# Investigating Single and Multi-Lane Traffic Flow Simulations via the Nagel-Schreckenberg (NaSch) Cellular Automata Model

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The Nagel-Schrekenberg (NaSch) Cellular Automata model [1] is one of the most studied and used models in modelling traffic flow, due to its simplicity, but at the same time being robust enough to simulate real traffic flow. It considers the maximum velocity allowed along the road, the headway (which is the distance between the current vehicle and the vehicle in front of it) and the vehicle's current and previous position. One extra bit that the NaSch model has that the earlier versions of the CA model did not have was the account for driver eccentricity.

In the study of traffic, the *fundamental relationship diagram* is described as the relationship between the flow rate (or current) of the vehicles on a road against the density of vehicles on the road. The flow rate is calculated by the number of vehicles passing through a point per lane for the duration of the simulation. The point of the graph is to find out the optimal density for a configuration of roads.

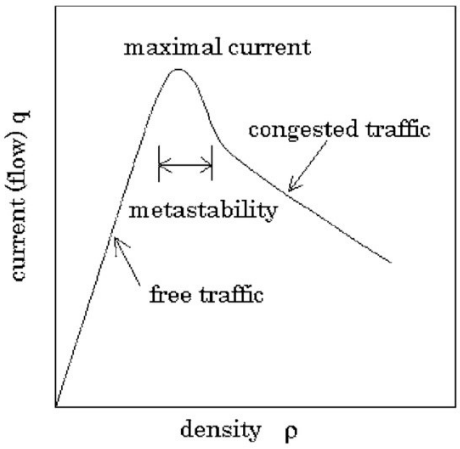


*Figure 1: Fundamental Density diagram. The maximal current is where the movement of traffic is best. It is used to find the best ratio of current (car flow rate) to density. From [2]*

Another important diagram is the *time-space diagram*, where snapshots of the road are taken each specific time interval. By looking at these graphs, one can find the "backwards jam" on a road. These graphs are handy when investigating behavior of traffic when there are obstacles on the road.

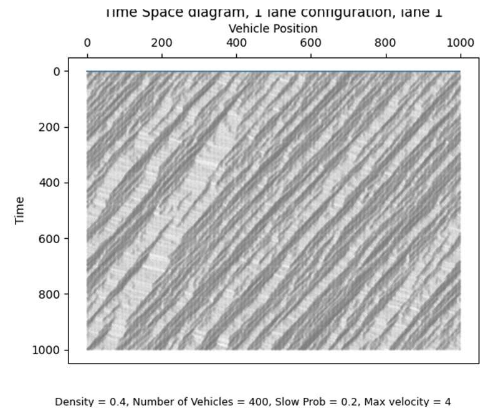


*Figure 2: Time - Space diagram of a single lane road.*

Investigating the average velocity along a lane is also crucial as it can give information on how fast the vehicles can recover from road obstacles (e.g., road collision).

The simulation will consist of a circular road, where multiple parameters can be altered. Vehicles are assigned random positions, velocities, and lanes. The simulations considered:

- Changing the number of lanes along a road.
- Changing the maximum velocity (increasing / decreasing the speed limit).
- Increasing driver eccentricity by increasing the chance a driver slows down.
- Having the above but with obstacles in a lane.

From the simulations, it has been concluded that:

Having more lanes along a road (while allowing lane switching) is advantageous compared to a single lane.

While increasing the maximum velocity allowed for a potentially faster travel along the road, it gives a greater range of velocities possible for a vehicle. Vehicles along a road will take a longer time to reach the peak average velocity / equilibrium (when vehicles are travelling with minimal jam).

Decreasing driver eccentricity (random slowing down) greatly improves overall traffic flow.

The effect of the parameters is further emphasized when there are obstacles along the road. Vehicles being allowed to switch lanes meant that the time taken to recover from the obstacle is greatly reduced.

# References

[1] *A cellular automaton model for freeway traffic.* **Schreckenberg, K. Nagel and M. 1992.** 1992, J. Physique I, 2, pp. 2221-2229.

[2] *The physics of traffic jams.* **Nagatani, Takashi. 2002.** 2002, Vols. Rep. Prog. Phys. 65 1331–1386, .