NAHSC Workshop #3

Societal & Institutional Viability and Environmental Considerations

Alan Lubliner

Parsons Brinckerhoff

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Scope of Research in 1996

- State of knowledge of societal & institutional viability not at fine screening level to classify "institutional impediments," & evaluate societal factors as concept discriminators
- Defining and debating AHS concepts helped bound issues
- Findings being applied to analysis of concept attributes and system requirements

8-2

PSA Results: Issues, Risks, Concerns, Conclusions

- Coordinating Multiple Jurisdictions
- Multiple Regulations, Procedures
- Ownership and Operation
- Roles of Public, Private Sectors
- Cost, Risk of Uncertainties, Delays
- Liability
- Privacy
- Intellectual Property
- Promoting Market Competition
- Market Demands
- Public Acceptance and Education
- Impact on Land Use
- Air Quality/ Fuel Consumption
- Complexity of Technology for User

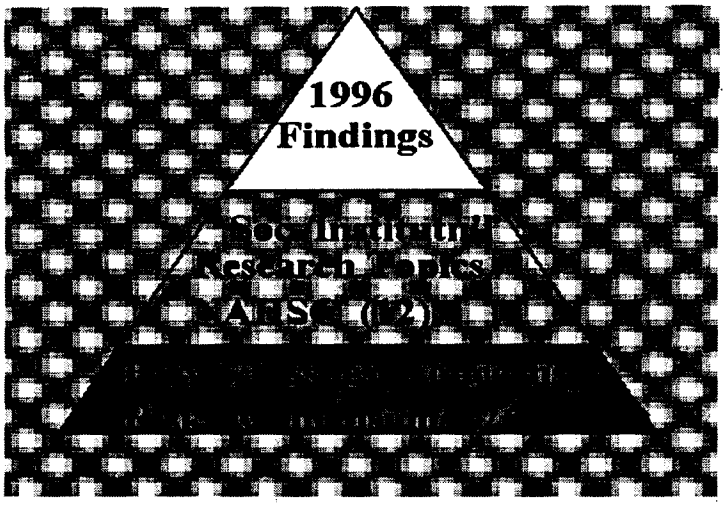
8-3

NAHSC Research Agenda Post-Workshop #1

- AHS and Local Land Use, Economic Development Plans
- Agency/MPO/State DOT Process
- Public, Private Sector Roles in Construction and Operation
- Institutional Considerations for Operations, Maintenance
- Liability
- AHS and Sustainable Development
- Market Demands
- the Human in the System
- AHS Transit Operations
- Inst'l, Soc. Costs, Benefits, Tradeoffs
- Social Equity
- Other Environmental

8-4

Evolution of Societal, Institutional, Environmental Considerations



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Institutional Perspective: Development, Ownership, Operation, Regulation

- AHS development and major infrastructure changes -- as with other new technologies -- may require a major paradigm shift in highway-related institutions
- Major infrastructure changes will require investment analysis used for other major highway and transit investments
- AHS transit/HOV may take form different from AHS for other private vehicles
- AHS may take different forms in different geographic settings

8-6

Institutional Perspective

During past year, examined:

- Agency/MPO/State DOT process in several US regions: issues that shape transportation funding, implementation decisions
  - New York, Office of the Mayor
  - Denver City Council, President
  - Denver Regional Council of Governments
  - Colorado DOT
  - Houston Metro
  - Houston/Galveston Area Council
  - Texas DOT
  - Pittsburgh Department of City Planning

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Institutional Perspective (continued)

- Local and Regional Input during past year (continued)
  - Pittsburgh Department of Transportation
  - Southwestern Pennsylvania Regional Planning Commission
  - San Diego Association of Governments
  - Southern California ITS Priority Corridor
  - Minneapolis
  - Caltrans Planning & Operations Staff
  - focus groups at ITS America Annual Meeting, Houston
  - discussions with TRB Freeway Operations Committee, APTA R&D Committee

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Institutional Perspective (continued)

- Operations & Maintenance issues
  - Low tolerance of delays, queues entering freeways
  - Limited storage (on-ramp and rejected vehicle) space
  - Limited capacity at off-ramps and on local streets to accommodate high capacity AHS throughput volumes
  - Staffing and staff skills/education, training
  - Limited ROW for additional lanes; limited potential for additional ROW or for elevated structures

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Institutional Perspective (continued)

- Liability
  - Potential shifts in legal responsibility
  - Limiting liability exposure through legislation
  - Acceptance of increased exposure with reduced likelihood of accidents, reduced cost
  - Insurance premium discounts from improved safety (reduced liability)

8-10

Institutional, Environmental Perspective

- Effect on Land Use/Urban Form
  - AHS, of itself, unlikely to have significant impacts on land use
  - Possibility for beneficial effects on land use patterns
  - AHS may follow demographic trends by supporting maintenance of mobility for enlarged future elderly population

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Institutional, Environmental Perspective (continued)

- Public Transit
  - Increased capacity provided by AHS can provide for future growth required by Houston Metro busway/HOV system
  - AHS Transit Operations Concept developed
  - Automation provides opportunities for transit systems with constrained ROW
    - Pittsburgh
    - Cleveland
    - Seattle
    - Chicago
  - Other applications include bus maintenance facilities/operations (Chicago, Seattle)

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Societal Perspective

During past year, examined:

- Market issues through surveys
  - Current freeway system generally high-rated, but gets lower marks for driver stress, congestion, environmental impact
  - AHS received positive comments on potential merit and traffic safety
- Understanding differences in benefits, and costs, to different stakeholders

8-13

Other Environmental/Energy Considerations

- Air quality requirements documented by state, region, based on conformit/non-attainment status
- Reductions in fuel consumption/emissions during AHS operations, as a result of improved traffic flow and reduction of wind resistance (when operated in platoons) modeled and quantified

8-14

Open Questions for the Breakout Session

- Are we looking at the right issues?
- Is there political/institutional support for additional investment in highway infrastructure to provide significant travel time savings, trip time predictability, additional capacity, improved safety, reduced driver stress, air quality/energy benefits?
- Under what circumstances can additional dedicated AHS lanes be added to existing highways, particularly in urban areas?
- Will highway agencies and manufacturers accept increased proportional risk in return for an overall reduction in vehicle accidents and severity?

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NAHSC Workshop #3

Societal & Institutional Viability and Environmental Considerations

Steve Weber

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Societal, Institutional, & Environmental Considerations Disclaimer

Most of the considerations that have been identified are social constructs that have developed in response to the conditions that exist today. They can be expected to evolve as conditions change. The development of a viable AHS concept has the potential to force changes to existing procedures, regulations, and societal priorities.

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Precursor Innovations

- HOV Lanes: Adding lanes generally easier than taking lanes
- ETC: Agency coalitions ensure coordinated equipment standards, private participation possible (results mixed)
- Cruise Control: Limited regulation/safety standards, OVSS requires manufacturers to self-certify their compliance
- Inter-Agency Cooperation: Focus on business principles/cost recovery; generally financed by toll collection; rivalries predictable, but not insurmountable

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Five Who's

- Who Owns?
  - Infrastructure
  - Vehicles/Equipment
  - Radio Frequency
- Who Pays?
  - Vehicle purchases
  - User fees/tolls, excise taxes, general funds
- Who Operates?
  - Drivers
  - Highway system

8-19

Five Who's (Cont.)

- Who Maintains?
  - Vehicle Owner
  - Infrastructure
- Who Regulates and Enforces?
  - Law enforcement
  - State DMV's
  - Office of Vehicle Safety Standards
  - FHWA

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Investment Analysis

- ISTEA requires MIS for all major transportation investments with significant federal funding
- Emphasis on public involvement
- Focus on problem solving, identification of goals & objectives, purpose & need
- Consideration of all reasonable alternatives and modes
- Evaluation of performance & environmental issues based on goals & objectives
- Selection of investment strategy

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Investment Criteria

Each study is different, with different criteria. Certain criteria would concern an AHS.

- **Mobility: Effects on capacity, travel time, VMT**
- **Cost: Capital, O&M, life-cycle**
- **Revenue: tolls & user fees**
- **Environmental: Air quality, traffic impacts, EMR**
- **Energy Consumption**
- **Community Opinion**
- **Financing Plan**

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Financing/Deployment

- **Need for sufficient market penetration if/ when dedicated lanes are completed and opened**
- **Transit, freight and other "fleet" users need to be brought on at earliest stages**
- **D-BOM and ETC offer opportunities for private participation and innovative financing**

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Liability/Insurance

- Reduction in driver control = increase in exposure of manufacturers & highway agencies
- Agencies may accept increased exposure if it comes with an overall reduction in claims
- D-BOM contracts generally include clause that limits contractor liability, provided that highway meets state design criteria
- Premium discounts for drivers possible if system can demonstrate significant reduction in accidents / severity

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Market Issues: Internet Survey

- 460 participants via ITS America & NAHSC web pages. Self-selected group, mostly professional males age 25-45. Pen & pencil version adminstered at Boston Forum.
- Current freeway system rates poorly on driver stress, congestion, environmental impact; neutral on safety; and rates well on cost
- AHS had positive comments on potential merit and safety, negative comments on cost and safety/reliability
- Most important AHS attributes: traffic info & navigation aids, improved driver training, control over vehicle speed, restricted lane use, reduction in driving stress

8-25

Stakeholder Interests

- Society as a whole: Broad interest in most costs & benefits, particularly safety
- Users: Performance, reliability/comfort/ convenience, environmental, costs
- Agencies: Environmental, Capital/O&M costs
- Industries
  - Transit/Trucks: Performance, reliability/ comfort, capital/O&M costs
  - Manufacturers/Construction: Jobs, spin-offs, capital/O&M costs
  - Insurance: Safety, licensing, inspections

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Environmental Considerations

- Environmental review required at federal (NEPA) and state levels
  - Air quality
  - Electro-magnetic radiation
  - Traffic impacts
  - Noise
  - Property takings
  - Socio-economic/equity issues

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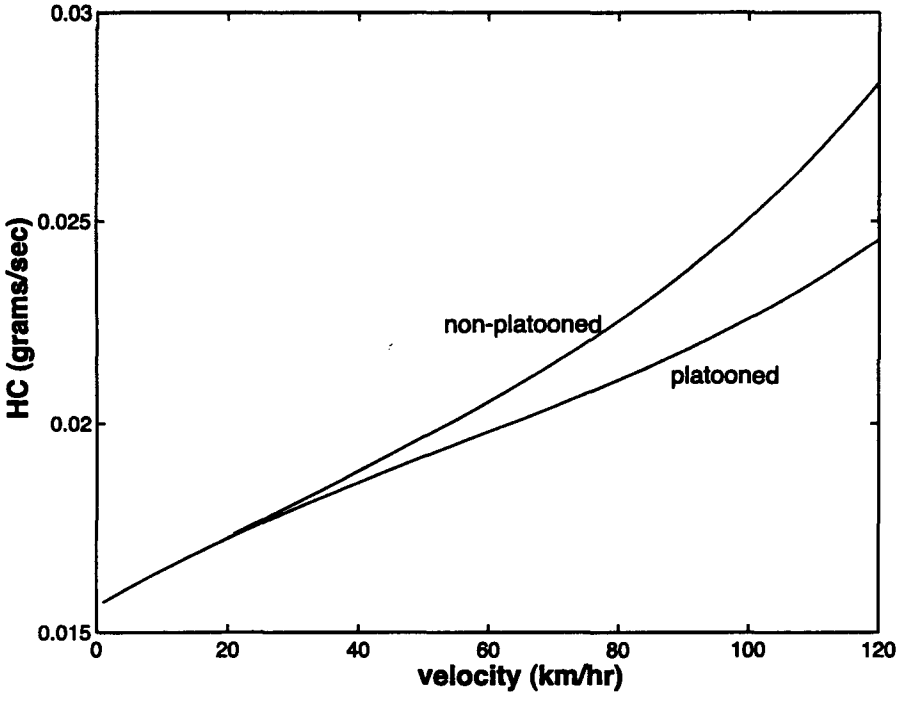
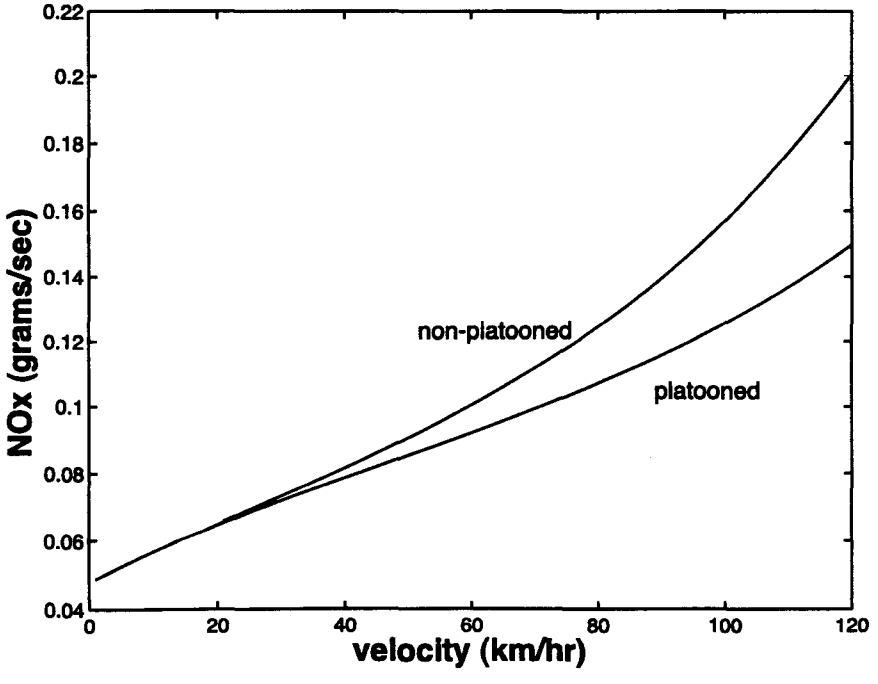
HC vs.Velocity for 20 Vehicles



- Constant velocity hydrocarbon emission rates for 20 vehicles platooned and non-platooned.

NOx vs.Velocity for 20 Vehicles



- Constant velocity NOx emission rates for 20 vehicles platooned and non-platooned.

Instructions for First Round of Breakouts- Analysis Results

Steven E. Shladover

Breakout Session Topics

- 1-A • AHS Throughput and Travel Time Analysis
- 1-B • AHS Safety Analyses
- 1-C • AHS Infrastructure Cost Analyses
- 1-D • AHS Societal, Institutional, Energy and Environmental Analyses

First Breakout Sessions
General Questions (1 of 3)

- **Clarity:**
  - **Are the analyses understandable?**
  - **Are the results presented clearly?**
  - **Are the most significant issues addressed?**
- **Credibility:**
  - **Does the analysis approach make technical sense?**
  - **Are the underlying assumptions reasonable? (if not, which ones?)**
  - **Are the results believable? (if not, why?)**

First Breakout Sessions
General Questions (2 of 3)

- **Conclusions about concept attributes**
  - **Do the results support significant conclusions?**
  - **Do these weigh heavily for or against some attributes?**
  - **What further analyses are needed to support strong conclusions?**
  - **Are you prepared to make choices for or against some attributes based on these analyses?**

First Breakout Sessions
General Questions (3 of 3)

- Further work needed?
  - Are the analyses seriously incomplete for concept definition purposes?
  - What is the most important further work that should be done here?
  - Is there other relevant pre-existing work that should be cited here?
- Concerns?
  - Have we overlooked something important?
  - Is the emphasis appropriate?
  - Other?

Breakout Session Process

- 1:15 - 2:00
  More detailed briefings on results of analyses

- 2:00 - 3:30
  Discussion of analysis results:
  - Clarity?
  - Credibility?
  - Conclusions about concept attributes?
  - Further work needed?
  - Concerns?
  - Answers to specific questions for each session

NAHSC Moderator, Recorder, and Domain Expert in each session to capture discussion points

Instructions for Second Round of Breakouts

Concept-Distinguishing Issues

Steven E. Shladover

Breakout Session Topics

- **2-A** • Automated driving in mixed traffic
- **2-B** • Development of AHS infrastructure
- **2-C** • Driver roles in partially and fully automated vehicle systems
- **2-D** • AHS standardization vs.local options

Automated Driving in Mixed Traffic - Issues

- What would be the progression from driver control to fully automatic control?
- What technical issues need to be addressed in order for this to work? How long should that take?
- How would the vehicle market develop?
- How safe must each vehicle be relative to conventional (manual) driving?
- What false positive (false alarm) rates are acceptable?
- What additional hazards must the vehicle be able to handle? What anomalous driver behaviors?
- What are the implications for overall traffic flow?
- What are the liability implications?

Development of AHS Infrastructure - Issues

- What *corridor* throughput increases are needed to serve expected demand?
- What are right-of-way constraints (urban, suburban)?
- How about an all-new AHS right of way?
- What construction costs are sustainable based on throughput increases?
- How should AHS lanes be separated from manual traffic?
- How to interface AHS lanes with existing roadways?
- How to accommodate future growth in AHS usage when developing first AHS lane(s)?
- What geometric design standards would be needed?

Driver Roles in Partially and Fully Automated Vehicle Systems

- Driver attentiveness with varying levels of vehicle automation capability?
  - ability to detect obstacles
  - ability to respond to emergencies
- Driver ability to resume control of an automated vehicle following a failure?
  - what warnings needed to elicit a safe response?
  - how long to respond?
- Permissible driver intervention in automated operations?
  - at will?
  - sometimes?
  - never?

AHS Standardization vs. Local Options - Issues

- What minimum standards are needed for national interoperability of vehicles?
- What standards are needed to ensure an acceptable level of safety?
- What standards are needed to promote economic viability and market development?
- What options are needed to adapt to urban, suburban, intercity and rural needs?

AHS Standardization vs. Local Options - Issues (cont.)

- What must be left to local decision making?
- What must be left open to encourage technological advances?
- What should be the scope of standards (domestic vs. international, inter-vehicle vs. intra-vehicle)

Breakout Session Outline

- 8:00 - 8:20 am
  Briefing on issues and results developed to date

- 8:20 - 10:00 am
  Discussion
  - Credibility of results presented
  - Significant findings
  - Other sources of relevant knowledge
  - Additional issues needing attention
  - Implications for concept attributes
  - Specific questions for each topic

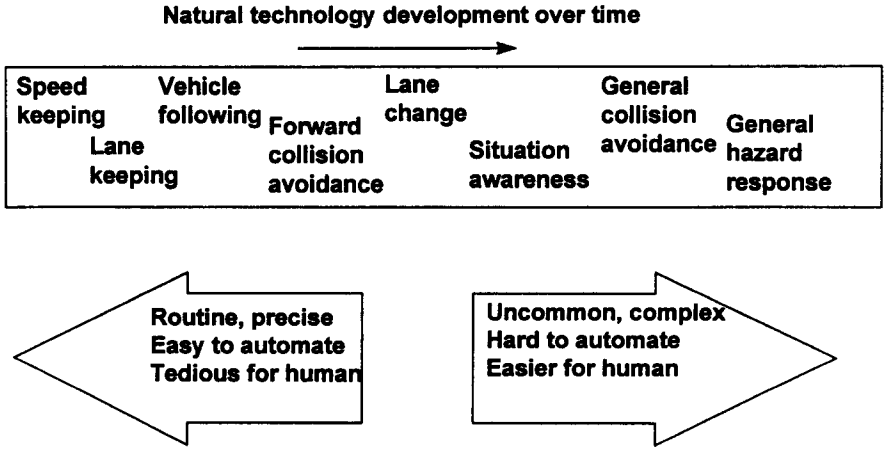
Operations and Technology Issues for Mixed with Manual Traffic

Carol Jacoby

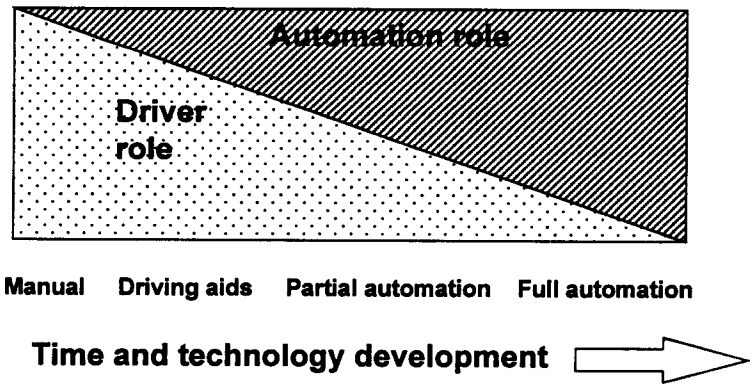
Advantages of an AHS That Does Not Depend on Dedicated Lanes

- Potentially seamless growth from near term driver aids
- Stakeholder feedback: converting a lane to AHS or adding a lane is expensive and time-consuming
- Some stakeholders said dedicated lanes are not viable due to:
  - cost
  - limited right-of-way
  - community impacts
- Applicability beyond congested urban areas
- Broad applicability leverages benefits

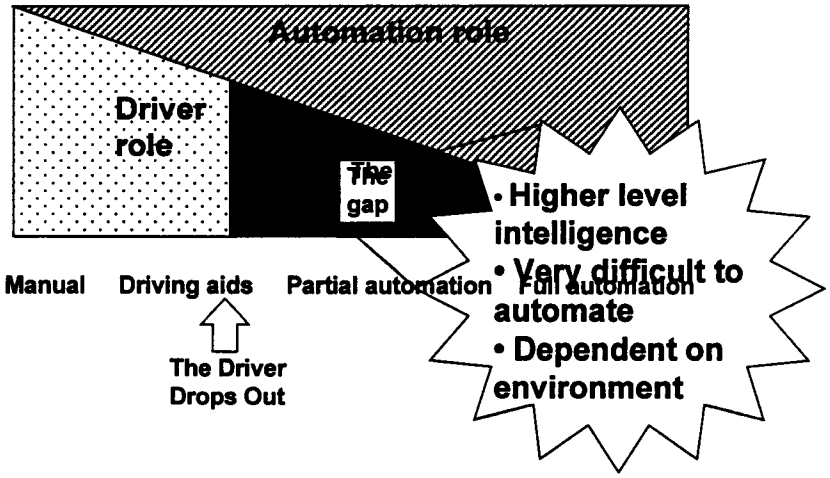
There is a Range of Driving Tasks



The Ideal Evolution Path Gradually Shifts Control from the Driver to Automation



In Reality the Driver Becomes Inattentive

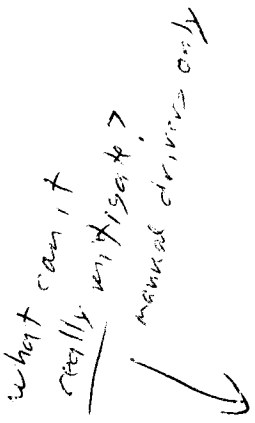


Implications

- Getting to full automation mixed with manual will occur later than a dedicated lane approach
- Full automation in manual traffic requires:
  - Intensive research into driver actions, hazard recognition, situation awareness, hazard avoidance, etc.
  - Research goal -- identify all driver actions requiring reaction
  - Design of an evolutionary path that keeps the driver involved until technology catches up
- The nature and extent of the problem is not yet well understood
- Consider solutions between freely mixed and strictly dedicated

dedicated lanes don't necessarily fit this!

Safety Background



- A fully automated vehicle in mixed traffic must react, without driver assistance, to any emergency...
- Debris will fall off other vehicles
- Other drivers will drive erratically
  - The system cannot control their actions
  - Such actions are difficult to predict
  - There is a wide range of driver condition, skill, and style
  - Normal driver response patterns are difficult to emulate
- What do drivers do right? Can it be automated?
- What must the system handle?
- Can/must it do everything better than the human driver?
- A dedicated lane can mitigate much of this

Safety Issues for Full Automation in Mixed Traffic

- Hazard response may require coordination with other vehicles
- The automated vehicle has strong sensing capability but weak "thinking" capability
- Some "obvious" hazards are hard to recognize
- Some "obvious" non-hazards may cause a hazard response
- Driving behavior is not well understood
- Assignment of liability is difficult
- Liability risk is difficult to control

But automation promises to reduce the 60 - 90% of accidents caused by human error

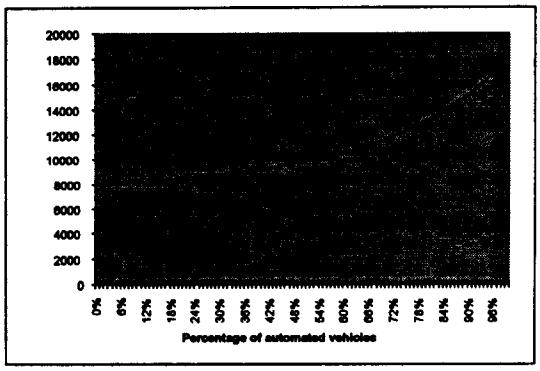
Example Roadway Throughput for Mixed Lanes

Assumptions

- **5 lanes, 67 mph**
- **Automated vehicles in mixed traffic have high cooperation, maintain 1/2 sec buffer behind manual**
- **Turbulence not modeled**

Observations

- **No drop in capacity by introducing automated vehicles**
- **Significant throughput increases take high market penetration**



Conclusions

Throughput

- **High throughput requires designated or dedicated lanes**
- **The first automated vehicles have little impact**

Safety

- **A major challenge is responding to all safety threats**
- **Driver involvement is critical to a safe evolutionary path**
- **Dedicated lanes will have safe, fully automated operation earlier**

Completely transparent * depends what you mean by "safe"

Conclusions (cont.)

- **Mixing with manual traffic supports a wide range of applications**
- **Early systems have significant safety benefits, such as preventing run-off-road in rural areas**
- **But the driver will need to be kept involved until full emergency reaction is perfected**
- **Research into driver action is necessary to assess when and whether full automation is possible in manual traffic**
- **Early fully automation systems will require controlled, dedicated lanes**

Discussion Questions

→ Dutch AHS people find 10% - 20% AHS penetration dampens shock wave

→ Driver drop-out → is it an excuse for liability shift?

→ mixed traffic is market-driven; platoons public-driven

* → Dedicated lanes still have similar problems, but less frequent; Liability → driver + OEM
→ roadway owner

Safety

- How can we determine what hazards the automated vehicle would be expected to respond to?
- How can we determine what driver actions the automated vehicle would be expected to respond to in mixed traffic?
- How much safer than current manual driving does each automated vehicle need to be? Does it need to be safer under all possible situations or is a major improvement in overall safety enough?
- How often can the vehicle erroneously try to avoid a non-hazard without losing credibility?
- What are safety requirements for rural roads?

Deployment and Market Development

- What would motivate a vehicle owner to buy a car that can operate automatically in mixed traffic?
- The early systems will need to keep the driver attentive. It will be many years before the technology supports full automation. How much of a negative is it if the driver is not able to do other tasks while driving?
- What are the steps to get to fully automated control without losing the necessary driver attentiveness?
- How will the automated vehicle market develop?

Liability and Throughput

Liability

- **What are the liability issues for automated operation in mixed traffic? Can they be solved?**

Throughput

- **Is it acceptable to wait many years for throughput improvements as the market builds?**
- **How valuable is a small throughput improvement throughout the region?**