9	Not ascertained	1,334	
	Total	1,659	

Q14b. The sounds made by the adaptive cruise control system are easy to understand.

Category	Description	Count	Percentage
1	Strongly Disagree	4	1.25
2	Disagree	10	3.11
3	Neutral	59	18.38
4	Agree	87	27.10
5	Strongly Agree	69	21.50
	Not Applicable	90	28.04
	Subtotal valid responses	321	100.00
8	Don't Know (written on form)	2	0.62
9	Not ascertained	1,338	
	Total	1,659	

Q14c. Using adaptive cruise control system relieves me of stress when driving

Category	Description	Count	Percentage
1	Strongly Disagree	15	4.59
2	Disagree	42	12.84
3	Neutral	89	27.22
4	Agree	104	31.80
5	Strongly Agree	54	16.51
	Not Applicable	21	6.42
	Subtotal valid responses	327	100.00
8	Don't Know (written on form)	2	0.61
9	Not ascertained	1,332	
	Total	1,659	

Q14d. I tend to change lanes less frequently when using adaptive cruise control.

Category	Description	Count	Percentage
1	Strongly Disagree	8	2.45
2	Disagree	43	13.15
3	Neutral	75	22.94
4	Agree	123	37.61
5	Strongly Agree	50	15.29
	Not Applicable	26	7.95
	Subtotal valid responses	327	
8	Don't Know (written on form)	2	0.61
9	Not ascertained	1,332	
	Total	1,659	100.00

Q14e. I tend to follow the vehicle ahead more closely when using adaptive cruise control.

Category	Description	Count	Percentage
1	Strongly Disagree	73	22.39
2	Disagree	145	44.48
3	Neutral	58	17.79
4	Agree	22	6.74
5	Strongly Agree	5	1.53
	Not Applicable	21	6.44
	Subtotal valid responses	326	100.00
8	Don't know (written on form)	2	0.61
9	Not ascertained	1,333	
	Total	1,659	

Q14f. I tend to set adaptive cruise control to a shorter gap (closer following distance) in heavy traffic than in light traffic.

Category	Description	Count	Percentage
1	Strongly Disagree	53	16.26
2	Disagree	88	26.99
3	Neutral	59	18.10
4	Agree	43	13.19
5	Strongly Agree	16	4.91
	Not Applicable	65	19.94
	Subtotal valid responses	326	100.00
8	Don't know (written on form)	2	0.61
9	Not ascertained	1,333	
	Total	1,659	

Q14g. My adaptive cruise control sometimes locks on to a vehicle other than the vehicle immediately in front of me.

Category	Description	Count	Percentage
1	Strongly Disagree	62	19.14
2	Disagree	86	26.54
3	Neutral	47	14.51
4	Agree	70	21.60
5	Strongly Agree	23	7.10
	Not Applicable	34	10.49
	Subtotal valid responses	324	100.00
8	Don't know (written on form)	2	0.62
9	Not ascertained	1,335	
	Total	1,659	

Q14h. More cars cut me off or pull in front of me when I am using adaptive cruise control.

Category	Description	Count	Percentage
1	Strongly Disagree	25	7.65
2	Disagree	65	19.88
3	Neutral	92	28.13
4	Agree	95	29.05
5	Strongly Agree	17	5.20
	Not Applicable	31	9.48
	Subtotal valid responses	327	100.00
8	Don't know (written on form)	2	0.61
9	Not ascertained	1,332	
	Total	1,659	

Q15. Please rate how well the adaptive cruise control would assist you to avoid colliding with the vehicle in front of you under the following circumstances?

Q15a. You are following a vehicle in stop-and-go traffic.

Category	Description	Count	Percentage
1	Not at all	84	25.69
2	Poorly	35	10.70
3	Fairly Well	57	17.43
4	Perfectly	22	6.73
8	Don't know	129	39.45
	Subtotal valid responses	325	100.00
9	Not ascertained	1,332	
	Total	1,659	

Q15b. You encounter a stopped car in your lane ahead.

Category	Description	Count	Percentage
1	Not at all	49	14.89
2	Poorly	22	6.69
3	Fairly Well	92	27.96
4	Perfectly	51	15.50
8	Don't know	115	34.95
	Subtotal valid responses	329	100.00
9	Not ascertained	1,330	
	Total	1,659	

Q15c. You are following a vehicle on a curvy road.

Category	Description	Count	Percentage
1	Not at all	47	14.33
2	Poorly	65	19.82
3	Fairly Well	69	20.04
4	Perfectly	24	7.32
8	Don't know	123	37.50
	Subtotal valid responses	328	100.00
9	Not ascertained	1,331	
	Total	1,659	

Q16. How often have you encountered each of these conditions?**Q16a. The adaptive cruise control system would slow unexpectedly when there is no vehicle immediately ahead of you.**

Category	Description	Count	Percentage
1	Very Often	4	1.24
2	Often	13	4.02
3	Occasionally	43	13.31
4	Rarely	73	22.60
5	Never	190	58.82
	Subtotal valid responses	323	100.00
9	Not ascertained	1,336	
	Total	1,659	

Q16b. The adaptive cruise control system would brake abruptly or brake hard causing the vehicle behind you to get uncomfortably close, or to brake hard.

Category	Description	Count	Percentage
1	Very Often	3	0.93
2	Often	6	1.85
3	Occasionally	49	15.12
4	Rarely	86	26.54
5	Never	180	55.56
	Subtotal valid responses	324	100.00
9	Not ascertained	1,335	
	Total	1,659	

Q16c. The adaptive cruise control system would accelerate unexpectedly.

Category	Description	Count	Percentage
1	Very Often	4	1.23
2	Often	9	2.77
3	Occasionally	40	12.31
4	Rarely	60	18.46
5	Never	212	65.23
	Subtotal valid responses	325	100.00
9	Not ascertained	1,334	
	Total	1,659	

Q16d. You forgot to turn off the system.

Category	Description	Count	Percentage
1	Very Often	4	1.23
2	Often	7	2.16
3	Occasionally	39	12.04
4	Rarely	71	21.91
5	Never	203	62.65
	Subtotal valid responses	324	100.00
9	Not ascertained	1,335	
	Total	1,659	

Q16e. The system shut itself off unexpectedly.

Category	Description	Count	Percentage
1	Very Often	3	0.93
2	Often	5	1.55
3	Occasionally	22	6.83
4	Rarely	41	12.73
5	Never	251	77.95
	Subtotal valid responses	322	100.00
9	Not ascertained	1,337	
	Total	1,659	

Q17. Do you normally use the same gap (headway) setting or do you adjust the gap based on driving conditions ?

Category	Description	Count	Percentage
1	I don't know how to change the amount of gap between my vehicle and the vehicle ahead	47	15.11
2	I always choose the same setting for the amount of gap between my vehicle and the vehicle ahead	86	27.65
3	I change the amount of gap between my vehicle and the vehicle ahead as driving conditions change	158	50.80
4	My system doesn't allow changing the following distance	20	6.43
	Subtotal valid responses	311	100.00
9	Not ascertained	1,348	
	Total	1,659	

Q18. At what gap (headway) setting do you usually have the adaptive cruise control set?

Category	Description	Count	Percentage
1	At the shortest setting, which is as close to the lead vehicle as the system allows	35	11.01
2	At a medium setting	121	37.05
3	At the longest setting, which is as far from the lead vehicle as the system allows	76	23.90
4	My system doesn't allow changing the following distance	24	7.54
5	I don't know	62	19.50
	Subtotal valid responses	318	100.00
9	Not ascertained	1,341	
	Total	1,659	

Q19. Since you have owned your vehicle with adaptive cruise control, have you driven any other vehicle equipped with only conventional cruise control and had a collision or a "close call" because you expected the vehicle you were driving to automatically slow down?

Category	Description	Count	Percentage
1	Yes	12	3.70
2	No	312	96.30
	Subtotal valid responses	324	100.00
9	Not ascertained	1,335	
	Total	1,659	

Q20. Does your adaptive cruise control system create any new driving problems or safety concerns for you?

Category	Description	Count	Percentage
1	Yes	45	13.93
2	No	277	85.76
8	Don't know	1	0.31
	Subtotal valid responses	323	100.00
9	Not ascertained	1,336	
	Total	1,659	

Q20. If yes, please explain.

Category	Description	Count	Percentage
1	<i>Adapting to the change between non-cruise or Conventional Cruise Control and ACC</i>	7	14.89
2	<i>ACC responses on turns/curves</i>	3	6.38
3	<i>Sudden changes in speed</i>	12	26.67
4	<i>Sensors pick up vehicles in other lanes/Big vehicles</i>	4	8.89
5	<i>Other vehicle merging</i>	6	13.33
6	<i>Remaining alert</i>	2	4.26
7	<i>Relying too much on system</i>	2	4.26
94	<i>Other</i>	10	21.28
	Subtotal valid responses	46	
	Total respondents who answered "Yes" to Q20.	45	100.00
95	Response did not pertain to the question	1	2.13
96	Text response not reported	3	6.38

Q21.To what extent have you been confused about what speed the adaptive cruise control is set to?

Category	Description	Count	Percentage
1	Extremely confused	4	1.23
2	Very confused	3	0.92
3	Moderately confused	17	5.21
4	Slightly confused	48	14.72
5	Not at all confused	254	77.91
	Subtotal valid responses	326	100.00
9	Not ascertained	1,333	
	Total	1,659	

Q22.To what extent have you been confused about what following distance the adaptive cruise control is set to?

Category	Description	Count	Percentage
1	Extremely confused	7	2.16
2	Very confused	6	1.85
3	Moderately confused	25	7.72
4	Slightly confused	44	13.58
5	Not at all confused	242	74.69
	Subtotal valid responses	324	100.00
9	Not ascertained	1,335	
	Total	1,659	

Q23. How has your reliance on adaptive cruise control changed since you first drove the vehicle?

Category	Description	Count	Percentage
1	I rely on it more now than I did in the beginning.	86	26.87
2	I rely on it less now than I did in the beginning.	30	9.38
3	My reliance has stayed about the same.	204	63.75
	Subtotal valid responses	320	100.00
8	Don't know (written on form)	0	0.00
9	Not ascertained	1,339	
	Total	1,659	

Q23. I rely on it more now than I did in the beginning, why?

Category	Description	Count	Percentage
1	<i>Reduction in stress of driving</i>	9	10.71
2	<i>Level of comfort/knowledge with using ACC/Trust system</i>	35	41.67
3	<i>Increased safety</i>	9	10.71
94	<i>Other</i>	1	1.19
	Subtotal valid responses	54	
	Total respondents who responded "more" to Q23.	86	100.00
95	Response did not pertain to the question	1	1.19
96	Text response not reported	31	36.90

Q23. I rely on it less now than I did in the beginning, why?

Category	Description	Count	Percentage
1	<i>Poor quality of operation/unreliable</i>	6	20.00
2	<i>Uncomfortable with ACC</i>	0	0.00
3	<i>No longer learning/Novelty wore off</i>	1	3.33
94	<i>Other</i>	1	3.33
	Subtotal valid responses	8	
	Total respondents who reported "less" to Q23.	30	100.00
95	Response did not pertain to the question	2	6.67
96	Text response not reported	20	66.67

Q24. Have you ever unintentionally collided with something when you had the adaptive cruise control engaged (turned on) ?

Category	Description	Count	Percentage
1	Yes	2	0.61
2	No	325	99.39
	Subtotal valid responses	327	100.00
9	Not ascertained	1,332	
	Total	1,659	

Q24. If yes, please describe the situation?

Category	Description	Count	Percentage
1	<i>Event was related to ACC use</i>	0	0.00
2	<i>Stationary object</i>	2	100.00
3	<i>Moving object/vehicles/motorcycle</i>	0	0.00
4	<i>Pedestrian/bicyclist</i>	0	0.00
	<i>Other</i>	0	0.00
	Subtotal valid responses	2	
	Total respondents who answered "Yes" to Q24	2	100.00

Q25. Overall, are you a safer driver using adaptive cruise control than you would be if you only used conventional cruise control?

Category	Description	Count	Percentage
1	Yes, safer	123	38.44
2	Neither more nor less safe	174	54.37
3	No, less safe	23	7.19
	Subtotal valid responses	320	100.00
9	Not ascertained	1,339	
	Total	1,659	

Q26. Is there anything about the way the adaptive cruise control system works that you think should be improved or changed?

Category	Description	Count	Percentage
1	Yes	93	30.49
2	No	210	68.85
	Subtotal valid responses	305	100.00
8	Don't know (written on form)	2	0.66
9	Not ascertained	1,354	
	Total	1,659	

Q26. If yes, please explain.

Category	Description	Count	Percentage
1	<i>Unsafe and/or uncomfortable reduction or increase in speed</i>	25	24.75
2	<i>Area of sensitivity/coverage</i>	33	35.48
3	<i>Ease of use</i>	9	8.91
4	<i>Flexibility of settings</i>	8	8.60
5	<i>Reliability</i>	6	6.45
6	<i>Vehicles merging</i>	3	3.06
7	<i>Resume cruise speed more quickly</i>	3	2.97
8	<i>Audible warning</i>	8	8.60
94	<i>Other</i>	11	10.89
	Subtotal valid responses	106	
	Total respondents who responded "Yes" to Q26	93	100.00
95	Response did not pertain to the question	6	5.94
96	Text response not reported	1	0.99

Q27. Have you recently stopped (given up) driving?

Category	Description	Count	Percentage
1	Yes	0	0
2	No	332	100.00
	Subtotal valid responses	332	100.00
9	Not ascertained	1,327	
	Total	1,659	

Q27. If yes, please explain.

Category	Description	Count	Percentage
1	<i>Deteriorating driving skills</i>	0	0.00
2	<i>Vision problems</i>	0	0.00
3	<i>Crash/Accident or other incident</i>	0	0.00
94	<i>Other</i>	0	0.00
	Subtotal valid responses	0	0.00
	Total respondents who responded "Yes" to Q27	0	0.00
95	Response did not pertain to the question	0	
96	Text response not reported	0	

Q28. In general, do you believe that car manufacturers are doing enough to design vehicles to accommodate an aging population?

Category	Description	Count	Percentage
1	Yes	1,103	71.07
2	No	384	24.74
	Subtotal valid responses	1,552	100.00
8	Don't know (written on form)	65	4.19
9	Not ascertained	107	
	Total	1,659	

Q28. If you answered no, then what more do you believe could be done?

Category	Description	Count	Percentage
1	<i>Improve user interface (displays and/or controls) Simplified and larger controls</i>	78	20.31
2	<i>Improved visibilities around vehicle / reducing blind spots / improve mirrors</i>	61	15.89
3	<i>Improved safety features (e.g. backing aids)</i>	44	11.46
4	<i>Improved entry/exit access</i>	30	7.81
5	<i>Seating/seat belt (size and comfort)</i>	18	4.69
6	<i>Reduce cost for safety features</i>	8	2.08
7	<i>Make safety features available on all vehicles (not just high end)</i>	16	4.17
8	<i>Improved gas mileage/other energy conservation</i>	17	4.43
9	<i>Increased automation</i>	20	5.21
10	<i>Minimize pedal confusion</i>	5	1.30
94	<i>Other</i>	47	12.24
	Subtotal valid responses	344	
	Total respondents who responded "No" to Q28	384	100.00
95	Response did not pertain to question	51	13.28
96	Text response not reported	64	16.67

APPENDIX D: DISCUSSION GUIDE FOR TELEPHONE INTERVIEWS WITH OWNERS OF ADAPTIVE CRUISE CONTROL SYSTEMS

Telephone Interview Discussion Guide

Hello— (introduce yourself, and identify you are from the Automobile Club of Southern California and you are an Automotive Research Specialist in the Club's Automotive Research Center.)

Some time back we sent you a survey about your experience with (adaptive cruise control) in your Year/Make/Model. You indicated you would like to participate in our follow-up telephone interviews. This will only take a few minutes, is now a good time, or can you suggest a better time?

On your survey you indicated that the (adaptive cruise control) on your car could be improved—read comment from written questionnaire. Probe further into this comment.

Ask if they have any specific examples of when the (adaptive cruise control) was particularly helpful or caused a problem.

Have you changed your driving habits as a result of the (adaptive cruise control)? If so how? How long did that take?

If they answered no to the last question, "In general, do you believe that car manufacturers are doing enough to design vehicles to accommodate an aging population? Probe into what they think can be done.

APPENDIX E: COMMENTS FROM TELEPHONE INTERVIEWEES WHO OWN ADAPTIVE CRUISE CONTROL

ID	Age	Gender	Q26 - Improvements	Technology - Helpful/Hurtful	Change driving habits	Q28 - Mfg's not doing enough	Other concerns
7195	66	M	When going around curves sometimes the laser fixes on a vehicle in another lane. That needs correcting. When using the ACC it slows down fine but when accelerating it is very aggressive, I feel that needs improvement.	Generally I find the adaptive cruise control helpful. No real problems.	I haven't really changed my driving habits because of the adaptive cruise control. It really takes some getting used to though.	I think the manufacturers are doing enough for older drivers. I would like to see night vision added like I read about. I'm generally pleased with my vehicle it's getting easier and easier to drive.	none
6533	37	M	Currently the system comes to an abrupt stop when another car cuts in front of me. If that vehicle then continues across my path into another lane the system then accelerates hard to catch up to the vehicle in front. I don't use it much in town because of that.	Problems: hard braking and accelerations The system is hard to use in moderate to heavy traffic. The ACC is generally useful light to moderate traffic when I use the largest lane space setting.	I have changed my driving habits when using the system. I use the longest setting and look further down the highway. I drive more defensively. It took about a week playing with the system to get used to it. It didn't take long for us to realize it wasn't as cool as we thought it would be.	I feel they are doing OK. They are continually improving the cars.	none
7069	68	M	I would like a louder emergency alert instead of the softer beeping I now have with the ACC. I would like a greater following distance setting than I now have.	I have no problems with the system. It's great when on long highway trips. I just came back from a five hour trip to Arizona	I haven't changed my driving habits. My father was a LA Cop. He drilled safe driving habits into me. It took me one trip to Las Vegas to learn the system. I feel the salesman should have trained me or provided	That's a loaded question, what do you consider an aging population? I can't answer that.	"You are looking to cover your butt or reduce insurance costs or increase rates." I explained the intended use of the survey.

ID	Age	Gender	Q26 - Improvements	Technology - Helpful/Hurtful	Change driving habits	Q28 - Mfg's not doing enough	Other concerns
					a training video or something.		
6458	71	M	The sun at low angles turns the system off. Using the wipers also turns the system off. That needs improvement. The system accelerates hard to close the gap between my car and the one in front if a gap opens up, that's annoying.	I like the system because if someone cuts in front of me the system applies the brakes before I can react to slow me down. I use it in heavy traffic with a short setting for that reason. I don't recall having any problems with the system.	I have become dependent on the system in traffic; I allow the system to apply the brakes before [I do]. It took me about 2 to 3 months to really come familiar with the system. I did not get any training with the system, only a manual.	I would like to see alcohol detectors in the vehicle for drivers convicted of DUIs. Dual position memory driver seats are great when two different people use the car.	He asked how the study would be used. I explained our intent.

ID	Age	Gender	Q26 - Improvements	Technology - Helpful/Hurtful	Change driving habits	Q28 - Mfg's not doing enough	Other concerns
8135	80	M	The ACC is too responsive for normal highway driving, it will down shift and accelerate hard on slight grades and when making up distance to the lead car. I would like to see 2 to 3 mph increments on the system for speed settings instead of the 5mph increments the system now has, this would attract less law enforcement attention on the highway	The system is very useful when someone cuts in front of you, it can react faster than you can apply the brake. It's also useful in heavy traffic since it paces the car in front of you and you do not have to constantly use the throttle and brake to keep pace with traffic. The system quits in the rain, there is a warning light that lets you know. I haven't had any problems with it.	I have changed my driving habits a little since I have the ACC. I can relax a little more when coming up on traffic since it will adjust its speed automatically. It took me about ten minutes to become used to the system. It's a great benefit.	I would like to see automatic dimming rear view mirrors on the outside as well as inside. Get rid of polarized displays so polarized sunglasses can be used effectively.	He asked how the study would be used. I explained our intent.
6071	76	M	Eliminate the longest distance or gap setting, I never use it. I would like to be able to engage the standard cruise control easier than it is now.	I find the system very useful in the diamond lane and on trips. The system saves a lot of gas on trips and has the added safety benefit of reacting quickly when someone cuts in front of you without warning.	My driving habits haven't changed too much because of the ACC; I find it to be a great safety system in traffic because it can brake quickly when someone cuts in front of me. It took me a couple of times using it to become used to it especially the distance control with the two smaller gaps.	I don't believe the manufacturers are doing all they could, I have a bad back and it's difficult for me to turn to see what's beside my car. I would like the ability to know what's beside my car; I think some cars now have that capability.	none

ID	Age	Gender	Q26 - Improvements	Technology - Helpful/Hurtful	Change driving habits	Q28 - Mfg's not doing enough	Other concerns
5855	40	M	It would be nice if the acceleration of the vehicle, after an obstacle leaves, could be adjusted. It accelerates fairly hard. Also in tight turns it sometimes picks up other vehicles.	I find the system very useful in every-day traffic when the speed is constantly changing. I just set it and it does most of the work. I don't recall any problems however it does accelerate hard when a space opens up in front of you.	The system probably keeps a better distance between cars than I do. Time? It didn't take that long to get used to, perhaps a couple days of driving after reading the owner's manual.	I'm forty years old now and don't really any thoughts on that. The ACC has advantages for every driver.	He asked how the study would be used. I explained our intent.
136	46	M	I would like a greater following distance setting available than I now have with the system. Also, when the road curves the system occasionally will pick up a car in a lane beside you. I would like a warning when it detects that situation.	It's very useful on the freeway and particularly long trips. Also, when you are coming into the city and encounter slowing traffic it will react for you and slow down. It's fairly conservative and will warn you to take over.	I don't think I have changed my driving habits using the system since I'm conservative in my driving and still pay attention. It took me a couple of months and several trips before I became comfortable with the system.	I never thought about it.	He asked how the study would be used. I explained our intent.

ID	Age	Gender	Q26 - Improvements	Technology - Helpful/Hurtful	Change driving habits	Q28 - Mfg's not doing enough	Other concerns
3324	62	M	The system needs a wider beam or something to compensate for turns in the road where the vehicle sees a temporary gap in the signal and accelerates until it regains the vehicle in front of it. This also happens when there are dips or rises in the road. They need to overcome this problem. Also the system needs to be more intuitive and should factor in speed, weather, and traffic, and adjust.	Adaptive cruise control needs to be used on open highways and not in the city. It's good for long trips. I've experienced problems where the system accelerates and then brakes as it loses and regains the vehicle in front.	I haven't really changed my driving habits and I'm still not comfortable with the system for the reasons I mentioned earlier. My wife refuses to use the ACC, she does not trust it.	A lot of drivers should not be driving on the road today. I've seen more bad drivers lately than at any time in my life. Driver training should be made mandatory for every driver and the manufacturers should sponsor this, especially for the teen drivers I've seen lately. Driver training is no longer given in high school.	I explained our intent.
535	58	M	The system on my Infiniti is very sensitive to semi trucks in other lanes. When the highway curves it will lock onto trucks in other lanes and abruptly slow down. This happens in other than straight line driving. This needs improvement. This took some getting used to.	I think this technology is very beneficial and I use it at its maximum setting. I mentioned the problem with it locking onto trucks in other lanes.	I haven't necessarily changed my driving habits but I have become more conscious of vehicles in front of me and when they cut in because of the systems abrupt braking when that happens. It didn't really take long to get used to it except for the abrupt braking.	Systems such as Adaptive Cruise Control can help older drivers along with systems like lane departure control; unfortunately they are only available only in upscale cars. I think the manufacturers are dragging their feet because of economics.	none

ID	Age	Gender	Q26 - Improvements	Technology - Helpful/Hurtful	Change driving habits	Q28 - Mfg's not doing enough	Other concerns
2594	87	M	On making a lane change, a wider view on the sensors might avoid the speed changes, when passing through the gap in coverage from the car in the lane you are leaving to the car in the lane you are moving into. That needs improving. The system also takes some time to react when someone cuts in front of you in your lane, it can come pretty close sometimes. Otherwise it's a fantastic system.	The system is very beneficial for general cruising on the interstate. I haven't had any other problems except the cutting in problem I mentioned earlier.	I don't think I have changed my driving habits using the system. I set the adaptive cruise control 5 mph above the speed limit and it works fine as traffic changes speed. It is such a fine system that I became comfortable with it within five minutes or so.	"Good question" I think the insurance companies and the DMV are doing older drivers a disservice. The DMV should be testing older drivers on a regular basis say starting at 80. Most older drivers do not turn their heads and look before they change lanes. Some drivers look, others don't. They need training. Also I would like to see a better mirror to see behind my vehicle.	none
3567	74	M	I would like more assurance that it will work in emergencies. When I first got the car I was showing my daughter how the system worked at low speed and came very close to another car, I was going about twenty mph and had to hit the brakes hard. I never trusted the system after that.	I generally use the system when taking long trips on the freeways; it's a very convenient system to have for that. I did not have any problems with the system.	I don't think I changed my driving habits since I got the adaptive cruise control; it's very good for the freeway. I got used to it right away.	I think the manufacturers are doing enough. I would like a louder alarm for the ACC when you get close to another car. The ACC has a lot of potential for safety since it always pays attention even if your mind wanders. I now have a car without ACC and do not feel as safe as I did when I had it.	none

ID	Age	Gender	Q26 - Improvements	Technology - Helpful/Hurtful	Change driving habits	Q28 - Mfg's not doing enough	Other concerns
4335	67	M	My adaptive cruise control will pick up vehicles in another lane when the highway curves; I'm aware of that now. Other than that I like it very much.	I find the adaptive cruise control very useful on long trips, which is how I generally use it. The system saves me gas since I'm not going between the gas and brakes to keep my speed steady. Also the system gives you a warning beep when someone cuts in front of your path in case you have a little highway hypnosis going on.	I have changed my driving habits since I began using the ACC more often. I'm comfortable enough with the system that I will use in town where there is a long stretch between signals. It took me about two months to become fully used to the system since I don't drive every day.	I think the manufacturers are doing enough to accommodate seniors; I have memory settings on my seats and mirrors, and the gas pedal and brake pedal move in and out. The doors and tailgate are power, it has a rear-view video camera etc. (The member's Infiniti SUV sounds like it is fully equipped).	I explained the purpose of our survey.
9411	75	M	I found out when I first got the system that it switches off in heavy rain when you turn the wipers on full. Also when you are coming up on a slow vehicle, the system gradually slows your car, and then when you change lanes around the slow vehicle your car will accelerate hard to regain its set speed.	The system is especially useful when someone cuts in front of you sharply, it will brake hard and sound an alarm to warn you. I haven't had any problems with the system in twenty thousand miles of driving. We make a trip to the Midwest each summer and we rely on the adaptive cruise control since you can relax a little using it.	Except for the examples I've given I don't think so. I got used to the system after the first couple of times using it.	No, I don't think all the manufacturers are doing enough. The Toyota Sienna Van I drive has a high seating position that's easy on your legs. Too many cars have you setting on the floor with your legs straight out. I don't think that's good for seniors. The member mentioned "they could drop the price".	I'm glad to see someone's paying attention to that.

ID	Age	Gender	Q26 - Improvements	Technology - Helpful/Hurtful	Change driving habits	Q28 - Mfg's not doing enough	Other concerns
1180	46	M	The ACC turns off in heavy rain. When going up a hill my car will get real close to the vehicle in front of me and then brake sharply when it's too close. I would like to see that improved. Also the vertical detection range should be increased to detect raised vehicles.	I find the ACC especially useful on long trips on the open highway. I also use it in town where it works OK sometimes. The ACC hasn't caused me any problems except on inclines like I mentioned.	I don't think I have changed my driving habits because of the ACC. I use the conventional cruise control more often since it has one mph increments and the ACC has 5mph increments. It didn't take long to learn. I read the owner's manual and experimented with it.	I don't know except the vehicles are going much faster now. For safety measures I would like a sensor that warns when there is a vehicle beside you when you want to change lanes.	I explained the purpose of our survey.
2018	45	M	I feel the ACC brakes too hard when someone cuts in front of me and when a slower car moves out of the way my vehicle accelerates very hard to regain its set speed. I think the acceleration should be more gradual	On the open highway I find the ACC is great, I have tried using it in the city but find it to difficult to use. I use the standard cruise control more often because I can control the rate of braking. The ACC hasn't caused problems for me.	I use the ACC on the open highway mostly so I haven't changed my driving habits much. I use standard cruise control more often on local driving. It didn't take any time at all to get used to it.	I will say no only because I feel the control layout in some cars is confusing and could be hard for a senior to figure out.	I explained the purpose of our survey.

ID	Age	Gender	Q26 - Improvements	Technology - Helpful/Hurtful	Change driving habits	Q28 - Mfg's not doing enough	Other concerns
6280	58	M	The ACC is pretty good as it is, however it brakes fairly hard when someone cuts in front of me into the lane, but I guess it has to prevent a collision. I have only used it about ten times. I don't drive many miles each year.	I find the ACC useful when traveling in moderate freeway traffic conditions. I haven't had any problems since I'm still very cautious using it.	I haven't really changed my driving habits since I've used it so few times. I'm still getting used to the system. I need to read more about it. I still do not fully trust this computer-based system.	The short answer is no, my wife and I find it is more difficult to get into certain cars as we get older. Entry and exit is a problem that's needs to be looked at and especially blind spots in cars, that's a big issue. Visibility from my Jaguar is a problem.	No, I haven't thought much about it, I read about surveys like this and also car magazines to keep up with what's happening in the automotive world

DOT HS 810 917
March 2008



U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

