# 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**

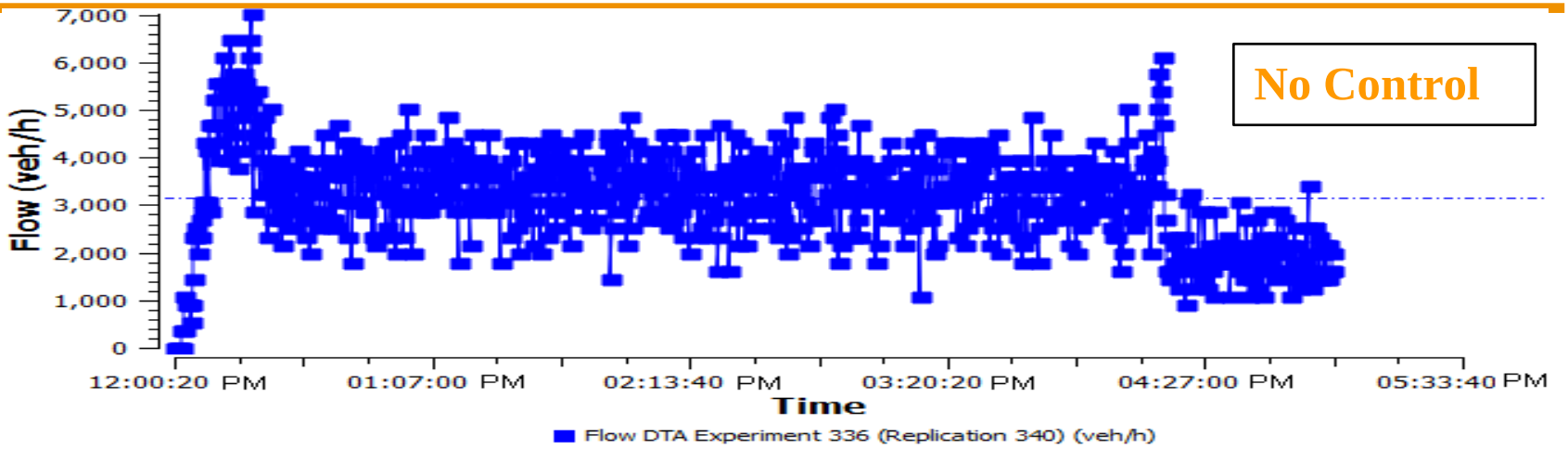
# Potential Near-Term Scenarios

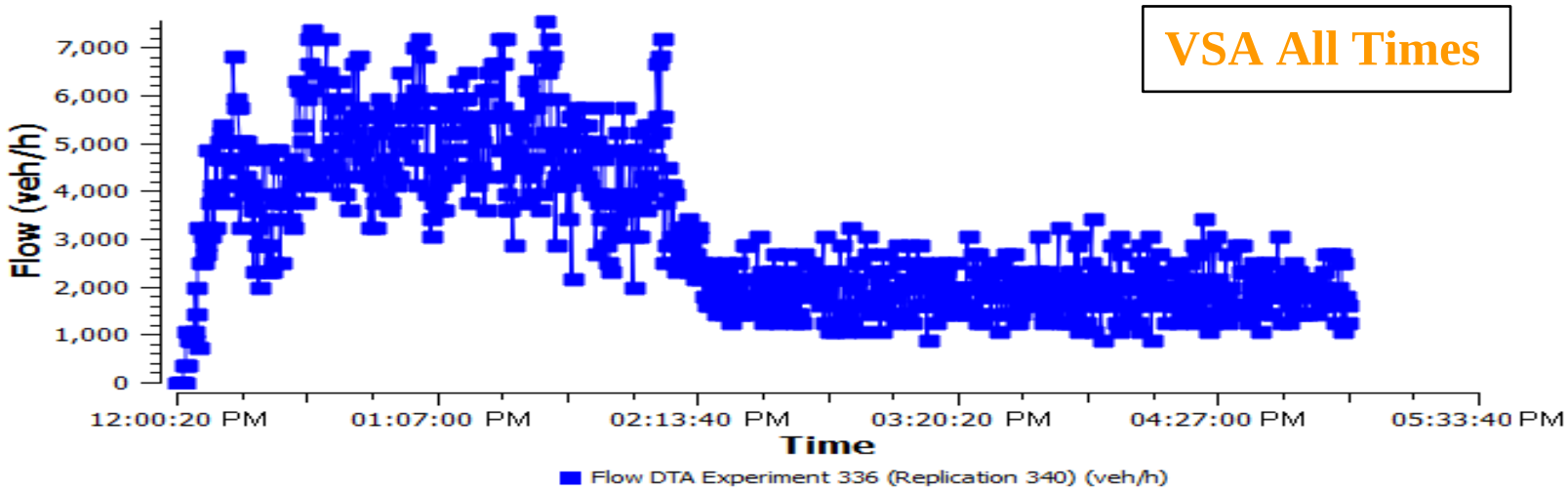
1. **Variable speed targets to dissipate congestion using I2V Cooperative ACC**
2. **Increasing lane capacity using V2V Cooperative ACC**
3. **Close-formation truck platoons in dedicated truck toll lanes, saving energy and increasing lane capacity**
4. **Transitways for use by equipped buses, vanpools and potentially carpools**
5. **?**
6. **?**

# 1. I2V Cooperative ACC

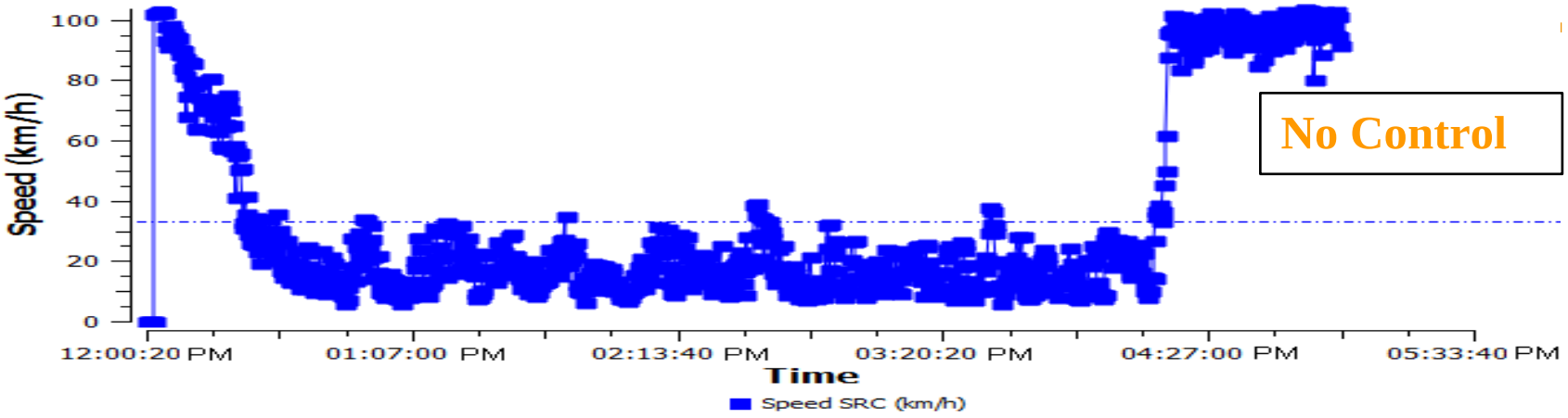
- **TMC predicts desired speed for each managed lane segment and time step to maximize capacity of downstream bottleneck**
  - **Simulations show potential improvements**
- **Variable speed advisory (VSA) values are broadcast to all passing vehicles**
- **I2V CACC vehicles receive VSA values and use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

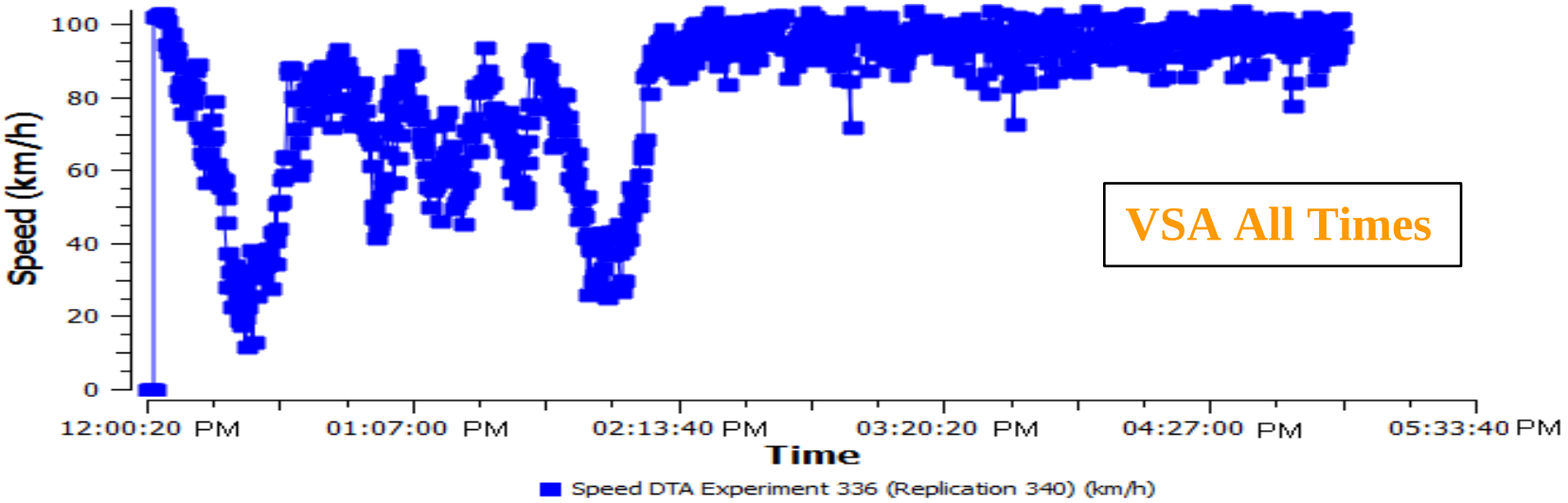
# Simulated Bottleneck Flow Improvement with VSA



# Simulated Bottleneck Speed Increase with VSA

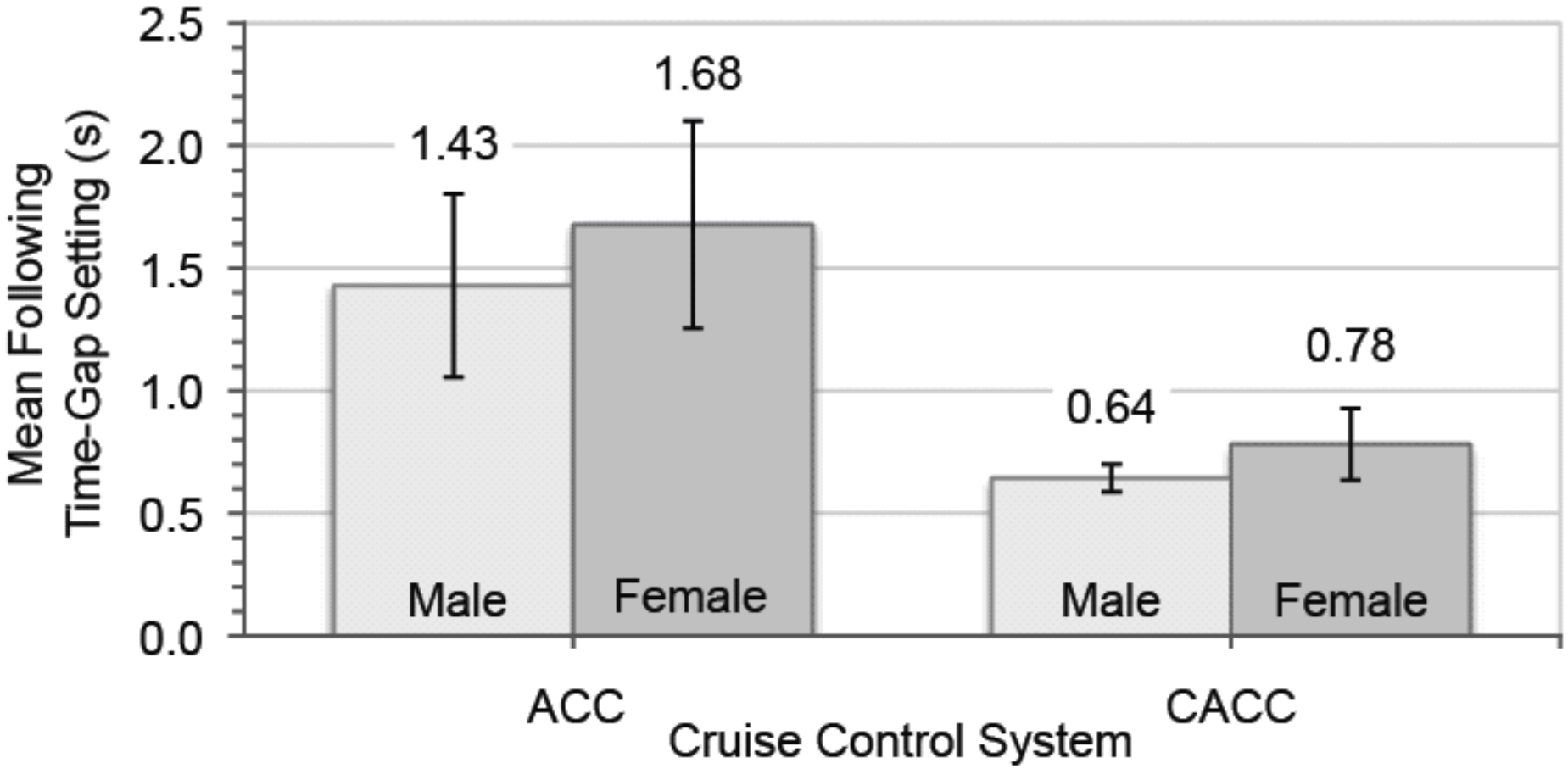


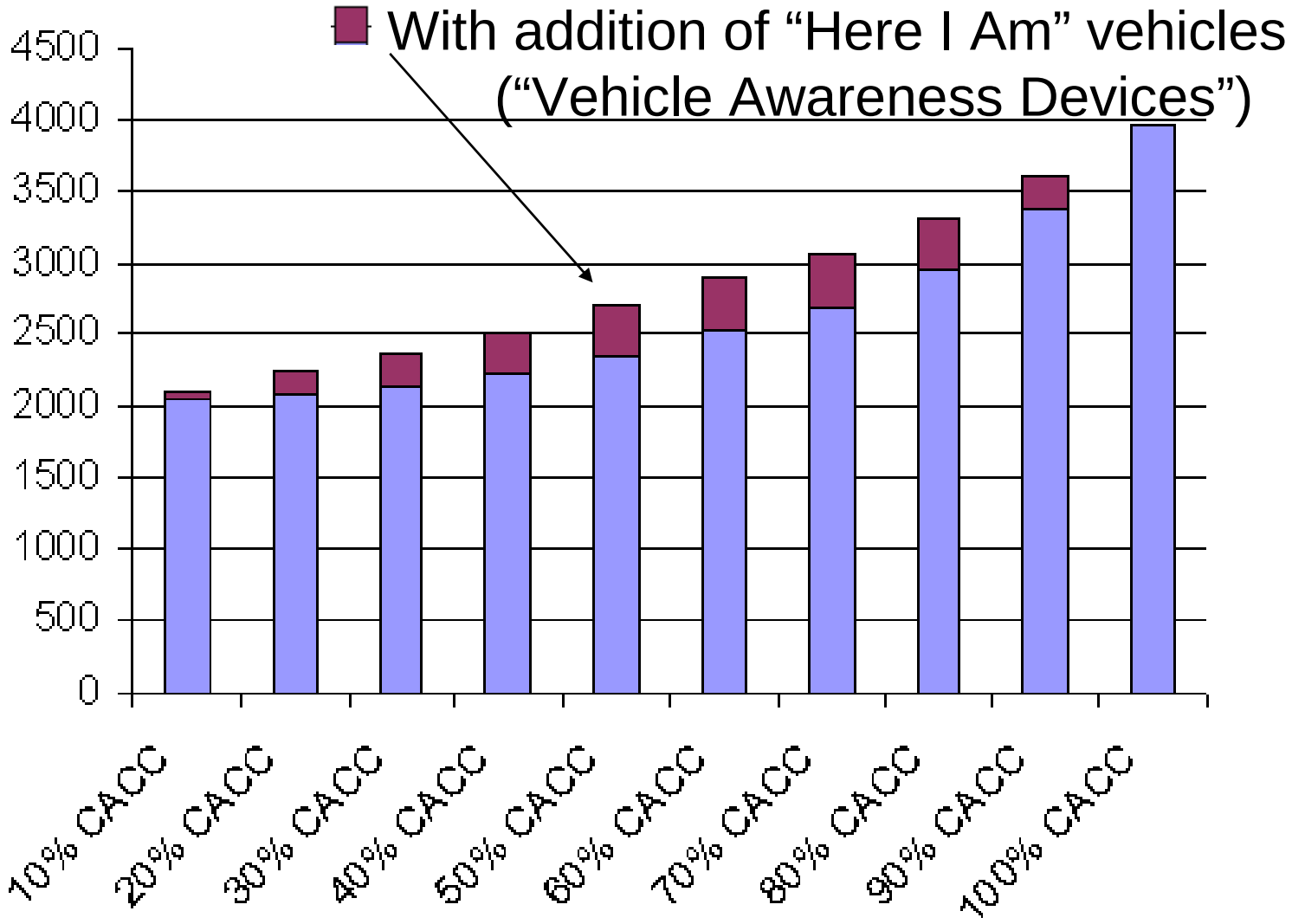
# 2. V2V Cooperative ACC

- **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)



# Simulated Lane Capacity vs. CACC Market Pen.

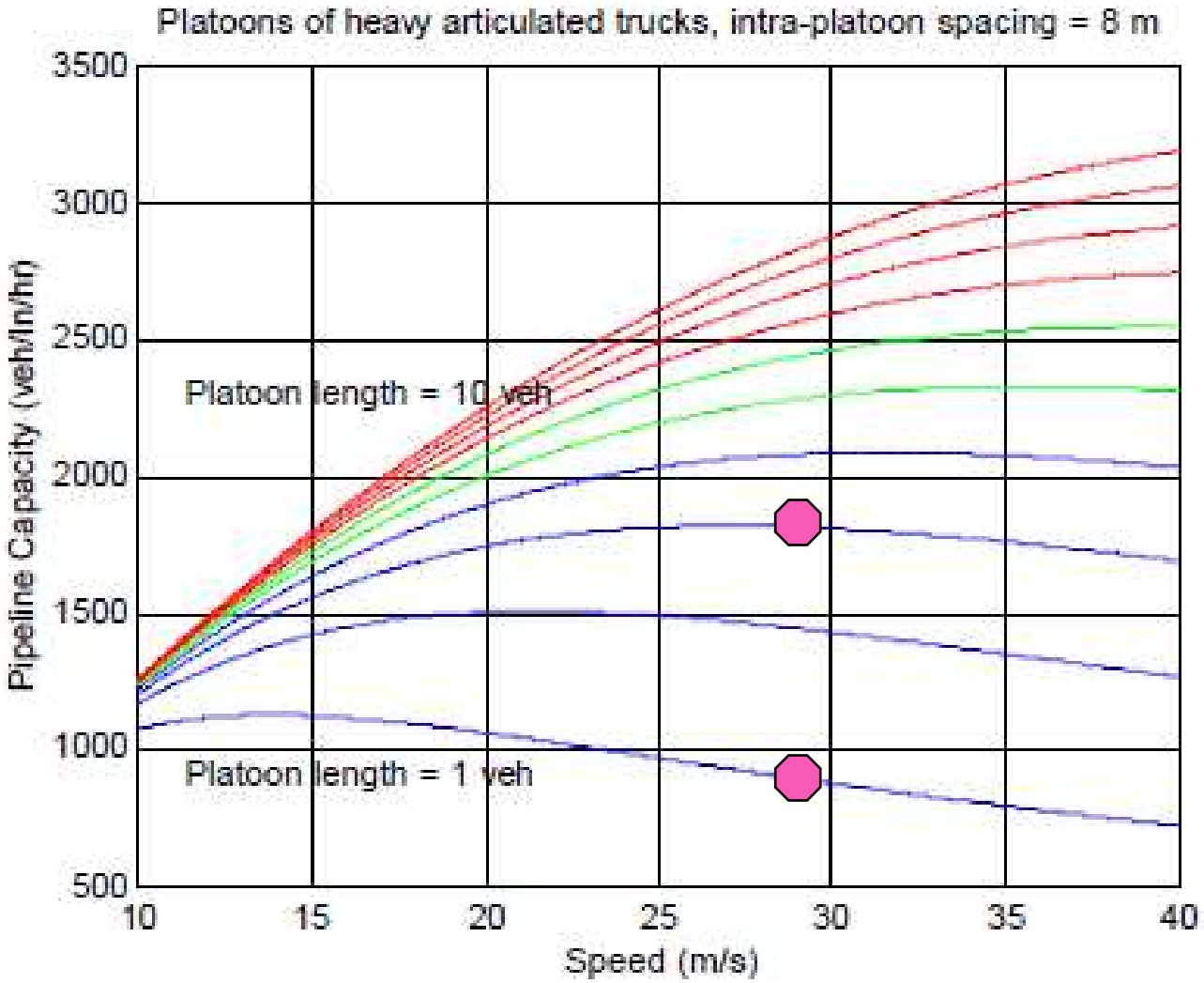


# 3. Dedicated Truck Lanes with Automated Truck Platoons

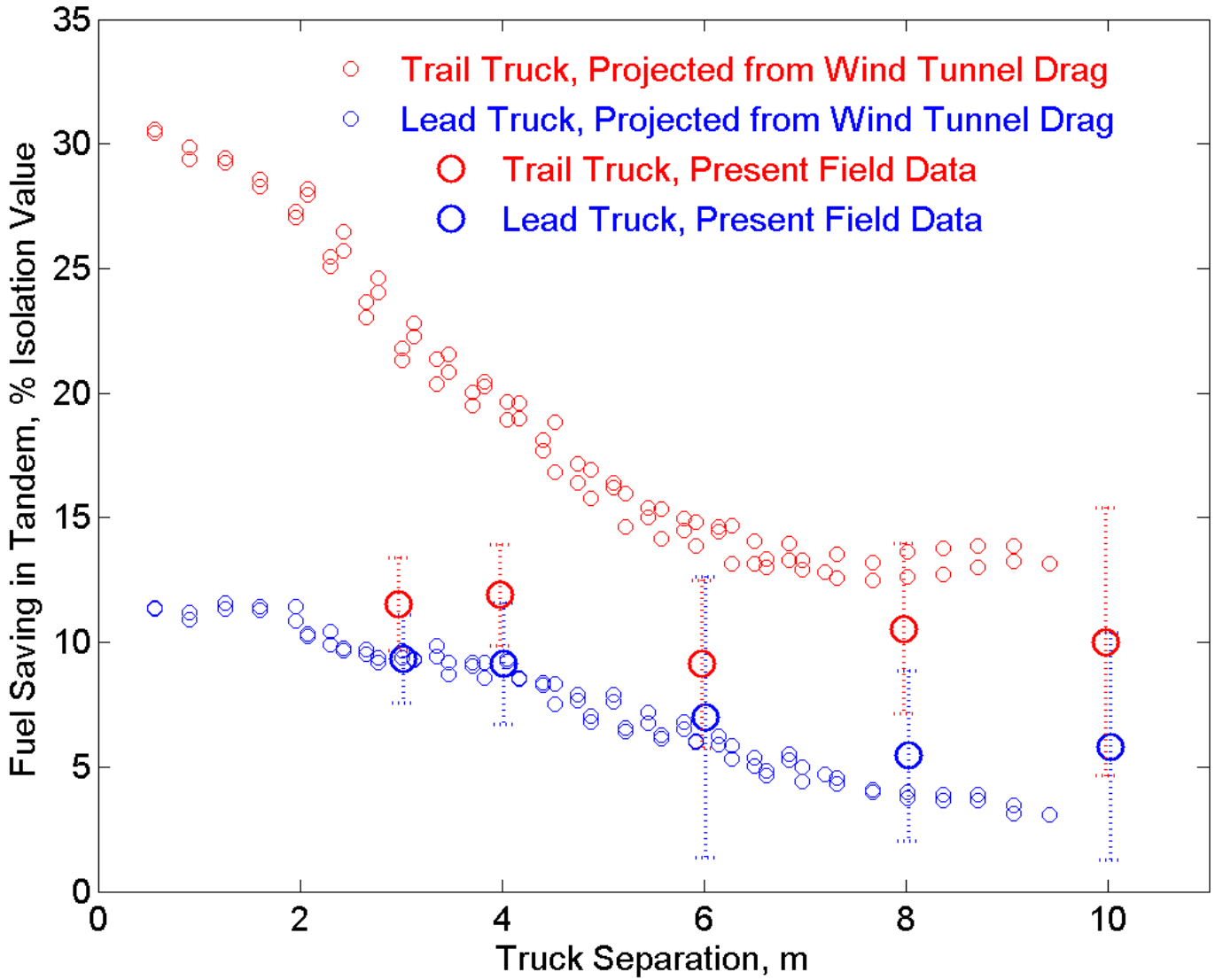
- **Excluding light duty vehicles substantially improves safety**
- **Separating trucks from light duty vehicles is attractive to general public**
- **Facilitates formation of automated truck platoons, promoting significant energy savings (cost savings for truck operators)**
  - **3-truck platoons could 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



# 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**