The Seattle Department of Transportation's ITS Program - Lessons Learned from a Leading Edge Urban ITS

1. Introduction
The City of Seattle today is facing the challenges that come with being one of the fastest-growing major cities in the country. At the same time, global trends are reshaping our transportation needs and the tools available to meet them. The NextGen ITS Program provides the tools for Seattle to manage the demands of a multimodal transportation network.

2. Systems/Services Provided
Key elements of the program include: traffic responsive and traffic adaptive traffic signals; providing congestion information on our Traveler's web site, based on a variety of detection approaches including a recent WiFi/bluetooth system; travel time calculation and posting on DMS and on the Traveler's web site; remodeling our TOC to support 24X7 operations and to serve as a tactical operations center for major events and construction closures; upgrading the city-wide telecommunications network to support ITS; and establishing partnerships with Police and Fire, as well as our own SDOT Maintenance staff to provide better information to the traveling public when the ROW is affected.

The services provided can be generally categorized in three main areas:

1. Optimized arterial operations.
2. Providing the public with information
3. Coordinating with various agency partners to manage incidents

To provide these services, SDOT ITS staff monitor and manage, via the SDOT Transportation Operations Center (TOC):

- 200 Traffic Cameras
- 34 Dynamic Message Signs (DMS)
- 12 corridors with travel time messaging posted on the DMS
- Travel times posted to web for these same 12 corridors and the entire downtown
- Congestion monitoring on an additional 10 corridors posted to the web
- 1100 traffic signals, including 6 traffic responsive corridors
- An estimated 25 incidents that affect traffic every day
- 100 major events or road closures each month
- Travelers web site (seattle.gov/travelers and iphone app), plus twitter feed

We are attaching a public information piece to further describe our services.
3. Background and History

The physical features surrounding the City of Seattle influenced the City’s land development and the associated transportation network. With water bounding the east and west sides of the city, and a downtown centered between the north and south ends of the city, travel patterns tend to be north-south. The transportation network is also fairly fragile. As the geography narrows near the Central Business District (CBD), capacity is reduced, and any incidents in the CBD cause widespread and long-lasting congestion.

Overall, SDOT has historically been able to maintain good N-S traffic signal progression using TOD semi-actuated operations. Things began to change in the mid 1990s, when tech industry development accelerated, and the population and jobs began to grow.

In 2003, an ITS Program Strategic Plan was prepared by SDOT. Although many needs were identified in that plan, a single core strategy was emphasized around which all SDOT’s ITS Program was based. SDOT had been subject to maintenance staff reductions, as was (and remains) the case for many cities in the US. That, combined with an aging infrastructure, was resulting in failures that threatened the public’s safety. SDOT was not adequately staffed to perform basic preventative maintenance, and all the maintenance crews were busy responding to failures caused in part by the lack of basic maintenance. When span wire supports for traffic signals began to fail, causing traffic signal heads to fall into the street along with the span wire (there was fortunately no people or property damage due to any of the span wire failures), SDOT ITS staff chose to draw attention to the issue. Another option would have been to scramble to correct such failures and avoid any focus on perceived or real failures and potential negative perceptions of the overall maintenance operation. By comparing staffing levels to national guidance for maintenance, and showing the span-wire support that had been sawn through by the span wire, causing the failure, a compelling case was made. A careful but direct approach to leadership was made and the funding needed to increase maintenance staffing was provided.
Five years later, in 2008, the Strategic Plan was updated. The update occurred at the height of the recession, and funding cutbacks were required by all departments at the City. The City had implemented CCTV and other technologies to support minimizing field call-outs, and the CCTV were posted on the City’s web site. Plus, a small Traffic Management Center was implemented and the leadership was pleased with the ability to use the CCTV during incidents, events, and emergencies. Plus, the public response to the CCTV on the web was very positive. The focus of the Strategic Plan aligned with the austerity programs in place. It called for leveraging existing investments in communications and other technologies to improve operations and efficiency. The City began adding new services and functions in a highly cost-conscious approach. Chief among these investments was a major controller change-out program and new central signal software which enabled new functions, and upgrading pedestrian indications to LED.

SDOT began preparing for the reconstruction of the SR 99/ Alaskan Way Viaduct in the late 2000’s. SR 99 hugs the Elliott Bay shoreline on the west boundary of the Central Business District, and carries extensive freight and other traffic. Funds became available to the City to mitigate construction traffic impacts. Key corridors where traffic impacts were expected were identified in the environmental review. Traffic signal upgrades were identified, including traffic responsive operations, to support mitigation. In addition, SDOT ITS staff successfully incorporated an emphasis on driver information as part of the mitigation approach to help spread traffic across the available roadway capacity. SDOT implemented a program to gather travel times and other congestion information on arterials, and to post this information to a new web site, and on arterial DMS. The public response to the new travel time and congestion information was very positive. The system is timely and accurate.

In 2011, SDOT ITS staff were asked to support the City’s multi-modal transportation vision. Without support for all modes, the growth in Seattle would not be sustainable. The City began reallocating ROW to bikes, buses and streetcars, resulting in a loss of some car capacity. SDOT ITS staff beefed up their bike detection capabilities, expanding transit signal priority, and scrambled to update signal timing and detection to meet the needs. By being part of the solution, SDOT ITS gained political capital at the City.

Despite everything that the SDOT ITS program was able to accomplish, the challenge of increased traffic due to high growth and increased density, and a fragile street network has become an opportunity for the SDOT ITS program to move ahead once again. The City is not fully covered with travel time detection, many corridors remain on TOD plans, and CCTV coverage is good, but not universal. When a major incident occurred one afternoon on SR 99 in 2014, police closed the roadway in both directions for more than 8 hours. The spillover effect was disastrous. People were stuck for 3 hours on buses and in their own cars, trying to leave downtown. The electeds demanded change. SDOT leadership wanted to know why important tools such as CCTV cameras, traffic responsive signals, DMS, and other systems were not installed everywhere across the city, and wanted SDOT ITS operations staff to be more closely connected with police in responding to incidents. SDOT ITS staff began the process of building connections with Seattle Police Department staff, and were provided with support for an array of ITS deployments, including an expanded Traffic Operations Center that is designed to serve as a joint operations center for major special events, construction closures, and incidents. When a semi overturned on SR 99 in March of this year, SDOT ITS operations staff were able to provide the
information that SDOT leadership wanted. The message that ITS is not just a “cool toy” but a core part of transportation operations in a major City was clear.

4. Lessons Learned
The following provides some of the lessons learned over the past decade or more.

Lesson Learned: Be More Than a Great Traffic Engineer - Enter the Realm of City Politics.
Although this lesson learned seems obvious, it is core to ensuring ongoing support of the ITS Program. Sometimes, ITS needs do not align with the City’s other most pressing needs. To garner support, the SDOT ITS Program message has been continually evolving to align with the City leadership and elected’s priorities.

As discussed earlier in the history of the program, the messages have ranged from “Meet basic maintenance to preserve public safety” to “Leverage existing investments” to today’s “Lead the way in incident management”. Each time, SDOT ITS staff stepped outside their core competency of traffic engineering to understand the overall dynamics at place in a large city. They carefully developed messages, supported by proofs that could be embraced by SDOT leadership and electeds, further ensuring ongoing ITS program support.

Lesson Learned: Cautiously Embrace New Technology
ITS technologies have been evolving and expanding at a rapid pace. Most hold great promise for effectiveness. SDOT chose to embrace new technologies, but with caution. The approach generally relies on other locations to be the first adopters. Whenever new technologies are proposed, an RFI or RFP is released that requires listing of locations where the system was deployed before for the same function SDOT plans, including agency contact information. If SDOT is the first to attempt a new technology or new application of existing technology, they usually work with the vendors to get free or reduced-cost equipment and support. In either case, a very limited pilot project is fielded and evaluated as a first step, with strict success criteria defined. This approach has been used for their ground-breaking transit signal priority deployments; for first national deployment of license plate reading cameras to calculate arterial travel times; for the use of Sensys-brand detection for traffic signal operations, including bike detection; and recently SDOT issued contracts for traffic data-as-a-service that includes provisions and criteria for deployment of any new, untested systems. If the data-as-a-service deployment does not provide adequate accuracy, the vendor must remove it at their cost and is not paid for the pilot.

Lesson Learned: Lead Communications Network Decisions With Scalability
SDOT had developed a hybrid communications network with the primary purpose of communicating with traffic signals. It consists of copper twisted pair, fiber, and a variety of wireless technologies. When the demands on the network increased with the introduction of CCTV cameras, the focus was on getting the network to support the cameras, and doing so in a way that was supportive of maintenance. For most traffic signal equipment deployed in the past, the best approach was to purchase as few different types of equipment as possible to ease the maintenance burden. SDOT followed that same tenet when selecting an encoder, and did not consider scalability of that piece of equipment, and in fact the maintenance burden is very high due to ongoing problems with those encoders.
When designing an upgrade to the network, scalability was a core consideration, simply because the network upgrade was needed as more and more ITS devices were fielded. However, the selection of equipment was based on topologies of modern IT system. But traffic signal controllers and other end devices are not necessarily “modern. The design did not consider how the high number of “dumb” end devices would impact the network. Today, the network that SDOT has evolved into is not scaled for much expansion. IT does not include a Layer 3 in the field. There is one large domain residing in layer 2. Although there are separate VLANs, there are some messages that are broadcast everywhere, and message logs are often full. A stop-gap measure is to install more web switches across the network so that staff can remotely power cycle, rather than having to send a maintenance staff person to the field simply to power cycle a switch.

SDOT worked closely with the City’s IT Department on creating a network design that would support projects implementing many new traffic cameras, DMS, vehicle detectors, license plate readers, and other ITS equipment. We discussed what type of growth might be on the horizon, and examined the existing hybrid serial/IP network. A solution was implanted which split the IP network into 32 VLANs separating hosts and switches by geographic sectors and devices type (eg: north video VLAN). We also created a joint ownership model where Seattle IT managed the layer-3 routers and firewalls existing in the TMC, and SDOT personnel managing the hundreds of layer-2 switches in the field. We had to overcome a number of challenges initially due to the fact that the routers and switches were not interoperable from a Spanning Tree perspective (loop detection protocol) which caused a number of systemic outages. That issue was overcome, but as the network continued to grow, other issues began to emerge. Although we have 32 VLANs, many messages still traverse the entire network beyond the router on the native VLAN. An example of that type of message is a topology chance message, which is sent and recorded by every switch. We also have rings which are much too large, leading to system instability. We are once again working on a plan for to create the next generation of network architecture, which will likely introduce more layer 3 switches into the field, thus reducing the size of groups of switches receiving messages on the native VLAN. We will also take advantage of our abundant fiber plant and reduce our ring sizes to limit the number of hops from the routers.

Lesson Learned: ITS Communications Networks Require both “Inside” and “Outside” Staff Support
This issue may be unique to cities with unionized maintenance staff, and was an important hurdle to cross for SDOT. With the advent of ITS, communications networks to support them that traditionally were installed inside buildings were installed outside, in the field. The overall operations and maintenance of these networks requires a single point of responsibility, and the division between inside and outside equipment is irrelevant. At SDOT, the union representing the maintenance staff pushed to ban SDOT IT staff from performing any work on equipment located in the field, as they saw this as encroaching on union staff positions. For SDOT, the issue wasn’t that the maintenance staff were not qualified, but the scheduling of crew time, and the crew cost were issues. SDOT ITS was able to prevail based on the unique staff support needs of a telecommunications network. Today, both SDOT IT staff and maintenance staff are able to perform work on field communications equipment, but SDOT IT staff retain full control over all communications equipment.
Lesson Learned: Follow a Systems Engineering Approach When Designing ITS Technology
SDOT has been fortunate in that several ITS staff are very talented and comfortable with new technologies. Over the past 20 years, staff tinkered with systems to create useful and effective solutions to specific issues. This tinkering became an entrenched approach of testing while designing while operating that ultimately was not sustainable as the ITS technologies expanded. One internally-created solution designed for a specific purpose would be transferred to another use and fail as it was not specifically designed for that use. Today, following a systems engineering approach to technology solutions that includes a concept of operations and derivation of system requirements is the City’s approach. This allows the systems to be designed to support a broader array of current and anticipated needs, and produces more stable systems. This is the approach used for the City’s Traveler’s web site, and for an upcoming test of a rail crossing delay estimation system soon to be piloted.

Lesson Learned: One Incident Will Consume A Single Transportation Operator
SDOT’s TOC is staffed 16 hours per day, seven days per week. Staff continually scan CCTVs, congestion detection systems, the fire and police dispatch communications, and update the web site and send a Twitter feed if something of note needs to be broadcast. Once a major incident occurs, staff are on the phone with SDOT maintenance on the scene, with Police dispatch, with other partner agencies, to get updates, and continuously changing DMS messages, the web site, and the Twitter feed with respect to that incident. A single staff person can manage the workload for only one major incident. They are not able to monitor for other incidents in a comprehensive way across the City. During a major incident, SDOT does get complaints that incidents are missed, and leadership at SDOT can notice as well. SDOT ITS staff are developing approaches to manage this issue including communicating with leadership on expectations for performance during major incidents, and working to leverage other staff from other departments to support the TOC operations. At some point in the long term, it is hoped that automation will support staff, such as is done for freeway incident management. Arterials are not the same as freeways, and automated freeway incident management systems do not meet SDOT’s needs.

5. What’s Next for the SDOT ITS Program
In addition to expanding coverage for CCTV, travel time and congestion information (and posting these to the web), SDOT is focused on the following new initiatives:

- Further improving our incident management response. An after-action review of the response to our most recent major SR 99 closure is being conducted by the Seattle Police Department. Upon completion of that review, new protocols will be instituted in partnership with SPD and SDOT to improve incident management. We are also evaluating our current procedures that include sending SDOT maintenance staff to incidents to communicate status and provide any necessary support to SPD.
- Implementing a traffic adaptive signal system in the CBD. We are currently completing modeling of the entire downtown network to develop traffic adaptive timing approaches in this densely spaced grid that contains more than 350 traffic signals. An RFP will soon be released for the central system to manage the adaptive network.
• Expanding traffic responsive operations to more corridors. The expansion will focus first on corridors where SR 99 reconstruction impacts are anticipated, and will then expand beyond as funding becomes available.
• Developing new approaches to managing bus and street car operations. In partnership with King County Metro, we will soon be evaluating approaches to detecting buses in mixed traffic to enable queue jump and other transit-focused operations. Note that our current transit signal priority system is based on inputs from the King County Metro GPS-based AVL system.
• Continue to put forward ITS solutions that align with the leadership’s multimodal vision. We recently installed a two-way bike only lane on a one-way street through downtown Seattle complete with bike-only signal phasing. Demands for pedestrian priority (as part of our City’s Vision Zero initiative) and for street car and Bus Rapid Transit are emerging, and we are continually looking for innovative technologies to support these needs.
My RapidRide bus doesn’t seem to stop too often at traffic signals. How do they do that?

» Signals are timed to minimize delay for all modes, with progression through adjacent traffic signals.

» Traffic signals and buses communicate to extend the green signal for approaching buses.

I love it that the traffic signals will change for me. How do they do that?

» TOC staff monitor traffic cameras, dispatch feeds, and communicate directly with emergency responders and others to detect and manage incidents.

» Staff post the information to electronic message signs.

Wow, that sign says there is a blocking crash ahead. I think I will go another way. How do they do that?

» Bicycle detection is installed on major corridors (on the major street), and at signalized trail crossings, so bicyclists can be detected just like cars.
That tweet I just got says there is a crash on Elliott. Good thing I downloaded the Travelers app to my iPhone. I see that congestion and travel times are terrible!! I think I will ride my bike to my appointment now, or I will be late. I am glad they do that, but how do they do that?

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