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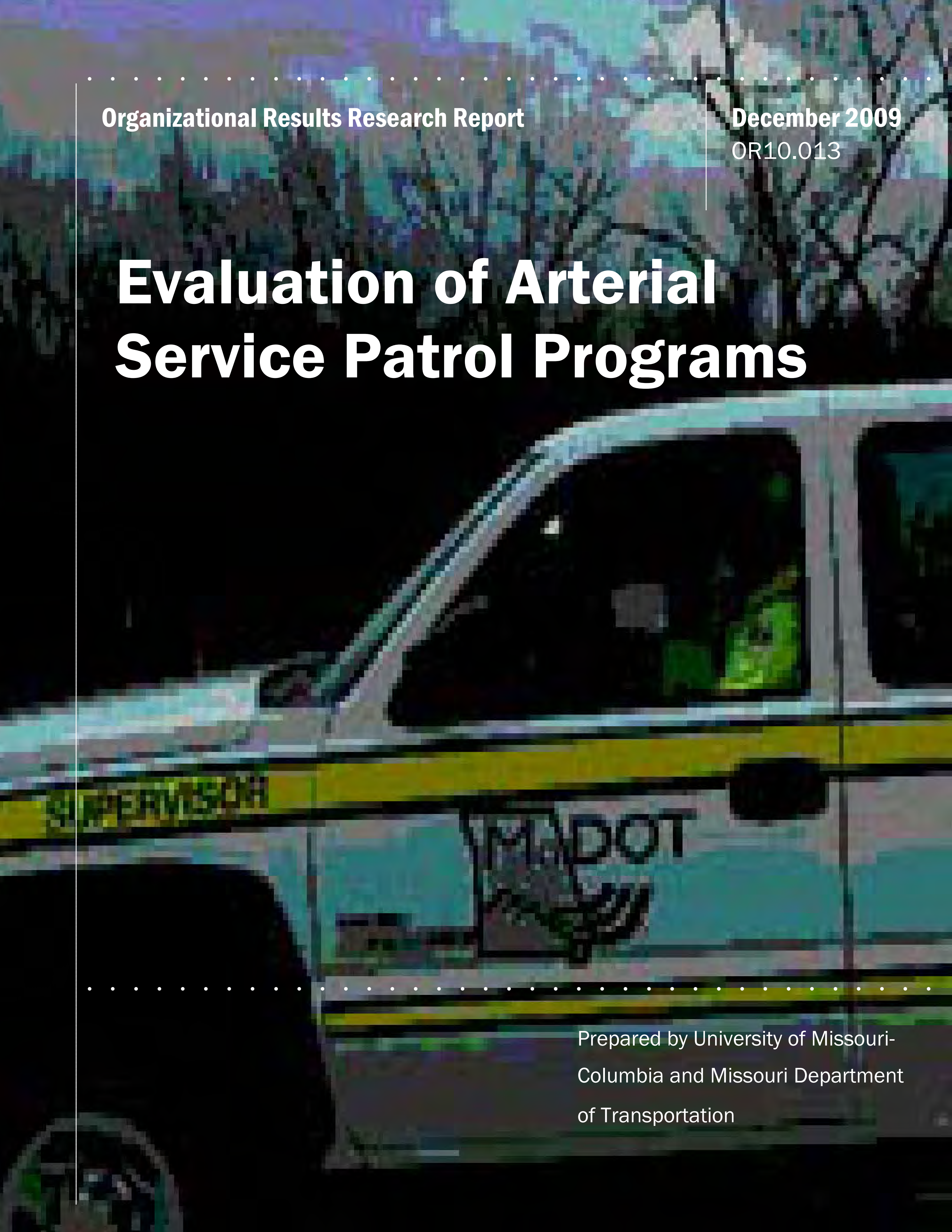
Evaluation of Arterial Service Patrol Programs



Prepared by University of Missouri-Columbia and Missouri Department of Transportation

Evaluation of Arterial Service Patrol Programs

MoDOT Project RI 09-004

Tom Ryan, Venkat Chilukuri, Michael Trueblood
HDR Engineering
326 S. 21st Street, Suite 400
St. Louis, MO 63103
Phone: (314) 425-8300
Fax: (314) 425-8301
E-mail: thomas.ryan@hdrinc.com

Carlos Sun
University of Missouri – Columbia
Department of Civil and Environmental Engineering
E2509 Lafferre Hall
Columbia, MO 65211
Phone (573) 884-6330
Fax (573) 882-4784
E-mail csun@missouri.edu

MoDOT Project Monitor: Tom Blair, District-6
MoDOT Project Liaison: William Stone, Organizational Results

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16. Abstract

This evaluation of the Arterial Service Patrol named I-64 Traffic Response (TR) is an interim report covering the first full year of operation. This Arterial Service Patrol was part of a regional traffic management strategy to address mobility issues during the two-year full closure I-64 construction project. Initial results shows an estimated conservative annual benefit-cost ratio of 8.3:1 based on the factors of traffic delay, emission impact, secondary crash, and staff savings. This Interim Report will be updated and finalized as part of the 2009 Annual Report for I-64 Economic and Regional Mobility Impact Study. The Interim Report was developed to help assist MoDOT in their initial evaluation of the arterial service patrol program. TR services can be viewed as vital component of an overall Traffic Incident Management (TIM) strategy. Responders, such as the police, validate this perspective by commenting that TR is better equipped to handle traffic control, which allows the police to take other actions such as investigating the incident. The evaluating team initial recommendations are:

1. TR is valid best practices when a major construction impacts a region's mobility
2. TR should be considered as viable TIM's strategies when addressing major urban region's safety and traffic congestion concerns

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RESEARCH RESULTS

A sustainable transportation system requires better utilization of available limited resources to deliver a **safe** and **efficient** transportation system. Sustainability is the act of balancing the environmental, community, and economic needs of the man made and natural environments that we live in for present and future generations.

MoDOT is a national leader in developing and implementing Traffic Incident Management (TIM) elements as part of a Missouri transportation system. From their successful Motorist Assist (MA) programs in St. Louis and Kansas City to their statewide Emergency Response (ER) efforts on major interstates, they are partnering with other emergency response staff to better utilize resources to deliver a quicker and safer clearance of incidents along major congested roadways. Through these TIM efforts, MoDOT and partners are providing a more sustainable transportation system that addresses the three elements of sustainability: environment, community and economy through the achievement of a safer and more efficient transportation system.

This study builds on previous regional TIM - MA evaluation efforts and presents the results of the evaluation of the arterial service patrol (I-64 Traffic Response, TR) deployed during the I-64 major construction project to demonstrate the value of TIM practices on major arterials. The following is a summary of findings:

<u>**I-64 Traffic Response Program**</u>

- **Conservative benefit-cost ratio is 8.3 to 1**
- **Reduced 183 secondary crashes per year with a potential annual benefit social of $4,980,468**
- **Reduced $1,034,000 in annual congestion cost**
- **Supports Community Emergency Response**
  - **Safer and Quicker Incident Response and Clearance**
  - **Reduction in ER resources for TIM activities freeing them up for other Community needs**

The three elements of sustainability are present in the St. Louis Regional TIM activities. Environmental issues pertain to both natural and man made environments in which we live. Improved air quality and safer transportation facilities are direct benefits for the community.

The community's transportation needs are better served when regional partners work cooperatively together to maximize limited resources. Having the right person (i.e. TR Operator) doing what they are trained for (i.e. traffic control) can save lives and time while improving the quality of life for those living in or traveling through the community.

A region's economy is strongly linked to how well their transportation system performs. The movement of people and goods impacts everyone from their travel expenses to the products they purchase. Improving safety and reducing traffic congestion gained through TIM activities will save lives, time, and money.

Everyone wins – the traveling public gains improved safety and reduced travel times at less cost. Emergency Response gains improved safety within incident sites and reduction in time spent on scene through quicker coordinated clearances. Highway agencies (MoDOT and St. Louis County) gain improved traffic flow along their transportation facilities with results in improved satisfaction of the traveling public that financially supports regional emergency response and highway agencies.

EXECUTIVE SUMMARY

A sustainable transportation system requires better utilization of available limited resources to deliver a **safe** and **efficient** transportation system. MoDOT is a national leader in developing and implementing Traffic Incident Management (TIM) elements as part of the sustainable transportation system in Missouri. From their successful Motorist Assist (MA) programs in St. Louis and Kansas City to their statewide Emergency Response efforts on major interstates, they are partnering with other emergency responders to better utilize resources to deliver a quicker and safer clearance of impacting incidents along major congested roadways. Through these TIM efforts, MoDOT and partners are providing a more sustainable transportation system that helps to achieve the two foremost objectives of providing safer and efficient travel in Missouri.

This document presents the results of the evaluation of the arterial service patrol (I-64 Traffic Response – TR) deployed during the I-64 major construction project to demonstrate the value of TIM on major arterials. The following is a summary of findings:

- I-64 Traffic Response conservative benefit-cost ratio was 8.3:1
- I-64 Traffic Response reduced 183 secondary crashes per year
- I-64 Traffic Response reduced $1,034,000 in annual congestion cost

In this interim report, an initial evaluation of the I-64 Traffic Response (TR) program was also performed by examining representative arterial segments. TR is an arterial service patrol that travels and monitors major adjacent arterials along I-64 within the triangle area of I-70 (North) – I-44 (South) and Missouri Route 141 (West). This program will operate for a two-year period while I-64 is closed for re-construction. The interim report covers the first year of operation and will be finalized when the second year operation can be considered and included into the report.

The I-64 Traffic Response program, as a mobility strategy for I-64 construction project, can be considered a successful component of the region's mobility plan. Traffic movement along adjacent arterial corridors has seen peak period traffic demand increased up to 50% with only minor impacts. The I-64 Traffic Response program has played a major role in making this happen. Conservative estimates in the four assessment areas – traffic delay cost, emission impact cost, secondary crash cost and response staff savings shows a benefit/cost of 8.4. This evaluation will be updated when 2009 traffic information becomes available.

The additional 2009 traffic information will provide two post-deployment years and should help further validate and strengthen initial findings. The Final I-64 Study Report, which will be published in late 2011, is exploring the potential impacts from a major construction project that has 2-year full closure. The I-64 Traffic Response program was deployed as mobility strategy to improve travel in the region.

Traffic models were developed along two adjacent arterial corridors that demonstrated traffic delay and emission impacts that could occur if a lane was closed due to an incident. The output from these traffic models was used to establish cost for traffic delay and emission impacts. Based on field records and an on-going survey conducted throughout the entire 2008 year, estimated cost for delay and emission were calculated on actual incident information. A very conservative savings of $1,034,078 were determined for traffic delay and emission savings. Since these savings were only developed based on one year of data, a year two evaluation will be performed to determine if the estimates developed can be demonstrated in year two.

Impacts from secondary crashes that result from another incident were assessed on state-only roadways in 2008. The I-64 Study report will be updated in the future to reflect county roadways served in the region by the arterial service patrol program along with 2009 crashes. The $4,980,468 potential savings were based on the following:

1. A crash reduction estimation of 5% that all crashes are secondary crashes. This estimation was based on previous study done in St. Louis.
2. From information gathered in hand-out service surveys and the output of traffic models developed to assess impacts from incident lane closures, we concluded that about 50% of secondary crashes could be reduced. This estimation was based on quicker responses to incidents would reduce associated secondary crashes.

Comparing 2008 (7,323 total crashes) to the annual average of the four pre-construction years 2004 through 2007 (8,086 total crashes), the estimated 184 secondary crashes that could have been potential reduced is reasonable.

Figure I show the difference in Incident Progression Curves (IPCs) between average arterial and freeway incidents. IPCs represent the temporal and spatial zones of influence of a primary incident. Figure I show that freeway incidents have a much larger zone of influence, thus explaining differences in B/C between arterial TR and freeway MA programs. While this additional crash evaluation was developed and reviewed in this interim evaluation, its content will be explored further in the final report to further validate and confirm the 5% factor used.

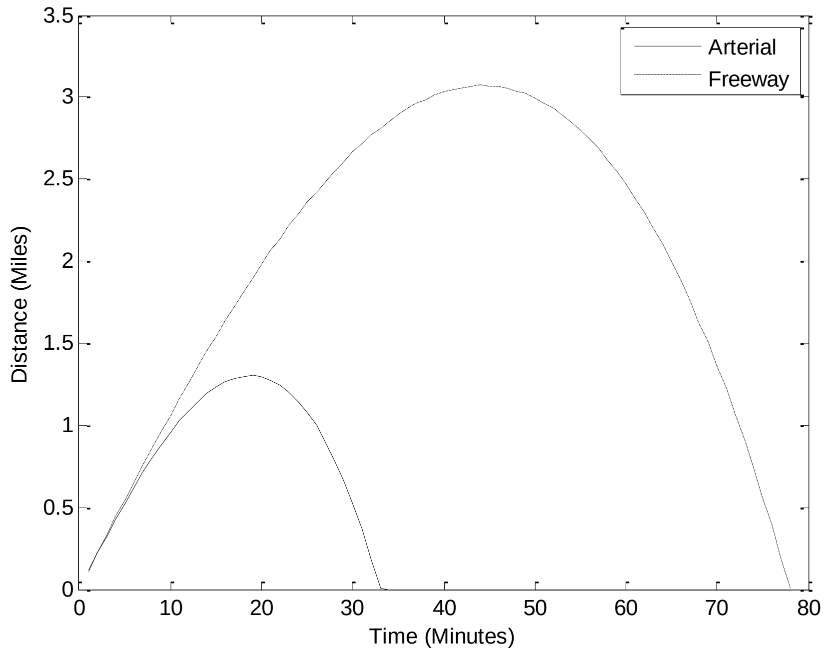

Figure I. Comparison between Arterial and Freeway IPCs

The final area was the reduction or savings experience in having the I-64 Traffic Response available to respond in a timely manner thus reducing the need for others to respond. This savings was $57,977. This permits police, highway department employees, and others to continue their other normal duties without being called to response to various related incidents.

The results from this project show that the utilization of a service patrol to manage incidents along adjacent arterial corridors for the major construction project along I-64 has merit and serves the traveling public well.

TR enhances the overall Traffic Incident Management (TIM) strategy. Interviews with police agencies consistently affirm the MA/TR service patrol's have excellent working relationships with police, and the service patrol's value in handling traffic control in TIM related incidents which enables police to focus on other high priority duties. As a result of the benefit-cost analysis, evaluators recommend:

- In future projects, arterial TR should be considered as mobility strategy for all major construction with extended periods of full closures or major reduction of traffic capacity along the corridor under construction.
- In the development of this interim report, the study team concluded that an arterial TR program could be a valuable mobility strategy in address non-recurring congestion along major arterials. As part of the final report, the study team will further explore and evaluate the following potential factors:

    - Regional and Corridor characteristics that could serve as a guideline in selecting potential corridors for inclusion into a regional arterial TR program.
    - Regional characteristics should take a holistic regional view of the importance a corridor plays in managing and moving traffic during peak periods or during major incidents. Does the corridor serve as a major arterial in moving commuter traffic or does the corridor serve as a major alternative route during an incident on adjacent higher level roadways?
    - Corridor characteristics should take a segmental corridor view that considers corridor traffic demand, roadway capacity, and historical crash and incident information. Volume to Capacity (v/c) ratio, Level of Service (LOS), Travel Time Index (actual speed divided post speed), crash rates and incident information are performance measurements that indicate potential impacts that could be used in determining the corridors that would benefit most from TR services.
- Priority corridors could then be determined and standard operating procedures (SOP's) developed based on regional and corridor characteristics. A dispatch service approach using TMC or 911 Center operators to dispatch TR services based on known TR operators' availability and response time to the incident. The availability of regional ITS components could further assist in the dispatch process in determining the potential impact of the incident.

GLOSSARY

B/C	Benefit-to-cost ratio: a popular method for assessing the societal benefits against the costs of a particular project or alternative.
Gateway Guide	The Intelligent Transportation Systems initiative in St. Louis, Missouri, which includes a regional Traffic Management Center.
FSP	Freeway Service Patrol: a service provided by departments of transportation that involve patrolling sections of roadways, managing incidents, and assisting motorists.
IPC	Incident Progression Curve: a curve displaying the queue resulting from incidents over time and space that is used for classifying secondary crashes.
MA	Motorist Assist: a freeway service patrol program in the St. Louis region that includes Emergency Response in the off hours.
TIM	Traffic Incident Management: the systematic, planned, and coordinated use of human, institutional, mechanical, and technical resources to reduce the duration and safety and mobility impact of incidents.
TMC	Traffic Management Center.
TR	Traffic Response: arterial service patrol of roads adjacent to the I-64 reconstruction project to address traffic problems and motorist issues and keep traffic moving.
ER	Emergency Response: are resources, including police, fire, ambulance, wrecker services, etc., needed to assist in clearance of incidents from transportation facilities
VMS	Variable Message Sign.

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1. INTRODUCTION

This interim report presents the results from an initial evaluation of the I-64 Traffic Response (TR) program.

1.1 I-64 Traffic Response Strategy

This report is intended to document an evaluation of the implemented mobility strategy on the New I-64 construction project. This construction project will improve more than ten miles of an urban interstate facility that carries daily traffic volumes approaching 170,000 vehicles per day. During the regional traffic management planning process, diversion of traffic onto adjacent arterials was recognized as a potential concern based on the full closure construction approach being used on this project.

Critical Arterials were identified and mobility strategies were developed that would support increased traffic flow conditions on these arterials. The I-64 Traffic Response Program was one of those strategies identified and implemented. **One primary function of this report is to evaluate the effectiveness of the I-64 Traffic Response program as a mobility strategy for the New I-64 construction project.** This program is jointly sponsored by St. Louis County and MoDOT. This arterial service patrol was deployed to help reduce potential mobility impacts along adjacent arterial corridors based on anticipated traffic diversions from the I-64 construction project.

Service patrols are widely used across our national freeways to assist in reducing impacts caused by non-recurring congestion events (i.e. crashes, stalled vehicles, etc.). Some limited deployments have been used on arterials to address traffic flow impacts caused by major construction projects, major incidents, special major events, etc.

The St. Louis area already has a highly successful freeway service patrol identified as the MA program. They also have an Emergency Response program that supports police, fire, other emergency response staff and the general public during night-time and off peak weekend periods. The I-64 Traffic Response, along with these two current programs, provide emergency and traffic incident management support for both state- and county-managed and operated roadways.

I-64 Traffic Response Program's Purpose is to minimize the duration of incidents by responding with minimal delay to clear incidents and restore access to all traffic lanes. The achievement of this purpose will ensure that maximum traffic capacity is maintained thus minimizing motorists' delays. An incident/event is defined as any roadway impact that occurs along the roadway or shoulder areas that can reduce traffic capacity flow (i.e. debris, stalled vehicle, crash, etc.).

The following Table 1.1.1 provides general information on the I-64 Traffic Response Program:

Table 1.1.1 I-64 Traffic Response Program

Staffing	Hours of Operations	Equipment
1 – Supervisor	Weekdays 5 am to 9:30 pm	6 – Pick-up Trucks
10 – Operators	Weekends 8 am to 6:30 pm	Warning Light Bar and Arrow Board
11 – Total	Holidays 5 am to 9:30 pm	Traffic Cones and Stop Signs
		Radio, Direct Connect Phone and Scanner
		Full Compliment of Tools

Patrol Zone Coverage area (Figure 1.1.1):

- Patrol Zone 1 – Coverage area is from I-70 (North) to I-64 (South) and from Route 141 (West) to Route 67/Lindbergh (East)
- Patrol Zone 2 – Coverage area is from I-70 (North) to I-64 (South) and from Route 67/Lindbergh (East) to St. Louis City Limits (East)
- Patrol Zone 3 – Coverage area is from I-64 (North) to Route 30 (South) and from Route 141 (West) to Routes 61/67/Lindbergh (East)
- Patrol Zone 4 – Coverage area is from I-64 (North) to Route 30 (South) and from Routes 61/67/Lindbergh (West) to St. Louis City Limits (East)

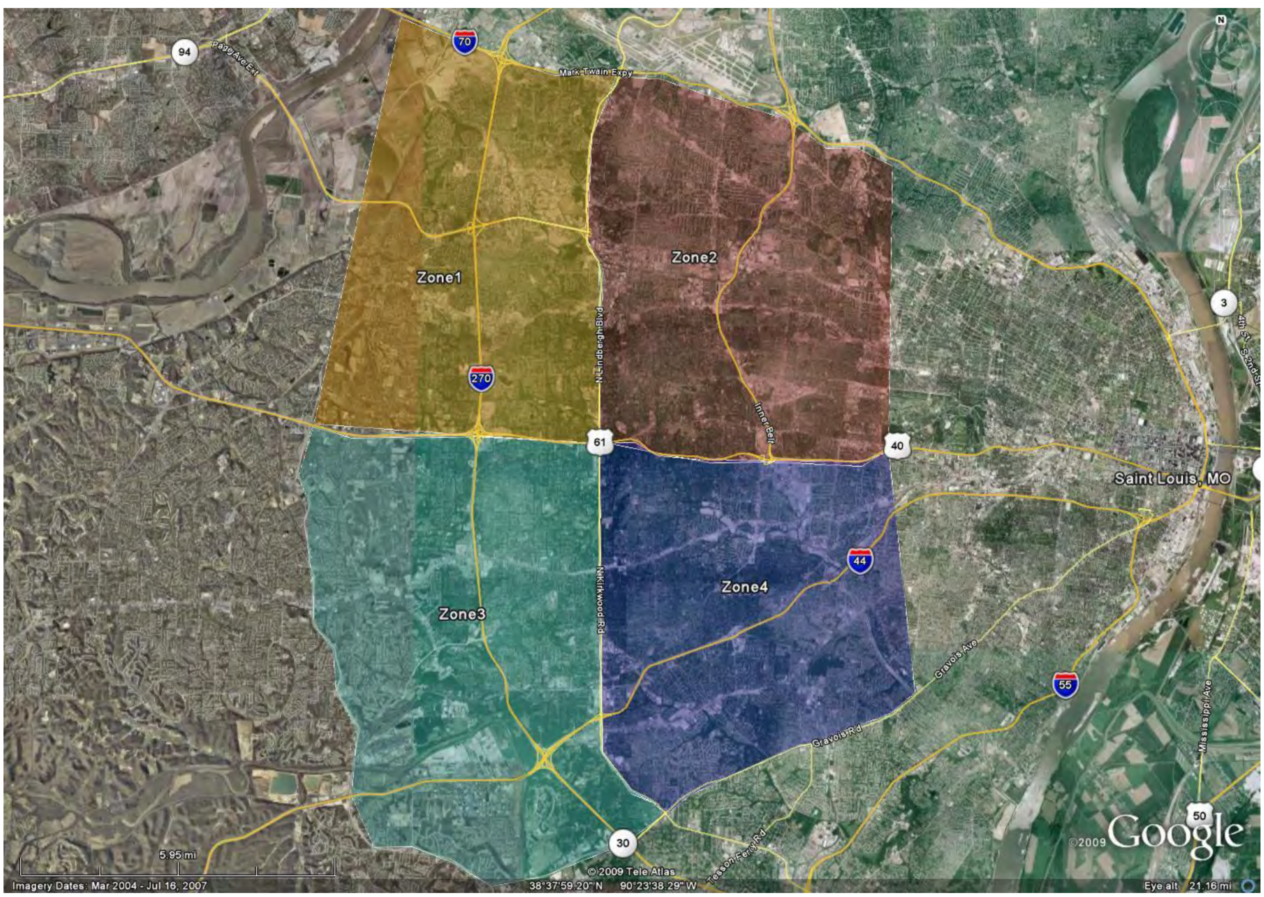

Figure 1.1.1 Map of Patrol Zone Coverage

1.2 Assessment Factors

The determination of the right assessment factors is very important, so the value/benefit of the regional arterial service patrol can be ascertained. The identification of potential factors was determined based on regional assessments from across our nation. The following factors were identified and evaluated in determining potential benefits associated with an arterial service patrol program:

- Reduction in traffic delay
- Reduction in fuel and emission
- Reduction in secondary crashes
- Reduction in response staff (emergency and operations)
- Improved public support

The assessment of value/benefits for the first four factors can be determined based upon estimated user cost savings. The savings can then be compared to actual program costs to derive a benefit/cost ratio for the program. The fifth factor has value, but its performance measurement is public perception which is not easily quantifiable like cost savings. But the development of positive public opinions does have a value. Providing valuable services that enhances the regional transportation system is viewed positively by the general public and will affect how they consider future support requests in addressing transportation needs.

The first four factors will be discussed further in this document; however, the fifth factor should also be recognized for its value. There were almost 800 returned mail-in surveys from people who received this program's service patrol assistance in 2008. The overwhelming opinion of the responses was very positive, and they found the program valuable and effective. They also reported that the operators were knowledgeable, courteous, professional, and followed good safety procedures in performing their duties. Table 1.2.1 provides a summary of the mail-in surveys:

Table 1.2.1 Mail-in Survey Evaluation Information

I-64 Traffic Response Program is	Definitely	Probably		
Valuable	788	9		
I-64 Traffic Response Program overall	Very Satisfied	Satisfied	Very Dissatisfied	Percentage of Very Satisfied or Satisfied
Effectiveness	754	29	1	99.9%
I-64 Traffic Response Operators are	Very Satisfied	Satisfied	Very Dissatisfied	
Knowledgeable	739	42	1	99.9%
Courtesy	775	19	1	99.9%
Professionalism	772	23	1	99.9%
Safety Procedures	770	27	1	99.9%

Table 1.2.2 provides information on the response time as reported in surveys by the motorists. The response time reported in the surveys was very good when compared with other methods of response. The roving and dispatch methods applied seemed to be very effective in getting to incidents in very timely manner. Response within 10 minutes was achieved 64.2% of the time and response within 20 minutes was 86.7%. Table 1.2.2 below provides statistical data that will be useful in the assessment of the program's effectiveness.

Table 1.2.2 Response Time from I-64 Traffic Response Users

Response Time	Number	Percentage	Cumulative Percentage
< 5 minutes	253	32.3	32.3
5 to 10 minutes	250	31.9	64.2
10 to 20 minutes	177	22.6	86.7
20 to 30 minutes	61	7.8	94.5
30 to 40 minutes	24	3.1	97.6
> 40minutes	19	2.4	100

Quicker response and clearance has proven an effective method of reducing non-reoccurring traffic congestion. This reduction in traffic congestion also has a positive impact on making roadways safer. Information gained in these surveys is statistically sound, since approximately 5% of motorists receiving services completed a survey.

1.3 Interactions with Other Agencies

Since incident management is an important role of FSPs such as MA and TR, it is important to understand the context of Traffic Incident Management (TIM) and the roles of each of the factors. The factors involved with TIM usually include police, fire, 911 dispatch, towing and recovery, emergency medical services, hazardous materials (HAZMAT), transportation agencies, and the media (FHWA, 2000). The success of TIM depends not only on each partner performing capably, but also on the efficient coordination among all the partners.

While there might be some overlap in some of the functions, there are certain functions that are particular to a specific partner. In the case of TR, some functions such as debris removal, traffic control, detection, and verification can be performed by others, such as the police. However, TR is the most suitable partner for many of those functions because of the training, equipment, and its role as part of the overall Intelligent Transportation Systems' (ITS) deployment in St. Louis.

One could argue that some functions, such as traffic control, can also be performed by the police. However, many police agencies prefer that TR handle such functions so that the police can be freed up for other tasks such as accident investigation, and TR operators have more traffic control equipment than other responders such as arrow boards, barricades, and cones. Police agencies were contacted for the MA study to obtain their qualitative assessment of their working relationship with MA/TR and very positive responses were received.

2. LITERATURE REVIEW

Only one major evaluation of arterial service patrol was found.

2.1 Review of Arterial Service Patrol Evaluations

The literature on the arterial response side is scarce. One evaluation report was the first phase report of the Regional Emergency Action Coordination Team (REACT) (Battelle, 2002). The geographical scope included the northwest portion of metropolitan Phoenix. The main objective of REACT was to provide traffic management for emergencies on arterial roadways. But the incident management situations included automobile accidents, hazardous material spills, power outages, weather related emergencies, fires, and criminal investigations. REACT provided for incident response using trucks equipped with traffic control equipment including variable message sign (VMS) boards. The evaluation focused on quantifying the benefits from reductions in travel delay, fuel use, emissions, secondary crashes, and police and fire personnel labor. Traffic simulation and likelihood analysis were both used to estimate benefits. B/C was estimated 6.4:1 for the existing operations and 8:1 if the operation reached capacity.

2.2. Review of Secondary Crash Analysis Methodology

The REACT study and the 2003 St. Louis Motorist Assist study were utilized sources in determining an estimated percentage for secondary crashes. The REACT used an estimated 10% of total crashes to be secondary crashes while 2003 St. Louis used a more conservative 5% of total crashes for secondary crashes. The identification of secondary crashes can provide a potential reduction in crashes.

3. TR MOBILITY AND SAFETY STRATEGY ASSESSMENT METHODOLOGY

3.1 Assessment Methodology

When incidents (stalled vehicles, crashes, etc.) occur that block roadway lanes or adjacent shoulder areas, the roadway’s capacity to handle traffic flow is reduced. This reduction in traffic flow, especially during peak travel times, causes delay and increases the potential for secondary crashes. With the potential of increased traffic on arterial corridors, the I-64 Traffic Response program was developed and implemented as a mobility strategy of the New I-64 construction project. The first four assessment factors mentioned in Section 1.2 will be further defined as evaluation factors in next few sections.

3.1.1 Reduction in traffic delays

Reduction in traffic delays was determined by using CORSIM, a comprehensive microscopic traffic simulation computer model. The CORSIM evaluation approach was used to take advantage of the model’s output that estimates traffic delay, increased fuel consumption and air quality impacts. These estimated values can easily be converted to transportation user and emission impact costs.

CORSIM models were developed for two arterial corridors that run adjacent and parallel to the I-64 construction – Route 100 (Manchester) and Route D (Page). Seven CORSIM scenarios (see Table 3.1.1.1 below) were developed and evaluated to gain insight on how lane blockage could impact travel along these corridors. Utilizing estimated costs for these two control corridors, total estimated costs for all roadways served by the I-64 Traffic Response program are developed. The response time information gained through the on-going survey and knowing the total number of responses throughout the entire year 2008 will support the calculation of estimated savings.

Traffic delay may result from several different blockage conditions – a single lane, multiple lanes, and shoulder area. This evaluation has taken a conservative approach in analyzing only the single lane blockage. The research team understands that multiple lane blockage presents potential increased traffic delays, while a shoulder area blockage presents potential decreased traffic delays. The single lane blockage is more common than the multiple lane blockages and provides a good medium approach in assessing potential traffic delay impacts.

Table 3.1.1.1 CORSIM Model Scenarios Developed and Evaluated

Model	Traffic Data	Incident/Impact
Baseline	2007	No Incident
Post-construction 1a	2007	No Incident
Post-construction 1b	2007	Incident 5 minutes lane blockage
Post-construction 2a	2007	Incident 15 minutes lane blockage
Post-construction 2b	2008	Incident 15 minutes lane blockage
Post-construction 3a	2007	Incident 30 minutes lane blockage
Post-construction 3b	2008	Incident 30 minutes lane blockage

The measures of effectiveness (i.e. delays, emission, etc.) were extracted and summarized based on an average of five CORSIM runs during both the AM and PM peak periods: minimum, maximum and average for total corridor delay. These total corridor delay outputs were used to determine the total corridor delay differences between a no incident, 5-minute incident lane blockage, 15-minute incident lane blockage, and 30-minute incident lane blockage. Both pre-construction (2007 baseline) and post-construction (2008) traffic data were used in the evaluation.

The 5-minute incident lane blockage was initially developed and evaluated during the baseline development phase and was found to have little impact difference between it and the no incident condition. The 5-minute incident lane closure is included in this report, but was not carried forward for further evaluation based on the slight difference between it and no incident condition. This analysis did set the low-end threshold on when potential traffic impact begins since there was little traffic impact was noticed.

Appendix E contains a technical memo that provides more detailed information on the CORSIM Methodology and Results.

In this study, AM and PM peak periods were analyzed only for the purpose of this study with the 15 and 30 minute incidents. Traffic demand and available capacity are major components of an incident impact on a particular roadway facility. Incidents along major corridors will reduce the available capacity during heavy traffic demand thus accelerating traffic congestion and delay.

Off peak periods were not assessed in this report, since traffic demand is less and reduction in available capacity from a single lane blockage caused by minor incident can normally be managed with limited to no traffic delay. Major traffic incidents (roadway blockage of greater than 30 minutes) were also not evaluated, since they are fewer in numbers. Limited resources were available for the evaluation of the I-64 Traffic Response program strategy in the overall I-64 study, so the study team had to explore an efficient method to evaluate this deployed mobility strategy. This evaluation's focus was made on the conditions during peak periods of the day.

Further future evaluation of off peak conditions and major incidents could result in additional cost savings. The Phoenix's REACT Program (Battele, 2002), a similar arterial service patrol program for major incidents only, was evaluated and found Benefit/Cost (B/C) factors ranging from 6.4 to 1 (for 100 incidents) to 8 to 1 (for 200 or more incidents). Based on the information, it would be reasonable to see additional benefits when including major and off peak incidents in a future evaluation effort.

Within each CORSIM model, a lane closure was replicated to simulate incidents with duration of 15 minutes and of 30 minutes that were placed upstream and downstream from a central major cross street. A total of eight incident scenarios (4 for 15 minutes and 4 for 30 minutes) were developed and evaluated for each corridor. Traffic data input from 2007 (pre-construction) and 2008 (post-construction) were evaluated for the eight incident scenarios. An average overall corridor delay (in hours) was determined for each incident scenario. The average of these runs was used in determining the total delay difference in pre-construction and post-construction conditions.

From these CORSIM outputs, hourly traffic impact cost information was developed for traffic delay, fuel consumption and air quality impacts. These calculations are presented in **Appendix C**. Traffic delay cost is discussed in the following paragraphs with fuel consumption and air quality (emission) impact costs discussed in Section 3.1.2.

As previously mentioned, two control corridors were evaluated to determine an estimated hourly cost for traffic delay associated with incidents. The selected two corridors provide a good approximation of what would be expected across the various arterial corridors served by the I-64 Traffic Response Program. While the corridors vary in actual roadway geometrics, they would have similar traffic congestion levels during peak hour conditions when traffic demand approaches roadway capacity. The average of the two corridors' traffic delay cost per hour was used to prorate the remaining corridors by looking at the various incidents (assists) served during 2008.

In 2008, 16,063 incidents (assists) were performed and information recorded through field records, and a summary is contained in **Appendix D.** The summarized information includes the coverage zone area, response types, fuel used and its associated cost, number of assists with lane blockage, number of minutes in the lane after the operator arrived, and total miles driven. This information proved to be very valuable when correlating estimated traffic delay costs into an hour factor to the total number of responses.

There were 6,428 incidents (assists), or approximately 40% with lane blockage. The other assists were performed with vehicles on a shoulder and after they were moved to adjacent parking area. The average lane blockage after the operator arrives was 15.1 minutes calculated from field records on the total assists in 2008. Table 1.3.1, Response Time from I-64 Traffic Response Users, can be built based upon on a good statistical correlation to determine the estimated assists with lane blockage. Estimated lane closure time equals response time plus the average land blockage. The assists were group based on the Table 3.1.1.2:

Table 3.1.1.2 Lane Blockage and Estimated Lane Closure Time for 2008 Assists

Response Time	Mail in Survey Information	Percent of Lane Blockage	Assists in 2008	Estimated Lane Closure Time (minutes)
< 5 minutes	253	32.3%	2074	15 to 20
5 to 10 minutes	250	31.9%	2050	20 to 25
10 to 20 minutes	177	22.6%	1451	25 to 35
20 to 30 minutes	61	7.8%	500	35 to 45
30 to 40 minutes	24	3.1%	197	45 to 55
> 40minutes	19	2.4%	156	> 55
Total	784		6428	

Grouping the assists' estimated lane closure time period based on response time and average lane blockage from field records provide the study team with an evaluation method to derive associated costs using the CORSIM models output. By using the derived cost factors from the CORSIM 15 minute and 30 minute outputs, one can calculate estimated total delay in hours. Once the study team derived the hourly cost, increased labor, gas and emission expenditures could be determined.

From a previous national search on information for the labor cost associated with travel delay costs, estimated costs were determined. These delay costs includes labor cost differences for trucks and autos, and also includes vehicle occupancy factors. Truck percentages were determined from MoDOT's annual traffic count information. These cost factors were used to determine cost of traffic delay cost. The associated labor cost (shown in Appendix C) is $23.82 per hour.

It is very difficult to measure both the pre-deployment and post-deployment conditions with many different variables and provide a reasonable cost savings. This program will not reduce all associated traffic delay nor will it reduce all potential secondary crashes. However, quicker response and clearance of incidents will reduce associated traffic delays and secondary crashes. While developing this evaluation, it was discovered that five minutes make little difference in the overall corridor delay. This fact was used in determining a reasonable percentage of traffic delay that could be used to estimate a reduction when a service patrol program is utilized. The results are discussed in Section 6 of this report.

3.1.2 Reduction in fuel and emission savings

Reduction in fuel and emission savings were also derived from the CORSIM output files. The estimated fuel and emission savings reflect the difference between pre-construction (2007) and post-construction (2008) conditions. The analysis of potential savings is also shown in Appendix C and was calculated in a similar manner that traffic delay was calculated. The emission reduction cost factors were determined through a national database, and the fuel cost was obtained from the Missouri Department Natural Resources for the 2008 period. The emission impact costs are Hydrocarbon (HC) $1.14 per pound, Carbon Monoxides (CO) $2.49 per pound and Sulfur Oxides (NO_x) $2.39 per pound. The results are discussed in Section 4 of this report.

3.1.3 Reduction in secondary crashes

Reduction in secondary crashes was derived from previous information developed nationally and locally in determining a percentage of secondary crashes being caused as result of another initial incident (crash, stalled vehicle, etc.). In a 2003 study conducted by the University of Missouri (UMC, 2003), an evaluation of a previous Chicago area study (Morris, 1994) was reviewed to assess the study's information and methodology in determining the impact of secondary crashes. Based upon the information collected, they developed secondary crash spatial (distance) and temporal (time) thresholds for the St. Louis area.

This information lead to defining an impacted incident area that was then used to determine a potential percentage of secondary crashes that occurred within these thresholds that could be attributed to another initial identified incident (crash, stalled vehicle, etc.). The secondary crash factor established from the 2003 study was 5 percent. For background information only, Chicago used 15 percent, while the Phoenix study previously mentioned also referenced the Chicago study as a baseline used 10 percent in their evaluation of an arterial service patrol. Five percent is a reasonable conservative factor, since it was based on a previous local study and is below other percentages being used for secondary crash analysis.

Crash data for 2008 from state-only roadways was used to determine potential secondary crashes. Since the I-64 Traffic Response program covers both state and county roadway facilities, use of state-only is a conservative approach in the assessment of secondary crashes. As part of an ongoing and related I-64 study, the county roadway crash information will be assessed along with 2009 crash information when available.

Table 3.1.3.1, Average Comprehensive Cost from the National Safety Council, was used to quantify the costs associated with the reduction in secondary crashes. These values are similar to AASHTO values and differentiate injuries into three different categories. These comprehensive costs include both an economic loss component as well as a measure for the value of lost quality of life that was obtained through empirical studies of what people actually pay to reduce their safety and health risks. This source breaks down crashes into severity categories and provides an estimate of cost for severity.

Table 3.1.3.1 Average Comprehensive Cost by Crash Injury Severity – 2007

Type of Crash	Cost
Death	$4,100,000
Incapacitating injury	$208,500
Non-incapacitating evident injury	$53,200
Possible injury	$25,300
No Injury – Property only	$2,300

The analysis of cost savings from secondary crashes is also shown in **Appendix C, Worksheet D**. There were 7,323 total crashes along state roadways only within I-64 Traffic Response zones in 2008. Table 3.1.3.2 shows the number of crashes by severity for the state routes only. Using the 5% secondary crash would mean that 367 crashes could have been considered as secondary crashes. The results and the discussion on how many potential secondary crashes could be reduced with the TR program will be further discussed in Section 4 of this report.

Table 3.1.3.2 State Route Arterial Crash Data – 2008

Route	Fatal	Injury	PD	Total
30	2	240	699	941
40	1	75	268	344
61	0	158	603	761
67	0	85	260	345
100	0	214	932	1146
115	0	109	276	385
141	4	86	413	503
180	0	183	492	675
340	0	236	762	998
366	0	133	393	526
D	2	144	553	699
Total	9	1663	5651	7323

3.1.4 Reduction Response Staff

Along major arterials, support for incident mitigations requires various response staff (police, fire, highway workers, etc.) to provide needed services. Lane or partial lane closures caused by stalled vehicles, debris in the roadway or crashes can have major impacts on traffic flow along major arterials. The I-64 Traffic Response program provides response to these incidents and can normally clear them without additional staff from other responding agencies. Potential cost savings can vary depending on who responded to these incidents. The cost of response by the I-64 Traffic Response operator in most cases could be done at a lower cost and quicker time since it is their primary duty.

The I-64 Traffic Response field records were reviewed, and this information was used to help assess these potential cost savings. This information is available in **Appendix D** and provides information on all assists performed in 2008. Table 3.1.4.1 provides a summary of the I-64 Traffic Response 2008 field reports based on the type of services rendered.

Table 3.1.4.1 Total Assists by Service Type for 2008

Service	Assist	Service	Assist
Tire	1346	Signal/Lighting	209
Dispense Fluid	992	Signing MoDOT/County	359
Debris Removal	1921	Pavement Deficiencies	92
Spill	34	CMS/DMS	132
Lost Motorist	954	Construction Zone Deficiencies	77
Abandoned Vehicle	2211	Navigation/Aviation Lighting	1
Mechanical	2811	Dead Animals	315
Crash	2327	Flooding	51
Other	2124	Ice/Snow	103
I-70 Express Lane	4	Total Assist	16063

This information was used in developing a method to determine potential response staff savings. As mentioned previously, "who normally responds" to these incidents provide key information to where potential savings can be attributed. Debris removal, for example, would normally require a highway (state or county) agency response.

A flat tire assist might require some response by a roadside service provider (AAA), but most likely would be changed by the driver on site if assistance was not available. Crashes would require police or a multi-organizations (both public and private) response based on the nature or severity of the crash. Table 3.1.4.2 breaks the services down to "who normally respond" to the type of incident.

Table 3.1.4.2 Services by Who Normally Response

Highway	Assist	Multi-Organizations	Assist	Driver	Assist
Debris Removal	1921	Spill	34	Tire	1346
I-70 Express Lane	4	Abandoned Vehicle	2211	Dispense Fluid	992
Signal/Lighting	209	Crash	2327	Lost Motorist	954
Signing	359			Mechanical	2811
Pavement	92				
CMS/DMS	132				
Construction Zone	77				
Special Lighting	1				
Dead Animals	315				
Flooding	51				
Ice/Snow	103				
Total	3264	Totals	4572	Totals	6103

Service “Other” was removed since it can not be defined without knowing additional information related to each assists. Extensive investigation would be required to determine the nature of the 2,124 assist listed as “Other”. The exclusion of these would tend to provide a conservative estimation of cost for reduction response staff.

Cost savings for **highway agency response** is the difference in cost between dispatching a maintenance worker compared to that of an I-64 Traffic Response operator. The maintenance worker could be working or could be off-duty, thus requiring overtime. Response time most likely in either situation would typically be longer than that of an I-64 operator. Safety plays a very important part when looking at these services – quick response to the incident scene and clearance is important to the safety of the traveling public. Two things should be noted though – first, an I-64 operator’s vehicle is normally better equipped to respond; and second, when a maintenance worker leaves an assigned project to respond, it could cause their work site to be under-staffed, potentially having an impact on safety.

Cost savings for **multi-organizational responses** can be attributed to the difference in services provided by an operator that reduces or eliminates response from other organizations. For example, an abandoned vehicle can be initially tagged by an I-64 operator, thus reducing the need for a police officer. The savings is the cost difference between those who did respond and those that would have responded.

Police are often dispatched to provide support in a non-crash incident (i.e. vehicle breakdown) along major arterials, especially in peak periods. Also, some crashes along major arterials for safety reasons require two police officers. One officer will investigate the crash while the second provides traffic control around the crash scene. The issue is safety for those involved in the incident, as well as those traveling through the incident site. Service patrols have been very helpful in reducing police officers performing traffic control.

Similar examples can be made for other incident response. Again safety plays a very important role in multi-organizations responses. The I-64 Traffic Response operator is trained and equipped to provide traffic control. The premise of providing standard traffic control practices provides the traveling public with good information to make better informed decisions while traveling through incident scenes.

Cost savings for **driver responses** are the difference in the driver handling the incident versus the I-64 Traffic Response operator handling it. The operator is equipped with special tools and traffic control devices to handle the incident quicker and safer. The safety benefit extends beyond those involved in the actual incident. The traveling public benefits from a quicker clearance both in traffic delay and safety. These savings are more related to a reduction in congestion and safety that are accounted for in other potential savings.

The analysis of potential savings is shown **Appendix D**. The results are discussed in Section 4 of this report.

4. TR MOBILITY AND SAFETY STRATEGY RESULTS

4.1 Traffic Congestion Benefits

Since the CORSIM models provide information that is directly related to potential savings experienced through traffic delays like labor cost, fuel consumption and emissions, these items were combined as traffic congestion benefits. These associated traffic congestion costs were computed from CORSIM runs for the 2007 baseline year and 2008 construction year and differences determined. Table 4.1.1 shows the differences in appropriate metrics for increase traffic volumes, labor, fuel, and emission with an estimated cost per incident. The "average" combines the two corridors to create an average cost. The incident traffic congestion metrics were determined based on a 15-minute and a 30-minute lane closure. These associated costs per incident could then be used to help assess potential impacts from incident based on length of lane closure time.

Table 4.1.1 Computed Incident Traffic Congestion Metrics (15-minute and 30-minute lane closure)

Route	Time of Day	Closure Duration	Increased Traffic Volume (2007 to 2008)	Total Delay (peak hr)	Fuel (Gallons)	Emissions (lbs)			Cost of Incident ($/hr)
						HC	CO	NO	
Rte. 100	AM	15 Min	35%	43	92	0.9	41.2	2.7	1430
		30 Min		46	102	1.0	45.8	3.0	1538
	PM	15 Min	26%	52	117	1.1	52.6	3.4	1751
		30 Min		63	148	1.4	66.3	4.3	2135
Rte. D	AM	15 Min	15%	22	23	0.1	3.4	0.3	610
		30 Min		24	29	0.1	4.3	0.4	667
	PM	15 Min	20%	80	89	0.4	13.0	1.3	2211
		30 Min		74	100	0.5	14.7	1.5	2108
Average	AM	15 Min	25%	33	58	0.5	22.3	1.5	1020
		30 Min		35	66	0.5	25.0	1.7	1103
	PM	15 Min	23%	66	103	0.8	32.8	2.4	1981
		30 Min		68	124	0.9	40.5	2.9	2122

From information gained in surveys distributed, the response times from those receiving services can be determined. There were 784 mail-in surveys (almost 5% of total assists) received. This sample size can statistically estimate the time of response of all assists. Using these percentages for various response times (i.e. less that 5 minutes), the number of assists performed in 2008 can be prorated to determine the estimated number of assist in each Response Time period (see Table 4.1.2).

From the I-64 Traffic Response Field Records, it was determined that the average lane blockage, once an operator arrived, was approximately 15.1 minutes. The range for lane blockage was from 1 minute to 448 minutes in 2008 for all four zones. It was also determined that a lane blockage occurred 40% of the time. Estimated lane closure is equal to response time plus average lane blockage time.

Formulas were developed and used to calculate the amount of potential 15 minute delay impacts and the amount of potential 30 minute delay impacts for AM and PM peak periods. AM and PM peak periods are about 7 hours per day or approximately 21% of the week. The potential savings were determined by these formulas in Appendix B and are shown in Table 4.1.2. This information is shown in worksheet A – Cost of Delay and Emissions in **Appendix D**.

Table 4.1.2 Potential Cost Savings of Traffic Delay and Emission

Response Time	Mail-in Survey Information	Percent	Incidents in 2008	Estimated Lane Closure (in minutes)	Potential Savings
< 5 minutes	253	32.3%	5184	15 to 20	$2,550,698
5 to 10 minutes	250	31.9%	5122	20 to 25	$3,190,138
10 to 20 minutes	177	22.6%	3626	25 to 35	$2,732,756
20 to 30 minutes	61	7.8%	1250	35 to 45	$806,356
30 to 40 minutes	24	3.1%	492	45 to 55	$317,255
> 40minutes	19	2.4%	389	> 55	$251,160
Total	784		16063		$9,848,363
				AM PM	$2,068,156

The potential savings related to traffic congestion is $2,068,156 and includes traffic delay costs such as labor, fuel consumption and emissions. The study team understands that the complete peak period potential savings is not possible, so a more viable assessment was considered. We found that the first 5 minutes of a lane closure had little to no impact on congestion and we also found that a 15-minute lane closure showed impact. We understand that through quicker response and clearance will reduce the impacts to lane closures. Using the mid-point between 5 to 10 minutes equates to 50% response time to incidents and lane closures. A 50% potential savings or $1,034,078 is a reasonable estimation for reduction in congestion cost.

4.2 Roadway Safety Benefits

In determining the potential savings in reducing the number of secondary crashes that could be attributed to direct results of other incidents, a review of the crash data for 2008 was conducted for state roadways only served by the I-64 Traffic Response program. Additional evaluation of county roadways also serviced by the I-64 Traffic Response program will be completed under the I-64 study in the future, and the study will amend this document to reflect the additional crashes. Table 4.2.1 shows the results of this crash evaluation based on severity. The five (5) percent reduction factor discussed in Section 3 was applied along with National Safety Council Average Comprehensive Cost factors for each severity type to obtain an estimated cost for secondary crashes.

Table 4.2.1 Potential Secondary Crash Savings

2008 Type of Crash	State Route Only Crashes	Potential Secondary Crashes by Type	Cost per Crash Type	Estimated Savings
Fatal	9	0.5	$4,100,000	$1,845,000
Serious Injury	112	5.6	208,500	$1,167,600
Minor Injury	1551	77.6	53,200	$4,125,660
Property Damage	5661	283.1	9,990	$2,827,670
Total	7333	366.7		$9,965,930

In 2008 there were 7,323 total crashes on state roadways only. Using the 5% secondary crash rate, it would mean approximately 366 crashes could be secondary crashes. Crash data in 2007 showed 7,752 crashes and the average for the four prior years was 8,087 crashes. The predicted 366 crash reduction in 2008 is reasonable when compared to previous years with the understanding that traffic demand on these arterial corridor was up significantly.

Again, the study team understands that the complete secondary crash reduction savings is not possible, so a more viable assessment was considered. We found that the first 5 minutes of a lane closure had little to no impact on congestion and we also found that a 15-minute lane closure showed impact. We understand that through quicker response and clearance will reduce the impacts to lane closures including secondary crashes. Using the mid-point between 5 to 10 minutes equates to 50% response time to incidents and lane closures. A 50% reduction in secondary crashes or 166 crashes with potential savings of $4,980,468 is a reasonable estimation.

Appendix D worksheet provides more detailed information regarding secondary crashes.

4.3 Region Response Staff Benefits

The reduction response staff is the third potential cost savings benefit experienced when I-64 Traffic Response operators respond to incidents along arterial corridors. There are three potential assist responses categories:

- Highway assist where the highway agency would normally respond
- Multi-organizations assist where two or more public/private organizations would respond
- Driver assist where the driver would handle their own response

Knowing the type of responder is a key element in determining the response cost and potential savings that can be achieved similar to the I-64 Traffic Response Program. General note: 2,124 assists were identified as “other” in field records. Since it would be difficult to ascertain the specific nature of the assist, they were omitted. This omission would increase the potential cost savings for this benefit. The following Table 4.3.1 listed the breakdown into these categories:

Table 4.3.1 Assist by Response Category

Highway	Assist #	Multi-Organizations	Assist #	Driver	Assist #
Debris Removal	1921	Spill	34	Tire	1346
I-70 Express Lane	4	Abandoned Vehicle	2211	Dispense Fluid	992
Signal/Lighting	209	Crash	2327	Lost Motorist	954
Signing	359			Mechanical	2811
Pavement	92				
CMS/DMS	132				
Construction Zone	77				
Special Lighting	1				
Dead Animals	315				
Flooding	51				
Ice/Snow	103				
Total	3264		4572		6103

Highway assists were developed into two scenarios – maintenance staff response during normal work hours and maintenance staff response during after hours. Scenario one is normal work hours and scenario two is off-duty hours. I-64 Traffic Response works 103.5 hours per week compared the standard 40 hour week. This fact established the percentage breakdown for the two scenarios. Cost difference and response times were considered for both scenarios and are listed Table 4.3.2 with total potential savings:

Table 4.3.2 Highway Assist Category

Scenario	Percentage	Assist	Time	Hours	Cost Savings
Scenario One	38.6%	1260	1/2 hour	630	$8,706
Scenario Two	61.4%	2004	1 hour	2004	$41,545
Total		3264		2634	$50,251

Multi-organization assists were reviewed by assist type; and determination of cost savings was determined by the cost difference in who responded, thus reducing the need for response by other agencies. Starting salaries for county patrol, city police and I-64 Traffic Response operator was compared and a difference of $7.53 per hour was determined. Table 4.3.3 shows potential cost savings for reduction cost when I-64 Traffic Response was used to respond to multi-organizations assist.

Table 4.3.3 Multi-organization Assist Category

Service	Assist	Time Factor	Reduction (hrs)	Salary Difference	Cost Savings
Abandoned Vehicles	2211	15 minutes	553	$7.53	$4,162
Crash	2327	45 minutes	419	$7.53	$3,154
Spill	34	30 minutes	17	$24.14	$410
Total	4572		989		$7,727

Driver assists benefits would be included in cost savings from traffic congestion and reduction in secondary crashes. The driver would probably perform their own assist and the only potential cost savings provided through the I-64 Traffic Response program would be quicker clearance. No additional cost savings were calculated for this assist.

The total cost savings was calculated at $57,997. Appendix D and Appendix E provides more detailed information on the assessment of response staff cost savings.

4.4 Benefit/Cost Ratio Assessment

It is very challenging to measure both the pre-deployment and post-deployment conditions due to the number of different variables that exist. However, a reasonable cost savings can be determined based on information readily available as discussed above. This type of program does not reduce all traffic delay and congestion associated with incidents nor does it reduce all potential secondary crashes. However, there is no denying that quicker response and clearance does have a positive impact.

Based on this understanding, an approach is used that utilizes information known from the 2008 survey and information gained in this study. Five minute lane closure scenarios show that there is very little traffic impact. Traffic impact from a lane closure begins between 5 and 15 minutes and continues to grow. The survey reports that 32.3% of motorists received I-64 Traffic Response services in less than 5 minutes and 64.2% received assistance with 10 minutes.

Traffic delay impacts are noticed when lane blockage is greater than 5 minutes. The potential for secondary crashes and traffic congestion starts after the first 5 minutes. From response time, the median between 5 and 10 minute response time is around 50%. Understanding that a quicker safer clearance of incidents will have the largest impact this interim study used a 50% reduction factor. Table 4.4.1 below uses a 50% reduction factor to better reflect the potential savings from traffic delay and congestion and secondary crashes. One hundred percentage is used for response staff savings, since it a truly measurement of actual savings based on service provided.

Table 4.4.1 Calculated Benefit/Cost Assessments - I-64 Traffic Response Program

Total Savings	50%
Traffic Delay and Congestion Savings	$1,034,078
Secondary Crash Savings	$4,980.468
Response Staff Savings	$57,977
Total Savings	$6,072,523
Benefit/Cost	8.347
Program Cost 2008	
Equipment Cost	$23,520
Annual Cost - Labor, gas, etc.	$703,980
	$727,500

5. CONCLUSION

The I-64 Traffic Response program as mobility strategy for the I-64 construction project can be considered a successful component of the region's mobility plan. Traffic movement along adjacent arterial corridors has seen peak period traffic demand increased up to 50% with only minor impacts. The I-64 Traffic Response program has played a part in making this happen. Conservative estimates in the four assessment areas – traffic delay costs, emission impact costs, secondary crash costs, and response staff savings shows a benefit/cost of 8.3.

Traffic delay costs were developed by traffic modeling based on change in traffic flows between the pre-construction 2007 year and construction 2008 year. One lane closures were modeled and several model runs were made to get a better understanding of total corridor delay. The output from these models helped in the assessment of additional costs associated with lost production (labor cost) and fuel cost.

These same traffic model runs provided the emission impacts costs for the region based on increased emissions. A very conservative $1,034,078 savings was determined for traffic delay and congestion savings that only used a 50% reduction of potential peak period hours when impacts to roadway closures are the highest.

Impacts from secondary crashes that result from another incident were assessed on state-only roadways, and this report will be updated in the future to reflect county roadways. The $4,980,468 potential savings were based on the estimation that 5% of all crashes are secondary crashes. With 7,323 total crashes in 2008, the predicted 366 secondary crashes based on the 5% factor and reduced to 183 secondary crashes (50% reduction) to present a more realistic and reasonable reduction in secondary crashes. Comparing to the four previous (2004 through 2007) years, there was a reduction in 2008 of 754 crashes that could further validate the reduction in secondary crashes.

The final area was the reduction or savings experience in having the I-64 Traffic Response available to respond in a timely manner, thus reducing the need for others to respond. This savings was $57,977. This permits police, highway department employees, and others to continue their other normal duties without being called to respond for traffic incidents.

Based on these findings, one conclusion is that the utilization of a service patrol to manage incidents along adjacent arterial corridors of a major construction has merit and serves the traveling public well.

APPENDIX A. ANNUAL PRIMARY AND SECONDARY CRASHES IN ST. LOUIS

The following figures show the annual primary (vertical scale on the right) and secondary (vertical scale on the left) crashes. The figures from each arterial look very different by visual inspection, but the correlation of the primary to the secondary crash is visually obvious. No analysis was conducted to explain the differing curves from each arterial. **This crash information was developed in the interim report. It will be updated and used in the final report to confirm the initial secondary crash reduction factor of 5%.**

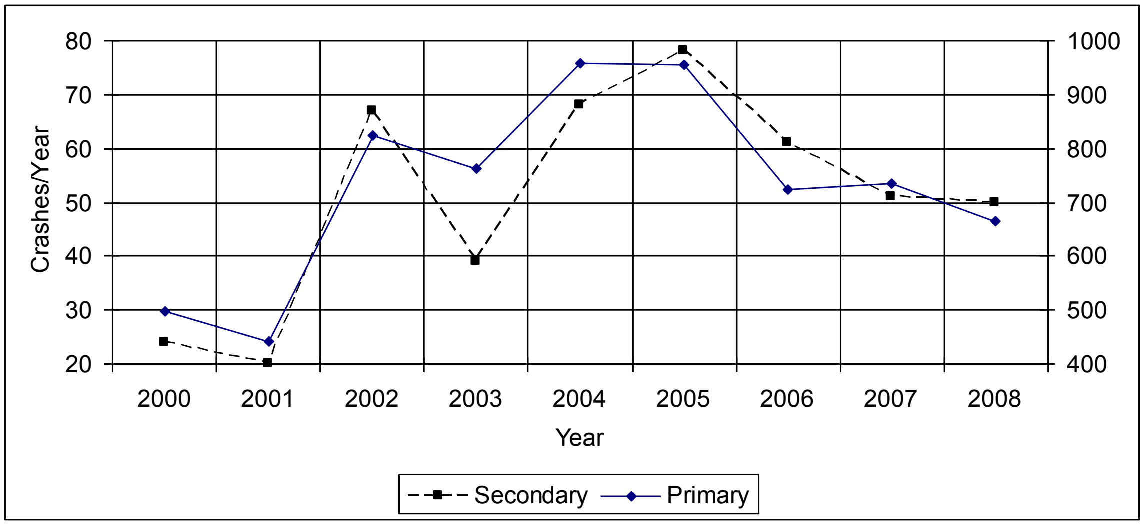

Figure A1. MO-30

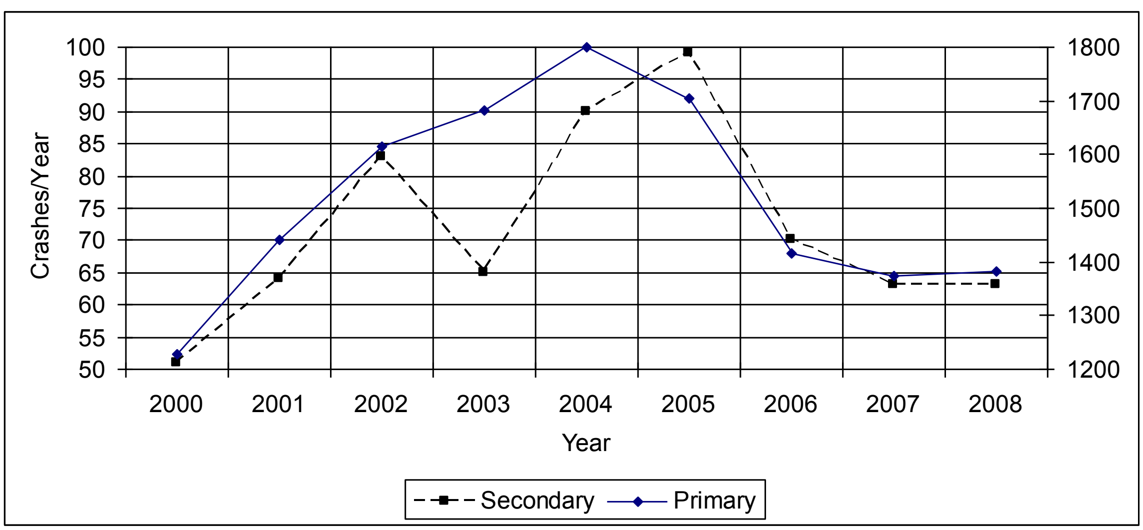

Figure A2. MO-100

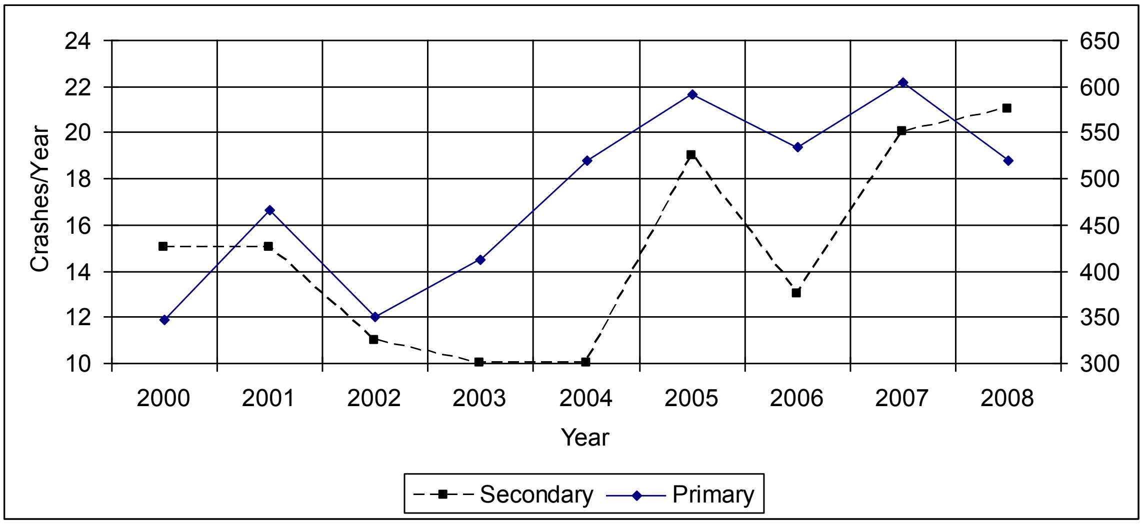

Figure A3. MO-141

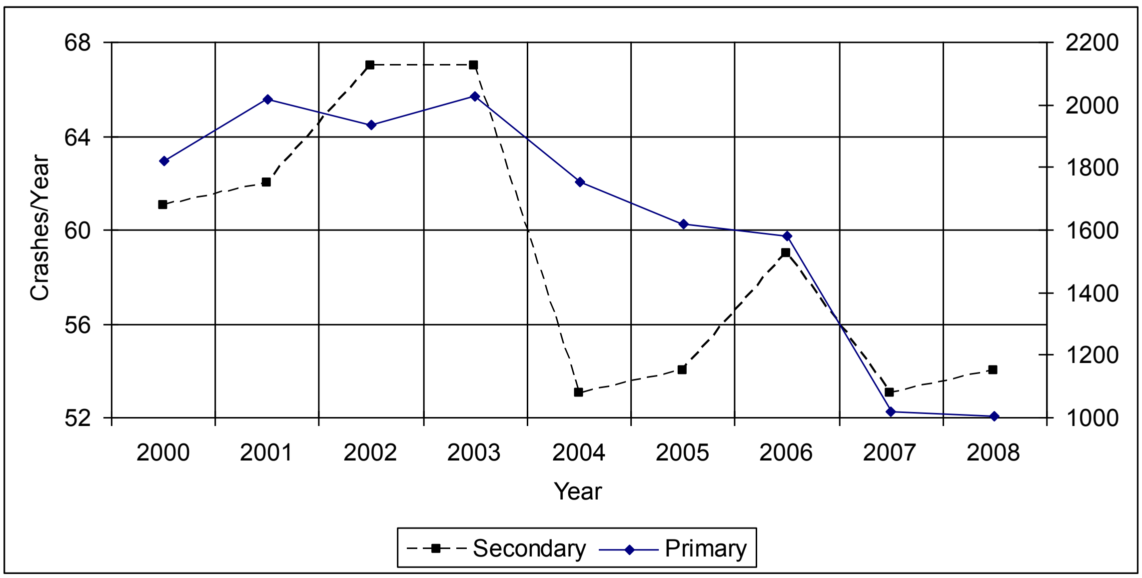

Figure A4. US-67

APPENDIX B. SECONDARY CRASHES BY SEVERITY IN ST. LOUIS

The following tables present the annual secondary crash statistics for study arterials. Incident-caused secondary crashes are ones caused by non-crash incidents such as parked motor vehicles, animals, and other non-fixed objects. (E.g. objects from vehicles, fallen tree). The sum of the fatal, disabling injury, minor injury, and PDO columns should equal the number of non-redundant secondary crashes. **This crash information was developed in the interim report. It will be updated and used in the final report to confirm the initial secondary crash reduction factor of 5%.**

Table B1. MO-30

Year	Incident Caused Secondary Crashes	Fatal	Disabling Injury	Minor Injury	PDO	Non redundant Secondary Crashes
2000	22	0	0	6	18	24
2001	17	0	1	2	17	20
2002	59	0	11	15	41	67
2003	33	1	2	7	29	39
2004	57	3	1	16	48	68
2005	66	1	3	15	59	78
2006	52	1	8	12	40	61
2007	48	0	3	16	32	51
2008	43	0	2	15	33	50
Totals	397	6	31	104	317	458
Average	44.11	0.67	3.44	11.56	35.22	50.89
Std. Dev.	16.93	1.00	3.64	5.22	13.54	20.03

Table B2. MO-100

Year	Incident Caused Secondary Crashes	Fatal	Disabling Injury	Minor Injury	PDO	Non redundant Secondary Crashes
2000	42	0	1	8	42	51
2001	43	0	1	12	51	64
2002	56	1	7	18	57	83
2003	37	0	3	13	49	65
2004	59	0	5	25	60	90
2005	62	0	6	20	73	99
2006	47	0	2	15	53	70
2007	54	0	5	15	43	63
2008	44	0	3	16	44	63
Totals	444	1	33	142	472	648
Average	49.33	0.11	3.67	15.78	52.44	72.00
Std. Dev.	8.66	0.33	2.18	4.89	9.90	15.39

Table B3. MO-141

Year	Incident Caused Secondary Crashes	Fatal	Disabling Injury	Minor Injury	PDO	Non redundant Secondary Crashes
2000	11	0	1	4	10	15
2001	11	0	0	4	11	15
2002	6	0	1	1	9	11
2003	7	0	1	1	8	10
2004	8	0	0	0	10	10
2005	11	1	1	1	16	19
2006	11	1	0	1	11	13
2007	16	0	2	3	15	20
2008	15	0	0	3	18	21
Totals	96	2	6	18	108	134
Average	10.67	0.22	0.67	2.00	12.00	14.89
Std. Dev.	3.35	0.44	0.71	1.50	3.46	4.28

Table B4. US-67

Year	Incident Caused Secondary Crashes	Fatal	Disabling Injury	Minor Injury	PDO	Non redundant Secondary Crashes
2000	35	0	5	18	38	61
2001	33	0	3	13	46	62
2002	36	2	2	13	50	67
2003	37	0	2	16	49	67
2004	36	0	2	9	42	53
2005	38	0	8	16	30	54
2006	41	1	7	15	36	59
2007	44	0	2	17	34	53
2008	38	2	0	15	37	54
Totals	338	5	31	132	362	530
Average	37.56	0.56	3.44	14.67	40.22	58.89
Std. Dev.	3.28	0.88	2.65	2.69	6.94	5.73

APPENDIX C. TRP BENEFIT COST TOOL APPENDIX

Attached as a separate electronic document

APPENDIX D. TRAFFIC RESPONSE APPENDIX D

Attached as a separate electronic document

APPENDIX E. MEMO: CORSIM METHODOLOGY

Attached as a separate electronic document

REFERENCES

AASHTO (2003) *User Benefit Analysis for Highways (The Redbook)*. American Association of State Highway and Transportation Officials. Washington, D.C.

Battele (2002) *Regional Emergency Action Coordination Team (REACT) Evaluation*. Final Report. Prepared for Maricopa County Department of Transportation. Battelle Memorial Institute. Phoenix, Arizona.

FHWA (2000) *Traffic Incident Management Handbook*. Federal Highway Administration. Prepared by PB Farradyne. November.

Morris, M. and Lee. W.,(1994). "Survey of Efforts to Evaluate Freeway Service Patrols". Transportation Research Record, 1446, 77-85.

UMC (2003) Evaluation of the Motorist Assist Component of Gateway Guide in St. Louis, Missouri. Statewide Evaluation of Intelligent Transportation Systems in Missouri. Interim Report. Department of Civil and Environmental Engineering. Columbia, Missouri.