

FHWA Advanced Research Forum

Berkeley, California

October 26-27, 2005

Summary Report

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1.0 Overview

The Federal Highway Administration conducted three think tank forums in 2005, as part of its commitment to develop a robust advanced research agenda. The final 1.5 day forum was held at the Faculty Club, UC-Berkeley, October 26 and 27, 2005. Planning support was provided by the Volpe Center and futurist Glen Hiemstra of Futurist.com. The intent of the forums was to convene stakeholders and seek ideas to assist the Agency in establishing a strategic agenda for advanced research.

About thirty-five participants gathered for this interactive event with expert speakers on breakthrough technologies such as new materials, next energy possibilities, traffic flow monitoring for safety, and NASA's research on *Small Aircraft Transportation Systems* (SATS). The final presentation, from NASA, reviewed not just prospects for personal air travel but also the way that the SATS program was organized and managed. Through a series of structured presentations and discussions, the participants explored issues impacting the future of transportation and identified advanced research needs. Then, using a modified version of the nominal group technique for group decision-making, the participants developed a list of suggested research topics, and ranked the priority items.

Presented here are the key results of the forum, the recommendations for advanced research topics. Next is a summary of the presentations, which framed the participants' discussion and identification of advanced research topics. The summary concludes with participants' impressions and comments on the synergy around the purpose of the forum and possible next steps for an FHWA advanced research agenda and program.

1.1 Forum Purpose

1. Scan across disciplines, within and outside the transportation area, to search for promising research and technology that could fundamentally improve transportation.
2. Develop a set of recommended areas, topics or questions for consideration as part of a strategic agenda for advanced research.

1.2 Recommending Advanced Research Agenda Topics

Participants convened in three working groups. First, in each group individuals listed their ideas for advanced research. Participants were asked to consider ideas that would be "game changers" by encouraging breakthrough innovation, have high leverage in terms of being high pay-off for high risk, would fit between basic research and applied research, and which would be strategic in terms of seeking outcomes rather than simply being interesting research. In addition, the teams were reminded of the two-part definition of advanced research provided by King Gee: "Research that involves and draws upon basic research results to provide a better understanding of phenomena and develop innovative solutions. Sometimes referred to as exploratory research in order to convey its more fundamental character, its broader objectives, and the greater uncertainty in expected outcomes compared to problem-solving research."

When individuals had their personal lists, ideas were shared around the table and a master list was created for the group, eliminating overlapping ideas. These were then discussed at the table, with an emphasis on clarifying the ideas, and on why particular ideas ought to be preferred over others. When called upon, the table groups reported their lists to the entire forum. These breakout group results are listed in the Appendix. All participants discussed the

lists, noting themes and common ideas. Among the themes that were obvious were the following:

Themes from discussion following group brainstorm

- Much focus on Driver-Vehicle-Highway Interaction & Systems
- Some suggestions focus on Processes, others on Technologies
- Key role of freight is noted
- Safety is evident but not called out in most recommended ideas
- Nano-materials are a focus, particularly in their potential for infrastructure
- A need is seen for integrated transportation infrastructure, rather than the generalized infrastructure that has been traditional, in which one highway meets all needs
- A need is seen for information technology & systems research that goes beyond classic ITS, including communications technology, virtuality, impacts of “Digital Native” generation
- Knowledge management systems are mentioned
- There is a need for integrating organizations to get on the same page with research; collaborative research management strategies
- Need for model verification, field testing, benchmarking systems; for example partner with CalTrans which desires to do real verification tests
- How to build sustainable research over years, despite congressional policy and leadership shifts
- Aging of the population and related issues needs attention
- Alternative fuels research issues for FHWA include costs, effects, perceptions, impact on revenue
- Need to think beyond cars and trucks

Each working group went back to their group list, clarified their opinions, and then used nominal group technique to indicate their preference for the top research ideas. Each group reported the top 3 to 4 priorities to all participants.

After discussion of the resulting list of 12 items, participants expressed their preference in one more round of voting, using a weighted voting process. The results below fell into three basic tiers, with the vote total for each item noted.

2.0 Recommended Advanced Research Agenda Topics

Tier 1

- Innovative look at cross-country container movement of freight, including potentially separate lanes, pipelines, segregated systems, automated systems (37)
- Develop and provide a totally automated vehicle-driver-highway system (26)
- Innovative traffic flow monitoring and control systems (25)

Tier 2

- New materials and building processes for increased longevity, decreased cost, and sustainability (18)
- How will our society need to travel, and what will business travel needs be in 2050? (17)
- Land use and transportation (16)
- Human cognition and perception regarding how people use and understand multilayer systems (14)
- Safer rural highway system (13)
- Seamless movement between modes. Better integration of ITS into design. ID of hot spots. (12)
- How will transportation systems support sustainability? (12)

Tier 3

- Improved highway-vehicle interaction (9)
- New energy sources that are sustainable and clean (5)

3.0 Forum Framework: Summary of Presentations and Discussion

Each presentation is included on the final CD as PowerPoint slides in PDF format.

Day 1, September 20, 2005

3.1 Welcome: King Gee and J. Richard Capka

King Gee, Associate Administrator for Infrastructure at FHWA, personally welcomed the attendees and provided background on the advanced research initiative. The FHWA mission includes enhancing mobility through innovation, leadership and public service. The role of FHWA's research and technology activities cover the innovation process, developing and deploying new products and services, education and training. This workshop is the third of three to be held this year. TRB's Research and Technology Coordinating Committee (RTCC), which serves FHWA in an advisory capacity, was to be briefed on the outcomes of these workshops on November 1, 2005. Comments from this briefing will be included in the final report.

As part of King's welcome, in a video presentation J. Richard Capka, FHWA Acting Administrator, emphasized the value of this activity to the FHWA and stressed 1) the need to raise awareness of what is going on in advanced research, 2) the need to reward partnerships with funding, and 3) the need to encourage innovation and move ideas into practice.

King provided an overview of the FHWA's definition of advanced research and strategic vision as outlined in the agency's Corporate Master Plan. He emphasized the FHWA's strong interest in enabling innovations for a better transportation future. *He defined advanced research as exploratory research designed to develop a better understanding of phenomena, and to develop innovative solutions.* He hopes that these forums will identify advanced research theme clusters, with an emphasis on higher risk and long term issues as well as leading to an implementation of research results. In addition, he provided a brief overview of the recently passed SAFETEA-LU legislation and dollar amounts available for advanced research.

3.2 Table Exercise: What is your image of the future?

Glen Hiemstra asked participants, "What words or pictures come to mind when thinking about the future?" This warm-up exercise works with the idea that our images of the future play a powerful role in shaping our present actions. Change the image of the future, and you begin to change how we behave in the present day. Individuals at tables shared their images, and examples were cited for everyone to hear.

Images of the future articulated by participants include:

- Global
- Energy constrained
- Variety & Equity
- Optimized
- Inter-modal
- Interconnected
- Sustainable
- Communications, more virtual
- Heavily taxed
- Debt
- Individualized
- Environmentally friendly
- Population density
- Automated
- Faster paced
- Smarter pricing
- Nano
- Sensors
- Safer
- Less Patient
- Gridlock

3.3 Presentations: The World and Transportation in 2050

Glen outlined key lessons from the future:

1. The future creates the present.
2. Breakthroughs must be compelling.
3. People you see in 2050 will be different.
4. Energy Tipping Point is approaching.
5. Great technology revolutions to come.
6. The way it is, is not the way it will be, economically, environmentally.
7. Travel – vehicles, roads, systems will evolve or change fundamentally.
8. Systems should be integrated.
9. Every impossible thing may someday be possible.

Glen reviewed broad trends shaping the world of transportation. Highlights included:

- Some parts of the world will shrink in population while the U.S. will grow, by as many as 100 million by 2050, depending on immigration policies. At the same time, US growth may slow much sooner if fertility rates continue downward trend.
- Most population growth concentrated in mega-cities.
- Transportation and related businesses have become global.
- Economic growth looks uncertain and full of discontinuities, although the developing world anticipates robust growth (with resulting demands for transportation).
- Energy outlook is for plentiful supplies of carbon but not of cheap oil, and decreasing supply leads us to use expensive dirty carbon. Thus the next 50 years will see an energy transition, sooner rather than later.

Glen asked questions about:

- U.S. population growth projections, which seem exaggerated in light of global dynamics.
- Impact of the aging population, which is underestimated.
- Millennials or, “digital natives” are the largest population cohort since the baby boomers.
- Impact of the first “digital native” generation coming of age, and taking information technology beyond what we “digital immigrants” imagine.
- How do we maintain economic growth and robustness with a declining population?
- Are we at an energy tipping point – i.e., the end of cheap oil? What happens if the end of oil comes sooner than expected? Will use of alternative fuels increase/decrease health problems?
- Impact of new technologies, primarily vastly improved telecommunications, next energy wave technologies, and nanotechnologies.
- A greater technology revolution yet to come.

3.4 Physical Performance, Infrastructure & Materials: Roundtable 1

Dr. Franz-Josef Ulm, Associate Professor, MIT Department of Civil and Environmental Engineering:
"Re-Engineering Concrete Infrastructure: from the Nanoworld of Materials Science to the Bridge of the Future."

- Translating nanotechnology into the largest day-to-day use is most notable in advances in concrete production and use.
- Pay off in millions of dollars has not arrived yet, but is coming soon.
- Our current approach to building infrastructure is not sustainable.
- What concrete and oranges have in common – nanoscale.

- Nano-engineering for high density “glue” in concrete as well as low density glue.
- Next-generation bridges:
 - Need longer life-spans with higher durability and less maintenance.
 - Demonstrate adaptability to new traffic.
 - Have improved reliability and safety as well as immunity to extreme events.
 - Must be environmentally friendly.
 - Must provide for easier and faster construction.
- Lessons are being learned from the “Bridge of the Future” project in Kentucky:
 - An example of a government (i.e., FHWA)/university/industry (i.e., private sector) partnership to achieve the funding necessary.
 - Strong linkage between FHWA, academia and industry is key to success. Industry partners need financial incentive to get involved and stay involved.
 - Nanotechnology used to produce stronger yet narrower girders for use in bridge construction.
- C-Crete Technology is key:
 - Needs to be application friendly.
 - A true change of culture results from shift to the nano-scale.
- Need for Human Resources development to foster the profession itself.
- We must face and deal with legal aspects, especially those associated with complex partnering arrangements.
- Partners themselves must be strong.
- Rather than saying one is “under the microscope,” we should get used to saying one is “under the nano-scope.”

Table Discussion: *Following each speaker, table groups discussed their impressions, and then general comments were made to the whole group. A sample of questions and comments...*

- Is there a nano-program for re-cycling roadway materials, etc? This is conceptually possible, but is a question of the amount of energy required to do so.
- Cement production releases 5-7% of carbon dioxide emissions into the environment annually – nano-scale materials in the production of cement could reduce this level significantly. In an ideal world, we would have no cement.
- How has the Bridge of the Future project been able to produce a working prototype? The project laid out unattainable goals and then let the partners run with it – the result being a working prototype.
- Have the health and environmental impacts been researched, i.e., unintended consequences? The fact is that “nano” is no more hazardous than today’s material compositions – it’s the materials used that will make the difference.

The ability to peer into the molecular structure of matter and then to manipulate the matter at that level is radically new, in existence literally for less than two decades. Being so new, the field is still considered exotic and distant in its applications. In his discussion of nano-concrete, Professor Ulm illustrated to participants that nano research is on the threshold of delivering major advances in big things, like bridge infrastructure. Delivering this innovation may not be a matter of technology, Ulm pointed out, but rather a matter of organization culture and public acceptance. Imagining a bridge deck only three inches thick is one thing, but being willing to build and then to drive on one is another. An additional complexity is the culture of the construction industry, which, for example, can live with relatively large fault tolerances when a deck is 6-8 inches thick, but would have to move to much smaller tolerances when the deck is only 3 inches thick. Moving from nanostructure to infrastructure, a phrase that originated at the Minneapolis forum, appears to be a very fruitful area for advanced research.

3.5 Energy Future, Sustainability, Safety: Roundtable 2

Professor Joan Ogden, Environmental Science and Policy, UC Davis, and Co-Director of Hydrogen Pathway Program, ITS-Davis: *"Hydrogen Infrastructure: Prospects and Research Needs"*

- Hydrogen as fuel can be produced from a variety of ready fuel supplies including solar, biomass, wind, natural gas sequestration from coal, etc.
- Hydrogen infrastructure can be built new or can use existing infrastructure
- We must have a combination of both infrastructures for efficient and effective use of hydrogen.
- Hydrogen offers long-term emission reduction and provides for diverse fuel supply.
- Numerous hydrogen production facilities already exist in the U.S. – enough to currently supply 2% of energy consumption
- Technical challenges include cost, storage on vehicles, hydrogen production systems and safety perception.
- Transition to hydrogen leads to the following questions:
 - How long will it take?
 - Where will the hydrogen come from?
 - How much will it cost?
 - How will it happen?
- Pilot programs world-wide are already showing promise.
- The California Hydrogen Highway Network is an example of a public-private partnership showing great promise throughout the state. 200 Demo projects are encompassed in this initiative.

Table Discussion: *Table groups discussed their impressions, and then general comments were made to the whole group. A sample of questions and comments...*

- As a country that is relatively new in its development, what will China do in terms of adopting this alternative to fossil fuels? Different policies exist in different areas within China – e.g., Shanghai is limiting cars and road building; Beijing is encouraging massive road building, thereby exponentially increasing the use of vehicles. With no cohesive national agenda, we don't see a push toward a hydrogen-based transportation system.
- Cultural change will be necessary for the public to adapt.
- Can incentives to cultural change be found?

It is recognized that a tipping point looms for energy use in vehicles, whether that is a few years away or a couple of decades. Less clear is whether FHWA advanced research ought to focus in this area, or whether to leave that to other agencies and programs. Professor Ogden did not answer that question directly, but laid out a reasoned case for how and why a hydrogen infrastructure is a real possibility. The advanced research program must decide its role in studying or encouraging the next energy era.

3.6 Human Performance and Safety: Roundtable 3

Dr. Pravin Varaiya, Nortel Networks Distinguished Professor, Department of Electrical Engineering and Computer Sciences, University of California, Berkeley: *"Congestion and Safety: Research Opportunities and Prospects"*

- Conditions in California today represent delay or, increases in “extra” time spent traveling.
- We must have genuine political leadership and societal changes, but instead have inertia adding to extra travel times.
- Tomorrow the focus will be on vehicle-infrastructure integration.
- The challenge of tomorrow will be in the area of cost-benefit gaps.
- In the future we will have increased automation in the form of guided highways, but the challenge of cost and a dedicated infrastructure will remain.
- Better data collection is needed, through improved sensor technology and capabilities.
- We must increase the use of ramp metering, proven to be an effective traffic control measure.
- Need intersection decision support tools, a key to increased safety.
- There is a need for standards – local v. national and within the auto industry itself.

Table Discussion: *Table groups discussed their impressions, and then general comments were made to the whole group. A sample of questions and comments...*

- HOV has proven to be useless without ramp-metering. Studies have shown reduced per-lane capacity of HOV facilities and overall reduction in roadway capacity.
- What is meant by freeways being poorly managed? Response: the existing transportation network is not being used to its full capacity. Relatively minor improvements can pay big dividends.
- The public does not know or understand the concept of ramp-metering. Attention given to educating the public could go a long way.

Professor Varayia challenged the participants to recognize that the highway infrastructure is under-utilized because it is not well managed. He made the case that aggressive and intelligent ramp metering, alone, can improve highway speeds and reduce travel time substantially. Participants questioned the notion that aggressive ramp metering will not impact local streets, but the speaker countered that such impacts are minimal, and can be managed with smart signal timing. Varayia also argued that HOV lanes do not serve their purpose in promoting commuting car pools, and thus they ought to be utilized in a well-managed highway system. Varayia also illustrated that smart vehicle-infrastructure interfaces, namely intersection warning systems will be able to reduce accidents at intersections. On this there was agreement.

3.7 Technical Performance and Mobility: Roundtable 4

Guy Kemmerly, Director of NASA Small Aircraft Transportation Systems (SATS) program: *"Prospects for Travel in the 3^d Dimension: Implications for research, technology advances, community design, infrastructure and mobility"*

- SATS provides operating capabilities that could enable people and goods to travel faster, anywhere, anytime, with particular focus on trips of 150-600 miles.
 - Uses small aircraft (4-10 passengers), and
 - Under-utilized rural and suburban airports, many having no radar or towers.
- The project developed technologies and demonstrated the feasibility of four operating capabilities.
- The project assessed the technical, operational, and environmental impact of SATS operating capabilities on the NAS and on the airport infrastructure.
- Enabling technologies include:

- “Highway in the Sky” (HITS) information systems
- Enhanced Vision System
- Head-Up Displays
- Advanced displays
- Decision-aiding automation
- Combined Vision System (enables shifting from computer projected display to seeing the ground through overcast via sensors, with smooth transitions)
- Case studies and simulations have been developed/conducted.
- Certification of developed systems is on-going.
- SATS provides for ease of use.
- Remaining issues:
 - Communications: Datalink, Secure WWW Services/Data, SW Radio
 - Cost
 - Training
 - Initial Purchase Rental: Certification, Liability, Manufacturing
 - Operations: Fuel, Insurance, Maintenance
 - Community Acceptance
 - Noise
 - Emissions
 - Culture
 - Reliability
 - Vehicle
 - Educating the Public

Table Discussion: *Table groups discussed their impressions, and then general comments were made to the whole group. A sample of questions and comments...*

- What are some of the factors hindering implementation? Air Traffic Control unions, for example, are strongly opposed to the concept.
- What are the implications for highways?
- Will SATS be cost effective?

Guy Kemmerly explained that the SATS program was not aimed at putting an aircraft in every driveway, but rather grew out of an analysis of a travel gap that exists between about 150 miles and 5-600 miles, where driving takes too long, and commercial flying is too expensive and inconvenient. If small aircraft could be made economical, safe, and reliable, the program believes that the private sector and individuals would provide air flight alternatives in this “sweet spot.” The SATS program was intended to develop and demonstrate the various technical capabilities necessary to make such flights feasible. Kemmerly reported success as the program winds down. Regarding impacts on surface transportation, they are minimal generally – SATS analyses suggest that 1-2% of car trips would be replaced by flights -- but impacts could be more substantial locally. That is, certain resort communities and neighborhoods near small airports could see sufficient increased traffic that ground facilities including roads will need improvements. Beyond that, the IT, communications, and instrumentation developed for SATS has obvious and potential applications to improving driver-vehicle-infrastructure communications. Finally, the agency-academic-private sector partnerships that enabled SATS are a research organization model worth studying. This sentiment was also emphasized by Professor Ulm.

4.0 Closing Discussion

Debra Elston began the closing session by summarizing her impressions:

- Importance of partnerships and the willingness to partner.
- A briefing of the results of the three think tanks will be made to the TRB/RTCC and FHWA R&T Leadership Team on November 1-2, 2005.
- The Conduct of Research TRB committee is hosting a panel session on advanced research at TRB on Tuesday January 24, 2006, 1:30PM-3:15PM, Washington Hilton Hotel.
- The advanced research forum findings will be distributed at TRB in January,

Participants noted that this think tank put a significant emphasis on innovations in freight movement as an advanced research area. It is assumed that freight traffic will increase substantially over the next two decades. Making breakthrough improvements in freight movement will lead not just to economic efficiency but also to enhanced personal mobility and safety. Participants clarified that they were calling for “leap frog” ideas for freight movement, not merely incremental improvements. Such ideas could include things like automated containers or using off-peak time on light and commuter rail systems to move robotic freight containers, along with similar discontinuous possibilities.

As had happened at the previous two forums, participants wondered whether they had done enough regarding safety, as the prioritized research topics tended to improve safety but not specifically name safety as a research area. After some discussion the group felt that safety was adequately addressed, yet at the same time recognized a need for advanced research to tackle 40,000 deaths head on as a priority.

Individuals encouraged FHWA to consider some of the ideas which were not selected but nevertheless are intriguing. One of these is advanced research on the capacity of the transportation system to absorb and respond to “extreme events,” whether they are natural or human caused. Other areas that stood out for consideration were policy research, the tremendous impact of an aging population, and a sufficient focus on human behavior instead of technology.

Participants noted that achieving results in the real world involves complex human, social and political systems, and wondered how well these systemic issues may be addressed. Finally, there was discussion of the ability to take theoretical advanced research into the field for validation, and California participants encouraged FHWA to consider California as a possible test bed for such “validation research.” It was noted that CalTrans, for example, is very interested in collaborating on such research.

5.0 Some General Observations

- The recommendations of this forum fell into some similar categories as those of the previous sessions:
 - Research on automation of the human-vehicle-infrastructure interface for the purposes of improved mobility and improved safety. This is seen as going beyond the classic Intelligent Transportation Systems research of the past decade and a-half, to encompass human factors, telecommunications, virtual presence, the impact of the digital native generation dominating the traveling and working public, and more.
 - Research on new materials for improved sustainability and durability of infrastructure along with decreased cost. Nanotechnology is considered a key technology research area for this, but not the only area. Further, there is a desire that FHWA advanced research in nanotech not duplicate the extensive research being done elsewhere, but rather focus the fruits of that research on transportation issues.
 - Systems thinking is assumed to be a fundamental need for advanced research, including integration with land use issues, environmental sustainability, political and social policy research, and public health interactions.
- The recommendations of this forum also differed from the other two, in highlighting the need for research on the following:
 - Innovative and breakthrough approaches to moving freight, which it was argued has tended to be under-researched but is of potentially very high impact.
 - Research on very long-term travel needs, particularly as related to changing demographics.
- There was strong encouragement again for FHWA to seek multi-party and inter-agency research opportunities to leverage limited dollars.
- The coming decades seem to strongly suggest that business not as usual will be the norm, and all kinds of new thinking is required. We will need new mechanisms to *enable* radically new transportation solutions.

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Appendix

Brainstorming Advanced Research Agenda Ideas – Team Results

Below are the initial results of the three working groups, who produced lists of suggested advanced research topics or issues using a modified nominal group technique. These results formed the material for the final recommendations. Results are listed with the score that each item received within the working group when using the nominal group scoring method.

YELLOW TABLE: Initial Advanced Research Agenda Topics and votes

1. How will our society need to travel, and what will business travel needs be in 2050? (11)
2. Innovative traffic flow monitoring systems & control systems (11)
3. Develop and provide robust automated vehicle-highway systems (9)
4. How will transportation systems support sustainability (7)

5. Design of sustainable, advanced materials through nanotechnology (6)
6. Develop ways to move information acquisition and use into productive mode (5)
7. Identify truck only opportunities and implications for design and operation (5)
8. Program to identify and solve institutional barriers to innovation (5)
9. Develop segregated roadway design concepts (4)
10. Technology and strategies to reduce need for travel (4)
11. Advanced computation initiative (simulation, molecular modeling, RTD of highways) (4)
12. Specially designed commuting vehicles on dedicated lanes (4)
13. Controlling traffic around ports and terminals (3)
14. Aggressive development of vehicle communications systems (3)
15. Case studies of institutional challenges to automating traffic (2)
16. Task force for studying AHS (2)
17. Materials that do not deteriorate (1)
18. Innovative concepts for intersection traffic control (1)
19. Freight pipelines (1)
20. Modify infrastructure to accommodate more aggressive ramp metering (1)
21. Technical and economic requirements of automated vehicles (1)
22. Grand challenges for advanced research
23. Link roadway with vehicles
24. New sensors and IT to assess damage in aging infrastructure
25. Simulation and modeling technology to assess physical and behavioral performance
26. Vehicle-driver diagnostics based on vehicle-driver performance
27. Innovative transportation competition for 2050
28. Behavior of infrastructure in response to extreme events
29. Establish & maintain an advanced research program with partners
30. Incorporation of high amounts of waste products in more durable structures
31. Pedestrian assistance technologies to expand small area mobility
32. Self healing materials for transportation
33. Moving people and goods in highly congested areas
34. Light rail on highways
35. Electrical lines on highways
36. Human factors for safety
37. Dual-mode transit

ORANGE TABLE: Initial Advanced Research Agenda Topics and votes

1. Super innovative cross-country container movement (19)
2. Improved vehicle–highway interaction, better instrumentation of infrastructure (13)
3. Land use and transportation (13)
4. Safer rural systems (11)

5. Behavior norms in safety (9)
6. Ways to distribute resources equitably (9)
7. Decreased time for improvements, such as pavement on a roll (6)
8. Truck – vehicle separation (4)
9. Spatial travel demand, both individual and aggregate (4)
10. Nanotechnology to improve infrastructure sensing (4)
11. Increasing non-motorized travel (3)
12. Statistical approaches to identify high risk (2)
13. GIS to link highway to other data (alcohol outlets, etc.) (2)
14. Public health effects, positive and negative (2)
15. Pricing methods and p/p/p (2)
16. Improve service life – 100 year pavements (1)
17. Image recognition for pedestrians and bikes (1)
18. Academic & industry collaboration on networked traffic controllers and distributed control algorithms
19. Impact of digital natives on transportation
20. Construction and maintenance automation
21. Hydrogen test bed for truck fleets
22. Link transportation network characteristics and land use to energy use and pollution
23. Container tracking
24. Transportation security

RED TABLE Advanced Research Agenda Topics and votes

1. Seamless movement between modes. Better integration of ITS into design. ID of hot spots (14)
2. New materials and building processes, for increased longevity, decreased cost, and sustainability (13)
3. Human cognition and perception regarding how people use and understand multilayer systems (10)
4. New energy sources that are sustainable and clean (9)

5. Personal mobility devices for an aging population (7)
6. Alternative financing mechanisms post gas tax (6)
7. Knowledge management systems (6)
8. Freight – how to position and move goods, what are the modal options, and what are industry incentives? (6)
9. Designing places for mobility without travel (5)
10. How to maximize flow through existing resources (4)
11. Improving economic performance of travel systems, including household cost of living impacts (4)
12. Transportation behavior change, making choices, integrating change (4)

13. R&D on electromagnetic resistant vehicle to reduce crashes, injuries, fatalities, crash costs and insurance premiums (4)
14. ITS – enhance roadway-vehicle interaction (3)
15. Policy research on political obstacles to improving highway safety (2)
16. Alternate fuel mag lev (2)
17. Personal vehicle – design & development of short trip personal vehicle (2)
18. Improve land-use, transportation systems modeling & planning (2)
19. Understand broadband super highway for travel (1)
20. Virtual meeting technologies (1)
21. High risk, high payoff innovative contracting techniques
22. Adapt existing technology to transportation applications
23. More holistic financing models – who reaps benefits & costs, impact and efficiency
24. Travel ports – intersections of modes
25. Smart cars for older drivers
26. Can nanotech be used to create new materials for roadway infrastructure
27. How do we expedite Inter-modal flow of traffic
28. Evaluate and improve human capabilities to improve safety
29. Demand-side strategy for goods movement
30. Improve project cost and time estimates