HOW MUCH FASTER?

SIMULATING AND QUANITFYING CAV EFFICIENCY GAINS AT STOP-CONTROLLED INTERSECTIONS

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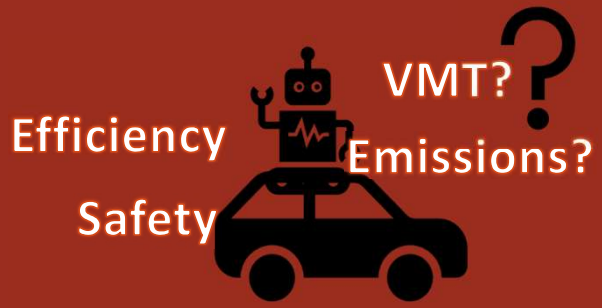
The Big Picture: CAVs- Promise & Questions



- CAVs*: Promise of efficiency, safety, improved mobility...
- But questions remain: Impact on total travel (VMT**)? Net environmental effect?
- Need to quantify specific benefits accurately.

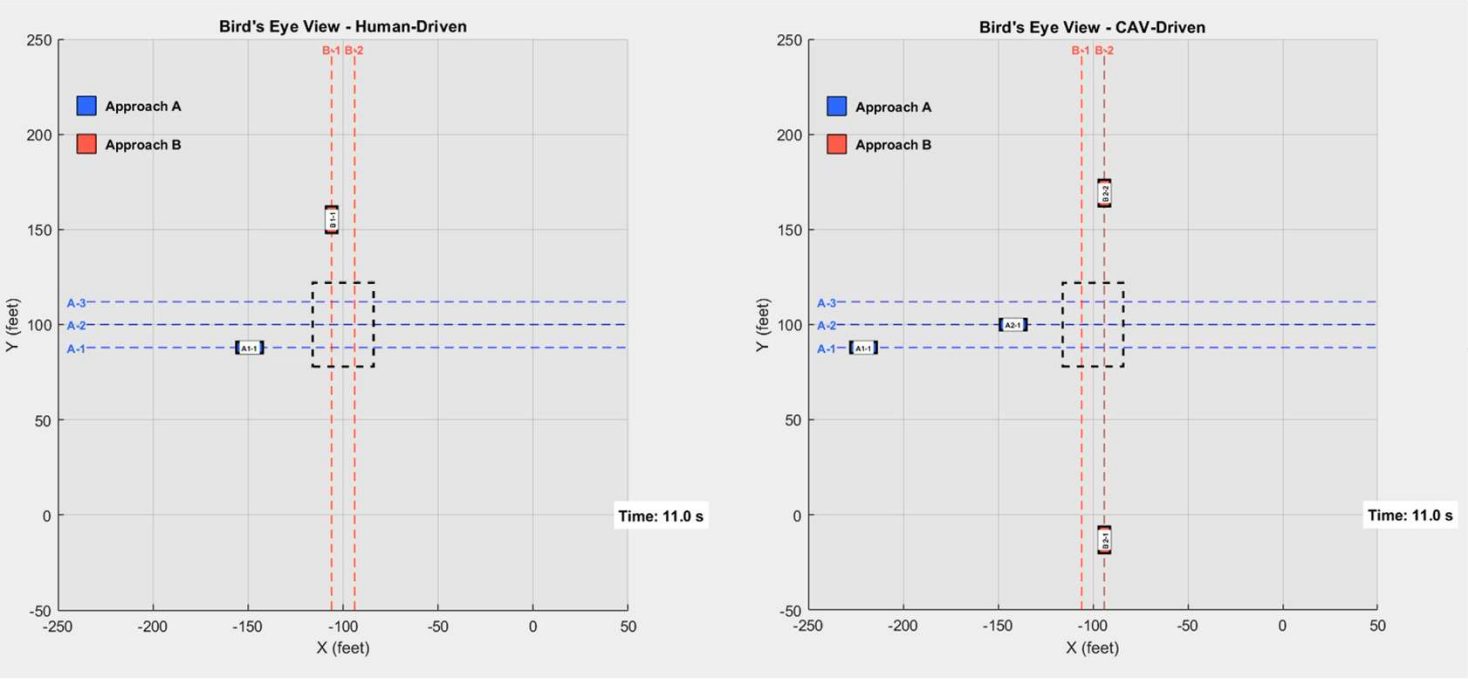
*CAV: Connected and Automated Vehicles
** VMT: Vehicle Miles Traveled

Focusing on a Key Bottleneck: Stop-Controlled Intersections

- Source of real-world delay, congestion, fuel waste
- Our question: What measurable efficiency gains can basic CAV parameters provide here, under existing rules?

Image Source: Image generated by Gemini

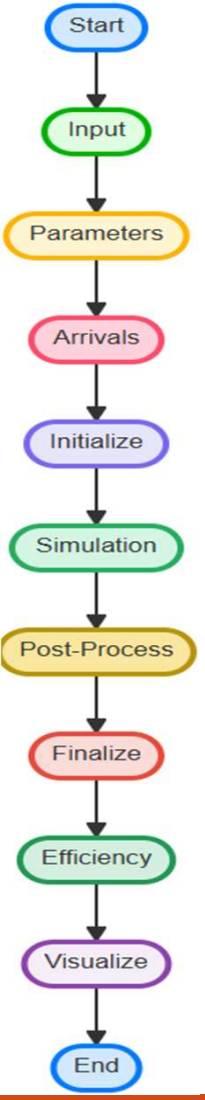
Approach: Head-to-Head Simulation



- Developed MATLAB simulation of multi-lane, stop-controlled intersection.
- Compared HDV* vs. CAV performance using distinct parameters**.

*HDV: Human-Driven Vehicles

**Source: A mixed traffic capacity analysis and lane management model for connected automated vehicles: A Markov chain method (2017, Ghiasi, Hussain, Qian, Li)



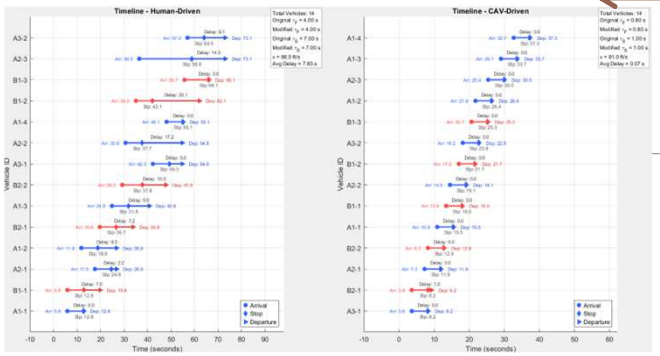
Core Logic: Prioritized Scheduling + The "Safety Check"

- Consecutive vehicles in the same approach that arrive earliest and are ready at stop line gets priority to proceed next.
- Key Feature: Novel Conflict Resolution Algorithm in Post-Process ('Safety Check').
- Ensures safety by enforcing minimum time gaps; determines final departure order.

*Primary Scheduling Logic has been taken from Professor Xiaopeng Li's CIVENGR570 L7 CAV applications at intersections.pptx

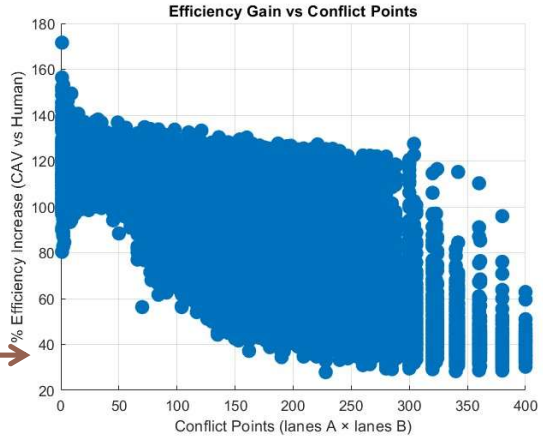
Simulation Experiments

1 Detailed Run (3x2 lanes)



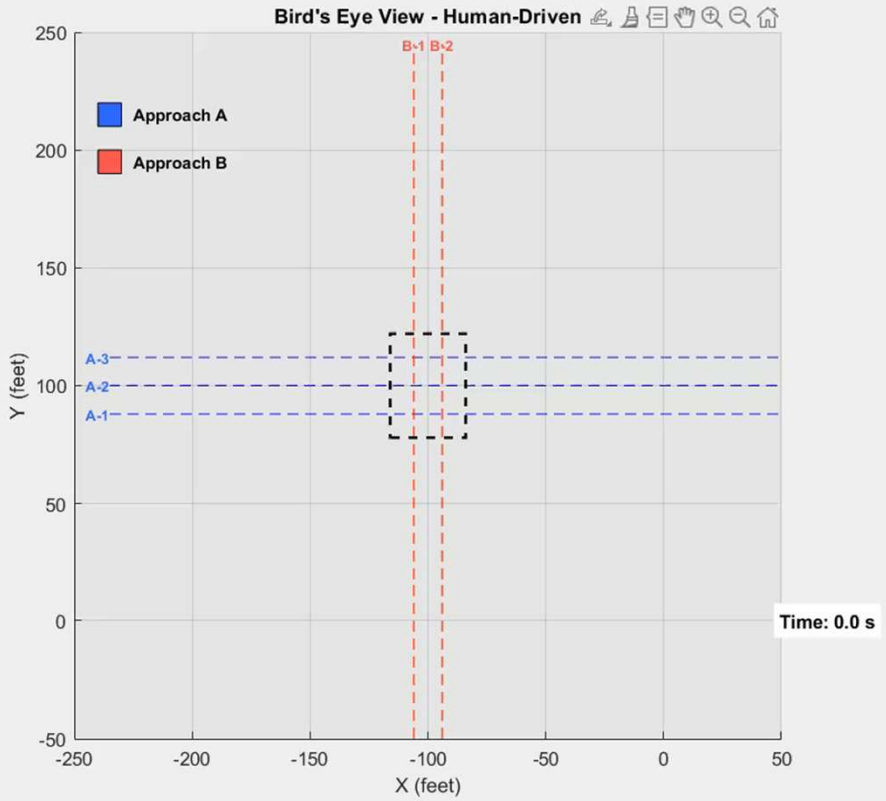
- Single Run Analysis: Detailed look at a 3x2 lane intersection.
- Multi-Run Analysis: 50,000 trials with randomized complexity* (1-20 lanes per approach).

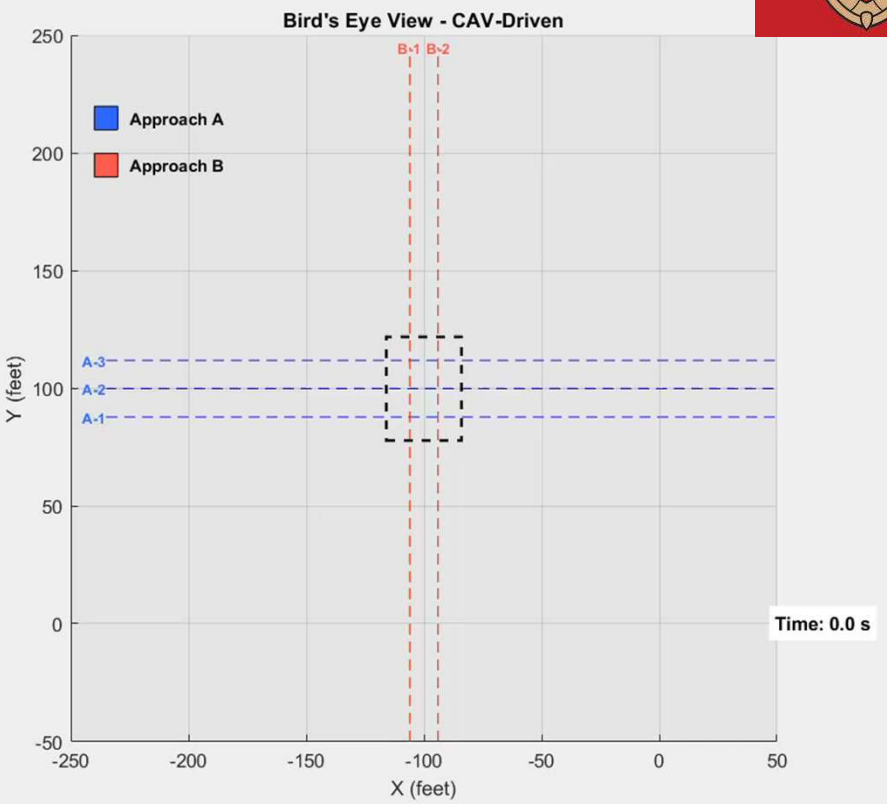
50,000 Random Runs (Varying Complexity)



*Intersection Complexity (More Lanes = More Complex)

Single Run Results: CAVs Show Major Gains

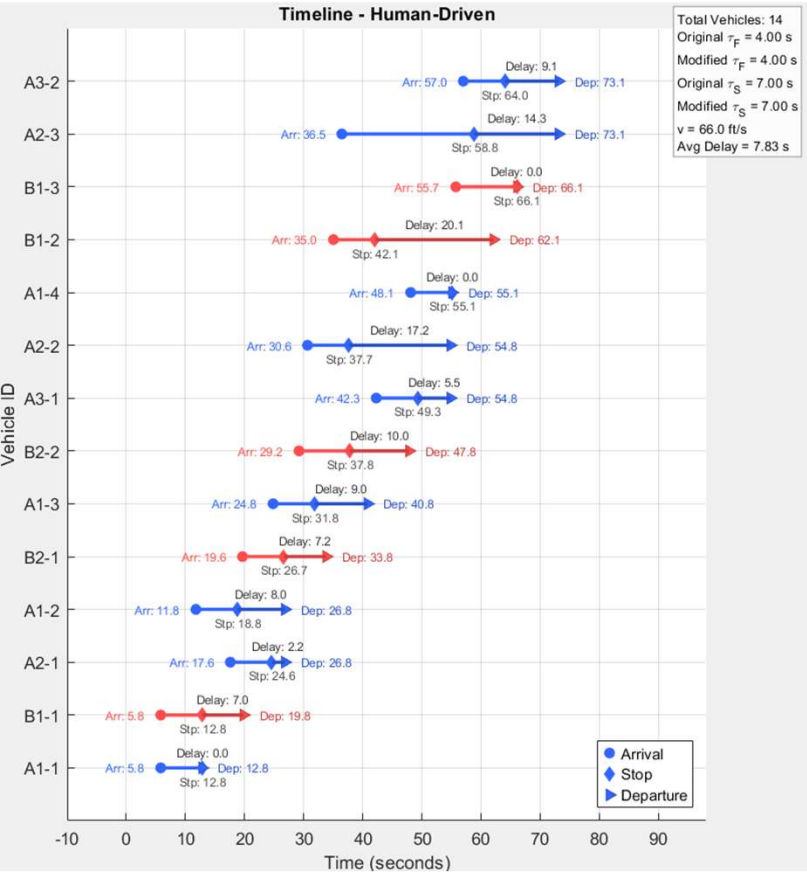


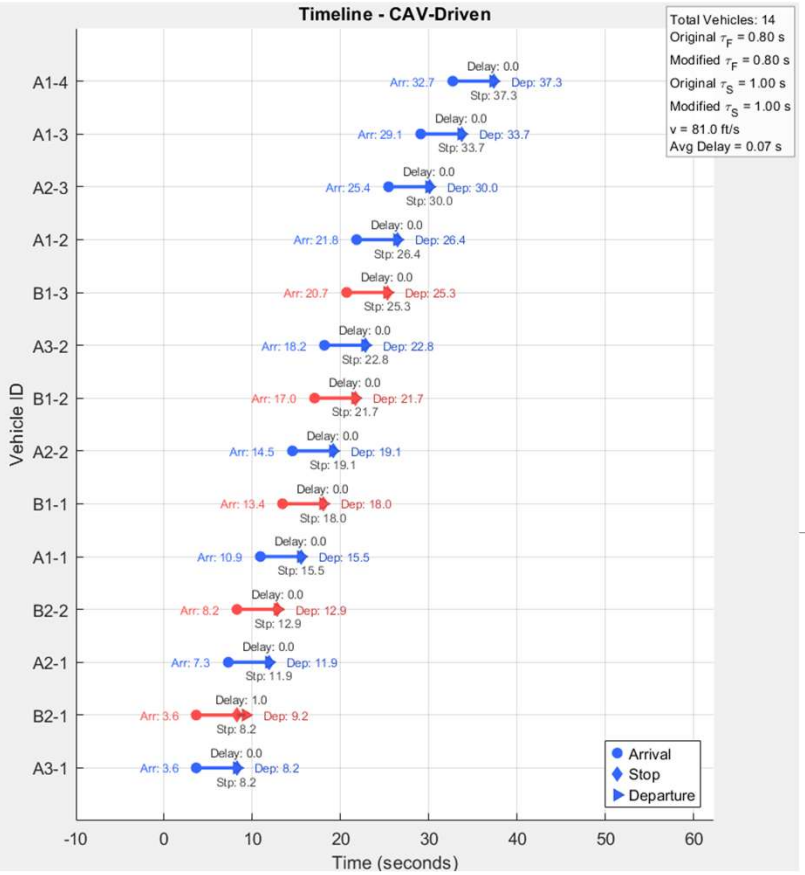


Note: Xi-j="j"-th vehicle in Lane "i" of approach "X"

Pause

Single Run Results: CAVs Show Major Gains



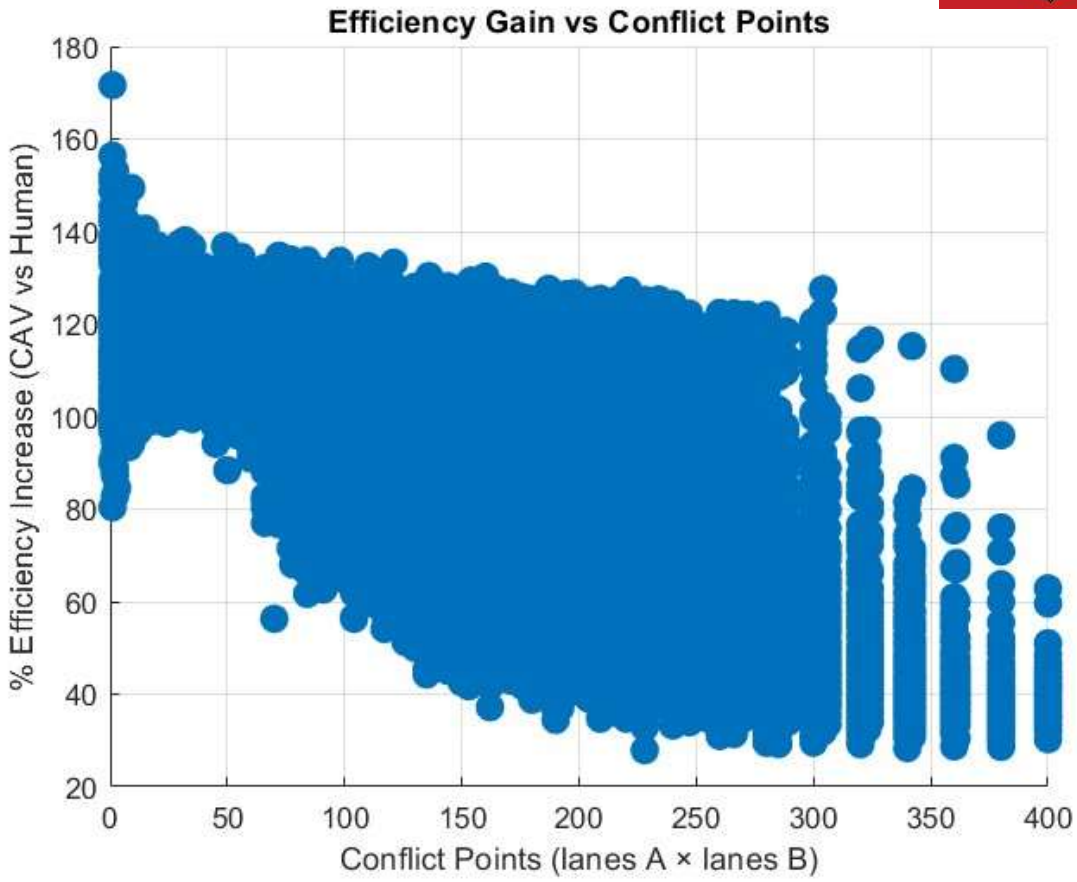


- >2x Faster Clearance
- >99% Delay Reduction
- 107% Throughput Efficiency Gain*.

*Throughput: The number of vehicles moving through a road in a specific time

Multi-Run Results: Impact of Complexity

- Consistent Efficiency Gains across diverse scenarios.
- Trend: Highest % gains at lower complexity, but high variance (spread).

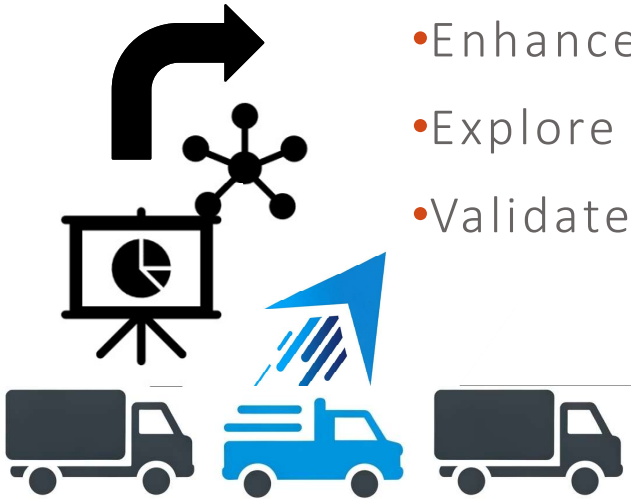


Key Findings

- Basic CAV parameters = Substantial baseline efficiency boost (~100%+) for stop signs.

- Conflict resolution method enables realistic multi-lane simulation.
- Benefit is robust, but context (complexity, traffic) matters.

Next Steps & Future Research



- Enhance Realism (acceleration, turns, stochastic behavior).
- Explore Advanced CAV Strategies (platooning, cooperation).
- Validate & Expand Scope (real data, network impacts).

Conclusion

- CAV parameters offer significant efficiency gains for stop-signalized intersections.
- This method provides a robust way to analyze that.

Thank You

https://github.com/arm-nix/cav-stop-intersection-simulation

Questions?