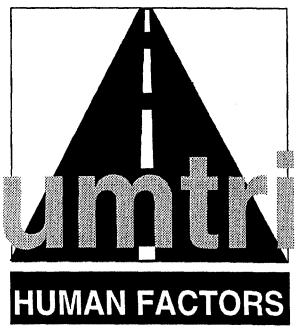
Technical Report UMTRI-2001-15 December, 2001

Automotive Industry Trends in Electronics: Year 2000 Survey of Senior Executives

Paul Green, Mike Flynn, Gary Vanderhagen, Joe Ziomek, Esther Ullman, and Ken Mayer



Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTRI-2001-15		

3. Title and Subtitle	5. Report Date
Automotive Industry of Trends in Electronics: Year 2000 Survey of Senior Executives	December, 2001
	6. Performing Organization Code: account 377218
7. Author(s): Paul Green, Mike Flynn, Gary Vanderhagen, Joe Ziomek, Esther Ullman, and Ken Mayer	8. Performing Organization Report No.: UMTRI-2001-15
9. Performing Organization Name and Address: The University of Michigan Transportation Research Institute (UMTRI) 2901 Baxter Rd, Ann Arbor, Michigan 48109-2150 USA	10. Work Unit no. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address: Jointly funded by a consortium of 11 organizations	13. Type of Report and Period Covered: 6/2000 - 5/2001
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This study surveyed automotive executives to obtain insight into the future of automotive electronics. Four hundred executives received the 24-question multi-part surveys. There were 84 usable responses, mostly from high level executives, with 71% of those responding being CEO, presidents, vice-presidents, or directors.

Respondents noted supplier roles, as well as the overall pace of change, would continue to increase. They felt some supplier-OEM relationships were too driven by price, but in successful relationships, there was considerable technical expertise and R&D conducted by both parties. They strongly agreed that purchasing electronics in "chunks" improved the product.

Respondents wanted to know what communications standards would be adopted and the nature of government-regulation driver distraction. They noted product plans were most likely to be upset by a more rapid than expected change from internal combustion to alternative power sources and 12 to 42 v systems.

Product features likely to reach 10% market penetration for luxury vehicles in 2004 include built-in wireless phone interfaces, GPS navigation, automatic collision notification, satellite radio, removable media for entertainment and data, email/Internet access, PDA docking station, and adaptive cruise control.

17. Key Words	18. Distribution Statement
driving, human factors, telematics, safety, supplier relations, future vehicles, vehicle electronics	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classify. (of this report)	20. Security Classify. (of this page)	21. No. of pages	22. Price
(None)	(None)	106	

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Automotive Industry Trends in Electronics: Year 2000 Survey of Senior Executives

Summary

UMTRI-2001-15 **October, 2000**
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Ann Arbor, Michigan, USA

1 Data Collection

- 24-question survey
- 84 automotive executives responded
- 45% were vice-presidents or above, 73% were directors or above
- Representatives from assemblers, integrators, Tier One/Tier Two suppliers, etc.
- 42% were in design/engineering

2 General Conclusions

Overall

1. No single outstanding response for most questions
2. Often little discrimination between options
3. Overall agreement in responses of OEMs and suppliers
4. Pace of change will quicken
5. Competitive focus on current major organizations
6. Concerns about regulations for telematics
7. General need for standards

Other key specific conclusions

1. Purchasing electronics as chunks will improve vehicles (yes:no by 2:1 margin).

2. Plans for future electronics will be most disrupted by:
    a. In general, more rapid introduction of technology
    b. Expanded driver distraction legislation
    c. Faster than expected adoption of 42 v
    d. Lack of wireless standards
    e. Insufficient wireless infrastructure for demand

3 Product Development Process and OEM-Supplier Relationships

What is the major OEM-supplier problem?

Problem	%
Assemblers too preoccupied with price	16
Failure to create OEM-supplier partnership	12
Lack of industry standards and requirements	12
Excessively long automotive development cycle	12

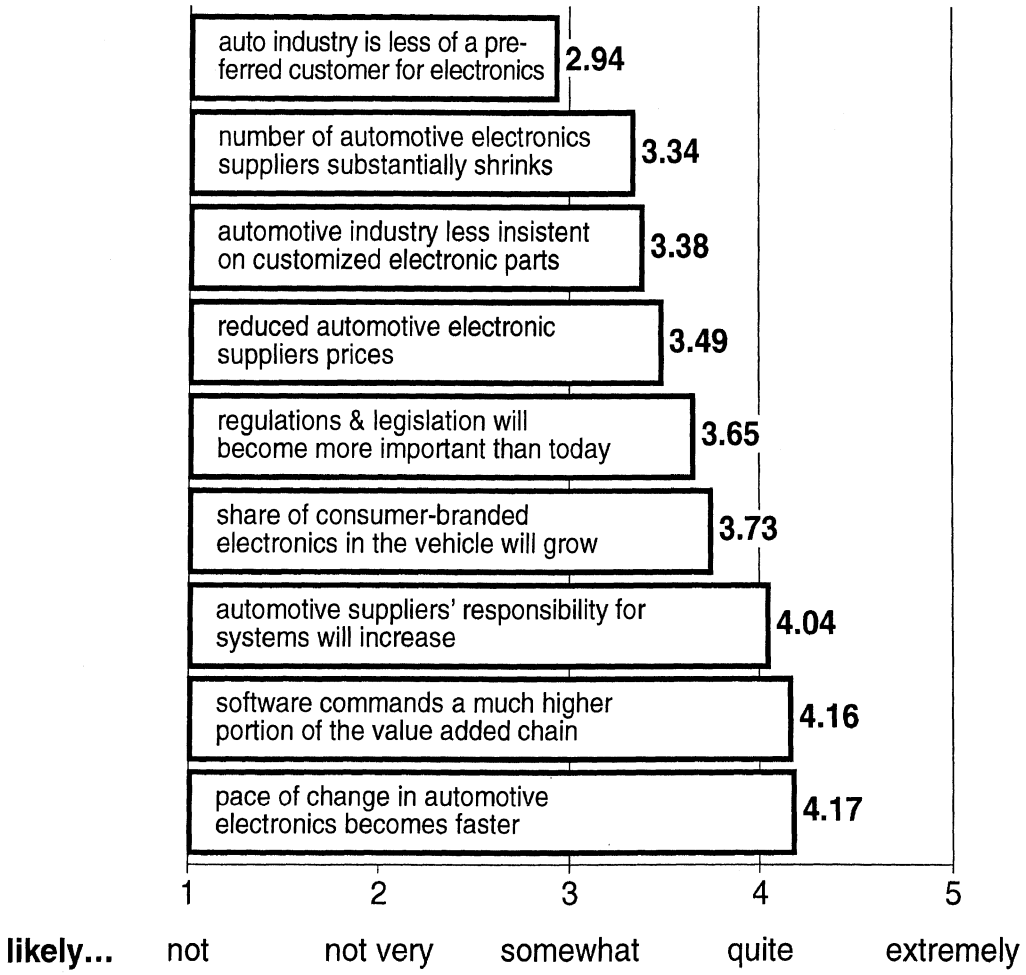
What are the attributes of outstanding OEMs and suppliers?

Attribute	OEM	Supplier
Has working relationship with supplier		x
Technically savvy workforce	x	
Systems view of vehicle		x
Onsite customer support		x
R&D investment	x	x

How can the development time for electronics be reduced?

Mean Effectiveness		Solution
Power-train	Driver Information	3=Somewhat effective, 4= Effective, 5=Extremely effective
3.79	**4.33**	Open architecture standards independent of applications
3.00	**4.21**	Provide plug and play (open) bays with utilities
3.49	**4.07**	Commodity product standardization
3.45	**4.04**	Upgrade capability for applications software in the field
3.60	**4.02**	Greater software reconfigurability
3.62	**3.79**	Specify and purchase as tested subsystems/modules
3.21	**3.79**	Common electronics boxes with full software configuarability
3.87	**3.61**	Very good design rules to aid design and manufacturing
3.23	**3.61**	Develop "lightning track" process for this class of applications
3.11	3.46	Eliminate detailed internal component-level specifications
2.42	3.42	Include more consumer & non-automotive electronics suppliers
3.58	3.40	Pre-analyzed "design chunks," cataloged for use
3.98	3.37	Improved simulation and analysis tools
2.32	3.30	Shift increasing share of intelligence to server-based hubs
3.49	3.25	Adherence to assurance/stress testing vs. life testing
2.75	2.93	Utilize a supplier advisory council

How likely is each development by 2005?



4 Electronics Content of Future Vehicles

How important are the factors that affect the electronics content of vehicles?

Quite Important	Somewhat—Quite Important
Communications	Revenue opportunities
Safety	Vehicle performance
Comfort and convenience features	Entertainment
	Model differentiation
	Cost
	Networking
	Quality

When Will Features be Available in 10% of New Luxury Vehicles?

Category	Mean	Feature (up to 2007 only)
Entertainment and convenience	2004.7	Satellite radio
	2004.8	Removable media for entertainment and data
	2005.2	MP3 support
	2005.8	Built-in electronic toll and payment tag
	2006.3	Karaoke
Driver information and communication	2004.3	Built-in wireless phone interface
	2004.4	GPS navigation
	2004.8	Email/Internet access
	2004.8	Built-in PDA (e.g., palm) docking station
	2005.2	Bluetooth support
	2005.3	Automatic download of traffic information
	2005.6	Downloadable software features
	2005.6	Downloadable software fixes
	2005.8	General purpose text/data speech capability
	2005.9	Large general purpose display
	2005.9	Off-board applications via data link
	2006.2	General purpose computer (e.g., AutoPC)
	2006.8	Open electronics bay with utilities
	2006.9	Interface to wearable computer
Safety and security	2004.6	Automatic collision notification
	2004.8	Adaptive cruise control
	2005.0	Rear parking aid
	2005.3	Blind spot detection and warning
	2005.5	Voice operation of some controls
	2005.6	Forward collision warning
	2005.7	Forward parking aid
	2005.7	Lane departure warning
	2005.9	Night vision
	2006.0	Black box crash recorder
	2006.1	Forward collision braking only
	2006.3	Drowsy driver detection
	2006.8	Fingerprint or voice-controlled entry
Electrical, propulsion, and control	2005.7	Dual voltage (42/12 volt)
	2006.0	Active suspension
	2006.7	42 v electrical system

What is the Most Likely Unexpected Product Success/Failure?

success: voice recognition (17%) failure: email/Internet (20%)

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ACKNOWLEDGMENTS

This project was supported by funding from the following organizations:

* Automotive Engineering International
* Delphi Automotive Systems
* Hella North America Incorporated
* IBM Corporation
* Johnson Controls Incorporated
* NEC Technologies Incorporated
* Robert Bosch Corporation
* Roland Berger & Partner LLC
* Temic Automotive of North America Incorporated
* Visteon Automotive Systems
* Yazaki North America Incorporated.

Their support is graciously acknowledged.

The authors would like to sincerely thank Sara Booms and Michael Delaney for assisting in collection of the data.

INTRODUCTION

There are many general indicators and projections of significant growth in the market for automotive electronics. These include print and online articles (Hansen, 2000), news stories, surveys of the topic, and growth of the Convergence Conference on automotive electronics.

Although many of these references are potentially related to the research described in this report, this document owes its lineage to prior studies conducted by UMTRI, in particular its Office for the Study of Automotive Transportation (OSAT). This report emphasizes the OSAT studies, which fall into two categories: (1) product oriented and (2) process and organizationally oriented.

Product Oriented

Ribbens and Cole (1989), the first automotive electronics Delphi study, was an offshoot of Delphi V, the fifth of a series of studies examining the future of the automotive industry. The series is named after the Delphi Method (not Delphi Electronics), a two-step process developed by the Rand Corporation. In step one, experts independently make projections about the future in response to specific questions so they are not effected by group interactions/dynamics in responding. In step two, experts are given mean/median responses and written comments of other unidentified experts so that they reconsider their answers to the specific questions and add to them.

The Ribbens and Cole Delphi study investigated the application of automotive electronics to passenger vehicles. The study involved "key personnel in engineering/management positions" (Ribbens and Cole, 1989, p. iii). Further specifics on the sample (size, job titles, etc.) are not provided and cannot be inferred from the data as only percentages are provided.

Topics covered include (1) general overview, (2) engine and drive-train, (3) instrumentation/communication/navigation, (4) chassis, (5) electrical/electronics technology, and (6) comfort/convenience/entertainment. Specific topics included the make/buy ratios for electronic subsystems, the year of introduction of automotive radar, the market penetration of ultrasonic atomization, the market penetration of solid state instrument panel displays, the inhibiting factors to active suspension, microprocessor use by category, etc.

Some key projections (shown in Table 1) included:

Table 1. Selected Major Findings from Ribbens and Cole (1989)

Projection for Year 2000	Was the prediction accurate?
Distributorless ignition and multipoint timed sequential fuel injection market penetration will exceed 80%.	yes
Anti-lock brake market penetration will exceed 80%.	no, too high
Electronically controlled suspension market penetration will be 30%.	no
Liquid crystal displays will be 35% of all solid state displays systems.	yes
Reconfigurable flat panel displays will be developed and introduced.	yes
MUX will be used in about 40% of vehicles to link vehicle information systems with subsystems.	no, too high
The voltage level will increase from 12 to 48 volts.	no
Zoned climate control will increase.	yes

Table 2 shows market projections for Ribbens and Cole for specific systems that are also considered in this document. Note that most predictions were too optimistic, primarily because of cost pressures after the study occurred. Two estimates appearing in different sections of Ribbens and Cole, are provided for traction control. They also projected that voice recognition would appear in 1995 and rear video systems by 2000.

Table 2. Electrical/Electronic Features in North American Passenger Vehicles

Projection for Year 2000	Market Penetration Projected for 2000	Prediction Accurate?
Anti-lock braking	75	no, too high
Electronically-controlled automatic transmission	60	no, too high
Traction control (anti-spin)	30-40	no, too high
Electronically-controlled suspension	30	no, too high
Electronic or keyless entry	30	no, too high
Alphanumeric digital IP displays	25	no, too high
Cellular phones	20	no, too high
Information systems	20	no, too high
Solid-state analog IP displays	20	no, too high
Head-up display	20	no, too high
Continuously variable transmission (electronic controls)	10	no, too high
Drive by wire	10	throttle - yes, no for brake, steering
Navigation systems	8	no, too high
CRT or dot matrix screens	7	no, too high

Table 3 shows the make/buy percentages overall for the major U.S. vehicle producers. The report contains additional percentages for various electronic subsystems (engine control, cruise control, etc.). These estimates predate any efforts towards industry consolidation. The splits of Delphi from GM and Visteon from Ford, along with the Daimler-Chrysler merger, make interpretations of these results difficult.

Table 3. Make/Buy Percentages for Manufacturers for Electronic Hardware in 2000

Manufacturer	Make (%)	Buy (%)
GM	65	30
Ford	50	50
Chrysler	30	70
Japanese (North American operations)	20	75

Underwood, Chen, and Ervin (1991) explored the future development and market penetration in ten categories using the Delphi approach. (See Underwood, 1989 for additional details, specifically tallies of the barriers to and driving forces for market penetration.) The survey began with 32 panelists from 13 organizations. In the final third round, 22 panelists remained. Unlike other Delphi studies, this survey did not ask for the year at which a particular percentage of market penetration would be achieved, but rather the year in which a particular category of penetration would be achieved. There was no indication if the context was North America or worldwide. Given that the participants appear to be primarily from the U.S., a North American focus is assumed.

Table 4 shows the year 2000 projections for the ten systems examined. Most of the predictions were too optimistic.

Table 4. Market Projections from Underwood, Chen, and Ervin (1991)

System	Projection for year 2000	Prediction accurate?
Automated highways	Successful lab test	yes
Automated guideway systems	System introduction	no
Collision avoidance	System introduction	no
Cooperative route guidance	Some use by commercial vehicles	no
Collision warning	Some use by commercial vehicles	no
Speed and headway keeping	Some use by commercial vehicles	no
Automatic tools and road pricing	Majority use by commercial vehicles	no
Automatic vehicle navigation	Majority use by commercial vehicles	no
Automatic vehicle location	Majority use by commercial vehicles	no
Motorist information	Majority use by automobiles	no

Underwood (1992) describes a two-round Delphi study involving 55 authors of papers at the Vehicle Navigation and Information Systems (VNIS) conference, in which market projections were obtained for 30 systems. For driver information and assistance systems (20 of the 30), participants identified when introduction, 5%, and 50% market penetration would be achieved for luxury, commercial, and all vehicles, as well as mandated use. Data were collected under two scenarios, $15 million/year of federal support for 10 years and $100 million/year of support. Other information was obtained for advanced traffic information systems and commercial vehicle systems.

Table 5 shows the 5% market penetration figures for luxury and all vehicles for the $15 million/year scenario, data that can be used to determine if the projections for the year 2000 have been realized. Given the international nature of the meeting that panelists attended, worldwide market penetration is assumed.

Table 5. Market Projections from Underwood (1992)

System	Projection- 5% Market		Prediction correct?
	Luxury	All vehicles	
Route specific, real-time traffic	1996	1998	No
Mayday	1996	1996	No
Map matching & dead reckoning nav	1996	2005	No
Multilateration navigation (Teletrac)	1996	Never	No
Static historic data	1997	2000	No
Real-time guidance based on traffic	1997	2000	No
GPS navigation	1997	2000	No
Vehicle probes to ID traffic	2000	2000	No
Beacon based navigation	2000	2005	No
Forward collision warning	2000	2004.5	No
Back-up and blind spot detection	2000	2004	No
Adaptive cruise control	2000	2005	No
Automatic backup braking	2001	2010	No
Rollover warning (trucks)	2002	2010	Unlikely
IR vision enhancement	2005	2015	Too early to know
Automatic lane keeping	2010	2020	Too early to know
Ground-based radio nav. (Loran)	2015	Never	No
Automated platooning	2035	Never	Too early to know
Automatic driving	2035	Never	Too early to know

Over the last several years, trends in automotive electronics have been examined as part of the OSAT Delphi surveys, e.g. in Delphi X (Cole and Londal, 2000).

More recently, Richardson and Green (2000) carried out a review of the Intelligent Transportation Systems (ITS)–the convergence of computers, communications, and automotive product design–whose core centers on automotive electronics. This

literature review relied upon the authors' files, the UMTRI Library, and the Internet, along with limited interactions with colleagues. The report examined general market trends for ITS in North America as was described in the literature. In addition, the study also examined (1) specific trends associated with the E911 mandate, (2) mobile Internet devices, (3) navigation systems, and (4) vehicle communication buses. Product liability concerns pertaining to ITS and adaptive cruise control and collision avoidance/warning systems were also examined.

The key findings were:

- The most desired features were adaptive cruise control and Mayday services (43% and 38% of drivers wanted, respectively, median prices of $400 and $500).
- The E911 mandate will result in all cellular phones having Global Positioning Systems (GPS) within the next few years.
- 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. Eventually, the most popular device may be a wearable computer or a wrist computer.
- The intelligent data bus will be the de facto standard in the next few years.
- Product liability concerns are particularly significant for adaptive cruise control, advanced vehicle control systems, and collision avoidance/warning systems.

Roland Berger and Partners (2000) report a summary of interviews with forty experts regarding the market for interior automotive electronics. Other than the names of the employers, data on the experts (titles, etc.) was not reported. The report provides projections for revenue growth for various vehicle components, identifies industry mergers and acquisitions and the companies that have resulted, contrasts the capabilities of various suppliers, and provides information about the restructuring of the industry. Other than means, statistical evidence for changes is not provided.

If any pattern has emerged, it is that the projections, almost without exception for 5% product market penetration, are too optimistic and by several years. There are cases, however, for example for cell phones, where projections have been realized, but none where penetration has been sooner than expected.

Process and Organizationally Oriented

Although there have been a few questions regarding processes for developing automotive electronics in prior Delphi studies, the topic has not received much emphasis. In contrast, supplier-OEM differences have received considerable attention in prior Delphi studies, though not with regard to automotive electronics. The most comprehensive coverage of development processes appears in the Automotive Product Design and Development Delphi (Kota, Londal, Flynn, Cole, Belzowski, and Ullman, 1998). They reported both suppliers and manufacturers use a similarly structured product development process, but the OEMs' processes are used more uniformly and are better supported than for suppliers. Generally, there were no large differences

between manufacturers and suppliers, with selected exceptions. (For example, suppliers thought ergonomics and government regulations have greater influence on chassis design than did manufacturers.) There were no questions that only concerned automotive electronics development.

Thus, although there have been many previous studies of both product and process issues, there was little current information, especially regarding process issues. There has been much discussion of the differences in product development cycle times between motor vehicles and electronics, but little data on how to bridge the gap.

Accordingly, this project was conducted to fill that knowledge gap. This survey emphasized the top ten concerns for future electrical and electronics applications, trends, and the three to five issues that wake up automotive executives in the middle of the night. The survey concerned both product and process issues, with a special effort to distinguish the views of the automotive manufacturers and suppliers.

In contrast to many of the prior UMTRI Delphi surveys that typically take a year to complete, this project was a quick turnaround effort with initial results available six months after funding was provided. This timing addressed the rapid pace of change in the industry; an effort that took a year to complete would be obsolete when completed. However, because the time available for survey revisions, survey pretesting, data collection, data analysis, and report writing was limited, and the multiple rounds required by the Delphi method were not possible, data was instead collected using a survey.

SURVEY METHOD

Survey Development and Distribution

The survey was constructed to maximize sponsor input and the knowledge of the technical team, to keep the development time short, to be completed relatively quickly (an hour or less was the target), and to be unambiguous. The survey was developed in several steps. The initial draft was based on brainstorming by the members of the project team. As companies joined the project, they provided a list of three to ten candidate questions for the survey. Those lists were used to create new questions for the survey, to revise the initial set of questions, and in some cases, to turn individual questions into multiple questions.

Given the survey length constraint, not all candidates' questions could be included in the survey. The following criteria were used to select questions:

- Sponsor(s) wants to know
- Each sponsor can see some of their questions in the final survey
- Industry really wants to know
- Question provides new information
- Results allow connection with previous studies (e.g., prior Electronics Delphi) to show trends
- Outcomes concern something likely to occur over next few years
- Knowing the answer will help sponsors make better decisions
- Question can be phrased unambiguously
- Question can be framed as a closed answer
- Answer is publishable
- Answer has continuing value (useful in future)
- Respondents have the knowledge to answer the question

Once the initial draft was revised, a second set of iterations was completed to group similar questions together, remove jargon, clarify the wording of the questions, make questions more succinct, and narrow the set down to about 20 questions (excluding respondent information). Limited pilot testing was helpful. If the survey had been longer, it would have taken too long to complete, discouraging potential respondents from completing it and leading to an unacceptable low response rate. Also, lengthening the survey would have increased the analysis time, in conflict with the desire for a quick turnaround effort. As a consequence, some good suggestions for questions could not be included in the survey.

The target set of respondents was high-level industry executives in or working with the automotive industry. Candidate survey respondents were those involved with other OSAT affiliation activities, individuals identified by the sponsors of this project, or people known to the project team. Initially, 449 individuals were contacted, of whom 83 (18%)

responded within the four-week time frame . Of these, 20 indicated they lacked the expertise to respond to the survey and 90 indicated they would respond. Of those 90, 13 wanted web access, 14 wanted paper copies, and 60 requested the survey via email. Candidates were phoned or emailed that the survey would be appearing, and then several weeks after the survey was distributed, they received a reminder via phone or email. For email, the response rate was close to 50%. Of the 83 respondents, a significant number involved hard copy. Additional information on the sample appears in the Results section of this report.

Survey Description

The survey, summarized in Table 6, consisted of seven parts. A blank survey is in Appendix A. Most of the 24 questions had multiple parts and required a free response (short written) answer, though several used five-point rating scales.

Table 6. Survey Content

Part	Title	# Items	Example Content
I	Instructions		Emphasized no "right" answers
II	Respondent information	4	Employer and description, job title and area of technical expertise, their business culture
III	Strategic issues	7	Importance of factors influencing electronic content of vehicles, identify developments that might alter plans for power-train, wireless communication, etc., what respondents want to most know about the future
IV	Organizational issues	5	Identifying the major problem between suppliers and manufacturers, how to incorporate ideas from new suppliers, attributes of manufacturers and suppliers who best integrate vehicle electronics
V	Product timing	2	Effectiveness of factors (plug and play, design chunks, etc.) allowing faster inclusion of vehicle electronics, how suppliers and manufacturers should coordinate electronics & vehicle development cycles
VI	Safety & usability standards	2	Effectiveness and likelihood of various safety standards
VII	Products & automotive features	4	Year when 10% installation rate for luxury vehicles is reached for many features (PDA, Bluetooth, MP3 support, forward collision warning, 42 volt, etc.)

RESULTS

Data Reduction and Analysis

Prior to coding, an analyst reviewed all surveys for completeness and reasonableness. If there were questions about specific answers, an effort was made to contact the respondent for clarification. Where suspect responses could not be verified (e.g., one respondent claimed his company's total revenue was $3), they were deleted.

Multiple choice and open-ended questions were processed separately. Using codes developed by the authors and others, an outside contractor keyed in responses to multiple choice questions. Means and histograms were then used to check individual and combinations of responses for reasonableness and missing data. Corrections were made where feasible.

To identify significant differences, ANOVA, either one-way (to determine if significant differences existed, such as between the importance of factors leading to some outcome, the predicted dates of products achieving some level of market penetration, etc.) or two-way was computed, with the company category (OEM, Tier One, etc.) as the second main effect. In computing means and comparing differences (of various ratings of likelihood and effectiveness), the data were assumed to be on a ratio scale even though categorical ratings were obtained. Significant differences were determined using a Tukey-Kramer post-hoc analysis, with $p<.05$ used to cite differences as statistically significant.

Prior to coding, two or three analysts reviewed open-ended questions, which were then checked by the project team. The intent of the review was to group together similar responses, using the respondents' original words in many cases. From this process, data on the frequency of various responses were obtained.

For the open-ended questions, anywhere from 40 to 120 responses were obtained, with the number varying with the question. For questions where more than one response was provided but only one was requested, all responses were included to maximize the information obtained.

To avoid overwhelming the reader, only comments provided by five or more respondents appear in the Results section. (See Appendix B for the full list of responses for each question.)

Note that the survey consisted of six parts (respondent information, strategic issues, organizational issues, product timing, safety and usability standards, and products and automotive features). Results pertaining to those sections are given in that order, with each part covered separately in the remainder of the Results section.

Respondent Information

The survey included questions about the respondent (present and career emphasis (e.g., engineering, sales), job title, and business culture (e.g., North American)). The survey also included questions about their employer including type (e.g., Tier One), total

revenue, and percentage of its business that is electronics and that is automotive. (For exact wording, see Appendix A.)

Job titles and career assignments (questions 2a and 3) reported by respondents are shown in Table 7. Table 8 shows job titles and current assignments (questions 2b and 3). Several key points emerge. First, notice the substantial number of respondents who were in very senior positions. Thirty-eight of the 83 respondents (45%) were at the vice president level or above and 73% were directors or above. In terms of professional backgrounds, 47 of the 83 (57%) spent most of their careers in design or engineering, though only 35 (42%) were currently in that role. This most likely indicates individuals with technical backgrounds moving to other areas as they were promoted. However, it is critical for a survey emphasizing technology to be completed by individuals with technical backgrounds, and that was achieved.

Table 7. Frequencies for Career Experience (Questions 2a and 3 Combined)

Job Category	Job Title					
	VP	Director	Manager	Engineer	Forgot	Total
Design/Engineering	21	15	9	1	1	47
Finance	3	1	0	0	0	4
Info Systems	1	1	0	0	0	2
Marketing	0	1	0	0	0	1
Purchasing	2	1	4	1	0	8
Sales	4	1	3	0	0	8
Other	7	2	3	1	0	13
Total	38	22	19	3	1	83

Table 8. Frequencies for Current Assignment (Questions 2b and 3 Combined)

Job Category	Job Title					
	VP	Director	Manager	Engineer	Forgot	Total
Design/Engineering	14	10	9	1	1	35
Finance	3	0	0	0	0	3
Info Systems	1	1	0	0	0	2
Marketing	3	2	4	1	0	10
Purchasing	1	0	0	0	0	1
Sales	1	2	0	0	0	3
Other	15	7	6	1	0	29
Total	38	22	19	3	1	83

Table 9 shows how the job titles for current assignments were distributed by company (employer) type. The overall level of seniority in the various company types was roughly equal.

Table 9. Job Titles Represented for Each Company Type (Questions 1a and 3 Combined)

Company Type	Job Title					
	VP	Director	Manager	Engineer	Forgot	Total
OEM	5	7	2	0	1	15
Integrator	10	5	0	1	0	16
Tier 1	12	6	8	1	0	27
Tier 2	5	2	7	1	0	15
Other	6	2	2	0	0	10
Total	38	22	20	3	1	84

Summary data on the organizations represented appears in Table 10. Notice that the respondents are well distributed among the categories and only the "other" category (a collection of a variety of companies) has less than 15 responses. Thus, the sample size is sufficient to make meaningful statistical responses between categories.

Table 10. Summary of Companies Represented (Questions 1a, 1b, and 1c Combined)

Company is predominantly	Sample size	Mean total revenue (billion)	Business is automotive	Business is electronics and embedded software
Vehicle assembler	15	$93.8	93%	21%
Systems integrator	16	$13.7	78%	31%
Tier One	27	$15.6	72%	45%
Tier Two	15	$6.1	29%	43%
Others	10	$4.7	71%	34%
	83 (total)	$22.6 (mean)	69% (mean)	35% (mean)

Note: A vehicle assembler is an original equipment manufacturer (OEM). A systems integrator is a company that provides electronics modules and systems directly to an OEM. A Tier One supplier provides electronic parts and components directly to an OEM. A Tier Two supplier provides parts and components to other suppliers. The "other" category includes contract R&D organizations, tool suppliers, consultants, independent test laboratories, etc.

The responses make sense. The assemblers had the largest revenue, followed the Tier Ones, integrators (e.g., Visteon, Delphi), and the Tier Twos. Except for the vehicle assembler category, responses spanned a wide range, typically one order of magnitude, but in some cases two orders. The assemblers were almost exclusively automotive in their business (93%) followed by the system integrators and Tier One companies. In contrast, the Tier Two suppliers obtained a minority of their business from the automotive industry. Electronics represented only a portion of the business of assemblers and integrators, but approached half of the business of suppliers, though

there was considerable variation. Overall, the distribution of the percentage was bivariate, with electronics content being a small share of total revenue (typically 20%), but in several cases almost 100% of the business was electronics (Figure 1).

The automotive distribution was also quite wide (Figure 2), but a significant number of organizations were near or at 100% automotive.

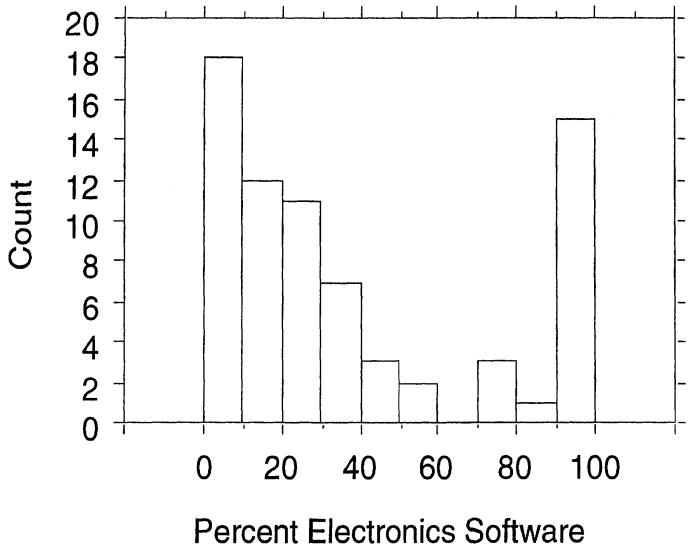

Figure 1, Percentage of Software that is Automotive Electronics

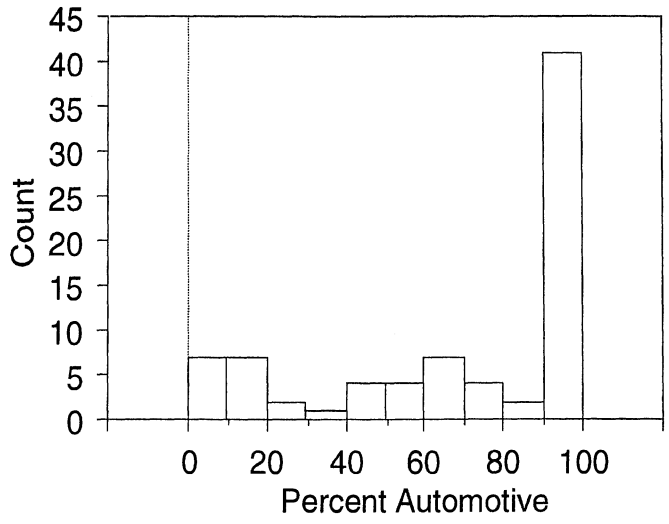

Figure 2, Percentage of Business that is Automotive

Finally, while the goal of this project was to gain insight into worldwide trends, the focus was on North America. As shown in Table 11, 83% of those responding were from a North American business culture, and except for the Tier One suppliers (which included some European respondents), the sample was almost exclusively North American.

Table 11. Frequency of Identification of Business Cultures
(Questions 1a and 4 Combined)

Category	Business Culture				
	North America	Europe	Japan	Other	Total
OEM	12	1	0	0	13
Integrator	14	1	1	0	16
Tier One	21	5	1	0	27
Tier Two	10	2	0	0	12
Other	7	1	0	1	9
Total	65	10	2	1	78

Strategic Issues

In this section and those that follow, responses are grouped more strictly by question to facilitate understanding of the results. Questions in the section concerned (1) factors affecting electronic content in the future, (2) competitors for new electronics business, (3) the likelihood of various developments in the near term, (4) events that could affect future plans, (5) what respondents would like to know about the future, and (6) the dollar volume required for a global electronics supplier.

Figure 3 shows the tallies for question E1 (factors affecting future electronics content), the mean weighted responses, and significant differences found using a Tukey-Kramer post-hoc analysis. For this question, there were no significant differences among the three most important factors (communications, safety, and comfort/convenience). All factors identified had some degree of importance, with the least important factor, quality, being between somewhat and quite important. Also absent were any significant differences in the mean ratings assigned by each company category ($p=0.25$) or an interaction between company category and the factors considered ($p=0.30$).

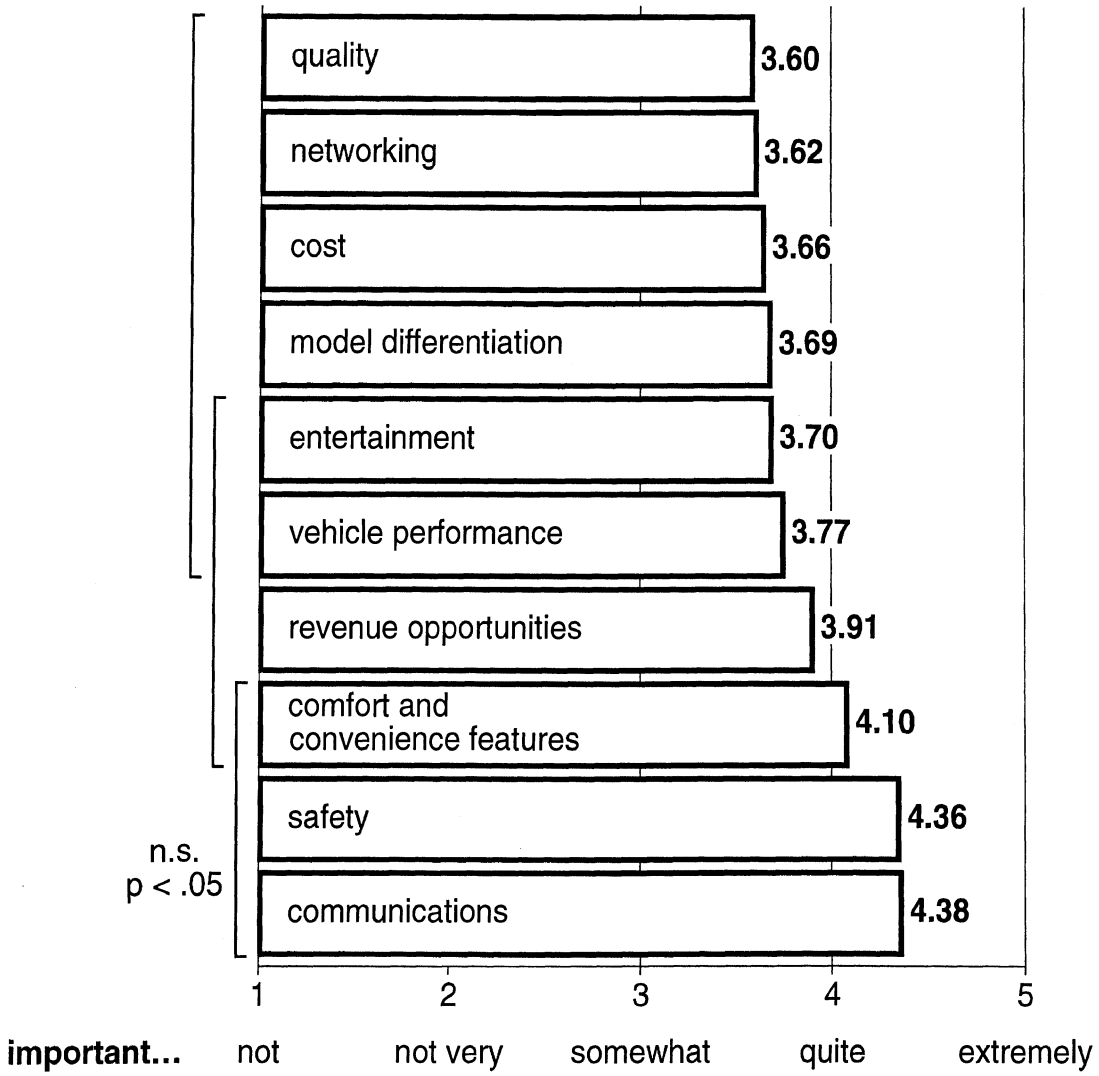

Figure 3. Importance of Factors that Increase Vehicle Electronic Content over the Next Five Years (Question E1)

Figures 4 and 5 show the estimated likelihood and effectiveness of competitors for future business in electronics. Respondents believe that spin-offs and system integrators will be the significantly most likely and effective competitors, though automotive component suppliers were also rated as significantly effective. In terms of the influence of the respondent's organization, there were significant ($p=0.03$) but slight differences between company categories (assembler=3.53, integrator=3.59, Tier One=3.41, Tier Two=3.76, other=3.53), but there was no interaction between company category and competitor ratings ($p=0.21$). Thus, given the lack of an interaction, many decisions can be made using responses from either manufacturers or suppliers.

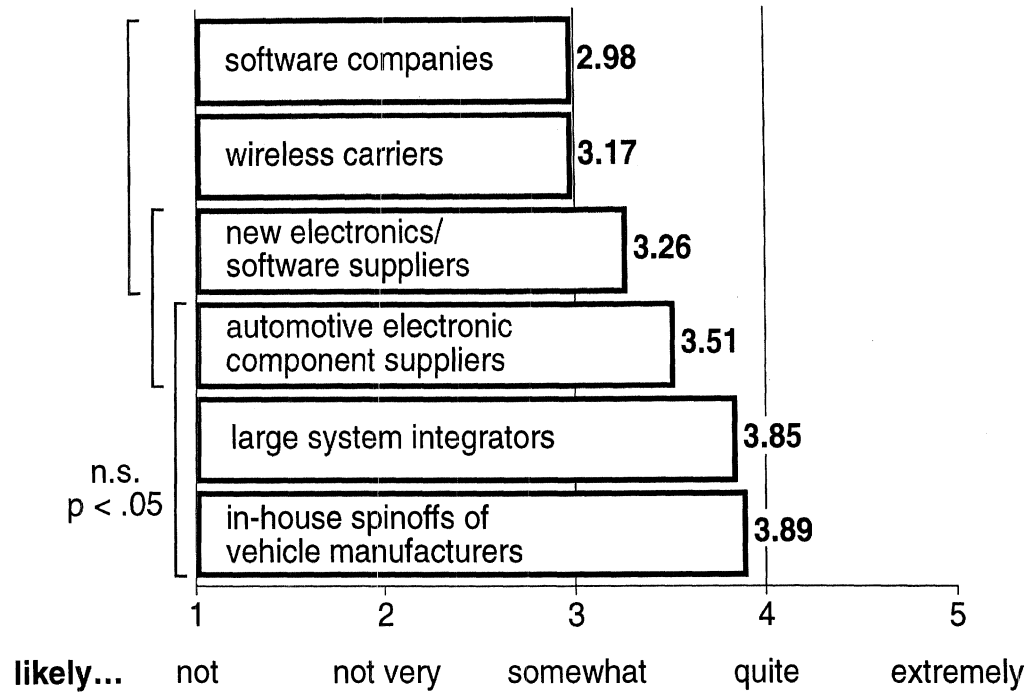

Figure 4. Likelihood of Being Strongest Competitors for Automotive Communications and Information Business? (Question E2)

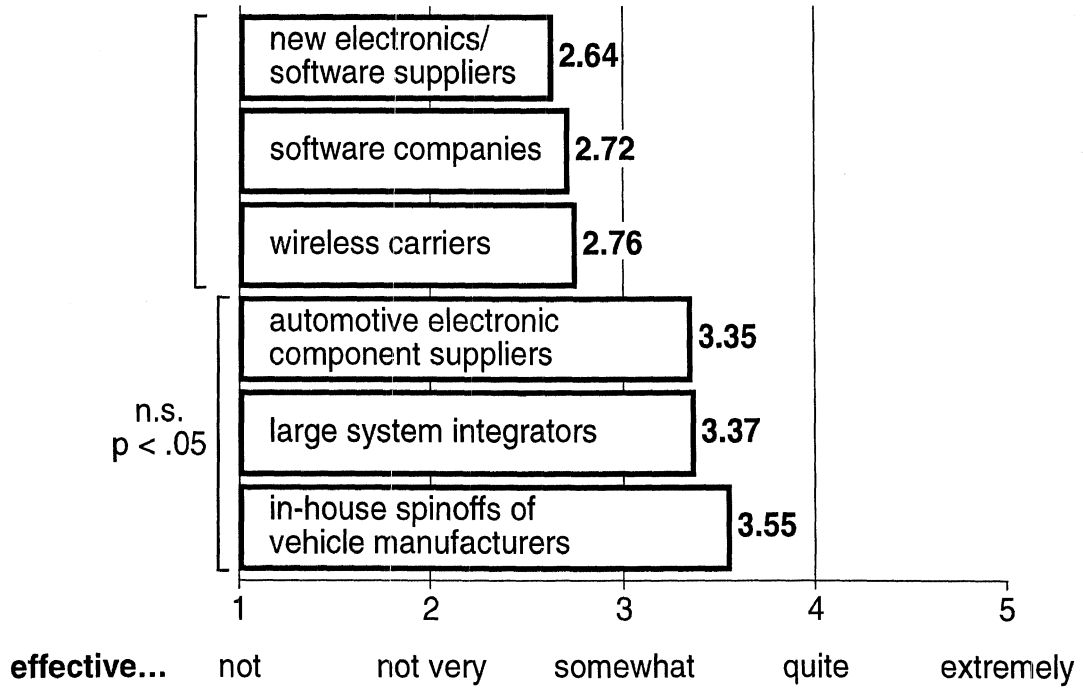

Figure 5. Effectiveness as Competitors for Automotive Communications and Information Business? (Question E2)

Figure 6 identifies the likelihood of various developments by 2005. All were identified as at least somewhat likely. The significantly most likely event was a faster pace of change, followed by an increase in importance of software, and then by an increase in the responsibility of suppliers, all of which were quite likely. Interestingly, although electronics will play a greater role in vehicles in the future, respondents viewed erosion of the automotive industry's status as a preferred customer was somewhat likely. There

were no differences due to the company the respondent represented (p=0.07) or interaction between company categories and competitor ratings (p=0.42).

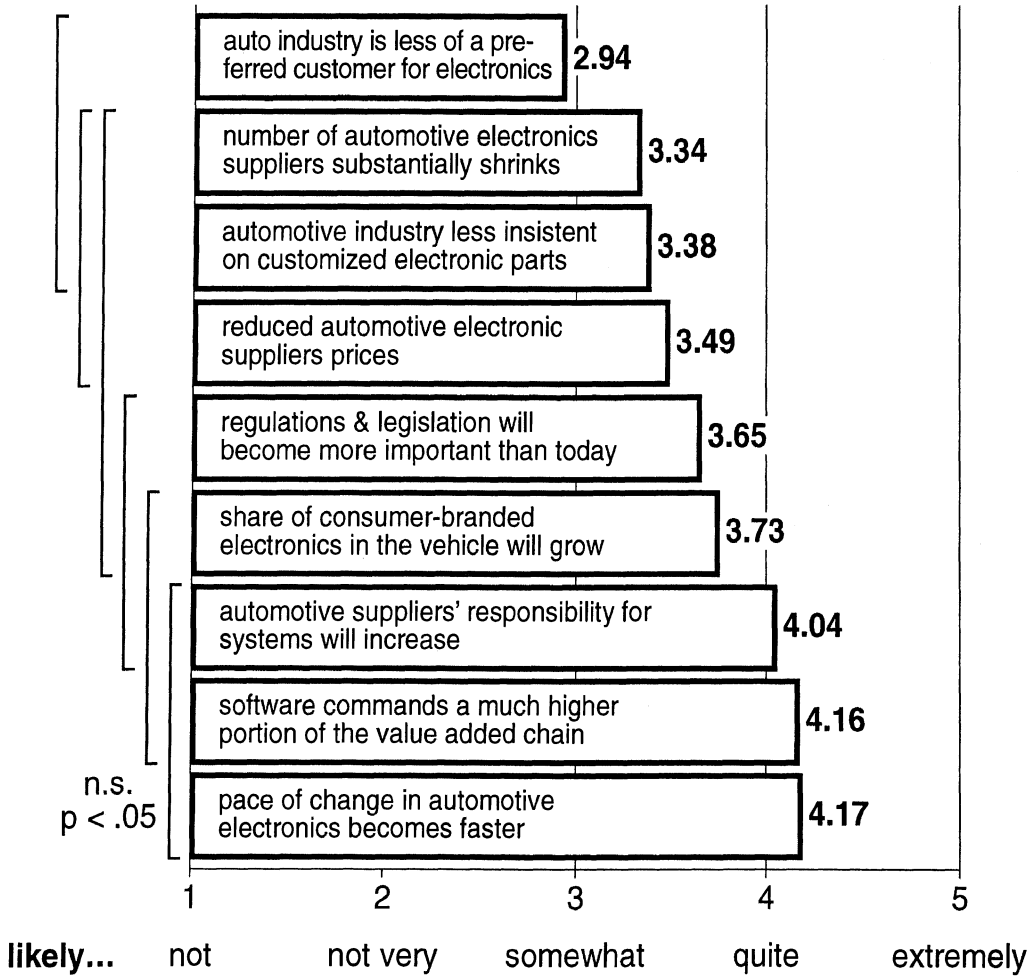

Figure 6. How Likely Is Each Development by 2005? (Question E3)?

Table 12 shows comments by at least five respondents that could disrupt future plans in electronics for five system categories (power-train, power distribution, customer features, wireless communications, and infrastructure). (The full list of responses appears in Appendix B.) Typically, there were 40 responses to concerning each of the five system categories. In general, there was a substantial degree of misunderstanding of this question, with the "misunderstood question" response sometimes being the most common response (about eight such responses on average for each part). When misunderstood, participants often repeated part of the question. For example, for drive-train and vehicle control, participants might indicate that developments related to engines, one of the examples given, was their primary concern. This problem decreased the amount of information obtained from these questions but did not diminish the value of legitimate responses.

Table 12. Potential Disruptions of the Introduction of Automotive Electronics

System Category	Potential Disruptions to Electronics Introduction	N	Total
Power-train and vehicle control (Question E4a)	N/A (literally said no effect or N/A)	7	46
	Change of energy source - internal combustion to alternative	6	
	Accelerated intro of new technology -CVT, DBW, valve actuation, increased networking	6	
	Misunderstood question (examples: "vehicle control", control of power-train and vehicle is the most significant for our business)	6	
Electrical power distribution and networking (e.g., wiring, electrical controls, data distribution) (Question E4b)	Faster than anticipated adoption of 42 v	13	
	Faster than anticipated intro of new technology (networking, protocols, open architecture)	11	45
	Misunderstood question	6	
Vehicle customer features (e.g., radio, driver information, safety, computers/office, etc.) (Question E4c)	Misunderstood question	10	40
	Expanded driver distraction legislation	5	
Wireless communications (e.g., voice, data) (Question E4d)	Misunderstood question	7	40
	Failure to establish and follow consistent technology standards	5	
	Expanded use of wireless N/W versus hardware (Bluetooth)	5	
	Increased (distraction) legislation limiting feature expansion	5	
	Inability of wireless infrastructure to support demand	5	
Infrastructure (e.g., regulations, standards, liability, etc.) (Question E4e)	Misunderstood question	8	38
	Expanded driver distraction legislation	7	
	Not applicable	5	

Potential disruptions participants identified were generally system specific and included:

- A change in the power source for power-train systems (from internal combustion to something else, 6/46 respondents-13%)
- A more rapid than expected introduction of new technology in general (also 13% for power-train)
- Faster than expected adoption of 42 v technology (29% for power distribution)
- Increased driver distraction legislation (13% for wireless communications, 18% for infrastructure)

Few respondents were concerned about slower than expected introduction of new technology (never more than three for any part). (For additional details, see Appendix B.)

As shown in Table 13, almost everyone had some thoughts as to what they would want to know about the future of automotive electronics, but there was not much convergence as to what that might be. By far, the most common response (by a factor of two) concerned the networking standard in place in the future (16%). As in the previous question, future government regulation of telematics (7%) and the penetration of 42 v systems was of interest (6%).

Table 13. What about Automotive Electronics in 2003 Would You Most Want to Know Now? (Question E5)

What you would most want to know?	N
What communication standard will be in place for full networking	13
How much government regulations (legislation) in telematics	6
Misunderstood question	6
Will customer accept telematics	5
Penetration of 42 v systems	5
What will be the importance of analytical design, testing, simulation tools	5
Total	81

In the last few years, there have been a significant number of supplier mergers. The general belief is that suppliers that are not broadly based and large will not be competitive in the future. Table 14 provides some data relating to this point. Given the limited number of responses for OEMs, the estimates provided for that category are suspect. For Tier One and Tier Two suppliers, the estimates are about 2 billion dollars and 500 million dollars. The values in Table 14 should be viewed with some caution. In all cases the standard deviations exceed the means, indicating considerable disagreement in the estimates. To provide further context, year 2000 data for all suppliers (not just those providing electronics) with worldwide sales in excess of $3 billion (U.S.) are shown in Table 15.

Table 14. Minimum Sales for a Company Such as Yours to be a Global Supplier of Automotive Electronics? (Question E6a)

Category	N	Missing	Mean ($)	Standard Deviation ($)
OEM	3	12	384,000,000	535,000,000
Integrator	14	2	965,000,000	1,293,000,000
Tier One	21	6	2,174,000,000	2,458,000,000
Tier Two	11	4	497,000,000	612,000,000
Other	5	5	1,601,000,000	1,948,000,000

Table 15. Suppliers with Sales in Excess of $3 Billion in Year 2000

#	Company	2000 Total Worldwide OEM Auto Parts Sales (Billions)	#	Company	2000 Total Worldwide OEM Auto Parts Sales (Billions)
1	Delphi	26.4	16	Continental	5.5
2	Visteon	18.6	17	Faurecia	5.3
3	Bosch	17.8	18	DuPont	5.1
4	Denso	16.4	19	Michelin	4.4
5	Lear	14.1	20	GKN	4.3
6	Johnson Controls	11.9	21	Autoliv	4.1
7	TRW	11.0	22	Eaton	4.0
8	Magna	10.1	23	Bridgestone/Firestone	4.0
9	Dana	9.4	24	Freudenberg and NOK	4.0
10	Valeo	8.6	25	Siemens	3.7
11	Aisin	8.3	26	Federal-Mogul	3.4
12	ArvinMeritor	6.6	27	Goodyear	3.3
13	Yazaki	6.0	28	American Axle	3.1
14	ThyssenKrupp	5.8	29	BorgWarner	3.0
15	ZF	5.8	30	TK Holdings (Takata)	3.0

Source: Automotive News (March 26, 2001), Top 150 Suppliers, *Automotive News*, p 29-34.

How to reach the desired size is shown in Table 16. Table columns are sorted from most to least popular. The most common methods are merger and acquisition (33%), followed by joint ventures (28%). There is no evidence of major differences in strategy likely to be employed by the different categories of companies.

Table 16. How to Reach the Desired Size (Question E6b)

Category	Best way to reach desired level, number of responses					
	Merger and acquisition	Joint venture	Expand customer base	Expand product line	Other	Total
OEM	2	2	1	1	0	6
Integrator	4	2	4	3	2	15
Tier One	9	8	1	0	3	21
Tier Two	1	4	2	2	1	10
Other	4	1	1	1	0	7
Total	20	17	10	7	6	60

One reason for growth of the major suppliers is the OEM trend to outsource larger parts of motor vehicles (so called "chunks") to suppliers. Figure 7 shows that respondents felt this was a beneficial strategy. In general, respondents in each category agree this will

give manufacturers better features by a 2:1 ratio, except for Tier Two suppliers, where respondents are almost unanimous.

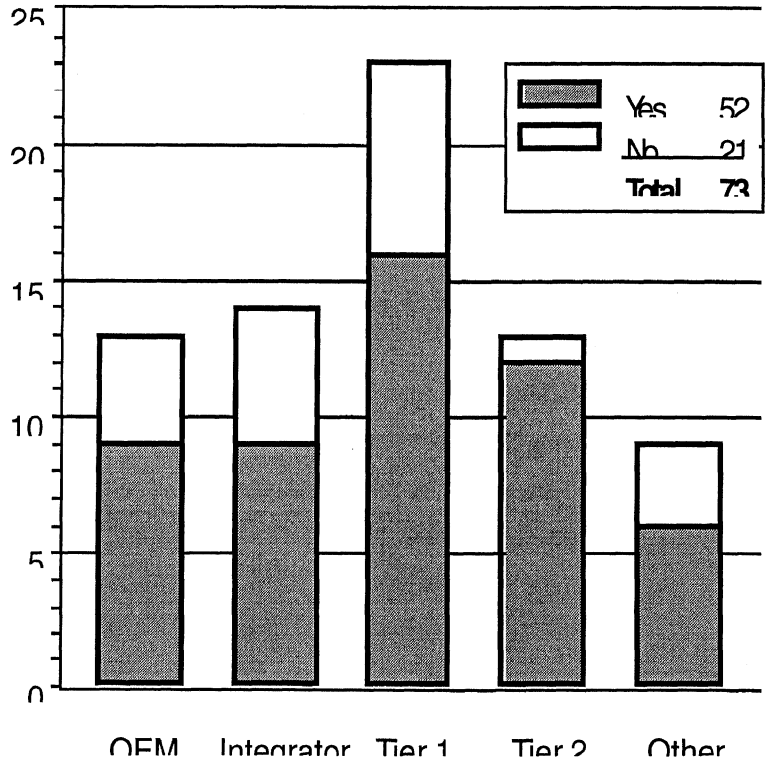

Figure 7. Will OEM Purchasing of Electronics as Parts of Larger Subsystems (Chunks) Give OEMs Better Vehicles? (Question E7)

Organizational Issues

Questions in this section addressed (1) problems between OEM and suppliers, (2) incorporating new suppliers, (3) CEO direction to enhance implementation of electronics, and (4) the attributes of outstanding OEMs and suppliers in incorporating electronics, and (5) enhancing relationships with various business cultures.

If suppliers are to have more responsibility, then problems between OEMs and suppliers must be minimized. Problems cited at least five times by respondents are shown in Table 17. No single problem stood out. Common problems included excess OEM focus on price (16%), and the lack of a partnership, the lack of design standards, and long OEM development cycles (all 12%).

Table 17. What Problem between OEMs and Electronics Suppliers Most Interferes with Meeting Purchaser Needs? (Question E8)

What is the major OEM-supplier problem?	N
Vehicle assemblers too preoccupied with price, stifles options	13
Failure to create partnership between OEM and supplier	10
Lack of viable corporate or industry standards and requirements	10
Excessively long automotive development cycle relative to electronics	10
Lack of understanding of the consequence of large disparity in automotive and electronics development cycles	7
Difference in perception of customer needs and acceptance between suppliers and OEMs	6
Inadequate systems engineering by OEM	5
Total	81

In the previous question, several responses touched upon the incorporation of new ideas. As shown in Table 18, the most common suggestion (by a factor of two) was for new suppliers to establish partnerships with established suppliers (19%). Other noteworthy suggestions included earlier involvement in design (10%), rewards to suppliers (8%), and open architecture standards (8%).

Table 18. How Can OEMs Work with Suppliers to Incorporate New Electronics Technology into Products? (Question E9)

How can OEMs work with suppliers to incorporate electronics?	N
Partner new suppliers with old established suppliers for new technology	12
Earlier involvement in design cycle	6
Vehicle assembler to encourage, reward, provide incentives, and support suppliers	5
Create open architecture standards	5
Create advance development programs	5
Total	62

There was astounding agreement as to what one directive from the CEO would most enhance the company's implementation of electronics and software technology. Of the 43 respondents, only one suggestion was offered by five or more respondents. That suggestion, from 14 (one third) of the respondents, was that more funding was needed for research and development. (See Appendix B for the complete list of responses.)

Tables 19 and 20 show attributes of OEMs and suppliers that successfully integrate electronics into vehicles. There were more than 81 responses (the number of respondents) provided because respondents were asked to provide two or three attributes. Many of the same reasons were cited by for both organizations. For example, the most common attribute of OEMs was a working relationship with a supplier (19/154 = 12%). From the supplier perspective, 5% of respondents mentioned a close working relationship with an OEM, and 3% referred to a historical relationship. For OEMs, the second most common reason was a technically savvy workforce (12%) that understood new technology (8%). Thus, as OEMs transfer responsibility for

systems to suppliers, they must maintain the expertise to manage, evaluate, and integrate new technology. For suppliers, the key factors were a system view of the entire vehicle (9%) and R&D expenditures and staff (9%). Likewise for the OEMs, a commitment to research was cited as an important attribute (6%). Thus, if there are themes from responses to this question, they are working relationships between OEMs and suppliers, a technically savvy workforce, and research and development funding.

Table 19 Attributes of Outstanding OEMs (Question E11a)

Attributes of Outstanding OEMs	N
Has working relationship with supplier	19
Has a workforce with technical expertise	16
Has strong technical bias to understand new technology	11
Committed to investment, research, planning, adoption, and integration	10
Increase investment in research, planning, adoption, and integration	10
Has top management interest	8
Willing to help supplier and give NRE	6
Strong method for system supplier selection	6
Demonstrates risk tolerance	5
Total	154

Table 20 Attributes of Outstanding Suppliers (Question E11b)

Attributes of Outstanding Suppliers	N
Have system-view expertise with entire vehicle	14
Have huge R&D expenditure and support staff	14
Developed base technology in strategic area, provide significant onsite customer support	12
Have strong software and control group (depth of R&D expertise) and electronics systems	10
Have close working relationship with OEM, based on mutual trust	8
Understand customer need, customer oriented	6
Share OEM vision, future	5
Have senior expertise and experience in electronics, leadership	5
Promote innovation and reward	5
Have strong reputation/historical relationship	5
Total	132

The automotive industry is truly global and as indicated by the previous question, working relationships are important. To understand such, respondents were asked what they could do to improve relationships with Japanese, European, and North American companies. Respondents from OEMs and Tier One suppliers responded in regard to each other. Indirect suppliers responded in regard to their largest customer. As shown in Table 19, the reasons offered were consistent across all cultures—the need for local offices and joint development/partnerships. Note the cultural competency, language skills, and attitudes were not cited that often. Thus, what seems

to predominate is execution of the business relationship, not the symbols of a relationship.

Table 21. How Electronics Development Can Be Improved

Culture of Partner	Development Improvement	N
Japanese (N=70)	Provide on-site support capability/local offices	23
	Cooperative/joint development	16
	Exhibit cultural competency, market needs NA to Japan, language	7
European (N=61)	Develop partnerships with European companies	17
	Have local office and staffing	9
North American (n=57)	Expand collocation of engineers at site local	7
	Develop partnerships	7

Product Timing

This section contained three questions that addressed the value of specific factors to speed the development of two categories of systems, and more generally, what OEMs and suppliers can do to improve coordination.

Figure 8 shows the mean effectiveness of various factors in reducing the development time for power-train and vehicle control electronics. In general, almost all of the solutions proposed were somewhat effective, though several choices (improved simulation and analysis tools, design rules, and open architecture standards, the top three choices) were close to being effective, that is, rated as 4 in the survey. However, there were no statistically significant differences among the top nine factors listed.

In terms of company category differences for power-train and vehicle control, there were some differences in the overall ratings ($p=0.03$) with means of 3.44, 3.16, 3.38, 3.19, 3.27, and 3.44 for assemblers; 3.38 for Tier One suppliers; 3.27 for others; 3.19 for Tier Two suppliers; and 3.16 for integrators. Company category by factor interaction was not significant ($p=0.87$).

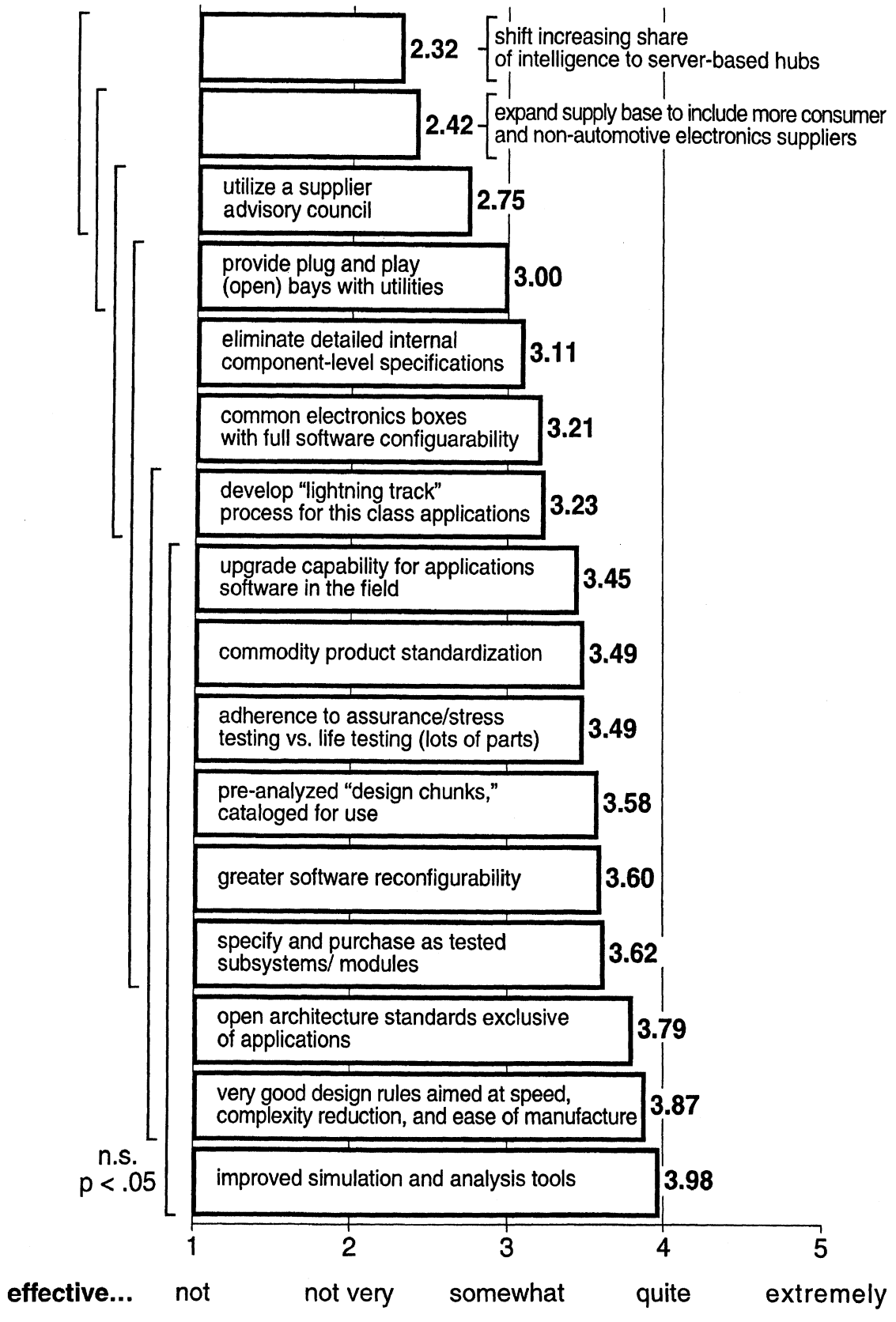

Figure 8. Effectiveness of Factors in Reducing Development Time for Power-train and Vehicle Control Electronics (Question E13)

For telematics (Figure 9), the clear emphasis was on standardization with open architecture, plug and play, and commodity product standardization as the top three

solutions. Those solutions and field upgrading and greater software configurability were all rated as effective (4). As before, there were no significant differences between the large number of potential solutions, in this case the top seven. In contrast to the solutions for power-train, good design rules and improved simulation have much lower relative rankings, suggesting that the solutions to reducing development time were not the same for all systems. However, for both product categories, use of a supplier advisory council and shifting intelligence to server-based hubs were not highly regarded.

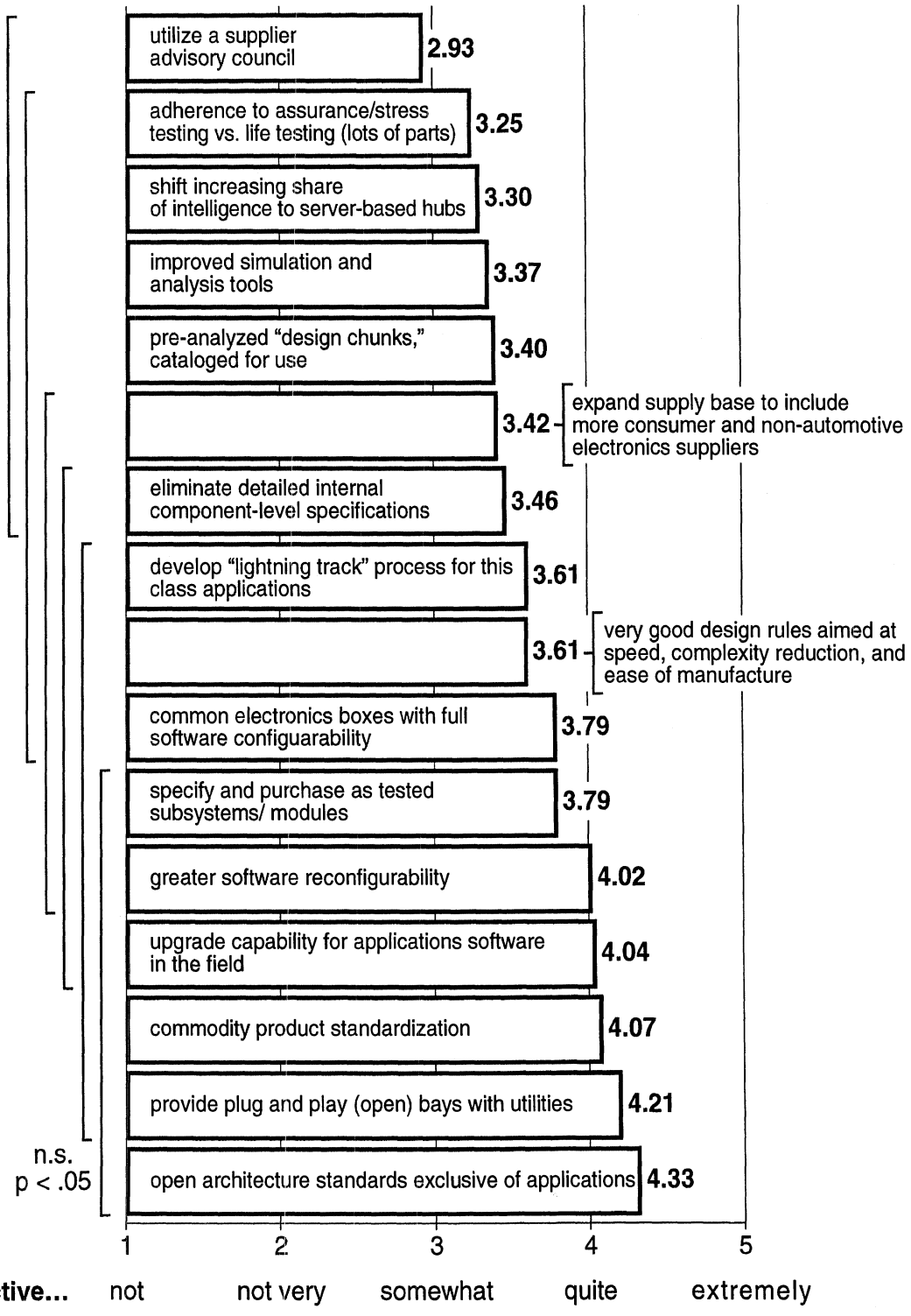

Figure 9. Effectiveness of Factors in Reducing Development Time for Entertainment, Telematics, and Consumer Electronics (Question E13)

For entertainment, telematics, and consumer electronics, there were highly significant between-company category differences ($p<0.0001$), with means of 3.92 for assemblers, 3.71 for others, 3.66 for Tier Ones, 3.60 for Tier Twos and 3.47 for integrators. The company category by factor interaction was not significant ($p=0.89$).

In the previous section, there was discussion of the importance of suppliers and OEMs working together. Table 22 shows the steps respondents reported that OEMs and suppliers can take to mesh the fast electronics development cycle with the slower automotive cycle. As in previous questions, the focus in on suggestions offered by at least five respondents, with the complete set of responses appearing in Appendix B. Several suggestions in this table, including coordinated planning (11%) and having the OEM reduce cycle time (6%) were not in the previous fixed list . Of the suggestions offered, standard/open architecture was the most common suggestion (nearly 20%) for either group regarding what OEMs should do.

Table 22. Steps to Improve Coordination (Questions E14a and b)

Group	Step to Improve Coordination	N
OEMs N=111	Standardize architecture/open architecture	20
	Use plug and play architecture with firewall	13
	Include supplier earlier in design cycle	8
	Reduce vehicle development cycle time	7
	Have ability to make running within model year changes	6
Suppliers N=86	Develop communications/long-term planning with OEM	10
	Support plug and play	8
	Build product bookshelf	5

Safety and Usability Standards

Given the frequency with which standardization is noted as a key factor in supplier-OEM coordination, and the frequency with which government regulation was cited as an important factor for telematics, these topics received special attention. The two questions in this section concerned the likelihood and effectiveness of factors that would foster safety and usability, and the topic of standards for those purposes. Of the factors most likely to foster safety and usability (Figure 10), market forces and product liability were rated most highly, with both being rated as quite likely, closely followed by media attention. Except for manufacturer and supplier standards, and state and local laws, all factors listed were at least somewhat likely to foster safety and usability. There were no significant differences in the rated likelihood of various types of standards (SAE, manufacturer, etc.).

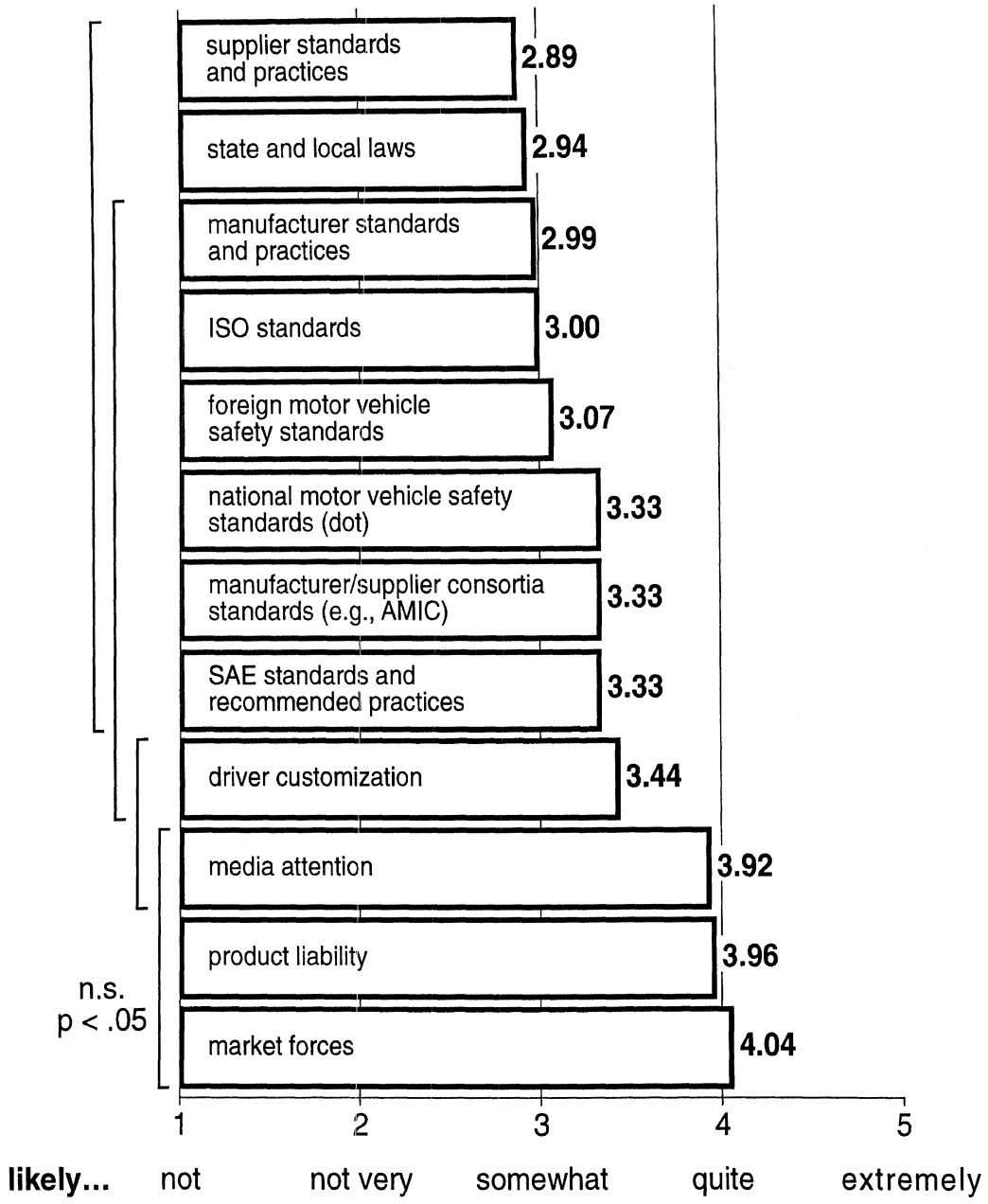

Figure 10. Likelihood of Fostering Telematics Safety and Usability in the Next Three Years (Question E15)

In terms of effectiveness (Figure 11), market forces were still considered the most important factor. However, consortia standards were considered to be almost as effective, and to the authors' surprise, more effective (but not statistically so) than U.S. DOT standards, even though the federal standards are legal requirements. It could be that regulations are not likely within a three-year period. As with the likelihood data, state and local laws were rated as less effective than other means of fostering safety. In this case, all factors except state and local laws and ISO standards were rated as at least somewhat effective. Interestingly, while considered to be likely, media attention was relatively ineffective in fostering safety and usability. There were almost no statistically significant differences in the effectiveness data. Furthermore, there were statistically significant differences in the mean ratings for likelihood between organizations ($p<0.0001$, other=3.35, integrator=3.27, Tier One=3.26, assembler=3.18, Tier Two=3.10) but not interactions between company category and factors.

Further, as with likelihood, there were significant differences between company categories ($p<0.0001$, 3.61=assembler, other=3.34, integrator=3.28, Tier One=3.20, Tier 2=3.11), but the category by factor interaction was not significant ($p=0.99$). Notice how much more likely the assemblers thought all factors would be versus all four remaining company categories.

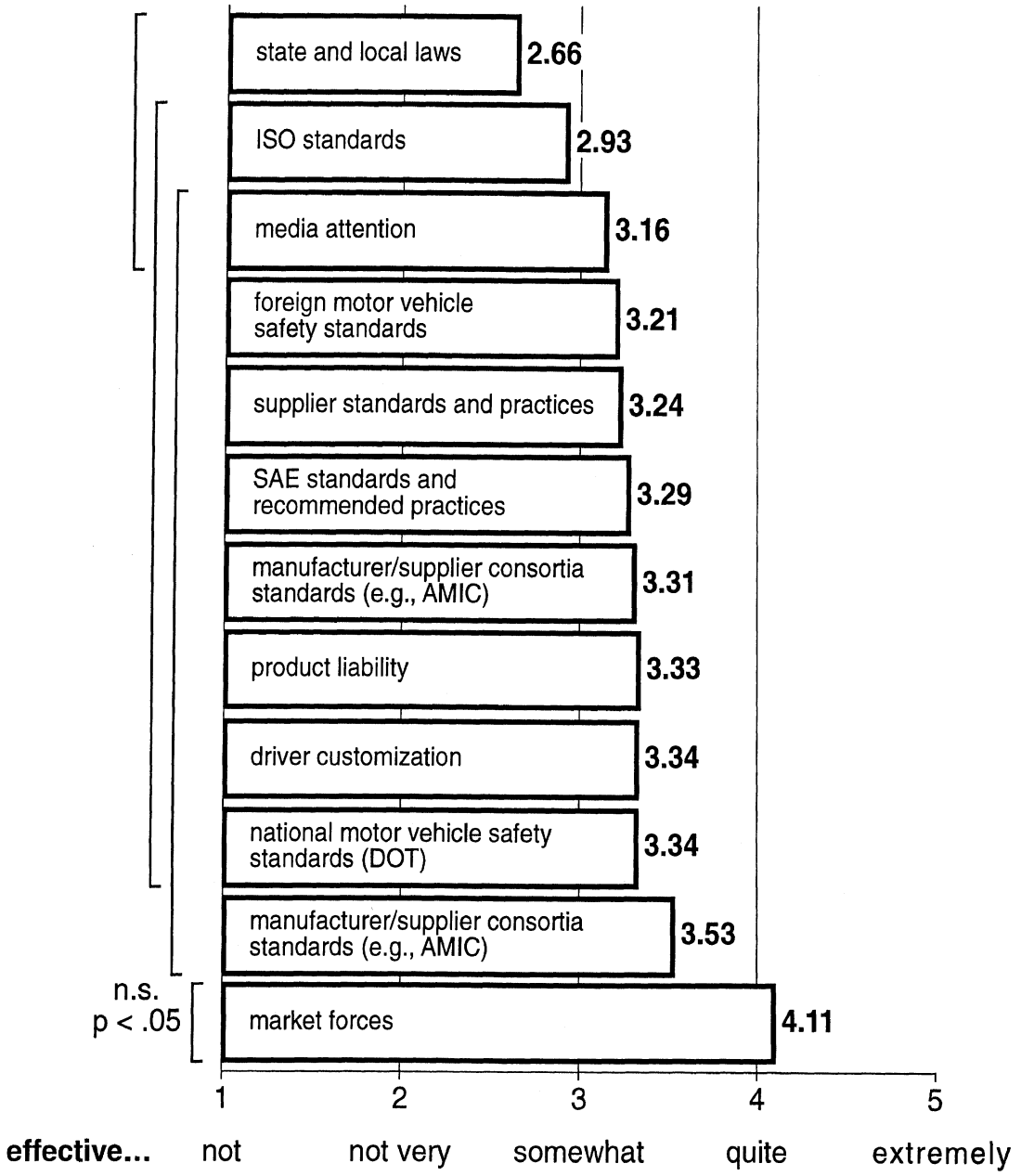

Figure 11. Effectiveness in Fostering Telematics Safety and Usability in the Next Three Years (Question E15)

Standards development should be responsive to industry needs. Figure 12 shows respondents' ratings of the importance of standardization by topic. All topics were in the range of somewhat important to quite important and there were no statistically significant differences in importance except for voice recognition, which had a lower priority. Given the rise in interest in voice interfaces in the six-month period between data collection and completion of the report, that finding may not be true at the present time. The topic with the highest priority was collision warning and avoidance alarms,

and in general, there was a trend for auditory information being rated as more important for standardization than visual information. However, given the lack of significant differences in these data, other evidence may need to be considered in establishing standardization priorities.

As with other questions for which ratings were obtained, there were significant differences between company categories (p=0.005, assemblers=3.60, Tier Two=3.52, other=3.50, Tier One=3.39, integrator=3.20), but no interaction between company category and the items needing standardization (p=0.97).

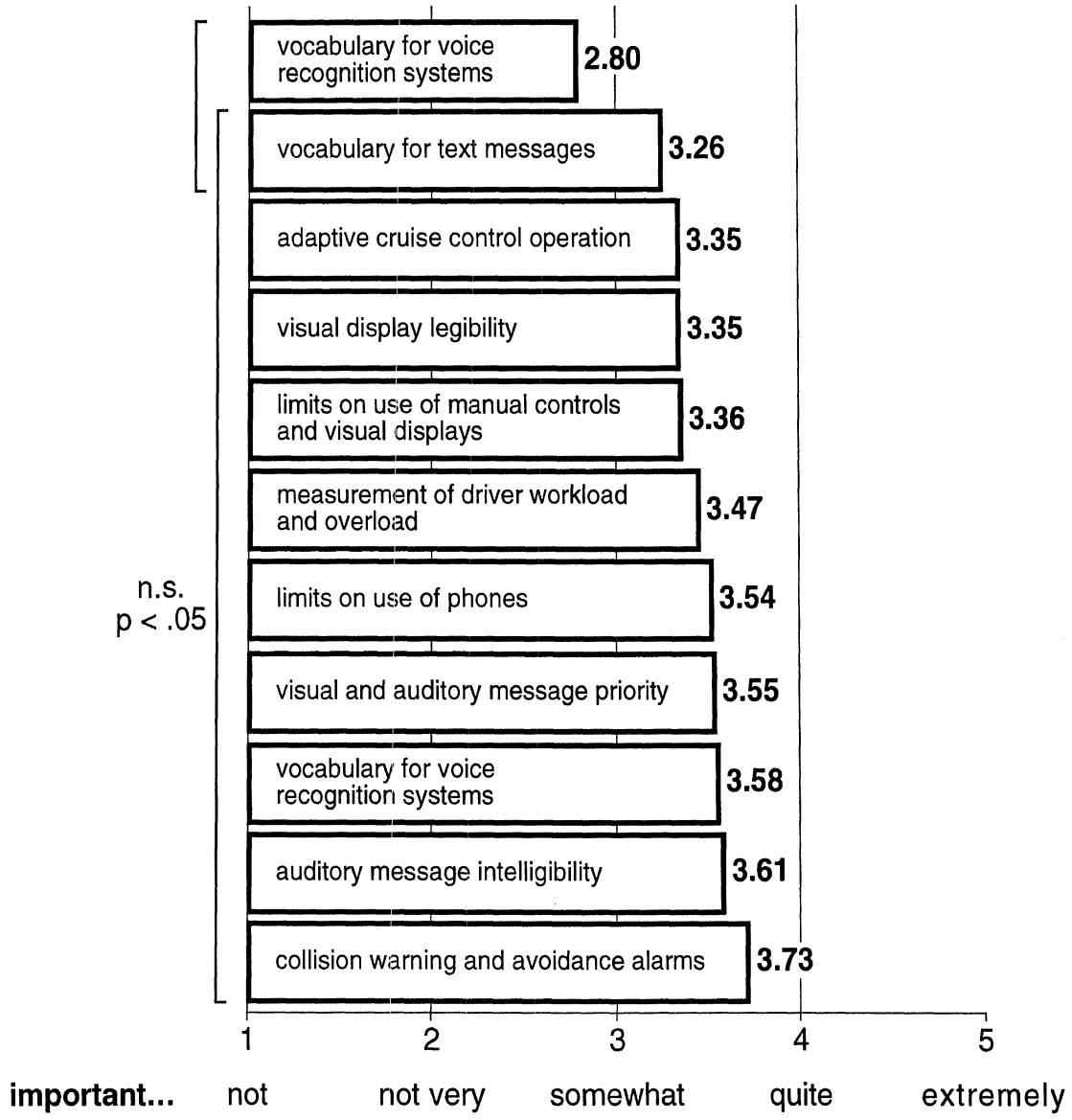

Figure 12. Importance of Achieving Standardization (Question E16)

Products and Automotive Features

The only question in this section concerned the model year that respondents expected each electronic accessory/feature to be installed in 10% of new luxury vehicles (>$35,000 base price). Features have been grouped by category in Table 23. Readers should note that in computing market penetration estimates, "after 2008" was treated as 2009 to facilitate computation. This adjustment may suggest that some features will

appear sooner than respondents had intended. Statistically significant differences were all determined within categories. Response rates to this question were quite high, with typically five people out of the 84 in the sample not responding.

There were differences between company categories ($p<0.0001$, integrator=4.80, other=4.41, Tier One=4.23, assembler=4.19, Tier Two=4.10), with assemblers predicting products further off in the future than other groups. However, there were no significant interactions between company categories and predictions for specific product features ($p=0.74$).

Table 23. Expected Year of 10% Penetration in New Luxury Vehicles (Question E17)

Category	Group	Mean	Never	Feature
Entertainment and convenience	A	2004.7	2	Satellite radio
	A	2004.8	4	Removable media for entertainment and data
	A,B	2005.2	1	MP3 support
	B,C	2005.8	12	Built-in electronic toll and payment tag
	C	2006.3	62	Karaoke
Driver information and communication	A	2004.3	1	Built-in wireless phone interface
	A	2004.4	0	GPS navigation
	A	2004.8	0	Email/Internet access
	A,B	2004.8	10	Built-in PDA (e.g., palm) docking station
	A,B	2005.2	0	Bluetooth support
	B	2005.3	0	Automatic download of traffic/congestion information
	B,C	2005.6	2	Downloadable software features
	B,C	2005.6	2	Downloadable software fixes
	B,C	2005.8	0	General purpose text/data speech capability
	C,D	2005.9	7	Large general purpose display
	C,D	2005.9	6	Off-board applications via data link
	D,E	2006.2	9	General purpose computer (e.g., AutoPC)
	E,F	2006.8	10	Open electronics bay with utilities
	E,F	2006.9	11	Interface to wearable computer
	F	2007.1	14	Large area HUD
Safety and security	A	2004.6	1	Automatic collision notification
	A,B	2004.8	0	Adaptive cruise control
	A,B,C	2005.0	1	Rear parking aid
	A,B,C,D	2005.3	2	Blind spot detection and warning
	B,C,D,E	2005.5	1	Voice operation of some controls
	C,D,E	2005.6	3	Forward collision warning
	D,E	2005.7	4	Forward parking aid
	D,E	2005.7	6	Lane departure warning
	E	2005.9	9	Night vision
	E,F	2006.0	16	Black box crash recorder
	E,F	2006.1	8	Forward collision braking only
	E,F,G	2006.3	9	Drowsy driver detection
	G,H,I	2006.8	7	Fingerprint or voice-controlled entry
	H,I	2007.1	25	Alcohol-impaired driver detection
	I,J	2007.6	15	Automatic lane control
	K	2008.0	20	Forward collision braking & steering
Electrical, propulsion, and control	A	2005.7	4	Dual voltage (42/12 volt)
	A,B	2006.0	7	Active suspension
	C,D	2006.7	1	42 v electrical system

D,E	2007.1	1	Brake by wire
D,E	2007.1	4	Drive by wire
E	2007.2	6	Hybrid drive-train (electric/combustion)
F	2008.2	26	All-electric drivetrain

Following common practice, nonsignificant differences were identified using the scheme shown in Table 24. In this example, there is a significant difference between factors 1 and 2 because they are in different groups. However, there are no differences between 2 and 3, and 3 and 4, but there is a difference between 2 and 4.

Table 24. Scheme to Identify Significant Differences

Group	Factor
A	1
B	2
B,C	3
C	4

In terms of entertainment and convenience features, satellite radio, removable media, and MP3 support were equally likely to achieve 10% market penetration in the near term. In contrast, 62 of the 84 respondents (74%) did not think karaoke would achieve 10% penetration. Figures for the Japanese market might be different.

For driver information and communication, features most likely to see short term introduction included built-in phone interfaces, GPS navigation, email/Internet access, PDA station, and Bluetooth support. Interestingly, significant market penetration of something like an AutoPC was not expected until 2006 with 11% of the sample saying it would never be installed. It was, however, more likely than an open electronics bay, wearable computers, and a large-area HUD.

For safety and security systems, automatic collision notification, adaptive cruise control, rear parking aid, and blind spot detection/warning were predicted to have the most near-term introduction. On the other end of the spectrum, 19% of respondents said that a black box crash recorder would never achieve 10% market penetration in luxury vehicles. Other unlikely items included automatic lane control (18%), forward collision braking and steering (23%), and alcohol-impaired driver detection (30%).

For electrical propulsion and control, the significantly more near term items were dual voltage and active suspension. In contrast, 31% thought all-electric drive-trains would never achieve 10% market penetration in luxury vehicles.

Table 25 provides a chronological overview of market penetration, sorted by year. Given that new vehicles take three to four years to develop, the features listed for 2004 and 2005 are either currently being designed for some vehicles, or for a more limited set, are planned for later years.

Table 25. Expected Feature Introductions Sorted by Year

Mean	Never	Feature
2004.3	1	Built-in wireless phone interface
2004.4	0	GPS navigation
2004.6	1	Automatic collision notification
2004.7	2	Satellite radio
2004.8	4	Removable media for entertainment and data
2004.8	0	Email/Internet access
2004.8	10	Built-in PDA (e.g., palm) docking station
2004.8	0	Adaptive cruise control
2005.0	1	Rear parking aid
2005.2	1	MP3 support
2005.2	0	Bluetooth support
2005.3	0	Automatic download of traffic/congestion information
2005.3	2	Blind spot detection and warning
2005.5	1	Voice operation of some controls
2005.6	2	Downloadable software features
2005.6	2	Downloadable software fixes
2005.6	3	Forward collision warning
2005.7	4	Forward parking aid
2005.7	6	Lane departure warning
2005.7	4	Dual voltage (42/12 volt)
2005.8	12	Built-in electronic toll and payment tag
2005.8	0	General purpose text/data speech capability
2005.9	7	Large general purpose display
2005.9	6	Off-board applications via data link
2005.9	9	Night vision
2006.0	16	Black box crash recorder
2006.0	7	Active suspension
2006.1	8	Forward collision braking only
2006.2	9	General purpose computer (e.g., AutoPC)
2006.3	62	Karaoke
2006.3	9	Drowsy driver detection
2006.7	1	42 v electrical system
2006.8	10	Open electronics bay with utilities
2006.8	7	Fingerprint or voice-controlled entry
2006.9	11	Interface to wearable computer
2007.1	14	Large area HUD
2007.1	25	Alcohol-impaired driver detection
2007.1	1	Brake by wire
2007.1	4	Drive by wire
2007.2	6	Hybrid drive-train (electric/combustion)
2007.6	15	Automatic lane control
2008.0	20	Forward collision braking and steering
2008.2	26	All-electric drive-train

How do automotive executives think about the future and project what might appear and when? Depending on the company, any introduction within three to four years is typically one being considered and possibly designed for a vehicle scheduled to go into production. However, at any given time, executives are most likely not just familiar with one product but several, each at a different state of development. Beyond three to four years, projections are less well grounded in product plans. One could therefore speculate that projections simply represent a process of constantly increasing uncertainty about the future. If that is the case, a simple linear model relating predictions of marketing inroads with percentage never makes sense. Figure 13 shows such a relationship. That linear plot accounts for 54% of the variance, a reasonable approximation (and the regression was statistically significant, $p<0.0001$). However, the regression equation has a negative intercept, which does not make sense, and inspection of the data shows the "% never" level is quite close to zero for 2004 and 2005.

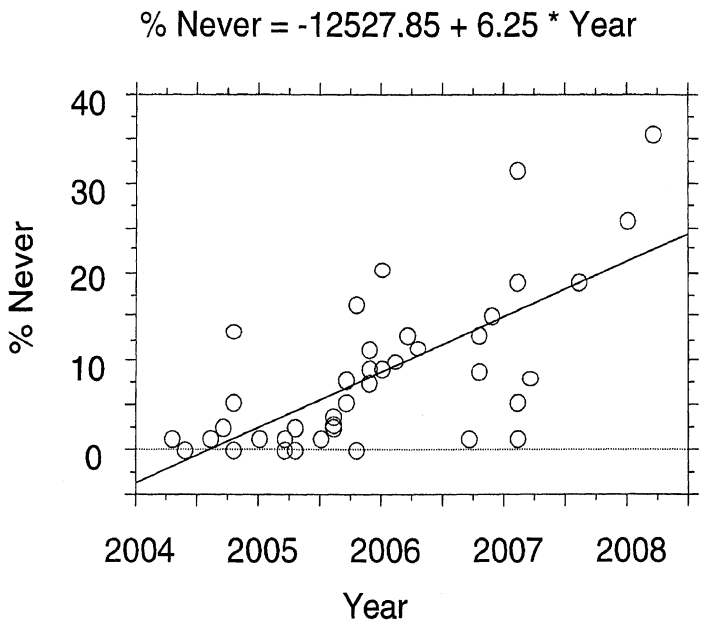

Figure 13. Linear Prediction of % Never from Year

A two-process model consists of two rates of constantly increasing uncertainty, one for the short term, and a second more long term. A simple two-process model could introduce a second quadratic term to reflect the long term. In this model (Figure 14), regression analyses showed that neither the linear nor quadric year terms achieve statistical significance (both $p=.056$) and, in fact, the quadratic model accounted for an identical amount of variance as the linear model. Given a preference for parsimony, the linear model is superior.

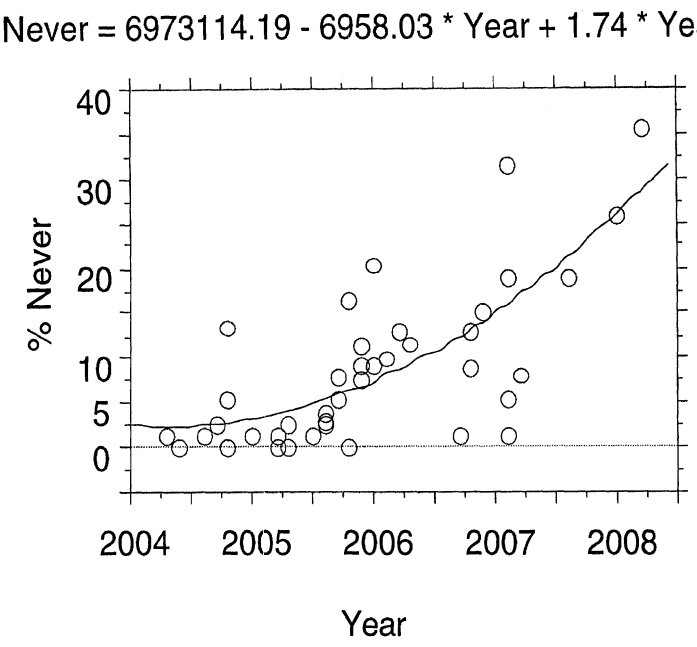

Figure 14. Quadratic Prediction of % Never from Year

Given assumptions about the process, a third alternative would be to say that respondents know approximately when features will be introduced in the near term, so percentage should never be close to zero. Only beyond current model production, say 3.5 (since vehicles take three to four years to develop), would there be uncertainty. Since the data was collected in the third quarter of 2001, 3.5 years would be the first quarter of 2005 (2005.25).

Using the data points before 2005.25, a linear regression was significant (p=0.0001) and the regression accounted for 53% of the variance. A similar regression for after 2005.25 was also significant (p=0.0025), but only accounts for 41% of the variance in that part of the data set (in part because of the reduced range of the data set). (See Figures 15 and 16.) Splitting the data range into pieces does not improve the prediction accuracy. Thus, the data suggest a single component model of predicting the future is best.

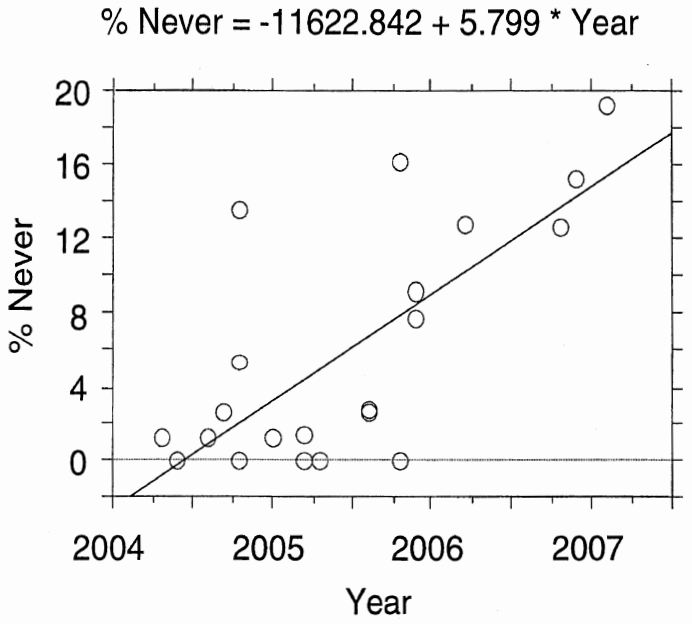

Figure 15. Regression Analysis of Near Term Data

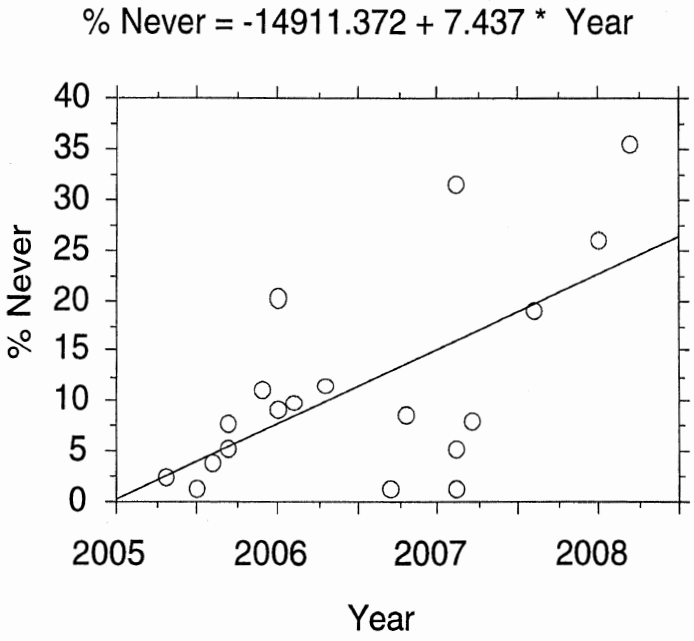

Figure 16. Regression Analysis of Far Term Data

Table 26 shows the features that respondents predict to be unexpected successes (real sleepers) and unexpected failures (real bombs) in 2003. In each case, there was one outstanding choice: voice recognition for the unexpected success (10 out of 60 respondents or 17%) and email/Internet for the unexpected failure (10 out of 49 respondents or 20%). Reasons for these predictions were not obtained.

Table 26, Unexpected successes and failures (Questions E18 and E19)

Result	Product or Feature	N
Unexpected success (N=60)	Voice recognition	10
	Bluetooth	5
	Driving aids (parking assist)	5
	ACC	5
Unexpected failure (N=49)	Email/Internet	10
	Navigation	6
	Three-button telematics (OnStar)	6
	Entertainment	5

To achieve many of the new features, changes in infrastructure may be needed. Table 27 shows those identified by respondents for North America, Europe, and Japan. Interestingly, the most common response was the need for standardized architectures and protocols (27% in North America, 35% in Europe), though it was not clear for what they are needed. Telematics seems to be one obvious choice. The second most common need was for real-time traffic information (16% in North America, 20% in Europe).

Table 27. Infrastructure Changes Needed (Question E20)

Region	Change Needed	N
North America (N=56)	Standardized architecture/protocol	15
	Real-time traffic information	9
	Wireless communication service	7
	Wideband or extended bandwidth for increased wireless traffic	5
Europe (N=49)	Standardized architecture/protocol	17
	Real-time traffic information	10
Japan (N=37)	Standardized architecture/protocol	9

CONCLUSIONS

This report summarizes input from 84 senior executives in the automotive industry, most of whom were directors or above, and predominantly from North America. Respondents represented a variety of OEMs, suppliers, and other key industrial organizations. The findings are believed to be indicative of senior automotive industry executives in North America.

Confidence in the responses is question-specific. For the ranking questions, confidence can be expressed in statistical terms. For the free-response questions, statistics were not provided and in many cases consensus was not strong, with only 10-15% of the sample offering the most common response.

Some of the most pertinent questions in the survey are summarized below.

Who Will be the Major Competitors for Automotive Communications and Information Business in the Future?

The major future competitors will most likely be the in-house spin-offs (Delphi and Visteon), along with large system integrators. Automotive electronics suppliers were also considered to be effective competitors in the future. New electronics suppliers, wireless carriers, and software companies were considered only somewhat likely and less than somewhat effective.

Mean sales to be a global supplier were estimated to be $380 million for OEMs, $970 million for integrators, $2.2 billion for Tier One suppliers, $500 million for Tier Two suppliers, and $1.6 billion for others. For the last year, at least the top 30 suppliers all had revenues in excess of $3 billion.

Preferred means for achieving the desired size were merger and acquisition (33%) and joint ventures (17%). Strategies were consistent across all organizational categories.

What Should be Considered in Developing Future Product Strategies?

Vehicle electronics content will be most influenced by communications, safety, and comfort and convenience features. Revenue opportunities, vehicle performance, entertainment, model differentiation, cost, networking, and quality were rated between somewhat important and quite important.

To plan for the future (2003 in particular), 17% wanted to know what communication standard would be in place for full networking. Other items of interest included government telematics regulations, customer acceptance of telematics, the market penetration of 42 v systems, and the importance of analytical design, testing, and simulation tools.

Respondents felt that by 2005, the pace of change in automotive electronics would increase, software would command a much higher portion of the value added, and automotive supplier responsibility would increase. These developments were all rated as quite or extremely likely. Other developments were rated between somewhat and

quite likely (customer-branded vehicle electronics grow, regulations and legislation become more important, supplier prices decline, insistence on customized parts declines, and the number of suppliers substantially shrinks).

In envisioning the future, the quickening pace of change was often mentioned. Participants were generally concerned that new technology would be introduced more rapidly than expected, disrupting product plans for automotive electronics. Specific examples include (1) a change from internal combustion to alternatives affecting powertrain and vehicle control design, (2) the introduction of 42 v affecting electrical power and networking, (3) driver distraction legislation affecting telematics, and (4) the lack of wireless communication standards.

Will Electronics "Chunks" Lead to Better Vehicles?

Participants felt chunks would lead to better vehicles by a 2 to 1 margin in all company categories except Tier Two, where the ratio was 12:1.

What Problems are There in Manufacturer-Electronics Supplier Relationships and How Can They be Resolved?

How OEMs and suppliers can improve their working relationships has been the topic of considerable discussion. Participants, typically about 15%, noted that problems occur most commonly because of too much focus on price, a lack of partnerships and industry standards, and long automotive development cycles. In terms of improving relationships, the most commonly mentioned item was the need for partnerships (both to work with suppliers to incorporate new electronics technology and as an attribute of organizations that successfully integrate electronics into vehicles). Other key attributes include suppliers with a system view and technically savvy OEMs and suppliers with R&D support. More spending on R&D was identified as the most important directive a CEO could make to enhance implementation of electronics/software technology.

Given the global nature of the automotive industry, vehicle electronics are often developed by collaborating organizations with different business cultures. Commonly cited steps to improve such interactions included on site/local offices and developing partnerships. Surprisingly, foreign language skills were not often cited.

What Can be Done to Improve the Product Development Process?

Improvements noted were system specific, though the development of design standards, improved processes, and support for software upgrades were common themes. More specifically, accelerated power-train development and improved simulation and analysis tools were thought to be quite effective. Design rules, open architecture standards, subsystems purchasing, design chunks, software reconfigurability and upgradability, and product standardization were mentioned to a lesser degree. No single solution stood out. For telematics, open architecture was thought to be more than quite effective, were plug and play, product standardization, and field software upgrades. Also cited as effective were subsystem purchasing and reconfigurable hardware.

Few respondents specifically mentioned the mismatch of the short electronics development cycle with the long vehicle development cycle. However, when addressed, it was commonly recommended that both manufacturers and suppliers adopt standardized architectures and plug and play, and that they involve suppliers early in design.

Safety and Usability Standards –What Might Happen in the Next Three Years?

Respondents felt market forces were quite likely (and most effective) in fostering such standards, though product liability and media attention were close likelihoods. Other factors were between somewhat and quite likely/effective.

In terms of which attributes of interfaces to standardize, virtually all of those listed (display legibility, collision warning and avoidance alarms, etc.) were rated as between somewhat and quite important. No single factor or grouping stood out as more important.

What New Product Features are Likely and When?

Features achieving a 10% installation rate in luxury vehicles by 2004 include a built-in phone interface, navigation, automatic collision notification, satellite radio, removable media for entertainment and data, email/Internet access, PDA docking station, and adaptive cruise control. For 2005, likely items include a rear parking aid, MP3 support, Bluetooth support, automatic downloads of traffic information, blind spot detection and warning, voice operation of some controls, downloadable features and fixes, forward collision warning, lane departure warning, 42/12 voltage, built in toll tag, general purpose speech capability, large general-purpose display, off board applications via a data link, and night vision. Karaoke was considered unlikely at any time. Of the applications considered, voice recognition was deemed as the unexpected success and email/Internet the unexpected failure.

Closing Thoughts

Survey respondents depicted a changing automotive landscape, some of which was not surprising at a surface level. Clearly, suppliers are becoming more important and require significant sales to avoid being purchased by stronger competitors. The feeling was that this approach would lead to better vehicles, for example, as indicated by support from all categories of companies for purchasing in chunks.

To improve suppliers and OEMs working together to incorporate new technology, technical competence, both from OEMs and suppliers, and R&D funding were recurrent themes. The factors influencing the development of new technology were system specific; Key items include the influence of 42 v, standards for communications, and government regulation of telematics.

It is clear that a large array of new product features will occur in the next two to three years, especially telematics applications. Given the time required to produce a motor vehicle and the position of the respondents, their projections are not mere speculation about the future, but represent current product plans. In contrast to prior research

which has involved the two-step Delphi method, research that has resulted in overly optimistic predictions, only a single step survey was used here and the focus was on more near-term predictions. It will be interesting to see how the uncertainties expressed by respondents affect those plans.

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APPENDIX A – BLANK SURVEY FORM

University of Michigan
Transportation Research Institute
Office for the Study of Automotive Transportation
1210 Buhr Building, 837 Greene Street
Ann Arbor, MI 48104-3213
Phone: 734/764-5592
Fax: 734/615-4003
Email: tjimenez@umich.edu

AUTOMOTIVE ELECTRONICS SURVEY
OF
SENIOR INDUSTRY EXECUTIVES

VERY IMPORTANT **RETURN BY: **08/21/00** **

Your reply will be held in strictest confidence. However, to enable us to include you in future mailings, **please attach your business card or complete the box below.** It will be kept separate from your reply. – Thank you.

NAME:

TITLE:

DEPT:

COMPANY:

DIVISION:

ADDRESS:

STE/MC/PO/CIS:

PHONE: FAX:

EMAIL:

For Office Use Only

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3. INSTRUCTIONS

- The survey covers a broad spectrum of areas relevant to automotive electronics. You are not expected to know all the "right answers." Our aim in this study is to gather expert opinion to determine where there is consensus, as well as where there is uncertainty about **current and future** developments. You do not need to fill out items you have no knowledge of; however, we are interested in gathering the range of views that each of you provide, whether you represent a manufacturer, supplier, system integrator or other organization.
- You and your company's confidentiality are protected. Data is aggregated and no specific identifying information is included in the final report.
- Thank you very much for your time. The survey should take approximately an hour to complete.

II. RESPONDENT INFORMATION

1. Please provide the following background information:

a. Your company is predominantly a(n):

- ☐ Vehicle assembler
- ☐ Systems integrator: electronics part/component module/system, direct to manufacturer
- ☐ 1st tier supplier: electronics part/component supplier, direct to manufacturer
- ☐ 2nd tier supplier: electronics part/component supplier, to other part/component supplier
- ☐ Other (please specify):

b. What is your company's total revenue? Approximately $

c. The percentage of your overall company business is in:

Electronics and embedded software	___%
Other (please specify):	___%
Total	100%

d. What percent of your business is in automotive? ___ %

2. Please mark the appropriate box for the next two questions:

1. a. Where have you had most of your experience over your career?
   b. Where are you currently assigned?

	MOST EXPERIENCE OVER CAREER	CURRENTLY ASSIGNED
DESIGN/ENGINEERING	☐	☐
FINANCE	☐	☐
INFORMATION SYSTEMS	☐	☐
LOGISTICS	☐	☐
MANUFACTURING	☐	☐
MARKETING	☐	☐
PURCHASING	☐	☐
SALES	☐	☐
OTHER (PLEASE SPECIFY)		

3. What is your title?

4. Which business culture do you find most compatible?

BUSINESS CULTURE	
NORTH AMERICAN	☐
EUROPEAN	☐
JAPANESE	☐
OTHER (PLEASE SPECIFY):	☐

III. STRATEGIC ISSUES

E-1 How important is each of these drivers for putting more electronic content into vehicles over the next five years?

SCALE →	1	2	3	4	5
	NOT AT ALL IMPORTANT	NOT VERY IMPORTANT	SOMEWHAT IMPORTANT	QUITE IMPORTANT	EXTREMELY IMPORTANT

DRIVER	1	2	3	4	5
COMFORT AND CONVENIENCE FEATURES	☐	☐	☐	☐	☐
COMMUNICATIONS	☐	☐	☐	☐	☐
NETWORKING	☐	☐	☐	☐	☐
ENTERTAINMENT	☐	☐	☐	☐	☐
SAFETY	☐	☐	☐	☐	☐
VEHICLE PERFORMANCE	☐	☐	☐	☐	☐
COST	☐	☐	☐	☐	☐
REVENUE OPPORTUNITIES	☐	☐	☐	☐	☐
QUALITY	☐	☐	☐	☐	☐
MODEL DIFFERENTIATION	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐

(III. Strategic Issues – Continued)

E-2 Who do you perceive to be the strongest competitors for automotive new business opportunities offered by communications and information technologies? (Rate likeliness and effectiveness)

LIKELINESS SCALE →	1	2	3	4	5
	NOT AT ALL LIKELY	NOT VERY LIKELY	SOMEWHAT LIKELY	QUITE LIKELY	EXTREMELY LIKELY

EFFECTIVENESS SCALE →	1	2	3	4	5
	NOT AT ALL EFFECTIVE	NOT VERY EFFECTIVE	SOMEWHAT EFFECTIVE	QUITE EFFECTIVE	EXTREMELY EFFECTIVE

	LIKELINESS					EFFECTIVENESS				
	1	2	3	4	5	1	2	3	4	5
LARGE SYSTEM INTEGRATORS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
AUTOMOTIVE ELECTRONIC COMPONENT SUPPLIERS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NEW ELECTRONICS/SOFTWARE SUPPLIERS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
WIRELESS CARRIERS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
SOFTWARE COMPANIES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
IN-HOUSE SPINOFFS OF VEHICLE MANUFACTURERS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(III. Strategic Issues – Continued)

E- 3 How likely is each of the following developments by 2005?

LIKELINESS SCALE →	1	2	3	4	5
	NOT AT ALL LIKELY	NOT VERY LIKELY	SOMEWHAT LIKELY	QUITE LIKELY	EXTREMELY LIKELY

DEVELOPMENT	1	2	3	4	5
THE AUTOMOTIVE INDUSTRY'S STATUS AS A PREFERRED CUSTOMER FOR THE ELECTRONICS INDUSTRY ERODES	☐	☐	☐	☐	☐
THE AUTOMOTIVE INDUSTRY HAS TO RELAX ITS INSISTENCE ON CUSTOMIZED ELECTRONIC PARTS	☐	☐	☐	☐	☐
THE NUMBER OF AUTOMOTIVE ELECTRONICS SUPPLIERS IN THE INDUSTRY SUBSTANTIALLY SHRINKS	☐	☐	☐	☐	☐
THE PRODUCT OF AUTOMOTIVE ELECTRONIC SUPPLIERS WILL COMMAND MUCH LOWER PRICES	☐	☐	☐	☐	☐
AUTOMOTIVE ELECTRONIC SUPPLIERS' RESPONSIBILITY FOR SYSTEM DESIGN/MANUFACTURE WILL INCREASE	☐	☐	☐	☐	☐
THE SHARE OF CONSUMER-BRANDED ELECTRONICS IN THE VEHICLE WILL GROW	☐	☐	☐	☐	☐
REGULATIONS AND LEGISLATION WILL BECOME EVEN MORE IMPORTANT DRIVERS OF AUTOMOTIVE ELECTRONICS THAN THEY ARE TODAY	☐	☐	☐	☐	☐
THE PACE OF CHANGE IN AUTOMOTIVE ELECTRONICS WILL BECOME EVEN FASTER THAN IT IS TODAY	☐	☐	☐	☐	☐
SOFTWARE WILL COMMAND A MUCH HIGHER PORTION OF THE VALUE ADDED CHAIN	☐	☐	☐	☐	☐

(III. Strategic Issues – Continued)

E-4 Considering reasonably possible developments and events, which one would most disrupt your company's strategic commitments for automotive electronics in each of the following vehicle areas:

a. Powertrain and vehicle control (e.g., engine, transmission, braking, steering, attitude, etc.)

b. Electrical power distribution and networking (e.g., wiring, electrical controls, data distribution)

c. Vehicle customer features (e.g., radio, driver information, safety, computers/office, etc.)

d. Wireless communications (e.g., voice, data)

e. Infrastructure (e.g., regulations, standards, liability, etc.)

(III. Strategic Issues – Continued)

E-5 What one piece of information or fact about the state of automotive electronics in 2003 would you most want to know right now?

E-6 a. What is the effective minimal dollar volume of sales required for a company such as yours to be a global supplier of automotive electronics?

$

b. In general, what is the one best way for smaller companies to reach this level?

- ☐ Expand its product line
- ☐ Expand its customer base
- ☐ Joint venture
- ☐ Merger and acquisition
- ☐ Other (please specify):

E-7 Do you think the trend towards OEM purchasing electronics as part of larger subsystems or "chunks" will give the vehicle manufacturers better vehicles (features, cost, quality, timing)?

☐ Yes ☐ No Why?

IV. ORGANIZATIONAL ISSUES

E-8 What one problem between vehicle manufacturers and electronics suppliers most interferes with meeting the needs, desires and preferences of vehicle purchasers?

E-9 How can vehicle manufacturers more effectively incorporate new suppliers with novel ideas for electronics technology into their product development activities?

E-10 What one directive from your CEO would do the most to enhance your company's implementation of evolving vehicle electronics and/or software technology?

(IV. Organizational Issues – Continued)

E-11a Please consider vehicle manufacturers that are outstanding in integrating electronics into their vehicles. What 2 or 3 organizational attributes of these companies, if any, account for their successful integration of electronics into their vehicles?

1.

2.

3.

E-11b Please consider suppliers that are outstanding in integrating electronics into their customers' vehicles. What 2 or 3 organizational attributes of these suppliers, if any, account for their successful integration of electronics into their customers' vehicles?

1.

2.

3.

(IV. Organizational Issues – Continued)

E-12 Please answer the next three questions utilizing the following table:

IF YOU ARE A:	*ANSWER IN REGARD TO:*
VEHICLE MANUFACTURER	*YOUR LARGEST ELECTRONIC SUPPLIER*
SYSTEMS INTEGRATOR OR DIRECT SUPPLIER	*YOUR LARGEST VEHICLE CUSTOMER*
INDIRECT SUPPLIER	*YOUR LARGEST ELECTRONIC CUSTOMER AMONG AUTOMOTIVE SUPPLIERS*

a. What should your company do to improve its effectiveness in vehicle electronics development with Japanese companies?

b. What should your company do to improve its effectiveness in vehicle electronics development with European companies?

c. What should your company do to improve its effectiveness in vehicle electronics development with North American companies?

V. PRODUCT TIMING

E-13 What changes to the development process would allow the faster cycling of the latest electronics into vehicles for: 1) powertrain and vehicle control applications and 2) entertainment, telematics, and consumer electronics applications. Please rate the effectiveness of each driver.

SCALE →	1	2	3	4	5
	NOT AT ALL EFFECTIVE	NOT VERY EFFECTIVE	SOMEWHAT EFFECTIVE	QUITE EFFECTIVE	EXTREMELY EFFECTIVE

DRIVERS	POWERTRAIN AND VEHICLE CONTROL					ENTERTAINMENT, TELEMATICS AND CONSUMER ELECTRONICS				
	1	2	3	4	5	1	2	3	4	5
COMMODITY PRODUCT STANDARDIZATION	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
PROVIDE PLUG AND PLAY (OPEN) BAYS WITH UTILITIES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
COMMON ELECTRONICS BOXES WITH FULL SOFTWARE CONFIGUARABILITY	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
OPEN ARCHITECTURE STANDARDS EXCLUSIVE OF APPLICATIONS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
GREATER SOFTWARE RECONFIGURABILITY	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
UPGRADE CAPABILITY FOR APPLICATIONS SOFTWARE IN THE FIELD	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
SHIFT INCREASING SHARE OF INTELLIGENCE TO SERVER-BASED HUBS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
IMPROVED SIMULATION AND ANALYSIS TOOLS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
PRE-ANALYZED "DESIGN CHUNKS," CATALOGED FOR USE	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
VERY GOOD DESIGN RULES AIMED AT SPEED, COMPLEXITY REDUCTION, AND EASE OF MANUFACTURE	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ADHERENCE TO ASSURANCE/STRESS TESTING VS. LIFE TESTING (LOTS OF PARTS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
DEVELOP "LIGHTNING TRACK" PROCESS FOR THIS CLASS APPLICATIONS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ELIMINATE DETAILED INTERNAL COMPONENT-LEVEL SPECIFICATIONS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
SPECIFY AND PURCHASE AS TESTED SUBSYSTEMS/ MODULES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
UTILIZE A SUPPLIER ADVISORY COUNCIL	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
EXPAND SUPPLY BASE TO INCLUDE MORE CONSUMER AND NON-AUTOMOTIVE ELECTRONICS SUPPLIERS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(V. Product Timing – Continued)

E-14a What one or two steps should the vehicle manufacturers take to better coordinate the shorter product development cycle time for electronic features with the longer cycle time for vehicle development?

1.

2.

E-14b What one or two steps should the electronics suppliers take to better coordinate the longer product development cycle time for vehicle development with the shorter cycle time for electronic feature development?

1.

2.

VI. SAFETY & USABILITY STANDARDS

E-15 To foster the safety and usability of telematics applications, how likely do you think the following are to occur in the next 3 years and how effective will they be if they occur?

LIKELINESS SCALE →	1	2	3	4	5
	NOT AT ALL LIKELY	NOT VERY LIKELY	SOMEWHAT LIKELY	QUITE LIKELY	EXTREMELY LIKELY

EFFECTIVENESS SCALE →	1	2	3	4	5
	NOT AT ALL EFFECTIVE	NOT VERY EFFECTIVE	SOMEWHAT EFFECTIVE	QUITE EFFECTIVE	EXTREMELY EFFECTIVE

DRIVER	LIKELINESS					EFFECTIVENESS				
	1	2	3	4	5	1	2	3	4	5
MANUFACTURER STANDARDS AND PRACTICES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
SUPPLIER STANDARDS AND PRACTICES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
MANUFACTURER/SUPPLIER CONSORTIA STANDARDS (E.G., AMIC)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
SAE STANDARDS AND RECOMMENDED PRACTICES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NATIONAL MOTOR VEHICLE SAFETY STANDARDS (DOT)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
FOREIGN MOTOR VEHICLE SAFETY STANDARDS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
STATE AND LOCAL LAWS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ISO STANDARDS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
MARKET FORCES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
MEDIA ATTENTION	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
DRIVER CUSTOMIZATION	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
PRODUCT LIABILITY	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

E-16 How important is achieving standardization for each of the following capabilities and attributes?

SCALE →	1	2	3	4	5
	NOT AT ALL IMPORTANT	NOT VERY IMPORTANT	SOMEWHAT IMPORTANT	QUITE IMPORTANT	EXTREMELY IMPORTANT

CAPABILITY/ATTRIBUTE	1	2	3	4	5
VISUAL DISPLAY LEGIBILITY	☐	☐	☐	☐	☐
AUDITORY MESSAGE INTELLIGIBILITY	☐	☐	☐	☐	☐
VISUAL AND AUDITORY MESSAGE PRIORITY	☐	☐	☐	☐	☐
COLLISION WARNING AND AVOIDANCE ALARMS	☐	☐	☐	☐	☐
VOCABULARY FOR VOICE RECOGNITION SYSTEMS	☐	☐	☐	☐	☐
VOCABULARY FOR TEXT MESSAGES	☐	☐	☐	☐	☐
MEASUREMENT OF DRIVER WORKLOAD AND OVERLOAD	☐	☐	☐	☐	☐
LIMITS ON USE OF MANUAL CONTROLS AND VISUAL DISPLAYS	☐	☐	☐	☐	☐
LIMITS ON USE OF VOICE RECOGNITION SYSTEMS	☐	☐	☐	☐	☐
LIMITS ON USE OF PHONES	☐	☐	☐	☐	☐
ADAPTIVE CRUISE CONTROL OPERATION	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐

VII. PRODUCTS & AUTOMOTIVE FEATURES

E-17 Please place an (x) in the model year you expect each electronic accessory/feature to reach a 10% installation rate in the luxury vehicle segment? (>$35,000 base price)

ELECTRONIC ACCESSORIES/FEATURES	2003	2004	2005	2006	2007	2008	2008+	NEVER
ENTERTAINMENT AND CONVENIENCE								
BUILT IN ELECTRONIC TOLL AND PAYMENT TAG	☐	☐	☐	☐	☐	☐	☐	☐
KAROKE	☐	☐	☐	☐	☐	☐	☐	☐
MP3 SUPPORT	☐	☐	☐	☐	☐	☐	☐	☐
REMOVABLE MEDIA FOR ENTERTAINMENT AND DATA	☐	☐	☐	☐	☐	☐	☐	☐
SATELLITE RADIO	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐
DRIVER INFORMATION AND COMMUNICATION								
GPS NAVIGATION	☐	☐	☐	☐	☐	☐	☐	☐
AUTOMATIC DOWNLOAD OF TRAFFIC/CONGESTION INFORMATION	☐	☐	☐	☐	☐	☐	☐	☐
BUILT IN WIRELESS PHONE INTERFACE	☐	☐	☐	☐	☐	☐	☐	☐
BLUETOOTH SUPPORT	☐	☐	☐	☐	☐	☐	☐	☐
BUILT IN PDA (E.G., PALM) DOCKING STATION	☐	☐	☐	☐	☐	☐	☐	☐
EMAIL/INTERNET ACCESS	☐	☐	☐	☐	☐	☐	☐	☐
INTERFACE TO WEARABLE COMPUTER	☐	☐	☐	☐	☐	☐	☐	☐
DOWNLOADABLE SOFTWARE FEATURES	☐	☐	☐	☐	☐	☐	☐	☐
DOWNLOADABLE SOFTWARE FIXES	☐	☐	☐	☐	☐	☐	☐	☐
GENERAL PURPOSE COMPUTER (E.G., AUTO PC)	☐	☐	☐	☐	☐	☐	☐	☐
GENERAL PURPOSE TEXT/DATA SPEECH CAPABILITY	☐	☐	☐	☐	☐	☐	☐	☐
LARGE AREA HUD	☐	☐	☐	☐	☐	☐	☐	☐
LARGE GENERAL PURPOSE DISPLAY	☐	☐	☐	☐	☐	☐	☐	☐
OFF BOARD APPLICATIONS VIA DATA LINK	☐	☐	☐	☐	☐	☐	☐	☐
OPEN ELECTRONICS BAY WITH UTILITIES	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐

(VII. Products & Automotive Features – Continued)

ELECTRONIC ACCESSORIES/FEATURES (CON'T)	2003	2004	2005	2006	2007	2008	2008+	NEVER
SAFETY AND SECURITY								
ADAPTIVE CRUISE CONTROL	☐	☐	☐	☐	☐	☐	☐	☐
LANE KEEPING								
DEPARTURE WARNING	☐	☐	☐	☐	☐	☐	☐	☐
AUTOMATIC LANE CONTROL	☐	☐	☐	☐	☐	☐	☐	☐
FORWARD COLLISION WARNING	☐	☐	☐	☐	☐	☐	☐	☐
FORWARD COLLISION AVOIDANCE								
AUTOMATIC BRAKING ONLY	☐	☐	☐	☐	☐	☐	☐	☐
AUTOMATIC BRAKING AND STEERING	☐	☐	☐	☐	☐	☐	☐	☐
FORWARD PARKING AID	☐	☐	☐	☐	☐	☐	☐	☐
REAR PARKING AID	☐	☐	☐	☐	☐	☐	☐	☐
NIGHT VISION	☐	☐	☐	☐	☐	☐	☐	☐
BLIND SPOT DETECTION AND WARNING	☐	☐	☐	☐	☐	☐	☐	☐
AUTOMATIC COLLISION NOTIFICATION (DIAL UP ON CRASH)	☐	☐	☐	☐	☐	☐	☐	☐
BLACK BOX CRASH RECORDER	☐	☐	☐	☐	☐	☐	☐	☐
FINGERPRINT OR VOICE-CONTROLLED ENTRY	☐	☐	☐	☐	☐	☐	☐	☐
IMPAIRED DRIVER								
ALCOHOL-IMPAIRED DRIVER DETECTION	☐	☐	☐	☐	☐	☐	☐	☐
DROWSY DRIVER DETECTION	☐	☐	☐	☐	☐	☐	☐	☐
VOICE OPERATION OF SOME CONTROLS	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐
ELECTRICAL, PROPULSION, AND CONTROL								
42 VOLT ELECTRICAL SYSTEM	☐	☐	☐	☐	☐	☐	☐	☐
DUAL VOLTAGE (42/12 VOLT)	☐	☐	☐	☐	☐	☐	☐	☐
DRIVE BY WIRE	☐	☐	☐	☐	☐	☐	☐	☐
ACTIVE SUSPENSION	☐	☐	☐	☐	☐	☐	☐	☐
BRAKE –BY WIRE	☐	☐	☐	☐	☐	☐	☐	☐
HYBRID DRIVETRAIN (ELECTRIC/COMBUSTION)	☐	☐	☐	☐	☐	☐	☐	☐
ALL-ELECTRIC DRIVETRAIN	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐
OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐	☐	☐	☐

E-18 Which one vehicle electronic product or feature do you think could be the unexpected success (real sleeper) in 2003?

E-19 Which one vehicle electronic product or feature do you think could be the unexpected failure (real bomb) in 2003?

E-20 What is the single most needed infrastructure (on-board vehicle or external service) for data communication applications, such as traffic information/routing, downloadable software, email, or Internet, to become high demand features?

a. North America: _____

b. Europe: _____

c. Japan: _____

THANK YOU VERY MUCH FOR TAKING THE TIME TO COMPLETE THIS SURVEY

APPENDIX B – TABULAR SUMMARY OF RESPONSES TO SURVEY

Table B-1. How important is each of these drivers for putting more electronic content into vehicles over the next five years? (Question E-1)

Importance ->	Not		Somewhat		Extremely			
		Not Very		Quite				
Driver	1	2	3	4	5	total	mean	group
communications	0	1	8	32	43	84	4.38	A
safety	0	1	9	30	43	83	4.36	A
comfort and convenience features	0	1	19	37	26	83	4.10	AB
revenue opportunities	0	5	24	31	23	83	3.91	B
vehicle performance	0	4	28	35	17	84	3.77	BC
entertainment	0	5	32	33	14	84	3.70	BC
model differentiation	1	11	24	25	21	82	3.69	C
cost	2	7	28	25	22	84	3.66	C
networking	0	7	29	30	16	82	3.62	C
quality	1	8	33	25	16	83	3.60	C

Table B-1. Who do you perceive to be the strongest competitors for automotive new business opportunities offered by communications and information technologies? (Question E-2)

Likelihood	Not		Some what		Extremely			
		Not very		Quite				
Competitor	1	2	3	4	5	Total	Mean	group
in-house spinoffs of vehicle manufacturers	2	5	17	35	23	82	3.89	A
large system integrators	1	12	14	28	27	82	3.85	A
automotive electronic component suppliers	2	13	25	27	16	83	3.51	AB
new electronics/ software suppliers	1	18	31	22	10	82	3.26	BC
wireless carriers	3	23	22	27	8	83	3.17	C
software companies	5	21	27	30	0	83	2.98	C

Effectiveness ->	Not		Some what		Extremely			
		Not very		Quite				
Competitor	1	2	3	4	5	Total	Mean	group
in-house spinoffs of vehicle manufacturers	0	8	30	34	9	81	3.55	A
large system integrators	4	16	18	34	10	82	3.37	A
automotive electronic component suppliers	2	15	28	30	8	83	3.35	A
wireless carriers	7	30	25	15	5	82	2.76	B
software companies	8	28	27	16	4	83	2.72	B
new electronics/ software suppliers	11	27	22	19	2	81	2.64	B

Table B-3. How likely is each of the following developments by 2005? (Question E – 3)?

Likelihood ->	NOT	SOMEWHAT NOT VERY		EXTREMELY QUITE			
Development	1	2	3	4	5	total	Mea
the pace of change in automotive electronics will become even faster than it is today	0	14	8	36	33	82	4.1
software will command a much higher portion of the value added chain	0	5	7	39	30	81	4.1
automotive electronic suppliers' responsibility for system design/manufacture will increase	0	4	9	49	20	82	4.0
the share of consumer-branded electronics in the vehicle will grow	0	9	21	34	17	81	3.7
regulations and legislation will become even more important drivers of automotive electronics than they are today	0	15	15	34	17	81	3.6
the product of automotive electronic suppliers will command much lower prices	1	9	33	27	12	82	3.4
the automotive industry has to relax its insistence on customized electronic parts	4	16	19	29	13	81	3.3
the number of automotive electronics suppliers in the industry substantially shrinks	2	15	27	27	10	81	3.3
the automotive industry's status as a preferred customer for the electronics industry erodes	9	25	21	12	13	80	2.9

Table B-4. Which reasonably possible development or event would most disrupt your company's strategic commitments for automotive electronics in powertrain and vehicle control (Question E-4a)?

Development	N
N/A (literally said no effect or N/A)	7
Change of energy source- IC to Alternative	6
Accelerated intro of new technology -CVT, DBW, Valve actuation, increased networking	6
Misunderstood question (examples: "vehicle control", control of powertrain and vehicle is the most significant For our business)	6
Stricter Emissions Regulations/Tougher	3
Increased supplier responsibility /outsourcing incl. T2	3
Increased insourcing	2
Greater government intervention	2
Industry consolidation creating 2-3 mega sup	1
Greater OEM System Integration	1
Safety regulations-changes	1
None	1
Intro of new technology- Shortfall	1
Economic turndown	1
Fuel Price increase significantly	1
Greater use of "super-module" Power PC/CarPC	1
Inability to use advanced tool	1
Relax Emissions regulations	1
Availability of tech people	1
TOTAL	46

Table B-5. Disruptions to strategic commitments for electrical power distribution and networking (e.g., wiring, electrical controls, data distribution) (Question E-4b)?

Disruption	N
Faster than anticipated adoption of 42 v	13
Faster than anticipated intro of new tech (networking, protocols, open arch)	11
Misunderstood question	6
Slower than anticipated adoption of 42 v	3
Not Applicable	2
Reversal of trend to network, return to point to point hardwire	2
Change in propulsion tech	2
increased emphasis on cost	2
Increased part shortage	1
Increased chunk sourcing	1
increased influence of systems integration on electronics sourcing	1
Shortfall in technology used	1
TOTAL	45

Table B-6. Disruptions to strategic commitments for vehicle customer features (e.g., radio, driver information, safety, computers/office, etc.) (Question E4-c)?

Disruption	N
Misunderstood	10
Expanded driver distraction legislation	5
Not applicable	4
Lack or acceptance of auto industry tech standard	4
Greater integration with aftermarket	3
Expanded use of comp/office tech in vehicle	3
Lack of availability of low cost data wireless	3
Economic turndown	2
Unexpected emergence of new tech features (satellite)	2
Availability of global wireless infrastructure	1
Greater use of non-auto supplier	1
Increase use of P&P architecture	1
Increased number of niche vehicles	1
TOTAL	40

Table B-7. Disruptions to strategic commitments for Wireless communications (e.g., voice, data) (Question E4-d)?

Disruption	N
Misunderstood	7
Failure to establish & follow consistent tech standards	5
Expanded use of wireless N/W vs. hardware (Bluetooth)	5
Increased (distraction) legislation limiting feature expansion	5
Inability of wireless infrastructure to support demand	5
Not Applicable	4
Availability of low cost wide b/w national coverage	3
Discovery that microwave radiation is harmful	2
Greater use of non auto suppliers	2
Change in demand	1
Lack of technological support	1
TOTAL	40

Table B-8. Disruptions to strategic commitments for Infrastructure (e.g., regulations, standards, liability, etc.) (Question E4-e)?

Disruption	N
Misunderstood	8
Expanded driver distraction legislation	7
Not Applicable	5
Expanded legislation (driving time FMVSS)	4
Expanded fuel economy and emissions requirements	3
Expanded regional QS or ISO standards	2
Expanded regulations for urban vehicle usage	1
Energy shortage	1
Introduction of flight recorders (requirement?)	1
Liability second to customer demand	1
Lack of acceptance of tech standards	1
Open standards allow greater competition	1
Legislation requiring major paradigm shift allowing new comp	1
Safety regulations (air bag, out of position)	1
Liability issue decrease new feature intro	1
Total	38

Table B-8. What one piece of information or fact about the state of automotive electronics in 2003 would you most want to know right now? (Question E-5)

Desired Information	N
What communication standard will be in place for full networking	13
How much government regulations (legislation) in telematics	6
Misunderstood question	6
Will customer Accept Telematics	5
Penetration of 42 v systems	5
What will be the future importance of analytical design, testing, simulation tools	5
level of penetration for high speed vehicle network	4
which supplies will survive/dominate each segment	3
what safety specific comp stand	3
will elect lead or follow parallel in systems integration	2
will OEMs allow electronics to greater different features (drive by wire)	2
Monthly fee for vehicle data	2
how many suppliers will be used for a given elect system	2
what level of intelligence will be in the vehicle, portables, sensors	2
where will the prime focus be (safety comfort...)	2
what percentage of vehicles with Internet access	1
what will be role of OEM & system integrator in defining implementation	1
What will be electronics penetration of non luxury vehicle	1
how much OEM outsourcing will occur?	1
What is the level of architecture standardization	1
What are 5 fastest growing vehicle electronics in 5 year sales projections	1
will added microwave bandwidth be available	1
what are cost reliability availability for key new electronic comp`	1
which class of company (e2) will be the communication and info suppliers	1
what are the emission standards	1
what is the level of system integration	1
will top management "will" reach the working level	1
what will be the principal technology for presence, position and size of occupant for safety systems	1
will there be definitive plug n play standards	1
what is the vehicle market size	1
penetration of new features (voice activation)	1
what is OEM outsourcing strategy	1
what will be the presumptions in power-train emissions, hybrid, etc.	1
What will HMI look like	1
Total	81

Table B-9. What one problem between vehicle manufacturers and electronics suppliers most interferes with meeting the needs, desires and preferences of vehicle purchasers? (Question E-8)

Problem	N
Vehicle assemblers too preoccupied with price, stifles options	13
Failure to create partnership between OEM and sup	10
Lack of viable corporate or industry standards & requirements	10
Automotive excessively long development cycle relative to electronics	10
Lack of understanding of consequence of large disparity in auto & elect devel cycle	7
Difference in perception of customer needs and acceptance between sup and OEM	6
Inadequate systems engineering by OEM	5
Excessive specialized standards	4
Product quality and reliability	3
OEM purchasing practices to focused on cost	2
OEM unwillingness to change of production methodologies	1
OEM unwillingness to use tech methods proven in other industries	1
OEM reluctance to allow more design control @ sup level	1
Warranty obligation	1
Vehicle manufacturers are small users of electronics	1
Late changes and Indecision	1
Lack of optimization of system components	1
Lack of open architecture standards	1
Greater use of non traditional suppliers	1
Product liability limits new tech/features	1
lack of systems engineering capacity at electrical supplier	1
Total	81

Table B-10. How can vehicle manufacturers more effectively incorporate new suppliers with novel ideas for electronics technology into their product development activities? (Question E-9)

Response	N
Partner new suppliers with old established suppliers for new tech	12
Earlier involvement in design cycle	6
Vehicle Assembler to encourage, reward, provide incentives, and support suppliers	5
Create open architecture standards	5
Create advance development programs	5
Allow integrators to bring in new technology	3
Strive to be less risk adverse	3
Promote collaborative efforts between suppliers	3
Realize cost cant be bottom line	2
Commit to field trial	2
Improved planning capability	2
Provide support/training for new suppliers	1
Create relationships with first tear suppliers	1
Relaxing requirements	1
Better define requirements	1
Be open to new methods of engineering design	1
License new technology to tier 1 suppliers	1
Use simulation to model electronics	1
Listen	1
Serve as lower supplier	1
Faster evaluation, approval & integration of new ideas	1
Do not limit suppliers	1
Use of black box engineering	1
Use of new business model accelerate adopt of new tech, cap, prod	1
Add on site OEM support to supplier	1
Total	62

Table B-11. What one directive from your CEO would do the most to enhance your company's implementation of evolving vehicle electronics and/or software technology? (Question E-10)

CEO Directive	N
Allow more money on R&D	14
Create standard core h/w & s/w across line (reduce develop $)	3
Issue policy statement of strategic goal review	2
Apply development technology to target vehicle program	2
Commitment to gaining electronics capacity	2
Formulation of single group to focus on auto	2
Provide funding to share r&d cost over more then one model	2
Create an innovation lab	1
Global design development process for new model	1
Increase new product development	1
Specify/measure electronic content as a business goal	1
Partnering suppliers with "biggies" in auto industry	1
Sell stake in automotive electronics	1
Demonstration of dedication to newest technology	1
Higher profit from automotive products	1
Implement design develop as system vs. component	1
Implement more pre-development testing	1
Start new group w/separate budget for development	1
Implement 100% telematics installation	1
Electronics as key enabler differentiate new veh	1
Mandate % review of elec	1
Allow more money for acquisitions	1
Issue statement that automotive is good, economically viable	1
Total	43

Table B-12. Please consider vehicle manufacturers that are outstanding in integrating electronics into their vehicles. What 2 or 3 organizational attributes of these companies, if any, account for their successful integration of electronics into their vehicles? (Question E-11)

Outstanding Manufacturer Organizational Attributes	N
Has working relationship w/supplier	19
Has a workforce with technical expertise	16
Has strong technical bias to understand new tech	11
Committed to investment, research, planning, adoption & integration	10
Increase investment in research planning adoption and integration	10
Has top management interest	8
Willing to help supplier and give NRE	6
Strong method for system supplier selection	6
Demonstrates risk tolerance	5
Empower suppliers	4
Provides creative/fun atmosphere	4
Realizes need for speed innovation	4
Maintain end customer focus	4
Maintain receptive pressure	4
Relationship exists between engineering and purchasing	4
Highly responsive	4
One tech rep for all elec & electronics sys of all car lines	3
Vehicle seen as complete system	3
Willing to take R&D risk	3
Has flat org allowing quick decisions and focused inv.	3
Understands product/minimize launch risk	2
Can manage cost and value	2
Understanding of electronics/technology	2
Open to supplier integration	2
Exhibits entrepreneurial leadership	1
Is Driver for technology	1
Shows commitment to elect w. Cont/ invest	1
Has vision of direction of technology	1
Sees relationship between electronics and vehicle nature	1
Understands price performance expectation	1
Does not have a not invented here attitude	1
Has desire to differentiate	1
Has upper market segment aim	1
Is disciplined approach to adoption and integration of new tech	1
Is active in racing-high tech development	1
Has flexible in house organization	1
Is focus on advanced safety	1

Central organization specific to new features Corp direction	1
Has history in business	1
Receptive to new business models in terms of engagement	1
Understanding changing technology	1
over arching objectives that define identify of company	1
Market knowledge	1
Adv. Development w/future business	1
Software expertise	1
Not tied to in-house/pseudo in house elec	1
Continuous improvement	1
Strong definition of prod usage	1
Discipline in val testing	1
TOTAL	154

Table B-13. Please consider suppliers that are outstanding in integrating electronics into their customers' vehicles. What 2 or 3 organizational attributes of these suppliers, if any, account for their successful integration of electronics into their customers' vehicles? (Question 11b)

Outstanding Supplier Organizational Attributes	N
Have a system view expertise w/entire veh	14
Have huge R&D expenditure and support staff	14
Developed base tech in strategic area, provide signif. onsite customer support	12
Have strong software & control group (depth of R&D expertise)electronics sys	10
Have close working relationship w/OEM, based on mutual trust	8
Understand customer need, customer oriented	6
Share OEM vision, future	5
Have senior expertise & experience in electronics, leadership	5
Promote innovation and reward	5
Have strong reputation/historical relationship	5
Demonstrate commitment to industry	4
Are of critical mass	4
Are technology leaders	3
Have the ability to successfully partner	3
Have strong internal relationships across functional groups	3
Willingness to take risk	2
Design Electro & mech. simultaneously, one total assay	2
Do marketing research	2
Have cost awareness	1
Use open system for h/w & s/w	1
Able to grow through acquisitions	1
Understanding of automotive requirements	1
Have high end target market for sophisticated electronics. OEM partner	1
Use open arch to allow longer shelf life for new electronics	1
Are aggressive	1
Exhibit execution of delivery commitment	1
Have non-automotive content	1
Have understanding of electronics as main company focus	1
Create cost effective proposals	1
Use TQM	1
Provide resources to support OEM	1
Have a central development organization	1
Willing to adjust internal process to accommodate special requirements	1
Have ability to understand changing tech	1
Have strong technical links to manufacturing.	1
Have in house development capabilities for major components	1
Have proven experience in vehicle interpretation of electronics	1

Have manufacturing and production capabilities	1
Have non vertical integration mentality	1
Are conservative w/leading edge technology for next generation	1
Have a wide breadth of product line	1
Produce quality parts	1
Have a good location	1
TOTAL	132

Table B-14. What should your company do to improve its effectiveness in vehicle electronics development with Japanese companies? (Question E12-a)

Steps to Improve Effectiveness with Japanese Companies	N
Provide on site support capability/ local offices	23
Cooperative/joint development	16
Exhibit cultural competency, market needs NA to Japan, language	7
Develop & prove before commitment	3
Have vision	2
Develop relationships	2
Develop new unique product (software or hardware) expertise	2
Commit as tier 1/2 supplier global prod line	2
Acquire Japanese electronic supplier/merger	2
Provide super-graphical design tools	1
Strive for and create stable relationships	1
Frequent & deep conversations w/OEM engineers	1
R&D	1
Technical center w/clear & original objective	1
Maintain high quality prod & intro new tech with data &value	1
Improve tech stream, delivery process & mkt presence	1
Provide local support to few establish & use as leverage	1
Aggressive demo of superior tech	1
Government friending	1
Manufacturing quality	1
TOTAL	70

Table B-15. What should your company do to improve its effectiveness in vehicle electronics development with European companies? (Question E12-b)

Steps to Improve Effectiveness with European Companies	N
Develop partnerships with European companies	17
Have local office and staffing	9
Have experience/expertise in key technical field	4
Focus more on base R&D in Europe w/dedicated product	4
Build strong mgmt relationships	2
Re-deploy engineering groups to more effectively manage opportunity	2
Demonstrate superior tech and innovation	2
Frequent communications, overcome language barrier	2
Develop new advanced low cost technology	2
Have ability to find lowest cost solution	2
Expand European electronics capability	2
Commitment to global production lines	2
Provide better graphical tools to lower cost	1
Target high end vehicle segment	1
Early involvement on future development products	1
Critical mass	1
R&D	1
Target advanced tech solution	1
Understand (sub system) requirements	1
Spend more time with Euro OEM	1
Develop marketing in Europe	1
Leverage company strength in Euro	1
Align w/Euro affiliate	1
TOTAL	61

Table B-16. What should your company do to improve its effectiveness in vehicle electronics development with North American companies? (Question E12c)

Steps to Improve Effectiveness with North American Companies	N
Expand collocation of engineers @site local	7
Develop partnerships	7
Develop new technology focus w/competitive price	4
Expand sales force, electronics capability	3
Provide lower cost/better quality	3
Take advantage of NAFTA w/local development	2
Strive for exclusive or proprietary access to new development	2
Develop better systems integration capability-full service supplier	2
Honor global tier 1/2 commitment	2
Involve electronics earlier in design process	2
Demonstrate value add to IE w/systems integration	1
Provide quality on time deliverables	1
Develop & prove prior to business commitments	1
Make commitments	1
Maintain status quo	1
Develop lower cost design tools	1
Develop shelf engineering products and platforms	1
Capability for system integrator to compensate for OEM deficiency	1
R&D	1
Communications regarding capabilities	1
Develop broader product offerings	
More effective communications of capabilities	1
Develop reference designs	1
Work with production development to insure smooth integration on sub systems	1
Increased "end customer" market research	1
Have more people, increased manufacturing capability	1
Use rigorous target setting, planning	1
Focus on solutions for convenience-especially safety	1
Develop better relationships	1
Ability to voice and follow strategies	1
Continue to aggressively demonstrate product superiority	1
Adapt to NA bus practices	1
Internal support staff	1
Understand vehicle systems engineering	1
TOTAL	57

Table B-17. What changes to the development process would allow the faster cycling of the latest electronics into vehicles for: 1) powertrain and vehicle control applications and 2) entertainment, telematics, and consumer electronics applications. Please rate the effectiveness of each driver. (Question E-13)

SCALE →	1	2	3	4	5
	NOT AT ALL EFFECTIVE	NOT VERY EFFECTIVE	SOMEWHAT EFFECTIVE	QUITE EFFECTIVE	EXTREMELY EFFECTIVE

DRIVERS	POWERTRAIN AND VEHICLE CONTROL						ENTERTAINMENT, TELEMATICS AND CONSUMER ELECTRONICS					
	1	2	3	4	5	total	1	2	3	4	5	total
COMMODITY PRODUCT STANDARDIZATION	3	11	19	28	12	73	0	4	11	33	26	74
PROVIDE PLUG AND PLAY (OPEN) BAYS WITH UTILITIES	0	10	15	22	13	72	2	3	8	26	37	76
COMMON ELECTRONICS BOXES WITH FULL SOFTWARE CONFIGUARABILITY	6	11	22	28	8	75	0	9	18	27	24	78
OPEN ARCHITECTURE STANDARDS EXCLUSIVE OF APPLICATIONS	5	6	20	19	22	72	0	1	9	27	39	76
GREATER SOFTWARE RECONFIGURABILITY	3	6	21	26	18	74	0	5	20	22	28	75
UPGRADE CAPABILITY FOR APPLICATIONS SOFTWARE IN THE FIELD	0	11	22	29	12	74	1	6	9	32	27	75
SHIFT INCREASING SHARE OF INTELLIGENCE TO SERVER-BASED HUBS	15	24	21	8	2	70	4	13	25	19	13	74
IMPROVED SIMULATION AND ANALYSIS TOOLS	0	6	12	25	29	72	4	13	23	19	15	74
PRE-ANALYZED "DESIGN CHUNKS," CATALOGED FOR USE	3	6	20	29	13	71	1	12	23	27	12	75
VERY GOOD DESIGN RULES AIMED AT SPEED, COMPLEXITY REDUCTION, AND EASE OF MANUFACTURE	0	7	13	30	23	73	0	11	19	31	15	76

ADHERENCE TO ASSURANCE/STRESS TESTING VS. LIFE TESTING (LOTS OF PARTS)	3	8	23	26	13	73	5	16	25	17	12	75
DEVELOP "LIGHTNING TRACK" PROCESS FOR THIS CLASS APPLICATIONS	2	13	23	19	6	63	1	8	21	25	13	68
ELIMINATE DETAILED INTERNAL COMPONENT-LEVEL SPECIFICATIONS	9	17	18	13	11	68	6	14	16	17	17	70
SPECIFY AND PURCHASE AS TESTED SUBSYSTEMS/ MODULES	4	7	21	23	14	69	2	8	17	25	20	72
UTILIZE A SUPPLIER ADVISORY COUNCIL	10	18	30	10	4	72	9	18	26	16	7	76
EXPAND SUPPLY BASE TO INCLUDE MORE CONSUMER AND NON-AUTOMOTIVE ELECTRONICS SUPPLIERS	20	19	19	9	4	71	5	8	23	25	13	74

Table B-18. What one or two steps should the vehicle manufacturers take to better coordinate the shorter product development cycle time for electronic features with the longer cycle time for vehicle development? (Question E14a)

Steps Manufacturers Can Take to Overcome Product Cycle Mismatch	N
Standardize arch/open arch	20
Use plug & play arch w/firewall	13
Include supplier earlier in design cycle	8
Reduce vehicle development cycle time	7
Have ability to make running w/in model year changes	6
Use design validation procedure for veh w/ electrical supplier	4
Stop changing mind-freeze date	4
Maintain better interface with supplier engineering team	4
Use simulation & common tools	4
Develop standard communication protocol	3
Change current development process	2
Develop industry standards	2
Supplier technology council to give manufacture heads up on new tech	2
Use more software	2
Judge by vehicle not virtual prototype	2
Use electronics to shorten develop cycle	2
Use more trial pilots/special runs	2
Start electronic cycle later	1
Design for portability	1
Plan for more functional features in product development cycle	1
Issue statement early on for new programs	1
Use improved software tools	1
Have a good plan and follow through	1
Gain supplier confidence	1
Remember elect initial devel standard time, revision cycle is faster	1
Source bigger chunks	1
See elect supplier as system integrator, modular leaders	1
Hold space for latter additions	1
Need to team OEM/tier 1 to share proprietary info	1
Have less stringent requirements for book shelving	1
Protect for changes	1
Server based applications	1
Use more independent modules w/in chunks	1
Accept different life cycles	1
Minimize management	1
Accept risk	1
Design to upgrade	1
Standardize testing	1
Eliminate detailed component level spec	1

Pay for flexibility	1
Develop special electrical bus for electronics	1
TOTAL	111

Table B-19. What one or two steps should the electronics suppliers take to better coordinate the longer product development cycle time for vehicle development with the shorter cycle time for electronic feature development? (Question E14b)

Steps Suppliers Can Take to Overcome Product Cycle Mismatch	N
Develop communications/long term planning w/OEM	10
Support plug and play	8
Build product bookshelf	5
Ensure fast turn to allow electronics cycle to start later	4
Standardize tech for comm, applications & communication between	4
Understand vehicle environment (& OEM needs)	4
Use software simulation	4
Use more software control	3
Develop strong partnerships	3
Standardize components	3
Use team development approach early w/OEM	3
Use electronics re-programmable on the fly/upgradeable	3
Standardize electrical & mechanical interfaces	3
Develop better technology roadmap	3
Expose leading edge tech to decision makers	3
Demand firm specs	2
Use open arch to make change on fly	2
Develop new innovations	2
Ability to make running changes w/in model years	1
Develop and maintain flexible standards	1
Develop industry standards	1
Maintain transparency of interfaces	1
Design in automation	1
Develop combined software apps	1
Exhibit proven performance of manufacturing capability	1
Retain engineers	1
Hold active part in design review process	1
Develop advanced engineering using state of the art technology	1
OEMs learn electronics biz tricks	1
Provide on site customer support	1
Maintain extra system capability	1
Integrate into larger system chunks	1
Create systems level designs	1
Improve reliability/robustness of rel s/w & h/w	1
Recognize reliability and usability of consumer electronics not acceptable	1
TOTAL	86

Table B-20. To foster the safety and usability of telematics applications, how likely do you think the following are to occur in the next 3 years and how effective will they be if they occur? (Question E-15)

likeliness and effectiveness scales	1	2	3	4	5
	not at all	not very	somewhat	quite	extremely

FACTOR	LIKELINESS						EFFECTIVENESS					
	1	2	3	4	5	total	1	2	3	4	5	total
MANUFACTURER STANDARDS AND PRACTICES	3	19	37	18	3	80	3	14	26	27	9	79
SUPPLIER STANDARDS AND PRACTICES	5	23	33	18	2	81	5	15	21	31	7	79
MANUFACTURER/SUPPLIER CONSORTIA STANDARDS (E.G., AMIC)	3	13	25	33	6	80	3	7	26	28	16	80
SAE STANDARDS AND RECOMMENDED PRACTICES	2	10	36	26	7	81	4	11	33	26	6	80
NATIONAL MOTOR VEHICLE SAFETY STANDARDS (DOT)	5	14	22	28	12	81	5	13	26	25	10	79
FOREIGN MOTOR VEHICLE SAFETY STANDARDS	5	17	27	21	7	77	3	14	30	24	6	77
STATE AND LOCAL LAWS	12	23	18	18	10	81	12	26	26	11	5	80
ISO STANDARDS	6	11	40	19	1	77	7	12	40	14	3	76
MARKET FORCES	3	3	8	39	28	81	0	0	19	35	26	80
MEDIA ATTENTION	2	4	14	40	21	81	5	15	29	23	8	80
DRIVER CUSTOMIZATION	4	8	27	31	9	79	3	10	26	32	6	77
PRODUCT LIABILITY	2	3	20	34	22	81	7	11	25	24	13	80

Table B-21 How important is achieving standardization for each of the following capabilities and attributes? (Question E-16)

SCALE →	1	2	3	4	5
	NOT AT ALL IMPORTANT	NOT VERY IMPORTANT	SOMEWHAT IMPORTANT	QUITE IMPORTANT	EXTREMELY IMPORTANT

CAPABILITY/ATTRIBUTE	1	2	3	4	5	total
VISUAL DISPLAY LEGIBILITY	0	20	20	34	7	81
AUDITORY MESSAGE INTELLIGIBILITY	0	12	26	27	17	82
VISUAL AND AUDITORY MESSAGE PRIORITY	0	10	27	32	13	82
COLLISION WARNING AND AVOIDANCE ALARMS	1	7	27	26	21	82
VOCABULARY FOR VOICE RECOGNITION SYSTEMS	2	8	26	27	18	81
VOCABULARY FOR TEXT MESSAGES	1	12	37	23	8	81
MEASUREMENT OF DRIVER WORKLOAD AND OVERLOAD	2	13	28	23	14	80
LIMITS ON USE OF MANUAL CONTROLS AND VISUAL DISPLAYS	3	16	23	23	15	80
LIMITS ON USE OF VOICE RECOGNITION SYSTEMS	10	24	23	13	7	77
LIMITS ON USE OF PHONES	3	14	16	32	15	80
ADAPTIVE CRUISE CONTROL OPERATION	1	16	27	23	14	81

TABLE B-22. PLEASE PLACE AN (X) IN THE MODEL YEAR YOU EXPECT EACH ELECTRONIC ACCESSORY/FEATURE TO REACH A 10% INSTALLATION RATE IN THE LUXURY VEHICLE SEGMENT? (>$35,000 BASE PRICE) (QUESTION E-17)

ELECTRONIC ACCESSORIES/FEATURES	2003	2004	2005	2006	2007	2008	2008+	NEVER	MISSIN	TOTAL
ENTERTAINMENT AND CONVENIENCE										
BUILT IN ELECTRONIC TOLL AND PAYMENT TAG	7	12	12	13	8	2	11	12	6	83
KAROKE	0	2	1	5	2	0	2	62	9	83
MP3 SUPPORT	8	16	28	10	4	2	5	1	9	83
REMOVABLE MEDIA FOR ENTERTAINMENT AND DATA	15	12	24	14	2	2	1	4	9	83
SATELLITE RADIO	17	16	22	13	5	1	1	2	6	83
DRIVER INFORMATION AND COMMUNICATION										
GPS NAVIGATION	32	14	15	9	4	2	2	0	5	83
AUTOMATIC DOWNLOAD OF TRAFFIC/CONGESTION INFORMATION	13	16	20	9	9	5	5	0	6	83
BUILT IN WIRELESS PHONE INTERFACE	26	21	17	7	4	1	1	1	5	83
BLUETOOTH SUPPORT	4	22	24	14	3	2	5	0	9	83
BUILT IN PDA (E.G., PALM) DOCKING STATION	12	20	17	10	7	3	0	10	4	83
EMAIL/INTERNET ACCESS	18	16	24	9	8	2	1	0	5	83
INTERFACE TO WEARABLE COMPUTER	1	6	12	8	11	3	22	11	9	83
DOWNLOADABLE SOFTWARE FEATURES	10	6	21	18	13	5	2	2	6	8
DOWNLOADABLE SOFTWARE FIXES	8	12	19	12	14	5	5	2	6	83
GENERAL PURPOSE COMPUTER (E.G., AUTOPC)	6	6	15	16	7	6	11	9	7	83
GENERAL PURPOSE TEXT/DATA SPEECH CAPABILITY	7	12	19	18	9	7	7	0	4	83
LARGE AREA HUD	2	3	5	9	11	11	15	14	13	83
LARGE GENERAL PURPOSE DISPLAY	8	8	14	14	15	7	6	7	4	83
OFF BOARD APPLICATIONS VIA DATA LINK	7	8	14	14	8	8	7	6	11	83
OPEN ELECTRONICS BAY WITH UTILITIES	1	2	9	13	14	12	12	10	10	83

ELECTRONIC ACCESSORIES/FEATURES (CON'T)	2003	2004	2005	2006	2007	2008	2008+	NEVER	MISS	TOTAL
SAFETY AND SECURITY										
ADAPTIVE CRUISE CONTROL	17	12	24	12	6	6	3	0	2	82
LANE KEEPING										
DEPARTURE WARNING	4	8	16	17	7	13	6	6	5	82
AUTOMATIC LANE CONTROL	0	4	6	7	11	8	27	15	4	82
FORWARD COLLISION WARNING	3	10	21	20	6	10	6	3	3	82
FORWARD COLLISION AVOIDANCE										
AUTOMATIC BRAKING ONLY	3	6	11	11	6	14	20	8	3	82
AUTOMATIC BRAKING AND STEERING	0	1	4	3	5	9	36	20	4	82
FORWARD PARKING AID	11	8	21	10	9	6	6	4	7	82
REAR PARKING AID	30	10	12	13	5	1	5	1	5	82
NIGHT VISION	6	8	13	16	11	11	7	9	2	83
BLIND SPOT DETECTION AND WARNING	9	11	19	13	15	7	3	2	3	82
AUTOMATIC COLLISION NOTIFICATION (DIAL UP ON CRASH)	26	11	21	10	5	1	4	1	3	82
BLACK BOX CRASH RECORDER	6	4	13	15	5	6	12	16	5	82
FINGERPRINT OR VOICE-CONTROLLED ENTRY	3	1	18	10	13	12	17	7	2	83
IMPAIRED DRIVER										
ALCOHOL-IMPAIRED DRIVER DETECTION	0	3	7	8	8	10	18	25	3	82
DROWSY DRIVER DETECTION	1	3	14	14	11	14	13	9	3	82
VOICE OPERATION OF SOME CONTROLS	16	12	21	9	9	4	5	1	5	82
ELECTRICAL, PROPULSION, AND CONTROL										
42 VOLT ELECTRICAL SYSTEM	1	5	14	17	14	11	14	1	6	83
DUAL VOLTAGE (42/12 VOLT)	4	10	19	20	12	5	3	4	6	83
DRIVE BY WIRE	4	5	6	9	14	15	21	4	5	83
ACTIVE SUSPENSION	9	7	12	16	10	7	10	7	5	83
BRAKE –BY WIRE	1	2	8	16	16	14	19	1	6	83
HYBRID DRIVETRAIN (ELECTRIC/COMBUSTION)	1	3	9	12	10	10	23	6	9	83
ALL-ELECTRIC DRIVETRAIN	0	0	1	2	10	7	27	26	10	83

Table B-23. Which one vehicle electronic product or feature do you think could be the unexpected success (real sleeper) in 2003? (Question E-18)

Feature That Could Be an Unexpected Success	N
Voice recognition	10
Bluetooth	5
Driving aids (parking assist)	5
ACC	5
GPS/Navigation	4
Drive by wire	3
Roll control/act suspension/dynamic control	3
Alt entry (keyless, fingerprint)	3
MP3	3
Satellite link	2
Entertainment	2
Built in PDA	2
Marketing changes	2
Electric Vehicle electronics	2
Internet	1
CVT	1
Black box	1
Dual voltage	1
Supplier to develop chunks	1
Three button telematics (OnStar...)	1
Occupant detection	1
IDIS	1
Wideband, increased bandwidth, Gen 3 cellular	1
TOTAL	60

Table B-24. Which one vehicle electronic product or feature do you think could be the unexpected failure (real bomb) in 2003? (Question E-19)

Feature That Could Be an Unexpected Success	N
Email/Internet	10
Navigation	6
Entertainment	5
Three button telematics (OnStar)	6
Driving aids (parking assist)	4
Night vision	2
Air bags	2
Dual voltage	1
Active noise reduction	1
Std phone interface	1
Electronic vehicle dynamic controls	1
Empower sup to integrate elec into chunks	1
ACC	1
Hybrid propulsion	1
Auditory feedback	1
Karaoke	1
Tire press	1
Computer is vehicle	1
Passive entry	1
Satellite radio	1
In-vehicle palm device	1
TOTAL	49

Table B-25. What is the single most needed infrastructure (on-board vehicle or external service) for data communication applications, such as traffic information/routing, downloadable software, email, or Internet, to become high demand features in a. North America, b. Europe, and c. Japan? (Question E-20)

Single Most Needed Infrastructure in North America	N
Standardized Arch/Protocol	15
Real time traffic information	9
Wireless communication service	7
Wideband or extended bandwidth for increased wireless traffic	5
In vehicle -mail support	4
On-board PC	3
Bluetooth	3
Satellite communications link	2
Human/Machine Interface	2
GPS/wireless	1
Power	1
Integrate powertrain /Vehicle control sys	1
Voice recognition	1
Plug and play	1
Dual Voltage	1
TOTAL	56

Table B-26. Single Most Needed Infrastructure in Europe

Single Most Needed Infrastructure in Europe	N
Standardized Arch/protocol	17
Real time traffic information	10
Wideband or extended bandwidth for increased wireless traffic	3
Bluetooth	3
Wireless communication service	3
On board vehicle	2
Internet	2
Human/Machine Interface	2
GPS/wireless	1
Satellite communications link	1
Faster wireless	1
Integrated power/control	1
Software upgradeable through flash download	1
Expansion capability	1
Plug and play	1
TOTAL	49

Table B-27. Single Most Needed Infrastructure in Japan

Single Most Needed Infrastructure in Japan	N
Standardized Arch/Protocol	9
Wireless communication service	4
Internet	4
Real time traffic information	3
Wideband or extended bandwidth for increased wireless traffic	3
Bluetooth	3
dual voltage	2
Human/Machine Interface	2
GPS/wireless	1
Plug and play	1
Onboard Vehicle	1
Software upgradeable through flash download	1
Legislation	1
Satellite communication link	1
Integrated power/control systems	1
TOTAL	37

COUNTER BALANCED TASK LIST

6 Sec Tasks ordered per 6 subjects (6 x 6)
Sec Tasks repeated after 6th trial
All Trials contain an ED Task
4 ED Tasks ordered per 6 subjects (4 x 6)
ED tasks repeated after 4th and 8th trials
Between Trials (X) - 12 ED Tasks
1 PER TRIAL 1 PER BET TRIAL

KEY			
Event Det Tasks		Secondary Tasks	
Front Right	FR	Incoming Hand Held	incHH
Front Left	FL	Incoming Hands Free	incHF
Back Right	BR	HVAC	hvac
Back Left	BL	Radio	rad
		Voice Mail Hand Held	vmHH
		Voice Mail Hands Free	vmHF

SUBJECT

TRIAL	1	2	3	4	5	6
1	vmHH _BR	incHF _FL	hvac _FR	vmHF _BR	incHH _FL	rad _BL
X	_FR	_BR	_BL	_FR	_BR	_FL
2	rad _BL	vmHH _FR	incHF _FL	hvac _BL	vmHF _FR	incHH _BR
X	_FL	_BL	_BR	_FL	_BL	_FR
3	incHH _BR	rad _FL	vmHH _FR	incHF _BR	hvac _FL	vmHF _BL
X	_FR	_BR	_BL	_FR	_BR	_FL
4	vmHF _BL	incHH _FR	rad _FL	vmHH _BL	incHF _FR	hvac _BR
X	_FL	_BL	_BR	_FL	_BL	_FR
5	hvac _BR	vmHF _FL	incHH _FR	rad _BR	vmHH _FL	incHF _BL
X	_FR	_BR	_BL	_FR	_BR	_FL
6	incHF _BL	hvac _FR	vmHF _FL	incHH _BL	rad _FR	vmHH _BR
X	_FL	_BL	_BR	_FL	_BL	_FR
7	vmHH _BR	incHF _FL	hvac _FR	vmHF _BR	incHH _FL	rad _BL
X	_FR	_BR	_BL	_FR	_BR	_FL
8	rad _BL	vmHH _FR	incHF _FL	hvac _BL	vmHF _FR	incHH _BR
X	_FL	_BL	_BR	_FL	_BL	_FR
9	incHH _BR	rad _FL	vmHH _FR	incHF _BR	hvac _FL	vmHF _BL
X	_FR	_BR	_BL	_FR	_BR	_FL
10	vmHF _BL	incHH _FR	rad _FL	vmHH _BL	incHF _FR	hvac _BR
X	_FL	_BL	_BR	_FL	_BL	_FR
11	hvac _BR	vmHF _FL	incHH _FR	rad _BR	vmHH _FL	incHF _BL
X	_FR	_BR	_BL	_FR	_BR	_FL
12	incHF _BL	hvac _FR	vmHF _FL	incHH _BL	rad _FR	vmHH _BR
X	_FL	_BL	_BR	_FL	_BL	_FR

TRIAL	7	8	9	10	11	12
1	vmHH _BR	incHF _FL	hvac _FR	vmHF _BR	incHH _FL	rad _BL
X	_FR	_BR	_BL	_FR	_BR	_FL
2	rad _BL	vmHH _FR	incHF _FL	hvac _BL	vmHF _FR	incHH _BR
X	_FL	_BL	_BR	_FL	_BL	_FR
3	incHH _BR	rad _FL	vmHH _FR	incHF _BR	hvac _FL	vmHF _BL
X	_FR	_BR	_BL	_FR	_BR	_FL
4	vmHF _BL	incHH _FR	rad _FL	vmHH _BL	incHF _FR	hvac _BR
X	_FL	_BL	_BR	_FL	_BL	_FR
5	hvac _BR	vmHF _FL	incHH _FR	rad _BR	vmHH _FL	incHF _BL
X	_FR	_BR	_BL	_FR	_BR	_FL
6	incHF _BL	hvac _FR	vmHF _FL	incHH _BL	rad _FR	vmHH _BR
X	_FL	_BL	_BR	_FL	_BL	_FR
7	vmHH _BR	incHF _FL	hvac _FR	vmHF _BR	incHH _FL	rad _BL
X	_FR	_BR	_BL	_FR	_BR	_FL
8	rad _BL	vmHH _FR	incHF _FL	hvac _BL	vmHF _FR	incHH _BR
X	_FL	_BL	_BR	_FL	_BL	_FR
9	incHH _BR	rad _FL	vmHH _FR	incHF _BR	hvac _FL	vmHF _BL
X	_FR	_BR	_BL	_FR	_BR	_FL
10	vmHF _BL	incHH _FR	rad _FL	vmHH _BL	incHF _FR	hvac _BR
X	_FL	_BL	_BR	_FL	_BL	_FR
11	hvac _BR	vmHF _FL	incHH _FR	rad _BR	vmHH _FL	incHF _BL
X	_FR	_BR	_BL	_FR	_BR	_FL
12	incHF _BL	hvac _FR	vmHF _FL	incHH _BL	rad _FR	vmHH _BR
X	_FL	_BL	_BR	_FL	_BL	_FR