Traffic Flow Modeling
Operational Issues on Staten Island
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Introduction

Staten Island is the fastest growing county in terms of population in New York State, with a growth rate of 17.1% from 1990 to 2000. This growth is expected to continue for the next 30 years, with the population reaching 633,000 by 2030. This increase in population places a burden on the existing transportation system and has resulted in the creation of extensive road congestion and traffic delay.

This congestion needs to be managed to promote the common good of the county, the city and the region. Strategies for congestion management include:

1) adding capacity on roads, transit and railroads
2) improving the performance of the existing system
3) encouraging users to utilize the system in ways that produce less congestion

While all three of these techniques need to be applied to the congestion on Staten Island, each alternative will require different levels of cost and infrastructure. Also, each of the three solutions will be more or less effective depending upon the existing infrastructure and urban development form.

Adding Capacity

Adding road, rail and transit capacity is both appropriate and logical, given the existing level of population density on Staten Island. This dense development (currently at 7,500 people per square mile), makes viable many mass transit solutions including Light Rail, Bus Rapid Transit and extensions to the New York City Subway.

Adding road capacity is particularly problematic, as additions to the road system would likely induce further traffic on the network as well as undermine air quality in the region. Strategic additions such as the median bus lane on the Staten Island Expressway offer benefits that may provide improved travel times for Island commuters. Road capacity

offers some potential for congestion improvement, but this represents a long-term solution that will require significant capital expenditures and a long development time. Road capacity problems (bottlenecks) account for 40% of the traffic congestion nationwide according to the Federal Highway Administration (FHWA).

Encouraging Better System Utilization

Encouraging system users to utilize the system in ways that produce less congestion have the potential to provide some relief, however, the existing background traffic conditions may utilize any capacity freed up by modification of road user behavior. These modifications include telework (telecommuting), flexible work schedules, and land use and zoning changes that encourage transit-oriented development. While these items offer the potential for significant gains in the future, in particular the land use and zoning changes, they may have only a very limited impact on short term Staten Island congestion as the existing transportation network is very extensively utilized.

Improving the Performance of Existing Capacity

Improving the performance of the existing system has probably the most potential in the short run to significantly improve transportation performance with low capital investment. By deploying a comprehensive program of performance enhancements to the existing transportation network, the flow parameters of the road network in particular could be improved substantially.

These performance enhancements include techniques such as incident management, ramp metering of flow onto highways, improved management of work zones, traffic signal optimization and flow management at toll plazas.

Incident management provides the support services and information technology to rapidly deploy police, fire, rescue and towing resources to respond to a given accident or random events that impact traffic flow. By quickly intervening, we are able to remove or mitigate the traffic flow impacts of these incidents. According to the FHWA, traffic incidents are responsible for 25% of the congestion nationwide. A rapid response team deployed near the key highways on Staten Island could provide significant congestion benefits.[1]

Management of work zones also can improve flow, with deployment of maintenance and repair crews at non-peak hours to reduce the flow impact of lane closures and/or rubbernecking. Only the number of lanes that are (absolutely) necessary for repair should be closed to travel. It appears that in some situations, repair crews close off more lanes than required which puts a highway in a traffic load condition in the remaining lanes where it has total failure (jam loading conditions). Say, for instance, if there were 1 instead of 2 lanes closed on a highway, the highway would have continued to operate (slow flow). The difference is dramatic as it is a highly complex problem when it jams, traffic moves at a crawl and upstream traffic flow capacity is decreased significantly.

[1] In fact, the Triborough Bridge and Tunnel Authority and the Port Authority already both provide rapid response teams to maintain flow on the bridges linking Staten Island with New Jersey and Brooklyn.

There is also an additional exposure of accidents in this stop and go mode of flow congestion.

However, the strong peak loading on Staten Island highways as well as the overall high utilization rate of the existing highway network limits our ability to deploy road crews at off-peak hours, as the highways operate at very high capacity levels on an average weekday. The Staten Island Expressway (SIE) has a reported average daily traffic load of 147,000 vehicles at Mid-Island. This flow represents over 12.25 hours of full capacity loading on each lane on the SIE. This loading leaves relatively little time to perform needed maintenance in "off-peak" hours.

Finally, the optimization of traffic signals, ramp flow metering and toll plaza operations offers the potential for significant performance improvement to the flow on both Island arterials as well as on surface streets. The opportunity to provide bus prioritization traffic signals could provide us we a better level of performance of the existing bus system as well as encourage the shift from private automobile to mass transit. The toll plazas can and should be optimized to reduce the delay caused by the collection of tolls on the Island bridges.

Case Study – Toll Plaza Operations

Our recent research (co-authored with Dr. Jonathan Kramer of Kutztown University of Pennsylvania) offers some insight of how focusing on the performance of the existing capacity has the potential to improve flow conditions. Our work explored the potential for traffic flow improvements at toll plazas and the impact of high-speed toll collection on system performance.

Toll collection systems today rely on electronic tolling (ETC) to collect revenue without delaying or slowing vehicles. This has the potential to provide significant flow improvements and can avoid bottlenecks created by revenue collection. Yet the existing toll collection systems that are deployed on Staten Island have a number of flaws that reduce their performance and increase congestion. The TBTA's Verrazano-Narrows Bridge management currently operates an electronic toll collection facility with gate arms on each ETC lane that requires all 100,000+ vehicles a day to slow to 0 miles per hour to pay the toll. This creates additional marginal congestion as well as limits the throughput (total vehicles processed per hour) of the plaza. This excessive slowing also creates additional air pollution due to the need for each vehicle to reaccelerate to highway speeds after paying the toll.[2]

An additional flow problem that can be created by toll plaza operations is the need to continually rebalance the number of booths that offer different types of collection methods. On Staten Island, the Port Authority has both mixed payment booths (cash and electronic tolling) as well as low speed EZ-Pass and high-speed EZ-Pass (at the

[2] See Peters, Jonathan R. & Kramer, Jonathan K. "The Inefficiency of Toll Collection as a Means of Taxation: Evidence from the Garden State Parkway" published in Transportation Quarterly, Summer 2003 for further discussion on this point.

Outerbridge Crossing). During different periods of the week as well as at different times of the year, participation in electronic tolling varies. This creates the need to reallocate booths, with higher numbers of booths needed for mixed payment during periods of low electronic tolling participation.

Our research[3], presented at the 2006 National Academies of Science Transportation Research Board Meetings, provide insight into how this mix of booths can severely impact road performance. We have observed significant delays created on Staten Island by the misallocation of booths on the Island bridges. On December 24, 2005, one of the co-authors experienced a queue of over 4 miles (in excess of a 45 minute delay) at the Outerbridge Crossing (photo 1 taken in middle of the delay) caused by both a misallocation of booths (a shortage of mixed payment booths) as well as booth closures (Photo 2 shows plaza configuration on December 24, 2005 at about 5:30 PM)[4]. As is clearly visible in Photo 2, the electronic tolling lanes (both low speed EZ-Pass as well as the high speed EZ-Pass lanes) are underutilized and traffic is flowing at maximum speed through these lanes, while the mixed payment booths are overloaded.

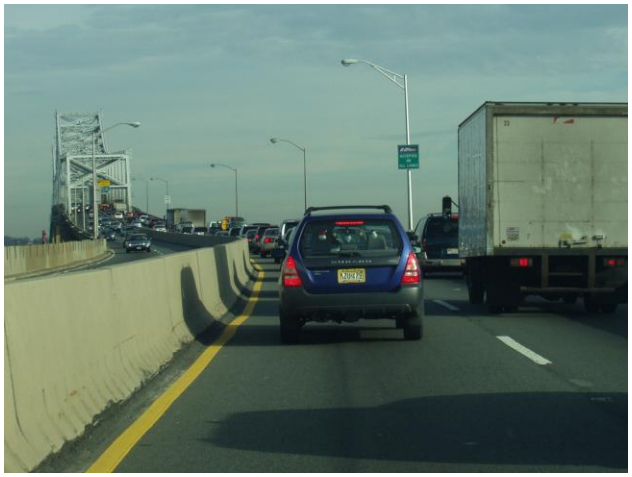

Photo 1 - Outerbridge Crossing Delay
Source: The Authors, December 24, 2005

Photo 2 – Toll Plaza Configuration and Queue
Source: The Authors, December 24, 2005

This misallocation of booths resulted in a significant degradation of the toll plaza performance during a period when road demand was at a peak. The misallocation impacts all users of the facility, as the road suffers from queue blocking (vehicles waiting for the mixed use booths block EZ-Pass vehicles from reaching EZ-Pass Lanes). The net result is a massive reduction in road capacity, excessive delays and more pollution. The plaza can and should be operated with a goal of maximizing the flow performance of the regional

[3] Peters, Jonathan R., Kramer, Jonathan K. and Kress, Michael E. "Transitioning Barrier Toll Collection Systems to Open Road Tolling: Flow and Management Issues" TRB Annual Meetings, Washington DC, January 2006.

[4] These flow conditions increase the probability of accidents on the facility, due to the repeated accelerations and decelerations that occur in this type of traffic. This situation, therefore, decreases road capacity in two ways – by the queuing caused by the actual toll plaza and also by the additional delays caused by more frequent traffic incidents.

transportation network. More advanced management techniques and flow models should be applied to these facilities.

Conclusions

Congestion management on Staten Island presents a number of interesting and unique challenges for planners. While Staten Island has many of the population and development aspects that can and should make the community function well with mass transit solutions, the lack of critical infrastructure investments over the last 40 years has created a community that is over-dependent on private automobile travel.

It also appears that no one agency seems to be monitoring and managing traffic flow on Staten Island in a coordinated way. Given the critical dependence of the Staten Island community on the road network – which serves the local automobile driver, through travelers, freight shipments and also as our main mass transit system corridors, careful, systematic analysis and management of road flow conditions are warranted.

To resolve this situation, we must apply a variety of techniques on a number of systems. As outlined above, there are a number of improvements that can be made with minimal cost that should provide significant congestion mitigation in the near term. Longer term solutions include increased mass transit infrastructure and a return to development patterns that are centered around regional transportation systems.