Lecture #2: Microscopic Flow Characteristics  
(May's Book, Chapter 2)

Part 1: Traffic characteristics and analysis (ch.1)

- What’s involved in building traffic simulation models
- Vehicle generation using random numbers
- Sort out what's involved in the analytical process of traffic performance
- Framework for fundamental characteristics of traffic flow
- Framework for traffic analysis techniques

Part 2: Microscopic flow characteristics (ch.2)

- Why do we need to find a proper headway distribution?
- Flow rate and headway distribution; what kind of distribution would be best fit?
- Characteristics of random headway state (relating Poisson arrival to negative exponential time headway distribution; distribution calculations)
- Constant headway state (use of normal distribution or flat uniform distribution)
- Intermediate headway state (Pearson type III)
- 8 steps to apply the Pearson type III distribution to traffic
Milestones and Deliverables for a Microsimulation Study
(Source: Traffic Analysis Tools by FHWA)

Much of the management of a microsimulation study is the same as managing any other highway design project: establish clear objectives, define a solid scope of work and schedule, monitor milestones, and review deliverables. The key milestones and deliverables for a microsimulation study are shown below:

<table>
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<tr>
<th>Milestone</th>
<th>Deliverable</th>
<th>Contents</th>
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<tbody>
<tr>
<td><strong>1. Study scope</strong></td>
<td>1. Study scope and schedule</td>
<td>Study objectives, geographic and temporal scope, alternatives, data collection plan, coding error-checking procedures, calibration plan and targets</td>
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<tr>
<td></td>
<td>2. Proposed data collection plan</td>
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<td></td>
<td>3. Proposed calibration plan</td>
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<td>4. Coding quality assurance plan</td>
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<td><strong>2. Data collection</strong></td>
<td>5. Data collection results report</td>
<td>Data collection procedures, quality assurance, summary of results</td>
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<td><strong>3. Model development</strong></td>
<td>6. 50% coded model</td>
<td>Software input files</td>
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<td><strong>4. Error checking</strong></td>
<td>7. 100% coded model</td>
<td>Software input files</td>
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<td><strong>5. Calibration</strong></td>
<td>8. Calibration test results report</td>
<td>Calibration procedures, adjusted parameters and rationale, achievement of calibration targets</td>
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<td><strong>6. Alternatives analysis</strong></td>
<td>9. Alternatives analysis report</td>
<td>Description of alternatives, analytical procedures, results</td>
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<tr>
<td><strong>7. Final report</strong></td>
<td>10. Final report</td>
<td>Summary tables and graphics highlighting key results</td>
</tr>
<tr>
<td></td>
<td>11. Technical documentation</td>
<td>Compilation of prior reports documenting model development and calibration, software input files</td>
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Two problems are often encountered when managing microsimulation models developed by others:

- Insufficient managerial expertise for verifying the technical application of the model.
- Insufficient data/documentation for calibrating the model.

The study manager may choose to bring more expertise to the review of the model by forming a technical advisory panel. Furthermore, use of a panel may support a project of regional importance and detail, or address stakeholder interests regarding the acceptance of new technology. The panel may be drawn from experts at other public agencies, consultants, or from a nearby university. The experts should have had prior experience developing simulation models with the specific software being used for the particular model.

The manager (and the technical advisory panel) must have access to the input files and the software for the microsimulation model. There are several hundred parameters involved in the development and calibration of a simulation model. Consequently, it is impossible to assess the technical validity of a model based solely on its printed output and visual animation of the results. The manager must have access to the model input files so that he or she can assess the veracity of the model by reviewing the parameter values that go into the model and looking at its output.

Finally, good documentation of the model calibration process and the rationale for parameter adjustments is required so that the technical validity of the calibrated model can be assessed. A standardized format for the calibration report can expedite the review process.

What’s Involved:

Some of the Major Components in a Simulation Model

- Vehicle generation
- Driver characteristics
- Car following logic
- Lane changing logic
- Traffic control
- Etc.

(Example: SimTraffic ➔ See the Options-Intervals and Volumes Menu)
Figure 10.3

Several Statistical Distributions.
Lecture 2

(a) State at time, t₀, before any vehicles have been moved
(all vehicle positions are synchronous)

(b) State after vehicles 10, 16 and 22 have been moved (to t + 4Δt)
the others have not been processed as yet (at t₀)

(c) State at time, t₁ + 4Δt
vehicle positions are synchronous

(d) State at time, t₁ + 2Δt
vehicle positions are synchronous

Figure 10.4
Vehicle Positions during Lane-Change Maneuver
Generating Random Variates (Headways) for Vehicle Generation
(Note that the equation in page 10-9 of ch10 has an error. See next page)

Generating Random Variates (Headways) for Vehicle Generation
(Note that the equation in page 10-9 of ch10 has an error.)

Shifted Exponential (Negative) Distribution

\[ P(h > t) = e^{-\frac{t - \bar{h}}{\bar{h}}} \]

Mean headway

\[ P(h < t) = 1 - e^{-\frac{t - \bar{h}}{\bar{h}}} \]

Shift \( \tau \)

PDF

CDF

Generating vehicles (randomly generate headway values).

1. Generate a random number between 0 and 1. This corresponds to a \( P(h < t) \) value. Each random number has equal probability of occurrence.

2. Once a random number is given, we can find a headway that corresponds to that probability value, using the CDF.
Let $R$ be a random number created. Then,

$$R = 1 - e^{-\frac{t-T}{T-T}}$$

$$R - 1 = -e^{-\frac{t-T}{T-T}}$$

$$1-R = e^{-\frac{t-T}{T-T}}$$

$$\ln(1-R) = -\frac{t-T}{T-T}$$

$$- (T-T) = t-T$$

$$\ln(1-R)$$

$$t = - (T-T) \ln(1-R) + \Phi \delta$$

Rewrite this one using the following variables, then you can get the expression you find in page 10-9 of Ch.10 Traffic Flow Theory nomograph.

$t \rightarrow R$ headway generated (Random variate)

$T \rightarrow H$ average headway

$T \rightarrow \Phi_{min}$ Shift

$$h = (H - \Phi_{min})[-\ln(1-R)] + \Phi_{min}.$$ (The nomograph's expression is incorrect.)

$$h = (H - \Phi_{min})[-\ln(1-R)] + \frac{H}{\Phi_{min}}$$
The Analytical Process

**TABLE 1.2** Framework for Fundamental Characteristics of Traffic Flow

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<th>Macroscopic (Groups of Units)</th>
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<td>Microscopic (Individual Units)</td>
<td>Macroscopic (Groups of Units)</td>
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<tr>
<td>Flow</td>
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<td>relationships</td>
<td>(Chapter 10)</td>
<td>relationships</td>
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<td></td>
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<td>(Chapter 13)</td>
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*aSee also Chapter 8*