

## A Better Multimodal Regional Congestion Model

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Regional traffic models can provide invaluable estimates of the effects of various transportation improvement alternatives in terms of congestion, usually something like regional travel-time or average travel delay per mile. However, such models are extremely complex, expensive to set up and run, and like any such large computer models, extremely sensitive to seemingly minor input errors. There is a need for something simpler.

We postulate a simple model of regional average congestion travel delay, DEL, (minutes/mile) as a function of

$V^*$ , “regional volume”, ps-mi/day<sup>1</sup>

$C^*$ , “regional capacity”, defined as a general linear additive function of

FLM freeway lane-miles,

ALM, arterial lane miles, and

TPM, transit daily person-miles,

of general linear additive form:

$$C^* = K_1 (FLM + K_a ALM + K_t TPM)$$

with Regional delay, an as yet unspecified function,  $F$ , of the  $V^*/C^*$  ratio

$$DEL = F(V^*/C^*) .$$

Function type,  $F$ , and all  $K$  parameters are to be determined by best fit to the TTI, 2003, 83 city database of { DEL, FLM, ALM, and, TPM}<sup>2</sup>.

Some initial trials with a multiple non-linear curve fit program (“Table Curve”©) trying several thousand simple function types, established that the best fitting simple function is a power law,

$$DEL = K_o + K_f ( V^*/C^* )^{K_e}$$

This is significantly similar to the well known “BPR” function, used (with variations) in most traffic models, for travel time of a simple homogeneous roadway segment as opposed to a region comprised of many such segments.

$$TravelTime = T_o ( 1 + 0.15 (V/C)^4 )$$

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<sup>1</sup> “Regional Volume” and “Regional Capacity” as defined here are not the same as “volume” and “capacity” as defined by TRB and ITE for homogeneous roadway segments.

<sup>2</sup> “Urban Mobility”, annual, Texas Transportation Institute. The TTI methodology and estimates for travel-time delay are complex, somewhat subjective, have not been explained well enough to support independent verification, and may be questioned, but as of this date they are the only, and best existing adequate base of such data. TTI is starting to collect actual loop sensor data which will give a more accurate direct measure of travel-time delay and it is hoped that this analysis can soon be redone with loop sensor based travel delay data.

Initial trials also established that  $K_0$  is not significantly different from zero so can be set to zero without significant loss of accuracy. We then have

$$DEL_{\min/mi} = K_f \left( \frac{V^*}{K_1 (FLM + K_a ALM + K_t TPM)} \right)^{K_e}$$

In this form, it is clear by inspection that  $K_1$  and  $K_f$  are mutually dependent and therefore indeterminate. That means we can, without any loss of generality, choose  $K_1$  arbitrarily. Noting that the denominator term

$$(FLM + K_a ALM + K_t TPM)$$

has the dimensions of FLM, [lane-miles] and can be referred to as “system equivalent freeway lane-miles”, we can choose to define  $K_1$  to normalize it so that  $V^*/C^*$  is unity for the median US city in the TTI database. The  $V^*/C^*$  ratio for any other region then has the specific significance:

“regional transport system load factor relative to the median US city”.

That median city (actually urbanized area) in the TTI 2003 database turns out to be Raleigh-Durham N.C. and the corresponding normalizing constant is

$$K_1 = 25,085 \text{ ps-m/day/ln-mi}^3$$

giving the final parametric form:

$$Del_{\text{minutes/mile}} \equiv K_f \left[ V^* / C^* \right]^{K_e}$$

where

$$C^* = K_1 [FLM + K_a ALM + K_t TDPM]$$

$$K_1 = 25,085 \text{ (ps - mi / day) / (ln - mi)}$$

1)

The four unknown parameters,  $K_t$ ,  $K_a$ ,  $K_f$  and  $K_e$  are determined by best fit, non-linear regression on the TTI 2003 data. The regression (least squares fit) results are as follows

$$K_a = 0.3524$$

$$K_t = -0.0323$$

$$K_f = 0.2219$$

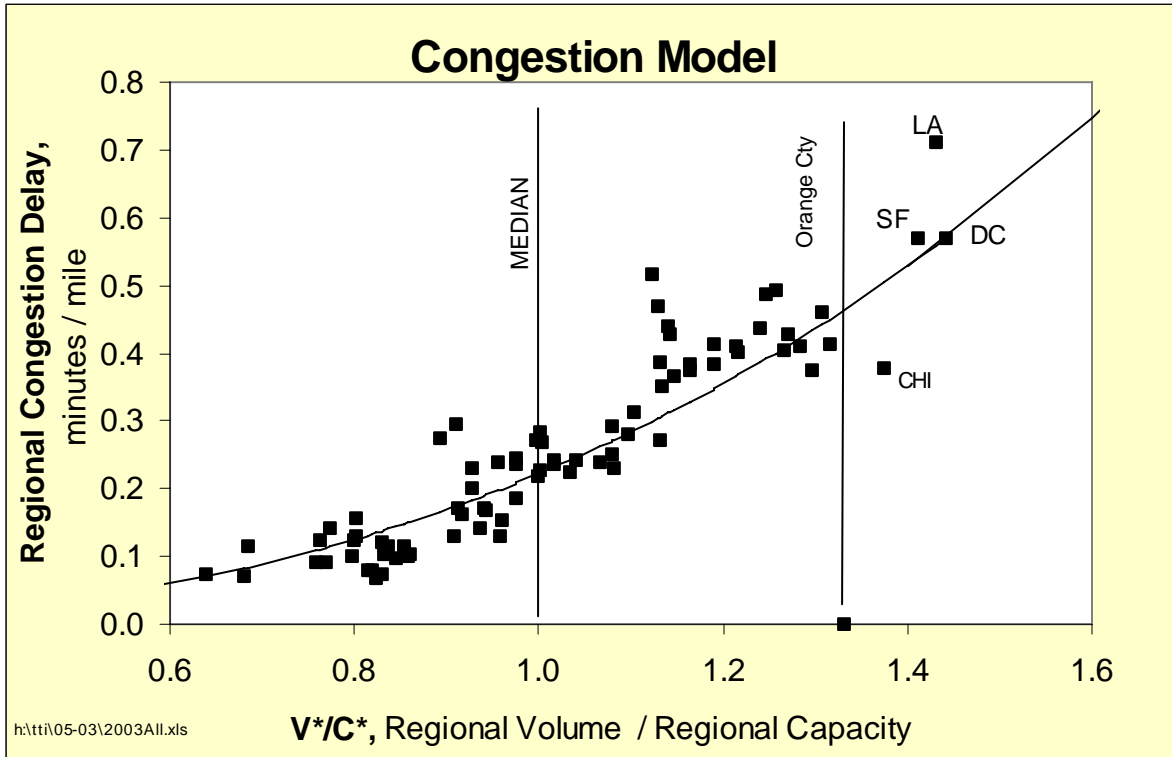
$$K_e = 2.581, \text{ and}$$

$$R^2 = 74\%$$

2)

<sup>3</sup> The TTI data give 15,390 (veh-mi/day)/(effective lane-mi) which is converted to ps-mi, using the 2001 NHTA value of Average Vehicle Occupancy for all US, all trip purposes, all travel times AVO= 1.63 ps/veh, resulting in 25,085 ps-mi/lane-mi. .

Figure 1 following plots the data points and fit as functions of the normalized  $V^*/C^*$  ratio. Each of the points represents one of the 83 US urbanized areas in the 2003 TTI database.



The regression function is a simple and reasonably useful predictor of regional congestion, as defined by TTI's regional average travel delay, minutes/mile.