An Analysis of Relationship between Lane-Changing Behaviors and Traffic Flow based on Microscopic Traffic Simulation

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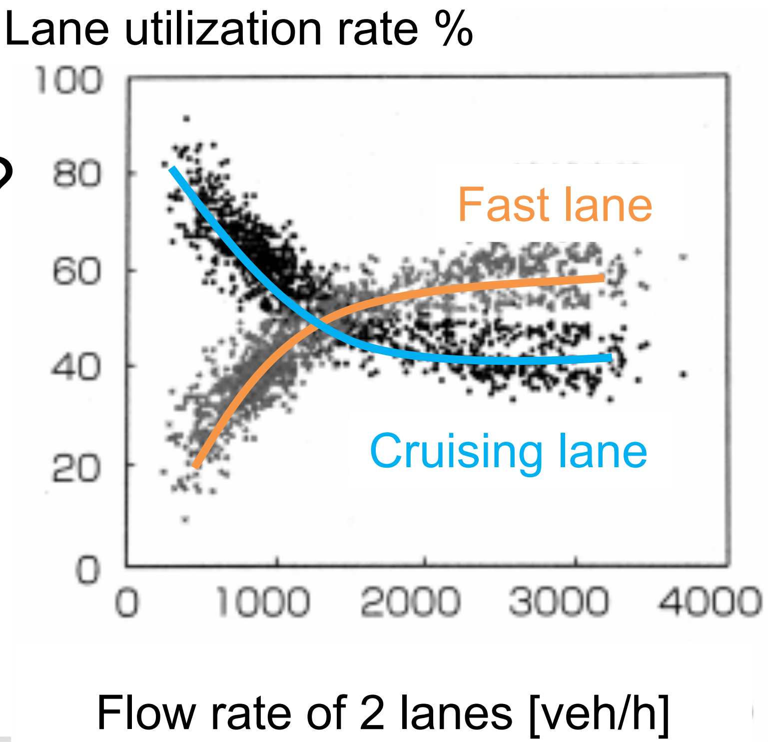
Background

† Lane utilization rate is a important factor of realizing flow rate.

- One of congestion factor is by high utilization rate of fast lane on bottleneck.



- How to control this rate?
- Control …

1. Behavior of vehicle
2. Lane regulation …

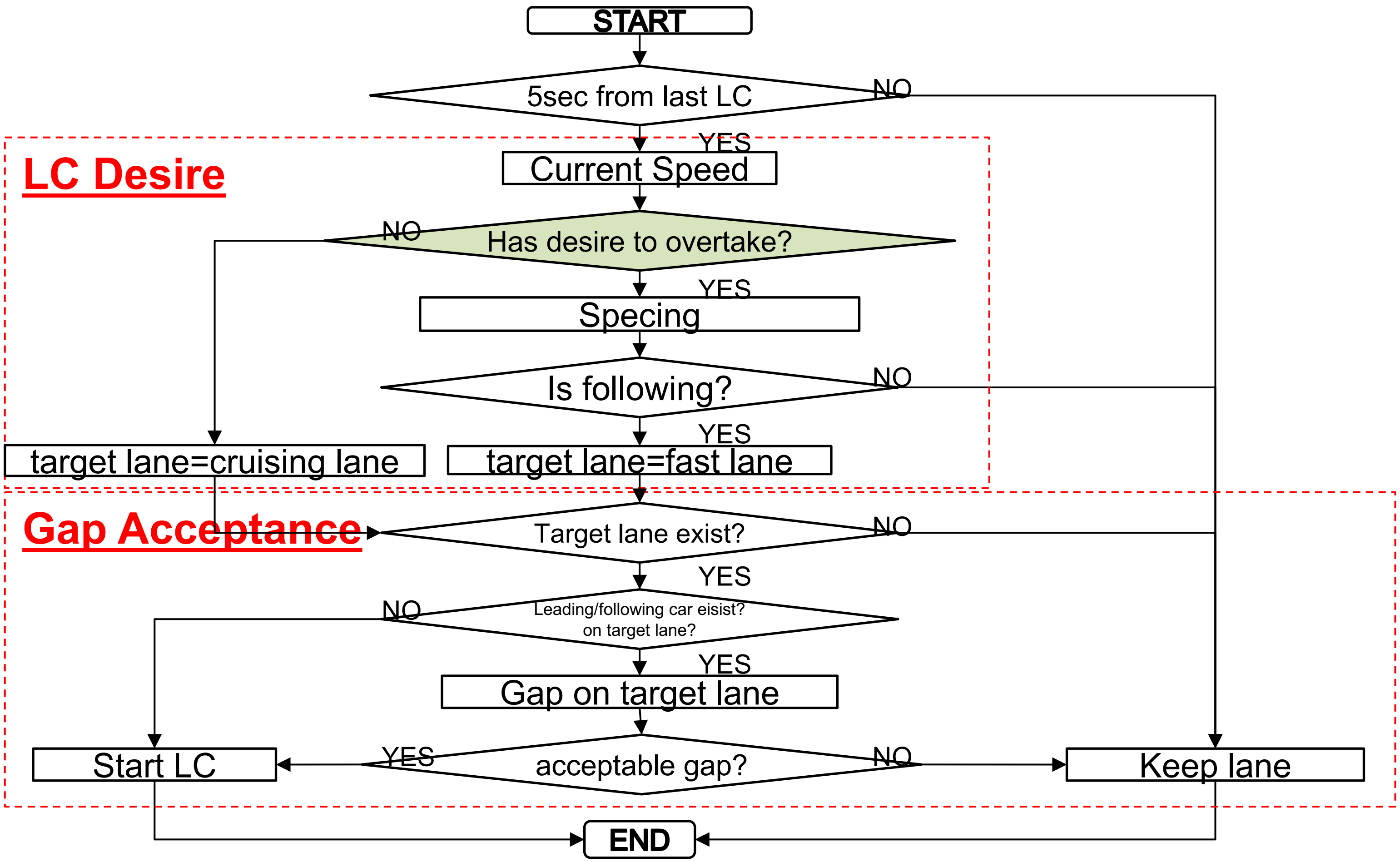
Objective

- To analyze relationship between lane-changing behaviors and traffic flow.
  - Microscopic behaviors
    v.s. macroscopic index

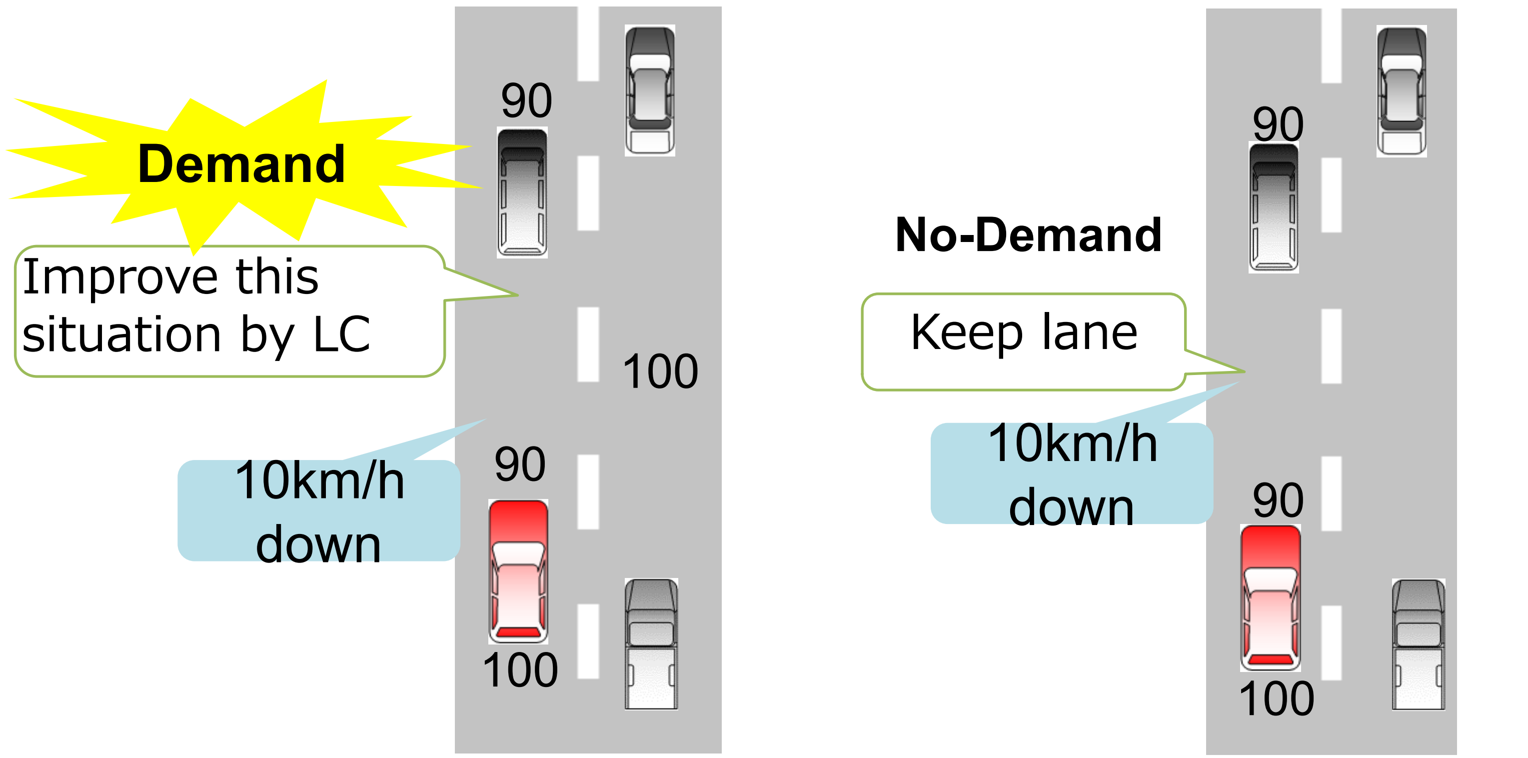
- Method
  - Simulation with simple models.
    - Simple lane-changing model
    - Simple following model
  - Find the benchmark for lane-changing parameters.

Lane-changing model

- Based on Gap Acceptance Model



Lane-changing model



Low Δv (5km/h) | High Δv (15km/h)

LC suppression parameter Δv

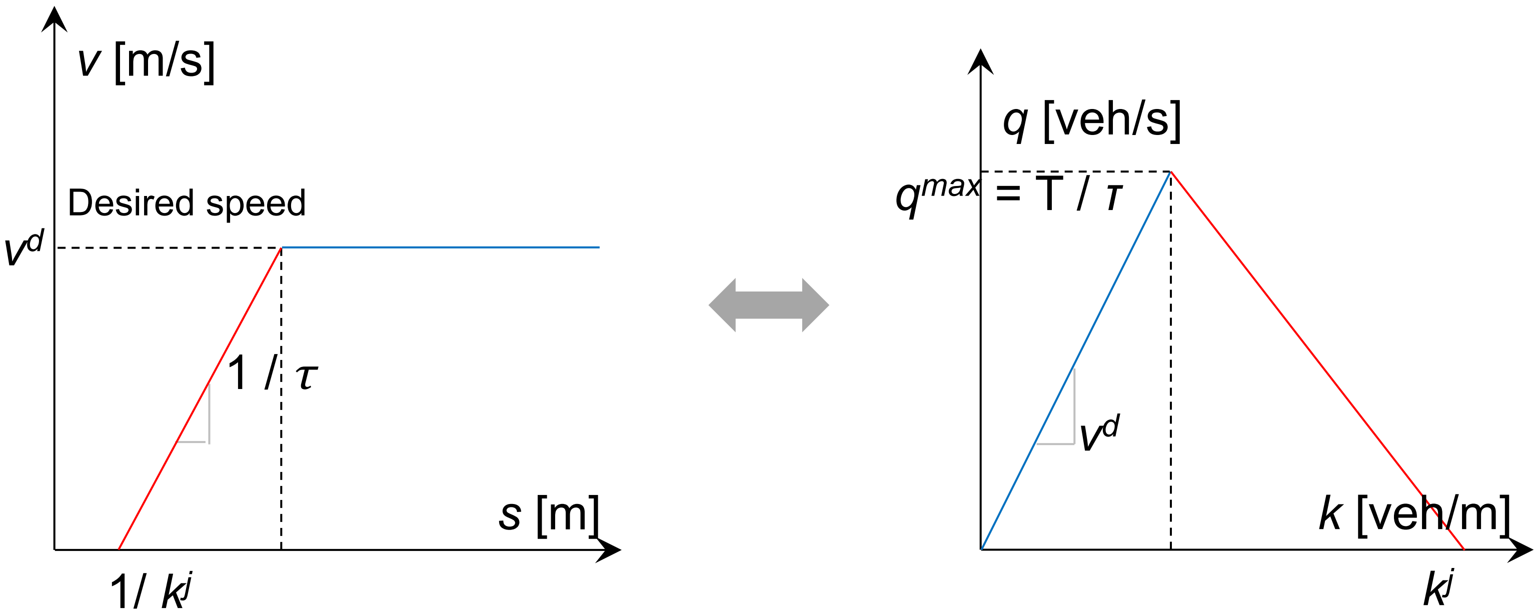
Lane-change is requested when :
Driving speed – desired speed < Δv

- Indicates how the driver endures the low speed
- Speed gain incentive is suppressed by this parameter.

Following model

† FD based model (Newell1993)

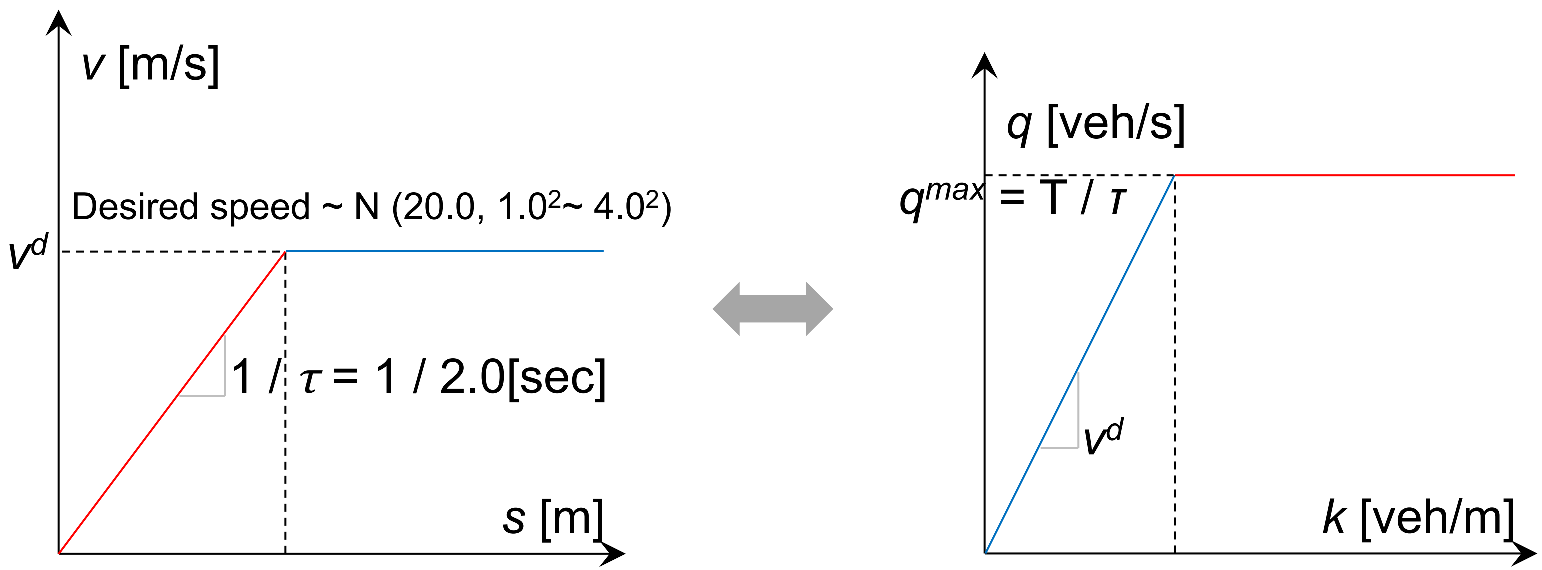
- 3 parameters



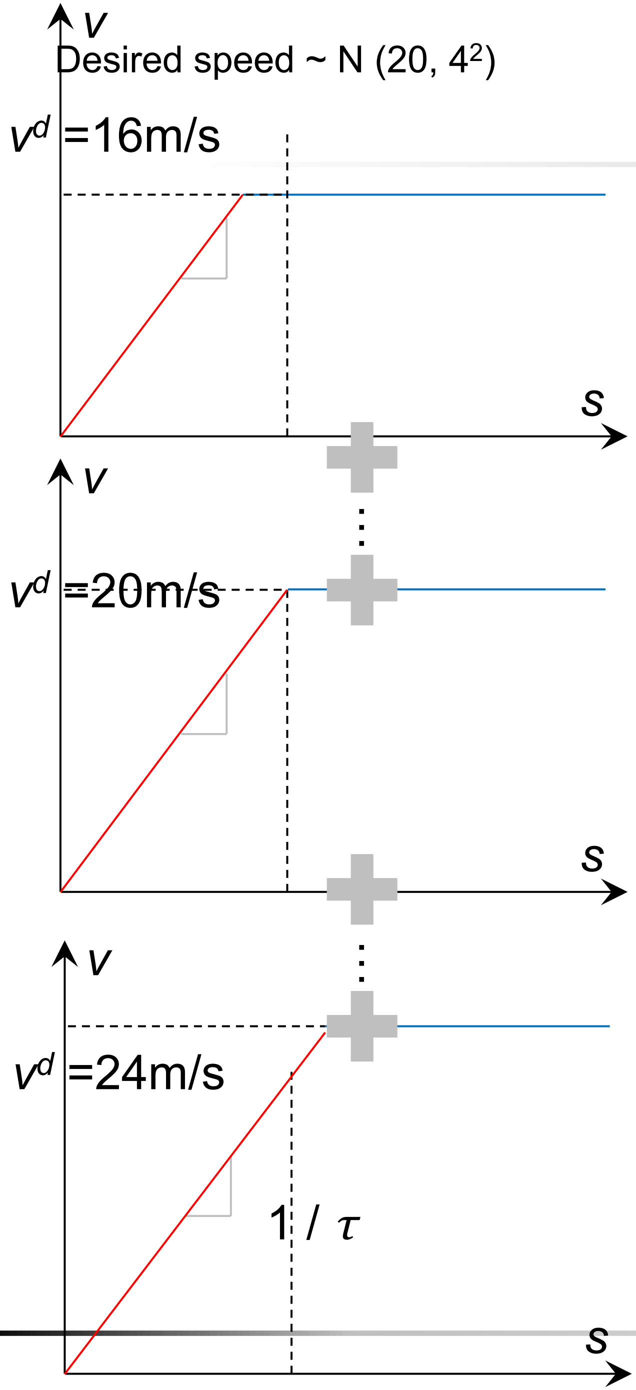
Following model

† Simplified FD model ignoring congestion

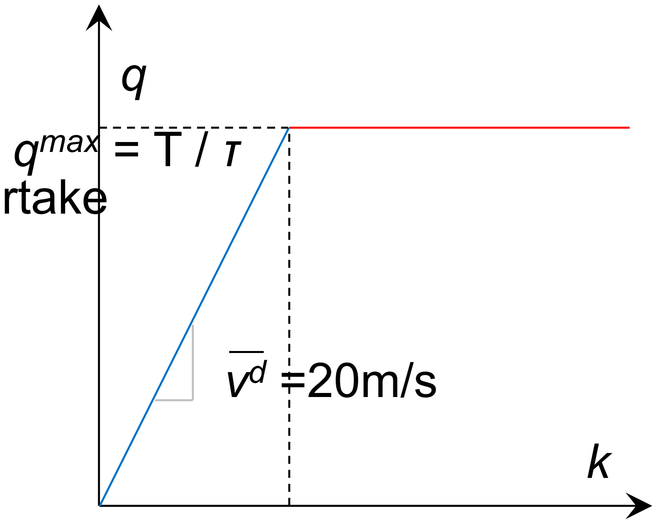
- 2 parameters
  : desired speed v^d & response time τ
- Flow rate won't be decrease in high density sitution.
  - To analyze / find some clearly-understandable benchmark



Following model



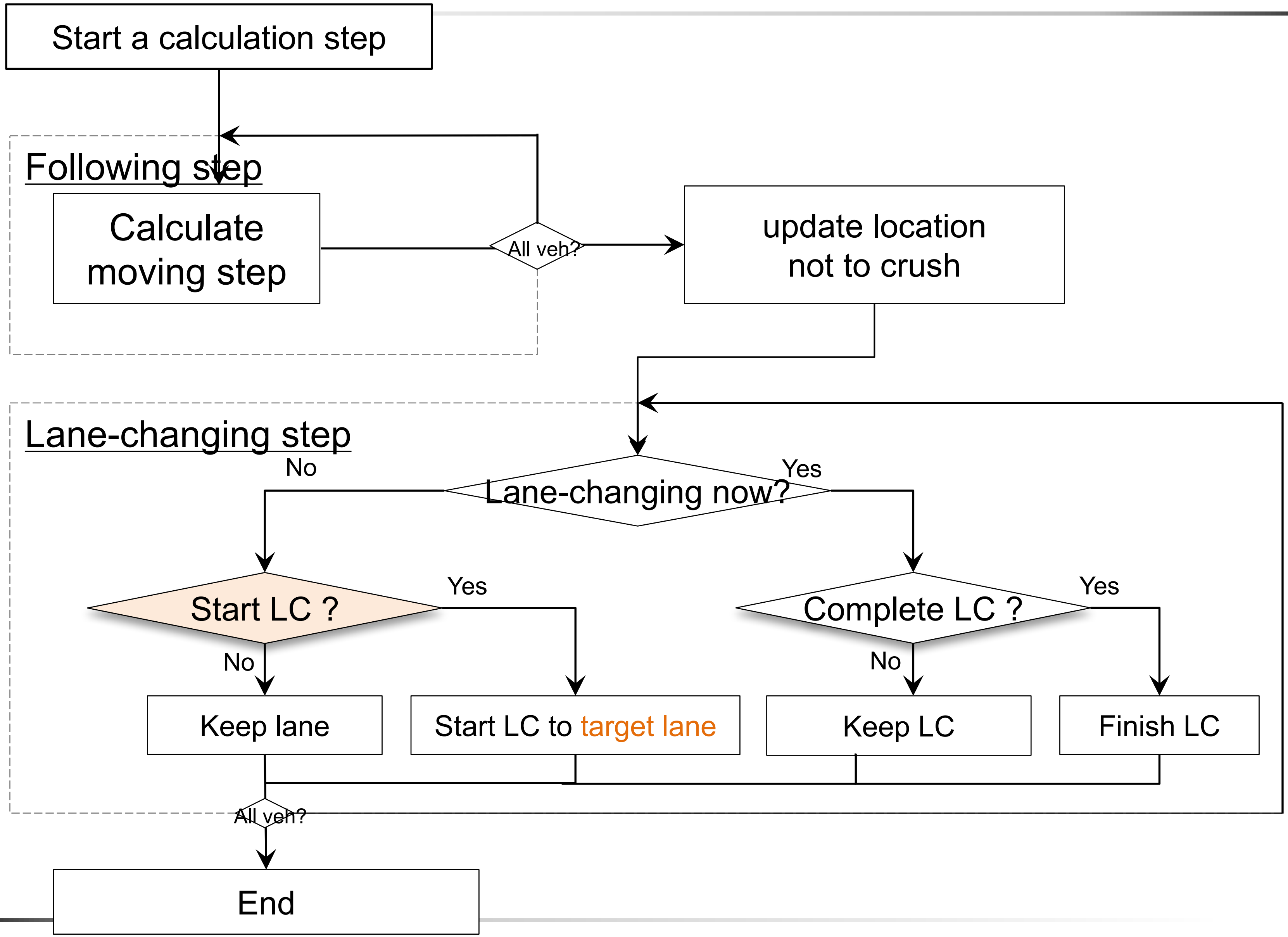
Many lanes
Enough space to overtake



Limited lanes
Limited space to overtake

?

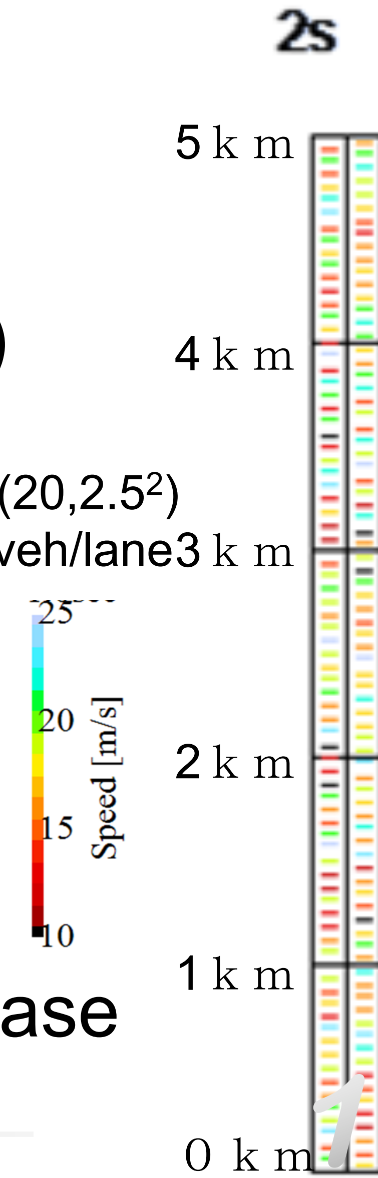
Simulation Model Framework



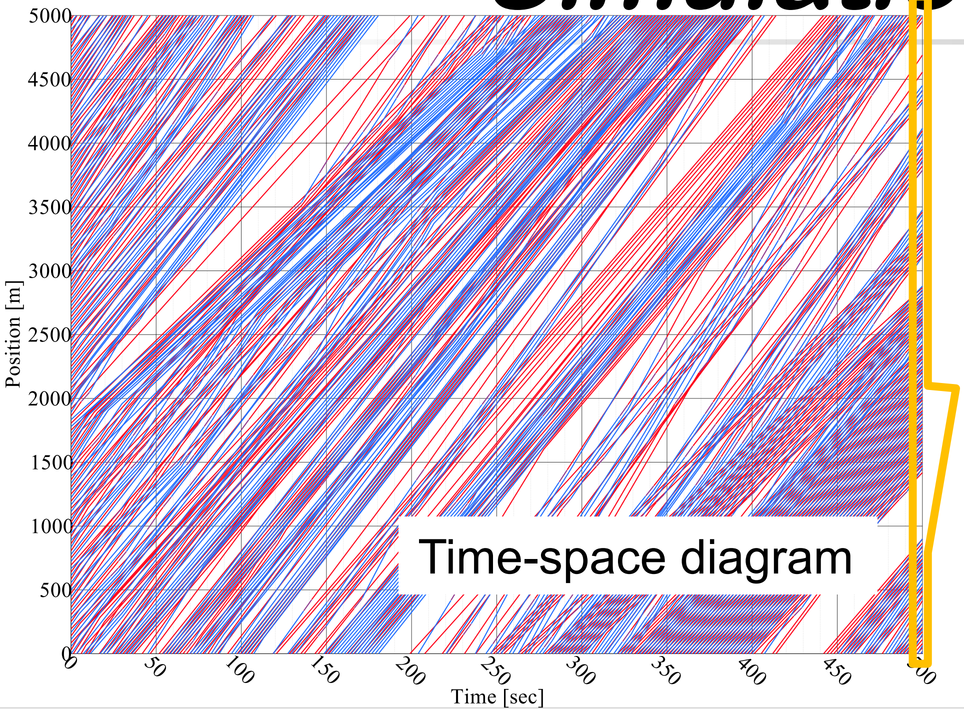
Simulation Settings

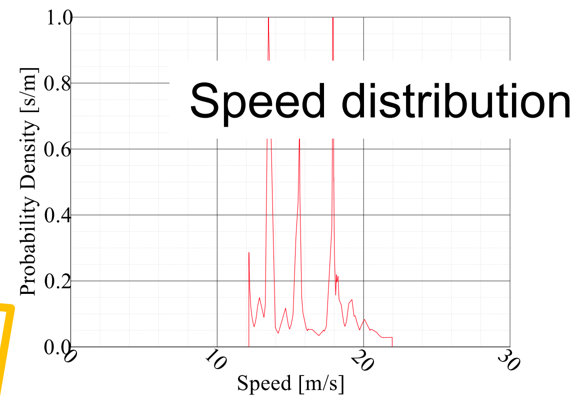
1. Lane change suppression (Δv)
   - **0.0 ～ 15.0**
2. Distribution of desired speed
   - **N (20 m/sec, (1.0, 2.5, 4.0 m/sec)^2)**
3. 5 km circular road with 2 lanes
4. Initial density is uniform
   - **2.0 ～ 50.0 veh/km/lane**
   - Vehicles with different v^d are **located randomly**.
5. Gets aggregated values (means)
   - **every 125 sec x 100 records** for 1 case

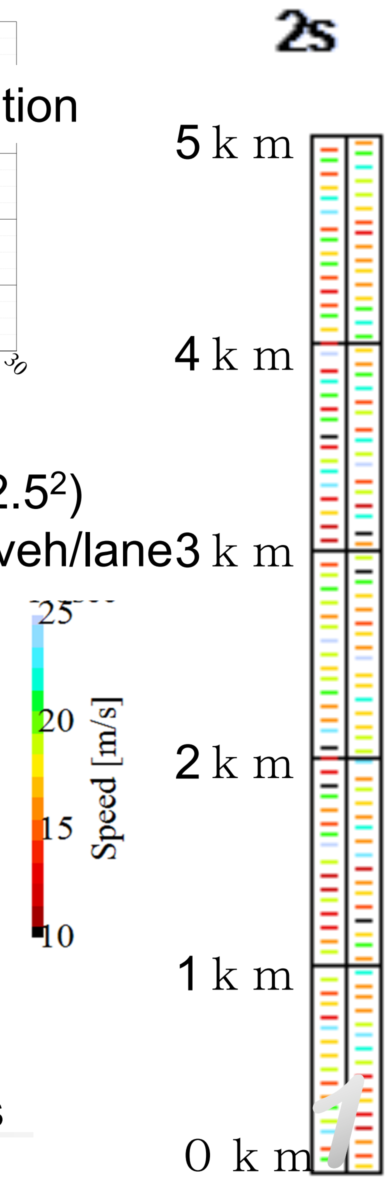
→ v^d~N(20,2.5^2)
k=18 km/veh/lane



Simulation running image

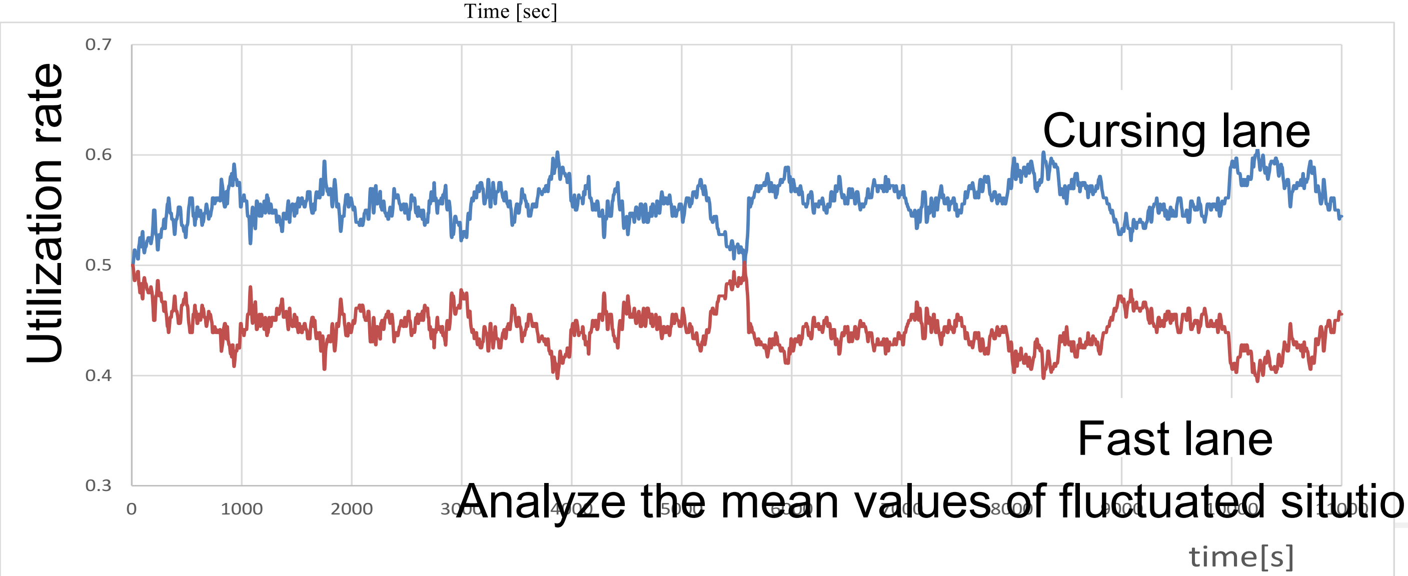






v^d~N(20,2.5^2)

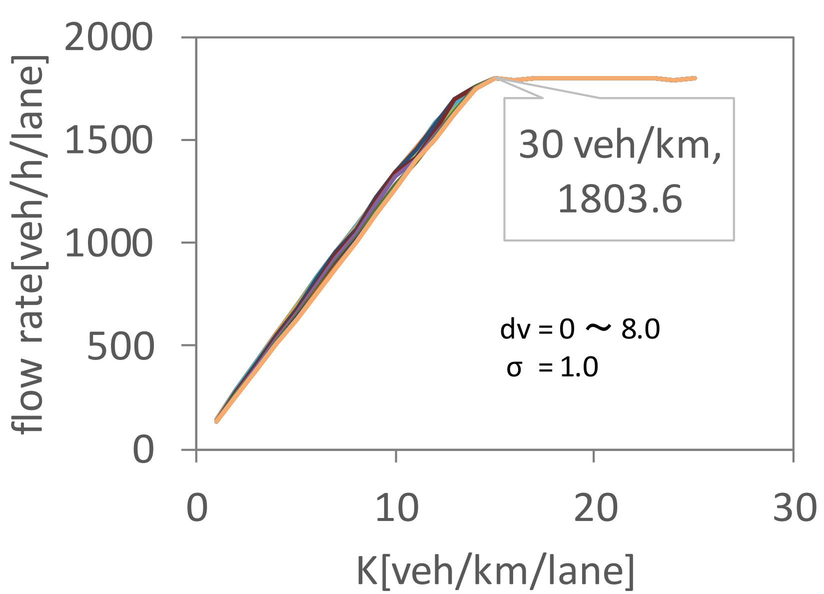
k=18 km/veh/lane

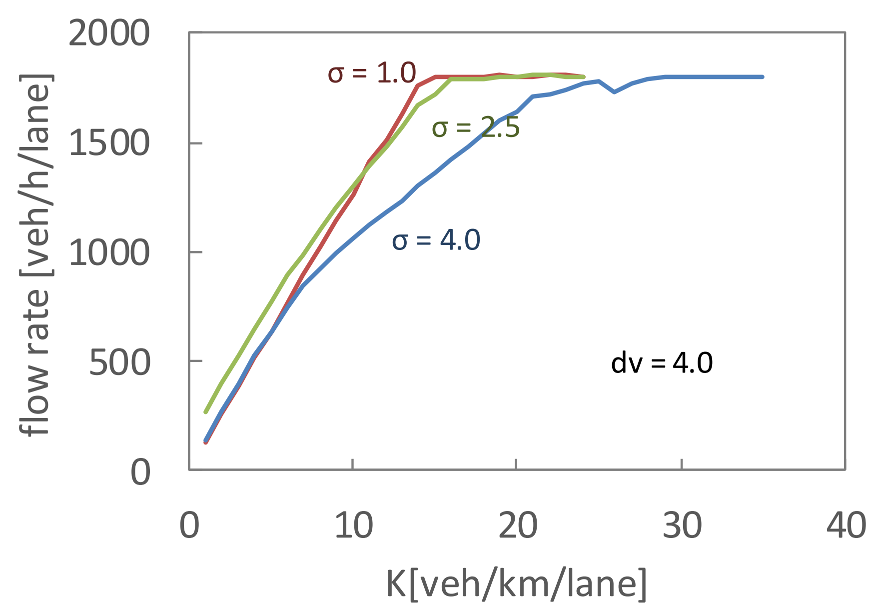


Analyze the mean values of fluctuated situtions

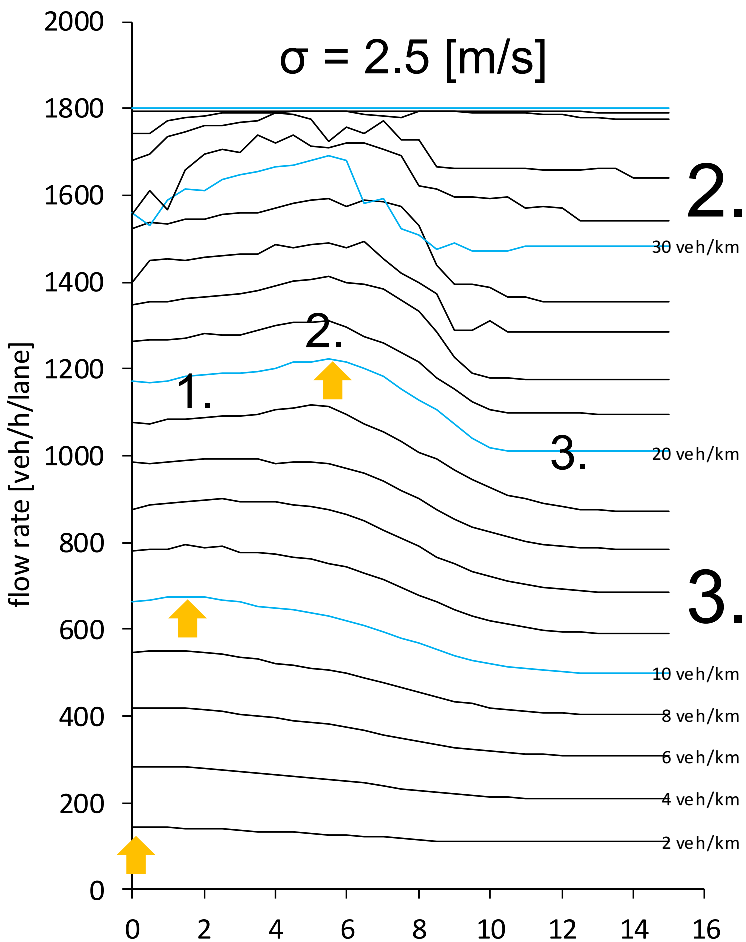
Result overview

- Maximum flow rate (=1800veh/h) is derived from response time (=2sec) of following model.
- No-differences on FD of QK among different dv(s)
- In high SD (σ) case,
  the flow rate is resulted in low value.





Flow rate and lane-changing



Δv = desired speed – lane-changing speed

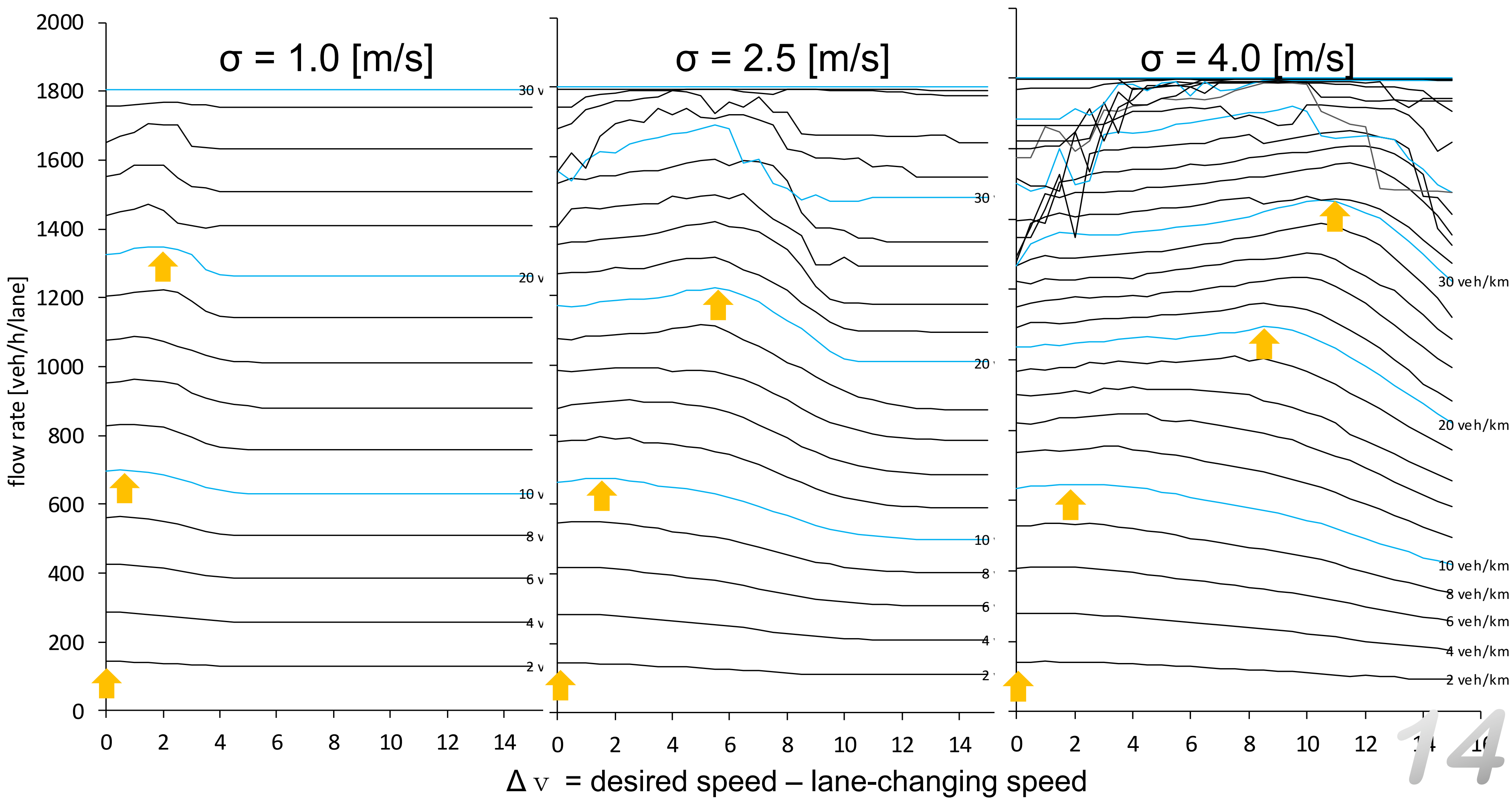
1. Case with <u>low</u> Δv
   - Left side of the arrows
   - Vehicles with low desired speed are enter the fast lane.

is close to the real world

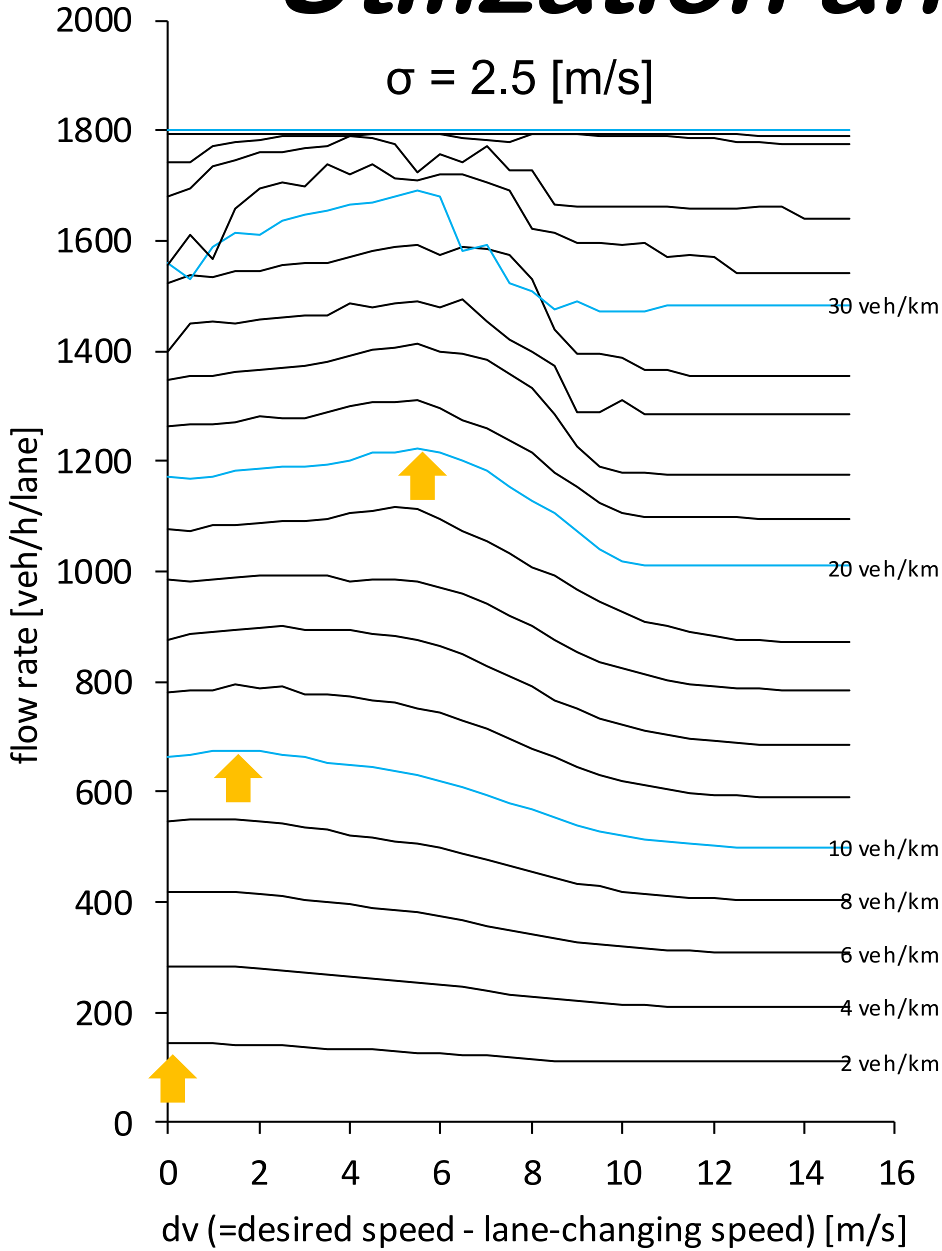
2. Case with <u>middle</u> Δv
   - Around the arrows
   - Vehicles are divided into 2 lanes corresponding those speeds efficiently.
3. Case with <u>high</u> Δv
   - Right side of the arrows
   - Almost all vehicles are located on the cruising lane.

Flow rate and lane-changing

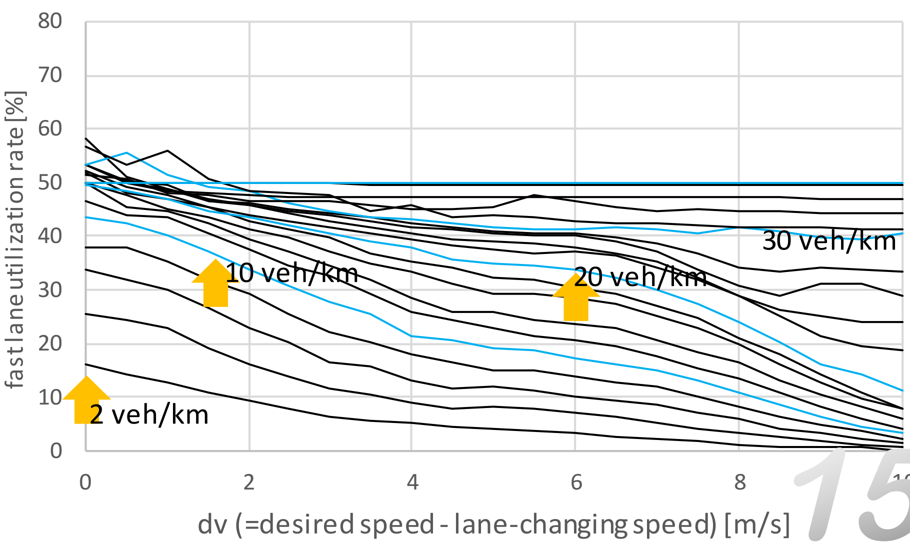
- Δv value which maximizing the flow rate is lager on case with larger standard division.



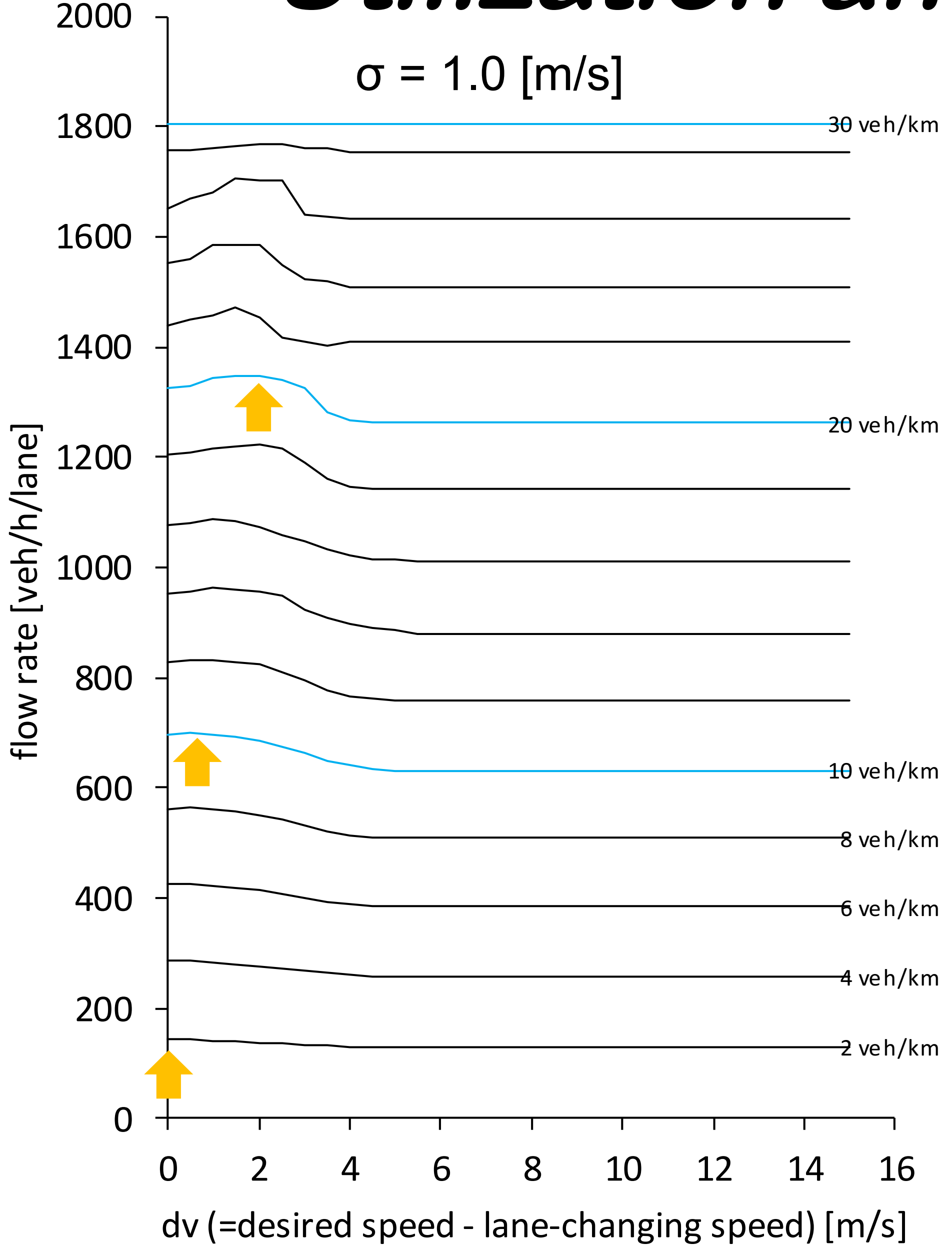
Utilization and lane-changing



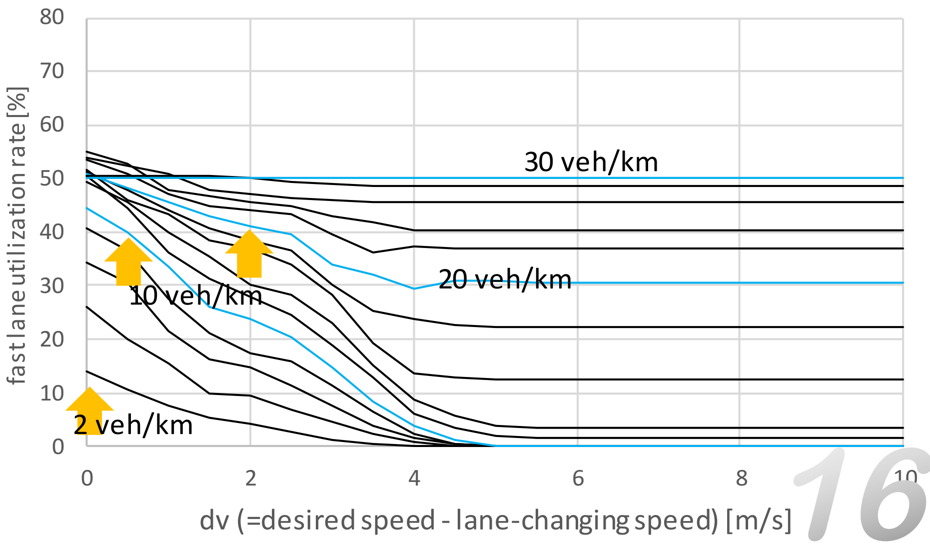
- Middle SD case
  - Utilization rate of fast lane is around 40% in situation when the flow rate is maximized



Utilization and lane-changing



- Small SD case
  - Utilization rate of fast lane is around 40% in situation when the flow rate is maximized



Summary

- Relationship between flow rate, lane utilization, desired speed and LC demand suppression parameter in lane-changing model is analyzed based on simple simulation.
  - LC suppression value which maximizes the flow rate is lager on case with larger standard division.
    - Utilization rate of fast lane is around 40% in situation when the flow rate is maximized.
  - The maximum flow rate is appear when the lane-changing
    - Flow rate would increase when lane-changing were limited.