

# Time Space Diagrams for Thirteen Shock Waves

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## **ABSTRACT**

This paper presents microscopic time-space diagrams for several shock waves over 100-200 m distances. The diagrams should be of general interest to researchers studying congested traffic. As such, the primary focus of this paper is on presenting the data rather than analysis. The author is only aware of a handful of similar data sets (most notably the work of Treiterer and Myers from the late 1960's and early 1970's. The small number of studies is due to the inherent difficulties of tracking several vehicles over a long distance. Future work will focus on analysis of the shock waves.

**KEY WORDS:** Highway Traffic, Congestion, Shock Waves, Time-Space Diagrams

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The Contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California. This report does not constitute a standard, specification or regulation.

## ABOUT THE SEQUENCES

This paper presents time-space diagrams for twelve shock waves on I-680 and one shock wave from Hwy 99. In the process of extracting vehicle trajectory data for an on going research project, it became clear that the time-space data were of general interest to fellow researchers studying congested traffic. The author is only aware of a handful of similar data sets (most notably the work of Treiterer and Myers from the late 1960's and early 1970's).

For this study, we video taped several sections of highway and calibrated the mapping from the image plane to world coordinates at each site. Individual sequences were digitized at one frame per second and vehicle positions were manually recorded in each frame. Vehicle position was defined to be the projection of the nearest corner of the vehicle onto the ground plane and the same corner was used for all vehicles at a given site. Since the data are from departing traffic, we used the right or left hand corner of the rear bumper.

The first section presents twelve shock waves (mostly stop waves) from southbound I-680, just north of Hwy 24 in Walnut Creek, California. Sequences 1-9 were collected during the morning peak on April 24, 1996, while sequences 10-12 were collected during the morning peak on April 29, 1996. Figure 1 shows a sample frame from one of the sequences. All data were observed in lane 3 (the leftmost lane is lane 1). There were no lane changes into or out of lane 3 during the observation periods and the largest vehicles observed were comparable to pickup trucks. Velocity-time diagrams are shown immediately below the time space diagrams for reference. Note that the first vehicle of each sequence is not shown in the velocity diagram and the velocity data for a given vehicle is plotted in the same color as the corresponding trajectory data. All sequences are plotted at the same scale for comparison.

Sequences 4,7,8 and 9 show "slow" waves transforming into "stop" waves. While sequences 6, 10 and 12 appear to show the start of a second disturbance.

The second section presents a single shock wave from northbound Hwy 99 at Mack Rd in Sacramento, California during the morning peak on April 10, 1996. Figure 2 shows a sample frame from this sequence. The left most lane is a High Occupancy Vehicle (HOV) lane and the lane begins at the base of the camera pole. Unlike the Walnut Creek data, this sequence does include lane changes. Only the trajectories that entered lanes 2 and 3 within the camera's field of view were tracked, thus, a few vehicles from lane 1 and the on-ramp are omitted because they did not enter lane 2 or 3. Note that an individual trajectory may be split across two or more figures as the vehicle changes lanes.

As vehicles recede from the camera the digitized image resolution decreases, introducing measurement noise. This phenomena is evident in the jagged trajectories as vehicles get further from the camera.

Of greater significance is the progression of the disturbance over 150 m. It is possible to measure the speed of the disturbance by adding equi-velocity lines to the graph (not shown) and measuring their slope. The disturbance is traveling at approximately 12.5 km/h in both lanes.

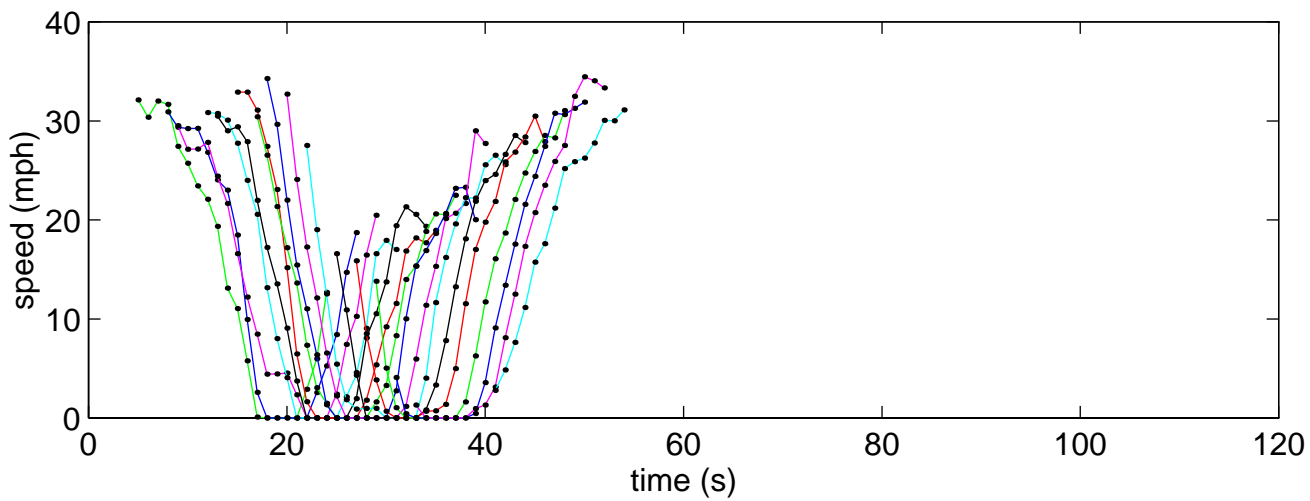
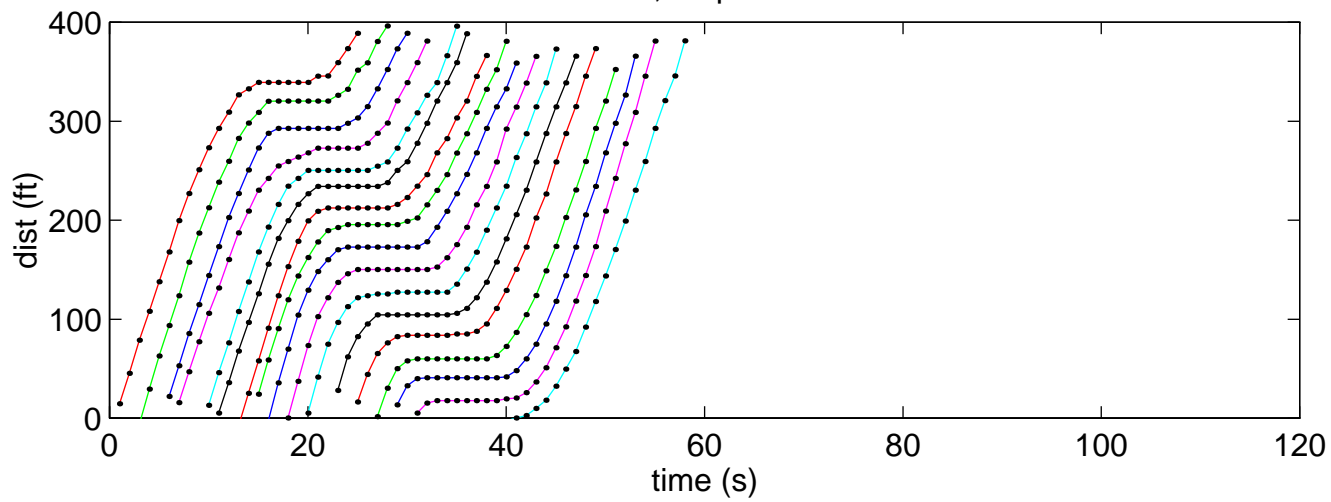
Note that a backward moving "stop" wave in lane 3 smears over the "slow" wave in lane 2 about 50 seconds into the sequence. This "stop" wave spreading is due to a single driver maneuvering from the on-ramp to the HOV lane.

The author would like to thank Michael Lee and Brian Simi of Caltrans for their assistance collecting data.

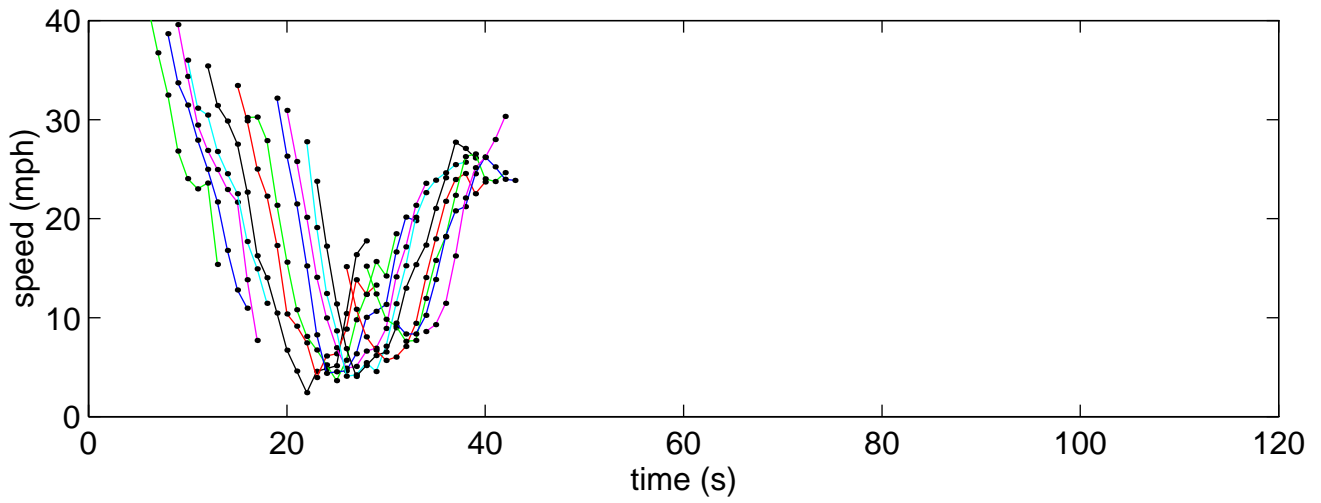
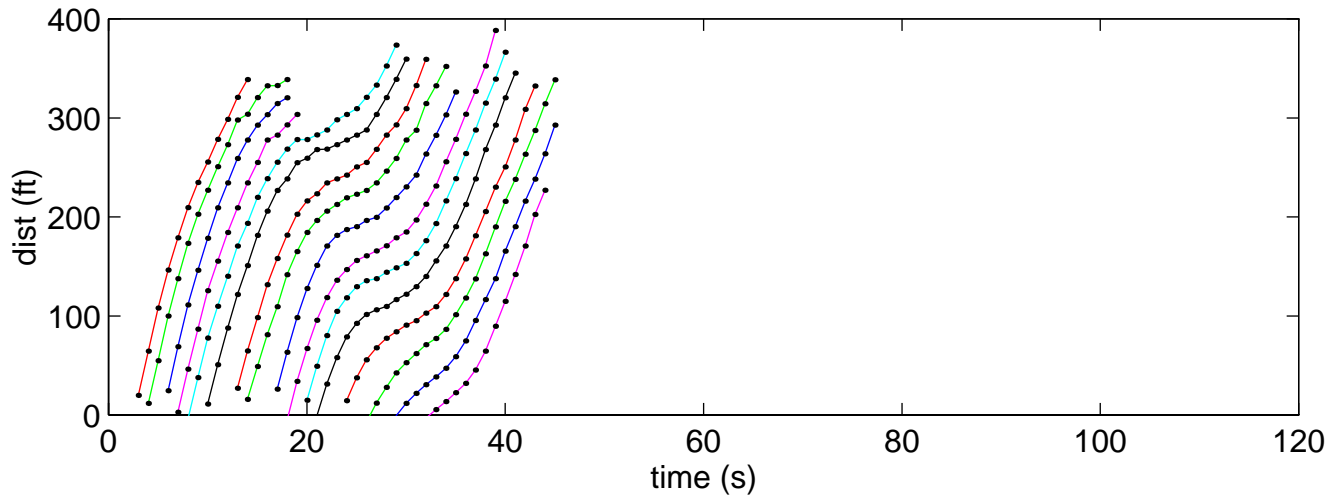
Figure 1, A sample frame from the I-680 test site



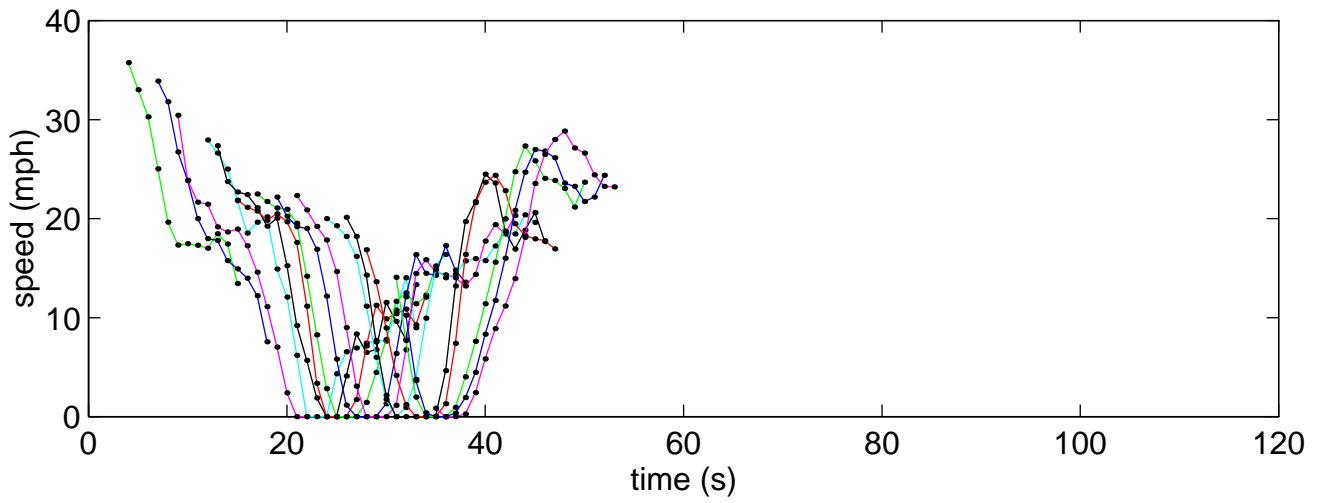
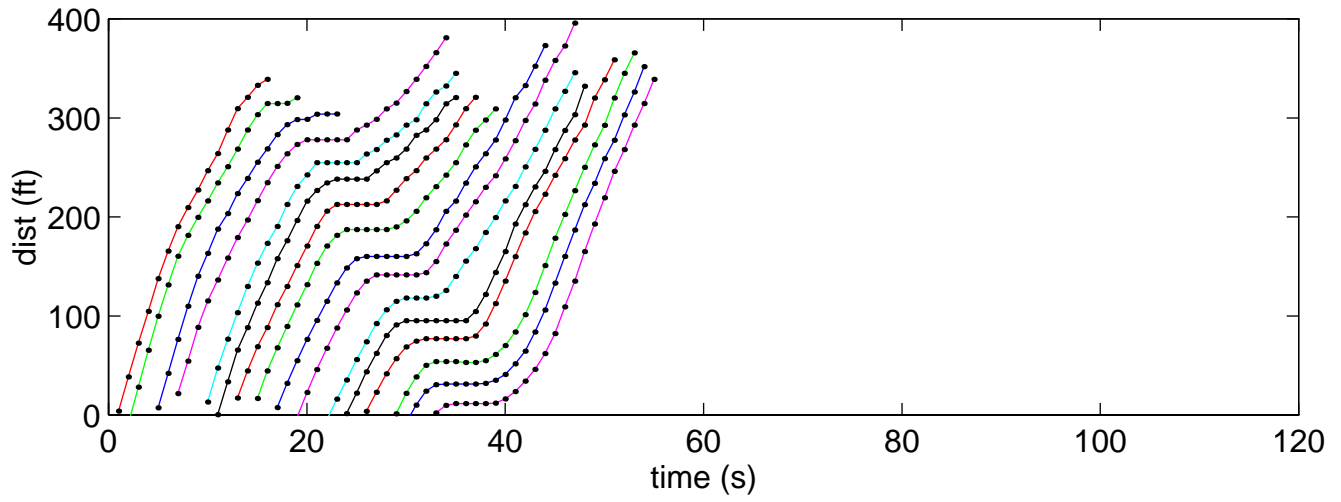
I-680, sequence 1



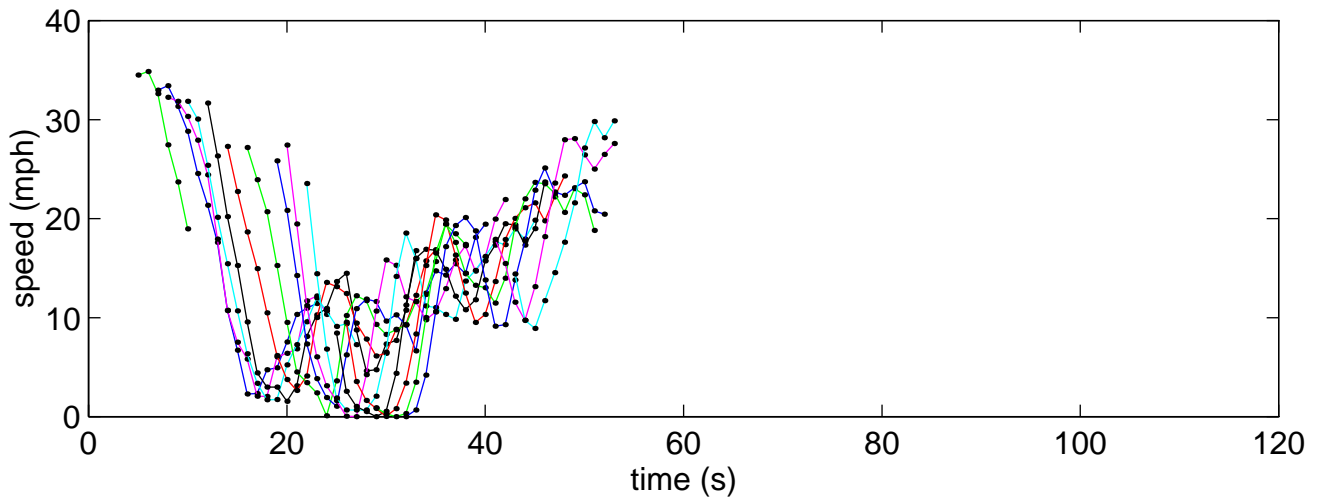
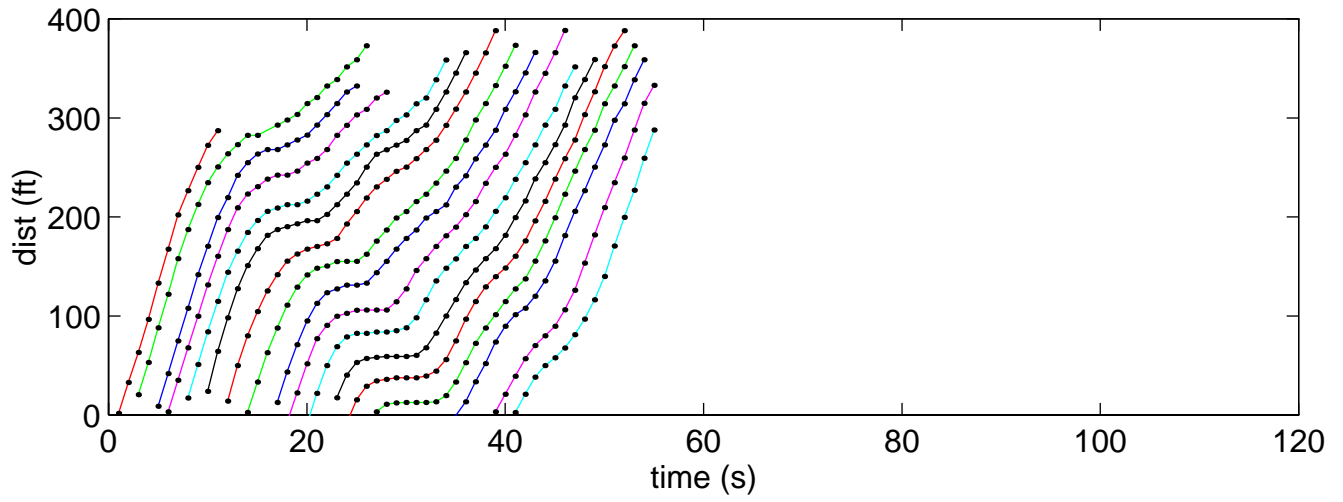
I-680, sequence 2



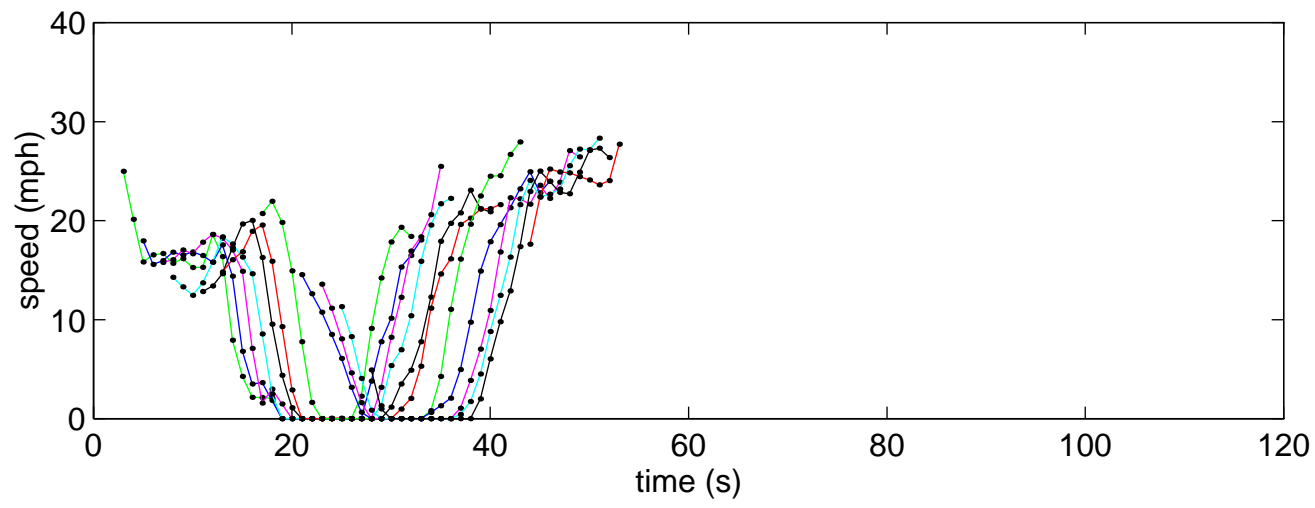
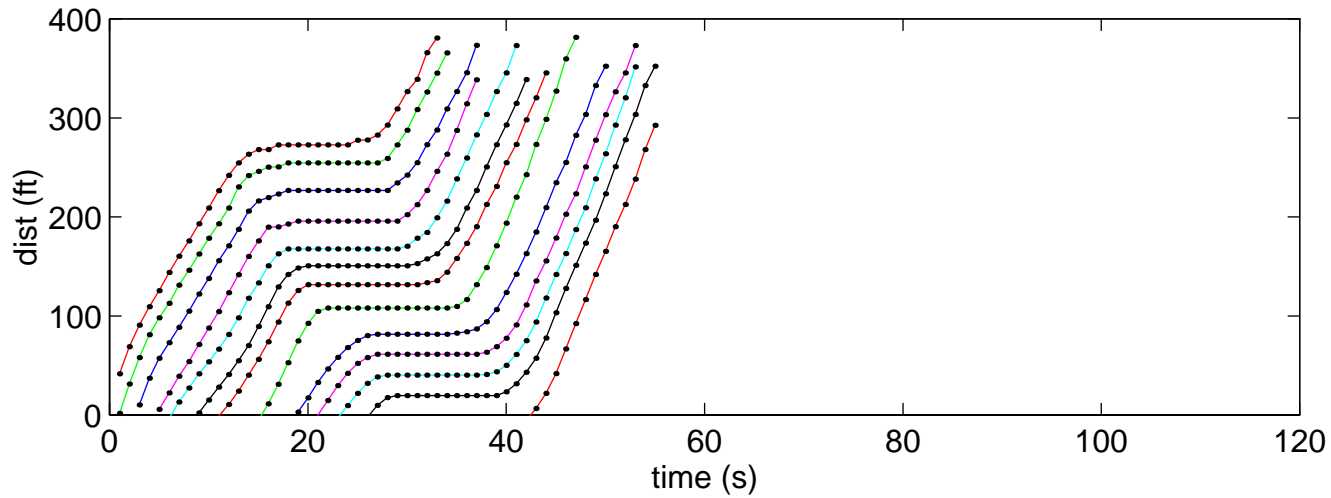
I-680, sequence 3



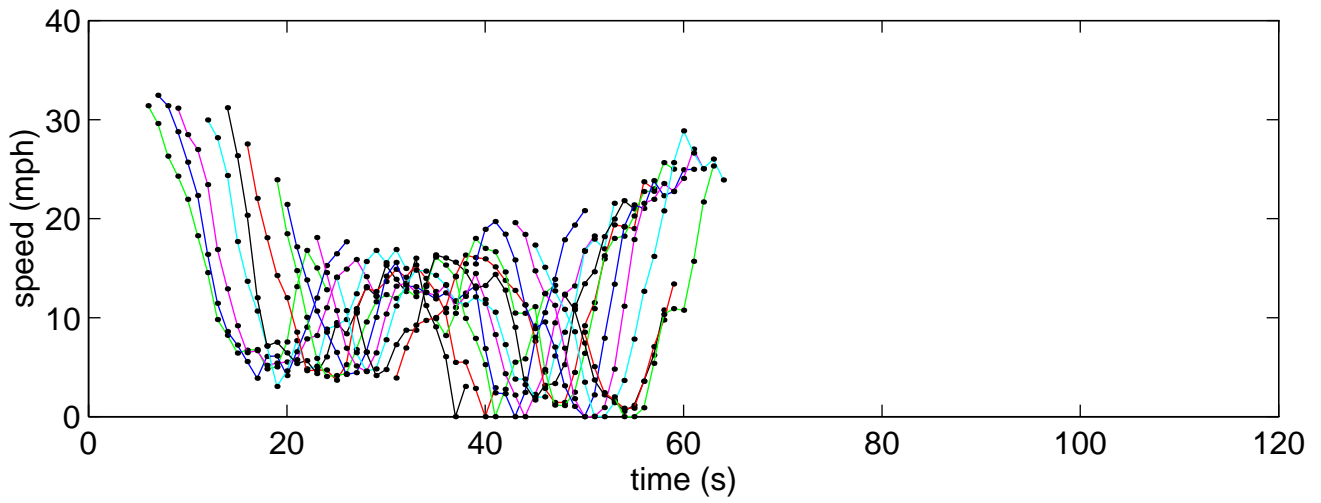
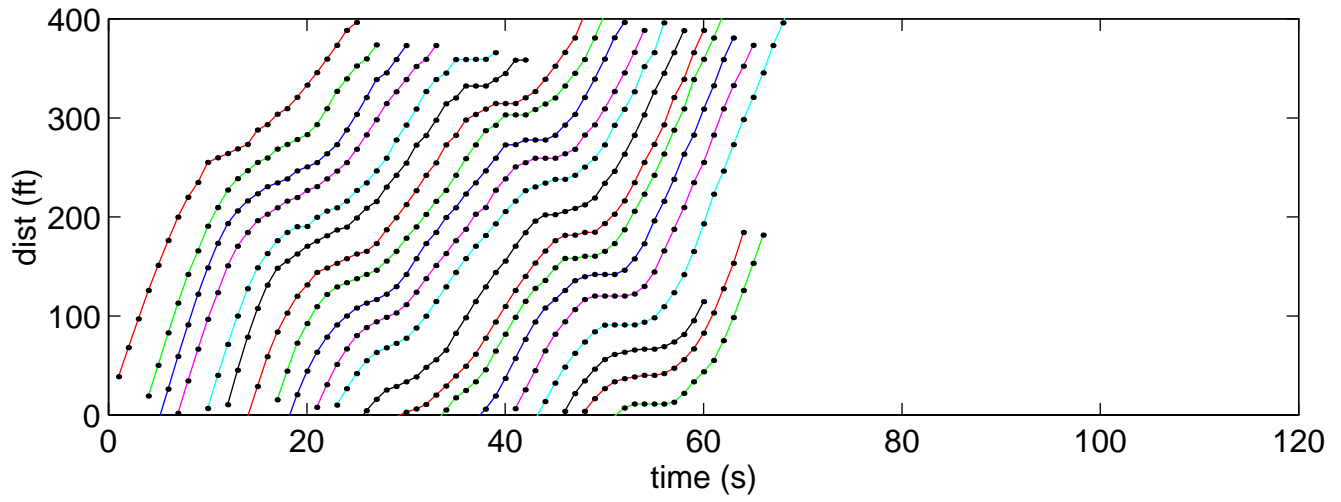
I-680, sequence 4



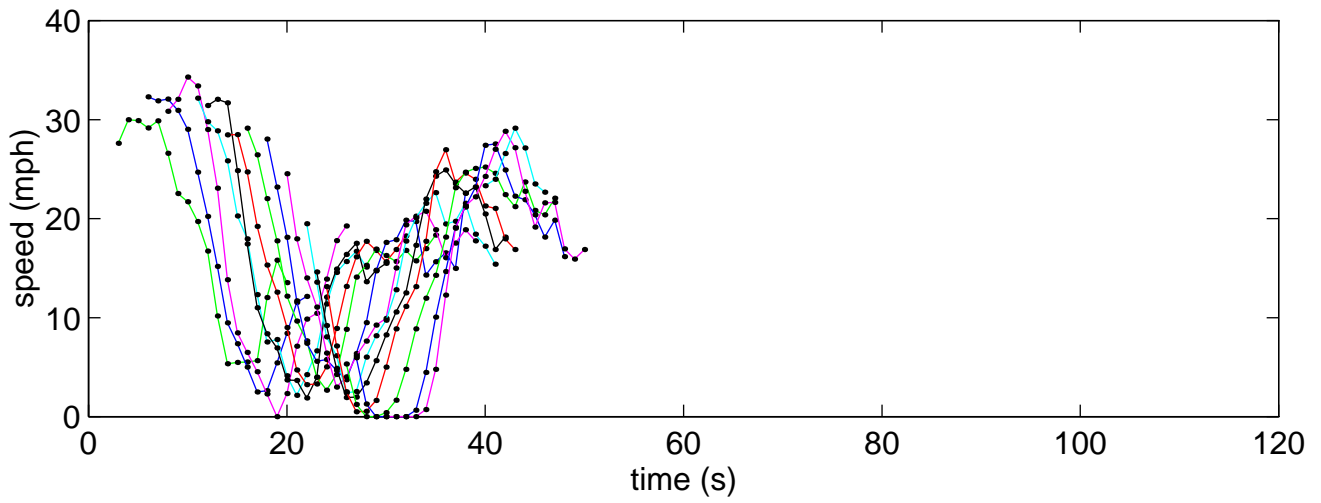
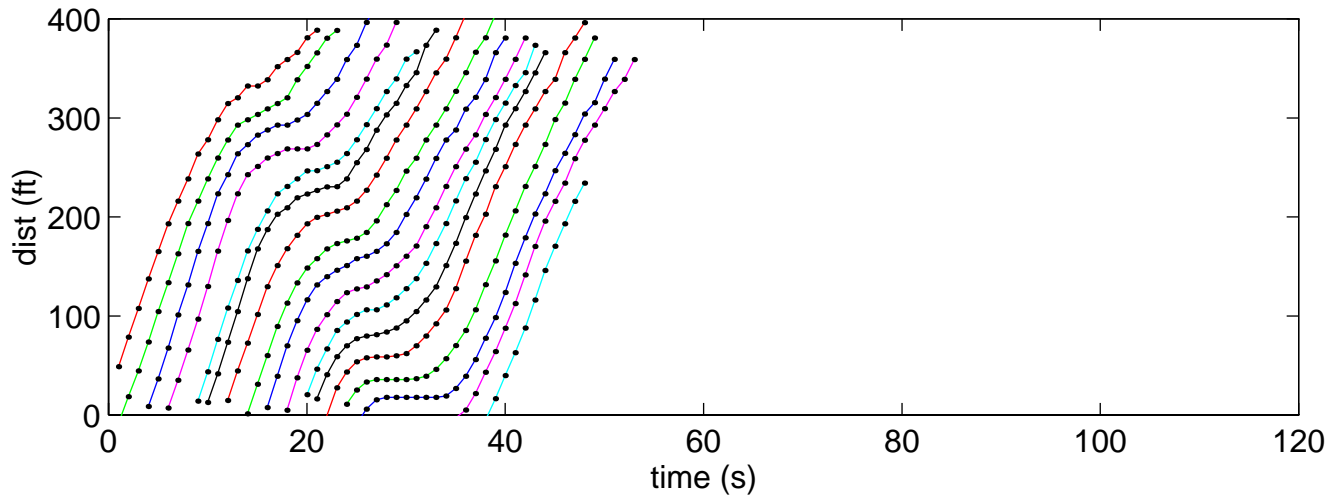
I-680, sequence 5



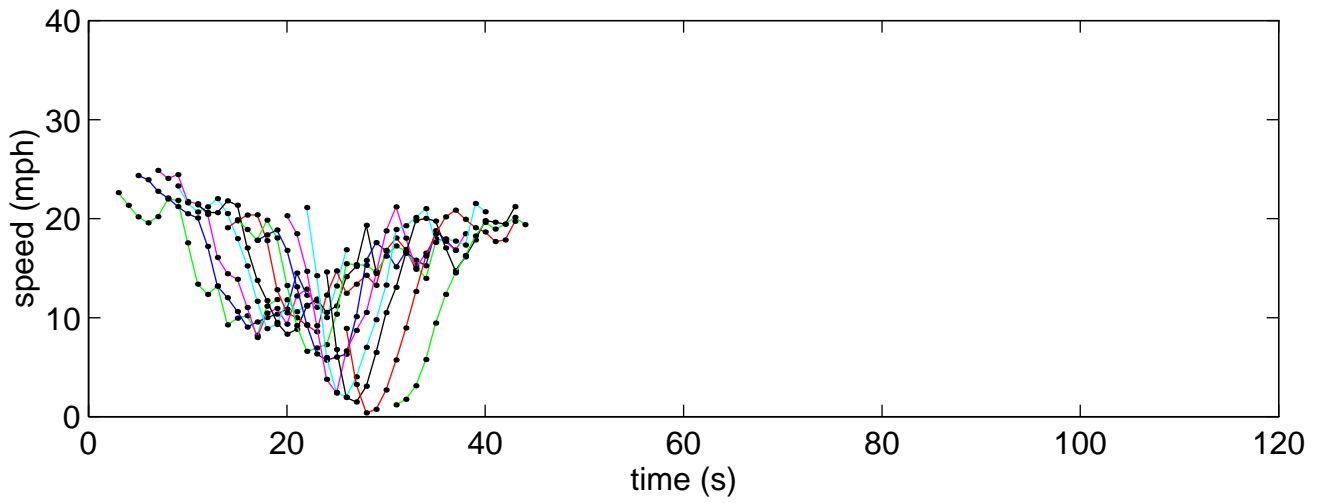
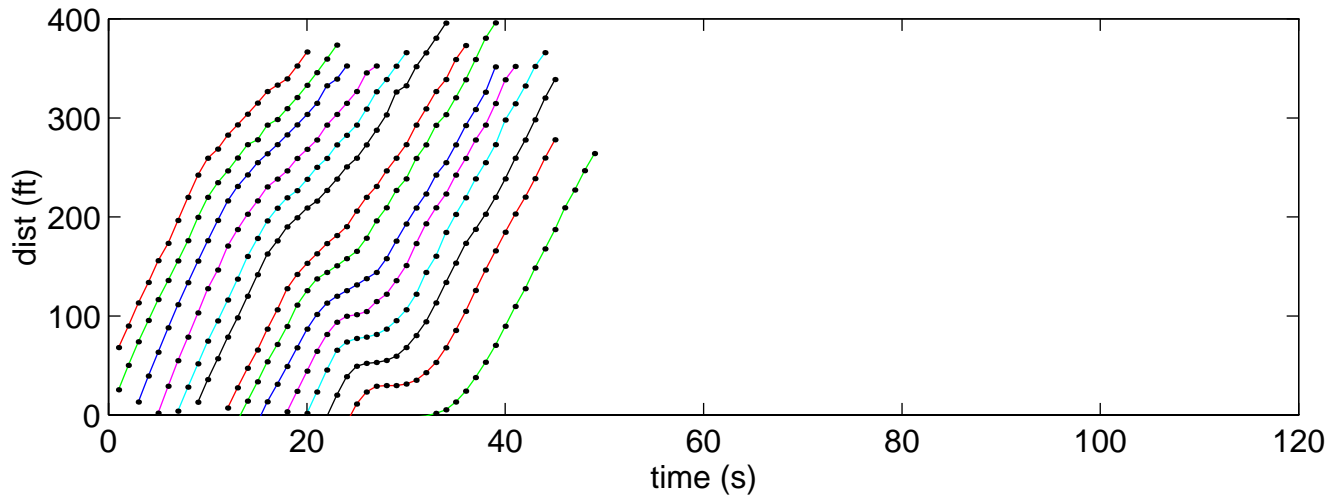
I-680, sequence 6



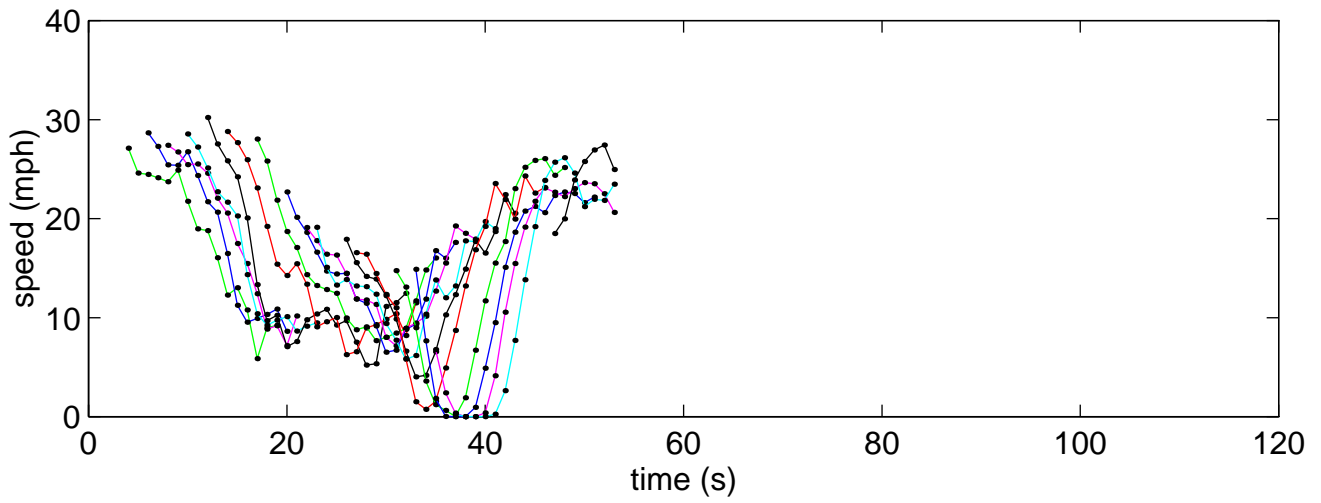
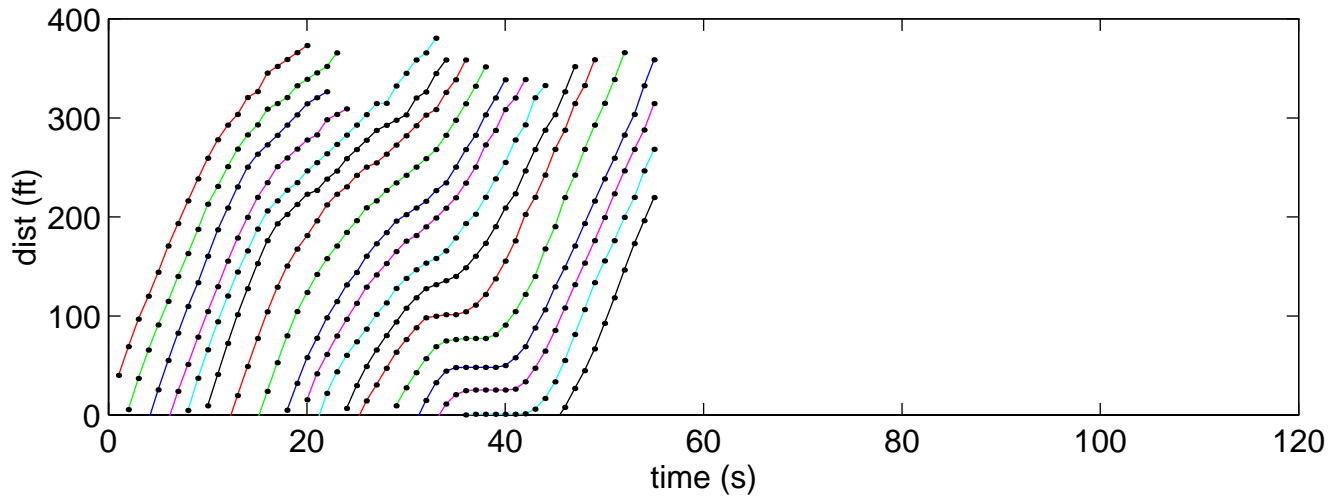
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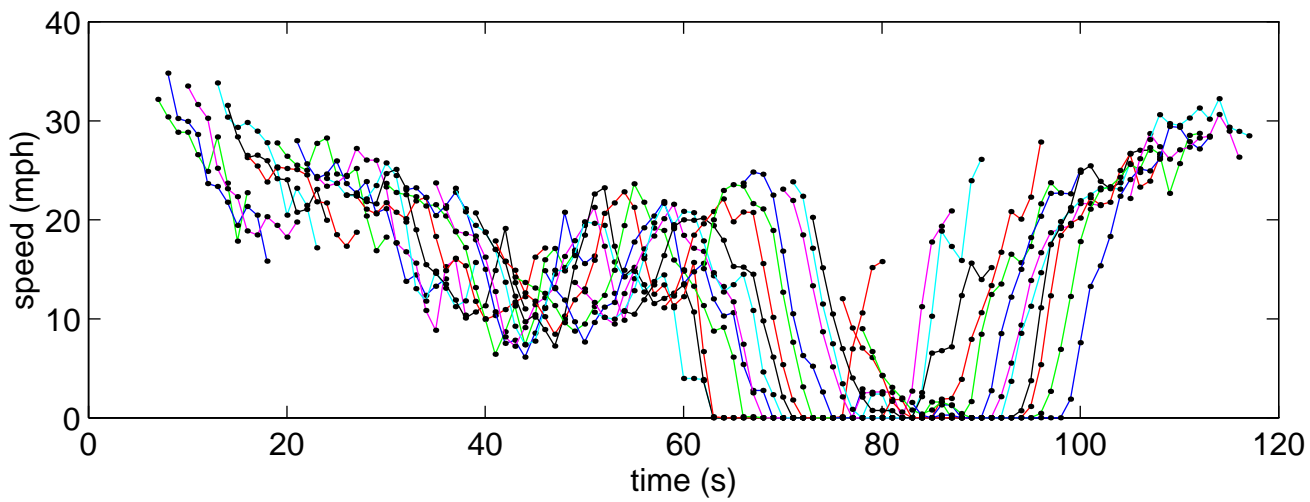
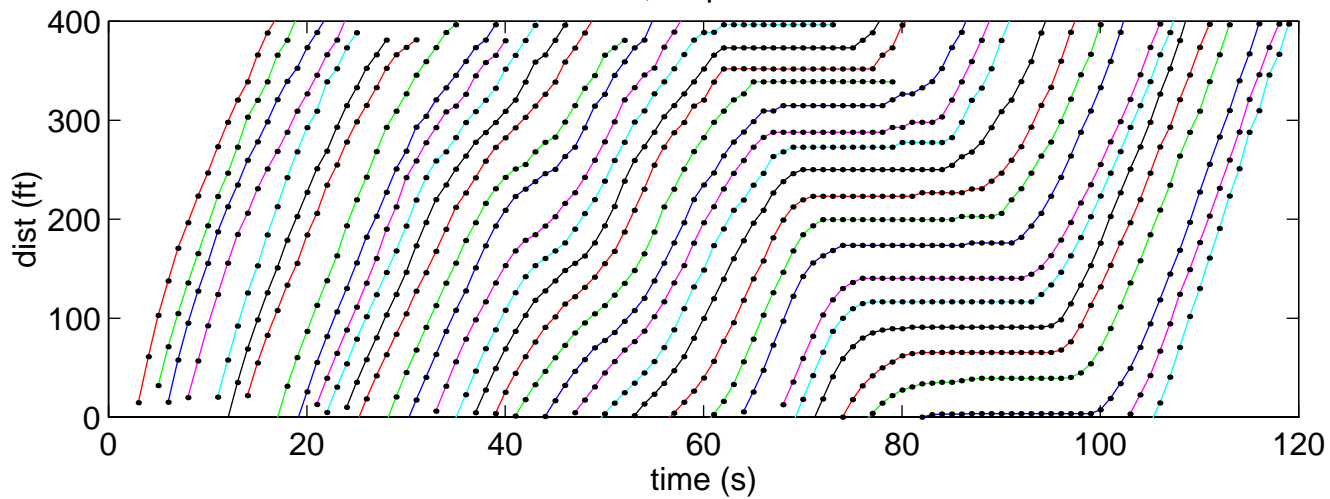
I-680, sequence 8



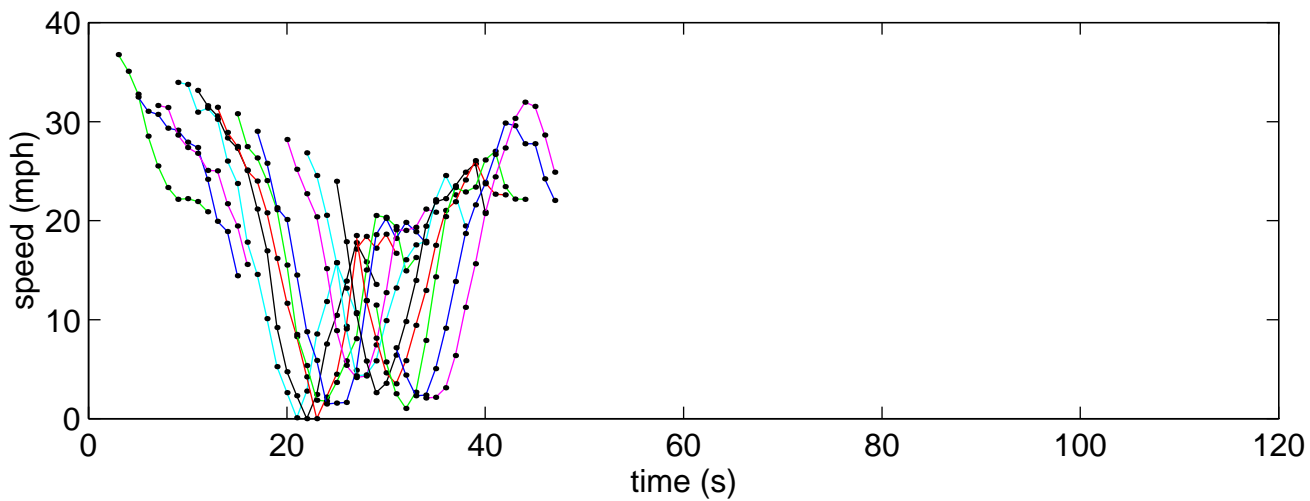
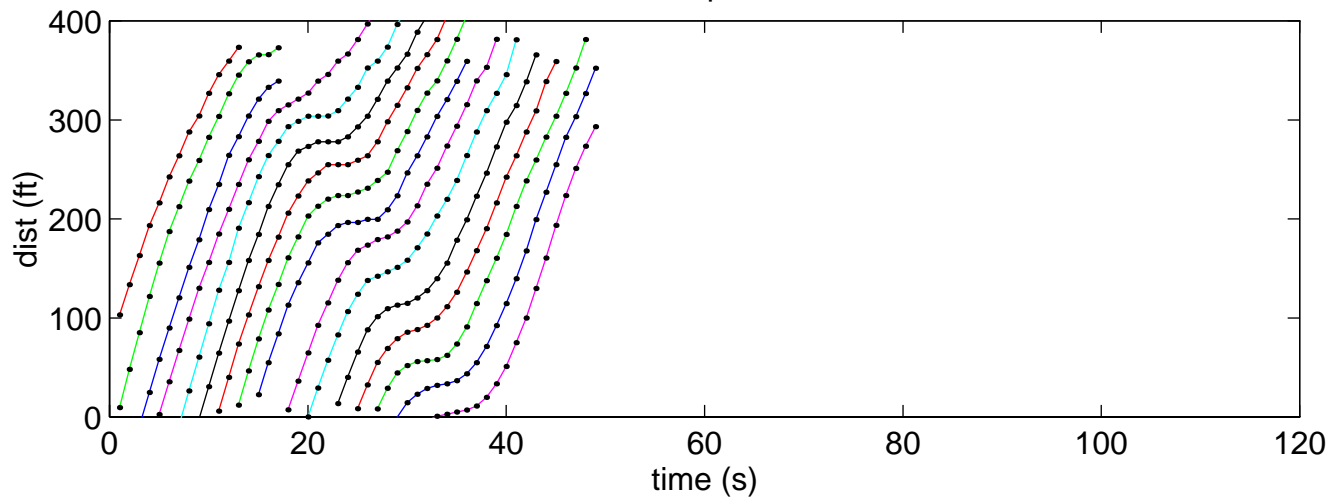
I-680, sequence 9



I-680, sequence 10



I-680, sequence 11



I-680, sequence 12

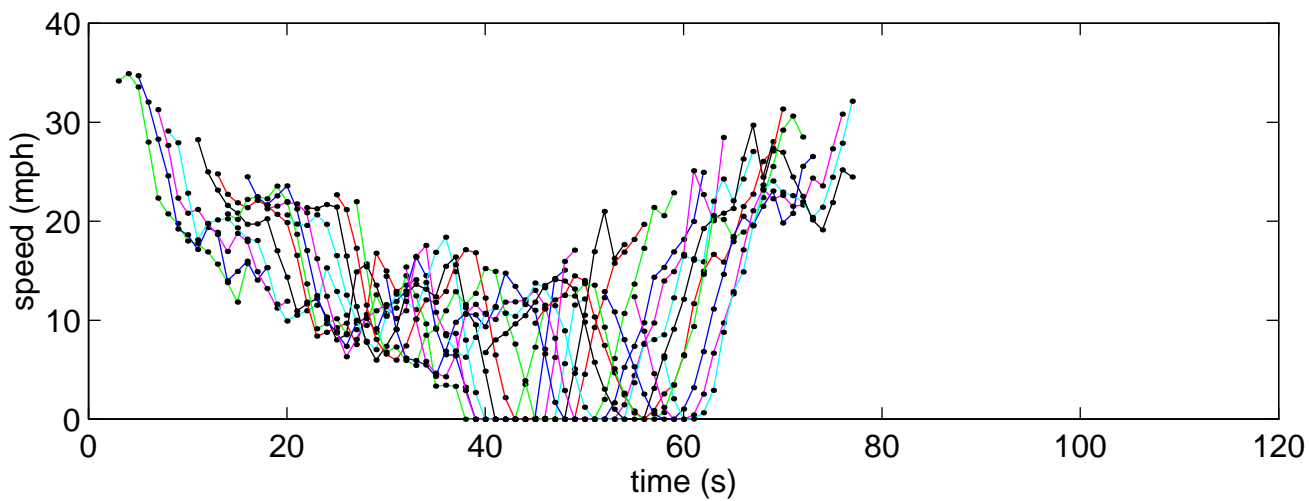
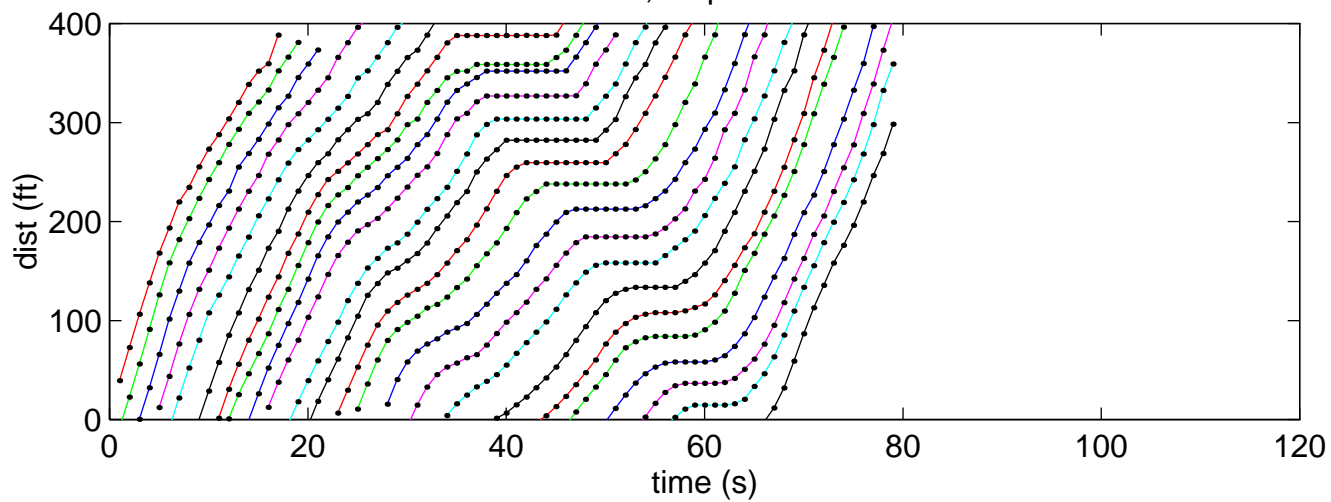
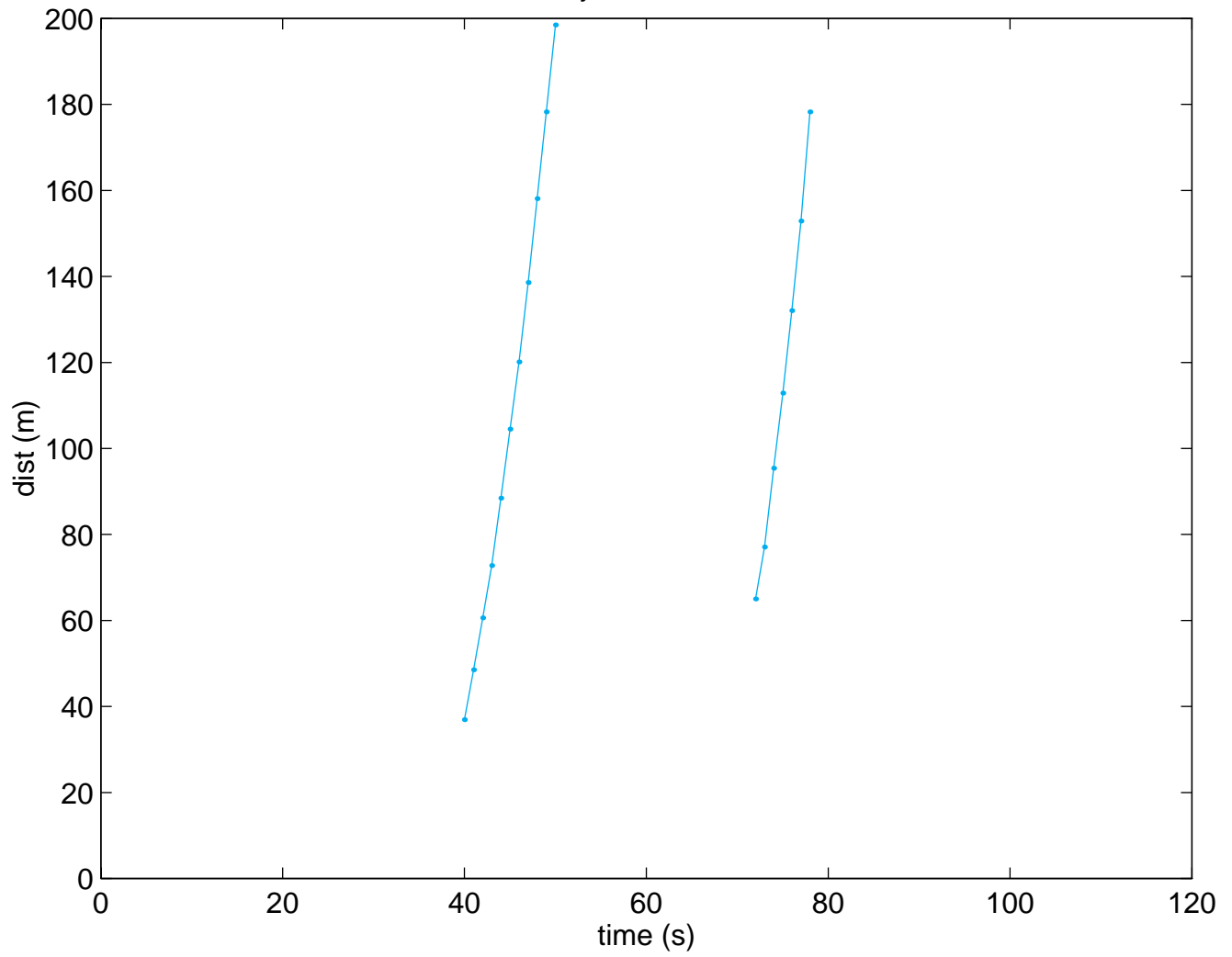


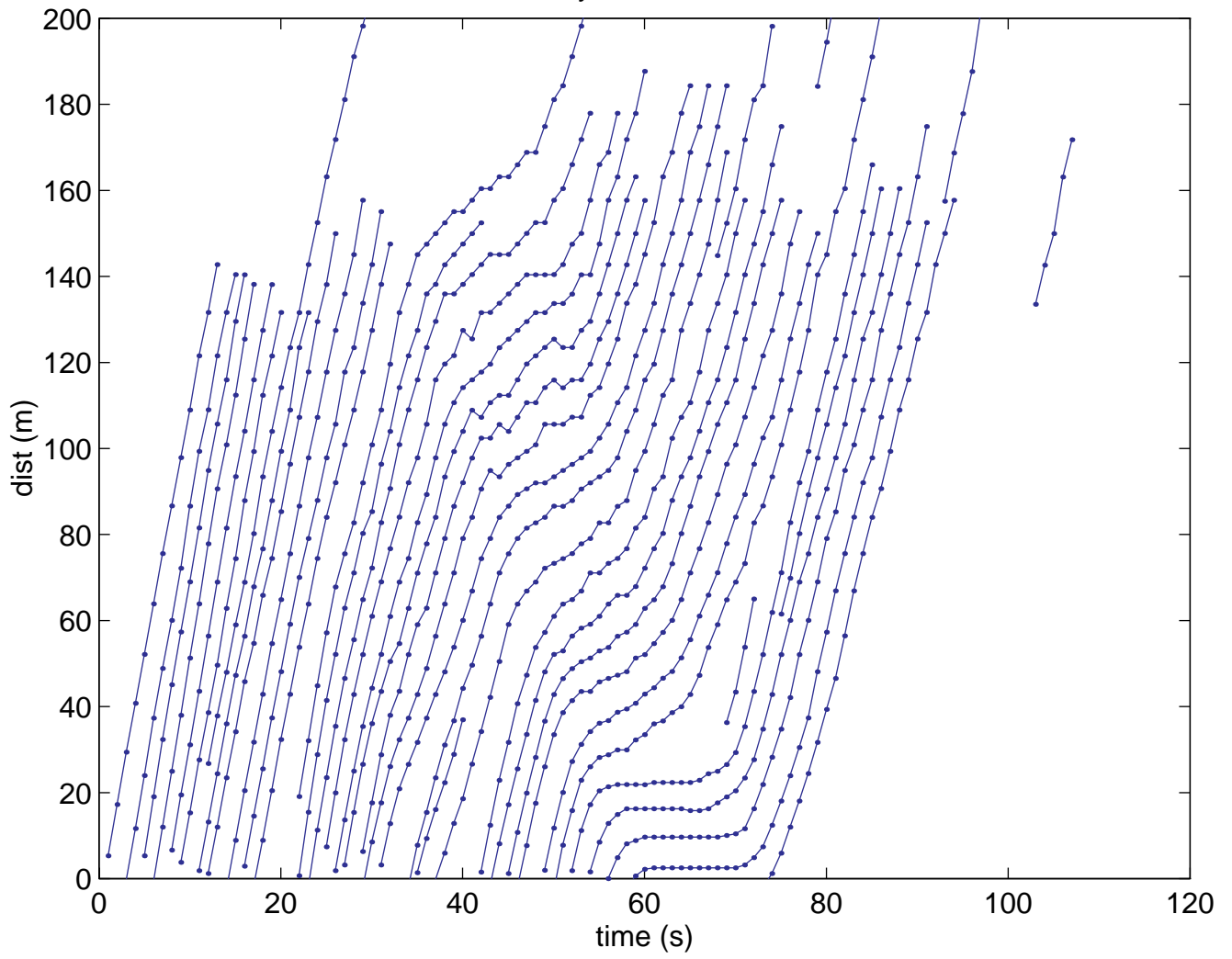
Figure 2, A sample frame from the Hwy 99 test site



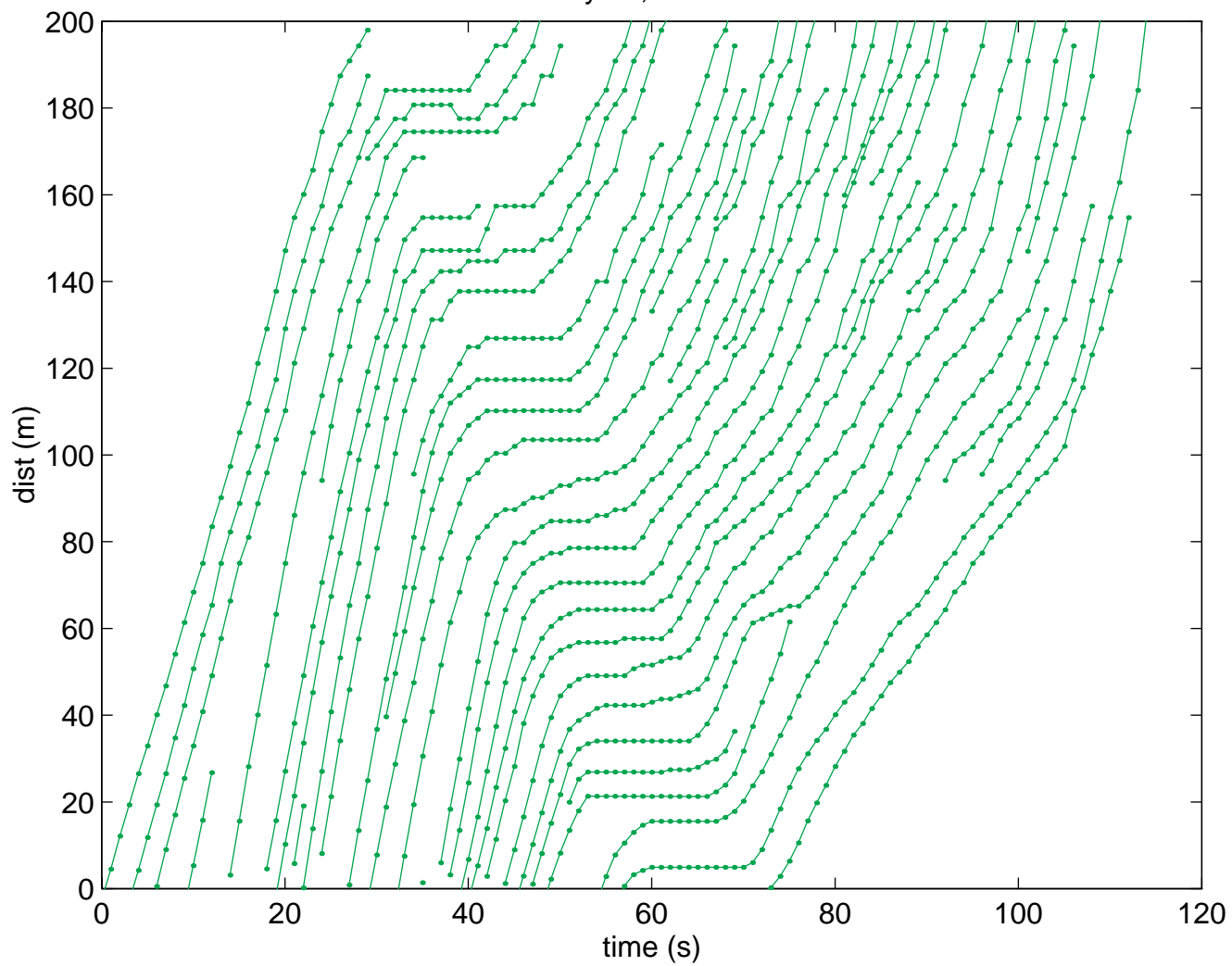
Hwy 99, lane 1



Hwy 99, lane 2



Hwy 99, lane 3



Hwy 99, on ramp

