AUTONOMOUS VEHICLES ON ARTERIAL STREETS AND INTERSECTIONS - A SIMULATION ANALYSIS

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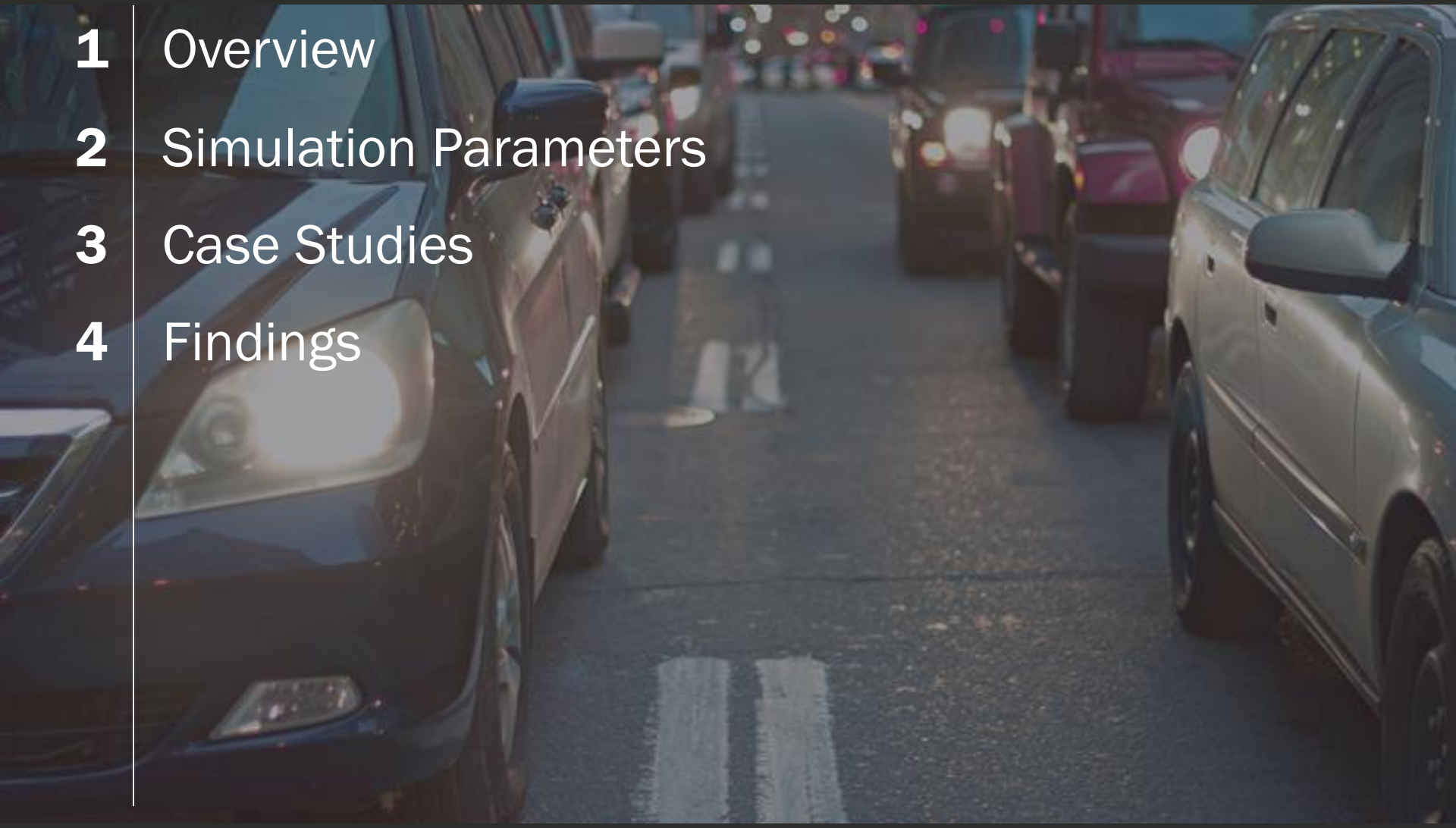
FEHR PEERS

OUTLINE.



OVERVIEW.

Why study this?

Purpose:

- Using calibrated existing traffic models to evaluate potential effects of autonomous vehicles (AVs) on city streets where the traffic flow is interrupted by signals and the roadway space is shared with other modes of travel.

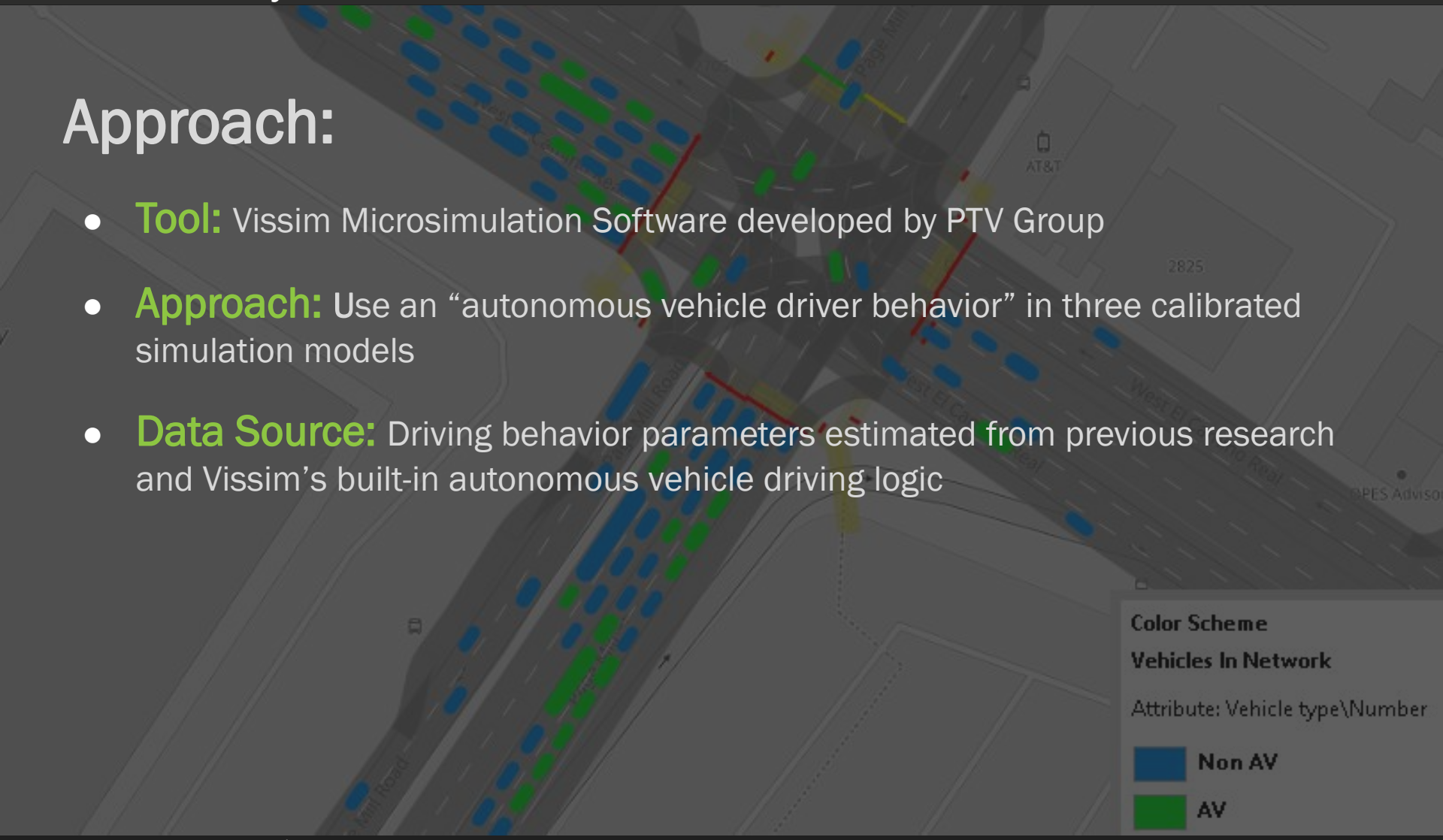
- While the exact driving behavior and adoption timeline is uncertain, this study conducts sensitivity tests to examine the effects across a range of AV driving behavior and various market penetration rates.

OVERVIEW.

How do we study this?

Approach:

- **Tool:** Vissim Microsimulation Software developed by PTV Group
- **Approach:** Use an "autonomous vehicle driver behavior" in three calibrated simulation models
- **Data Source:** Driving behavior parameters estimated from previous research and Vissim's built-in autonomous vehicle driving logic



PARAMETERS.

Simulation model inputs

Key Parameters:

- **SAE Level 5 Autonomy:** Full autonomy that does not require any human control
- **Consistent AV Driving Behavior:** All AVs have the same driving behavior
- **Travel Demand:** Induced demand is not accounted for in this analysis
- **Signal Timing:** Base traffic signal timings remain unchanged
- **Roadway Space:** No dedicated AV lanes or reallocation of roadway space
- **AV Fleet Size:** Vehicle size remains the same as today

This analysis focuses on the effects of driving behavior and penetration rates, therefore parameters listed above are held constant…They can be adjusted and tested as the primary variable.

SAE: Society of Automotive Engineers

PARAMETERS.

Simulation model inputs

Driving Behavior Research

Car-following Behavior

Detection & Reaction to Signals

V2I Communication

Lateral Behavior

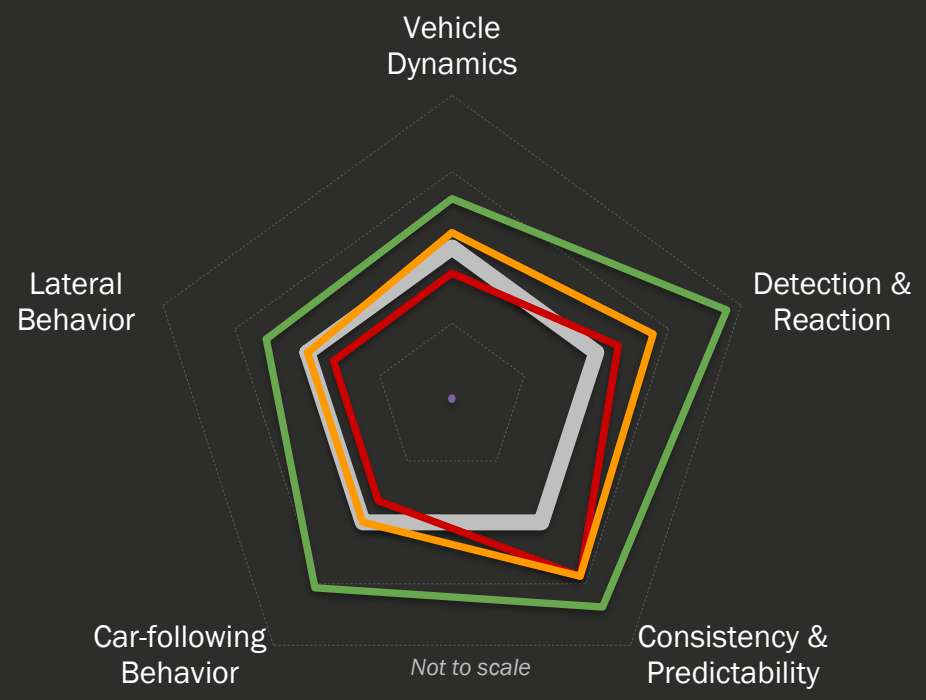
Interaction with Non-motorists

V2V Communication

Note: V2I and V2V communication is simplified in this analysis, modeled as reaction time, start-up time, and fluctuation in speeds

PARAMETERS.

Simulation model inputs



Human Drivers

Existing conditions: driving behavior of average human drivers.

AV: Conservative

Potential near-future AV scenario with some operating parameters being more conservative than human drivers, while other parameters being similar or slightly improved with more advanced technology.

AV: Moderate

Most operating parameters are similar to average human drivers but are more consistent; some parameters are improved due to more advanced technology.

AV: Optimal

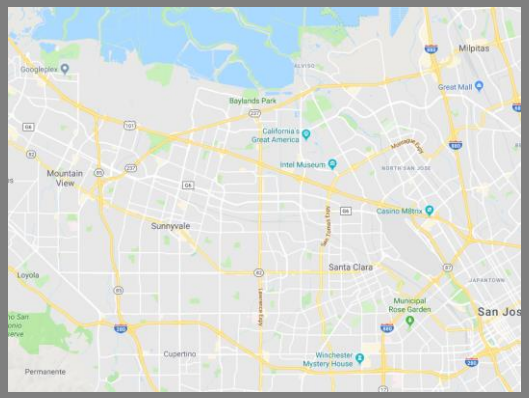
Operating scheme with reduced headways, clearance distances, improved vehicle dynamics and communication capabilities. All parameters are improved from existing conditions.

CASE STUDIES.

Where are the study locations?

Case Study 1
Multimodal Intersection

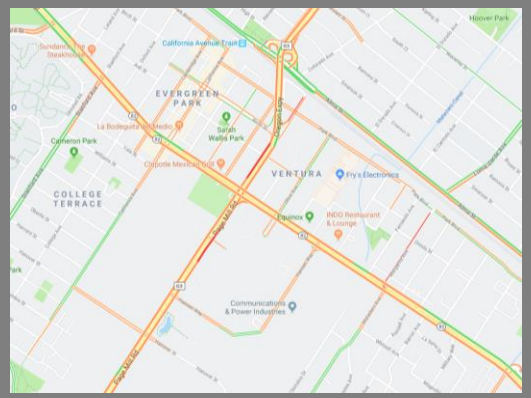
Intersection in Santa Clara County, CA



- F&P AV parameters
- 4 AV scenarios
- Suburban office complex
- Signalized intersection
- Heavy bike/ped/bus activity

Case Study 2
Undersaturated Corridor

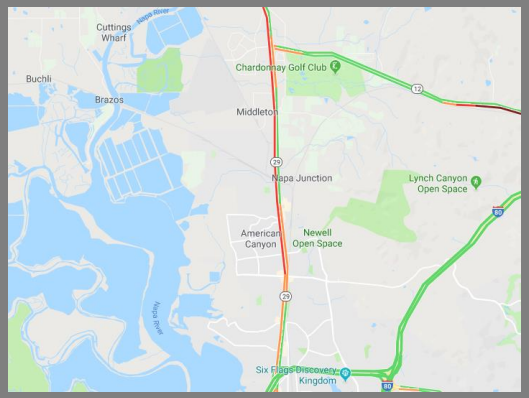
El Camino Real, Palo Alto, CA



- Vissim built-in AV parameters
- 15 AV scenarios
- Retail use
- Two-mile multi-lane arterial
- 6 signalized intersections

Case Study 3
Oversaturated Corridor

SR-29, American Canyon, CA



- Vissim built-in AV parameters
- 15 AV scenarios
- Five-mile two-lane rural highway
- 7 signalized intersections

CASE STUDIES.

Case Study #1: Multimodal Intersection

Travel modes:

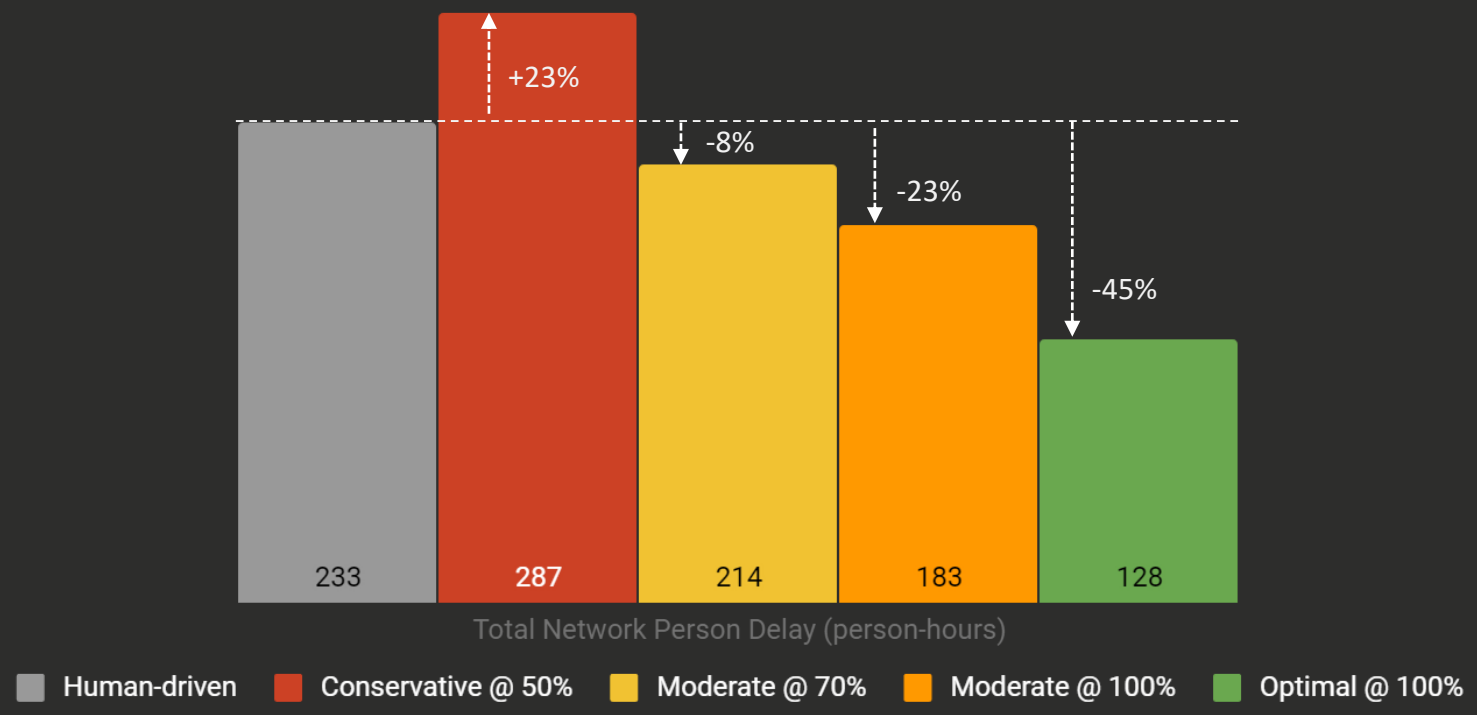
- Passenger vehicles
- Buses/shuttles
- Cyclists
- Pedestrians

Simulation Scenarios		
Scenario	Driving Behavior	AV Penetration Rate
Existing	Human Driver	0%
1	Conservative	50%
2	Moderate	70%
3	Moderate	100%
4	Optimal	100%

CASE STUDIES.

Case Study #1: Multimodal Intersection

Network Person Delay (person-hours)

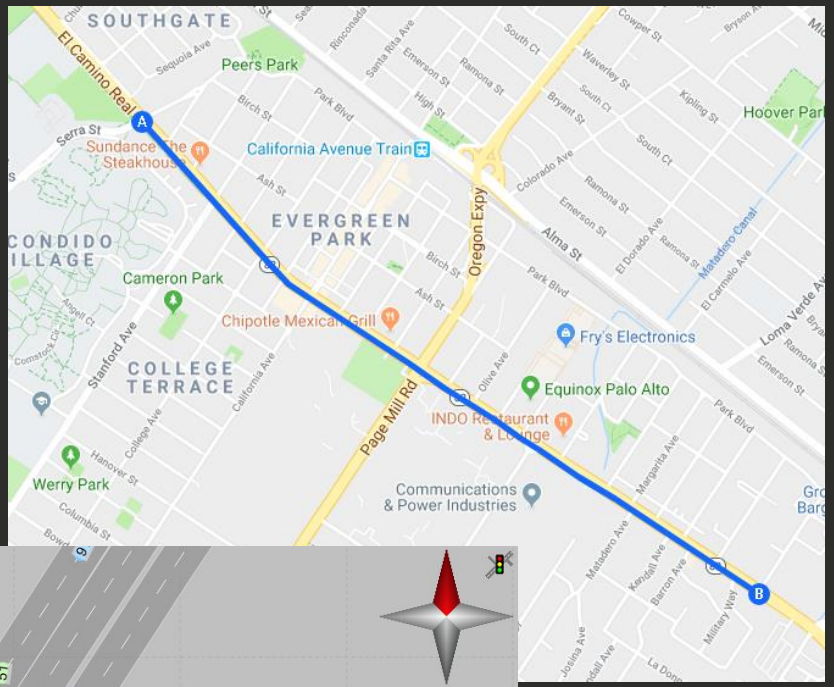


CASE STUDIES.

Case Study #2: Undersaturated Corridor

El Camino Real in Palo Alto, CA

- Two-mile arterial: 6 signalized intersections
- 15 Scenarios:
  - 3 AV Behaviors X 5 Penetration Rates



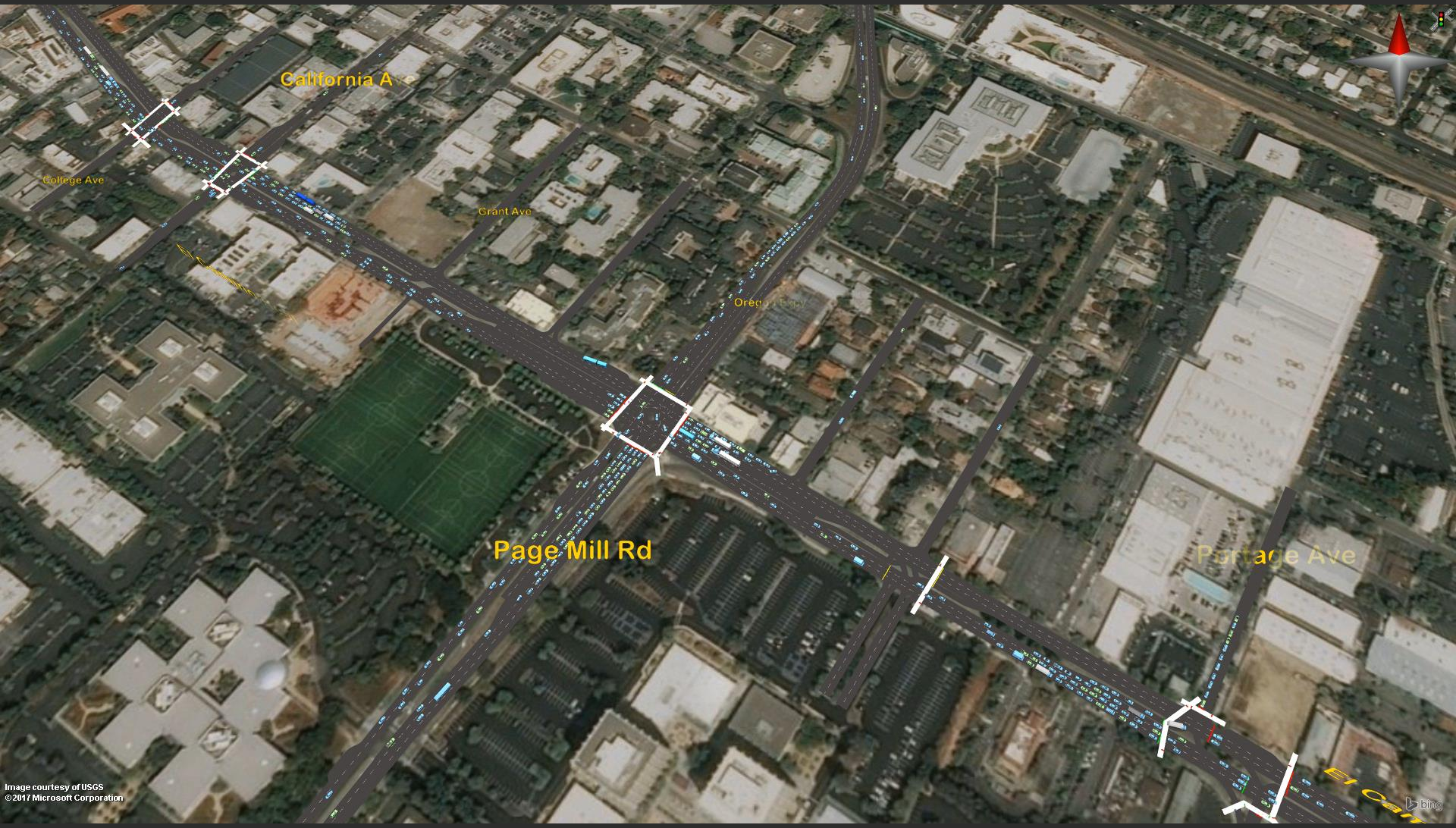
CASE STUDIES.

Case Study #2: Standstill Conditions at Signal

CASE STUDIES.

Case Study #2: Undersaturated Corridor

Video Clip #1



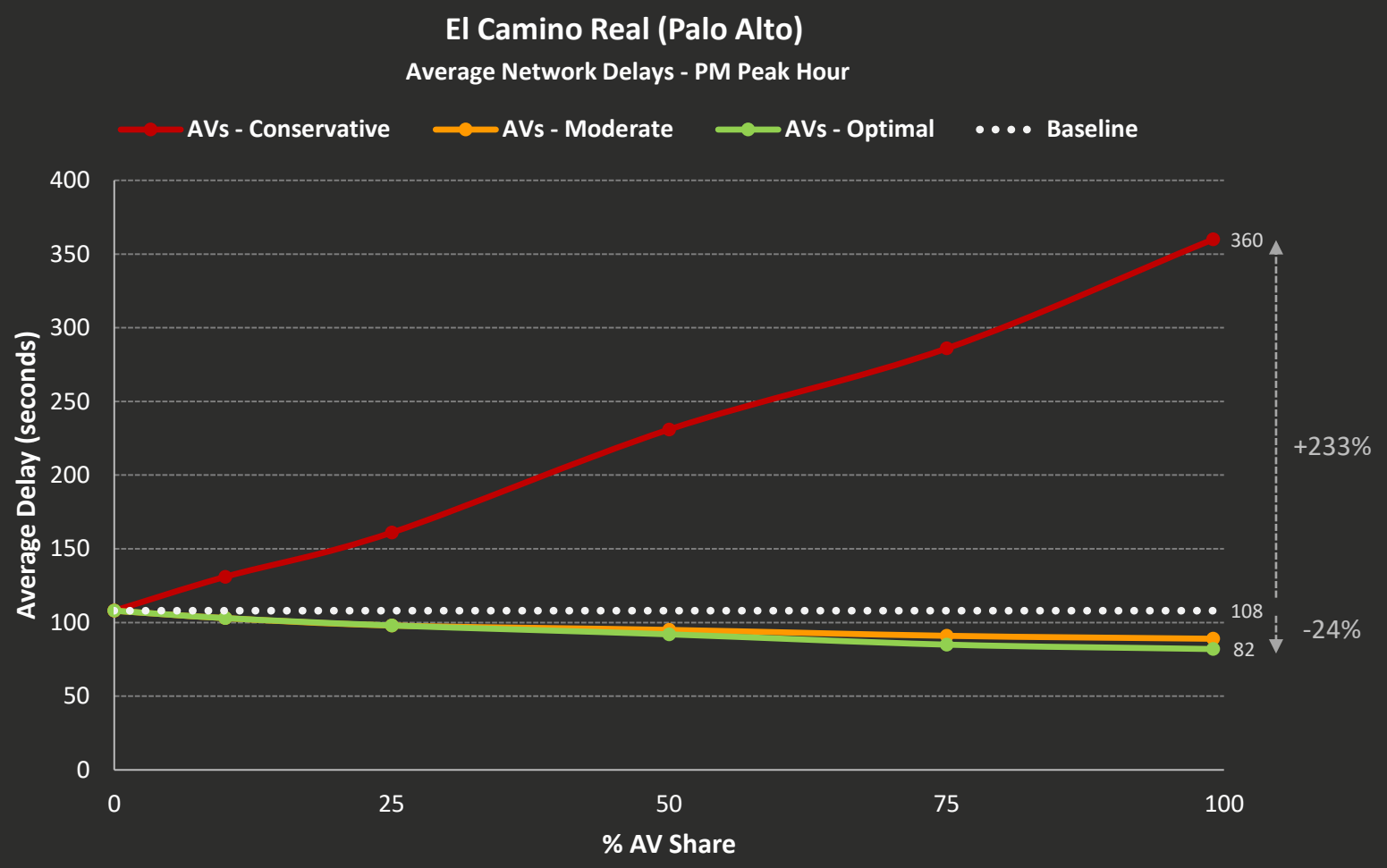
CASE STUDIES.

Case Study #2: Undersaturated Corridor

Video Clip #2

CASE STUDIES.

Case Study #2: Undersaturated Corridor

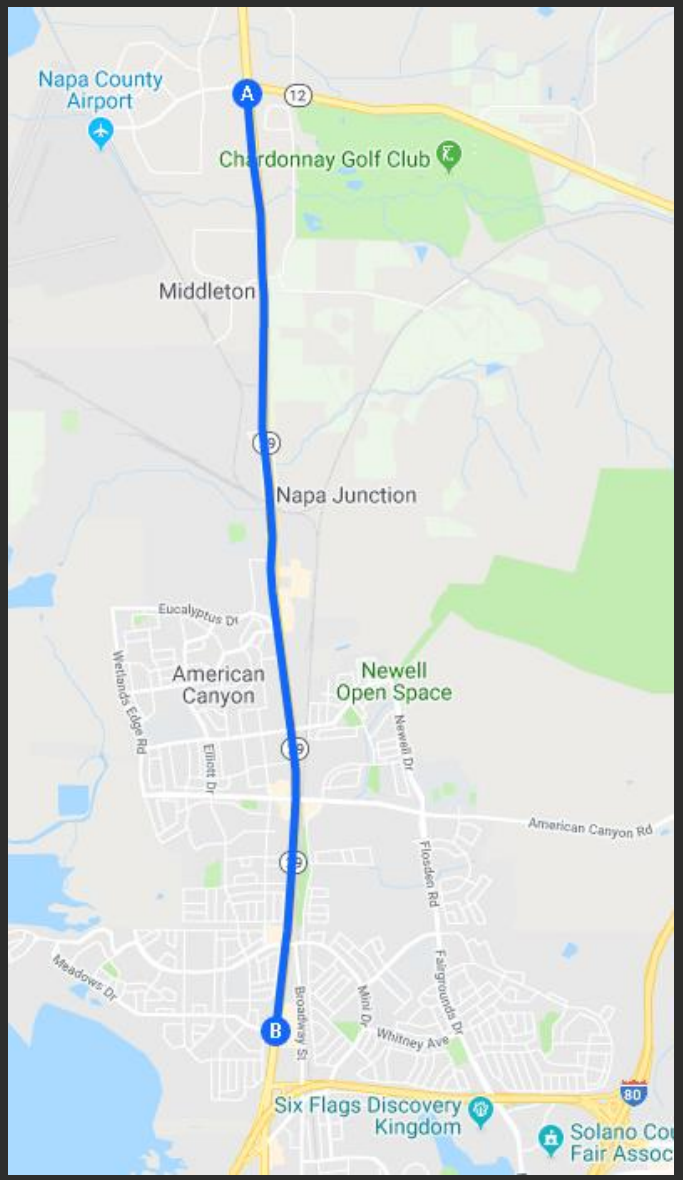


CASE STUDIES.

Case Study #3: Oversaturated Corridor

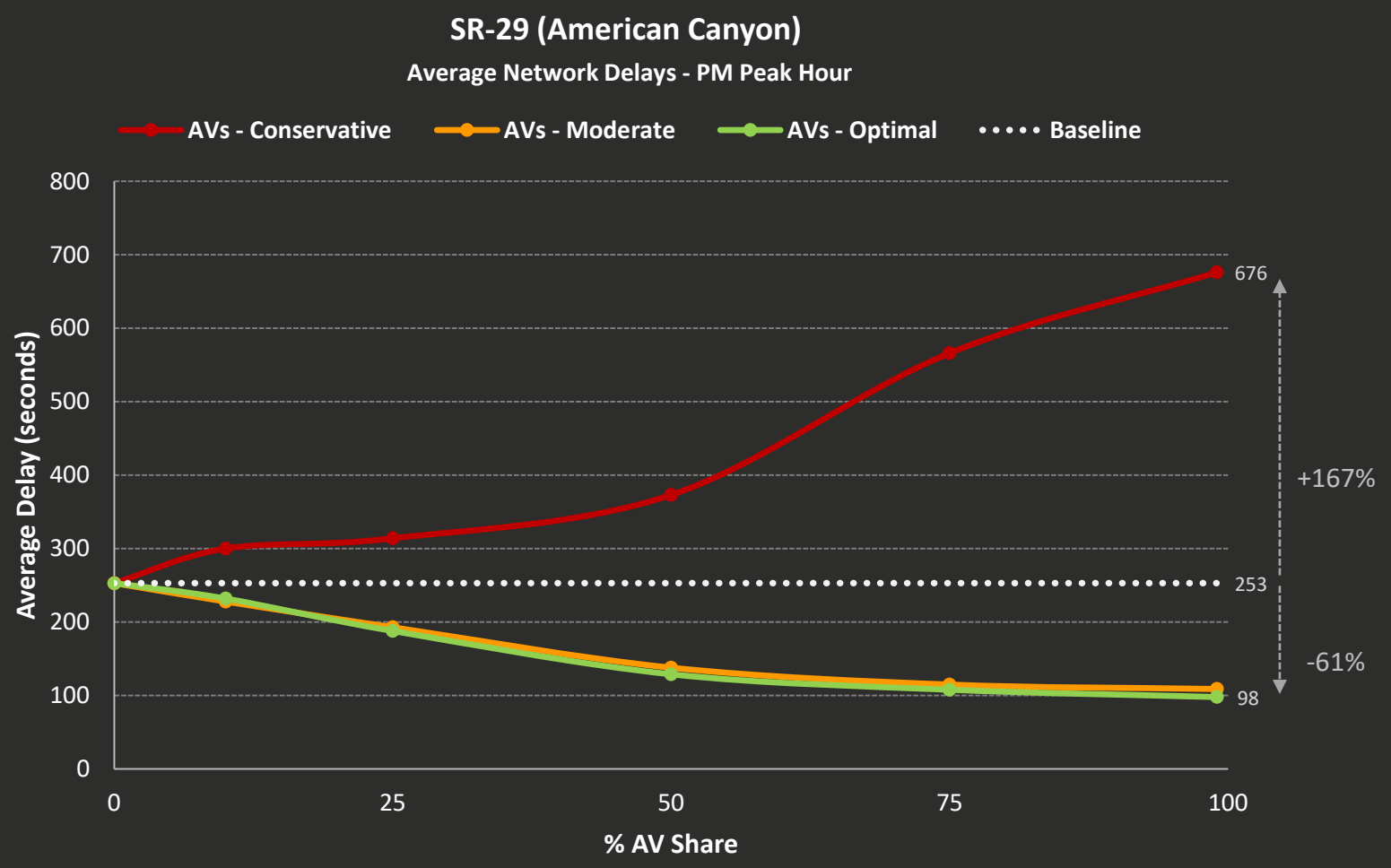
SR-29 in American Canyon, CA

- A five-mile stretch of rural highway
  - 7 signalized intersections
- A heavily congested arterial with congestion spanning multiple hours
- 15 Scenarios:
  - 3 AV Behaviors X 5 Penetration Rates



CASE STUDIES.

Case Study #3: Oversaturated Corridor



FINDINGS.

Analysis summary

Fleet penetration and driving behavior of AVs significantly affect roadway operations and infrastructure capacity:

- Potential to experience more congestion in the near-future as AVs behave more conservatively than human drivers
- As AVs mature and become a larger portion of the fleet, they could utilize existing infrastructure more efficiently and result in additional capacity

FINDINGS.

Key takeaways

While AVs continue to evolve and regulations are being developed, there are a lot of unknowns regarding how AVs would behave and the corresponding effects on the transportation system.

Take a scenario-planning approach to evaluate potential effects of AVs and make recommendations and decisions that are resilient to the wide range of possible outcomes.

Potential Future Applications:

- Effect of change in vehicle fleet size
- Effect of mixed AV behavior (i.e. AVs made by different manufactures)
- Effect of dedicated AV lanes
- More complex V2V and V2I algorithms
    - Vissim + COM, Python or external driver module
- Effect of induced travel
- Curbside utilization and management

Thank you for your time.

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