



# Managed Lanes: Challenges and Opportunities for Connected and Automated Vehicles (CAVs)



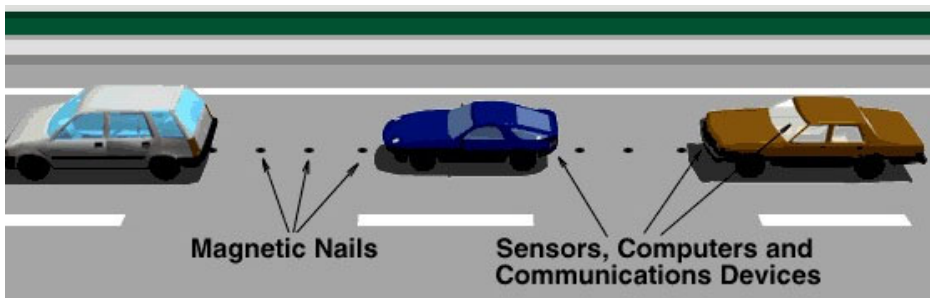
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***Costa Navarino, Messinia, Greece***  
***29-31 May 2019***

# Background: Automated Driving in Managed Lanes

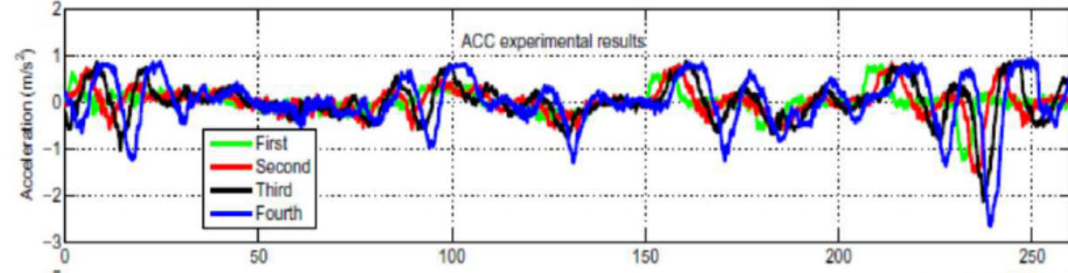
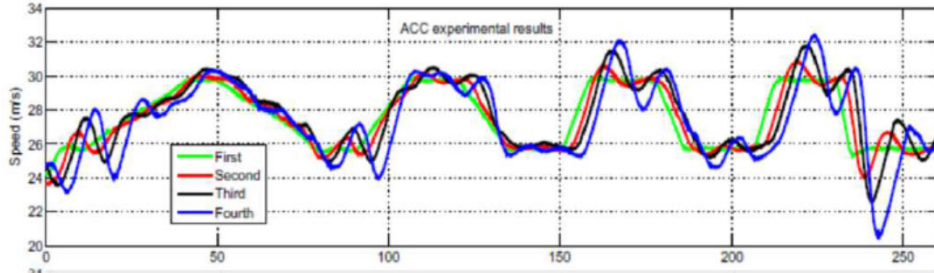
## Automated Highway Systems (AHS) Demo '97 I-15 Managed Lanes, San Diego

- Automated Check-in/Check-out
- Lateral and Longitudinal Controls
- Automated merging/diverging
- Malfunction Management & Analysis

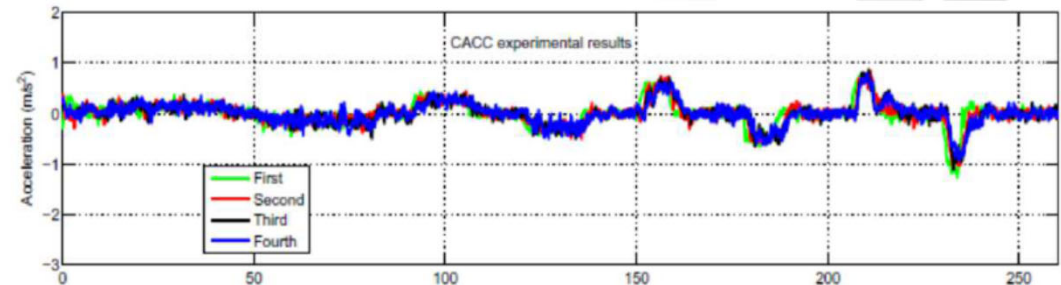
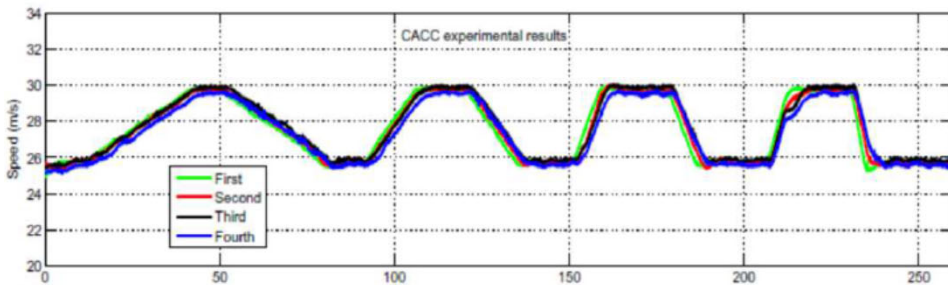


# Operation of Connected Vehicles (CACC)

## Field Tests

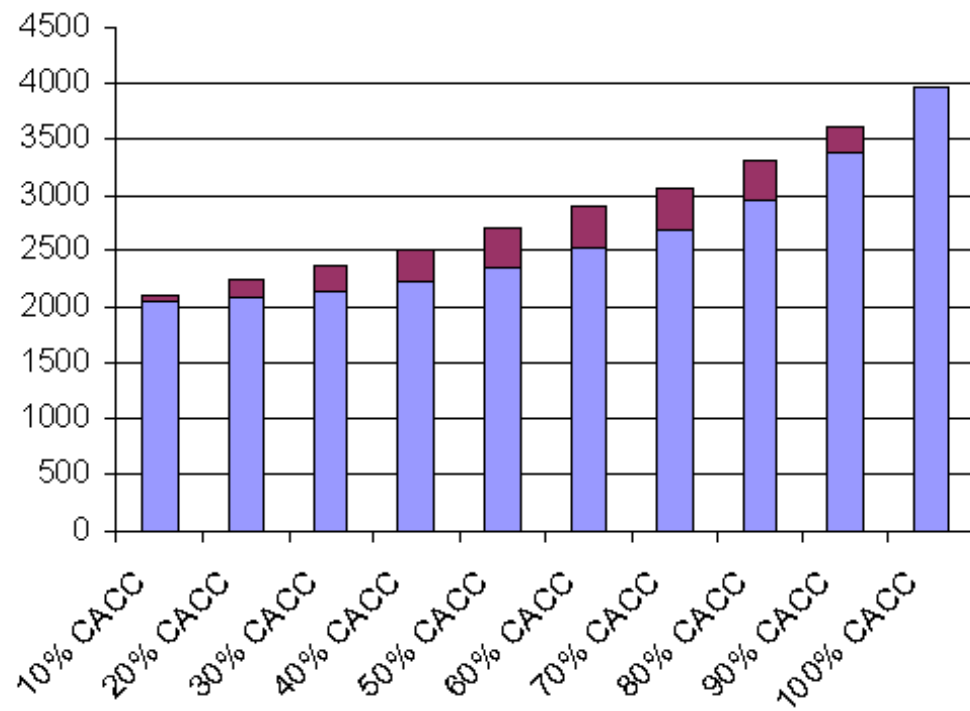


## ACC: Speeds/Accelerations (*Not Connected*)

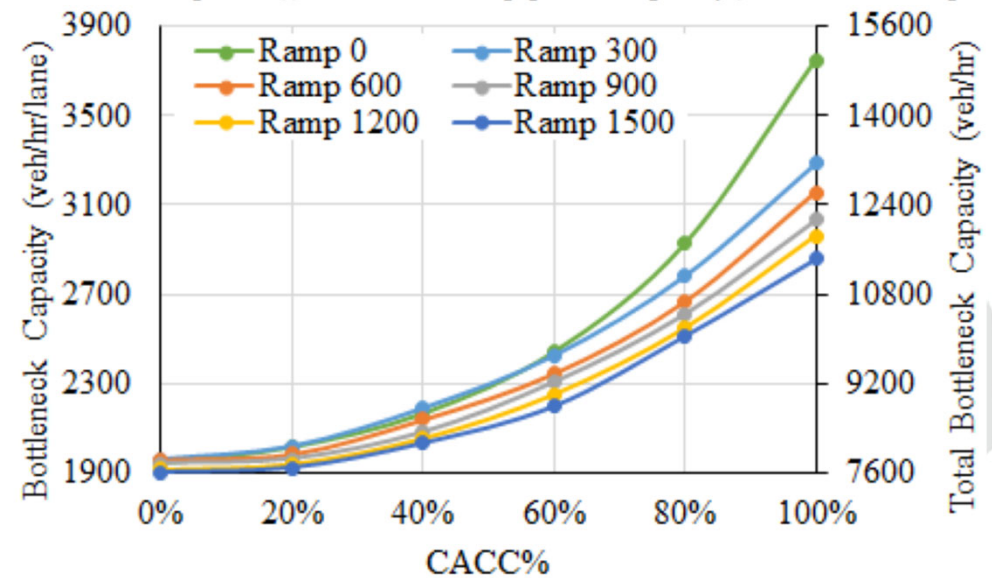


## CACC: Speeds/Accelerations (*Connected*)

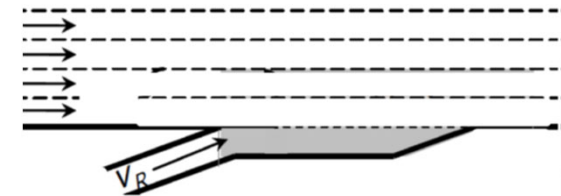
# Lane Capacity vs. CACC Market Penetration



**Basic Freeway Section**



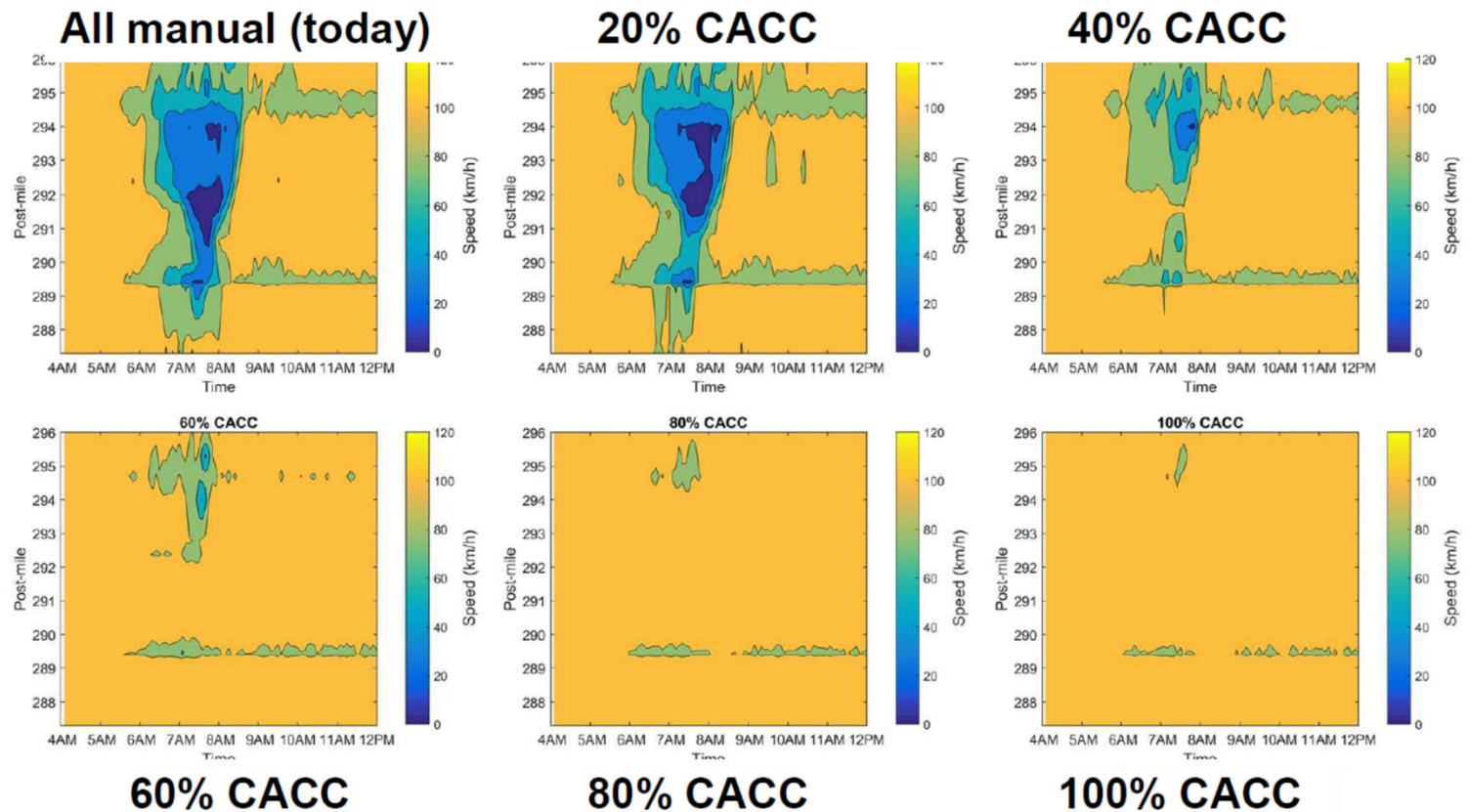
**Merging Section**





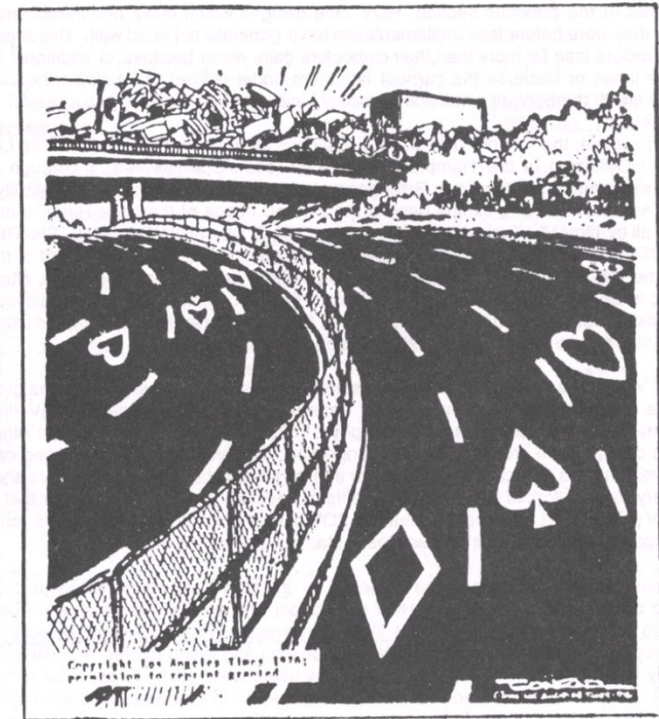
# Freeway Speeds vs. CACC Market Penetration

**SR-99 Freeway CA**  
**Existing Volumes**  
**4 am -12 noon**



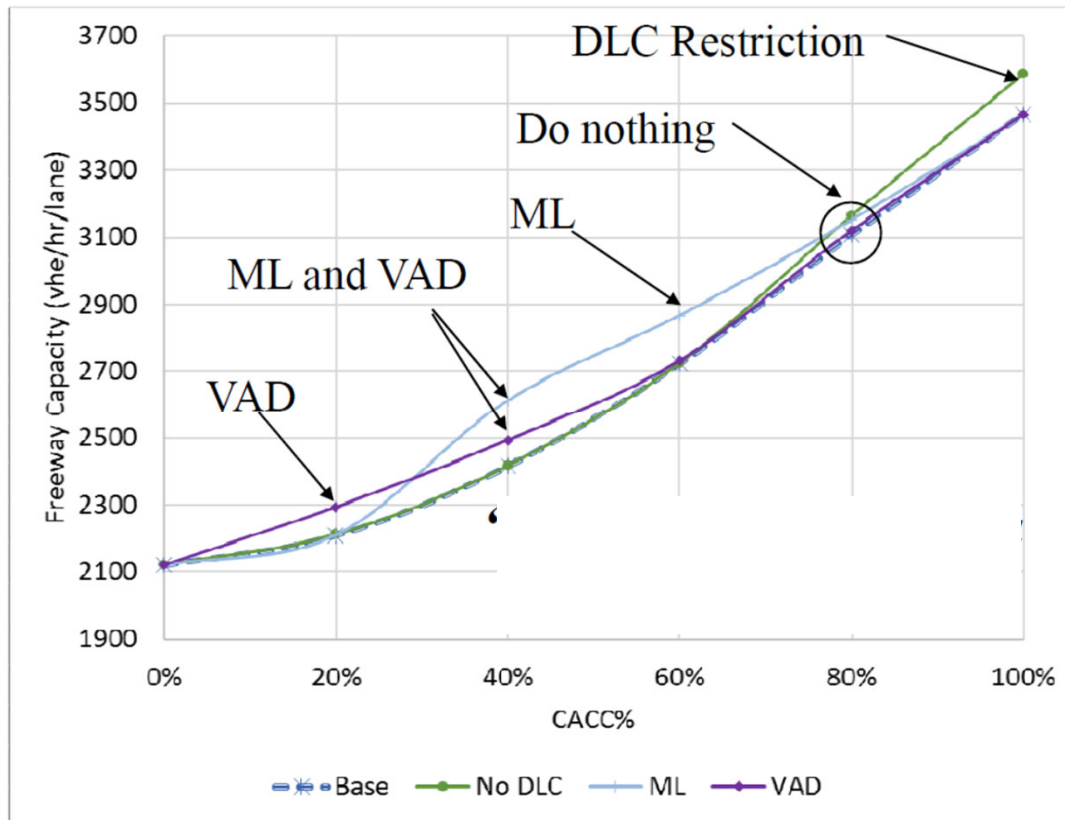
# CAVs in Managed Lanes

- **Designation of selected lanes as CAVs only lanes**  
market penetration (MP)  
Operating conditions
- **Higher lane capacities on CAV only lanes**  
Coordination with merging traffic
- **Exclusion of manually driven vehicles improves safety and facilitates testing of automation options**
- **Higher lane throughput by CAVs offers potential for user discounts**



*Introduction HOV I-10,  
Los Angeles, 1974*

# Impacts of Operational Strategies on Freeway Lane Capacity with CACC



**Managed Lanes (ML) strategy Works best:**

- 40% CACC with 1 ML
- 60% CACC with 2 ML
- 80% CACC with 3 ML

**VAD: Vehicles Awareness Device, DLC: Discretionary Lane Changing**

# Modeling CAVs: Challenges and Opportunities

- **Existing Traffic Models Lack Features to Account for Changes due to CAVs**  
Simplified assumptions on CAVs car-following, lane changing models  
Car-following model for mixed traffic  
Interactions with manual driven vehicles  
Macroscopic traffic flow relationships
- **New Models Needed to Leverage Technological capabilities, and Capture Emergent Interactions**  
Operational and communication protocols  
Modeling platoon streams for CAVs
  - Platoon stability*
  - Impacts of latency*