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Trends in North American Intelligent Transportation Systems: A Year 2000 Appraisal

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16. Abstract

This report examines general market trends for Intelligent Transportation Systems (ITS) in North America and specific trends associated with (1) the E911 mandate, (2) mobile internet devices, (3) navigation systems, and (4) vehicle communication buses. Product liability concerns pertaining to ITS in general and adaptive cruise control (ACC) and collision avoidance/warning (CA/W) are also examined. Information pertaining to these topics was assembled via internet searches, review of the author's personal files, and personal communication with colleagues. This is a quick turnaround report, so many topics were not examined in great depth.

Key findings are: (1) The most desired features were ACC and Mayday services (43% and 38% of drivers want, respectively, median prices of $400 and $500). (2) The E911 mandate will result in all cellular phones having GPS within the next few years. (3) In the short term, it is uncertain if the most popular mobile internet device will be a phone with PDA functions or a PDA with phone functions. In the long term, the most popular device may be a wearable computer or a wrist computer. (4) The intelligent data bus (IDB) will be the defacto standard in the next few years. (5) Product liability concerns are particularly significant for ACC, advanced vehicle control systems, and CA/W systems.

17. Key Words		18. Distribution Statement	
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1 ISSUES

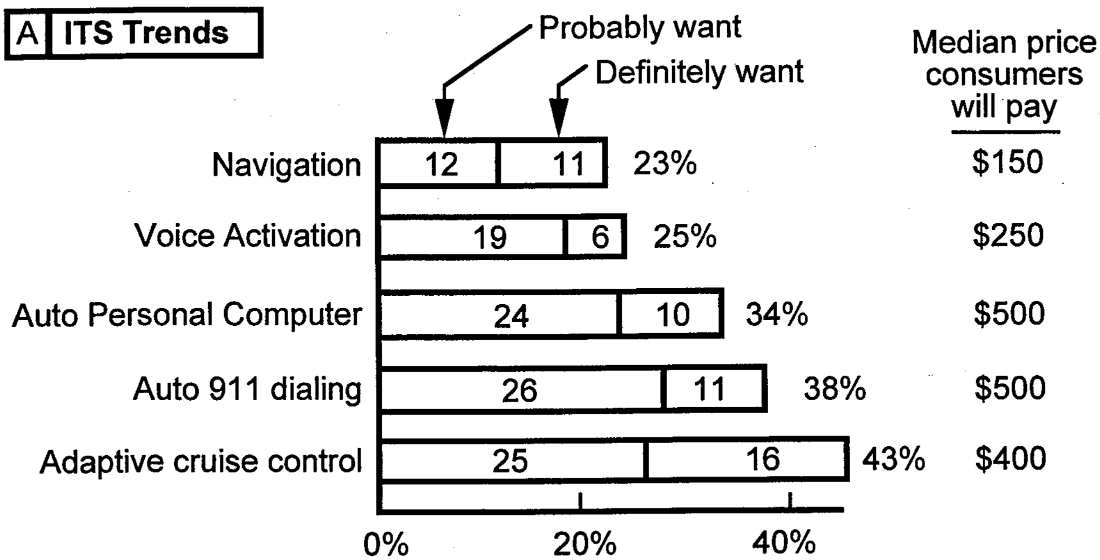
A	general trends	**ITS** technologies in North America; customer interest in ITS
B	specific trends	describe **FCC E911 rule**; impact on Mayday systems, telematics
C		**mobile Internet devices**; impact on in-vehicle telematics
D		**navigation systems**
E		vehicle communication buses, especially **IDB**
F	product liability	**PL** concerns for ITS in general; ACC and collision avoidance

2 METHOD

Internet search supplemented by personal files and contacts

3 SELECTED FINDINGS

A ITS Trends



Predicted Market Penetration (% Cars Produced) by 2009 from Michigan Delphi

System	Penetration
Navigation	25%
OnStar-like Service	25%
Collision Warning	22.5%
In-Vehicle Messaging	20%
Adaptive Cruise Control	15%
Automatic Toll Collection	10%

Note:
The report contains a large and detailed table containing predictions by year for various technologies. Readers are encouraged to review that table.

B FCC E911 Rule and Phones

- to comply, phones must have ALI capability within next few years, probably via GPS
- automatic location identification (ALI) accuracy is 50 m for 67%, 150 m for 95%
- systems sharing ALI will see some cost reductions and market growth
- exponential increases in number of subscribers over time
- wireless subscribers may outnumber wireline subscribers in future
- large growth expected for services resembling OnStar (Mayday plus other services)
- vehicles supporting Bluetooth-capable phones expected within next year
- future support for WAP and VoiceXML (for phone access of internet) is unknown

C Mobile Internet Devices

- **market for mobile devices will continue to grow**
- leading PDA OS for next year or so will be Palm

Possible future devices	Comment
Phone with PDA functions	phone manufacturers have economy of scale
PDA with phone functions	internet could reduce call costs; voice quality is a concern
Laptop with a phone	probably too bulky
Wearable computer	belt-mounted computer is easy to carry; glasses display can be "geekish" but display area is large
Wrist computer	culturally accepted to wear a device on wrist and look at it for information; small display is limiting
Something else	not yet invented or well known

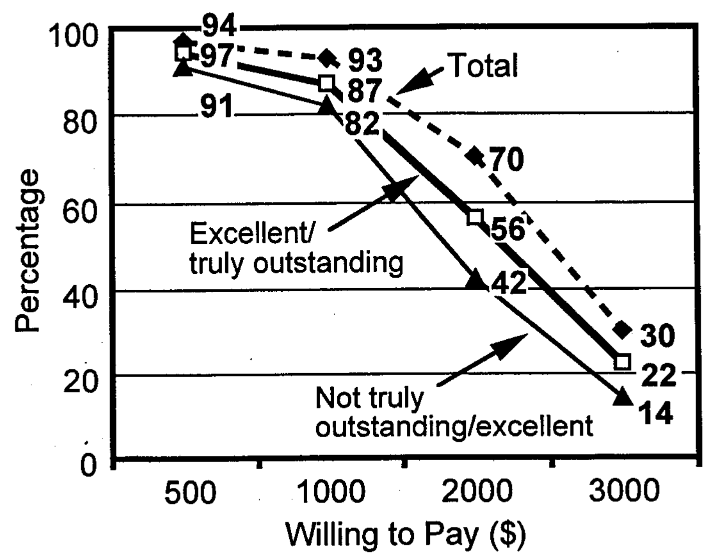
For automotive applications, the following questions need to be addressed:

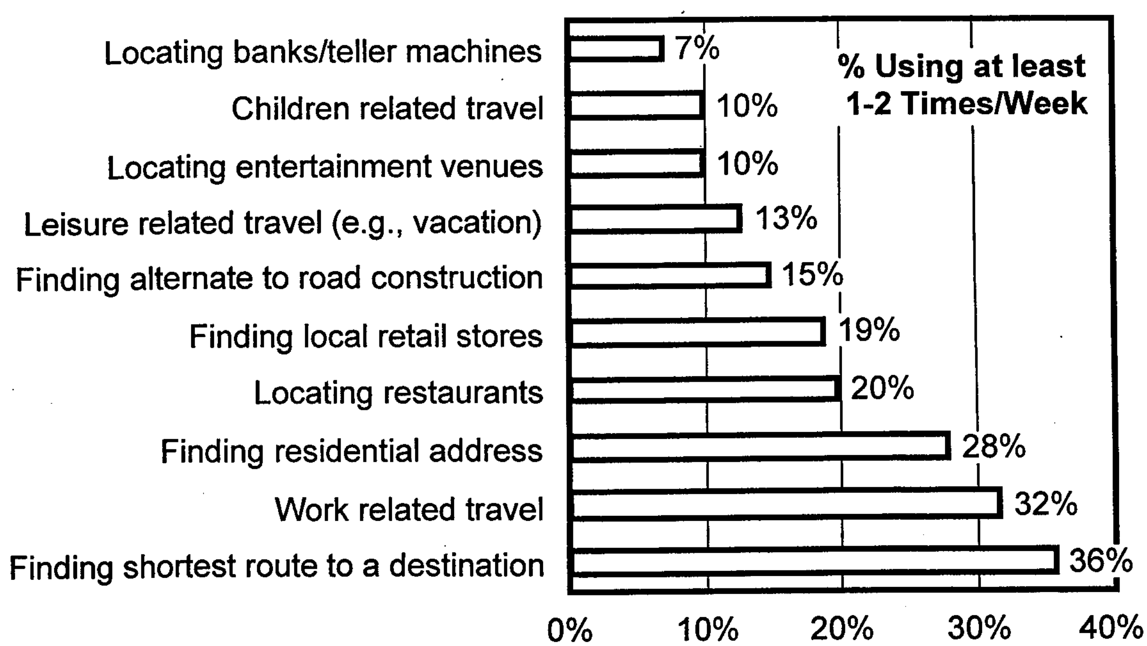
- What data needs to be synchronized between the car and the portable device?
- How will the device and the car communicate (e.g.,IR, Bluetooth, docking station)?
- What will be used for input (e.g., voice, handwriting, gestures?) and output (HUD, eyeglasses)?
- What kinds of information will be exchanged (address lists, email, news, etc.)?
- How much is too much for people to do while driving?

D Navigation Market

Future Developments

- ISO usability test standard developed
- voice input becomes more common
- HUD for output
- wearable computer implementations





E | IDB Prediction: Except for certain time-critical, mission-critical systems (e.g., air bags), IDB will be the standard bus.

- Short develop cycles require standard plug and play interfaces.
- The IDB Forum has successfully coordinated its efforts with other related organizations (TSC, AMI-C).
- The engineering community has seen the value of IDB at plugfests.
- The standards are technically sound and build upon existing standards.

F | Product Liability NOTE: As the authors are only informed observers of ITS, an attorney-at-law should be contacted for legal opinions relating to product liability.

Primary Legal Issues and Reasons Delay Is Expected

System	Delay	Legal Issues
Adaptive Cruise Control	y	Liability suits; compliance with SAE and ISO practices should provide some protection to manufacturers
Advanced Vehicle Control (AVCS)	y	Negligence, strict product liability, breach of warranty major concerns assuming control from the driver; likely target of legal action
Collision Avoidance/ Collision Warning	y	Defective design liability, strict liability for manufacturing defects, negligence for inducing driver reliance on imperfect systems, failure to install systems in all vehicles
Navigation	n	Liability due to crash-induced distractions (while entering data or reading text), liability due to with map errors (leading to violation of traffic laws); compliance with SAE and ISO standards offers protection

4 FUTURE RESEARCH

1. How does the accuracy of various ITS technology forecasts (Delphi, marketing firms, etc.) compare with each other and with actual market data?

2. How can the relative benefits safety technologies be predicted from the type of device, the impact on driver performance, likely changes in risk-taking, and other factors?

3. How can the success of ITS products be predicted from product characteristics such as the visibility of the device, the visibility of device controls and displays, the specific safety benefit (e.g., reduction in fires, protection of children), and so forth?

DISCLAIMER

With a few exceptions, the material presented in this document has been gathered from a variety of reports done by others. The authors have not analyzed the methods used by others in developing those forecasts and make no claims pertaining to their accuracy.

ACKNOWLEDGEMENTS

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I. OBJECTIVES

This report examines six specific topics regarding the future of intelligent transportation systems (ITS). Specific objectives in writing this report are to:

1. Provide an overview of the trends for ITS technologies in North America, including market trends (and any indicators of customer interest).

2. Provide a detailed analysis of the impact of the FCC mandate relating to the E911 location requirements, and how the mandate will affect the current Mayday systems, future sales of these systems, and the overall telematics market.

3. Provide a detailed analysis of onboard vehicle telematics systems and mobile devices and their relation to the traditional office/home based Internet devices.

4. Provide a detailed analysis of the current navigation system market (e.g., onboard map type versus two-way-communication type).

5. Provide a detailed analysis of the current vehicle communication bus system activities (e.g., CAN or IDB), current connectivity applications, and future possibilities relating to these buses.

6. Provide a detailed analysis of the North American product liability concerns relative to ITS in general. Further, provide specific analyses of how the product liability environment will affect the future of adaptive cruise control (ACC) and collision-avoidance systems (night vision, FVCWS, LDWS, etc.) in North America.

Each topic is covered in a separate section. Suggestions for future research are also provided.

II. METHOD

In order to meet the project objectives, the authors identified, obtained, and synthesized relevant information in the thirty professional person days available. Because of this constraint, they were not able to address all of the objectives in detail, nor provide the breadth and depth they would have preferred. Nonetheless, they believe that the material provided is a useful overview of the issues.

To complete the report in a timely fashion, no new data were added after March 2000, though editing continued for another month. Even as the report went to press, relevant events were unfolding (for example, expected increases in OnStar subscribers), and new ones were expected. The authors expect that by early 2001 there will have been significant changes in the industry and an update will be needed.

The method used in preparing this report is as follows. Most of this information was obtained from searches of the internet. Searches examined:

1. Web sites known to contain information specifically related to the objectives (such as the Intelligent Transportation Society of America (www.itsa.org), the Federal Communications Commission (www.fcc.gov), and the Intelligent Data Bus Forum (www.idbforum.org),

2. Sites identified using common search engines (yahoo.com, askjeeves.com, google.com) and key words/phrases (telematics, automotive navigation, market, etc.), and

3. Links to sites identified using the first two methods.

In addition, the authors searched their own personal libraries, the UMTRI Library, and files on their computers; and consulted colleagues, especially at the U.S. Department of Transportation and at the Intelligent Transportation Society of America (ITS America). Project constraints ruled out extensive interactions with colleagues or new initiatives.

Finally, this report includes analyses of the information provided concerning the future of ITS in-vehicle technologies. From the analysis, summaries of the current status and future trends (for one and five years into the future) of these technologies were developed.

III. NORTH AMERICAN ITS TRENDS

Objective: Provide an overview of the trends for ITS technologies in North America, including market trends and any indicators of customer interest.

A. Introduction

This section includes market forecasts for ITS technologies based on government, industry, and consumer data. Part B of this section contains a discussion of what consumers report they want in ITS technologies. Part C presents a content analysis of ITS topics in the news and provides an overview of which ITS technologies are getting attention in national discussions. Part D includes market projections for ITS systems, including an analysis of the various forecasts for the technologies. A table is presented that lists forecasts for the entire ITS market, adaptive cruise control, automatic / electronic toll collection, collision/obstacle warning systems, navigation systems, factory-installed displays, vehicle safety-monitoring systems, driver safety-monitoring systems, and driver vision-enhancement systems. Forecasts are variously reported for years between 2001 and 2015. The forecasts are taken from published sources, and the years of data presented are based on their availability in those sources. Sources are noted directly next to the forecasts in the text.

B. What People Want in ITS Technologies

J.D. Power and Associates has surveyed consumers on what they want and what they are willing to pay for new vehicle features. The results of the survey are listed in Figure 3.1. As many as 38% of those surveyed are willing to pay a median price of $200 for proximity sensors in their vehicles. Drivers are interested in purchasing navigation systems, hybrid transmissions, rain-sensing wipers, automotive personal computers, voice activation, and gasoline/electric hybrid engines. Navigation systems were reported at 34% desirability at a median price of $400, and auto personal computers at 25% at a median price of $500.

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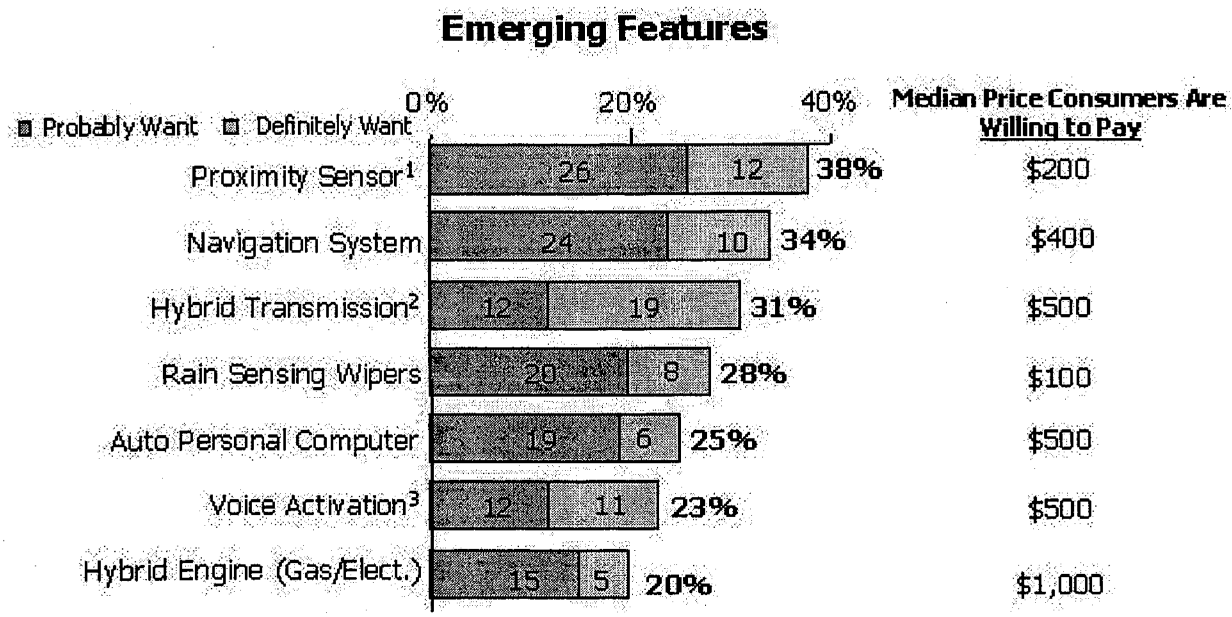


Figure 3.1. Features Consumers Want and What They Are Willing to Pay
Source: www.jdpower.com/images/FCR99Graph.gif

Table 3.1 presents the most desired features per vehicle segment. This includes traditional as well as emerging features for different vehicle classes. The only ITS technology discussed in this report that is most desired in any segment is adaptive cruise control. This is on the preferred list for compact car buyers. It is interesting to note that technologies such as navigation systems or traffic information did not make the list of the top five desired emerging technologies even in luxury vehicles.

Table 3.1. Most Desired Features Per Segment

Segment	Traditional Features	Emerging Features
Compact Car	Air Conditioning	Daytime Running Lights
	Automatic Transmission	Smart Passenger Airbag
	Power Door Locks	Side Impact Airbags
	Power Windows	Run-Flat Tires
	Anti-Lock Braking System	Adaptive Cruise Control
Midsize Car	Air Conditioning	Daytime Running Lights
	Power Door Locks	Smart Passenger Airbag
	Power Windows	Side Impact Airbags
	Automatic Transmission	Electronic Traction Control System
	Power Mirrors	Hybrid Transmission
Sporty Car	Air Conditioning	Electronic Traction Control System
	Power Windows	Smart Passenger Airbags
	Power Door Locks	Side Impact Airbags
	Power Mirrors	Daytime Running Lights
	Remote Keyless Entry	Run-Flat Tires
Luxury Car	Air Conditioning	Side Impact Airbags
	Power Windows	Electronic Traction Control System
	Power Door Locks	Daytime Running Lights
	Power Mirrors	Smart Passenger Airbag
	Anti-Lock Braking System	Hybrid Transmission
Sport Utility Vehicles	Air Conditioning	Smart Passenger Airbag
	Power Door Locks	Daytime Running Lights
	Power Windows	Electronic Traction Control System
	Power Mirrors	Side-Impact Airbags
	Automatic Transmission	Run-Flat Tires
Pickup	Air Conditioning	Smart Passenger Airbag
	Automatic Transmission	Daytime Running Lights
	Drivers Armrest	Hybrid Transmission
	Anti-Lock Braking System	Electronic Traction Control System
	Power Door Locks	Side Impact Airbags
Van	Air Conditioning	Smart Passenger Airbag
	Automatic Transmission	Side Impact Airbags
	Power Door Locks	Daytime Running Lights
	Power Windows	Electronic Traction Control System
	Drivers Armrest	Run-Flat Tires

Source: J.D. Power and Associates 1999 APEAL Feature Contenting Report

Source: www.jdpower.com/images/FCR99Chart.gif

Safety features are in greater demand by consumers in all vehicle classes. Figure 3.2 indicates the desirability of safety features to consumers and the median price that consumers are willing to pay. Of the safety-related ITS technologies reported, 43% of the consumers desired adaptive cruise control (at a median price of $250), and 38% of them desired automatic 911 Dialing (at a median price of $100).

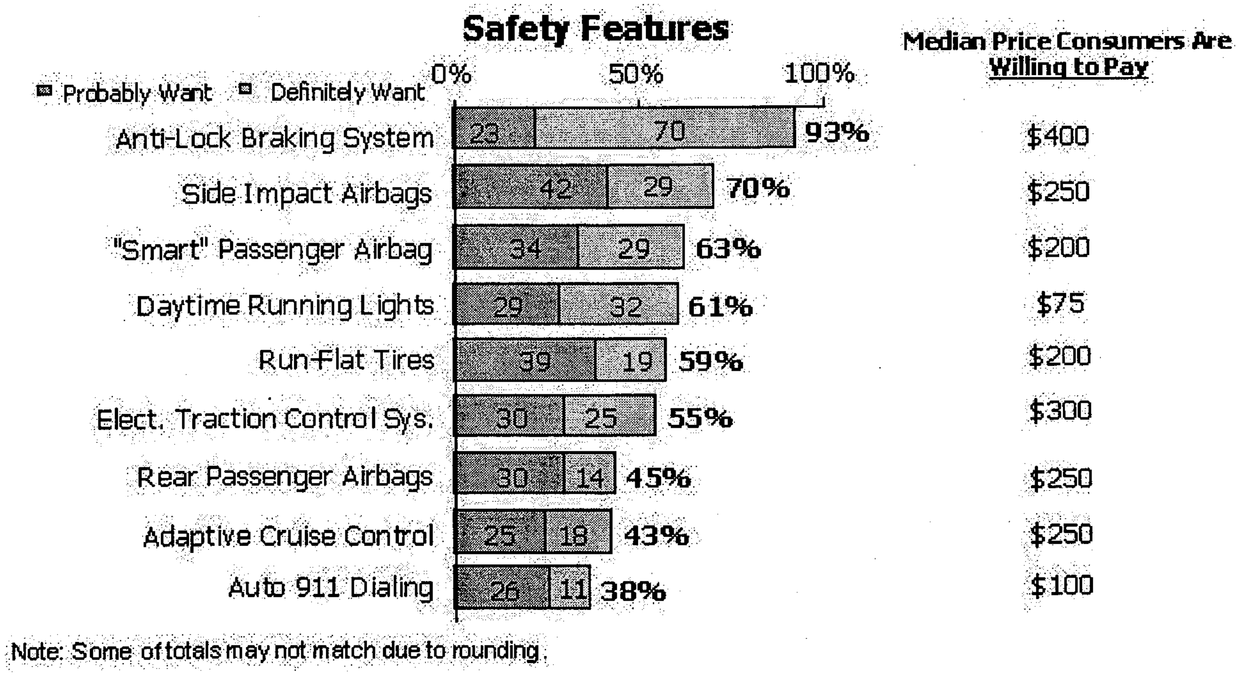


Figure 3.2. Desirability of Safety Features

Source: www.jdpower.com/images/FCR99Graph.gif

C. ITS Topics in News Articles

Product and service announcements in the press suggest future market directions. To provide data for analysis, all stories on the ITS-America Telematics ListServ, concerning telematics posted from December 1999 until February 2000 on the ITS-America web site news column, were saved. During that time period, 70 news stories, mostly press releases, were posted. Items were categorized by the type of company mentioned in each story, the type of product or service mentioned, and the purpose of the announcement. In many cases, more than one category was selected. Readers are cautioned that the summaries provided represent a first approximation. In the ideal situation, more time would be available to obtain a larger sample size and there would be time to reconsider the categories selected.

Nonetheless, several interesting insights can be gained from this data. First, with regard to who is mentioned in the story, data suppliers (such as companies providing traffic information) and hardware suppliers (both tier 1 and tier 2) were listed most often

(Figure 3.3). This is quite different from the traditional automotive press where the Big 3 would predominate.

Second, the most common application mentioned (Figure 3.4) is *other*, and except for the *other* category, no category exceeds 15%. This indicates that no single application is getting more attention than any other in ITS.

Finally, the most common purpose of these announcements (Figure 3.5) is to identify new services, followed by strategic partnerships. Thus, to a significant degree, ITS efforts still are just being planned.

Overall, these data suggest a major shift in the automotive industry focus, at least in ITS applications, from the auto manufacturers to the suppliers, and a shift from products to services.

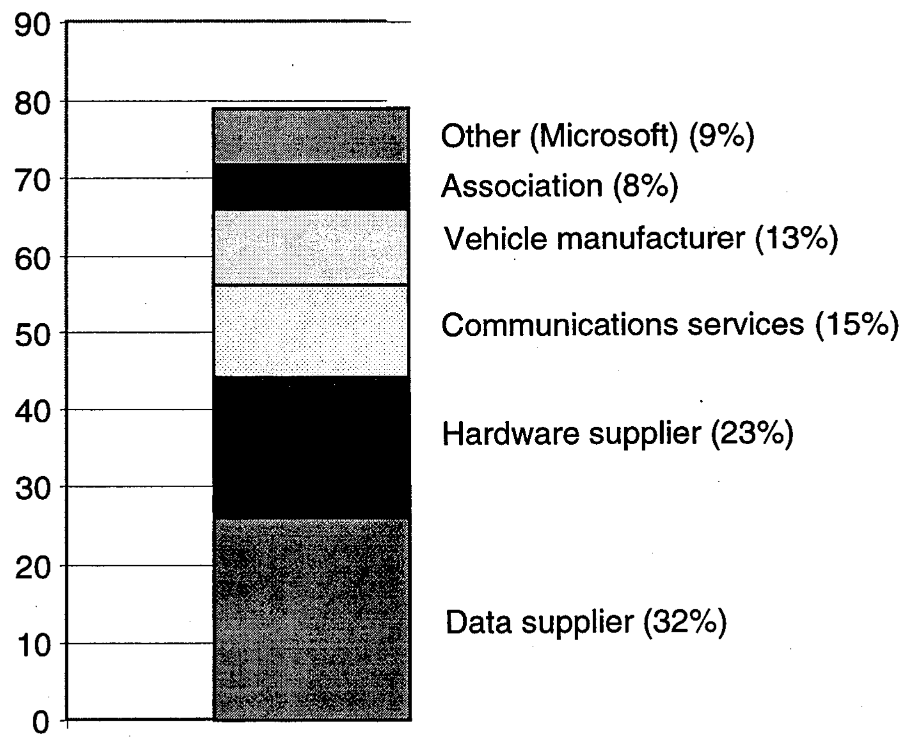


Figure 3.3. Number of News Items by Company Type in the Story
(Example, 32% of the companies mentioned were data suppliers)

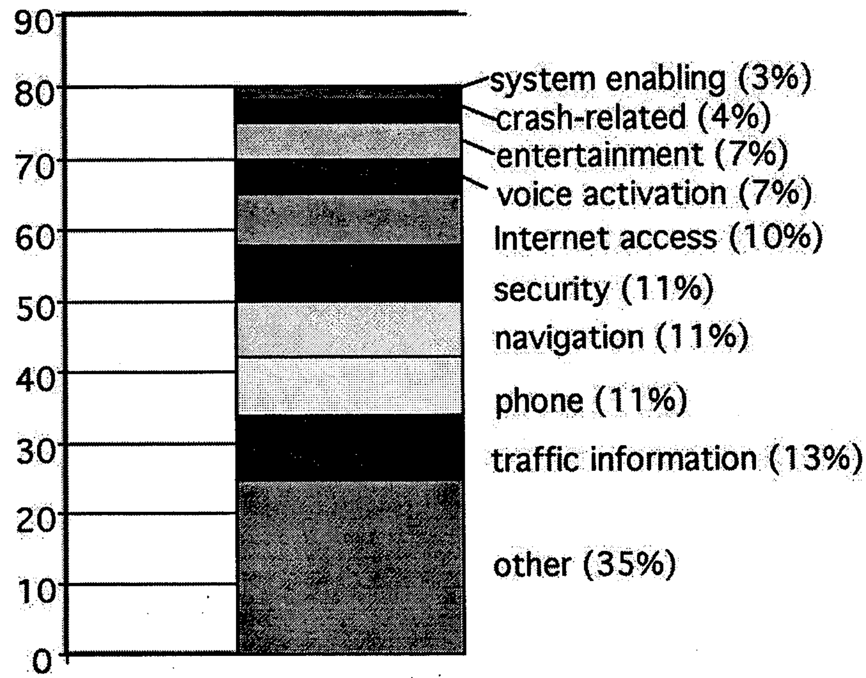


Figure 3.4. Product/Service Application

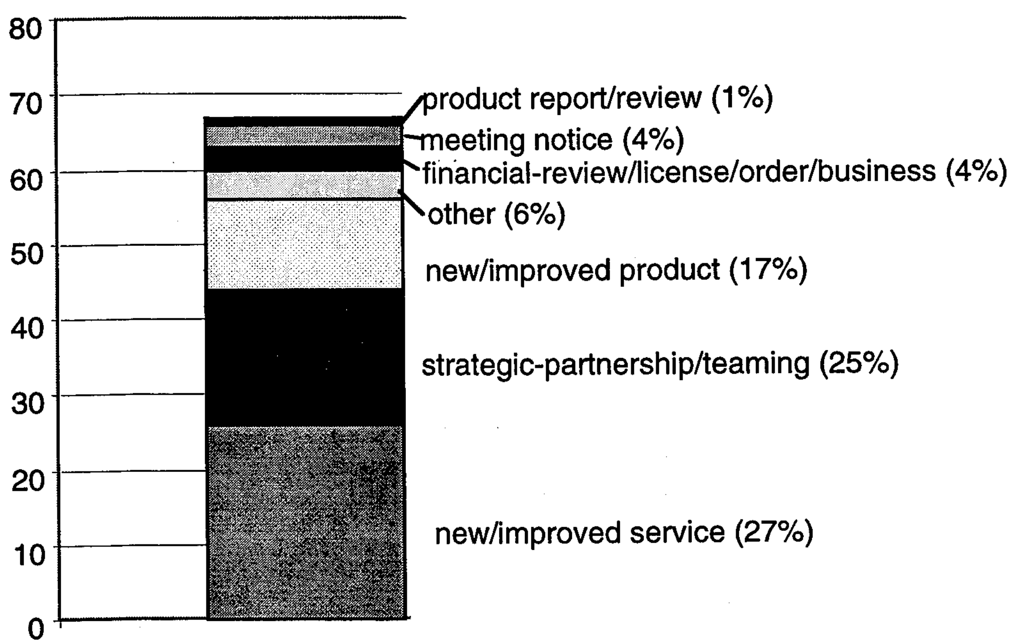


Figure 3.5. Number of News Items By Purpose in the Story

Source: Original analysis by Paul Green of the ITS Telematics ListServ, December, 1999-February, 2000.

D. Market Projections for ITS Systems

This section presents market projections for ITS systems for various years 2001 to 2015. Table 3.2 presents a summary of those forecasts. Before the table are analyses of the forecasts, including estimates by the authors, of the most likely futures for ITS in-vehicle systems. Note that the future estimates by the authors are based on their experience and not on the development of any specific models for this purpose. The authors recommend a thorough analysis of these estimates prior to reliance on them.

The first group of forecasts presented is for the overall U.S. ITS market. Subcategories include public and private markets and investments. The key number to focus on is the total US consumer ITS market of $16 billion in 2005. It stands to reason that this should equal the sum of the public and private shares of the market. Keep in mind that these data come from different sources and are presented differently. The private sector market is reported as $61 billion over the period 1997 through 2005. The public-led market is predicted to be $46 billion over the period 1996 through 2005. Data disaggregated over time were not presented in the sources used. But, if a straight-line growth curve between the initial and final year is assumed for each market, the estimates of markets for the private and public sectors, respectively, in 2005, would be approximately $11 billion and $9 billion, summing to $20 billion. If a simple average over the years were assumed, the estimates would be about $6.7 billion and $4.6 billion, summing to $11.3 billion. The $16 billion total estimate fits squarely in that range.

The second ITS category for which there is a forecast is adaptive cruise control. Only one estimate is provided, and that estimate is based on a survey of automotive industry executives and experts who report that 15% of the cars produced in 2009 will have this technology.

The third ITS category for which market forecasts is provided is automatic toll collection. Four estimates are presented, and one is an outlier. If we consider the estimate of 10% of the vehicles sold in 2009 having automatic-toll-collection technology, that would mean that there would be about 2 million ATC-equipped vehicles in an estimated 20-million-vehicle market. If the technology costs about $200 per vehicle, the total in-vehicle market would be $400 million in one year. This is not far from the Tucker forecast of $440 million in 2008 (Tucker, 1998). On the other hand, the Apogee estimates are very low, about $2 million per year after 2005 (Apogee Research, Inc. and Wilbur Smith Associates, 1997). The authors are inclined to agree with the greater forecasts, particularly given the penetration of this technology in dense urban areas.

The fourth ITS category is collision/obstacle warning. Cole and Londal (2000) report expectations of about 22.5% of the cars built in 2009 to be equipped with collision warning systems. The two market estimates presented are very similar, given that one set contains point estimates, and the other range estimates. In the post-2005 time period, they are both in the $5 to 7 billion range per year. For 2005, we could estimate a market of about $2 billion for this category.

The fifth ITS category is navigation. In this grouping are four different estimates for four different technologies. Industry executives and experts estimate that GPS/cell phone-based safety systems and navigation systems will be in 25% of vehicles produced in 2009, and 20% of the cars produced that year will have in-vehicle message systems. That same year, Tucker estimates that the traffic information market will be about $1.2 billion (Tucker, 1998). Further estimates on traffic information are as follows: "Two recent surveys paint very different pictures in answering this question. In Seattle, the fall 1997 survey indicates that 6% of all respondents would be willing to pay $10 a month for route-specific traffic information. In New York, a recent survey indicates that about 40% would be willing to pay $10/month for an improved traveler information system. ...56% said they would pay $5/month." (Richards and West, 1999, p. 8). Given the interrelationships among all these technologies, there is no way to accurately analyze differences among the estimates.

The sixth category is factory-installed displays. Counts are presented for digital displays and head-up displays installed in domestically produced 1998 model year vehicles. These are presented to show the actual base upon which estimates of future factory-installed ITS technologies are being built.

The seventh ITS category for which a forecast is presented is vehicle safety monitoring. Range estimates are provided for this system, and we estimate the 2005 market to be about $0.5 billion.

Driver safety monitoring (primarily alertness monitoring) is the eighth category for which forecasts are presented. The Apogee market estimate is approximately $.5 billion in 2005, and the EIA/ITSA estimate is $1.4 billion for that year. A three-fold range in estimates is not unexpected in forecasts going out five years.

The ninth ITS category is driver vision enhancement. The two sets of estimates for these are very similar, approximating a $2 billion market in 2005.

Table 3.2. Forecasts of ITS Technology in the United States

TECHNOLOGY	FORECAST YEAR														SOURCE
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	
Total US Consumer ITS Market			$2.5B					$16B					$27B	$28B	Joint EIA/ITSA, p.10
Public–led ITS Market (1996)				$46B									$35B		Apogee, p. 45.
Total US Private Sector ITS Market (1997)*				$61B									$318B		Apogee, p. 5
Total US Government Expenditures on ITS	$2.4B							$2.2B to $4.2B							Joint EIA/ITSA, p.10
ITS Public Capital Investment	$2B	$2.3B	$2.7B	$3B	$3.3B	$3.7B	$4.1B	$4.6B							Joint EIA/ITSA, p. 52
Adaptive Cruise Control												15% of cars produced			Cole and Londal, p. 108
Automatic Toll Collection												10% of cars produced			Cole and Londal, p. 108
Automatic Toll Collection							$3.9 B market								Costello
Automatic Toll Collection ($M)			48.3	61.6	79.1	102.5	134.2	177.5	237.6	321.6	440.4	610.6	857.3	5733.8	Tucker, p.15
Automatic Toll Collection (1997)*				$0.01B									$0.02		Apogee, p.4
Collision Warning Systems												22.5% of cars produced			Cole and Londal, p. 108
Obstacle Warning Systems				$5B									$54B		Apogee, p. 5

TECHNOLOGY	FORECAST YEAR													SOURCE
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	
Obstacle Warning System			<$0.1B					$2.7B					$6.2B	$6.5B	Joint EIA/ITSA, p.14
Navigation System												25% of cars produced			Cole and Londal, p. 108
GPS/Cell-phone-based safety system, e.g., OnStar												25% of cars produced			Cole and Londal, p. 108
In-Vehicle Message System												20% of cars produced			Cole and Londal, p. 108
Traffic Information Market ($M)			115.1	144.4	182.6	232.6	298.6	386.2	503.6	662.1	877.9	1174.3	1584.7	8176.4	Tucker, p.16[illegible]
Factory-Installed Digital Displays	378,568														Ward's, p. 320
Factory-Installed Head-up Displays	82,152														Ward's, p.32[illegible]
Vehicle Safety Monitoring Systems (1997)*	◄			$2B				►	◄				$7B	►	Apogee, p. 5
Driver Safety Monitoring Systems (1996)*	◄			$2B				►	◄				$27B	►	Apogee, p. 5[illegible]
Driver Safety Monitoring Systems			$0B					$1.4B					$2.7B	$3.8B	Joint EIA/ITSA, p.16
Driver Vision Enhancement Systems (1996)*	◄			$2B				►	◄				$42B	►	Apogee, p. 5[illegible]
Driver Vision Enhancement Systems			$0B					$2.1B					$4.7B	$4.9B	Joint EIA/ITSA, p.17

* (year) indicates the lowest year of the range of forecast reported.

IV. PHONES, THE FCC E911 MANDATE, AND MAYDAY SYSTEMS

Objective: Provide a detailed analysis of the impact of the FCC mandate relating to the E911 location requirements, and how the mandate will affect the current Mayday systems, future sales of these systems, and the overall telematics market.

A. Introduction

In many ways, these topics are tied together. The initial reason many people wanted cell phones in their vehicles was for security. If they had a problem, they could call for help. While cell phones in vehicles now see many other uses, security is still a key issue, and for that reason, these topics have been bundled.

The structure of this section is similar to others, with market data (Part B) following this introduction, along with specific information on the FCC E911 rule and projections for the future (Part C).

B. Market Projections for Phones and Mayday Services

The demand for wireless phone service is growing and will continue to grow. The latest data (Figure 4.1) from CTIA (Cellular Telephone Industry Association) show an exponential growth in the number of subscribers over time with 76,000,000 subscribers identified in the United States in 1999. Some have predicted the disappearance of wireline phones in the future, with all calls being placed using wireless phones. Trends in this direction have already occurred in the Scandinavian countries where market penetration is very high. Factory-installed mobile phones are an increasingly common option. A total of 27,999 such phones were installed in 1998 model-year domestic cars produced in the U.S., Canada, and Mexico for the U.S. market (Ward's 1999 Automotive Yearbook, p. 321).

Industry forecasts for mobile and wireless net users appear in Table 4.1.

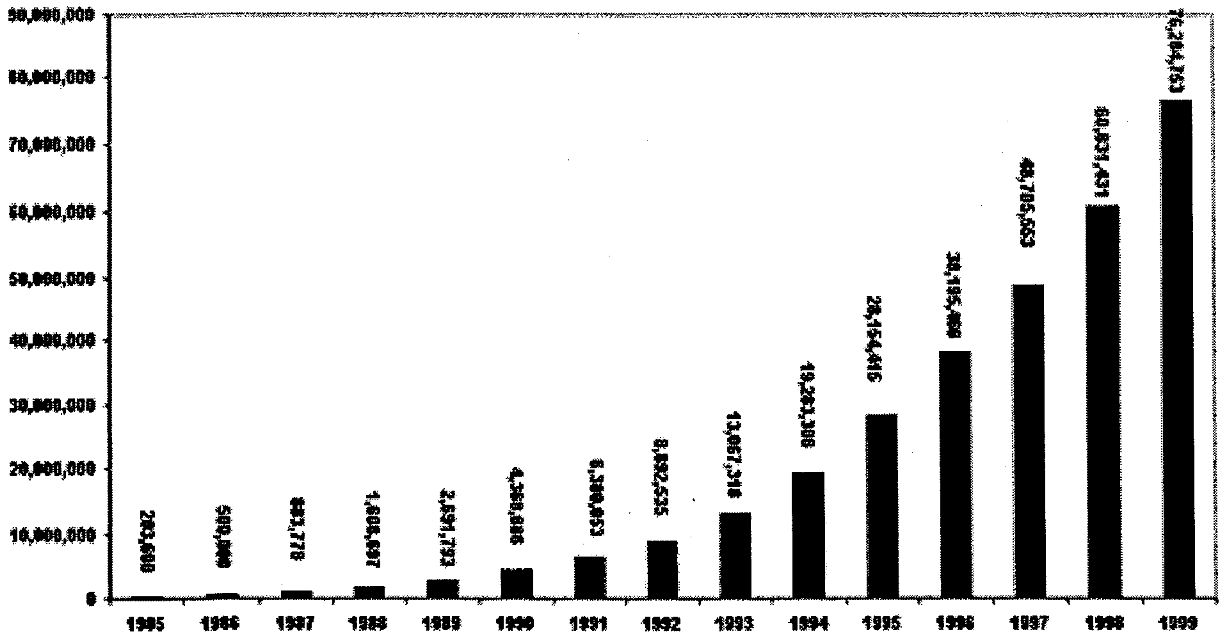


Figure 4.1. Wireless Subscribership: June 1985 – June 1999

Source: http://www.wow-com.com/wirelesssurvey/
(Cellular Telephone Industry Association Semi-Annual Wireless Industry Survey)

Table 4.1. Industry Forecasts for Mobile and Wireless Net Users

Source	Data
Ericsson, 10/19/99	120 million 3rd generation mobile users by 2004; Total number of mobile telephone users in 2004 from 1 billion to 1.1 billion
Cahners In-Stat Group, 10/27/99	24 million people receiving data over wireless net devices; Currently, there are about 1.7 million such users, which represent only 2 to 3 % of the traffic over wireless networks.

Source: Costello (2000)

Following are the predictions for the mayday market derived from several sources (Figure 4.2). The main source of the difference seems to be what the estimate includes (vehicle hardware alone, support services, etc.). Also note that the assumed growth pattern differs between source (linear versus exponential). There is no evidence available indicating that one source is better than another.

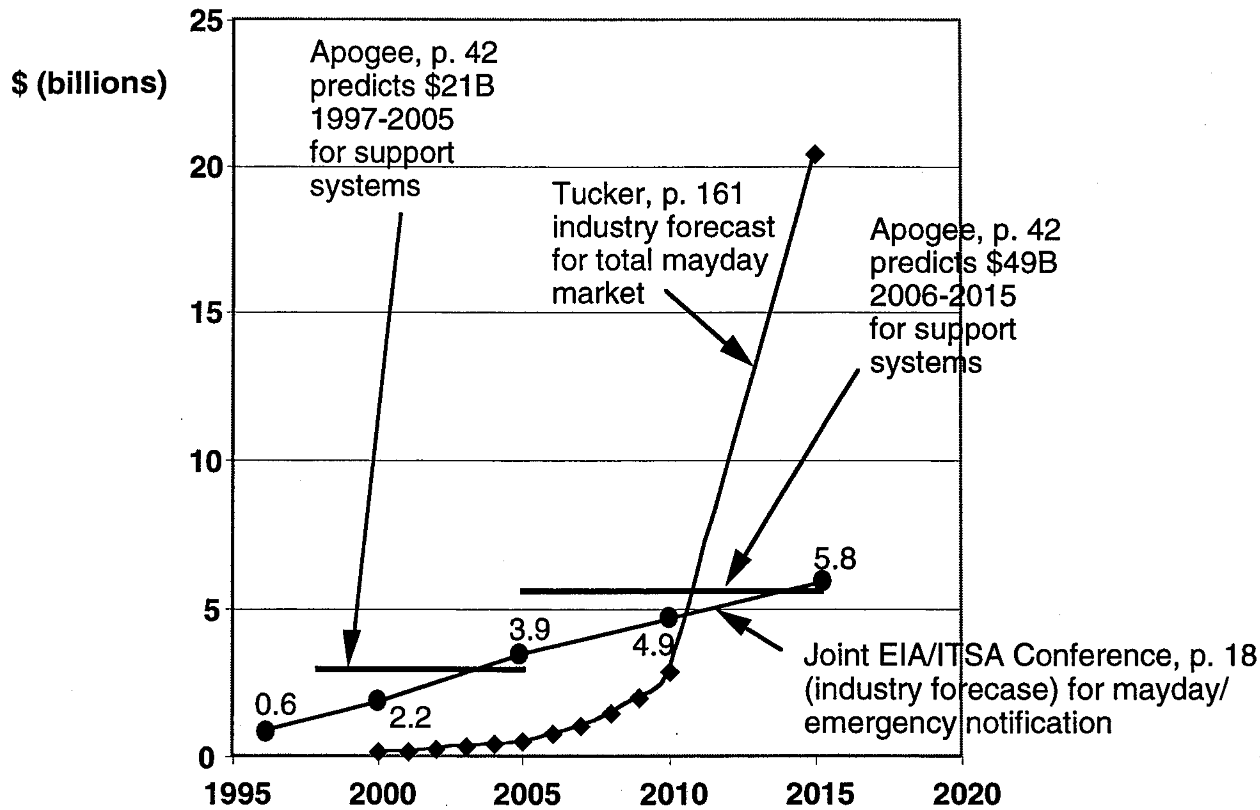


Figure 4.2. Market Projections for Mayday Systems

In terms of market penetration, the UMTRI Delphi study projects that 25% of all passenger cars produced in North America by 2009 will have a GPS/cellular-phone-based safety system (e.g., GM OnStar) and 20% will have in-vehicle message systems (Cole and Londal, 2000, p. 108.)

As of October 1998, there were about 30,000 OnStar units in use in about 31 General Motors models. Users at that time had to pay a $1,300 fee, install a car phone, and pay a $22.50 monthly fee. "In the Detroit area, prices for a phone and installation are in the $400 range. Air time can cost between $20 and $50 per month." Because the units were slow selling, GM waived the $1,300 fee for October through December 1998. (Woodyard, 1998, p. 4.)

The 1999 OnStar subscriptions in 1999 were 100,000. GM wants one million by the end of 2000 and four million subscribers by the end of 2003. "The base subscription for factory-installed OnStar costs $199 per year. If installed at a dealership, it costs an additional $699." (Miller, 2000, p. 6).

C. What is the E911 Rule and What Is Its Impact?

The E911 rule issued the U.S. Federal Communications Commission (FCC Docket 99-245, October 6, 1999) requires carriers to provide automatic location identification for wireless phones to speed assistance in emergency situations. For wireline callers, the 911 center gets the phone number of the caller (from the caller ID feature and, using a data base, the location of the caller). For cell phone calls, automatic number identification (ANI) is not generally available, especially immediately. If the caller does not know their precise location and cannot determine it precisely, emergency services cannot be precisely dispatched to the caller. (For details see www.nena9-1-1.org/legislation/wireless_e911.htm; click on FCC 99-245: Revision of the Commission's Rules. A complete listing of E911 activities appears on http://www.fcc.gov/e911/.)

This rule has been under discussion for some time, with the timing of the rule, funding for system enhancements, and the accuracy requirements being the topics discussed. Key participants in the effort are the LEC (the local exchange carrier, i.e., the local phone company) and the PSAP (the Public Safety Access Point, who answers the phone when 911 is dialed).

There are two deployment phases. Phase 1 requirements specify what be have in place by April 1, 1998. At that time the PSAPs were to have in progress or partially completed an effort to give a rough estimate of caller's location and dialable call-back number using data provided by the local carriers.

The Phase II requirements (revised October 1999) for automatic location identification (ALI) are shown in Table 4.2. For network-based solutions 67% of the location identifications must be with 100 m, 95% within 300 m. For handset solutions, the requirements are 50 m for 67%, 150 m for 95%.

Table 4.2, FCC 911 Phase II Requirements

Trigger/Action	When	Requirement
Once any PSAP request is received	March 1, 2001	Sell and activate ALI-capable handsets
	October 1, 2001	Ensure ≥ 50% of all new handsets activated are ALI-capable
	October 1, 2002	Ensure ≥ 95% of all new digital handsets activated are ALI-capable (Automatic Location Information, the location of the caller)
For the area from a requesting PSAP	Within 6 months or by October 1, 2001 (whichever is later)	Ensure 100% of all new handsets are ALI-capable
		implement network upgrades to locate handsets
		deliver location information to PSAPs
	Within 2 years or by December 31, 2004 (whichever is later)	undertake reasonable efforts to ensure 100% ALI-capable phones
Use best practice to locate roamers		
For network-based solutions	Within 6 months of a PSAP request	50% ALI
	Within 18 months of a PSAP request	100% in 18 months

These rules emerged as a result of discussion between the FCC, the carriers, and organizations representing the cellular phone industry and 911 centers. See Table 4.3. The most definitive source is the FCC web site (www.fcc.gov/searchtools.html and search under E911).

Table 4.3. Key Organizations in E911 Activities

Federal Communications Commission (www.fcc.gov)	Sets the rules
Cellular Telecommunications Industry Association (www.wow-com.com)	Trade group of cellular manufacturers and service providers
Association of Public Safety Communications Officials Int'l (APCO) (www.apcointl.org or www.apco911.org)	E911 center operations (training, coordinates frequencies)
National Emergency Number Association (NENA) (www.nena9-1-1.org)	Foster universal emergency phone #
National Association of State Nine One One Administrators (NASNA)	Manage 911 centers

D. What is the Future?

FCC

Based on the FCC docket, the phone carriers must offer automatic location identification by October 1, 2001 for all of the handsets they sell, and half of those activated must have that feature. By 2002, 95% of the phones activated must have that feature. Handset accuracy must be 50 m for 67%, 150 m for 95%. As a practical matter, the only way to obtain the desired accuracy is for the handset to know its precise location, probably via GPS. Relying on triangulation from cell towers cannot guarantee the desired accuracy (because the towers might be aligned in unusual ways or there may be too few towers in range). It is reasonable to assume that by October 1, 2001 all new phones sold will provide ALI (probably by GPS) to meet the FCC accuracy requirements (50 m for 67% of calls, 150 m for 95%) and by the end of 2004, virtually all phones will meet FCC accuracy requirements. Because of the FCC requirements for service, there have been suggestions that some carriers would buy back customer phones (or exchange them for ALI-capable phones) to assure those carriers met the FCC service requirements.

Thus, the one-year prediction is that almost all phones sold at that time will be ALI-capable and that by five years almost all phones will be ALI-capable. The wide-scale availability of ALI-capable phones is a significant enabler for navigation systems, because eliminating the need for the GPS chip set can reduce the system cost.

One concern is that providing ALI-capable phones to all may decrease the demand for mayday and related services such as OnStar. The authors have not found any discussion of this in the literature, and if anything, demand will increase because economies of scale (from mass production of ALI-capable phones) will reduce hardware costs. In the event of a crash, automatic collision-notification systems will contact the service center, and they in turn will contact the local PSAP. While desired, there has been no discussion evident of making the call to the PSAP automatic. Furthermore, people will still initially contact the service center for nonemergency items (road service, directions) and contact the PSAP directly (via 911) to report criminal activity. Recently, the federal government established 411 as the number to call to report traffic problems to reduce the burden on 911 centers. If anything, ALI-capable phones mandated by the 911 rules should cause a growth in the use of services such as OnStar. Consequently, 5 years into the future, use of these services is expected to be much more widespread than now. Furthermore, ALI-capable phones should stimulate the sales of navigation systems to some degree by reducing hardware costs, though much of the cost is associated with the data storage device and the display. Those costs have declined in the past and should decline in the future, especially the storage device.

Beyond the FCC rules, there are several other key developments (e.g., Bluetooth, WAP, and VoiceXML) that will impact the sale of phones and the phone services available.

Bluetooth

Bluetooth is a wireless technology specification for small-form factor, low-cost, short-range radio links between mobile PCs, mobile phones and other portable devices. It delivers opportunities for rapid ad hoc connections, and the possibility of automatic, unconscious connections between devices. It can eliminate cabling between devices. Bluetooth specifications are being developed by the Bluetooth Special Interest Group (http://www.bluetooth.com/). Key members include 3Com, Ericsson, IBM, Intel, Lucent, Microsoft, Motorola, Nokia and Toshiba. Microsoft is not a member. There are 1,525 members of the Bluetooth Special Interest Group. U.S. automotive companies that belong include Delco, Navistar, InfoCar AB, and NHK Spring.

Bluetooth phones contain low power, short-range radio links that allow a small number of phones to connect to each other (as walkie-talkies and by passing the cellular network), connect to local wireline links (acting as a portable phone), and send local data to each other, to and from laptops, and to and from networks. They will also have the ability to assist in synchronizing various data storage devices (e.g., PCs, organizers, etc.). By design, they will provide a significant bridge to the wireless world and predictions are they will markedly reshape communications. Version 1.0 of the Bluetooth specification was released in the second quarter of 1999, and version 2.0 will be released either this year or next year.

Bluetooth has generated significant excitement in the communications industry, and many automotive designers are looking towards providing Bluetooth support in motor vehicles. Many believe that motor vehicle support for Bluetooth in the future will occur very soon with the primary consideration being the relatively long development cycles of motor vehicles. Most likely only a few companies will provide Bluetooth support in one year. In five years, the authors would expect most manufacturers to provide Bluetooth support for all luxury vehicles.

WAP

The Wireless Application Protocol (WAP) is a worldwide standard (both a communications protocol and an application environment) for linking digital mobile phones, pagers, personal digital assistants, two-way radios, and other wireless terminals to the Internet. This protocol promises to support easy access to the Internet via a telephone (see http://www.wapforum.org/, http://www.gsmworld.com/technology). Founding members of the WAP Forum include Nokia, Ericsson, Motorola, and Phone.com. The Forum has about 120 members.

WAP is designed to work with most wireless networks such as CDPD, CDMA, GSM, PDC, PHS, TDMA, FLEX, ReFLEX, iDEN, TETRA, DECT, DataTAC, Mobitex. WAP can be built on any operating system including PalmOS, EPOC, Windows CE, FLEXOS, OS/9, JavaOS etc. The latest version of the specification suite is 1.2, released in December of 1999. The plan is to update the specifications every six months.

When last reviewed, the WAP standard was incomplete. Key elements relating to sending information to mobile devices and wireless telephony still need standardization. A major concern is that applications written in WML (wireless markup language) will have to be rewritten for each small-screen device to get content from an HTML device. An alternative approach is a general purpose web portal specifically design to handle web content for each wireless device The eventual success of WAP and the need for automotive support of WAP is uncertain. There seem to be some differing opinions as to how WAP should be implemented (Schwartz, 2000, http://cnn.com/2000/TECH/computing/03/23/wireless.confusion.idg/index.html). The authors are uncertain as to the market penetration of WAP in the future.

VoiceXML

Version 1.0 of the VoiceXML specification was released just before the first draft of this report was completed (http://www.vxmlforum.org/). The Voice eXtensible Markup Language is intended to make Internet content voice and phone accessible, and is advertised as the voice analog of HMTL in terms of usage and impact on the net. The key members of the Voice XML Forum include AT&T, IBM, Lucent, and Motorola. At this point, there has been no significant negative press about VoiceXML, but the specification has been available for only a few weeks. The extent to which the standard lives up to its promise is yet to be determined, and, therefore, the authors are not able to offer one- or five-year predictions.

V. RELATIONSHIP OF ONBOARD TO OFFICE / HOME INTERNET DEVICES

Objective: Provide a detailed analysis of onboard vehicle telematics systems and mobile devices and their relation to the traditional office/home based internet devices.

A. Introduction

As the processing speed, memory, input, display, and communications capability of personal computing and communications devices grows, the desire for them to interact with in-vehicle systems grows. These devices include phones, PDAs (personal digital assistants), laptop computers, pagers, and others. The sections that follow provide market trends for some of these devices, and some speculation with regard to the future.

B. Market Assessments and Projections

What Is the current situation? (Customer history)

The best ownership data the authors were able to obtain in the time available was for households in the Puget Sound region in 1997 (Table 5.1). Since three years have elapsed since the data were collected, the estimates are likely to be quite low for several categories.

Table 5.1. Technology Ownership (1997)

Technology	Percent Ownership (1997)
Cable TV	69 %
Desktop computer at home	68
Access to a desktop computer at work	49
Desktop computer at home	53
Cell phone	41
Internet and/or online access	34
Pagers	12
Navigation unit in car	1
PDA	0.5

Source: Richards and West, 1999, p.6.

Much better data exists on growth of the internet. An example of the many predictions that exist appears in Figure 5.1. All growth estimates for the internet are very optimistic.

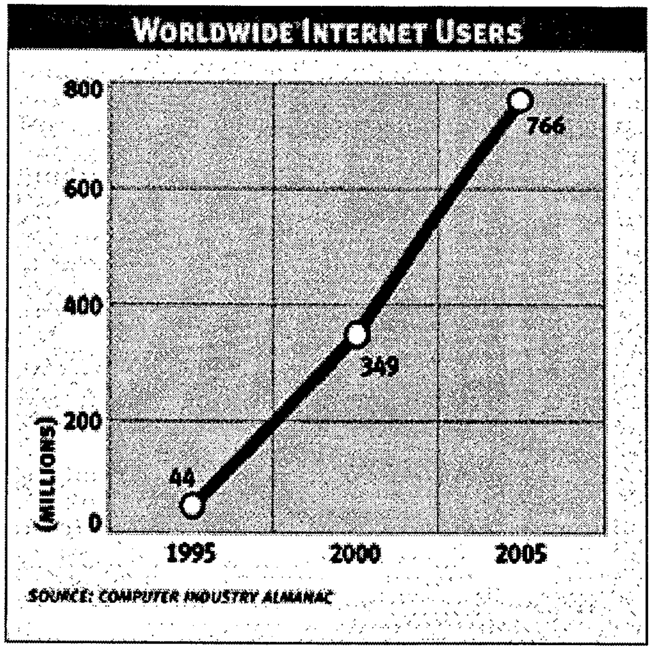


Figure 5.1. How many internet users will there be in the future?
Source: Lawrence (2000) http://www.idg.net

How Will the Sales of PDAs Increase?

At the present time, the sales leader for PDAs is Palm Computing as shown in Figure 5.2. Industry predictions are that the Palm operating system will predominate and not be surpassed by Windows.

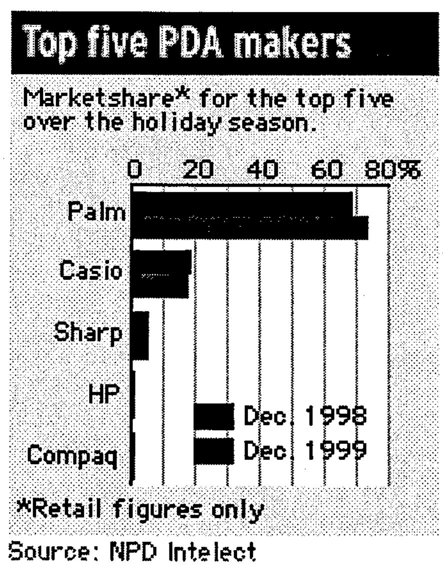


Figure 5.2. Top Five PDA Makers
Source: Miles (2000); http://news.cnet.com/news/0-1006-200-1527697.html

By the year 2002, sales of PDAs will be 16 million units per year and 35 million in 2003 (http://members.aol.com/pdasusan/pocketpress/).

3. Future Communications & Internet Devices: Some Issues

No one seems to know what devices people will commonly use in the future. People could carry either single or multiple personal electronic devices, though for convenience, a single device appears more likely.

Potential options include the following:

a. Phone that gains PDA functionality
b. PDA that gains phone functionality (maybe via the internet)
c. Laptop with a phone
d. Wearable computer
e. Wrist computer
f. Something else not yet invented or well known

Phones with internet capability are already in production, though they as yet do not have the full functionality of a PDA. If the quality and speed of internet-based phone connections can be improved, then a computing device that is internet-centric, not a phone, could be the most widely accepted device in the future, primarily because of the cost of wireless service. PDAs are now receiving considerable attention, and there has been work on making phone calls over the internet for some time, but there are as yet no devices on the market (of which the authors are aware) with this capability. The authors do not believe that a laptop with a phone will be the winning product. They are just too heavy.

Wrist computers are a realization of the two-way wrist radio (from the American Dick Tracy comic strip) as a telephone with advanced features. There have been demonstrations of wrist-mounted telephones, and wrist watches with enhanced features (calculators, data storage, etc.) have been available for some time. The advantage of a wrist mounted device is the ease of discretionary access, and the acceptance on an input device and a display on the wrist in most cultures.

Wearable computers are a very interesting idea that for the most part are still an idea being explored by university and industrial laboratories. Wearable computers consist of a belt mounted computer, sometimes with buttons mounted on it, and a miniature projection unit to display data on the wearer's eye glasses. For these devices to be more widely marketed, the display cost needs to be reduced and the "geekish" characteristics associated with them needs to be eliminated. The authors believe that ten years from now wearable computers will be as common as laptop computers are now and have the potential for being the device people use.

For automotive applications, the following questions need to be addressed:

- What data need to be synchronized between the car and the portable device?
- How will the device and the car communicate (e.g., infrared (IR) link, wireless link such as Bluetooth, in-vehicle docking station)?
- What will the driver interface or interfaces be? (Voice, handwriting, and gestures are all possibilities for input and a head-up display (HUD), or large LCD displays could be used for output. If a wearable computer is provided, then glasses-mounted displays are likely.)
- What kinds of information will be exchanged (address lists, email, news, etc.)?
- How much is too much for people to do while driving?
- How do tasks that are done in the office or at home need to be modified for execution while driving?

There is a need for significant research to understand the use of these advanced devices in an automotive context, but there is no evidence that anyone is conducting this research or even thinking of supporting it.

The authors predict the continued market penetration of cell phones and PDAs one year into the future. The situation in five years is uncertain.

VI. NAVIGATION SYSTEM MARKET

Objective: Provide a detailed analysis of the current navigation system market (e.g., onboard map type versus two-way-communication type).

A. Introduction

Of the telematics applications being considered, the market for navigation is the most mature. There are millions of systems on the road in Japan, and systems are beginning to appear in quantity in the U.S. and Europe. The remainder of this section contains market projections (Part B), data on which features drivers want (Part C), and predictions for the future (Part D).

There are two key documents in the literature that provide a current view of the navigation market, (1) the J.D. Power 1999 Navigation Usage and Satisfaction Study (J.D. Power, 1999) and (2) the Strategis Group telematics report (The Strategis Group, 1999). The authors have not been able to obtain copies of these rather expensive documents, though those interested in specifics of the navigation market are urged to do so.

B. Market Projections

Figure 6.1 and Table 6.1 show several market projections for navigation information and products. Notice that the Tucker forecast is for exponential growth, whereas the Apogee data is only point-in-time projections. However, the Apogee data are more specific with regard to the type of product, indicating that out-of-vehicle products will predominate over in-vehicle products, and dynamic route guidance over static.

Historically, the U.S. market for systems for which navigation tasks are off-board has been poor because of the lack of infrastructure and communication problems. (For example, Ali-Scout failed because of beacon problems.) Systems that utilize the phone system have promise, but driver reactions to significant phone bills are uncertain. Nonetheless, systems such as OnStar and Rescu have been successful, and many manufacturers are considered offering similar services. While use of these systems will grow, the authors believe that on-board navigation systems will continue to predominate.

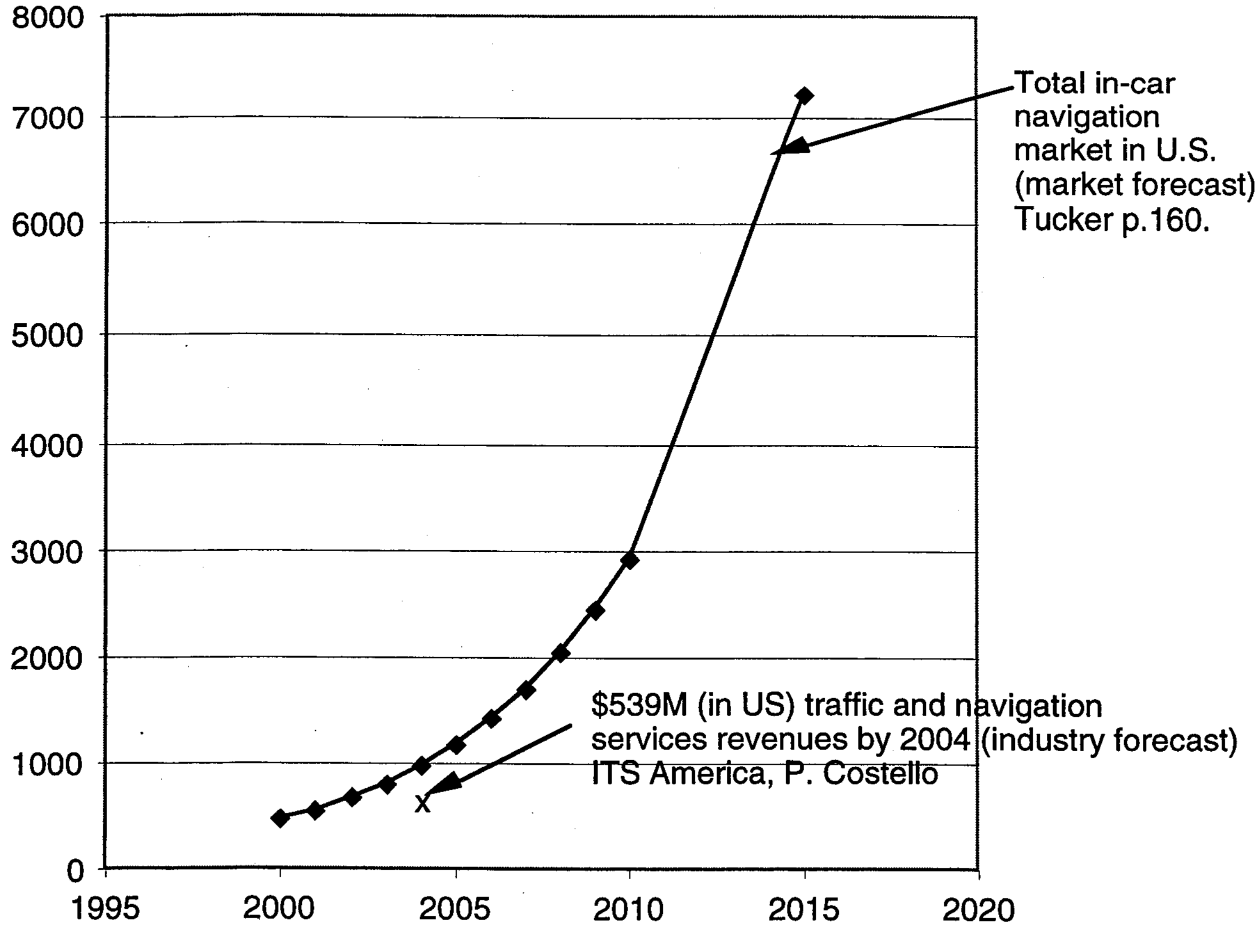


Figure 6.1. Overall Market Predictions for Navigation System Revenue Growth

Table 6.1. Apogee Predictions for Navigation Systems

	Dyanmic Route Guidance		Static Route Guidance	
	In-vehicle	Out of vehicle	In-vehicle	Out of vehicle
1997-2005	0.07	188	11	12
2006-2015	10	601	52	29

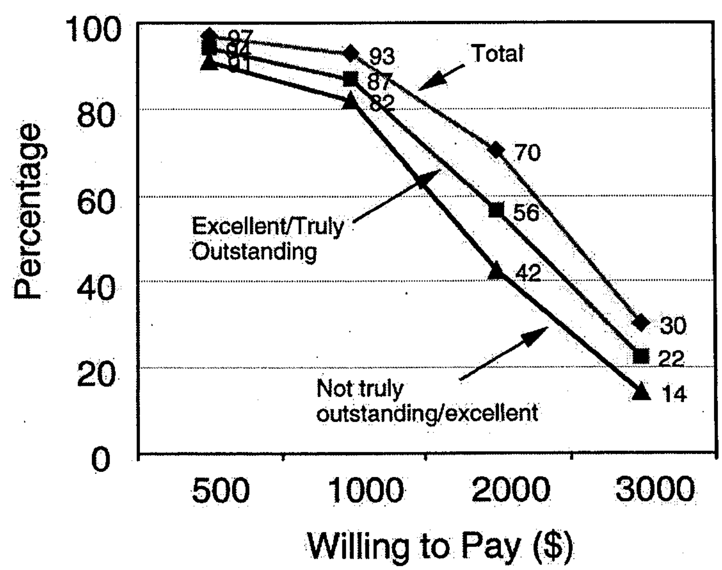
Developed from: Apogee, p. 47, 49, 50 (industry forecast)

Another indicator of the size of the market is the Delphi estimate (an industry forecast) that 25 percent of passenger cars produced in North America will have a navigation system by 2009 (Cole and Londal, 2000, p. 108.). A more optimistic forecast from ITS America is that the global (not just the U.S.) in-vehicle navigation-systems market will be $16 billion by the end of year 2004 (Costello, 2000, personal communication). Comparison of these different estimates is difficult because they are estimates for different items.

How likely are people to purchase an optional navigation system?

Figure 6.2 contains the latest data from J.D. Power on their estimates for what customers are willing to pay for navigation systems of various qualities. The key information comes from the 1999 J.D. Power Navigation Usage and Navigation Study supplemented by other studies. The study includes more than 3,000 consumers who recently purchased or leased vehicles with a factory-installed navigation system. Two-thirds of the respondents indicate they use their system once or twice weekly, with 19 percent reporting they use it daily. These data are recent and the sample size is large, so the values are probably reasonable. Older data the authors have collected suggest mean willingness to pay values of $500, not percentages in the high 90s. The reason for the difference is sampling. Respondents in the Power study all drove luxury or near-luxury brands (Acura, Lexus, Porsche, Jaguar, Volvo, BMW, Mercedes) and generally represented buyers with more discretionary income. Other studies have examined the driving public as a whole, not the luxury market segment. However, the general conclusion is there will be significant product sales for $500 systems is still true.

Figure 6.2. Willingness to Pay for Navigation Systems



Source: J.D. Power (1999). *The Power Report*, November, 1999, p. 6.

What the are the most desired navigation features?

Figure 6.3 shows the features desired by customers, again from the J.D. Power survey. Details concerning data collection, sampling, etc. can be obtained from the original survey, a resource the authors do not have. Notice the key features are street and intersection address entry, turn arrows, automatic route recalculation, and voice support. While it might be tempting to provide as many features as possible, designers should realize that providing many features can create an excessively complex interface, making access to the key features difficult and diminishing rather than enhancing product quality.

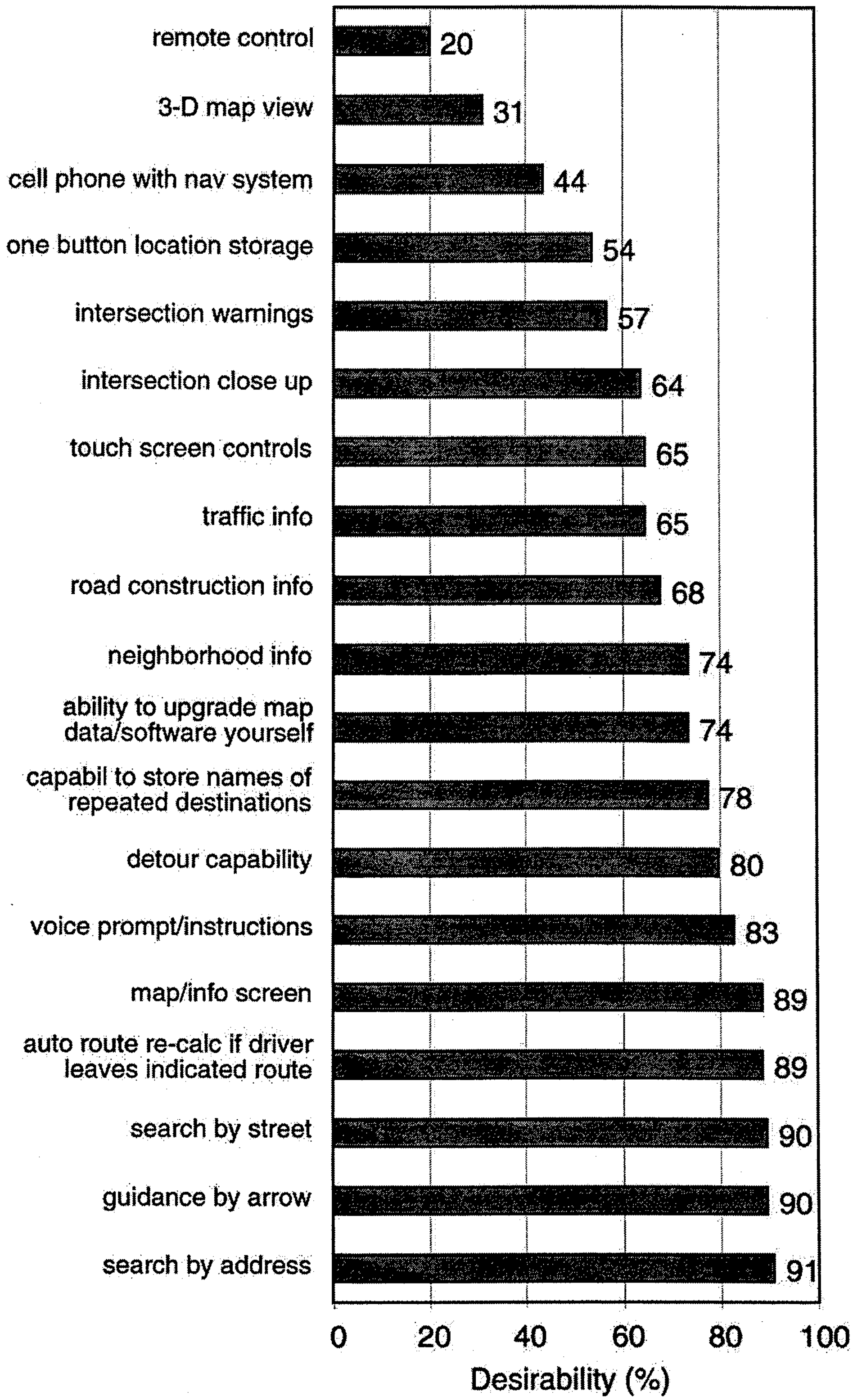


Figure 6.3. Desired Navigation System Features

Source: J.D. Power (1999). *The Power Report*, November, 1999, p. 7.

How often and for what do drivers use navigation systems?

Figures 6.4 and 6.5 provide data on frequency of use and which features are used. Notice that although almost one-fifth of the respondents use a navigation system daily and over 40 percent use it at least once per week, a significant percentage of respondents use a navigation system irregularly.

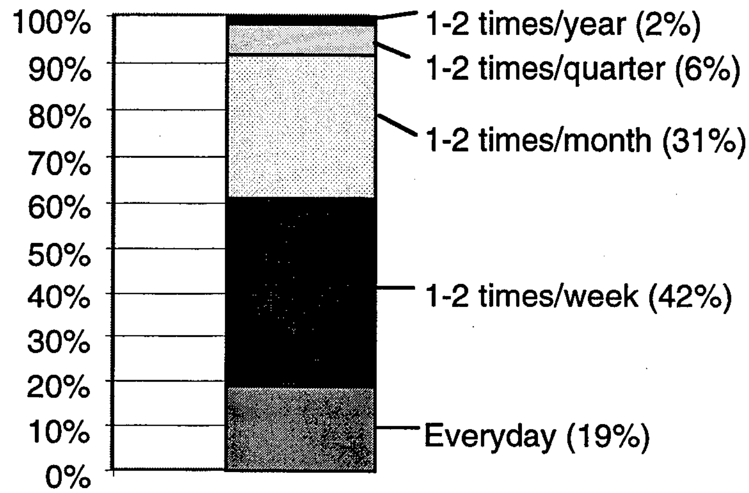


Figure 6.4. How Often Do You Use Your Navigation System
Source: J.D. Power (1999).

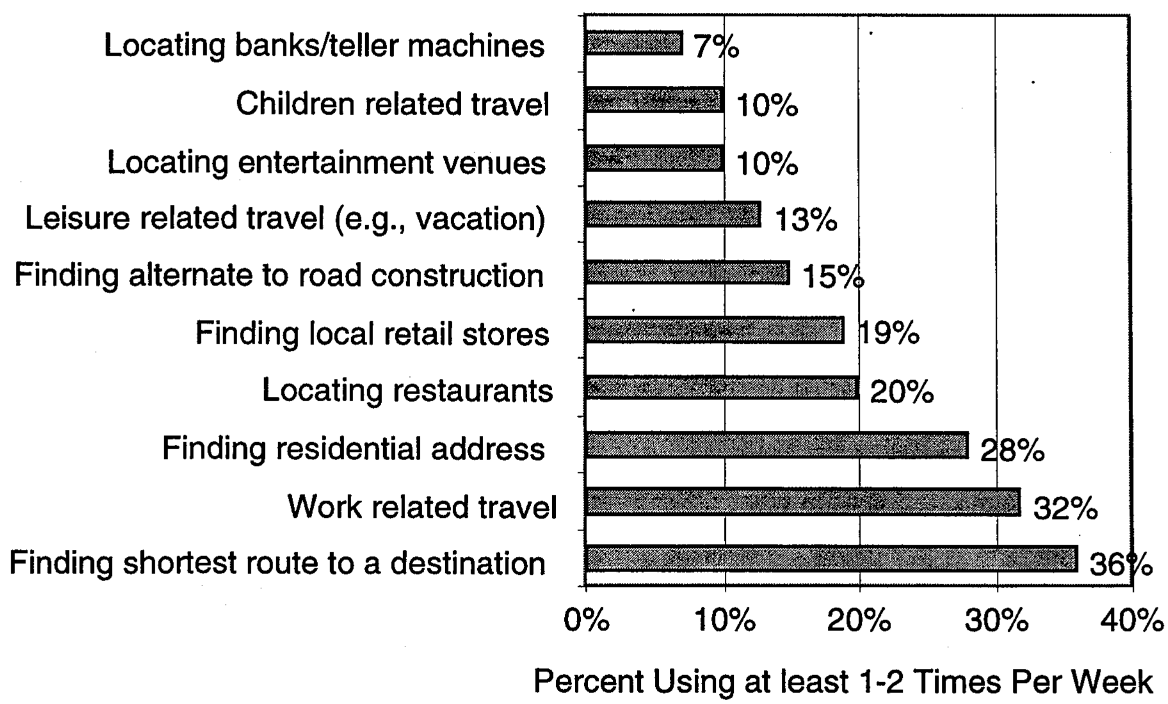


Figure 6.5. How Often Do You Use Your Navigation System For...
Source: J.D. Power (1999).

D. The Future

As a result of the FCC 911 rule, the authors expect that almost all mobile phones will have a GPS capability in a few years. For vehicles with those phones, adding a navigation system should be much less expensive than for vehicles with GPS-capable phones. A second potential trend is the move towards providing a general purpose computing resource in the vehicle. For navigation systems, the most computer-intensive task is route calculation, followed by map updating. An available computing resource would also lower navigation system cost. There are also predictions that large LCD displays may appear whose surface will be shared among systems. Certainly this is the trend in luxury vehicles. The missing element is a mass storage device (CD, hard drive, or something else) to retain the map data. Thus, the future for navigation systems in the U.S. is quite good.

However, the need for navigation systems is less critical in the United States than in Japan, where navigation systems are very popular. In the United States, streets are named, buildings are numbered spatially, and streets are arranged in a grid fashion. Furthermore, there are sometimes patterns to street naming that provide orientation information (e.g., in Detroit, Eight Mile Road is one mile south of Nine Mile Road). There is clearly a need for navigation systems in the rental car market, and this market is beginning to be tapped. A second key market is older drivers, a market that has yet to be given much attention. Older drivers limit their driving because they cannot see well at night; they have trouble reading signs during the day; and they find they are more easily lost. For older drivers, the loss of mobility is a major problem. Navigation systems will remove some restraints on their travel, and if easy to use, are most welcome.

In the United States, most navigation systems have voice guidance, a turn display, a map mode, and an interface for entering destinations. To drive to most destinations, the voice and turn display are sufficient, though the map display is helpful. For those reasons, large navigation displays being widely marketed in Japan are less critical for the United States in terms of driver performance, though they may generate showroom interest.

The design of future navigation systems will be significantly affected by SAE and international standards. In the United States, SAE Recommended Practice J2364 ("the 15-second rule") has been approved at the committee level and is expected to be approved at higher levels (Green, 1999a,b; Society of Automotive Engineers, 2000). The rule is now being treated as a working procedure at Ford, Toyota, and Nissan, and most likely other companies as well. That rule specifies that no navigation task can be accessed in a moving vehicle if it cannot be completed statically (while parked) in 15 seconds. Some government officials have expressed interest in reducing the time to 10 seconds. Many navigation systems now being produced in the U.S. do not comply with the 15-second rule. Except for simple entries (e.g., pressing a "go to home" key or selecting a destination from a short list), most methods for entering street addresses and intersections are too slow to comply with this rule. Hence, many forms of destination entry will occur while stopped.

The U.S. delegation to ISO TC22 / SC 13 / WG8 (Road Vehicle Ergonomics, Transport Information and Control Systems) has submitted SAE J2364 for consideration as an ISO standard. There were also submissions from Japan to consider total glance time and from Germany to consider the maximum time allowed for a single glance using an occlusion procedure. The initial opinion of the navigation task force was that an ISO standard should consider all of these ideas. This compromise should please all of the delegations and should lead to a comprehensive evaluation procedure. Unfortunately, because of its complexity, this procedure is likely to be costly and time consuming to complete. At the present time there are no data comparing how real systems fare when evaluated using the American, Japanese, and German procedures and criteria. It could be that systems either pass or fail all three procedures simultaneously, and some of the procedures are redundant. There are no plans to conduct research to compare the evaluation methods proposed, and without data, the selection of test methods for a standard is likely to take time, delaying the development of a standard.

Over the last few years there have been significant improvements in the recognition accuracy of speech systems. One potential application is for destination entry in navigation systems. The challenge is that the destination vocabulary (the city and street names) is huge and subject to pronunciation differences. Even for human beings familiar with a local geography, spelling out a destination name is often needed. Spelling is likely to be required in this context as well. However, spelling a name is an attention-demanding task that is not easy to do while driving. In fact, research conducted by Tijerina, Parmer, and Goodman (1999) showed that when speaking to a navigation unit, drivers looked away from the road to the microphone. Hence, drivers experienced "eyes-off-of-the road" and "mind-off-of-the-road" distractions. It should be noted, however, that the magnitude of these distractions was much less than when a keyboard was used for data entry. Thus, voice recognition has the prospect of reducing the level of distraction associated with destination entry, but not eliminating it.

For the short term, the interface technology associated with navigation systems is unlikely to change. However, there is the prospect that in the future large area HUDs may be used to display information. Research on the merits of these displays over in-vehicle displays is limited (e.g., Green, Williams, Hoekstra, George, and Wen, 1993; Steinfeld and Green, 1998), but they clearly are helpful. Further work is needed.

For the medium term, there is significant interest in integrating traffic information into navigation systems. Several companies have plans to deliver traffic information to customers via pagers. What is necessary is integration of that information into the navigation system. Such information will be of value to commuters.

A more futuristic possibility is that the presentation of navigation information by a wearable computer on glasses worn by drivers. There are no studies of using wearable computers to present information to drivers.

In summary, the authors believe that ISO standards will have a significant impact on the design of navigation systems for the next few years and will motivate designers to improve the safety and ease of use of these systems, especially for data entry. These standards may have some impact on products within one year, and all products will comply with them in five years. The development of these standards is likely to be delayed by the lack of research, with the absence of data potentially leading to a much more complex and costly-to-implement standard than is necessary.

Speech recognition and HUDs have the prospect of significantly improving the safety and ease of use of this product over the next few years. Speech input is likely to be an element of the navigation system interfaces within five years. However, the authors believe that in the long term the navigation interface could be a wearable computer.

The authors' opinion is that the leading impediment to more wide-scale purchasing of navigation systems in the U.S. is cost, followed by ease of use. Overcoming ease of use impediments could lead to a significant increase in sales, especially for older drivers, but customer demand for navigation systems in the United States will not reach the levels in Japan because of fundamental differences in geography and the driving environment. Overall, the authors see steady growth over the next year with some acceleration over the next five.

VII. VEHICLE COMMUNICATION BUS

Objective: Provide a detailed analysis of the current vehicle communication bus system activities (e.g., CAN or IDB), current connectivity applications, and future possibilities relating to these buses.

A. Introduction

Information on vehicle communication buses is described in the two parts that follow. These parts describe the intelligent data bus (IDB, Part B) and the future of in-vehicle communications (Part C). The authors would like to point out that much less information on this topic than on others in the report was available to them.

B. What is IDB?

The intelligent data bus is a serial communication-bus technology that allows a wide variety of consumer electronics components to share information across a common network in a vehicle. IDB is slated for use with OEM or after-market electronic devices (www.idbforum.org). The IDB emerged as the growth in electronics and shorter design cycles have emphasized the need for standardized, plug-and-play interfaces (Wright, 1999). Previous efforts in Europe to develop controller-area-network (CAN) standards have led to ISO 9141 and in the U.S. SAE J1850. However, SAE J1850 allows for considerable variation. Ford uses a different physical layer from GM and Chrysler. GM and Chrysler have different frame-formats above physical layer and all have proprietary messages. A critical event was the U.S. Environmental Protection Agency (EPA) and the California Air Resources Board (CARB) mandating use of the OBD-II connector for the onboard diagnostics port. This, in turn, had implications for the data stream emerging from it.

The original IDB proposal was IDB-T (IDB for telematics, a 115.2-kbps, RS-485-like, multidrop serial bus). The next (current) version of IDB (developed with AMI-C), recently approved version is known as IDB-C (or IDB-CAN). This version replaces the RS-485 physical layer with a 250-kbps CAN physical layer. This standard builds upon ideas from SAE J2366, J2367, J2368, J1760, and SAE J2284. The new bus is thought to be technically superior, but more costly, than IDB-T. Deployment is likely in some model 2002 vehicles.

C. The Future

Wright (1999) believes that by 2002 or 2003 models for mission-critical networks, most U.S. vehicles will use a standard Class C CAN implementation (500-kbps CAN bus), SAE J2284 (physical- and data-link-layer spec), which in turn uses the ISO 11898 physical layer. This approach may not work for air bag sensors, drive by wire, and ABS.

For class B networks, GM is adopting the J2411 single-wire version of CAN, and Ford is developing the proprietary UART-Based Protocol (UBP). Some believe that for mission-critical tasks (air bags, braking), time-division multiple-access (TDMA) will work better than CAN, because CAN is event or interrupt driven and will not allow device response within the required latency. In addition, some of these devices required operating voltages well above those for IDB to fire actuators. For those purposes, other communication architectures (e.g., distributed systems interface-DSI) may be appropriate.

Also in progress is the development of the next generation intelligent data bus, IDB-M (multimedia), a bus designed to support medium- to high-speed audio and digital applications. Cooperative efforts are underway with AMI-C, JSK/JAMA, ERTICO, and the 1394 (firewire) Trade Association.

There is good reason to believe that IDB will be a success. There seems to be a good working relationship between SAE and the IDB, and the IDB has a good connection with the Telematics Suppliers Consortium (TSC, www.telematics-suppliers.org) and AMI-C (Automotive Multimedia Interface Consortium; www.ami-c.com).

TSC is an organization of leading companies from the automotive electronics, wireless communications, information technology, consumer electronics and related industries. The key members are Alpine, ATX Technologies, Clarion, Cue, Etak, HP, Kenwood, InfoMove, LoJack, Mannesmann VDO, Microsoft, Motorola, NavTech, Qualcomm, Siemens, and Visteon.

AMI-C is an organization of vehicle manufacturers interested in developing software to allow a plug and play capability of installed electronic devices for information, communication, and entertainment. Much of the current documentation concerns the development of usage case scenarios. The key members are DaimlerChrysler, Ford, General Motors, Renault, and Toyota.

Another key element in the future is HAVi, though their role in automotive applications is less significant that IDB, TSC or AMI-C. HAVi (Home Audio/Video Interoperability; www.havi.org) is an organization concerned with interconnecting and controlling digital AV electronics appliances connected in home audio/video networks based on IEEE-1394 (firewire). The major members of HAVi are electronics manufacturers (Grundig, Hitachi, Matsushita Electric, Philips, Pioneer, Samsung, Sharp, Sony, Sun, Thomson, Toshiba). Although many of the devices of interest are unlikely to appear in passenger cars (cable modems, set top boxes, digital TVs, internet TVs, intelligent storage devices for AV content, video phones and internet phones), some of those devices could appear in RVs and large trucks. In addition, because of collaboration between the IEEE-1394 group and IDB, HAVi's work is important to automotive applications. Current HAVi documents include the HAVi V1.0 specification, HAVi V1.0 test specification, and HAVi Java API V1.0.

Thus, the authors' view is that the IDB effort will be a success. This is because if manufacturers rely on proprietary or partially proprietary data buses, they will not be able to deliver products to market in a timely manner. Given the vastly shortened automotive cycle, plug and play of electronic components is critical. Further, in contrast to previous efforts shepherded by several organizations (SAE, IEEE), the IDB Forum has established positive working relationships with organizations representing various constituencies (automotive manufacturers, electronics suppliers), and there seems to be a willingness to develop commonly acceptable standards. The IDB Forum has made a significant effort to present the case for their efforts at professional conferences, something SAE and IEEE generally do not do, and demonstrations at conferences ("plugfests") have been used to support the need for and usefulness of the IDB standards.

However, because vehicle bus architecture is a core vehicle characteristic specified early in design and a characteristic on which considerable vehicle engineering is based, the authors cannot forsee wide use of IDB within one year. Widespread use in five years seems reasonable, depending on when the specifications for IDB-M are released.

VIII. PRODUCT LIABILITY AND ITS

Objective: Provide a detailed analysis of the North American product liability concerns relative to ITS in general. Further, provide specific analyses of how the product liability environment will affect the future of adaptive cruise control (ACC) and collision-avoidance systems (night vision, FVCWS, LDWS, etc.) in North America.

Disclaimer: The comments in this section represent the authors' summary of the literature complemented by their own observations. The views presented are those of two observers of the industry, not those of attorneys-at-law. The advice of legal counsel is recommended to address legal issues.

A. Introduction

This section presents the legal issues pertaining to intelligent transportation systems. They include not only liability, but privacy, antitrust, and other matters as well. In general, some legal issues apply across a range of ITS technologies. To set the tone for this section, we note that the ITS-America Strategic Plan says the following about legal issues.

"Product liability may inhibit the willingness of private sector companies to develop products that differ greatly from existing products.... There is a very real danger that some IVHS applications that are technically feasible will not come into use without substantial changes in tort and product liability law. Those changes appear unlikely given current trends in legal reform..."

Regarding antitrust: "If a joint R&D venture has no anti-competitive effects, or if any such effects are outweighed by the pro-competitive effects, then the venture does not violate the antitrust laws. Furthermore, recovery for violations that do occur is limited to actual damages for joint R&D ventures that have been properly disclosed to the U.S. Department of Justice and the Federal Trade Commission."

Regarding privacy: "One major concern that had to be addressed early in the operational test design of the HELP/Crescent project was privacy safeguards for the drivers and owners of commercial vehicles participating in the project. Such concern required use of a private contractor to manage data as a buffer between public and private participants, with limitations placed on public access to the data. Similar concerns will surface from participants in other projects.

"Appropriate safeguards and guidelines on the control and use of IVHS information must therefore by built into the process in order to alleviate concerns over the inappropriate use of data and in order to protect the privacy of individual vehicle users." (IVHS America, 1992, pp. III-125 – III-128)

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The remainder of this section covers these points in detail. Legal issues relating to ITS technologies are presented first in this section. They are followed by reported opinions on these issues. Analyses of issues for the future then follows. Legal issues relating to ITS are constantly evolving. An upcoming event that is expected to increase the knowledge regarding legal issues is a mock trial pertaining to human factors and ACC at the Human Factors and Ergonomics Society annual meeting in July 2000 in San Diego. All of the evidence to date suggests this will be a landmark event, setting the tone for legal issues from a human factors perspective.

B. Legal Issues and ITS Technologies

Table 8.1 lists several ITS technologies and the legal issues associated with them. The listing of legal issues was developed based on a search of traditional and internet-based literature and contact with people in public agencies; it represents a synopsis of that information. No contact was made with attorneys in private organizations. Some of the legal issues are stated more explicitly than are others. These varying levels of specificity are due to the method of presentation in the literature.

Table 8.1. Summary of ITS Legal Issues by System

System	Legal Issues
Adaptive Cruise Control	Liability suits
Advanced Traffic Management Systems (ATMS)	Privacy, equity, product liability, tort liability, antitrust, procurement, intellectual property rights
Advanced Vehicle Control Systems (AVCS):	Negligence, strict product liability, breach of warranty, fraud, negligent representation, and fraudulent or negligent advertising
Collision Avoidance	Defective design liability, strict liability for manufacturing defect, negligence for inducing driver reliance in a system that fails to avoid all accidents, failure to install collision avoidance systems in all vehicles, potential cause of accidents
Collision Warning	Product liability, negligent design, negligent manufacturing, defective product claims, negligence in not providing collision warning devices in all vehicles
Electronic Toll Collection	Privacy, equity, product liability, tort liability, antitrust, procurement, intellectual property rights
Navigation	Liability issues related to errors and misrepresentation of map and demographic data, determining liability responsibility between the owner of the data and the purchaser, third party claims such as injury caused by the map database or the device using it; product liability: negligence and strict liability, breach of express and implied warranty, privacy safeguards

Readers should bear in mind that much of the advice presented in this section was offered before ITS standards were developed. If those cited were solicited for opinions now, their views could be different because safe and accepted practice has been better defined and the technology is better understood.

C. Reported Opinions on Legal Issues Relating to ITS Technologies

This part provides published opinions on legal issues regarding the ITS technologies listed in the table above, and they are presented in the order used in the table. All views found in the literature search, including those that conflict, are presented.

1. Adaptive Cruise Control

Even though the expectation is that those technologies that transfer the control of the vehicle from the driver have the highest potential for legal issues, there is very little in the literature on legal issues pertaining to adaptive cruise control (ACC). Two articles indicate the surety of liability suits and the impact of that surety.

"Holger Meinel, senior researcher at Daimler Benz Aerospace AG (Ulm, Germany), was quick to make a point stressed by all the companies working in this field. "This is not anti-collision radar," he said. "It's not a safety feature, it's a comfort feature.

"The source of this distinction is concern that if adaptive cruise control is marketed as a safety feature, the first accident that occurs involving a vehicle equipped with millimeter-wave radar will bring a damaging liability suit. That's why companies are at great pains to point out that the driver retains control and responsibility." (Clarke, 1998).

Product liability is always "a concern when new products are involved. The fear of lawsuits has helped slow the introduction of adaptive cruise control in the USA, even as European drivers begin to use it. "There's a certain amount of 'Let's wait and see what happens in Europe,'" says Nick Ford, business development manager for adaptive cruise control systems at TRW Automotive Electronics." (Content, 1999).

The authors have observed that in many situations concerning automotive product liability, compliance with recognized technical standards is given significant weight. For ACC systems, the relevant documents are SAE draft standard J2399 (Society of Automotive Engineers, 1999) and ISO committee draft standard 15622 (International Standards Organization, 1999).

Of the developed product markets for motor vehicles (United States, Japan, Europe), the U.S. clearly has the most contentious product liability context for product manufacturers. Of the ITS systems to be deployed in the near term, ACC is the only system to potentially have fundamental implications for how people drive. Therefore, ACC products are most likely to appear in other markets where the initial problems during deployment will have the least serious legal consequences.

The core of the debate is whether ACC should be considered a comfort system or a safety system. In discussions of this issue, some manufacturers' representatives have supported the comfort perspective while others the safety perspective. However, what matters is not what engineers believe it to be, but how drivers actually envision and use ACC systems. If drivers extrapolate from normal driving that ACC systems will protect them in crashes (that is, ACC systems are for safety) and those systems do not, then the manufacturers could be at risk for liability actions.

2. Advanced Traffic Management Systems (ATMS)

A 1993 report by the USDOT indicates a range of legal issues related to ATMS that might deter their introduction (Transportation Research Board, 1993, p. 31).

Legal issues pertaining to traffic management include privacy and equity. In addition, "A number of other legal issues could greatly affect (ATMS) deployment. They include product liability and other tort liability, antitrust, procurement, and intellectual property rights. Liability doctrines and practices may significantly deter private sector designers and manufacturers from the development and introduction of new technologies to the surface transportation system. Exposure to risk of expensive product liability suits raises the cost to the private sector. Vehicular accident cost, primarily borne by the driver today, may fall on (ATMS) product manufacturers."

On the other hand, a later report by DOT in 1997 indicates that legal issues were not a problem for ATMS by 1994 (U.S. DOT, 1997, pp. E-22 – E-25).

"The USDOT 1994 report to Congress indicated that "to date there was no compelling evidence that concerns over potential liability have inhibited development and deployment of ITS technologies for traffic management and traveler information."

As with other systems, compliance with recommended design practice provides significant legal protection to manufacturers. There are not design guidelines or practices for ATMS development or deployment overall, and the most closely related set of design guidelines are for control rooms (Kelly, 1995).

3. Advanced Vehicle Control Systems

A variety of opinions exist on AVCS ranging from no expectations of difficulty in implementation due to liability issues to significant problems.

Conclusions of the Workshop on Liability Issued in Advanced Vehicle Control and Automated Highway Systems are as follows. (National Automated Highway System Consortium, et al., 1997).

"There is no present belief that liability concerns *per se* will stop the development and preliminary deployment of either AVCS or Automated Highway Systems (AHS).

"There is little direct evidence that liability concerns are presently hindering the development and deployment of ITS general, nor of either AVCS or AHS specifically.

"While liability is often cited as a barrier to the development and introduction of new technology into the marketplace, all groups (at the workshop) except Industry/Manufacturers believed that competition within industries was a bigger factor.

"Fear of liability, particularly concerns about possible changes in the allocation of liability as control of the vehicle becomes more automated, is a reality. Consideration of this fear may likely influence designs of future products.

"If it can be proven that AHS enhances both the intended and actual safety of the product, then the reality of liability will be substantially reduced.

"Recommendations (of the Workshop were):

"Potential liability problems can be managed, if addressed early on, with techniques as consulting legal counsel throughout the development phase of AVCS and AHS technologies.

"In order to control potential exposure to liability, it is essential to manage expectations of new technology through realistic public education about the actual limits, capabilities, and benefits of the proposed technology.

"More education and outreach to the insurance industry and to safety groups is needed to promote understanding and acceptance of these emerging technologies."

"AVCS manufacturers, sellers, and designers could face significant exposure under existing tort law to claims for negligence, strict product liability, breach of warranty, fraud, negligent representation, and fraudulent or negligent advertising. A variety of legislative changes to the law, however, could drastically diminish that potential tort liability, by preemption state tort law, limiting liability, modifying tort doctrines, mandating alternative dispute resolution and various other reforms." (Nossaman, Gunther, Knox & Elliott, 1993).

"The most serious legal constraint to IVHS research, development, and deployment seems to remain tort liability problems of advanced vehicle controls systems." (Syverud, 1993, p. 49-51.)

4. Collision Avoidance Systems

The one report identified that treated collision avoidance systems indicates a strong likelihood of liability concerns.

The USDOT 1994 report to Congress indicated that "the focus of concern in the legal community has shifted to the potential for liability resulting from advanced collision avoidance systems, particularly those that remove control from the driver. Many believe that because of the litigious nature of our society, these ITS technologies are more likely to be introduced in countries other than the United States, as developers adopt a wait-and-see approach (USDOT, 1997).

"The tort liability concerns with collision-avoidance systems are very similar to those of the collision-warning systems. When accidents occur after a collision-avoidance system fails to warn the driver or take corrective action, manufacturers could be held (1) strictly liable under a defective design liability claim, (2) strictly liable for a manufacturing defect, or (3) negligent for inducing driver reliance in a system that fails to avoid all accidents. In addition, manufacturers may also be sued for failing to install collision-avoidance systems in all vehicles. These are exactly the same strategies that will be used against manufacturers of collision-warning systems, and they are likely to transfer significant liability. Furthermore, manufacturers of collision-avoidance systems will face additional liability since these systems can potentially cause accidents.... (Collision-avoidance systems) may actually increase the number of accidents. The liability for almost all accidents in cars equipped with collision-avoidance systems would conceivably fall on the manufacturer."

5. Collision-Warning Systems

The one report identified on collision-warning systems indicates a strong expectation of liability concerns (Ayers, 1994, p. 21-23).

"Although collision-warning systems leave full control of the vehicle in the driver's hands, they are likely to induce some degree of driver reliance as motorists come to expect warnings when their vehicles get dangerously close to other vehicles. This reliance may provide a basis for shifting liability to manufacturers of these systems for accidents that occur when the systems malfunction or fail to provide warnings as a result of design limitations (e.g., the system may be unable to detect impending collisions with motorcycles, or its performance may degrade under certain weather and/or road conditions). The brunt of this liability will be faced by the manufacturers who produce and distribute the collision-warning devices. Estimates of the likely extent of this liability can best be developed from the analogous manufacturer-supplied safety devices that exist today: seatbelts and airbags.... (S)uits claiming negligent design or manufacture of both seatbelts and airbags are common. Both types of suits can be expected with collision-warning systems, and the liability will likely be much higher given the technical challenge of designing a system that lives up to driver expectations.

"In addition to negligent design and defective product claims, negligence suits alleging the failure to provide collision-warning devices in all cars can be expected."

SAE is currently developing a standard for forward collision-warning systems (SAE J2400).

6. Electronic Toll Collection

Several legal issues are expected with electronic toll collection as reported in one Transportation Research Board document (Transportation Research Board, 1993).

"Legal issues pertaining to electronic toll collection include privacy and equity. In addition, a number of other legal issues could greatly affect (ETC) deployment. They include product liability and other tort liability, antitrust, procurement, and intellectual property rights. Liability doctrines and practices may significantly deter private sector designers and manufacturers from the development and introduction of new technologies to the surface transportation system. Exposure to risk of expensive product-liability suits raises the cost to the private sector. Vehicular accident cost, primarily borne by the driver today, may fall on (ETC) product manufacturers."

7. Navigation Systems

The documents on navigation systems report expected liability issues to be of concern.

"Liability was identified as a concern by many of the ITS map database providers interviewed (in a study done for the Federal Highway Administration). The liability issue exists because inaccurate map data may be the impetus to accidents and other harmful events. According to vendors, liability is always a concern and should be viewed in two ways (University of Tennessee, 1995).

"The first involves determining liability responsibility between the owner of the data and the purchaser. In this case it is relatively easy to resolve through comparative indemnification or specific allocations in contracts ... In addition, some survey respondents indicated the onus for liability would be on the actual device utilizing map data rather than on the data provider directly.

"The second type of liability involves third-party claims. In cases such as personal injury caused in part by the map database or the device using it, problems are unavoidable. Some government agencies have a type of umbrella policy which could shield potential map data providers, but in general it is not possible to contract away third party liability claims. Some examples of potential map data liability concerns include the following:

- A route guidance system tells the user to turn left into a lake. Who pays for the damage/injuries?
- A driver using an in-vehicle map system unknowingly turns the wrong way down a one-way street and gets into an accident. Can he sue for damages?
- The database displays a speed limit of 65 miles/hour. The speed limit is actually 55 miles/hour and the user gets a speeding ticket. Who should be held responsible?
- A vehicle is routed through a dangerous area that would otherwise be avoided. Who should be blamed if a mugging or car-jacking results?
- An emergency response vehicle carrying a heart attack victim gets to a hospital ten minutes late because of inaccurate map data. The patient dies. Is the navigation system at fault?
- A product meant for private automobiles is accidentally used in an RV. If this vehicle is carrying petroleum fuel and is routed through a tunnel prohibiting the transportation of gas, could the system be held libel because the database did not include the restriction?

"ITS is still in its infancy and according to the interview respondents there have been no such incidents as described above. With the proliferation of ITS technologies, however, there are sure to be liability claims. One private agency participant suggested the best way to alleviate the liability concern would be for government to agree upon a performance standard. Once the standard is established, Congress should change the law so that compliance with the standard serves as a complete defense to a claim of negligence or liability. Failure to meet this standard, on the other hand, would establish the existence of a defect and guarantee liability. Currently no standards exist; therefore each case would be determined on an ad hoc basis. Consequently, data providers must be cautious under the present conditions.

"Other suggested ways to guard against potential liability include: a) obtaining insurance and/or negotiating comparative liability based on fault (for example, party A represents both A and B in a liability suit, while B shares a portion of the fault), and b) making the data as accurate as possible and document that a good faith effort was made in developing the product. The most effective defense under current laws is to ensure that only the minimal risk possible remained in the data and that all the reasonably perceived risk was considered before making the product available for ITS.

"The general consensus of the phone survey was that liability is an issue to be considered in developing map data for ITS but it has not nor should not serve as a significant barrier to deployment. One vendor expressed the opinion that liability is a fact of life for all products made available to the commercial market and ITS is no exception. The only solution is to do whatever possible to minimize liability risks but be aware that these risks can never be eliminated entirely. According to the survey respondents, no one has been afraid to participate in map data related ITS projects because of the threat of liability. There may be instances whereby costs are passed on to end users through higher prices, but in general the threat of liability should not stifle the development of innovative map database products for ITS."

Another author reports on OnStar. "The latest OnStar wrinkle ... is the addition of remote diagnostics to the list of services subscribers can receive. The OnStar center can now interrogate 266 system codes covering engine, powertrain, antilock brakes and air bags. The idea is that if a warning light illuminates on the dashboard, a subscriber calls it in. The advisor has a list of the codes and what to do in case one of them is activated. He or she can then advise the motorist to turn the car off and wait for assistance, schedule an appointment at the GM dealership, or take other action. This takes service to a whole new level. But also raises a number of liability issues." (Cannon, 1998).

Regarding geographic information systems (GIS), Mennecke notes, "With increased GIS use and data accessibility comes the potential for negative impacts on society. For instance, issues related to errors and misrepresentation of both spatial data and demographic data can potentially result in legal liability for data purveyors and users ..." (Mennecke, 1997).

Probably the most relevant set of design requirements for ATIS is the standards pertaining to navigation (e.g., "The 15-Second Rule") described earlier. The general feeling in the human factors community is that the major safety concerns are the long periods for which the driver's eyes are off the road during destination entry, followed by the visual demands (long eyes-off-the-road times) associated with complex maps. A third concern stems from situations where the voice instructions are viewed as commands rather that guidance. This can occur, for example, when the voice is an assertive male, or the tone is forceful ("Turn now" versus "Prepare to turn"). When viewed as commands, people may change lanes without looking, make turns when traffic lights indicate not to, and make other errors because they believe the car "knows everything." These problems can be eliminated by careful design. These operational problems will probably be far more important than those caused by data base errors.

The following comments reveal a range of views regarding advanced traveler information systems (ATIS). The USDOT reports no evidence of problems, as does Syverud. But, he notes that there is a possibility of legal issues in the future. A 1993 report for the Federal Highway Administration indicates the range of such potential problems (USDOT, 1997).

The USDOT 1994 report to Congress indicated that "to date there was no compelling evidence that concerns over potential liability have inhibited development and deployment of ITS technologies for traffic management and traveler information."

Based upon literature search and interviews, "it appears that certain possible IVHS legal constraints have not yet materialized and are unlikely to do so in the future. These 'non-issues' include antitrust constraints and tort liability constraints for ATMS and ATIS applications (Syverud, 1993).

"Of course, it is possible that antitrust law or products liability problems will emerge some time in the future to constrain ATMS and ATIS.

"This study has found several substantial legal constraints to IVHS technology that are nevertheless manageable through a variety of feasible approaches. The author believes that many of the procurement, intellectual property, and contractual negotiation problems that inspire the most bitter complaints today can be overcome through education efforts and experience of IVHS player with the unique procedures and problems of IVHS procurement at the federal, state, and local levels...."

"Regarding ATIS, there is potential tort liability regarding (1) product liability: negligence and strict liability, and (2) breach of express and implied warranty." (Nossaman, Gunther, Knox & Elliott, 1993).

D. Analysis of the Future

This part includes (1) analyses of the product liability issues that are expected to hold in the future, (2) predictions as to which technologies might be delayed in being introduced in the U.S. because of legal issues, and (3) what actions can be taken by companies involved in providing of ITS services to mitigate ITS-related legal issues.

The authors would like to emphasize that within the last year or two, significant progress has occurred in the development of Society of Automotive Engineers Standards and Recommended Practices for some of these systems, as well as of ISO Standards. It is expected that progress on the SAE efforts will slow because the U.S. Department of Transportation has not elected to support additional standards development. This situation is likely to lessen the extent to which the U.S. delegation can contribute to ISO standards discussions and will potentially slow ISO efforts to some degree as well.

It can be expected that some ITS technologies are more likely to be affected by legal issues than others. Those that stand out as legal targets are the ones, such as adaptive cruise control and advanced vehicle control systems, that transfer any control away from the driver. The authors believe that the continuing development of SAE and ISO standards will be a significant factor in reducing the uncertainty associated with legal issues. Although they do not eliminate a wide range of liability concerns, they provide a clear basis for identifying accepted practice, a key point in these matters. Specifically, different technologies will have different legal issues attendant to them in the future.

The United States is more litigious than most other developed countries. Automotive companies have often reported that concern over lawsuits resulting from the introduction of safety technologies has inhibited their introduction. It can be expected that this will continue over the next several years, with regard to safety technologies, as well as intelligent-transportation-system technologies. Concern over potential lawsuits will cause companies to (1) build the expected cost of litigation into the product business plan, (2) engage in activities such as those noted below that will minimize their liability concerns, and/or (3) delay the introduction of products until they have evidence that lawsuits will be minimal.

For all technologies, prudent strategies to mitigate the impact of potential liability would include education of the potential users of the technologies and insurance to cover liability-lawsuit cost. However, the authors believe that the predominant and most effective strategy will be to emphasize product designs that minimize risks to drivers and to support independent safety evaluations of products. Furthermore, manufacturers and suppliers are strongly encouraged to support the development of international standards, either by participating in meetings or supporting experts who are available to attend. Further, a major roadblock to progress within SAE and ISO has been the lack of research dealing with issues pertaining to standards.

Following are the authors' expectations concerning the legal issues likely to be relevant in the future, delays in technology implementation that could be expected due to the legal issues, and some actions that could be used to minimize liability. These are presented by each ITS system, in turn. Again, legal counsel should be sought to deal with these issues.

1. Adaptive Cruise Control

Liability suits are expected if ACC is marketed as a safety feature, and possible liability can be expected because of dependence on the system. Because of a fear of liability lawsuits, companies may wait and see what happens in Europe. This is consistent with the observation above that those technologies that transfer control from the driver are the ones likely to cause legal problems for industry. Liability can potentially be decreased by pointing out to drivers that they retain vehicle control and responsibility.

2. Advanced Traffic Management Systems

Future legal issues regarding ATMS include privacy, equity, liability, antitrust, procurement, and intellectual property rights. Some have indicated that there have been no liability suits in the past and that there are likely to be no delays in this technology due to liability concerns. Syverud notes that there is a possibility of antitrust law or products liability problems. We expect that these will not cause product delays. Manufacturers should educate vehicle drivers on the limits of the systems to mitigate liability concerns.

3. Advanced Vehicle Control Systems

Legal experts report that negligence, strict product liability, breach of warranty, fraud, negligent representation, fraudulent or negligent advertising, and tort liability are likely to be future legal issues regarding AVCS. One view is that there is no belief that liability concerns *per se* will stop or delay the development and preliminary deployment of AVCS. We disagree. We expect that there will be a continuing liability concern over AVCS in the United States until technology and humans interact in a nearly fail-safe way or until the United States becomes less litigous. To limit liability, manufacturers should support changes in legislation that could diminish potential tort liability by limiting liability, modifying tort doctrines, and mandating alternative dispute resolution. Fear of liability, as technology takes more control of the vehicle, is likely to influence designs of future products. Manufacturers should prove that AVCS enhances the intended and actual safety of the vehicle and should consult legal counsel throughout the development phase of the technologies. Further, they should manage expectations of new technologies though realistic public education about their actual limits, capabilities, and benefits. This carries over to advertising the product. In addition, manufacturers should educate the insurance industry and safety groups about these technologies.

4. Collision-Avoidance Systems

Expected legal issues include strict liability under a defective-design liability claim, strict liability for a manufacturing defect, negligence for inducing driver reliance in a system that fails to avoid all accidents, and failing to install collision avoidance systems in all vehicles. We expect that there will be some delays in implementation due to the expectation of liability suits. Educating the consumer on the capabilities and limitations of the system should help in decreasing liability issues.

5. Collision-Warning Systems

Expected legal issues include liability regarding negligent design and defective products, and failure to provide collision-warning devices in all vehicles. We expect delays due to anticipated liability suits. These can be mitigated by providing information to drivers on the design limitations of the technologies and educating them about minimizing reliance on warning expectation.

6. Electronic Toll Collection

Future legal issues are expected to include privacy, equity, and liability doctrines and practices. We believe that delays in implementation due to expected liability are not likely. As with other technologies, educating the consumer on the capabilities and limitations of the system should mitigate liability issues.

7. Navigation Systems

Although there are potential liability issues due to inaccurate map data and third party claims after an injury caused in part by the map database, the major consideration for navigation systems is the extent to which use of the technology distracts drivers. This includes problems occurring while drivers enter destinations or read maps. There is evidence from Japan of navigation-system-induced crashes (Green, 2000). The potential involvement of ITS devices in crashes is not recorded in many databases, increasing the uncertainty as to the number of crashes in which use of these products was a causal factor. Other issues with regard to advanced traveler information systems include negligence and strict liability, and breach of express and implied warranty.

Given the growth in implementation of these technologies in some markets (e.g., high-price and rental vehicles), we do not expect delays in the implementation of navigation systems, including advanced traveler information systems, due to legal issues. However, the possibility, of course, exists.

Regarding database issues, liability responsibility between the owner of the data and the purchaser can possibly be resolved through comparative indemnification or specific allocations in contracts. Further, manufacturers can ensure that all products are tested in compliance with SAE and ISO recommended practices, and that such tests occur early in design (when concepts are being evaluated) and when the final product is available. Having tests conducted by independent outside organizations can reduce challenges that tests are biased. As noted above, compliance with SAE J2364 and related ISO standards should minimize the number of system-induced crashes and provide a defense where faulty design is alleged.

IX. FUTURE RESEARCH

During this project, several questions arose whose answers could be useful in helping the sponsor develop future product plans.

Problem 1: The report of this project includes forecasts from several sources, but checking their accuracy was beyond the scope of the project.

> Question: How do the various forecasts (Michigan Delphi, industry strategy/marketing organizations, government, consumer surveys) for ITS technologies compare with each other and, for older forecasts, with actual market data?

Problem 2: There are a large number of potential safety innovations that the sponsor may wish to implement in future vehicles. However, predictions of lives saved depend on how the product, service, or procedure is viewed and utilized by drivers. For example, when the speed limit was reduced in the United States to 55 mi/hr, the gains were much larger than expected. In contrast, ABS has provided minimal safety benefit.

> Question: How can the relative safety benefit of an innovation be predicted from a description of a device, the phase of a crash affected (pre-crash, crash, post-crash), the impact on driver performance, likely changes in risk-taking, and other factors.

Problem 3: The focus of this project has been on identifying ITS products drivers are likely to want. There is a substantial body of literature on successful product innovation. That body could be applied here to develop a formal method (checklist, regression model, etc.) for identifying appealing products.

> Question: What are the characteristics of products that customers are likely to want? Characteristics might include the visibility of the device, the visibility of controls and displays for it, the specific safety benefit (e.g., reduction in fires, protection of children), and so forth.

X. REFERENCES

Apogee Research, Inc. and Wilbur Smith Associates. (May, 1997). ITS National Investment and Market Analysis, Washington, D.C.: ITS America and U.S. Department of Transportation.

Ayers, D. R. (March, 1994). Tort Reform and "SMART" Highways: Are Liability Concerns Impeding the Development of Cost-Effective Intelligent Vehicle-Highway Systems? (Technical Report VTRC 94-R6), Charlottesville, VA: Virginia Transportation Research Council, (http://www.bts.gov/NTL/DOCS/ayers.html).

Cannon, B. (September, 1998). Intelligent Transportation Systems, An Evolving Technology, Motor Age Online. http://www.motorage.com/edindex/0998138.HTM, Accessed 3/19/00.

Cellular Telephone Industry Association (2000). CTIA's Semi-Annual Wireless Industry Survey; http://www.wow-com.com/wirelesssurvey/.

Clarke, P. (1998). Adaptive Cruise Control Takes to the Highway, EETimes.com. http://eet.com/story/OEG19981020S0007. Accessed 3/19/00.

Cole, David E. and Londal, Gerald F. (2000). Delphi X Forecast and Analysis of the North American Automotive Industry, Volume 1: Technology, Ann Arbor, MI: University of Michigan Transportation Research Institute, Office for the Study of Automotive Transportation.

Content, T. (October 25, 1999). Technology Could Lead to Safer Cruising, USA Today, http://www.usatoday.com/money/consumer/autos/mauto607.htm. Accessed 3/19/00.

Costello, P. (February, 2000). Intelligent Transportation Society of America, Data files on Intelligent Transportation System Market, Washington, D.C.: Intelligent Transportation Society of America.

Federal Communications Commission. (1999). Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems, (FCC Docket 99-245), October 6, 1999, Washington, D.C.: Federal Communications Commission, http://www.fcc.gov/Bureaus/Wireless/Orders/1999/fcc99245.pdf or http://www.fcc.gov/e911/welcome.html#otpres and under Recent FCC E911 Actions, click one one of the choices for "Third Report & Order."

Green, P. (1999a). Estimating Compliance with the 15-Second Rule for Driver-Interface Usabilty and Safety, Proceedings of the Human Factors and Ergonomics Society 43rd Annual Meeting, Santa Monica, CA: Human Factors and Ergonomics Society, CD-ROM.

Green, P. (1999b). The 15-Second Rule for Driver Information Systems, ITS America Ninth Annual Meeting Conference Proceedings, Washington, D.C.: Intelligent Transportation Society of America, CD-ROM.

Green, P. (2000). Crashes Induced by Driver Information Systems and What Can Be Done to Reduce Them, paper to be presented at the Convergence 2000 Conference, Dearborn, Michigan.

Green, P., Williams, M., Hoekstra, E., George, K. and Wen, C. (1993). Initial On-the-Road Tests of Driver Information System Interfaces: Examination of Navigation, Traffic Information, IVSAWS, and Vehicle Monitoring (Technical Report UMTRI-93-32), Ann Arbor, MI: The University of Michigan Transportation Research Institute.

International Standards Organization (1999). Road Vehicles – Adaptive Cruise Control Systems – Performance Requirements and Test Procedures (ISO Committee Draft Standard 15622, International Standards Organization, document CD 15622 TC204/WG14/N143.17), Geneva, Switzerland, International Standards Organization.

Intelligent Vehicle-Highway Society of America (IVHS) (1992). Strategic Plan for Intelligent Vehicle-Highway Systems in the United States (Report IVHS-AMER-92-3). Washington, D.C.: Intelligent Vehicle-Highway Society of America, http://search.bts.gov.

J.D. Power (1999). J.D. Power Navigation Usage and Navigation Study (http://www.jdpower.com/jdpower/releases/navigation110899.htm)

J.D. Power (November, 1999). Navigation Systems: The Beginnings, The Power Report, 6-7, Agoura Hills, CA: J.D. Power and Associates.

J.D.Power (2000). Most Desired Features Per Segment, 1999 APEAL Feature Content Report, www.jdpower.com/images/FCR99Chart.gif.

J.D.Power (2000). Features Consumers Want and What They are Willing to Pay for Them in Their Next Vehicle, 1999 APEAL Feature Content Report, www.jdpower.com/images/FCR99Graph.gif.

Joint EIA/ITS America (1997). Forecasting the Market Potential of Intelligent Transportation Systems Into the 21st Century, Forecast Conference of Intelligent Transportation Systems Opportunities, Arlington, VA: Electronics Industry Association.

Kelly, M.J., 1995. Human Factors Handbook for Advanced Traffic Management Center Design, Atlanta, GA: Georgia Tech Research Institute.

Lawrence, S. (February 7, 2000). The Net World in Numbers, http: www.idg.net.

Mennecke, B. E. (1997). Understanding the Role of Geographic Information Technologies in Business: Applications and Research Directions. Journal of Geographic Information and Decision Analysis, 1(1), 44-68, http://publish.uwo.ca/~jmalczew/gida_1/Mennecke/Mennecke.htm. Accessed 3/19/00.

Miles, S. (January 20, 2000). Study: Handheld sales up 169 percent, CNETnews.com, http://news.cnet.com/news/0-1006-200-1527697.html.

Miller, J. (February 7, 2000). GM Expects Other Makers to Start Using OnStar, Automotive News, 5680, 6.

National Automated Highway System Consortium, ITS America, and American Association of State Highway & Transportation Officials (February 5-6, 1997). Joint Workshop on Liability Issues in Advanced Vehicle Control and Automated Highway Systems (Workshop Report), document 9704, Washington, D.C.: Intelligent Transportation Society of America, http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/7hk01!.pdf.

Nossaman, Gunther, Knox & Elliott (December 1, 1993). Possible Impediments to Development of Advanced Traveler Information Systems: An Analysis of Potential Tort Liability. Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration.

Richards, M. R. and West, M.J. (1999). ITS from Coast to Coast: Outreach and Marketing the Seattle and New York MDI Projects. Seattle, WA: Pacific Rim Resources.

Schwartz, E. (March 23, 2000). Confusion Reigns as Wireless Internet Solutions Proliferate, CNN.com>technology>computing, http://cnn.com/2000/TECH/computing/03/23/wireless.confusion.idg/index.html.

Society of Automotive Engineers (1999). Adaptive Cruise Control (ACC) Human Factors: Operating Characteristics and User Interface (SAE Draft Standard J2399), available from Ann Arbor, MI: University of Michigan Transportation Research Institute.

Society of Automotive Engineers (2000). Navigation and Route Guidance Function Accessibility While Driving (SAE Recommended Practice J2364), draft of January 20, Warrendale, PA: Society of Automotive Engineers.

Steinfeld, A. and Green, P. (1998). Driver Responses to Navigation Information on Full-Windshield, Head-Up Displays, International Journal of Vehicle Design, 19 (2), 135-149.

Strategis Group (October, 1999). U.S. Telematics Marketplace: 1999 (Report Order Code R57-122W), Washington, D.C.: Strategis Group.

Syverud, K. (March 31, 1993). Legal Constraints to the Research, Development, and Deployment of IVHS Technology in the United States, Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration.

Tijerina, L., Parmer, E., and Goodman, M.J. (1998). Driver Workload Assessment of Route Guidance System Destination Entry While Driving: A Test Track Study, Proceedings of the Fifth ITS World Congress, Washington, D.C.: Intelligent Transportation Society of America.

Transportation Research Board (1993). Electronic Toll and Traffic Management (ETTM) Systems, A Synthesis of Highway Practice (NCHRP Synthesis 194), Washington, D.C.: National Highway Cooperative Research Program.

Tucker, P. (1998). Intelligent Transport Systems, A Review of Technologies, Markets, and Prospects, London, U.K.: Financial Times Automotive.

U.S. Department of Transportation (USDOT) (1997). Nontechnical Constraints and Barriers to the Implementation of the National ITS Program: 1996 Report to Congress, Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration, Joint Program Office for Intelligent Transportation Systems.

University of Tennessee Energy, Environment, and Resources Center; ALK Associates Inc.; Oak Ridge National Laboratory; Viggen Corporation (September 29, 1995). Meeting National ITS Spatial Data Needs, Task C2: Nationwide Map Database and Location Referencing System Project Draft Final Report, McLean, VA: Federal Highway Administration, Office of Safety and Traffic Operations, IVHS Research Division, http://itsdeployment.ed.ornl.gov/spatial/document/html/finlrpt.htm. Accessed 3/19/00.

Ward's Communications (1999). Automotive Yearbook (61st ed.), Southfield, MI.: Ward's Communications.

Woodyard, M. (October 5, 1998). GM Offer Seeks to Boost Sluggish Sales of OnStar, Automotive News, 73 (5787), 4.

Wright, M. (1999). Auto Electronics Prep for a Multimedia Future, EDN Access (August 19 cover story); www.idbforum.org/news.htm.