ANALYSES USING EXISTING DATA
SHRP2 S01(A)

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Outline

Project overview

Data sources

Counterfactual approach to conflicts/near-crash

Computational demonstration

Ongoing work

Conclusion

Project Focus

S01 RFP: “Two central issues for the planned analysis of the driving behavior field study are the statistical relationship of surrogate measures of collisions (conflicts, critical incidents, near collisions, or roadside encroachments) with actual collisions…”

How do we estimate crash propensity from observations of surrogate events?

Conflicts vs Near Crashes

Conflicts: “A traffic conflict is an observable situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision *if their movements remain unchanged*”

-ICSTCT

Near crashes: “Any circumstance that requires a *rapid, evasive maneuver* by the subject vehicle, or any other vehicle, pedestrian, cyclist, or animal *to avoid a crash*. A rapid, evasive maneuver is defined as a steering, braking, accelerating, or any combination of control inputs that approaches the limit of the vehicle capabilities” –100-Car Study

Our Phase II Work

Emphasis on:

- Car-following crashes
- Gap-selection crashes

Data Sources:

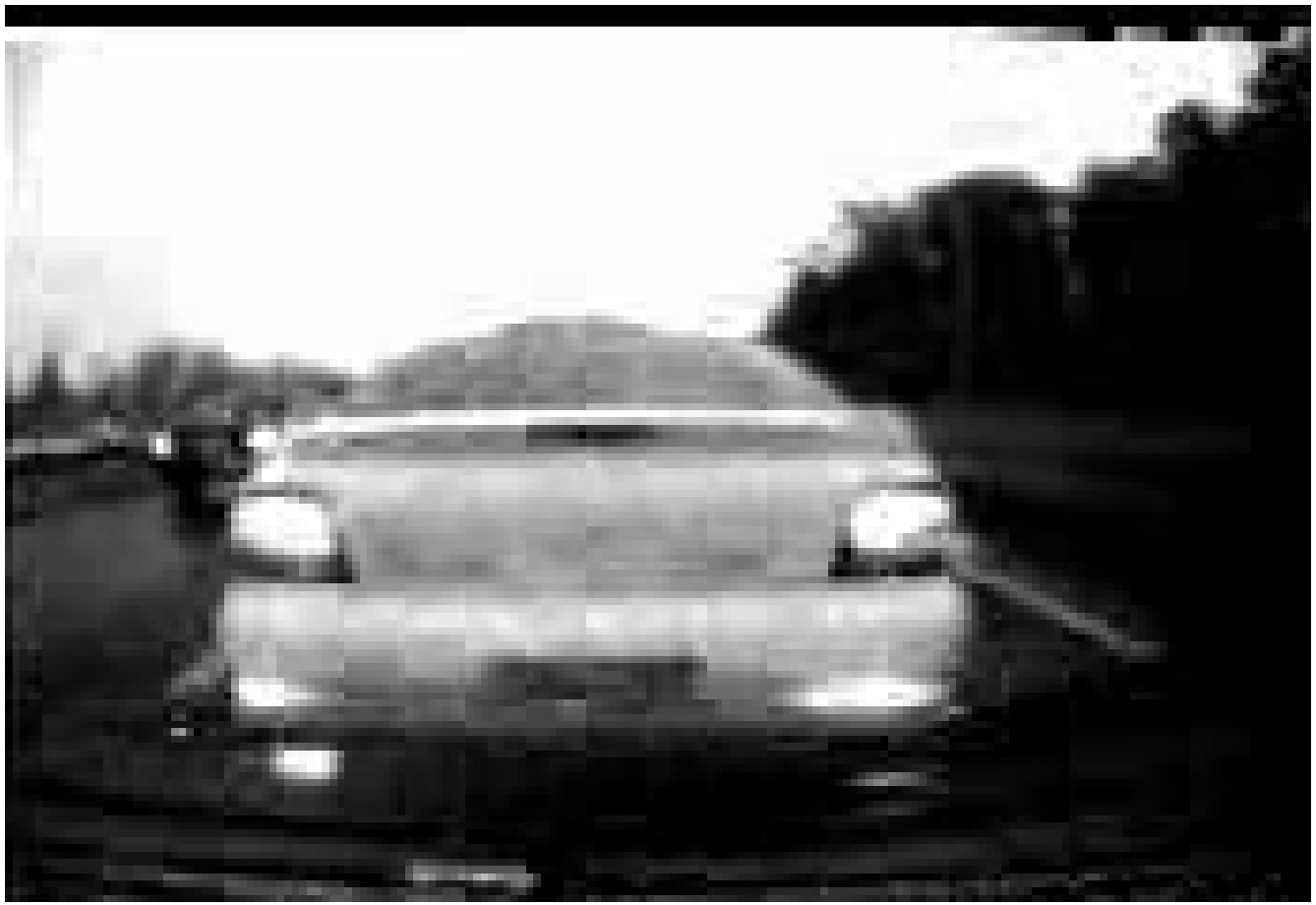
(1) Video of I-94 rear end crashes

(2) 100-Car vehicle-based data

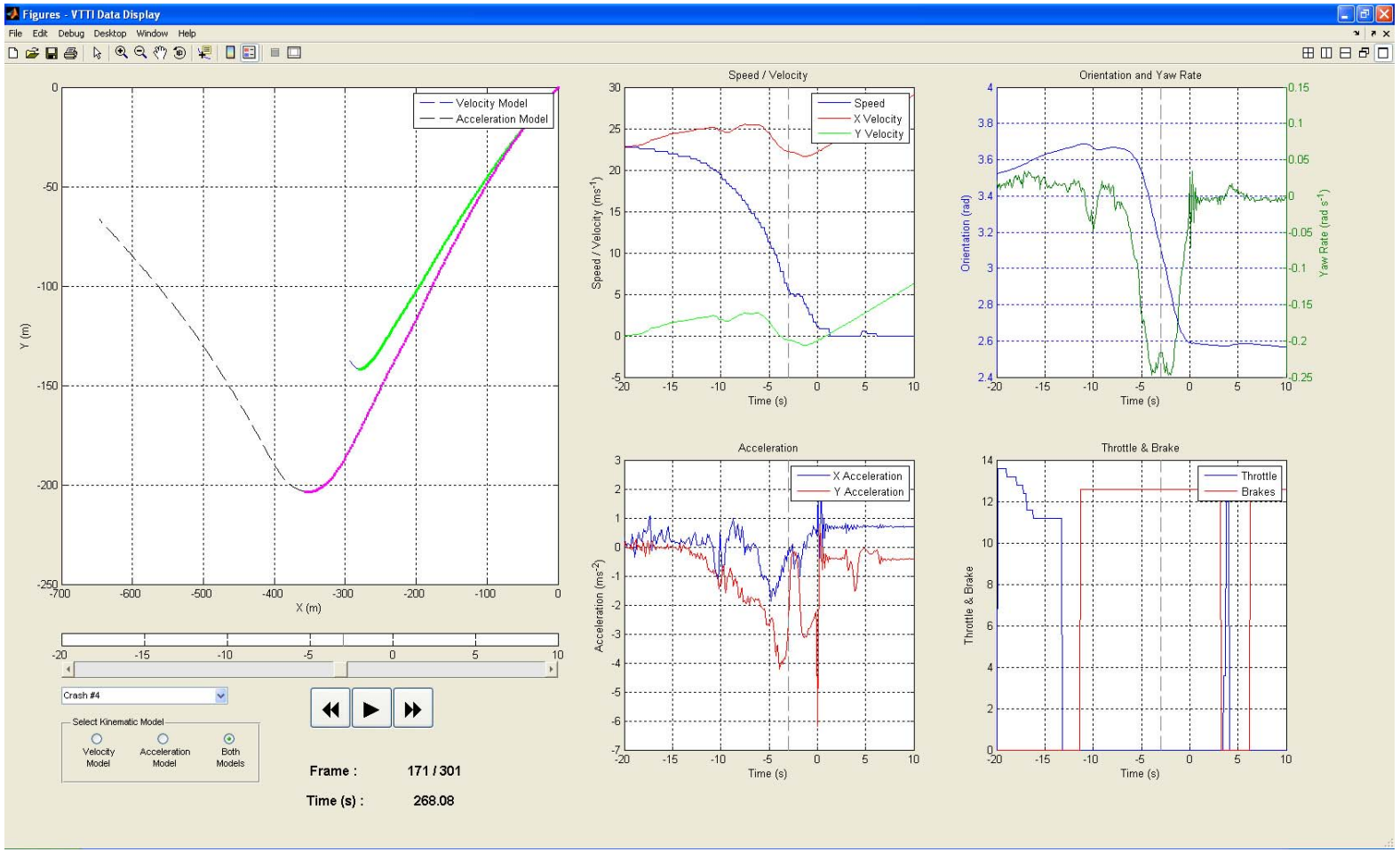
(3) Radar/video of intersection crashes/near-crashes

I-94 Video Data

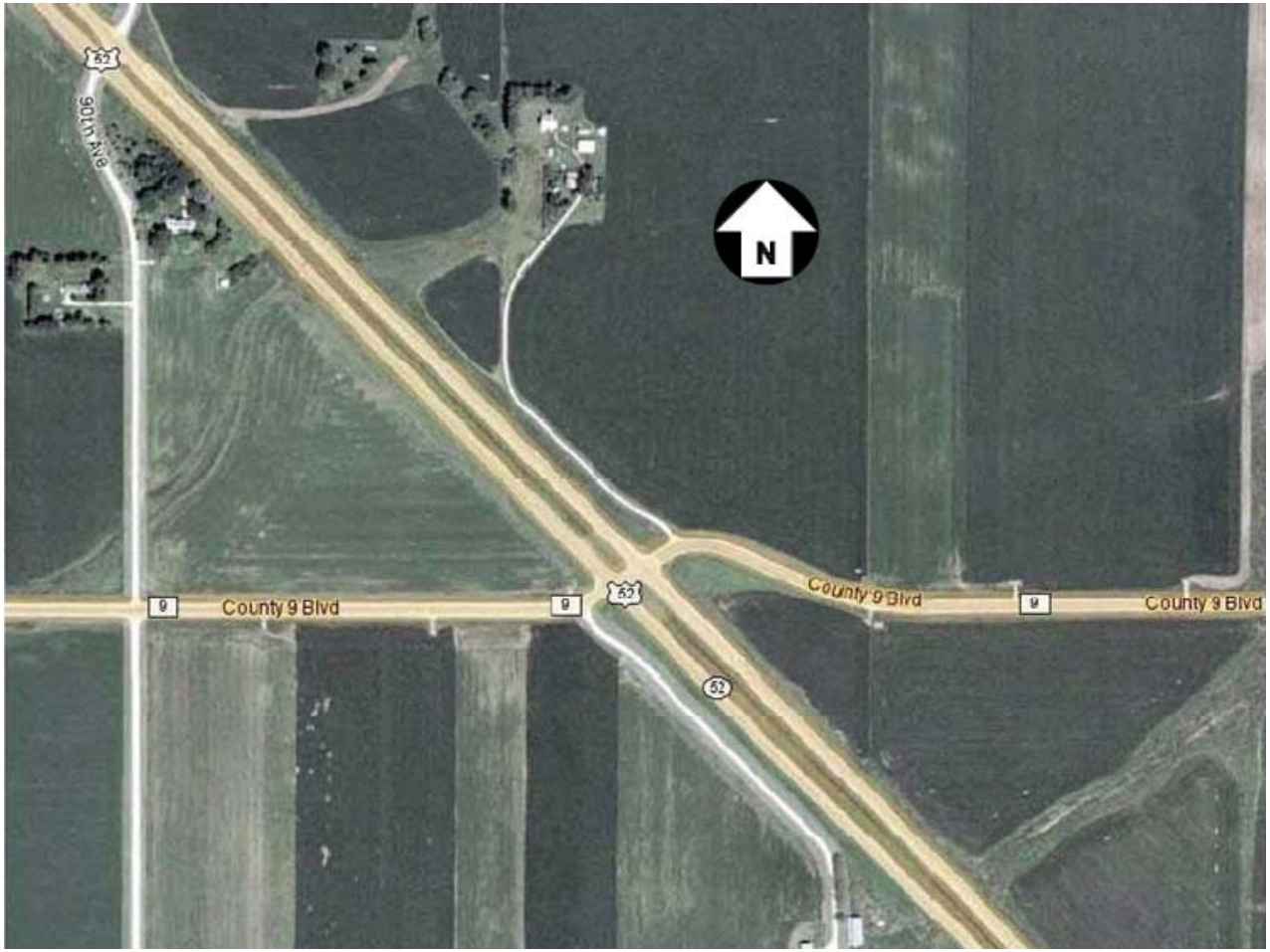
100-Car Vehicle-Based Data



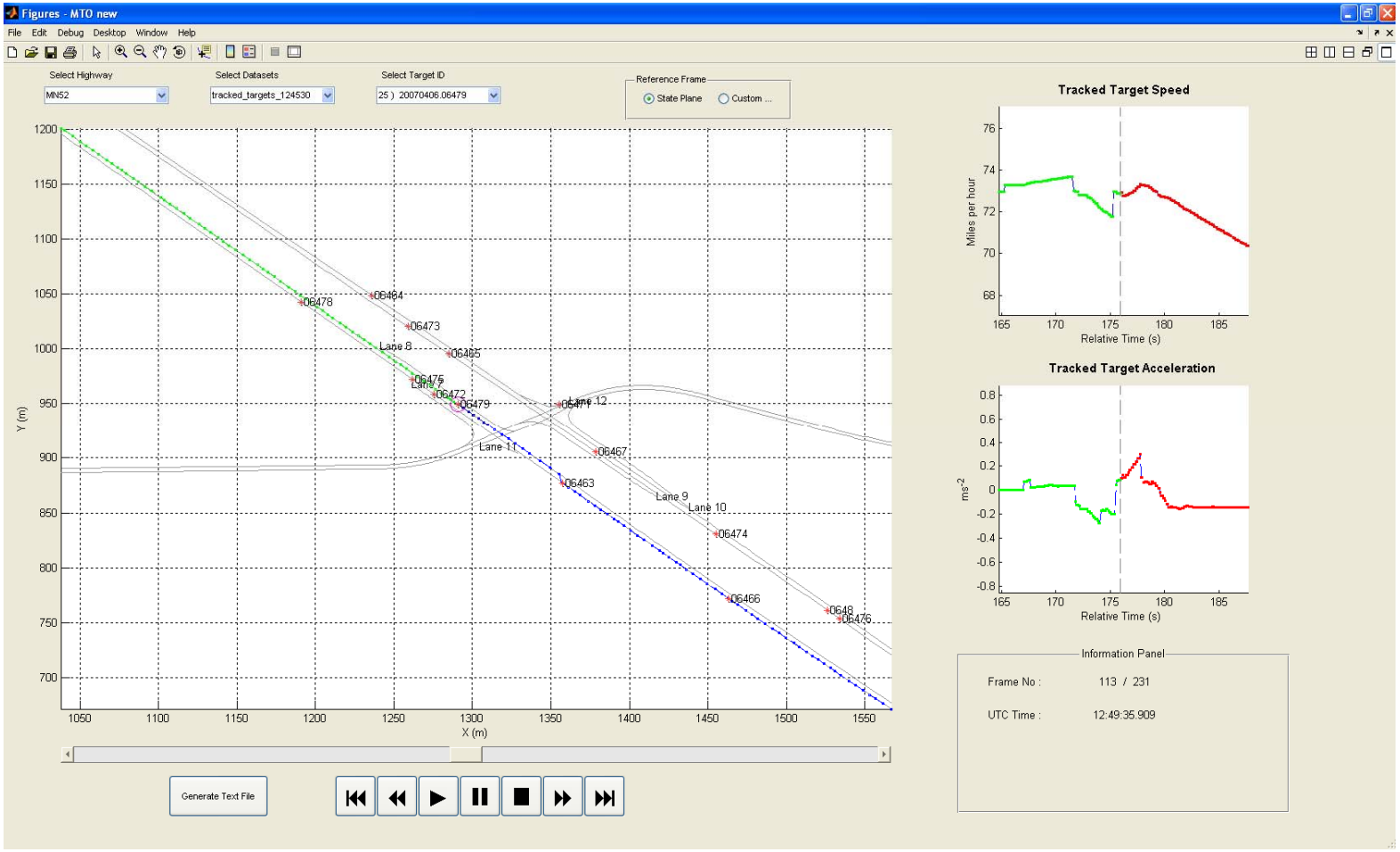
100-Car Data Browser



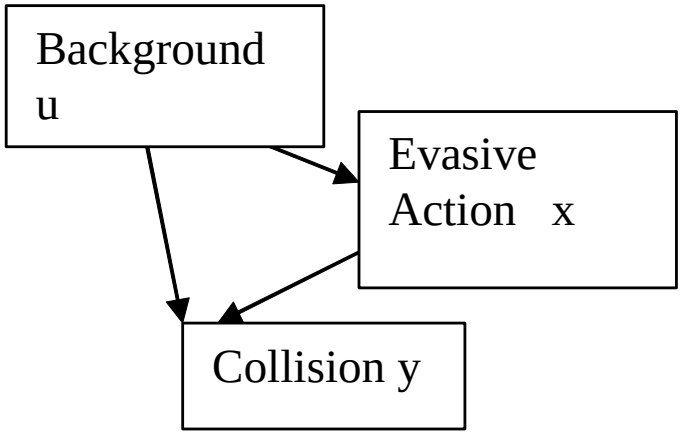
CICAS Site-Based Data



Intersection Data Browser



Starting Point: Abstract Collision Model



Collision function:

y(u,x) = 0, no collision

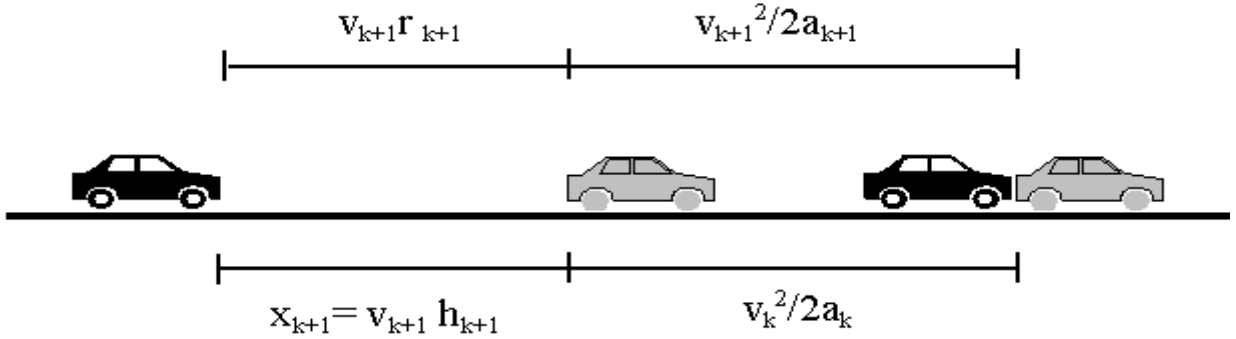
= 1, collision

Joint distribution:

P(y,x,u)=

P(y|x,u)P(x|u)P(u)

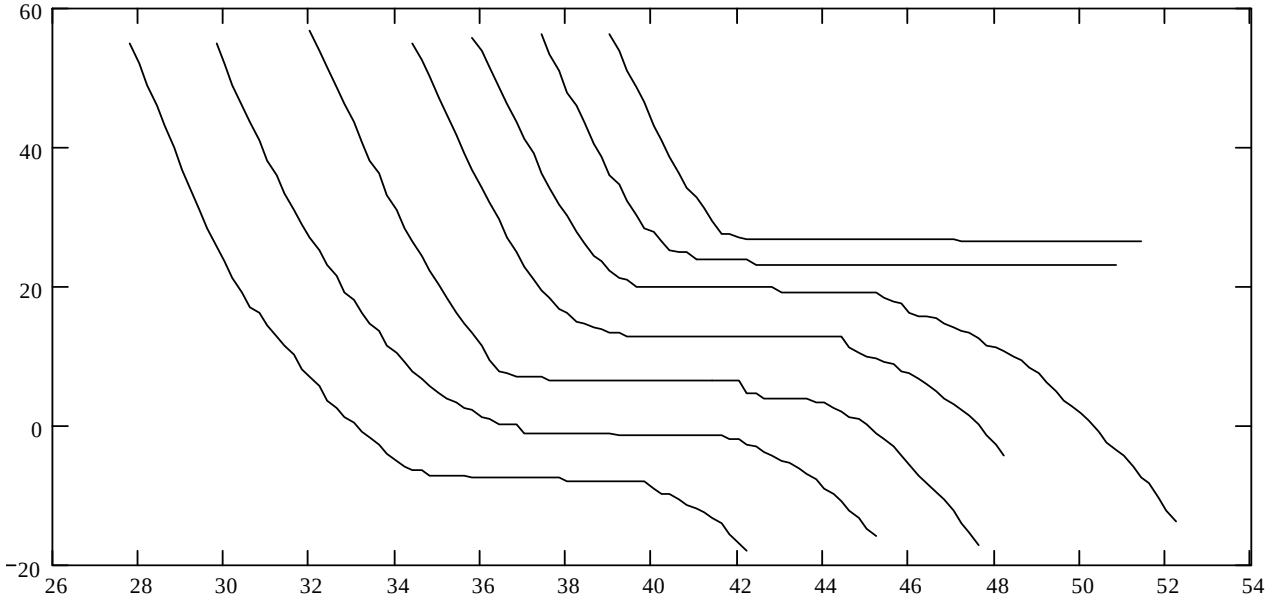
Example:
Simple Rear-End Collisions



$$y(u,x) = \begin{cases} 0, & if\ v_2 r_2 + \dfrac{v_2^2}{2a_2} \le h_2 v_2 + \dfrac{v_1^2}{2a_1} \\ 1, & if\ v_2 r_2 + \dfrac{v_2^2}{2a_2} > h_2 v_2 + \dfrac{v_1^2}{2a_1} \end{cases}$$

Trajectory Data from I-94 Video

Trajectories for 7 vehicles, with collision between 6 & 7.



Estimates of Background Conditions/Evasive Actions

Posterior means

Vehicle	v_k(fps)	h_k(sec)	r_k(sec)	a_k(fps^2)	a_{k0}(fps^2)	t_{0k}(sec)
1	50.0	--	--	6.8	--	28.2
2	46.7	1.69	1.91	6.5	6.2	30.1
3	41.8	2.00	4.21	12.6	11.4	34.3
4	42.3	1.87	1.86	14.2	12.8	36.1
5	39.3	1.21	1.44	16.0	14.4	37.6
6	42.3	1.17	1.07	17.3	17.1	38.7
7	41.7	1.24	1.65	20.3	24.8	40.3

Conflicts and/or Near-Crashes?

Interaction between vehicles 1 and 2

- Minimum successful deceleration about 6.2 ft/sec^2
- Actual deceleration about 6.5 ft/sec^2
- Satisfies definition of “conflict”

Interaction between vehicles 5 and 6

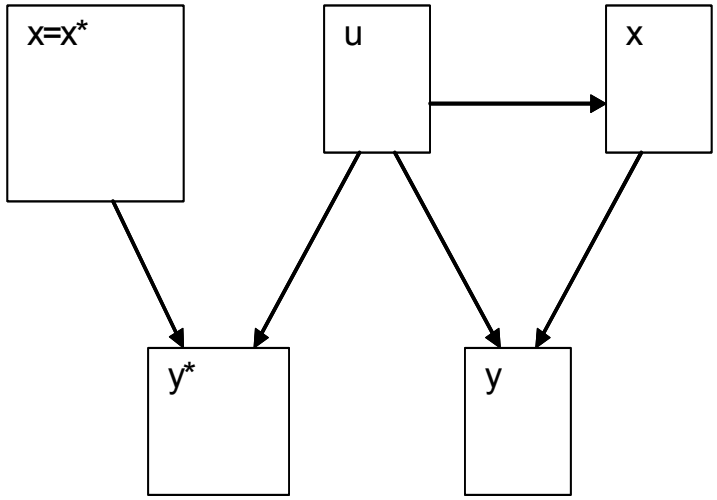
- Minimum successful deceleration about 17.1 ft/sec^2
- Actual deceleration about 17.3 ft/sec^2
- Satisfies definition of “conflict”

Informally, 5-6 interaction seems more like “near-crash”

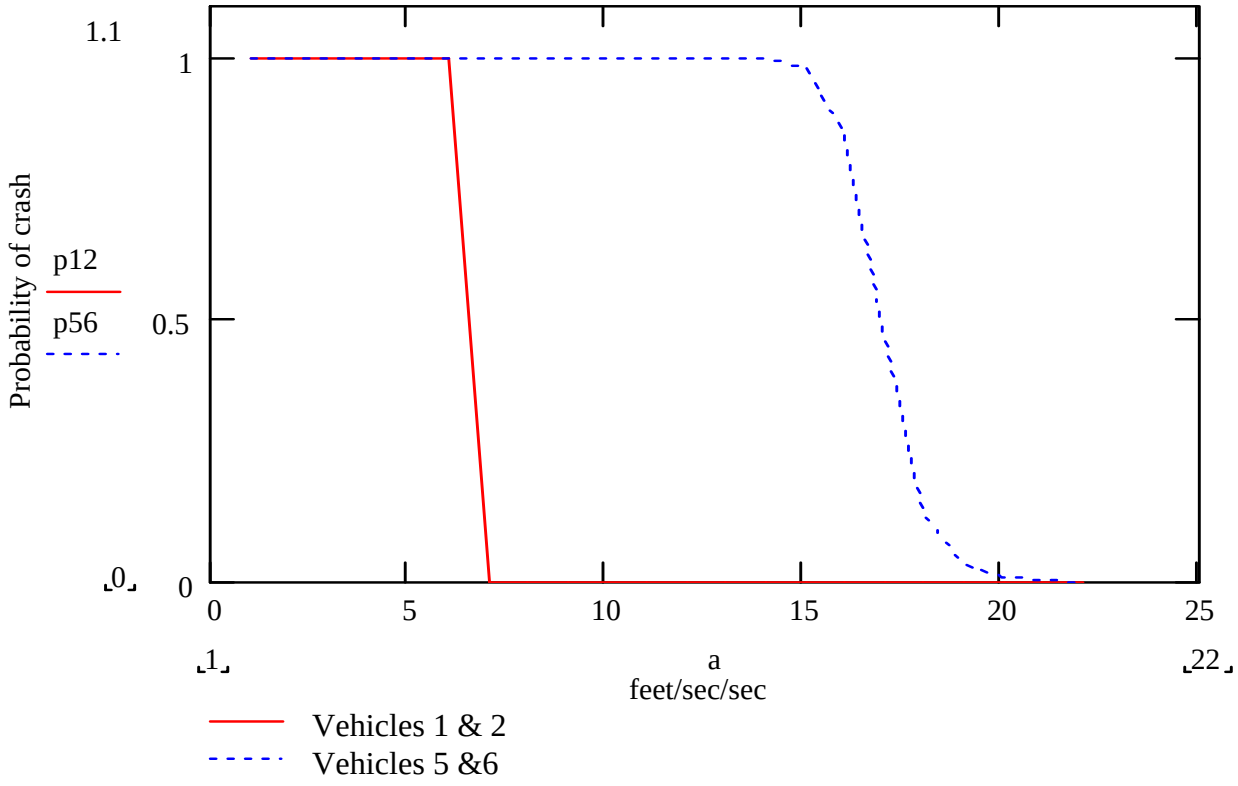
Estimates are to some extent uncertain

Twin Network Method for Computing What-If Probabilities

1. Abduction: Compute posterior distribution for background variables p(u|data)
2. Action: Set evasive action to x=x*
3. Prediction: Compute P(y*=1) using p(u|data)



Crash Probabilities vs Counterfactual Deceleration



Incorporating "Extremeness" of Evasive Action

Counterfactual analysis

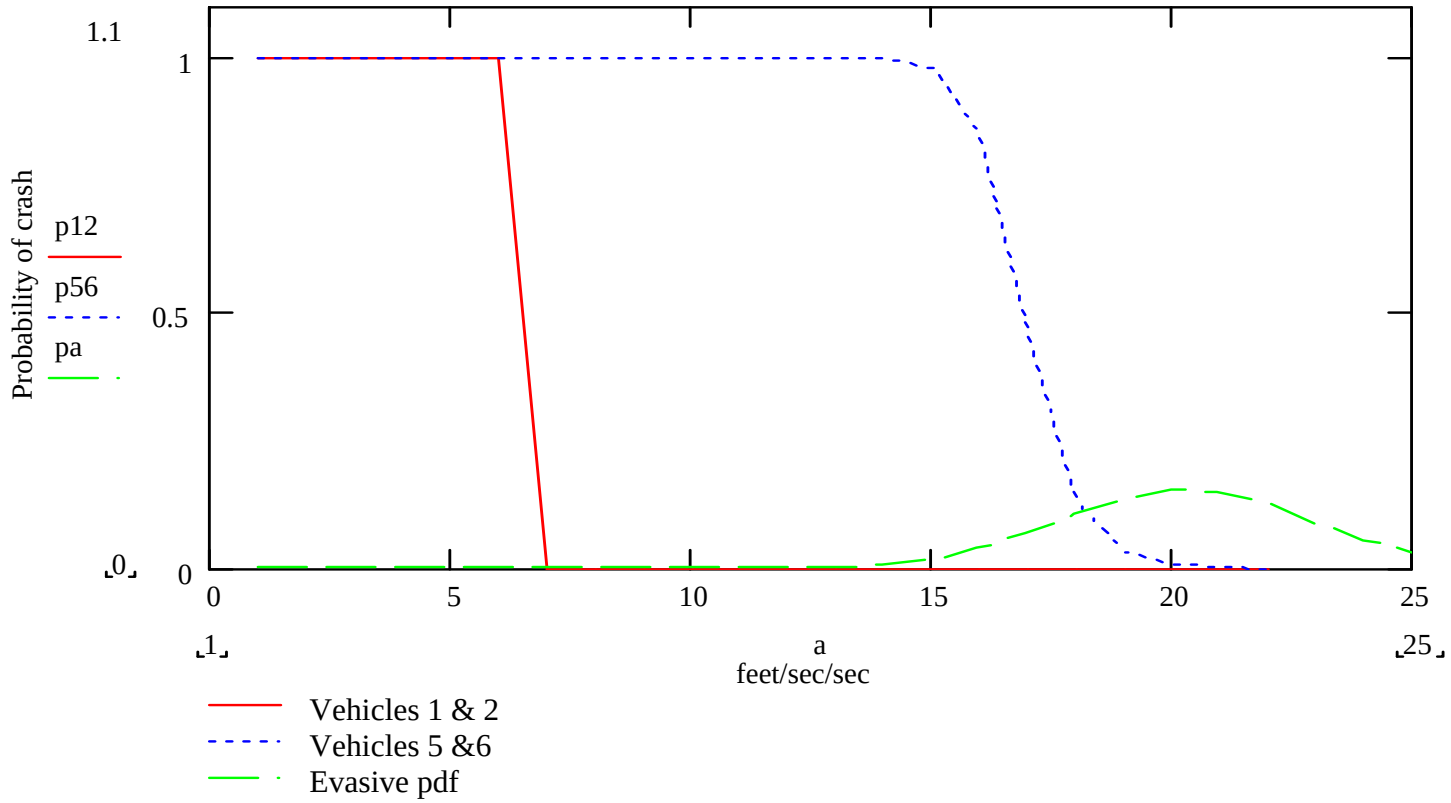
a. gives probability a near crash could have been a crash, as function of hypothetical avoidance actions,

b. ignores feasibility of actions

Simple(st?) evasive action distribution:

a ~ [20.3, 2.6] ft/sec^2 (Fambro et al 1997)

Crash Probabilities with Evasive Action Distribution



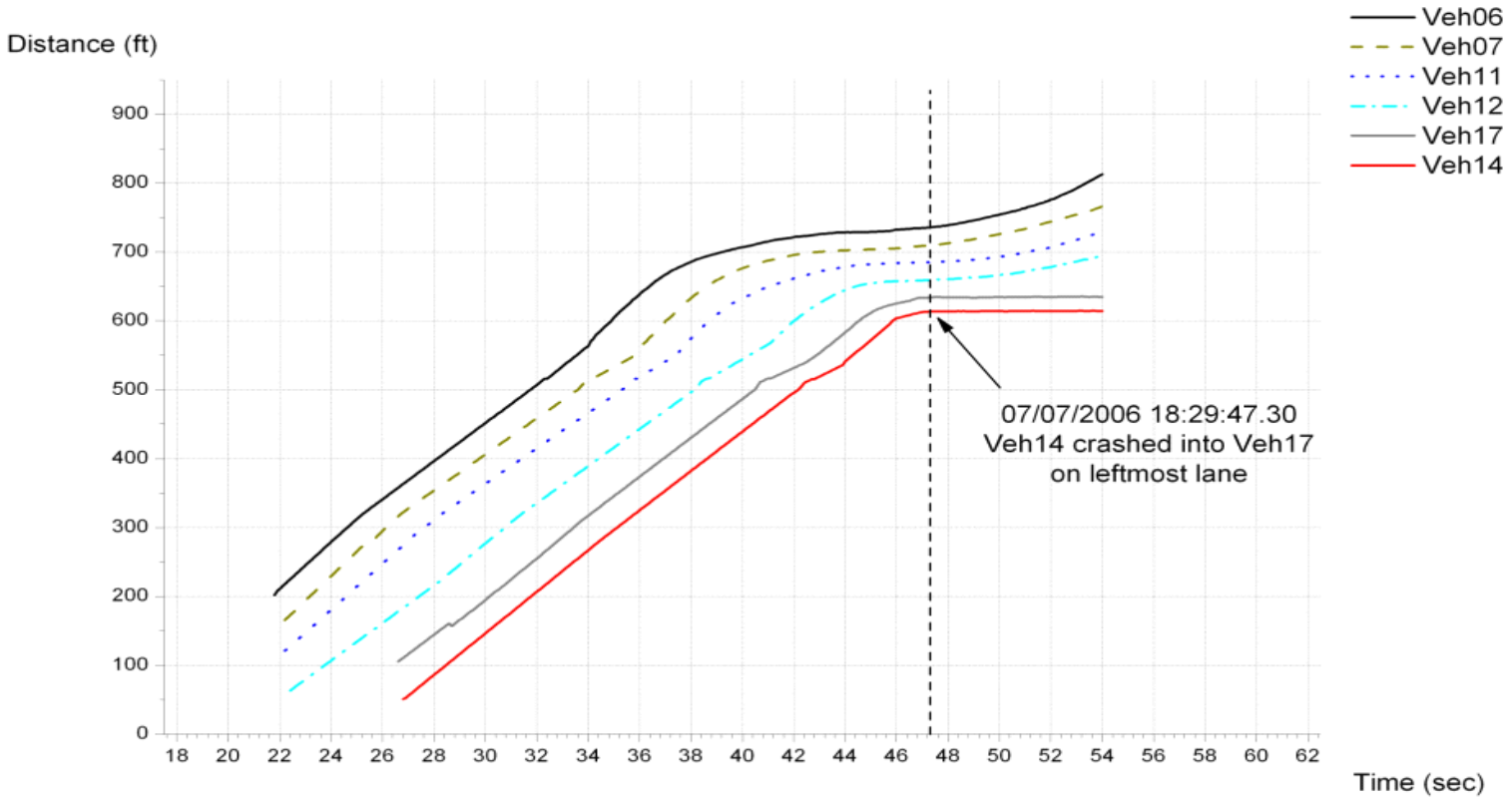
Crash Probabilities Incorporating Avoidance Actions

Leader	Follower	P(crash)
#1	#2	0
#2	#3	0
#3	#4	0
#4	#5	.004
#5	#6	.138
Sum		.142

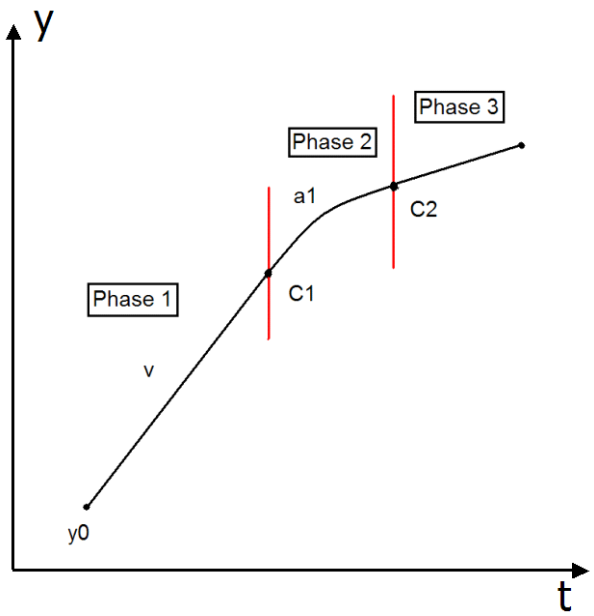
Sum gives expected number of crashes from this set of conflicts

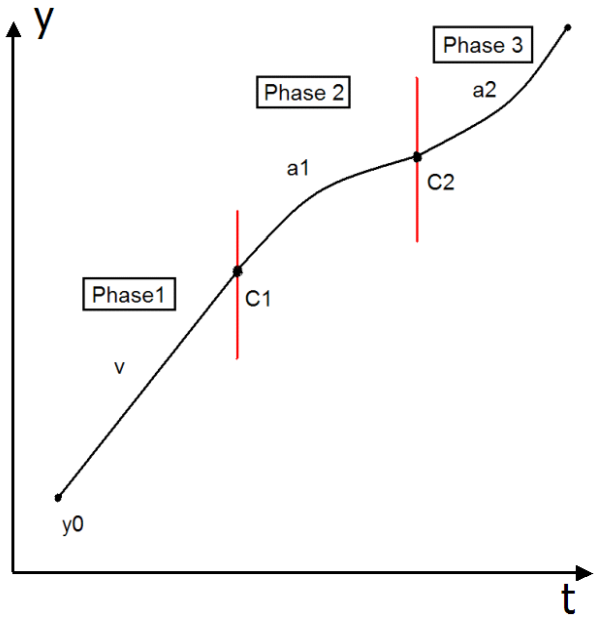
Complications

Additional trajectory set for I-94 data set

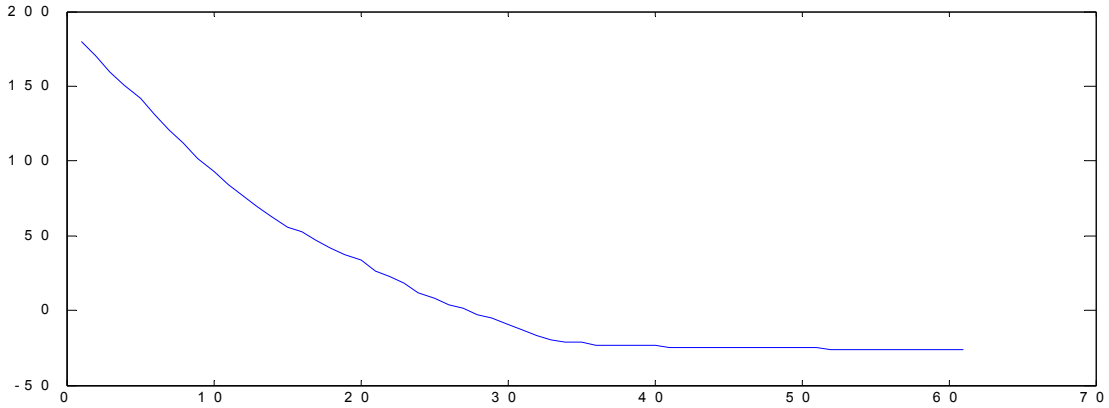


Additional Trajectory Types





Difference Equation Models for Complicated Trajectories



Example: Simple model of braking to stop:

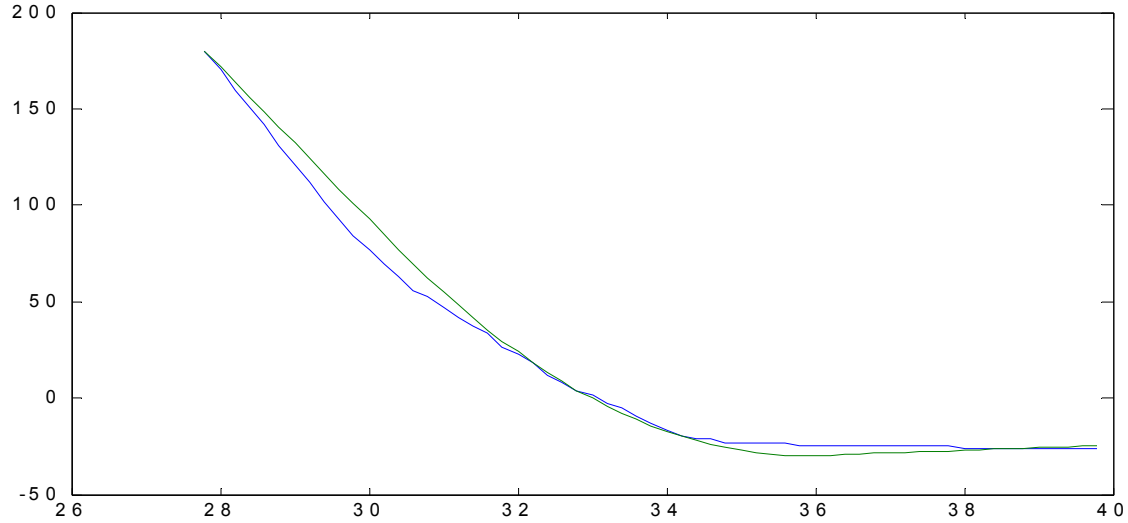
$x(t) = x(t-1)+v(t-1)\Delta$, $x(0)=x0$

$v(t) = v(t-1)+a(t-1)\Delta$, $v(0) =$ **v0**

$a(t) = 0$, $t <$ **t0** or $t > t0+v0/a0$

$=$ **a0**, otherwise

Observed Trajectory vs Difference Equation Model



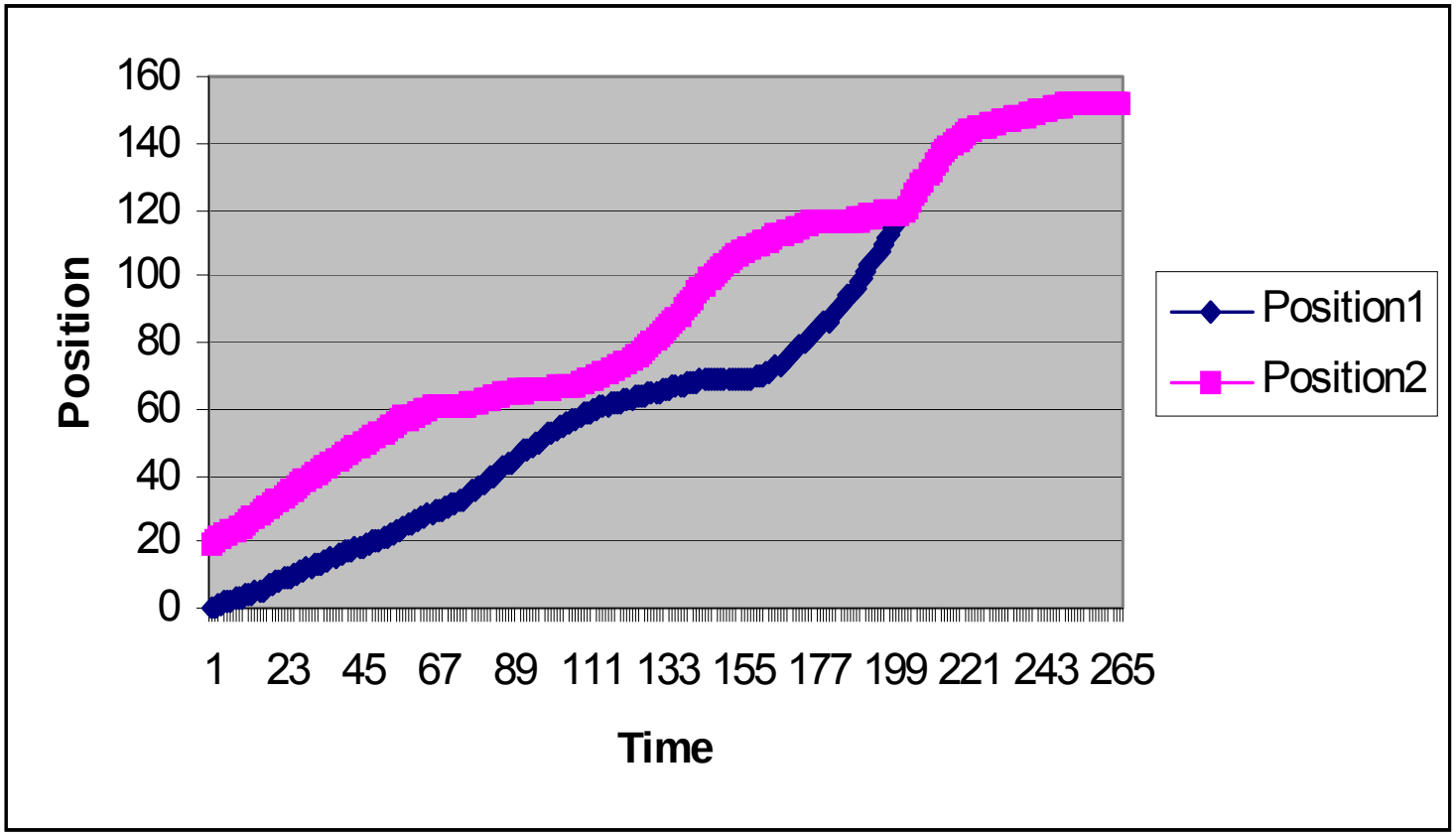
Model Parameter Values:

v0 = 40.14 fps

t0 = 2.6 seconds

a0 = -7.44 fps2

Leader-Follower Trajectories Developed from 100-Car Study



Bottom Line

When we can

(1) Specify a physical model of conflict

(2) Estimate the conflict's background variables

(3) Identify plausible model of evasive action

Then we can

Compute probability that conflict could have been a crash

Ongoing Work

(1) Structural Models/Background Estimation

Emphasis on difference equation models,

Nonlinear least-squares/time-series,

Bayes estimation via Gaussian process approximations.

(2) Evasive Action Models

More realistic model of rear-end braking,

Modeling steering as additional evasive action

(3) Angle crashes

Structural modeling

Identification of near-crashes from CICAS database

QUESTIONS?