



Comparing HCM and Other Capacity/Speed Measures Using NGSIM Data

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What do we do w/ NGSIM data?



Source: mat.gsia.cmu.edu

10/2/2006

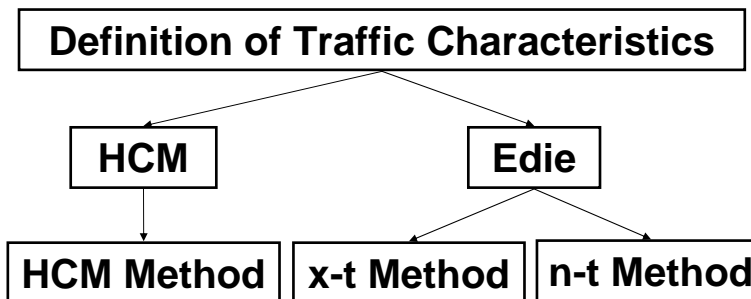
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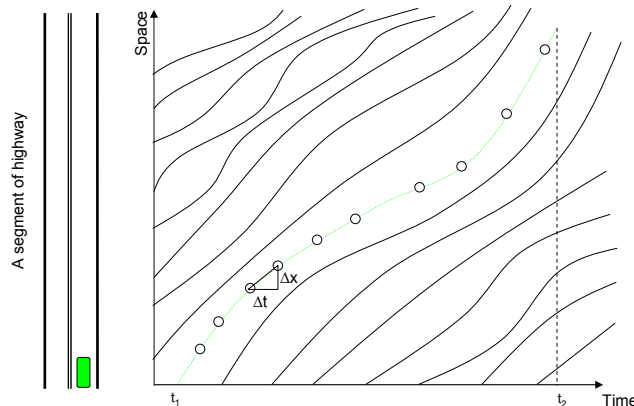


Objectives and Definitions

- # We use the MGSIM data to study direct methods to determine traffic parameters
- # By “direct methods”, we mean those based on definitions of traffic characteristics



Vehicle Trajectories



Trajectory

Vehicle speed

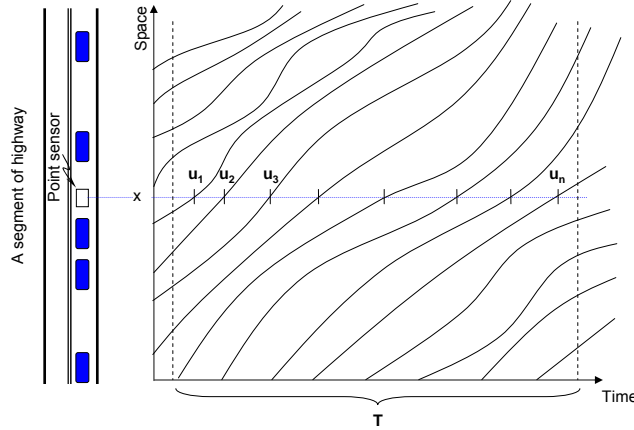
$$u = \frac{\Delta x}{\Delta t}$$

Travel time

$$\Delta t = t_2 - t_1$$



HCM Method



Flow

$$q = \frac{n}{T}$$

**SMS
(harmonic)**

$$\bar{u}_s = \frac{1}{\frac{1}{n} \sum_{i=1}^n \left(\frac{1}{u_i} \right)}$$

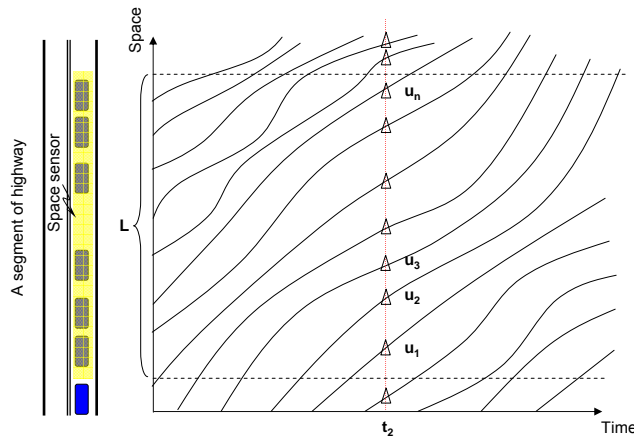
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HCM Method



Density

$$k = \frac{n}{L}$$

**SMS
(Instant photo)**

$$\bar{u}_s = \frac{1}{n} \sum_{i=1}^n u_i$$

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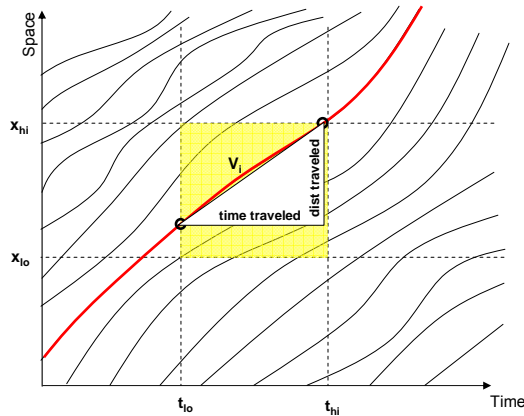
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x-t Method

3 Basic quantities



1. Total Distance

$$d(A_n) = \sum_{i=n_{lo}}^{n_{hi}} \{ \min(x^{(i)}(t_{hi}), x_{hi}) - \max(x^{(i)}(t_{lo}), x_{lo}) \}$$

2. Total Time

$$t(A_n) = \sum_{i=n_{lo}}^{n_{hi}} \{ \min(t^{(i)}(x_{hi}), t_{hi}) - \max(t^{(i)}(x_{lo}), t_{lo}) \}$$

3. Region Area

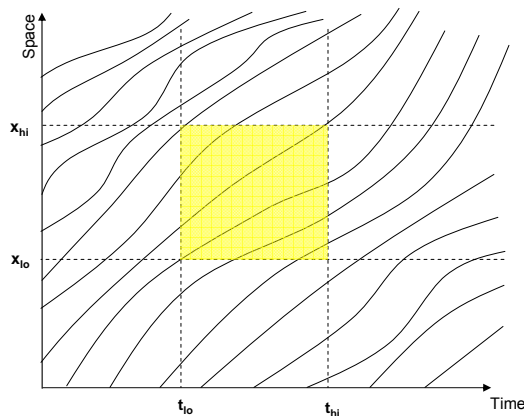
$$|A_n| = (x_{hi} - x_{lo})(t_{hi} - t_{lo})$$

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x-t Method

3 Traffic Characteristics



1. Flow

$$q(A_n) = d(A_n) / |A_n|$$

2. Density

$$k(A_n) = t(A_n) / |A_n|$$

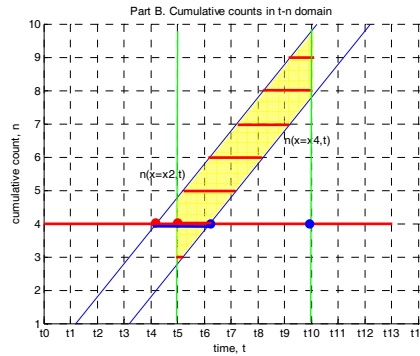
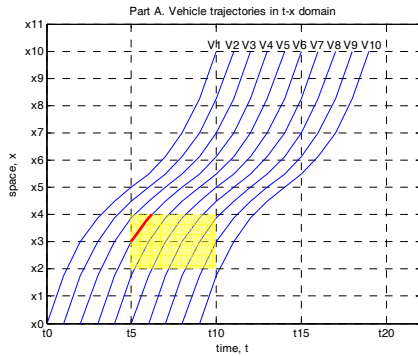
3. SMS

$$\bar{u}_s(A_n) = d(A_n) / t(A_n)$$

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n-t Method



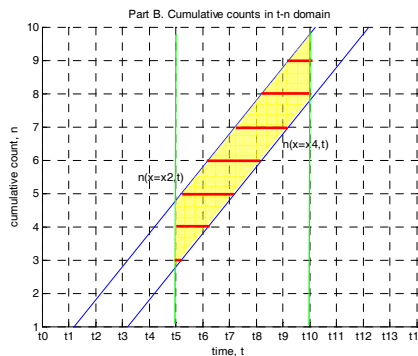
$$t^{(4)}(A_x) = \min(t_{x=x_4} (n=4), t_{10}) - \max(t_{x=x_2} (n=4), t_5)$$

$$d^{(4)}(A_x) = t^{(4)}(A_x) \frac{x_4 - x_2}{t_{x=x_4} (n=4) - t_{x=x_2} (n=4)}$$

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n-t Method



1. Total Distance

$$t(A_x) = \sum_{i=n_{lo}}^{n_{hi}} t^{(i)}(A_x) = \sum_{i=n_{lo}}^{n_{hi}} \{ \min(t_{x=x_{hi}}(n_i), t_{hi}) - \max(t_{x=x_{lo}}(n_i), t_{lo}) \}$$

2. Total Time

$$d(A_x) = \sum_{i=n_{lo}}^{n_{hi}} d^{(i)}(A_x) = \sum_{i=n_{lo}}^{n_{hi}} t^{(i)}(A_x) \frac{x_{hi} - x_{lo}}{t_{x=x_{hi}}(n_i) - t_{x=x_{lo}}(n_i)}$$

3. Region Area

$$|A_x| = |A_n| = (x_{hi} - x_{lo})(t_{hi} - t_{lo})$$

Flow $q(A_x) = d(A_x) / |A_x|$

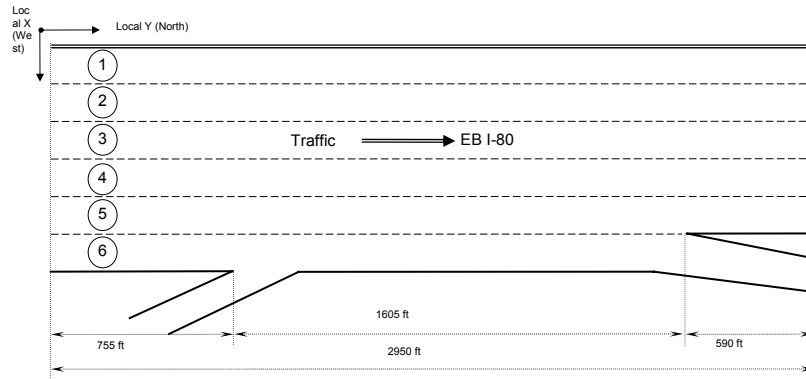
Density $k(A_x) = t(A_x) / |A_x|$

SMS $\bar{u}_s(A_x) = d(A_x) / t(A_x)$

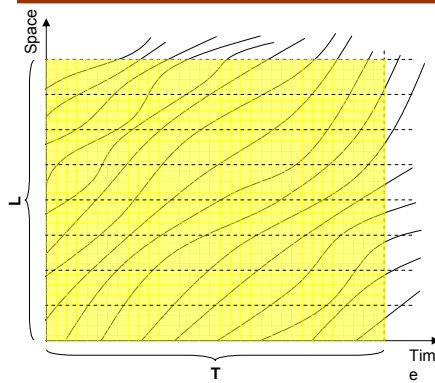


Comparison

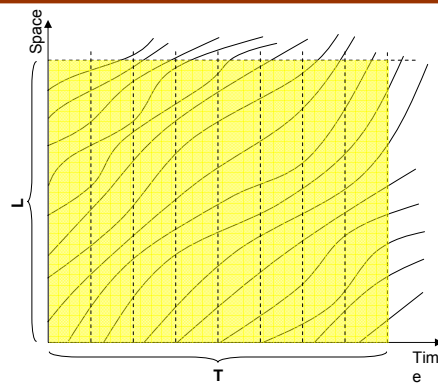
- # Historically, it has been very difficult and expensive to empirically compare HCM and Edie because this requires a common set of data involving both point sensors and space sensors.
- # Fortunately, we are able to do so because of the effort of NGSIM.



Comparison



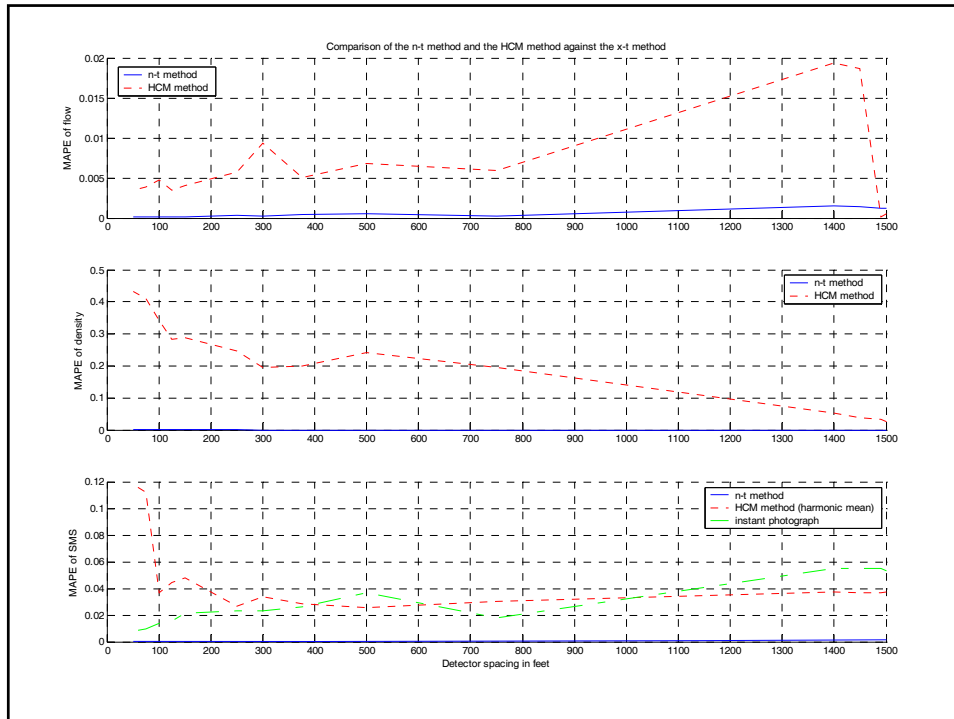
Compare 3 methods with varying detector spacing



Compare 3 methods with varying detector headway

$$MAPE = \frac{1}{N} \sum_{i=1}^N \left| \frac{y - y_0}{y_0} \right|$$

where N is the number of samples, y is a traffic stream characteristics (i.e. flow, density, or SMS) determined using the n-t method or the HCM method, and y₀ is the corresponding traffic stream characteristic determined using the x-t method.



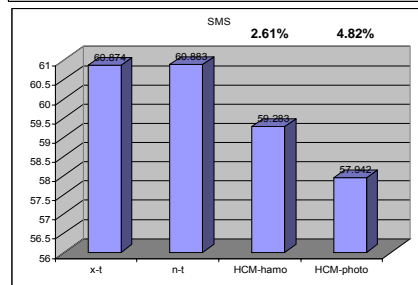
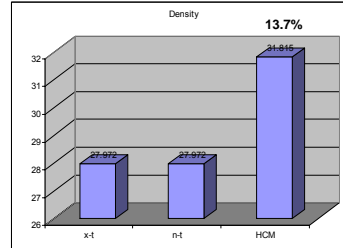
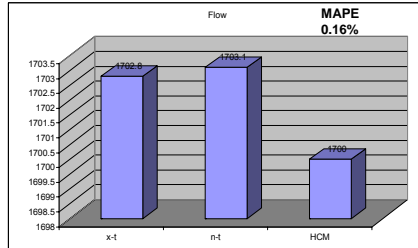
Conclusions: Detector Spacing

For the same detector spacing:

- ⊕ HCM yields error in **flow** by 0.5-2.0% when compared to x-t method
- ⊕ HCM yields error in **density** by 10-40% when compared to x-t method
- ⊕ HCM yields error in **speed** by 2-6% when compared to x-t method
- ⊕ n-t and x-t methods are **identical** in density, and nearly so in flow and speed



Comparing the 3 methods for a typical ¼ mile detector spacing



Detectors in Space Domain

$X_{lo} = 755$ ft, $X_{hi} = 2055$ ft

Spacing = 1300 ft

Detectors in Time Domain

$T_{lo} = 40$ sec, $T_{hi} = 340$ sec

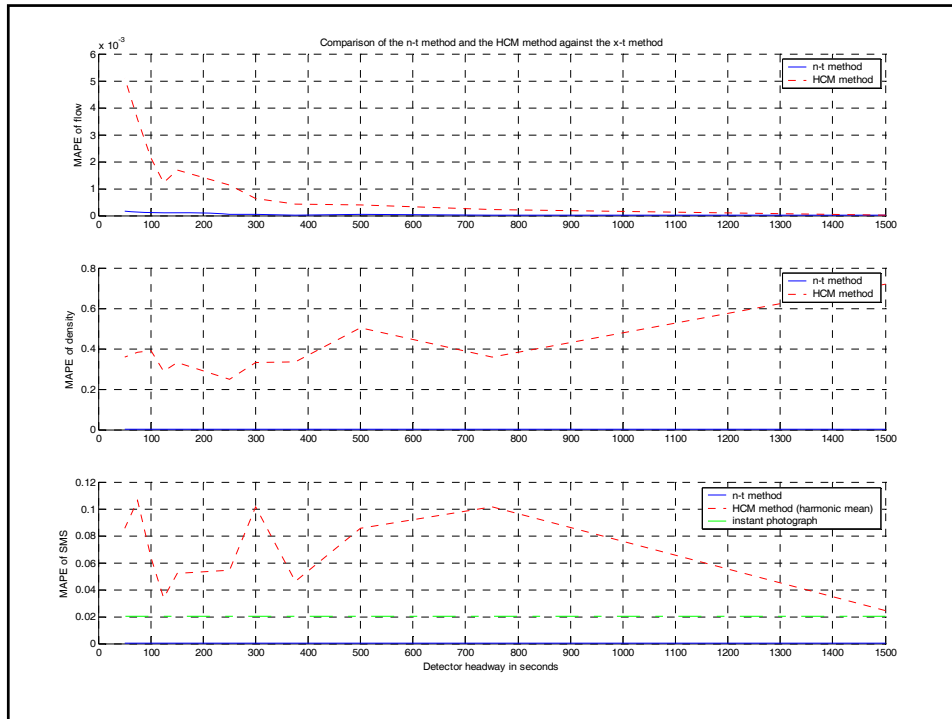
Headway = 300 sec



Comparing the 3 methods for a typical ¼ mile detector spacing

For a typical ¼ mile (1300 ft) detector spacing:

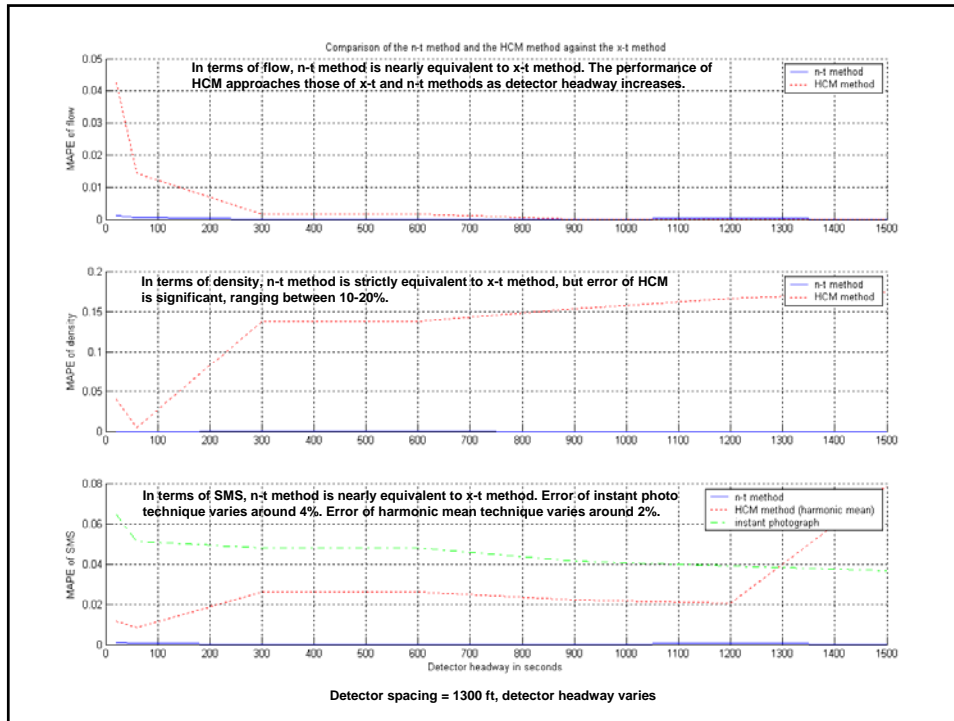
- ⊕ HCM underestimates **flow** by 0.16% when compared to x-t method
- ⊕ HCM overestimates **density** by 13.7% when compared to x-t method
- ⊕ HCM underestimates **speed** by 2.6-4.8% when compared to x-t method
- ⊕ n-t and x-t methods are **identical** in density, and nearly so in flow and speed



Conclusions: Detector Headway

For the same detector headway:

- ⊕ For detector headways less than 300 seconds, HCM yields error in **flow** by 0.1-0.5% when compared to x-t method
- ⊕ As detector headway increases, the performance of HCM approaches that of x-t method
- ⊕ HCM yields error in **density** by 20-60% when compared to x-t method
- ⊕ HCM yields error in **speed** by 2-10% when compared to x-t method
- ⊕ n-t and x-t methods are **identical** in density, and nearly so in flow and speed



Questions Comments?

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