

# Automated Vehicles and Infrastructure Planning/Policy

Chandra R. Bhat\* and Ram M. Pendyala\*\*

\* Center for Transportation Research, The University of Texas at Austin

\*\* Arizona State University, Tempe, AZ



Presentation at the Florida Automated Vehicle Summit, Tampa, Florida, Nov. 14,  
2013

# Presentation Overview







- 1 Motivation
- 2 Automated Vehicle Technology
- 3 Infrastructure Planning
- 4 Traveler Behavior Considerations
- 5 The Bottom Line

# Motivation

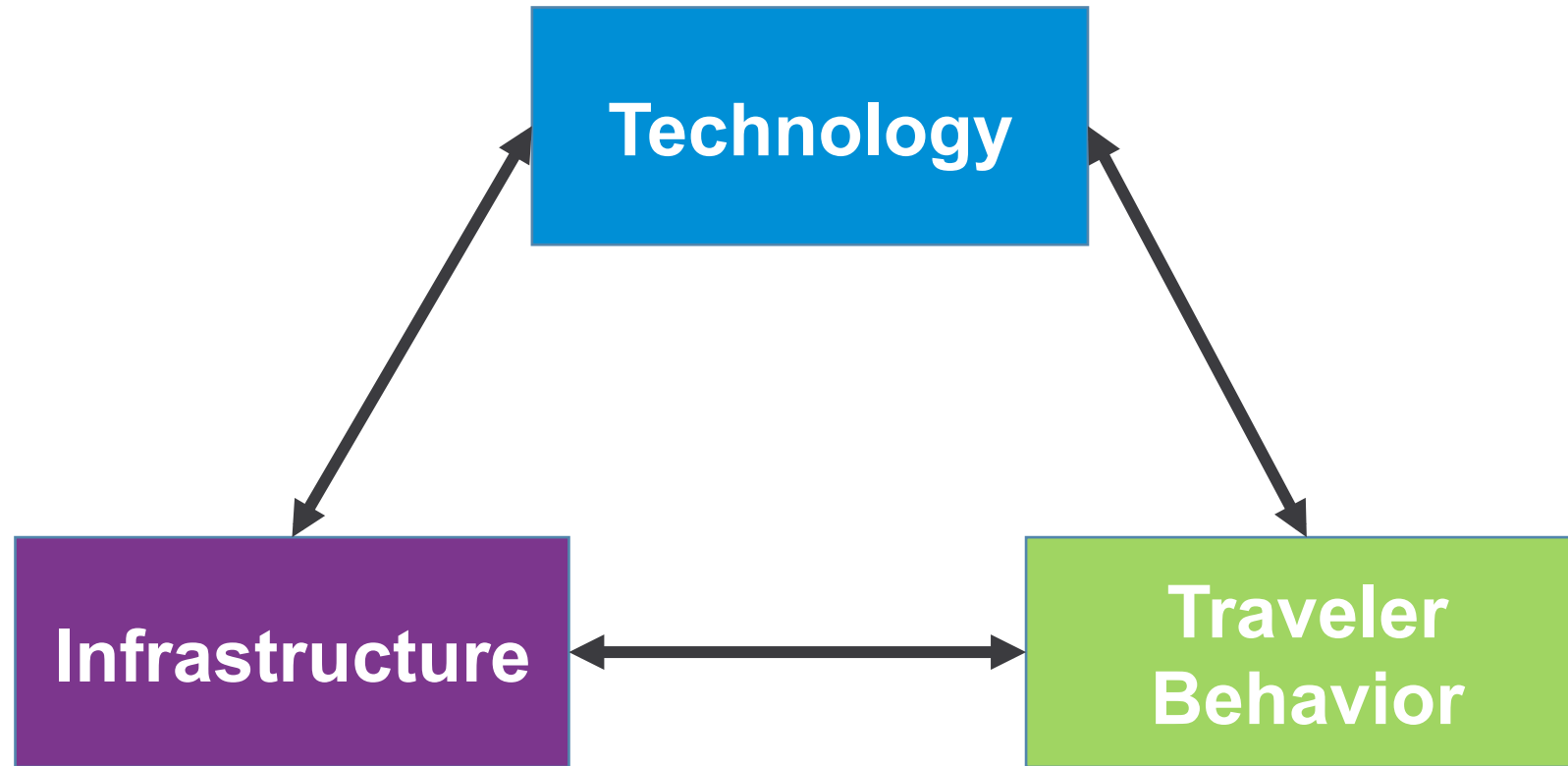
# The Context

- ❑ **Automated Vehicles:** Vehicles that are able to guide themselves from an origin point to a destination point desired by the individual
  
- ❑ Individual yields near-full or partial control to artificial intelligence technology
  - Individual decides an activity-travel plan (or tour-specific information)
  - The plan is keyed into the car's intelligence system
  - The car (or an external entity connected to the car) decides on a routing and circuit to complete the plan
  
- ❑ User will still retain some control (even during a single trip)
  - Possibility of changing her/his activity plan enroute
  
- ❑ Individual may make more “on-the-fly” decisions regarding her/his daily activity-travel pattern

# Motivation for Automated Driving

1	<i>Zero Emission</i>	<ul style="list-style-type: none"><li>- Optimization of traffic flow management</li><li>- Reduction of fuel cons. and CO2 emission</li></ul>	
2	<i>Demographic change</i>	<ul style="list-style-type: none"><li>- Support unconfident drivers</li><li>- Enhance mobility for elderly people</li></ul>	
3	<i>Vision Zero</i>	<ul style="list-style-type: none"><li>- Potential for more driver support by avoidance of human driving errors</li></ul>	
4	<i>Increasing traffic density</i>	<ul style="list-style-type: none"><li>- Optimization of traffic flow management</li><li>- Convenient, time efficient driving via automation</li></ul>	
5	<i>Economy</i>	<ul style="list-style-type: none"><li>- Ensure unique selling proposition</li><li>- Attractive products by technological leadership</li></ul>	
6	<i>Maturity of driver assistance systems</i>	<ul style="list-style-type: none"><li>- Sensors are approved and cost-effective</li><li>- Actuators (steering, ...) in series production</li></ul>	

# Automated Vehicles and Transportation



# Automated Vehicle Technology

# Two Broad Types

## Autonomous (Self-Driving Car)



Artificial Intelligence is:

- completely located within the vehicle
- “outward-facing” in that sensors blast outward from the vehicle to collect information without receiving data inward from other sources
- used to make autonomous decisions on what is best for the individual driver
- not shared with other entities beyond the vehicle
- “Capitalistic” set-up

## Connected Vehicle



Artificial Intelligence is:

- wirelessly connected to an external communications network
- “inward-facing” with the vehicle receiving external environment information through wireless connectivity, and operational commands from an external entity
- used in cooperation with other pieces of information to make decisions on what is “best” from a system optimal standpoint
- shared across multiple vehicles
- “Socialistic” set-up



# Autonomous (Self-Driving) Vehicle



- ❑ Google cars have successfully driven 500,000 miles
- ❑ Set 2018 as expected release date for self-driving car

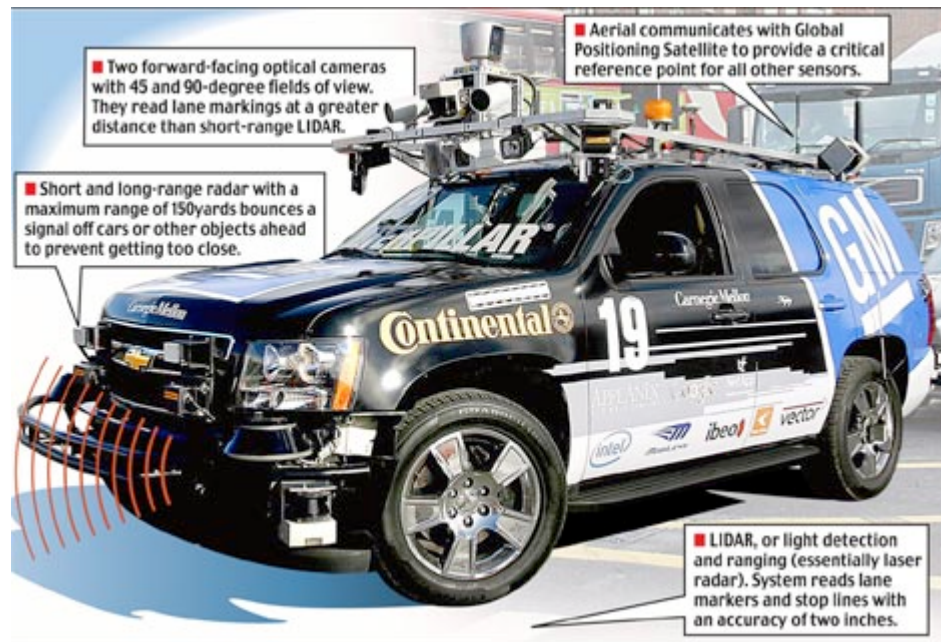
*Sight to behold: a blind man behind wheel of self-driving car*  
Google self-driving car takes legally blind man over 'carefully programmed route'

# Autonomous (Self-Driving) Vehicle

Elon Musk: Tesla's driverless car will be street-ready in three years

Tesla raises the stakes with a bold about driverless cars.

**Volvo plans self-driving cars in 2014, envisions accident-free fleet by 2020**

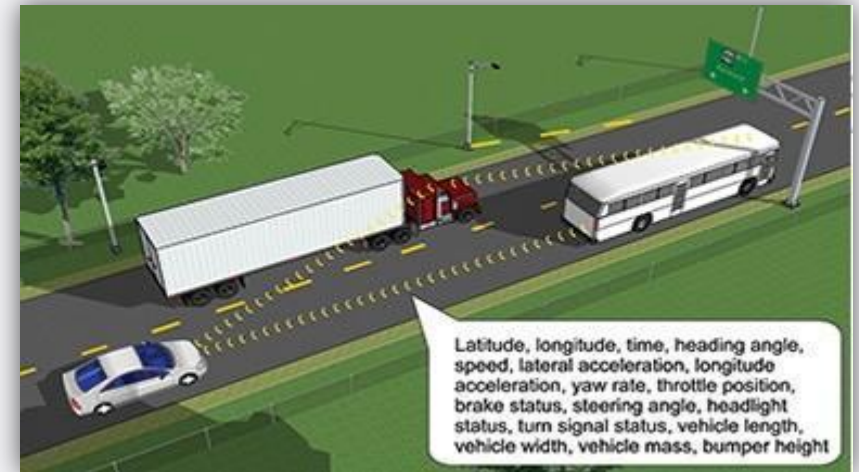


**Nissan Sets Goal of Introducing First Self-Driving Cars by 2020**

# Connected Vehicle Research

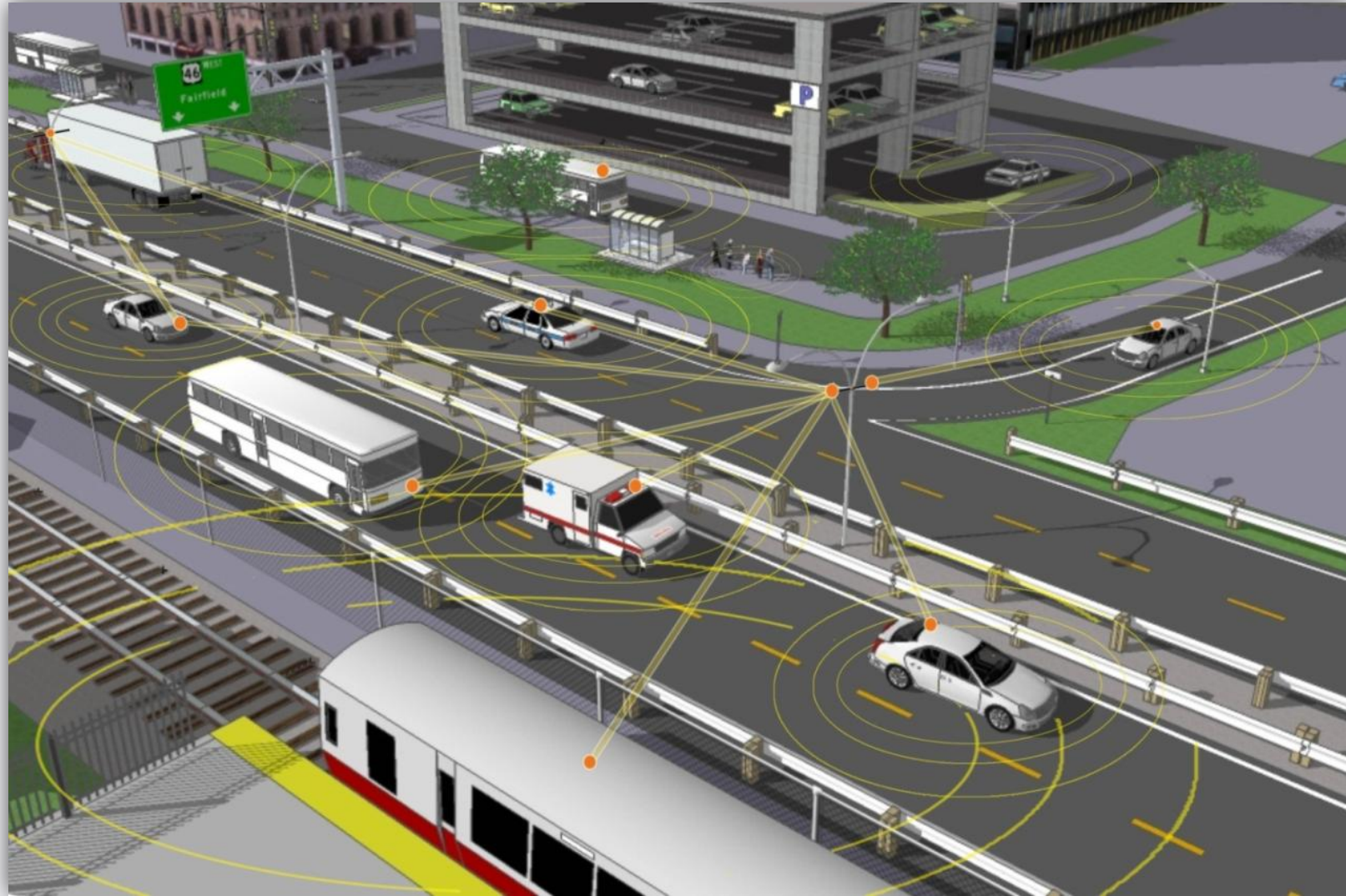
Connected vehicle research addresses a suite of technologies and applications that use wireless communications to provide connectivity:

- ❑ Among vehicles of all types
- ❑ Among vehicles and a variety of roadway infrastructures
- ❑ Among vehicles, infrastructure, and wireless consumer devices



An initiative of the USDOT  
Intelligent Transportation Systems Joint Program Office

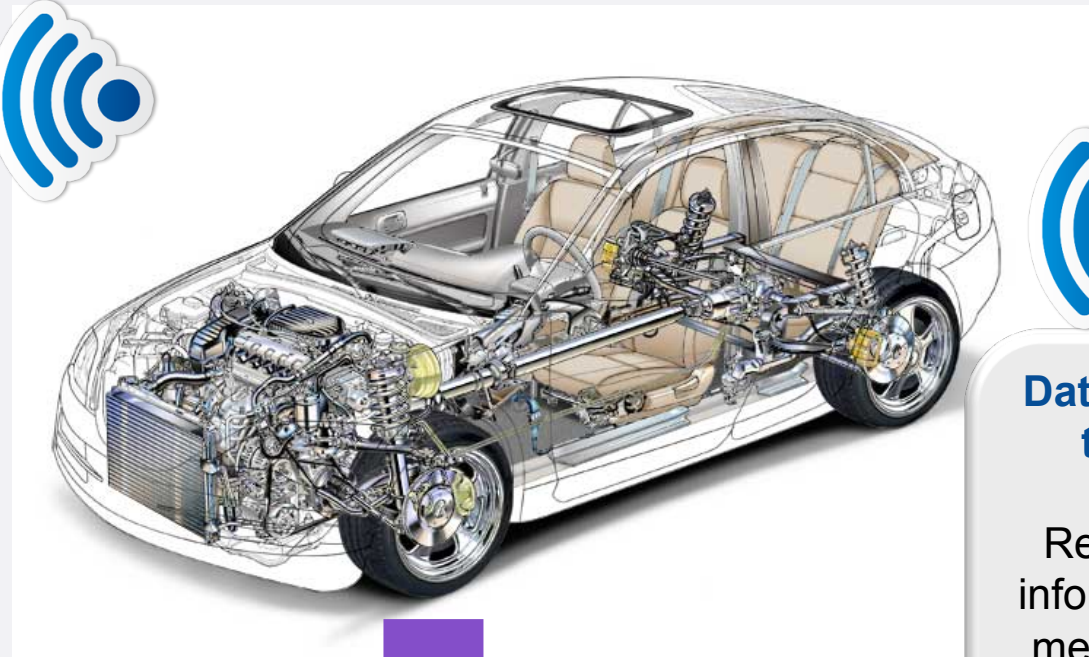
# Connected Vehicle Research



# A “Connected” Vehicle

## Data Sent from the Vehicle

Real-time location, speed, acceleration, emissions, fuel consumption, and vehicle diagnostics data



## Data Provided to the Vehicle

Real-time traffic information, safety messages, traffic signal messages, eco-speed limits, eco-routes, parking information, etc.

## Improved Powertrain

More fuel efficient powertrain including; hybrids, electric vehicles, and other alternative power sources



Source: *USDOT*

# Levels of Vehicle Automation

- ❑ Level 0: No automation
- ❑ Level 1: Function-specific Automation
  - Automation of specific control functions, e.g., cruise control
- ❑ Level 2: Combined Function Automation
  - Automation of multiple and integrated control functions, e.g., adaptive cruise control with lane centering
- ❑ Level 3: Limited Self-Driving Automation
  - Drivers can cede safety-critical functions; not expected to monitor roadway constantly
- ❑ Level 4: Full Self-Driving Automation
  - Vehicles perform all driving functions and can operate without human presence or intervention

# Government Recognition

- ❑ Several states in the US passed legislative initiatives to allow self-driving cars to navigate roadways
  - California, Nevada, and Florida
- ❑ National Highway Traffic and Safety Administration Policy Statement
  - Policy guidance on licensing, safety, testing
- ❑ Autopilot Systems Council in Japan
- ❑ Citymobil2 initiative in Europe



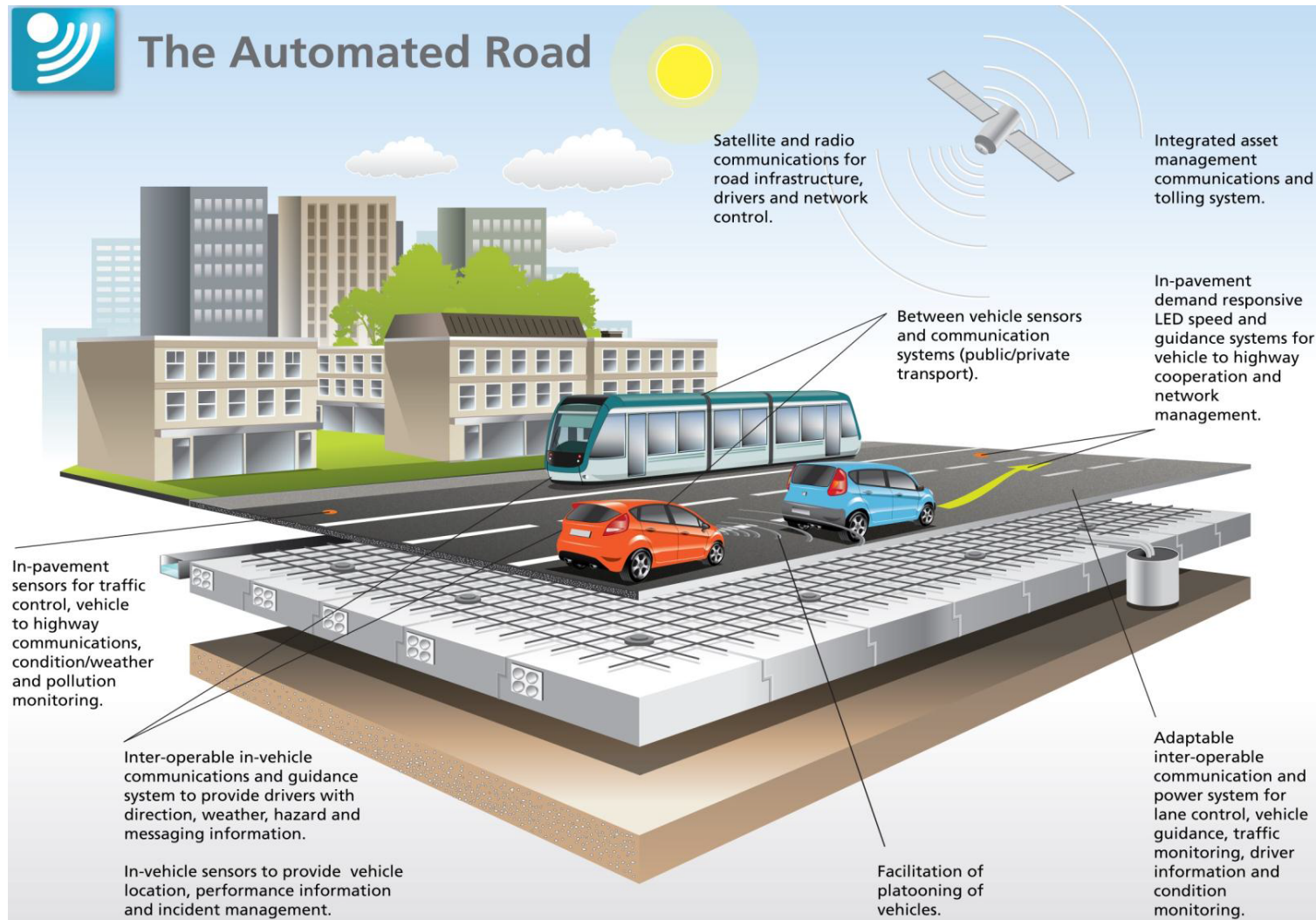
# Infrastructure Planning



# Infrastructure Needs/Planning Driven by...

- ❑ Potentially increasingly complex activity-travel patterns
- ❑ Growth in long distance travel demand
- ❑ Limited availability of land to dedicate to transport infrastructure
- ❑ Budget/fiscal constraints
- ❑ Energy and environmental concerns
- ❑ ICT and mobile processing platform advances

# Smarter Infrastructure



Source: <http://www.foreveropenroad.eu/>

❑ Technology and infrastructure combination can lead to many benefits

❑ Potential safety enhancements

- Virtual elimination of driver error (primary factor in 80 percent of crashes)
- Enhanced vehicle control, positioning, spacing, and speed harmonization
- How about offsetting behavior on part of drivers? Need to eliminate possibility of offsetting behavior...
- No drowsy drivers, impaired drivers, stressed drivers, or aggressive drivers
- Reduced number of incidents and network disruptions

## ❑ Potential capacity enhancements

- Vehicle platooning greatly increases density (reduced headways) and improves flow at transitions
- Vehicle positioning (lateral control) allows reduced lane widths and utilization of shoulders; accurate mapping critical
- Optimization of route choice, passage through intersections, and navigation through and around work zones

## ❑ Potential energy and environmental benefits

- Increased fuel efficiency and reduced pollutant emissions through vehicle operation improvement
- Clean-fuel vehicles
- Car-sharing provides additional benefits

But Let's Not Forget  
Traveler Behavior  
Issues!

# Impacts on Land-Use Patterns

- ❑ Live and work farther away
  - Use travel time productively
  - Access more desirable and higher paying job
  - Attend better school/college
  
- ❑ Visit destinations farther away
  - Access more desirable destinations for various activities
  - Reduced impact of distances and time on activity participation
  
- ❑ Influence on developers
  - Sprawled cities?
  - Impacts on community/regional planning and urban design



# Impacts on Household Vehicle Fleet

- Potential to redefine vehicle ownership
  - No longer own personal vehicles; move toward car sharing enterprise where rental vehicles come to traveler
  
- More efficient vehicle ownership and sharing scheme may reduce the need for additional infrastructure
  - Reduced demand for parking
  
- Desire to work and be productive in vehicle
  - More use personal vehicle for long distance travel
  - Purchase **large** multi-purpose vehicle with amenities to work and play in vehicle

# Impacts on Household Vehicle Fleets





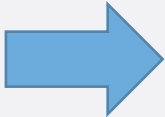
# Impacts on Mode Choice

**Automated vehicles** combine the advantages of **public transportation** with that of **traditional private vehicles**

- Flexibility
- Comfort
- Convenience
- Catching up on news
- Texting friends
- Reading novels

What will happen to **public transportation**?

Also Automated vehicles may result in lesser walking and bicycling shares

**Time** less of a consideration 

**So, will Cost** be the main policy tool to influence behavior?

# Impacts on Mode Choice

- ❑ Driving personal vehicle more convenient and safe
- ❑ Finding parking space no longer onerous
- ❑ Traditional transit captive market segments now able to use auto (e.g., elderly, disabled)
- ❑ Reduced reliance/usage of public transit?
- ❑ However, autonomous vehicles may present an opportunity for public transit
  - Reliable transit service
  - Lower cost of operation (driverless)
  - More personalized service - smaller vehicles providing demand-responsive transit service

# Impacts on Long Distance Travel

- ❑ Less incentive to use public transportation?
- ❑ Should we even be investing in high capital high-speed rail systems?
  - Individuals can travel and sleep in driverless cars
  - Individuals may travel mostly in the night
  - Speed difference?



# Impacts on Commercial Vehicle Operations

- ❑ Enhanced efficiency of commercial vehicle operations
- ❑ Driverless vehicles operating during off-peak and night hours reducing congestion
- ❑ Reduced need for infrastructure



# Diffusion Effects

- ❑ Uncertainty in pace of technology availability, affordability, and adoption (market penetration rate)
- ❑ Will automated vehicles completely replace individual-driven vehicles?
- ❑ Need for mixed vehicle operations for considerable amount of time
- ❑ Infrastructure that accommodates both manual and automated vehicles
- ❑ Intelligent infrastructure with dedicated lanes for driverless cars
  - ❑ Managed lanes offer opportunity to accommodate self-driving vehicles (dedicated technology-equipped lanes)

# The Bottom Line

# The Bottom Line

- Uncertainty, Uncertainty, Uncertainty
- More uncertainty implies more need for planning
- But planning must recognize the uncertainty (need a change in current thinking and philosophy)
- Conduct studies to understand possible behavioral responses and develop scenarios
- Will policy tool primarily be cost-based?

# Thank You

