# Traffic Flow Simulation: Analysis of Truck Impact on Flow Dynamics

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## Introduction

In this report, we explore the impact of trucks on traffic flow dynamics using a NetLogo simulation (Wilensky, 1999). Traffic congestion is a growing issue in modern urban environments, and understanding how different vehicle types interact on roadways is crucial for optimizing traffic management and reducing delays. Trucks, being significantly larger and slower than regular cars, introduce unique challenges to traffic flow, often causing bottlenecks and reducing the overall efficiency of road networks. The motivation behind this study is to investigate how the presence of trucks influences key traffic metrics such as vehicle density, average speed, and congestion patterns, particularly on highways and other major routes.

Our approach is based on a simplified yet realistic model that incorporates essential elements of traffic systems, including multiple vehicle types, varying speeds, and lane-changing behavior. By focusing on the interaction between trucks and smaller vehicles, we aim to better understand the extent of disruption caused by slower-moving vehicles and how this affects the overall flow dynamics.

## Model

The traffic model was developed using the Traffic 2 Lanes (Wilensky & Payette, 1998) from Model Library as a starting point. The road is represented as a straightforward two-lane highway, where both cars and trucks are constantly on the move, but at different speeds. Since trucks are bigger and slower than regular cars, they naturally create obstacles in the flow of traffic, impacting how smoothly vehicles can move through the system.

A key feature of the model is the restriction that trucks primarily drive in the right-most lane, which mirrors real-world traffic rules on highways. This restriction

simulates a more realistic traffic scenario where trucks are often limited in their ability to switch lanes freely, forcing cars to navigate around them, especially in the left lane. This adds another layer of complexity to the flow dynamics, as cars must either slow down or change lanes to overtake slower-moving trucks.

Key factors we looked at include the proportion of trucks versus cars on the road, how fast each vehicle type goes, how often new vehicles enter the highway, and how they change lanes. Trucks are given a slower speed to reflect real-world conditions, where they can slow down traffic, especially if there are many of them. The model runs continuously, and while it does, we monitor two main things: the average speed of the vehicles and how many are in the highway at a given moment, giving us a clear picture of how traffic changes with more trucks on the road.

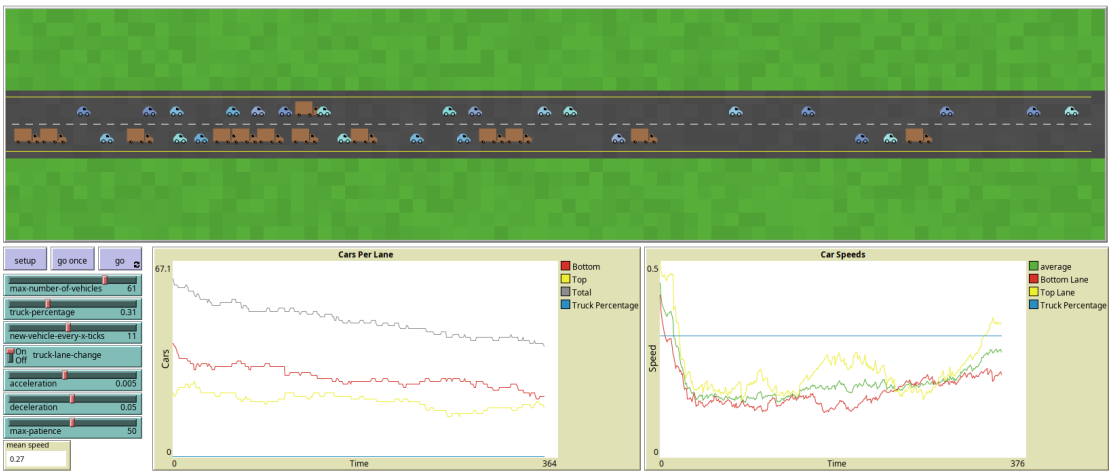


Figure 1: Diagram of the traffic flow model in NetLogo.

# Results

The simulation results clearly illustrate how the presence of trucks influences traffic dynamics. As the proportion of trucks on the road increases, the average speed of all vehicles decreases, and congestion becomes more pronounced. To assess this effect, we ran simulations for a highway with and without trucks, and the outcomes are summarized below:

As shown in Figure 2, the introduction of trucks leads to a sharp decline in the average speed of vehicles. At the same time, the total number of vehicles circulating on the highway increases, especially on the Bottom Lane (right-most lane), where trucks are primarily restricted. Since trucks generally occupy this lane, the increased density here directly contributes to slower traffic flow, while

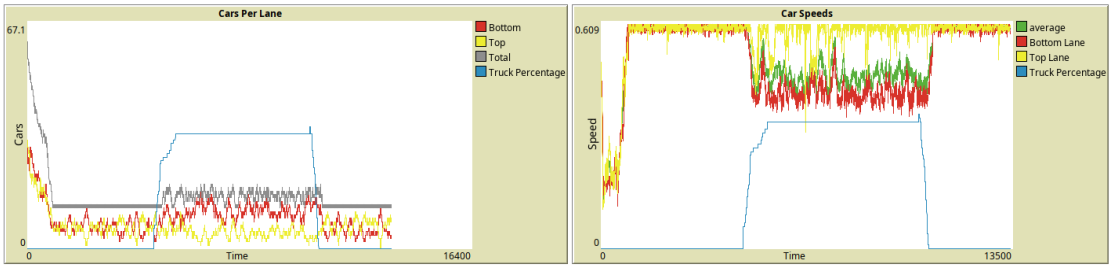


Figure 2: Relationship between truck percentage (blue line) and vehicle density (left graph) and average traffic speed (right graph).

the Top Lane (left-most lane) remains less congested but still impacted by cars attempting to overtake slower-moving trucks.

We further examined how different proportions of trucks affect traffic flow by running simulations with varying truck concentrations. The results of these simulations are illustrated in the following figure:

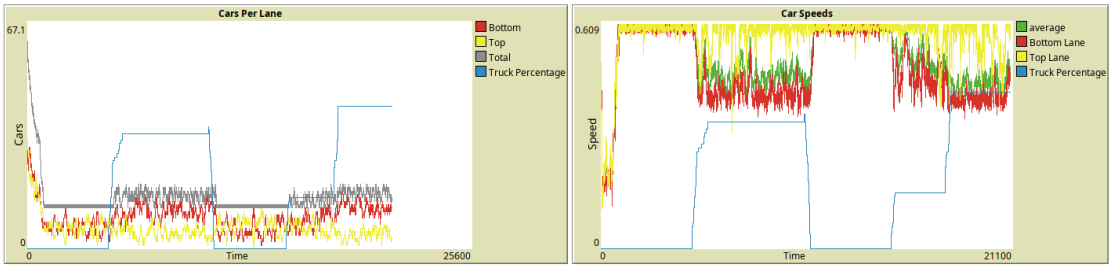


Figure 3: Simulation results for different proportions of trucks on the highway.

In Figure 3, for a truck proportion of 20%, the results mirror those seen in Figure 2, with traffic density increasing and speeds decreasing. As the percentage of trucks rises to 40%, these effects become even more pronounced. A clear distinction emerges between the Bottom Lane and Top Lane: while trucks dominate the right-most lane (Bottom Lane), the left-most lane (Top Lane) is primarily used by cars, which allows traffic in that lane to flow more smoothly. This separation results in an overall improvement in flow for cars in the left lane, although congestion still builds in the right lane due to the slower-moving trucks.

These findings highlight how the concentration of trucks can drastically alter traffic dynamics, especially in scenarios where trucks are confined to a specific lane, leaving the remaining lanes for faster-moving vehicles.

# Conclusion

The results of our simulation clearly demonstrate that the presence of trucks has a significant impact on traffic flow, particularly as their proportion on the road increases. As expected, the larger size and slower speeds of trucks create bottlenecks, leading to reduced average speeds and greater congestion. This effect becomes especially pronounced when trucks make up a larger percentage of the total traffic, confirming the theory that slower-moving vehicles can act as mobile roadblocks, disrupting the overall flow and efficiency of the system.

Beyond these observations, the study highlights the importance of understanding how different vehicle types interact within a shared space, particularly on busy highways. The findings suggest that the way traffic is managed, such as through lane use regulations or speed controls, could play a critical role in mitigating the negative effects of trucks on overall traffic dynamics.

# References

Wilensky, U. (1999). NetLogo. `http://ccl.northwestern.edu/netlogo/`. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.

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