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SIEMENS CONCERT: City of Seattle

Use of ATMS to Enhance and Extend Signal Operations

Abstract:

Today's signal systems are part of a complex environment that includes varied and disparate data sources and many different types of resources to manage. In addition, the complexity of operations has increased as demand threatens to overwhelm the traditional capabilities of a traffic management center.

Siemens CONCERT allows agencies such as the Seattle Department of Transportation (SDOT) to enhance their operations by introducing new data sources into more sophisticated logic. CONCERT also combines the benefits of time-of-day operations with traffic responsive elements to support expansive traffic networks and increasing daily demand, as well as adaptive corridors and special event handling.

This paper discusses SDOT's selection process as well as the Seattle CONCERT "Concept of Operations" implementation, next steps, and implications.

I. Background

Seattle is the fastest growing large city in the United States according to the latest census figures, a spot it has held twice in the last five years. Such dramatic population growth contributes to ongoing traffic issues across the city. This is particularly true in the central business district (CBD), where new office and residential high rises under construction will further concentrate the population and the traffic. For example, Amazon is completing the last of its three new headquarters buildings in the downtown area, and other companies are following its lead.

One aspect of the city that can't grow to meet demand, however, is the road and highway system. Seattle's topology is a source of both its beauty and its traffic congestion. The city is bound by Lake Washington and Puget Sound to the east and west. The north and south parts of the city are connected by bridges across the Freemont Cut, Lake Union, and Montlake Cut. There is no room to build new roads. In the CBD specifically, the topology has led to a dense network of intersections and a traffic system that is very sensitive to changes such as construction or accidents as far as 10 miles away.

Another constraint is the aging traffic control infrastructure. For example, the downtown controllers are more than 30 years old and the conduits have no space for additional wiring. A traditional upgrade of the downtown system would call for new controllers, cabinets, traffic detectors at every intersection, and a great deal of construction to install the necessary conduits. The Seattle Department of Transportation (SDOT) determined this extensive infrastructure upgrade was cost-prohibitive.

Instead, SDOT needed a solution that would make the best use of its existing infrastructure, increase operational and network efficiencies, and position it for future improvements. As part of its Next Generation ITS (Intelligent Transportation Systems) program, SDOT has been integrating advanced technologies into its transportation infrastructure. The answer to unsnarling the CBD's congestion problem involved just such a technology – CONCERT ATMS (Advanced Traffic Management System) and its ability to integrate data from disparate sources and incorporate custom logic to provide more full-featured signal control.

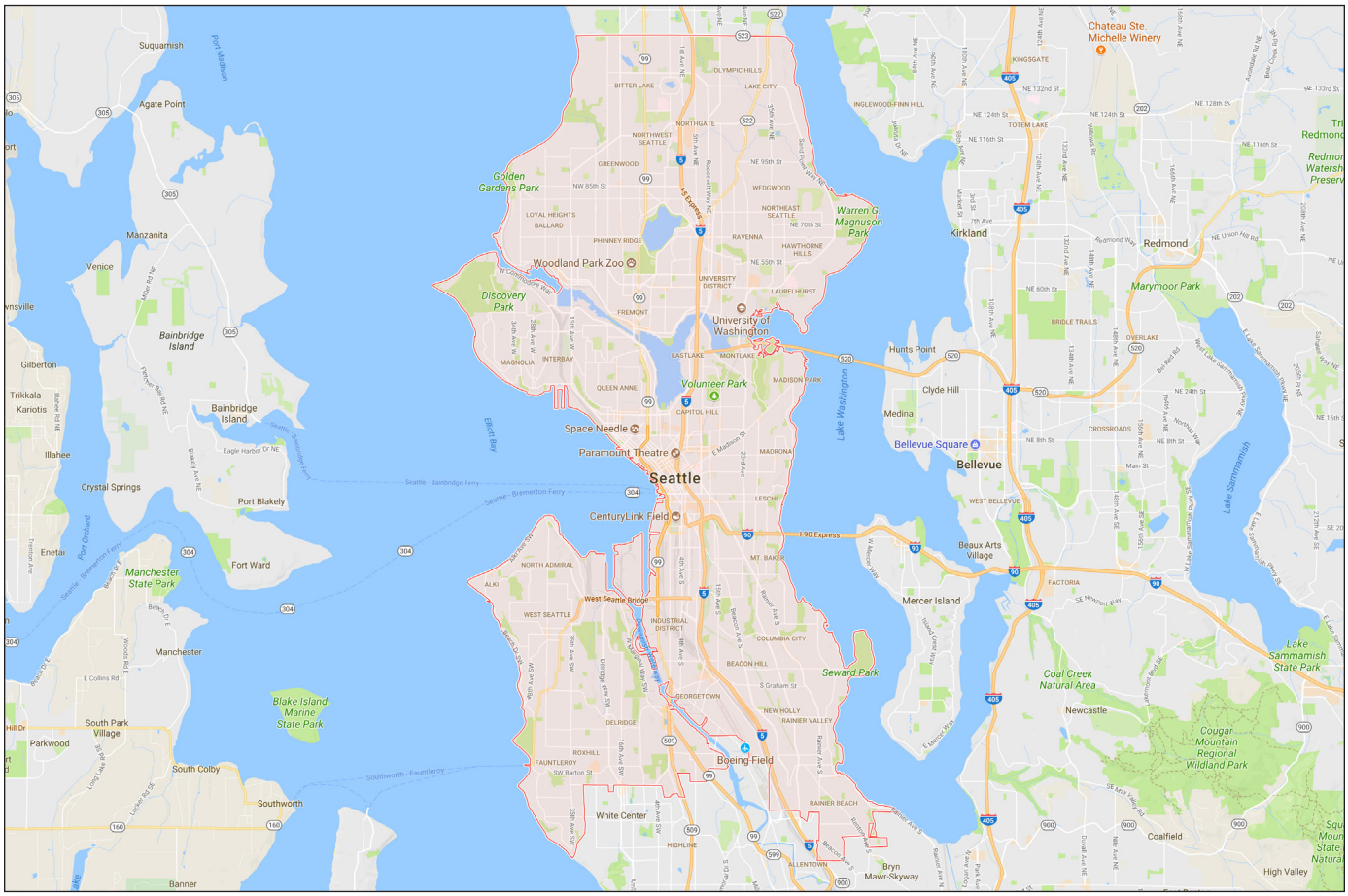


Figure 1: Seattle is bound by Puget Sound and Lake Washington

II. About CONCERT

Part of the SiTraffic CONCERT suite, Siemens CONCERT ATMS is an integrated traffic management platform that allows SDOT to improve traffic planning and run more effective control strategies in response to real-time situations. CONCERT pulls data from multiple, disparate systems and uses it to generate information for everyone who needs to know it – from the staff at SDOT's Transportation Operations Center (TOC) to drivers, bicyclists, and pedestrians. This information can also be used to enable innovations such as adaptive traffic signal timing, which provides SDOT the ability to dynamically respond to changing traffic conditions in the CBD.

SDOT worked with DKS Associates to develop the Concept of Operations, which included an evaluation of potential solutions. Before selecting CONCERT, SDOT and DKS considered four other alternatives. They looked at updating time of day signal timing only, traffic responsive pattern selection, adaptive signal operations, and Quick Response.

- Simply updating time of day (TOD) signal timing had the benefit of not requiring additional detectors and CCTV cameras; however, it did not address SDOT's issue with inflexible operations that can't respond to the CBD's dynamic traffic conditions. This solution is more suited for areas that have predictable traffic.
- Traffic responsive pattern selection (TRPS) involves developing TOD signal timing plans that accommodate the different traffic patterns typically expected in a given geography. System detectors then identify the traffic pattern at hand and trigger the appropriate timing plan; however, it can take the TRPS system 10 to 20 minutes to calculate the parameters that trigger the timing plan change, making it too slow for the relatively frequent changes in CBD traffic.
- Adaptive signal operations systems respond to changing traffic conditions but require detectors on all intersections and often for all movements. SDOT rejected this solution because of the extensive cost to install sufficient detection and to upgrade controllers and cabinets in order to support the new software.
- Quick Response (QR) is a module within Siemens TACTICS, a traffic control system SDOT currently uses to monitor traffic signals and handle some special event needs. QR activates programmed responses for events based on specified triggers, such as the arrival of a ferry at Coleman Dock or large events at Key Arena. It does not, however, have the ability to integrate information from two important sources of data SDOT relies on: the Washington State Department of Transportation (WSDOT) and the Acyclica sensors used to generate travel times.

Unlike the other options, CONCERT provided SDOT with the added flexibility of being able to incorporate other sources of data, such as WSDOT and Acyclica, in addition to the information provided by its existing TACTICS center. This capability was a major consideration in SDOT's selection of CONCERT.

In total, CONCERT offered seven major advantages that made it the logical choice for SDOT.

- A cost-effective solution. It uses existing controllers and cabinets and requires fewer new detectors to monitor the entire CBD. Instead of deploying detection for 300 signals, SDOT could complete a major upgrade deploying only 20.
- Integrates data from all of SDOT's information sources, including WSDOT and Acyclica. Users can manage all incoming information and outbound commands from one interface.
- Uses logic that is easy to understand and develop to trigger fully or partially automated responses. The number of rules employed can range from 20 to 30, to 50,000 or more.
- Enables more dynamic traffic management. It incorporates demand information in addition to time of day in order to increase the responsiveness needed for rapid, real-time handling of congestion throughout the CBD.
- Data visualization and the ability for the TOC to monitor all of the disparate traffic information systems from one overarching platform and workstation.
- Makes use of more data than just the last few minutes of traffic information and uses it more intelligently. For example, when taking into account current conditions, it also looks for patterns over time that help determine which traffic plan to select during rapidly changing conditions on the street. CONCERT also allows SDOT to write algorithms that eliminate any potential inefficiencies in transitions from one plan to the next that could occur with some of the other options.
- A flexible system, making it easy to adapt to future needs. In short, CONCERT synchronizes all traffic and traffic-related systems to work together to fulfill the city's traffic and mobility strategy today and tomorrow.

III. Seattle CONCERT concept

Seattle's need for a responsive, flexible system that could deal with the complexities of the CBD's zone system called for the power that CONCERT's strategy module could provide. SDOT decided to do a phased roll-out of the system, with an initial focus on dynamic signal control and enhanced traffic management for events at the Seattle Center. This would allow TOC staff to become expert users of the system before its other capabilities are added.

Dynamic signal control takes into account information from Seattle's multiple sources, including in-pavement sensors, WSDOT detectors on freeways and ramps, CCTV cameras, and Acyclica travel time monitoring devices. The CBD has multiple CCTV cameras for traffic management and recently added new ones to improve coverage of critical corridors. SDOT also recently deployed an extensive network of Acyclica devices that use WiFi to track signals from portable electronic devices such as cell phones. Acyclica gathers time stamps for all the detected devices and uses them to measure travel times along given routes.

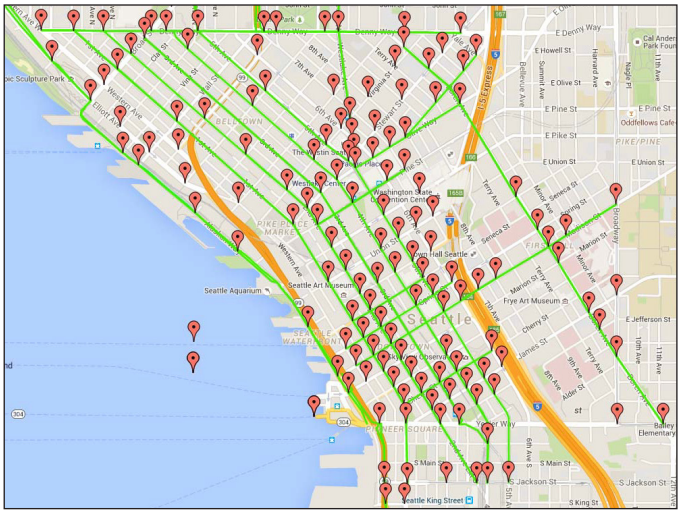


Figure 2: Location of all the Acyclica Devices in the CBD area

CONCERT enables dynamic signal control by pulling information from multiple sources, determining optimal plan selection, and then sending appropriate signal plan requests using the SiTraffic CONCERT suite.

CONCERT automatically collects data from WSDOT, Acyclica, and other sources to create profiles of daily traffic. With this data in hand, the TOC staff used the strategy module to develop customized logic statements to address these traffic patterns, including the thresholds that will trigger the appropriate signal plan selection. This gives SDOT the flexibility to trigger signal timing based on demand rather than just TOD. For example, using TOD only to trigger peak hour timing unnecessarily introduces delays if traffic increases before or after the set hour. Powered by CONCERT, SDOT's signal control handles the conditions when they actually occur, optimizing operations and easing the flow of traffic.

Demand response also comes into play with the Seattle Center, the location of a variety of large and small events ranging from rock concerts to local festivals. SDOT wanted a better way of handling the traffic that occurs when larger events end and cars leave the Center's parking garages. In the past, it was necessary for a staff member to wait at the TOC for a call that the event was over before manually triggering the so-called flush plans that disperse traffic. CONCERT is able to automate the flush plans by using aggregated information from Acyclica sensors that detect event-goers' foot traffic as they approach the garages. The result is faster dispersal times without the need for a staff member at the TOC.

IV. Implementation

The existing CBD traffic signal system was last re-timed in 2008, so updating the TOD signal timing plans was the first stage of implementing CONCERT. The CBD is bound by Alaskan Way to the west, Denny Way to the north, South Jackson Street to the south, and Boren Avenue to the east. The east boundary of James Street and Madison Street was extended up to Broadway. There are 260 intersections.

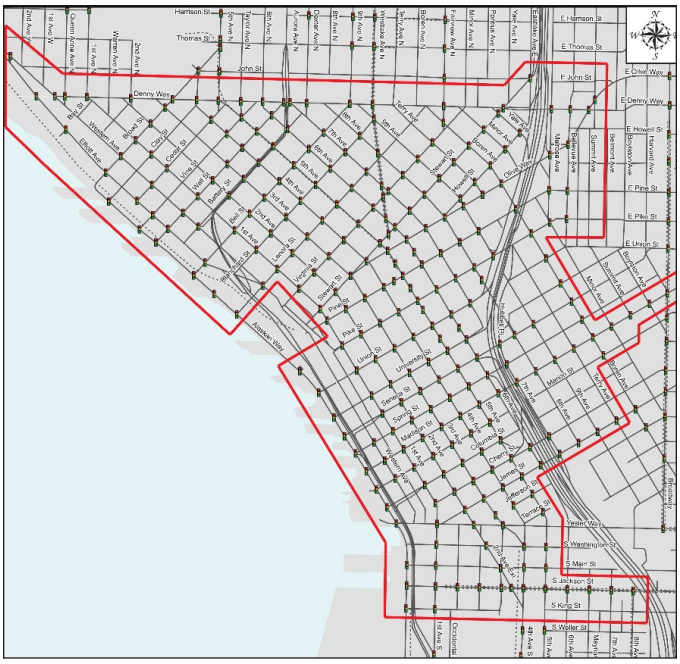
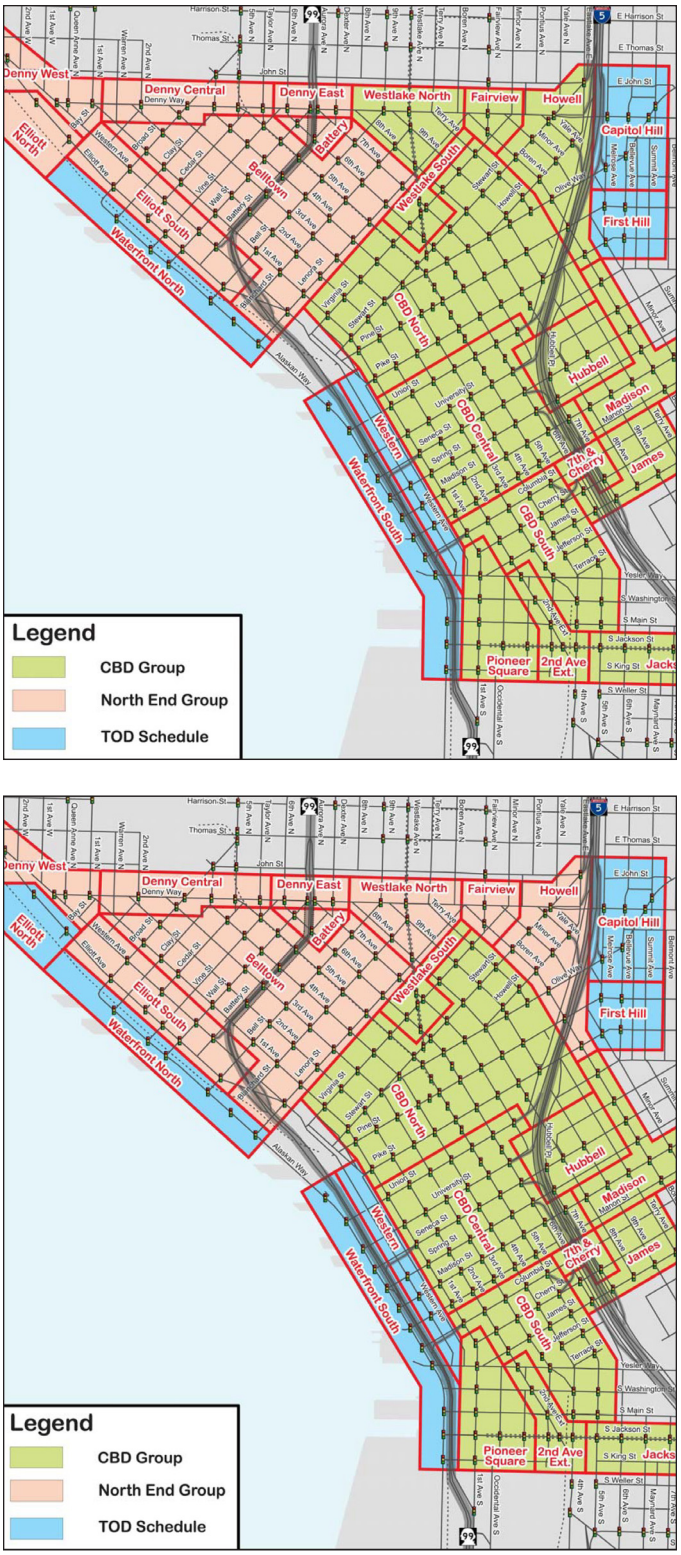


Figure 3: CBD Study Area



Figures 4 & 5: CBD Super Groups – AM Operation (top) and PM Operation (bottom)

SDOT began the process by dividing the 260 intersections into 27 zones, up from the original 11 zones. This allowed greater flexibility in cycle length selection and the deployment of special event timing plans; however, some of the zones operate together during normal operations. With this in mind, SDOT identified two main Super Group zones that act together when transitioning to the new TOD plan: the CBD Group and the North End Group. Complexity was added by the fact that some intersections belong to one zone for part of the day and a different zone for another part of the day. For example, the AM Super Groups differ from the PM Super Groups. CONCERT provided both the flexibility and computing power to accommodate SDOT's more complex planning and enable better traffic management.

Most of the CBD did not have detection, so they still run on fixed time. Only three locations on Denny Way had existing Sensys detectors. To take advantage of CONCERT's dynamic signal control feature, it was necessary to install new Sensys detectors on key corridors in the CBD that would indicate changing congestion conditions. SDOT staff studied traffic throughout the day in the two Super Groups to determine the best locations where demand would indicate when AM and PM plans should be activated and terminated. The staff identified 12 locations on key arterials where the supply volume and occupancy data would be most useful in determining when to change the timing plans.

The next step was to review the data for each of the 12 locations to set the threshold volume or occupancy for triggering timing plan changes. If volume and occupancy are the only criteria for transitioning from one plan to another, however, there is a risk of transitioning too early, too frequently, or out of sequence. For example, a controller could transfer from Late Night to AM to Off Peak and then back to AM based solely on volume or occupancy. To resolve these issues, the staff defined the windows of time when the AM or PM plan could turn on.

SDOT worked with Siemens to turn the occupancy and volume thresholds as well as time-frame restrictions into algorithms for implementation in CONCERT. The algorithms were programmed in such a way to give CONCERT the live data it needs to make decisions without actually changing live controllers. This gives SDOT staff time to test algorithm performance before going live and affecting traffic.

SDOT also worked with Siemens and Acyclica to develop the pedestrian detection application for the Seattle Center garages. The Acyclica sensors near the entrances to the garages use Bluetooth WiFi to detect the number of cell phones passing by. As the number of cell phones surges, a predetermined threshold is reached. Through the Signal Timing module, CONCERT automatically triggers the special event timing before people get to their cars, quickly dispersing the traffic by using flush plans.

V. Next steps and implications

As the city continues to grow and the CBD becomes busier, CONCERT will do its part in improving traffic flow. Benefits of the system include:

- Less congestion, particularly during morning and evening rush hours
- Faster dispersal of traffic following special events at the Seattle Center by an estimated 30% to 40%
- Less time spent in traffic, improving the quality of life for Seattle citizens
- Long-term scalability, allowing SDOT to keep pace with population shifts and new construction

SDOT already plans to incorporate incident response and dynamic messaging into the next phase of CONCERT expansion. The goal is to automate as many routine tasks as possible so the TOC staff can focus on those that require attention, such as a road closure due to an accident. CONCERT helps synchronize the activities that need to take place after an accident, including signal timing changes and message deployment by showing all of the traffic network information in one location. This allows the TOC staff who manage the incidents and coordinate activities between the city road maintenance department, the police, and the fire department to respond quickly.

CONCERT can then be used to send out messages on dynamic road signs as soon as possible to alert drivers of road closures and alternate routes. The messages can also be relayed on the Traveler's Information Website or 511 phone number, highway advisory radio, and SDOT Twitter. The system keeps an incident database that helps streamline the process for future occurrences in the same locations.

Given CONCERT's scalability, SDOT can expand its application outside the city's core. For example, Seattle features a number of bridges that open to let boats through. They are in a row and open sequentially as the boat traffic passes from one to the next. SDOT plans to add these bridges to the incidents that CONCERT helps coordinate. When the first bridge is up, the system will send a signal to prepare for the second bridge to open, which triggers the third, and so on. This will allow TOC staff to change the signal timing to help flush the traffic as the bridges close. SDOT also plans to use CONCERT to help manage traffic preceding and following Mariners and Seahawks games, which can bring an additional 48,000 and 70,000 people, respectively, to the downtown area. This includes using CONCERT to incorporate Acyclica pedestrian tracking data to trigger special event signal timing plans at the stadiums' parking garages.

Additional capabilities are also available, such as relaying airport information to drivers. In Europe, the system has even been used to support efforts to manage air quality by managing the congestion that produces high emissions. When data from air quality measurement stations reach certain thresholds, the system can automatically, or with staff confirmation, change signal timing to increase the flow of traffic. If congestion is unavoidable, CONCERT can help move the traffic concentration from the city center to a location like a bridge that is better ventilated.

About the Report

Siemens would like to thank the City of Seattle, Western Systems, and DKS Associates for their support, including providing data and lending expertise.

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