The Promise and Challenges of Transportation Cyber-Physical Systems

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Transportation Accidents

- Trains
  - Metro in DC
  - Spain train accident
  - Brooklyn train accident
  - Positive Train Control?
- Planes
  - Asiana plane crash
  - Planes landing at wrong airports or sleeping past the right airport
- Automobiles
  - 1.2 million die every year

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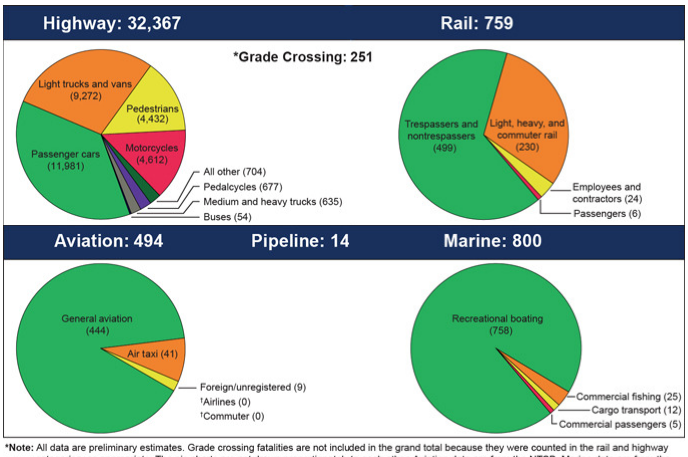
Aggregate US Statistics

- 34,434 Transportation Fatalities In 2011



*Note: All data are preliminary estimates. Grade crossing fatalities are not included in the grand total because they were counted in the rail and highway categories, as appropriate. The pie charts are not drawn proportionately to each other. Aviation data are from the NTSB. Marine data are from the Department of Homeland Security. All other data are from the U.S. Department of Transportation.

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The Potential

- Zero crashes, injuries and fatalities
- Fewer traffic delays and higher throughput
- Increased mobility for the elderly and the disabled
- Less pollution and higher mileage
- Higher quality of life

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Challenges

- Basic Science
- Connectivity
- Automation
- Smart Cities
- Security and Privacy
- Technical Challenges

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Scientific Challenges

- A Theory of Uncertainty for CPS
  - Specialized for transportation uncertainties
  - Correct by construction?
- Verification and validation
  - given an arbitrarily large # of real-world conditions
- Hybrid systems control
  - lateral and longitudinal control
- "ilities":
  - Scalability, dependability, timeliness, maintainability, affordability, … all together.
- Abstractions for spatio-temporal constraints and multiple time-scales

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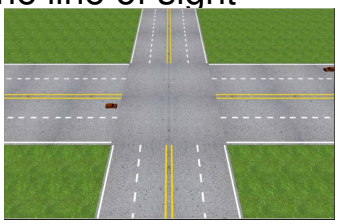
Connectivity Challenges

- Extending sensing beyond the line of sight
- < 100% market penetration
- Vehicles and safety apps
- Pedestrians at crosswalks
- Bicyclists: buffers
- Smarter infrastructure: lights and signs
- Protocols for intersections and grade crossings
- Encryption and certificate revocation



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Automation Challenges

- Exogenous: What happens when GPS is not available, or corrupted? Road, lighting and weather conditions
- Endogenous: What happens when sensors report bad data?
- HMI: What is the role of the human driver?
- Connectivity: Does connected automation help or hurt?
- Correctness: How do we deal with unlimited and special scenarios safely?
- Decision making: How does the CPS choose among bad alternatives when push comes to shove?

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Smart Cities

Transportation is at the core of Smart Cities

- Harmonizing speeds
- Minimizing bus/car collisions with pedestrians
- Managing grade crossings
- Dealing with failures in convoys
- Closing the loop with mobility analytics
  - Metropolitan-scale traffic management
- Improving throughput with adaptive traffic lights
- Interacting with urban design, road design, parking garages

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Security and Privacy

- How do we prevent malicious takeover of intelligent transportation systems?
- How should the system in motion deal with intrusions when detected?
- How do we prevent unauthorized access to privacy information?
  - While allowing access under emergency conditions?

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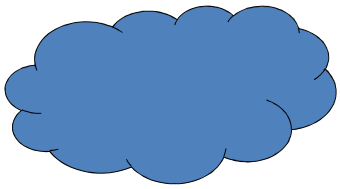
Technical Challenges

- Clouds and cloudlets for transportation CPS
- “Environment in the loop” testing
- Testbeds
- New technologies like LTE Direct



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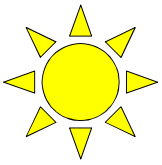
Summary

- Too many accidents, injuries and fatalities
- High promise for Transportation CPS
- Host of challenges
- This workshop is a step towards looking at a research roadmap for the future



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The Next Generations

- Next-gen aviation
- Connected automation
  - Vehicle connectivity mandate?
- Positive Train Control?
- Over-conditioning Syndrome
  - Human is no longer ready to take over

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