Connected/Automated Vehicles (CAVs) and DOE

Jacob Ward
Program Manager, Analysis
Vehicle Technologies Office
Energy Efficiency and Renewable Energy
U.S. Department of Energy (DOE)

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Perspective: CAVs in a DOE Context

**DOE mission**
The mission of the Energy Department is to ensure America’s security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions.

**VTO mission**
The U.S. Department of Energy's Vehicle Technologies Office develops and deploys efficient and environmentally friendly highway transportation technologies that will enable America to use less petroleum. These technologies will provide Americans with greater freedom of mobility and energy security, while lowering costs and reducing impacts on the environment.

CAVs in context:
- greater mobility
- lower cost
- enviro-friendly
- energy security
National goals & Standards

- Reduce GHG emissions in the range of 17% by 2020 *
- Reduce net oil imports by 50% by 2020 *
- Achieve CAFE Standards 54.5 mpg by 2025

*Major Administration Goals
EERE Existing Capabilities: Current RDD&D Focus

• EERE is DOE’s primary applied research office
• Research, Development, Demonstration, and Deployment
  – Vehicle Electrification
  – Materials Lightweighting
  – Advanced Combustion
  – Drop-in Biofuels
  – Fuel Cell Technology
  – Hydrogen Infrastructure
  – Deployment (e.g., Clean Cities)
  – Grid Systems Integration
Another Perspective: EERE in a CAV Context

1) Existing EERE Capabilities

2) Leveraging existing expertise for CAVs

3) Expanding expertise for future priorities

Collaboration
• Data infrastructure (hardware, software)
• Controls (diagnostics, sensor development)
• Systems modeling (vehicle testing, data collection and analysis)

Wealth of ongoing activity in the CAV space (U.S. DOT, private sector)
### Synergies and [DOE] Opportunities in Connected Mobility & Energy

<table>
<thead>
<tr>
<th>Existing Activities</th>
<th>Potential Outcomes</th>
</tr>
</thead>
</table>
| **Autonomy**        | • Efficient driving  
                      | • Platooning        
                      | • Assisted parking  |
| **Safety & Collision Avoidance** | • Reduced idling  
                              | • Significant light weighting  
                              | • Enhanced aerodynamics |
| **Multimodal Transportation** | • Lowest carbon trip planning  
                                  | • Automated carpooling |
| **V2X**             | • Vehicle-to-Vehicle (V2V)  
                      | • Traffic signal management (V2I)  
                      | • Grid system integration (V2G) |
| **Data as a Service** | • Big data analytics  
                          | • Efficient routing  
                          | • Optimizing corridor efficiency |

**can DOE contribute [efficiently/effectively]?**

**can outcomes affect DOE mission(s)?**
Researchers have performed *preliminary* estimations of some benefits.

**Examples of DOT/AERIS - *Estimations per Vehicle***

<table>
<thead>
<tr>
<th>Technology</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eco Approach &amp; Departure</td>
<td>• 5-10% fuel reduction for an uncoordinated corridor&lt;br&gt;• Up to 13% fuel reduction for a coordinated corridor</td>
</tr>
<tr>
<td>Eco-Traffic Signal Timing</td>
<td>• 5% fuel reduction when optimizing for the environment (e.g., CO2)&lt;br&gt;• 2% fuel reduction when optimizing for mobility (e.g., delay)</td>
</tr>
<tr>
<td>Eco-Traffic Signal Priority</td>
<td>• Eco-Transit Signal Priority provides up to 2% fuel reduction benefits for transit vehicles&lt;br&gt;• Eco-Freight Signal Priority provides up to 4% fuel reduction benefits for freight vehicles</td>
</tr>
</tbody>
</table>

The accelerated introduction of advanced vehicle technologies will allow for mobility optimization → *advanced technologies allow us to decouple energy from mobility*

While safety benefits can be extrapolated, **energy benefits cannot be generalized as they completely depend on the network and scenario**
Current State of Research & Expanding CAV Intersection(s)

**Complexity**

- **High**
  - DOE existing expertise:
    - Vehicle energy modeling and control
    - Vehicle design & technology
    - Market penetration
    - Energy benefits & GHG impact at National Level

- **Low**
  - NREL, ORNL, ITS America...

**Scale**

- **Single Vehicle**
- **Short sections (< 5 miles)**
- **Large sections (> 5 miles)**
- **Network**
- **Nation**

**Large Scale Traffic Flow Simulation**

**Capabilities to further develop (??):**
- Multi-disciplinary system integration
- Behavioral model(s)
- Others (?)

**Existing Studies**

**DOE Expertise**

**DOT Expertise**
## DOE Scope Under Consideration

### Scoping Criteria:
- Must have a direct or immediately indirect impact on DOE corporate objectives for reduced petroleum consumption and reduced GHG emissions
- Initial scoping using multi-lab expert opinion to drive foundational studies
- Foundational studies will drive prioritization of future research portfolios

<table>
<thead>
<tr>
<th>In-scope Activities</th>
<th>Out of Scope Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficient driving (i.e., smoother braking…) and routing (i.e. Eco-routing)</td>
<td>Safety</td>
</tr>
<tr>
<td>Powertrain and vehicle optimization (i.e., aero, light weighting, downsizing, control…)</td>
<td>Liability / Legal Issues</td>
</tr>
<tr>
<td>X2X connectivity (i.e., Eco-approach, Eco-routing, Eco-driving, Platooning…)</td>
<td>Human Machine Interface (HMI)</td>
</tr>
<tr>
<td>Effects on mobility (i.e., traffic patterns, flow) and driver behavior (i.e. VMT, mode shift…)</td>
<td></td>
</tr>
<tr>
<td>CAVs to grid interactions and cybersecurity</td>
<td></td>
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<tr>
<td>Interaction with built environment and urban form (i.e., car sharing…)</td>
<td></td>
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<tr>
<td>Business model innovations</td>
<td></td>
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</table>
Foundational studies estimate ranges of energy effects

Foundational studies convey energy effect uncertainty

- Energy impacts can be dramatic
  - Potential for large improvements in energy and fuel intensity
  - Increased use intensity may counteract

- Significant uncertainty exists
  - Total combined impacts from >90% savings to >150% increase in energy use—further research warranted
Current efforts inform expanding EERE expertise for future priorities

**Current EERE R&D Efforts** (Foundational studies, deeper research)

- DOE prioritizing CAV “layers” in which to participate
- Coordinating across agencies to leverage funding

**Possible Future Research**

- **Refine foundation studies** on energy impacts
  - Understanding and reducing uncertainties
  - Better system interaction modeling
  - Further energy-focused data collection and analysis
- **Increase collaboration**: engage with USDOT, UMTRI, RITA, NHTSA, ITS America, Non-Profits
- **Continue leveraging of existing expertise**
  - Hardware, software, physical & data infrastructure(s), cyber security
  - Diagnostics, controls, and sensor development
  - Systems modeling and vehicle testing
  - Data collection and analysis
R&D Efforts at the Nexus of Energy and Mobility

Leverage Existing Expertise

- Use Case/Policies
- Traffic Flow Model
- Hardware Evaluation
- Vehicle Energy Model
- Grid Integration
- Vehicle Ownership/Market Penetration

Regional & National [Energy, GHG, etc.] Benefits

Near Term (FY15-16): Conduct Foundational Studies on Potential Gains

1. **Hardware evaluation** to assess the benefits and provide inputs to the models
2. **Consider vehicle controls** expertise for Connected Vehicles context
3. **Leverage other existing tools, vehicles & High-Performance Computing** for Automated Vehicles

Longer Term (FY17 & beyond)

- **Follow CAV R&D Roadmap** addressing market introduction and technical barriers
- **Perform R&D** to mitigate the technical barriers (emphasize collaborations)
- **Deeper research** based on identified areas of opportunity (vehicle design and technologies)
Questions? Suggestions?

Jacob Ward
jacob.ward@ee.doe.gov
vehicles.energy.gov