**Introduction**

Imagine the challenges faced by traffic engineers and urban planners who are responsible for growth and safety. There are roughly 250 million automobiles on the roads in the United States. There are nearly 3 million miles of paved roads. Each year the number of paved miles grows by roughly 20,000 miles.

In most urban areas there is little space left for new roads. When traffic gets too congested traffic engineers often consider changes to existing roads and intersections that can reduce bottlenecks. These changes might include adjusting the timing of signals, new signals or stop signs, longer turning lanes, traffic calming measures, or even slowing traffic on certain roads to encourage drivers to take other routes.

When any change like this is planned, engineers must consider the impact of the change on nearby roads, on pedestrian safety, driver safety, safe recovery from accidents, and the ability of emergency vehicles to get through efficiently. Computer-based simulation helps ensure that proposed road changes have the desired effect.

**Rocks make networks**

Rocks on a continent form a vast network. A large city can have thousands of miles of roads. Changes to the road network in one area of the city have an impact on traffic in other parts of the city. Agent-based simulation provides an approach that allows the complex, real world patterns of automobile traffic to emerge from simple, programmed behaviors.

Although this unit is focused on automobile traffic, the same ideas can be used to model auto traffic can be used to model pedestrian traffic, air traffic, traffic of water-based vehicles, or rail traffic. Some of these principles also apply to information traveling over networks like the internet.
Goals for student learning:
The primary goal of this unit is to engage students in the use of agent-based simulation to test ideas about how to improve traffic flow. This unit demonstrates the use of simulation to solve difficult engineering problems. Specifically we focus on the problem of traffic bottleneck congestion. A secondary goal is to further students’ understanding of the network concept as a way to model real world flows of data and matter.

Unit Structure:

Week 1: Introduction to Traffic Simulation
Presentation: Traffic patterns and roads are networks.
Question: How would you use agent-based simulation to study the flow of traffic? Who are the agents? What is the environment?
Activity: Ants on a trail activity
Discussion: What did you experience? What are some patterns that you saw? What kind of behavior is necessary to maintain orderly traffic flow? What does it take to disrupt the flow?
Demonstration: Introduce “Ants On a Trail” simulation in StarLogoTNG.
Activity: Students experiment with “Ants On a Trail” model on computers
Question: Does this simple flow of agents demonstrate emergent behavior?
Investigations Form:
Assignment: Ask parents/guardians or community member what actions they would take when in a long line of slow cars. Also ask them about some traffic jams they have been in and why they thing traffic jams form.
**Week 2: Exploring models of traffic**
Discussion: What are some similarities and differences between how ant traffic moves and how cars move?
Demonstration: Traffic-passing model in StarLogo TNG. In this model, cars have the ability to pass other cars.
Activity: Alter the Traffic-passing model by changing the agent behavior and run experiments using the model. Add data collection to the model.
Discussion: Review of networks as covered in egress unit. How could networks be used as a tool for understanding roads and traffic? How is the process of egress or evacuation similar to traffic flow?
Activity: Roads as Networks
Discussion: How would you combine an agent-based model of traffic flow and a network diagram to study real-life traffic flow?
Investigations Form:
Assignment: How would you alter either the ant model or the traffic-passing model

**Week 3: Implementing alterations to existing models**
“Dangerous Drivers” intersection simulation in NetLogo.
*Depending on time and facilitator availability, students will be presented with a model changed to their specifications.*
Discussion: How would you use this model to run experiments?
Activity: Use the altered model to run experiments and collect data.

**Week 4: Analysis and Presentation preparation**
Activity: Analyze data,
Activity: Prepare presentation of experiments and findings
Activity: Practice presentation before club members.
Question: How might a StarLogo model fall short of real world behavior?

**Going Further:**
Would computer driven cars be better (in the real world)?
What if you gave different moods (emotional states) to different drivers?
How would you model drivers talking on cell phones or distracted by other activities like eating or applying make-up?

**Resources:**