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EVALUATION OF THE CRASH EFFECTS OF THE QUEENSLAND SPEED CAMERA PROGRAM IN THE YEAR 2005

by

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Evaluation of the crash effects of the Queensland speed camera program in the year 2005

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Abstract:

This study extends the evaluation of the Queensland speed camera program reported in Newstead and Cameron (2003) and the update studies of Newstead (2004) and Newstead (2005) to estimate the crash effects of the program during 2005. It adds a further period of 12 months post program experience to that covered in the previous evaluations. Methods of evaluation and generic hypotheses tested are the same as in the previous evaluations.

Results of analysis showed the Queensland speed camera program resulted in sustained large crash reductions over the year 2005. Crash effects within 2km of a defined speed camera zone give the best indication of program performance with this area covering 84% of reported crashes in Queensland based on speed camera zones used up until July 2006. Analysis in this study estimated a reduction in fatal to medically treated crashes in this area of 49% during 2005 with a corresponding reduction in all reported crashes, including non-injury crashes, of 34%. These translate to annual savings of around 8,300 fatal to medically treated severity crashes and 9,800 crashes of all severity levels in 2005. Total savings in costs to society corresponding to these estimated crash savings were in the order of $2 billion.

Key Words:
Speed camera, speed enforcement, statistical analysis, road trauma, injury, collision, evaluation, research report

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EVALUATION OF THE CRASH EFFECTS OF THE QUEENSLAND SPEED CAMERA PROGRAM IN THE YEAR 2005

1. BACKGROUND AND STUDY AIMS

During 2003, the Monash University Accident Research Centre (MUARC) completed a comprehensive evaluation of the crash effects of the Queensland speed camera program. The evaluation estimated significant crash reductions due to the implementation and growth of the program in areas local to zones where speed cameras operated over the period from program commencement in May 1997 to the end of the evaluation period at June 2001. Full details of the evaluation and its findings appear in Newstead and Cameron (2003).

Since the end of June 2001, the period covered by the initial evaluation, the Queensland speed camera program has continued to grow in terms of its coverage of the Queensland crash population and in its hours of operation. In order to establish the effectiveness of the program in the period from June 2001 to December 2004, Queensland Transport commissioned MUARC to undertake two extensions of its original evaluation to cover this later period. The results of this study are reported in Newstead (2004) and Newstead (2005) and estimated sustained large crash effects of the Queensland speed camera program from June 2001 through to December 2004.

The broad aim of this research was to establish the effect of the speed camera program on crash frequency in Queensland over a further extended program post implementation than had previously been evaluated. Specifically, the study focused on the effects of the program over the full calendar year of 2005 in terms of:

- Percentage crash savings
- Absolute crash savings
- Social costs of the estimated absolute crash savings

2. EVALUATION DESIGN AND HYPOTHESES

2.1 EVALUATION DESIGN

The evaluation design used in this study is the same as that used in the original evaluation of the Queensland speed camera program by Newstead and Cameron (2003) and in the updated evaluations of Newstead (2004) and Newstead (2005). It is a quasi-experimental design, comparing crash history at sites influenced by the hypothesised speed camera effects against that at appropriately chosen control sites. The treatment area of the quasi-experimental design is the area within 6km of speed camera zones operational within the time frame of the evaluation data. As in the original study, the hypothesised treatment area has been broken into three separate annuli, 0km to <2km, 2km to <4km and 4km to <6km, in order to examine the possibility of different program effects as distance from the camera zones increased. All areas outside of the 6km hypothesised area of influence of the speed camera program served as the control area.

Like the original evaluation, the 'before' period in the evaluation design was defined as January 1992 to December 1996. Five years before treatment crash history was used in order to minimise possible regression-to-the-mean effects caused by the non-random selection of the speed camera operation sites (Nicholson, 1986). Complete reported crash data was available up to December 2005 giving a maximum post-implementation period from January 1997 to December 2005. Although the camera program was only implemented in May 1997, January to April 1997 was included in the post implementation period because of the presence of intensive publicity prior to the program launch.

2.3 EVALUATION HYPOTHESES TESTED

The generic null hypothesis tested in this evaluation is that the introduction of the speed camera program in Queensland had no effect on crash frequency in areas within a 6km radius of speed camera zones that had been used up to July 2006. This has been assessed against the two-sided alternative hypothesis that the introduction of the speed camera program has led to a change in crash frequency in the defined areas of influence. As a result of the study design, the alternative hypothesis also allows for differential crash effects of the speed camera program within each 2km annulus around the speed camera zones. A two sided alternative hypothesis used in this evaluation makes no presumption about the direction of the crash effects of the speed camera program and hence gives the most conservative statistical significance values on the program crash effect estimates. If a one sided alternative hypothesis is considered more appropriate by the reader (for example, if it is hypothesised that the program only reduces crashes of each severity level), statistical significance values presented should be halved, whilst the point estimates of crash effects will remain the same.

3. DATA

3.1 CRASH DATA

Queensland Transport provided data on all reported crashes in Queensland over the period January 1992 to December 2005 in unit record format. Each crash record had information in the following fields:

- Crash number
- Crash date
- Crash severity (fatal, serious injury (hospital admission), medically treated injury, other injury, no injury)
- Police region of crash
- Speed zone of crash
- Distance of crash from nearest operational speed camera zone centroid (km)

Data was defined as belonging to treatment or control groups using the distance of the crash from the centroid of the nearest approved speed camera zone. In the original study of Newstead and Cameron (2003), it was thought that the crash data had been labelled according to the distance of the crash from the nearest operational speed camera site. Since then, it has been established that the distance was actually relative to the nearest speed camera zone centroid, a labelling convention also used for the data in this update study and the previous update studies of Newstead (2004) and Newstead (2005). Because most speed camera zones only have between 1 and 2 operational sites on average (see Newstead and

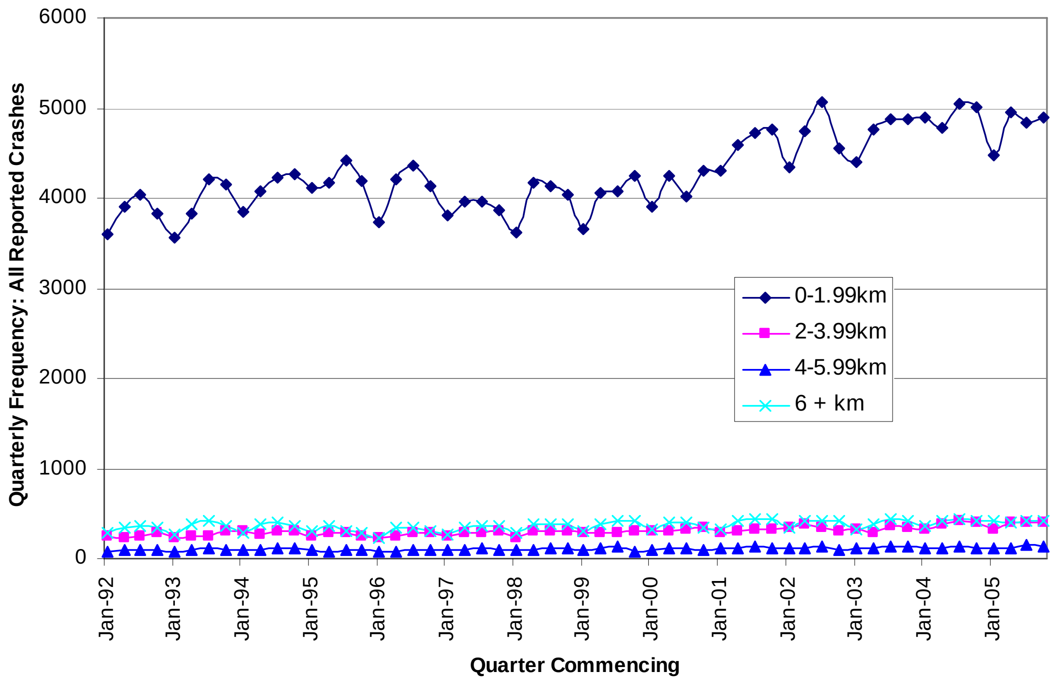
Cameron, 2003), the change in definition of the distance labelling made essentially no difference to the interpretation of the original study outcomes.

Within the 6km radius treatment group area, treatment group annuli were defined as: less than 2km from a speed camera zone; 2km or more but less than 4km from a speed camera zone and 4km or more but less than 6km from a speed camera zone. Control areas were all those outside the defined treatment annuli. Crashes were assigned as being in the before or after implementation periods using the date of the crash.

Queensland Transport assigned the distance of each crash in the data from the nearest approved speed camera zone centroid using Geographical Information System (GIS) software that related the physical location of crash sites and speed camera zone centroids. As in the original evaluation of Newstead and Cameron (2003) and the update studies of Newstead (2004) and Newstead (2005), the labelling of crash data with respect to the distance to the nearest speed camera zone, referred to any speed camera zone that had been used up to the time of matching the data (July 2006). This was irrespective of whether the camera zone had been used operationally or not at the time of the crash. Implications for the interpretation of analysis are as for the original study.

Figure 1 shows quarterly trends in all reported crashes in Queensland by distance from the nearest speed camera zone that had been operational to July 2006. It shows that around 84% of reported crashes in Queensland have occurred within 2km of a (eventual) speed camera zone centroid, rising to 91% when considering up to 4km from a speed camera zone. It also shows that around 7% of crashes happened a distance of 6km or more from the nearest speed camera zone (that became operational sometime during May 1997 to July 2006). These proportions are higher than found in the original study of Newstead and Cameron (2003), reflecting increased coverage of the Queensland crash population through continued growth in the number of speed camera zones utilised over the period July 2001 to July 2006. However, they are consistent with the proportions identified in the update study of Newstead (2005) suggesting program geographical coverage of the program has not grown significantly over the period from July 2005 to July 2006.

Figure 1: *Number of police reported crashes in Queensland by distance from speed camera zone*



4. METHODS

Net crash effects of the Queensland speed camera program under the quasi-experimental study design have been estimated using a Poisson regression statistical model. The analysis approach used here is the same as that used in the original study of Newstead and Cameron (2003) and the update studies of Newstead (2004) and Newstead (2005). A Poisson regression model was felt to be appropriate for analysing the crash data for a number of reasons. Firstly, crash count data is widely considered to follow a Poisson distribution (Nicholson, 1986). It is also constrained to be non-negative as well as often being highly skewed in distribution, both factors accommodated by the log transformation in the log-linear model. Furthermore, the log-linear model structure assumes factors affecting crash outcomes, such as road safety campaigns, affect crash numbers in a proportionate way. This is in contrast to a linear model that assumes additive affects of external factors and can hence predict negative crash numbers under certain circumstances. Poisson regression models are also commonly used in the analysis of experimental designs in medical research (Breslow and Day, 1987).

The form of the model fitted to the monthly crash data frequencies of treatment and control data for each crash severity considered is given by equation 1.

$$\ln(y_{ijm}) = \alpha + \beta_i + \delta_i m + \gamma_j + \phi_{ij} \ldots \text{(Equation 1)}$$

where

y	is the monthly crash count
i	is an indicator for treatment annulus or control series
m	is a linear month indicator variable
j	is the speed camera program indicator
$\alpha, \beta, \delta, \gamma, \phi$	are parameters of the model

The indicators in the model take the following values.

m	= 1 in the first quarter of data
	= 2 in the second quarter of data etc.
i	= 0; control series (crashes 6km or greater from a speed camera zone)
	= 1; outer treatment annulus (crashes less than 6km but 4km or greater from a speed camera zone)
	= 2; middle treatment annulus (crashes less than 4km but 2km or greater from a speed camera zone)
	= 3; inner treatment annulus (crashes less than 2km from a speed camera zone)

The speed camera program indicator, j, has been defined for annual program estimates as follows.

j	**= *0*** if month was before introduction of speed camera program
	= *1* if month was in the first year after introduction of speed camera program
	= *2* if month was in the second year after introduction of speed camera program
	etc.

The net effect of the speed camera program in treatment annulus *i* in time period *j* after program implementation measured as a net percentage reduction in crash frequency is given by Equation 2.

$$\Delta SpeedCamera_{ij} = (1 - \exp((\phi_{ij} - \phi_{i0}) - (\phi_{0j} - \phi_{00})) \times 100\% \qquad ...(2)$$

Equation 2 is measuring the change in treatment area crash frequency from before treatment to time period j after treatment, adjusted for corresponding changes in crash frequency in the control areas over the same time period.

In practice, parameterisation of the factors in the model given by equation 1 leaves parameters being 'aliased'. 'Aliased' parameters refer to those that are unable to be estimated because they are a linear product of other parameters in the regression design matrix. Aliased parameters are set to zero in the regression equation. With careful parameterisation and fitting of the model in equation 1, it is possible to alias the parameters ϕ_{0j} and ϕ_{i0} for all values of *i* and *j*. This leads to a reduction in Equation 2 to give Equation 3.

$$\Delta SpeedCamera_{ij} = (1 - \exp(\phi_{ij})) \times 100\% \qquad ...(3)$$

The form of Equation 3 is much more convenient in practice as statistical testing of the difference in ϕ_{ij} from zero tests directly the significance of the change in crash frequency in speed camera annulus of influence *i* in time period *j* after program implementation. Similarly, the variance of ϕ_{ij} can be used to compute confidence limits on the estimated change in crash frequency.

All Poisson log-linear regression models were fitted using the GENMOD procedure in the SAS statistical analysis software (SAS, 1993).

5. RESULTS

5.1 CRASH EFFECT ESTIMATES

Percentage Crash Reductions

Table 1: *Estimated percentage crash reductions attributable to the Queensland speed camera program for 2005.*

Crash Severity	Distance From Camera Zone	Estimated Crash Reduction *(Statistical Significance)*
Fatal and Hospital Admission	0-1.99km	42.33% *(0.0024)*
	2-3.99km	22.78% *(0.3357)*
	4-5.99km	-10.14% *(0.7936)*
Medically Treated	0-1.99km	48.31% *(0.0029)*
	2-3.99km	12.99% *(0.6513)*
	4-5.99km	-8.84% *(0.8474)*
Fatal to Medically Treated	0-1.99km	48.65% *(<.0001)*
	2-3.99km	20.55% *(0.2537)*
	4-5.99km	14.24% *(0.7759)*
Other Injury	0-1.99km	31.01% *(0.2248)*
	2-3.99km	-12.36% *(0.7906)*
	4-5.99km	44.52% *(0.345)*
No Injury	0-1.99km	10.95% *(0.4555)*
	2-3.99km	20.16% *(0.3038)*
	4-5.99km	2.46% *(0.9378)*
All Severity Levels	0-1.99km	33.94% *(<.0001)*
	2-3.99km	18.88% *(0.1359)*
	4-5.99km	1.84% *(0.926)*

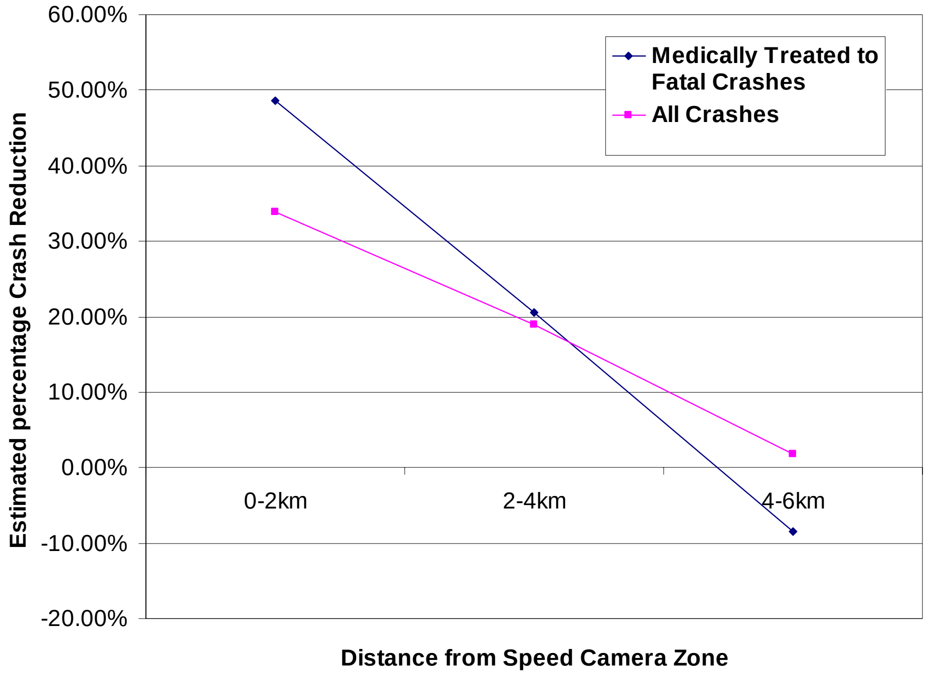
NB: Negative crash reduction estimates indicate an estimated crash increase

Results presented in Table 1 give the estimated crash reductions associated with the introduction of the Queensland speed camera program for the year 2005. The table presents both the estimated percentage crash reduction, where negative results indicated an estimated crash increase, as well as the statistical significance of each estimate. Low statistical significance values indicate the estimated crash reduction is not likely to have been obtained by chance variation in the quarterly crash data counts when no real crash reduction occurred. The information presented in Table 1 is an extension of that presented in Table 2 of Newstead and Cameron (2003) and in Table 1 of Newstead (2004) and Newstead (2005).

Table 1 shows sustained crash reductions attributable to the speed camera program in Queensland in 2005 and is particularly evident when examining results for higher severity crashes within 2km of speed camera zones. Estimated reductions in fatal and hospital admission crashes within 2km of speed camera zones are estimated to be 42%, with estimate being highly statistically significant. The estimated reduction is slightly higher in magnitude to previous estimates for the years 2001 to 2004 by Newstead (2004) and Newstead (2005). However, because the 95% confidence limits on the 2005 estimates overlap with those on estimates for previous years, it is not possible to say the 2005 estimate is statistically significantly higher than those for prior years.

Table 1 further confirms two general trends in the speed camera crash effects observed in Newstead and Cameron (2003) and in the update analyses (Newstead, 2004, 2005). Results show a continued differential effect of the speed camera program on crashes by crash severity level. Estimates of fatal to medically treated crash effects within 2km of speed camera zones are in the order of 40-50%, compared to other injury and non-injury crashes where estimated crash reductions are generally less than 30%. This point is illustrated in Figure 2 which plots estimated crash reductions in 2005 by annulus of influence for all crashes combined and for fatal, hospital and medically treated crashes combined. Figure 2 shows the clear differential of crash effects in the more severe crash severities in the 0-2km and 2-4km annuli compared to when the minor crash severities are included. This is particularly the case in the inner most annulus The differential becomes less clear in the outer annulus, however, it should be noted that the estimated crash effects for both these crash groupings are not statistically significant in the outer annulus (see Table 1). Results in Table 1 also show the continuing trend of estimated crash reductions being greatest nearest the camera zone (0-2km) and least in the furthest annulus (4-6km). This is also clearly illustrated in Figure 2.

Figure 2: *Year 2005 Percentage crash reduction by injury severity and distance from speed camera zone*



Absolute Crash Savings

Estimates of the absolute magnitude of crash savings attributable to the speed camera program during 2005, rather than just the percentage reductions shown in Table 1, are shown in Table 2. These have been derived by using the estimated annual percentage reductions in Table 1 along with the observed post-program crash frequency by crash severity level and annulus of influence. There are a number of ways of deriving actual crash savings from the percentage reduction estimates. This is because the Poisson log-linear model used to derive the percentage reduction estimates is a multiplicative form, being a product of the change due to non-treatment factors in the treatment group, reflected by the parallel changes in the control group, as well as changes attributed to the treatment itself. The absolute magnitude of crash change attributed to the treatment will depend on whether the control effects or the treatment effects are assumed to have influenced the treatment area crashes first. In the figures presented in Table 2, the effects reflected by the control group are assumed to have changed the treatment area crashes first, giving the most conservative estimate of the number of absolute crashes saved by the speed camera program.

Table 2: *Estimated total crash savings attributable to the Queensland speed camera program for 2005.*

Crash Severity	Distance From Camera Zone	Estimated Absolute Crash Saving
Fatal and Hospital Admission	0-1.99 km	3095
	2-3.99 km	123
	4-5.99 km	-15
Medically Treated	0-1.99 km	4236
	2-3.99 km	52
	4-5.99 km	-10
Fatal to Medically Treated	0-1.99 km	8288
	2-3.99 km	198
	4-5.99 km	-22
Other Injury	0-1.99 km	1173
	2-3.99 km	-18
	4-5.99 km	126
No Injury	0-1.99 km	959
	2-3.99 km	150
	4-5.99 km	4
All Severity Levels	0-1.99 km	9842
	2-3.99 km	354
	4-5.99 km	10

NB: Negative crash saving estimates indicate an estimated crash increase

It should be noted in Table 2 that the estimates of crashes saved for all severity levels combined and for fatal to medically treated crashes aggregated were not obtained by taking a sum of the estimates from the individual crash severity levels. They were based on specific estimates of crash effectiveness from the statistical procedures applied to data from those severity levels aggregated and, as such, will be more precise than estimates gained from simply summing the savings from the individual crash severity levels.

Table 2 shows the Queensland speed camera program has continued to result in significant estimated crash savings over the 2005 year. Reflecting the percentage crash savings shown in Table 1, Table 2 shows substantial savings in absolute crash numbers being estimated in the 2005 year. Net savings in crashes of all severities were estimated to be in the order of 10,200. Similarly, estimated net savings in medically treated to fatal crashes were around 8,400, a large proportion of the total savings.

As in Newstead and Cameron (2003) and Newstead (2004, 2005), translation of percentage crash costs into absolute crash savings by annulus of influence around the speed camera zones shows the majority of crash savings to be made in the 0-2km annulus. This reflects that both the highest percentage crash savings were estimated in this annulus as well as 84% of the Queensland crash population falling within this distance from a speed camera zone (Figure 1). As in the original study, assessment of the success of the program is best reflected in the crash savings in the 0-2km annulus.

5.2 CRASH COST SAVINGS ESTIMATES

Using the estimates of annual crash savings presented in Table 2 along with estimated crash costs, savings in crash costs attributable to the Queensland speed camera program over the 2005 year have been estimated and are given in Table 3. Crash cost figures used were those estimated by the Bureau of Transport Economics (BTE, 2000) by crash severity based on the human capital approach. In 2005 basis Australian dollars, the crash cost estimates from the BTE were $2,047,615 for a fatal crash, $505,390 for a crash resulting in hospital admission, $17,065 for a minor or other injury crash and $7,195 for a non-injury crash. Original cost estimates were given by the BTE in 1996 dollars. These have been inflated to 2005 dollars using the CPI difference between June 1996 and June 2005

In the original study of Newstead and Cameron (2003), the crash costs given by the BTE were adjusted by the Consumer Price Index at June of each program year. It was necessary to estimate crash costs using this method in the original study of Newstead and Cameron (2003) in order to compare them to annual program cost estimates to give an overall program Benefit-to-Cost (BCR) ratio estimate. Since a BCR estimate was not required for this study update, all costs have been given in 2005 Australian.

It is clear from the estimates in Table 3 that the Queensland speed camera program has continued to result in substantial savings to the community through reduced crash costs throughout the 2005 years.

Table 3: *Estimated total crash cost savings attributable to the Queensland speed camera program for 2005.*

Crash Severity	Estimated Crash Cost Saving to Society
Fatal + Hospital	$1,912M
Medical	$73M
Other	$22M
No Injury	$8M
Total	$2,016M

6. CONCLUSIONS

Analysis in this study has been able to update estimates of the crash effects of the Queensland speed camera program over the year 2005. It extends the initial evaluation of the speed camera program reported in Newstead and Cameron (2003) that estimated crash effects of the program only to mid-2001 as well as two update analyses of Newstead (2004) and Newstead (2005) which extended the period covered until December 2004.

Results of analysis showed the Queensland speed camera program resulted in sustained large crash reductions over the year 2005. Crash effects within 2km of a defined speed camera zone give the best indication of program performance with this area covering 84% of reported crashes in Queensland based on speed camera zones used up until July 2006. Analysis in this study estimated a reduction in fatal to medically treated crashes in this area of 48% during 2005 with a corresponding reduction in all reported crashes, including non-injury crashes, of 34%. These translate to annual savings of around 8,300 fatal to medically treated severity crashes and 9,800 crashes of all severity levels in 2005. Total savings in costs to society corresponding to these estimated crash savings were in the order of $2 billion.

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