

Application I:

Highways and Cooperative Adaptive Cruise Control Mobility Assessment

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Agenda

- Introductions
- Objective
- Methodology
- Modeling Paradigm
- Simulation Environment
- Simulation Process
- Travel Trajectory
- Results
- Conclusion

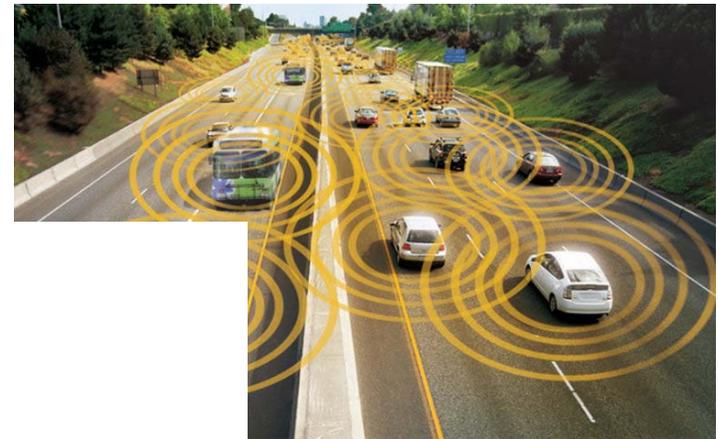
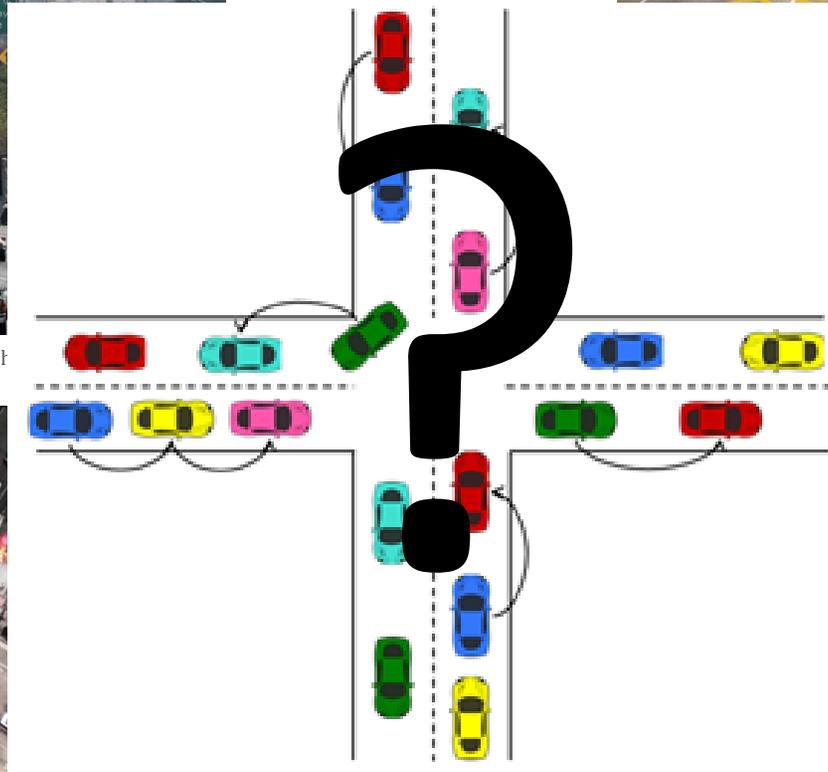
Challenge



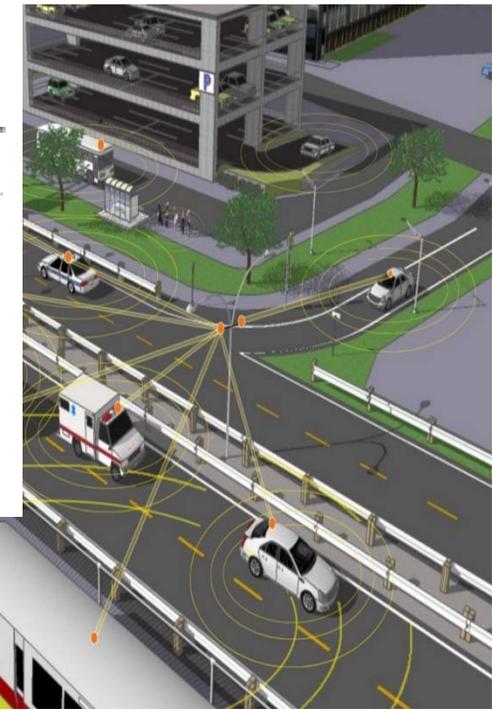
<http://thehill.com/policy/transportation/248060-federal-budget-approves-8-billion-highway-patch>



<http://www.nydailynews.com/new-york/navid-baraty-intersection-gallery-1.1548667?pmSlide=1.1548661>



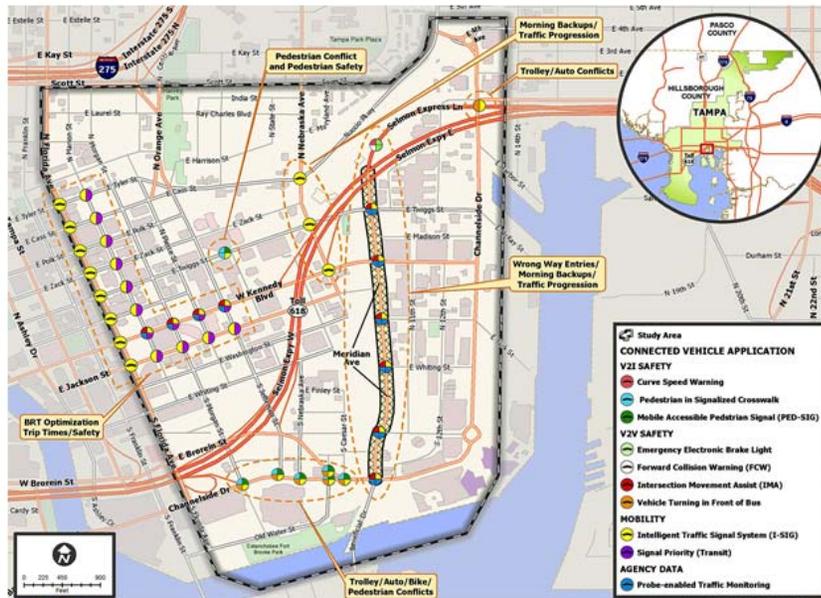
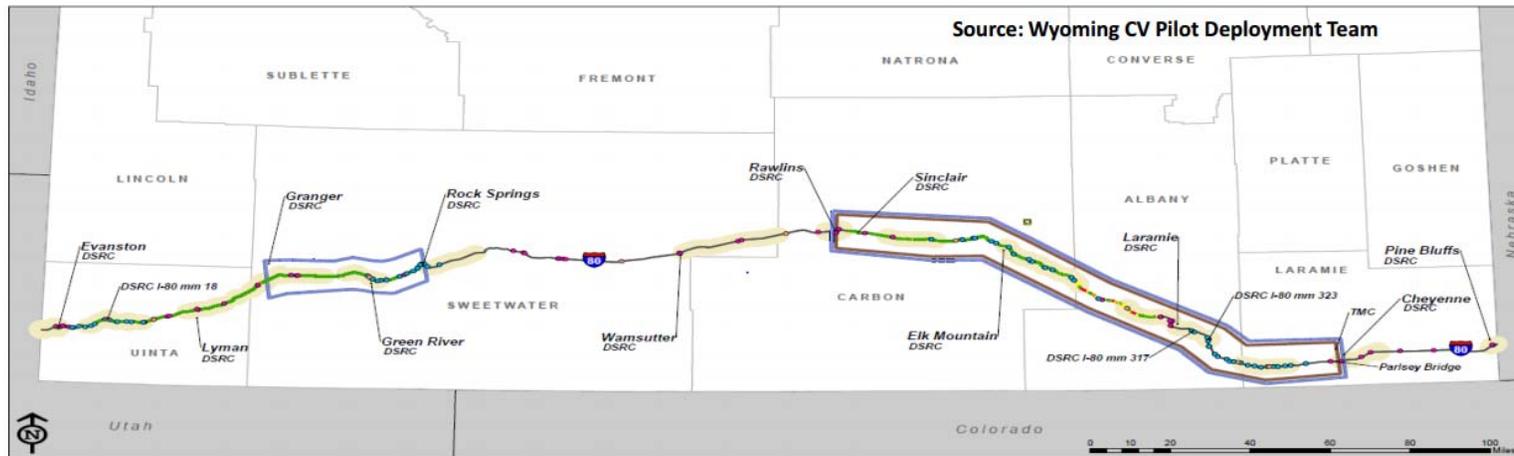
transportation



<http://www.networkworld.com/article/2220182/wireless/us-to-let-everyday-drivers-test-advanced-wireless-auto-safety-technology.html>

Initiative

Wyoming I-80 Corridor - Connected Vehicle Map



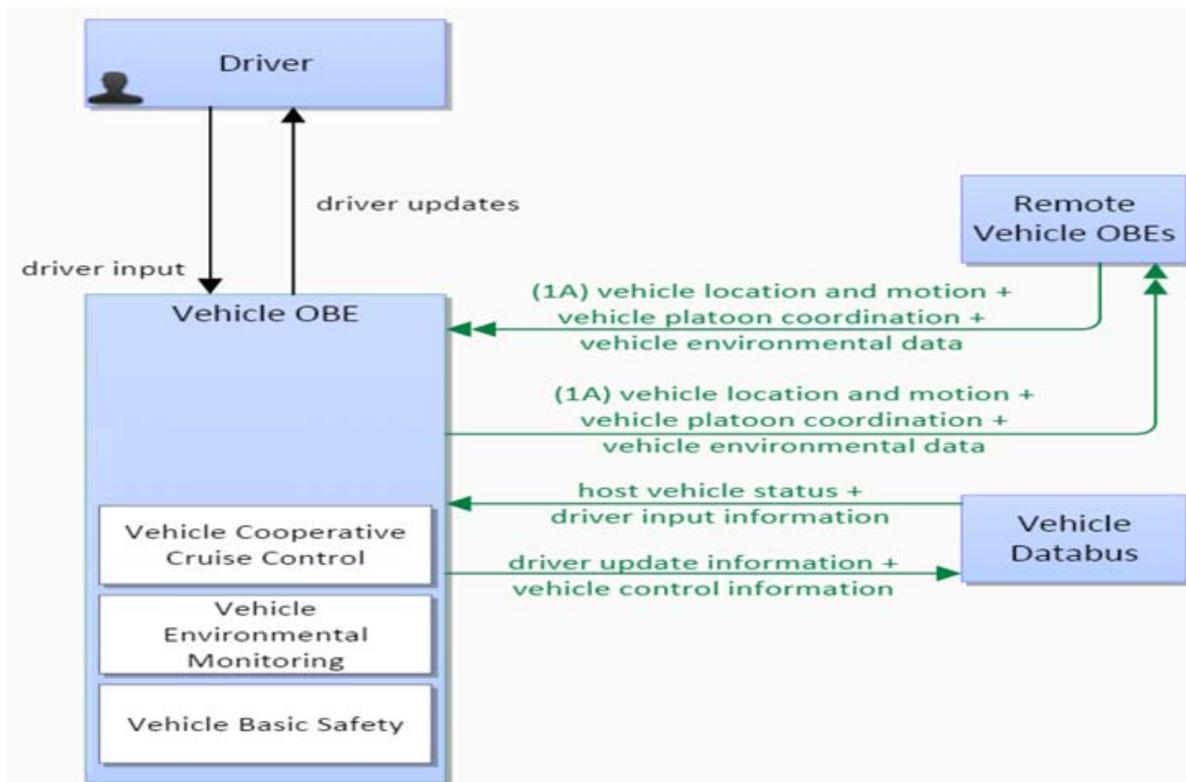
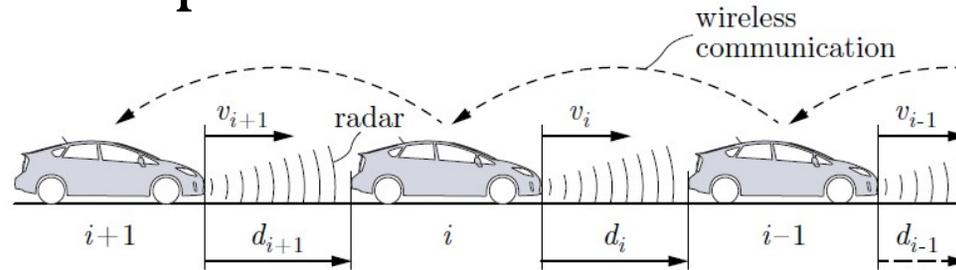
Connected Vehicle Pilot Deployment-Downtown Tampa



New York City Pilot Deployment Site Map

<http://www.its.dot.gov/pilots/wave1.htm>

Cooperative Adaptive Cruise Control



Objectives

Questions

- What are the impacts of Cooperative Adaptive Cruise Control have on traffic operations?
- What is the importance of the adoption rate?

Objectives

- Observe an effect of CACC over the base scenario for different market penetration rates.
- Discover estimates for critical adoption rates

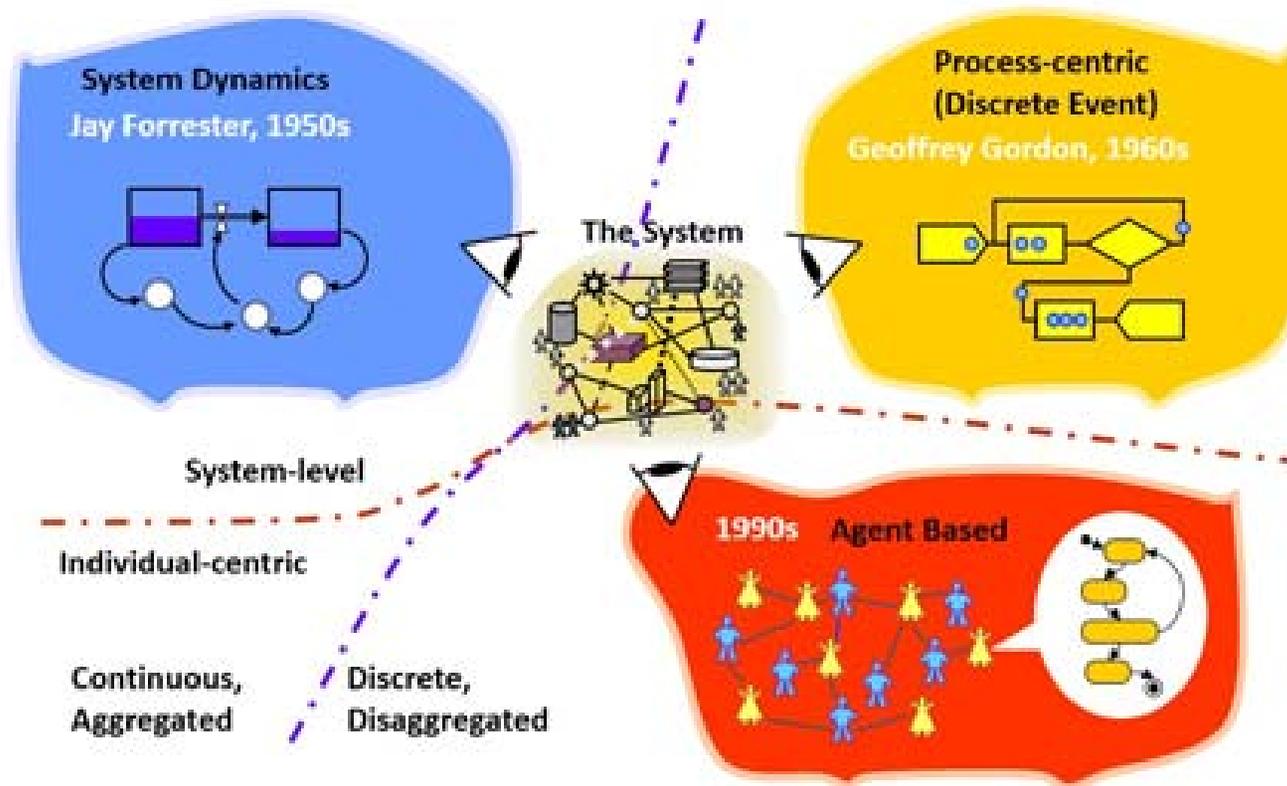
Methodology



- One lane on a 3.5-mile stretch of straight continuous highway
- No on- or off-ramps
- Normal weather condition
- A 1-mile section of reduced speed (bottleneck) in the middle
- Speed limit set at 70 mph
- Bottleneck speed limit set at 10 mph



Modeling Paradigm



<http://www.anylogic.com/learn-simulation>

Simulation Environment: Parameters

Poisson Vehicle Arrivals
Mean inter-arrival time is 4 sec



Negative Exponential Inter-arrival

$$f(x, \lambda) = \begin{cases} \lambda e^{-\lambda x} & x \geq 0 \\ 0 & x < 0 \end{cases}$$

Initial Arrival Speed
between 60 to 40 mph



Uniform Initial Speeds

$$f(x) = \begin{cases} \frac{1}{b-a} & a \leq x \leq b \\ 0 & x < a \text{ or } x > b \end{cases}$$

Market Penetration of CVs



Bernoulli Vehicle Type Selection

$$f(x, p) = \begin{cases} p & x = 1 \\ 1 - p & x = 0 \end{cases}$$

Simulation Environment: Car-following (Non-CV)

Leading Car Behavior

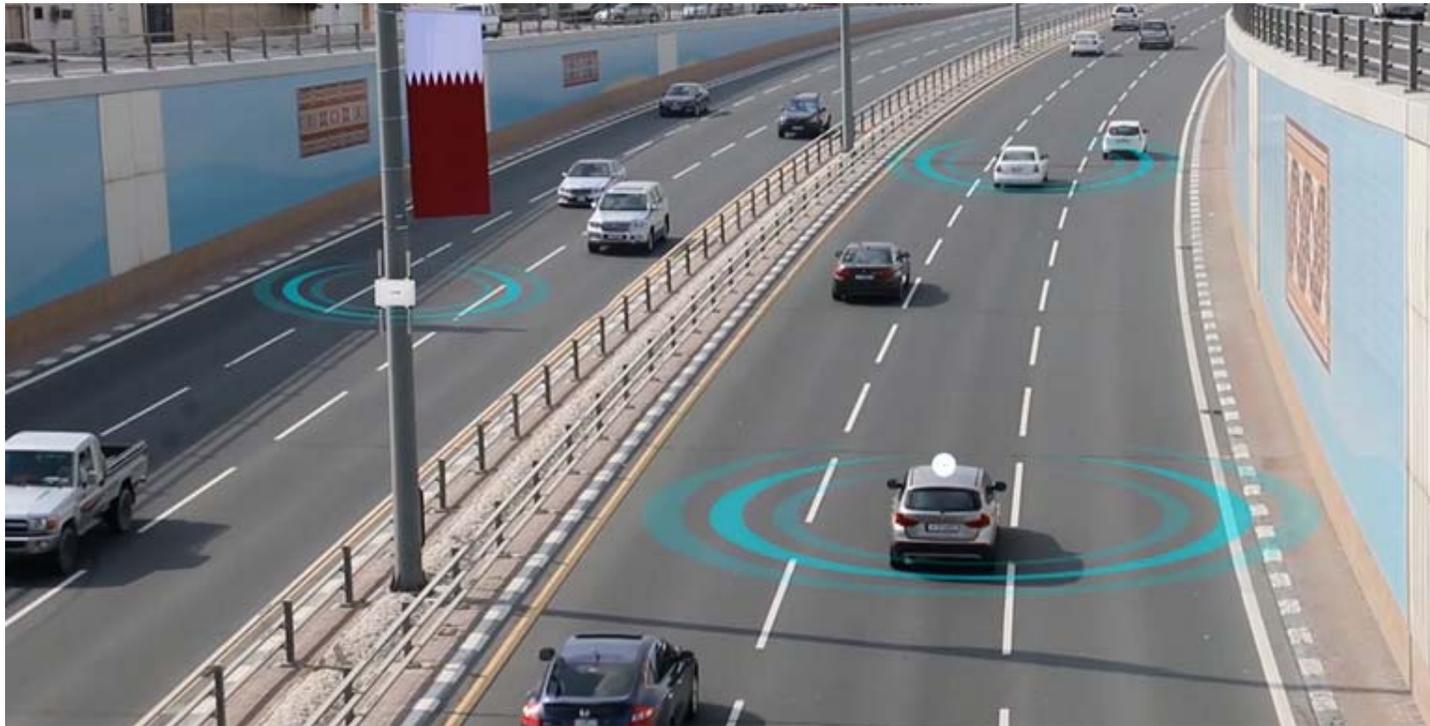
Parameter	Rate
Acceleration	3.3 ft/s^2
Deceleration	7.9 ft/s^2

Car-Following Behavior

$$a_{n+1}^{t+\Delta t} = \alpha \frac{V_{n+1}^t{}^m}{[X_n^t - X_{n+1}^t]^l} [V_n^t - V_{n+1}^t]$$

Parameter	Notation	Value
Distance headway exponent	l	2
Speed exponent	m	0
Jam density	K_j	200 vpm
Free Flow Speed	V_f	70 mph
Sensitivity Coefficient	α	0.35 mi^2/hr
Reaction Time	Δt	0

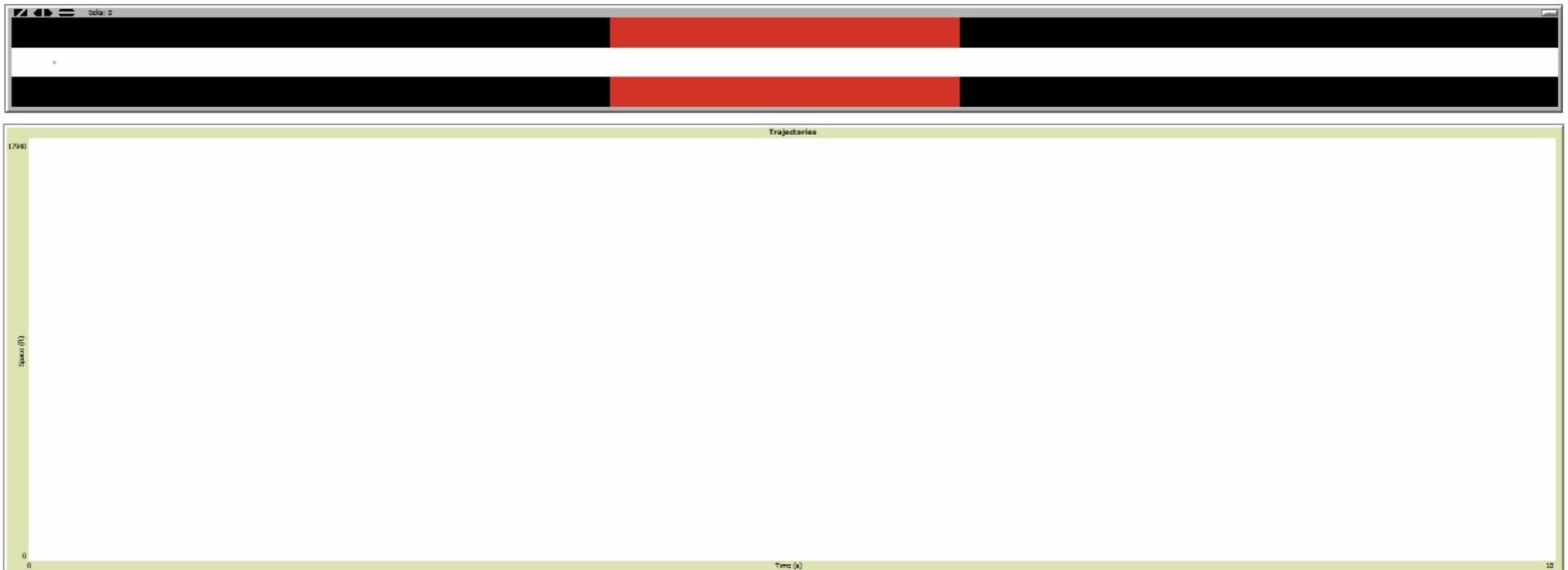
Simulation Environment: Car-following (CV)



$$\textit{Desired Speed} = \frac{\textit{Space Headway}}{\textit{Desired Time Headway}}$$

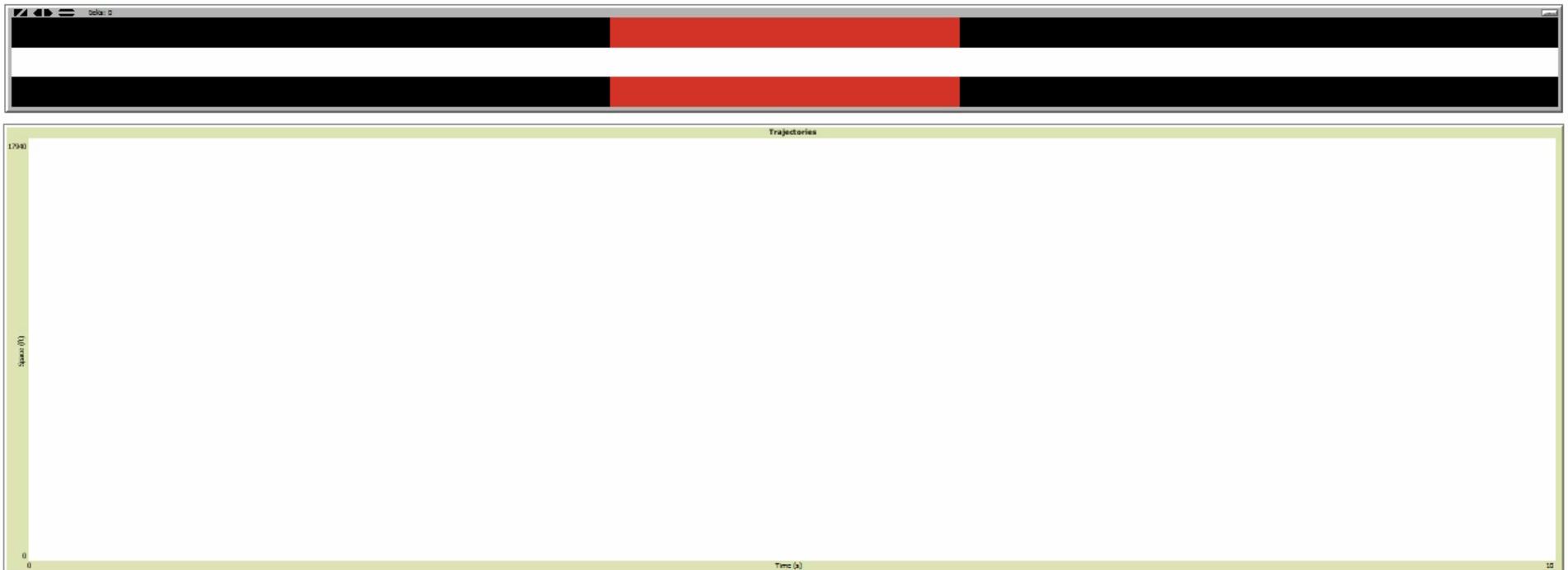
Summation Process

0% Connected Vehicle – 100% Ordinary Vehicle



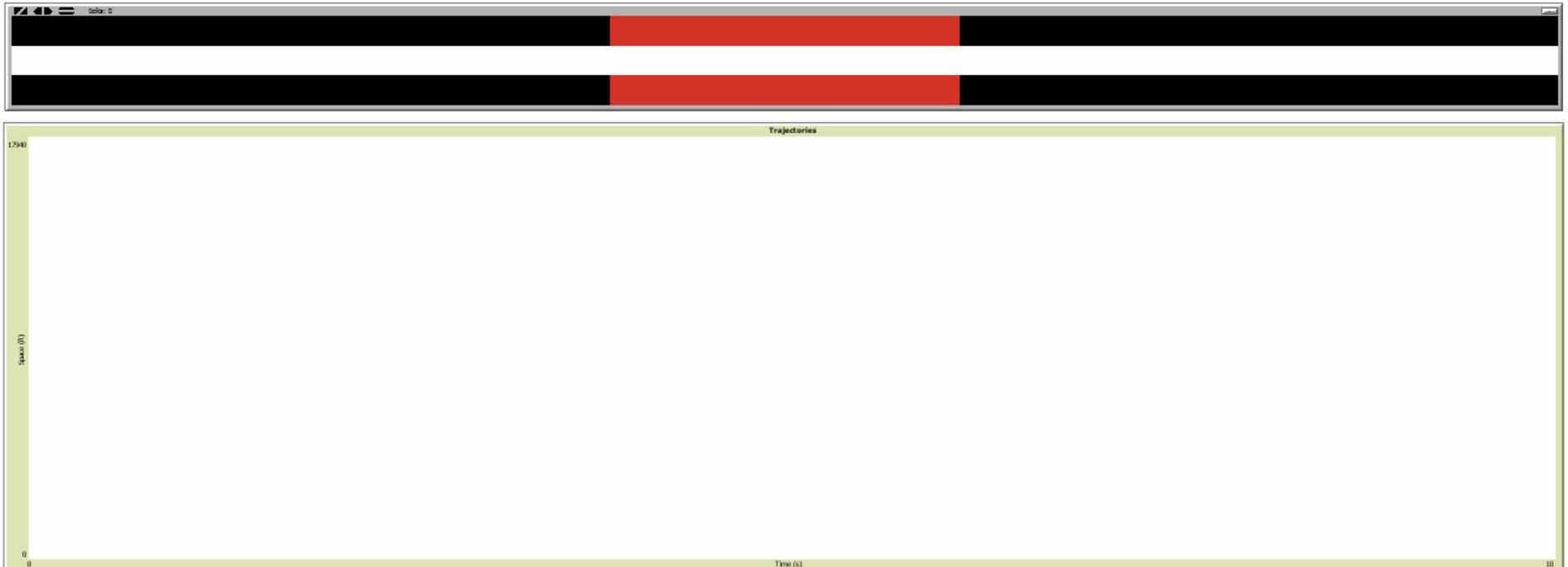
Summation Process

50% Connected Vehicle – 50% Ordinary Vehicle

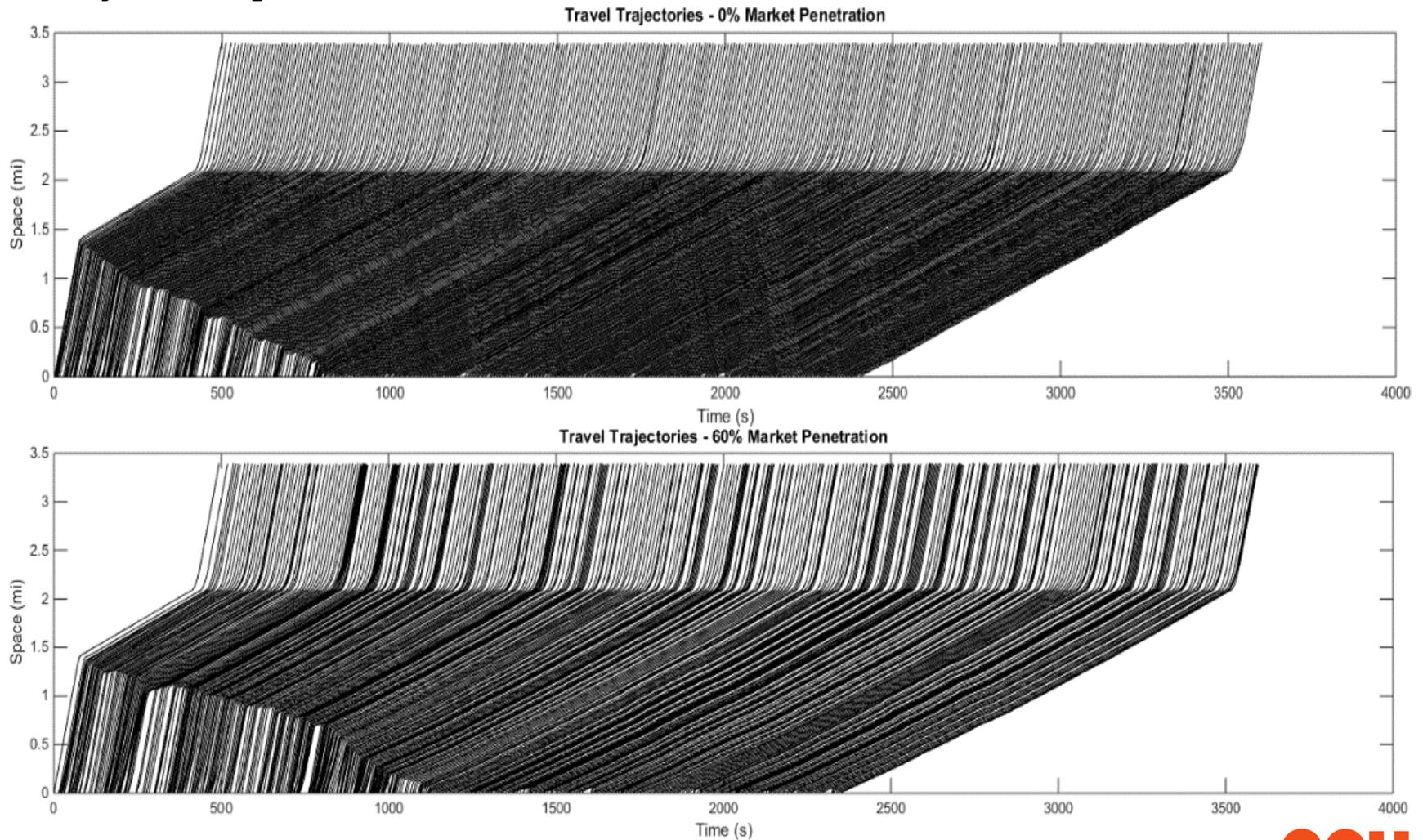


Summation Process

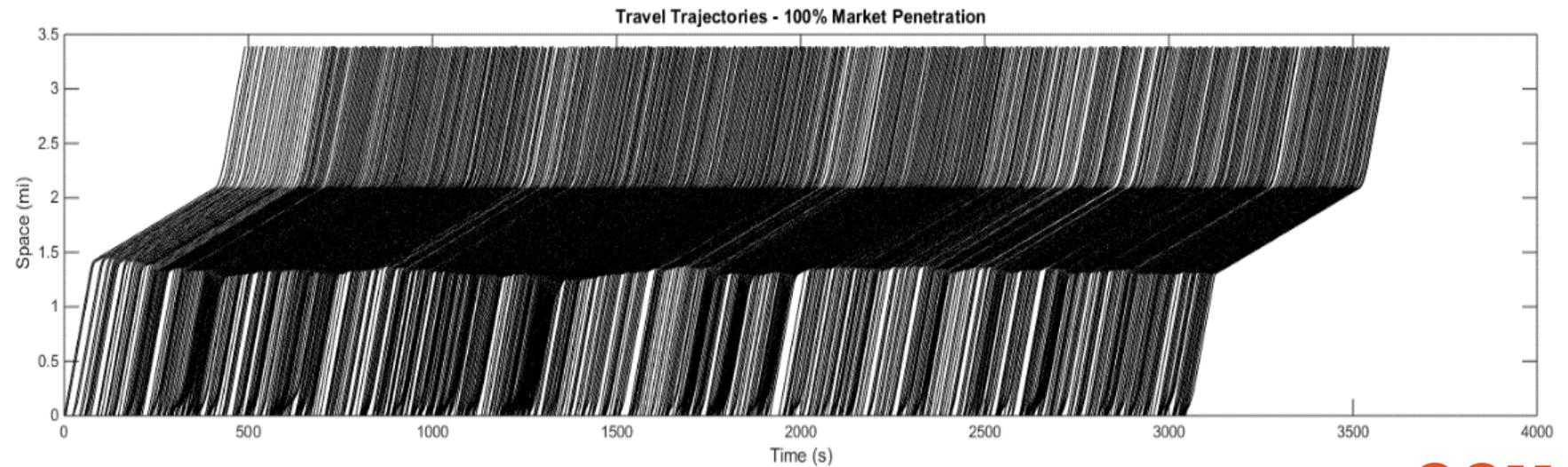
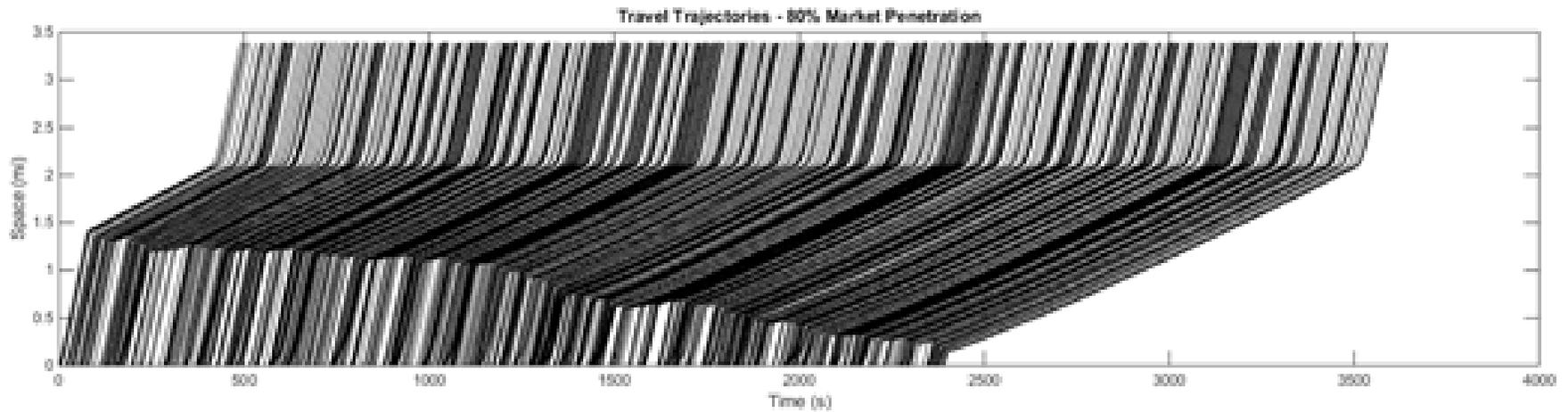
0% Connected Vehicle – 100% Ordinary Vehicle



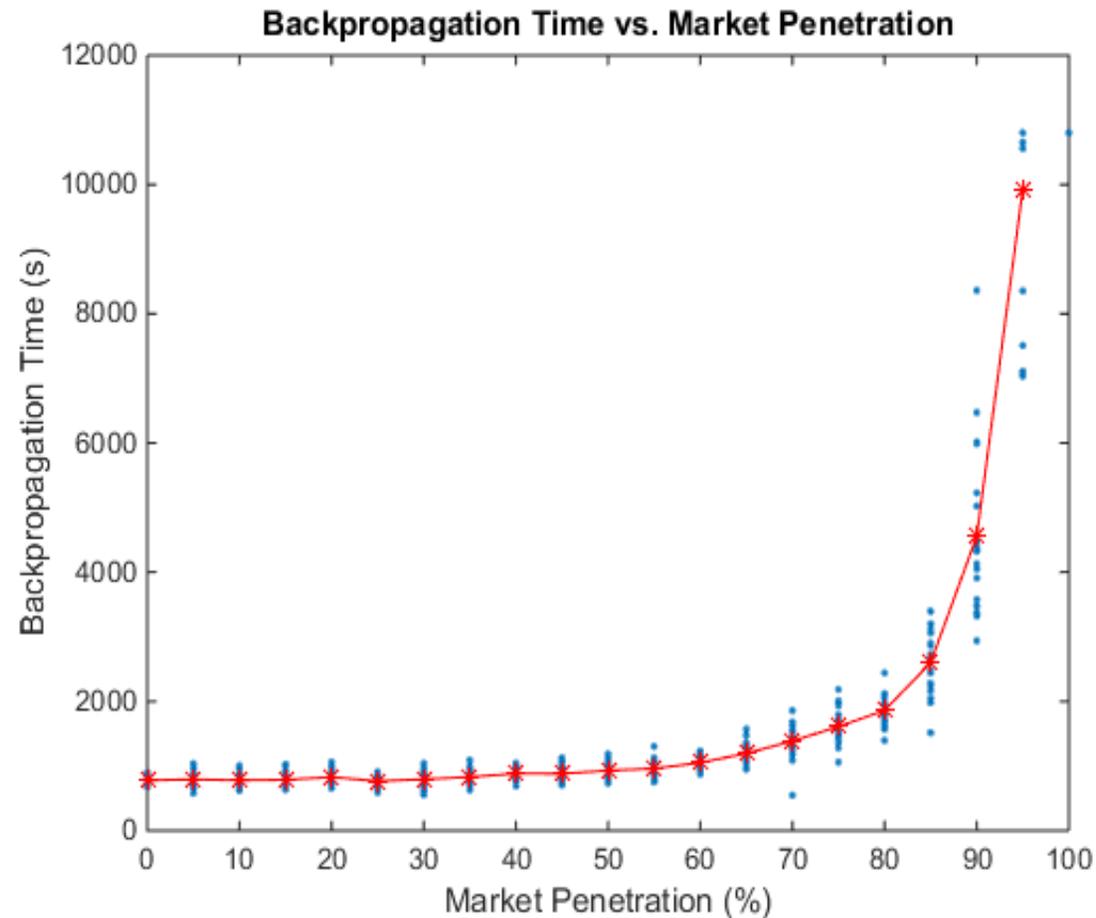
Trajectory – Shock Wave



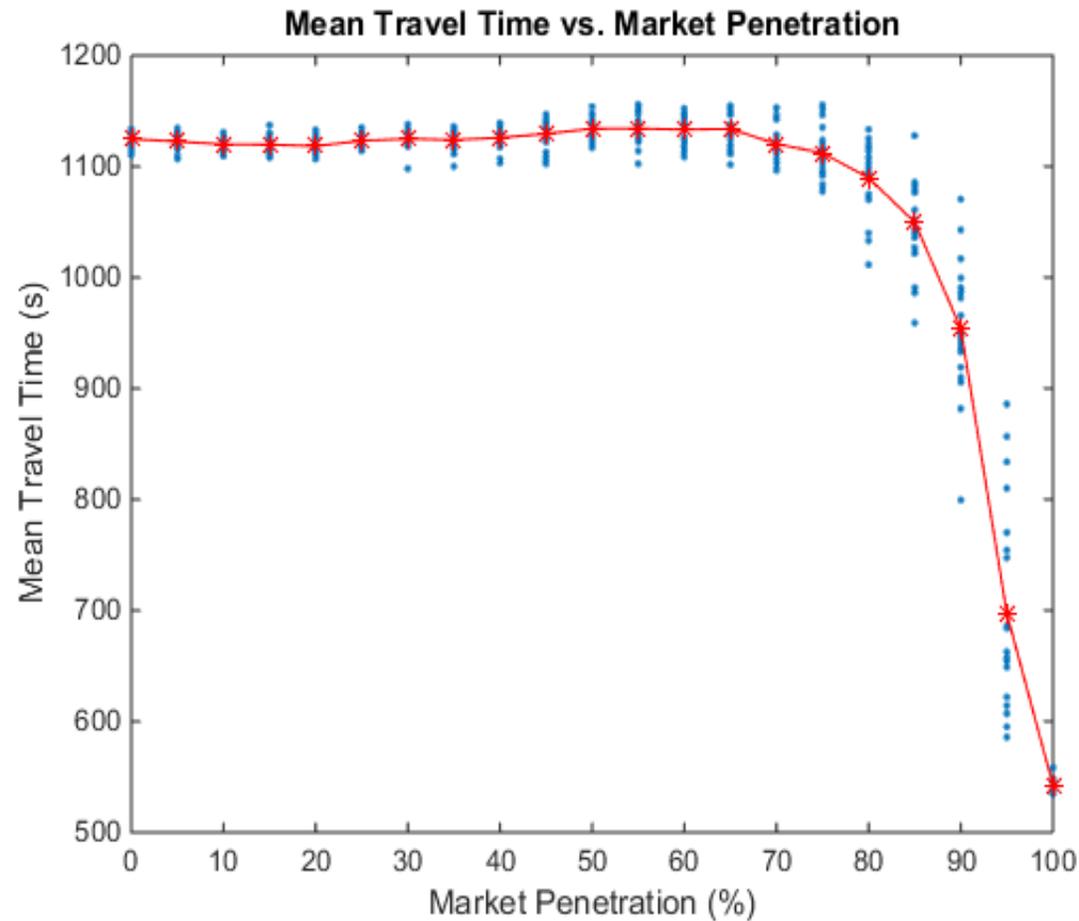
Trajectory - Platooning



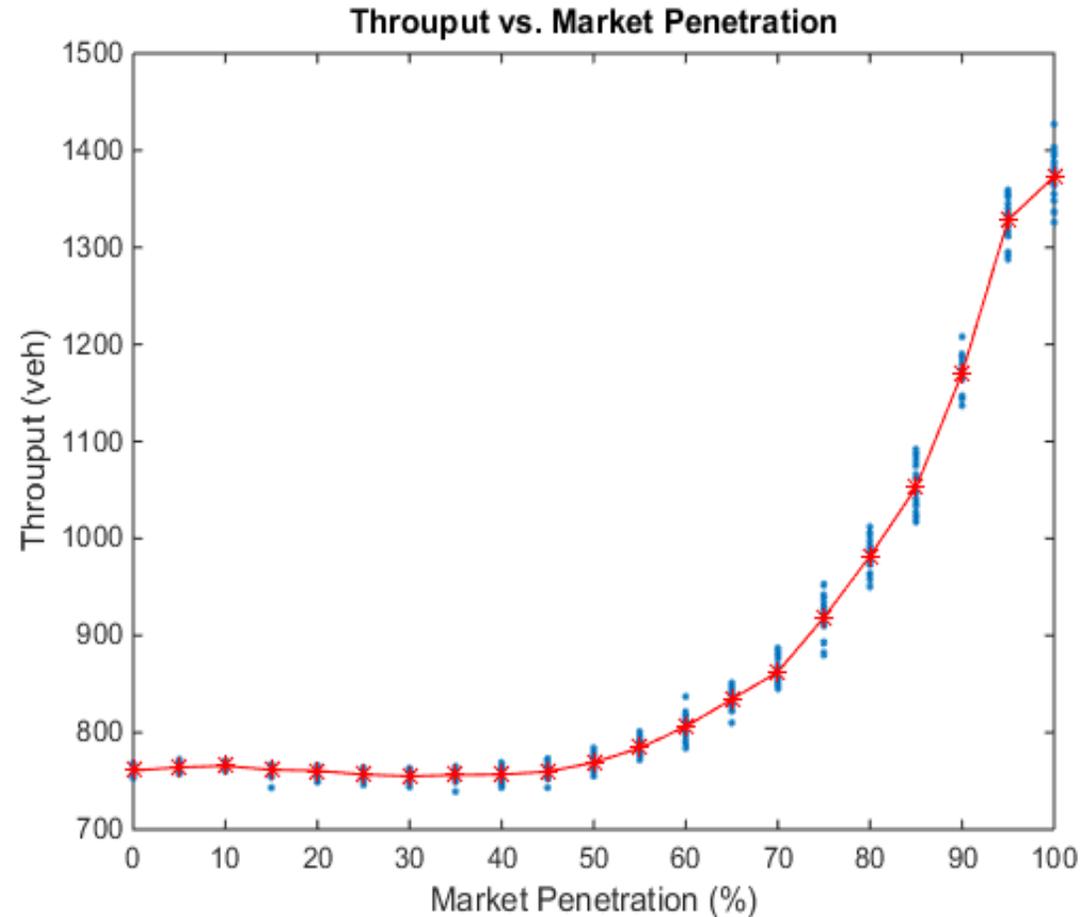
Results – Backpropagation Time vs. Market Penetration



Results – Mean Travel Time vs. Market Penetration



Results – Throughput vs. Market Penetration



Conclusions

