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STAKEHOLDER REQUIREMENTS FOR TRAFFIC SIGNAL PREEMPTION

AND PRIORITY IN THE WASHINGTON, DC REGION.

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Abstract: This paper has two objectives. The first is to identify the needs, issues and concerns that local elected officials, and transportation and emergency personnel from the Washington, D.C. area have regarding signal priority and preemption systems. The second objective is to use these needs, issues and concerns to generate a set of system objectives and general requirements that state and local decision makers might use in evaluating these systems in the future. The paper reports that while emergency and transit

agency personnel are actively interested in this technology, they and the other stakeholders have significant questions and reservations to be considered in the adoption and deployment of preemption and priority systems.

1. INTRODUCTION

Traffic and traffic congestion often challenge the delivery of essential public services such as emergency vehicles or transit. For this reason, Intelligent Transportation Systems (ITS) research has long focused on measures to promote and improve the delivery of these services over congested roadways. This paper addresses two such measures, signal preemption and signal priority. By and large, the literature has focused on the capabilities of various existing systems and their impact on real or hypothetical traffic or accident patterns. This paper, however, looks at the differing issues, needs, and concerns that elected officials and transit, traffic and emergency personnel in a region have regarding the implementation, installation, maintenance and use of both types of systems. These findings are then used to design stakeholder-driven system objectives as well as general system requirements. Future research will use these general system requirements to develop detailed technical requirements.

Differentiating Preemption from Priority

Signal *preemption* technologies preempt normal traffic signal cycles at an intersection in order to facilitate the safe passage of fire and emergency vehicles. These technologies have been available to local jurisdictions for over twenty years. Indeed, many jurisdictions, including a number in the Washington Metropolitan Region, already have such systems installed using both hardwired and wireless technologies.

More recently, a related concept, signal *priority* for transit, has received increased attention. Signal priority is often differentiated from preemption in that priority is only granted to specific transit vehicles and only under certain conditions, such as when a bus

has fallen significantly behind schedule or is on an express route. Also, transit is most often granted priority at the beginning of a green phase or the green phase is extended to allow it to pass through an intersection. Transit is generally not able to preempt or shorten a red, though this too has been tried (1).

Research Method and Outline of Paper

Three steps were taken to examine these questions. The first step was to review and synthesize the literature that is available. The second step was to interview stakeholders within the three major regional jurisdictions, Maryland, Virginia and the District of Columbia. The interviews utilized an interview guide (derived from the findings of the literature review and other background research) to ensure consistency. In all 37 stakeholders were interviewed, eight from DC, five from MD and 18 from Virginia (this larger number is due in part to a larger number of jurisdictions on the Virginia side of the region) as well as four with staff of the Washington Metropolitan Transit Authority (which operates the metrorail and largest bus system in the region) and two with staff of the Metropolitan Washington Council of Governments (the regional metropolitan planning organization). The final step was to summarize the issues, needs, and concerns identified by stakeholders in the form of requirements for preemption and priority systems in the Region.

The structure of the paper reflects these research steps. Section 2 presents the literature synthesis; Section 3 discusses the interviews in greater detail and presents the issues, needs and concerns that stakeholders identified regarding both preemption and priority strategies within the Region; Section 4 identifies the system objectives and general requirements for both preemption and priority identified from the interview

findings; and Section 5 summarizes the findings and provides some concluding remarks on future research.

2. LITERATURE

The literature on priority and preemption tends to be about the technical details of the systems and the simulated or measured impact that they have on traffic conditions or other variables. When it comes to the motivations and the institutional concerns, needs, and issues that confront the agencies and localities that install these systems, the literature is significantly more limited.

The published literature on signal preemption and priority falls generally into four categories: 1) technical reports - both published and not - on the composition, operation, and logic of priority and preemption systems; 2) reports, papers, and presentations prepared related to field tests and other experiences with these technologies; 3) computer simulation reports and results; and 4) product and system installation announcements in the industry press. A smaller body of literature consists of the local or national surveys that a number of highway departments have conducted (2,3). A review of the technical specifications of specific projects can be found in Dion (8) and Collura et al (9).

If there is any information to be found on the institutional aspects of installing and operating these systems it is in the surveys and in the reports generated by field tests and other experiences. For Example, the Virginia Department of Transportation (VDOT) undertook a review of preemption systems in Virginia (2). This study found that while the use of preemption in the state was widespread in terms of the number of jurisdictions using it in one form or another, the actual number of signals in Virginia jurisdictions with preemption is low. While the report's focus is Virginia, it is based on a survey of traffic

agencies nationwide. The survey generated responses from 50 agencies in 17 states. The largest group of the responses, 16 in all, came from Virginia. Ninety-four percent of those responding had preemption of one type or another. Of those responding 36% indicated that signal preemption disrupts the operation of coordinated signals, while 22% indicated it did not, and the rest either did not answer the question or were uncertain.

The VDOT survey also asked about the institutional, regulatory and legal issues that local agencies encounter in applying signal preemption. Agencies were asked about the policies and guidelines they had created for the use of preemption by emergency vehicles. The survey found that while a majority (72%) of agencies stated that guidelines and policies would be useful, only 36% had such policies. None of the states or localities that responded to the survey had laws that would allow for the prosecution of violators but 66% of the respondents stated that emergency personnel did not abuse the preemption system.

One important finding was that there was some variation between who provided the funding for installation and who maintained the system. For example the federal government provided some funding for installation in 7% of the jurisdictions but provided no funding for maintenance.

The survey also found that the fire department initiated the preemption effort in 33% of the localities, making them the top advocates for installing preemption. In the survey local officials were second in their interest (13%).

Finally, the VDOT survey found that 82% of jurisdictions responding had not done a follow-up analysis of the effectiveness of preemption.

In Maryland a number of reports have been conducted on various transit priority (and rail transit preemption) systems (4,5,6) and a pilot project was also undertaken in Washington, DC (7). Maryland also has some experience in signal preemption for light rail, which concluded that traffic engineers must be able to balance the needs of transit with the needs of road, and must move away from a "railroad rules" mentality in the case of light rail (6). The D.C. report mentions the need for drivers to become accustomed to the system. Beyond, this however, these reports do not treat institutional issues or stakeholder input in any significant way.

The City of Phoenix evaluated emergency vehicle preemption systems in a survey similar to Virginia's that accompanied a number of local field tests (3). Their national survey queried 10 cities to which Phoenix has chosen to compare itself for such studies and eight local jurisdictions. The survey asked 22 questions about the technology, its use, and institutional issues such as happiness with the warrantee, funding sources, unwarranted use and the criteria used for locating the equipment. Fifteen of the 18 responding cities and jurisdictions used signal preemption. The funding for the programs was mixed. While most used the operating budget, a wide range of bonds, grants, and state funds were used particularly for purchasing and installation. Only one of the jurisdictions reported suspected abuse of the systems, but only three used "event logging" to track use of the system. Most cities used some sort of interlocking method to disable the preemption device such as when the parking brake is engaged. Intersections were chosen primarily based either on the level of congestion or their designation as fire routes. Some of the cities and local jurisdictions also included state routes and arterials.

3. INTERVIEWS AND FINDINGS

This section focuses on the issues, concerns, and needs expressed by local traffic, transit and emergency personnel and elected officials in the Washington, DC Region about the installation and use of priority and preemption systems. A secondary objective here is to begin identifying what these stakeholders want and expect preemption and priority to achieve for their jurisdictions, agencies and for the Region.

It is important to note here that the responsibility for traffic control systems is shared between state and county agencies in Maryland, with state responsibility for state routes, and local responsibility on local routes. In Virginia, by contrast, VDOT has complete responsibility in most counties, with the exception of Arlington in the Washington, DC Region. The cities of Falls Church, Fairfax, Alexandria, Manassas, Manassas Park and Vienna also have jurisdiction on most state and local routes within city boundaries. Fire and EMS, on the other hand, are completely local functions in both states. The jurisdictional arrangement in Virginia poses particular challenges of coordination, collaboration, and accountability. The District of Columbia operates as a single unit with all of these functions falling under the city government, though there are some coordination issues with various federal police forces. These institutional differences contributed significantly to determining the responses of interviewees.

While the literature revealed relatively little focus on institutional issues in installing, implementing and maintaining these systems, stakeholders in the Washington Region appear to have a number of issues, needs and concerns that traffic and transit agencies should be aware of, if they are to pursue preemption and priority strategies.

Elected Officials

In general, elected officials were supportive of preemption for fire, police, and emergency vehicles. Many elected officials were more reluctant about priority.

Preemption

Elected officials had some minor concerns about traffic disruption caused by preemption, but on the whole felt that and that their voters would be supportive of the system. When asked about unwarranted use, elected officials took the position that fire departments could generally be trusted to use the system properly and to adequately address any instances of misuse. None of the elected officials stated that preemption was among their top traffic priorities, though they did indicate that they were aware of considerable interest in the fire communities of some suburban and outlying jurisdictions.

The primary objective that elected officials gave for installing preemption was to reduce the time it took for emergency vehicles and personnel to respond to an emergency. Most elected officials mentioned the safety of emergency personnel as a secondary objective. Some elected officials indicated that preemption would likely increase the safety of the motoring public.

The most widely voiced concern was over the costs of installation compared to its benefits. All the elected officials interviewed, however, clearly saw the benefits of such a system, and hence cost was seen as a surmountable obstacle. Another concern for elected officials, particularly those from suburban jurisdictions, was that preemption might cause traffic delays on side streets. Once again, if the perceived benefits were obtained, traffic disruption was thought to be acceptable trade-off.

There were some more institutional concerns about interoperability and operations. The top concern of local officials had to do with the deployment schedules and locations, installation and maintenance of the systems. This was particularly true in Virginia, where VDOT is responsible for state *and* most county roads. While most Virginia elected officials felt inter-jurisdictional, interoperability was important, they felt that VDOT's statewide structure required it to account for other considerations that could limit its ability to be responsive to current and future local needs and concerns regarding preemption. All elected officials felt that ownership and fiscal responsibility for maintenance and operation of the systems must be clearly understood by fire, emergency and state (for VA and MD) and local transportation departments before deployment.

Priority

Most elected officials were considerably less comfortable with transit priority both as a technical and a political issue. There was complete agreement that the primary objective for such a system should be schedule adherence. Elected officials also suggested that priority might enable buses to be run more frequently and therefore become more convenient for their constituents. Some questioned whether priority could be part of a larger rider information system. Most elected officials felt that if schedule adherence, frequency, and information were improved, it might in turn help to increase the bus ridership. One official even suggested that providing "priority" might raise the status of bus riders and thereby help contribute to ridership. All in all, however, most elected officials questioned whether any benefits that priority provided would offset the additional costs.

Beyond cost, the concerns of elected officials about priority were many. Above all the concern was that priority would disrupt traffic and worsen congestion and delay. Each elected official mentioned the need for *local* field tests to show that traffic conditions improved or at least became no worse. Without such a clear result, elected officials felt that priority would not be able to garner much political support within their jurisdictions or among elected officials regionwide.

Another concern was that the system would not provide any significant improvement for bus on-time performance. It was suggested that there were many other things that could be improved, such as the overall coordination of traffic signals across jurisdictions that would have a greater impact on the on-time performance of buses.

Some of the elected officials interviewed also were concerned about potential backlash from motorists who might raise "tax-equity" issues upon seeing such a system installed for buses. One elected official felt that transit was too "random" to be allowed priority.

On the one hand, those elected officials from more urban jurisdictions were more supportive of the priority's goals. They were also more sanguine about their voters' response if such a system were installed. On the other hand, urban elected officials also questioned whether priority would be capable of providing any real benefit to their bus operations given the congestion on their streets as well as the frequency of both stops and buses in their jurisdictions.

A final concern among elected officials was that traffic agencies might be reluctant to give up control over their signals to allow priority. Preemption apparently had enough political support to override any similar reluctance.

Emergency Personnel

Emergency personnel in the Region are clearly supportive of preemption. In some counties such as Loudon County, VA, and Prince George's County, MD, fire and emergency services are very actively negotiating with state highway departments and elected officials to have these systems installed.

Preemption

The primary objective of using preemption systems according to the emergency personnel is to increase the safety of emergency personnel. Preemption seems to be a top priority in some of the outlying suburbs. In these parts of the Region the problem seems to be adjusting to increasing congestion and new traffic patterns and signals. All emergency personnel mentioned that improved insulation, cell phones, air conditioning and radios in cars all mean that drivers are less likely to hear the sirens of their vehicles. A secondary objective for emergency personnel is to reduce traffic accidents that occur when cars stop suddenly or swerve to allow emergency vehicles to pass. The third objective is to reduce their response time to emergencies. As they are quick to point out, failure to meet either of the first two objectives will certainly have an impact on this last objective.

Emergency personnel are concerned about ease of use, the cost of equipment and the space that the equipment requires in fire engines and ambulances. They are also concerned about upkeep of the system and whether there will be greater maintenance costs.

There is some differentiation in emergency personnel responses. For example, there was more concern among management than emergency personnel more generally about

unwarranted use. In those jurisdictions with volunteer companies, management and professional firefighters expressed some concern about unwarranted use, unsafe behavior, and assuring accountability among volunteer companies. While this concern was not great, in localities with all-professional companies, interviewees did not express a similar concern or expressed the view that any problems that emerge could be easily treated with formal or informal policy measures.

Also there were divergent attitudes toward the use of a confirmation light to indicate to the emergency driver whether a call for preemption has been received or not. Some respondents felt this would improve safety and driving, while others thought such a light might cause emergency drivers to overlook normal precautions they might take at an intersection.

All emergency personnel responded that inter-jurisdictional interoperability was important for Virginia jurisdictions, but less so for those in Maryland. This was because in Maryland, fire and emergency medical services are the operated by large county jurisdictions, Montgomery and Prince George's counties, and have relatively few cross-border calls. In Virginia, however, there are a number of smaller jurisdictions including independent cities. The only regional interoperability for which there might be a need would be between Washington, DC and Maryland. Many Northwest Washington, DC residents use Maryland ambulance services. It was pointed out, however, that Washington, DC does not have any "first call" agreements (where one jurisdiction agrees to serve an area in another jurisdiction as if it were its own) with Maryland counties and the level of interaction does not begin to approach what is found among Washington D.C.'s Virginia neighbors.

The emergency personnel agree that preemption should be used for emergencies only and that its use might be conditional on the use of emergency lights or other technical checks. For example some jurisdictions have linked the system to the doors of the vehicle, the parking brake, or the transmission.

Under similarly controlled conditions, the fire and emergency personnel supported the use of the system by the police. The Fairfax County Fire personnel suggested that they are often called to a scene and it quickly becomes apparent that it is also a police incident. The sooner the police arrive to calm a situation down or intervene, the quicker the emergency medical personnel can begin treating victims. While police powers are generally confined to a single jurisdiction, state police as well as special police forces such as Park Police, Metro Police, Secret Service and others. are inter-jurisdictional and may desire inter-jurisdictional interoperability.

The police stakeholders interviewed suggested that cost was a serious concern. Also they did not want a technology that their officers had to switch on at intersections. There was some concern that the preemption technology might interfere with red-light enforcement camera technology that is being installed throughout the Region. A further concern of emergency personnel - and certainly traffic professionals as discussed below - is how multiple calls for preemption will be sorted out. What happens when multiple vehicles approach an intersection at the same time responding to the same or different calls? For emergency personnel the question comes up out of concern for safety; for traffic personnel there is the further concern for the impact of multiple calls within a short timespan on traffic signal timing plans and coordination.

Priority

The chief concern among emergency personnel was that transit priority systems not disrupt the operation of the preemption system or the granting of preemption to their vehicles.

Traffic Agency Representatives

Traffic agency representatives have serious concerns about the implementation of both preemption and priority systems. Preemption causes concern due to the variability in time and direction with which a signal can be preempted, given that emergency vehicles are granted unconditional preemption in emergencies. As indicated above, they also worry about the effect of multiple preemptions in a short time period as multiple units respond. Costs, maintenance and signal control are also mentioned. When it comes to signal priority, there is more agreement that on a limited basis, priority could be integrated into signal operations. This greater comfort appears to be due to the regularity of bus schedules and the fact that priority is only conditionally granted.

Preemption

There are three concerns among traffic professionals related to preemption.

1. Preemption has great potential to disrupt traffic and signal cycles due to the intrinsic uncertainty in when a signal will be preempted and the fact that preemption is typically granted automatically irrespective of traffic conditions.

2. Preemption equipment and its integration adds a greater degree of complexity to the traffic control system, potentially complicating repairs, maintenance and adjustments.
3. There is concern about who will control and determine the specifications of the system and the schedule for its installation.

The primary objective for preemption according to traffic professionals should be to reduce response time for emergencies. There was a concern that preemption might make traffic less safe due to shortened, irregular cycles and increased traffic congestion. On the one hand, traffic professionals also worried that emergency personnel might come to rely too heavily on preemption technology rather than common sense and therefore might be less careful than they currently are. On the other hand, they questioned whether preemption actually reduced response times, particularly if fire personnel continued precautions similar to those practiced today. A number of stakeholders in the traffic community pointed out that fire trucks already have a form of preemption with their sirens and lights.

The traffic community was concerned less about instances where the light is preempted by a single, isolated vehicle, for example a passing ambulance, and more concerned about incidences where there are multiple preemptions at an intersection or along a corridor within a short period of time. This might occur either as multiple units respond to single incident or on heavily used intersections as units respond to different incidents. They were concerned that when this occurs the signal system would have a hard time reestablishing coordination and returning traffic flow to normal levels.

Another concern is the commitment of elected officials to the signals and whether there would be sufficient money budgeted to maintain and adjust them over time in order to keep them operating and appropriately timed.

The primary need expressed by the traffic professionals was for accurate accounting of preemption activity so that they could address problems and understand the impact of preemption on their traffic system. They voiced a need for technical conditions that could be built into the systems to assure that they were only used when vehicles were actively responding to emergencies. There was also a strong consensus among traffic professionals that only selected intersections could be candidates for preemption based on the specific problems or needs experienced by the emergency community. There was a strong consensus against system-wide preemption. For example, local officials in Maryland felt that preemption on the roads they controlled was probably unwarranted, while MSHA does install preemption on the major arterials under its control in Prince George's County in consultation with the county fire department.

Today, Washington, DC, Maryland, and Virginia have some form of preemption installed and they expect more to be installed. Therefore, the chief issue is to minimize the systems' impacts on traffic flow. For this reason there was a lot of focus by traffic professionals interviewed on instituting conditionality to reduce the instances in which preemption could be granted and to avoid multiple preemptions in a corridor. All the traffic professionals mentioned that they feel accountable to local residents and receive many citizen complaints when traffic is snarled.

Priority

The traffic professionals interviewed indicated that transit priority might not be as disruptive to the flow of traffic as preemption. The reasons for this are twofold.

1. Conditions for granting priority are explicitly part of the system.
2. Buses operate according to schedules; their arrival and impact on an intersection can be better anticipated and accommodated.

Maryland is currently pursuing priority at both the state and local level. Though the interest is primarily in Montgomery County, there have also been discussions of transit priority in Prince George's and it may be part of future transportation plans. As discussed above, the experiences of MSHA have been generally positive. Montgomery County currently grants priority via human intervention from their centralized Advanced Traffic Management System (ATMS), but they are studying the feasibility of a more automated and sophisticated system, including the use of global positioning systems (8). In Washington, DC, there is currently money budgeted to test both priority and preemption in the Georgia Avenue corridor. In Virginia, Arlington County is starting a test of priority using its newly installed SCOOT traffic management system. Virginia does not have any existing transit priority projects.

Though traffic professionals in the Virginia jurisdictions of the region view priority as more manageable, they are not in any sense more enthusiastic about installing, coordinating and maintaining these systems. This is because while they are less worried about traffic disruption, they are more concerned that the system will not significantly improve transit schedule adherence or increase ridership. They also anticipate complaints by angry motorists who perceive transit getting special treatment or causing delays on the

road. In Maryland and Washington, DC similar concerns about the benefits of such a system for suburban and urban bus routes were also voiced. Though there was less concern about automobile driver reactions in Maryland, they had some difficulties, specifically with a group called "Citizens for Rational Traffic Laws," when the current priority systems were installed.

Again, there was a consensus that they would need accountability from the transit system and that the transit system must be accountable to the needs of the overall system. Furthermore, there has to be a clear understanding of who will be responsible for installation, maintenance, operation, and repair of the system; there must also be an adequate budget for these items.

Traffic officials also raised the issue of bus occupancy as a condition for granting priority at an intersection. A number of traffic professionals had concerns about granting priority to half-empty buses. This was thought to be a problem since, 1) bus priority is intended to increase the number of people moved along a roadway; and 2) the reaction from motorists upon seeing buses with few passengers getting priority is likely to be stronger.

Finally, traffic officials stressed their concern that the burden for interoperability not be placed on the signal system by requiring numerous different systems to be installed at intersections or at the ATMS. Rather the requirement should be that vehicles have all the necessary equipment to communicate with the various priority systems installed along the route that they are cleared to activate.

Transit Officials

Priority is not a top priority for transit officials as much as it is part of a larger ITS plan that is still taking shape. The objectives of the priority system will be to improve on-time performance, perhaps improve frequency and the efficiency with which buses can be deployed and thereby also reduce wear on buses.

Preemption

Transit officials had little concern or issue with preemption. There was universal agreement with granting emergency vehicles priority over transit at signals.

Priority

The primary concern that transit officials have is that their operators and equipment not be burdened unnecessarily by the system. Drivers should have their attention on the road, not on activating the system. Also given the harsh conditions on a bus, they would prefer the technology to be outside the bus as much as possible. In this regard, Washington Metropolitan Area Transit Authority (WMATA) and many of the local transit authorities have already installed GPS systems as part of electronic annunciation or other systems. A chief concern expressed by WMATA officials was that the priority system be integrated with other on-board systems and that it use the full potential of GPS and other systems that would be part of their larger ITS strategy, which has yet to be completed. A final concern is whether the systems will deliver as promised, and under what conditions they can be best utilized.

Interoperability is also an issue for priority. As with preemption, intrastate, inter-jurisdictional interoperability is a requirement for any system. Transit officials suggested,

however, that while relatively few bus routes cross the region's major state boundaries, within the WMATA service area buses are moved around among jurisdictions frequently. Therefore interstate interoperability is also preferred.

Section Summary

Preemption is a top priority for fire and emergency management and personnel, and less so for police. Beyond emergency management and personnel, however, neither preemption nor priority is a top priority among the stakeholders interviewed in the Region. There was, however, significant interest in the potential of both of these systems to facilitate the delivery of essential public services over increasingly congested roads. Transit professionals and elected officials are interested in seeing further proof of what priority can achieve in terms of schedule adherence, operational efficiency, and ridership increases for local bus transit systems. Traffic professionals are interested in priority and its ability to help them move people over roadways - though the level of enthusiasm varies greatly across the region. Traffic officials are very concerned about preemption's impact on traffic and safety.

4. SYSTEM OBJECTIVES AND REQUIREMENTS

Summarizing and synthesizing the comments of the interviewed stakeholders yields the following sets of objectives for preemption and priority as well as a set of general system requirements.

System Objectives for Preemption

For preemption three system objectives were identified. These objectives are presented here based on how frequently they were mentioned by interviewees.

1. The system shall significantly *reduce response time to emergencies*.
2. The system shall significantly *improve the safety and health of emergency personnel* by reducing accidents, relieving stress or both.
3. The system shall *reduce accidents between non-emergency vehicles related to responding emergency units* at intersections where it is installed.¹

System Objectives for Priority

Stakeholders also suggested four policy requirements for priority systems. Again they are presented here in order of how often they were mentioned.

1. The system *shall improve schedule adherence*.
2. The system *shall improve the efficiency with which buses run, reducing operating costs and allowing greater schedule flexibility*.
3. A priority system *shall be part of a larger ITS system that includes improved rider information and other services*.
4. Priority *shall increase the overall efficiency with which the road network is used* by contributing to an increasing in bus ridership.

General System Requirements

In order to achieve these objectives and address the concerns, needs and issues raised by stakeholders the system must also meet some requirements.

¹ The problem here is that these statistics are not uniformly collected in the region at the moment. None of the Jurisdictions interviewed was currently able to provide a report on how often such accidents occur, though anecdotal evidence was used to suggest that they are frequent.

***Accountability* - The system shall provide technical safeguards and convenient data retrieval so that users can be held accountable for individual instances and patterns of use.**

Accountability is a general system requirement. It is largely a response to concerns about unwarranted use by emergency personnel. While the majority of interviewees felt that formal and informal guidelines would suffice in most cases, most did not have such guidelines in place. Record keeping, technical interlocks such as linking the system to emergency lights and other controls were also suggested. Most thought that it was important to be able to know when a signal had been preempted and by what vehicle. An important element in this regard, mentioned most often by the traffic and transit communities, was the need for good record keeping and data extraction capabilities so that problems can be discovered early and addressed in a timely and acceptable way.

***Interoperability* - The system shall be interoperable interjurisdictionally: within Northern Virginia for preemption and regionwide for transit.**

For emergency use, a strong consensus emerged that intra (rather than inter) state, interjurisdictional interoperability was needed. Within states, there are mutual aid and "first call" agreements that cause out-of-jurisdiction units to respond within a jurisdiction. More than elsewhere this is the case in Virginia, where there are many jurisdictions working together in this way. There is only a limited need for interoperability between Prince George's and Montgomery counties. Similarly, between the District and the Maryland counties it is not a priority of either jurisdiction. It was generally agreed that interoperability was not an issue between Virginia jurisdictions and the rest of the region.

Buses operate across jurisdictional lines including from Virginia to Maryland and the District. It is preferable that if a bus priority system or systems are installed that they allow buses to use priority throughout their route. Given that relatively few buses cross state boundaries in the Region, interoperability may not require a single system. WMATA representatives did mention that an aspect of the interoperability might be that most of the hardware is outside the bus. A single bus might have multiple devices, or devices that can be switched out easily. All this is uncertain, however, as WMATA is still developing its ITS plan. In any case, the shape of interoperability will be highly dependent on meeting the other requirements listed here, particularly minimizing the responsibility of the operator to interact with the system (above) and the ease of maintenance (discussed below).

Flexible and Adjustable - The system shall be flexible enough to be implemented under a wide variety of conditions; it must be capable of being adjusted significantly once installed.

The interviewees wanted the system to give them significant leeway in terms of its installation, its operations, and the conditions for granting preemption. The primary motivation for this was to be able to match the operation of the system to local and real time traffic conditions. The system has to be flexible in the configurations in which vendors make it available, its installation, and its operation.

Furthermore, once it has been installed the system must be easily adjusted both on an intersection-by-intersection and system-wide basis. Most stakeholders felt that traffic conditions and patterns remain very dynamic in the region; congestion is likely to both increase and shift. For transit demand levels, equipment, and of course the traffic around

a bus all change and therefore so do the routes and frequencies of their services. As with preemption, flexibility is necessary to meet the needs of specific bus routes and specific problems at specific intersections. Without flexibility and adjustability, preemption systems are likely to become very burdensome over the long run, if not quickly obsolete.

Ease of Maintenance - The system shall be easily maintained and require a minimum of coordination between agencies to effect repair and maintenance.

There was very broad consensus from traffic, transit, and emergency officials that before any preemption system is installed on a broad basis, the Region must be certain that the elements of the system will be easily accessible and easily and inexpensively repaired or replaced. There was a significant concern on the part of emergency, traffic, and transit personnel that a system would be installed without an adequate budget for maintenance and adjustments. Elected officials were concerned about finding a reliable source of funding.

Clear Control of Operations and Maintenance - The system and its individual components shall allow agencies to clearly define their individual responsibilities for operations and maintenance.

The operation and maintenance of the system must allow, traffic, transit and emergency agencies to easily coordinate activities and responsibilities. It must not interfere with the traffic community's ability to maintain and operate signals or require lengthy coordination between agencies for routine maintenance.

Minimal Operator/Equipment Interaction - The system shall minimize interaction with vehicle operator(s).

One key and distinct requirement to come from the transit and emergency communities is that operators not be required to interact with the equipment or that this interaction be minimized. Conditions for use should be built into the devices or controlled from a central location. Transit operators should not be distracted from the requirements of the road or their passengers.

5. CONCLUSIONS

Therefore, the major findings for this research can be summarized as follows.

- Though there is significant interest in signal priority and preemption throughout the region, it does not appear to be a top priority for elected officials or traffic or transit agencies
- Signal preemption is a priority for the emergency services community.
- Vendor marketing is often an important factor in creating a local impetus to pursue preemption and priority strategies.
- One objective of *preemption* according to a majority of the stakeholders should be to reduce the time for emergency personnel to respond to an emergency. A second objective mentioned was to improve operator safety. A final priority was to reduce accidents associated with responding emergency units.
- A top objective of *priority* according to the stakeholders should be to improve schedule adherence. It should also be noted that many stakeholders felt that by increasing the efficiency of Buses priority might lead to ancillary benefits such as increased frequency and reduced maintenance costs.

- Local stakeholders varied in the issues, concerns and needs that they identified. At the most general level, the following generalizations obtained:
 - a. Elected officials are concerned about system costs and traffic disruptions;
 - b. Emergency personnel are concerned that cost constraints might restrict the system's full and timely implementation at dangerous and important intersections;
 - c. Traffic personnel are concerned about traffic disruption, maintenance costs and unwarranted use; and
 - d. Transit officials are concerned about ease of operation, compatibility with existing and anticipated on-vehicle systems and the distribution of costs.

Future research in this project will be to translate the general requirements of stakeholders into technical requirements in order to evaluate specific technologies (Task 2). Based on the findings of this analysis, the third task is to undertake simulations of both priority and preemption based on local conditions in the Washington Metropolitan region and considering the requirements, needs and issues raised here. The fourth task in this project is to conduct field studies of various technologies and strategies.

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