City of Winston-Salem
Department of Transportation

Winston-Salem

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Safety Improvement Report
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INTRODUCTION

Statistically speaking, traffic crashes are rare events and most people go through their daily routines without experiencing them. However, the number of opportunities for crashes to occur is staggering. When the low probability of occurrence and a large number of opportunities to occur are combined and spread over a sizeable geographical area, crashes go unnoticed, quietly extracting a sizeable toll in both human and economic terms.

In human terms, 32,885 people died and nearly 2.4 million people were injured in traffic crashes in the United States in 2009. This is the equivalent of a jet liner, with 90 people onboard, crashing each day of the year without survivors. In North Carolina, in 2009, the toll was 1,344 people killed and 109,499 injured. Twenty-nine of these fatalities and 2,644 of these injuries happened in Forsyth County.

Crashes also extract a significant economic toll. A March 2008 AAA report[1] placed crash costs at 2.5 times those imposed by congestion. It also noted that nearly half of all the nonrecurring congestion resulted from traffic incidents. Thus, reducing crashes reduces both crash and congestion costs. In 2008, North Carolina's and Forsyth County's[2] annual traffic crash costs were pegged at $11.2 billion and $310 million respectively.

Congestion is an obvious, pervasive and real time phenomena that motorists experience each day. It impacts our quality of life. Crashes, on the other hand, are rare events that seem to have the most profound impact on the people involved, their families, friends and loved ones. It is clear that efforts to reduce both crashes and congestion should be areas of major emphasis.

The planning, construction, operation and maintenance of our transportation system is generally the responsibility of transportation departments and the planners, engineers and other transportation professionals they employ. However, responsibility for traffic safety has always been divided. Historically, the four pillars of traffic safety have been education, enforcement, engineering and emergency services.

Each profession involved with traffic safety has different metrics by which to measure its impact. Public education campaigns tend to measure their effects in terms of public awareness. The effectiveness of enforcement is usually measured in terms of citations written. Vehicle manufactures test to make crashes more survivable and add systems that help make crashes avoidable. Improved emergency medicine measures increases in survivability. Transportation engineering improvements measure their impact in improved mobility and reduced crashes.

The potential impacts and sustainability of each type of safety effort are also quite different. Public education and special enforcement efforts tend to have limited shelf

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[1] Crashes vs. Congestion- What's the Cost to Society, prepared for AAA, prepared by Cambridge Systematic, Inc. , Bethesda Maryland.

[2] North Carolina 2009 Traffic Crash Facts, North Carolina DOT's Division of Motor Vehicles, Raleigh, NC

lives and can be expensive. Improved vehicle designs help reduce injury and avoid crashes but, the benefits are only available to those driving the newest cars. Better emergency medicine increase survivability. However, effective traffic engineering improvements reduce crashes a benefit that accrue to all users all the time.

ENGINEERING BASED SAFETY PROGRAMS

Typically, traffic engineering based safety efforts follow a common methodology. A list of crash locations that meet some minimum threshold is produced. The list is ranked in some priority order. Locations are studied; countermeasures are designed and implemented at locations in the order of their ranking. It is the framework for traffic engineering based safety efforts that was first set out in the Highway Safety Program Manual, [3] which stemmed from the Highways Safety Act of 1966. It is a model that has served well, but it is a model that was targeted for state highway agencies with funds and staff designated specifically to carry out safety projects.

At the local level, funds are rarely designated specifically for engineering based safety projects. Many local governments have neither sophisticated crash data systems, nor staff to locate and prioritize and analyze possible countermeasures. Consequently, safety efforts are viewed as the responsibility of state agencies.

However, the nature of crashes suggests that a less strenuous, more clinical approach can be effectively employed. William Sacks,[4] defined 3 types of crash locations.

- Hazardous Crash Locations- Those with crash histories that are statistically aberrant.
- High Crash Locations - Those with crash histories that exceed the average.
- Critical Crash Locations - Those where some remedial action, to reduce the frequency and/or severity of crashes offers a desirable return on investment.

By definition, critical locations may or may not be hazardous or high crash locations. The notion of critical crash locations implies that places exist where crash remedies are easy to define and inexpensive to implement. (A group of crashes that may be overlooked by typical engineering safety programs.) If crash locations exist, that can be easily identified and inexpensively treated, an additional and simpler process may supplement exiting safety efforts.

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[3] U.S Department of Transportation, Federal Highway Administration, National Highway Safety Bureau, Highway Safety Program Manual, Volume 9, Identification and Surveillance of Accident Locations (Loss Prevention Analysis, U.S. Department of Transportation, January, 1969.

[4] Sacks William L., Testimony of the Highway Safety Foundation with Respect to S.893, The Highway Safety Act of 1973, Subcommittee On Transportation, Committee on Public Works, United States Senate, 93rd Congress, 1st Session, Washington, D.C., 1973.

A LOW COST SAFETY IMPROVEMENT PROGRAM (ANOTHER TOOL)

A Low Cost Safety Improvement Program is a derivative of the traditional approach. While it employs many of the same type of analytical tools used in traditional program's, it does not rely on the production of elaborate priority lists or funds designated only for safety projects. It is an everyday part of traffic engineering activities and uses traffic maintenances forces and traffic signs, traffic signals and traffic markings to produce quick, and inexpensive safety improvements.

The low cost approach is simple and straightforward. If a location displays a pattern or patterns of crashes, and a possible remedy is evident, the location is treated and the treatment is evaluated. Locations can be identified in any number of ways including: inquiries from citizens or the press, problems discovered while conducting other traffic engineering studies, complaints, computerized listings, etc.

WINSTON-SALEM'S LOW COST SAFETY IMPROVEMENT PROGRAM

When questions arise about a location, a collision diagram is prepared, usually from police crash reports that are filed by location. If the diagram shows a pattern or patterns of crashes, the site is visited, traffic operations are observed, existing conditions noted, the collection of other relevant data occurs and possible countermeasures are considered. If a countermeasure is chosen, traffic maintenance forces implement the change and the collisions diagram showing the, "Before," conditions is finalized. A second collision diagram is opened to record the location's crash history until the After period equals the Before period. (Typically, before and after periods each contain 3 to 4 year of data.) The final before and after collision diagrams are compared, evaluated and the results catalogued in a safety library. Since countermeasures are targeted at a specific crash pattern or patterns, the location is evaluated based on the change in the targeted pattern(s). However the change in its overall crash frequency and changes in the overall frequency of injuries and the dollar value of property damage are also monitored. At any location, the change in Total Crashes attributable to a particular countermeasure is at best proportional to the change in Targeted Crashes.

Locations that require more complicated and expensive countermeasures are also evaluated and included in the program once funds are found and the projects are built.

It is our goal to include at least 150 crash locations in our program annually. Typically, 1/3 or more of these cases come directly from citizen input. Each year we produce a two volume report. The first volume is an executive summary showing its historical impacts and changes in targeted crashes, total crashes, injuries, and property damage aggregated over the history of the program and for each location currently under study. The second volume shows before and after collision diagrams at each of the 150+ locations currently under study. The program also maintains a library of completed before & after studies. The library is updated annually as evaluations become final.

The program does not spend a significant amount of time and effort on the problem identification phase of the process. Any problem, deemed correctable is addressed. Similarly, the program does not spend significant time on countermeasure selection since the tools used to fix problems are generally low cost and limited to basic traffic engineering tools and techniques available. Evaluation involves the simple comparisons of percentage changes, in before and after crash counts, observed over equal time periods. The percentage changes are tested using a simple graph of the Poisson Distribution form Lunenfeld.[5]

HISTORICAL PROGRAM RESULTS

What can a Low Cost Safety Improvement Program contribute to a community?

For 25 years, Winston-Salem's Department of Transportation has engaged in clinically based low cost ,traffic engineering based safety program. It has completed 858 studies that measure the changes in traffic crashes, at locations, before and after changes in traffic control, or the roadway were made. This data has been compiled into a safety library that is an evolving body of knowledge about the effects of particular countermeasures to reduce certain types of crashes. Table's I & II include all the data in the crash library. Tables III & IV present data on specific crash problems and their solutions with at least 5 completed before and after studies.

TABLE I
SUMMARY OF RESULTS FOR
858 COMPLETED BEFORE & AFTER STUDIES

	BEFORE	AFTER	%CHANGE
TARGETED CRASHES	8,502	4,078	-51%
TOTAL CRASHES	18,659	15,129	-18%
# OF INJURIES	11,058	7,575	-31%
PROPERTY DAMAGE	$52,297,979	$41,916,241	-19%

TABLE II
SUMMARY OF CHANGES FOR
816 COMPLETED BEFORE & AFTER STUDIES

	# DECLINES	# INCREASES	# TIES	% DECLINE
TARGETED CRASHES	726	95	36	84.6%
TOTAL CRASHES	588	231	39	68.5%
# OF INJURIES	578	229	42	67.4%
PROPERTY DAMAGE	573	280	5	66.8%

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[5] Luenfeld, Harold, "Evaluating Traffic Operations, Safety and Positive Guidance Projects," Traffic Performance and Program Division, Office of Traffic Operations, Federal Highway Administration, Washington, D.C. , 1980

Table I, aggregates and summarizes the results of these 858 studies in terms of their impact on targeted crashes, total crashes, injuries and property damage for the 25 years of the program's existence. These results reflect the change measured between before and after periods of equal or nearly equal lengths. Over the programs history targeted crashes have been reduced by 51%, total crashes by 18%, injuries by 31% and property damage by 19%. Since many of the interventions continue to provide safety benefits well beyond the after period the true impact of the program is likely understated.

Table II presents another perspective of the same data. It looks simply at each of the 858 completed studies and determines if targeted, and total crashes and the injuries and property damage they produce, increased, decreased or remained constant upon completion of the after study. In nearly 85% of the studies crashes targeted for reduction are reduced. In about 2/3rd of the studies total crashes, injuries and the $ value of property damage are reduced following treatment. When evaluated statistically, the number of locations where targeted crashes, total crashes, injuries and property damage decline are each well above the levels that chance would predict.

Tables III & IV presents data on specific crash problems and their solutions at signalized and non- signalized locations. The first column defines the type of problem treated i.e. targeted crashes. The second column describes the treatment or countermeasure employed. The third column identifies the number of completed studies associated with a particular treatment. The fourth column shows the overall percentage reduction in targeted crashes associated with each treatment. The last column shows the overall percentage reductions in total crashes associated with each treatment.

TABLE III
SUMMARY OF PROBLEMS & TREATMENTS
WITH 5 OR MORE COMPELTED STUDIES
Signalized Locations

Problem	**Treatment**	**Studies**	**%Change Targeted**	**%Change Total**
Angle Crashes	Change 8” signals to 12”	102	-47.4%	-12.6%
“	Add Backplates	24	-42.4%	-10.5%
“	Install 1sec. All Red	7	+1.2%	+6.7%
“	Add Auxiliary Signal Head	17	-51.4%	+3.4%
“	Install Signal Ahead Signs	12	-36.1%	-6.3%
“	Red T Display	15	-34.1%	-0.3%

TABLE III
SUMMARY OF PROBLEMS & TREATMENTS
WITH 5 OR MORE COMPELTED STUDIES
Signalized Locations
Continued

Problem	**Treatment**	**Studies**	**%Change Targeted**	**%Change Total**
"	Install 2 sec. All Red	5	-31.6%	- 19.0%
"	Change to farside display	5	+24.9%	-14.9%
"	Install LED signals	5	-12.9%	-30.7%
"	Change 8" to 12" signals + Signal Ahead Signs	6	-35.5%	-11.2%
"	Change 8" to 12" signals + Change to Far side display	8	-48.4%	-31.4%
"	Install Directional Signs	6	+26.0%	-5.2%
Nite Angle Crashes	Remove signals from late nite/ early a.m. flash program	45	-82.4%	-28.8%
Left-Turn Crashes	Create left-turn lane within existing roadway width	9	-69.4%	-19.1%
"	Add l-turn signal phase(s)	33	-74.6%	-11.3%
"	Replace protected/permissive phase with protected only	12	-96.8%	-6.9%
Rear-End Crashes	Add Auxiliary Signal Head	6	+21.4%	+9.7%
Sideswipe Crashes	Advanced Signing	5	-44.6%	-8.9%

TABLE IV
SUMMARY OF PROBLEMS & TREATMENTS
WITH 5 OR MORE COMPELTED STUDIES
Non Signalized Locations

Problem	Treatment	Studies	%Change Targeted	%Change Total
Angle Crashes	Install centerlines & stop bars on Stop approaches+ change 24” Stop signs to 30”	6	-67.4%	-44.9%
“	Install centerlines & stop bars on Stop approaches	38	-53.7%	-34.7%
“	Install All-Way Stop	56	-85.9%	-73.8%
“	Add left side Stop sign	25	-34.5%	-7.1%
“	Add Stop Ahead Message on pavement	8	-27.1%	-6.4%
“	Replace Yield with Stop	8	-76.6%	-26.9%
“	Move Stop Bars to extended curb line + left side Stop sign	32	-33.6%	-16.2%
“	Move Stop Bars to extended curb line	40	-33.6%	-1.8%
“	Install traffic signal	39	-71.9%	-23.1%
“	Install centerlines & stop bars on Stop approaches + Stop Ahead Message on pavement	6	-24.1%	+6.1%
“	Install median	5	-87.5%	-63.9%
“	Add left side Stop sign + Install centerlines & stop bars on Stop approaches	10	-64.4%	-40.4%
“	Realign int. to 90 deg.	6	-13.3%	+67.3%
“	Trim Trees	8	-25.9%	+6.2%

TABLE IV
SUMMARY OF PROBLEMS & TREATMENTS
WITH 5 OR MORE COMPLETED STUDIES
Non Signalized Locations
(continued)

Problem	Treatment	Studies	%Change Targeted	%Change Total
“	Install Stop Bar	5	-66.8%	-37.2%
Left Turn Crashes	Create left-turn lane within existing roadway	5	-52.9%	+23.2%
Rear End Crashes	Create left-turn lane Existing roadway	11	-91.2%	-28.2%
“	Build left-turn lane	6	-97.4%	-47.8%
“	Build/Improve Accel. Lane	9	-96.8%	-83.2%
“	Replace Yield w. Stop	5	-3.3%	-8.9%
Ran off Road Hit fixed Obj.	Install Chevrons	8	-67.9%	-10.8%
“	Move Fixed Object	5	-46.7%	-24%
“	Add Vertical Clearance Signs	5	+10.7%	+28.4%
“	Install Double Arrow Panel	5	-91.6%	-29.7%

The data in Tables III & IV account for nearly 75% of all the completed before and after studies in the library. It is important that the data on the percentages changes in targeted and total crashes not be interpreted as Accident Modification Factors. Simple before and after studies lack the rigor to produce information of that quality. However, the percentage changes give a direction and an order of magnitude to changes in crash frequency that can be achieved by using traffic engineering tools and techniques in a simple low cost safety improvement effort.

CURRENT RESULTS

Table V shows Targeted & Total crashes at the 103 locations in this year’s program. The table shows the number of months and the number of targeted and total crashes in the Before & After periods. The evaluation section shows the expected number of these crashes and the percentage change. The column titles STAT. SIG.? notes whether the change is statistically significant according to the Poisson distribution test. The column contains two responses separated by a slash. The first pertains to Targeted Crashes; the second to Total Crashes. **Yes** means the change is statistically significant, **No** means it is not and **NA** mean it can't be measured. (Too few crashes in the sample.) The last column entitled EVAL. TYPE notes the location's status in the program. **Final** means the study has ended this year. **Interim** indicates the study is continuing, and **New** means it was initiated this year. New cases do not have evaluation data available. The appendix contains a similar table that summarizes injury and dollar value of property damage data for each location in this year's program.

HIGHLIGHTS

Table V is lengthy, presenting data on each location in the Program. Highlights from the table follow:

- Of the 109 locations in this year's program, 42 locations had final evaluations, 58 locations are in the interim phase and 9 new locations entered the program.

- Among the 42 locations with final evaluations, Targeted Crashes were reduced by 63%.

- Among the 58 locations with interim evaluations, there is currently a 65% reduction in Targeted Crashes.

- Of the 42 locations with final evaluations, 22 of the measured declines in Targeted Crashes were statistically significant at the 95% confidence limit. Under random conditions, one might expect to find two statistically significant decline.

- Six of the 42 locations with final evaluations had too few Targeted Crashes during the before period to permit an individual statistical evaluation. In one of these cases, Targeted Crashes were eliminated; in four cases they were reduced and in one there was an increase.

- In 35 of the 4 final cases Targeted Crashes declined, in 4 cases there was no change and in 31 cases they increased. When tested statistically, the likelihood of observing 25 declines in 38 cases (ties must be omitted) is nearly 0, ruling out chance as the agent of change.

- Of the 58 locations with interim evaluation data, 16 of the measured declines in Targeted Crashes are currently statistically significant at the 95% confidence limit.

- Seven of the 58 interim cases have too few Targeted Crashes in the before period to be statistically evaluated. There have been no Targeted Crashes at five of these locations. Targeted crashes have declined at the other two location.

- Presently, in 55 of the 58 cases with interim data, Targeted Crashes are declining.

They are increasing in 3 cases. The likelihood of observing 55 declines in 58 cases is less than 1 in 1,000 ruling out chance as the agent that is producing these changes.

DISCUSSION & CONCLUSIONS

Howard Anderson[6] writing in the December 1976 issue of Traffic Engineering magazine, maintained, that, “engineers can contribute the lions share to the reduction of accidents on our nation’s highways.” While what constitutes, “the lions share,” can be debated, the results produced by Winston-Salem’s program show that basic traffic engineering efforts focused on safety can prevent crashes. Using only traffic engineering tools and techniques to reduce targeted crashes by more than half, speaks volumes about the role traffic engineers can and should play.

It should be noted that locations selected and treated in the Winston-Salem data rarely were sub-standard as defined by the Manual of Uniform Traffic Control Devices or other engineering documents. In fact, the treatments used in the program (Tables III & IV) tend to be enhancements or supplement existing standard traffic control elements. Simply assuring that standards are met does not ensure safety

There is also other evidence of the program’s contribution to crash reduction. In the booklet entitled, North Carolina Traffic Crash Facts 2009[7], cities with 10,000 or more population are given a composite ranking based on reported crashes, crash severity and crash rates based on population. The higher the ranking, the safer the city is judged to be. Currently 70 cities are ranked so rankings run from 1 to 70. Winston-Salem, which is the state’s 4th largest city, ranked 14th in this composite scale. This ranking is better than any of our peer cities, Charlotte, Greensboro, and Raleigh and clearly is better than many smaller towns.

Because Winston-Salem comprises a large portion of Forsyth County the program also contributes to a much better than expected ranking for the County too. Forsyth County is listed as the 4th most populous county in the state, has the 4th highest number of registered motor vehicles and also ranks 4th in annual vehicle miles of travel. Despite ranking near the top of each of these categories, Forsyth County’s crash rate was ranked 85th in the state.

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[6] Anderson, H. L., “Let’s Try to Dispel Some Highway Safety Myths,” Traffic Engineering, Volume 46, No. 12, Institute of Transportation Engineers, Washington, D.C. , 1976

[7] North Carolina 2009 Traffic Crash Data, North Carolina, Raleigh, NC

In the end Winston-Salem's Safety Improvement Program is:

Responsive- looking at locations suggested by citizens, the press and other sources, where pattern of crashes suggest a possible countermeasure.

Accountable- defining, in advance, the reduction in crashes necessary for any improvement to be judged successful.

Responsible- using information on the program's past successes and failures to help choose future countermeasures.

Economical- using existing resources and low cost, easily implemented solutions.

Simplicity, in terms of time and effort is essential if local governments are going to be involved in safety efforts. Clearly, the model employed by Winston-Salem is simple in every aspect from problem identification, countermeasure selection, implementation and evaluation.