Connected and Automated Vehicle Systems: State of the Art and TRB Activities

TRB Annual Meeting

January 2015

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Traditional transportation technologies have matured to the point of diminishing returns

Intelligent transportation systems (ITS) have been developing gradually for the last 25 years

- –Infrastructure (Roads, Signals, Signs, Tolling)
- –Vehicle systems (Sensors, Communications)

Automation overcomes driver limitations

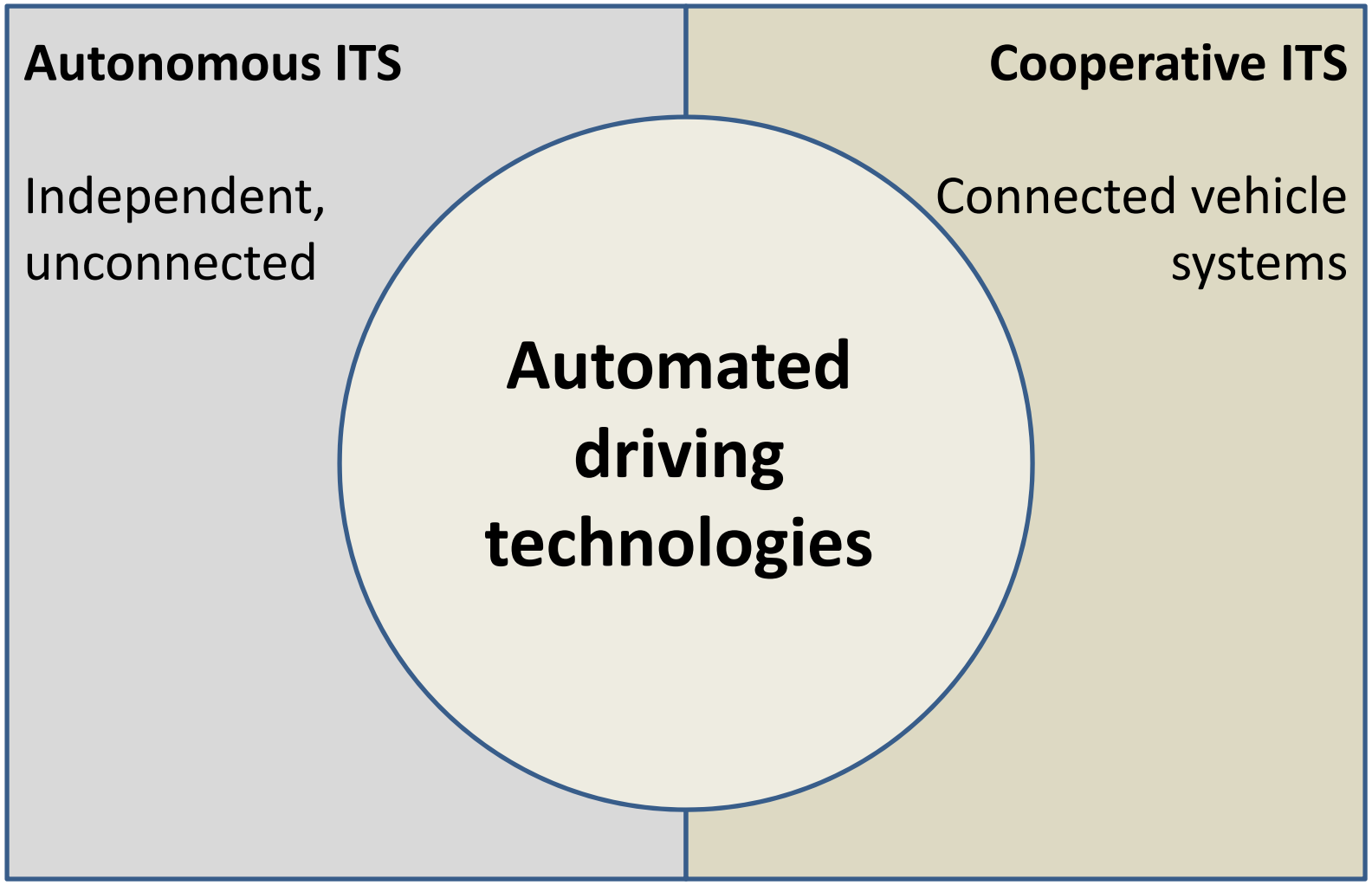
Connectivity integrates vehicles and roadways into an intelligent transportation system

Automation; a tool for solving transportation problems

- Alleviating congestion
  - Increase capacity of roadway infrastructure
  - Improve traffic flow
- Reduce energy use and emissions
  - Aerodynamic “drafting”
  - Improve traffic flow (signal phase and timing)
- Improve safety
  - Reduce and mitigate crashes
    - Fatal crash MTBF > 3 million vehicle hours
    - Injury crash MTBF > 65,000 vehicle hours

SAE automation levels

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*	
***Human driver* monitors the driving environment**							
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a	
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes	Adaptive cruise control OR Lane keeping assist
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes	Adaptive cruise control AND Lane keeping assist
***Automated driving system* ("system") monitors the driving environment**							
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes	Traffic jam pilot Automated parking
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes	Highway driving pilot Closed campus driverless shuttle Driverless valet
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**	Automated taxi Car share repositioning


Autonomous ITS
Independent, unconnected
Cooperative ITS
Connected vehicle systems
Automated driving technologies

Autonomous Driving

Pros

–Significant interest motivated by DARPA challenges and Google publicity.

–Minimal reliance on infrastructure or other vehicles.

–Reduced privacy concerns

–Reduced cyber security issues

–Benefit not dependent on market penetration/adoption.

Cons

–Limited information regarding vehicle state to infrastructure.

–Limited information regarding other vehicle states.

–Limited information regarding traffic, road and weather conditions.

–Significant hype and misinformation, compounded by misleading vocabulary

- –“Driverless”
- –“Self-driving”
- –“Autonomous”

Connected Driving

Pros

–Better information regarding vehicle state to infrastructure operators.

–Better information regarding vehicle state to other vehicles and drivers.

–Better information and guidance about traffic, road, and weather conditions.

Cons

–Reliance on infrastructure or other vehicles. Significant infrastructure cost.

–Privacy concerns

–Cyber security issues

–Benefit dependent on market penetration/adoption

–Significant hype and misinformation

- –"V2V crash avoidance technology has game-changing potential. . ."
- –"Research into the overwhelming safety benefits provided by a connected vehicle environment."

Automated vehicle symposia - History

- 125 participants
- Educated transportation community on recent progress in automation research, especially activities outside the U.S.
- Co-sponsored by 5 TRB committees

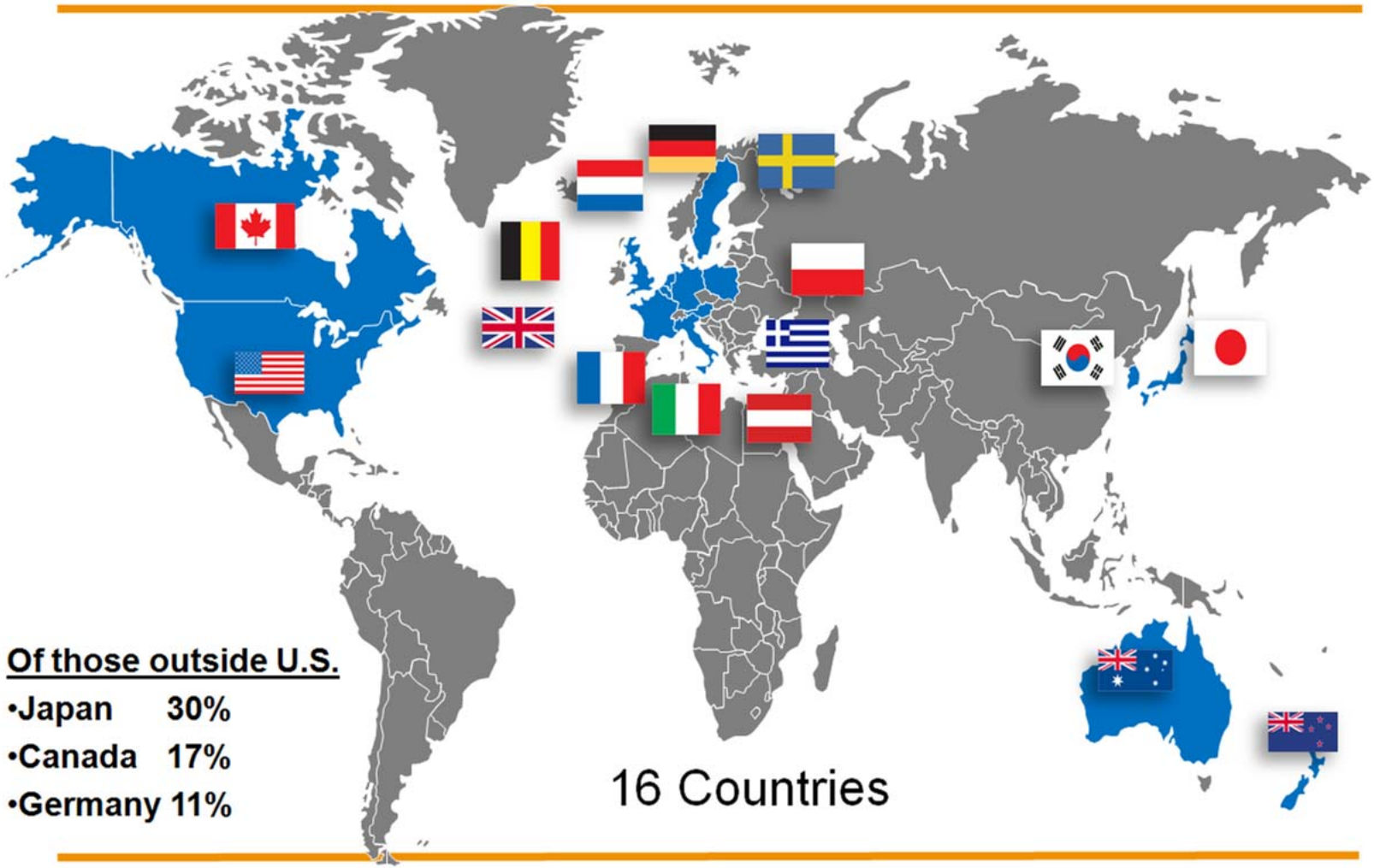
- 335 participants
- Hosted by Stanford University
- Focused on challenges and opportunities for road vehicle automation
- Resulted in 40+ research needs statements
- Co-sponsored by 7 TRB committees

- 572 participants
  - 44% industry
  - 34% acad/research
  - 22% government
  - (25% international)
- Produced in partnership with AUVSI
- Details in following slides

TRB Sponsoring Committees (2012 – 2014)

–Intelligent transportation systems | AHB15
–Vehicle – Highway automation | AHB30
–Emerging technology law | AL040
–Major activity center circulation systems | AP040
–Emerging & innovative public transportation & technologies| AP020
–Vehicle user characteristics | AND10
–Cyber security | ABE40(70)
–Transportation energy | ADC70
–Managed lanes | AHB35
–Travel analysis methods | ADB00 (2014)
–Transportation demand forecasting | ADB40 (2014)
–Statewide multimodal transportation planning | ADA10 (2014)

AVS 2014 International Attendees



AVS 2014 Plenary Sessions

Plenary Day 1

Opening Keynote:
Ralph Herrtwich, Daimler AG

Manufacturer and Supplier Briefings:
Bosch, BMW Group, Nissan Research Center

Digital Infrastructure Panel:
Nokia HERE, Google

Technology Issues Panel:
VisLab, Technical University of Crete, Carnegie Mellon University, MIT

Plenary Day 2

Clifford Nass Memorial Lecture:
Don Norman, UCSD

Manufacturer and Supplier Briefings:
GM, Continental, Valeo, Google

European Automation Projects:
CityMobil2, AdaptIVe, Drive Me (Volvo)

Societal and Non-Technical Issues and Challenges Panel:
Texas A&M, Stanford, Toyota Research, J.D. Power

Plenary Day 3

Public Sector Addresses:

U.S. Department of Transportation

National Highway Traffic Safety Administration

U.S. Department of Energy

European Commission

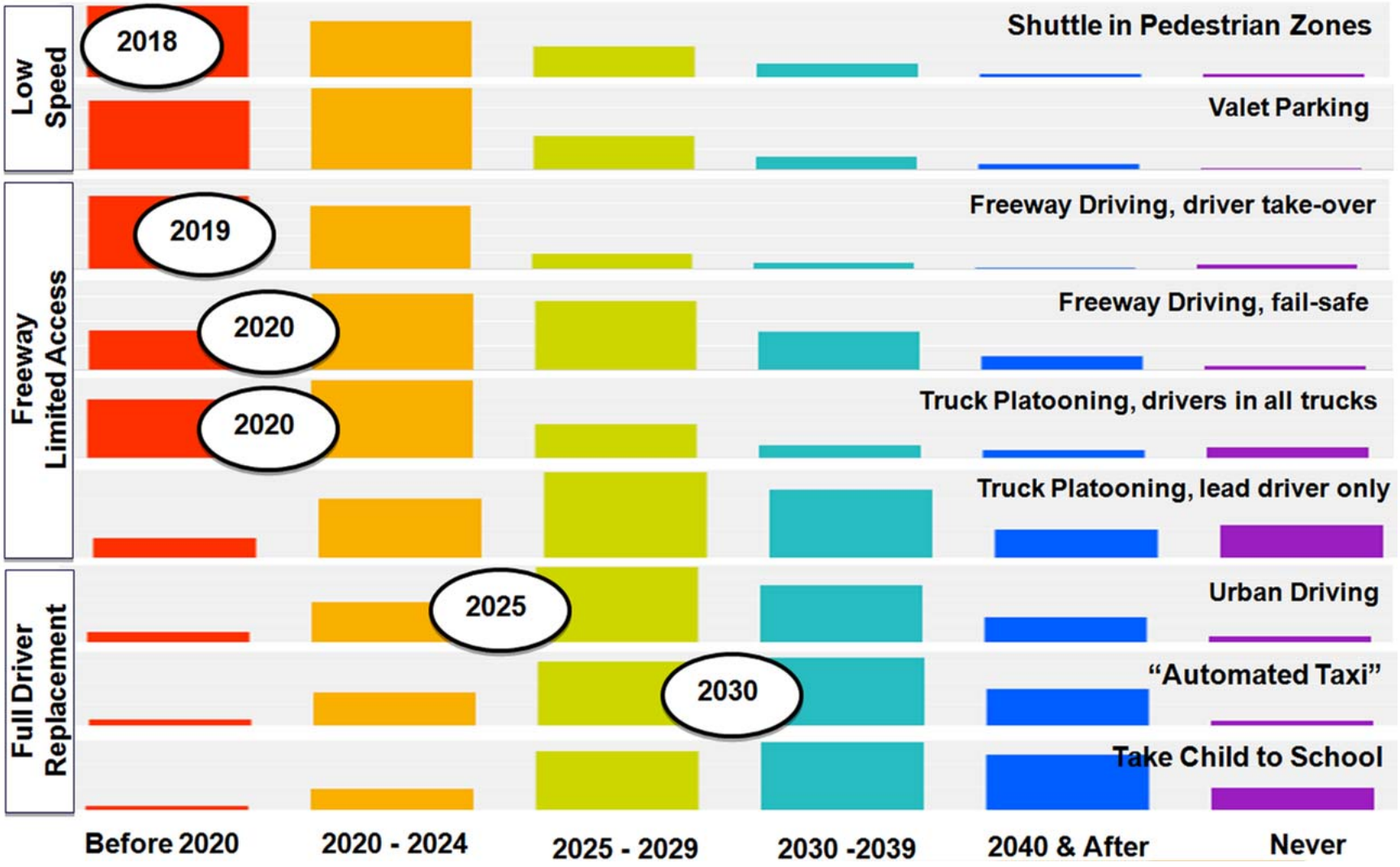
Japan Ministry of Land, Infrastructure, Transportation, and Tourism

California DMV

AVS 2014 Breakout Sessions

1. Evolutionary and Revolutionary Pathways to Automated Transit and Shared Mobility
2. Regional Planning and Modeling Implications of Driverless Cars
3. Roadway Management and Operations with Automated Vehicles
4. Truck Automation Opportunities
5. Legal Accelerators and Brakes
6. The State and Future Direction of Automated-Vehicle Human Factors
7. Near-Term Connected/Automated Technology Deployment Opportunities
8. Personal Vehicle Automation Commercialization
9. Technology Roadmap, Maturity and Performance: Operational Requirements for Vehicle-Road Automation Systems and Components
10. Road Infrastructure Needs of Connected-Automated Vehicles

Survey of Attendees – Market Introduction



Planning for AVS 2015: July 21-23, Ann Arbor

Challenges and opportunities of road vehicle automation (Joint subcommittee of AHB30, AHB15)

Thursday 15 January, 8:00 – 12:00, Convention Center, Salon C

–Subcommittee created to cut across all TRB technical committees, with the mission of producing workshops/symposia
–Planning starts Thursday: Ideas discussed, break-out topics and volunteers identified
–Participation open to all volunteers

Contact info

- **Automated Vehicles Symposium 2014 proceedings at:**
  http://www.auvsi.org/avs2014/proceedings
- **Automated Vehicles Symposium 2015:**
  http://www.automatedvehiclessymposium.org/home

- **Jane Lappin, AHB15 Chair (Volpe Center):**
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AUTOMATED VEHICLES SYMPOSIUM 2015

DRIVERS. VEHICLES. INFRASTRUCTURE.

SYMPOSIUM: JULY 21-23, 2015
ANCILLARY MEETINGS: JULY 20 and 24, 2015
University of Michigan | Ann Arbor, Michigan | USA

AUVSI TRB

MOBILITY TRANSFORMATION CENTER

HOME

www.automatedvehiclessymposium.org

SAVE THE DATE

The Automated Vehicles Symposium 2015 will be a multidisciplinary forum designed to advance the deployment of automated vehicles. Each day will kick off with high-level presentations by some of the brightest minds in the field. Network over lunch, and then in the afternoon, choose from interactive breakout sessions where you can go in-depth with your colleagues, share perspectives and have an open dialogue on the industry's most pressing issues.

HIGH-LEVEL PRESENTATIONS

INTERACTIVE BREAKOUT SESSIONS

NETWORKING OPPORTUNITIES