MAG NON-RECURRING CONGESTION STUDY

MAG Contract No. 418 Project No. PL10-1
Technical Memorandum No. 4 – Relevant Countermeasures, Required Resources, and Cost Effectiveness

INTRODUCTION

The Lee Engineering/TTI team is conducting a study on non-recurring congestion (NRC) for the Maricopa Association of Governments (MAG). This technical memorandum is the fourth in a series to document the effort on the study. This technical memorandum summarizes the work completed for Task 4 of the study which identified countermeasures that are relevant and feasible for the MAG Region. It builds on the countermeasures found in the literature review (Task 1/Technical Memorandum #1) and the results of the data collection and analysis phase (Task 3/Technical Memorandum#3). Planning level cost estimates were considered for these countermeasures based on available national and local databases. The applicability of the listed countermeasures to the MAG Region was considered along with the likely resources required to implement and maintain them. Finally subsets of the countermeasures pertaining to freeway and arterial applications were determined to guide further consideration and possible pilot project development.

CAUSES OF NON-RECURRING CONGESTION IN THE REGION

Arterial Corridors

As documented in Technical Memorandum #3, vehicle incidents were the dominant source of non-recurring congestion. Vehicular incidents and construction made up 81 percent of weekday ("W") non-recurring congestion on the arterial test corridors. This percentage was split between vehicular incidents at 47 percent and construction at 34 percent. Roadway construction activities included scheduled or unscheduled (i.e., emergency) roadway improvements and/or maintenance. These include activities such as general construction and utility repair. The next closest non-recurring congestion cause was weather at 10 percent, which was a higher contributor of non-recurring congestion than on the freeway test corridors.

These same two primary causes of non-recurring congestion were found for weekends ("WE") on arterials; however, their order of contribution reversed. Construction made up 42 percent of weekend non-recurring congestion on the arterial test corridors followed by vehicular incidents at 30 percent.

Given these results, the Team recommends focusing on potential arterial countermeasures that mitigate non-recurring congestion caused by vehicular incidents and road construction activities.

Freeway Corridors

The primary sources of non-recurring congestion on freeways were vehicular incidents and construction events. These two primary causes of non-recurring congestion made up 96 percent of weekday NRC on the freeway test corridors. Vehicular incidents made up 80 percent of weekday non-recurring congestion. These incidents included vehicular crashes as well as minor breakdowns or debris/roadway hazards. Construction events made up 16 percent of weekday non-recurring congestion. These events included scheduled or unscheduled (i.e., emergency) roadway improvements and/or maintenance. They include activities such as general construction, bridge repair, ramp work, guardrail work, landscaping, line painting, road work, roving work crew, and utility work.

The same two primary causes of non-recurring congestion, vehicular incidents and construction, made up 91 percent of weekend non-recurring congestion on the freeway test corridors. However, their proportions were significantly different than during weekday operations. Construction events made up 46 percent. This measurement could reflect Arizona Department of Transportation's (ADOT) encouragement of nights and weekend construction, particularly for major on-going construction projects. Vehicular incidents made up 45 percent of weekend non-recurring congestion.

Given these results, the Team recommends focusing on potential freeway countermeasures that mitigate non-recurring congestion caused by vehicular incidents and road construction activities.

CORRIDORS WITH MOST NON-RECURRING CONGESTION

Arterial Corridors

A ranking was developed for the arterial study corridors to determine which ones had the most non-recurring congestion and the potential to be candidates for the pilot project to be identified in Task 6. Table 1 shows each of the arterial test corridor rankings based on the average of: (1) the rank based on total vehicle-hours of non-recurring congestion and (2) the rank based on the percentage of non-recurring congestion when compared to total congestion.

Although the Indian School Road Corridor ranked highest, it should be noted that high levels of construction activities for the duration of data collection period on the corridor had an impact on the construction source of non-recurring congestion compared to a typical or normal month.

Alternatively, 35th Avenue has historically experienced incidents that support its ranking within the test corridors.

Table 1. Arterial Test Corridor Ranking

AWAM Equipped Segments	W + WE NRC (veh-hrs)	Veh-hr Rank	% NRC	% NRC Rank	Avg Rank	Rank
Indian School Rd Corridor	16,920	1	18%	1	1.00	**1**
35th Ave Corridor (with Bell)	15,013	2	12%	3	2.50	**2**
7th St Corridor	11,993	3	15%	2	2.50	**3**
Rural Rd Corridor (with Rio Salado, Mill, and University)	5,801	4	5%	4	4.00	**4**
51st Ave Corridor (with Thunderbird, Peoria, & Northern)	5,383	5	5%	5	5.00	**5**

Freeway Corridors

The same ranking system for arterials was applied to the freeway test corridors to see which ones had the most non-recurring congestion and the potential to be candidates for the pilot project to be identified in Task 6. Table 2 shows each freeway test corridor's ranking based on the average of: (1) the rank based on total vehicle-hours of non-recurring congestion and (2) the rank based on the percentage of non-recurring congestion when compared to total congestion.

Although the US 60 corridor ranked highest, it should be noted that the I-10 corridor (SR 51 to I-17) is part of the I-10 Integrated Corridor Management System demonstration project which could be used to help leverage funding of potential countermeasures.

Table 2. Freeway Test Corridor Ranking

Freeway Test Sections	W + WE NRC (veh-hrs)	Veh-hr Rank	% NRC	% NRC Rank	Avg Rank	Rank
US 60 EB: 1-10 to Loop 101	100,184	1	81%	2	1.50	**1**
I-10 WB: SR51 to I-17	99,588	2	53%	3	2.50	**2**
I-17 SB: I-10 to I-10	16,389	5	85%	1	3.00	**3**
Loop 202 WB: 46th Street to 22nd Street	43,148	3	39%	4	3.50	**4**
I-10 WB: Ray Road to Southern Avenue	39,398	4	22%	5	4.50	**5**

Conclusions About Countermeasure Focus

As reported in the previous technical memorandum, non-recurring congestion (NRC) accounted for 11% of the total congestion (non-recurring + recurring) estimated for the arterial test corridors during the study period. For the freeway test corridors, the percentage of total congestion attributable to non-recurring congestion was 48%. However, determining where to focus NRC countermeasures based on these relative percentages is inappropriate considering the estimated magnitude of delay they represent. Although the relative proportion of NRC on the arterial test corridors may be much less than the freeway proportion, the MAG Region's extensive arterial grid system comprises 82% of the region's lane-miles. Therefore, in terms of regional delay caused by NRC, the contributions from arterial travel cannot be disregarded. Based on this conclusion, the following discussion includes descriptions of countermeasures approriate for freeway or arterial applications (and in some cases, countermeasures applicable to both facility types).

EFFECTIVENESS OF NRC COUNTERMEASURES BY SOURCE OF CONGESTION

Freeways

This section of the technical memorandum reviews the current experience and the effectiveness of countermeasures on freeways that are being used to address the vehicle incident and construction-related non-recurring congestion.

Incident NRC Countermeasures for Freeways

Many urban areas are developing regional transportation management systems that incorporate surveillance, communication, command, and traveler information. This is similar to the intelligent transportation systems ADOT and the local agencies are implementing in the MAG Region. Two examples of the benefits of these regional systems are:

- The Houston TranStar system, in Harris County, Texas, which integrates the freeway management system, a freeway incident management program, ramp meter signals, closed circuit television verification, changeable message signs, HOV lane system, a regional computerized traffic signal system, emergency management operations, and motorist assistance program, showed a saving of 30 minutes for major freeway incidents. Total annual estimated delay savings is 572,095 vehicle-hours. Estimated economic value of these savings is $8,440,000 annually. TranStar has been shown to have an approximate benefit-to-cost ratio of 10:1.

- The NaviGAtor program, in Atlanta, GA resulted in an average 46-minute reduction in incident duration time and reduced incident delay by 7.25 million vehicle-hours. The NaviGAtor incident management component reduced the average incident duration time from 67 minutes to 21 minutes or by 69 percent. There were an estimated 13,544,000 vehicle-hours of delay before the program was implemented and only 6,290,000 vehicle-hours of delay after NaviGAtor. This amounts to a 54 percent reduction in delay. The NaviGAtor system includes a traffic management center (TMC), freeway management components, advanced traveler information systems, and an incident management program. TMC operators use vehicle detectors, closed circuit television (CCTV) cameras, dynamic message signs (DMS), and ramp meters to collect traffic data and manage incidents. When TMC operators identify an incident, they dispatch a Highway Emergency Response Operator (HERO) to provide motorist assistance or traffic control.

Other studies have focused on the effectiveness of individual countermeasures. One such countermeasure is to improve the detection and response time relating to incidents. Determination and verification of a location and the nature of incident that has occurred can reduce the impact of an incident. Improved detection and verification can be done through a variety of methods including improved closed-circuit TV (CCTV) camera coverage, deployment of service patrols, use of motorist call-in, police and fire dispatches; aerial, TOC/TMC observations, and use of private traffic data.

Examples of the benefits from CCTV camera surveillance have been found as follows:

- In Monroe County, New York, the camera deployment and ITS integration project reduced incident validation times by 50-80 percent saving 5-12 minutes per incident.
- In Toronto, the COMPASS traffic monitoring (CCTV and loop detectors) and traveler information on Highway 401 decreased the average incident duration from 86 to 30 minutes per incident.
- In Brooklyn, an incident management system on the Gowanus and Prospect Expressways used CCTV, highway advisory radio, dynamic message signs, and a construction information hotline to improve average incident clearance time by about one hour, a 66 percent improvement.

The MAG Region has existing implementation of CCTV camera surveillance. They are located high above the roadway to provide visibility of traffic incidents. Most CCTV's can pan, tilt, and zoom from any workstation at the ADOT Traffic Operations Center (TOC). TOC control room staff constantly monitors the CCTV cameras. When staff becomes aware of an incident, they use these cameras to verify the incident and determine the appropriate response (e.g., post messages on Dynamic Message

Signs). Five valley television stations have access to ADOT's live CCTV camera feeds to show freeway conditions.

The freeway test corridors are equipped with CCTV cameras and no improvements to the current implementation are suggested.

Examples of the benefits from implementation of freeway service patrols or courtesy patrols are as follows:

- Typically a freeway patrol program is designed to reduce traffic congestion and improve highway safety by responding to and assisting in traffic incidents.
- The benefit-to-cost ratio of Florida's Road Ranger freeway service program is 3.2:1 (ranging from 2.31:1 to 21.4:1 in different districts).
- The Motorist Assistance Program in Houston has a benefit-to-cost ratio as high as 23.3:1 with a positive impact on incident and delay reduction.
- The Alabama Service and Assistance Patrol (ASAP) program has an estimated benefit-to-cost ratio ranging from 1.7:1 to 23.4:1 with an average of 9.2:1. The mobility benefit ranged from $985,900 to $13,878,400 for 2005. Based on simulation, the ASAP creates almost uniformly increasing delay reductions with increasing incident duration reductions.

The MAG Region has existing implementation of freeway service patrols. More than a half-dozen vehicles assist motorists in the MAG Region 18 hours a day, 7 days a week. This service is operated by the Department of Public Safety (DPS).

Site management and response teams are used to manage equipment and personnel and quickly remove the incident and minimize impact on traffic flow.

- ADOT's Arizona Local Emergency Response Team (ALERT) has averaged 15 major incident calls per month, or 185 a year, between 2001 and 2007. The average response time has ranged from 22 to just 18 minutes in 2006-07. The six-year average response time is 19 minutes, and the average incident duration has been 3 hours, 18 minutes.

The MAG Region's ALERT program uses specially equipped vehicles that respond to incidents throughout the region, providing on-site command and control, portable DMS capability, and more. Deployment of additional ALERT vehicles on the freeway test corridors during peak hours is a possible countermeasure for non-recurring congestion.

Another countermeasure is to install push bumpers on law enforcement vehicles to remove disabled vehicles.

- This is already implemented in the MAG Region as nearly all police and DPS vehicles have push bumpers. No improvements to the current implementation are suggested.

Quick clearance programs for freeways have also be used to move vehicles from the roadway after a crash immediately and restore traffic flow and reduce secondary crashes.

- In Houston, Texas, their SafeClear program was responsible for decreasing the number of freeway crashes 10.4 percent and decreasing by nearly 2,000 crashes after first year of implementation. This equated to a $35 million savings.
- Arizona Revised Statutes (§28-674) currently requires vehicles involved in crashes on limited access freeways to be removed, if possible and can be done safely, to a safe refuge area.

The MAG Region has existing resources that are used in conjunction with one another to clear incidents on freeways quickly. The ADOT TOC control room includes 32 video monitors and large screens used to display traffic speed and weather information. There are four workstations in the control room; operators at two of the stations monitor traffic in the MAG Region and the other operators monitor traffic throughout the remainder of the state. The ADOT TOC control room staff constantly monitors the Department of Public Safety (DPS) Computer Aided Dispatch (CAD) system, speed maps, and CCTV cameras. When staff becomes aware of an incident, they use the cameras to verify the incident and determine the appropriate response (e.g., dispatch DPS, post messages on Dynamic Message Signs, enter information into the Highway Condition Reporting System (HCRS)).

A potential improvement would be to increase the number of ADOT TOC operators for at least the weekday peak periods. Another potential improvement would be to increase the accuracy of the speed and travel time maps in real time. Currently, freeway speeds are obtained at fixed points on the freeway—i.e., time-mean speed information. Obtaining better traffic data should be explored, as that would enable the generation of real-time space-mean vehicle speeds which are a more accurate representation for travel time. Such an improvement may also be useful in assessing instantaneous level of service conditions.

Examples of the benefits of implementing fixed or portable dynamic message signs to inform motorists about vehicle incidents are as follows:

- Modeling of 9 ITS projects in San Antonio, Texas indicated that integrating DMS, incident management, and arterial control systems could reduce delay by 5.9 percent. It also showed that freeway and arterial crashes could reduce by 2.8 and 2 percent, respectively.
- Another simulation study of the effectiveness of dynamic message signs indicated that integrating traveler information with traffic and incident management systems in Seattle, Washington could reduce delay by 1 to 7 percent, reduce stops by about 5 percent, lower travel time variability by 2.5 percent.
- Simulation of using dynamic message signs to warn drivers of incidents as part of a freeway management system in Fargo, North Dakota showed network travel times could be reduced by 8 percent and speeds increased by 8 percent.

The MAG Region has existing deployments of dynamic message signs (DMS). They are large signs over freeway lanes used to display messages to the public once an incident has been verified by ADOT TOC staff. Nearly 120 miles of the freeway system is equipped with DMS. The existing DMS locations should be evaluated to determine whether additional locations would benefit the traveling public due to high incident/congestion conditions. Due to the common occurrence of commuters using multiple freeways, it would benefit drivers if DMS were located in advance of major interchanges or decision points. Messages displayed in the DMS should also be evaluated to determine whether information display could be improved such as route diversion suggestions and more accurate travel time.

Another freeway countermeasure is ramp metering. Ramp metering has been used for over 40 years in some urban areas as a method to prevent mainline freeway traffic flow from breaking down due to high volumes of traffic entering the freeway from ramps.

- A 2008 evaluation of ramp metering in the Minnesota Twin City region found a 22 percent freeway travel time savings and a 14 percent increase in throughput. They study found a 15:1 benefit cost ration when using just the cost of the ramp metering system.
- Study on I-880 in San Francisco showed a potential 33.2 percent delay reduction with ramp metering.

The freeway test corridors and most MAG Region freeway sections are equipped with ramp metering in use during directional peak hours on weekdays. They are active only during AM and PM peak periods and the metering rate is determined from mainline traffic flows just upstream of the ramp. Until recently ADOT did not have full control of the ramp meter operation from the TOC. It is suggested that ramp meters be operated with more advanced control through the ADOT TOC. This is currently being addressed by ADOT.

Construction Activity Countermeasures for Freeways

The following second set of countermeasures is focused on reducing the non-recurring congestion caused by construction activity. There have been some large, comprehensive construction management efforts taken for reconstruction of major freeway sections and interchanges. These include a number of countermeasures to address non-recurring congestion caused by construction activity.

- In Albuquerque, New Mexico, work zone surveillance and response at the "Big I" Interchange reduced average clearance time by 44 percent. Work zone surveillance was achieved through closed circuit television cameras (CCTV), broadband wireless communications, and directional antennas. Motorists approaching the interchange of I-25 and I-40 were made aware of traffic conditions (lanes affected) via information displayed on dynamic message signs (DMS), and through strategic deployment of portable changeable message signs (CMS). In addition, pre-trip traffic information was updated every three minutes on the "BIG I" Internet web-site.

The use of route diversion to direct traffic to alternate route(s) around work zones has shown to be an effective countermeasure.

- FHWA document reports between 50 and 85 percent of drivers surveyed said that they changed their route at least sometimes in response to travel time, delay or alternate route messages provided by work zone ITS. Reductions in queue lengths from 56 to 60 percent are possible with simulations indicating reduction in system-wide total delay may range from 41 to 75 percent.

Highway Advisory Radio (HAR) is a countermeasure that uses a local radio station dedicated to providing traveler information.

- In Brooklyn, an incident management system on the Gowanus and Prospect Expressways used CCTV, highway advisory radio, dynamic message signs, and a construction information hotline to improve average incident clearance time by about one hour, a 66 percent improvement.

Another countermeasure is to restrict construction activity during peak conditions. Non-peak (major) construction policy implementation can include region-wide or statewide policy prohibiting major construction activities during peak periods along urban freeways.

- ADOT does restrict construction activities during peak periods along urban freeways. Results of this are evident in the data collection analysis where weekends have the highest percentage of non-recurring congestion.

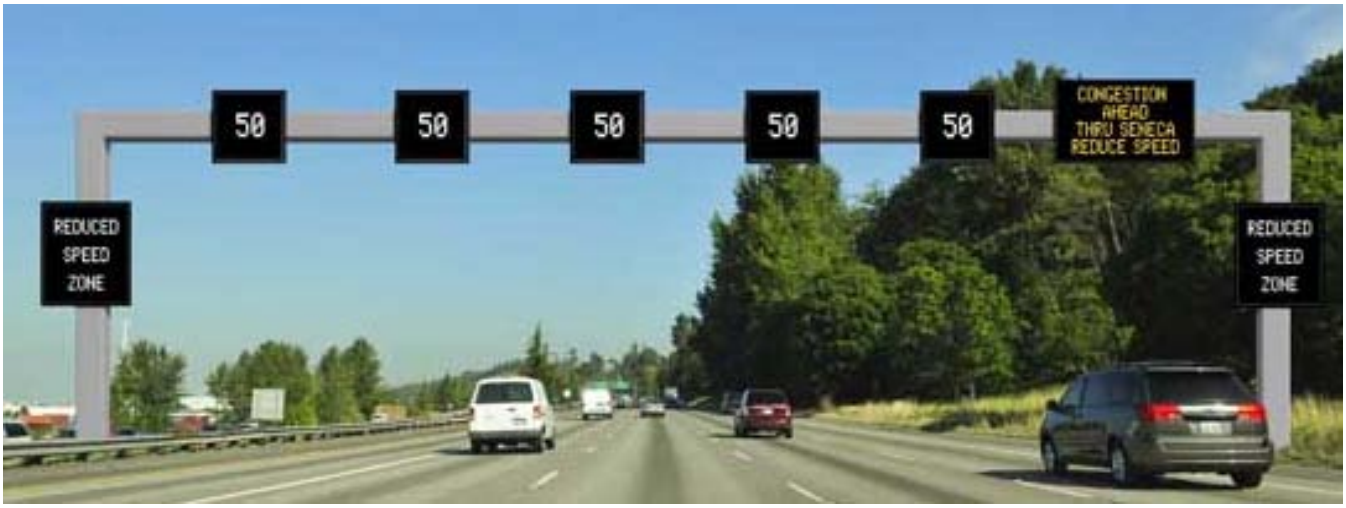
Basic infrastructure elements of the Freeway Management System are installed when any new freeway is constructed in the MAG region; however, often additional FMS features are not installed at the same time but are scheduled to be designed and constructed later when the level of service on the freeway approaches LOS D.

Route diversion could be improved through use of more DMS in the region showing messages prior to multiple interchanges or popular arterial diversion routes that would allow motorists to change their route prior to encountering the freeway segment under construction. In addition, DMS messages could be displayed prior to roadwork notifying drivers of the duration of construction activities and best alternative routes. Implementation of better traffic diversion information involves policy decisions and it is currently being by the Incident Management Coalition.

Highway Advisory Radio is not implemented in the MAG Region and it is not suggested as a countermeasure for NRC. Local radio and TV stations already have excellent access to traveler information.

Some states have begun using the Dynamic Lane Merge to improve the traffic flow in advance of, and at, lane closures. Traffic sensors are used to monitor flow and, as queuing increases on the approach to a lane closure, signs are activated to regulate the merge, advising motorists to either merge early or late depending on traffic conditions.

- Michigan Department of Transportation test of early merge found: 1) average travel speed increased from 40 to 46 mph during the morning peak period, and 2) crashes were reduced from an average of 1.2 per month during the 4 months prior to activation to no crashes after activation.



Source: www.wsdot.wa.gov

The use of variable speed limits (VSL), as part of Active Traffic Management, to manage speed (aka speed harmonization) on freeway corridors is gaining interest in the United States based on successful experiences in Europe. ITS technologies have been implemented that monitor traffic flow to change speeds to minimize speed differentials and maintain speed limit compliance. Successful European experience has typically implemented variable speed limits in conjunction with another treatment such as hard shoulder running during the peak periods.

- A Michigan DOT 2003 study found that as both the speed limit displayed by VSL and operating speed increased, driver compliance improved, and more consistent speeds resulted.

The MAG Region has implemented Active Traffic Management only to a limited extent, with much of it seen in arterial traffic management. The associated traffic management strategies that are not currently implemented in the MAG Region are speed harmonization, queue warning, temporary shoulder use, junction control, construction site management, and truck restrictions. Active Traffic Management on one or more freeway test corridors should be investigated further as a possible countermeasure for NRC.

Another countermeasure that can be used for freeways or arterial streets under construction is smart work zones. Through the use of detectors and dynamic message signs, smart work zones can inform drivers of queues, delays, and need for diversion when conditions warrant due to lane closures. These systems can reduce mainline traffic volumes and improve perceived and actual safety.

- A 2008 USDOT report on the benefits of intelligent transportation systems in work zones, found an average 52 percent reduction in mainline traffic volume for I-294 in the District of Columbia and 10 percent reduction in mainline traffic volumes for a project on I-35 near Hillsboro, Texas.

There are also several emerging countermeasures being testedg in pilot projects around the country. The actual benefits and costs of the projects are still pending. Examples of these are as follows:

- Dynamic ramp closures – San Francisco, California
- Shoulder running – Seattle, Washington; Minneapolis, Minnesota
- Traffic prediction – New Jersey Turnpike, New Jersey.

The potential use of AWAM type devices, vehicle probe data or crowd sourcing may provide the data feed needed to consider the development of a traffic prediction model for advanced determination of likely non-recurring congestion conditions in the future.

Another approach to mitigating non-recurring congestion is to attempt to minimize the number of incidents occurring due to vehicle breakdowns. State-mandated vehicle safety inspections would help to control the number of unsafe vehicles operating on the roadways. At least 18 other states have periodic programs (annual or biannual) in place; however, some studies have suggested the cost-effectiveness of vehicle safety inspections is insignificant.

Table 3 below lists all of the non-recurring countermeasures mentioned above that are focused on mitigating non-recurring congestion caused by incidents and road construction activities on freeways.

Table 3. Summary of NRC Countermeasures for Freeway Application

NRC Countermeasures	NRC Countermeasure Focus		Incident Element Focus					Applicability to MAG Region		Possible Next Steps
	Construction	Incidents	Public Awareness	Reducing # Incidents	Faster Detection	Faster Response	Faster Clearance	Currently in Use	Future Considerations ➔	
511 Traveler Info Dissemination	✓	✓	✓					✓	✓	Enhance
CCTV Camera Surveillance	✓	✓			✓			✓	✓	Enahnce
Highway Advisory Radio (HAR)	✓	✓	✓					X	✓	Test Variant
Info Dissemination via Permanent DMS	✓	✓	✓					✓	✓	Improve
Monitor Conditions per Real-Time Traffic Prediction	✓	✓			✓	✓		X	✓	Test
Restricted Work Zone Hours	✓							✓	✓	Enhance
Use of Dynamic Lane Merge Control	✓							X	✓	Consider
Use of Full or Dynamic Ramp Closures	✓	✓					✓	X	✓	Consider
Use of Smart Work Zones	✓							X	✓	Consider
Use of Variable Speed Limits	✓	✓		✓				X	✓	Test
Availability of Site Management/ Response Teams		✓				✓		✓	✓	Enhance
Broadcast Dynamic Route Diversion		✓	✓					X	✓	Consider
Enforce Quick Clearance Program/Law		✓	✓				✓	✓	✓	Improve
Install More/More Advanced Vehicle Detectors		✓			✓			✓	✓	Enhance
Permit Shoulder Running		✓				✓	✓	X	✓	Consider
Required Vehicle Safety Inspections		✓		✓				X	X	none
Use of Dynamic Lane Assignment		✓		✓			✓	X	✓	Test
Use of Advanced Ramp Metering System		✓		✓				✓	✓	Pending
Use of Service Patrols		✓		✓	✓	✓		✓	✓	Enahnce
Vehicles Equipped w/ Push Bumpers		✓					✓	✓	X	none

Arterials

There are very few examples of current experience and the effectiveness of non-recurring congestion countermeasures on arterials that are being used to address vehicle incident and roadway construction activities.

Countermeasures that can be applied to arterials to address either incident- or construction-related non-recurring congestion are:

Intelligent Transportation Systems (ITS)

The City of Scottsdale is an example of city-wide ITS deployment. They combine an advanced traffic management system with CCTV, DMS, and a media/public communication system. From the Scottsdale TMC, signal timing can be adjusted "on the fly" and manual control of the intersection can be taken to clear long queues of vehicles. Scottsdale Traffic Management sends incident notifications to local media who broadcast on local public radio and offer direct notification to the public's cell phones. Scottsdale's use of ITS allows them to efficiently handle large crowds at special events such as the Phoenix Open Golf Tournament, held in Scottsdale. This particular event used to require 50 "on-street" police officers to manually operate the intersections affected by the event. Now it just takes one police officer, trained in basic signal operations, posted at the Scottsdale Traffic Management Center.

Service Patrols

Nearly all of the service patrol type strategies around the nation are being applied mainly on limited access highways. The REACT program operated by Maricopa County, focused mainly on roads in unincorporated areas and a few cities in the West Valley, is perhaps the only program or one of very few such programs focused on arterials.

- A 2002 evaluation of Maricopa County's Regional Emergency Action Coordination Team (REACT) program showed a benefit to cost ratio ranging from 6.4:1 to 8:1 at that time.

CCTV

Increasingly, signalized intersections are being equipped with CCTV and their traffic signals are able to be dynamically managed from a traffic management center. Since arterial corridors parallel to freeway corridors are often used as route diversion, communication to local TMCs regarding freeway incidents may decrease non-recurring congestion. The results of Technical Memorandum 3 indicate that only multiple lane or full freeway closures affect parallel roadways one interchange upstream from an incident.

DMS

Some cities in the MAG Region utilize permanent DMS, such as the Scottsdale, Phoenix, Peoria, Glendale, Surprise, Gilbert, and Chandler (all varying in extensiveness). The locations for the DMS are chosen primarily due to special event centers or proximity to freeway corridors. Permanent DMS could be installed on critical commuter corridors to provide travel time information and freeway conditions to motorists.

These, and other cities, also deploy portable DMS. These are commonly used upstream from construction zones. City transportation departments could work with local police to have a portable DMS system ready for deployment in their vehicles. This would provide a benefit for vehicular incidents in particular.

Push Bumpers

Push bumpers are already in use on nearly all DPS and police vehicles in the MAG Region.

Restrict Construction Activity During Peak Periods

Most cities in the MAG Region restrict construction activity during the AM and PM peak hour and require full access and lane capacity at major intersections. The arterial volume data collection from this study indicates that traffic volumes remain elevated throughout the day. Limiting construction activities to night and weekends may decrease non-recurring congestion.

Construction Activity Route Diversion

Most cities provide information regarding planned roadway construction activities on their websites. Alternate route information is often provided. An improvement for the public would be to have this information from all MAG Region cities and towns obtainable from a central location with up-to-date information.

Dynamic Signal Timing

The City of Scottsdale maintains 18 signal timing plans for each signal. Eight are emergency plans that can be quickly enabled for traffic collisions, stalled vehicles, or heavy event traffic. The City of Mesa will be implementing an Adaptive Traffic Control System (ATCS) around a major activity center. If their deployment proves to reduce delay, it may be the impetus to consider ATCS at other locations where highly variable traffic patterns occur. High variability can be caused by holiday shopping, special events, construction activities, and vehicular incidents.

Table 4 on the next page summarizes the NRC countermeasures that are applicable to arterial deployment. The information also suggests possible countermeasure considerations for the MAG Region based on its pre-existence (and opportunity for improvement) or potential for benefit based on use in other states.

Table 4. Summary of NRC Countermeasures for Arterial Application

NRC Countermeasures	NRC Countermeasure Focus		Incident Element Focus					Applicability to MAG Region		Possible Next Steps
	Construction	Incidents	Public Awareness	Reducing # Incidents	Faster Detection	Faster Response	Faster Clearance	Currently in Use	Future Considerations ➔	
511 Traveler Info Dissemination	✓	✓	✓					✓	✓	Enhance
CCTV Camera Surveillance	✓	✓			✓			✓	✓	Enahnce
Dynamic Signal Timing to Adjust to NRC Events	✓	✓		✓				X	✓	Pending
Info Dissemination via Permanent DMS	✓	✓	✓					✓	✓	Improve
Info Dissemination via Portable DMS	✓	✓	✓					✓	✓	Test
Restricted Work Zone Hours	✓							✓	✓	Enhance
Availability of Site Management/ Response Teams		✓				✓		✓	✓	Enhance
Broadcast Dynamic Route Diversion		✓	✓					X	✓	Consider
Required Vehicle Safety Inspections		✓		✓				X	X	none
Use of Service Patrols		✓		✓				✓	✓	Enahnce
Vehicles Equipped w/ Push Bumpers		✓					✓	✓	X	none

RESOURCES NEEDED

Resources refer to the capital cost to implement and the ongoing operation and maintenance costs. The operation and maintenance costs typically include the human resources (or additional staffing) needed to operate and maintain a project or system. There is capital cost information from around the country on projects that attempt to mitigate non-recurring congestion caused by incidents and construction activity. There is less information, however, on the operation and maintenance costs as well as detailed information on the transferability of projects to other regions around the country. This section highlights the information available on the resources required to deploy.

The following highlights some of the costs available for representative projects from around the country:

<u>Freeways</u>

- The MAG Region has had a Freeway Service Patrol Program since 2001.
- The Road Ranger Program in Florida that implemented freeway service program had a total cost of $1.1 million which averages about $55,500 per corridor.
- The annual cost of Houston TranStar includes annualized capital costs, annual operational costs of the Houston TranStar systems, and the annual cost of operation and maintenance of the field installations. The annualized cost estimate of $27.7 million.
- Motorist Assistance Patrol, Harris County, TX had an estimated benefit-cost of 23.3:1 with an annual cost of $362,000.
- SafeClear Program, Houston, TX had an estimated benefit-cost of 8.14:1 when considering its annual (capped) cost of $4,300,000 and first-year benefits of $35,000,000.
- The benefits of the NaviGAtor incident management program were determined during a before-and-after study that analyzed twelve months of data in the Atlanta metropolitan area. The HERO Motorist Assistance Patrol combined with the NaviGAtor incident management strategies had a benefit-cost ratio of 4.4:1 with a cost of $42M.

- The cost of the Alabama Service and Assistance Patrol (ASAP) during the 2004-2005 was $594,300.
- In the late 1990s, Monroe County Department of Transportation (MCDOT) undertook the ITS Camera Deployment and Systems Integration Project. The cost was $279,000 (2006).
- The Minnesota Twin City ramp metering study estimated an annual capital cost of $746,000 and an annual operating and maintenance cost of $896,000.
- Michigan DOT leased a Dynamic Lane Merge (DLM) system for I-94 reconstruction project initially for $120,000 (included design, install, calibrate, test, operate, and maintenance). The cost has dropped to $30,000 per deployment per direction (included installation, operation, inspection, maintenance, and removal).
- Minnesota DOT deployed Dynamic Late Merge system for $900 per day per direction.
- Michigan DOT leased 7 variable speed limit (VSL) trailers for 6 months at $400,900.The VSL system, which was deployed along I-96 in Lansing, consisted of seven trailers with remote traffic microwave sensors, solar power, controllers with radio frequency communication, and light-emitting diode (LED) speed displays. Work zone speed limits were based on traffic congestion, weather, presence of workers, and other factors.
- North Carolina DOT leased smart work zone system along I-95 near Fayetteville for $235,000. The system consisted of six speed sensors, eight changeable message signs (CMS) (two were used on alternate routes), six pan-tilt-zoom cameras (three in each direction), a command center, one laptop, and a dedicated project website. Delay information (i.e., delay in minutes, current date and time) was calculated and automatically displayed in real-time on the CMS. When a pre-determined threshold was reached, the message was changed to provide travelers with alternate route information. The lease consisted of three items: mobilization, monthly rental, and remobilization. The bid was guaranteed for four months usage but not to exceed 10 months.
- Illinois DOT implemented a work zone Traffic Monitoring System (TMS) on I-64 construction project for $435,000. It consisted of 12 variable message signs (VMS) located within and in advance of the work zone so travelers can determine whether or not to take alternate routes, and 10 side-fire radar sensors. These sensors were mounted on portable trailers and measured speed, volume, and occupancy lane-by-lane. Real-time information about traffic conditions was posted to the VMSs and automatically posted to the www.64addlane.com web site. Data was transmitted via cellular-IP back to the server located at the vendor's site. IDOT traffic center had capability to change the messages on the VMSs. Text and e-mail alerts were transmitted when pre-determined thresholds were reached. The TMS was deployed for 30 months.
- The Arkansas State Highway and Transportation Department (AHTD) leased an automated work zone information system (AWIS) in West Memphis for $495,000 which was less than 4% of the total reconstruction project cost. The AWIS included 12 queue detectors and five remotely controlled DMS which were linked to a central base station server via wireless communications, three HAR units, five pagers, and an email alert system. The traffic detectors were installed one mile on each side of the work zone. The DMSs were deployed over approximately 9 miles on each side of the work zone. The HARs range was approximately 23 miles. The server processed data from the queue detectors and disseminated messages to the DMS and HAR based on predefined messages for specific traffic conditions. AHTD staff and others were informed of traffic conditions via email and pager alert systems. The lease included personnel to monitor the system. Usually one person was required for periodic system maintenance and to be on-call after hours. The terms of the lease called for a daily fee paid to the contractor and a lump sum for the HARs. The fee was assessed each day the system was operational, thereby the state did not pay for any system down time.

- A real-time work zone traffic information system deployed for the I-496 project in Lansing, Michigan had an estimated benefit-cost of 1.97:1 with a cost of $5M ($2.5M for real-time information components and $2.5M for the system).

Given the incidental cost information presented above coupled with the characteristic information presented previously in Table 3, the following subset of Freeway NRC Countermeasures are presented (in order of generally increasing estimated implementation costs/complexity) for further consideration, and may become the impetus for this study's pilot project framework development:

- Installation, monitoring, and dissemination of vehicle sensors and its resulting data;
- Improved information dissemination via existing permanent DMS;
- Enhanced ramp metering system;
- Use of dynamic lane merge control within construction zones; and
- Implementation of Active Traffic Management strategies (e.g., dynamic lane assignment and/or variable speed limits)

Arterials

Due to limited deployment of systems specifically focused on monitoring for, or reducing, NRC on arterial roadways, data concerning resource needs is lacking. The one example, which is particular to the MAG Region, is cited below.

- A 2002 evaluation of the Regional Emergency Action Coordination Team (REACT) program, as implemented in the MAG Region at the time, estimated benefit-cost ratios from 6.4:1 (current operation) to 8.4:1 (maximum operation) with the following assumptions.

Callouts/year	Cost ($)	Benefit ($1,000)	B-C Ratio
100	103,200	664	6.43:1
150	126,550	996	7.87:1
175	142,350	1,162	8.16:1
200	158,100	1,328	8.40:1

In order to determine a subset of the arterial NRC countermeasures to consider further as part of this study, a qualitative assessment of their resource needs and ease of implementation was conducted. The countermeasures that were determined to have a combination of the least resources required and an implementation that could be carried out the easiest were (in order of generally increasing estimated implementation costs/complexity):

- Installation, monitoring, and dissemination of vehicle sensors and its resulting data;
- Improved information dissemination via existing permanent DMS;
- Use of portable DMS to disseminate immediate information concerning NRC event; and
- Dynamic signal timing to adjust traffic control to NRC events