MONASH University
Engineering

Model calibration and validation

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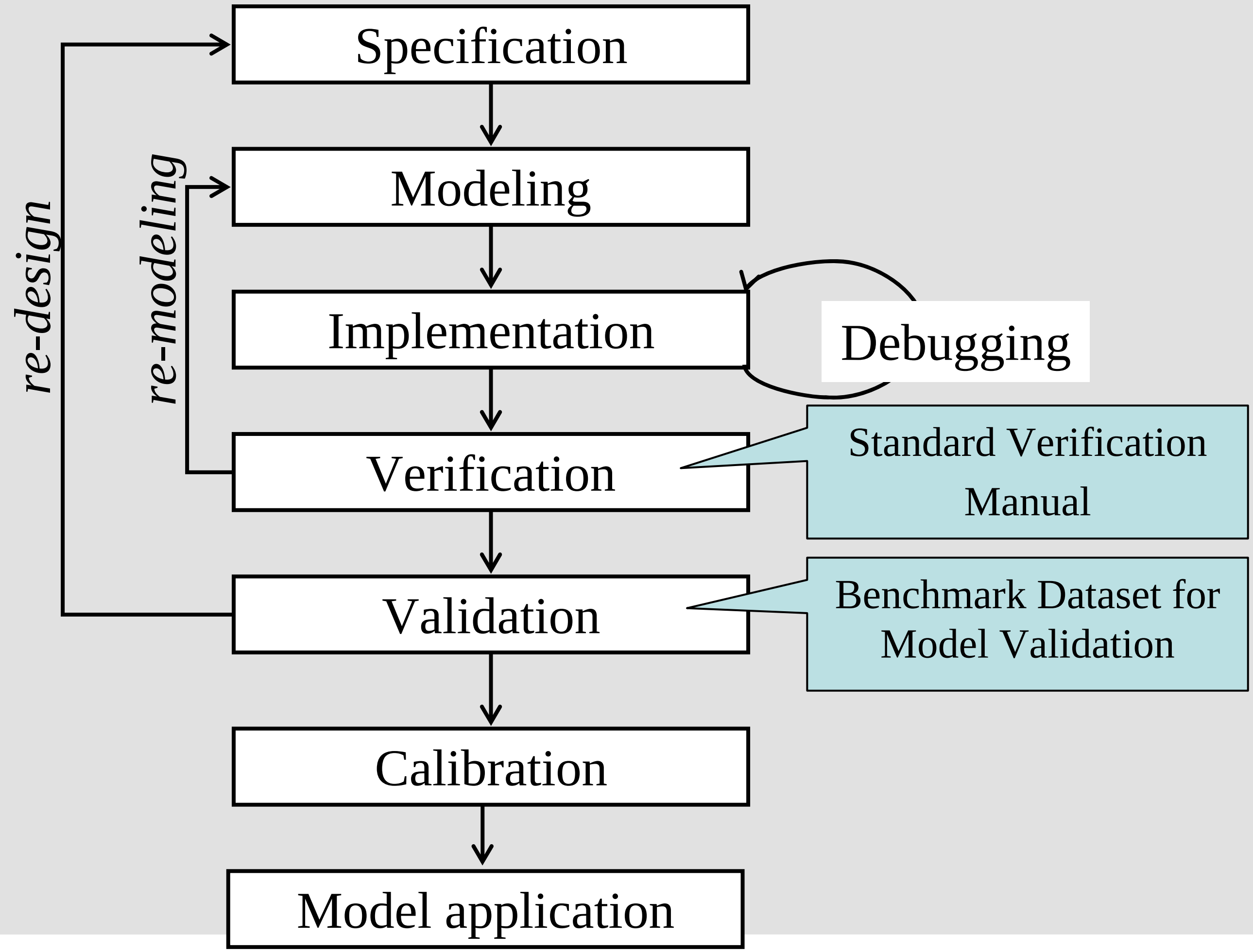
Presentation Outline

1. Introduction
2. Verification and Validation
3. Calibration
4. Discussion

Simulation model development and application



Definitions:

- **Verification**
  - To confirm the model is able to reproduce the basic traffic phenomena considered in the modeling stage.
  - verification process should be conducted at the onset of the modeling task to ensure that the model logic is correctly represented by the computer codes and that the whole system functions as intended.
- **Validation**
  - Validation is considered to be the process of determining the extent to which the model fundamental rules and relationships are able to portray actual traffic behaviour as specified by the underlying theories and field data.
- **Calibration**
  - the calibration process involves assigning appropriate values to default input parameters so as to reflect the local traffic conditions being modeled.

Verification objectives:

1. Ensure that, for a given input, the program code provides output that are consistent with the logic on which the program code is based.

2. Conduct limited sensitivity testing to verify that outputs are consistent over the range of typical input values.

Validation objectives:

(Analytical and field validation or quantitative and qualitative approach)

1. Provide measures that reflect the model's ability to match the selected benchmark (analytical solution or field data) for a particular application domain.

2. Provide a sample of default parameters, together with the range of inputs, for which the validation is applicable.

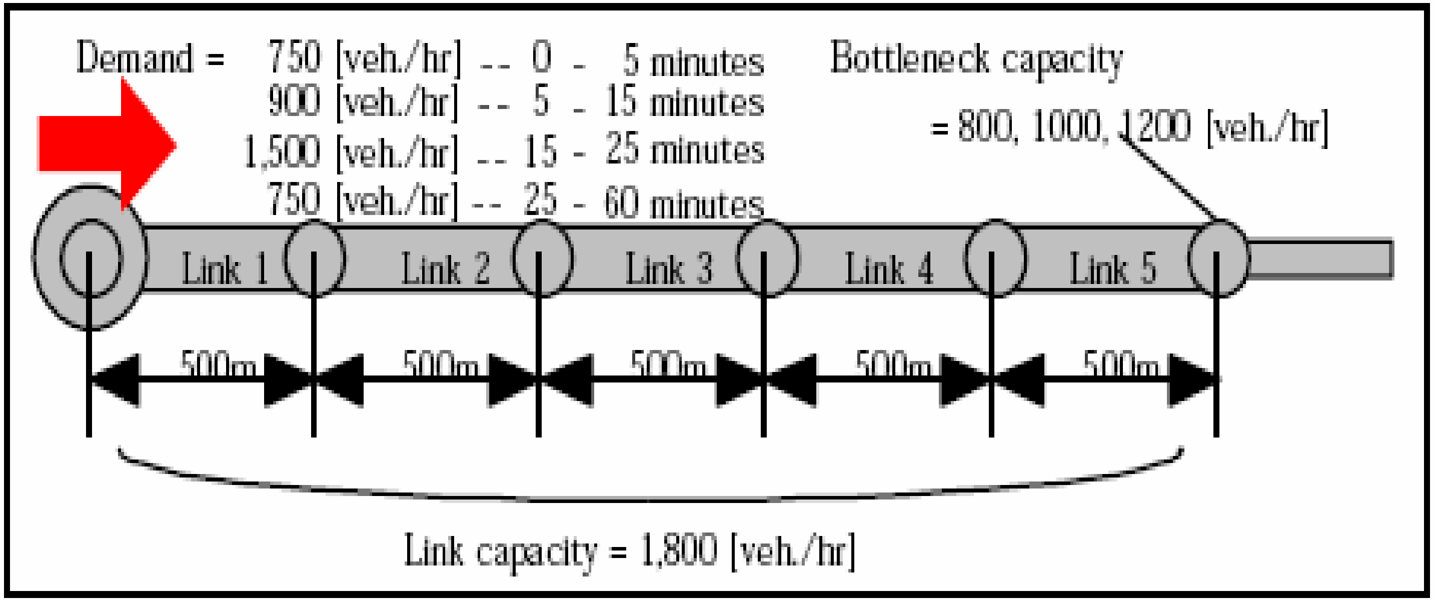
3. Provide the results of a sensitivity analysis of the model about the default parameters in order to indicate the potential rate at which the error increases for a given calibration error level.

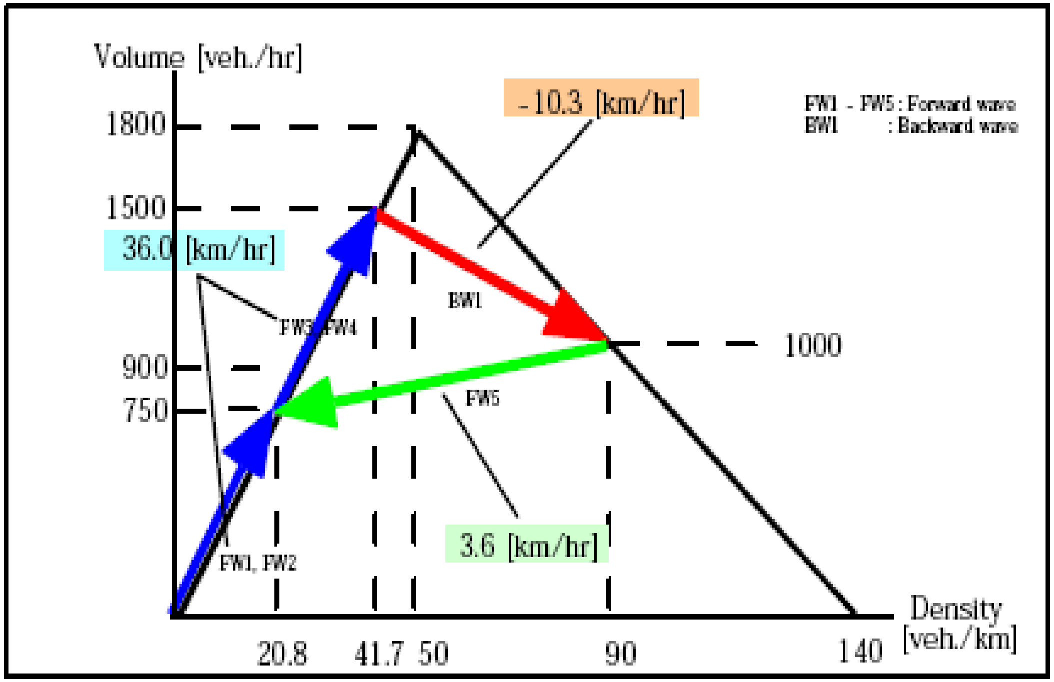
Japanese verification and validation Manual
Japan Society of Traffic Engineers

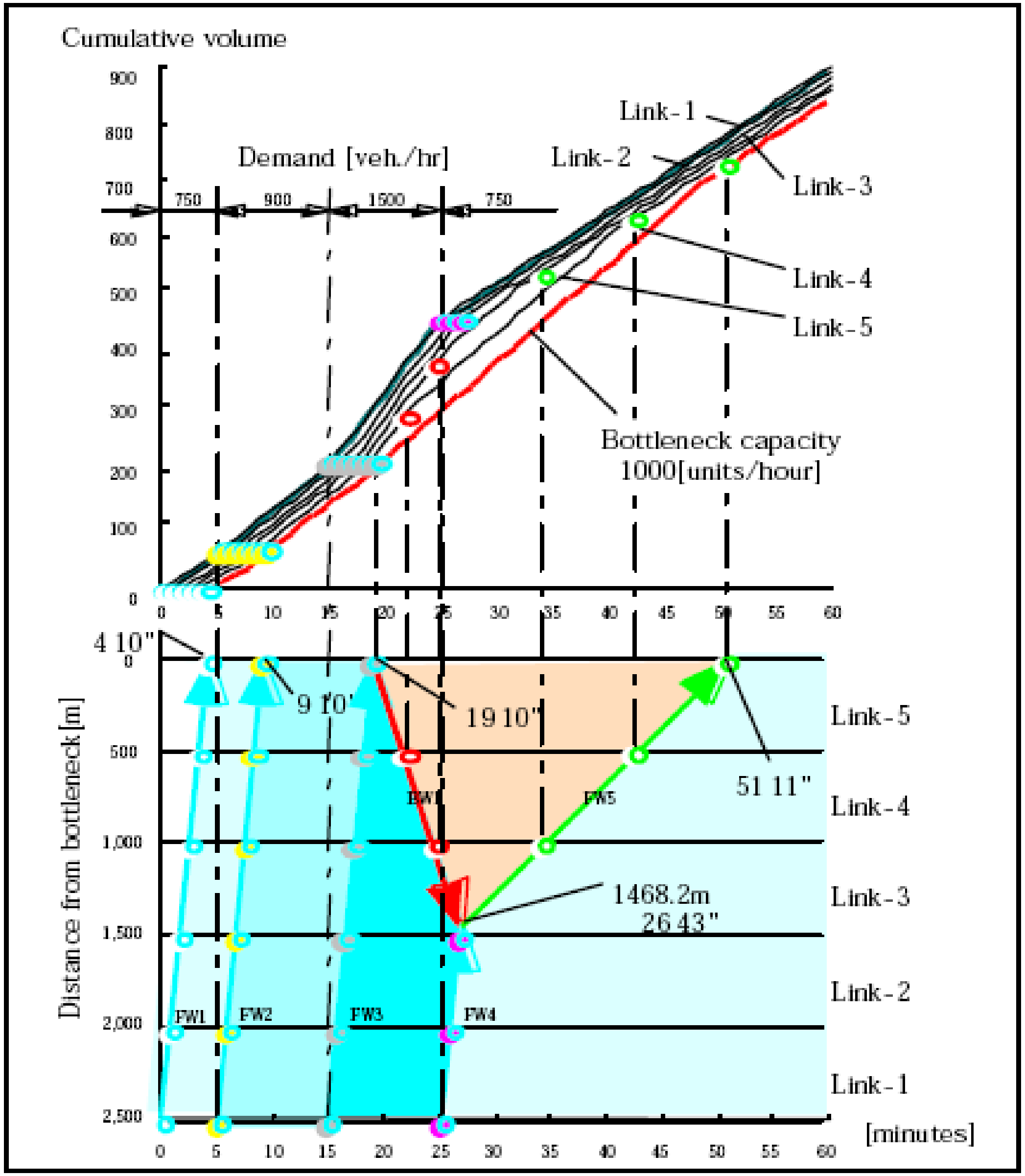
Six basic task to be verified for a Network simulation model:

1. **Generation of vehicles and flow conservation**
   – headway distribution pattern, generated volume, ...
2. **Bottleneck capacity / saturation flow rate**
   – at simple road sections and at signalized intersections
3. **Shockwave propagation during traffic congestion**
   – comparing the results against shockwave theory...
4. **Gap acceptance at an intersection**
   – right (left) turn capacity
5. **Merging / diverging capacity**
   – what merging / diverging ratio will be achieved ?
6. **Drivers' route choice behavior**
   – comparing the simulation results against theoretical route choice principles (DUO/DUE/SUE) using a simple network

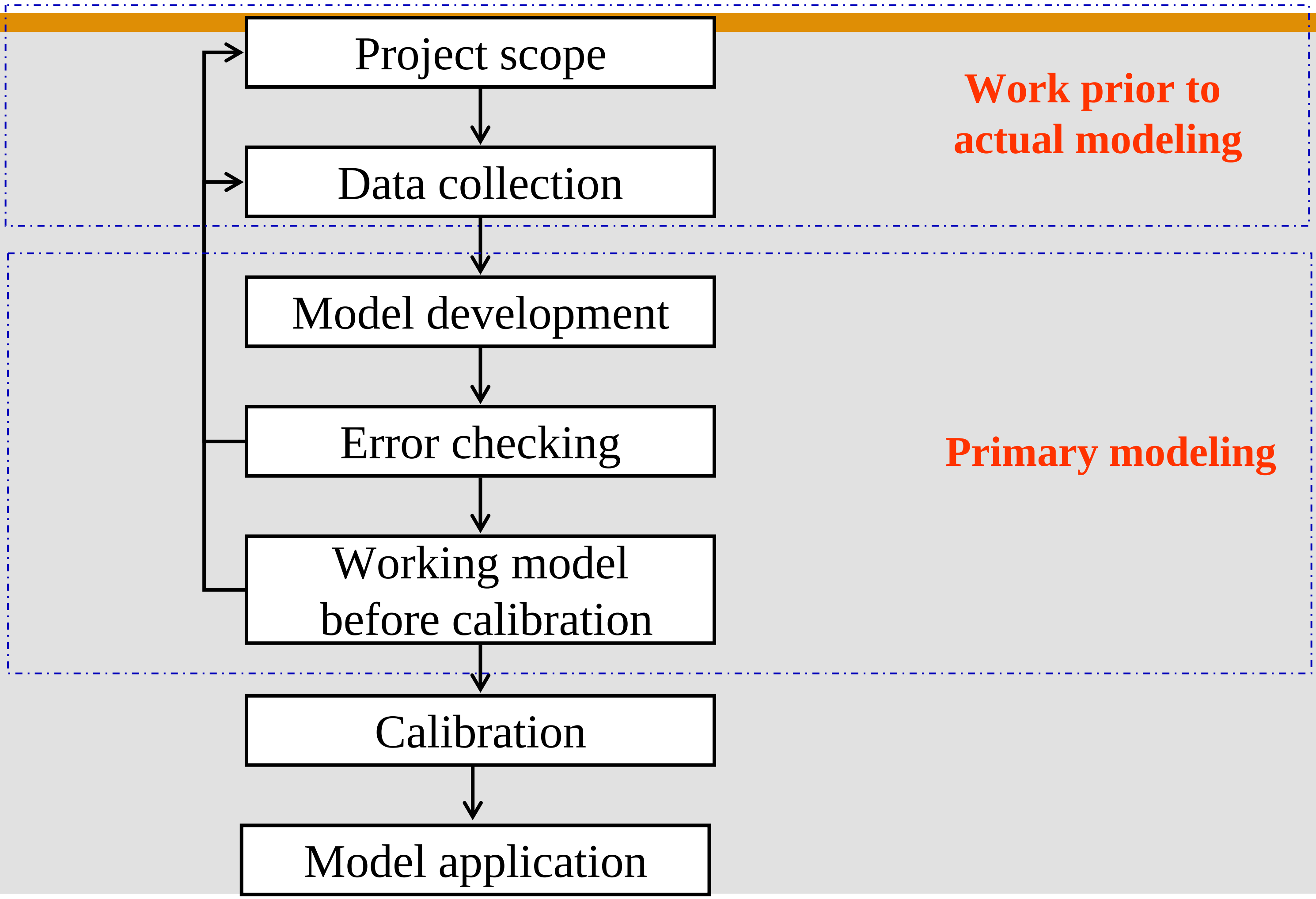
Shockwave propagation example




Volume [veh./hr]
1800
1500
900
750
36.0 [km/hr]
-10.3 [km/hr]
FW1 - FW5 : Forward wave
BW1 : Backward wave
BW1
FW3, FW4
1000
FW5
FW1, FW2
3.6 [km/hr]
Density [veh./km]
20.8
41.7
50
90
140


Cumulative volume
Demand [veh./hr]
750
900
1500
750
Link-1
Link-2
Link-3
Link-4
Link-5
Bottleneck capacity
1000[units/hour]
4 10"
9 10'
19 10"
51 11"
1468.2m
26 43"
FW1
FW2
FW3
FW4
FW5
BW1
Distance from bottleneck [m]
[minutes]

Simulation model development



Calibration key points:

Calibration involves the assessment and adjustment of numerous model parameters and each of which could potentially impact the simulation results.

These parameters are usually highly correlated.
(Assignment=f (route choice) and Route choice= f (travel time) and Travel time=f (traffic flow)

It is essential to break the calibration process into a series of logical steps.

The modeler should attempt to keep the set of adjustable parameters as small as possible to minimize the required calibration effort.

However, the tradeoff is that more parameters allow the modeler more freedom to better fit the calibrated model to the specific scenario.

Calibration strategy:

Most popular calibration strategies take advantage of the following three-step process:

1. Calibrate capacity parameters.
2. Calibrate route choice parameters.
3. Calibrate overall model performance.

Global (aggregate) calibration
Local (disaggregate) calibration

Capacity calibration

Calibrate the parameters which cause the model to best reproduce observed traffic capacities in the field.

A global calibration is conducted first, followed by link-specific fine tuning local calibration.

1. Collect field measurements of capacity,
2. Obtain model estimates of capacity (note 1 and 2),
3. Select calibration parameters (note 3),
4. Set calibration objective function (note 4),
5. Perform search for optimal parameter value,
6. Fine-tune the calibration.

Continue…

Note 1: Remove false bottleneck

Note 2: Increase the demand temporarily if necessary

Note 3: Global parameters such as:

- Mean following headway
- Driver reaction time
- Minimum stopping distance
- Startup lost time
- Queue discharged headway

Link-specific capacity parameters account for roadside factors that affect link capacity such as parking friction and grades.

Note 4: Objective functions such as:
MSE (minimum square error), MAE (minimum absolute error)
MNE, etc

Route choice calibration

Calibrate the route choice parameters (route choice algorithm) in the model to better match the observed flows

A global calibration is
conducted first, followed by link-specific fine tuning local calibration.

Global parameter such as : Weighted actual cost and time, drivers familiarity, etc

Overall model performance calibration

In this step of the calibration, the overall traffic performance predicted by the model is compared to the field measurements such as travel time, queue lengths, the duration of queuing, etc.

Calibration target

Example:

8 parameters with each parameter having a range of 4 values

There will be $4^8=65536$ possible combinations

And The number of simulation runs would be much larger if multiple simulation runs were required to reduce stochastic variability.

Therefore the modeler should know when to stop where large investments in effort yield small improvements in accuracy.

New techniques

Simultaneous optimization

Development of surface function

1. Defining study goals
2. Determine required field data
3. Choosing measure of performance
4. Identification of calibration parameters
5. Experimental design
6. Development of surface function $Y = f(x_1, x_2, x_3, ..)$
7. Determination of parameter sets based on surface function
8. Establish evaluation criteria
9. Evaluation of parameter sets with multiple run
10. Selection of best parameter set

Drawbacks: things to watch carefully

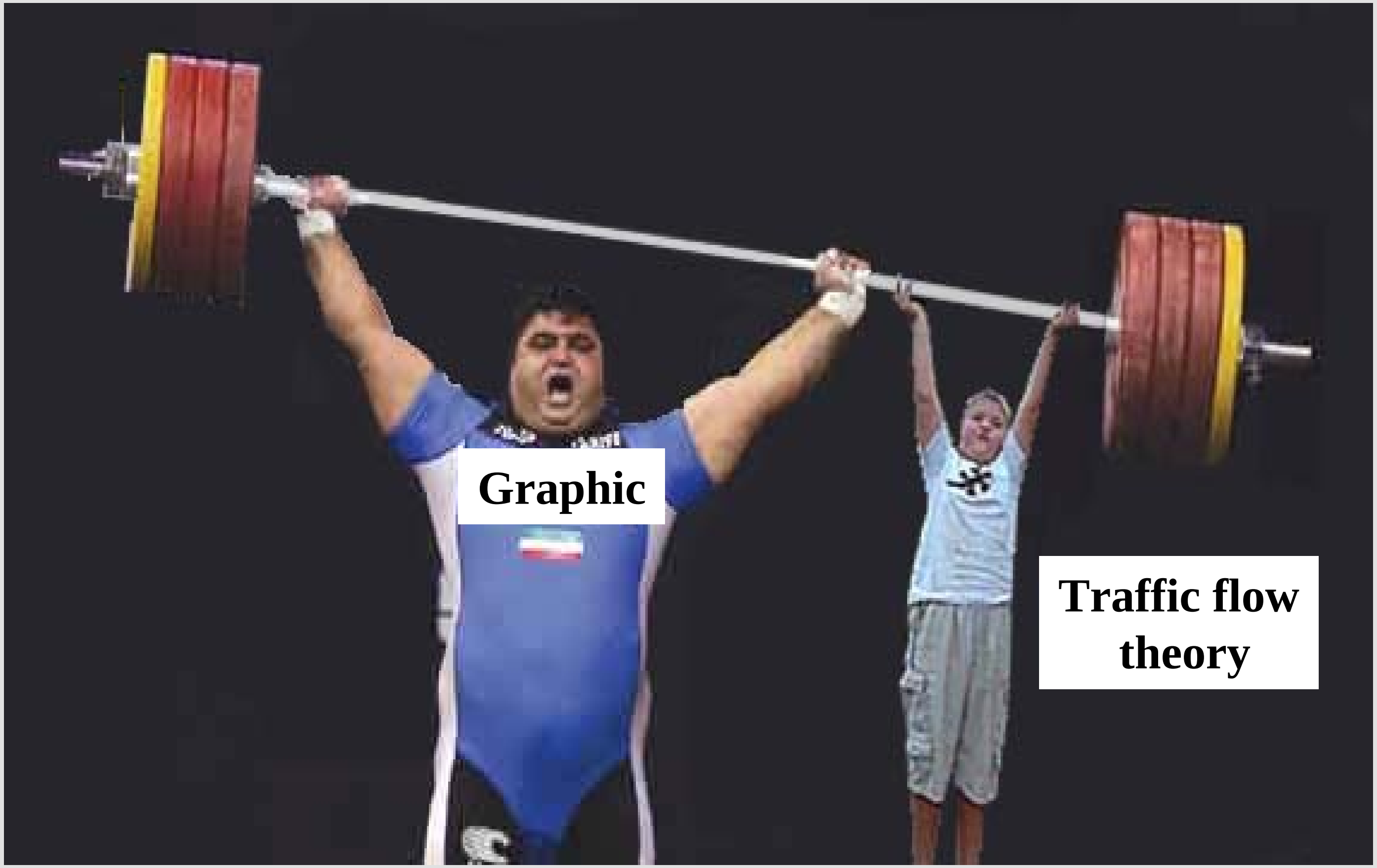
The difficulties of modeling congested traffic conditions in merging and weaving areas with existing simulation models are well acknowledged (Gomes et al. 2004, Prevedouros and Wang 1999).

Gomes et al. reported that VISSIM is incapable of modeling an entrance ramp under heavy traffic flows.

Sarvi (2002) reported several major problems such as very unrealistic driver behavior, long queue and underestimated maximum throughput while using PARAMICS to model a congested freeway ramp merging and weaving section (-15%)

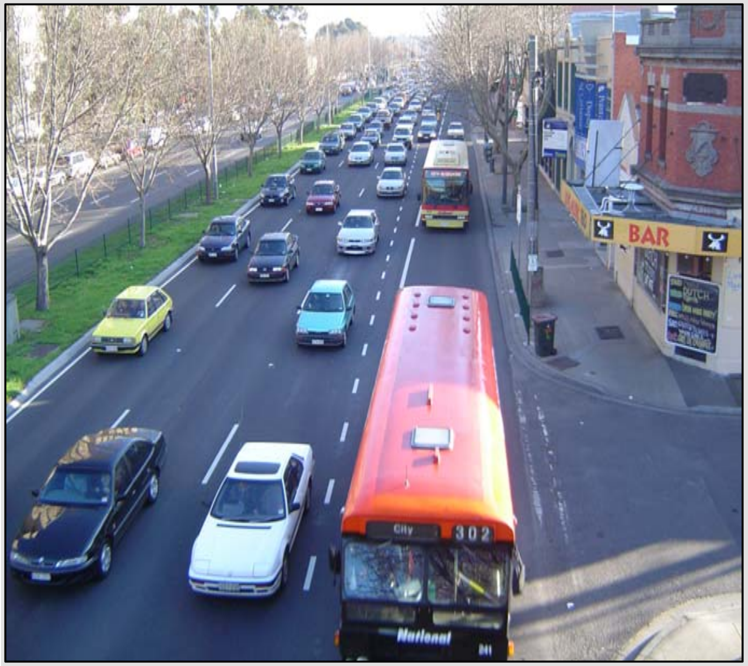
The major limitation of most of the existing microscopic simulation models is to employ a global car-following model to capture acceleration characteristics of drivers in all driving situations (utilizing a same car-following model to model driving in a basic freeway section as well as driving in the vicinity of a merging section (Panawi and Dia 2005))

Future challenges



(continued)

- **Bus (transit) vehicles driving behaviour**
- **Heavy commercial vehicles driving behaviour**
- **Public transport network modelling**



Future of simulations?

Driver behaviour studies and modeling using new technology **(tactical lane changing, truck-car-interaction, fuzzy-logic, neural network, etc)**

Auto tuning and calibration

Online simulations

Nanoscopic simulation

Discussion