Potential Synergies Between Managed Lanes and Automated Vehicle Operations

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Outline

• Managed lane attributes relevant to early use for automated vehicle operations

• Potential early use scenarios
  – I2V cooperative ACC for speed control
  – V2V cooperative ACC to increase lane capacity
  – Truck platoons in truck toll lanes
  – Transitways for buses, vanpools and carpools

• Cross-cutting topics for discussion
Relevant Managed Lane Attributes

- Separation from general mixed traffic
- Access based on communication capability (for electronic payments)
- Financing mechanism for construction (and operation and maintenance) of new lanes
- New business model of customer service
- Special cases that could be restricted to heavy vehicles (transitways or dedicated truck lanes)
Separation from General Traffic

- Maximize market penetration of equipped vehicles in the “special” lane (more V2V interaction opportunities)
  - *All* vehicles may have communication capability, to verify interactions
- With well-defined access and egress points, minimize interactions with general traffic to maximize safety
- Potential to simplify driving environment (minimize complicated traffic conditions)
If all vehicles can communicate...

• Gain performance benefits from V2V communication
  – Tighter car-following control
  – Damping shock waves (smoothness, energy, emissions)
  – Verification of maneuvers and safety

• Gain performance benefits from I2V communication
  – Variable speed advisories/targets to maximize flow
  – Merge coordination
  – Safety enhanced by ‘slow traffic ahead’ alerts
Electronic Payment for Financing

• Users pay directly for construction, O&M of lanes, relieving need for taxpayer support
• Automated vehicles, by using less roadway space through closer spacing, could get a substantial discount
  – Incentive to adopt and use automation
  – Aligns user interest with operator interest in maximizing throughput
• Roadway access could become a service business, with travelers as customers
  – Quality of service needed to justify payments
Customer Service Business Model

- Users pay for an enhanced transportation service (faster, smoother, less stressful…)
- Users “opt in” to use the facility/service
  - Analogy to mobile phones for privacy?
- Operational issues such as speeds and gap settings could be managed through financial incentives rather than law enforcement
Special Heavy Vehicle Lanes

- Special cases of managed lanes, based on specific local needs
- Exclusion of light-duty vehicles improves efficiency and safety

- Transitways to improve service for bus riders and operators
- Truck lanes to improve truck operational efficiency
Potential Near-Term Scenarios

1. Variable speed targets to dissipate congestion using I2V Cooperative ACC

2. Increasing lane capacity using V2V Cooperative ACC

3. Close-formation truck platoons in dedicated truck toll lanes, saving energy and increasing lane capacity

4. Transitways for use by equipped buses, vanpools and potentially carpools

5. ?

6. ?
1. I2V Cooperative ACC

• TMC predicts desired speed for each managed lane segment and time step to maximize capacity of downstream bottleneck
  – Simulations show potential improvements
• Variable speed advisory (VSA) values are broadcast to all passing vehicles
• I2V CACC vehicles receive VSA values and use them as their CACC set speeds, so continuous driver attention is not required
• Safety benefits likely by avoiding “end of queue” speed drop surprises
Simulated Bottleneck Flow Improvement with VSA
Simulated Bottleneck Speed Increase with VSA

![Graph showing speed vs time with two lines: No Control and VSA All Times.]

- No Control
- VSA All Times
2. V2V Cooperative ACC

- Augment production ACC forward ranging sensor data with V2V communications from preceding vehicle and first vehicle in platoon
- Enhance user acceptance with tighter car following behavior and fewer cut-ins
- Damp out traffic shock waves
- Increase lane capacity toward 4000 vehicles per hour at 100% market penetration
Mean Time-Gap Preferences in Vehicle Following (Test Results)

![Graph showing mean time-gap preferences between males and females for ACC and CACC systems.]

- Males:
  - ACC: 1.43 seconds
  - CACC: 0.64 seconds

- Females:
  - ACC: 1.68 seconds
  - CACC: 0.78 seconds
Simulated Lane Capacity vs. CACC Market Pen.

With addition of “Here I Am” vehicles (“Vehicle Awareness Devices”)
3. Dedicated Truck Lanes with Automated Truck Platoons

• Excluding light duty vehicles substantially improves safety
• Separating trucks from light duty vehicles is attractive to general public
• Facilitates formation of automated truck platoons, promoting significant energy savings (cost savings for truck operators)
  – 3-truck platoons could double throughput per lane, avoiding need for multi-lane facilities in high-volume corridors
• Tolling in truck lanes can be related to value of time saved, which can be substantial
Truck Platoon Capacity Estimates

- NAHSC studies (1997)
Energy Savings from Truck Platooning

![Graph showing fuel savings in tandem versus truck separation, with data points for trail and lead trucks projected from wind tunnel drag and present field data.](image_url)
4. Dedicated Transitways (special bus lanes)

- Could be first adopters, with simplest institutional arrangement (one organization responsible for vehicles and infrastructure)
- Exclusion of other vehicles maximizes safety (avoids interactions with unequipped vehicles)
- Enables buses to provide service quality of rail transit, but at much lower cost
- Bus operations gain direct cost saving benefit, and equipment cost is small fraction of total vehicle cost
  - With high hourly operating costs, each minute saved could be worth a lot