RWR 4015
Traffic Simulation for Planning Applications

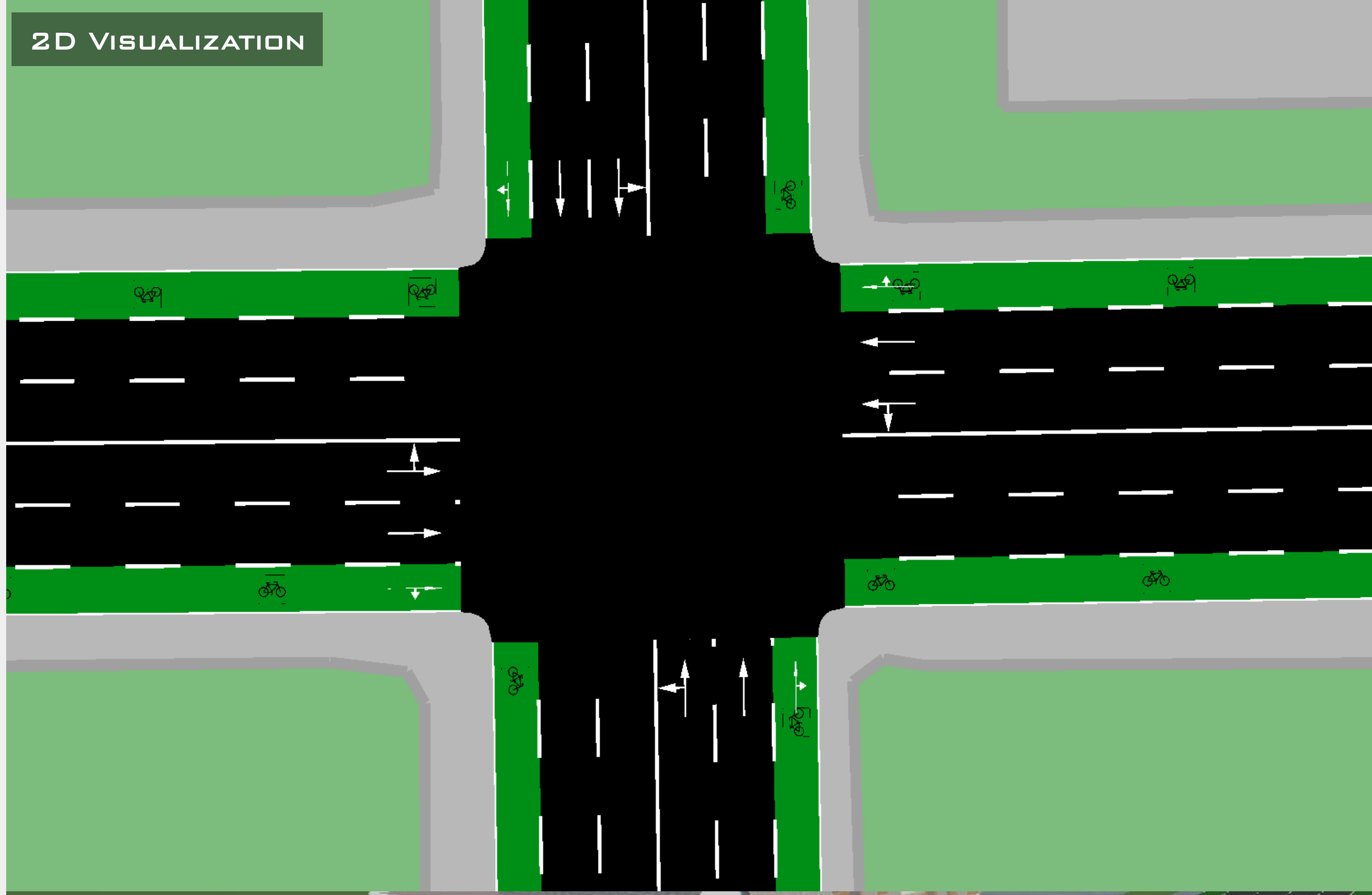
Dr. Ahmad Mohammadi

Week 2 | Lecture:
Fundamentals of Traffic Simulation

Fall 2026

RoadwayVR

roadwayvr.github.io/TrafficSimulationforPlanningApplications

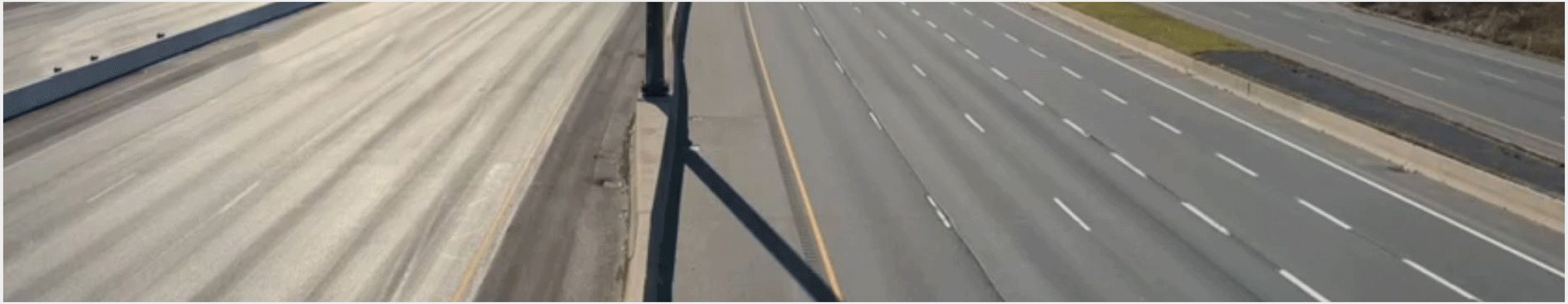


Agenda

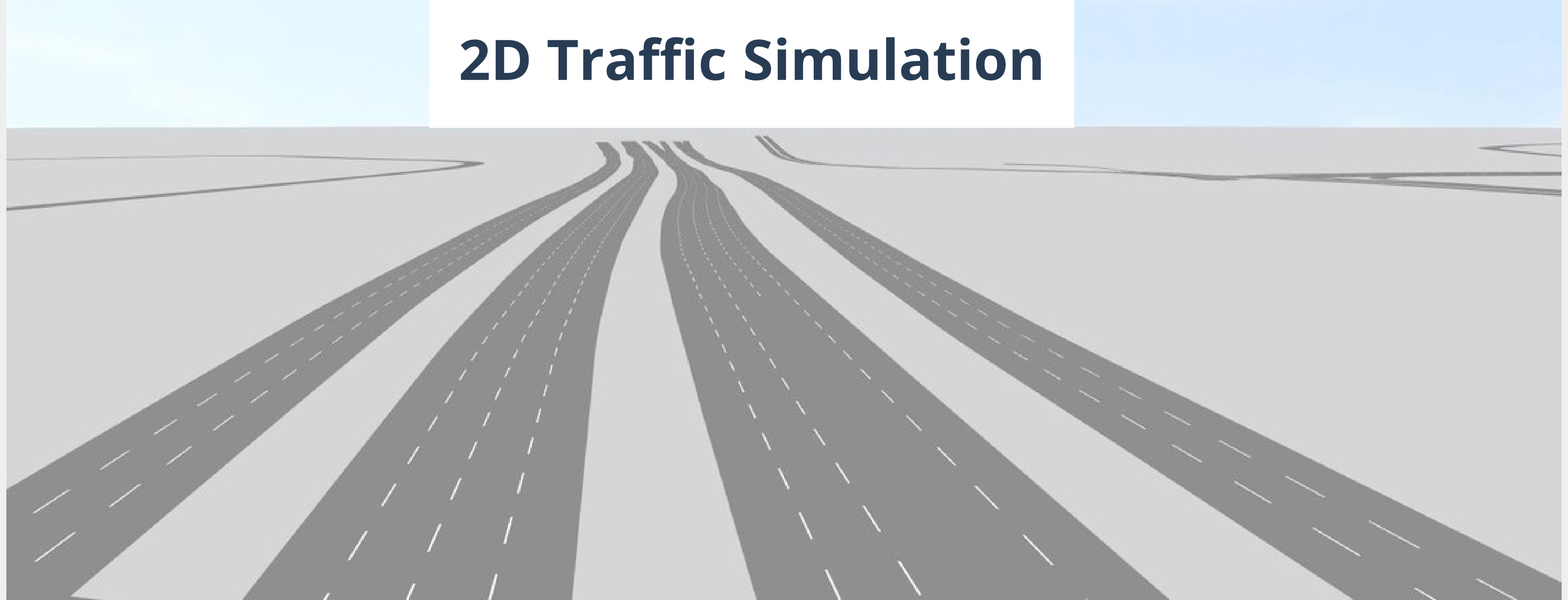
- Road Network Development
- Vehicles Characteristics
- Vehicle Dynamics
- Car Following and Lane Changing Models
- Traffic Theory
- Fundamental Diagram (Flow, Density, Speed)

Road Network Development

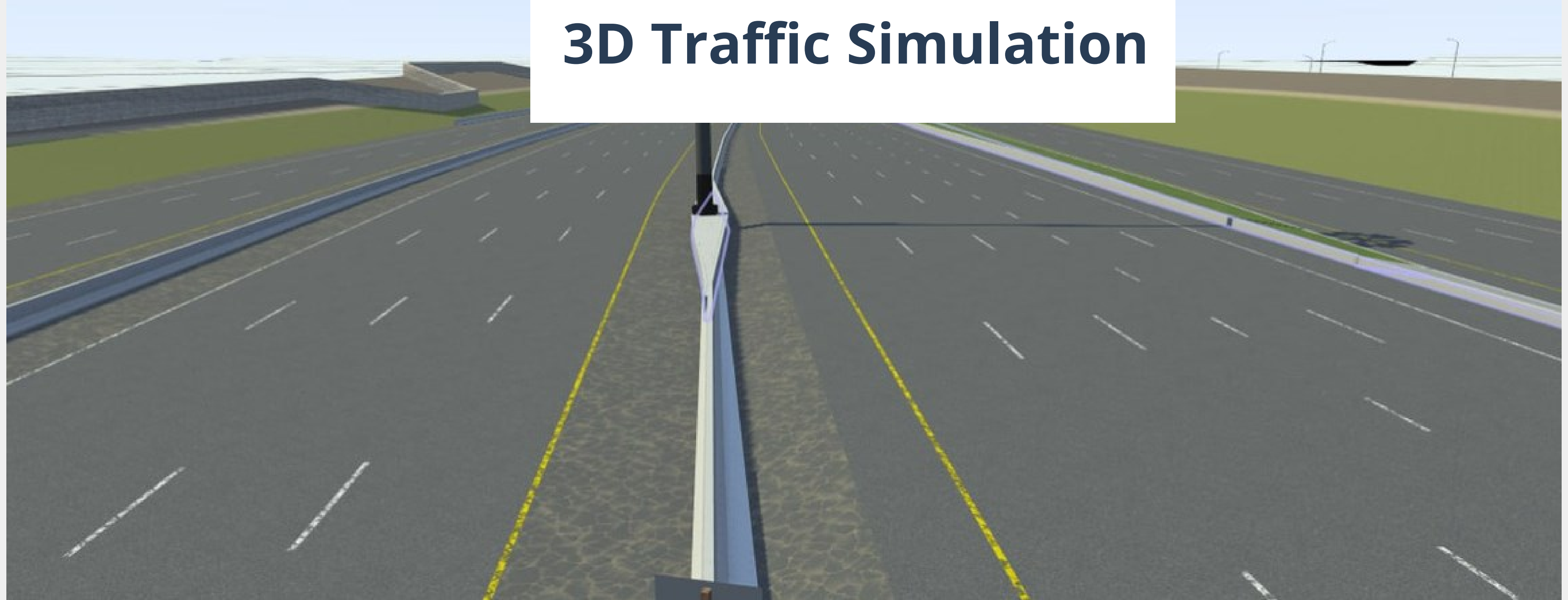
Real-World



2D Traffic Simulation



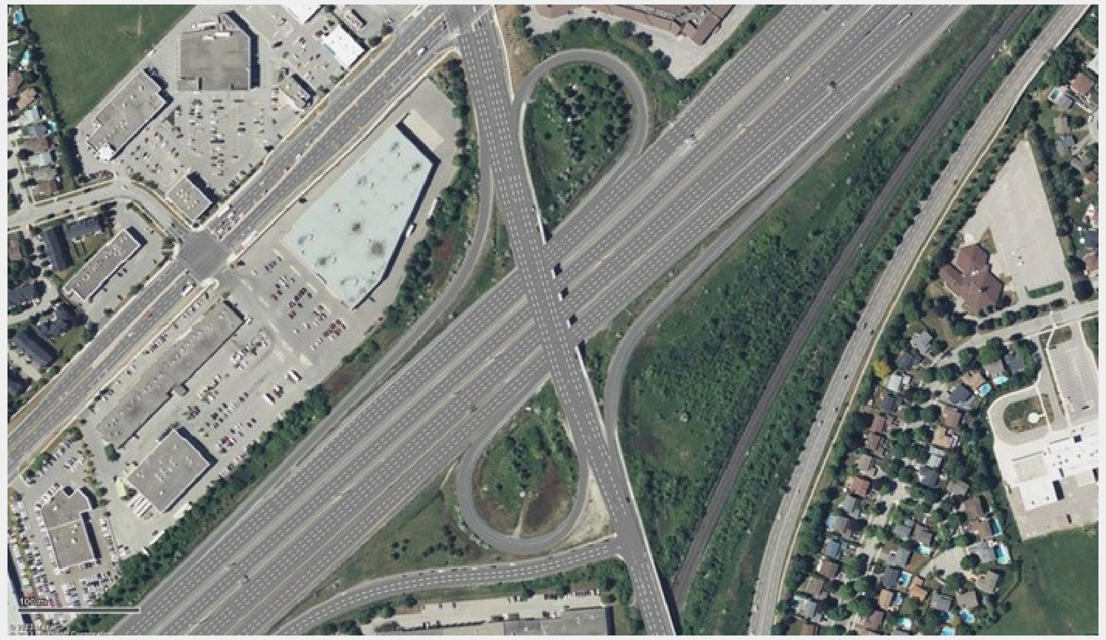
3D Traffic Simulation



Road Network Development

Step 1:
The Developed Network

Step 2:
The Network in
2D Traffic Simulation

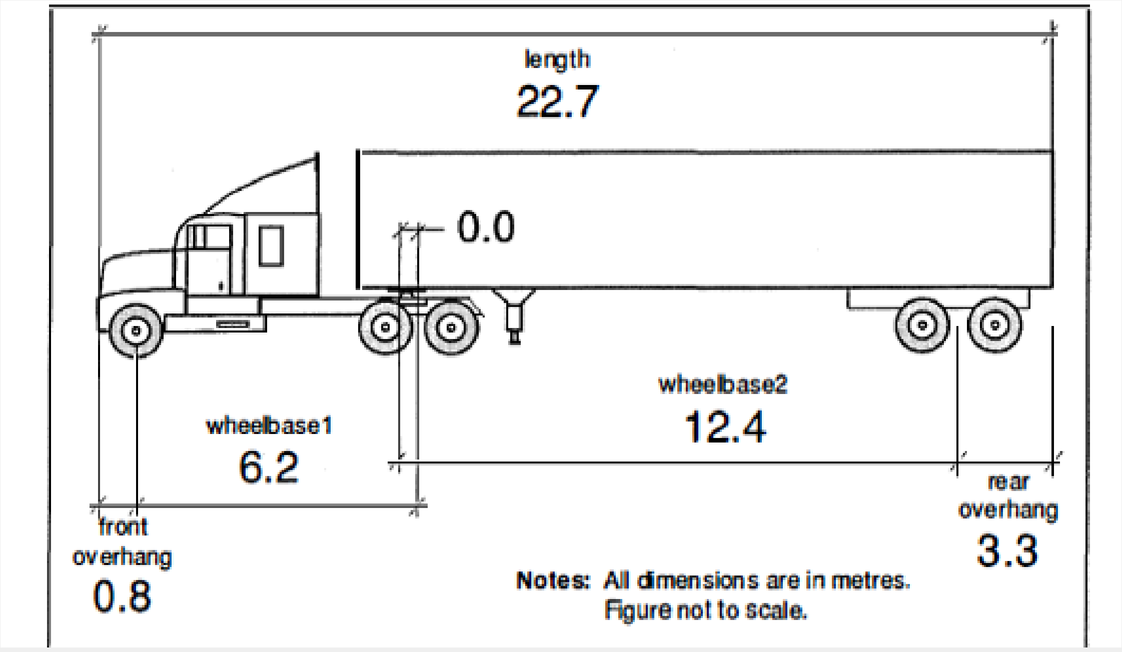


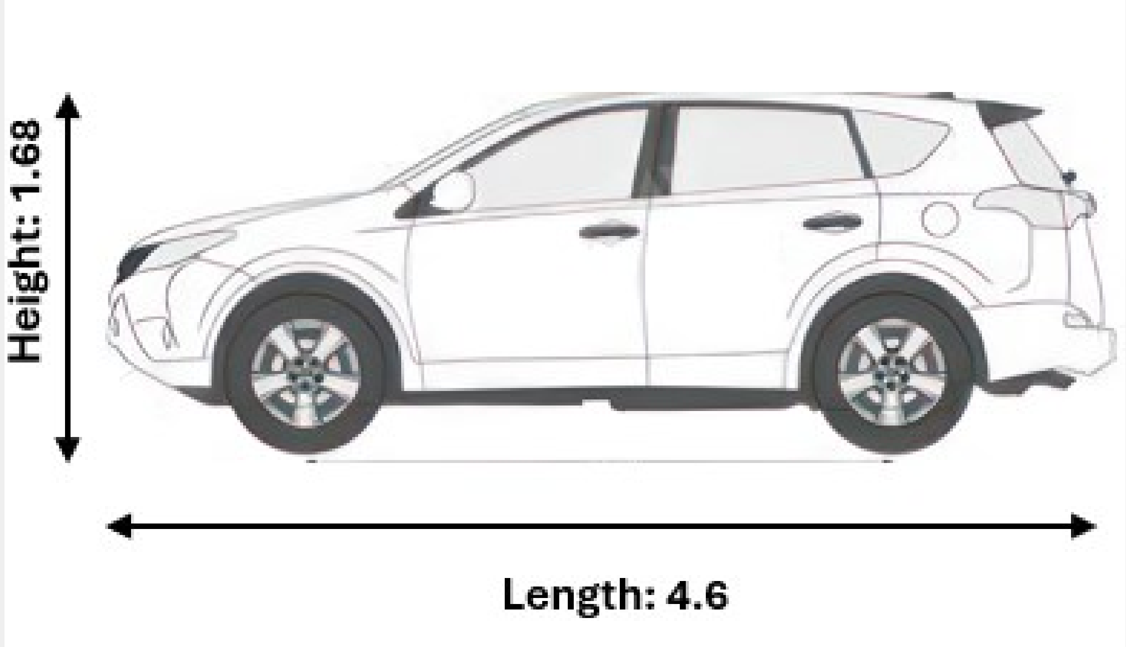
Step 3:
The Network in
3D Traffic Simulation

See video: https://youtu.be/ZoHbTjUBZfA

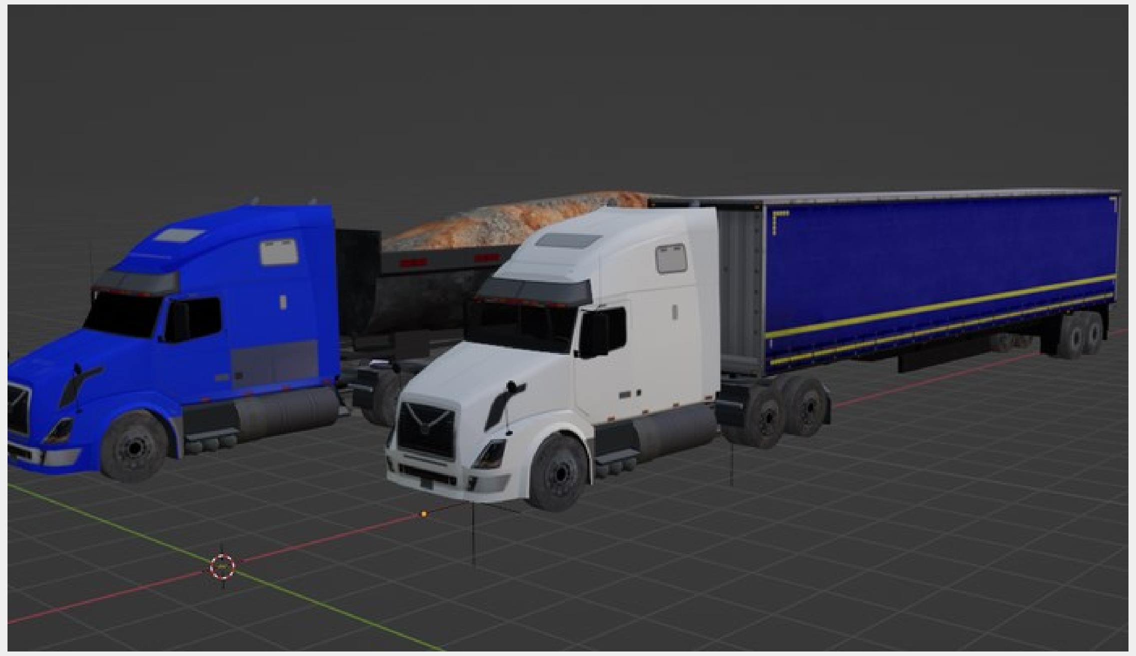
Vehicles Characteristics

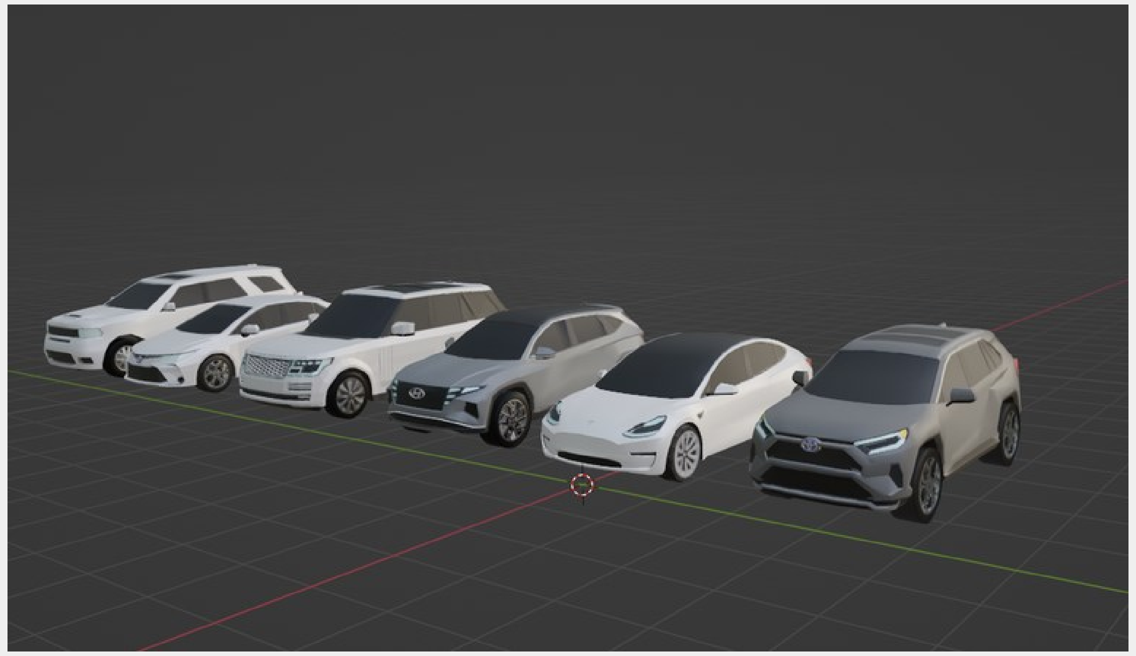
Real-World Dimension



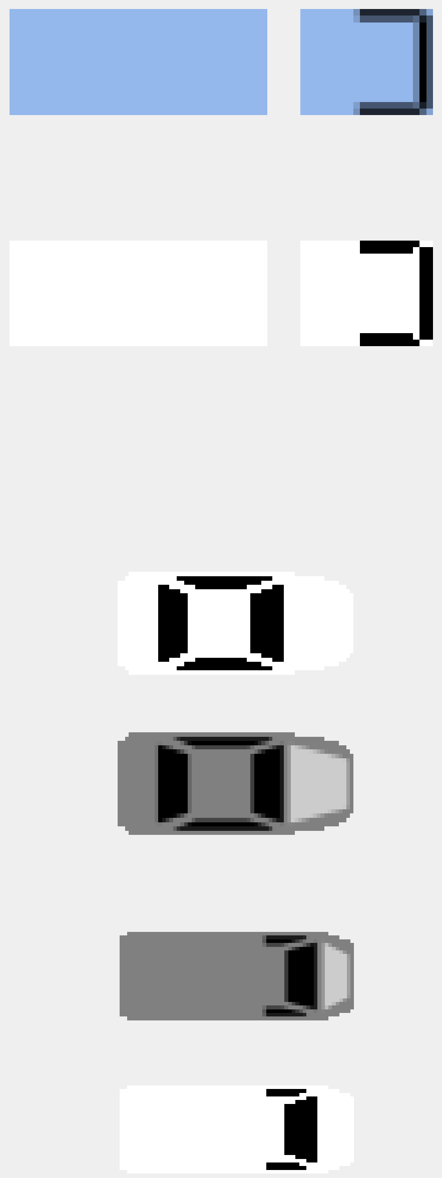


3D Traffic Simulation





2D Traffic Simulation



Vehicles Dynamics

Modelling the Behavior

Steering

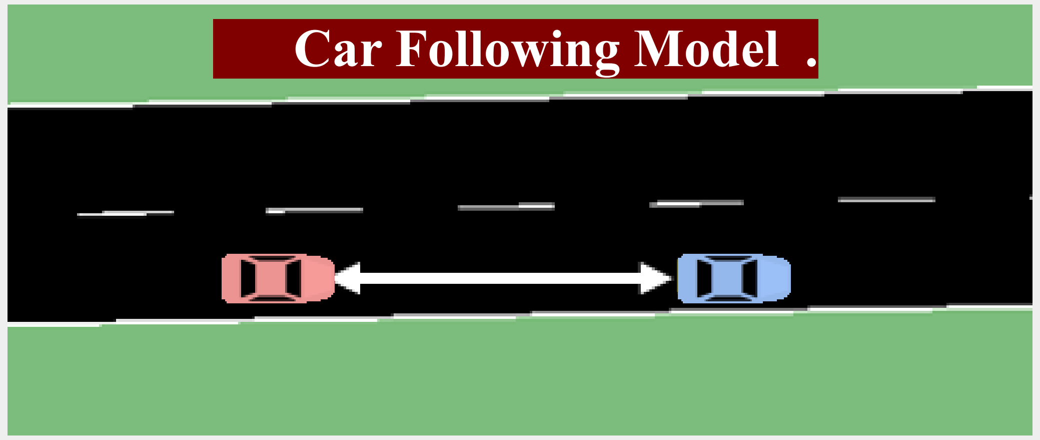
Braking/Acceleration

Real-World

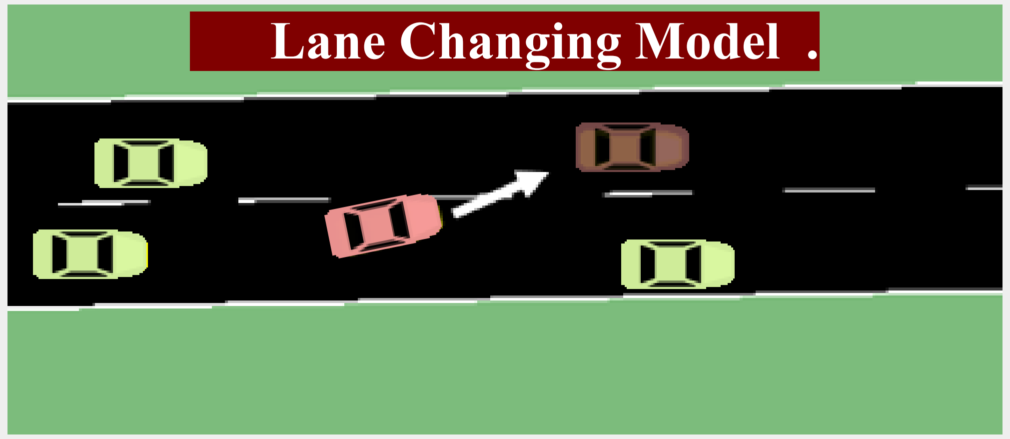
Simulation

Car Following and Lane Changing Model

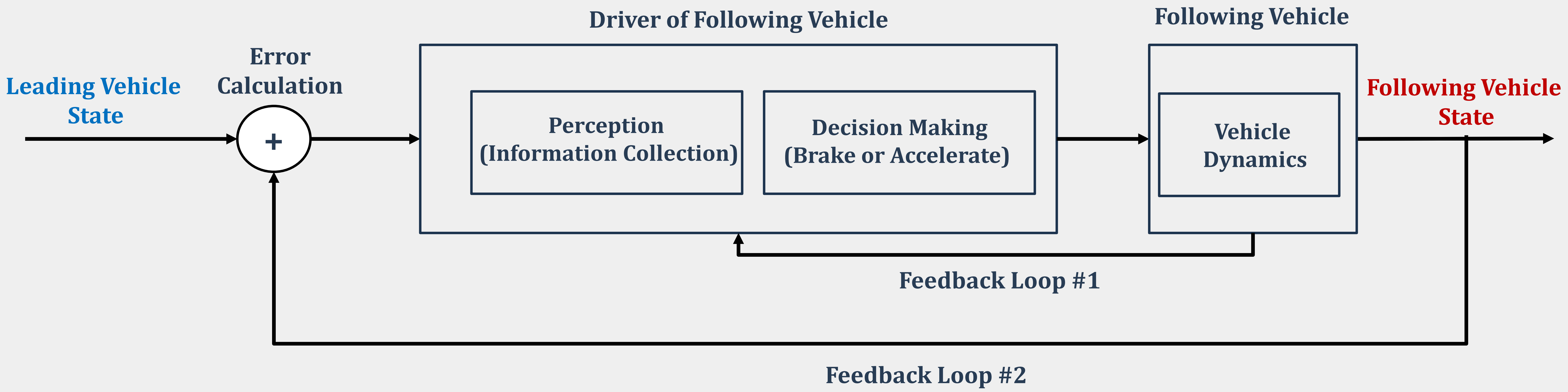
Longitudinal Movement

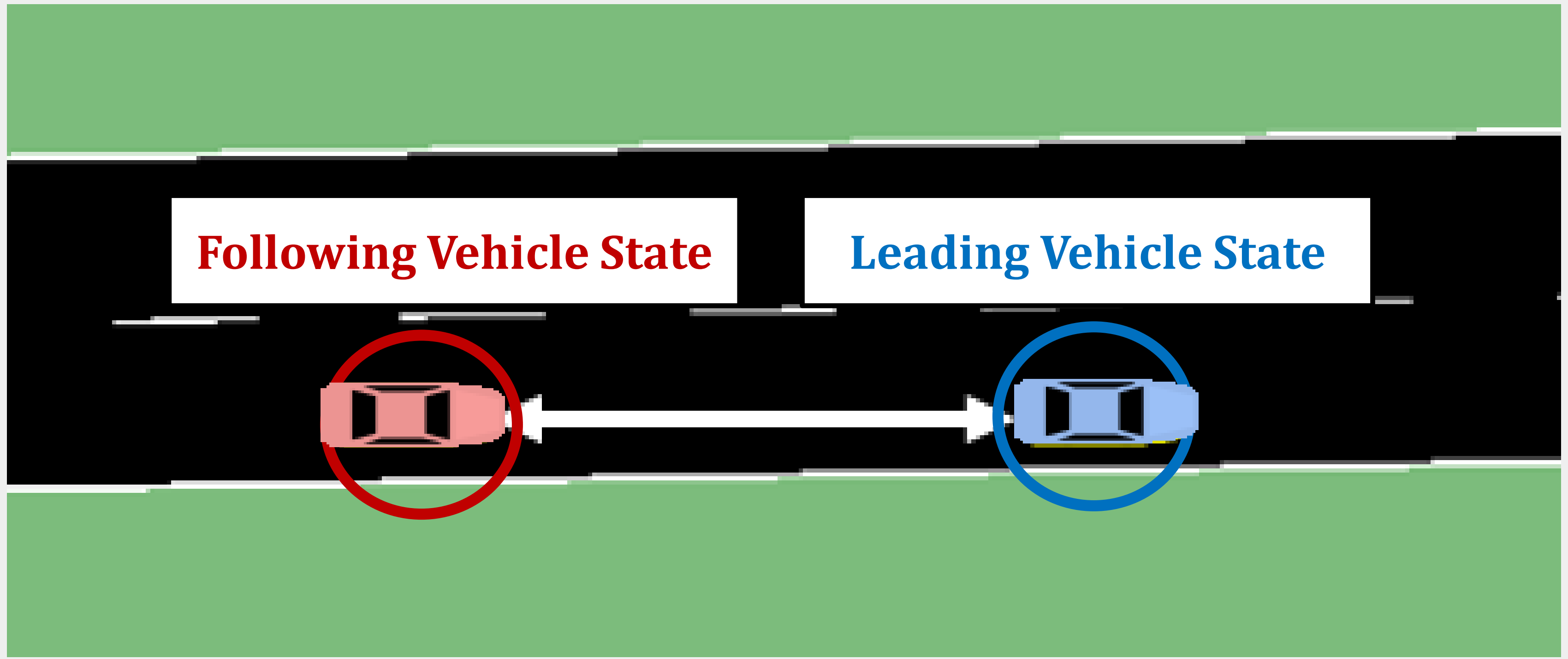


Lateral Movement



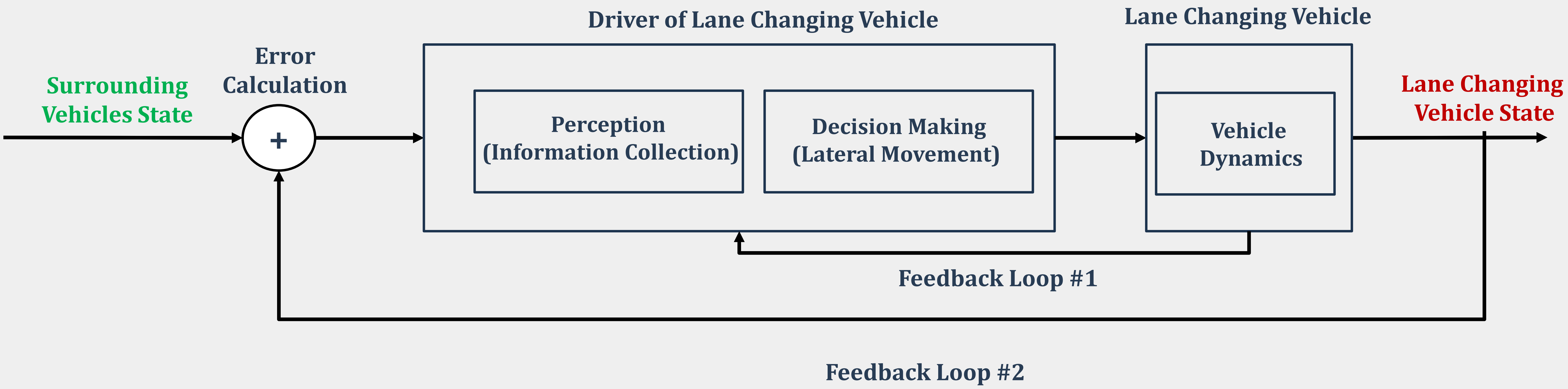
Car Following Model Flow Chart

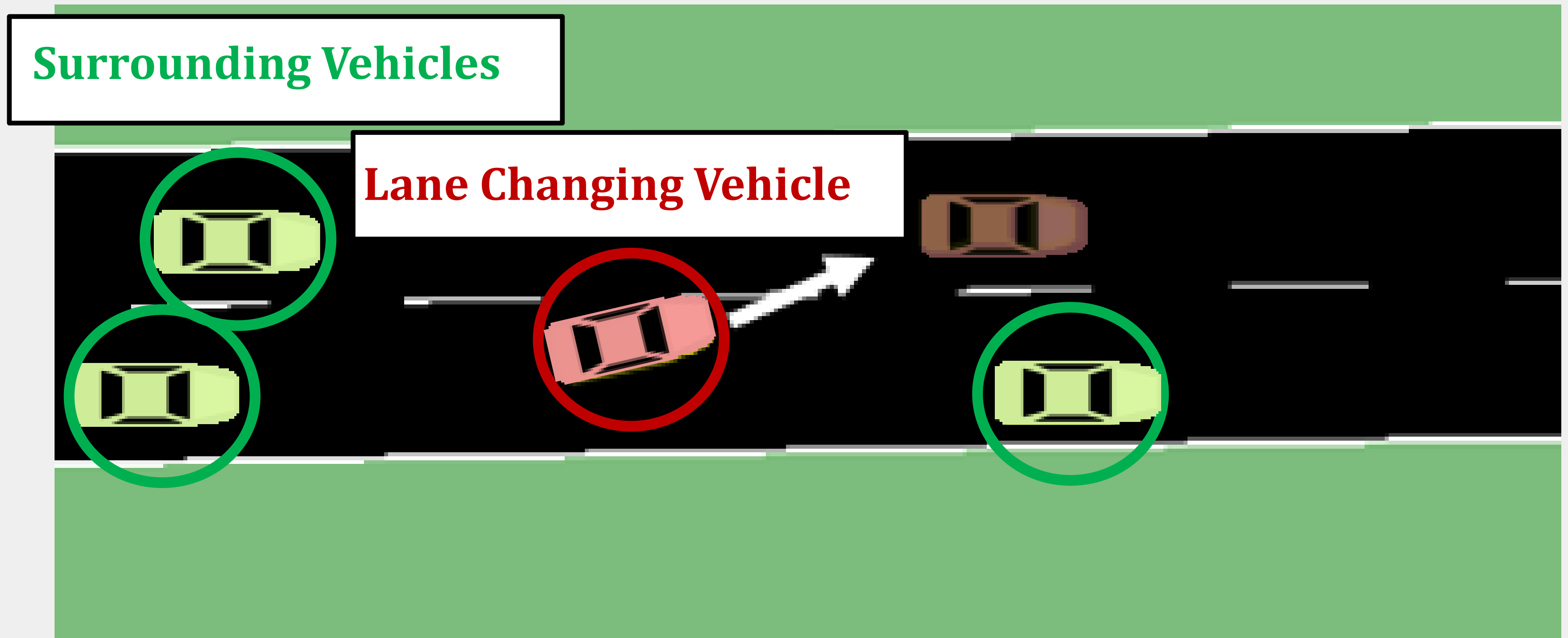




Reference:
Decision Making Flow in Car Following and Lane Changing Model, Rothery (2001)

Lane Changing Model Flow Chart





Reference:
Decision Making Flow in Car Following and Lane Changing Model, Rothery (2001)

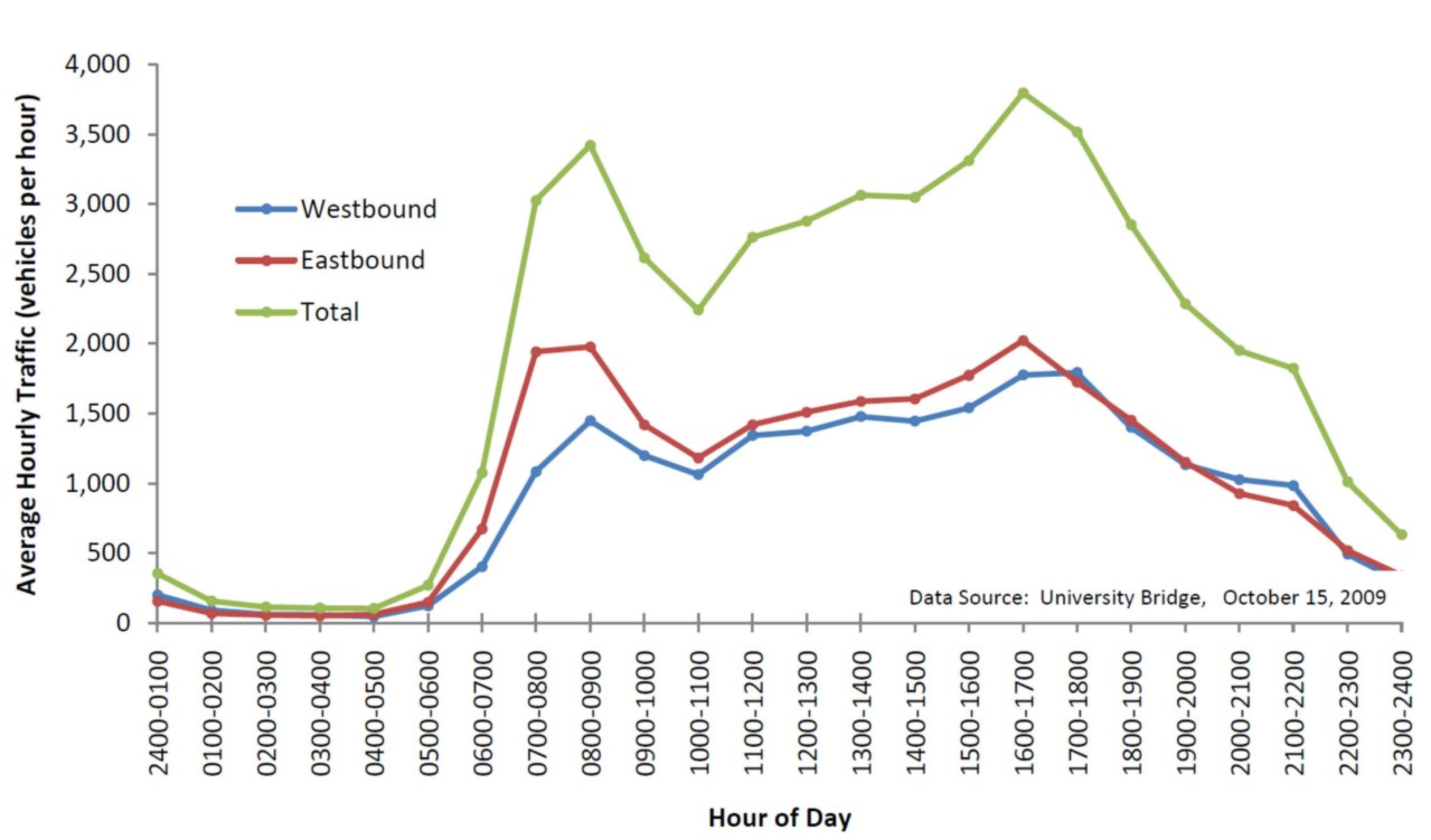
Traffic Volume

- **Traffic Volume (q):** The total number of vehicles (N) to pass over a given point or section of a lane or roadway during a given time interval (t).
- Traffic volumes can be expressed in terms of annual, daily, hourly, or sub-hourly periods

Ref.; Highway Capacity Manual 2000, TRB

Traffic Volume Distribution

- ❑ **Example Traffic Volume Distribution by Hour of Day**



Traffic Flow Rate

- **Flow Rate:** The equivalent hourly flow rate at which vehicles pass over a given point or section of a lane or roadway during a given time interval of less than 1 h, usually 15 min.

Ref.; Highway Capacity Manual 2000, TRB

Traffic Volume vs Flow Rate

❑ Relationship between Traffic Volume and Flow Rate

- **Numerical Example:**

q_{15}= **1,000 (veh./15min.)** → q_{60}= **4** × q_{15} = **4000 (veh/hr)**

q_{15}= **1,200 (veh./15min.)** → q_{60}= **4** × q_{15} = **4800 (veh/hr)**

q_{15}= **1,100 (veh./15min.)** → q_{60}= **4** × q_{15} = **4400 (veh/hr)**

q_{15}= **1,000 (veh./15min.)** → q_{60}= **4** × q_{15} = **4000 (veh/hr)**

- Total Traffic Volume ($q = \sum q_{15}$) for the study period (1 hr.): 1,000+1,200+1,100+1,000 = 4,300 veh./hr.
- Maximum Hourly Flow Rate = 4,800 (veh./hr.)

Peak Hour Factor (PHF)

- PHF definition: the ratio of total hourly volume into a peak 15-min flow rate with the hour. We use PHF to estimate an hourly traffic volume into a peak 15-min flow rate.

- Using the total traffic volume and flow rate info in previous slide, PHF = 4,300/4,800 =0.896
- Usually, PHFs in urban areas range between 0.80 and 0.98
- PHF → 1.0; Uniform Flow Rate (less flow variation within the hour)
- PHF → 0.25; Random Flow Rate (greater variability of flow within the hour)

ADT and AADT

- **ADT (Average Daily Traffic):** The total volume of traffic passing a point or segment of a highway facility in both directions for less than a year period divided by the number of days in the study period (e.g. 6 months, 1 month, …, 1 week, 2 days)

- **AADT (Annual Average Daily Traffic):** The total volume of traffic passing a point or segment of a highway facility in both directions for one year divided by the number of days in the year

Density

- **Density (K):** The number of vehicles on a roadway segment averaged over space, usually expressed as vehicles per kilometer (usually per lane) → No. of vehicles occupying a given length of road (usually 1km) in a single lane (veh/km/lane)

Speed (v_s)– Flow (q)– Density (k)– Relationship

- $q = v_s \times k$

Where:

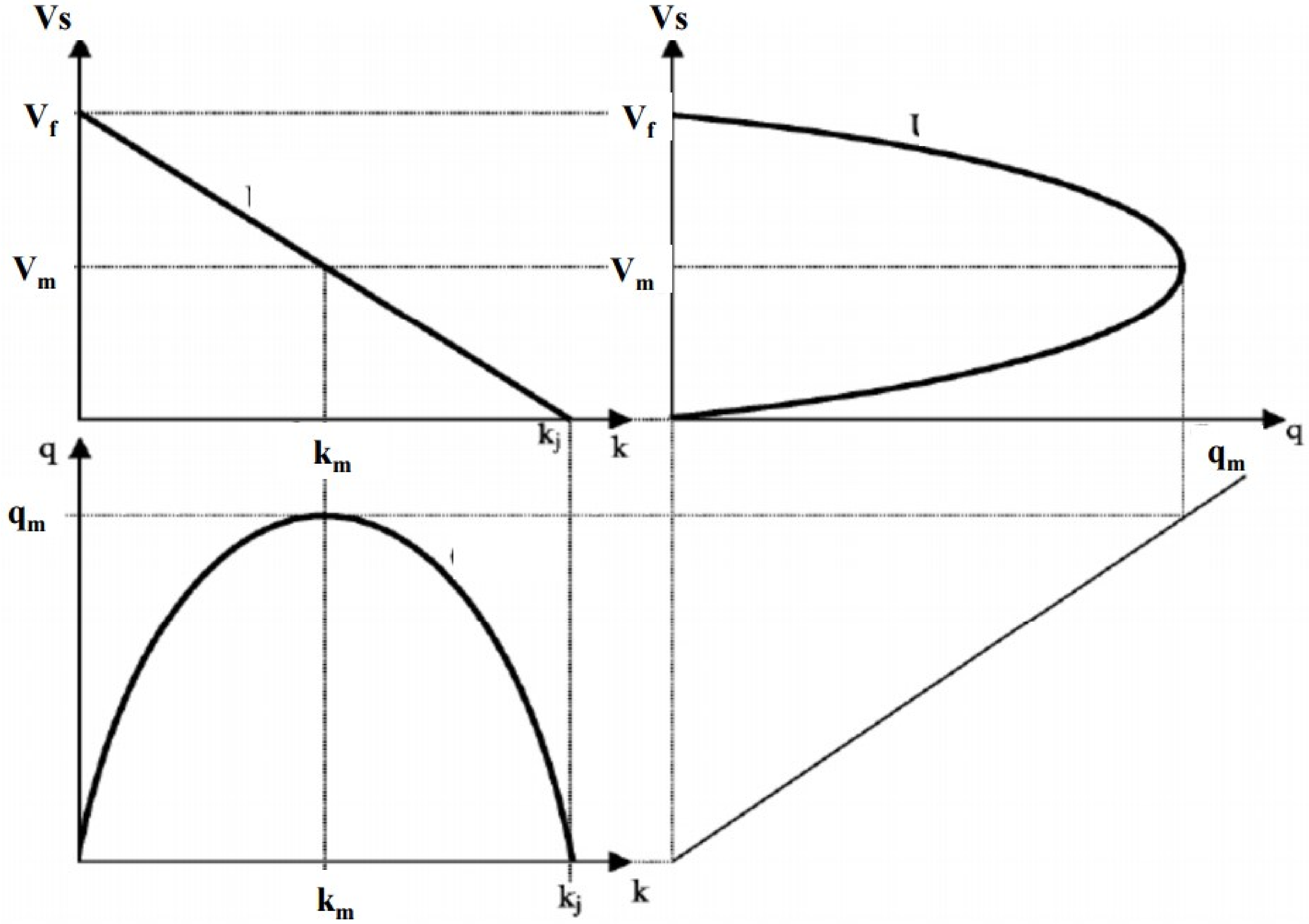
q = Traffic Volume or Hourly Flow (veh/hr)

v_s = Space Mean Speed (km/hr)

k = Density (veh/km)

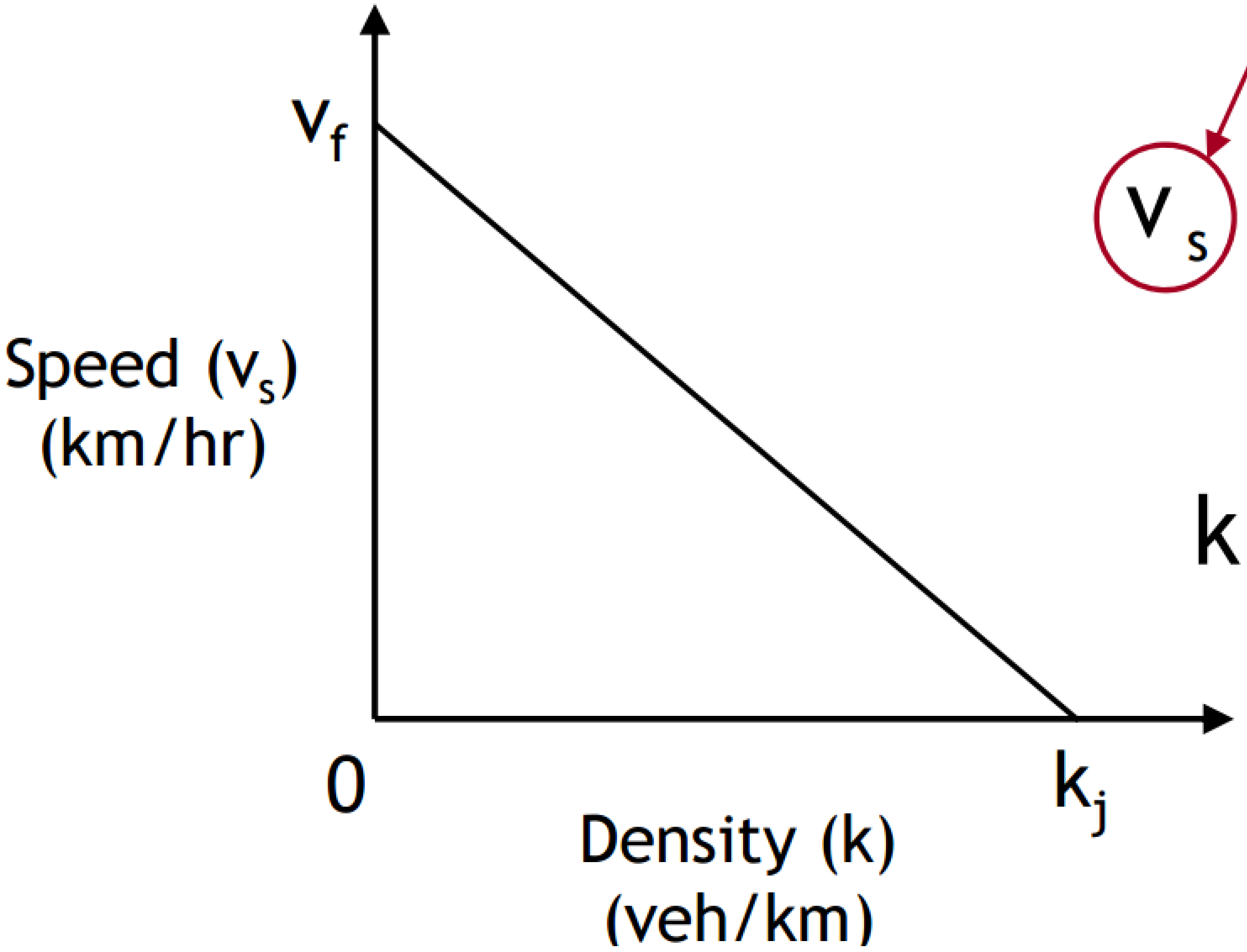
Speed (v_s)– Flow (q)– Density (k) Relationship

❑ **Greenshield's Model (1934):**



Speed (v_s)– Density (k) Relationship

❑ **Greenshield's Linear Speed-Density Model (1934):**



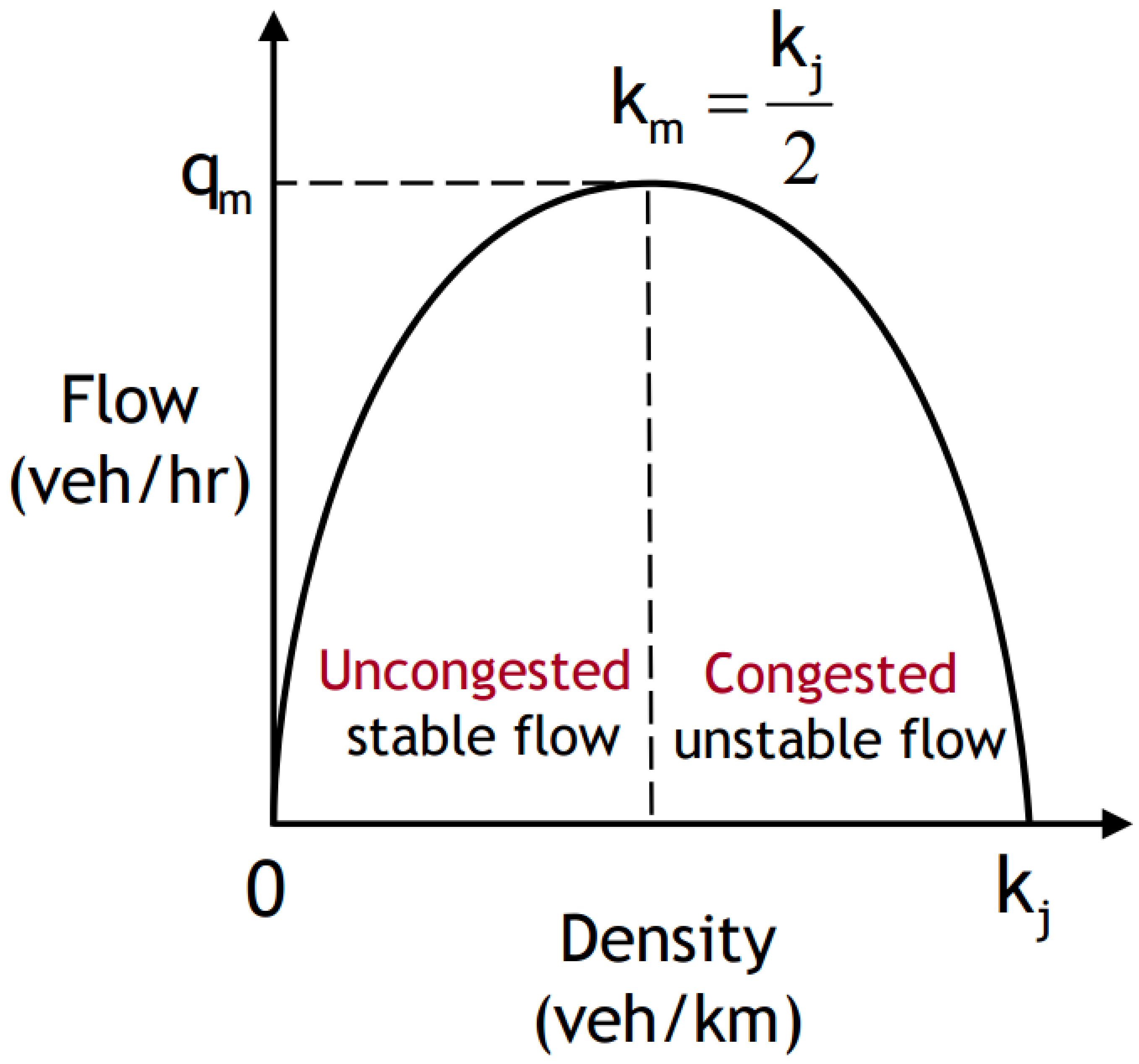
Space Mean Speed

$$v_s = v_f\left(1 - \frac{k}{k_j}\right)$$

$$k = k_j\left(1 - \frac{v_s}{v_f}\right)$$

Flow (q)– Density (k) Relationship

❑ **Greenshield's Flow-Density Model (1934):**



$$q = v_f\left(k - \frac{k^2}{k_j}\right)$$

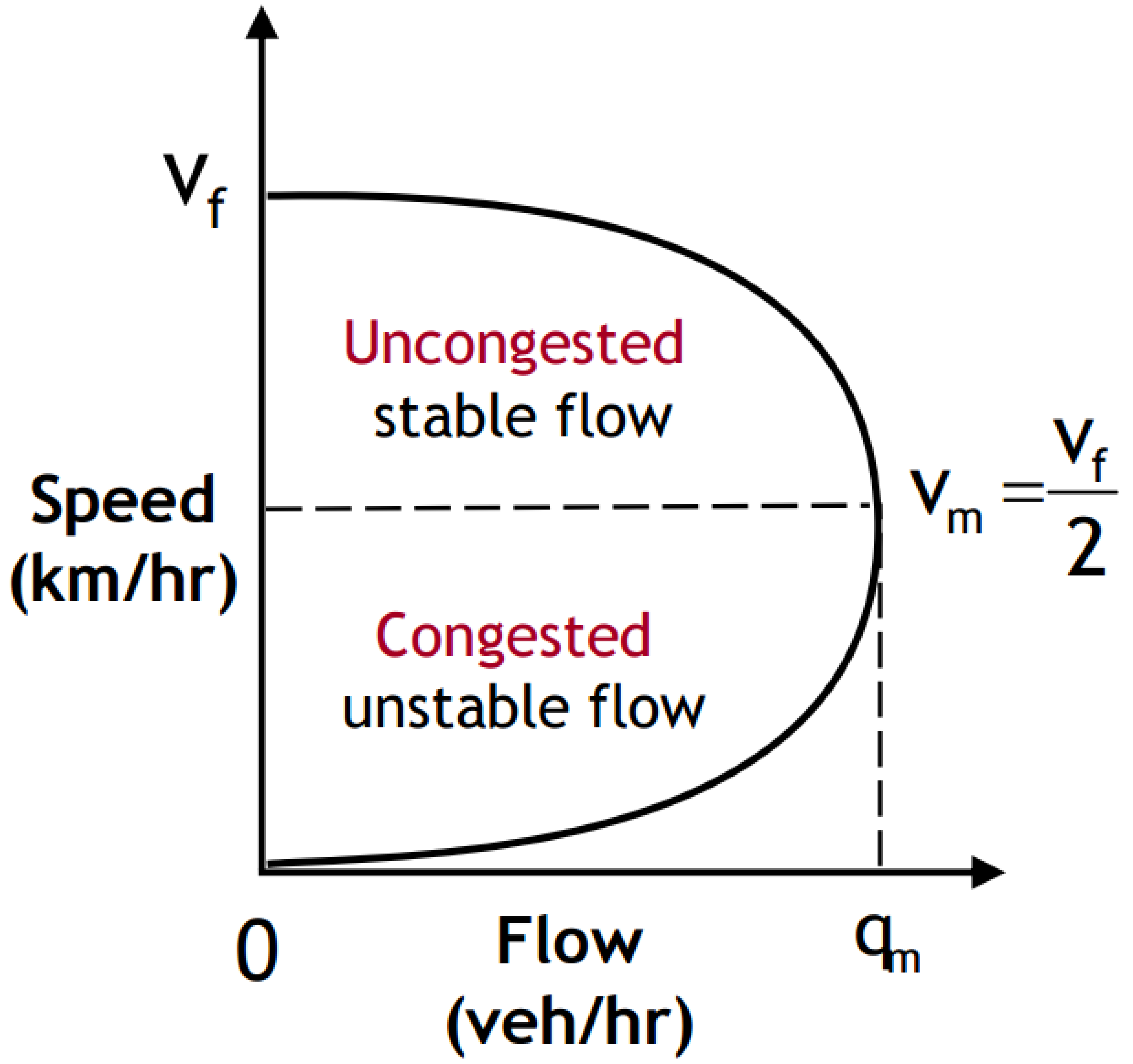
$$v_m = \frac{v_f}{2}$$

$$q_m = v_m \cdot k_m$$

$$= \frac{v_f \cdot k_j}{4}$$

Speed (v_s)– Flow (q) Relationship

- Greenshield's Flow-Speed Model (1934):



$$q = k_j\left(v_s - \frac{v_s^2}{v_f}\right)$$