The Impact of Factoring Traffic Counts for Daily and Monthly Variation in Reducing Sample Counting Error

SAM GRANATO

Transportation agencies often determine what the annual average daily traffic (AADT) count is on streets and highways by counting traffic for short time periods (usually for 24 hours) and then estimating the AADT based on this count and a numerical factor that takes into account day-of-week and/or seasonal variations in traffic volumes found at a small number of permanent automatic traffic recording stations (ATR's). Considerable research has been devoted to help state departments of transportation (DOTs) and other agencies develop cost-effective programs to develop factoring procedures to ensure reasonably accurate estimates of AADT from short-term counts. The U.S. DOT has also published estimates of sample error as a function of the volume in an *un*factored count. However, no recent research has been found that provides answers or guidance as to how much (sampling) error remains in the estimation of AADT from a *factored* short-term count in urban areas. Such research is necessary to help agencies determine whether changes in counted volume over time represent a significant change in traffic flow or not, for how long a period of time should a count be taken to reach a desired level of confidence in the count, and to help develop a standard for traffic forecasting model performance regarding the minimization of discrepancies between counted and modeled traffic flows. This paper presents an analysis of just how much day of week/month of year factors can reduce the error of prediction of AADT from a short-term traffic count, utilizing data from an ATR station maintained by the Iowa DOT in Cedar Rapids, Iowa. The benefits of factoring are shown to be a one-quarter reduction in error of AADT prediction for a 24-hour count at this station, with minimal added benefit of a (consecutive) multiple-day count. The metropolitan planning agency will utilize these findings in future evaluations of forecasting model performance. Key words: traffic counts, count factoring, traffic model calibration.

OVERVIEW

Traffic and transportation agencies often estimate the annual average daily traffic (AADT) count on streets and highways by counting traffic for short time periods (usually 24-48 hours) and then making adjustments based on numerical factors that takes into account the day of week and/or seasonal variations in traffic volumes found at a small number of permanent automatic traffic recording stations (ATR's).

Linn County Regional Planning Commission, 6th Floor City Hall, Cedar Rapids, Iowa 52401.

Research has been devoted in the recent past to help state departments of transportation (DOTs) and other agencies that prepare traffic counts develop a cost-effective program of stratified permanent count stations that minimize AADT estimation error from short-term counts (*1*,*2*), with findings stressing the importance of length of counting time and proper clustering of ATRs into factor groups. The author has found no recent formal research, however, that determines for the end user of traffic data what the value of the factoring process is in reducing sample traffic count error in urban areas (and the results of older research has been called into question[*3*]). Such research is necessary for at least three reasons:

1. To help agencies determine whether changes in counted traffic volume over time actually constitute a significant change or not;
2. For how long a period of time should a count be taken to reach a desired level of confidence in the count;
3. To help planning agencies develop a standard for traffic forecasting model performance (regarding the minimization of discrepancies between counted and modeled traffic flows).

The U.S. DOT has published estimates of sample error as a function of the volume in an *un*factored 24-hour count (*4*), which has been incorporated into at least two "how-to" traffic forecasting manuals (*5*,*6*). However, it is not known if any planning agencies other than the Cedar Rapids metropolitan planning organization make use of this information in assessing the level of accuracy of their (base-year) traffic forecasts.

Cedar Rapids is a Midwestern city of about 110,000 people (metro area 150,000) with an employment base dominated by agribusiness, avionics, and telecommunications. While it is a significant employment and shopping destination for the surrounding rural area, it is not deemed a significant tourist destination, has no major universities, and does not host many "big-draw" special events (major league sports, festivals, etc.). Therefore, traffic patterns can be considered relatively stable for an urban area.

Traffic counts on city streets are conducted every two years by the Cedar Rapids Traffic Engineering Department (TED) at close to 1000 locations. This is done by leaving a mechanical counter at a street location for (typically) 24 hours during a weekday, than adjusting the count based on day of week/month of year factors supplied by the Iowa Department of Transportation (IDOT). This factoring is done based on a network of 124 ATR stations maintained by IDOT around the state, grouped into six categories based on type of roadway (interstate, primary road, local street) and surrounding environment (municipal or rural) (*7*). The counts are used locally to determine travel trends, calculate accident rates for intersections and "mid-block" street sections, and calibrate traffic simulation and forecasting models. The author has previously reported

TABLE 1 Johnson Avenue Daily Traffic Count Data And Variability

		Number of Daily counts	Average deviation from AADT			Percent reduction in error	
				"Internal" factors*	Published factors**	"Internal" factors*	Published factors**
Year	AADT	Used	Unfactored				
1991	9,673	72	6.1%	2.0%	6.2%	67	-2
1992	9,728	67	8.1%	2.3%	3.2%	72	60
1993	10,493	86	13.1%	3.2%	11.1%	76	15
1994	10,091	89	8.6%	2.9%	6.4%	66	26
Avg.	9,996	79	9.0%	2.6%	6.7%	71	25

* Factored for count site's "intra-year" day of week/month of year variation.
** Based on published factors for "municipal street composite," based on the previous three year's worth of traffic data from 12 ATR stations in the state of Iowa.

TABLE 2 Johnson Avenue Peak Hour Traffic Count Data And Variability

		Number of Daily counts	Average deviation from AAHT			Percent reduction in error	
				"Internal" factors*	Published factors**	"Internal" factors*	Published factors**
Year	AAHT	Used	Unfactored				
AM peak hour (7-8 a.m.)							
1993	571	86	32.9%	4.1%	24.9%	88	24
PM peak hour (4-5 p.m.)							
1994	869	86	14.3%	3.7%	9.5%	74	34

* Factored for count site's "intra-year" day of week/month of year variation.
** Based on published factors for "municipal street composite," based on the previous three year's worth of traffic data from 12 ATR stations in the state of Iowa.

that traffic forecasting model error in the metro area is not significantly different from sample counting error for count locations over 15,000 AADT (*8*), but this claim is based on published U.S. DOT research for unfactored counts (*4*). The purpose of this paper is to determine, at least for one urban area, how to adjust standardized estimates of traffic count error based on the factoring done locally. It is *not* the purpose of this paper to question IDOT's current count factoring methodology or suggest alternatives.

ANALYSIS

The case study described in this paper is based on an analysis of four year's worth of daily traffic counts from one ATR station located on a local arterial street (Johnson Avenue) in a residential area in the city of Cedar Rapids. The Johnson Avenue site is one of 12 ATR stations around the state classified as a "municipal street" station used to factor counts taken on any city street. "Municipal street composite" factors are made available annually to local agencies that reflect traffic patterns at these 12 locations during the three previous calendar years. The Johnson Avenue site carries about 10% of the combined volume of this group of stations (*7*). Therefore, the factors can be said to be somewhat, but not completely, independent of the traffic counts collected at Johnson Avenue.

For each of four consecutive years (1991-1994), traffic counts for individual days and their variation from the average count for that year were compared to the same counts factored for the statewide municipal street patterns and the remaining variation in those counts. Days of the year excluded from consideration are days where the local agency is not likely to conduct counts, days where traffic patterns are impacted by holiday travel, and days where IDOT has indicated that a count on a particular day at the site is an "estimate" due to maintenance or mechanical problems with the ATR. TED only conducts counts on weekdays from April to October. Therefore, as shown in Table 1, the average number of days in a year that ATR counts are considered useful for this study is about 80. The AADT at this location from 1991 to 1994, as published by IDOT, is about 10,000 with a coefficient of variation of about 4% (*7*).

As shown in Table 1, the impact of factoring counts varied widely among the four years, but has an overall average of 25%. (This is less than findings from comparable research for rural roads [*9*] which found an error reduction of 32% on Interstates and 37% on other roads.) When one looks at day of week and month of year variation *within* the April-October counting season at the Johnson Avenue site, it is apparent that most of the variation in traffic volume (about 70%) is due quite literally to day of week and monthly patterns. However, most of this potential gain in the accuracy of AADT

TABLE 3 Johnson Avenue Multi-Day Traffic Count Data And Variability

Year	AADT	Number of Multi-day Counts Used 48-hour	72-hour	96-hour	Average deviation from AADT (factored)* 48-hour	72-hour	96-hour
1991	9,673	53	34	15	6.1%	6.2%	6.2%
1992	9,728	65	41	20	2.1%	2.0%	2.0%
1993	10,493	63	40	19	10.9%	10.8%	11.3%
1994	10,091	66	43	21	6.2%	6.2%	6.3%
Avg.	9,996	62	40	19	6.3%	6.3%	6.4%

* Based on published factors for "municipal street composite," based on the previous three year's worth of traffic data from 12 ATR stations in the state of Iowa.

TABLE 4 Sample Count Error Compared to Traffic Forecasting Error

Traffic AADT Range	Number of counts*	Forecasting error Avg.	Std. Dev.	Sample Count Error Unfactored (4)	Factored	Forecast error significantly different? (95% Conf. Int.) Unfactored (4)	Factored
0-5000	340	45.6%	40.6%	19.9%	14.9%	Yes	Yes
5-10,000	236	26.6%	19.6%	15.0%	11.2%	Yes	Yes
10-15,000	84	14.9%	10.6%	12.4%	9.3%	Yes	Yes
15-20,000	42	11.9%	11.0%	10.7%	8.0%	No	Yes
20-30,000	33	11.6%	7.5%	9.1%	6.8%	No	Yes
TOTAL	735	32.5%	32.8%	16.4%	12.3%	Yes	Yes

* On the modeled major street network in the year 1990.

prediction is lost due to the fact that the published factors introduce errors in space (use of other count locations with different traffic patterns) and time (use of the previous three years of traffic patterns rather than the current year). A separate analysis of one year's worth of peak hour counts in 1993 (Table 2) indicates that while the factors have a comparable impact on reducing the error of peak hour traffic estimation, AM peak hour counts have considerably higher variability than PM peak hour counts - which is consistent with previous research findings (*10,11*).

Also significant, as shown in Table 3, is that longer count periods - in the form of 48, 72 or 96 consecutive hour counts during the weekday - were found to make only a 5% improvement in the accuracy of AADT estimation (with factoring). This is consistent with previous research findings in which count days scattered across two or more weeks in a counting season are recommended instead of a focus on any one particular week of the year (*3*). However, this recommendation would prove more costly to agencies conducting such multi-day counts than use of consecutive-day counts.

Finally, the author's previous claim of traffic forecasting model error not being significantly different from sample count error locally is reviewed. As shown in Table 4, while modeling error was within the 95% confidence interval at relatively high-volume count locations (AADT greater than 15,000) based on the U.S. DOT's published estimate of error for unfactored counts (*4*), an assumed 25% reduction in count error due to factoring means that model error is now considered significantly higher than count error at all levels of traffic volume.

CONCLUSIONS

Due to local economic factors and the method used to factor counts locally, it would stand to reason that appreciable gains in count accuracy could be achieved by factoring to account for the day of the week and month of the year, as is the current practice in Iowa. The findings from this paper show that this is not necessarily the case - even if the day of the week and the month of the year can literally explain most variations in traffic counts. This finding is due to spatial (use of factors developed from different locations than the short-term count site) and temporal (year the short-term count was taken versus years of the ATR traffic data used to develop the factors) considerations. This finding may be disappointing to those who expect more from the count factoring process, but important for "end user" agencies to keep in mind when local count programs reach counter-intuitive conclusions and are called into question by policymakers or other recipients of traffic count information.

While it is customary to say that further research is always needed in the topic of discussion, it needs to be stressed that only one count location was utilized in this study. From a research perspective, this and the unexplained year-to-year variability in the impact of factoring the daily counts are the obvious weaknesses of this study. While this location may not have an atypical traffic pattern relative to the rest of the state or the country, other agencies interested in determining how accurate their sample traffic counts are likely to be (even with factoring) should do as much background work as

they can in determining any local variations to statewide or regional traffic patterns. The use of only one ATR station in this study is a function of both the limited geographic scope of interest to the author, and the limited number of ATR count sites deemed relevant within this scope. The study method is a base from which others may want to make improvements.

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REFERENCES

1. Davis, G. Accuracy of Estimates of Mean Daily Traffic: A Review. *Transportation Research Record* 1593, TRB, National Research Council, Washington, DC, 1997, pp. 12-16.
2. Sharma, S. et al. Statewide Traffic Volume Studies and Precision of AADT Estimates. *ASCE Journal of Transportation Engineering*, Vol. 122, 1996, pp. 430-439.
3. Davis, G. *Estimation Theory Approach to Monitoring and Updating Average Daily Traffic.* University of Minnesota, Minneapolis, MN. Research Report # 97-05, January 1997.
4. Ferks, R. et al. *Guide to Urban Traffic Volume Counting.* U.S. Department of Transportation, Washington, DC, September 1981.
5. U.S. FHWA, *Calibration and Adjustment of System Planning Models.* U.S. Department of Transportation, FHWA-ED-09-015, December 1990.
6. JHK and Dowling and Associates. *CalTrans Travel Forecasting Guidelines.* November 1992.
7. Iowa Department of Transportation. *Automatic Traffic Recorders 1988-1997.* January 1988.
8. Granato, S. A Case Study in Calibration: Refining Traffic Forecasting Models for Small Urban Areas. *PC-TRANS*, Spring 1994, pp. 12-15.
9. Stamatiadis, N. and Allen, D. Seasonal Factors Using Vehicle Classification Data. *Transportation Research Record* 1593, TRB, National Research Council, Washington, DC, 1997, pp. 23-28.
10. Erhunmwunsee, P. Estimating Annual Average Daily Traffic Flow from Short Period Counts. *ITE Journal*, November 1991, pp. 23-30.
11. Sharma, S. Minimizing Costs of Manual Traffic Counts: Canadian Example. *Transportation Research Record* 905, TRB, National Research Council, Washington, DC, 1983, pp. 1-7.