The Role of Vehicle Automation and Intelligent Transportation Systems in Sustainable Transportation

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Charley’s Cars

1926 Ford
1936 Pontiac
1948 Ford convertible
1950 Pontiac
1958 VW Bug
1958 Austin Healey
1962 Ford Falcon
1964 Jeep Wagoneer
1968 Pontiac Catalina
1971 Chevy Blazer
1973 Opel Manta
1978 Pontiac Grand Am
1979 VW Sirocco
1983 BMW 318
1994 Chevy Truck
2000 Audi A6
2003 BMW X3
Too much of a good thing...

Mobility:

- personal mobility is an important part of a progressive society
- U.S.: the automobile has become essential element of life
- our mobility is often restricted due to limitations in transportation infrastructure

**Resource Management Problem:**
- if resources (transportation infrastructure) are limited and demand is high, congestion occurs → increased emissions
How do we minimize energy and emissions impacts from transportation?

• **Build cleaner, more efficient vehicles:**
  - make vehicles lighter (and smaller) while maintaining safety
  - improve powertrain efficiency
  - develop alternative technologies (e.g., electric vehicles, hybrids, fuel-cell)

• **Develop and use alternative fuels:**
  - Bio and synthetic fuels (cellulosic ethanol, biodiesel)
  - electricity

• **Decrease the total amount of driving: VMT reduction methods**
  - Better land use/transportation planning
  - Travel demand management

• **Improve transportation system efficiency**
  - **Intelligent Transportation System** (ITS) technologies
  - Connected Vehicles → Vehicle Automation
Key ITS Research Areas with Energy/Emissions Impacts

**Advanced Vehicle Control and Safety Systems: Vehicles**
- Longitudinal and Lateral Collision Avoidance
- Intersection Collision Avoidance
- Adaptive Cruise Control, Intelligent Speed Adaptation
- Automated Vehicles and Roadway Systems

**Advanced Transportation Management Systems: Systems**
- Traffic Monitoring and Management
- Corridor Management
- Incident Management
- Demand Management and Operations

**Advanced Transportation Information Systems: Behavior**
- Route Guidance
- En-Route Driver Information
- Traveler Service Information → connection to Transit
- Electronic Payment Services → variable pricing

- indirect versus direct energy/emissions savings
**Connected Vehicles:** providing better interaction between vehicles and between vehicles and infrastructure

- increased **Safety**
- better **Mobility**
- lower **Environment impact**
Eco-Approach and Departure at Signalized Intersections

Vehicle Equipped with the Eco-Approach and Departure at Signalized Intersections Application (CACC capabilities optional)

V2I Communications: SPaT and GID Messages

V2V Communications: Basic Safety Messages

Roadside Equipment Unit

Traffic Signal Controller with SPaT Interface

Traffic Signal Head

Source: Noblis, November 2013
Simulation Modeling…

baseline

deco approach & departure
• Cycle length of 60 sec (26 green, 4 yellow, 30 red)
• The vehicle approached the intersection when the light was red. The application guided the driver to slow down early and cruise pass the intersection when the light turned green, avoiding a full stop.

Typical fuel saved: 15%  20% savings with automation…
Real-World Experimentation:
Eco-Approach & Departure Example Run
Cooperative Adaptive Cruise Control applied to Intersections

Baseline: typical queuing

Arterial CACC Baseline
High Volume (800 vphpl)

CACC: ~17% less energy & emissions

Arterial CACC
High Volume (800 vphpl)
Different Intersection Management Systems

Stop signs

Traffic light

Intersection reservation system with automated connected vehicles

Source: David Kari, UCR, 2014
Intelligent Transportation Systems Take Away Points:

• ITS goals and strategies of improving safety and improving traffic performance (i.e. mobility) often reduce energy consumption and CO₂ emissions as a side benefit.

• Dedicated ITS strategies and systems can be designed to explicitly reduce energy consumption and CO₂ emissions: U.S. AERIS, Japan Energy ITS, EU EcoMove.

• Each ITS strategy can potentially reduce CO₂ emissions by approximately 5 – 15%; however with multiple strategies, greater savings can be achieved (ignoring induced demand).
Automation Take Away Points:

- Partial and full automation can provide better energy & emission results compared to human-machine interfaces, depending on design of control system.
- With automation, system design trade-offs will exist between safety, mobility, and the environment (e.g., automated maneuvers).
- Connected automated vehicles will likely have greater improvements in mobility and environment compared to autonomous vehicles.
- Potential induced demand effects: vehicle automation will likely increase travel demand so it may be necessary to also consider travel demand management techniques.