



SAVME STATUS

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What is SAVME

§A remote video based observation system that can measure kinematic vehicle behavior and inter-vehicle relationships over a section of roadway



History

- n **SAVME started as VME in 1992 with UMTRI as the prime contractor**
- n **Initial approach used lasers, but later (1996) moved to an image processing approach**
- n **Collected data in 1996 and 1999 on a straight arterial road**
- n **Conclusion of UMTRI Effort (Final Report 8/1/2000)**
 - Report states the system has clearly reached a status of readiness that can support specialized applications
 - Modest refinements to SAVME needed for large-scale deployment
 - Camera synchronization
 - Image processing camera to camera artifacts



History

- n **System delivered to NHTSA VRTC 8/2000**
- n **VRTC tasked to evaluate the “as delivered” system and fix problems identified in the Final Report**
- n **Installed system at TRC proving grounds and at a Columbus Ohio intersection**
- n **Identified many other problems**
- n **July 2002, VRTC funded to address issues found in evaluation and produce a system specification.**
- n **January 2004, collected data at the 3 most dangerous intersections in Columbus with the improved data collection system**



Problems Identified from Deployment

§ HARDWARE

- Tower design limited deployment to only 1 of the top 20 most dangerous intersections in Columbus Ohio
 - Required guy wires
 - Required large land area per tower (8300 sq. ft.)
- Tower required professional installation (geology survey)
- Data storage limited (4 hours per tower)
- Open loop data collection (no method to confirm images from multiple towers were synchronized)
- Camera calibration survey time consuming and dangerous



VRTC Improvements

§HARDWARE

§Improved tower design

- Self standing (no guy wires)
- Small footprint (576 sq. Ft.)
- No need for professional installation (self erecting)
- Data storage (virtually unlimited – video compression)
- Closed loop data collection (towers synchronized w/ GPS, images with embedded time stamp.)
- Upgraded cameras using off-the-shelf cables and fiber-optics
- Improved camera calibration survey method without compromising accuracy



Problems Identified from Deployment

§ SOFTWARE

- Not generic
 - Designed for a 2 camera system (not N camera)
 - “Hard Coded” for Plymouth Road installation
 - Some parts just did not work (i.e. Image stabilization)
 - Analysis software hard coded for 5 travel lanes that were horizontal in the image.
- Artifacts existed in single view not just camera to camera
- Segmentation and tracking had problems with stopped vehicles (Not much of a problem with UMTRI installation since it was not at an intersection)
- Image subtraction methods have problems when vehicles are stopped more than they are moving (intersections).
- Shadows and partial occlusions caused errors (time of day, year, etc)
- More of a “proof-of-concept” rather than a field deployable tool



VRTC Improvements

§ SOFTWARE

§Generic

- Can work with N cameras
- Not limited to a given road or intersection
- Analysis software is more generic. User can input and configure observation area.
- Improved camera to camera artifacts and developed better single view artifact rejection.
- Improved segmentation and tracking by using an image classifier algorithm rather than image subtraction
- Classifier can deal with shadows, partial occlusions, and stopped vehicles.



VRTC Improvements

n **2000 UMTRI Effort – (2 cameras 1700 cars per hr.)**

- 56 analyst-hours per hour of video data ***
- 28 analyst-hours per camera view per hour
- 60.7 tracks / hour

n **2002 VRTC Effort – (3 cameras 2400 cars per hr.)**

- 40 analyst-hours per hour of video data
- 13.3 analyst-hours per camera view per hour
- 180.5 tracks / hour

n **2004 VRTC Effort – (2 cameras 2000+ cars per hr.)**

- Have not processed enough data to have a representative number



Does SAVME Work?

SAVME's primary technical difficulties

- Finding the location of each vehicle currently in the frame
 - A trained classifier scans the image and judges if a set of pixels “looks” like a vehicle
 - ∅ Classifier does not depend on finding moving objects, making it better suited to intersections where traffic queues are largely stationary
 - ∅ Classifier can be trained to deal with new situations
- Tracking each vehicle location from one frame to the next
 - A Kalman filter estimates future vehicle positions and nearby measurements update the Kalman filter

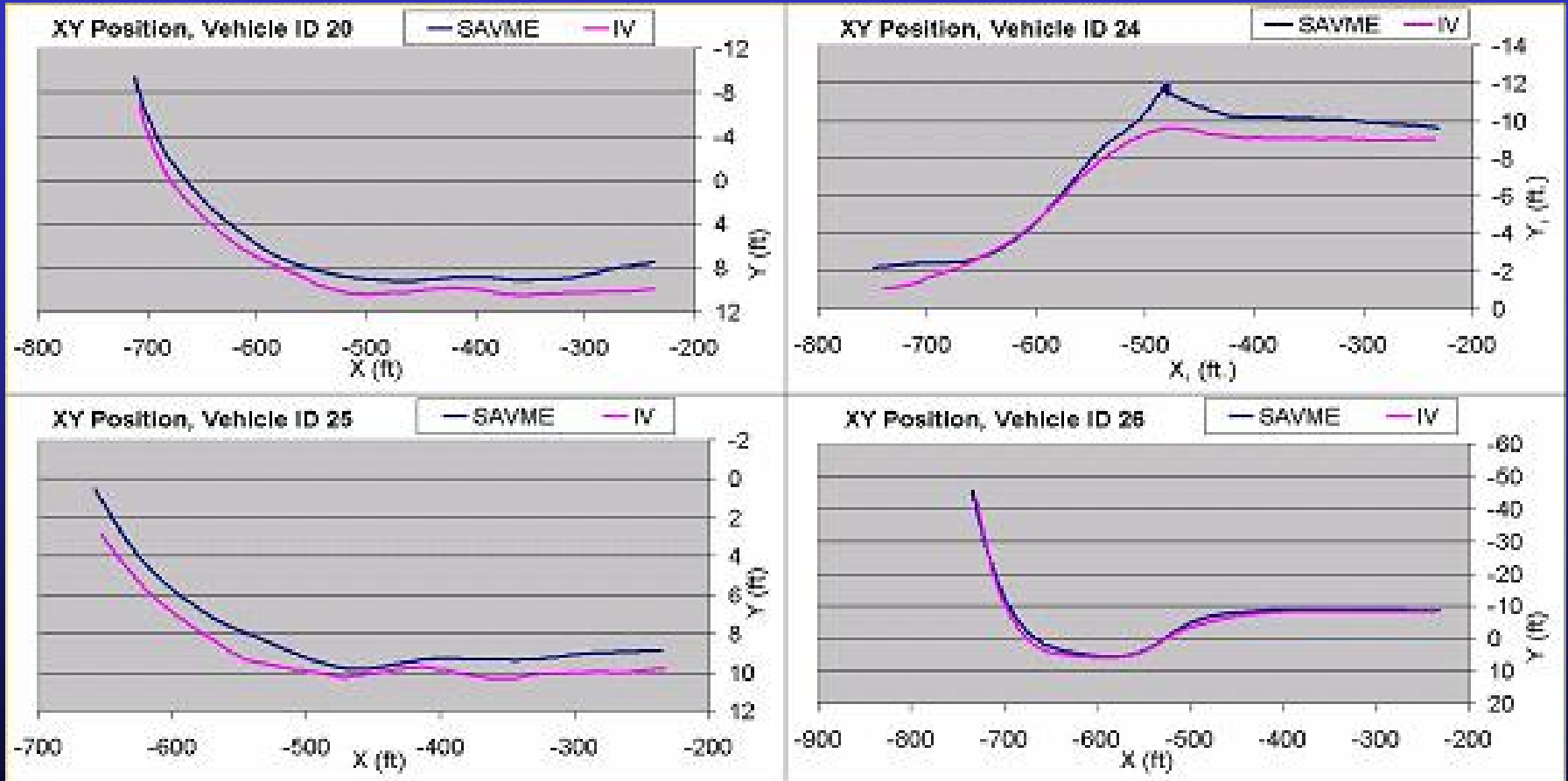


Does SAVME Work?

n Finding Vehicles in the Image



SAVME vs. IV



Classifier Issues

False negative– the classifier fails to indicate a vehicle when a vehicle exists

- A vehicle's orientation which was not represented well during training
- The appearance of a vehicle is different enough that the classifier fails to generalize from the training set
- The vehicle is too close to the sides of the image

False Positive– classifier indicates the existence of a vehicle when a vehicle does not exist

- Appearance of an untrained background is too close to the appearance of a vehicle

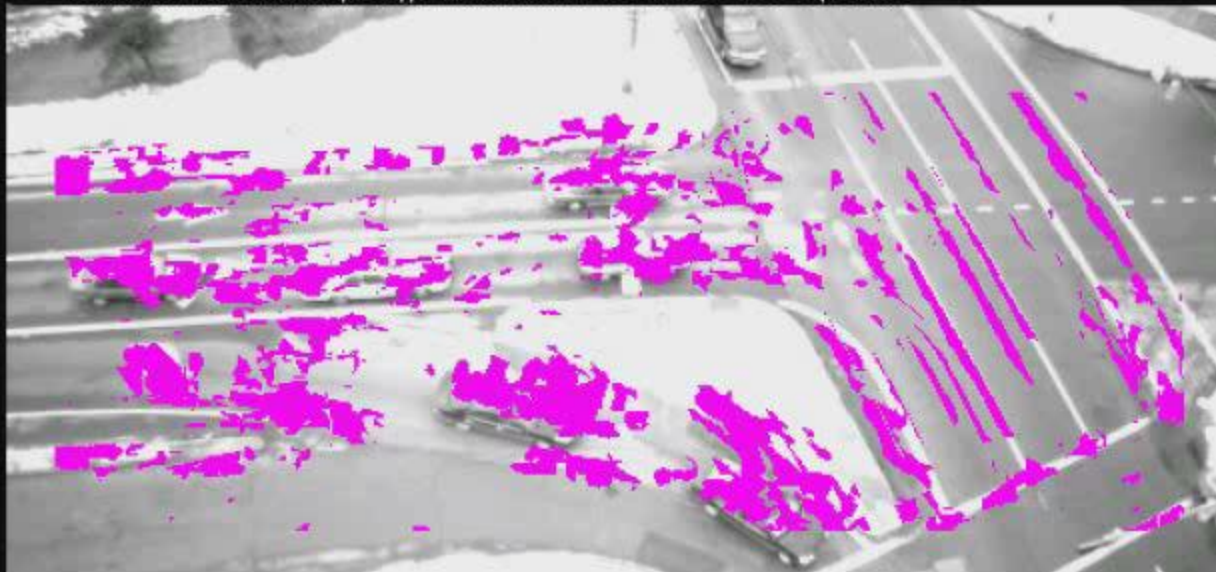


Tracking Issues

- n **Measurements can be noisy**
 - Depending on the situation, the classifier may be very noisy
- n **Clustering may not be correct**
 - Classifier measurements are clustered such that nearby measurements are combined to make a single measurement— this process may be incorrect
 - There may be more than one measurement per vehicle
 - There may be one measurement for multiple vehicles
- n **Problem is not real-time, but real-time methods are used**
 - The current tracker does not use “future” classifier measurements to find the track. It is possible that a tracking method which uses all the measurements could perform better



Frame #: 000000490 To: 002450 Tps: 03 pps Mean: 109.000000 Std: 56.912923 12096 Exp: 4000.5



Frame #: 000000490 To: 002450 Tps: 03 pps Mean: 109.000000 Std: 56.912923 12096 Exp: 4000.5



Does SAVME Work?

- The system cannot reliably automatically track all vehicles which pass in front of the camera
- While testing indicates that there are situations where performance is reasonable, there is no assurance that the automatic tracking system will work in general
- Even if the system is correctly tracking vehicles, human validation is necessary



Is SAVME ready for Field Deployment?



NO

Depending on the Research

- n **If the research questions to be answered require that all vehicles traveling through the camera(s) field of view be reduced automatically at any location during any time of day with minimal human intervention**
 - Example: SAVME identifies 90% of all cars accurately at location A.
 - 10% of all cars have to manually tracked
 - 1000 vehicles/hour -> 100 vehicles/hour manually tracked
 - 1 minute per vehicle to manually track -> 100 min
 - 300 days collection -> 8 hours a day = 2400 hours collected
 - 2400 hours * 100 min/hour = 240000 min or 4000 hours
 - 2 people working full time for 1 year could reduce this data!
 - 25 systems * 2 people per data set = 50 people a year
 - Loaded rate of staff (\$38/hour) = 3.8M / year



Is it Possible?

- n **Possibly in the future, but not likely given the time and scope of SHRP II**
- n **Computers keep getting faster and faster**
- n **Image processing techniques are constantly improving**
- n **5 – 10 years down the road**
- n **This is a very tough problem!**



Is SAVME ready for Field Deployment?



YES

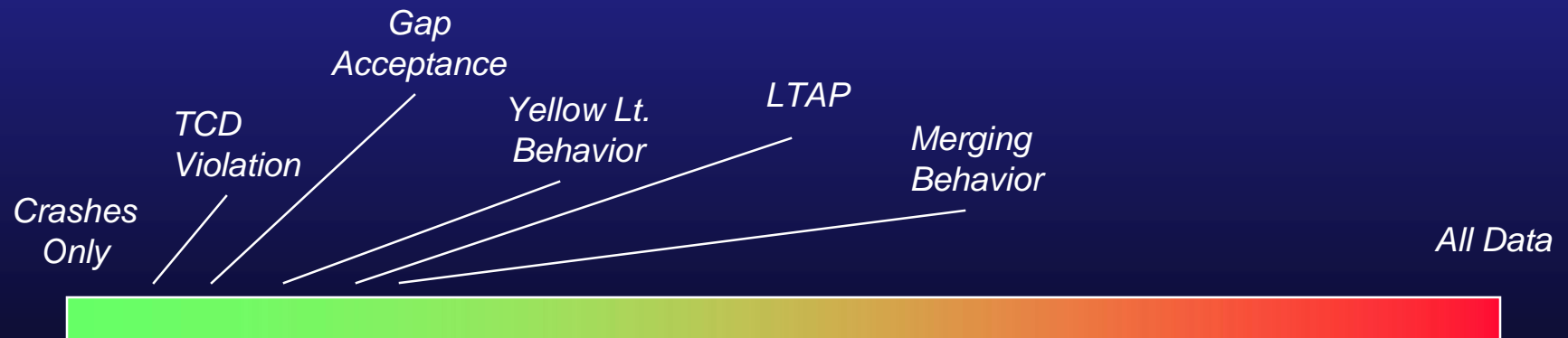
Depending on the Research

- n If the research questions to be answered require data from certain periods or events then SAVME can be a very effective tool.
- n Data can be selectively filtered by “pre-processing” video for times when conflicts or situations of interest occur

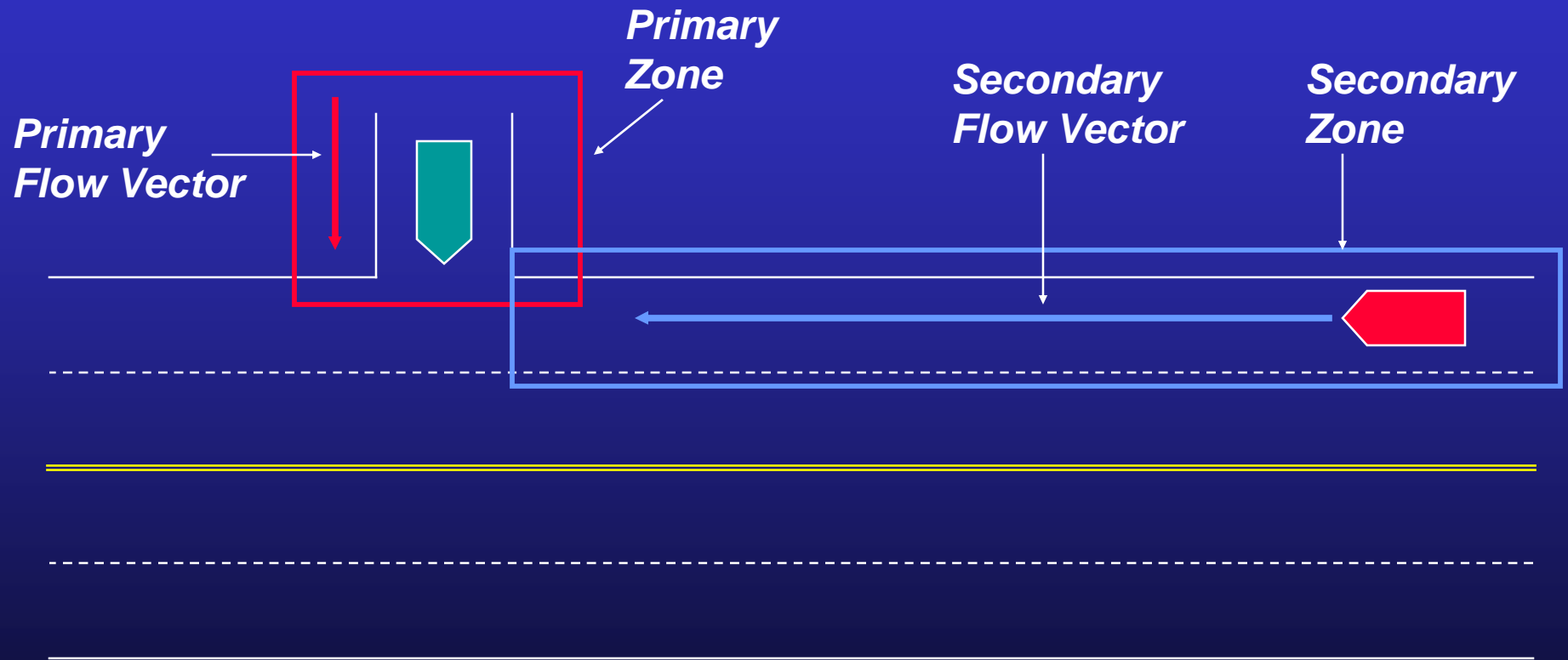


Pre-Processing

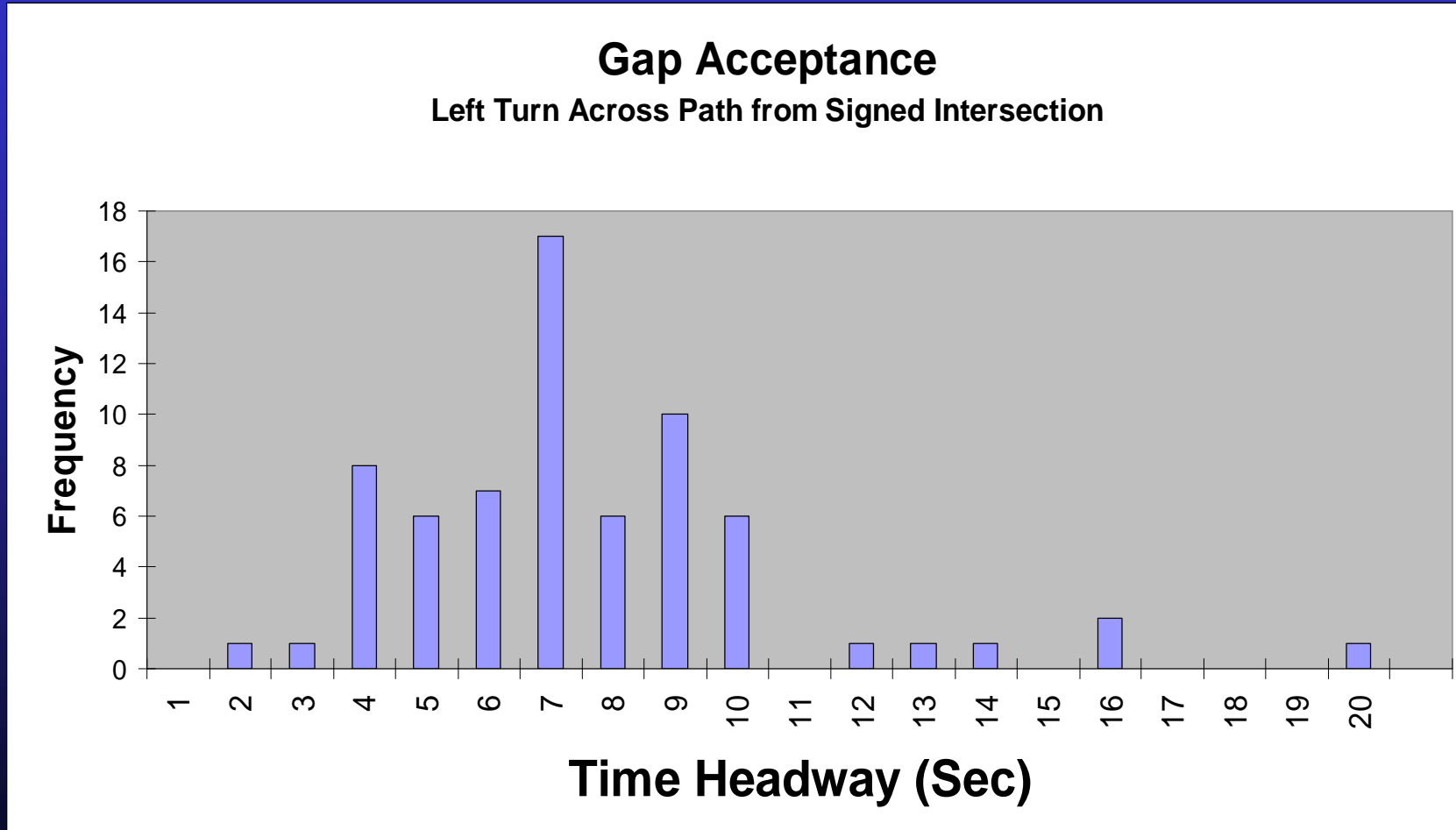
- n The SAVME definition of “Pre-Processing” is a method of reducing video data by using relatively simple foreground detection techniques.
- n Rather than attempting to calculate the entire trajectory of a vehicle, only the knowledge of a vehicle’s existence in a certain region and/or the state of some variable is desired.



Gap Acceptance Example



Gap Acceptance Example



Examples of Other Possible Data

Data / Event	Primary	Secondary	Flow
TCD Violation	Vehicle in defined violation area	Traffic Light is Red	Flow defined for primary
Gap Acceptance	Vehicle in zone entering roadway	Vehicle in zone to make gap decision	Flow defined for both
Yellow Lt. Behavior	Traffic light is yellow	Vehicle in zone where light is yellow	Flow defined for secondary
LTAP	Vehicle in left turn zone	Vehicle approaching primary	Flow defined for both
Merging Behavior	Vehicle in defined merging zone	none	Flow defined for primary



Conclusions

- n **SAVME is a very powerful tool to understand vehicle-vehicle and vehicle-infrastructure data**
- n **SAVME can generate a large N of data in a short period of time in a given location**
- n **Data collection is very easy, data processing is very difficult (20/80)**
- n **A great deal of effort is needed to process ALL of the data**
- n **Under certain conditions and more specific research questions, SAVME works and can provide statistically powerful data in a cost effective manner.**

