CITY OF KIRKLAND
ITS STRATEGIC PLAN

Prepared for:
City of Kirkland, WA

June, 2008

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Executive Summary

The City of Kirkland Intelligent Transportation System (ITS) Strategic Plan has been developed to provide a road map for the City in the interest of maximizing the operations and efficiency of the existing roadway infrastructure without adding additional roadway capacity. The ITS Strategic Plan includes two primary components: the ITS Master Plan and the ITS Implementation Plan.

The ITS Master Plan establishes the ITS Vision for the City, documents the existing conditions associated with ITS infrastructure, identifies ITS needs, documents the required ITS architecture, defines a preliminary set of projects and details the proposed ITS communications plan for the City. The ITS Implementation Plan builds on the Master Plan, detailing and prioritizing recommended ITS projects and highlighting procedures and policies recommended for development and adoption.

Together, the ITS Master Plan and the ITS Implementation Plan provide a comprehensive look at the City of Kirkland's existing system and needs, and provide a plan for implementing viable ITS projects that meet the City's specific needs over the next 5 years and beyond.

What is ITS?

ITS stands for "Intelligent Transportation Systems" and includes a variety of physical tools and technologies that are required to accomplish the tasks listed above. Some of these tools include signal controller upgrades, fiber optic communication, supporting communication equipment, cameras for monitoring traffic congestion and effects of signal timing, a data management system, dynamic message signs and transit signal priority.

Why ITS?

ITS provides a way for the City to make better use of its existing transportation infrastructure without needing to build additional roads. The main goal of the ITS system is to facilitate traffic flow within the City, reducing total travel time and delay for drivers. The ITS hardware and software applications proposed in the Strategic Plan help the City accomplish this goal and allow for capabilities such as:

- the ability to provide improved better signal timing and coordination along key corridors
- the ability to respond efficiently to signal malfunctions
- the ability to respond more quickly to incidents that may be blocking roadways
- the ability to communicate with drivers regarding incidents or wait times
- the ability to work with WSDOT, King County, and the neighboring cities to develop improved integration of freeway ramps and intersections with City corridors
- the ability to collect real time traffic data along key corridors
- the ability to use the collected data for planning and operations studies
- the ability to improve the management of special events

Who provided input for this ITS Strategic Plan?

During the master planning process, input was solicited from a wide range of project stakeholders, including the City of Kirkland Public Works, Maintenance and Operations, Police Department, Fire and Building Department, and the IT Department. Coordination meetings were also carried out with King County, City of Redmond, and the City of Bellevue.

From the stakeholder input and the technical review of the existing system, the need for improved signal coordination to improve corridor operations was identified as a high priority for the City of Kirkland. Based on this primary priority, a set of ITS projects were identified and detailed to form the basis of the Strategic Plan.

Where has ITS already been deployed in Kirkland?

King County implemented several ITS applications along NE 124th St as a joint project with Kirkland, Redmond, and WSDOT. The County remotely manages the corridor and the City recently installed a client workstation that is connected to the County's Traffic Management Center (TMC), which enables city staff to access and monitor the 124th St ITS system. This plan makes recommendation for system upgrades along the corridor to ensure compatibility with the City's communication standards.

Where will ITS applications be used in Kirkland?

The ITS Master Plan identified the following key traffic corridors within the City of Kirkland for ITS applications:

- NE 132nd Street Corridor (between 100th Ave NE and 124th Ave NE)
- Central Way / Downtown Corridor (6th St, Central Way, and Lake St S)
- NE 85th Street Corridor (between 114th Ave NE and 132nd Ave NE)
- NE 124th St Corridor System Upgrades (between 100th Ave NE and 132nd Pl NE)
- 6th St / 108th Ave NE Corridor (between 7th Ave S and NE 38th Pl)
- 124th Ave NE / 120th Ave NE Corridor (between NE 112th Pl and 132nd St NE)
- 124th Ave NE Corridor - South (between NE 85th St and NE 112th Pl)
- 132nd Ave NE Corridor (between NE 60th St and NE 80th St)
- Lake Washington Blvd / Lake View Corridor (between NE 68th St and NE 38th Pl)
- Juanita Triangle (98th Ave NE, NE 120th Pl, and NE Juanita Dr)

How much will it cost?

To implement the entire ITS Master Plan, the equipment, design, and construction cost is estimated at approximately $6.8 million (2008 dollars).

What are the recommended next steps?

Following the development of the strategic plan, the recommended next steps are:

- Develop standards for ITS design and implementation
- Identify the early opportunities where all or part of the proposed ITS projects could be implemented as part of individual projects listed in the City's CIP (Capital Improvement Program).
- Develop a Traffic Management Center as part of the NE 85th Street Improvement Project. This is very essential for the City to manage and operate the ITS system implemented as part of that project.
- Pursue grant funding opportunities now that the master plan has been developed

What happens after the proposed projects are complete?

Following construction and implementation of the proposed projects, City of Kirkland staff time will be required to maintain the system. It is critical that staff time be devoted to maintaining a database of traffic circulation within the City, developing and monitoring a range of signal timing plans for different times and needs within the City. City staff should be available to adjust signal timing and display messages to drivers in the event of an incident causing traffic congestion in a particular area, etc.

Only basic but essential ITS technologies have been recommended at this stage, setting up a robust ITS baseline system within the City. As technology changes and as the City progresses, new technologies may become desirable, feasible and even necessary for the City. The existing system has been designed to provide for future expansion. The system is also designed based on the National protocol for ITS, which ensures future compatibility with new technology.

City of Kirkland
ITS Strategic Plan

PART 1 – ITS Master Plan

CITY OF KIRKLAND
ITS MASTER PLAN

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Introduction

The City of Kirkland is located on the east shore of Lake Washington, and is approximately 10 miles east of downtown Seattle. The city has a population of over 45,000 and is mainly a residential area with other land uses such as commercial, industrial, etc. The City is surrounded by other cities of King County and pockets of unincorporated King County. The Cities of Bellevue and Redmond lie to the south and east, respectively.

Major transportation routes including Interstate 405 and State Highway 520 make the City of Kirkland accessible to the region. Interstate 405, which carries more than 100,000 vehicles per day, bisects the City providing access to other Eastside cities such as Bothell and Renton. State Highway 520, near the south boundary of the City, provides access to Seattle and the City of Redmond.

The City has ten roadways classified as primary arterials carrying up to 40,000 vehicles per day, and sixteen roadways classified as minor arterials carrying up to 20,000 vehicles per day. Four interchanges are located along I-405 within the City of Kirkland. The traffic signals located at the interchange ramps are within Washington State Department of Transportation (WSDOT) jurisdiction, and each interchange is controlled by ramp meters during peak periods. All of the primary and minor arterials within the City function as connections between the City of Kirkland and I-405 interchanges, as well as to areas in the neighboring cities.

The City of Kirkland is evaluating Intelligent Transportation Systems (ITS) for several reasons.

- It is not feasible to construct more roadways and highways to meet current and future demand. ITS provides mitigation to the growing congestion problem through better management of existing resources. By implementing ITS solutions in Kirkland, congestion is better managed and the quality of life is improved.
- The City Council and Transportation Commission has recognized that ITS can help the City improve the City's transportation system. As such, they have championed ITS initiatives to improve mobility and safety in Kirkland.
- There are funds available at the regional level to implement ITS, but the city must first establish a vision and plan for how to plan and implement ITS in Kirkland.
- Almost all of the City's neighboring jurisdictions have ITS plans in place and are well on their way to implementing ITS solutions. It is critical that Kirkland is not left behind in this area, but rather play a key role in the various ITS initiatives in the region and on the Eastside.

ITS is an alternative to capacity construction and complements existing infrastructure, which proved to be a cost effective method of improving the safety and efficiency of traffic flow in cities across the country. ITS consists of a combination of technical tools, concepts, software, hardware and advanced communication technologies. ITS must be planned and implemented in an integrated fashion, in order to achieve the desired safety and efficiency

improvements of both existing and future transportation facilities. Examples of ITS applications include traffic signal systems operation, transit signal priority, incident management, traffic management centers, traveler information systems, etc.

ITS Vision

An ITS Vision was developed as part of the ITS Strategic Plan in conjunction with City staff, to document the desired outcome of ITS implementation for the City of Kirkland. The City's current mission statement is:

> *"We are committed to the enhancement of Kirkland as a community for living, working and leisure, with an excellent quality of life which preserves the City's existing charm and natural amenities"*

In keeping with the City's existing mission statement, the City's ITS Vision was developed based on the key concepts of quality of living, preservation and enhancement of the community. Five fundamental components to the ITS Vision were identified and are listed below.

The City of Kirkland's vision for ITS technology applications is to:

1. ***Maximize the safety and efficiency*** of the City's transportation system for our residents, local businesses and visitors.
2. ***Optimize the City's investment*** in our transportation infrastructure.
3. ***Support emergency services*** in their efforts to save lives, provide security and protect the City's transportation infrastructure.
4. ***Enhance the quality of all modes*** of transportation services provided to residents and business owners (incl. transit, pedestrian, bicycle, freight, and personal vehicles).
5. ***Enhance the City's environmental quality*** by managing congestion.

The ITS Strategic Plan has been developed with the key components of the vision as guiding principles for the purpose and application of potential technologies and projects.

Existing Conditions

Existing transportation and communications infrastructure was reviewed and documented in order to develop an ITS plan that will serve the City now and in the future. The study area included for the review of existing conditions is shown in Figure 1. This map also illustrates the City's roadway classifications. Figure 2 shows locations of all traffic signals within City limits.

The following sections describe existing conditions for traffic signal and communications within the City.

In general, the City to date has made very modest investments in ITS systems with the exception of the City's mature fiber optic communication network. The other significant ITS effort within the City is the NE 124th Street ITS Corridor that was designed and implemented as a joint effort with King County, WSDOT, and the City of Redmond.

Existing Traffic Signal Ownership

The location and ownership of all traffic signals within the City of Kirkland are shown in Figure 2. Out all of the traffic signals within City of Kirkland limits, eleven signals are under WSDOT jurisdiction. These are signals along I-405 access ramps and they are currently timed and operated by WSDOT. In addition, another five traffic signals within the City limits are currently operated by King County, four of which are located along NE 132nd Street west of I-405 and one signal located on NE 124th Street east of I-405.

The City's current signal system is a "mixed bag" of equipment and standards. There are multiple types of signal controllers and most of them are legacy equipment which need to be replaced and/or upgraded to be compatible with an integrated ITS system. Most of the traffic signals are not interconnected making them difficult, inefficient, and expensive to manage. The City should consider adopting uniform standards for ITS infrastructure. By developing and adopting these standards, the City would be better able to manage its infrastructure.

Existing Communications Infrastructure

The City has constructed sections of conduit and communication cables over time for its signal projects and on some road projects. However, this network of cables and conduits was done without the benefit of a plan or framework. Although, some of the existing conduit system is not interconnected and has gaps in them, it can be used to expand the City's communication network.

The City has a robust fiber optic network that is deployed throughout the City as shown in Figure 3. This network is managed by the City's Information Technology (IT) and Public Works staff and is currently being used by different departments for multiple applications. The communication network has not been used to-date for ITS applications. Working together, IT and Public Works staff has reserved some fibers for future ITS/traffic

applications. This investment by the City is a valuable asset that should be leveraged to facilitate the implementation of ITS services in Kirkland.

NE 124th Street ITS Project

King County implemented several ITS applications along NE 124th Street as a joint project with Kirkland, Redmond, and WSDOT. The ITS project included a fiber optic communication system, CCTV cameras, TSP (Transit Signal Priority) equipment, emergency vehicle preemption, and new signal controllers.

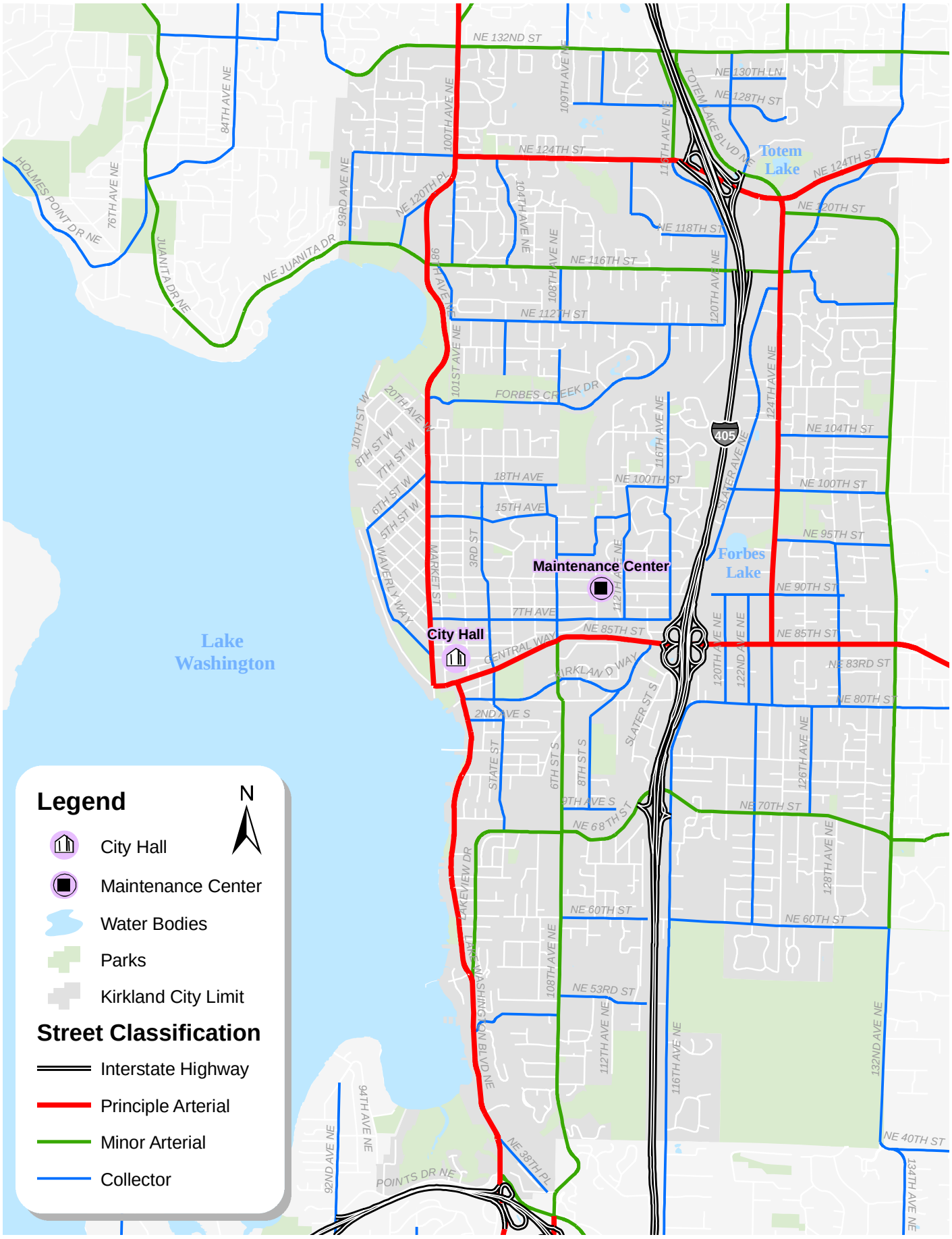
The County remotely manages the corridor from their traffic management center (TMC). The City recently installed a client workstation that is connected to the County's TMC, which enables City staff to access and monitor the 124th Street ITS system from City Hall.

Even though there is an ITS deployment along this key Corridor this plan will make recommendations to update the legacy equipment so it is compatible with the City's communication standards and to add new applications such as traveler information.

Key Findings

The following provides a summary of key findings based on the inventory review:

- The City's current ITS system consists mainly of the traffic signals
- Signal and ITS components are a "mixed bag"
- Signal interconnection is missing along key corridors so there is no remote access and management of ITS devices along these corridors
- Kirkland's robust fiber optic network is not currently used for ITS applications
- A unified set of design and construction standards for signal / ITS systems is desired
- A plan and vision for how to operate and move forward with the City's ITS system is needed.



Study Area

Kirkland ITS Strategic Plan

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FIGURE
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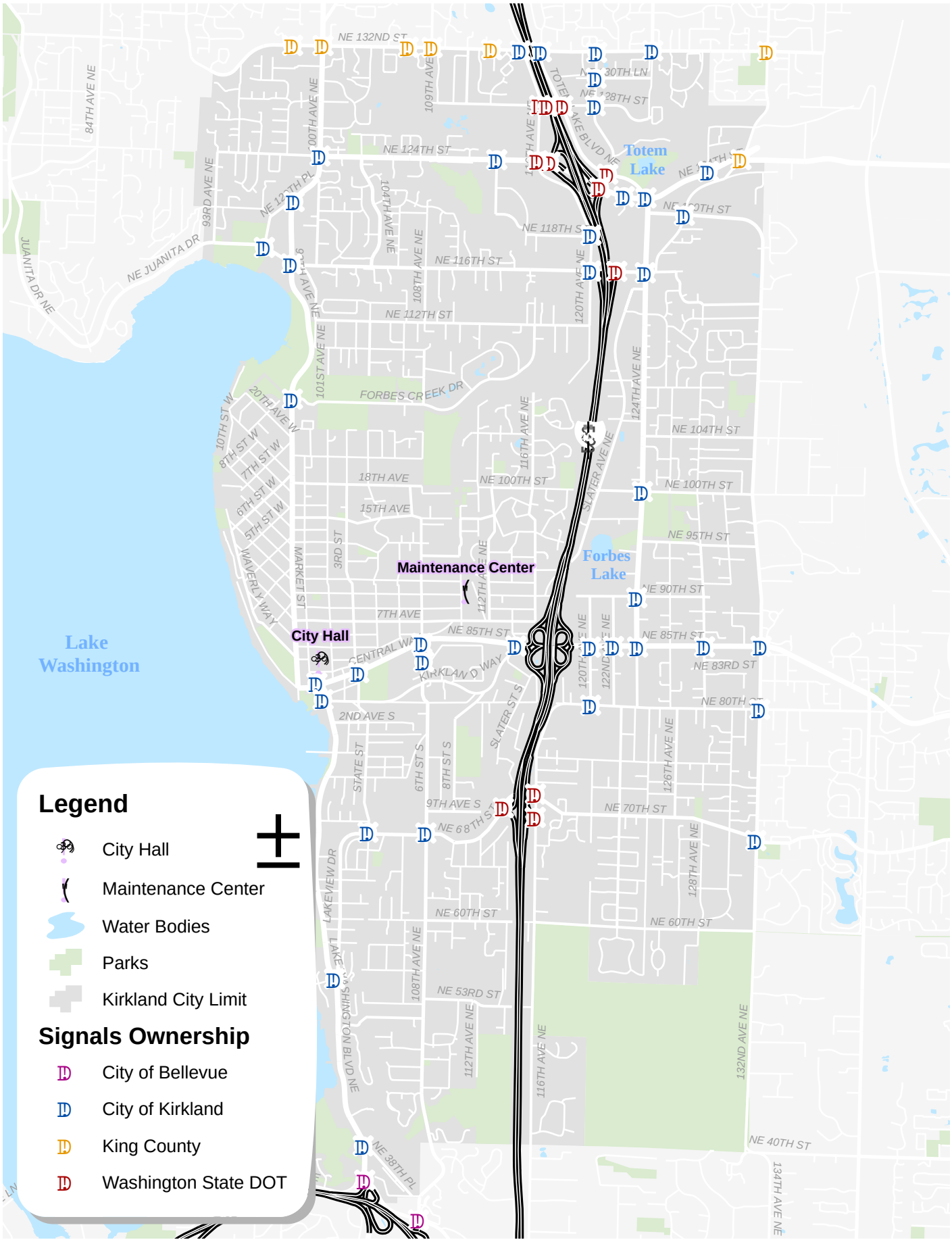

Existing Traffic Signals Ownership

Kirkland ITS Strategic Plan

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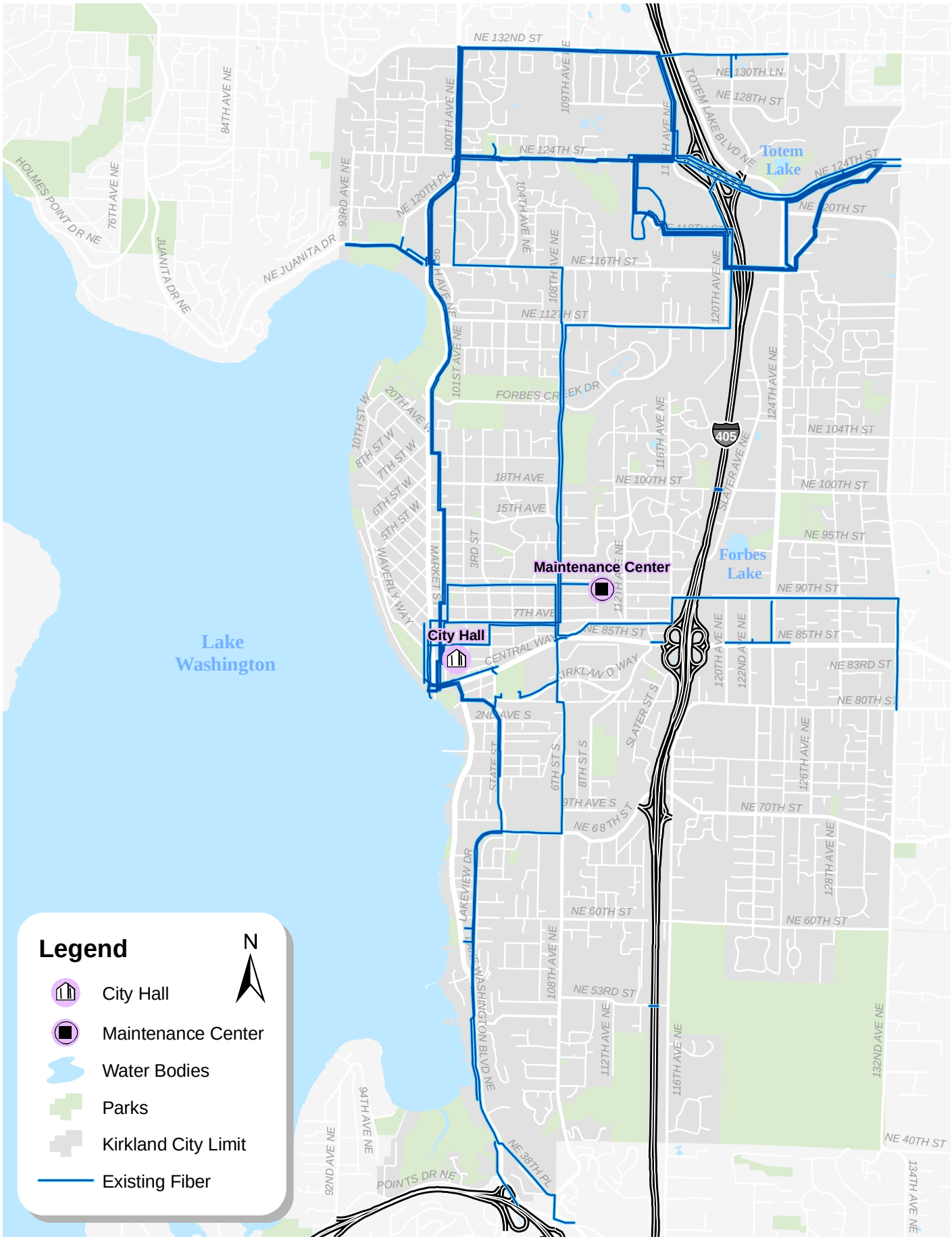
FIGURE
2



Existing Communications Infrastructure

Kirkland ITS Strategic Plan

FIGURE **3**

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Existing Conduit

Kirkland ITS Strategic Plan

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FIGURE **4**

Identified User Needs

While the existing conditions review provides a good understanding of the current infrastructure and locations where ITS applications may be well suited, it is equally critical to understand the needs and concerns of the stakeholders who rely daily on the City's transportation system. Stakeholder groups identified for this project include Kirkland Public Works engineering, Public Works operations and maintenance, IT Department, Police Department, Fire Department, as well as neighboring jurisdictions including King County, City of Bellevue, City of Redmond, and WSDOT.

In November 2007, the City's stakeholders met. At the meeting, the participants were introduced to Intelligent Transportation System (ITS) and were given different ITS examples.

A survey was distributed to meeting attendees prior to the meeting to identify user-specific ITS needs and priorities. The survey responses are summarized in the Appendix A of this master plan. In general, the City representatives' survey responses indicated an overriding need for improved travel predictability and efficiency within the City. The responses for the Public Works and Operations survey clearly indicated the need for improved system integration and updated technology, allowing more flexibility for signal timing and improved ease of adjusting to traffic conditions and maintaining traffic signal equipment. The responses for the Emergency Services survey indicated a need for real time traffic information. Real time information via a CCTV camera system with ability for viewing in emergency vehicles would improve the ability for emergency services to quickly respond to and clear incidents around the City.

The following is the list of transportation needs identified through stakeholders' discussions:

- City-wide traffic signal system upgrade;
- Interconnect and synchronize traffic signals;
- CCTV Cameras (Pan/Tilt/Zoom) along key corridors (Real time video access to police vehicle-Future);
- Driver information dissemination via variable message signs;
- Collect traffic data along key corridors in "real time";
- Use "real time" and archived traffic data in planning and operations studies;
- Coordinate signal operations with City of Redmond, City of Bellevue, King County, Sound Transit, and WSDOT;
- Share traffic data and video with City of Redmond, City of Bellevue, King County and WSDOT.

A separate meeting was held with the City's IT department to discuss the preferred methods and standards to implement future ITS improvements. We concluded that traffic/ITS services will utilize at least two ITS/traffic dedicated fibers and would use Gigabit Ethernet

(GigE) technology, which would be able to transmit information at a rate of a gigabit per second. The City's current fiber optic network uses the GigE communication technology/protocol. Ethernet switches are required at all of the ITS cabinets. IT staff expressed their interest and need to expand the existing communication network and to create redundancy. Future ITS project could help assist the City" IT staff achieve these goals.

Subsequent meetings with King County, City of Bellevue and City of Redmond were in December 2008. The meeting with the two neighboring cities highlighted the need for working relationships to be continued between the agencies, in order to improve operations of boundary corridors. The relationships and operations procedures will allow traffic data and resources sharing which will help cities to adjust signal timing accordingly. City of Redmond would like a physical connection to the Kirkland fiber optic network at 132nd Ave NE and NE 85th St and City of Bellevue would like a physical connection near SR 520 and Northup Way.

The meeting with King County affirmed the desire to share traffic information with the City. Currently, King County is already sharing data along NE 124th Street with the City through the County's Traffic Management Center (TMC).

WSDOT is in the planning phases for deploying an ITS sharing network called "traffic busters". The intent of this regional initiative is to enable information sharing between local agencies. Kirkland is involved in traffic busters planning and will be one of the agencies using this system. The planned ITS improvements for the City will accommodate connectivity to the proposed WSDOT "traffic busters" network.

ITS Architecture

The KITS Architecture is based on the National ITS Architecture. The National ITS Architecture provides a common framework for planning, defining, and integrating intelligent transportation systems. The National ITS Architecture was developed by the United States Department of Transportation (USDOT). The architecture defines:

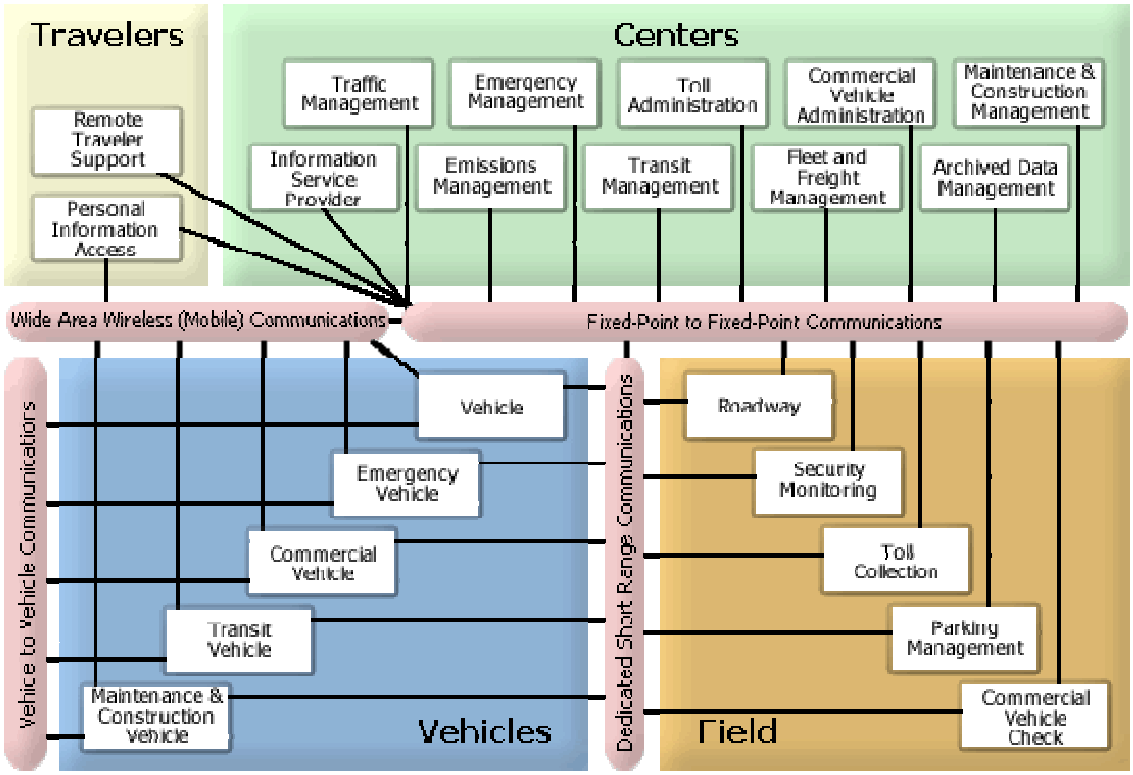
- The functions (e.g., gather traffic information or request a route) that are required for ITS.
- The physical entities or subsystems where these functions reside (e.g., in the field or the vehicle). Refer to Figure 5 for an overview of the National Architecture.
- The information flows and data flows that connect these functions and physical subsystems together into a complete integrated system.

The KITS Architecture consists of two main components as detailed later in this section:

- The logical architecture identifies functions to be performed.
- The physical architecture is where the functions will be performed.

The physical architecture defines the physical entities (subsystems) that make up an intelligent transportation system. The subsystems include entities such as traffic management centers, emergency management centers, vehicles, and roadway equipment, to name a few. The diagram shown below provides an overview of this concept.

Figure 5. National ITS Architecture Overview



Needs and Users Service Requirements

User services represent what the system will do from the perspective of the user. A number of functions are required to accomplish each user service. To reflect this, each of the user services is broken down into successively more detailed functional statements, called user service requirements (USRs). The logical architecture defines the processes or functions that are required to satisfy the user services.

Market Packages

Market packages identify pieces of the National ITS Architecture required to implement specific ITS services. A market package combines different subsystems, equipment packages, terminators, and architecture flows that provide the desired service. By mapping the user needs to the National ITS Architecture Market Packages, we arrive at the City's required market packages.

The proposed KITS market packages are summarized below.

AD1—ITS Data Mart

This market package provides a focused archive that houses data collected and owned by the City. It provides the basic data quality, data privacy, and data management common to all ITS archives and provides general query and report access to archive data users.

ATMS03—Surface Street Control

This market package provides the central control and monitoring equipment, communication links, and the signal control equipment that support local surface street control and/or arterial traffic management. A range of traffic signal control systems are represented by this market package ranging from fixed-schedule control systems to fully traffic responsive systems that dynamically adjust control plans and strategies based on current traffic conditions and priority requests. Additionally, general advisory and traffic control information can be provided to the driver while en route. This market package is generally an intra-jurisdictional package that does not rely on real-time communications between separate control systems to achieve area-wide traffic signal coordination. Systems that achieve coordination across jurisdictions by using a common time base or other strategies that do not require real time coordination would be represented by this package.

ATMS01-Network Surveillance

This market package includes traffic detectors, other surveillance equipment, the supporting field equipment, and fixed-point to fixed-point communications to transmit the collected data back to the Traffic Management Subsystem. The derived data can be used locally such as when traffic detectors are connected directly to a signal-controlled system or remotely (e.g., when a CCTV system sends data back to the Traffic Management Subsystem). The data generated by this market package enables traffic managers to manage traffic and road conditions, identify and verify incidents, detect faults in indicator operations, and collect census data for traffic strategy development and long range planning. The collected data can also be analyzed and made available to other users.

ATMS06—Traffic Information Dissemination

This market package provides driver information using roadway equipment such as dynamic message signs or highway advisory radio. A wide range of information can be disseminated including traffic and road conditions, closure and detour information, incident information, and emergency alerts and driver advisories. This package provides information to drivers at specific equipped locations on the road network. Careful placement of the roadway equipment provides the information at points in the network where the drivers have recourse and can tailor their routes to account for the new information. A link to the Maintenance and Construction Management subsystem allows real time information on road closures due to maintenance and construction activities to be disseminated.

APTS09—Transit Signal Priority

This market package determines the need for transit priority on routes and at certain intersections and requests transit vehicle priority at these locations. The signal priority may result from limited local coordination between the transit vehicle and the individual intersection for signal priority or may result from coordination between transit management and traffic management centers. Coordination between traffic and transit management is intended to improve on-time performance of the transit system to the extent that this can be accommodated without degrading overall performance of the traffic network.

System Benefits

ITS Data Mart (Data collection and archiving services)

This service provides the City the ability to collect real-time traffic data and performance measures and store this data for future use. Performance measures could include but not limited to corridor and/or intersection travel times, delay, speeds, etc. The real-time and performance measures are critical to the efficient operation of the transportation network while the archived data are useful for planning purposes.

Surface Street Control (Signal Management)

The ability of City staff to have remote access to ITS devices is critical to the overall operations and maintenance of these devices. It is also beneficial for City staff to have access to devices that are owned and operated by other agencies. For example, the City could benefit from knowing what message is currently set on a WSDOT-owned variable message sign on I-405 and have access to freeway video images especially when incidents are present that could affect City streets. Projects should include consideration for access and control that may be made available to the City police and fire department.

Transit Priority System

Transit signal priority provides for a more efficient and reliable mass transportation system. It also allows for the reduction of delays and stops to public transport vehicles.

Traveler Information

The City may wish to provide information to the general public including information to assist them in preparing for or during their trip. There is also a benefit to the general public by providing arterial congestion and incident information for key arterials in the City, as they may choose alternate travel routes, or may choose to vary their time of departure based on current traffic conditions. Regional information dissemination is a service that is currently being provided by WSDOT, specifically on area freeways such as I-5, I-405, and SR 520. The City of Bellevue and other agencies have or are in the process of deploying similar systems. The information made available by the City should also be shared with other key stakeholders such as WSDOT and King County.

Proposed Communication System

The KITS plan recommends that the City use its existing fiber optic network as the foundation to interconnect its existing and future ITS equipment. By doing so, the City would leverage its investment in its existing infrastructure. At the same time this communication network would be expanded and made more redundant as future ITS projects install fiber optic cables along key corridors. Figure 6 illustrates the proposed communications infrastructure.
The Communication System section of this document illustrates more the technical details and recommendations of the proposed system.

Proposed ITS Devices

The ITS devices include the following types of equipment/technologies:

- Signal controllers: The main function of advanced traffic signal controllers is to manage traffic flow at key intersections. Typically, this is done in conjunction with a central traffic signal management application. Currently the City does not have this capability. The City should consider a single controller standard that can meet its current and future needs. City staff is currently using the Econolite NEMA controller. This controller is capable of advanced traffic functions such traffic coordination, traffic responsive, data collection, and transit signal priority, and is currently using NE 124th St.
- Video Surveillance cameras: The main use of these devices is the ability of City staff to visually monitor the operation of the roadway network remotely and without needing to be in the field. When City staff adjust traffic signal timing they could easily determine the positive or negative effect of such change. In addition, City staff can be alerted to any incidents.
- Vehicle detection systems: The main function of the vehicle detection system is the collection of traffic data and to determine the performance of the intersections and corridors. In addition, they could also be used for assignment of right of way at signalized intersections. It is recommended that the City uses "non intrusive" detection systems for its future systems. These systems do not involve cutting the pavement or damaging the pavement structure or closing lanes to install these systems.
- Dynamic message signs for arterials: The main purpose of these signs is to communicate roadway and congestion conditions with the driving public. These signs are designed to work on key arterials and are approximately 3 feet tall by 8 feet wide.

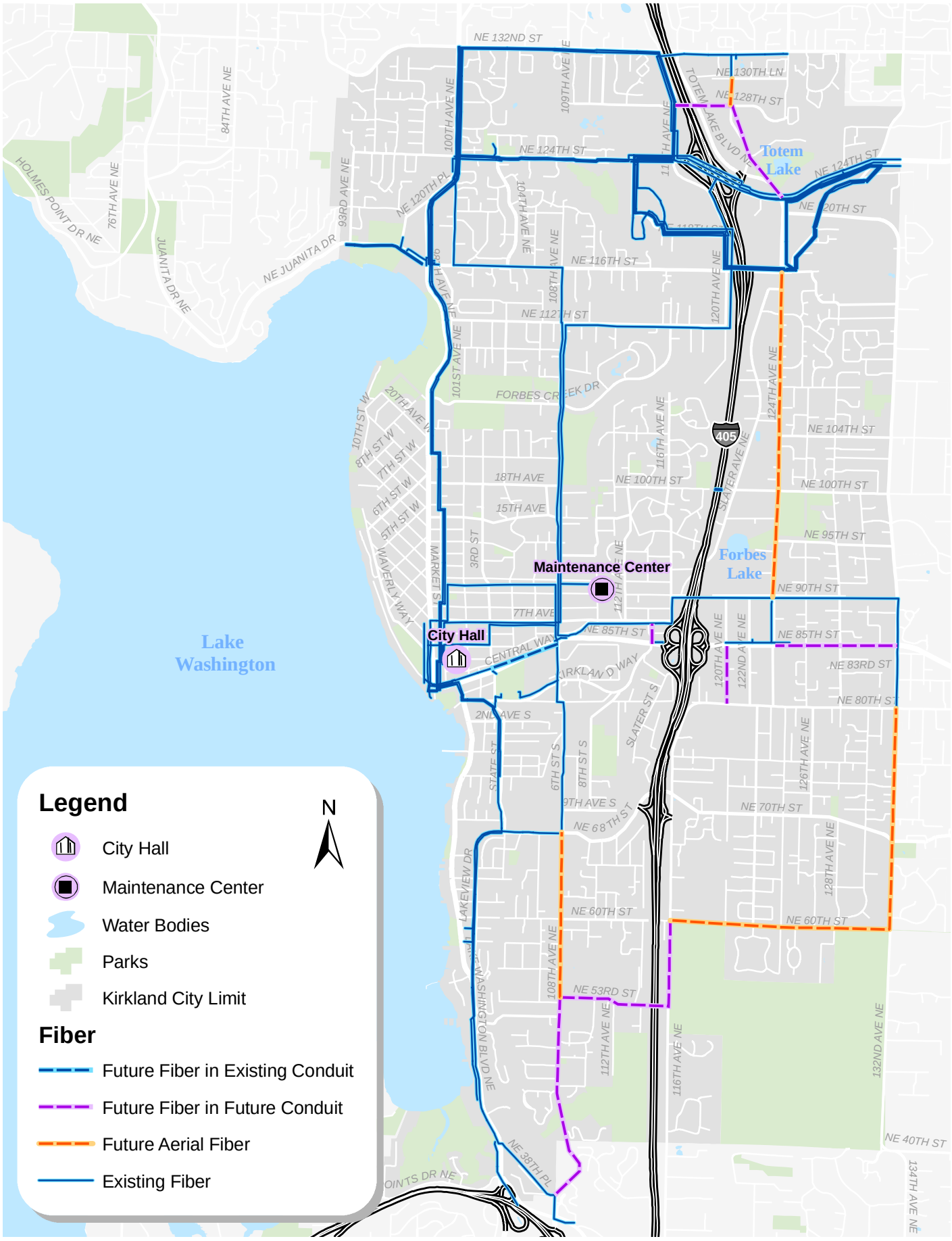
Figure 7 presents the proposed locations of the future ITS devices.

Proposed ITS Corridors

The proposed ITS Corridors are the key arterials within the City that provide mobility for the City's residents, visitors, and customers. The City should use the future ITS devices, communication system, and ITS applications to monitor and manage these Corridors in real-time. The City should be able to perform the following key functions remotely:

- Manage and optimize traffic signals
- Monitor the corridor in real-time for current operations and incidents
- Respond to incident and emergencies
- Collect and archive traffic data and performance measures
- Share traffic information/data with public and other agencies

Figure 8 shows the corridors where data and performance measures should be monitored.



Proposed Communications Infrastructure

Kirkland ITS Strategic Plan

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FIGURE
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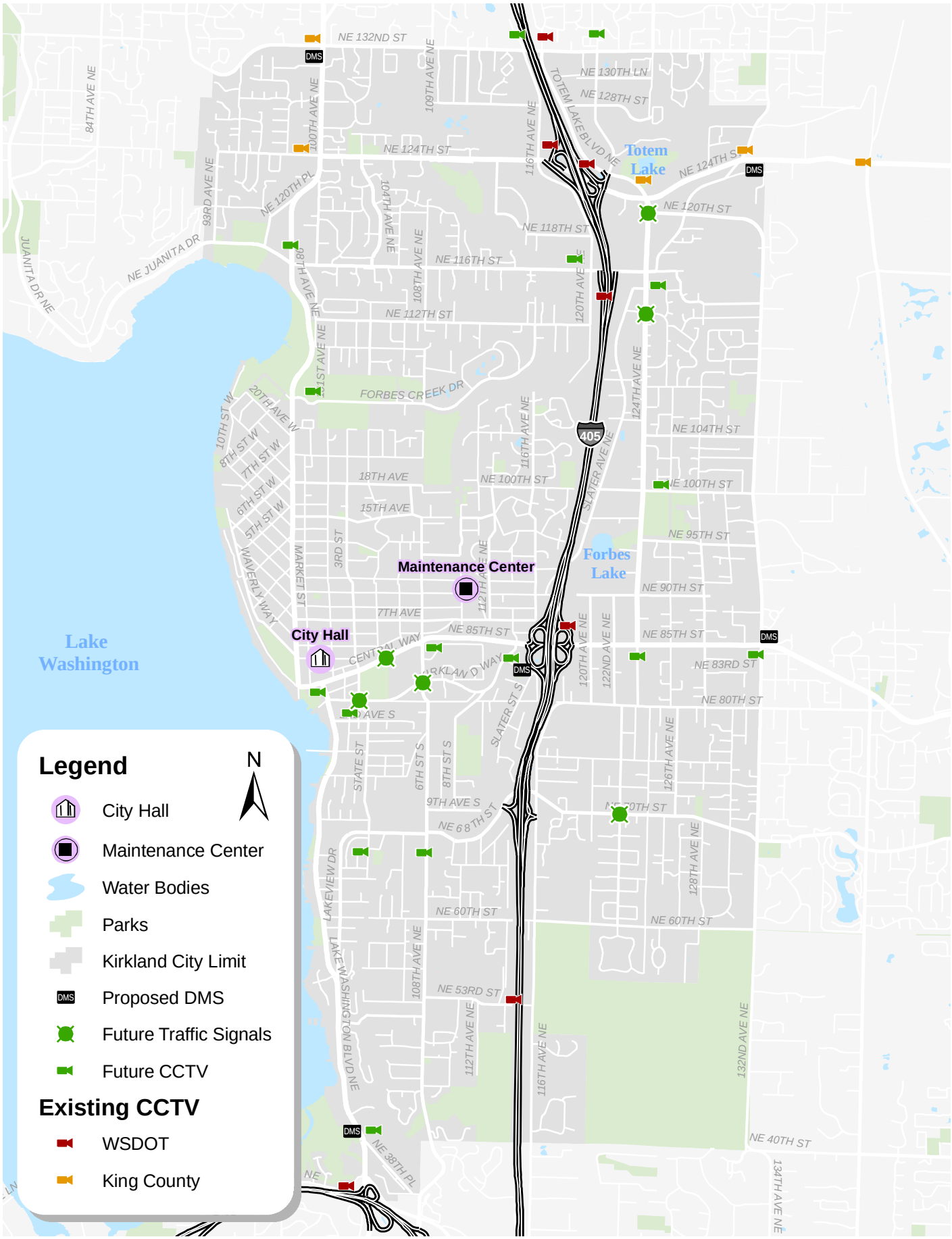

Proposed ITS Devices

Kirkland ITS Strategic Plan

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FIGURE
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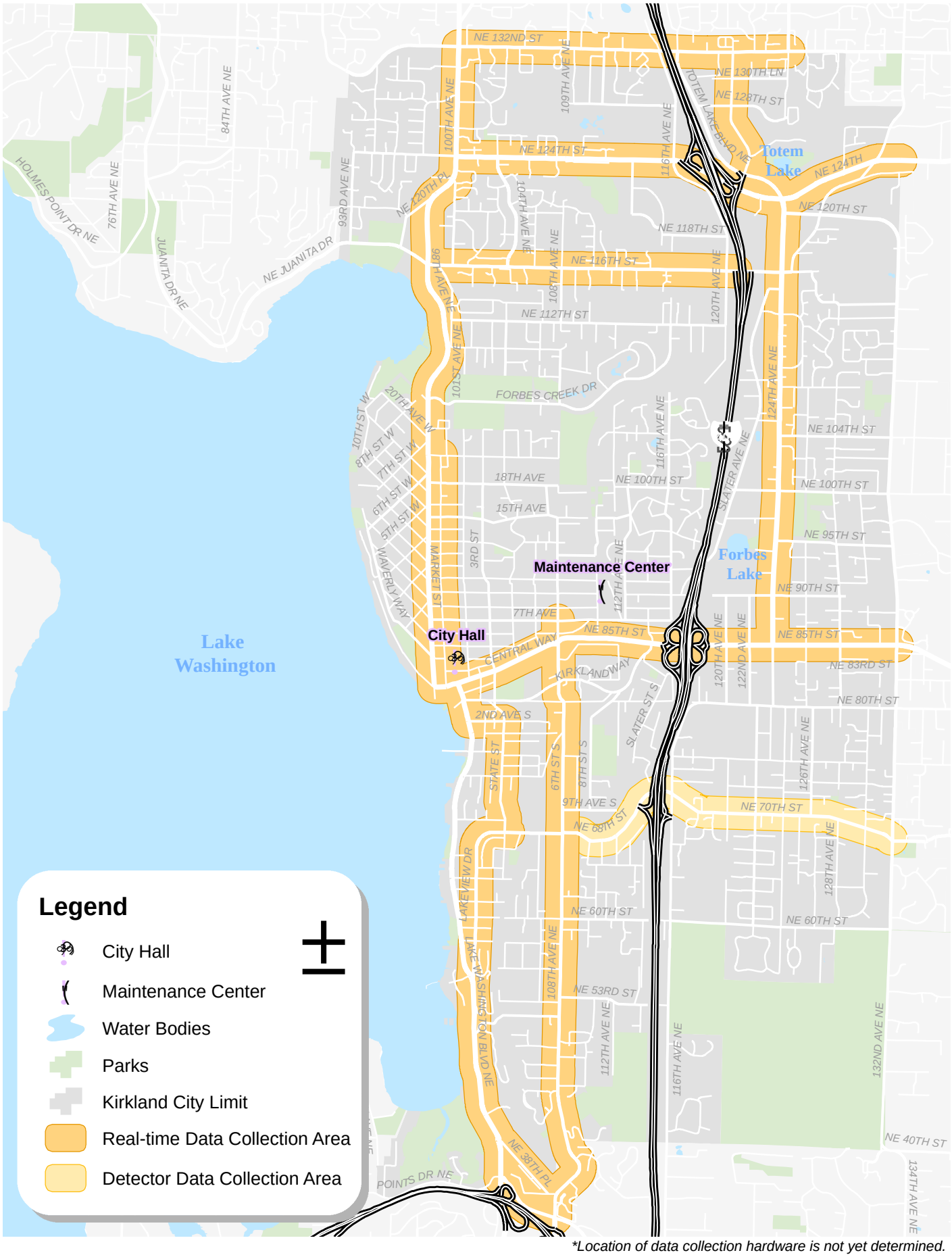

*Location of data collection hardware is not yet determined.

Proposed Data Collection Areas

Kirkland ITS Strategic Plan

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FIGURE **8**

The following table summarizes system benefits illustrated earlier.

Table 1. System Benefits Summary

Signal Management System	Transit Priority System	Traveler Information
A. Remote access to signals and rapid response	A. Increased transit ridership	A. Provide information about traffic congestion and road conditions
B. Real-time operational responses to current and projected conditions	B. Reduced passenger car trips along the corridor	B. Provide the public with accurate, timely information on transportation alternatives
C. Reduced congestion and more freely flowing traffic	C. Reduction in time for buses to complete a route round trip, which has the potential of reducing the number of buses required per route	C. Coordination with other agencies
D. 10 percent to 41 percent reduction in stops, 14 percent to 44 percent reduction in delay, and 2 percent to 13 percent reduction in fuel consumption*		

*Source: Intelligent Transportation Systems Benefits, USDOT, 2001

KITS Architecture

The ITS Architecture consists of :

- **Logical Architecture:** User Services and User Service Requirements from the National ITS Logical Architecture was used to define the functional requirements of City's transportation needs and services.
- **Physical Architecture**: The physical architecture (market packages and city-specific physical architectures) was used to address the issues surrounding where the required functions would be performed.

Both the logical and physical architectures were used to define the City's ITS requirements and are discussed in the following sections.

Logical Architecture

Logical architecture represents the functions that are required for ITS and the information that moves between these functions. The City's objectives supported by the "logical" functions are transmission of traffic flow and incident information, and device status and control. These functions support two primary "logical" functions described below.

Traffic Surveillance / Data Collection

This process provides traffic surveillance, data storage, and communication with traffic management centers. Traffic surveillance provides vehicle information on surface streets by using traffic field devices. Long term data are stored and used by signal operations and maintenance, and city planners. The data are also available for dissemination to other ITS functions and to other stakeholders, travelers and transit users.

The City's intention to collect and share traffic data could be met by the development of a data management system. The primary dissemination technology for the general public will likely be via a traveler information system using technology such as the internet or dynamic message signs. The City can also share and leverage information from other stakeholder agencies such as WSDOT and King County.

ITS Device Control

This process enables traffic control through devices that output information to motorized travelers on the surface streets and freeway network served by the City, County and WSDOT. Different hardware is used to implement this function such as signal controllers, dynamic message signs, etc. Moreover, access and control of ITS devices is beneficial to support the City's current and future traffic management functions. Device Control supports various types of traffic management strategies (information dissemination, active diversions, and road closures).

The traffic surveillance process, mentioned in the previous section, provides the traffic flow data required by these management strategies. This process would also facilitate the detection of equipment faults. This process includes the ability to select, view and control CCTV cameras, DMS, and signals. This process allows the selection of appropriate traffic control strategies to be implemented, for normal and special situations and during the different times of day, days of week and/or year.

Physical Architecture

The physical architecture addresses the physical structures, also named subsystems by National ITS Architecture, surrounding the "logical" functions described in the previous section and the equipment packages as described by the National ITS Architecture.

The overall physical architecture for the City is depicted in Figure 9 and assumes the sharing of information and control capabilities will reflect pre-defined operational and procedural agreements between the agencies. The principal concept of Kirkland's physical architecture is connecting ITS devices, Kirkland's traffic management center, operators, public safety departments, and other agencies to the City's Wide Area Network (WAN) which allows communication between each of these components.

The City's physical architecture subsystems, with associated equipment packages, are described in details in the following sections.

Archived Data Management Subsystem

ITS Data Repository

This equipment package collects data and data catalogs from one or more data sources and stores the data in a dedicated repository that is suited to a particular set of ITS data users. This equipment package includes capabilities for performing quality checks on the incoming data, error notification, and archive coordination. This equipment package supports a broad range of implementations, ranging from simple data marts that collect a focused set of data and serve a particular user

community to large-scale data warehouses that collect, integrate, and summarize transportation data from multiple sources and serve a broad array of users within a region.

Traffic Management Subsystem

This subsystem communicates with the other regional stakeholder Traffic Management Subsystems (TMS) to facilitate the provision of coordinated traffic information and control strategies in the agencies' jurisdictions. Kirkland's TMS would include numerous equipment packages to meet the City's needs. These equipment packages are not necessarily separate "systems" - rather they represent separate (but related) technical "applications" that will be operated at the City's TMC.

Traffic Data Collection

This equipment package collects and stores traffic information that is collected in the course of traffic operations performed by the Traffic Management Subsystem. This data can be used directly by operations personnel or it can be made available to other data users and archives in the region. This equipment package supports the collection of both real-time data (which would be used by agencies to provide traffic management services) and historical data (which could be used for planning purposes and also to analyze the effectiveness of certain traffic response strategies).

Traffic and Roadside Data Archival

This equipment package collects and archives traffic and roadway information for use in off-line planning, research, and analysis. The equipment package controls and collects information directly from equipment at the roadside, reflecting the deployment of traffic detectors that are used primarily for traffic monitoring and planning purposes rather than for traffic management.

Collect Traffic Surveillance

This equipment package collects, stores, and provides electronic access to the traffic surveillance data. This equipment package pertains primarily to CCTV camera images and traffic sensor data.

TMC Traffic Info Dissemination

This equipment package provides the capability to disseminate real-traffic conditions and incident related information to travelers. In addition to these links, dissemination of information between agencies through a wide area network is also important.

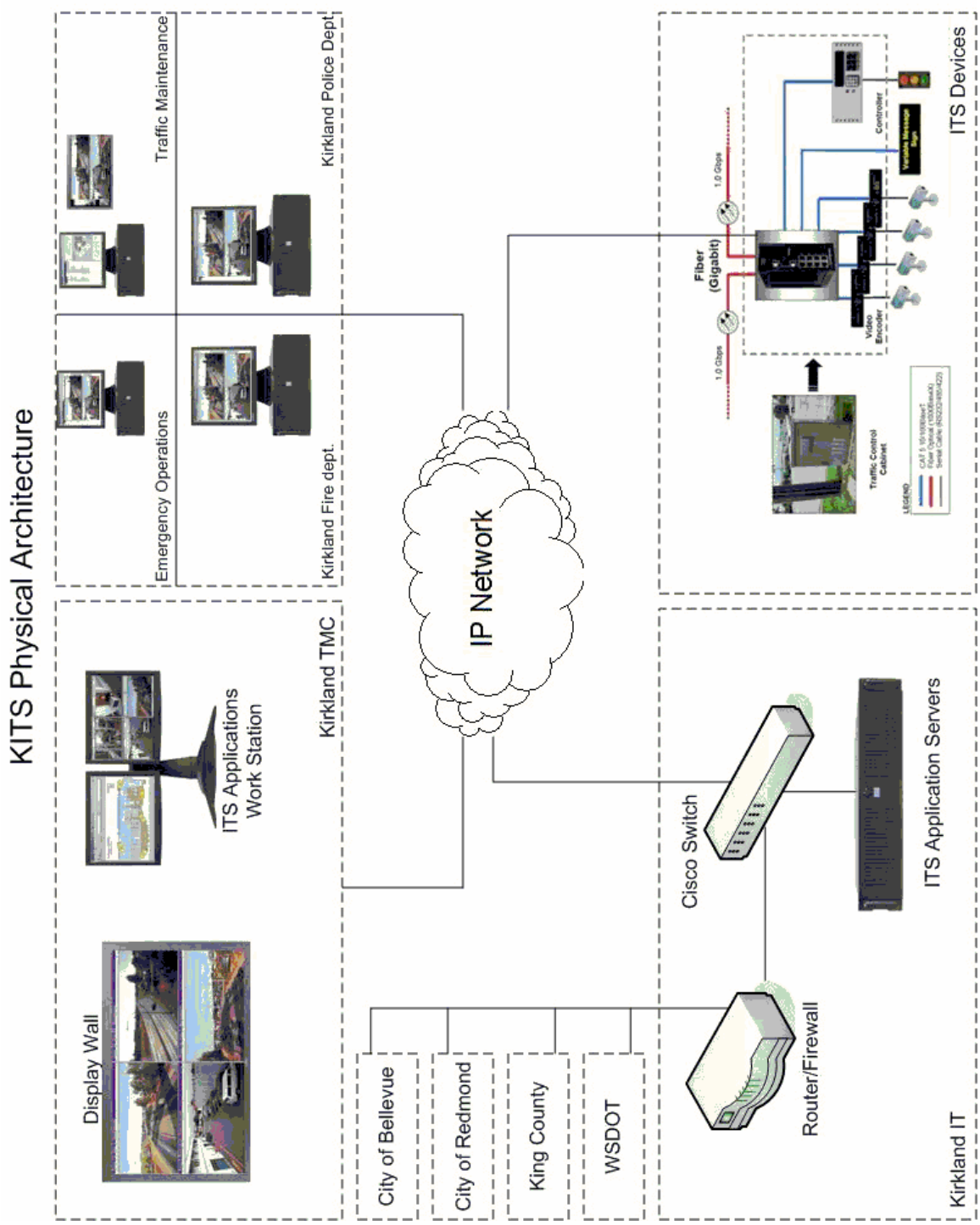
TMC Signal Control

This equipment package provides the capability for traffic managers to monitor and manage the traffic flow at signalized intersections. This capability includes analyzing and reducing the collected data from traffic surveillance equipment, and developing and implementing control plans for signalized intersections. Control plans may be developed and implemented that coordinate signals at many intersections under the domain of a single traffic management subsystem.

Traffic Maintenance

This equipment package provides monitoring and remote diagnostics of field equipment to detect field equipment failures, issues problem reports, and tracks the repair or replacement of the failed equipment.

Figure 9. Kirkland ITS Physical Architecture



Communication System

The main goal for the KITS communication system is to support the deployment and operation of ITS market and equipment packages that offer the following functionalities:

- Interconnect and optimize traffic signals remotely and in real-time
- Monitor traffic flow and operations using CCTV cameras
- Collect real-time traffic data
- Provide travel information to public
- Data sharing with other agencies

In order to provide the above functionalities, the communication system must provide a high bandwidth and speed network capable of supporting both video and data transmission. The system should also be scalable to accommodate future ITS applications in addition to other City communication needs.

Design Requirements and Considerations

Existing Communication System

Most of the City's current ITS infrastructure is not connected to a high bandwidth and speed network. The exception is the 124th Street Corridor which is interconnected via a high speed fiber optic cable.

Even though the existing ITS infrastructure is not currently interconnected, the City currently has a large fiber optic network deployed through out the City. This high bandwidth and high speed network connects many City facilities and supports many applications. This network has spare fiber optic strands that can be used for the KITS communication system. This network is managed by the City's information technology (IT) department. The City's current high speed network currently employs the Gigabit Ethernet (GigE) communication standard.

Reliability and Redundancy

The KITS applications require that the communication system to be operational at all times. The ideal system is fault tolerant, self healing, and route redundant.

Scalability and Security

The communication system should be capable of providing an easy and cost effective mechanism to grow and expand to accommodate future systems and applications. The system should be capable of providing a high level of security in order to protect the City's network and data.

Network Maintenance and Management

The communication network should be easily configurable, upgradable, and recover easily due to fault. The network should be managed via network management software (NMS) tools to ensure optimum operation and performance.

Commercial Off the Shelf and Environmentally Hardened Equipment

It is best if the communication system consists of commercial off the shelf (COTS) equipment and not custom or proprietary systems. In addition, the equipment should be environmentally hardened to withstand the harsh outdoors environment of the typical ITS field applications. It is highly recommended that any equipment used in ITS systems meet the NEMA TS2 environmental standards listed in Table 2.

Table 2. NEMA TS2 environmental Standards

Parameter	NEMA TS2
Temperature	-29 F to 165 F
Humidity	18% to 90% RH, non-condensing
Voltage	120-135VAC @ 57-63HZ
Vibration	0.5g @(5-30) Hz
Shock	10g's for 11ms

Bandwidth Requirements

The communication system for the KITS should be able to provide enough bandwidth to accommodate various ITS equipment such as CCTV cameras, dynamic message signs (DMS), traffic signal controllers, video detection and data, and communication with other neighboring jurisdictions such as Redmond and Bellevue. Typically, video transmission will require the most bandwidth and thus controls the design of the communication network. The data bandwidth requirements for the KITS are generally low.

Video can be transmitted in either analog or digital format, depending on the communication media ad technology used. The transmission of video in digital format is more efficient and cost effective. It also has many operational benefits namely in the areas of video collection, distribution, and archiving. There are many digital video formats and each has its own bandwidth requirements.

Table 3. Typical Bandwidth Requirements for Control Data

ITS Elements	Data Type	Bandwidth
Camera PTZ	Control Data	1200 to 19200 bits per sec (bps)
Traffic Signals	Traffic data, status	1200 to 19200 bits per sec (bps)
Detection System Data	Detector Data	1200 to 19200 bits per sec (bps)
DMS	Control Data	1200 to 19200 bits per sec (bps)

Table 4. Digital Video Encoding Systems

Video Encoding Scheme	Bandwidth
MJPEG	240 kbps
MPEG-2	3 to 15 mpbs
MPEG-4	1.5 mbps

The MPEG-4 video encoding scheme has become a very mature and cost effective solution for the transmission of digital video over communication networks. There are many local agencies that are successfully using MPEG-4 video encoding in the Puget Sound region. The main advantage of using MPEG-4 is the lower bandwidth requirement as compared with other encoding schemes such as MPEG-2.

Recommendations

Based on the existing City's deployment of a mature GigE communication network, it is recommended that the KITS communications network use the same technology/standard. This choice leverages the City's existing investment in its GigE network in addition to using a technology that is proven, reliable, and scalable. The following are the technology recommendations for KITS:

Table 5. KITS Communication Hardware

Item	Recommendation
Communication media	Single mode fiber optic for backbone and drop cables. Use 72 strand cable for backbone and 12 strand cable for drop cable. (Drop cable is required between backbone cable plant and each ITS/Signal cabinet,)
Network topology	GigE ring with start network hubs (figure 10)
Network switching	Layer 2 and layer 3 hardened and managed GigE switches with IGMP, VLAN, RSTP, RMON support
IP Video encoding	Hardened MPEG-4 video encoders
ITS equipment communication interface (signal controllers, DMS controllers, VDS, video encoders, etc.)	Ethernet Interface (RJ-45)

KITS Estimated Bandwidth Requirements

Table 6 provides a general overview of the KITS bandwidth requirements assuming a specific future number of ITS devices. In addition, the table assumes the use of a digital video encoding system (MPEG-4) with a 1.5 mbps bandwidth per video stream.

Table 6. KITS Estimated Bandwidth Requirements

	ITS Devices			
	CCTV	Detectors	Traffic Signals	Other
Total Devices on Backbone	30	100	40	20
Device Bandwidth (Kbps)	1500	9.6	9.6	9.6
Percent Utilization	50%	100%	100%	75%
Total Devices Bandwidth (Mbps)	23	0.96	0.38	0.14

Network Topology

A communications network consists of two primary application types: Local Area Network (LAN) and Wide Area Network (WAN). The LAN covers smaller geographic regions typically confined to a building (i.e., TMC) or a small geographic area whereas the WAN covers a larger area (city, county, region, or state). WANs typically consist of multiple LANs interconnected through a high-speed data network. Both are necessary and would work together to provide the City's communications network. The City's WAN can be viewed as a fiber optic backbone or as a series of communications hubs/nodes that are interconnected using optical fibers as the transmission media. Each hub/node functions to receive and transmit data and video over the fiber optic backbone, providing a means for equipment connected at one hub/node to communicate with equipment connected at another hub/node.

Common topologies for communications networks include the linear, star, ring and hybrid topologies.

The star topology is basically where one node serves as the primary central node and all other nodes and/or equipment are physically connected via point-to-point circuits. All communications pass through the central node. This configuration is often used in an environment such as a LAN hub or ATM switch/hub. This configuration is generally unreliable and susceptible to an entire network failure when the central node fails.

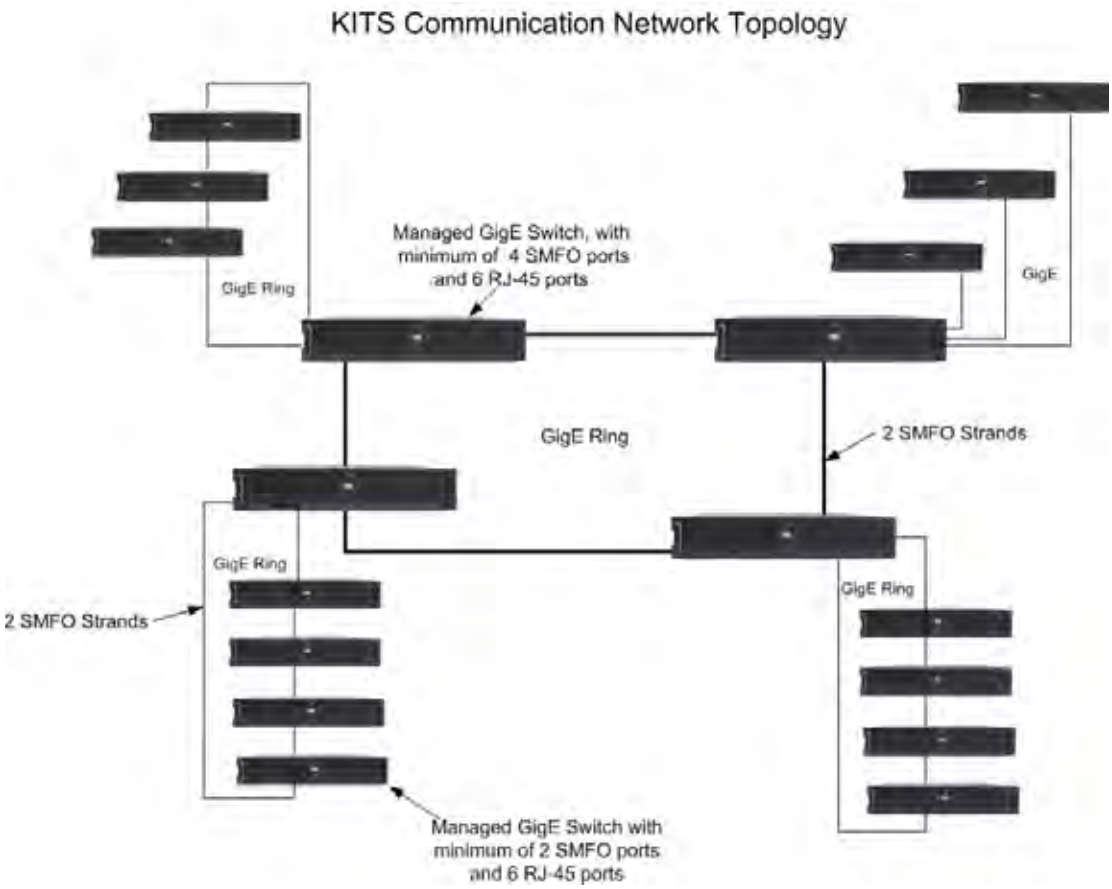
In a ring topology each communications network node is connected to two other communications network nodes. In most backbone applications, fault tolerance is an essential design consideration that guards against a general network failure in the event of a fiber break or an individual node failure. Examples of these kinds of events are when a backhoe operator accidentally cuts into an underground fiber cable between two nodes or a motorist crashes into a curbside cabinet that contains backbone communications equipment. Fault tolerance can be achieved by employing a dual counter-rotating ring (DCRR) topology with diversity routing. Communications equipment designed for DCRR architectures has the intelligence to sense failures and 'fold-back' around the point of failure, thus preserving basic network function. A ring topology is typically configured as a hybrid type with each node functioning as a central node in a local star configuration. The series of local stars are interconnected in a ring configuration.

For the City of Kirkland a hybrid topology is proposed. The backbone (core) of this hybrid network will utilize the existing fiber optic network.

The City's fiber network will function as the core of the hybrid network and would be used as the City's communications backbone between the TMC and the field communications hubs / nodes. Each of the communication hubs provides a field location where data and video can enter and exit the ring network. This will typically be at locations where master signal controllers are located.

Figure 10 illustrates the proposed network topology.

Figure 10. Network Topology



Appendix A: Meetings Summary

Meeting with City of Kirkland

Meeting date: November 2007
Stakeholders attended: City of Kirkland Public Works, Maintenance and Operations, Police and Fire department, and IT department
The answers to the issues discussed during the meeting are listed below.

EMS Staff Questionnaire

1. Would access to real-time traffic information (via video for example) be of use to you? If so, do you see the need to be able to view and control the camera feeds if they are available to you?

Yes, to both Fire Department (KFD) and Police Department (KPD). KPD would like to have access to the video from their vehicles but at a minimum from the communication center. This capability will allow them maneuver around congested areas, as well as gain incident information since the focus, when a call comes in, is on getting to the incident location as quickly as possible. Static images provided by other video monitoring department for the station are sufficient.
FD is more concern with accessibility to camera information on I-405 which belongs to WSDOT.
Specific areas of interest include major intersections/arterials. These include NE 124th St, NE 85th St, Market St, NE 70th St, and Downtown area.

2. Do you perceive a need to relay pertinent real-time traveler information to drivers? (notices of blockages, closures, construction, etc. via website, variable message sign or other means)

Yes. This is especially true for incident management. Variable message signs, or other automated signs to direct drivers to alternate routes would be very helpful. Earlier access to this information through the KPD and KFD communication department would be helpful.

3. Do your dispatchers require better real-time traffic information for pin-pointing or verifying accident reports, aiding response to incidents or providing faster information to your drivers?

Same as answer to question 1.

4. Do you perceive a need for fleet management? (Monitoring vehicle locations, etc.)

Yes. At present KPD accurate information on the vehicle locations would be a significant benefit to improving response times, with some potential safety benefits as well.
From KFD perspective, once vehicles leave the station, it is assumed they are on the way or at an incident location. The only contact is by radio at that point. A GPS system on all vehicles would help fleet management.

5. Do you need improved traffic signal response to emergency vehicles? If yes, are there specific locations that require improvement?

Opticom works pretty well and need to install it on all emergency vehicles, but the real problem is congestion which keeps anyone and everyone from moving and makes the preemption only minimally effective under these conditions.

6. Is there a need to access real-time video feeds at the scene of the emergency? If yes, please elaborate.

Yes, to KPD. Currently, KPD has "mobile –data" computer system on all vehicles with internet access and would like have access to real-time video incorporated into this system. As for KFD, Opticom system is sufficient for them.

7. From your perspective at the City of Kirkland, what are the top 3 transportation-related needs today?

a. Wider roads
b. Green light warning emergency vehicles ahead of time
c. Real time traffic information/images

Public Works Staff Meeting Questionnaire

1. Do you need the ability to collect and use traffic data? If so, what data would you like to collect and what would you like to use the data for?

Yes, we need the ability to systematically collect data without the need to outsource data collection. It is also desired to have the traffic counts be taken at various locations at the same time rather than having one location taken different days at other locations. Would like to collect volume counts, occupancy, number of time pre-empts triggered/intersection, and signal failure log. Would also like to collect pedestrian and bicycle movement data such as usage amount of midblock pedestrian flashing light. The latter data would be used to adjust signal timing of nearby intersection for pedestrian safety purposes. The City would use the traffic data to increase the efficiency and to manage the system.

2. Do you need surveillance cameras? If so, are there critical locations you would like to see cameras located, and how would you like to use these devices?

Yes, we need surveillance cameras to be located at critical intersections and segments (Juanita and Downtown areas). To be able to see the traffic operating in real time at Public Works Operations and Maintenance. The city would like the information to be used to adjust signal timing. Also would like the ability to record the information being viewed and generate a traffic flow map.

3. Do you perceive the need for transit integration between the City, KC Metro and Sound Transit? (including real-time information, transit signal priority, park-and-ride location information, etc.)

Yes, we would like to communicate with Transit. The priority is on NE 124th St. Equipments are currently in place and will be maintained by City of Kirkland. However, these equipments were bought by King County and are currently not operational.

4. Do you have a need for real time traffic information from neighboring jurisdictions? If so, what type of information would you like to have?

Yes. It would be helpful to report other congested areas which could clarify the cause of congested areas in Kirkland. This information could also be used to adjust signal timing at city boundary intersections.

5. Do you have adequate access to the existing transportation system components (signals, cameras, etc.) and to the information that is currently available on those systems? If not, what additional information do you need and how do you envision using that information?

No.

6. Do you perceive a need to relate pertinent real-time traveler information to drivers? (notice of blockages, closures, construction, etc. via internet, dynamic message sign or other means)

Yes, using flow map and esthetically pleasant DMS.

7. Do you perceive a need for monitoring pavement/surface conditions within the City?

Yes, for verifying potholes and bridge icing conditions.

8. What operations components do you feel need to be added to your existing signal system to improve reliability, responsiveness and/or operations?

Update signal system at some locations in the downtown area since they are too old and not manageable. Would also like to manage all signal system remotely. Battery back-up to keep signals operational are desirable.

9. Do you need the ability for fleet management (track vehicle locations, use for data collection, etc.)?

No.

10. From your perspective at the City of Kirkland, what are the top 3 transportation-related needs today?

a. Adequate transportation system
b. Modern and Maintainable System (Keep up with regional systems)
c. Exchange information with other agencies

The following lists the City's interests in practical applications of ITS technologies:

<u>Travel and Traffic Management</u>

- Pre-trip traveler information (via internet, including real time information)
- En-route driver information (via dynamic message signs, including real-time information)
- Traffic control
    - Interconnected traffic signal system
    - Integration of freeway ramp meters and arterial signals
    - Collecting and processing real-time traffic information
    - Traffic control room (ability to monitor traffic flow)

Public Transportation Operations

- En-route transit user information (via kiosks)
- Transit signal priority at traffic signals
- Public travel security (detection, identification and notification of incidents)

Information Management

- Data storage and archival for information collected

Meeting with City of Kirkland IT department

Meeting date: November 2007

Stakeholders attended: City of Kirkland IT department

Agenda:

- Planned physical communication improvements throughout the city
- Desired physical communication improvements to create network ring (redundancy)
- Physical communication network dedicated to ITS
- Ethernet switches requirements

Meeting with King County

Meeting date: December 2007

Stakeholders attended: City of Kirkland and King County

Agenda:

- NE 124th St ITS devices control
- Desire to share traffic information

Meeting with City of Redmond

Meeting date: December 2007

Stakeholders attended: City of Redmond city representatives

Agenda:

- Desire to share traffic information
- Physical connection point

Meeting with City of Bellevue

Meeting date: December 2007

Stakeholders attended: City of Bellevue public works, city representatives

Agenda:

- Desire to share traffic information
- Physical connection point

City of Kirkland
ITS Strategic Plan

PART 2 – ITS Implementation Plan

CITY OF KIRKLAND
ITS IMPLEMENTATION PLAN

Prepared for:

City of Kirkland, WA

June 2008

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Table of Contents

Introduction & Background

This Intelligent Transportation Systems (ITS) Implementation Plan has been prepared for the City of Kirkland as the second of two principal documents that will serve as the City's road map for future ITS projects, improvements and policies.

The Implementation Plan has been prepared to follow the ITS Master Plan and builds on it by detailing and prioritizing the recommended ITS projects. The reader is referred to the Master Plan for a complete review of ITS architecture, functionalities and options, existing traffic signal system and ITS infrastructure within the City, gaps in the infrastructure system, and needs and priorities identified by project stakeholders. Based on the Master Plan, this Implementation Plan provides detailed project information, prioritization, and highlights some special considerations.

The City of Kirkland's established vision was used as a basis for writing the ITS Master Plan vision, which is provided below for reference.

1. ***Maximize the safety and efficiency*** of the City's transportation system for our residents, local businesses and visitors.
2. ***Optimize the City's investment*** in our transportation infrastructure.
3. ***Support emergency services*** in their efforts to save lives, provide security and protect the City's transportation infrastructure.
4. ***Enhance the quality of all modes*** of transportation services provided to residents and business owners (incl. transit, pedestrian, bicycle, trolley, freight, and personal vehicles).
5. ***Increase use of mixed modes*** of transportation, ***improve integration*** of all modes to facilitate trip reduction strategies, and enhance the City's environmental quality.
6. ***Support local land use plans and regional/local ITS initiatives and standards.***

Existing conditions were documented in the ITS Master Plan and included traffic signal ownership, communications infrastructure, and the NE 124th Street ITS project. The existing conditions review established that the City's current ITS system consists mainly of traffic signals. However, signal interconnection along key corridors is missing, which prevents remote access and management of ITS devices along those corridors. In addition, Kirkland's robust fiber optic network is under utilized for ITS applications. An important finding of the existing conditions review in the Master Plan was the need for a plan and vision for operating and moving forward with the City's ITS system. Staff time must be devoted to this effort on the part of the City in order to attain a functional and viable coordinated system.

During the master planning process, the project team worked with a wide range of project stakeholders to evaluate existing traffic conditions within the city and determine relevant needs. The process revealed in general the need for:

- improved traffic signal management, optimization, and coordination,
- dissemination of real time traffic information to drivers,
- improved response to incidents and emergencies, and
- information sharing and coordination among jurisdictions.

Projects for Implementation

Goals and Objectives

Based on the existing conditions review, identified system needs and stakeholder input, the ITS Master Plan identified the following three prioritized project objectives:

1. **Upgrade, interconnect and coordinate traffic signals:** a need was identified to synchronize and optimize the traffic signals throughout the City. In order to synchronize and coordinate the City's traffic signals, they have to be interconnected, the hardware must be upgraded, and increased staffing should be provided to develop, implement and monitor timing plans. Both the infrastructure (communication interconnection and controller upgrades) and staffing are critical to the implementation and success of this effort.
2. **Capability to have remote access and control ITS devices:** The ability for City staff to have remote access to ITS devices is critical to the implementation of coordinated timing plans and to the overall operations and maintenance of these devices. It is also beneficial for City staff to have access for devices that are owned and operated by other agencies. For example, the City could benefit from knowing what message is currently set on a WSDOT-owned variable message sign on I-405 and have access to freeway video images especially when incidents are present. Similarly the City would benefit from information sharing with King County and the Cities of Redmond and Bellevue. Projects should include consideration for access and control that may be made available to City Police and Fire Departments.
3. **Information Dissemination:** Regional information dissemination is a service that is currently being provided by WSDOT specifically on area freeways such as I-405, SR 520, I-5, and I-90. King County, the City of Bellevue, and other regional agencies have deployed similar information dissemination systems. While the city is required to provide a service to the general public including the provision of information to the public to assist them in preparing for (or during) their trip, there is also a benefit to the general public by providing arterial congestion and incident information for key arterials in the city. The information allows the public to choose alternate travel routes, or to choose to vary their time of departure based on current traffic conditions. The City should also share the information with other key stakeholders such as WSDOT, King County, Bellevue, and Redmond. In addition, the City's ITS system should be designed in such a way as to provide for the capability of real-time traffic information for the Police and Fire Departments, even though direct connection is not discussed within this implementation plan.

Proposed Projects

Based on the project goals and objectives summarized above, several ITS projects have been identified for the City of Kirkland to meet the goals as well as the project vision and have been brought forward to the implementation phase of the project.

The ITS projects may be implemented in two ways: either on a location by location basis or as part of a system implementation process. This implementation plan presents projects planned for City arterials that include the necessary infrastructure for required ITS application. The City may choose to move ahead in a comprehensive manner by completely funding all projects identified or, depending upon funding and timing, the City may choose to separate out pieces of these projects at any time. For example, NE 85th Street Corridor

has been identified as a key corridor requiring ITS infrastructure and signal timing upgrades. This project has been detailed and prioritized as part of this plan, which includes a cost estimate assuming completion of the project at one time. Alternatively, the City could elect to upgrade several controllers in this corridor at a time aside from when the rest of the required communication infrastructure would be constructed. This type of project piecing can easily be done at the City's discretion as ITS implementation rolls forward and annual budgets are developed or could be funded through a bond issue.

For the purposes of this plan all improvements are divided into eleven individual corridor projects and two ITS infrastructure projects.

Each project is summarized on the following implementation plan project sheets. Each project sheet includes the project name, priority, description and need, location, dependencies, benefits and estimated costs.

Project Prioritization

Project priorities were established based on a range of transportation-centered criteria. The key criteria identified in the prioritization process of corridor projects include:

- existing intersection levels of service along the corridor and the anticipated increase in delay per vehicle at each intersection within the corridor
- annual average daily traffic traveling on the corridor
- to what degree the corridor serves regional traffic
- whether the traffic signals are spaced adequately for signal coordination on each corridor
- the level to which the corridor serves transit facilities including bus routes and park and ride lots
- the safety level along the corridor dictated by the number of accidents, and
- the ease of communication aspect which depends on the availability of conduits or fiber

The criteria used to rank the ITS infrastructure projects included the proposed projects' impacts on signal operations, system longevity, inter- and intra-agency communication, future system expansion, and also safety considerations. Each project's cost and the time savings it offers to city staff, were also used as ranking criteria for the identified ITS infrastructure projects.

The resulting prioritization yielded high priority projects, medium-high priority, medium priority projects, and low priority projects. All projects presented in this implementation plan specifically focused on the needs identified by the stakeholders and therefore are all ranked highly in this regard. However, the prioritization presented as part of the implementation plan is that of the projects relative to each other. Each project's prioritization is shown in the upper right hand of the project sheet and the background prioritization calculations are contained in Appendix A.

Project Description and Need

Each project summarized on the following sheets includes a project description and need statement that summarizes the technologies that form the particular project and the benefit. For all projects, it is recommended that one fiber pair be reserved and dedicated for future transit use along transit corridors in support of transit signal priority. Where feasible, fiber

should be run to bus stops or have capacity to do so in the future, to enable future real time passenger information displays.

Project Location

The project locations provided on the project sheets are intended to schematically represent the project location. Specific project limits and inclusions would be detailed in a preliminary design process. The reader is referred to the ITS Master Plan for larger project graphics.

Project Dependencies

Each of the nine projects presented in this plan are somewhat inter-dependent. The City's transportation system and roadway network will receive the most benefit and function with the most improvement to travel time and congestion with the full implementation of all thirteen projects. However, certain projects that have particular dependencies are highlighted in this section on each project sheet.

Benefits

ITS project benefits are often rated based on three general categories: safety and mobility, capacity and throughput and environmental benefit.

Each of these terms is defined relative to ITS projects by the Federal Highway Administration and is briefly summarized below.

> **Safety:** The safety goal focuses on reducing the number of crashes and lessening the probability of a fatality should a crash occur. Measures influencing crash occurrence include, but are not limited to vehicle speeds, speed variability and vehicle queuing. Improving mobility through the application of ITS components is often measured in terms of reduced vehicle delay and travel time.
>
> **Capacity and Throughput:** Effective system capacity is defined as the maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a given point or uniform section of a lane or roadway during a given time period under prevailing roadway, traffic and control conditions. Throughput is defined as the number of persons, goods, or vehicles traversing a roadway section or network per unit time.
>
> **Environment:** This benefit or goal pertains to the air quality and energy impacts of ITS services. This may include decreased emission levels and energy consumption related to fuel use and fuel economy.

Each of the projects presented on the following pages will contribute to improvements in each of these three critical areas. While individual project benefits may be more specifically characterized within each of these categories, the final conclusions and recommendations regarding the implementation of each project would remain unchanged, therefore the benefits are shown on each project sheet simply to acknowledge that each of the projects is linked to potential benefits in each of the three areas (safety, mobility and environment).

Cost Estimates

Preliminary cost estimates have been prepared for each project in order to evaluate the costs required to implement an ITS system for the City of Kirkland. All cost estimates are

prepared in 2008 dollars and represent a best estimate based on current equipment costs and construction rates. Project costs will fluctuate over time and will require a more detailed cost estimate when project design begins. The cost estimates are presented to provide the City with planning-level information to use for budgeting and grant application purposes. The specific components of each cost estimate are detailed in Appendix B.

Project Name:

NE 132nd Street Corridor
(between 100th Ave NE and 124th Ave NE)

Priority Ranking:

Medium - High

Project Description & Need:

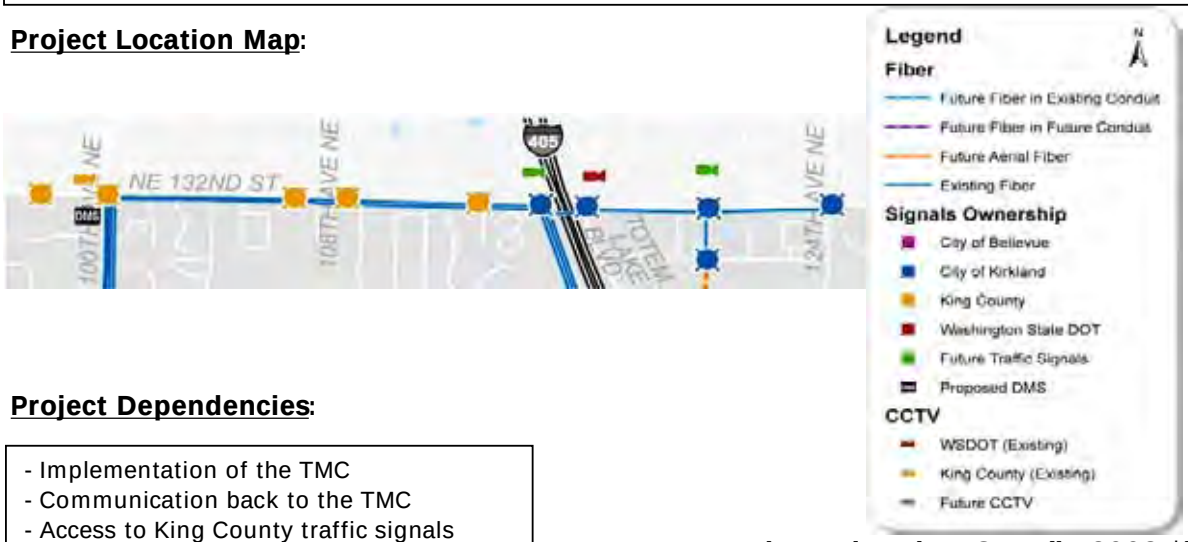
NE 132nd St corridor lies on the border line of the City of Kirkland and the Northshore Community of unincorporated King County. It is one of the City's important corridors carrying about 18,000 vehicles per day and providing east-west connectivity and access to I-405.

At present, there are eight signalized intersections along the corridor between 100th Ave NE and 124th Ave NE. Four of these signals are owned and operated by the City (those east of 112th Ave NE) while the other four are owned and operated by King County (west of 112th Ave NE).

The ITS project proposed along the corridor would improve traffic operations and safety especially in the peak periods. The figure below shows the recommended improvements which include upgrading the four City owned signals and installing two CCTV cameras at 116th Ave NE and 120th Ave NE. In addition a DMS is proposed along 100th Ave NE to provide motorists with access to real-time travel information along the NE 132nd St corridor.

The signals would inter-connect and connect to the City's proposed Traffic Management Center via the existing fiber infrastructure. This project will require collaboration with King County which currently has ownership of four signals west of 112th Ave NE. The information shared between the agencies will be used for signal timing plans and corridor coordination.

Project Location Map:



Project Dependencies:

- Implementation of the TMC
- Communication back to the TMC
- Access to King County traffic signals
- Coordination with King County ITS

Estimated Project Cost (in 2008 $):

$400,000

Project Components:

- 4 signal controller upgrades
- 2 CCTV cameras
- 1 DMS (Dynamic Message Sign)
- 4 Ethernet Switches

Project Benefits:

Safety	Capacity/ Throughput	Benefit to Environment
✓	✓	✓

Project Name:

Central Way / Downtown Corridor
(6th St, Central Way, and Lake St S)

Priority Ranking:

Project Description & Need:

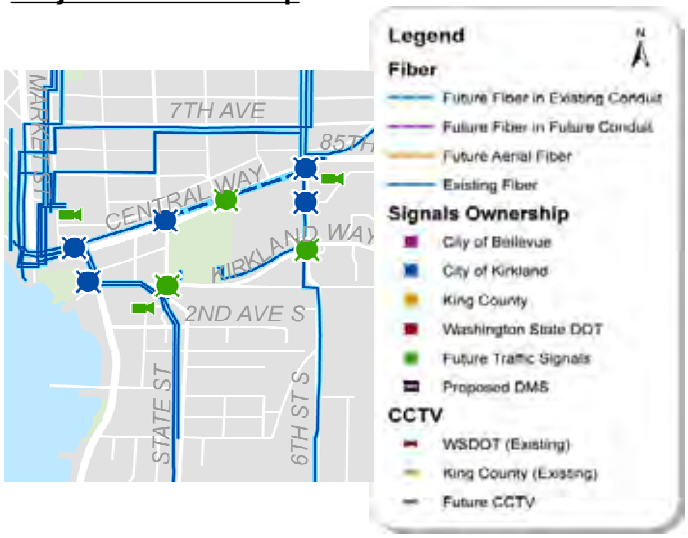
Central Way runs between 6th St and Lake St S providing access between the downtown area, I-405, and the City of Redmond (via NE 85th St). Lake St S and 6th St are north-south streets serving the downtown core. The operation of these corridors is critical to the traffic circulation in the downtown area and are considered together as one major corridor project.

The Central Way / Downtown corridor carries about 17,700 vehicles per day and is congested especially during peak hours and during events taking place in the downtown or on the waterfront. The proposed ITS project along this corridor is ranked as a high priority project which will improve traffic flow, increase safety, improve transit operations, and reduce travel time.

The proposed improvements are shown in the figure below. These include three CCTV cameras (at 6th St, Kirkland Way, and Lake St S), one DMS for real-time travel information (at 3rd St), five signal upgrades and two new signals. The signal upgrades are proposed at Central Ave / 6th St, Central Ave / 3rd St, Central Ave / Lake St S, 6th St / 4th Ave, and Lake St / Kirkland Ave intersections. The new signals are proposed at State St / Kirkland Ave and 6th St / Kirkland Way.

On the communication front, a new fiber connection is necessary between State St and 6th St. Once in place, the new fiber along the corridor will enable connection to the proposed City's Traffic Management Center.

Project Location Map:



Project Dependencies:

- Implementation of the TMC
- Communication back to the TMC

Project Components:

- 5 signal controller upgrades
- 2 new signals
- 3 CCTV cameras
- 1 DMS
- 7 Ethernet Switches
- 0.35 miles Fiber optic

Estimated Project Cost (in 2008 $):

$1,030,000

Project Benefits:

Safety	Capacity/ Throughput	Benefit to Environment
✓	✓	✓

Project Name:

NE 85th Street Corridor
(Between 114th Ave NE and 132nd Ave NE)

Priority Ranking:

Medium - High

Project Description & Need:

NE 85th St Corridor is an east-west principal arterial connecting Kirkland and particularly the downtown area to Redmond and featuring a full interchange with I-405. It carries on average about 40,000 vehicles per day and experiences congestion and travel time delays during peak periods.

At present there are six signalized intersections along the corridor between 114th Ave NE (Kirkland Way) and 132nd Ave NE. These intersections are owned and operated by the City and they are at the intersections of 85th St with 114th Ave NE, 120th Ave NE, 122nd Ave NE, 124th Ave NE, 128th Ave NE, and 132nd Ave NE. The proposed ITS project along the 85th St corridor will improve traffic flow, reduce travel time, and improve safety.

The proposed improvements, shown in the figure below, include three new CCTV cameras (at 114th Ave NE, 124th Ave NE and 132nd Ave NE), one DMS at 132nd Ave, and six signal controllers at the intersections identified above. The CCTV cameras are part of an ongoing project (NE 85th St Improvement project - currently in the design phase).

A new fiber optic connection is needed for this project between 132nd Ave NE and 124th Ave NE which is already included in the NE 85th St Improvement project. A new fiber connection is also needed along 114th Ave NE to tie to the existing fiber. Once in place, these connections will enable the communication with the City's proposed Traffic Management Center.

Project Location Map:

Project Dependencies:

- Implementation of the TMC
- Communication back to the TMC
- Completion of NE 85th St Improvement Project

Project Components:

- 6 signal controller upgrades
- 3 CCTV cameras
- 1 DMS
- 6 Ethernet Switches
- 0.67 miles Fiber optic (of which 0.57 miles are along 85th St)

Estimated Project Cost (in 2008 $):

$1,140,000

Project Benefits:

Safety	Capacity/ Throughput	Benefit to Environment
✓	✓	✓

Project Name:

NE 124th St Corridor System Upgrades
(between 100th Ave NE and 132nd Pl NE)

Priority Ranking:

High

Project Description & Need:

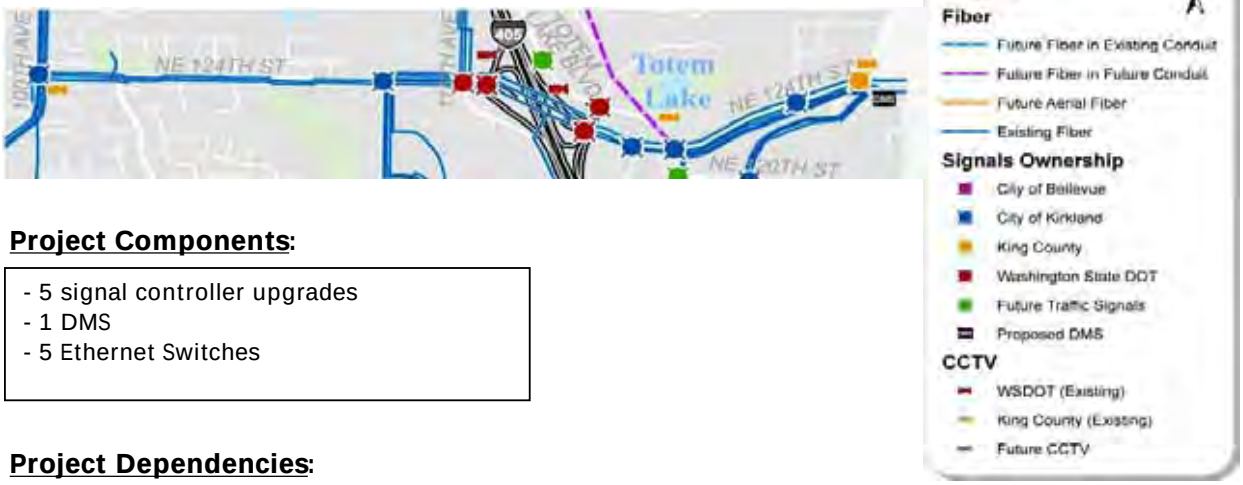
NE 124th St Corridor is a principal east-west arterial with average annual daily traffic of more than 30,000 vehicles per day. It provides for inter-city connectivity and has a full interchange with I-405.

ITS systems (owned and operated by King County) currently exist on this corridor. The proposed ITS project makes recommendations for system upgrades along NE 124th St, between 100th Ave NE to 132nd Pl NE (Slater Ave NE), in order to ensure compatibility with the City's communication standards. The proposed upgrades improve access to I-405 and the City of Redmond by reducing travel times along the corridor and improving signal operations. This project is found to be of a high priority based on the criteria used to rank the different proposed projects.

There are currently nine signalized intersections along the identified corridor. Three of which are operated by WSDOT (at 116th Ave NE and I-405 Ramps), one is operated by King County (at Slater Ave NE), and the remaining five are owned and operated by the City (at 100th Ave NE, 113th Ave NE, 120th Pl NE, 124th Ave NE, 128th Ln NE).

The project will include five new controllers at the City owned intersections and one DMS (at Slater Ave NE intersection). The communication to the proposed City's Traffic Management Center will be via the City's existing fiber infrastructure. This project will require collaboration with WSDOT and King County whereby the information shared between the agencies will be used for signal timing plans and corridor coordination.

Project Location Map:



Project Components:

- 5 signal controller upgrades
- 1 DMS
- 5 Ethernet Switches

Project Dependencies:

- Implementation of TMC
- Communication back to TMC
- Coordination with WSDOT and King County

Project Benefits:

Safety	Capacity / Throughput	Benefit to Environment
✓	✓	✓

Estimated Project Cost (in 2008 $):

$450,000

Project Name:

6th St/108th Ave NE Corridor
(Between 7th Ave S and NE 38th Pl)

Priority Ranking:

Low

Project Description & Need:

The 6th St / 108th Ave NE Corridor runs north-south between Kirkland Downtown and the City limits with Bellevue. It is bounded by 7th Ave S on the north end and by NE 38th Pl on the south end. The average daily traffic along the corridor is about 12,500 vehicles per day.

At present the only signalized intersection along the corridor is that of 6th St with NE 68th St. The priority ranking of 6th St / 108th Ave NE Corridor proposed ITS project was found to be low ***relative*** to the other proposed ITS projects. While this corridor ranks high on the transit score (being an important transit route), it ranks lower than other projects in terms of signal coordination score, average daily traffic score, level of service score, and the communication or ease of connectivity score.

The proposed project includes the upgrade of the 6th St / 68th Ave NE signal controller, a CCTV camera at the same location, and new fiber optic communication. The new fiber optics extension between NE 68th St and NE 38th Pl is considered essential for the completion of the communication network and the implementation of a network ring. The extension also creates a redundant link to the Lake Washington Blvd NE connection.

Project Location Map:

Project Dependencies:

- Implementation of the TMC
- Communication back to the TMC
- Coordination with the City of Bellevue

Project Components:

- 1 signal controller upgrade
- 1 CCTV camera
- 1 Ethernet Switch
- 1.45 miles of Fiber optic

Estimated Project Cost (in 2008 $):

$870,000

Project Benefits:

Safety	Capacity/ Throughput	Benefit to Environment
✓	✓	✓

Project Name:

124th Ave NE / 120th Ave NE Corridor
(Between NE 112th Pl and 132nd St NE)

Priority Ranking:

Medium-High

Project Description & Need:

The 124th Ave NE / 120th Ave NE corridor is a major north-south corridor east of I-405 that runs parallel to it and carries on average about 16,300 vehicles per day. For the purpose of this study the corridor was divided into two parts; a northern part extending between NE 112th Pl and NE 132nd St illustrated here, and a southern part between 85th St and NE 112th Pl presented on the next page.

Currently there are six signals along the northern corridor which are at the intersections of 124th Ave NE with NE 116th St (a high accident location) and NE 124th St, and the intersections of 120th Ave with Totem Lake Blvd, NE 128th St, NE 130th Ln, and NE 132nd St. Two new signals are also assumed to be implemented along the corridor, the first at 124th Ave NE / NE 112th Pl intersection (whose design is underway) and the second at the 124th Ave NE / NE 120th St intersection. All signals are owned and operated by the City except for the Totem Lake Blvd signal that provides access from/to I-405 and which is operated by WSDOT. Many intersections along this corridor currently operate over capacity levels during peak hours and significant increases in delay and queuing are expected in future years.

The proposed ITS project, depicted in the figure below, includes the upgrade of three controllers, installation of one CCTV camera (at NE 116th St intersection), and a fiber optic connection (between NE 124th St and NE 130th Ln). Note that the signal upgrades and CCTV cameras at NE 132nd St and NE 124th St and the DMS at NE 124th St were counted in the NE 132nd St and NE 124th St projects. The fiber connection enables communication with the City's proposed Traffic Management Center.

Project Location Map:

Project Dependencies:

- Implementation of the TMC
- Communication back to the TMC
- Completion of the NE 132nd St Corridor project
- Completion of NE 124th St Corridor project

Project Components:

- 3 signal controller upgrades
- 2 new signals
- 1 CCTV camera
- 5 Ethernet Switches
- 0.7 miles of Fiber optic

Estimated Project Cost (in 2008 $):

$995,000

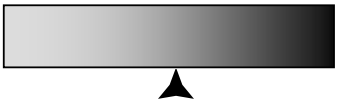
Project Benefits:

Safety	Capacity/ Throughput	Benefit to Environment
✓	✓	✓

Project Name:

124th Ave NE Corridor - South
(Between NE 85th St and NE 112th Pl)

Priority Ranking:



Medium

Project Description & Need:

The 124th Ave NE corridor between NE 85th St and NE 112th Pl is a principal north-south arterial that runs parallel to I-405 and carries on average about 15,000 vehicles per day part of which is through traffic mainly in the peak periods. The northern part of 124th Ave NE was considered earlier as part of the 124th Ave NE / 120th Ave NE Corridor.

At present, three signalized intersections exist along the 124th Ave NE Corridor (South) between NE 85th St and NE 112th Pl. These are the intersections with NE 85th St, NE 90th St, and NE 100th St.

The proposed ITS project, illustrated in the figure below, will improve traffic flow through the North Rose Hill area. It includes the upgrade of two signal controllers at NE 90th St and NE 100th St, installation of a CCTV camera at NE 100th St intersection, and the required fiber optic to provide communication to the City's proposed Traffic Management Center. The signal controller upgrade at 124th Ave NE / NE 85th St intersection was considered as part of the NE 85th St Corridor proposed ITS project.

Project Location Map:

Project Dependencies:

- Implementation of the TMC
- Communication back to the TMC
- Completion of 124th Ave NE / 120th Ave NE Corridor project
- Completion of NE 85th St Corridor project

Project Components:

- 2 signal controller upgrades
- 1 CCTV camera
- 2 Ethernet Switches
- 1.52 miles of Fiber optic

Estimated Project Cost (in 2008 $):

$244,000

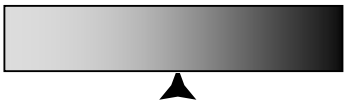
Project Benefits:

Safety	Capacity/ Throughput	Benefit to Environment
✓	✓	✓

Project Name:

132nd Ave NE Corridor
(Between NE 60th St and NE 80th St)

Priority Ranking:



Medium

Project Description & Need:

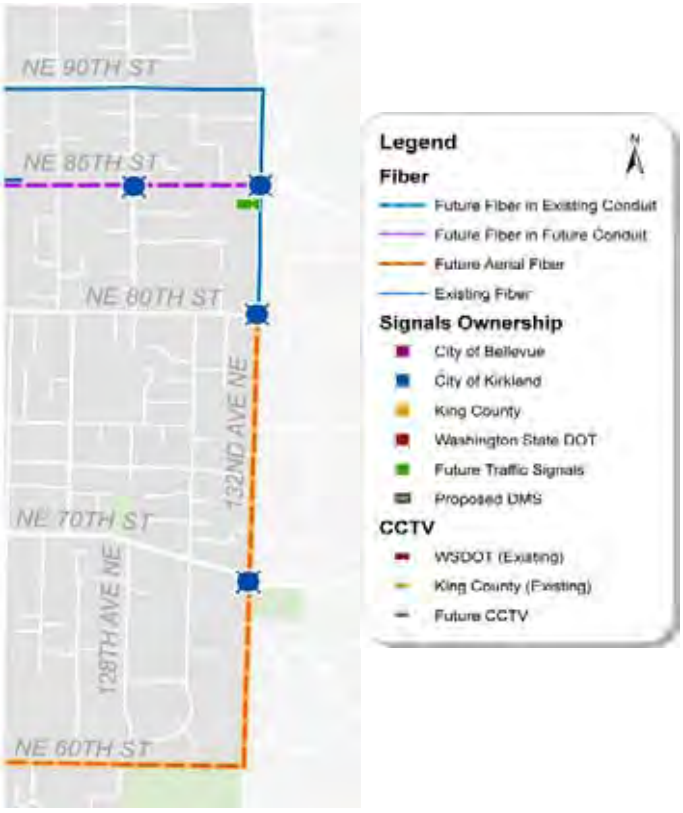
The 132nd Ave NE is a north-south corridor running along the city boundary separating Kirkland and Redmond. It is classified as a minor arterial and carries about 7,300 vehicles per day. The corridor runs parallel to I-405 and 124th Ave NE and provides for inter-city connectivity as well as through traffic.

The proposed ITS project extends from NE 60th St to NE 90th St. Currently there are three traffic signals along the corridor at the intersections with NE 70th St, NE 80th St, and NE 85th St.

The proposed project is depicted in the figure below and includes the upgrade of the signal controllers at the intersections of NE 70th St and NE 80th St in addition to the required fiber optic communication. Note that system upgrades at the 85th St intersection is accounted for in the NE 85th St Corridor project.

A new fiber optic segment, extending from NE 60h St to NE 90th St is needed to ensure connectivity of this project with the City's proposed Traffic Management Center. It should be noted that the low priority ranking of this project is relative to the other proposed ITS projects.

Project Location Map:



Project Dependencies:

- Implementation of the TMC
- Communication back to the TMC
- Completion of NE 85th St Corridor project

Project Components:

- 2 signal controller upgrades
- 2 Ethernet Switches
- 1.0 mile of Fiber optic

Estimated Project Cost (in 2008 $):

$209,000

Project Benefits:

Safety	Capacity/ Throughput	Benefit to Environment
✓	✓	✓

Project Name:

Lake Washington Blvd / Lakeview Corridor *(Between NE 68th St and NE 38th Pl)*

Priority Ranking:

Medium

Project Description & Need:

The Lake Washington Blvd / Lakeview Corridor, extending from the intersection of NE 68th St and State St to the intersection of Lake Washington Blvd with NE 38th Pl, provides strategic connections to SR 520 in the west, Redmond and I-405 in the east, and City of Bellevue in the south.

The corridor is classified as a principal arterial south of Lakeview Dr / Lake Washington Blvd intersection and as a minor arterial north of that location. It carries about 24,500 vehicles per day and experiences congestion and travel delays particularly in the peak periods.

At present, there are three signalized intersections along the corridor at the intersections of NE 68th St / State St, Lakeview Dr / Lake Washington Blvd, and Lake Washington Blvd / NE 38th Pl.

The proposed ITS project will improve traffic flow along the congested corridor. The ITS devices envisioned for this project include signal controller upgrades at the three intersections identified earlier and two CCTV cameras (one at NE 68th St / State St intersection and a second at the Lake Washington Blvd / NE 38th Pl intersection). A DMS is also recommended at the south end of the corridor to provide real-time travel information for motorists. The corridor would utilize the City's existing fiber infrastructure to connect to the proposed Traffic Management Center.

This project will require working closely with the City of Bellevue who owns and operates the traffic signal control at Lake Washington Blvd NE and Northup Way intersection. This project, once in place, will also provide an access point for information sharing between the two agencies.

Project Location Map:

Project Dependencies:

- Implementation of the TMC
- Communication back to the TMC
- Coordination with the City of Bellevue

Project Components:

- 3 signal controller upgrades
- 3 Ethernet Switches
- 2 CCTV cameras
- 1 DMS

Estimated Project Cost (in 2008 $):

$192,000

Project Benefits:

Safety	Capacity/ Throughput	Benefit to Environment
✓	✓	✓

Project Name:

Juanita Triangle
(98th Ave NE, NE 120th Pl, and NE Juanita Dr)

Priority Ranking:

High

Project Description & Need:

The Juanita Triangle is the triangle-shaped area formed by 98th Ave NE, NE 120th Pl and NE Juanita Dr. The 98th Ave NE Corridor (a principal arterial with average daily traffic [ADT] of 16,500 vehicles) is the continuation of 100th Ave NE and caters for inter-city connectivity as well as traffic between Bothell, Kirkland, and Bellevue. NE Juanita Dr is a minor arterial that has an average annual daily traffic of 18,000 vehicles. NE 120th Pl is a collector providing inter-city connectivity with ADT of 3,700 vehicles.

At present, there are three traffic signals in Juanita Triangle at the intersections of 98th Ave NE / NE 120th Pl, 98th Ave NE / NE Juanita Dr (NE 116th St) , and NE Juanita Dr / 97th Ave NE. Travel time delays are experienced in peak periods mainly at the 98th Ave NE / NE Juanita Dr (NE 116th St) intersection.

The ITS devices envisioned for this project include signal controller upgrades at the three intersections and a CCTV camera (at 98th Ave NE / NE Juanita Dr intersection). The corridor would utilize the City's existing fiber infrastructure to connect to the proposed Traffic Management Center.

Project Location Map:

Project Dependencies:

- Implementation of the TMC
- Communication back to the TMC

Project Components:

- 3 signal controller upgrades
- 1 CCTV camera
- 3 Ethernet Switches

Estimated Project Cost (in 2008 $):

$189,000

Project Benefits:

Safety	Capacity/ Throughput	Benefit to Environment
✓	✓	✓

Project Name:

Signal Upgrades at Isolated Intersections

Priority Ranking:

Low

Project Description & Need:

Four different locations were identified for proposed ITS projects as follows:

A. The intersection of NE 116th St with 120th Ave NE,
B. The intersection of NE 118th St with 120th Ave NE,
C. The intersections of Market St with Forbes Creek Dr, and
D. The intersection of NE 70th St with 122nd Ave NE.

While the former three intersections are already signalized, a traffic signal is proposed as part of this project at NE 70th St / 122nd Ave NE intersection.

The identified locations might have different scores in terms of the evaluation criteria used (connectivity, level of service, transit service, safety, etc.), however, the ***relative priority*** of these projects (single and combined) to the other proposed projects is considered low given the isolated nature of these intersections.

The ITS devices envisioned for this project include signal controller upgrades at the three signalized intersections identified earlier, a new signal for 70th St intersection, and two CCTV cameras (one at NE 116th St / 120th Ave intersection and the second at Market St / Forbes Creek Dr intersection). The existing signalized intersections allow for an easy tie-in to the City's existing fiber infrastructure and therefore connectivity to the proposed Traffic Management Center. The 70th St intersection will need fiber optics connections to tie-in.

Project Location Map:

Project Dependencies:

- Implementation of the TMC
- Communication back to the TMC

Project Components:

- 4 signal controller upgradess
- 2 CCTV cameras
- 3 Ethernet Switches

Estimated Project Cost (in 2008 $):

$262,000

Project Benefits:

Safety	Capacity/ Throughput	Benefit to Environment
✓	✓	✓

Project Name:

Communication System Expansion

Priority Ranking:

Medium

Project Description & Need:

This project proposes the expansion of the City's fiber optics communication network. The main objective of the project is to create a robust City-wide communication infrastructure by implementing a network ring.

The ring will require the installation of new fiber optics (illustrated in the figure below) along the following three segments:

- NE 53rd St from 108th Ave NE to 116th Ave NE
- 116th Ave NE from NE 53rd St to NE 60th St
- NE 60th St from 116th Ave NE to 132nd Ave NE

This project is dependent of the 132nd Ave NE and 6th St / 108th Ave NE proposed ITS corridor projects which will provide the missing communication links along 132nd Ave NE (south of NE 80th St) and along 6th St (south of NE 68th St) respectively. Once in place, these connections will provide the network ring and connect to the City's proposed Traffic Management Center.

The proposed project improves the system reliability, enables future system expansion, and improves inter-agency communication. Based on these criteria it is ranked as a medium ITS infrastructure project.

Project Location Map:

Project Dependencies:

- Implementation of the TMC
- Completion of NE 132nd St Corridor project
- Completion of 6th St / 108th Ave NE Corridor project

Project Components:

- 1.88 miles of Fiber optic

Estimated Project Cost (in 2007 $):

$93,000

Project Benefits:

Safety	Capacity / Throughput	Benefit to Environment
✓	✓	✓

Project Name:

Traffic Management Center (TMC)

Priority Ranking:

Project Description & Need:

The Traffic Management Center will serve as the main ***hub*** to manage and operate the City's current and future ITS devices and applications. It is a key component of the ITS strategic plan which leverages the existing systems and enables the City to properly and efficiently manage future traffic control hardware and software applications.

This project would build on the infrastructure and investment made to date. The following components and enhancements are envisioned for this project:

- expand the communications system coverage
- upgrade communication electronics
- install appropriate screens to monitor and respond to traffic congestion
- develop an ITS inventory database management system
- install the necessary equipment to enable information sharing with other agencies (two-way communication)
- coordinate with WSDOT, King County, Bellevue, Redmomd, and the City Police and Fire Departments on matters relating to incident response and City access to information

In addition, the TMC will drastically enhance the City's traffic data management capabilities, allowing effective utilization of the data collected from the ITS devices and infrastructure throughout the City (existing and installed as part of the ITS proposed projects). The TMC should house a data management system that serves in collecting, processing, and sharing information with relevant stakeholders. The collected data could be used for many purposes, including:

- maintaining an updated traffic count database
- making use of traffic data to optimize traffic signal timing
- using historical traffic trends on planning projects
- updating the City traffic forecasting model
- sharing critical information with other jurisdictions particularly when negotiating potential timing plans on corridors where jurisdiction is shared
- providing a better understanding of travel patterns and travel behavior

The TMC is assumed to be located in the City Hall (Transportation Department) and relocating it would require additional infrastructure costs.

Project Components:

- TMC software applications
- Server
- Monitors
- Client PC

Estimated Project Cost (in 2008 $):

$172,000

Project Dependencies:

- Connectivity to City wide traffic system
- Hardware from other proposed ITS projects
- One trained staff

Project Benefits:

Safety	Capacity/ Throughput	Benefit to Environment
✓	✓	✓

Recommended Policies and Procedures

In conjunction with the physical implementation of ITS technology and the staffing required to successfully operate and maintain the systems, there are several policies or procedures that are recommended for development and adoption by the City. These policies and procedures cover several areas that involve communication protocols and agreements, without which the City's ITS system may not operate in a smooth and efficient manner resulting in increased costs and delays.

The following five policies or procedures are highly recommended as part of the City of Kirkland's ITS Strategic Plan.

Intra-Department Roles and Responsibilities

What: A written document that could be in the form of a flow chart and/or written text, defining the main point of contact who is ultimately responsible for each of the following activities:

- the implementation of the ITS plan
- the information services associated with the ITS backbone
- development of signal timing plans
- coordination with WSDOT regarding interchange ramps (it is recommended that both an engineering and an operations staff member both be designated and have a designated counterpart at WSDOT)
- implementation of signal timing plans
- field adjustments to signal timing
- maintenance of traffic signal equipment
- operations and maintenance of ITS hardware and software

Why: Both the Public Works Engineering and Operations departments need to access to the traffic signal system, as it enables both the engineers and the maintenance and operations staff to work together as required. However, as new ITS systems are introduced and additional staff are added, the individual roles and responsibilities may become overlapped and possibly confusing, resulting in increased costs and decreased efficiency and capacity.

How: A written procedure should be prepared to define roles and responsibilities relating to the City's ITS system. Protocol should include a point person identified to be responsible for overseeing the implementation of the ITS Plan and identification of subsequent staff and their relative responsibilities.

Interagency Coordination

What: An agreement between the City of Kirkland and other agencies as needed, detailing the roles and responsibilities of both agencies regarding sharing information, implementing signal timing and maintaining the ITS system

Why: Several ITS projects will directly impact or involve another agency since many of the City of Kirkland's arterials include WSDOT interchanges or extend into neighboring jurisdictions including King County, Bellevue, and Redmond. Without an agreement, it may be difficult to rely on future staff to continue the relationship and intentions that become established as part of the ITS strategic planning process.

How: the current staff at each agency should continue to work together at multiple levels. Senior policy-setting staff should coordinate on the issues at hand regarding signal timing, access to equipment, maintenance of equipment, evaluation of corridors, location of equipment, etc. It is equally important that signal timing and maintenance staff from each agency develop a working relationship and establish responsibilities

Project Planning Process

What: This proposed policy or standard would be written for inclusion in planning and permitting processes, identifying ITS infrastructure components that would be required of all infrastructure projects.

Why: A wide range of projects, from small paving and utility projects to large development construction projects, are continually occurring within the City. Rather than spending additional funds to go back to projects already completed to install additional fiber conduit or roadway crossings (for example), each project should be required to provide these types of elements at the time of construction.

How: It is recommended that the City prepare a development standard requiring utility and roadway projects that will be within the City's right-of-way, to install at a minimum spare conduit and terminating junction boxes within the project's limits, as appropriate.

Franchise Agreement Renewals

What: Franchise agreements must be periodically renewed within the City and negotiations may be made at that time to explore opportunities for using franchise infrastructure for ITS communications. Examples of franchise infrastructure may include cable, internet service providers and phone service.

Why: As the City continues to grow and technology continues to develop and change, long term cost savings may be available to the City through these types of negotiations and agreements. Communication backbones will continue to be upgraded by franchises over time, in keeping with consumer demand. Rather than the City building brand new communication backbones or networks that may eventually become outdated, resources can be saved and directed towards ITS infrastructure hardware by relying on these types of franchise agreements.

How: Franchise agreement negotiations must include a representative from the public works department who is familiar with the City's needs in this area. It is recommended that a policy be adopted, providing a mechanism for the public works department to provide input into ongoing franchise agreement negotiations. The appointed public works representative should be very familiar with existing ITS facilities and needs each time the negotiations arise.

Information Sharing – Access & Control

What: A written agreement or documented protocol within the City between different departments, also addressing future departments who may desire to access count or video information.

Why: As new ITS systems are introduced and additional staff are added to the existing public works department, there may be some confusion regarding who can access data, when, how, and with what type of priority. Examples demonstrating the need for this protocol include ensuring traffic signal timings are not overwritten, that attempts to upload or download information do not occur simultaneously and that not more than one person attempts to control a camera at any given time. Information systems staff will also have access to parts of the ITS communication network, including switches and connection points. In the future it is anticipated that police and EMS may also benefit from sharing available information.

How: A written procedure should be prepared to define communication protocol for the City's ITS system. Protocol should include a point person identified who is responsible for overseeing the implementation of the ITS Plan, identification of staff and associated rights to information, identification of staff responsible for physical system components and maintenance and identification of staff responsible for development, deployment and fine tuning of timing plans, traveler information dissemination, etc. It is recommended that the Information Systems and Public Works engineering and operations departments work collaboratively to develop this agreement.

Special Considerations

This section illustrates some considerations particular to the Kirkland ITS Plan. These considerations include some early opportunities for ITS projects, staffing requirements, developing of ITS standards, and some funding considerations.

Short Term Opportunities

Some of the ITS projects proposed as part of this implementation plan could be performed as part of projects in the 6-year CIP (Capital Improvement Projects). These include the following projects:

The Kirkland Traffic Management Center

It is recommended that the Kirkland Traffic Management Center be developed as an integral part of the NE 85th St Street Improvement project. This is essential for the City to be able to manage and operate the ITS system implemented as part of the project.

The Communication Network Expansion

It is recommended that sections of the Communication Systems Expansion Project along NE 53rd Street and 116th Ave NE be constructed as part of the sewage project taking place at that location. This will significantly reduce the cost that the City would incur should this project be carried separately.

124th Ave NE / 120th Ave NE Corridor Project

Part of the system upgrades along this corridor should be incorporated as part of the new signal installations at 112th Pl NE and NE 120th St.

Central Way/ Downtown Corridor

This project is considered as a short term opportunity project since fiber connection can be easily completed given the presence of an existing conduit.

Staffing Requirements

Staff time should be devoted on the part of the City in order to attain a functional and viable ITS system. Staff time will be needed to operate and manage the system and to coordinate with neighboring jurisdictions in negotiating funding shares and completing Interlocal Agreements.

Development of ITS Standards

It is highly recommended that the City develop standards as it relates to all new traffic signal equipment and construction procedures throughout the City. These standards can be developed as part of the NE 85th St project or as a separate project. This will ensure future compatibility and interoperability of the City traffic signal control equipment, without which, ITS applications may not be able to provide the desired safety and efficiency improvements for the City's transportation system.

Funding Considerations

The Kirkland ITS Implementation Plan identifies key projects to be implemented in order to achieve the overall City goals to manage existing and future traffic congestion on City streets. A plan without a realistic funding mechanism will most likely sit on a shelf without ever being implemented.

ITS project funding should consider two key cost components:

1. Project design and construction cost
2. Operation and maintenance (O&M) cost

Project design and construction costs are typical of most transportation infrastructure projects. Typically there are large one-time capital outlay costs to construct the project based on project size and complexity, while O&M is a recurring annual cost. ITS projects, more than any other infrastructure projects, require a strong commitment to an ongoing O&M program. For this reason it is critical to ensure adequate funding is in place for an annual O&M program. Without such a program, any ITS project deployment will become obsolete in a few years without realizing much benefit.

Conclusions

This implementation plan has been prepared to summarize the ITS system requirements for the City of Kirkland based on the extensive existing conditions and needs assessment completed as part of the ITS Master Plan. The implementation plan details thirteen specific projects that are highly recommended to form the basis of the City's ITS system. If desired at a later point in time, additional ITS project components may be introduced to the system as time and funding allow.

Thirteen corridor projects have been individually documented and prioritized in this plan. Each project is considered to be a relatively high priority to the City, and as such, it is intended that all thirteen projects be implemented at some point in time as part of the City's ITS infrastructure. There are also five policies or procedures relating to inter- and intra-agency communication that are recommended for the City. These policies or procedures are recommended to enable smooth communication regardless of implementation schedule and staffing changes. They are also recommended to address key issues and experiences that have been learned by other agencies through similar project experience.

The thirteen proposed projects are anticipated to cost a total of $6.75 million (in 2008 dollars).

The projects and recommendations of this ITS Implementation Plan have been designed and prepared to provide the maximum benefit of the City's existing transportation infrastructure without relying on additional capacity. At the same time, the proposed system has been planned to accommodate both future ITS system infrastructure and uses, as well as for future roadway capacity and City growth.

Appendix A: Project Prioritization

APPENDIX A - Priority Assessment

Corridor Projects	Signal Coordination Score	Level of Service (LOS) Score	Average Daily Traffic (ADT) Score	Regional Route Score	Transit Corridor Score	Communication Score	Safety Score	Average Score	Ranking
Basis for the Scoring Criteria	*Signals Per Mile*	*Corridor Performance*	*Weighted ADT*	*City's Functional Classification*	*Number of Bus Routes* [1]	*Availability of Fiber*	*Average Accidents* [2]		*Average Score*
	> 5 = 4 pts	LOS F = 4 pts	>30,000 = 4 pts	Principle Arterial = 4 pts	>2 routes = 4 pts	Existing Fiber = 4 pts	> 1.25 = 4 pts		> 3.3 = High
	3.5 to 5.0 =3 pts	LOS E = 3 pts	15,000-30,000 = 3 pts	Minor Arterial = 3 pts	2 routes = 3 pts	Existing Conduit (whole corridor) = 3 pts	0.90 - 1.25 = 3 pts		2.5 - 3.3 = Medium - High
	1.5 to 3.5 = 2 pts	LOS D = 2 pts	5,000-15,000 = 2 pts	Collector = 2 pts	1 route = 2 pts	Existing Conduit (part of the corridor) = 2 pts	0.50 - 0.99 = 2 pts		2.2 - 2.5 = Medium
	< 1.5 = 1 pt	LOS A - LOS C = 1pt	<5,000 = 1 pt	Other = 1 pt	None = 1 pt	No Fiber / No Conduit = 1pt	< 0.5 = 1 pt		< 2.2 = Low
C 1 - NE 132nd Street Corridor	4	3	3	3	4	4	1	3.14	Medium - High
C 2 - Central Way / Downtown Corridor	3	4	3	4	4	3	3	3.43	High
C 3 - NE 85th Street Corridor	4	2	4	4	2	2	3	3.00	Medium - High
C 4 - NE 124th St Corridor	3	3	4	4	3	4	3	3.43	High
C 5 - 6th St / 108th Ave NE Corridor	1	2	2	3	4	1	2	2.14	Low
C 6 - 124th Ave NE Corridor - North	4	4	3	3	3	1	4	3.14	Medium - High
C 7 - 124th Ave NE Corridor - South	2	2	3	4	3	1	1	2.29	Medium
C 8 - 132nd Ave NE Corridor	2	3	2	3	2	2	2	2.29	Medium
C 9 - Lakeview Corridor	2	2	3	3	2	4	1	2.43	Medium
C 10 - Juanita Triangle	4	2	3	4	4	4	3	3.43	High
C 11- Signal Upgrades at Isolated Locations [3]	1	1	3	2	3	3	2	2.14	Low

ITS Infrastructure Projects [4]	Improves Signal System Operations	Improves System Longevity	Reduces City Costs	Improves Inter and Intra Agency Communication	Reduces City Time Demand	Enables Future System Expansion	Supports Safety Considerations	Average Score	Ranking
T 1 - Communication System Expansion	2	2	1	4	2	4	1	2.29	Medium
T 2 - Traffic Management Center	3	3	3	3	4	4	4	3.43	High

Notes:

1. Number of routes is based on King County Metro 2008 Transit System Map
2. Based on Intersection Average Number of Accidents per Million Entering Vehicles (MEV)
3. These are intersections at different locations with different scores. The reported score is the average
4. Scores for Infrastructure Projects are based on ranking system from 1 (low benefit) to 4 (high benefit)

Appendix B: Project Cost Estimates

	Equipment and Installation Costs														Design and Construction Management Costs				TOTAL
	Signal Controller	Controller Cabinet	CCTV	Video Encoders	Single Mode Fiber Optic Cable - SMFO (lf)	Conduit & Trenching (lf)	Ethernet Switches	Cable Vaults	Dynamic Message Signs (DMS)	Data Detection Systems [7]	Other	*Subtotal*	**MOB, B&I, OH, Profit, TEMP FAC, H&S, DEMOB (20%) [8]**	**Equipment & Installation Subtotal (includes 30% Contingency)**	Design (% of Equipment & Installation)	Traffic Control [10]	Construction Management (% of Equipment & Installation)	**Design Subtotal**	**Total Project Cost**
Unit Costs (in 2008 Dollars)	$3,000	$20,000	$2,500	$750	$1	$50	$2,000	$2,000	$75,000	$25,000					15%		7%		
Corridor Projects **:**																			
C1 - NE 132nd Street Corridor [1]	4		2	2			4	4	1	4		**$209,500**	**$251,400**	**$326,820**	$49,023		$22,877	**$71,900**	**$398,720**
C2 - Central Way / Downtown Corridor [2]	5	2	3	3	1,850	1,850	7	7	1	7		**$529,138**	**$634,965**	**$825,455**	$123,818	$26,600	$57,782	**$208,200**	**$1,033,654**
C3 - NE 85th Street Corridor [3]	6		3	3	3,500	3,000	6	6	1	6		**$579,375**	**$695,250**	**$903,825**	$135,574	$34,200	$63,268	**$233,042**	**$1,136,867**
C4 - NE 124th St Corridor [4]	5						5	5	1	5		**$235,000**	**$282,000**	**$366,600**	$54,990		$25,662	**$80,652**	**$447,252**
C5 - 6th St / 108th Ave NE Corridor	1		1	1	7,700	3,700	1	8		1	$27,600 [9]	**$452,625**	**$543,150**	**$706,095**	$105,914	$7,600	$49,427	**$162,941**	**$869,036**
C6 - 124th Ave NE / 120th Ave NE Corridor [2]	3	2	1	1	4,100	3,000	5	5		5	$7,600 [9]	**$507,925**	**$609,510**	**$792,363**	$118,854	$28,500	$55,465	**$202,820**	**$995,183**
C7 - 124th Ave NE Corridor - South	2		1	1	8,000		2	2		2	$47,000 [9]	**$120,250**	**$144,300**	**$187,590**	$28,139	$15,200	$13,131	**$56,470**	**$244,060**
C8 - 132nd Ave NE Corridor	2				5,280		2	2		2	$36,500 [9]	**$104,460**	**$125,352**	**$162,958**	$24,444	$9,500	$11,407	**$45,351**	**$208,308**
C9 - Lake Washington Blvd / Lake View Corridor	3		2	2			3	3		3		**$102,500**	**$123,000**	**$159,900**	$23,985		$11,193	**$35,178**	**$195,078**
C10 - Juanita Triangle	3		1	1			3	3		3		**$99,250**	**$119,100**	**$154,830**	$23,225		$10,838	**$34,063**	**$188,893**
C11 - Signal Upgrades at Isolated Locations	4		3	3			4	4		4		**$137,750**	**$165,300**	**$214,890**	$32,234		$15,042	**$47,276**	**$262,166**
Total for Corridor Projects	38	4	17	17	30,430	11,550	42	49	4	42		**$3,077,773**		**$4,801,325**	$720,199	$121,600	$336,093	**$1,177,892**	**$5,979,217**
ITS Infrastructure Projects **:**																			
T1 - Communication System Expansion [5]					9,500						$36,500 [9]	**$43,625**	**$52,350**	**$68,055**	$10,208	$9,500	$4,764	**$24,472**	**$92,527**
T2- Traffic Management Center												**$110,000**	**$132,000**	**$171,600**	$25,740		$12,012		**$171,600**
Video Wall											$10,000								
Public Works Traffic Shops											$5,000								
Wall Cabinets											$10,000								
Server and Applications [6]											$60,000								
System Integration											$20,000								
Staff Training											$5,000								
Total for ITS Infrastructure Projects					9,500	0					$110,000	**$153,625**		**$239,655**	$35,948		$16,776	**$24,472**	**$264,127**
																		Total for All Projects	**$6,243,344**
																		Sales Tax	**8.5%**	**$530,684**
																		Total (plus Tax)		**$6,774,028**
																		Low Total	**-30%**	**$4,741,820**
																		Medium Total	**0%**	**$6,774,028**
																		High Total	**50%**	**$10,161,042**

5% Order of Magnitude Cost Estimate

Notes **:**

1. Assumes the upgrade of City owned intersections only (no King County or WSDOT intersections were considered for upgrades)
2. The construction costs of the two new signals were not assumed (only the ITS components was priced - including the whole cabinet)
3. Some components of this project are being contracted as part of the 85th St Improvement Project (such as the construction of the fiber optic network)
4. Only the City owned intersections were assumed (no King County of WSDOT intersections were considered)
5. Assumes completion of the 6th St / 108th Ave NE and 132nd Ave NE Corridor Projects and that trenching on NE 53rd St and 116th Ave NE take place under Sewage Improvement CIPS
6. Includes the cost of Data Management Applications
7. Data Detection Systems include fixed cameras, cables, and detection boards. One system is assumd per intersection
8. Mobilization, Bond & Insurance, Overhead, Profit, Temporary Facilities, Health & Safety, and Demobilization
9. Cost of Aerial Communication (Messenger cable cost at $6 per linear foot - a 15% sag is also assumed)
10. Unit rate for Traffc Control Labor is assumed at $38 per hour

123 Fifth Avenue
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City of Kirkland ITS Strategic Plan
Developed By:

transpoGROUP

What happens after the proposed projects are complete?

Following construction and implementation of the proposed projects, City of Kirkland staff time will be required to maintain the system. It is critical that staff time be devoted to maintaining a database of traffic circulation within the City, developing and monitoring a range of signal timing plans for different times and needs within the City. City staff should be available to adjust signal timing and display messages to drivers in the event of an incident causing traffic congestion in a particular area, etc.

Only basic but essential ITS technologies have been recommended at this stage, setting up a robust ITS baseline system within the City. As technology changes and as the City progresses, new technologies may become desirable, feasible and even necessary for the City. The existing system has been designed to provide for future expansion. The system is also designed based on the National protocol for ITS, which ensures future compatibility with new technology.

City of
Kirkland
Intelligent Transportation System Strategic Plan

What is the ITS Strategic Plan?

The City of Kirkland Intelligent Transportation System (ITS) Strategic Plan has been developed to provide a road map for the City in the interest of maximizing the operations and efficiency of the existing roadway infrastructure without adding additional roadway capacity. The ITS Strategic Plan includes two primary components: the ITS Master Plan and the ITS Implementation Plan.

The ITS Master Plan establishes the ITS Vision for the City, documents the existing conditions associated with ITS infrastructure, identifies ITS needs, documents the required ITS architecture, defines a preliminary set of projects and details the proposed ITS communications plan for the City. The ITS Implementation Plan builds on the Master Plan, detailing and prioritizing recommended ITS projects and highlighting procedures and policies recommended for development and adoption.

Together, the ITS Master Plan and the ITS Implementation Plan provide a comprehensive look at the City of Kirkland's existing system and needs, and provide a plan for implementing viable ITS projects that meet the City's specific needs over the next 5 years and beyond.

What is ITS?

ITS stands for "Intelligent Transportation Systems" and includes a variety of physical tools and technologies that are required to accomplish the tasks listed above. Some of these tools include signal controller upgrades, fiber optic communication, supporting communication equipment, cameras for monitoring traffic congestion and effects of signal timing, a data management system, dynamic message signs and transit signal priority.

Why ITS?

ITS provides a way for the City to make better use of its existing transportation infrastructure without needing to build additional roads. The main goal of the ITS system is to facilitate traffic flow within the City, reducing total travel time and delay for drivers. The ITS hardware and software applications proposed in the Strategic Plan help the City accomplish this goal and allow for capabilities such as:

- the ability to improve signal timing and coordination along key corridors
- the ability to respond efficiently to signal malfunctions
- the ability to respond more quickly to incidents that may be blocking roadways
- the ability to communicate with drivers regarding incidents or wait times
- the ability to work with WSDOT, King County, and the neighboring cities to develop improved integration of free way ramps and intersections with City corridors
- the ability to collect real time traffic data along key corridors
- the ability to use the collected data for planning and operations studies
- the ability to improve the management of special events

Who provided input for this ITS Strategic Plan?

During the master planning process, input was solicited from a wide range of project stakeholders, including the City of Kirkland Public Works, Maintenance and Operations, Police Department, Fire and Building Department, and the IT Department. Coordination meetings were also carried out with King County, City of Redmond, and the City of Bellevue.

From the stakeholder input and the technical review of the existing system, the need for improved signal coordination to improve corridor operations was identified as a high priority for the City of Kirkland. Based on this primary priority, a set of ITS projects were identified and detailed to form the basis of the Strategic Plan.

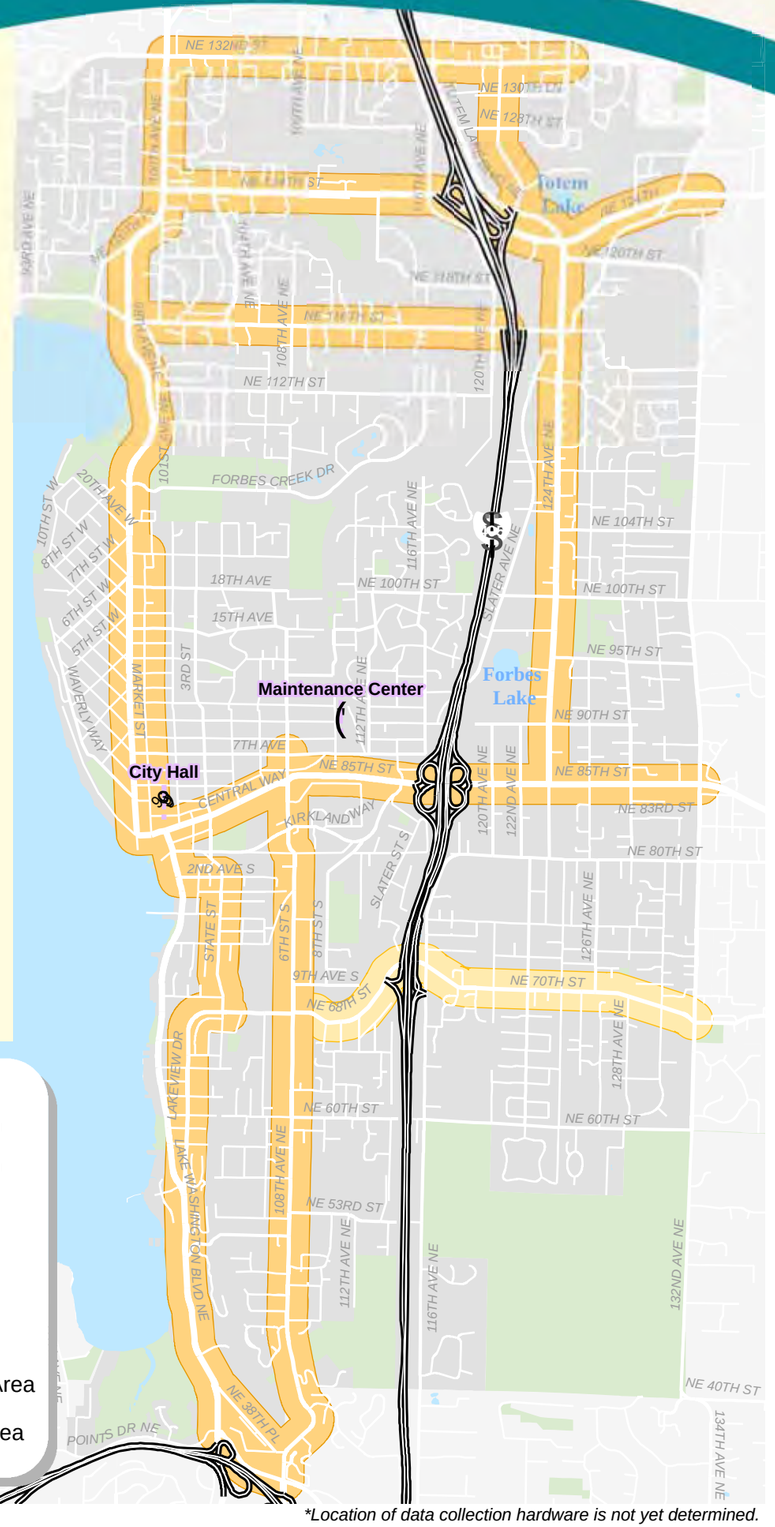
Where has ITS already been deployed in Kirkland?

King County implemented several ITS applications along NE 124th St as a joint project with Kirkland, Redmond, and WSDOT. The County remotely manages the corridor and the City recently installed a client workstation that is connected to the County's Traffic Management Center (TMC), which enables city staff to access and monitor the 124th St ITS system. The ITS Strategic Plan makes recommendation for system upgrades along the corridor to ensure compatibility with the City's communication standards.

Where will ITS applications be used in Kirkland?

The ITS Master Plan identified the following key traffic corridors within the City of Kirkland for ITS applications:

- NE 132nd Street Corridor (between 100th Ave NE and 124th Ave NE)
- Central Way / Downtown Corridor (6th St, Central Way, and Lake St S)
- NE 85th Street Corridor (between 114th Ave NE and 132nd Ave NE)
- NE 124th St Corridor System Upgrades (between 100th Ave NE and 132nd Pl NE)
- 6th St / 108th Ave NE Corridor (between 7th Ave S and NE 38th Pl)
- 124th Ave NE / 120th Ave NE Corridor (between NE 112th Pl and 132nd St NE)
- 124th Ave NE Corridor - South (between NE 85th St and NE 112th Pl)
- 132nd Ave NE Corridor (between NE 60th St and NE 80th St)
- Lake Washington Blvd / Lake View Corridor (between NE 68th St and NE 38th Pl)
- Juanita Triangle (98th Ave NE, NE 120th Pl, and NE Juanita Dr)



*Location of data collection hardware is not yet determined.