Speed Adjustments in T3 and CONCEPT

Introduction

This document presents the approach proposed for use in the TDM Transformation Tool (T3) for determining the appropriate speed adjustments to be applied to incoming TDM data, and for passing that information to the CONCEPT model. The variety of speed adjustment approaches and the fact that speed adjustments should be applied after any temporal allocations have been performed indicate the need for the speed adjustment process to be performed in the CONCEPT model rather that the T3 tool. The goal of the process described herein is to allow a variety of instructional inputs to be provided to T3 for how speeds should be adjusted and for T3 to pass that information to CONCEPT after applying the transformations and conversions that are part of the T3 data processing algorithm.

Background

The general form of the most common volume-delay function (the Bureau of Public Roads curve, or BPR curve) is:

$$S_a = \frac{S_{ff}}{1 + \left[A * \left(V/C \right)^B \right]}$$

where:

S_a	=	actual link speed (mph)
S_{ff}	=	reported link free flow speed (mph)
V	=	total link volume (vehicles OR vehicles per hour)
C	=	total link capacity (vehicles OR vehicles per hour)
A, B	=	curve calibration coefficients

An alternative type of speed adjustment commonly used is a table of adjustment factors by volume-capacity ratio, from which one can interpolate the required adjustment factor on a link-by-link and hour-by-hour basis.

In real-world applications, the BPR speed adjustment typically has the following constraints or additional rules:

- If the TDM provides a calculated congested speed, the lower bound of the computed actual link speed is set to the TDM congested speed.

- The volume-capacity ratio is often capped at some value (may be 1.0 or higher). Where the TDM reports a volume-capacity ratio higher than the cap value, the speed adjustment is calculated using the cap value rather than the reported value.
- The values of the curve calibration coefficients vary by free flow speed, functional class, and area type (urban/rural). Indeed, the coefficients may vary by other parameters (e.g., vehicle class); however, the current plan is to allow variability by free flow speed, functional class, and area type only.
- If lookup tables are provided listing the speed adjustment factor by volume-capacity ratio, these tables may be specified by functional class and area type as well.

The procedures described herein are designed to retain this level of flexibility as the TDM data are processed through T3 and output to the CONCEPT model.

Speed Adjustments in CONCEPT

The CONCEPT model will apply speed adjustments to the temporally allocated link-level data using the hourly volumes to determine the volume-capacity ratio to use. CONCEPT will offer 2 options for speed adjustment – BPR curves or lookup tables.

The general form of the BPR-based speed adjustment algorithm in CONCEPT is:

$$S_a = MAX\left(S_{cg}, \frac{S_{ff}}{1+\left[A * VCR_{adj}{}^{B}\right]}\right)$$

where:

S_a	=	actual link speed (mph)
S_{ff}	=	reported link free flow speed (mph)
S_{cg}	=	reported link congested speed (mph)
S_{cg}	=	0 if not reported
VCR_{adj}	=	adjusted volume-capacity ratio
VCR_{adj}	=	$MIN(VCR, VCR_{cap})$
VCR_{cap}	=	cap value on volume-capacity ratio
VCR_{cap}	=	∞ if not reported
VCR	=	reported volume-capacity ratio
A, B	=	curve calibration coefficients
A, B	~	*curve number, S_{ff}*

The link network data provided to CONCEPT will specify a BPR curve number to be applied to that link. A separate file will list the curve number, curve type (BPR or lookup table), and volume-capacity ratio cap value. Another file will list the curve number and

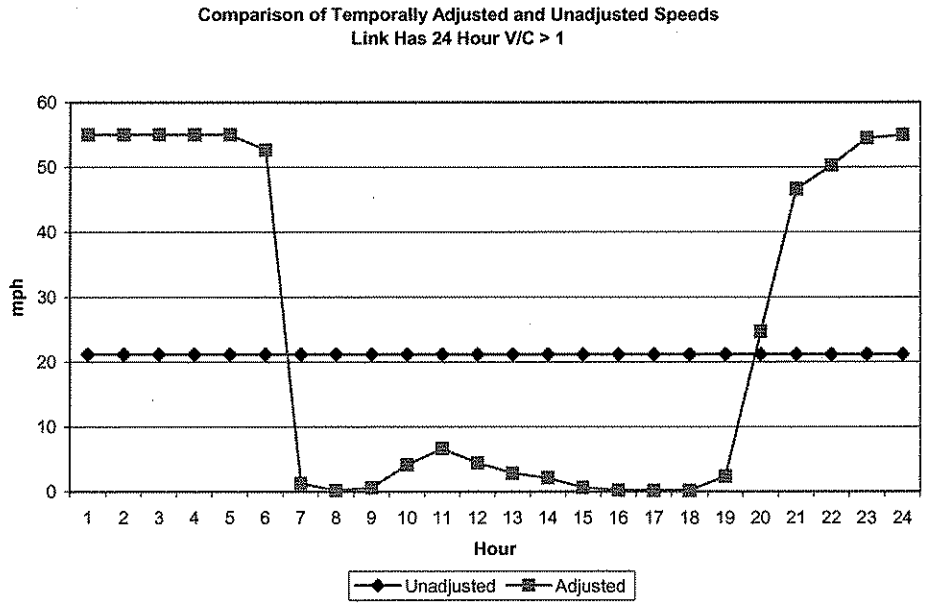
associated A and B coefficient values by speed bucket for each BPR type curve. CONCEPT will use the specified A and B coefficient values for the speed bucket in which the link free flow speed falls – no interpolation will be performed. If the free flow speed falls outside the specified speed range, the appropriate minimum or maximum bucket values for A and B will be used.

For adjusting speeds using a lookup table, CONCEPT will use a paired series of volume-capacity ratio values and adjustment factor values and will interpolate the adjustment factor to be used based on the actual volume-capacity ratio for the link for each hour. CONCEPT will use the first and last values (smallest and largest volume-capacity ratio values, respectively) as boundary values and will not extrapolate. The lookup tables will be defined by curve number, allowing different tables to be applied to each link in the network. As with the BPR curve data, the CONCEPT link network data will specify the curve number to use for each link. For curves identified as lookup table curves, no volume-capacity ratio cap value will be specified. An external file will list the lookup table values by curve number. The link free flow speed will be divided by the interpolated adjustment factor to determine the adjusted speed.

For both BPR-based and lookup table speed adjustments, if a congested speed is provided for the link, the maximum of the adjusted speed and the congested speed will be used as the actual link speed, otherwise the adjusted speed will be used.

As a general note, the curve numbers specified in CONCEPT will include the network identifier so that multiple networks can be modeled simultaneously without overlapping BPR curve numbers.

An example of a link with only a daily average volume and speed information that is adjusted using hourly temporal profiles and a BPR curve is displayed in the figure below.



T3 Inputs

The inputs to T3 describing the desired speed adjustments will be provided in four ASCII text files:

1. Curve number by functional class and area type. This file will follow the dimensioning conventions of other T3 input files, allowing the user the option of specifying a single curve number for all links, a set of curve numbers by functional class only, or curve numbers by functional class and area type. The absence of this file indicates to T3 that no speed adjustments are to be performed by CONCEPT. In this case, T3 will leave the speed adjustment curve number blank in the CONCEPT inputs.

2. Curve type and volume-capacity ratio cap value by curve number. For lookup table curves, the volume-capacity ratio cap will be left blank.

3. A and B coefficient values by speed bucket by curve number. The speed bucket definitions may use identical values for the upper and next lower bound speeds – the lower bound will be considered inclusive and the upper bound exclusive. For example, if two speed buckets are defined:

From Speed	To Speed	A	B
0	60	0.15	10
60	200	0.20	8

For a link free flow speed of 60 mph, the first bucket values (A = 0.15, B = 10) would be selected.

4. Lookup values of volume-capacity ratio and adjustment factor by function class, speed, and volume-capacity ratio.

Deleted: Lookup values of volume-capacity ratio and adjustment factor by curve number.

Since the T3 tool applies transformations to convert the incoming functional classes to the standard HPMS roadway types, the speed adjustment coefficients can not be passed to CONCEPT indexed by functional class. Therefore T3 will determine the appropriate curve number based on the functional class and area type of each link and pass CONCEPT the curve numbers on a link-by-link basis.

T3 Outputs

In addition to the normal VMT and trip outputs, T3 will write a set of RPO-MA records for the attributes FFSPD (free flow speed) and CGSPD (congested speed, if provided in the TDM output). The FFSPD group will include one record per network link, while the CGSPD will include one record per network link per TDM time period.

Note that if no curve numbers are provided to T3, the tool will not generate FFSPD or CGSPD records (or any of the records described below). Instead, T3 will generate SPEED records using the TDM-calculated speeds provided and will instruct CONCEPT not to apply any speed adjustments.

To capture the speed adjustment curve number for each link in the network, T3 will add an additional field to the end of the MobileML (Link Coordinates) records. The field will be called SPEED ADJUSTMENT CURVE ID and will be a character field of width 12. The field will contain the concatenated values of the network name (8 characters) and a unique curve number within that network (4 digits, left-padded with zeros).

T3 will also write 3 new files for use in CONCEPT:

1. the curve type file containing the curve id (concatenated network name and curve number), curve type ("BPR" or "TABLE"), and volume-capacity ratio cap value (MobileMC);

2. the BPR coefficients file containing the curve id and A and B values by speed bucket (MobileMP); and

3. the lookup table file containing the volume-capacity ratio and adjustment factor values for each curve id (MobileMV).

The format of these files will be documented in the RPO Data Exchange Protocol.

State	Network	V/C cap	Number Links	Speeds Input to CONCEPT	VMT Mix	Volume	Temporal Profiles Used
ILLINOIS							
	CATS	2	33,786	By link by period	HD and LD	Provided for 8 time periods	Illinois State
	ILDOT	none (no speed adjustments done)	258,400	Fixed by road class	Total Volume	24-hourly	Illinois State
INDIANA							
	Indianapolis	none (no speed adjustments done)	7,599	Daily free-flow and congested (used congested speed)	Total Volume	24-hourly	Illinois State
	INDOT	1	47,997	Daily free-flow	Total Volume	24-hourly	Illinois State
	NIRPC	none	9,023	am, pm, off-peak	Total Volume	am, pm, off-peak	Illinois State
MICHIGAN							
	MIDOT	none	7,101	Daily free-flow, congested	Total Volume	24-hourly	Michigan State
	SEMCOG	none (hourly speeds provided)	29,514	Hourly	Total Volume -- SEMCOG provided VMT-mix profiles	am, mid-day, pm, off-peak	SEMCOG provided
MINNESOTA							
	MN DOT	none (no speed adjustments done)	3,418	Average by road class	Total Volume	24-hourly	Minnesota State
	Twin Cities	none (speeds provided are nearly hourly)	20,923	By period (24 periods)	Total Volume	24 periods -- preprocessed to fall on the even hours	Minnesota State
MISSOURI							
	EWGCOG	none (speeds provided are by period)	40,394				
OHIO							
	Akron	0.8	11,924	Posted speed	Total Volume	24-Hourly	Michigan State
	Canton	0.8	9,735	Posted speed	Total Volume	24-Hourly	Michigan State
	Cincinnatti-Dayton	2.4	29,796	Free-flow travel time	Total Volume	24-Hourly	Michigan State
	Cleveland	0.8	16,966	Free-flow travel time	Total Volume	24-Hourly	Michigan State
	Columbus	1.3	22,740	Posted speed	Total Volume	24-Hourly	Michigan State
	Springfield	1.3	3,723	Posted speed	Total Volume	24-Hourly	Michigan State
	Toledo	1.3	11,529	Posted speed	Total Volume	24-Hourly	Michigan State
	Youngstown	0.8	9,184	Posted speed	Total Volume	24-Hourly	Michigan State
	Statewide	1.3	24,894	Average of AB and BA speeds	Total Volume	24-Hourly	Michigan State
WISCONSIN							
	SEWRPC	none (no speed adjustments done)	17,046	Congested and free-flow -- applied congested to morning and evening periods	Total Volume	5 periods	Wisconsin State
	WIDOT	none	135,128	Free-flow	Light-duty & heavy truck	24-Hourly	Wisconsin State

HPMS Adjustments Applied	Other
None	
None	
Conserved adjustment between freeways/other roadway types	
Conserved adjustment between freeways/other roadway types	
Conserved adjustment between freeways/other roadway types	Re-run with zero capacities reset to 99999.
Use a single county adjustment for Mason and Mecosta. For all other counties, use conserved adjustment between freeways/other roadway types.	Re-ran with 1.0 V/C cap.
Used 2002 HPMS adjustments.	
Used conserved adjustment on higher facility classes (with the exception of a handful that got county-wide adjustments). Filled in classes 8,9,17,19 with HPMS.	
Conserved adjustment between freeways/other roadway types	*** Set minimum speed to 5mph in T3 processory, maximum speed to 90mph. There were problems with crazy speeds being calculated.
Run without adjustment -- Missouri counties only.	
Conserved adjustment between freeways/other roadway types	Originally ran with 1.3 V/C cap
Conserved adjustment between freeways/other roadway types	Originally ran with 1.3 V/C cap
Conserved adjustment between freeways/other roadway types	
Conserved adjustment between freeways/other roadway types	Originally ran with 1.3 V/C cap
Conserved adjustment between freeways/other roadway types	
Conserved adjustment between freeways/other roadway types	
Conserved adjustment between freeways/other roadway types	
Conserved adjustment between freeways/other roadway types	Originally ran with 1.3 V/C cap
Conserved adjustment between freeways/other roadway types	Originally ran with no V/C cap
None. Add 4,513,488 VMT for Collectors.	
Conserved adjustment between freeways/other roadway types	