Towards a AVST/Driver Partnership: Research and Implementation Implications

“If at first, the idea is not absurd, then there is no hope for it” Einstein

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The University of Iowa

Challenges and Opportunities with AVST

- Challenges & Opportunities
- Driving as Stimulus and Response
- Driving as Control with a Joint Cognitive System
- Driving as Multi-level Control
- Driving as Adaptation of a Diffuse Organism
- Research & Implementation Implications

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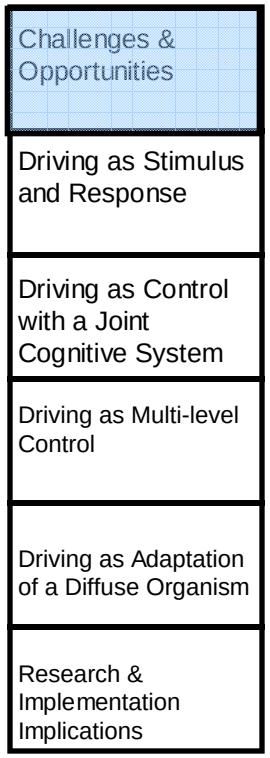
Capitalizing on the Opportunities



- Holistic rather than piecemeal—theoretically tractable, but practically difficult
- Consider human-technology as unit of analysis
- Augment human rather than automate
- Address underlying crash mechanisms—
  - Speed and following distance
  - Inattention
  - Expectations
  - Culture

Collision Warnings: Directing attention and response

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Cross-modal attention cueing—Stimulating one sense can direct attention in another sense

- Implication: Locate source of stimuli in similar spatial location
- Research issue: How does the internal "display" space of the vehicle map to the spatial location of roadway events?

- Multi-sensory integration—Several stimuli can sometimes be perceived as a unit with super-additive effects on speed of processing
  - Implication: Stimuli perceived separately can delay response
  - Research issue: What parameters govern multi-sensory integration with in-vehicle warnings to enhance response speed?

Failure of multi-modal sensory integration

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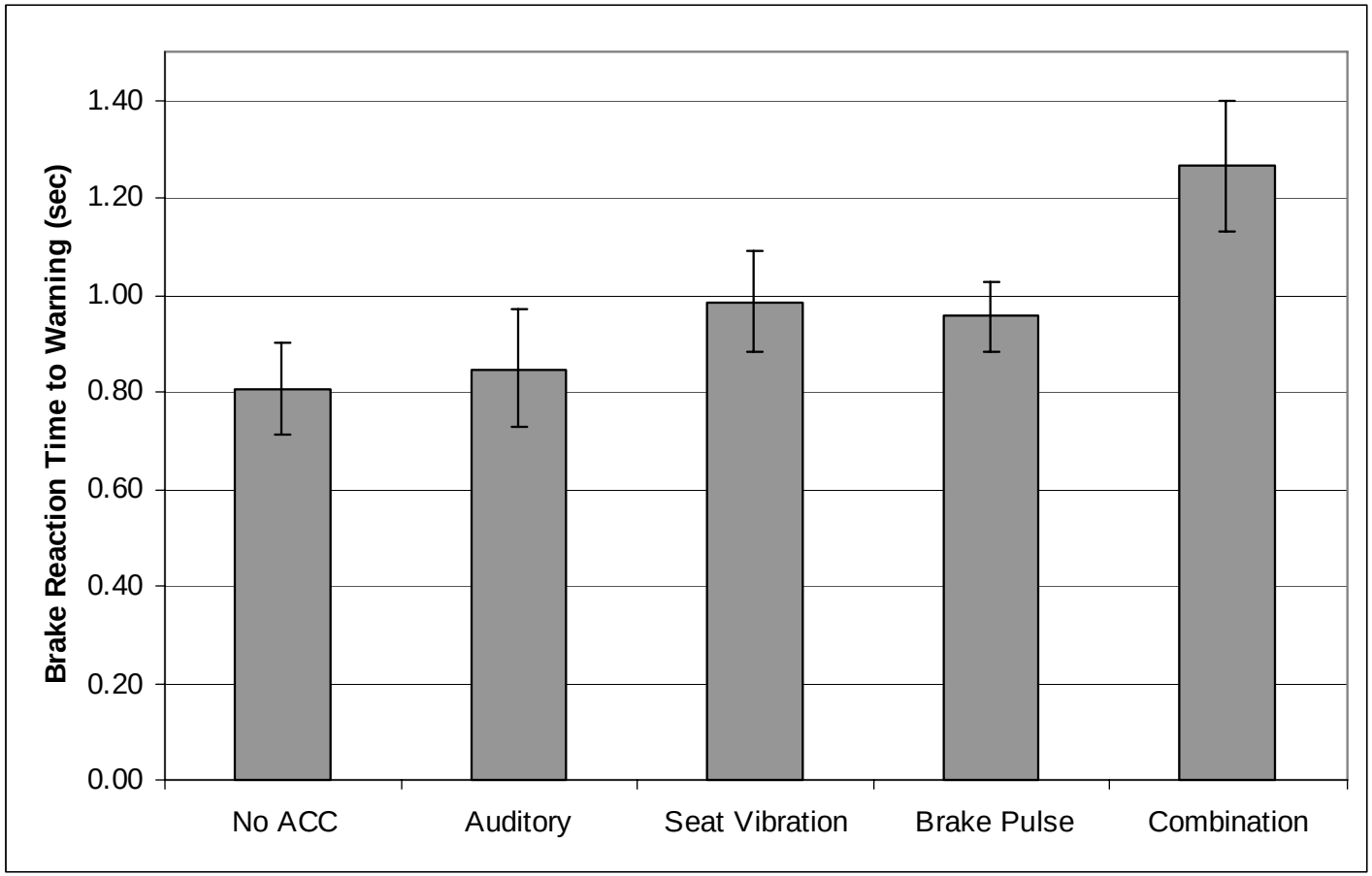

Graded and Ambient Information: Supporting control and situation adaptation

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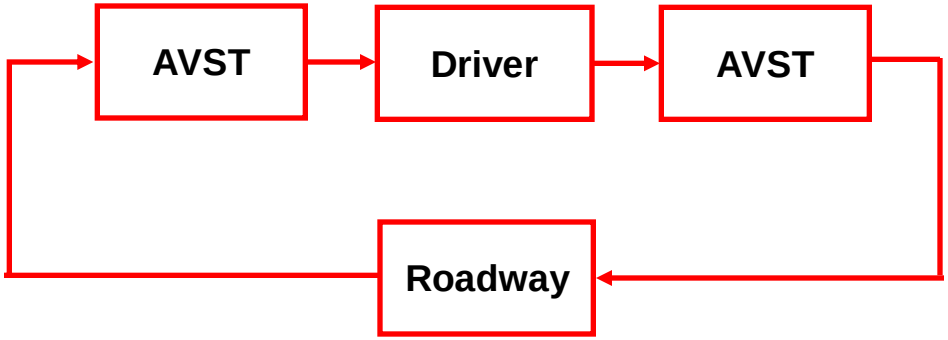

- Graded information provides context for warning
- Ambient information provides preattentive background to guide situation adaptation
  - Implication: Continuous information can guide expectations and reduce reaction time to events
  - Implication: Use urgency mapping and annoyance tradeoff principles to grade alerts
  - Research issue: How to combine multiple auditory and haptic streams to form a coherent whole?

Internal Models:
Designing for appropriate reliance

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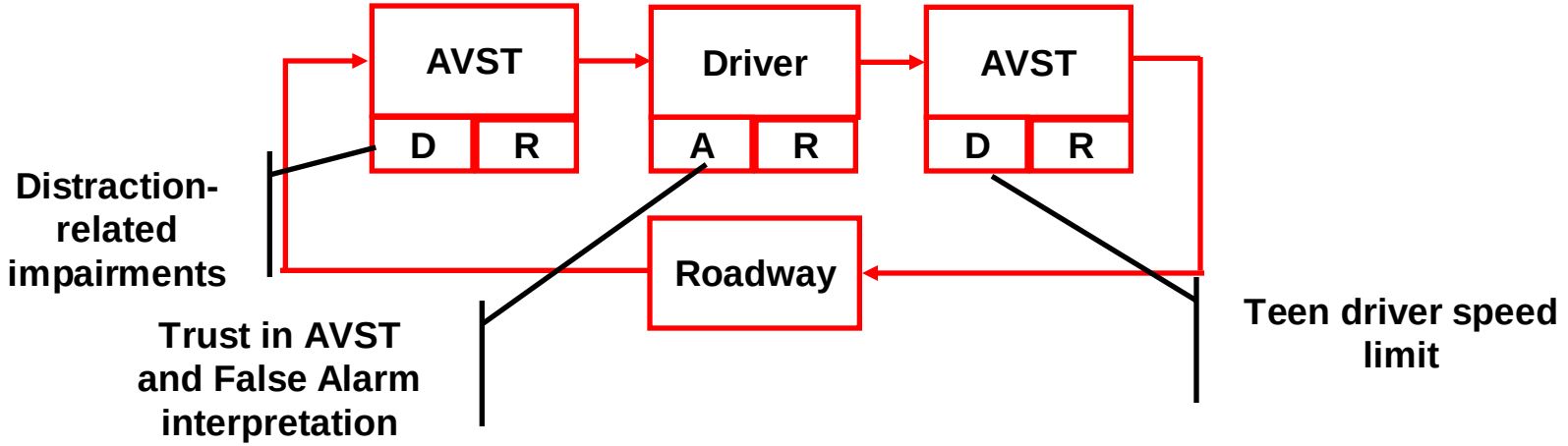

- Trust—part of the driver's internal model of the AVST that influences reliance
  - Implications: Support appropriate trust by representing AVST Performance, Process, Purpose
  - Research issue: Does the benefit of reducing false alarms with a more complex AVST outweigh the increased difficulty in developing appropriate trust?

Interface design to calibrate trust

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- Trustable systems may ease driver adaptation to differences between vehicles

Calibration of trust in technology

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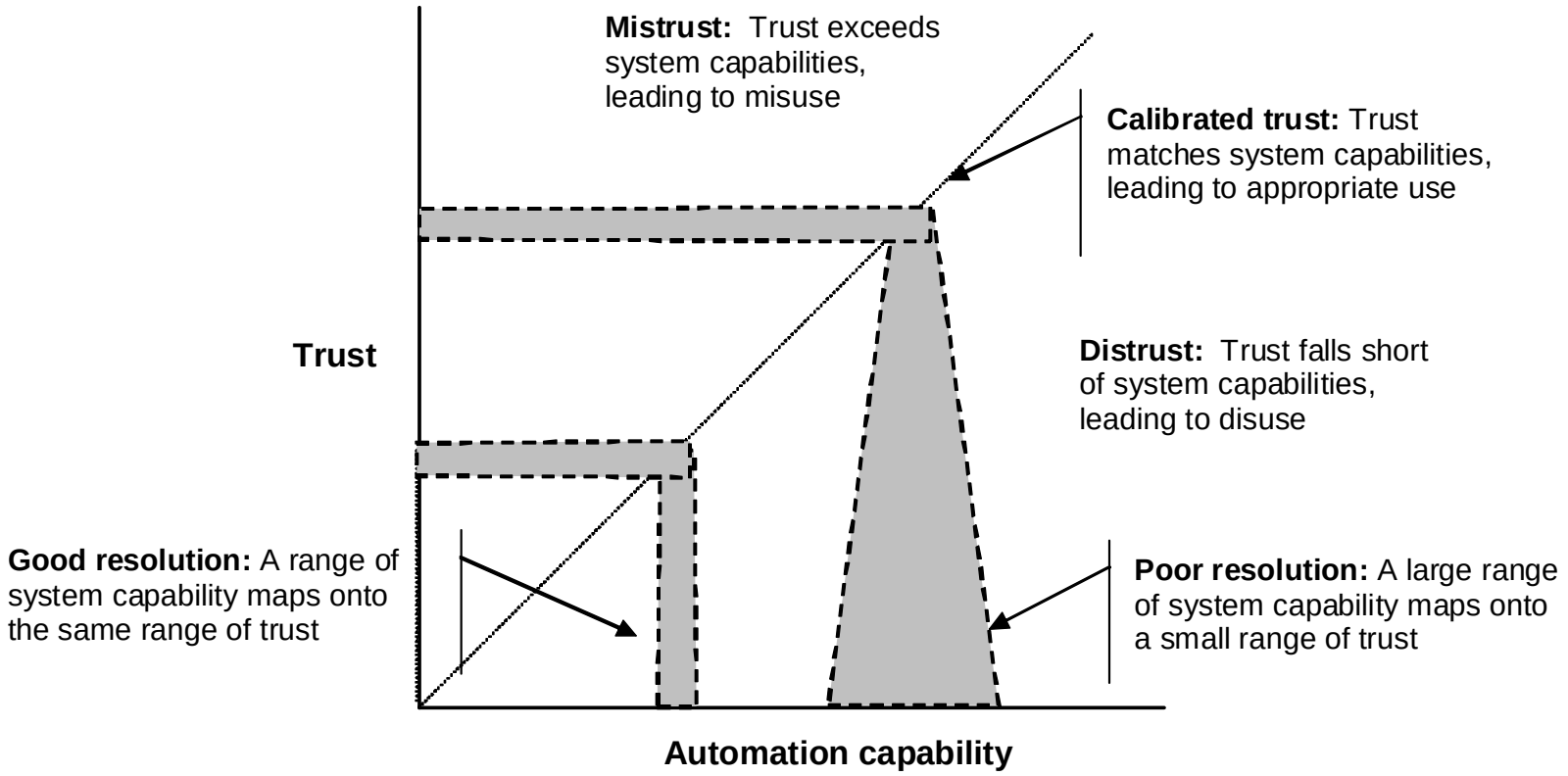

Similar visual metaphor appears on side mirrors

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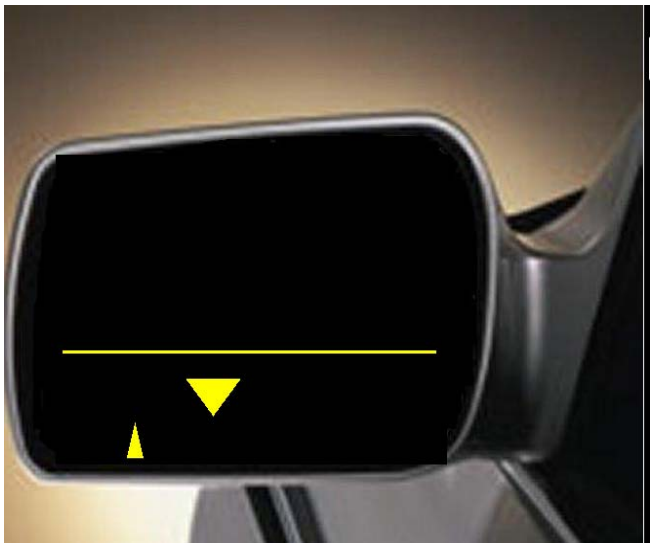

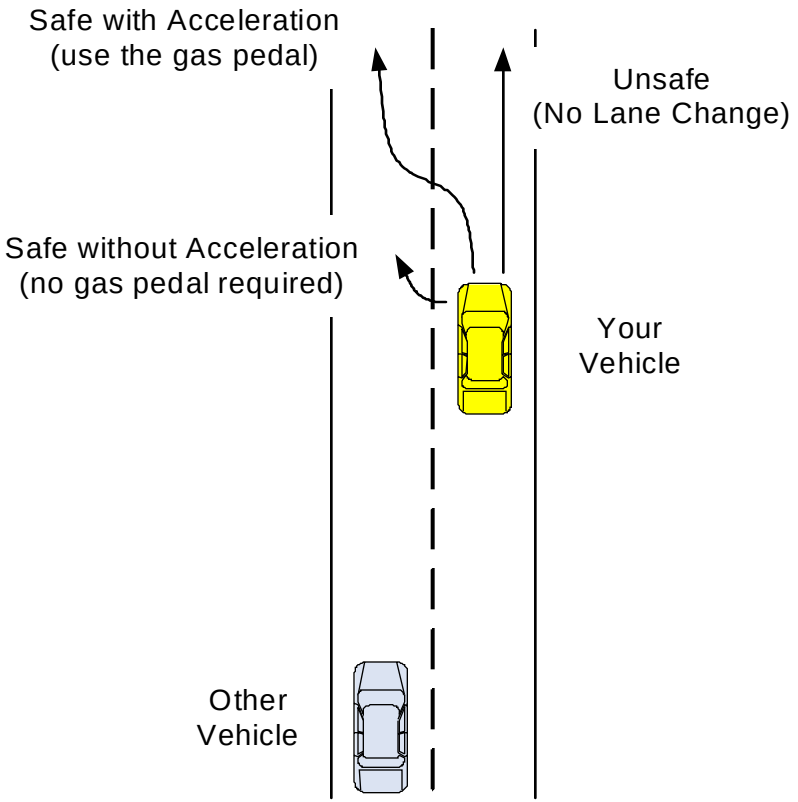

Challenges & Opportunities

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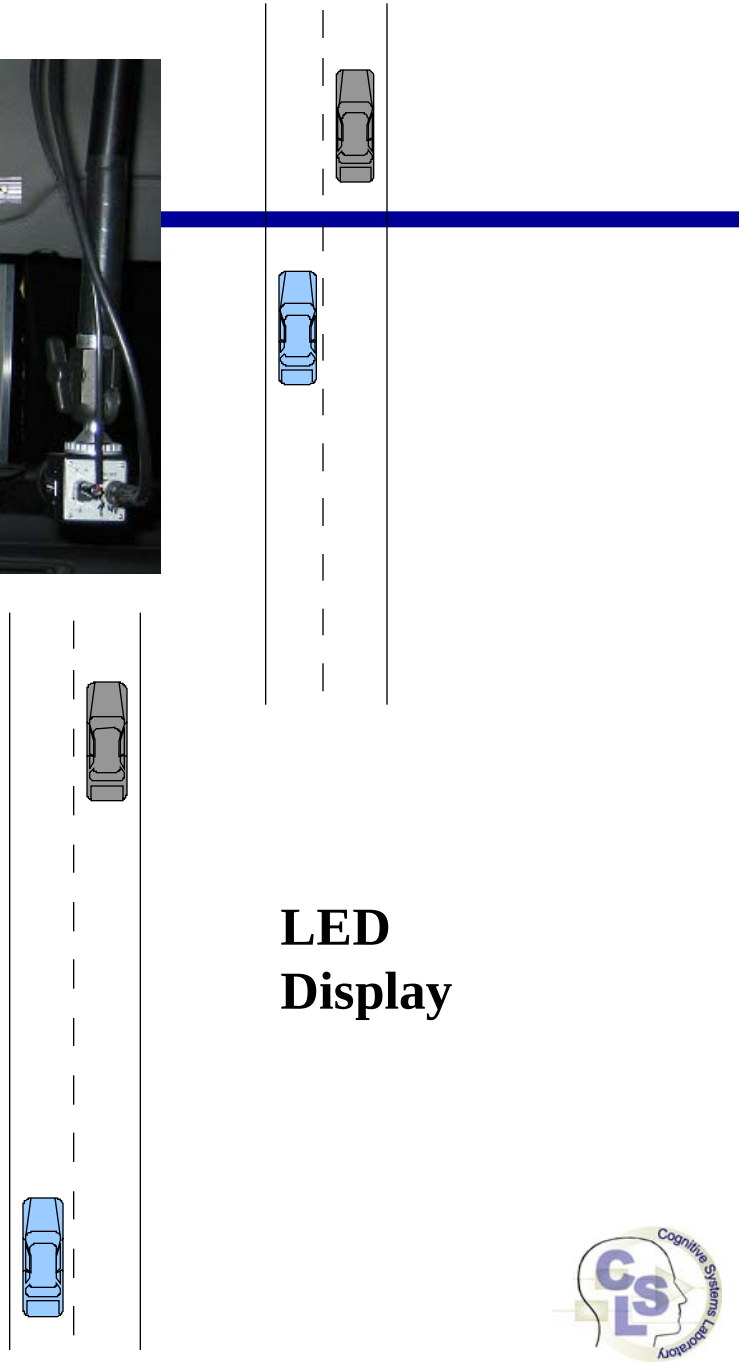
Close Behind

Far Behind



LED Display

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Traffic situation display

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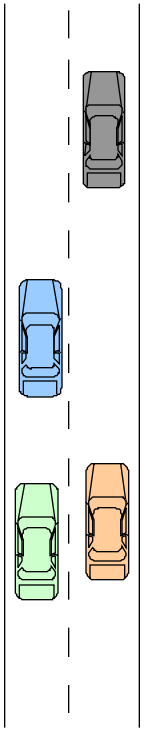
High traffic situation



Driving across Multiple Timescales: Preparing and teaching the driver

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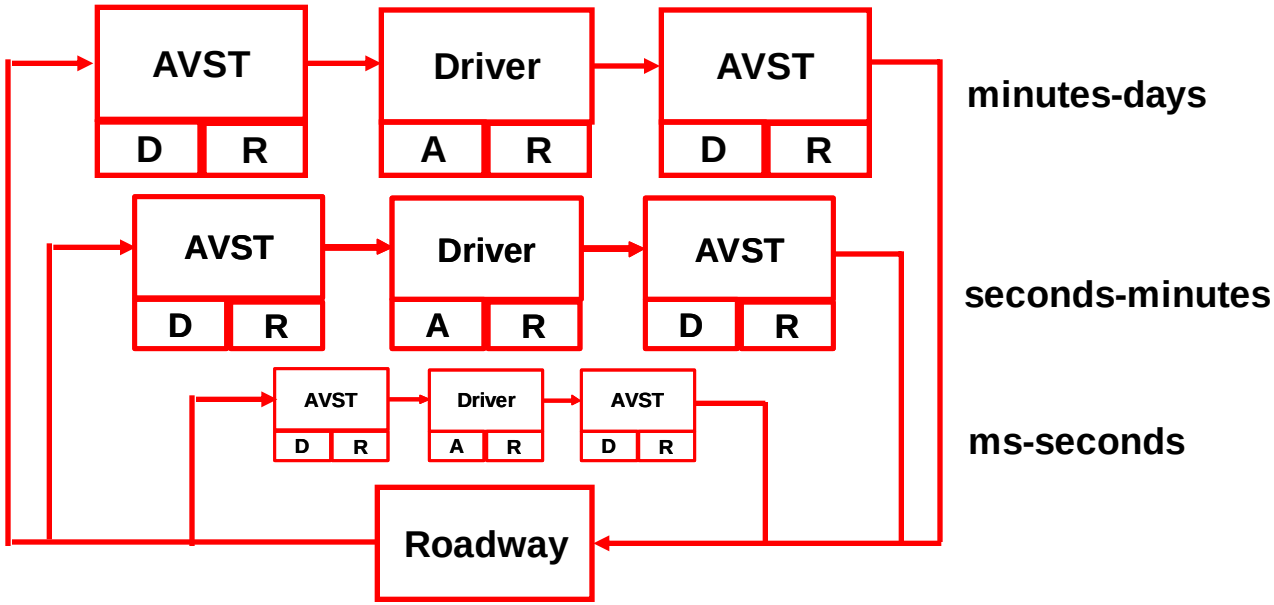

- Operational, Tactical and Strategic Levels of Control—milliseconds to months matter
  - Implication: The short time-constant of operational control suggests AVST at this level needs representation at other levels to promote understanding
  - Research issue: To what degree is the influence of AVST confined to one level?

Information before and after an event provides context to collision warnings

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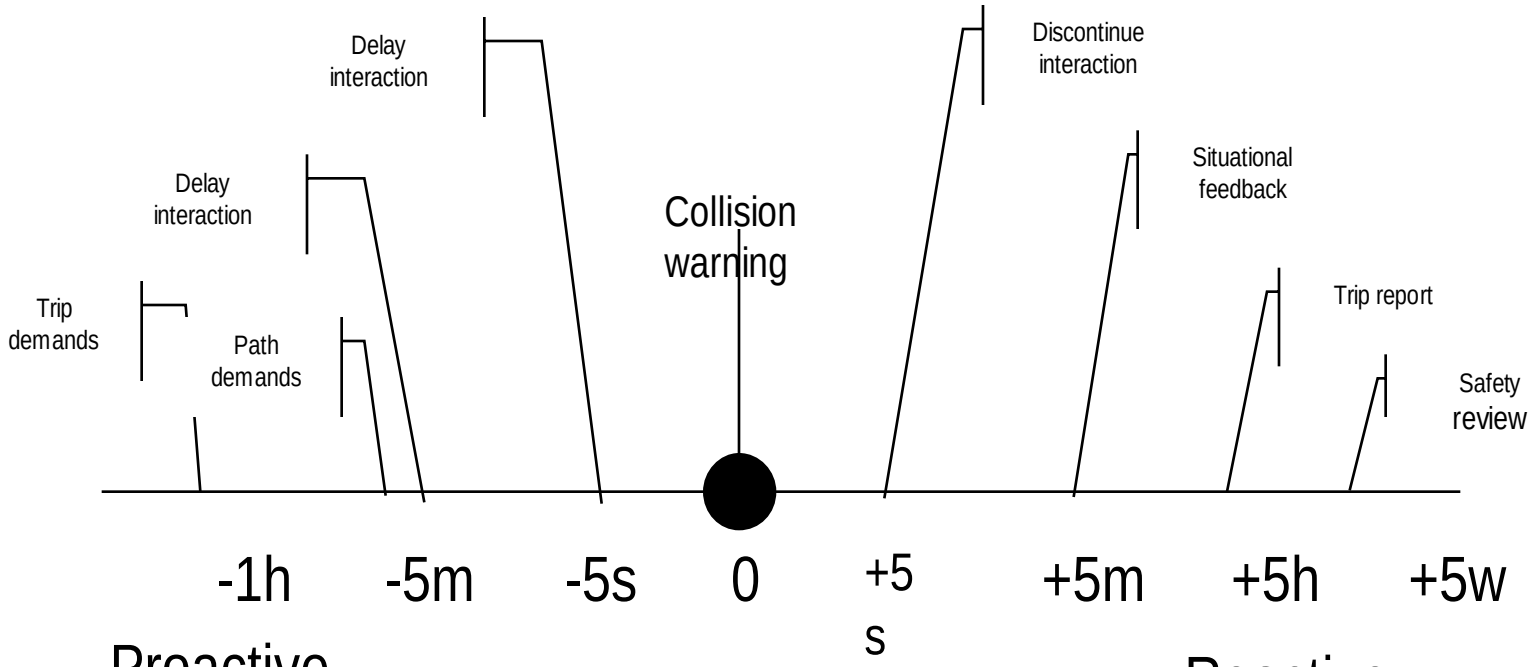

Traffic and Culture:
AVST shapes the behavior of a diffuse organism

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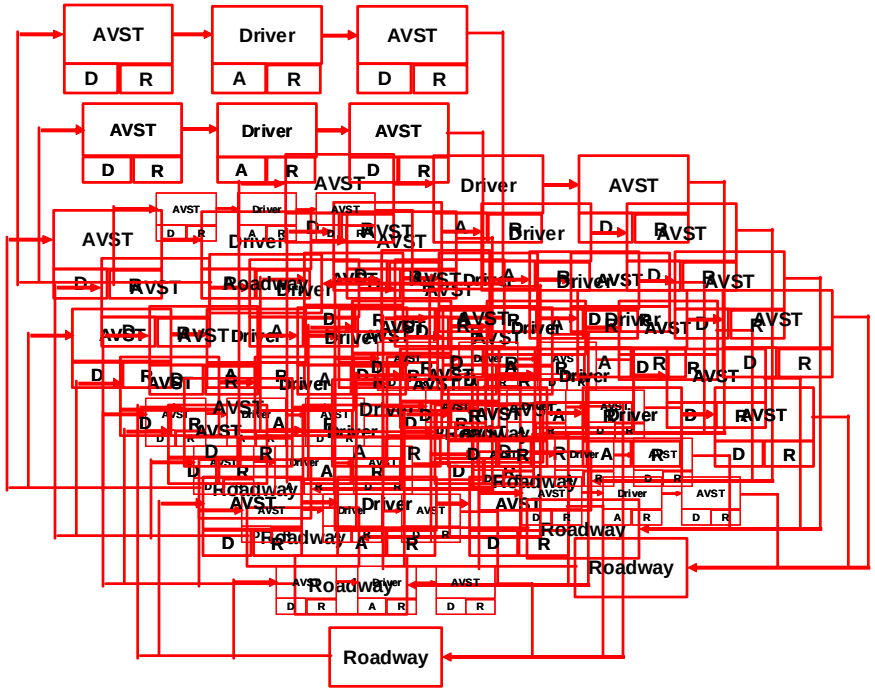

- Drivers/AVST are not isolated from others
  - Implication: AVST benefits may be most prominent in as they affect traffic and driving culture
  - Research issue: How does ASVT influence driving culture—perhaps the most powerful influence on traffic safety

Breakdowns in multi-driver compensatory processes

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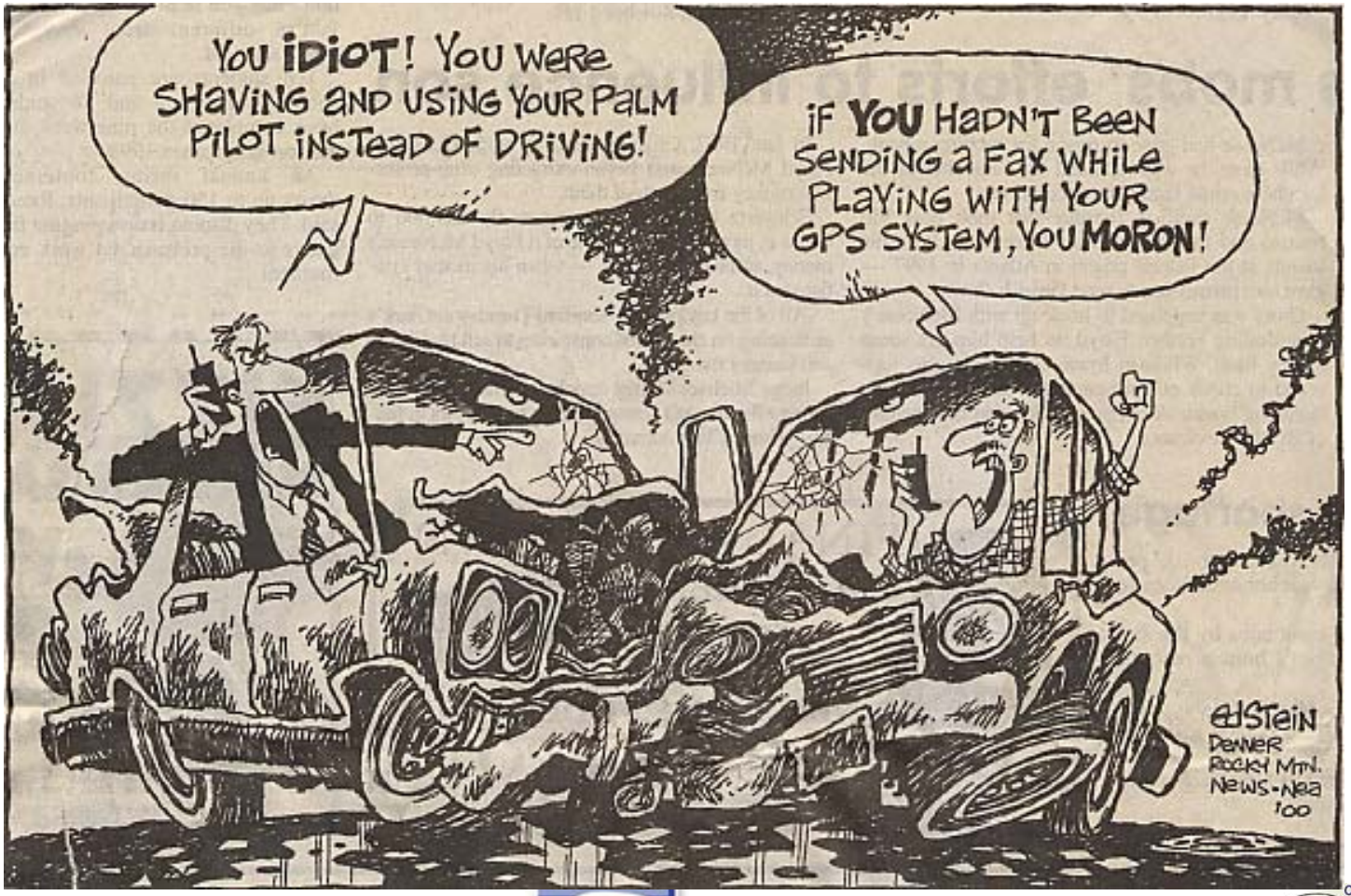

Towards a AVST/Driver Cyborg
Research and Implementation Implications

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Conception of the driver AVST relationship drives:

- Interface design
- System architecture
- Standardization
- Benefits analysis

More information:
http://www.engineering.uiowa.edu/~csl/

What would a collision avoidance system be like without a warning?

Select references

Challenges & Opportunities

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Research & Implementation Implications

- Ho, C., Tan, H. Z., & Spence, C. (2005). Using spatial vibrotactile cues to direct visual attention in driving scenes. *Transportation Research Part F: Traffic Psychology and Behaviour, 8*, 397-412.
- Lee, J. D., McGehee, D. V., Brown, T. L., & Marshall, D. C. (In press). Effects of adaptive cruise control and alert modality on driver performance. *Transportation Research Record*.
- Wiese, E. E., & Lee, J. D. (In press). Attention grounding: A new approach to IVIS implementation. *Theoretical Issues in Ergonomics Science*.
- Wiese, E. E., & Lee, J. D. (2004). Effects of multiple auditory alerts for in-vehicle information systems on driver attitudes and performance. *Ergonomics, 9*, 965-986.
- Marshall, D. C., Lee, J. D., & Austria, P. A. (In press). Alerts for in-vehicle information systems: Annoyance, urgency, and appropriateness. *Human Factors*.
- Lee, J. D., & See, K. A. (2004). Trust in technology: Designing for appropriate reliance. *Human Factors, 46*(1), 50-80.
- Seppelt, B. D. (2007). Making the limits of adaptive cruise control visible. *International Journal of Human-Computer Studies, 65*(3), 183-272.
- Lee, J. D., Hoffman, J. D., Stoner, H. A., Seppelt, B. D., & Brown, M. D. (2006). Application of ecological interface design to driver support systems. *International Ergonomics Association Conference*.
- Moeckli, J., & Lee, J. D. (In press). The making of driving cultures. In *AAA Compendium on Driving Culture*.