Role of the Driver in Vehicle Infrastructure Integration and Cooperation (VII-C)—Research Needs

September 22/23, 2005
Embassy Suites ─ Dulles North
Dulles, Virginia

Sponsored by:
TRB Committee on Vehicle-Highway Automation (AHB30)
TRB Committee on Intelligent Transportation Systems (AHB15)

Organizing Committee:
Richard Cunard, TRB
Tim Gordon, University of Michigan Transportation Research Institute
Helmut E Knee, Oak Ridge National Laboratory
Rodney Lay, Mitretek Systems
Michael Noblett, SEI LLC

Workshop Purpose: Bring research and broad transportation stakeholder interests to the table; develop and explore research questions that are critical to understanding and preparing for the *Role of the Driver in Vehicle Infrastructure Integration and Cooperation (VII-C)*.

Workshop Objective: *To identify basic components and priorities for a 5 to 10 year program of research, in the requirements for driving with VII-C.* This reflects the changing role, responsibilities, skills and knowledge needed for driving a vehicle that is partially automated, senses the environment via wireless communication, and performs cooperatively to reduce crash risk *–how are tasks/responsibilities allocated between driver and vehicle*?

Workshop product: *Action Plan for Future VII-C Driving Research*

Workshop Process: We will start with panel discussions to provide the perspectives of experts from a variety of stakeholder backgrounds, and then spend most of the time in three breakout group discussions. Throughout, we will aim to place the research in an operational context, including the impact on driving from vehicle-infrastructure cooperation services and real-world deployment considerations.

Registration Fee: $295
Web: www.TRB.org/Conferences/VII-C

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(as of 9/12/2005 and subject to change)

Workshop Agenda

Wednesday, September 21, 2005

6:00 pm Registration Open
6:30 pm Ice-Breaker Reception
7:30 pm Presentation on infrastructure crash avoidance warnings research by Turner-Fairbank Highway Research Center staff.

Thursday, September 22, 2005

7:30 am Registration Open / Coffee

8:30 am Introduction to Workshop:
Objectives, Processes, Product. Tim Gordon, Workshop Chair
Panel: Expectations for Driving with VII-C
Panelists will include: Ray Resendes, Tom Sheridan, Leonard Evans, Gene Faber, Jan Urbahn
Breakout Round 1: ***What will be the Environment?*** **—** Who are the stakeholders? What can't be changed (predetermined factors) and what must be better understood (critical uncertainties) in order to describe the driving environment with VII-C?

Lunch Speaker: Connie Sorrel, Chief of System Operations, VDOT

1:00 pm Breakout Round 1 Reports

Panel Continues: Implications for the Driving Task—the driver becomes more or less a passenger—more or less a beneficiary of vehicle-infrastructure integration/cooperation.
Breakout Round 2: ***Task Allocation between Driver and Vehicle*** **—** Bridging the gap between manual and advanced assisted driving.

- How much can we expect the vehicle to successfully do?
- How will the driver react to vehicle assistance during the driving task?
- As the vehicle does more of the driving task, how do we manage the primary task allocation and responsibility?
- What is the driver's mental model and how do we avoid confusing him or her?
- How will driving evolve if more supervision is added to hands on operation?
- How will the driver transition between VII enabled and conventional environments?

6:00 pm Workshop Dinner: Bob McQueen ***(speaker)***

Friday, September 23, 2005

8:00 am **Breakout Round 2 Reports.**
Breakout Round 3: ***Identify Enabling Research Needs*** **─** Programs and projects that could be conducted in a 5- to 10-year horizon in order to be ready for how drivers engage vehicle-infrastructure cooperation. Some research areas are:

- Advanced Vehicle Control (passive-to-active vehicle control)
- Vehicle-Infrastructure Communication (how vehicles and drivers stay connected to the transportation network)
- On-board vs. off-board intelligence
- Sensing and Measuring (the need for new, deeper and more accurate data and information)
- Advanced Sensor Technologies
- The Human Factors of New Driving Paradigms
- Fitting Bio-Metrics Into Driving
- Proliferation of Wireless On-Board Technologies
- Opportunities That Come With Drive-by-Wire.

Breakout Round 3 Reports

Working Lunch ─ Prioritizing / Allocating Research Agenda Recommendations

1:30 pm **Overall Ranking by Participants / Next Steps / Closing Remarks / Adjournment**

2:00 pm **Optional Tour to US DOT FHWA Turner-Fairbank Highway Research Center with a special presentation on the FHWA Driving Simulator Program.**

Role of the Driver in Vehicle Infrastructure Integration and Cooperation (VII-C)—Research Needs: Critical Issues

Workshop Introduction and Discussion

The purpose of this workshop will be to develop and explore a research agenda associated with the role of the driver in vehicles that are operated at least in part as 'subsystems' within a future integrated intelligent transportation system. The current push towards integration goes beyond conventional ITS, and is based on the hypothesis that widespread deployment of information and communications technology is capable of revolutionizing the transportation systems of the future, to dramatically improve safety and mobility. A more information intensive vehicle-infrastructure system might also provide additional security benefits, for example in managing disaster response and emergency evacuation.

There is global interest in developing this technology; a prime example of proposed deployment is USDOT's initiative for Vehicle Infrastructure Integration (VII). In this initiative, a specialized wireless network technology – Dedicated Short Range Communication (DSRC) – is to provide timely and secure communications between vehicles and roadside infrastructure, and to communicate a wide range of relevant information, especially relating to the transportation function itself. This is expected to enhance safety and efficiency in a way that is not possible when vehicles and drivers operate as essentially autonomous units. Vehicle Infrastructure Cooperation (VIC) takes account of the functional role of the driver as the critical link in the developing future integrated intelligent transportation system.

These new safety and mobility applications in ground vehicle transportation are still barely at the concept stage. Perhaps the most significant proposed safety application is for a Cooperative Intersection Collision Avoidance System (CICAS). The family of mobility applications has been referred to as MVII (including functions such as real-time dynamic route guidance, merge assist, Cooperative Adaptive Cruise Control or C-ACC, etc.) Both application areas implicitly assume elements of *functional cooperation between vehicles or between vehicles and the infrastructure*. The common feature of such systems is that communication will enable cooperative behavior that is beneficial to all who subscribe. For example in CICAS, the individual driver is expected to accept occasional nuisance alerts, knowing that the system reduces the risk of crashes. In C-ACC, the vehicle speed is controlled intelligently based on the external traffic speed, density and other road conditions, not only by the driver.

The above describes a "push for change" from policy-makers aimed at reinventing, or at least developing, the highway transportation system – as represented in Figure 1. The motivation for this, in terms of long-term safety and mobility needs, is well known. Implications for security are less clear at present, but these may also become significant. In parallel there is the traditional "push and pull" within the competitive auto market involving the global car companies and their customers – adding features on the car for personal safety, mobility, entertainment, comfort etc. The push is for sales, profits and market share, but as the right products become available the pull comes from a willing buying public – going beyond simple "driver acceptance" and into public imagination and excitement and willingness to part with hard-earned cash. Clearly this last component is critical to any eventual wide-scale deployment of VII for mobility and safety, so for this reason alone, understanding the drivers' role is critical. *One thing that is radically new here is that core VII applications will not be 'owned' by individual auto makers, and designing core functionalities requires consensus and common standards supported by objective research data.*

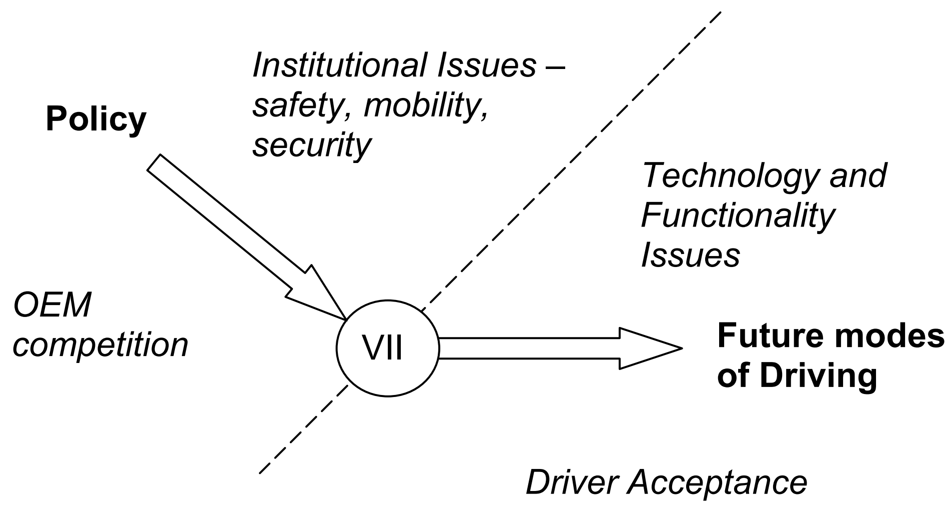

Figure 1. Pushing Change

While this TRB workshop aims to review some of these background institutional issues, the main focus will be on the *functional role of the driver*. In the context of an institutional push for change, a key question is whether the actual daily process of driving is supposed to stay the same. If so, how can the benefits of cooperation be achieved? If not, the fundamental nature of driving may need to change – to promote cooperative behavior at the transportation system level.

What is the current thinking about the role of the driver in the context of core safety and mobility applications of VII? In a recent paper from the US Department of Transportation, the communications and information architecture of VII is described with an as yet undefined role for the driver, Figure 2. Yet clearly the driver is a critical link in the way any VII enabled function will perform. This workshop will highlight a key area where a public research agenda appears both appropriate and necessary. In the long term, the driver is potentially the 'weakest link' in all these future plans, in terms of both motivation to invest and how well the VII-enabled systems will function.

Put another way, physical (wireless) integration between vehicles and the infrastructure (VII) needs functional integration in a world where (presumably) drivers still have choice; hence the need for a higher layer of Vehicle Infrastructure *Cooperation* (VIC) which really means developing the system so that driver decision making and control behavior actually delivers the desired cooperative benefits. This need not imply a new widespread magnanimity on behalf of the driving public, but it might well require new concepts for how drivers interact with their vehicles – again, if this is not true, what will really change?

One way to begin to consider these issues in more depth is through simplified metaphors for driving, as summarized in Table 1. The information here is aimed at promoting discussion - *the workshop itself is intended to explore these and other possibilities with the aim of setting a comprehensive research agenda*. For any particular mode or metaphor, the key questions seem to be: (a) Is it capable of providing simultaneous benefit at both levels - for the individual driver and entire transportation system? (b) Will incremental deployment bring immediate worthwhile gains?

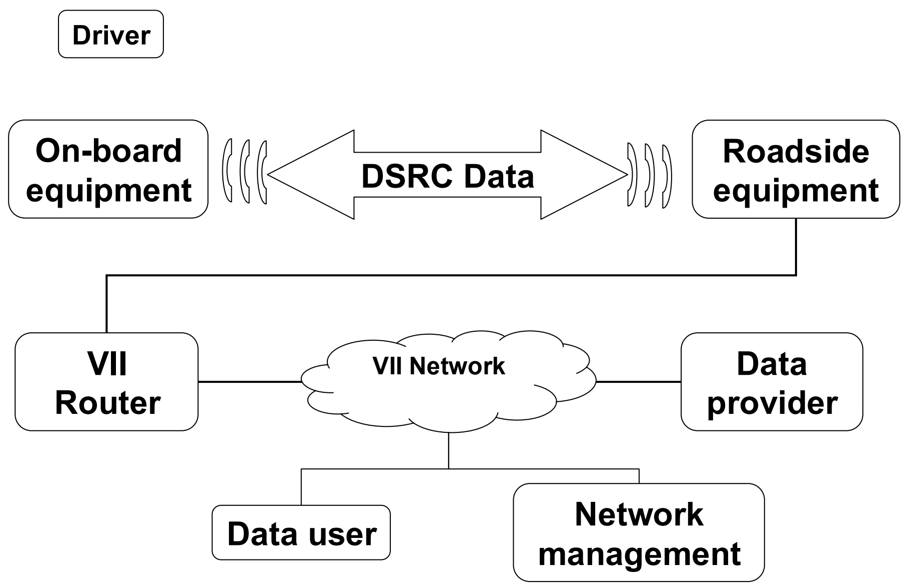

Figure 2. Vehicle Infrastructure Integration Architecture [*VII Architecture and Functional Requirements* - *Version 1.0,* April 12, 2005, ITS Joint Program Office, US Department of Transportation.]

If a consensus emerges that the nature of driving has to change, new metaphors and functional design concepts are needed. This impacts on an area that has traditionally been the sole responsibility of the auto manufacturers; auto makers will continue to play a pivotal role, but the research and development must have a coherent public dimension. And any new paradigm for driving will impact on other (non VII enabled) advanced vehicle functionalities, for example in vehicle-based crash mitigation systems. The common factor appears to be those systems external to the driver that identify complex situations (e.g. a crash is imminent) and make decisions (e.g. warn the driver or apply the brakes); there is fundamentally the same issue with the driver, whether the identification/decision process takes place at the vehicle or infrastructure level.

In summary, this workshop takes a driver-centric view of anticipated VII-related developments, and in particular to explore the functional role of the driver as the critical link in VIC. The hypothesis for the workshop to consider is that there really will be a paradigm shift – an order of magnitude change in the way drivers drive, something that goes beyond "adding the communications and designing suitable driver-vehicle interfaces".

Driving Mode or Metaphor	Driver	Host Vehicle	External Vehicles & Infrastructure	Comments
manual driving	driver responsible for all control, decisions and situational awareness	responds to driver demands, displays routine information	information transmitted for direct display to the driver	driving workload increases in proportion to the amount of information available—however, low level control assistance may be available, as in ABS and stability control (being largely transparent to the driver)
vehicle advisor – manual driving with support for situational awareness	driver responsible for control and decision making	compiles and fuses information	information moderated by the vehicle	driving is still fully manual, but the vehicle monitors the external situation and the driver state to provide appropriate information and warning
vehicle assistant – driver may delegate low-level tasks	responsible for situational awareness—alert to regain control as short notice	as advisor, but carries out basic automated driving functions – speed or direction control or possibly both	may directly interact with automated sub-functions to enable cooperative behavior	current ACC is of this type, albeit without the suggested information management for the driver—system scope is limited by the lack of situational awareness of the vehicle, but augmented by VII inputs
vehicle co-pilot – vehicle systems competent to fully take over the driving task under limited conditions	may carry out other tasks, anticipating timely warning before assuming control	does the driving and continuously monitors its own competency and the driver state	as above, but with greater scope for cooperative behavior	may require dedicated lanes to operate—managing the handover of control is an essential element of the system operation
vehicle Nanny – driver actions limited by vehicle control systems	drives manually until the vehicle systems apply override	Nanny applies direct control to limit driver decisions	information to and from the Nanny increases situational awareness and functionality	Nanny knows best – e.g. the speed is limited to obey traffic laws—driver looses ultimate authority
roadside Nanny – driver actions limited by external control systems	as vehicle Nanny, but override decisions arise from the infrastructure	as above	infrastructure may apply limited direct control into the vehicle – e.g. to force speed limits or disable cell phone use	as above
fully automated driving – driver is redundant except to choose destination and other preferences	there isn't one	fully autonomous within the infrastructure system constraints	interactions for traffic system management	not likely to be feasible in the large scale transportation system

Table 1. Some Possible Driving Modes and Metaphors.