RESOLUTION R-5420

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF KIRKLAND PERTAINING TO THE ADOPTION OF THE 2020 CITYWIDE INTELLIGENT TRANSPORTATION SYSTEM (ITS) PLAN AND EXECUTIVE SUMMARY.

1 WHEREAS, the Kirkland City Council approved funding in
2 the 2015-2020 Capital Improvement Program to perform a
3 Kirkland Citywide ITS Study; and
4
5 WHEREAS, the purpose of the Citywide ITS Study was to
6 revise the current 2008 ITS Plan and to develop a direction for the
7 ITS program based on the principles in the 2015 Transportation
8 Master Plan; and
9
10 WHEREAS, an interdepartmental City staff team in
11 collaboration with a consultant team lead by Smart City Traffic LLC
12 performed the necessary baseline analysis; needs identification;
13 concept of operations development; strategy, policy and project
14 identification and selection; and document preparation of the
15 2020 Kirkland Citywide ITS Plan and Executive Summary; and
16
17 WHEREAS, the Kirkland Transportation Commission met on
18 June 26, 2019 to review the draft 2020 Kirkland Citywide ITS Plan;
19 and
20
21 WHEREAS, the Kirkland City Council met in a study session
22 on March 3, 2020 to review, discuss and provide comments on the
23 draft 2020 Citywide ITS Plan and Executive Summary; and
24
25 WHEREAS, due to the COVID-19 pandemic expanding since
26 March in Kirkland and worldwide, creating significant economic
27 impacts to the nation and Kirkland in current and future years, it
28 is important to note that this ITS Plan does not commit the City
29 to a specific level of investment in specific years;
30
31 NOW, THEREFORE, be it resolved by the City Council of the
32 City of Kirkland as follows:
33
34 Section 1. The adopted 2020 Citywide ITS Plan and
35 Executive Summary shall be established as shown on Exhibit A to
36 this resolution.
37
38 Section 2. The adopted 2020 Citywide ITS Plan shall be
39 used generally by City staff to guide implementation of ITS related
40 strategies, policies and projects until the plan is next updated,
41 which at this time is anticipated to be five years hence.

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Passed by majority vote of the Kirkland City Council in open meeting this 05 day of May, 2020.

Signed in authentication thereof this 05 day of May, 2020.

Penny Sweet, Mayor

Attest:

Kathi Anderson, City Clerk

EXECUTIVE SUMMARY

Intelligent Transportation Systems (ITS) Plan

JANUARY 2020

City of Kirkland

This Intelligent Transportation System (ITS) Plan establishes operational goals of resiliency, reliability and responsiveness, as well as provides increased transparency to continuously measure and report on performance. Based on these goals it presents a proposed investment plan, including both capital and ongoing costs, to support the City of Kirkland's operations goals and multimodal goals described in the City's adopted Transportation Master Plan.

HOW THE PLAN WAS DEVELOPED

The development of the ITS Plan was accomplished over a 10-month period, and it is based on one-on-one interviews and workshops with key staff from Public Works, Planning, the Kirkland Fire Department (KFD), and the Kirkland Police Department (KPD). Through the course of the plan development process, program goals and objectives, and the proposed investment plan were developed. The work additionally included input on how the City would like to support multimodal operations on principal arterials.

ITS is used in Kirkland to provide efficient, multimodal, transportation mobility aligned with the City's goals and policies. ITS requires four core elements, working in alignment, to achieve the desired operations goals. The four elements are shown in Figure ES-1. This plan's approach is to identify the needs for each of the four core ITS elements based on the City's policy goals regarding road network operations.
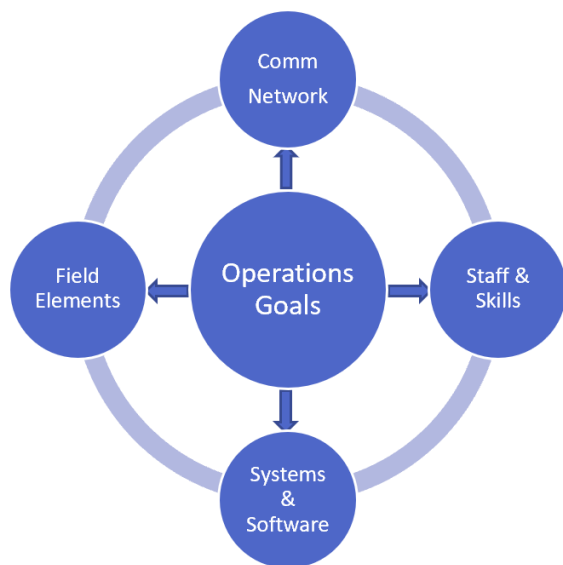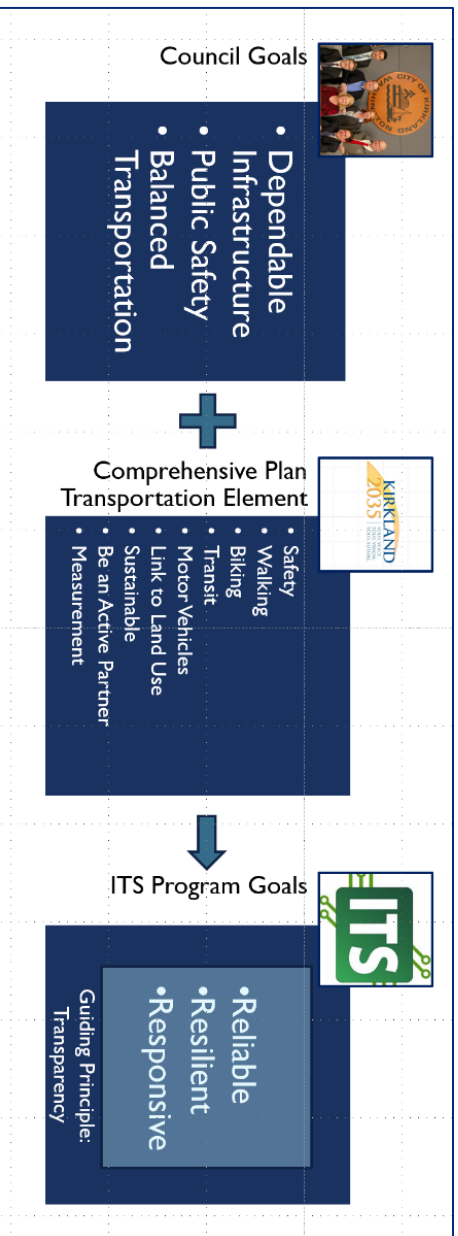

Figure ES -1: Operations Goals Drive the Investment Needs of the Four Core ITS Elements

- **Field Elements**: Consist of traffic signal controllers/ and associated equipment, CCTV cameras, and multimodal detection
- **Communications Network:** Includes the media (fiber, cellular or other), equipment and software to manage communications from the TMC to the field, and between traffic signals.
- **Systems and Software:** Provide traffic signal control, system health monitoring, video management, CCTV camera control, and other functions.
- **Staff and Skills**: Encompass the staff hours and skills needed to operate and maintain the ITS elements.

In other words, the operations goals of the City drive the investment needs for each of the four core ITS Elements.

ITS Program Goals and Guiding Principle

The ITS Program goals were developed based on goals defined by the City Council, and those identified in the Transportation Element of the City's Comprehensive Plan. The goals are bound by the Guiding Principle of transparency that has been established to lead the organization in the decision-making processes. The ITS Program Goals are customer-focused, and support multimodal operations.

The goals can be summarized as "The Three 'R's":

Reliable. The operation and delivery of services supported by ITS will be highly reliable. The goal is for there to be no traffic signal malfunctions due to causes that are within the City's control.

Resilient. When malfunctions occur (or damage to ITS infrastructure), the response and correction time will be as short as possible.

Responsive. ITS will be responsive to identified operations needs.

All of the goals are surrounded by a single Guiding Principle:

Transparency. The ITS Program will continuously measure and report on performance.

The Plan

The status of the City's existing four core ITS elements in terms of readiness for future ITS expansion was assessed to support project selection and prioritization. Figure ES-3, below, summarizes the results.

Figure ES -3: Readiness Evaluation of the Four Core ITS Elements

Communications Network — NOT READY
- Infrastructure physical reliability improvements needed
- Time to repair can be long
- Not future ready for additional ITS needs

Systems and Software — PART READY
- Supports current service level well
- Provides a platform to build on
- Lacking performance monitoring
- Fire Department signal pre-emption does not meet needs
- Time to repair can be long

Field Elements — PART READY
- Some locations lack detection, CCTV, proper controllers
- Passive pedestrian detection desired
- Bike detection is inconsistent
- Budgetary process for field element replacement not sufficient

Staffing and Skills — NOT READY
- Operations staff can maintain current operations/service level
- Operations staff unable to take full advantage of systems/software to improve service level
- ONE + Ops staff person below national std.
- Without 24X7 maintenance coverage, WSDOT will not allow City to take over signal operation
- Preventative maintenance cannot be fully performed – leads to more responsive maintenance
- TWO Maintenance staff below national std.

An investment plan including both capital and ongoing costs for operations and maintenance was developed to meet not only today's needs, but to ensure the city is ready for the future.

CAPITAL PROJECTS

Nine capital projects are proposed to meet the needs and to support achieving the operations concepts identified in this plan. The projects are prioritized into three rankings. Table ES-1: ITS Plan Capital Projects provides a summary of the proposed projects, their ranking, budgetary cost estimates, suggested implementation schedule and shows how the projects are mapped to the three ITS Plan goals and the Guiding Principle of transparency. The total investment in ITS capital projects is estimated at $4,980,000 over 5 years (2019 dollars).

Table ES-1: ITS Plan Capital Projects (2019 Dollars)

No.	Priority	Project	Budget Estimate (2019 Dollars)	Year 1	2	3	4	5	Reliable	Resilient	Responsive	Transparent
1	1	Performance Monitoring	$300,000	■					●	○	●	●
2	1	ITS Phase 3	$3,300,000	■	■	■	■	■	●	●	●	
3	2	GPS-Based Opticom	$500,000	■	■					○	●	●
4	2	Multimodal Detection Improvements	$500,000	■	■	■			○		●	○
5	2	Advanced Signal Ops Software	$175,000	■						●		
6	2	Staff Training	$20,000	■					●	○	●	○
7	2	Develop and Adopt ITS Design Stds	$35,000	■								●
8	3	Update ITS Plan	$100,000				■		●	●	●	●
9	3	WSDOT Signals Integration	$50,000			■					●	
		TOTAL	**$4,980,000**									

● = Strong mapping to goal or guiding principle
○ = Partial mapping to goal or guiding principle

ONGOING COSTS FOR OPERATIONS AND MAINTENANCE

Table ES-2 summarizes the estimated ongoing costs to meet the needs outlined in the plan.

Table ES-2: Ongoing Cost Estimates

NO.	PROJECT	BUDGETARY ESTIMATE BY YEAR (2019 DOLLARS)					RELIABLE	RESILIANT	RESPONSIVE	TRANSPARENT	Note
		1	2	3	4	5					
1	Comm Network Monitoring Software	$ 5,000	$ 10,000	$ 15,000	$ 15,000	$ 15,000	●	●		○	Licensing
2	Performance Monitoring	-	-	-	-	-	●	○	●	●	5 yr license due yr 6
3	Advanced Sginal Ops Software	-	-	$ 2,000	$ 2,000	$ 2,000		●			Licensing
4	Multimodal Detection	-	$ 10,000	$ 10,000	$ 10,000	$ 10,000	○		●	○	Bike app licensing
5	Maintenance Staff to Meet Min Need	$ 450,000	$ 450,000	$ 450,000	$ 450,000	$ 450,000	●	●	●		2 staff
6	Ops Staff to Meet Min Need	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000	●	●	●		1 staff
7	Maintenance Staff Stand-By	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	●	●	●		24X7 1 staff on-call
8	Additional IT Support	TBD	TBD	TBD	TBD	TBD	●	●	●		Includes weekend standby
9	Training	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	●	●	●		Training Costs
	TOTAL	$ 733,000	$ 748,000	$ 755,000	$ 755,000	$ 755,000					

● = Strong mapping to goal or guiding principle
○ = Partial mapping to goal or guiding principle

*IT Department to confirm cost of additional IT support, including IT weekend standby

The greatest share of the ongoing costs is related to meeting staffing needs, with costs for adding one operations staff person, and two additional maintenance staff reflected in the estimates. Remaining costs are for ongoing training, expanding IT staffing to complete 24X7 coverage, and various software licenses.

The investments that will produce the greatest value in meeting the ITS Plan Goals are those that add maintenance and operations staff. A reliable, resilient and responsive multimodal ITS operation requires a balance among the four core ITS elements. While the City has been working to keep pace with the growth in ITS maintenance and operations needs by adding staff positions, a deficit remains. Without additional investment in staff positions, the ability to meet the current and future needs of the City is compromised.

Summary

This ITS Plan is designed to not only meet today's needs, but the meet the multimodal demands of a growing city. Implementing this plan will provide future-ready ITS systems, field devices, staff, and communications network, meet the needs and expectations of the traveling public.

City of Kirkland

Intelligent Transportation Systems (ITS) Plan

January 2020

Prepared for:
City of Kirkland

Prepared by:
Smart City Traffic LLC

CITY OF KIRKLAND INTELLIGENT TRANSPORTATION SYSTEMS (ITS) PLAN

January 2020

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1   INTRODUCTION AND PLAN OVERVIEW

This Intelligent Transportation Systems (ITS) Plan was developed by the City of Kirkland to guide the City's future ITS Program. The plan is focused on achieving operations goals, and provides programmatic-level recommendations to improve ITS-related field infrastructure, central systems and software, the communications network, staffing, and policies and procedures.

1.1   BACKGROUND

Kirkland's first Intelligent Transportation System Strategic Plan (KITS) was completed in 2008. The plan led to the successful implementation of two major ITS initiatives - ITS Phase I and ITS Phase II. In addition to these ITS deployments, there have been other significant changes that affect the City's overall ITS Program including:

- ITS technology advances
- Annexation
- Changes to the City's land use
- Regional multimodal transportation opportunity changes (rail, transit)
- Update to the City's Comprehensive Plan
- Adoption of the City's Transportation Master Plan and Transit Implementation Plan

The City has also gathered more experience and expertise in the operations and maintenance of the existing ITS.

This ITS Plan has been developed to address the current and future needs of the ITS program against the backdrop of today's environment.

1.1.1   ITS Program Accomplishments Since the Previous Plan

The City has been successful in obtaining Federal Congestion Mitigation and Air Quality (CMAQ) and Federal Highway Safety Improvement Program (HSIP) grant funding for two major ITS initiatives: ITS Phase I and ITS Phase II. These initiatives together totaled approximately $5.3 million in ITS investment and were focused on enabling central management of traffic signals, CCTV, and other ITS elements such as video detection to improve traffic safety and flow. Field element improvements are shown on Figure 1-1.

The ITS Phase I project implemented key ITS infrastructure and systems including:

- Transportation Management Center (TMC)
- Field communications network expansion and connection to the TMC
- Central traffic signal system control software (TACTICs)
- Video monitors and associated video wall management software (Cameleon)
- Field elements on NE 85th St, Central Way, and the 98th Ave/Market St/ /Lakeview Drive/Lake Washington Blvd corridor (as shown on Figure 1) including:
  - Upgrades to traffic signal controllers and cabinets
  - CCTV cameras
  - Video detection

ITS Phase II, also shown on Figure 1-1, provided a geographic expansion of central traffic signal control and ITS and included:

- Field elements in the Totem Lake Urban Center vicinity on 120th Ave NE and NE 132nd St, as well as additional locations (as shown on Figure 1).   Note that controller upgrades on the NE 124th Street and 100th Ave NE corridors were implemented with funding from the Citywide Safety and Traffic Flow Improvement project, not as part of ITS Phase II (including upgrades to equipment turned over by King County in the annexation area to render it compatible with Kirkland's systems) Work included:
  - Upgrades to traffic signal controllers and cabinets
  - CCTV cameras
  - Video detection
- Field communications network expansion

Additional field ITS elements (primarily traffic signals) funded via other CIP and development projects have been, and continue to be, installed. In the past few years, the City has also been focused on deploying Rectangular Rapid Flashing Beacons (RRFBs) to support safe pedestrian movement. As of October 2019, the City operates and maintains:

- 68 Traffic Signals (47 connected to the TMC's central software via the fiber optic communications network)
- 46 CCTV cameras
- 195 video detection cameras
- 59 RRFBs
- 34 school zone flashers
- 32 radar speed signs
- 7 parking pay stations
- 3 emergency vehicle access controls
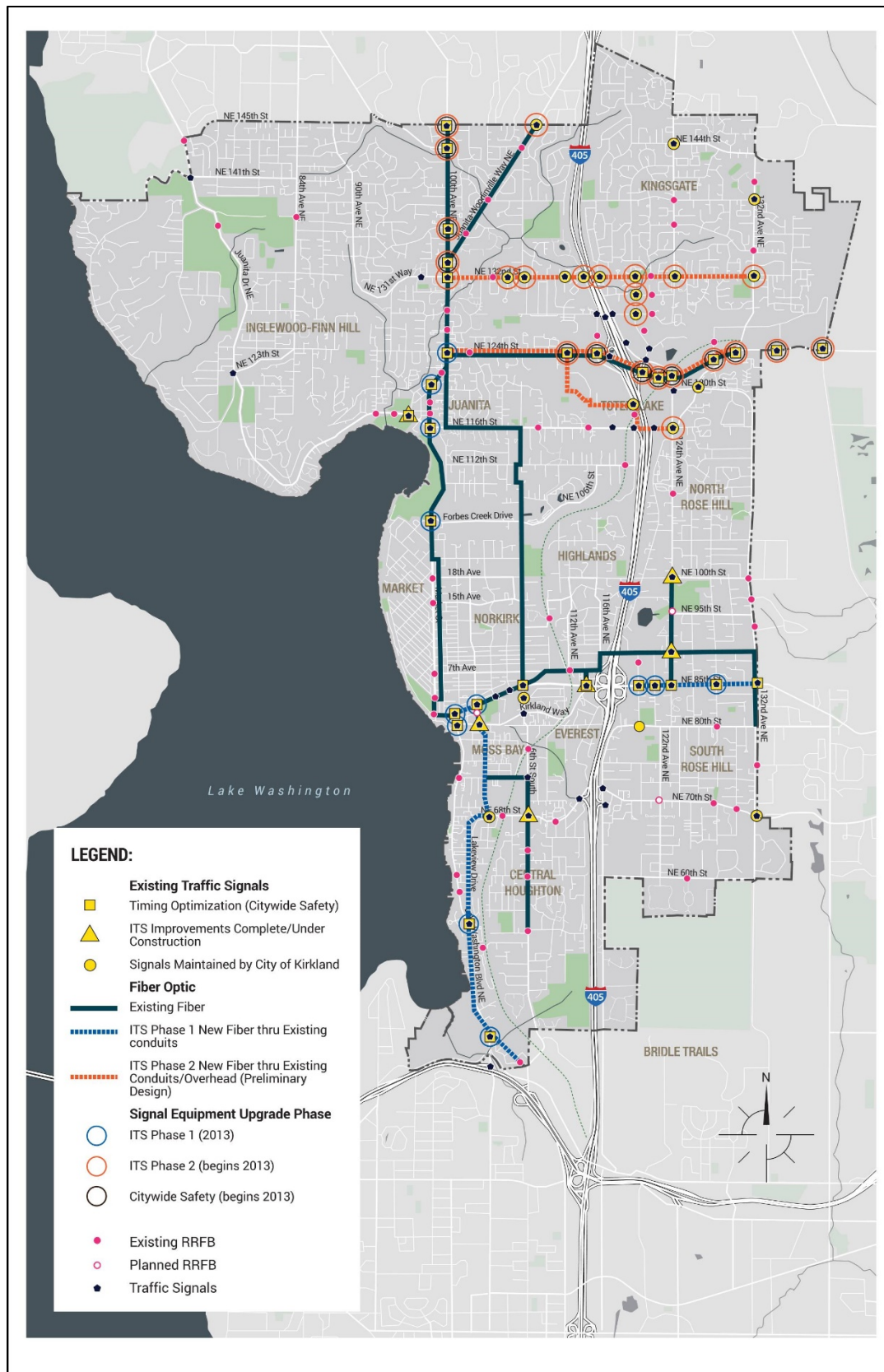
Figure 1-1: ITS Phase I and Phase II Field Work Completed

1.2 Four Core ITS Elements

ITS requires four core elements, working in alignment, to achieve the desired operations goals. The four elements are shown in Figure 1-2, below. This plan's approach is to identify the needs for each of the four core ITS elements based on the City's policy goals regarding road network operations.
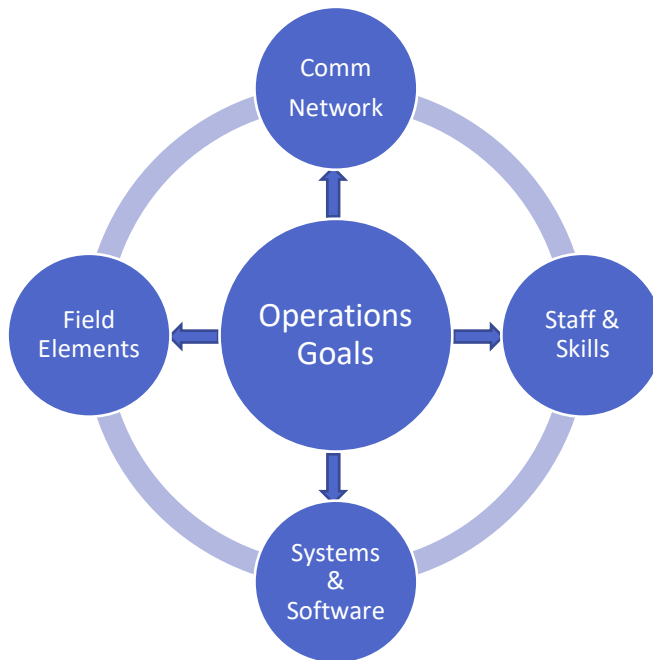
Figure 1-2: Operations Goals Drive the Investment Needs of the Four Core ITS Elements

The four core ITS elements are:

- **Field Elements**: Consist of traffic signal controllers/ and associated equipment, CCTV cameras, and multimodal detection
- **Communications Network:** Includes the media (fiber, cellular or other), equipment and software to manage communications from the TMC to the field, and between traffic signals.
- **Systems and Software:** Provide traffic signal control, system health monitoring, video management, CCTV camera control, and other functions.
- **Staff and Skills**: Encompass the staff hours and skills needed to operate and maintain the ITS elements.

1.3 Methodology and Plan Overview

The development of the ITS Plan was accomplished over a 10-month period and included one-on-one interviews and workshops with key staff. The process is depicted in Figure 1-3 and further described, below.

Figure 1-3: ITS Plan Development Process

1.3.1 Baseline

At the outset of the project, the state of the core ITS elements were reviewed, and staff from the Transportation, Information Technology (IT), Police and Fire departments were interviewed individually to understand the current conditions, the constraints, and to elicit thoughts on where the ITS Program should go in the future.

1.3.2 Identify Needs and Operations Concepts (Chapter 2)

Two workshops were held to develop an understanding of the City's ITS program needs, and to develop operations concepts for the City's transportation network. The needs identification was based on the baseline phase interviews, and on information gathered through the course of the project. An additional meeting was held to assess the potential for a GPS-based Opticom Emergency Vehicle Pre-Emption system to support improved KFD response times.

Operations concepts describe, in a readily understood manner, how ITS is intended to operate to support multimodal operations. Operations concepts can apply to the City/ITS system as a whole and can be developed to address specific roadways. Two "levels" of operations concepts were developed:

- Citywide: The citywide operations concept is focused on how reliable and resilient the ITS systems are. It answers the following questions:
  - Reliability: How often is it acceptable for ITS systems and devices to not function as required under "normal" conditions? Normal conditions do not include events outside the City's control such as earthquakes power outages, etc.
  - Resilience: How long should recovery take under "normal" conditions?
- Principal Arterials: Operations concepts for principal arterials in the city were developed to answer the following question:
  - How should the City manage traffic signal operations during the AM peak, PM peak and off-peak periods?

A clear understanding of the citywide and principal arterial operations concepts is necessary in order to define an overarching operations policy. Once defined, the overarching operation policy and operations concept can then be used to drive decisions regarding the systems and software, staff, communications network and field elements necessary to support the operations concept. Chapter 2 provides the operations concepts and a summary of needs.

1.3.3 Articulate Goals and Objectives (Chapter 3)

The needs and operations concept discussions were combined with the goals laid out in the Transportation Element of the 2035 Comprehensive Plan, and the 2017 City Council Goals to develop the goals and objectives for the ITS Plan. Objectives connected to these goals were then identified to support ITS Plan project selection. Chapter 3 provides the ITS Plan goals and objectives.

1.3.4 Select ITS Projects and Implementation Approach (Chapter 4)

ITS projects, including capital projects to address field elements and systems/software, projects involving procedures and standards, and staff needs including training were then identified to address the ITS Plan goals and objectives.

Chapter 4 provides a gap analysis comparing the existing state of the four core ITS elements to the state needed to accomplish the ITS Plan goals and objectives. This gap analysis was input to identifying and prioritizing projects. Chapter 4 also provides the ITS capital project phasing plan and includes both one-time (project) and ongoing cost estimates. The project phasing approach was based on two criteria:

1. Priority of the project based on alignment with ITS Plan goals and objectives.
2. Ability to complete the work either due to staff resource constraints, or logical implementation process/order needs.

1.4   WHITE PAPERS ADDRESSING FUTURE TECHNOLOGIES (APPENDIX A)

Two white papers were developed during the project to evaluate the City's possible policy approaches to two upcoming technologies, and are provided as Appendix A to this report:

- Parking management technologies (Smart Parking Systems)
- Connected and automated vehicles

2   OPERATIONS CONCEPTS AND NEEDS

The focus of this plan is on improving multimodal operations through the use of ITS. ITS provides tools for the City to meet multimodal mobility goals. One way to help define those goals is by describing, at a high level, how the City would like to operate its transportation network. This description is called an **Operations Concept**. Operations Concepts can be used to develop an overarching policy that directs technology selection, staffing, and policies and procedures. **Operations Concepts** can be developed for citywide (or ITS system-wide) operations, or for specific roadways, corridors, or subareas. For Kirkland, citywide and principle arterial operations concepts were developed.

> The Operations Concepts in this Plan describe how the City plans to deliver multimodal ITS operations. The Operations Concepts, together with the Operations Needs, guide the selection of proposed ITS investments.

The **Operations Needs** identify the parts of the four core ITS elements that need improvement to achieve the desired **Operations Concepts**. An analysis of relevant available data is provided to support understanding of the impact and magnitude of the Operations Needs. The Operations Concepts and Needs were developed via a series of workshops that included IT, Traffic, and Maintenance staff, as well as through interviews with the Kirkland Police and Fire Departments.

2.1   CITYWIDE OPERATIONS CONCEPT

The Citywide Operations Concept provides goals for delivery of multimodal operations in a reliable and resilient manner, and aligns with the City Council value and goal[1] for Dependable Infrastructure. Although the terms reliability and resiliency have several definitions, for the purpose of this ITS Plan, the Citywide Operations Concept answers the following questions:

> ### City Council Value and Goal [1]
>
> #### Value: DEPENDABLE INFRASTRUCTURE
>
> Kirkland has a well-maintained and sustainable infrastructure that meets the functional needs of the community.
>
> **Goal:** Maintain levels of service commensurate with growing community requirements at optimum life-cycle costs.

- **Reliability.** How often is it acceptable for ITS systems and devices to not function as required under "normal" conditions (not including catastrophic events outside the City's control e.g. earthquake, power outage)? Both central systems and field ITS affect overall reliability. For central systems, loss of service affects staff's ability to control and monitor the field systems and status, which can degrade operations. Loss of service of field ITS equipment can result in significant impacts to the traveling public.
- **Resiliency.** How long should recovery of central and field ITS take under "normal" conditions? Establishing uniform reliability and resiliency goals citywide is meant to additionally align with the

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[1] Source: City Council Values and Goals (updated 2017) accessed at:
https://www.kirklandwa.gov/Assets/CMO/CMO+PDFs/2016+Performance+Measures+City+Council+Goals.pdf

general public's expectations for consistent transportation operations service provision across the City.

2.1 RELIABILITY

The workshop discussions regarding reliability addressed the following:

- Whether the type of loss of service (dark, in flash, loss of coordination) mattered to the goal.

- Whether the location of the loss of service mattered to the goal, such as: a "critical" location (major/major, pinch point, etc.), isolated location, or a location(s) on a congested corridor.

- Whether timing of the loss of service mattered to the goal.

It was noted that consideration of the intersection(s) involved as well as the type of failure, time of day, traffic conditions, and ability of the affected intersection(s) to adapt should have an impact on the reliability (response) goals.

Loss of full functionality can occur due to several sources and can affect both central systems and field ITS. For example:

- Failures due to ITS communications connectivity most commonly result in loss of access and control to one or more intersections. More catastrophic failures due to ITS connectivity that affect large numbers of intersections can occur. These can be caused by network storms, software sending erroneous data, and security breaches. These are serious failures that require the strongest protective measures and response; however, they are also very uncommon.
- A failure resulting in signals operating in flash mode is most commonly caused by issues related to local equipment failures at the intersection, or as a result of power loss, rather than fiber/network/system failures.
- Dark signals are typically a function of power loss or damage to the controller assembly. Batteries (Uninterruptible Power Supplies (UPS)) or generators are the only protection against power outages.

2.1.1 Reliability Goal

The overall goal is to maximize reliability by reducing or mitigating instances of events that impact the traveling public. The ITS core components will be implemented to minimize instances or locations where reduction in functionality occur as a result of communication, equipment, systems, or engineering operations failures. Aspiring for 100% system reliability is not unusual for mission- and safety-critical systems, such as traffic signal systems.

The numbers, types and causes of outages and malfunctions should be tracked to determine if the City can achieve the reliability goal.

2.2 RESILIENCY

The second question addressed was "How long should recovery take under "normal" conditions? The longer that malfunctions and outages last, the greater risk exposure for crashes. One of the key

resource issues affecting response times are the shift and stand-by schedules of the departments that respond to outages. The departmental schedules of interest are:

- Field crews: The normal shift is 6:30 AM to 3 PM on working days. There is a general stand-by Public Works Streets Division maintenance staff person available outside normal shift hours for all Public Works emergencies. This staff person performs reconnaissance and triage of any off-shift emergencies, and will call out ITS maintenance staff when needed. ITS maintenance staff do respond to emergency call outs during after hours, but there are no staff specifically assigned to respond. The current ITS maintenance staffing level is inadequate to support development of a stand-by schedule for ITS.
- IT staff: IT staff are available during normal shift hours from 7:00 AM to 5:00 PM weekdays. There is standby staff available for weekend coverage from 5:00 PM Friday to 7:00 AM Monday, including all holidays (e.g. if a holiday falls on a Wednesday, IT staff are on stand-by from 5:00 PM Tuesday through 7:00 AM Thursday) for business-critical issues. There is no IT standby Monday through Thursday overnight (from 5:00 PM to 7:00 AM. During this time, after-hours IT support is accessed via an on-call phone number. Staff do respond to emergency call outs during after-hours, but there are no staff specifically assigned to respond.

2.2.1 Resiliency Goal

Table 2-1 presents the resiliency goals in terms of time to restore operations, and are based on the type of work needed to achieve normal operations. The goals address restoration of full operations, as opposed to full repair. Sometimes, the malfunction requires long-lead equipment for full repair (such as when poles or controller cabinets are impacted due to a crash). The time to repair is from the time of notification (not the time of the issue starting). Also note that the resiliency goals do not encompass malfunctions due to catastrophic events outside the city's control (e.g. weather-related, earthquake), the same case as for the reliability goals. Under current staffing levels, the goals are "stretch" goals. Meeting the off-shift goals may be especially challenging without additional ITS maintenance stand-by resources programmed to respond to off-shift outages.

Table 2-1: Maximum Time to Restore Field Operation Goals

Maximum Time to Restore Field Operation Goals*		
	If during normal shift hours	**If off shift**
FIELD WORK		
Not involving major reconstruction*	4 hours	24 hours
Involving major reconstruction*	24 hours	24 hours
COMMUNICATIONS NETWORK WORK		
All types of issues	8 hours	8 hours
CENTRAL SYSTEM WORK		
All types of issues	4 hours	8 hours

* Time to restore normal operation - final repair or reconstruction may take longer.

As noted earlier, the City is not able to implement stand-by staffing for traffic signal maintenance as there are not sufficient staffing levels to create a stand-by list. The IT department is on stand-by during weekends and holidays, with no stand-by overnights Monday through Thursday.

For central system failures, systems can be installed and configured to automatically fail-over to a back-up/stand-by central system. Communications systems can also be implemented with redundant paths to enable them to operate normally in the case of equipment failure or due to a break in the cable.

The response times and time-to-repair should be tracked, to understand how well the City is able to meet these goals. With an improved understanding of the repair history and needs, the City may choose to modify the goals, or change how resources are applied. Although the resiliency goals established are likely achievable, in particular if the reliability goals are met, the potential to establish stand-by schedules, and to pay staff for being on stand-by, is a barrier to improving response and repair times during "off shift" times.

2.3 PRINCIPAL ARTERIAL CONCEPT OF OPERATIONS

In a city, roads are classified as principal, minor, or collector arterials, and local streets. Principal arterials are meant to provide connections to other regional locations and freeways. The majority of the ITS systems in Kirkland are located on principal arterials, and these roads serve as the foundation of the City's street network.

Kirkland has developed a concept of operations for its principal arterials to guide ITS investments. When applied to a particular roadway or roadway segment, a concept of operations can include variations in desired operations by time-of-day, and can support the modal balance that is hoped to be achieved.

City Council Value and Goal [5]

Value: BALANCED TRANSPORTATION

Kirkland values an integrated multi-modal system of transportation choices.

Goal: Reduce reliance on single occupancy vehicles and improve connectivity and multi-modal mobility in Kirkland in ways that maintain and enhance travel times, safety, health and transportation choices.

The City works to provide a multi-modal balance in operating all roadways, aligned with the goals of improving access to all modes, minimizing Single Occupant Vehicle (SOV) travel, and enhancing travel times and safety. The concept of operations addressed modal balance, as well as overall traffic flow operations, in alignment with the City Council Value and Goal related to balanced transportation, and the Transportation Element of the 2035 Comprehensive Plan.

2.3.1 Modal Balance – Principal Arterials

The principal arterials were assessed for modal balance based on the need of roadways to accommodate pedestrian, cyclist, transit and vehicle travel. The Transportation Element of the City of Kirkland 2035 Comprehensive Plan provides a basis for evaluating how modes should be balanced on city streets, with the general hierarchy of modes noted as 1) walking, 2) biking, 3) transit and 4) vehicles. The plan notes that:

> This hierarchy is intended to help ensure that the needs of each group of users is considered in the City's planning process. This approach does not mean that users at the top of the hierarchy will always receive the most beneficial treatment on every street.

ITS can be deployed and operated in support of a defined modal balance goal. If pedestrians receive a higher emphasis than transit or vehicles, then they can interrupt the traffic flow by using an RRFB. Other priority treatments can include pedestrian "scramble", leading pedestrian phases or other pedestrian only phases at traffic signals. If pedestrians are not emphasized, but safe crossing is needed where there are no signals, then a HAWK signal, interconnected with the traffic signal system, would be considered. A HAWK signal allows pedestrians to cross without interrupting traffic flow on the principal arterial, and pedestrians would wait for service for as long as the traffic signal cycle requires to maintain optimal traffic flow.

Similarly, if cyclists receive a higher emphasis than vehicles or transit, ITS can support that operation. As a baseline, the City provides cyclist detection at traffic signals on roadways with bike lanes. When cyclists are traveling on a principal arterial with a bike lane, they are treated in essentially the same manner as vehicles. If cyclists are prioritized, delay to vehicle traffic could be introduced by way of treatments such as leading bicycle phases. In addition, if a bike lane or trail crosses a principal arterial, cyclists on cyclist-emphasis facilities could introduce delay to vehicle traffic if signals are modified to respond to bicycle detections at a high priority (in the same manner as pedestrians at an RRFB).

Transit treatments at traffic signals include transit signal priority, which can change the signal phase to support minimizing transit coaches stopping at traffic signals, and special transit-only phases serving transit in transit-only lanes.

In alignment with the comprehensive plan, four overall modal emphasis patterns for principal arterials were developed for this ITS Plan. A mode is noted as "emphasized" if it is allowed to introduce delay to another mode's flow. The term emphasized over prioritized is used to reflect that the operation must be implemented in a manner that does not result in unsafe operation of other modes, or that would excessively contribute to traffic congestion (reducing congestion is a key tool in minimizing air quality impacts from vehicles). For example, the pedestrian response to a button push at traffic signals may be made as short as possible, subject to it not introducing spillback congestion at adjacent intersections, to maintaining a reasonable level of coordinated traffic signal operations, and not creating such short timing for vehicles that it would increase the risk of rear-end crashes. Vehicle traffic flow patterns implemented in the AM and PM peaks are provided for information in Appendix B.

Four modal emphasis profiles were created for principal arterials, and are provided in Table 2-2, below.

Table 2-2: Modal Emphasis Profiles for Principal Arterial Concept of Operations

Emphasis Profile	Description	Modal Emphasis Ranking			
		Pedestrians	Cyclists	Transit	Vehicles
Urban Movement	Pedestrian movement has greatest emphasis, followed by cyclists, transit and vehicles last. This means that traffic control devices (such as RRFBs and traffic signals) may respond to pedestrian actuations in a way that minimizes delay to pedestrians, and doing so may add delay to all other modes. Cyclists are treated in a similar manner, and any special cyclist operations at traffic signals may add delays to transit and vehicle flow. Transit needs are also served in a manner that does not add undue delay to pedestrian and cyclist operations, and can add delays to vehicle flows. If only vehicles are present, or if vehicles and transit share lanes, then vehicle flow is optimized for minimization of travel time.	1	2	3	4
Transit Emphasis	On these road segments, transit movements have the most emphasis, followed by vehicles (or if in shared transit/vehicle lanes transit and vehicles may have the same emphasis), and pedestrians and bikes have the least and equal emphasis.	3	3	1	2
Pedestrian and Cyclist Emphasis	Pedestrians and cyclists both have the highest and equal emphasis on these roadways, followed by transit and vehicles, also with equal emphasis. Pedestrians and cyclists may cause delay to vehicle and transit movement. Since transit and vehicles have equal emphasis, transit operations will not add delay to vehicle operations at traffic signals.	1	1	2	2
Transit and Vehicle Emphasis	On these road segments, minimization of transit and vehicle delay is of highest emphasis. Safe movement of pedestrians and cyclists is maintained. However, pedestrians and cyclists are not allowed to introduce additional delay to transit and vehicle operations.	2	2	1	1

Figure 2-1, on the following page, shows the locations for each of the four emphasis profiles on the principal arterials.

Figure 2-1: ITS Modal Balance on Principal Arterials

2.3 NEEDS

Within the context of the operations concepts, the following have been identified as the key needs that must be addressed to improve multimodal road network operations in Kirkland. The needs are numbered for clarity. The numbering does not reflect a ranking of the needs.

1. Implement data storage and analytics capability to understand and evaluate operations. This is needed for both typical and incident operations, and includes automated analytics. The data must be available in real-time, and stored for studies and performance monitoring.
2. Reduce potential for major signal malfunctions. Increase robustness of network to limit the potential for a loss of access to intersection resources.
3. Provide staffing to meet needs.
4. Increase potential to respond quickly to equipment and system malfunctions, and increase recovery options.
5. Implement systems and detection to operate signals in manner to respond to transient fluctuations in demand, including to:
   – Freeway incidents
   – Surface street incidents/closures
   – School operations
6. Improve emergency services response times including increasing route selection capabilities, options to speed signal recovery, and provide data and analysis tools to evaluate usage and effectiveness.
7. Remove barriers to better operations at WSDOT signals.
8. Better serve a balance of multimodal operations.

Appendix C includes supportive traffic delay analyses demonstrating needs related to traffic operations.

1. IMPLEMENT DATA STORAGE AND ANALYTICS CAPABILITY TO UNDERSTAND AND EVALUATE OPERATIONS, AND REPORT ON PERFORMANCE

The traffic operations and engineering staff do not have tools to support continuous and comprehensive evaluation of operations and performance monitoring. Staff do monitor operations on an ad-hoc basis using the CCTV system, and work to implement signal timing and operations improvements based on those observations. However, the ability to monitor operations is limited as there is no system in place to support data gathering and analysis. Implementing a system and the detection that supports Automated Traffic Signal Performance Measures (ATSPMs) will enable improvements in operations and provide for performance monitoring.

ATSPMs consist of high-resolution data that allows traffic agency professionals to proactively find and correct flaws in the system. They provide the data and insights transportation professionals need to proactively enhance operations. Acting on the insights from ATSPMs leads to tangible citizen benefits, including reduced congestion, fuel cost savings, and improved safety on city streets. ATSPMs rely on there being sufficient detection and communications in place, and controller cabinet equipment that gathers data from traffic signal controllers, and central software to process and store the data.

ATSPMs allow traffic engineers to directly measure what they previously could only model. They minimize the cost and time spent manually counting vehicles and timing their progression through the corridors, and performing calculations or modeling. The data can be used for all types of planning and operations studies.

Last, ASTPMs provide a means to continuously report on operations performance, including understanding the effects of improvements. Notably, the FHWA has made ATSPMs a priority because of the many benefits.

2. REDUCE THE POTENTIAL FOR MAJOR SIGNAL MALFUNCTIONS

Traffic signal outages or flashing operations are, rightly, a key concern to the City, due to the impact on delay and safety. Outages and flashing signals increase the risk of crashes for all modes.[2,3] Malfunction flash operations are particularly difficult for pedestrians to navigate, as there is no signaled pedestrian right-of-way, and drivers are focused on successfully navigating the flashing vehicle signal operation. In addition to these safety impacts, the degradation of emergency services response times is also of concern.

The City occasionally experiences traffic signals going into flash or going completely dark. Most of these events occur because of power outages, crashes, or individual controller cabinet assembly issues. Any occurrence of signals going into flash is of concern, especially due to the increased risk of crashes when signals are in flash, but also due to the increased delays.

Some of the causes of outages or reduction in functionality include:

- Vehicle crashes affecting ITS infrastructure
- Software or firmware issues, including upgrades that are incompatible
- Communications network or switch failure
- Traffic signal cabinet equipment failures
- Power or communications cable cuts due to other construction (private or public)
- Power or communication loss/cable cuts due to severe weather conditions

The most catastrophic failures can occur due to malfunctions in communications network or control system equipment/software, or malicious internal or external attacks. To ensure protection from system-wide disruptions to normal operation, it is essential to expand the capacity, security, and resilience of the communications network. Recent changes to the existing communications network have improved overall network reliability. However, the existing network requires additional infrastructure improvements to increase reliability and protect against loss of communications due to fiber optic cable failure or breaks. In addition, the network requires these improvements to make it ready for the future of ITS, which will introduce additional data communications needs. So, improving the ITS communications network is not only core to achieving the reliability goal for the current systems,
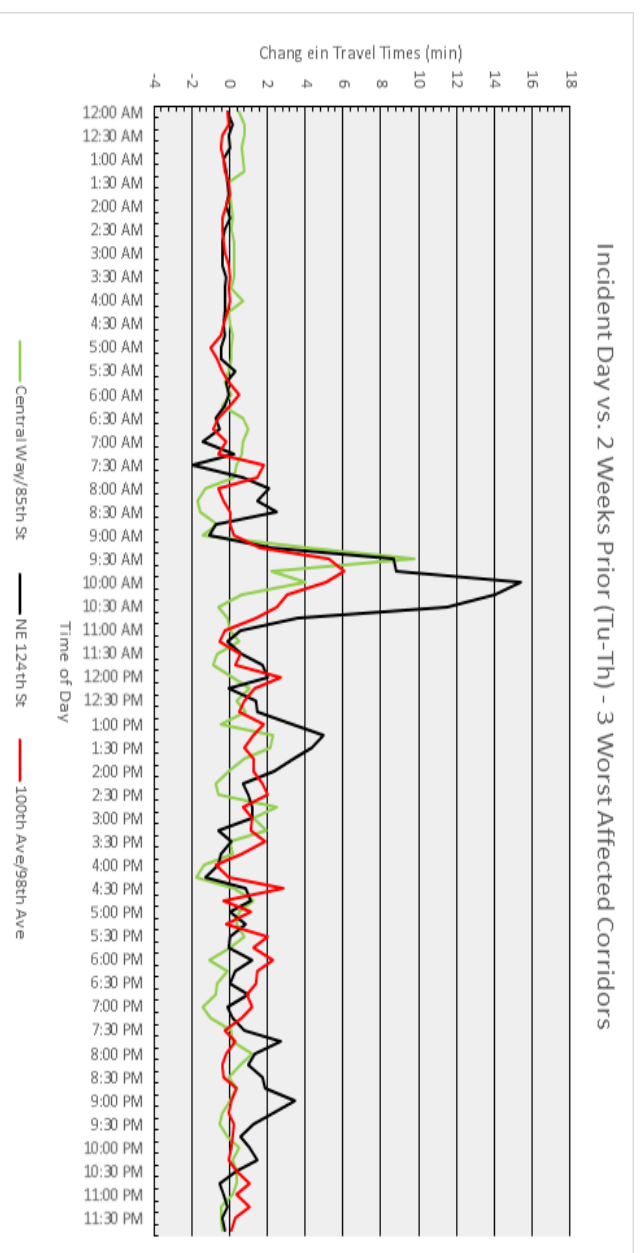
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[2] Watson, C. E. (2008). *Statistical Analysis of Crashes Occurring at Intersections in Malfunction Flash* (Master's Thesis).

[3]Hunter, M., Jenoir, P., Bansen, J., Rodgers, M. "Model of Flashing for Malfunctioning Traffic Signals", Journal of Transportation Engineering/Vol 137 Issue 7 July 2011.

but is required to ensure the City can deploy future ITS systems to provide the needed multimodal balance in transportation operations.

Delay Impact

As an example, on 10/3/2018 from approximately 9:00 AM, 40 traffic signals in the City were placed in flash due to an operator input error that occurred when sending an update to the traffic signal controllers. All signals were restored to normal operations by 11:30 AM that day. Figure 2-2 show the impact of the incident on travel times. Travel times on NE 124th St increased by up to 15 minutes – an increase of 110% over average travel times the week before. And travel times on Central Way/NE 85th St increased by as much as 10 minutes – some 75% longer than average. Significant delay increases lasted about 2 hours. It is noted that this event was very unusual in that it involved a significant number of signals.

Incident Day vs. 2 Weeks Prior (Tu-Th) - 3 Worst Affected Corridors

Legend: Central Way/85th St — NE 124th St — 100th Ave/98th Ave

Figure 2-2: Change in Travel Time on Worst Affected Principal Arterials Due to October 10, 2018 Traffic Signal Flashing Operation

Failures have also been caused by aging traffic signal control equipment infrastructure. Addressing these and other failure causes within the City's control suggest the following needs:

- Upgrade/replace aging traffic signal controllers and cabinets, and increasing the annual amount of funding provided for maintenance replacement (and maintenance staffing) for these and other ITS assets, based on estimated useful life of the assets. The City currently creates and funds a plan for equipment replacement, but the ITS maintenance staffing available to implement the replacements is insufficient to conduct the work.

- Provide additional maintenance staff to increase preventative maintenance and avoid cabinet equipment failures.

- Provide battery back-ups to support traffic signal operations in the case of loss of power. These can run an intersection with full functionality for about 4 hours, and up to 8 hours if in flash. The City's

new traffic signal cabinet specification includes battery back-up. Retrofits should focus first on equipping intersections on principal arterials.

3. PROVIDE STAFFING TO MEET NEEDS

The growth in traffic demands, in the City's geographic size due to annexations, and the number of ITS devices and traffic signals has placed growing demands on staff to operate and maintain the systems. To understand the need, a comparison of staff levels to national standards and peer agencies locally was completed.

Maintenance Staffing Needs

The staff responsible for ITS maintenance also maintain the City's street lighting. The overall number and types of devices they maintain (as of November 2019) are:

Item	Qty
Light Emitting Diode (LED) Streetlight Lamps	1148
Rectangular Rapid Flashing Beacons (RRFBs)	59
Radar Speed Signs	32
Solar Systems for RRFBs and Radar Signs	40
Closed Circuit Television (CCTV) Traffic Cameras	30
Video Detection Cameras	100
Traffic Signals	68

Their duties also include supporting construction inspection, testing controller cabinets supplied for private and City work, and responsive (emergency) maintenance. Using data from FHWA[4] and Oregon DOT[5], the City should have 5 technician positions plus a supervisor for a total of 6 ITS maintenance staff. Today, the city has 3 technician positions plus a supervisor - a deficit of 2 technicians. In addition, one of the three positions is an apprentice classification (two are journey level classifications). Most other agencies in the region require journey-level certification for all their positions. An apprentice is not available to perform the full range of ITS maintenance tasks, as they are less experienced, and time must be spent on training for the apprentice position. This lack of staff results in a cycle where maintenance is deferred, which can lead to outages or additional expenditures to repair.

> The City needs 2 additional ITS Maintenance Technicians persons to meet today's ITS needs.

The same methodology to estimate maintenance staff needs was applied to the Cities of Bellevue and Redmond. Each of these agencies has a different set of ITS infrastructure and maintenance responsibilities, but the majority of the ITS Maintenance staff workload is based on traffic signals, street lights, solar systems, and cameras (whether for detection or streaming video). Bellevue and Redmond ITS maintenance staff also are responsible for ITS communications fiber maintenance. The City of Bellevue (which manages 205 traffic signals, 30 solar systems, 120 CCTVs, and some 8000 street lights)

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[4]Gordon, R., and C. Braud. *Traffic Signal Operations and Maintenance Staffing Guidelines*. Report, FHWA-HOP-09-006, Federal Highway Administration, United States Department of Transportation, March 2009.

[5] Oregon DOT; *ITS Maintenance Plan*; December 1999.

has the required number of maintenance personnel, which includes one supervisor and 11 maintenance technician positions. City of Redmond (which manages 110 traffic signals, 10 solar systems, 67 CCTVs, and some 1600 street lights) requires 6 technicians and has 5 technician positions. Both Redmond and Bellevue staff all maintenance technicians at the journey level.

Impacts of the maintenance staffing deficit are experienced today. For example, there are several system detectors installed in the street to support improvements in traffic signal operations, but there are not sufficient staff resources available to connect these detectors to the system. Also, the City has purchased upgrades for the traffic signal controllers, however, the shortage of maintenance personnel has prevented completion of the upgrades.

Operations Staffing Needs

ITS requires personnel to optimize performance, and monitor and manage the systems and software. Based on guidance from the National Cooperative Highway Research Program (NCHRP) and FHWA[6], the City of Kirkland requires 2 operations staff solely for the

> **The City needs 1 additional ITS Operations Staff person (2 if the temporary position is not reauthorized) to meet today's ITS needs.**

management and operations of traffic signals including signal timing plan development and modifications, troubleshooting malfunctions and failures, and responding to citizen inquiries. The added needs of ITS such as integrating and troubleshooting CCTV cameras and video detection, supporting capital project design and construction, and the need to implement more responsive signal timing, place the City of Kirkland's need at 3 ITS operations engineering staff. Today there is one permanent and one temporary ITS operations engineering position, which results in a deficit of 1 position (as long as the temporary position remains in place). Because both Bellevue and Redmond operate extensive adaptive traffic control systems which require extra staff, we did not compare to those cities' operations staff levels.

4. REDUCE RESPONSE TIMES TO SIGNAL MALFUNCTIONS

Staff respond as quickly as they can to correct traffic signal malfunctions, including to flashing operations, but also to traffic pole knock-downs, signal lamp outages, and other malfunctions. As the ITS systems grow to meet the needs of a growing city, the demand for response to malfunctions will increase. Even as improvements to the reliability of the ITS systems are implemented, malfunctions may still occur. Constraints to improving response times include:

- IT staff are not on stand-by weekdays, Monday through Thursday from 5 PM to 7 AM. Locating available and appropriately trained staff if an incident occurs during these time periods takes extra time.
- Traffic signal maintenance staff are not required to be available after hours. Locating available staff if an incident occurs outside of normal work hours can take significant extra time. Today, there are insufficient maintenance staff numbers to create a stand-by schedule.

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[6] National Academies of Sciences, Engineering, and Medicine 2015. *Signal Timing Manual – Second Edition*. Washington, DC: The National Academies Press. https://doi.org/10.17226/22097.

- Access to software administrator functions of the central traffic signal control software is not available to Traffic staff, but only to IT staff. Traffic staff must submit a request be to IT for IT staff to access these administrator functions, which adds time to respond to malfunctions. Most cities in the region allow Traffic operations staff to access the administrative functions of central ITS software, and the City of Kirkland should evaluate providing such access to Traffic staff.
- A lack of automated alerts of problems to Traffic and IT staff. Software is not in place to provide such alerts, which would speed staff awareness of an issue or potential issue, and speed response.

5. OPERATE SIGNALS IN MANNER TO RESPOND TO SPIKES IN DEMAND, INCLUDING TO FREEWAY INCIDENTS, SCHOOL FUNCTIONS, AND SURFACE STREET INCIDENTS AND CLOSURES

Today, the traffic signal timing plans change based on the time of day and day of the week. The staff create timing plans for most arterials to support progression of traffic on the major arterial. Some signals operate on their own (isolated). All traffic signals are programmed to change timing plans based on the time of day, and those times are based on a review of historical traffic volumes.

These plans operate well, and provide needed progression on arterials. However, the traffic signals do not respond to unforeseen spikes in demand, such as from incidents, nor do they respond to school operations which can generate short-term spikes in traffic volumes. Additional detection, which may include ingesting WSDOT data to support I-405 incident response, will enable traffic signals to better respond to these conditions. Staff resources will also need to be allocated to develop the improvements to the timing plans.

See Appendix C for an analysis that illustrates the need with respect to I-405 incidents.

6. IMPROVE EMERGENCY SERVICES RESPONSE TIMES

The Kirkland Police Department (KPD) and Kirkland Fire Department (KFD) were interviewed to understand their needs with respect to ITS improvements. Both the police and fire department response vehicles are equipped with traffic signal emergency vehicle pre-emption (EVPE).

Response time increases are of concern to both the police and fire departments. The fire department indicated that response time improvement is a key departmental concern. The National Fire Protection Association (NFPA) has a voluntary fire department certification program. KFD participates in this program which enables fire departments to improve their outcomes. Response time is one measure in the certification process. NFPA certifications help fire departments provide the highest possible service level to the communities they serve.

In addition to increasing traffic volumes and congestion, both departments noted the following that have a negative impact on response times:

- Signal malfunctions. When signals go into flash, response times are reduced due to the added traffic congestion, and the need to travel more slowly through flashing traffic signals to ensure safety. The police noted that officers are not posted at flashing traffic signals, but can be dispatched if the signals go dark (fully inoperable). When signals are dark, the number of officers available for other response is reduced.

- Adequacy of current EVPE system. The current EVPE system significantly helps reduce emergency vehicle travel times, but has some limitations. The current system is designed to function at a single intersection at a time. The traffic signals can be programmed to respond at up to two intersections at a time. In addition, the system requires clear line-of-sight between the responding vehicle and the traffic signal for it to function. The system does not respond as quickly as needed on curved and hilly approaches due to the line-of-sight need. And, if a responder will be turning at an intersection, the traffic signal response is also delayed. Fire station egress is also of concern, as the responding vehicles must make several turns after exiting stations.

  Police also use the EVPE system. They report that they often clear the intersection prior to the EVPE providing a green in the preempt direction.

  Last, the current system can provide limited analytics to support improved response times. The City currently has not purchased the additional analytics software that is available with the current EVPE system.

- When EVPE is activated, it interrupts the traffic signal timing plans that provide traffic progression. Recovery takes up to three traffic signal cycles. Improvements in signal timing recovery would reduce delays to all traffic, and would require upgrades to the traffic signal central system software, and may also require additional traffic detection.

7. REMOVE BARRIERS TO BETTER OPERATIONS AT WSDOT SIGNALS

In Kirkland, there are four locations where WSDOT manages traffic signals at I-405 ramps and that can affect overall road network operations: NE 128th St, NE 124th St, NE 116th St and NE 70th Pl/NE 68th St. Currently, the WSDOT signals operate independently of the City's signals at all of these locations, with the exception of NE 124th St and northbound I-405 off ramps. NE 124th St and northbound I-405 off-ramps uses time based coordination to operate consistently with the signals on the rest of the City signals. The lack of communication between WSDOT and City systems limits the ability of the two agencies to work together to efficiently manage the signal system.

● WSDOT Traffic Signal
◉ COK Traffic Signal

Figure 2-3: WSDOT and City of Kirkland (COK) Traffic Signals in the area of the NE 124th St Interchange

To illustrate the issue, NE 124th St was examined. WSDOT's signals on NE 124th St were fully integrated and coordinated with the City's traffic signals before ITS Phase 2 was implemented. With the implementation of ITS Phase 2 WSDOT was no longer willing to be interconnected with the City's signal system on NE 124th St. Appendix C provides a travel time analysis on the segment of NE 124th St between 116th Ave NE and 124th Ave NE (this is the segment the INRIX source data defines), for conditions before and after WSDOT signals were removed from integration/coordination with the City's signals. The resulting analysis showed that travel times increased significantly in the eastbound direction post-implementation of ITS Phase 2.
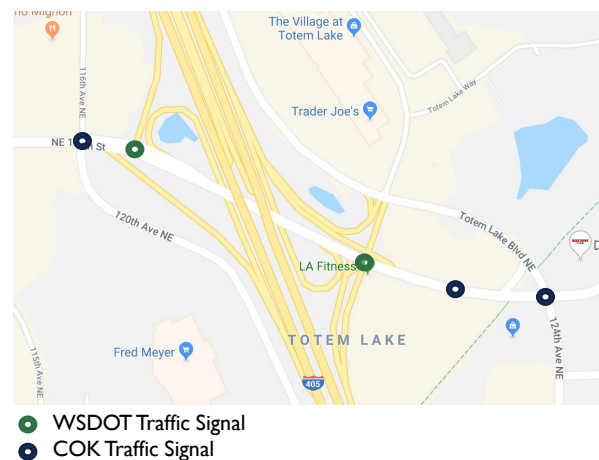
The key take-away from the analysis is that coordinating the City and WSDOT signals can produce real travel time improvements for transit and vehicles on city streets, which would include not only NE 124th St, but all locations where WSDOT signals are located in the midst of City signals, such as at NE 116th St. There are a range of options to improve traffic flow at WSDOT intersections. These range from requesting improvements from WSDOT, to implementing a data connection between the City and WSDOT systems, to fully connected coordinated control with compatible controller equipment. The City of Kirkland is not able to take over operations of the WSDOT intersections, as WSDOT requires 24X7 stand-by maintenance staffing of agencies that manage WSDOT-owned signal operations.

8. BETTER SERVE A BALANCE OF MULTIMODAL OPERATIONS

The ITS program has been diligent in serving multiple modes, in alignment with the City's Comprehensive Plan. Existing multimodal ITS includes:

- Bicycle detection on identified bike routes
- Pedestrian detection (push buttons) including rolling out accessible push buttons to serve the disabled population
- Rectangular Rapid Flashing Beacon (RRFB) deployments
- Transit signal priority/detection at the Totem Lake transit center (NE 128th St/Totem Lake Blvd), and at Forbes Creek Dr/Market St.

Based in staff interviews, the strategies and systems to better serve the balance of multimodal operations would include:

- More reliable cyclist detection
- Expanding the number of locations with cyclist detection
- Improved traffic signal operations to support pedestrian operations, with signal operations capabilities and timing (e.g. leading pedestrian intervals) that provides the appropriate balance between vehicle and pedestrian movements and align with Vision Zero goals. Passive pedestrian detection could also be considered to detect pedestrians in crosswalks to extend the time they have to cross. All such pedestrian treatments require analysis to ensure they will provide the safety and operations needed for a specific location.
- Additional transit signal priority strategies such as early transit green, conditional priority or other approaches based on transit operations needs.

3   GOALS AND OBJECTIVES

The development of the ITS Plan goals was based on an understanding of, and alignment with, overall City goals, as described in the Comprehensive Plan Transportation Element, and City Council values and goals. Figure 3-1 shows how the fusion of these two sources resulted in the ITS Plan Goals, and a Guiding Principle.
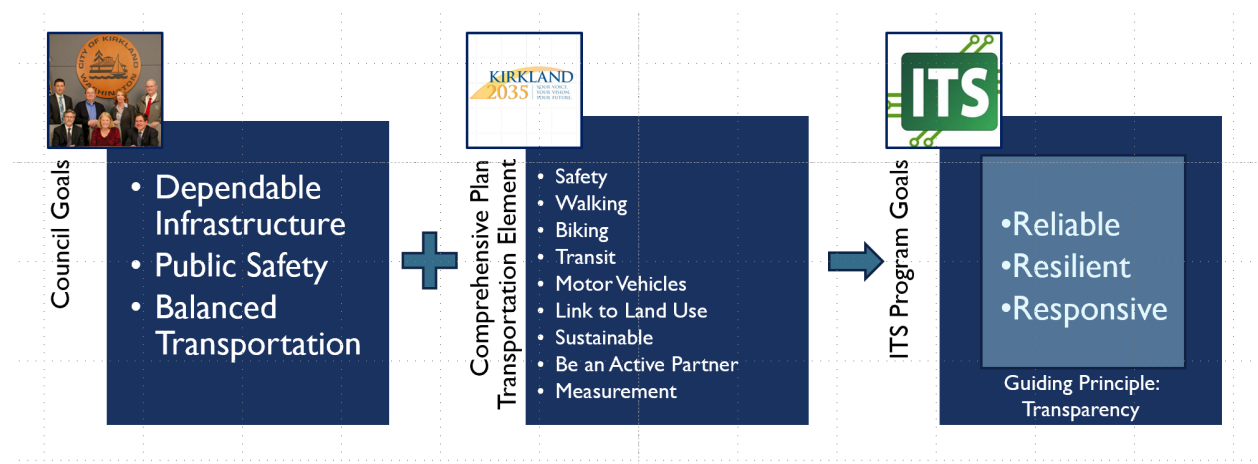
Figure 3-1: ITS Plan Goals and Guiding Principle

The following describes the ITS Plan Goals and Guiding Principle. Each of the goals and the Guiding Principle are outward customer-focused, to support the multimodal operations the City needs.

- **Reliable.** The operation and delivery of services supported by ITS will be highly reliable. There will be only very few traffic signal malfunctions due to causes that are within the City's control.
- **Resilient.** When there are malfunctions (or damage to ITS infrastructure), the response and correction time will be as short as possible.
- **Responsive.** Each of the four core ITS components – field ITS, staffing, communications network and systems/software – will be responsive to identified operations needs.

All of the goals are surrounded by a single Guiding Principle:

- **Transparency:** The ITS Program will continuously measure and report on performance.

3.1 ITS PLAN OBJECTIVES

The needs and operations concepts described in Chapter 2 were used to support development of the ITS Plan objectives, which further define the goals. Figure 3-2, below, provides the ITS plan objectives, aligned with the ITS Plan Goals. It also provides some potential measures to support the Transparency Guiding Principle.

RELIABLE Reliable delivery of service	RESILIENT Resilient delivery of service (quick recovery, quick responses)	RESPONSIVE Responsive to needs	GUIDING PRINCIPLE Transparency - Measure and report on performance
▪ No traffic signal failures or malfunctions – 100% uptime ▪ Future proof – ready for current and future changes in ITS technology ▫ Maintain a secure ITS network ▪ Provide resources for field device end-of-life change-out ▪ Provide battery back-up (UPS) for signal control and network equipment	▪ Resilient communications, systems, devices network ▪ Resilient level of staffing to respond ▪ Resilient back-up control strategies for central systems	▪ Safety focused first ▪ Multimodal – peds, bikes and transit ▪ Introduce traffic responsive operations, leveraging and adding to existing systems ▪ Implement system to provide detailed signal operations performance measurement to diagnose and correct signal timing ▪ Improve integration with WSDOT signal operations ▪ Reduce Emergency Services response times	• Travel time • Travel time reliability • Impacts of incidents on freeways • Emergency Services (KFD) response times • Reliability/Resilience • Other

Figure 3-2: Objectives Mapped to ITS Plan Goals

4 THE PLAN

The chapter presents the projects and initiatives proposed to be implemented over a five-year period to achieve the ITS Plan Goals. Both capital projects and ongoing operations projects are described.

4.1 HOW TO USE THE PLAN

The ITS Plan presents capital and ongoing (operations and maintenance funded) projects recommended to meet the City's ITS Goals and Guiding Principle. Each capital project is described in the project sheets which follow. The projects have been selected based on their ability to achieve the ITS Goals and/or support the Guiding Principal. Budgets have been developed to support the City's budgeting process, and for grant applications. These budgets will be refined as projects progress through early design.

Several of the capital projects are scalable. They can be implemented as a whole or in part. If they are scalable, the project descriptions so indicate. The City can select different "bundles" of capital projects by selecting whole or parts of the scalable projects to create a package of ITS elements that is the best fit to needs and funding constraints. All capital projects are eligible for Federal funds, and the City is encouraged to apply for such grants.

> **ITS PLAN GOALS and GUIDING PRINCIPLE**
>
> - Reliable
> - Resilient
> - Responsive
>
> Guiding Principle: Transparency

The plan also provides estimates of ongoing, or operations, costs. These costs are sometimes associated with license fees for capital projects that include software or service purchases. If a capital project that includes associated licensing fees is not selected or scaled back, associated reductions in operations costs would be realized.

4.2 THE FOUR CORE ITS ELEMENTS – READINESS FOR THE FUTURE

The status of the City's existing four core ITS elements in terms of readiness for future ITS expansion was evaluated to support project selection and prioritization. Figure 4-1 provides this evaluation.

Communications Network — **NOT READY**	
• Infrastructure physical reliability improvements needed • Time to repair can be long	• Not future ready for additional ITS needs

Systems and Software — **PART READY**	
• Supports current service level well • Provides a platform to build on	• Lacking performance monitoring • Fire Department signal pre-emption does not meet needs • Time to repair can be long

Field Elements — **PART READY**	
• Some locations lack detection, CCTV, proper controllers • Passive pedestrian detection desired	• Bike detection is inconsistent • Budgetary process for field element replacement not sufficient

Staffing and Skills — **NOT READY**	
• Operations staff can maintain current operations/service level • Operations staff unable to take full advantage of systems/software to improve service level • ONE + Ops staff person below national std.	• Without 24X7 maintenance coverage, WSDOT will not allow City to take over signal operation • Preventative maintenance cannot be fully performed – leads to more responsive maintenance • TWO Maintenance staff below national std.

Figure 4-1: Evaluation of Four Core ITS Elements

The two areas requiring the most attention to ensure that the City can move forward with improvements to multimodal operations using ITS are the Communications Network and Staffing/Skills.

4.2.1 Communications Network

The City has built out a communications network to serve ITS needs in a cost-efficient and opportunistic manner. The resulting communications network has served the City's ITS needs well for many years. To meet this plan's reliability and resiliency goals, and to be ready for future ITS needed to provide the required multimodal balance envisioned for the City, improvements to provide physical redundancy including physical and collapsed rings, and redundancy in communications switch hardware, should be implemented. Appendix C provides additional recommendations for the communications network.

The communications network itself is not documented in a comprehensive manner. The city is reliant on the knowledge of a sole IT staff person to manage and make changes to the network. If this person leaves the city, so does the information on the ITS communications network. Any new work must include implementation of readily maintainable and accessible communications network documentation.

4.2.2 Systems and Software

The City's ITS, including traffic signal operations, systems and software are powerful tools that can support some advanced and responsive traffic signal operations. They provide solid foundations to build on for future improvements.

The CCTV images are managed using a central distribution server. There are current issues with this server that prevent the City from posting CCTV images and streams to the internet, which would provide the public with important traffic condition information. The City is currently working with their system vendor to analyze and resolve this issue. This may require hiring specialized expertise to assist the City, if the source of the problem cannot be isolated

The existing emergency vehicle pre-emption (EVPE) only operates locally on an individual intersection, line-of-sight required for pre-emption, basis. This system does not support improvements in emergency vehicle response, nor does it provide the advanced pre-emption timing needed for KFD vehicles to make turns through traffic signals. As traffic grows with a growing Kirkland, emergency vehicle response times are expected to continue to increase unless new tools are implemented to support reductions in response times.

The City does not have ASTPM software, which would provide a tool for staff to assess signal operations performance measures in real-time. This software would allow for detailed analysis of system performance, providing information necessary to enable a quick response to changing traffic patterns, and to alert staff to any potential malfunctions.

The TMC is an essential part of the overall ITS infrastructure. The video wall is nearing its end of life, and will require replacement.

The maintenance shop (newly relocated to Building F in the maintenance yard) is not configured to support ITS maintenance tasks including testing and repair of equipment and traffic signal controllers.

4.2.3   Field Elements

The City's ITS field elements are generally sufficient to meet current needs. However, there are locations where:

- Detection failures occur, including for bicycle detection
- Seven of the 60 field traffic signal controllers (sited in isolated operations locations) are aging and unable to support future advanced operations
- Traffic signal cabinets are aging, and upgrades are needed at approximately one-third of the traffic signal locations. UPS are also needed at most existing traffic signal locations (some newer signals have been installed with UPS)
- Vehicle "system" detection is lacking, and the City is limited in its ability to implement improved traffic signal coordination or responsive timing

The City has purchased controller upgrades and has installed detection, but the shortage of maintenance staff has prevented installation and connection of these items.

4.2.4   Staffing and Skills

The City is fortunate to have excellent traffic signal operations, maintenance and IT staff to support the delivery of multimodal ITS. There are deficits in the number of staff needed to support the current and future ITS Program. Within the Operations staff, there is a deficit of one position (2 if the temporary position is not continued). The maintenance staff is 2 persons below the needed numbers to meet today's needs. It is recognized that one operations and one maintenance staff position was recently added, and these staff will help support current needs. It was noted earlier in this Plan that maintenance stand-by cannot be achieved without added staff. To move forward, additional staff are required.

Training is also important to ensure the maximum value can be extracted from the ITS resources in place. Regular training will also help ensure that institutional knowledge is not lost as staff retire or leave the City for other reasons.

Overall, the current status of the four core ITS elements is not sustainable. Each requires investment to ensure that a balance is maintained among the elements. Investment in ITS can support improvements in public perception of the City and how it meets transportation needs. The most recent public opinion survey[7] noted that Traffic has the greatest gap between the public's perception of importance and performance, as shown on Figure 4-2. It is also noted that the attitude towards the City's delivery of traffic services has fallen since 2016. Of course, several factors are included in any individual's opinion of traffic including transit service and regional traffic conditions. However, it suggests that the City can work to improve the citizen's perception of traffic service delivery.

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[7] EMC Research, *"City of Kirkland 2018 Biennial Residents Survey on Citizen Opinions and Priorities"*, 2018.
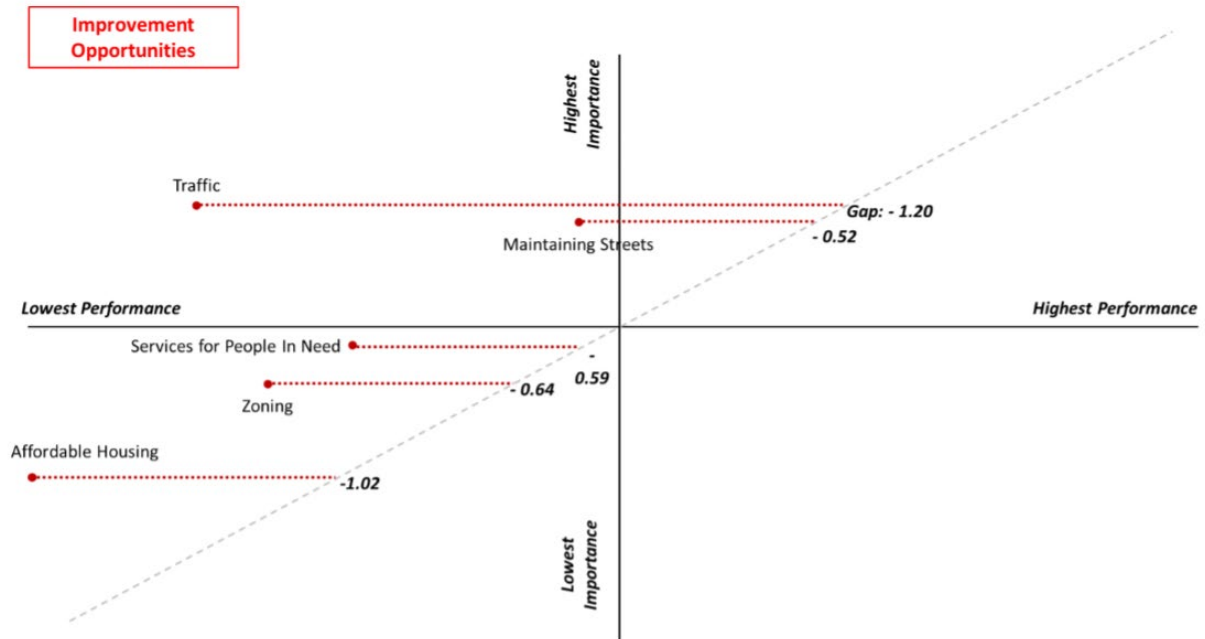
Figure 4-2: Importance Versus Performance Survey Results From 2018 Resident Survey

4.3   CAPITAL PROJECTS

Nine capital projects are proposed to meet the needs and to support achieving the operations concepts identified in this plan. The projects are prioritized into three rankings. Table 4-1: ITS Plan Capital Projects provides a summary of the proposed projects, their ranking, budgetary cost estimates, suggested implementation schedule and shows how the projects are mapped to the three ITS Plan goals and Guiding Principle of transparency.

The total investment in ITS capital projects is estimated at $4,980,000 over 5 years (2019 dollars).

Table 4-1: ITS Plan Capital Projects (2019 Dollars)

No.	Priority	Project	Budget Estimate (2019 Dollars)	1	2	3	4	5	Reliable	Resilient	Responsive	Transparent
1	1	Performance Monitoring	$300,000	▥					●	○	●	●
2	1	ITS Phase 3	$3,300,000	▧	▧	▧	▧	▧	●	●	●	
3	2	GPS-Based Opticom	$500,000	▥	▥					○	●	●
4	2	Multimodal Detection Improvements	$500,000	▧	▧	▧	▧		○		●	○
5	2	Advanced Signal Ops Software	$175,000	▥	▥						●	
6	2	Staff Training	$20,000	▧					●	○	●	○
7	2	Develop and Adopt ITS Design Stds	$35,000	▥							●	
8	3	Update ITS Plan	$100,000				▧		●	●	●	●
9	3	WSDOT Signals Integration	$50,000				▥				●	
		TOTAL	**$4,980,000**									

● = Strong mapping to goal or guiding principle

○ = Partial mapping to goal or guiding principle

The highest rated projects in the plan are:

#1. **Performance Monitoring.** Performance monitoring will provide staff with tools to prioritize deployments, to improve operations, and to report performance on an ongoing basis to elected and the public. The project includes automation of the performance measure, so that staff need not invest a great amount of time creating reports. Performance monitoring is essential to the Transparency Guiding Principle and they are important for measuring the return on investment of ITS projects. Performance monitoring would also help ensure the reliability and responsiveness of the ITS systems as it would provide better detection of malfunctions and improved traffic signal operations to meet needs.

#2. **ITS Phase 3.** ITS Phase 3 is focused on comprehensively upgrading core elements of the city's ITS to meet the needs of today and the future. Work will include:

- Essential upgrades to the Transportation Management Center systems and capabilities.
- Improvements at the Signal Shop to support expanded ITS test and repair capabilities.
- Upgrades to communications network to support reliable, resilient and responsive ITS services and traffic signal systems that the public relies on and expects today and into the future.
- Field device upgrades (detection, controllers, cabinets, CCTV cameras) at locations that are within the boundary of the communications network upgrades.

More information is provided in the project descriptions pages which follow.

#1   Performance Monitoring and Reporting System   Priority 1

BUDGET: $300,000		Map to Goal or Principle		BENEFITS
		Strong	Partial	
	RELIABLE	☑	☐	Improve public communications
	RESILIENT	☐	☑	Improve traffic signal timing
SCHEDULE: year 1	RESPONSIVE	☑	☐	Understand trends in travel times
				Evaluate effects of improvements
	TRANSPARENT	☑	☐	Support citywide planning/reduce data collection costs

PROJECT DESCRIPTION

Implement automated performance monitoring and reporting tool.

Includes:

- Implementation of travel time and performance measure detection in the field, data collection devices at controller cabinets, and 5 years license costs at 60 intersections
- Establishment of performance measures
- Automation of performance measure calculations
- Data archiving for use by all City departments for planning/study purposes
- Scope can be reduced to include fewer intersections

EXAMPLES OF AUTOMATED PERFORMANCE MONITORING AND METRICS
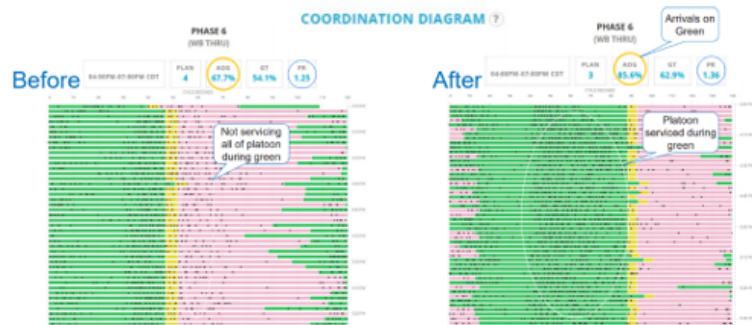
Automated Signal Operations Improvements Performance Metrics and Monitoring
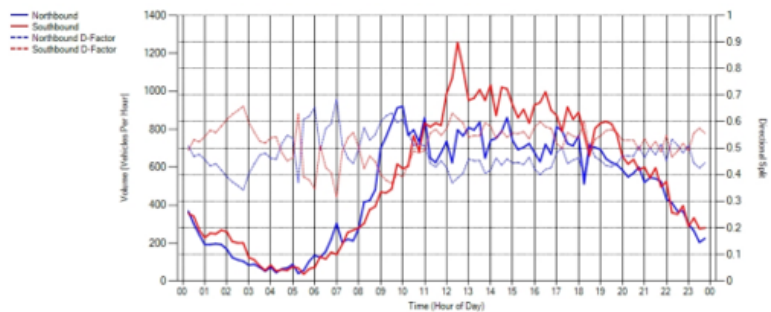
Automated Traffic Volume Data Gathering and Archiving
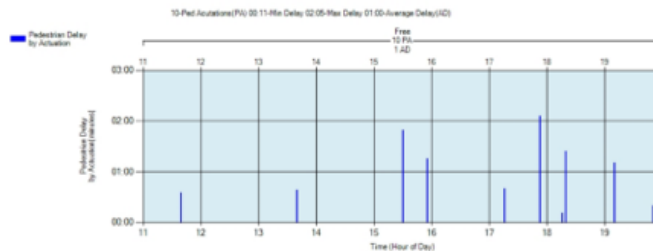
Automated Pedestrian Delay at Traffic Signals Performance Metrics and Monitoring

#2 ITS Phase 3 – Future Ready ITS

BUDGET:
$3.2 million

SCHEDULE:
years 1 to 5

	Map to Goal or Principle	
	Strong	Partial
RELIABLE	☑	☐
RESILIENT	☑	☐
RESPONSIVE	☑	☐
TRANSPARENT	☐	☐

BENEFITS

Fewer outages and malfunctions - when complete will enable the 100% Uptime/Reliability goal

Supports current and future ITS/video transmission needs

Future-ready to expand multimodal ITS capabilities and/or coverage

Supports maintenance response

PROJECT DESCRIPTION

Implement telecommunications, Traffic Management Center (TMC) improvements, maintenance signal shop improvements, and ITS infrastructure to provide virtual and physical redundancy, resiliency and capacity citywide.

Includes:

- Creates a reliable, resilient communications network
  - Overhead and underground fiber optic cable for physical redundancy, and added capacity at connections to ITS devices
  - Upgraded network equipment and hubs for capacity and reliability
  - Redundant servers for Traffic Signal and CCTV management systems
- Develops procedures for implementation and documentation of the network
  - Creates a process/system to improve ITS communications network asset management
- Includes essential upgrades to TMC systems and capabilities for resiliency and redundancy including additional server capacity and back-up/redundancy to speed restoration in case of failure
- Provides required improvements (electrical, IT, bench space, equipment) to traffic signal maintenance shop facility (Building F), and connectivity to central traffic signal system for expanded ITS diagnostics, test, and repair capability
- Includes upgrades to field ITS elements as needed, including upgrades to:
  - 10 CCTV cameras
  - Upgrade and add multimodal detection
  - 10 controllers/cabinets
- Planned for 4 "phases"
  - Design may modify final roll-out
  - Some or all of the phases can be accomplished (project can be scaled)
- Efficient "design-build" approach proposed

LEGEND:

━━━ Existing Fiber

● Existing RRFB

○ Planned RRFB
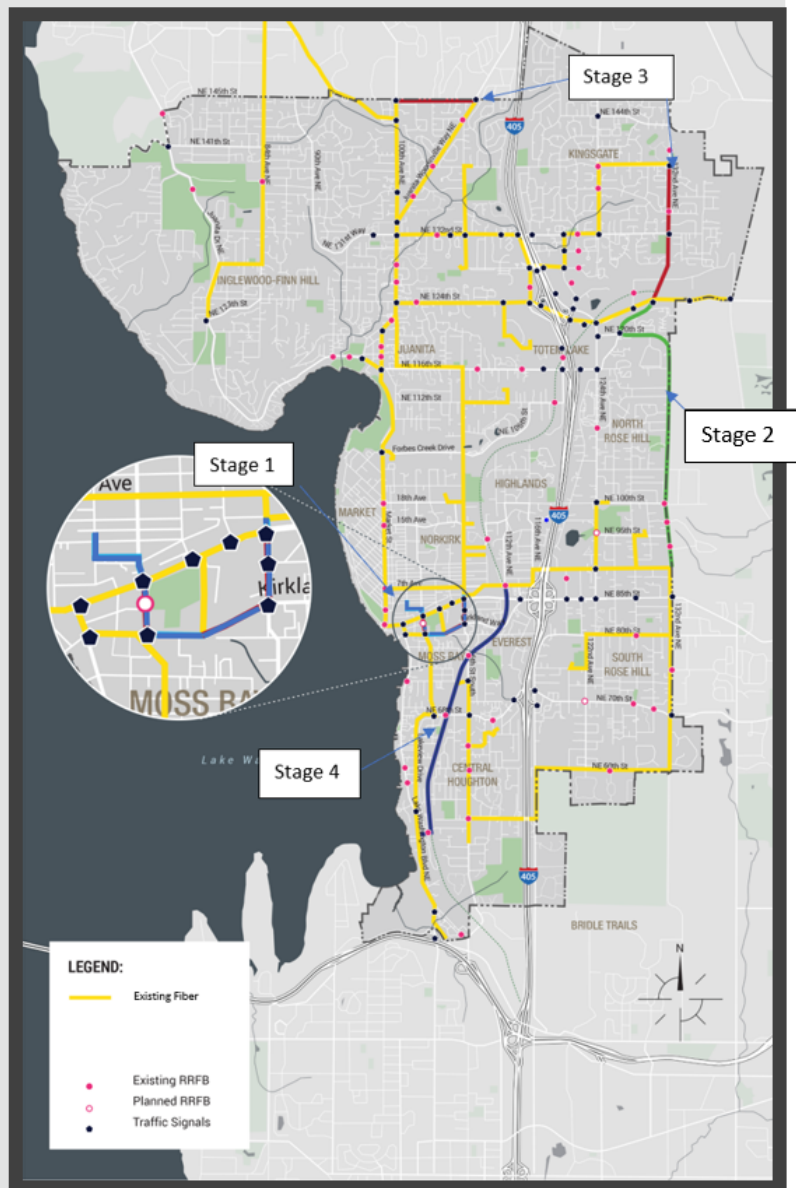
● Traffic Signals

#3 GPS-Based Opticom® Traffic Signal Pre-Emption Priority 2

BUDGET:
$500,000

SCHEDULE:
years 1 to 2

	Map to Goal or Principle	
	Strong	Partial
RELIABLE	☐	☐
RESILIENT	☐	☑
RESPONSIVE	☑	☐
TRANSPARENT	☑	☐

BENEFITS

Support reduced response times for KFD

Support reduced risk for KFD responders and the traveling public

Provides response time reporting tools

PROJECT DESCRIPTION

Implement GPS-based emergency vehicle traffic signal pre-emption software and systems. Provide for the capability to pre-empt around corners (not line-of-sight), increasing effectiveness of pre-emption calls for emergency responders. Provides fail-safe back-up to local operation in case of system failure.

Includes:

- Software platform with performance reporting tools
- Equipment for 20 intersections (remaining intersections are already equipped)
- Equipment installation on all KFD responder rigs and command vehicles

HOW IT WORKS

1. Opticom™ IR emitter sends a secure, encoded priority request to the intersection.

2. Opticom™ detector receives IR signal and relays the request to Opticom™ phase selector.

3. Opticom™ Multimode phase selector validates request from IR detector or GPS receiver, and alerts the traffic control system which requests a green traffic signal.

2. As vehicle enters radio range, Opticom™ GPS intersection equipment relays the request to Opticom™ phase selector.

1. Opticom™ GPS vehicle equipment transmits vehicle speed, direction and turn signal status to GPS intersection equipment.

CMS Use Central Management Software (CMS) to update system configuration, collect data and generate reports.

#4   Multimodal Detection Improvements

Priority 2

BUDGET: $500,000

SCHEDULE: years 1 to 5

	Map to Goal or Principle Strong	Partial
RELIABLE	☐	☑
RESILIENT	☐	☐
RESPONSIVE	☑	☐
TRANSPARENT	☐	☑

BENEFITS

More reliable and consistent cyclist detection

Contributes to Vision Zero goal

Improved pedestrian operations detection, including for disabled persons

More reliable vehicle detection, and additional detection for improved operations and performance monitoring

Purchase and install improved cyclist, pedestrian and vehicle detection, including vehicle system detection. Technologies may include traditional (loops) detection, or other (e.g. video, microwave, magnetometer) detection. Technology selection based on needs of each location. Potential to add passive pedestrian detection to support better pedestrian crosswalk clearance timing at signals – City will monitor progress of this emerging technology.

Includes optional purchase of a cyclist detection phone app/system. This system provides an app for cyclists to load on their phones, and provides detection of the cyclist on any approach at most traffic signals in the City. The system requires good cellular coverage, good GPS-based location service on the cell phone, and that the signal be connected to the City's central traffic signal software platform. Additional central software may also be required.

This project is scalable.

#5   Advanced Traffic Signal Operations Strategies and Software

Priority 2

BUDGET: $175,000

SCHEDULE: years 1 to 2

	Map to Goal or Principle Strong	Partial
RELIABLE	☐	☐
RESILIENT	☐	☐
RESPONSIVE	☑	☐
TRANSPARENT	☐	☐

BENEFITS

Improve operations during demand surges such as those due to:

- School operations and events
- Freeway incidents

Leverage existing traffic signal central control software capabilities to provide automated responsive operations. Budget includes outside consultant/vendor support to train staff on system set up and integration, and system use for these operations.

Procure and integrate operations software to support freeway incident detection and responsive operations. Includes consultant support for planning, signal timing development, and implementation. Requires added system detection near freeways to support operations, which is included in project #4, above.

This project can be scaled to include only one of the two elements noted above.

#6   Staff Training
Priority 2

BUDGET:
$20,000

SCHEDULE:
years 1 to 5

Map to Goal or Principle	Strong	Partial
RELIABLE	☑	☐
RESILIENT	☐	☑
RESPONSIVE	☑	☐
TRANSPARENT	☐	☑

BENEFITS

Ensures institutional knowledge is retained, despite staff turn-over, with 2X annual training schedule

Ensures staff can provide the highest quality signal and ITS operations

Reduces ITS Maintenance staff time devoted to CIP and Private construction as CIP Inspectors will be trained

Incorporate staff training standards into position descriptions and provide training. This includes regularly scheduled training up to twice per year in sessions to include staff from IT, ITS maintenance, Engineering, and Transportation (topic will dictate participation). Topics will include

- Advanced traffic signal timing strategies
- Interpretation of Purdue diagrams
- Vendor product training including operations, administration, installation, upgrades, and troubleshooting for central traffic signal and camera control platforms, and field equipment including multimodal detection

Develop materials and provide training for City CIP inspectors on ITS so they can inspect most ITS construction, ensuring ITS installations are correct and proper, and reducing rework and cost for CIP construction.

This project can be scaled to remove elements of the planned training.

#7   Develop and Adopt ITS Design Standards
Priority 2

BUDGET:
$35,000

SCHEDULE:
years 1 to 2

Map to Goal or Principle	Strong	Partial
RELIABLE	☐	☐
RESILIENT	☐	☐
RESPONSIVE	☑	☐
TRANSPARENT	☐	☐

BENEFITS

Ensures developer impacts to traffic operations and ITS infrastructure are addressed by defining construction standards related to ITS

Improves design and construction uniformity, reducing ongoing maintenance costs

Establish City of Kirkland-specific ITS standards and incorporate them into the City Design Standard. Include triggers for when ITS Design Standards require improvements be implemented (what, where, when).

#8   2024 ITS Plan Update

Priority 3

BUDGET: $100,000

SCHEDULE: year 5

Map to Goal or Principle	Strong	Partial
RELIABLE	☑	☐
RESILIENT	☑	☐
RESPONSIVE	☑	☐
TRANSPARENT	☑	☐

BENEFITS

Provides a milestone to measure progress in improving operations using ITS

Ensures ITS investments remain relevant in the face of changing needs, environment and technology

Update the 2019 ITS Plan. Create a new CIP and Operations plan and budget.

#9   Integration Plan for WSDOT Signals

Priority 3

BUDGET: $50,000

SCHEDULE: year 4

Map to Goal or Principle	Strong	Partial
RELIABLE	☐	☐
RESILIENT	☐	☐
RESPONSIVE	☑	☐
TRANSPARENT	☐	☐

BENEFITS

Reduce delay by improving traffic signal coordination on NE 124th St and NE 116th St

Develop technology strategies to enable traffic signal coordination. Project may include modelling of uncoordinated and coordinated traffic signal operations to illustrate benefits and impact to WSDOT facilities. Present information to WSDOT to negotiate operations improvements. Budget could include field equipment costs for ultimate implementation approach.

4.4 Ongoing Costs

Table 4-2 summarizes the estimated ongoing costs to meet the needs outlined in the plan.

Table 4-2: Ongoing Cost Estimates

NO.	PROJECT	1	2	3	4	5	RELIABLE	RESILIANT	RESPONSIVE	TRANSPARENT	Note
		BUDGETARY ESTIMATE BY YEAR (2019 DOLLARS)									
1	Comm Network Monitoring Software	$ 5,000	$ 10,000	$ 15,000	$ 15,000	$ 15,000	●	●		○	Licensing
2	Performance Monitoring	-	-	-	-	-	●	○	●	●	5 yr license due yr 6
3	Advanced Sginal Ops Software	-	-	$ 2,000	$ 2,000	$ 2,000		●			Licensing
4	Multimodal Detection	-	$ 10,000	$ 10,000	$ 10,000	$ 10,000	○		●	○	Bike app licensing
5	Maintenance Staff to Meet Min Need	$ 450,000	$ 450,000	$ 450,000	$ 450,000	$ 450,000	●	●	●		2 staff
6	Ops Staff to Meet Min Need	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000	●	●	●		1 staff
7	Maintenance Staff Stand-By	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	●	●	●		24X7 1 staff on-call
8	Additional IT Support	TBD	TBD	TBD	TBD	TBD	●	●	●		Includes weekend standby
9	Training	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	●	●	●		Training Costs
	TOTAL	$733,000	$748,000	$755,000	$755,000	$755,000					

● = Strong mapping to goal or guiding principle
○ = Partial mapping to goal or guiding principle

*IT Department to confirm cost of additional IT support, including IT weekend standby

The greatest share of the ongoing costs is related to meeting staffing needs, with costs for adding one operations staff person, and two additional maintenance staff reflected in the estimates. Remaining costs are for ongoing training, expanding IT staffing to complete 24X7 coverage, and various software licenses.

The investments that will produce the greatest value in meeting the ITS Plan Goals are those that add maintenance and operations staff. A reliable, resilient and responsive multimodal ITS operations requires a balance among the four core ITS elements. While the City has been working to keep pace with the growth in ITS maintenance and operations needs by adding staff positions, a deficit remains. Without additional investment in staff positions, the ability to meet the current and future needs of the City is compromised.

APPENDICES

APPENDIX A – WHITE PAPERS
- White Paper on Preparing for Automated and Connected Vehicles
- White Paper on Parking Systems

APPENDIX B – PEAK PERIOD TRAFFIC FLOW OPERATIONS – PRINCIPAL ARTERIALS

APPENDIX C – TRAFFIC OPERATIONS NEEDS ANALYSES
- Analysis of Impact of I-405 Incidents on City of Kirkland Principal Arterials
- Analysis of Impact of Removal of WSDOT Signals from Coordinated Operation

APPENDIX D – ADDITIONAL RECOMMENDATIONS FOR COMMUNICATIONS NETWORK IMPROVEMENTS

APPENDIX A

WHITE PAPERS

- White Paper on Preparing for Automated and Connected Vehicles
- White Paper on Parking Systems

White Paper on Preparing for Automated and Connected Vehicles

May 23, 2019

Introduction

The transportation industry is in the early stages of massive transformation, and many predict that it will undergo more rapid change in the next five years than has been experienced in the last 50 years. This change is coming in the form of new technologies and new mobility business models that are disrupting the ways that goods and people are transported on our roads and within our cities. The rapid development of automated and connected vehicles is one of the most significant areas of change, and cities are trying to make sense of an uncertain future.

Some call this the *Third Revolution of Transportation*, with the first two being the transition from horse and buggy to the automobile, and the second being the buildout of our nation's freeway system. With both of these first two transportation "revolutions", we as a society designed and built our cities around the automobile, and have experienced many adverse side effects of this ever since. As we enter this third revolution, we have an opportunity to learn from our past mistakes, and instead of building our cities around technology, we can decide what we want our cities to look like and make the technology work within that. Livability, safety and equitable mobility solutions for all of our citizens should drive this change, but this will not happen without proactive and progressive policy changes.

At the same time as these new technologies are becoming rapidly available, the new business models from the Shared Economy are also impacting people's mobility choices. Transportation Network Companies (TNC's) such as Uber and Lyft, are giving citizens more mobility options, but are also having negative impacts on congestion in our downtown corridors. The combination of shared mobility and automated vehicles are projected to have significant effects on parking, including both on-street and surface lot parking. The revenue impacts for our cities could be considerable, but this also opens an opportunity to rethink the way that we use our curb space and our right of way. To achieve the outcomes that we desire, we will need bold and proactive policy decisions.

This paper presents three policy positions the City could consider with respect to Connected and Automated Vehicles (CAV):

> **Policy #1 "Wait and See"** – Automated vehicles (AVs) are a low priority until the market demonstrates the technology is feasible and safe to operate.

> **Policy #2 "Moderate Welcoming"** – The City may choose to implement a pilot project to test an automated shuttle.

> **Policy #3 "Leading Edge"** – The City may choose to fund a deployment, and collaborate with other eastside cities to develop a subarea approach to AVs.

Purpose of This White Paper

This white paper describes automated and connected vehicles, identifies some relevant opportunities and applications, explains what the City of Kirkland can do to get ready, and provides potential policies and the implications.

Automated and connected vehicles use cameras, sensors, automated systems, and communication technology to automate the vehicle's acceleration, braking, and steering, and communicate warnings from other vehicles and the infrastructure.

Automated Vehicle Basics

Automated vehicles (AVs) have varying levels of automation ranging from adaptive cruise control, lane-assist technology up to full automation with no pedals or steering wheel. The Society of Automotive Engineers (SAE) has identified six levels of automation to describe the range of human involvement in the vehicle operation from full control (no automation) to full automation.

AVs will impact our transportation system in dramatic ways. They have the potential to eliminate nearly 90 percent of transportation fatalities and, if they are shared, could result in reshaping our City streets reducing the need for on-street parking.

Projections about when AVs will become common place vary like with any forecast, but most experts agree that AVs will be operating on our roadways faster than most people think. At a minimum, fleets – taxis, trucks, shared rides – will begin operating AVs on our city streets by 2020. In fact, Waymo is operating a fleet of automated vehicles in Phoenix, AZ today. Most vehicle manufacturers including Ford, forecast that they will have fully automated vehicles in the next couple of years. Once the technology is proven and reliable, the change to the majority of the fleet becoming automated will likely take between 10 and 20 years with nearly 95 percent of vehicles being fully automated around 2040.
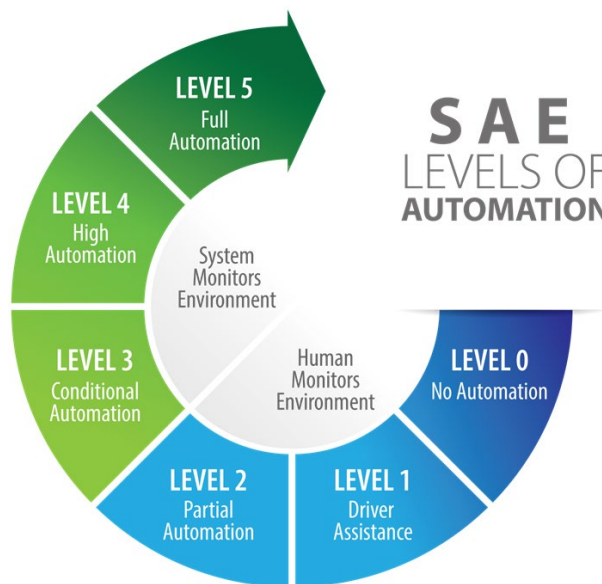
Connected Vehicle Basics

Connected vehicles (CVs) can send data to and/or receive data from their environments while in operation. Connected vehicles will be able to communicate with other moving vehicles and with the roadside infrastructure improving the situational awareness for both automated and human-driven vehicles. Using communication technology, vehicles will have advanced notification of incidents and/or events happening around them that the cameras and sensors on the vehicle otherwise would not "see." The following list presents a sample of the notifications that a connected vehicle could receive:

- Slowing or stopped vehicles ahead
- An approaching emergency vehicle
- Hazardous weather conditions or icing on the roadway
- Traveler information including road conditions ahead

The CV technologies involved are maturing rapidly, and their eventual use will require public agencies to provide supporting institutional and physical infrastructure.
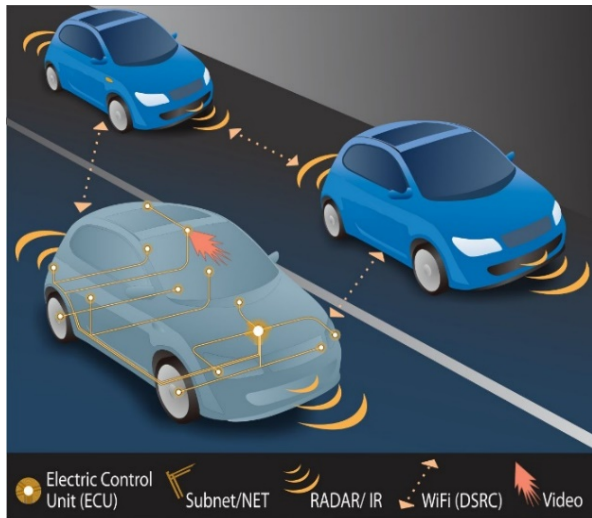
Vehicle-to-vehicle (V2V) communications
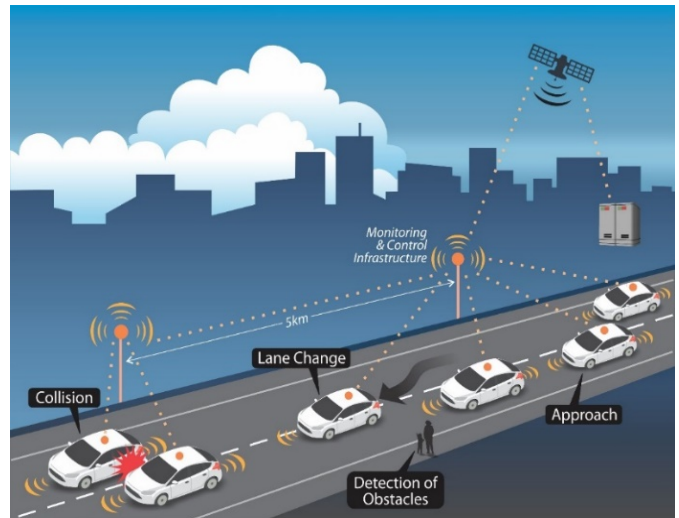
Vehicle-to-infrastructure (V2I)

Relevant Automated Vehicle Opportunities and Connected Vehicle Applications

This section presents relevant AV opportunities and CV applications to help policy makers, planners, and designers anticipate the breadth of implications AVs and CVs could have on our communities.

Automated Vehicle Opportunities

As we move forward considering AV policies, testing and implementing AV technology, it is important to be mindful that there are many applications for automated vehicle technology. Typically, the general public thinks of an automated vehicle as the 4-door sedan with all the technology on top or a low-speed automated shuttle. In reality, AVs will vary widely in size, shape, and functionality and be ready to support mobility options for people and movement of goods between and within cities. Everything from passenger vehicles, to transit vehicles, to long and short-haul trucks, to garbage trucks, to agricultural and mining equipment will have AV equivalents. When setting policies for our cities, it is vital to consider the full range of AV applications that will emerge.

For Kirkland, early AV deployment could include:

- Low-speed automated shuttles on dedicated routes either on campuses or public streets
- On-demand fleets of automated vehicles operated by a private service provider, such as Waymo, potentially reducing auto ownership as subscribers use vehicles on demand
- Automated local delivery vehicles

Connected Vehicle Applications

As part of its Connected Vehicle program, the USDOT has defined 56 distinct CV applications[8] that enable vehicles to "talk" to other vehicles or the infrastructure. This allows vehicles to share hazardous roadway conditions with other vehicles for example. The USDOT list of applications can be the starting point for the

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[8] https://www.its.dot.gov/pilots/cv_pilot_apps.htm

DKS

City to begin to consider which are most relevant to the City's goals and objectives and to narrow the list accordingly. For example, the City may choose a mobility application that connects the intersection to approaching vehicles and prioritizes green time based on the presence of high occupancy vehicles such as buses. USDOT categorizes the applications into high-level functional groups and associated application "bundles" including:

- Safety
- Data sharing
- Environment
- Road weather
- Mobility

A sample of CV applications that may be relevant to the City of Kirkland include:

- Transit and truck signal priority
- Intersection signal phase and timing information provided to drivers/vehicles
- Warning messages that vehicles are stopped ahead.
- Warning messages a vehicle may be running a red light violation warning provided to drivers/vehicles

The warning messages are provided in the vehicle, can be visual, sensory, and or auditory and aim to reduce rear-end crashes.

Many CV applications that share roadway condition information using the cellular network are feasible today, while CV applications using high-speed dedicated short-range communications (DSRC) radios currently have limited application since there is no Federal requirement to provide DSRC on vehicles, which results in very few vehicles equipped with DSRC radios. In addition, the DSRC standard has an uncertain future since the Federal Communications Commission (FCC) is currently considering opening up the dedicated connected vehicle frequency band (5.9 GHz) for use by cellular companies. At this time, it's not possible to predict a date for when the FCC will make a decision on the future of the 5.9 GHz band.

What the City Should Consider to Be Ready for the AV/CV Future

Every city is currently asking what they should do to be ready for automated and connected vehicles. It's an important question to consider such that cities can establish policies that ensure the technology deployed matches the community's goals.

What Should the City do to Prepare for Automated Vehicles?

Automated vehicles have the potential to reshape City streets. For instance, AVs may be shared, continuously operating vehicles that significantly reduce the need for parking and increase the demand for pickup/drop off zones. There are a few things the City may consider now to prepare for automated vehicles:

1. Conduct outreach to engage with a larger stakeholder audience composed of private sector stakeholders including local business and technology companies
2. Identify existing regulatory and/or legal hurdles to AV investment and testing
3. Consider policies and positions the City may choose when the private sector begins to operate AVs, particularly because AVs may increase overall vehicle miles traveled (VMT) if they are individually owned or driving around with zero occupants.
4. Consider and plan for AV use cases that may be meaningful in Kirkland

DKS

5. Follow the developments, learn from other public agency policies, and shape the City policy and direction based on lessons learned

What Should the City do to Prepare for Connected Vehicles?

Connected vehicles will need to communicate with the roadside infrastructure and intersections will serve as key data collectors organizing and communicating safety and traveler information. Intersections with traffic signals typically have the majority of equipment needed to support communications to a vehicle including high-speed communications, sensors, cameras, and a computer/controller. Even so, some improvements will be required to run a CV application and communicate directly to the vehicle.

Currently, there are three specific actions the City can take now to prepare for connected vehicles. The three things set the foundation for future connectivity and ensure the City's current transportation infrastructure investments align with a connected future.

1. Install (or continue to install) a reliable, resilient communications infrastructure with capacity to support CV applications.
    a. Improve throughput (e.g., fiber), reliability (IP-based networking and redundancy), coverage (field-to-center and center-to-center links)
    b. Installing communications infrastructure today enables new CV applications and supports many well-established systems such as signal priority, real-time data collection, adaptive signal control, automated signal performance measures, video sharing, video analytics, and traveler information.
2. Install the advanced transportation controller (ATC), which provides an intelligent intersection computer the City can use to operate future CV applications. Note: The City has been installing the Siemens M60 controllers, which are compliant with the ATC standard.
3. Plan additional capacity in intersection conduits and on poles, for potential public-private partnerships and future City needs

Potential Policies and the Implications

This section presents three policy positions the City could consider with respect to Connected and Automated Vehicles (CAV) and the potential benefits and drawbacks for each.

For any of the following three policies, the City of Kirkland should consider monitoring and measuring changes that occur including:

- **Change in parking demand on-street, in surface lots, and garages**. With shared, automated vehicles it is likely that parking demand will decrease.
- **Change in VMT**. With automated vehicles, VMT likely will increase unless shared-use policies are implemented, which encourage multiple passengers within the vehicles. The worst-case scenario is individually owned, automated vehicles traveling city streets with zero people on-board.
- **Change in curb use.** As on-demand rides and delivery services increase, the demand for pick-up/drop-off locations will increase changing how we use our curb space.

- **Change in interactions between vehicles and vulnerable road users**. Automated vehicles rely on sensors and cameras to navigate and avoid crashes. AVs must be able to "see" vulnerable road users, and the City should plan to monitor crashes involving automated vehicles.

Monitoring and measuring these changes can be accomplished using sensors, cameras, and/or third-party data. The City can also leverage communications infrastructure installed to traffic field devices to transport the field data to a central data monitoring system.

Policy #1: "Wait and See"

A "wait and see" policy is conservative about committing too early to a particular technology or solution. Recognition that there are many advances occurring in CAV with significant potential benefits in safety, mobility, and operational efficiency, but that the field is still too new to develop practices around—standards still evolving, core technologies still being evaluated, and how much of the purported benefits can actually be realized in a real-world setting is still being debated.

Leadership Position

"Wait and see": other agencies, regions, etc. are better suited to advance the development, testing, and validation of these solutions. The implication is that City will have less of an opportunity to influence how the applications and technology advance, regarding practices, standards, use cases addressed, partnerships, and location of investments.

CAV Investment Priorities

"Wait and see" policy promotes targeting CAV investments that satisfy two criteria: (1) are likely needed for future CAV applications and (2) also support immediate needs that have a well-understood benefit and value.

All three recommendations from the previous section—upgraded communications infrastructure, adoption of modern ATC controllers, and allocation of additional capacity in the field—satisfy both criteria.

These priorities provide the City the fundamental capabilities and capacity to introduce new functionality as CAV applications become established. And these investments can all be activated on day 1, supporting any number of established use cases.

Benefits	Drawbacks
- Lowest risk of committing resources and making investments in solutions that may become obsolete or do not provide benefit - The policy may be more in line with City's general philosophical approach; easier anticipated adoption and implementation	- Minimal ability to affect how technology evolves and what use cases are prioritized (i.e., once tech and applications are established, may not be well suited to City's needs) - Potential missed opportunity to leverage local technology/corporate partners

Policy #2: "Moderate welcoming":

A "moderate welcoming" policy maintains most of the conservativism of the "wait and see" policy, but seeks some limited, strategic opportunities to participate in and potentially influence the development of

DKS

CAV tech and applications. The City acknowledges the benefits of CAV and believes they may have applicability within the City. The City has identified a use case where CAV makes sense and is willing to expend budget, resources, and political capital to implement a limited test.

Leadership Position

Policy acknowledges that other regions and agencies will be at the leadership forefront (think San Francisco, Phoenix, Pittsburgh for AV testing and the various CV testbeds—New York City, Tampa, Wyoming, Columbus) but Kirkland can be opportunistic in the few areas it wants to develop and help influence how the technology and applications evolve. Leverage proximity to and relationship with local technology companies such as Google, Costco, T-Mobile or Microsoft.

CAV Investment Priorities

"Moderate welcoming" policy pursues the investments identified in "wait and see", but introduces more formal standards and requirements to integrate into future projects on a Citywide basis. Example strategies could include:

- Collaborate with other eastside cities – Bellevue, Redmond, WSDOT and others to develop a sub-area approach to CAV.
- Seek out a pilot/demonstration project and/or partnership arrangement with another agency or corporate partner. Examples:
  - AV shuttle pilot with a local technology partner such as Google
  - AV circulator around the waterfront
  - CV demonstration on Central Way—Signal Phase and Timing (SPaT), Transit Signal Priority (TSP), Freight Signal Priority (FSP), transit safety partnership w/ King County Metro
  - Make signal state info available publicly via an application programming interface (API) to enable app developers, original equipment manufacturers (OEMs) to integrate into real-time navigation/traveler information applications.

Benefits	Drawbacks
- Good overall risk balance—conservative long-term technology planning, limited scale/exposure in a higher-risk pilot - May raise the profile of City in CAV/technology world; a potential attractor for innovative technology companies (economic development opportunities)	- May represent a shift in City's approach with respect to investing in innovative technology, public-private partnerships; institutional/political pushback possible - Potential missed opportunities in areas not that are not emphasis areas.

Policy #3: "Leading edge":

An "all in" approach, with the City implementing one or more CAV concepts on a large scale. This policy represents the most significant shift and a bet that CAV is operationally ready. The City must be confident that both the technology is mature enough and that there is a concrete use case in Kirkland that would provide real safety, mobility, or efficiency benefits. Resulting from this policy would be a significant

dedication of budget, resources, and political capital. It may also result in new organizational and business models, with a closer partnership with third-party service providers or other private entities.

Leadership Position

Significant shift to establish a national leadership role in CAV.

CAV Investment Priorities

Significant investments in updating field equipment, potentially city-wide. Examples:

- Upgrade intersections to be DSRC V2I-capable and equip fleet vehicles (transit, freight, personal vehicles, etc.) with onboard CV equipment
- Automated bus/shuttle connector providing frequent service between key nodes (downtown transit center, park & ride, future light rail)
- Establish dedicated lanes for CAV
- Collaborate with other eastside cities – Bellevue, Redmond, WSDOT and others to develop a sub-area approach to CAV.

Benefits	Drawbacks
Riskier approach and the benefits are not well known, but if successful, could position the City as a leader in new and smart mobility applications and ultimately a potential attractor for innovative technology companies (economic development opportunities)	- Greater chance for failures on specific projects because the technologies are emerging - Potential missed opportunities in non-ITS related initiatives as limited resources are shifted under this approach.

Additional Resources

Provide a sample of resources the City can use to learn more and/or monitor progress.

- [NACTO Blueprint for Autonomous Urbanism](#)
- [Oregon DOT Automated Vehicle Use Cases](#)
- https://drivingtowardsdriverless.com/

PARKING SYSTEMS WHITE PAPER

This White Paper summarizes information supplied in a parking and curbside management technology review (Attachment B) conducted in support of the City's 2019 ITS Plan Update. It provides information to support future policy decisions related to the potential to implement future parking management technologies.

1. CURRENT PARKING MANAGEMENT APPROACH AND SYSTEMS

Today, the City focuses parking management in the downtown core, and in the area surrounding Juanita High School.

4.5 1.1 DOWNTOWN MANAGED PARKING

The City of Kirkland parking brochure, provided as Attachment A, identifies where parking is paid and/or time-managed. Two off-street parking lots are paid. No other parking lots, and no on-street parking is paid. Time management is as shown on Attachment A.

4.6 1.2 DOWNTOWN PRIVATE PARKING

Several private lots exist within and surrounding the Downtown core. These facilities contain a mix of free, pay-to-park, and permit parking. City staff gathered information on available parking at various locations, and shared the information with the Kirkland Chamber of Commerce (COC) to support the COC's coordination of matching businesses that need parking with parking space owners.

4.7 1.3 DOWNTOWN EMPLOYEE PARKING PERMIT

Downtown employees are encouraged to park in designated areas to allow downtown patrons to access optimum parking spaces. Employee parking is free with registration, although the City is exploring a paid registration system. Employee permit only-designated areas are located in the Peter Kirk Municipal Garage (located under the Kirkland Library), along Lake Avenue West (signed permit parking only area), and in the Wester Lot on 3rd Ave.

4.8 1.4 RESIDENTIAL PARKING PERMIT PROGRAM

Downtown. Residential parking permits are available for selected areas in the downtown.

Near Juanita High School. Parking on streets around Juanita High School are restricted by a residential permit program to limit spillover from the high school. Permits are required to park on the streets identified in Figure 1, below, from 8:00 a.m. to 2:00 p.m. on school days. Guests permits are also issued to residents.

Figure 3: Residential Parking Permit Program Near Juanita High School

4.9   1.5   CURRENT PARKING PAYMENT SYSTEMS

Off-street paid parking is available for up to four hours and costs $1 per hour from 9:00 a.m. to 9:00 p.m. Monday-Saturday. Parking may be paid via credit card at gate stanchions upon entering the parking lot. Kirkland also provides a mobile payment app for off-street parking (via PayByPhone®).

4.10   1.6   CURRENT PARKING ENFORCEMENT SYSTEMS

On-street parking is enforced using Parking Enforcement Officers (PEOs) of the Police Department Traffic Unit. The Traffic Unit uses a manual and electronic chalking system to monitor time-limited on- and off-street parking spaces (two to four hour limit). The system relies on license plate recognition (LPR) software which time stamps the license plate of each parked vehicle as the PEO drives by. During subsequent passes, any vehicle parked beyond the time limit triggers an alarm on the PEO's system, and the PEO then issues a citation.

2. 2014 - 2016 DOWNTOWN PARKING STUDY AND SUBSEQUENT ACTIONS

The City commissioned a Downtown Parking Study in 2014. The study recommended several actions, including increasing parking supply, changing time limits, and modifying the locations where Downtown employee parking permits were valid. The recommendations were implemented, and staff provided additional outreach and has conducted reviews of compliance and occupancy in the downtown area.

The study also recommended that in-lane counters be installed at paid parking and the Library garage.

3. CURRENT PARKING POLICY

The City's Comprehensive Plan outlines the following parking policies:

> Policy T-4.4 Take an active approach to managing on-street and off-street parking.

> Parking policy can have substantial effects on Urban Form. Ideally, parking occupancies are around 85 percent; at this level, parking spaces are available, but there is not a large vacancy indicating oversupply.

Pricing can be used to influence the choices people make about where and how long to park. Pay parking also generates revenue that can be used for a variety of purposes.

Kirkland's business areas; Downtown, Totem Lake, and neighborhood business districts have different needs for parking and should be treated individually.

Large amounts of new parking supply are often expensive and difficult to site. Therefore, efforts should focus on increasing supply strategically in smaller amounts. Where occupancies are high, pay parking has the potential to decrease demand for the best stalls and generate revenue for other improvements, but it is implementable only when supported by the community.

Effective signing and information about available stalls are other ways to get the most from existing supply. How employee parking is provided also has implications that affect Kirkland's downtown parking supply and therefore employee parking policy should be carefully considered. Parking spill over from commercial areas can have impacts on residential neighborhoods and those impacts should be monitored and appropriately mitigated.

Over the long term, increasing use of walking, biking and transit along with changes in land use will make differences in the amount of parking that is needed. Similarly, car sharing and other changes in car ownership may change the way parking is used. For example, places for cars to wait for shorter times may be an increasing need.

Policy T-7.7 Partner with the private sector and other "new" partners.

Kirkland should look for partners outside governmental agencies. Identifying and connecting with other partners could help fund or deliver a range of projects and services including bike share, transit alternatives, traffic data, parking solutions, and a range of improvements on the Cross Kirkland Corridor.

The City's approach to parking aligns with these policies. Potential consideration for changes to policy are discussed later in this White Paper.

4. TRENDS THAT MAY IMPACT PARKING DEMAND

The following current and future trends will affect parking demand, in particular in the City's Downtown core and potentially Totem Lake.

- **Curbside Management.** In addition to parking, the curbside faces competing demands including from:
    - *Transit.* Transit for stops and transit-only lanes (full or part-time), which reduce available on-street parking.
    - *Freight.* Many cities are seeing increased pressure to move freight loading/unloading zones to "around the corner" to minimize the impact on prime parking.
    - *Transportation Network Companies (TNCs).* The impact of TNCs (e.g. Uber and Lyft) will be on demand for loading/unloading. Aside from a reduction in parking demand, the biggest effect of TNC rides is the impact of passenger loading/unloading. Cities are beginning to have to turn on-street parking to passenger loading zones to support TNC use and minimize illegal and disruptive behavior of TNCs when picking up and dropping off passengers, with Las Vegas as a recent example. Some cities are requiring TNC space from private developments, and in private parking lots.
    - *Bicycles.* Bicycle lanes and cycle tracks may reduce available on-street parking.

NACTO and ITE's Complete Streets Council released an publication in December 2018 titled the Curbside Management Practitioner's guide (https://www.ite.org/technical-resources/topics/complete-streets/curbside-management-resources/), which provides more information and concepts for managing the curbside.

- **Reductions in Parking Demand.** Most studies suggest that parking demands, particularly in urban core areas, will trend down in the longer-term future due to the following:
  - *TNCs.* As noted above, TNCs are expected to reduce parking demands. In more densely developed and populated cities, hotels are seeing up to a 70 percent decline in parking by business travelers, although there is much less impact on leisure traveler parking, as well as banquet and local event parking. Restaurants and bars, particularly those with valet parking, are seeing up to an 80 percent reduction in parking, apparently due to concerns both for convenience and cost of parking, and to avoid drinking and driving.
  - *Car Sharing.* If car sharing services are embraced by the public, a reduction in vehicle ownership and associated parking demands will ensue.
  - *Trends in Car Ownership.* Although there has been a perception that car ownership per person is lower in younger populations, several recent studies indicate that there is no or insignificant changes in car ownership today. A recent MIT study[9] showed only a 1% decrease in car ownership by millennials. Similarly, a study by ThinkNow Research (https://thinknowresearch.com/blog/the-future-of-vehicle-ownership-2019-purchase-trends/) found little change is attitudes today towards car ownership among all age groups. However, they found that driving behaviors appear likely change due to TNCs, car sharing services, and electric scooter sharing services. The impact of these services will be to reduce parking in downtown core areas, with some persons parking on the periphery of the core and using scooters or TNCs to enter the core.
- *Autonomous (or automated) vehicles.* While many in the planning community project as much as a 90 percent reduction in parking demand in the U.S. within a decade or so due to autonomous vehicles (AVs), others believe it will be slower and much less impactful. This reduction requires an associated reduction in car ownership that, as noted above, is not (at least not yet) happening. Mary Smith, Vice President of Walker Consultants, a national parking management and consulting firm that engages both public and private sector clients, was recently interviewed by the Commercial Property Executive web site (https://www.cpexecutive.com/post/parking-demand-trends-the-impact-of-transportation-network-cos/). She noted that:

    "About one-third of Americans live in areas with a population less than 200,000 people, where shared TNC rides are unlikely to be nearly as cost-effective and convenience and comfort will play a bigger role. Further, we have 260 million non-automated vehicle (AV) cars on the road today, and millions more that will be sold in the next decade (before AVs are available to consumers). We think there will be a maximum reduction in parking demand across the U.S. of about 40 percent, and that the full impact won't be achieved

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[9] Generational Trends in Vehicle Ownership and Use: Are Millennials Any Different?, Christopher R. Knittel and Elizabeth Murphy, Massachusetts Institute of Technology, February 8, 2018.

until at least 2050. Where a parking facility serves activities that grow with population, like airports, downtowns and universities, the parking demand will continue to rise through about 2030 and then come back down to the demand today around 2050. Certainly, the impact will be much higher than a 40 percent reduction in the urban core areas, but it will be lower in suburbs and much lower in rural areas and smaller cities and towns."

The effects of AVs in the longer term will include a reduction in parking due to driverless TNC rides, "autonomous parking" by privately owned AVs, will allow passengers to be dropped at the door and then the car will go and park itself. AVs will not require as much real estate to park. AVs can park closer together, because car doors don't need to be opened at the parking stall. As a result, the capacity of parking facilities may go up at the same time parking demand goes down.

5. CONSIDERATIONS FOR FUTURE POLICY DIRECTION

Given that the trends noted above may not produce significant changes until some 25 years in the future – but could be realized sooner - the City should consider the following to help them prepare for an uncertain future:

- ***Explore Building Code Changes For Structured Parking.*** To prepare for a future where parking demand is reduced, the City should consider potential changes to building codes related to structured parking that support transitions to other uses. The design life of a typical commercial building is 50 years, and many buildings have a longer useful life before they are demolished. So, buildings constructed today should include considerations for an uncertain future. With a likelihood of reduced parking demand in the future, structured parking could be built to enable ready conversion to other uses. An analysis of the impact of such a Building Code requirement on construction costs should be conducted, to ensure that the economic impact is not so great as to reduce the attractiveness of development. Such a code change would apply to areas where parking supply is provided in parking structures and underneath buildings, such as in the Downtown and Totem Lake.

- **Position the City to Adapt to Technology Changes, and Support Parking Performance Monitoring.** The City should position itself to implement robust parking/curbside data analytics to understand trends within its own borders, enabling a more rapid response to change. The following initiatives are suggested for consideration by the City:
  - *Implement Permanent In-Lane Counters At City Pay and Free Parking Lots.* The 2014 Parking Study recommended that in-lane counters be installed at all parking lots, with wireless communications to a central computer to store the data. With this data, an improved understanding of City-owned off-street parking demand can be developed.

- *Code the Curb.* Taking on-street parking inventory a step further than current approaches, some private companies and a couple of large cities have attempted to "code the curb,", automating the inventory process. Such a concept would systematically record curb assets on city streets, and then automatically update them, either by applying AI features or by allowing users to submit updates to signage or regulations. An excellent resource for understanding a Code the Curb effort can be found at: https://www.citylab.com/transportation/2019/04/smart-cities-maps-curb-data-coord-sidewalk-tech-street-design/586177/.

  The inventory should focus on Downtown and potentially Totem Lake. With such a detailed and electronic inventory, the City will be better prepared to provide electronic data sets for performance monitoring, private sector use such as in parking applications, and potential future private-sector automated occupancy studies, perhaps using satellite imaging. The City could also explore developing an update to the GIS data set, possibly through a third party code-the-curb effort, through a traditional GIS mapping effort.

- *Technology Readiness.* The rapid pace of change in technology may lead to innovations in parking management systems and in parking user demands that the City will find important to support policy. Figure 2, below, provides an overview of the components of Smart Parking systems, and Table 1 provides capsule descriptions of each element and suggest how the City should position itself to be able to respond to opportunities in the future.
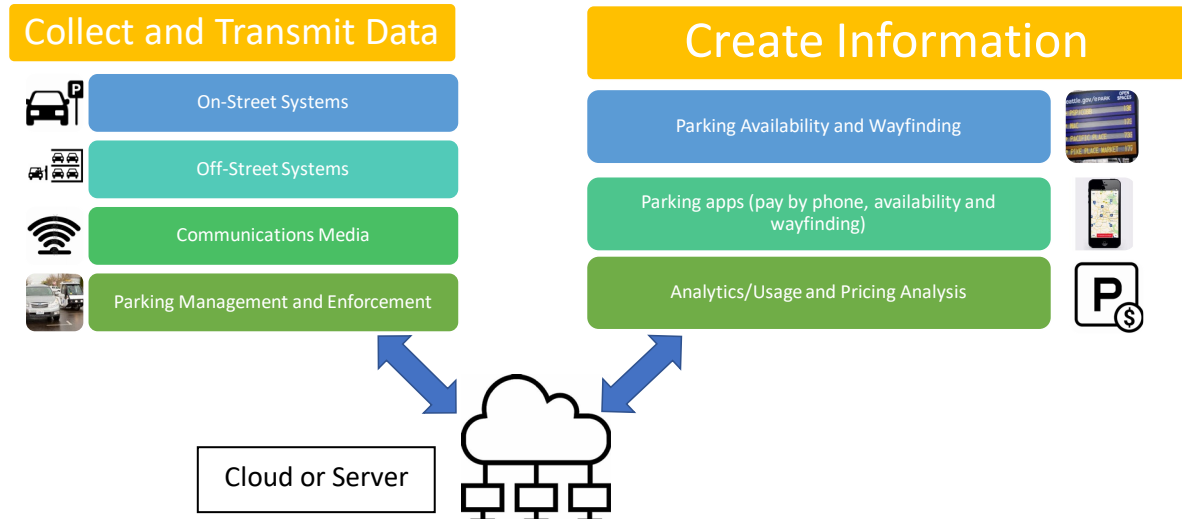

Figure 4: Overview of Smart Parking Technology Components

Table 3 (on two pages): Recommendations for City of Kirkland to Be Ready for Future Technologies

Technology Component	Description of Key Functions/Systems	Current City Implementation Status	Recommendation to Position for the Future
Foundational Technologies – Collect and Transmit Data			
On-Street Systems	May include: ■ Smart parking meters that prevent plugging the meter and use of previously paid time left over by another parker, and include occupancy detection. ■ Occupancy detection in the absence of smart meters such as detectors placed in spaces, video or other technology ■ Dynamic, demand-based pricing	Because there is no metered on-street parking in the City, none of these technologies have been implemented.	Implement electronic inventory such as a Code the Curb approach. See "Communications Media".
Off-Street Systems	May include: ■ Occupancy detection, either via in-lane detectors, or occupancy detectors in each space. ■ Dynamic, demand-based pricing	No off-street parking systems have been implemented to date.	Require future City-owned parking systems to provide open data interfaces, so data can be integrated into any future third-party applications and analytics. May also require the data be provided from private parking facilities.
Communications Media	May include: ■ Public-sector owned or leased private sector wireline communications ■ Public-sector owned or leased wireless communications	City fiberoptic (wireline) communications are in place between major City buildings.	Install Innerduct/conduit for future wireline communications whenever sidewalks or street are opened in Downtown and Totem Lake.
Parking Management and Enforcement	May include: ■ Dynamic, demand-based pricing ■ LPR-based enforcement systems ■ Hand-held enforcement systems ■ E-citations	City has implemented LPR-based enforcement, which includes capability to perform analytics.	Require future City parking management and enforcement to provide open data interfaces, for integration with analytics tools. See "Communications Media".

Technology Component	Description of Key Functions/Systems	Current City Implementation Status	Recommendation to Position for the Future
Data-Driven Technologies – Create Information			
Parking Availability and Wayfinding	May include: • Electronic message boards noting space availability at participating lots and potentially on-street locations. • Wayfinding signage • Data feed integrated with third-party web/phone applications	No parking availability or wayfinding systems are currently in place.	Require all parking technologies to include an open interface to integrate with any potential future parking availability and wayfinding systems.
Parking Apps	May include: • Parking payment • Parking availability • Parking wayfinding	City has implemented third-party parking payment app.	Require all parking technologies to include an open interface to integrate with third-party parking apps.
Analytics, Usage and Pricing Analysis	May include: Vendor-supplied or internally-developed analytics tools to assess usage, infraction frequency, and occupancy. Real-time dynamic pricing capability	City is using third-party analytics provided with LPR technology to support understanding of compliance with on-street restrictions.	Require all parking technologies to include an open interface to integrate with a vendor-supplied or City-developed analytics platform.

Free Parking

30-Minute Parking
- On-streets
- In lots

2 Hour Parking
- On-street

4 Hour Parking
- Peter Kirk Municipal Parking Garage located under the Kirkland Library. Entrance is on Kirkland Avenue.
- Market Street (Central to 6th Avenue)

Pay Parking

Up to 4 Hour Parking (Mon-Sat)
$1.00 per hour credit/debit/coin and **Pay by Phone*** from 9 a.m. to 9 p.m.
- Lakeshore Plaza lot/Lake & Central Lot from 9 a.m. to 9 p.m.

Private Pay Parking Lots
- Available for customer parking mostly in the evenings and on weekends.

Night and Weekend Non-restricted Parking

- City Hall visitor and non-assigned stalls
- Wester Lot on 3rd Ave. (next to City Hall)

Non-restricted Parking

No time-limit Parking
- 3rd Avenue between 1st and 2nd Streets

Boat Trailer Parking

- Heritage Park (April 1 - October 31)
- Westside of Market Street, Central to Waverly: (after 6 pm on weekdays; unrestricted time weekends and holidays)

♿ Accessible Parking

On-street Parking
- Central Way and Market Street (1)
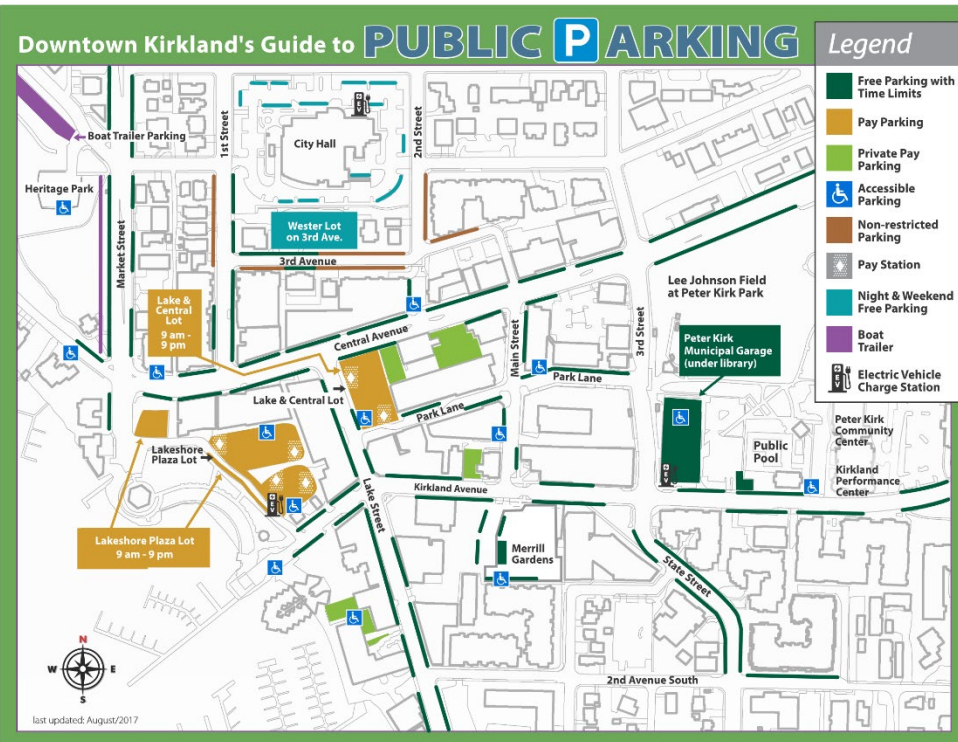- Main Street (1)   •   Lake Ave. West (1)

Parking Garages and Lots
- Merrill Gardens parking garage (1)
- Peter Kirk Municipal Garage (9)
- Lake Street lot (3)
- Lakeshore Plaza (5)
- Pool/KPC/PKCC (6)
- Central Way (1)
- Heritage Park (1)

( ) number of stalls

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Downtown Kirkland's Guide to PUBLIC PARKING

Legend
- Free Parking with Time Limits
- Pay Parking
- Private Pay Parking
- ♿ Accessible Parking
- Non-restricted Parking
- Pay Station
- Night & Weekend Free Parking
- Boat Trailer
- Electric Vehicle Charge Station

last updated: August/2017

APPENDIX B
PEAK PERIOD TRAFFIC FLOW OPERATIONS – PRINCIPAL ARTERIALS

- White Paper on Preparing for Automated and Connected Vehicles
- White Paper on Parking Systems

Subject to the modal balance/emphasis identified for each principal arterial, the goals for traffic signal operations is to minimize vehicular delay and travel times.

During the peak periods, traffic flows on principal arterials tend to be heaviest to and from the freeways, and the signal operations goal is to manage that flow. Figure 2-2 shows the desired flow emphasis in the AM and PM peak periods.

During the mid-day period and on weekends, the goal is to time traffic signals to respond to a balanced flow profile for the mainline movement on principal arterials. During the late night/early morning periods, traffic signals are operated in fully-actuated, or "free", operation, and rest in green on the mainline.

Figure B-1: Flow Emphasis on Principal Arterials

APPENDIX C
TRAFFIC OPERATIONS NEEDS ANALYSES

The analyses use traffic data provided by INRIX, a traffic travel time data provisioning firm. The data has some limitations due to the sources, which include cellular phone signals, fleet travel data, WSDOT traffic sensors, and others. Notably, during periods where there are low volumes such as the early morning hours, the sample size is small, and the data is less reliable for those periods. However, using the INRIX data to compare one time period to another to understand increases or decreases in travel times is a sound approach.

1. ANALYSIS OF IMPACT OF I-405 INCIDENTS ON CITY OF KIRKLAND PRINCIPAL ARTERIALS

I-405 SB Collision at NE 85th St Blocking One Right Lane

±9:30 AM start/clear by ±10:30 AM (November 6, 2019)

Figure C-1 shows the congestion on I-405 due to the incident from when it was first detected through incident clearance. Figure C-1 also provides percentage increases in travel times on Kirkland principal arterials, and shows overall travel on all principal arterials in all directions, and just southbound travel.
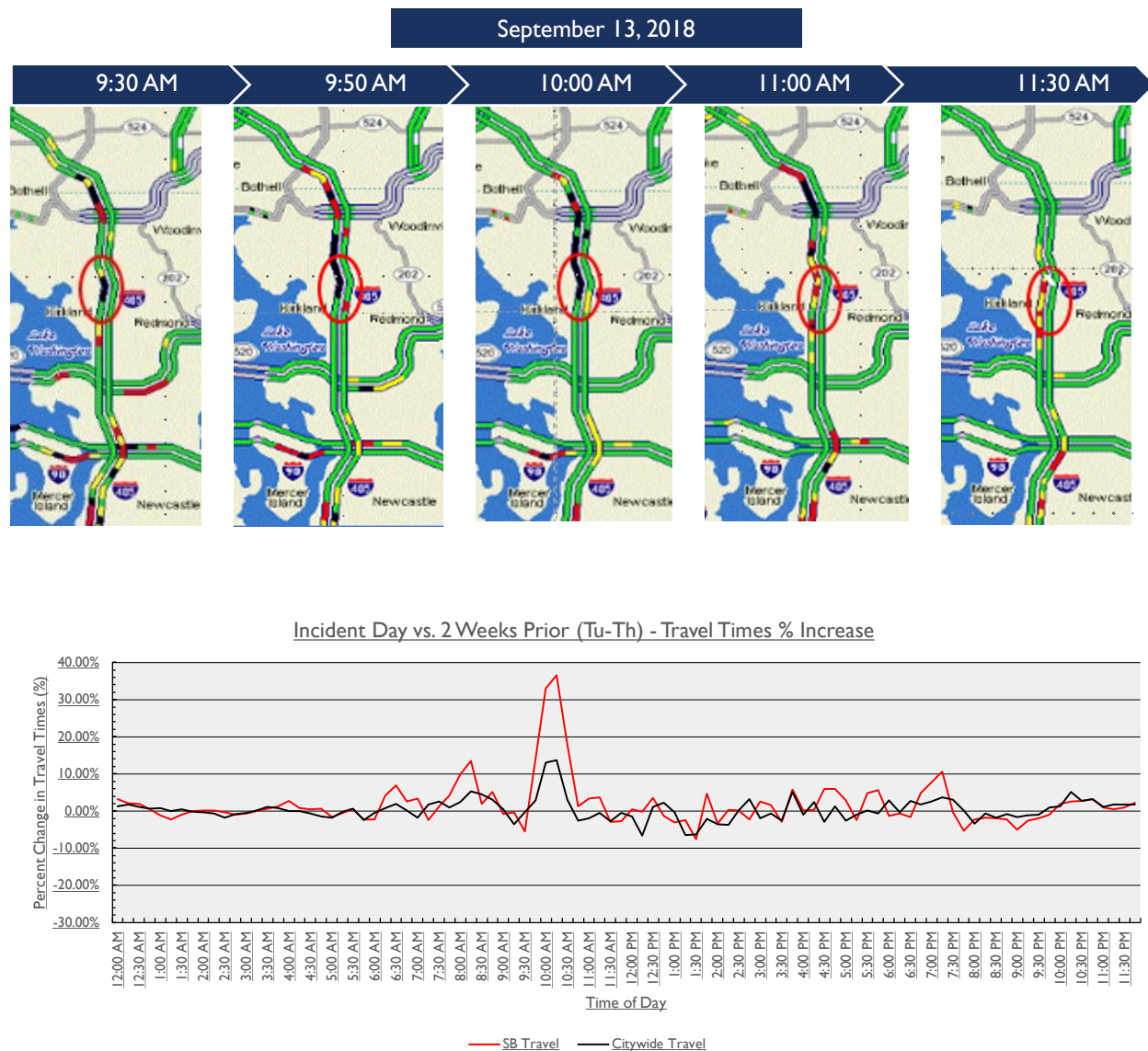

September 13, 2018

| 9:30 AM | 9:50 AM | 10:00 AM | 11:00 AM | 11:30 AM |

Incident Day vs. 2 Weeks Prior (Tu-Th) - Travel Times % Increase

Figure C-1: Impact of I-405 Minor Collision

The effect on travel times in Kirkland is clear. The maximum increase in average southbound travel times on all principal arterials was as much as 35%. For travel from the north end of the City to the

south, this represents an increase of about 5 minutes to a normally 15 minute trip (total 20 minutes). Across the city, average travel times during the incident increased as much as 15%.

The impact of a more severe I-405 incident is presented next.

I-405 NB Collision North of SR 527 Blocking 3 Right Lanes
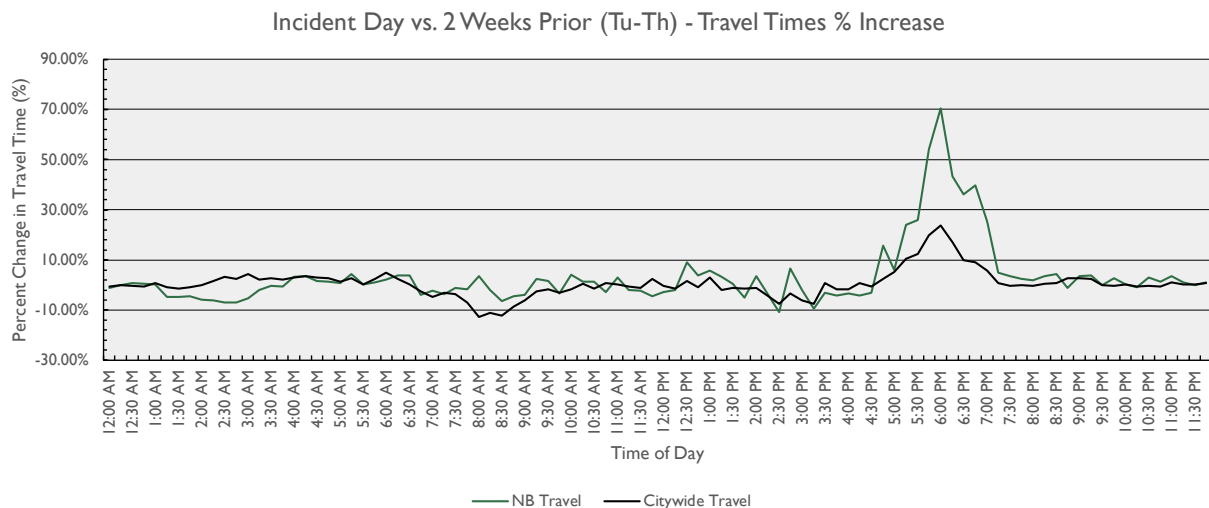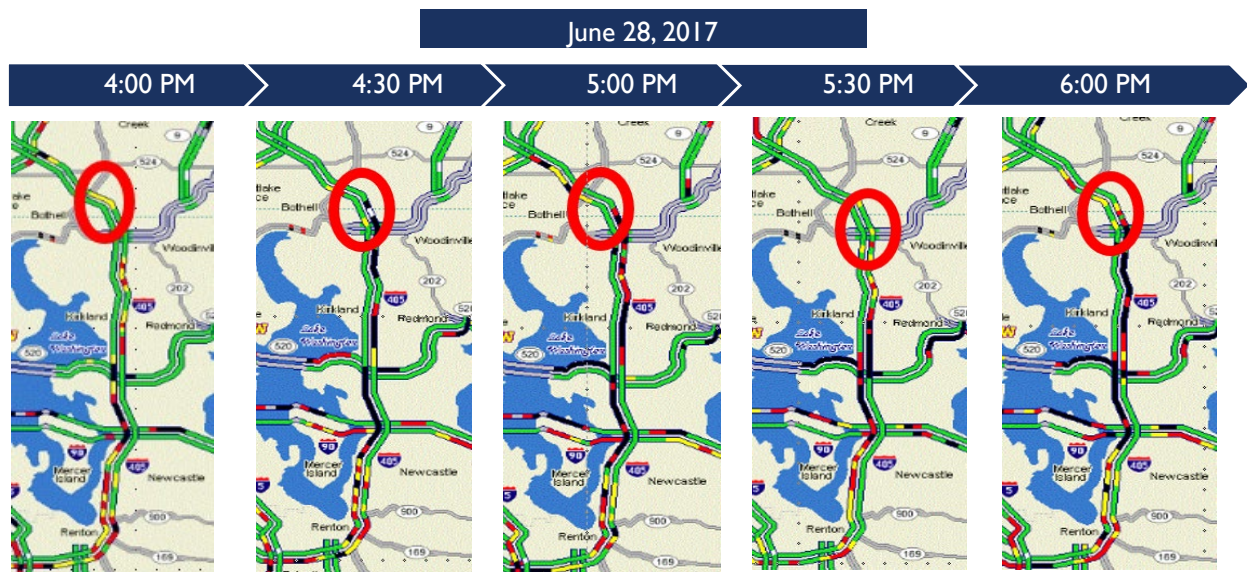**+4:00 PM start/clear by +5:45 PM**

Figure C-2: Impact of Major Collision on I-405

The impact of a major I-405 PM peak period incidents on travel in Kirkland is significant, as shown in Figure C-2. The maximum increase in average northbound travel times on all principal arterials was as much as 70%. For travel from the south end of the City to the north, this represents an increase of about

14 minutes to a normally 20 minute trip (total 34 minutes). In addition, the effect on PM peak travel times lasted for one hour past the time when the I-405 incident was cleared. Across the city, average travel times during the incident increased as much as 25%.

2. ANALYSIS OF IMPACT OF REMOVAL OF WSDOT SIGNALS FROM COORDINATED OPERATION

Figure C-3 shows the travel times before and after WSDOT removed signals from coordination for eastbound and westbound movements. Note that the early morning data is not reliable due to the small sample size. The data shows an increase in average travel time of approximately 20 seconds in travel time throughout the day for eastbound travel, and an increase of up to 20 seconds in the AM peak for westbound travel. This data is not a full representation of the added delay, such as for vehicles that turn onto I-405. It is an indicator that the change since ITS Phase 2 was implemented on NE 124th St resulted in a measurable increase in delay.
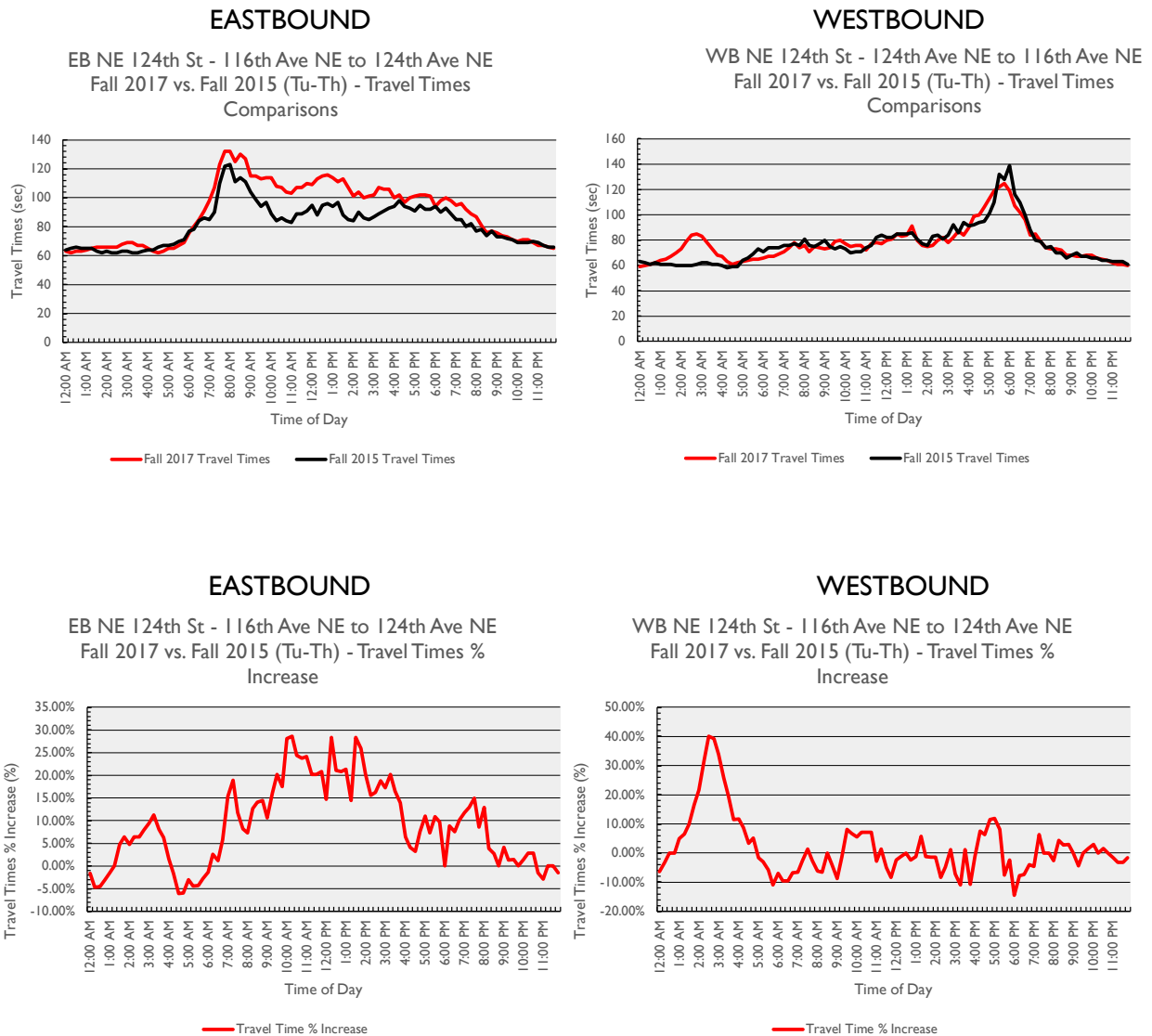
EASTBOUND

EB NE 124th St - 116th Ave NE to 124th Ave NE
Fall 2017 vs. Fall 2015 (Tu-Th) - Travel Times
Comparisons

WESTBOUND

WB NE 124th St - 124th Ave NE to 116th Ave NE
Fall 2017 vs. Fall 2015 (Tu-Th) - Travel Times
Comparisons

EASTBOUND

EB NE 124th St - 116th Ave NE to 124th Ave NE
Fall 2017 vs. Fall 2015 (Tu-Th) - Travel Times %
Increase

WESTBOUND

WB NE 124th St - 116th Ave NE to 124th Ave NE
Fall 2017 vs. Fall 2015 (Tu-Th) - Travel Times %
Increase

Figure C-3: Impact of Removal of WSDOT Traffic Signals From Coordination on NE 124th St

APPENDIX D
ADDITIONAL RECOMMENDATIONS FOR
COMMUNICATIONS NETWORK IMPROVEMENTS

The City has implemented improvements to the ITS communications network to support reliability. Specifically, the City has reprogrammed the existing switches to support a Layer 3 network topology. Layer 2 and Layer 3 refer to different parts of IT network communications. The 'layers' refer to how an IT network is configured.

2.1   LAYER 2 AND LAYER 3

Layer 2 is the data link where data packets are encoded and decoded into bits. The MAC (Media Access Control) sub layer controls how a computer on the network gains access to the data and permission to transmit it and the LLC (Logical Link control) layer controls frame synchronization, flow control and error checking.

Layer 3 provides switching and routing technologies, creating logical paths, known as virtual circuits, for transmitting data from node to node. Routing and forwarding are functions of this layer, as well as addressing, internetworking, error handling, congestion control and packet sequencing.

Layer 2 networks also forward all traffic, including network broadcasts. Anything transmitted by one device is forwarded to all devices. When the network gets too large, the broadcast traffic begins to create congestion and decreases network efficiency, and can even cause network failure.

Layer 3 devices, on the other hand, restrict broadcast traffic such as ARP and DHCP broadcasts to the local network. This reduces overall traffic levels by allowing administrators to divide networks into smaller parts and restrict broadcasts to only that sub-network.

This means there is a limit to the size of a layer 2 network. However, a properly configured layer 3 network with the correct knowledge and hardware can have infinite growth.

By moving to the Layer 3 network, the City is creating a more "future-proof" ITS communications infrastructure.

2.2   REDUNDANCY AND RELIABILITY

Adding physical fiber optic communications links the City's ITS Communications network will provide redundancy and improve reliability, and support adding new ITS devices in the future. It is recommended that, as additional fiberoptic cable is implemented, that the network be arranged in a mesh topology. The advantages of mesh topology include:

Mesh

- The arrangement of the network nodes is such that it is possible to transmit data from one node to many other nodes at the same time.
- The failure of a single node does not cause the entire network to fail as there are alternate paths for data transmission.
- It can handle heavy traffic, as there are dedicated paths between any two network nodes.
- Point-to-point contact between every pair of nodes, makes it easy to identify faults.
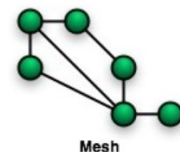
The mesh topology is more complex than those without additional redundant connections. Therefore, a potential disadvantage of this type of topology is that the administration of a mesh network can be more difficult.

2.3   LOCAL GROUP SIZE

Local groups of ITS devices/switches will be arranged in VLANs using Layer 2 switches, and connected to the Layer 3 network. These local groups will be arranged in a spanning tree topology, and the depth of that tree should not exceed a total of seven devices, which will allow for the addition of more devices in the future.

2.4   IMPLEMENTATION OF COMMUNICATIONS NETWORK IMPROVEMENTS IN ITS PHASE 3

The project "ITS Phase 3 – Future Ready ITS" includes several elements to improve overall ITS reliability, include adding fiberoptic cable and other improvements to the communications network to support the topology described above.

The project is proposed to be implemented in stages, with the first stage to include development and implementation of improved network documentation as needed with a more complex communications network.

Interim improvements can also be accomplished, such as implementing flat rings in early phases to improve physical redundancy, or reducing the number of intersections that are on a single sequential link to no more than six (if fiber optic pairs are available). Additional communications network hubs may also be implemented.

Each stage is also proposed to be pursued in an approach that includes developing the specific portion of the detailed design to be constructed as part of the project implementation. This approach is recommended based on the City's experience on past projects involving communications networks "inherited" from King County in the annexation area. On those projects, the plans relied on detailed inventory conducted by a design team. However, the approach resulted in several change-orders and the inventory was not consistent with the conditions the Contractor found in the field. This is a common issue with fiberoptic networks, and not a failing of the design approach. To avoid such issues on future projects, it is recommended that the detailed inventory and final design of the fiberoptic communications cable terminations will be included as part of the implementation Contractor's work, as will delivery of detailed configuration documentation.

The work is recommended to include development of a process to not only inventory and map communications assets, but creation of a readily accessible and readily updateable inventory that all staff involved with the communications network may have access to.