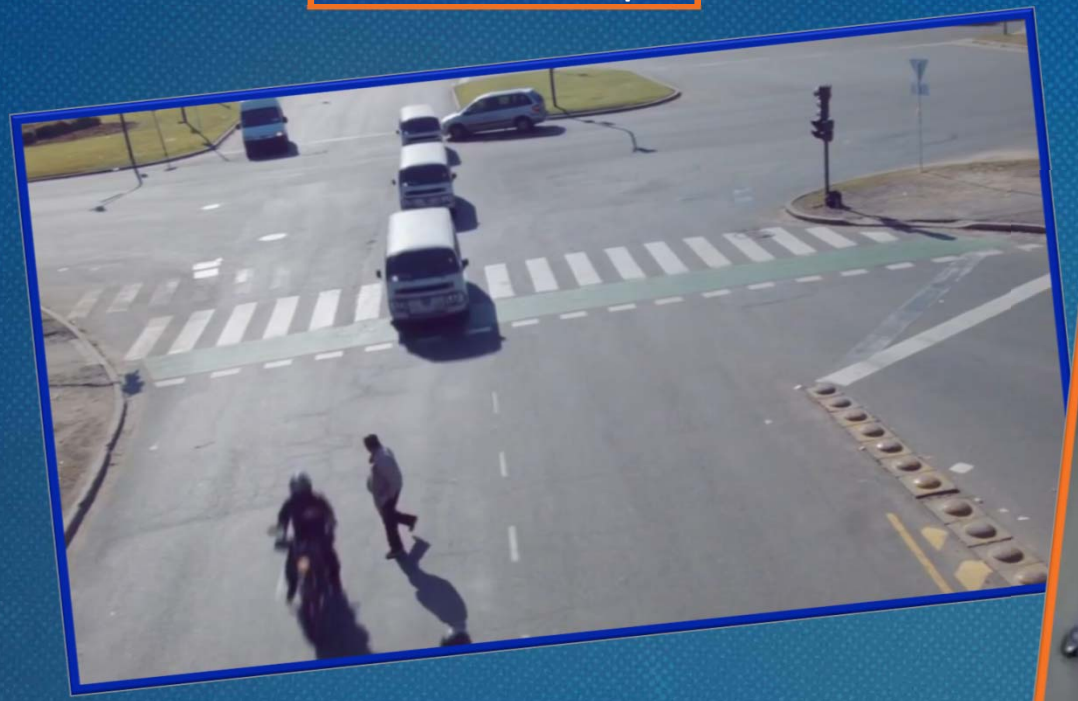
REALTIME INTERSECTION OPTIMIZER (RIO) UNDER CONVENTIONAL AND AUTOMATED VEHICLE TRAFFIC

ASH OMIDVAR

FSITE ANNUAL MEETING
OCT. 2018

Downtown Tampa



Courtesy: Black Sheep Production

Also Downtown Tampa

Courtesy: Art of War Live

Recursive State Equation for Automated vehicle Trajectory Optimization (ATO):

$$traj_{kl} = \begin{cases} FTO(sig, spt_{kl}, att_{kl}, traj_{(k-1)l}) & \text{for} \quad k \in K_l \backslash \{1\},\ type_{kl} = AV \\ FTE(spt_{kl}, att_{kl}, traj_{(k-1)l}) & \text{for} \quad k \in K_l \backslash \{1\},\ type_{kl} = CV \\ LTO(sig, spt_{kl}, att_{kl}, spd_m) & \text{for} \quad k \in \{1\},\ m \in M, type_{kl} = AV \end{cases} \quad \forall\, l \in \mathcal{L} \tag{1}$$

Sub-models to ATO model:

$FTO(.)$ to be Follower vehicles Trajectory Optimizer for AVs
$FTE(.)$ to be Follower vehicle Trajectory Estimator for CVs
$LTO(.)$ to be Lead vehicle Trajectory Optimizer for AVs

(2)

$$\Delta t_{kl,1} = \frac{v_2 - v_1}{a_1} \quad \forall\, l \in \mathcal{L}, \quad \forall\, k \in \mathcal{K}_l \tag{3}$$

$$\Delta t_{kl,2} = (d_0 - \frac{v_2^2 - v_0^2}{2a_1} - \frac{v_3^2 - v_2^2}{2a_3})/v_2 \quad \forall\, l \in \mathcal{L}, \quad \forall\, k \in \mathcal{K}_l \tag{4}$$

$$\Delta t_{kl,3} = \frac{v_3 - v_2}{a_3} \quad \forall\, l \in \mathcal{L}, \quad \forall\, k \in \mathcal{K}_l \tag{5}$$

$$T_{kl} = \sum_{n=1}^{3} \Delta t_{kl,n} \quad \forall\, l \in \mathcal{L}, \quad \forall\, k \in \mathcal{K}_l \tag{6}$$

$$D_{kl}(T_{kl}) = T_{kl} - \frac{d_0}{V_{kl}^{des}} \quad \forall\, l \in \mathcal{L}, \quad \forall\, k \in \mathcal{K}_l \tag{7}$$

$$(LTO) \min_{v_2, v_3, a_1, a_3} D_{kl}(T_{kl}) \tag{8}$$

subject to

$$t_{s_\phi} \leq \delta_{\phi l} T_{kl} \leq t_{s_\phi} + G_\phi + Y_\phi \tag{9}$$

$$v_2 \leq V_m^{max} \tag{10}$$

$$v_3 \leq V_m^{cross} \tag{11}$$

$$a^{max-} \leq a_1 \leq a^{max+}$$

$$a^{max-} \leq a_3 \leq a^{max+} \tag{12}$$

ajectory Optimizer
icle arrival information, vehicle attributes, and speed

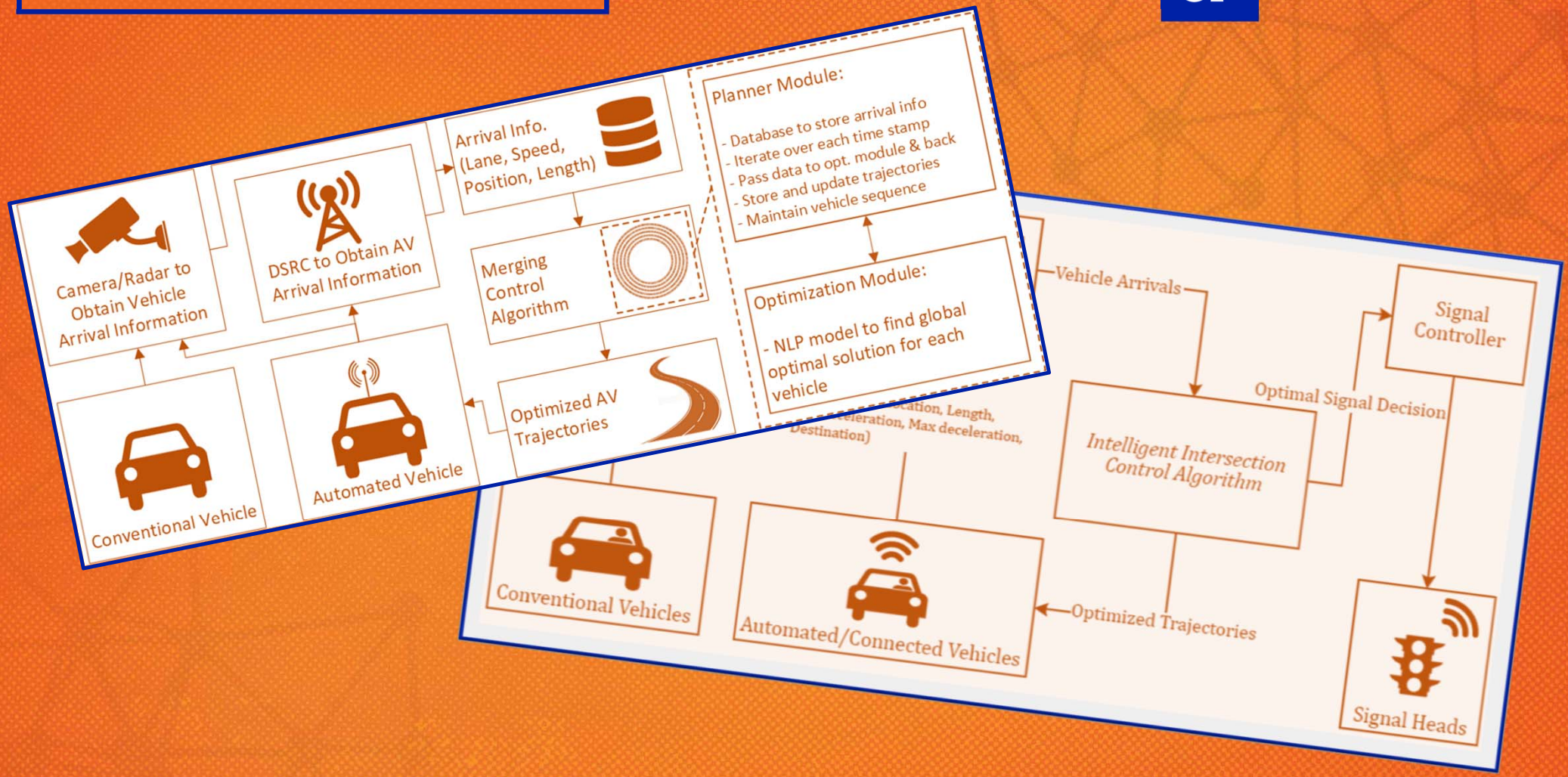
izer
ributes, follower vehicle arrival in-
lway for automated follower

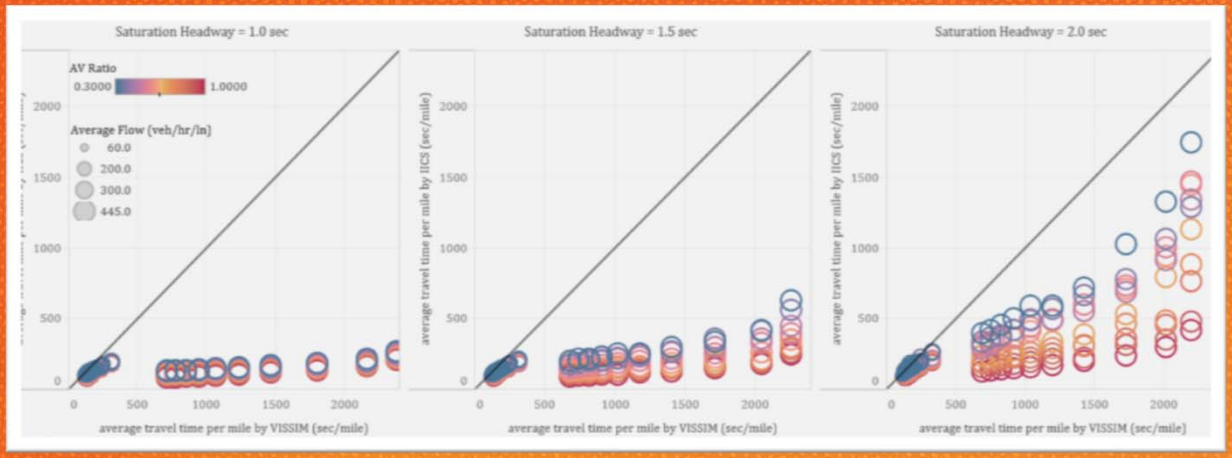
Conventional Follower vehicle Trajectory Estimator
ctory of lead vehicle, lead and follower's attributes, follower vehicle arrival

ory of conventional follower
FTE_Solver($spt_{kl}, att_{kl}, att_{(k-1)l}, traj_{(k-1)l}$)
tion time
ver initial distance to stop bar
0 do
$+ \Delta t$
te $v_{kl}(t)$ using Eq. 13
$- \{\frac{v_{kl}(t+\Delta t) - v_{kl}(t)}{\Delta t} | \tau \in [t, t + \Delta t]\}$
$_{kl}(\tau)\Delta t^2 + v_{kl}(t)\Delta t$

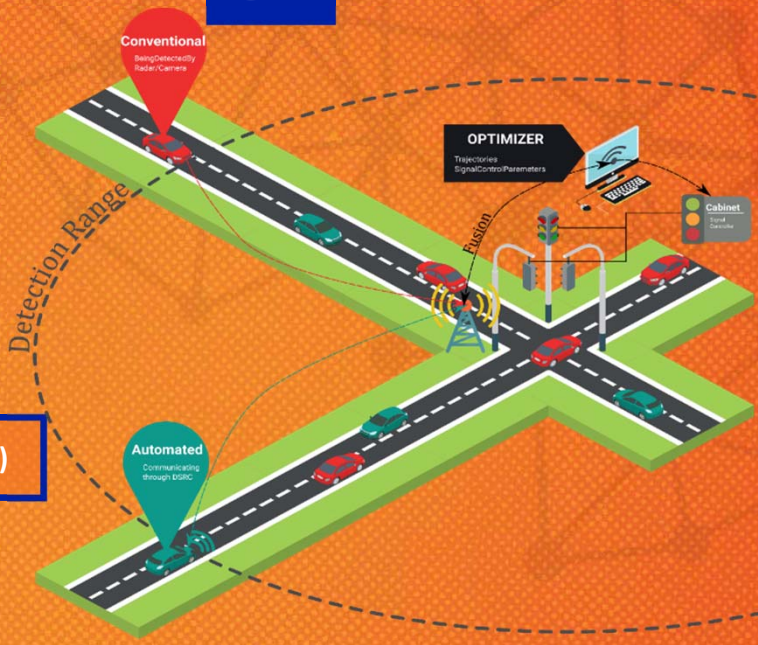
computed pairs of (t, d)
end procedure

REALTIME INTERSECTION OPTIMIZER (RIO)



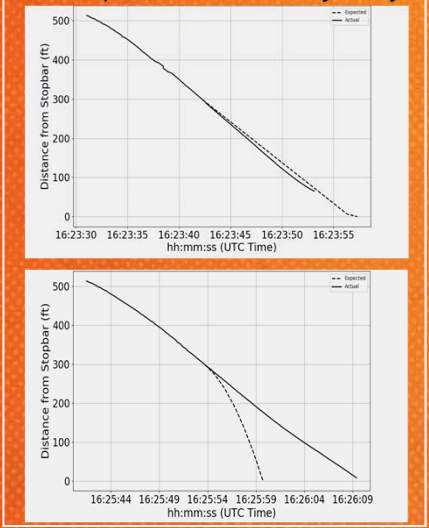


UF

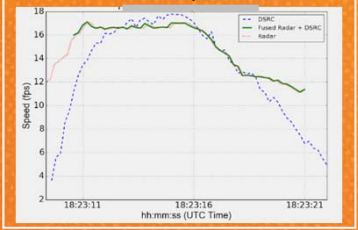


REALTIME INTERSECTION OPTIMIZER (RIO)

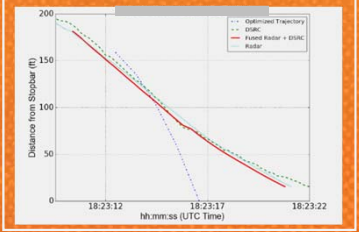
Conventional Vehicle Excepted Vs. Actual Trajectory



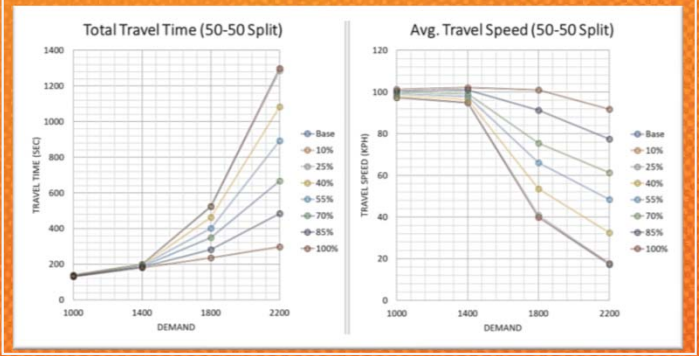
Fused Vehicle Speed Estimate



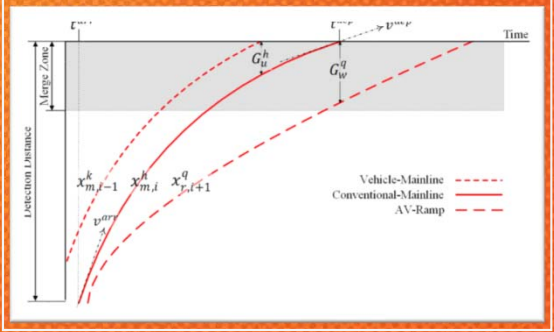
Fused Vehicle Location Estimate



IISC Performance in Freeway Merge for Different AV Penetration Rate

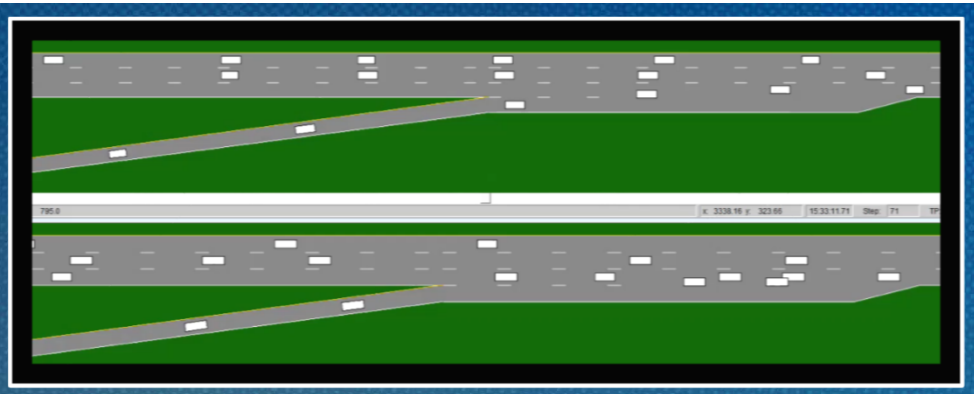


Resulting Trajectories at A Freeway Merge Area



UF

FIELD IMPLEMENTATION
(FDOT-TERL)



SIMULATION
(CORSIM)

SIMULATION / IMPLEMENTATION
(NaviGATOR)

Proposal

ENDORSEMENTS AND OFFERS FROM MAJOR AUTOMAKERS (Just Kidding!!!)

Asking for the followings in return for 50% of the share of RIO

1. **FSITE ANNUAL MEETING 2018 BEST POSTER / SHARKTANK AWARD**

2. A JOB OFFER (PLEASE) UPON MY GRADUATION!!

THANK YOU!

REFERENCES

[1] Omidvar A, Letter C, Elefteriadou L. An Overview of Existing Pilot and Testbed Activities to Advance Connected and Autonomous Vehicle Technology: Common Threads and Future Priorities. 2018. FDOT Contract BDV31 977-74, September 2017, 251 pages.

[2] Omidvar A, Pourmehrab M, Emami P, Kiriazes R, Esposito JC, Letter C, Elefteriadou L, Crane III CD, Ranka S. Deployment and Testing of Optimized Autonomous and Connected Vehicle Trajectories at a Closed-Course Signalized Intersection. Transportation Research Record. 2018:0361198118782798.

[3] Omidvar A, Elefteriadou L. Optimizing Freeway Merge Operations under Conventional and Automated Vehicle Traffic. Transportation Research Record. 2018 [article in Press]

[4] Pourmehrab M, Elefteriadou L, Ranka S, Martin-Gasulla M. Optimizing Signalized Intersections Performance under Conventional and Automated Vehicles Traffic. arXiv preprint arXiv:1707.01748. 2017 Jul 1.