Countywide Signal Optimization Plan

Final Report

October 2002

Submitted to the CCMPO for their approval.

Chittenden County Metropolitan Planning Organization

Communities working together to meet Chittenden County's transportation needs

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The preparation of this document was financed jointly by the eighteen municipalities in Chittenden County and the Chittenden County Transportation Authority; the Vermont Agency of Transportation; and the United States Department of Transportation, Federal Highway Administration, and Federal Transit Administration.

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Purpose of Project/Overview of Work

The purpose of this project is to develop an implementable program for regular maintenance of Chittenden County's 156 traffic signals.

The core components of this project are:

? Identify signal systems, including systems of related signals that can be analyzed for coordination. An important part of this component is to develop a traffic signal database and related GIS data layer for Chittenden County.

? Estimate engineering costs of maintaining efficient timing plan s, inclu ding identification of funding sources.

? Recommend a management approach for maintaining efficient timing plans.

Traffic Signals in Chittenden County

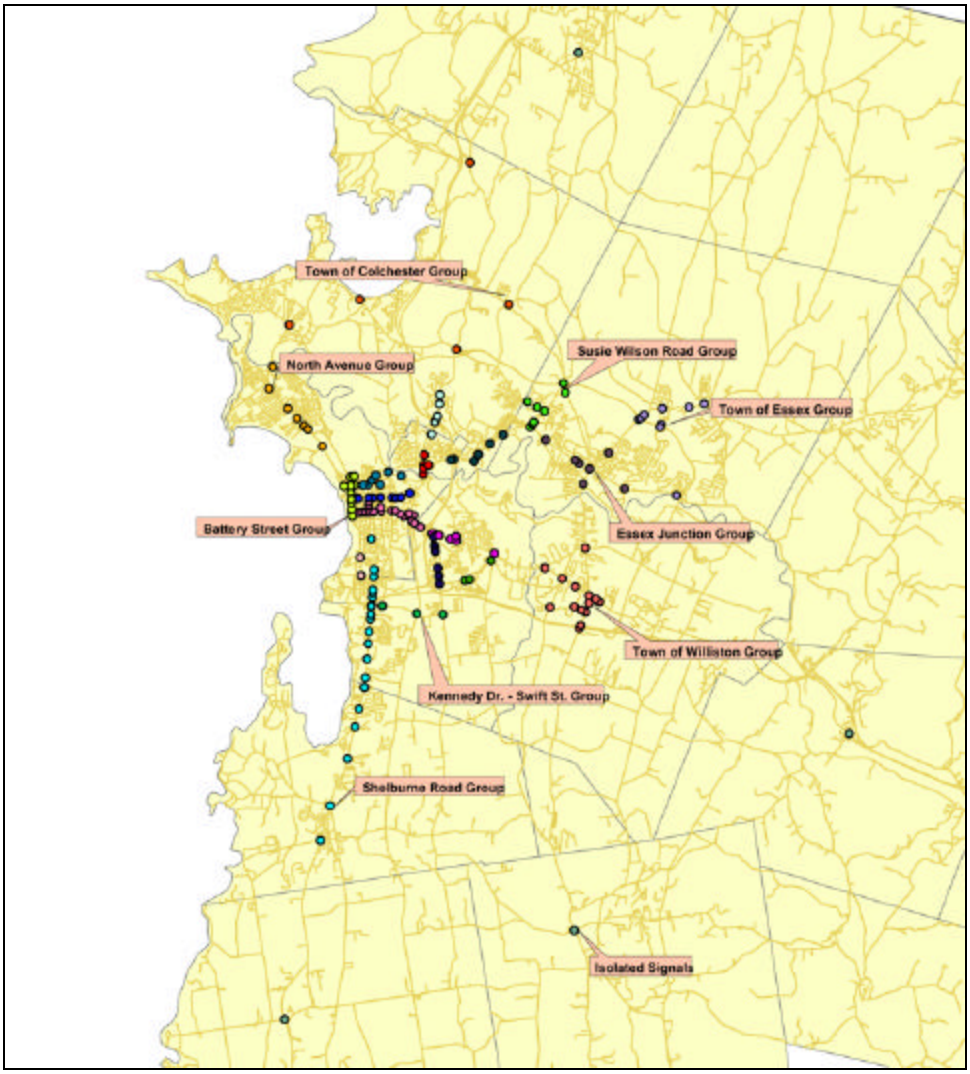
The locations of the signals in the database are shown in Figure 1 with selected groups highlighted.

Signal Systems/Groupings

Placing traffic signals within a designated group is designed to create efficiencies along one of three dimensions:

1. Technical: Same-grouped traffic signals can coordinate traffic flow between intersections and arterials. Coordinating the sequencing of mainline signals within a corridor is a goal that a signal maintenance program should strive to achieve. However, it is important to point out that there are limitations to the efficiencies that can be created through coordination. For example, minor unsignalized intersections, individual driveways, or high pedestrian crossing demands create points where coordination can be interrupted and diminished. Many of the signalized arterials in Chittenden County have significant minor street traffic that limits the potential of coordination.
2. Practical: Traffic signals located near each other, and not necessarily on the same arterial, may be grouped together due to the practicality of servicing signals in close proximity to each other.
3. Jurisdictional: In a few cases, traffic signals are grouped together according to municipal boundaries. In the cases where municipalities support a Public Works Department – the Cities of Burlington and South Burlington; the Towns Colchester, Essex, and Williston – many of the traffic signals not otherwise associated with a coordinated system are grouped together.

Figure 1: Chittenden County Signals



In addition to these dimensions, there are special considerations that merit discussion:

Intersections of Major Arterials

When major arterials in the region intersect, a decision is required regarding which arterial should take precedence. Designating preference is important in a technical sense when both arterials are able to be coordinated. Examples of such arterial intersections include:

? Susie Wilson Road/VT 15 (Essex)

? Williston Road/Dorset Street (South Burlington)

? Battery Street/Main Street (Burlington)

? Battery Street/Pearl Street-Colchester Avenue (Burlington)

Generally, the higher volume arterial should have precedence in developing coordinated timing plans when arterials intersect.

Interjurisdictional Signal Groups

Signal groups often cross municipal boundaries. Any plan to re-time signals within these groups will require coordination between the involved municipalities and, in many cases, VTrans. Examples of such signal groups include:

? US 7 – Shelburne Road (Burlington, South Burlington, Shelburne)

? Exit 16 (Winooski, Colchester)

? VT 15 (Winooski, Colchester)

? Colchester Ave.-Main Street (Burlington, Winooski)

Minor Signal Groups

There are a few signal groups that include intersections that may not be able to be coordinated due to the distances between intersections. Nevertheless, it may be reasonable to group these intersections due to their combined effect on east-west or north-south vehicle movement. Examples of such groups include:

? Swift Street (South Burlington)

? Kennedy Drive (South Burlington)

? Pine Street (Burlington)

? Old North End (Burlington)

A general description of each grouping follows.

Group 1: Battery Street; Burlington

This signal grouping encompasses the 12 intersections shown in Table 1. Figure 2 displays the locations of these signals.

Table 1: Intersections in the Battery Street Grouping

Street 1	Street 2	Municipality	Jurisdiction
No.Champlain St	Manhattan Dr	BURLINGTON	MUNICIPALITY
Park St	VT 127/Manhattan Dr	BURLINGTON	MUNICIPALITY
North St	No. Champlain St	BURLINGTON	MUNICIPALITY
North St	Park St	BURLINGTON	MUNICIPALITY
North St	North Ave	BURLINGTON	MUNICIPALITY
Battery St	Park St/Sherman St	BURLINGTON	MUNICIPALITY
Pearl St	No. Champlain St.	BURLINGTON	MUNICIPALITY
Battery St	Pearl St.	BURLINGTON	MUNICIPALITY
Battery St	Cherry St	BURLINGTON	MUNICIPALITY
Battery St	College St	BURLINGTON	MUNICIPALITY
Battery St	Main St	BURLINGTON	MUNICIPALITY
Battery St	King St	BURLINGTON	MUNICIPALITY

Figure 2: Area Map of the Intersections in the Battery Street Grouping

This grouping is based on the rationale of coordinated north-south movement on the westerly side of the City of Burlington. There is a high potential for achieving good vehicle progression on Battery Street due to the limited entering sidestreet traffic. Included in this grouping are three intersections on North Champlain Street -- at Pearl Street, at North Street, and at Manhattan Drive – which facilitate northbound vehicular movement. Also included is the intersection of North Street/North Avenue.

This intersection meters flow into the Battery Street arterial, and it was reasonable to include this intersection due to its relative proximity.

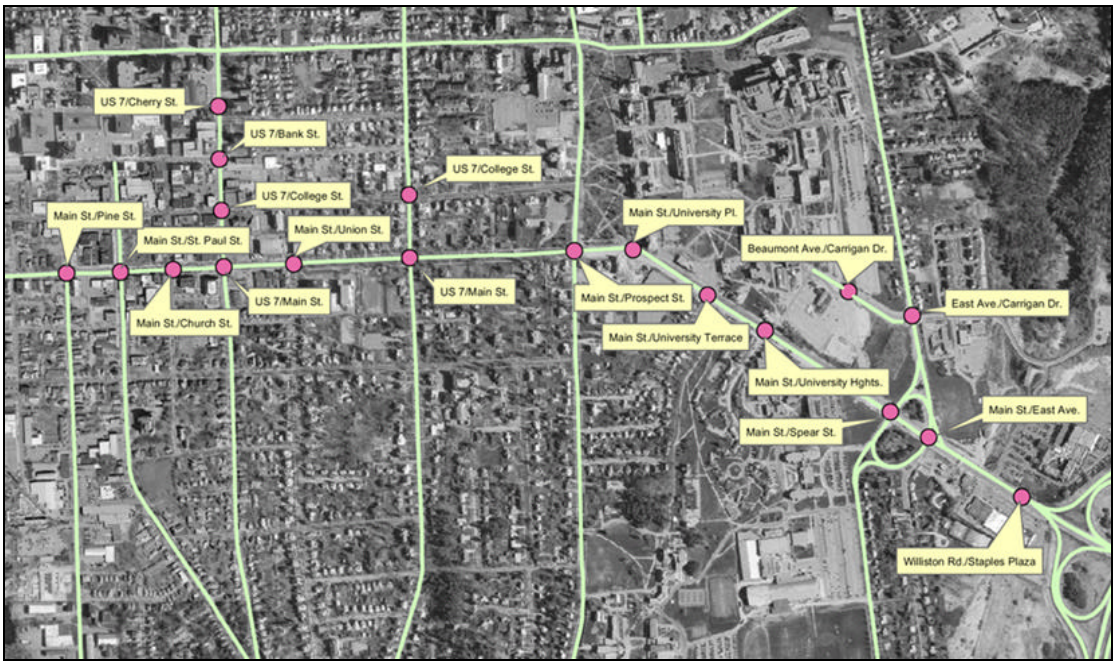
Group 2: Main Street; Burlington

This east-west arterial grouping is defined by Main/Pine to the west and Main/Prospect to the east. There are 19 intersections included, as shown in Table 2. Figure 3 displays the locations of the signals.

Table 2: Intersections in the Main Street Grouping

Street 1	Street 2	Municipality	Jurisdiction
Beaumont Av	Carrigan Dr	BURLINGTON	MUNICIPALITY
Main St	University Hghts	BURLINGTON	MUNICIPALITY
Main St	University Terrace	BURLINGTON	MUNICIPALITY
Main St	University Pl	BURLINGTON	MUNICIPALITY
Main St	Prospect St	BURLINGTON	MUNICIPALITY
US 7 (S Willard)	College St	BURLINGTON	MUNICIPALITY
US 7 (S Willard)	Main St	BURLINGTON	MUNICIPALITY
Main St.	Union St.	BURLINGTON	MUNICIPALITY
US 7 (S Winooski)	Cherry St	BURLINGTON	MUNICIPALITY
US 7 (S Winooski)	Bank St	BURLINGTON	MUNICIPALITY
US 7 (S Winooski)	College St	BURLINGTON	MUNICIPALITY
US 7 (S Winooski)	Main St	BURLINGTON	MUNICIPALITY
Main St.	Church St	BURLINGTON	MUNICIPALITY
Main St.	Saint Paul St	BURLINGTON	MUNICIPALITY
Main St.	Pine St	BURLINGTON	MUNICIPALITY
East Ave	Carrigan Ave	BURLINGTON	MUNICIPALITY
Williston Rd	Spear St	BURLINGTON	MUNICIPALITY
Williston Rd.	East Ave	BURLINGTON	MUNICIPALITY
Williston Rd.	Staples Plaza	SOUTH BURLINGTON	MUNICIPALITY

Figure 3: Area Map of the Intersections in the Main Street Grouping



Non-Main Street intersections are included in this grouping due to proximity and due to the significance that north-south flow on US 7 (Winooski Avenue southbound and Union Street northbound) has on affecting coordinated flow on Main Street.

Group 3: US 7-Shelburne Road; Burlington, South Burlington, and Shelburne

This grouping consists of 20 intersections (Table 3) and is the largest grouping in the region. The grouping is motivated primarily by the need to coordinate signal timings in the corridor.

Table 3: Intersections in the Shelburne Road Grouping

Street 1	Street 2	Municipality	Jurisdiction
US 7	Howard St	BURLINGTON	MUNICIPALITY
US 7	Prospect Pkwy	BURLINGTON	MUNICIPALITY
US 7	Flynn Ave	BURLINGTON	MUNICIPALITY
US 7	Home Ave	BURLINGTON	MUNICIPALITY
US 7	Shelburne Rd Plaza	BURLINGTON	MUNICIPALITY
US 7	I-189 Ramp C, WB	BURLINGTON	MUNICIPALITY
US 7	Swift St	SOUTH BURLINGTON	STATE
US 7	Queen City Pkwy	SOUTH BURLINGTON	STATE
US 7	Brewer Pkwy/K-Mart	SOUTH BURLINGTON	STATE
US 7	Laurel Dr./Hannafords	SOUTH BURLINGTON	STATE
US 7	Baldwin Ave.	SOUTH BURLINGTON	STATE
US 7	McIntosh Ave	SOUTH BURLINGTON	STATE
US 7	Holmes Rd	SOUTH BURLINGTON	STATE
US 7	Bartletts Bay/Green Mnt D	SOUTH BURLINGTON	STATE
US 7	Allen Rd	SOUTH BURLINGTON	STATE
US 7	Locust Hill Rd	SHELBURNE	STATE
US 7	Hillcrest Rd/Lakeview Dr	SHELBURNE	STATE
US 7	Bay Rd.	SHELBURNE	STATE
US 7	Long Meadow Rd	SHELBURNE	STATE
US 7	Harbor Rd/Falls Rd	SHELBURNE	STATE
US 7	Bostwick Rd/Marsette Rd.	SHELBURNE	STATE

Some of the most southerly intersections -- those located in Shelburne -- are not proximate enough to be included within a coordinated timing plan. Figure 4 shows the locations of the signals. They are included in this grouping because of their overall proximity and because coordination of these southerly traffic signals might prove to be more practical in the future as land use changes unfold. This grouping is only one of two that involves more than 2 municipalities.

As shown in Figure 4, there are 3 intersections that are currently interconnected – Home Avenue, Shelburne Road Plaza, and I-189 Ramp C. The Shelburne Road Reconstruction Project will interconnect a set of signals toward the southerly end of the corridor, from Holmes Avenue to Bay Road with underground conduit. A Master Intersection has not yet been selected for this signal system.

According to VTrans, the signals from Brewer Parkway/K-Mart to Baldwin Avenue along Shelburne Road (hereafter referred to as the Baldwin Avenue subgroup) have been connected via an aboveground hardwire in the past. However, the interconnection is not currently "live" and hence does not synchronize controller clocks. The existence of the interconnection creates the possibility of connecting this subgroup to the signals that will become interconnected after the Shelburne Road reconstruction project (Holmes Road to Bay Road, hereafter referred to as the Shelburne Road reconstruction project signals).

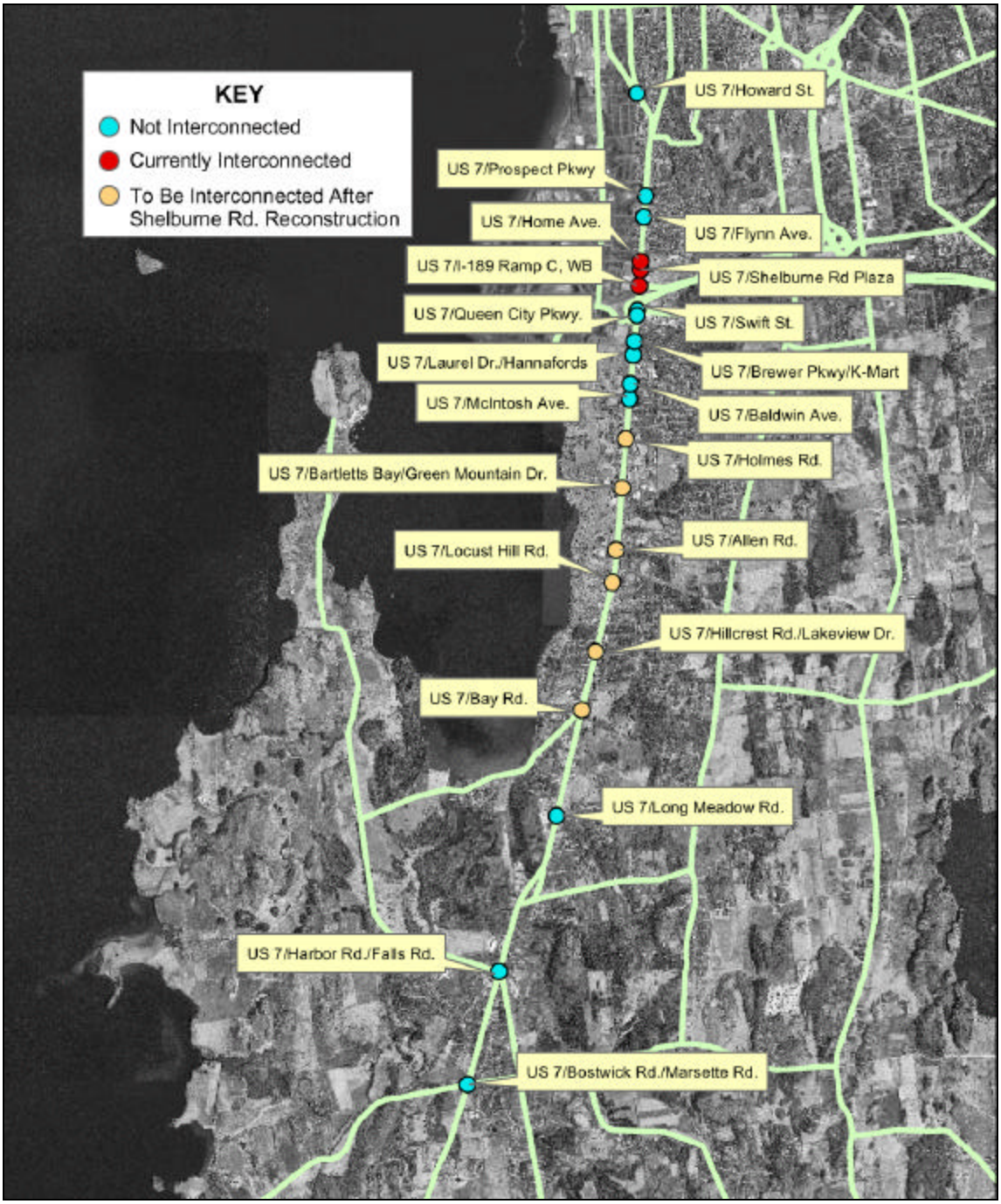
The signal at McIntosh Avenue is located in between these two groups of signals: the Baldwin Avenue subgroup to the north and the Shelburne Road reconstruction

project signals to the south. This particular signal will need to be connected to both of these subgroups of signals in order to make the linkage complete. Interconnecting these signals will require a connection between the aboveground interconnect (Baldwin Avenue subgroup) and the underground interconnect (Shelburne Road reconstruction subgroup). However, connecting the signals may require a new hardwire as well as confirmation that reconnecting the signals between Brewer Parkway and Baldwin Avenue is allowed.

The interconnection hardwire at Holmes Road will be placed in a conduit so that the signals that will be interconnected as a result of the Shelburne Road Reconstruction Project could be connected to the signals north of Holmes Road at a future date. However, no plans have been made to actually do this.

The controllers between Brewer Parkway and Baldwin Avenue are made by different manufacturers and will not be able to communicate with an Econolite master. Hence, coordination for these four signals (Brewer Parkway, Laurel Drive, Badlwin Avenue, and McIntosh Avenue) will need to be time-based. Additionally, funding for interconnecting these signals and right-of-way concerns are two important issues to consider.

Figure 4: Area Map of the Intersections in the Shelburne Road Grouping



Group 4: Pearl Street-Colchester Avenue; Burlington

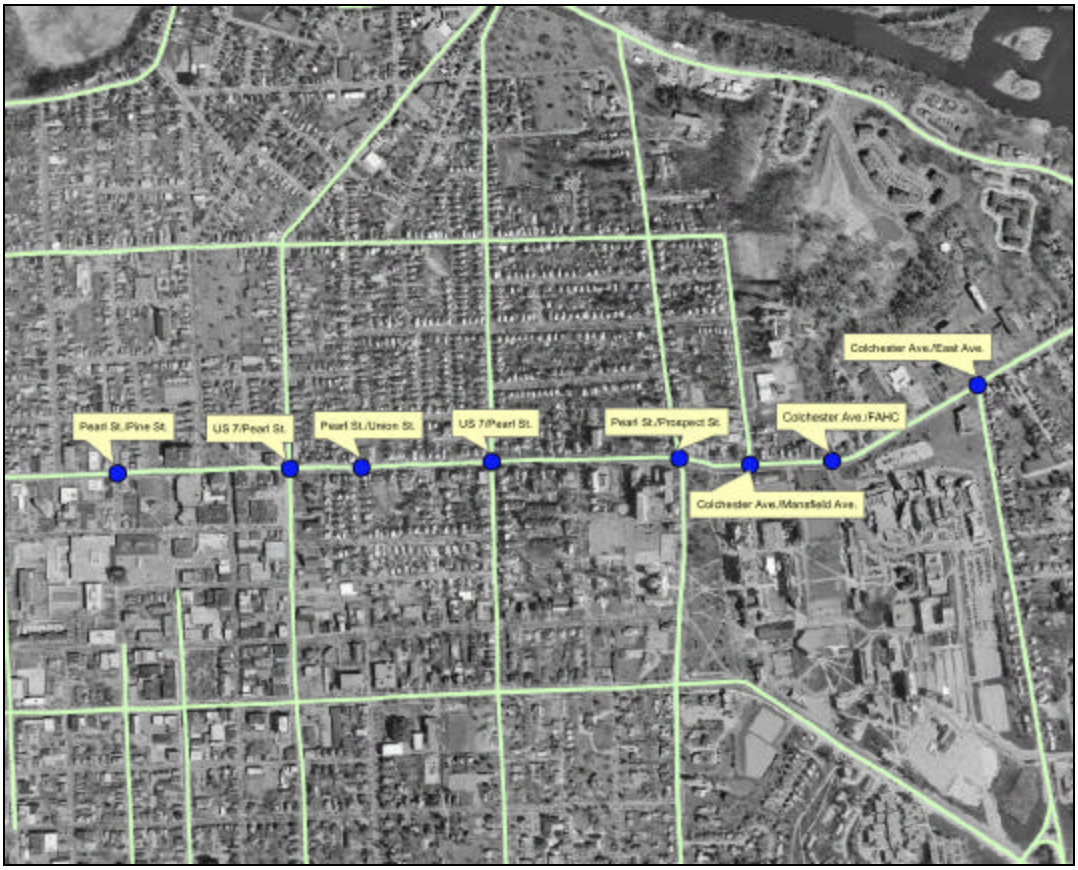
This grouping encompasses 8 traffic signals within Burlington that comprise the Pearl-Colchester arterial. This arterial is one of 4 key commuting routes into Burlington. Portions of the arterial lend themselves well to signal coordination. The group is defined by the Pearl/Pine intersection to the west and by the Colchester/East

Avenue intersection to the east (Figure 5). Table 4 shows the intersections included in this group.

Table 4: Intersections in the Pearl Street-Colchester Avenue Grouping

Street 1	Street 2	Municipality	Jurisdiction
Colchester Ave	East Ave	BURLINGTON	MUNICIPALITY
Colchester Ave	FAHC	BURLINGTON	MUNICIPALITY
Colchester Ave	Mansfield Ave	BURLINGTON	MUNICIPALITY
Pearl St.	Prospect St	BURLINGTON	MUNICIPALITY
US 7 (S Willard)	Pearl St	BURLINGTON	MUNICIPALITY
Pearl St	Union St.	BURLINGTON	MUNICIPALITY
US 7 (S Winooski	Pearl St	BURLINGTON	MUNICIPALITY
Pearl St	Pine St	BURLINGTON	MUNICIPALITY

Figure 5: Area Map of the Intersections in the Pearl Street-Colchester Avenue Grouping



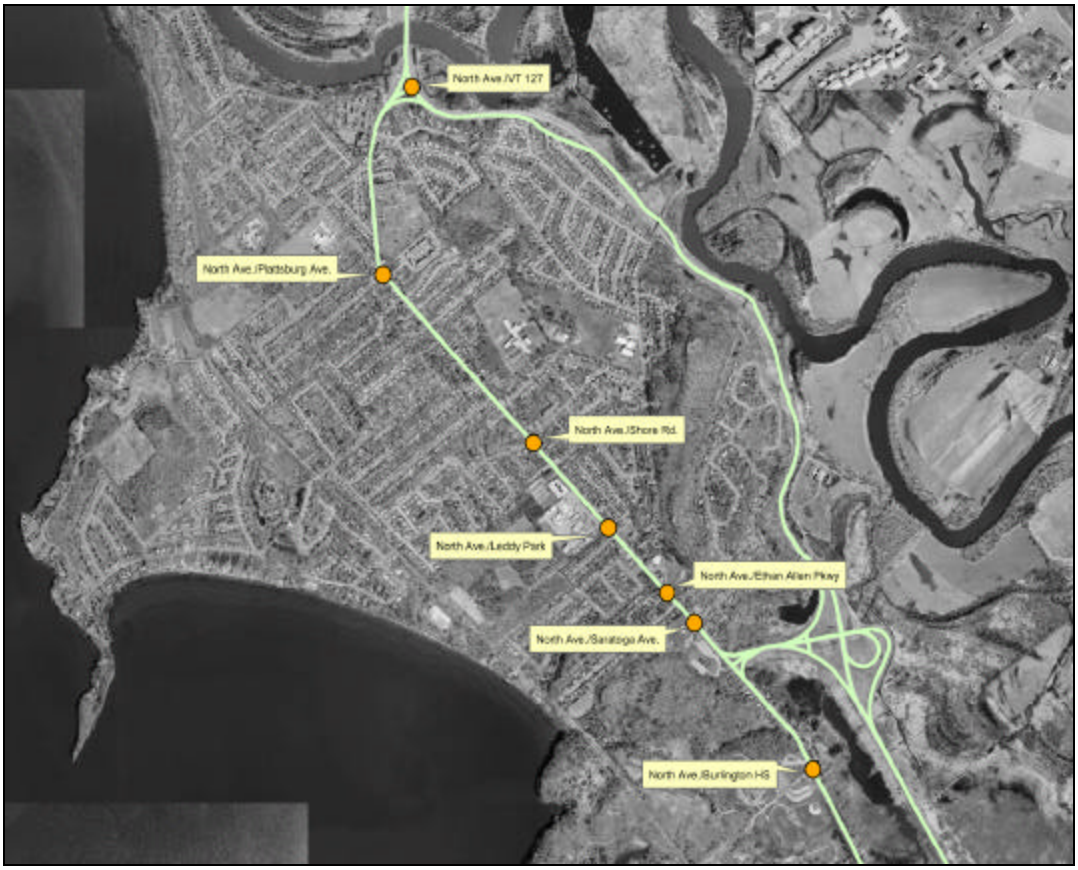
Group 5: North Avenue; Burlington

Table 5 lists the 7 intersections included in this group, and Figure 6 shows the locations of the signals. These intersections control vehicle movement on the North Avenue arterial serving Burlington's New North End.

Table 5: Intersections in the North Avenue Grouping

Street 1	Street 2	Municipality	Jurisdiction
North Ave	VT 127	BURLINGTON	MUNICIPALITY
North Ave	Plattsburg Ave	BURLINGTON	MUNICIPALITY
North Ave	Shore Rd	BURLINGTON	MUNICIPALITY
North Ave	Leddy Park	BURLINGTON	MUNICIPALITY
North Ave	Ethan Allen Pkwy	BURLINGTON	MUNICIPALITY
North Ave	Saratoga Ave	BURLINGTON	MUNICIPALITY
North Ave	Burlington HS	BURLINGTON	MUNICIPALITY

Figure 6: Area Map of the Intersections in the North Avenue Grouping



Group 6: Colchester Avenue-Main Street; Burlington, Winooski

An important set of traffic signals that require tight coordination are included in Group 6 (Table 6). These signals control the commuting outflow from Burlington during the PM peak hour. The close proximity of the intersections makes coordination a strong potential (Figure 7). The Barlow/VT 15 intersection is included due to its close proximity to the Main Street (Winooski) signals.

Table 6: Intersections in the Colchester Avenue-Main Street Group

Street 1	Street 2	Municipality	Jurisdiction
US 7	Spring St	WINOOSKI	MUNICIPALITY
VT 15	Barlow	WINOOSKI	MUNICIPALITY
US 7	VT 15	WINOOSKI	MUNICIPALITY
US 7	Canal St.	WINOOSKI	MUNICIPALITY
US 7	Colchester Ave	BURLINGTON	MUNICIPALITY

Figure 7: Area Map of the Intersections in the Colchester Avenue-Main Street Group

With the proposed mitigation in the Downtown Winooski Revitalization project, three of these signals would be removed and replaced by a downtown circulator. These signals are US 7/Canal, US 7/VT 15 (East Allen), and VT 15/Barlow. A new traffic signal is specified for the intersection of VT 15 (East Allen) and East Street, which will be a main entry drive to the redeveloped downtown site. This new traffic signal is most efficiently coordinated with the signals at the I-89 Exit 15 ramps.

Group 7: Old North End; Burlington

These 7 traffic signals are located in the Old North End and control flow on the North Winooski Avenue, Riverside Avenue, and North Street minor arterials (Table 7 and

Figure 8). They are grouped together due to their relative proximity. Each arterial could potentially be coordinated to its own traffic flow. In the case of North Street, its role in vehicle movement is subservient to the functions of Battery Street and North Champlain Street. Hence, it is sensible to group the intersection of North Street with those arterials in Group 1.

Table 7: Intersections in the Old North End Group

Street 1	Street 2	Municipality	Jurisdiction
US 7	Riverside Condos	BURLINGTON	MUNICIPALITY
US 7	Prospect / Intervale	BURLINGTON	MUNICIPALITY
US 7 (S Willard)	North St	BURLINGTON	MUNICIPALITY
US 7	Archibald St	BURLINGTON	MUNICIPALITY
US 7 (S Winooski)	North St	BURLINGTON	MUNICIPALITY
North St	Intervale/Elmwood	BURLINGTON	MUNICIPALITY

Figure 8: Area Map of the Intersections in the Old North End Group

Group 8: Pine Street; Burlington

This group includes the last two ungrouped signals in Burlington, located on Pine Street (Figure 9). These signals are at Lakeside and Flynn. Currently, no significant vehicle progression can be caused by coordinating these two signals. However, there have been discussions regarding signalizing the Pine/Howard intersection. Furthermore, the completion of the Southern Connector will result in 3 new signalized intersections along the Southern Connector and parallel to Pine Street. These future signals would be included in this group.

Figure 9: Area Map of the Intersections in the Pine Street Group

Group 9: Dorset Street; South Burlington

This grouping includes 7 intersections along Dorset Street (Table 8 and Figure 10). These intersections have a maintained hardwire interconnection, which greatly facilitates coordinated operations. All intersections are similarly equipped with signal preemption receivers as well.

Table 8: Intersections in the Dorset Street Group

Street 1	Street 2	Municipality	Jurisdiction
Dorset St.	100 Dorset St	SOUTH BURLINGTON	MUNICIPALITY
Dorset St.	U-Mall North/Market St	SOUTH BURLINGTON	MUNICIPALITY
Dorset St.	Dorset Square	SOUTH BURLINGTON	MUNICIPALITY
Dorset St.	U-Mall South	SOUTH BURLINGTON	MUNICIPALITY
Dorset St.	San Remo So/Aspen Dr	SOUTH BURLINGTON	MUNICIPALITY
Dorset St.	So.Burl HS	SOUTH BURLINGTON	MUNICIPALITY
Dorset St.	Kennedy Dr	SOUTH BURLINGTON	MUNICIPALITY

Figure 10: Area Map of the Intersections in the Dorset Street Group

Group 10: Williston Road; South Burlington

This group includes 6 intersections on Williston Road and one related intersection at White/Patchen (Table 9 and Figure 11).

Table 9: Intersections in the Williston Road Group

Street 1	Street 2	Municipality	Jurisdiction
Williston Rd.	Kennedy Dr.	SOUTH BURLINGTON	MUNICIPALITY
Williston Rd.	Hinesburg Rd	SOUTH BURLINGTON	MUNICIPALITY
White St.	Patchen Rd.	SOUTH BURLINGTON	MUNICIPALITY
Williston Rd.	White St.	SOUTH BURLINGTON	MUNICIPALITY
Williston Rd.	Clarion/Ramada	SOUTH BURLINGTON	MUNICIPALITY
Williston Rd.	Dorset St.	SOUTH BURLINGTON	MUNICIPALITY
Williston Rd.	I-89 Exit 14 Off Ramp	SOUTH BURLINGTON	MUNICIPALITY

Figure 11: Area Map of the Intersections in the Williston Road Group

Groups 11 and 12: Kennedy Drive-Swift Street; South Burlington

These 6 intersections control east-west movement on 2 minor arterials in South Burlington (Table 11). The two arterials – Kennedy Drive and Swift Street – are relatively proximate in location and were grouped together for this reason (Figure 12).

Table 10: Intersections in the Kennedy Drive-Swift Street Group

Street 1	Street 2	Municipality	Jurisdiction
Kennedy Dr.	Kimball Ave	SOUTH BURLINGTON	MUNICIPALITY
Kennedy Dr.	Hinesburg Rd	SOUTH BURLINGTON	STATE
Kennedy Dr.	Timberlane	SOUTH BURLINGTON	MUNICIPALITY
Dorset St.	Swift St.	SOUTH BURLINGTON	MUNICIPALITY
Swift St	Spear St	SOUTH BURLINGTON	MUNICIPALITY
Swift St.	Farrel Rd/VT Gas	SOUTH BURLINGTON	MUNICIPALITY

Figure 12: Area Map of the Intersections in the Kennedy Drive-Swift Street Group

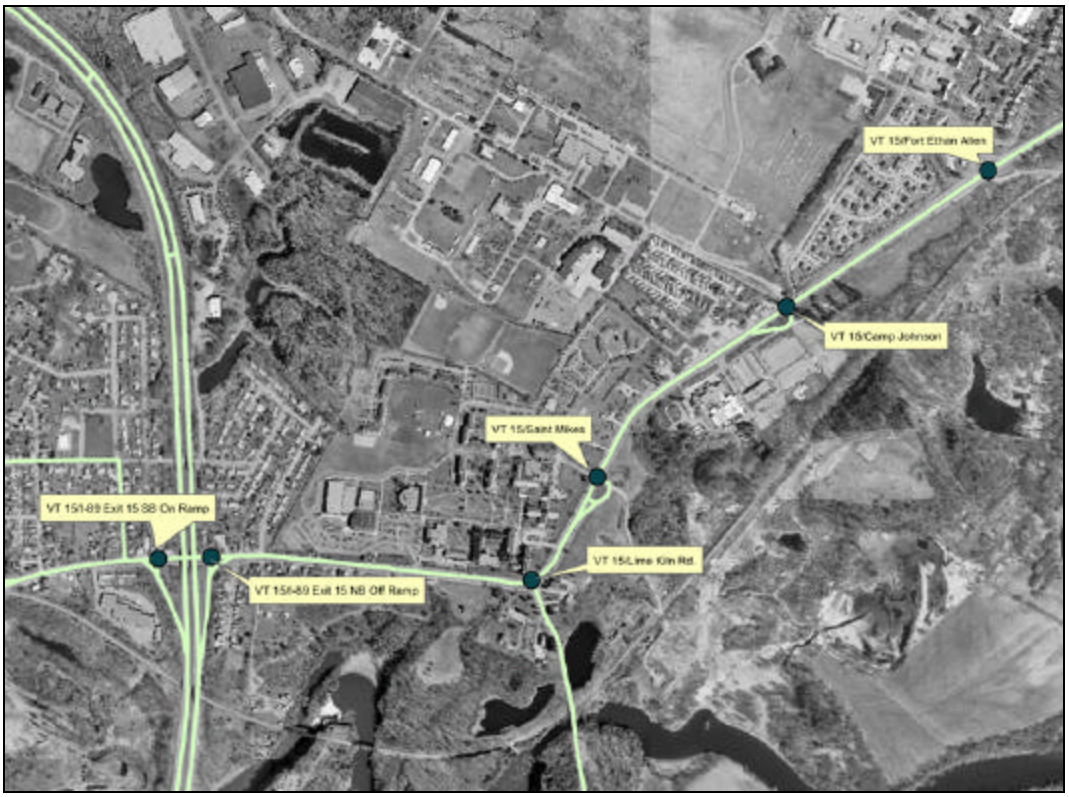
Group 13: VT 15; Winooski, Colchester

VT 15 is a major east-west arterial serving the region, connecting Burlington, Winooski, Colchester, and Essex (Figure 13). Table 11 shows the 6 intersections in this grouping. There is some potential for signal coordination among these 6 signals. Currently, a time-based coordinated timing plan is in effect for the two Exit 15 ramps combined with the VT 15/Lime Kiln Road intersection. As mentioned above, a future traffic signal at East Street in Winooski should be included in this group.

Table 11: Intersections in the VT 15 Group

Street 1	Street 2	Municipality	Jurisdiction
VT 15	Fort Ethan Allen	COLCHESTER	STATE
VT 15	CampJohnson	COLCHESTER	STATE
VT 15	Saint Mikes	COLCHESTER	STATE
VT 15	Lime Kiln Rd.	COLCHESTER	STATE
VT 15	Exit 15 NB Off-Ramp	WINOOSKI	MUNICIPALITY
VT 15	Exit 15 SB On-Ramp	WINOOSKI	MUNICIPALITY

Figure 13: Area Map of the Intersections in the VT 15 Group



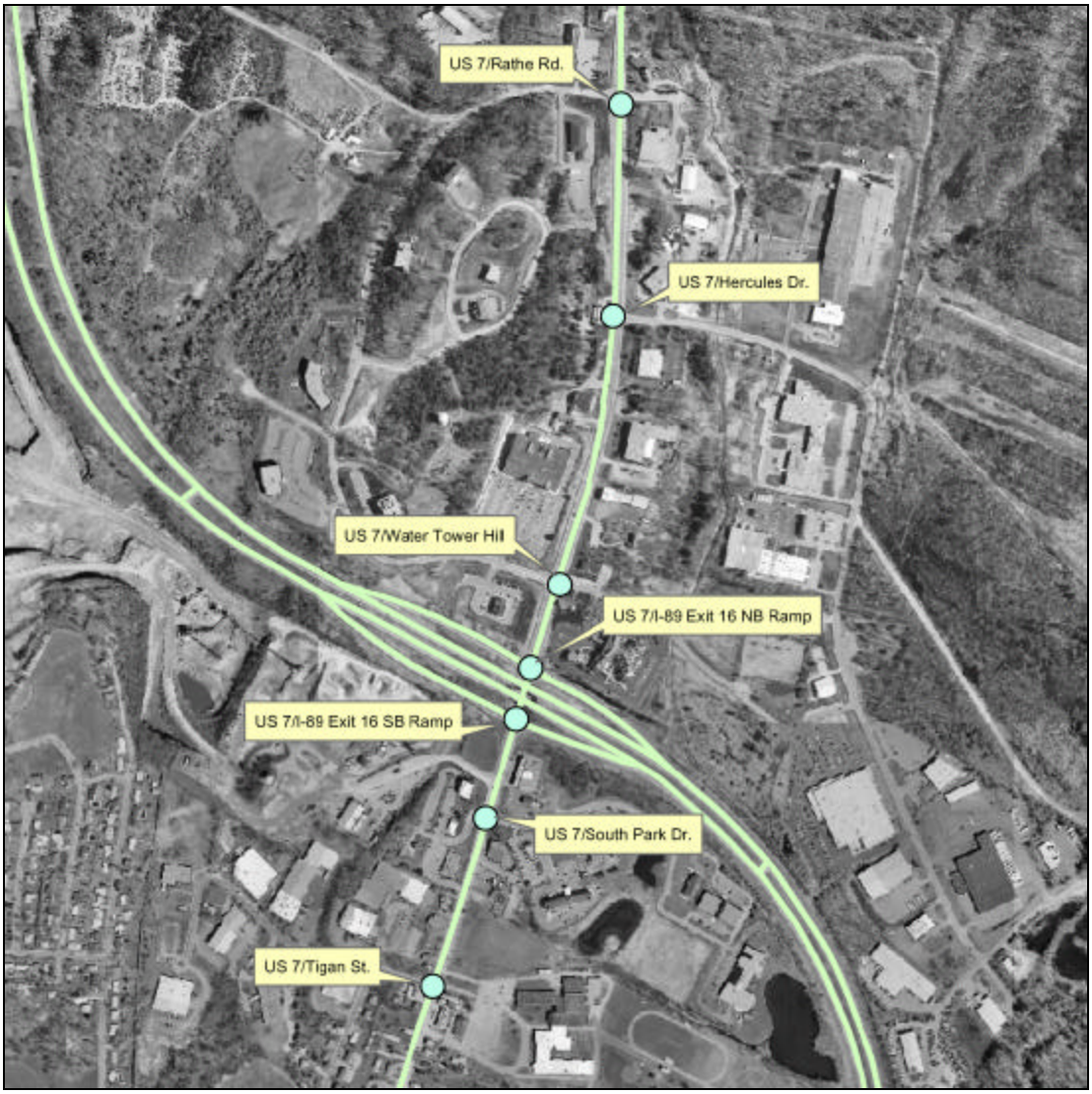
Group 14: Exit 16; Colchester; Winooski

Six intersections define this signal grouping, as shown in Figure 14. Coordinated operation has been recommended for a subset of these traffic signals, which are interconnected – Tigan Street to Water Tower Hill. Resource Systems Group has developed a coordination plan for this section of US 7 to be installed in September 2002.

Table 12: Intersections in the Exit 16 Group

Street 1	Street 2	Municipality	Jurisdiction
US 7	Rathe Rd.	COLCHESTER	STATE
US 7	Hercules	COLCHESTER	STATE
US 7	Water Tower Hill	COLCHESTER	STATE
US 7	Exit 16 NB Ramps	COLCHESTER	STATE
US 7	Exit 16 SB Ramps	COLCHESTER	STATE
US 7	South Park Dr	COLCHESTER	STATE
US 7	Tigan St.	WINOOSKI	MUNICIPALITY

Figure 14: Area Map of the Intersections in the Exit 16 Group



Group 15: Susie Wilson Road; Essex

Six intersections in the Town of Essex comprise this signal group (Table 13). Traffic progression on Susie Wilson Road can be enhanced with coordination, and Resource Systems Group has recently implemented a set of coordinated plans for this corridor (AM peak, PM peak, off peak, weekend). The Circ Highway signals are included in

this group. Two recently installed signals on Kellogg Road at New England Drive and Morse Road should also be included in this group. All of these signals are displayed in Figure 15.

Table 13: Intersections in the Susie Wilson Road Group

Street 1	Street 2	Municipality	Jurisdiction
Kellogg Rd	New England Dr	ESSEX	MUNICIPALITY
Kellogg Rd	Morse Rd	ESSEX	MUNICIPALITY
VT 2A	VT 289 WB Off Ramp	ESSEX	STATE
VT 2A	VT 289 EB Ramp/SWRD	ESSEX	STATE
Susie Wilson Rd.	Kellogg Rd.	ESSEX	MUNICIPALITY
Susie Wilson Rd.	Pinecrest St.	ESSEX	MUNICIPALITY
Susie Wilson Rd.	Grand Union Plaza	ESSEX	MUNICIPALITY
VT 15	Susie Wilson Rd.	ESSEX	STATE

Figure 15: Area Map of the Intersections in the Susie Wilson Road Group

Group 16: Essex Junction

Seven intersections in Essex Junction comprise this group (Table 14). These intersections control flow in and around the Five Corners intersection, as well as control commuting flow from the state's major employer, IBM. Coordinated operation can be maintained as an objective. However, traffic conditions are often

overcapacity during peak hours, minimizing the effectiveness of coordination. The location of these signals is shown in Figure 16.

Table 14: Intersections in the Essex Junction Group

Street 1	Street 2	Municipality	Jurisdiction
VT 117	Maple St Ext/IBM	ESSEX JUNCTION	MUNICIPALITY
VT 15	Brickyard	ESSEX JUNCTION	MUNICIPALITY
VT 15	VT 117/VT 2A	ESSEX JUNCTION	MUNICIPALITY
VT 2A	Park/South St	ESSEX JUNCTION	MUNICIPALITY
VT 15	South Summit St	ESSEX JUNCTION	MUNICIPALITY
VT 15	A&PShopping Ctr	ESSEX JUNCTION	MUNICIPALITY
VT 15	West St.	ESSEX JUNCTION	STATE

Figure 16: Area Map of the Intersections in the Essex Junction Group

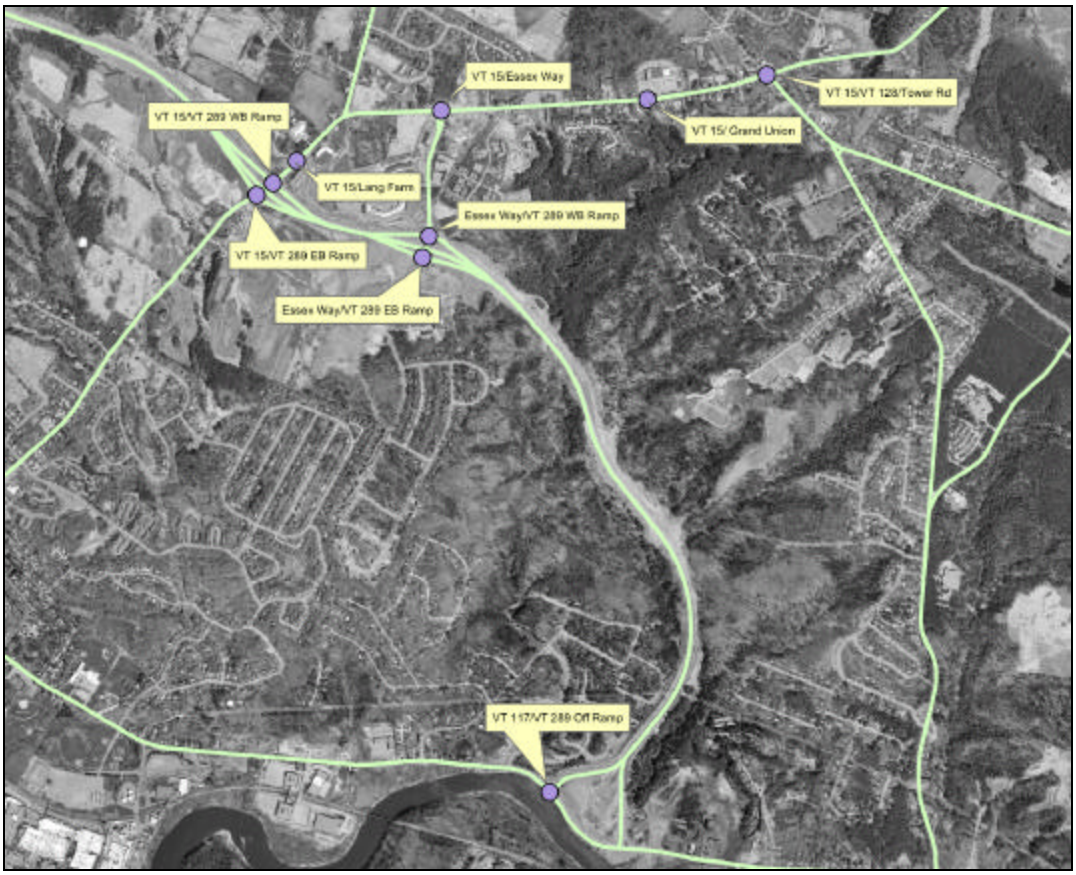
Group 17: Town of Essex

Nine intersections are included in the Town of Essex Group (Table 15). These include the traffic signals associated with access to the Circumferential Highway and with the Lang Farm development (Figure 17).

Table 15: Intersections in the Town of Essex Group

Street 1	Street 2	Municipality	Jurisdiction
VT 15	VT 128/Tower Rd.	ESSEX	STATE
VT 15	Grand Union	ESSEX	STATE
VT 15	Essex Way	ESSEX	STATE
VT 15	Lang Farm	ESSEX	STATE
VT 15	VT 289 WB Ramps	ESSEX	STATE
VT 15	VT 289 EB Ramps	ESSEX	STATE
Essex Way	VT 289 WB Ramps	ESSEX	MUNICIPALITY
Essex Way	VT 289 EB Ramps	ESSEX	MUNICIPALITY
VT 117	VT 289 Off Ramp	ESSEX	STATE

Figure 17: Area Map of the Intersections in the Town of Essex Group



Group 18: Town of Williston

Fourteen intersections are included in the Town of Williston Group (Table 16 and Figure 18). Most of the Williston traffic signals control traffic flow in and around Tafts Corners. There is some potential for coordinated flow on the VT2A and Williston Road corridors, and there are important signal design considerations at the intersections of these arterials. In addition, the Town of Williston has a Public Works Department that would likely coordinate signal timing update efforts. Hardwire interconnection exists along VT 2A (I89 Southbound off Ramp to Williston Road) and along Marshall Avenue (Brownell Avenue to VT 2A).

Table 16: Intersections in the Town of Williston Group

Street 1	Street 2	Municipality	Jurisdiction
VT 2A	IndustrialAve/Mnt.View	WILLISTON	STATE
Williston Rd.	Industrial Ave	WILLISTON	STATE
Williston Rd.	Brownell Rd.	WILLISTON	STATE
Williston Rd.	Harvest Lane	WILLISTON	STATE
Williston Rd.	VT 2A	WILLISTON	STATE
US 2	Boxwood St	WILLISTON	STATE
US 2	Simons Plz/Maple Tree Pl Rd	WILLISTON	STATE
VT 2A	Connor Way	WILLISTON	STATE
VT 2A	Marshall Ave/Maple Tree Pl Rd	WILLISTON	STATE
Marshall Ave	Hannafords	WILLISTON	MUNICIPALITY
Marshall Ave	Harvest Lane	WILLISTON	MUNICIPALITY
Marshall Ave	So.Brownell Rd	WILLISTON	MUNICIPALITY
VT 2A	I-89 Exit 12 NB Ramp	WILLISTON	STATE
VT 2A	I-89 Exit 12 SB Ramps	WILLISTON	STATE

Figure 18: Area Map of the Intersections in the Town of Williston Group

Group 19: Town of Colchester

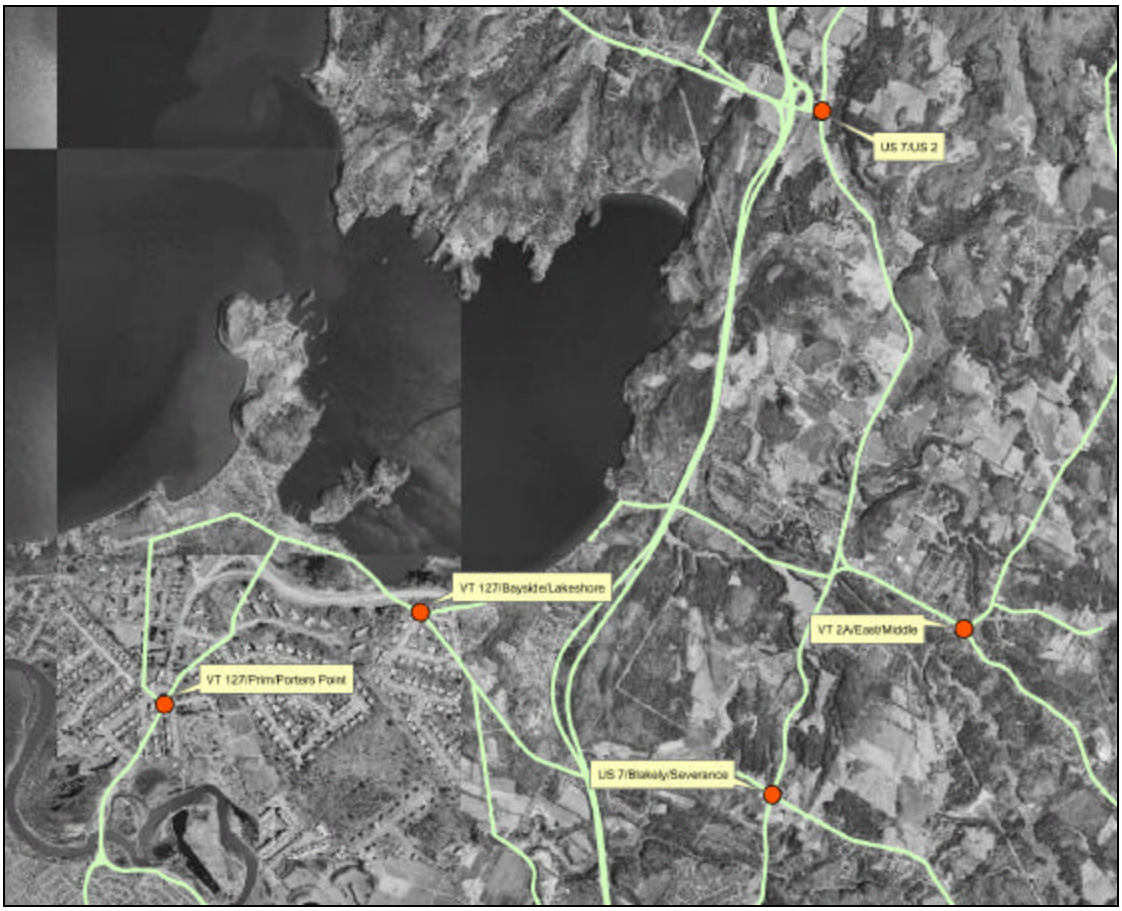
Five intersections in the Town of Colchester have been grouped together (Table 17). These intersections are outside of the coordinated system proximate to Exit 16

identified as Group 14. Since the Town has its own Public Works Department that would coordinate efforts to update signal timing plans, it made sense to group these signals together (Figure 19).

Table 17: Intersections in the Town of Colchester Group

Street 1	Street 2	Municipality	Jurisdiction
VT 2A	East/Middle	COLCHESTER	STATE
US 7	US 2	COLCHESTER	STATE
US 7	Blakely/Severance	COLCHESTER	STATE
VT 127	Bayside\Lakeshore	COLCHESTER	MUNICIPALITY
VT 127	Prim/Porters Point	COLCHESTER	MUNICIPALITY

Figure 19: Area Map of the Intersections in the Town of Colchester Group



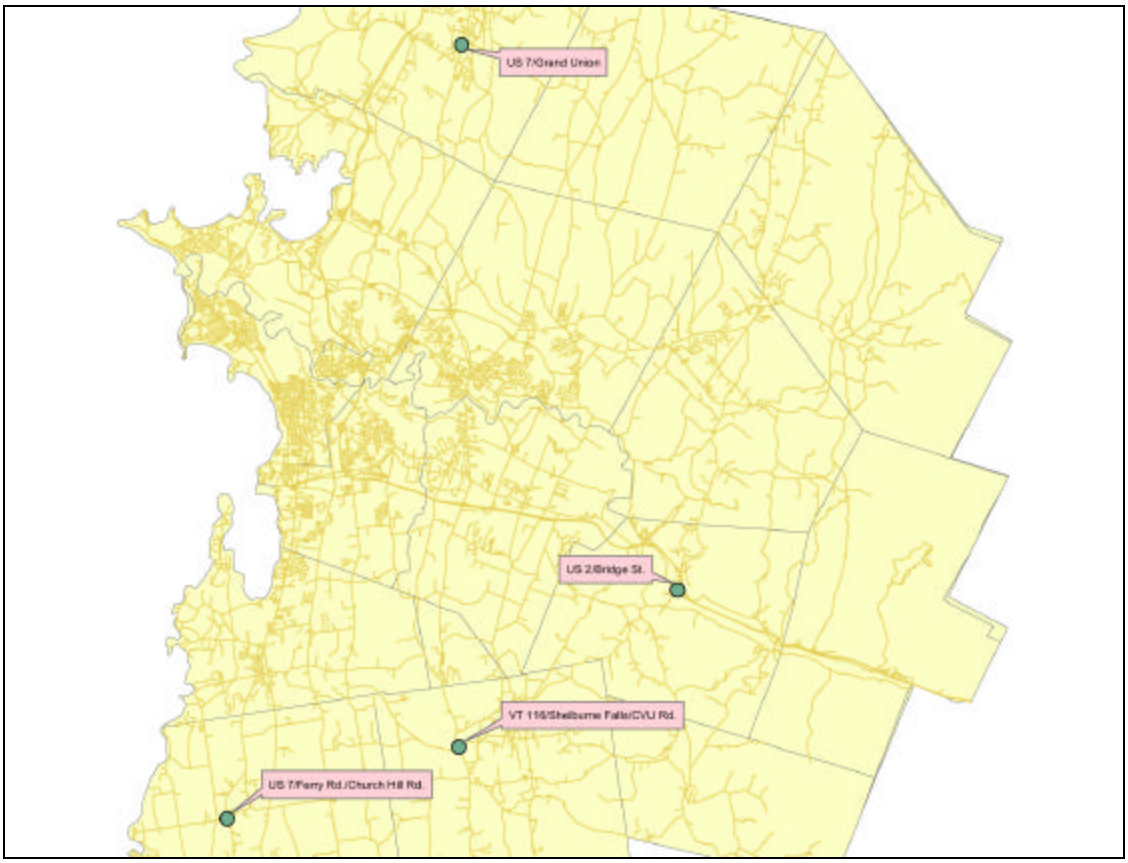
Group 20: Isolated Signals

There are 4 remaining signals in the region, each located in a separate town (Table 18 and Figure 20). Each traffic signal shown in Table 19 operates in isolation from any signal system and each is maintained by VTrans.

Table 18: Isolated Signals

Street 1	Street 2	Municipality	Jurisdiction
US 7	Grand Union	MILTON	STATE
US 2	Bridge St.	RICHMOND	STATE
VT 116	Shelburne Falls/CVU Rd.	HINESBURG	STATE
US 7	Ferry Rd./Church Hill Rd.	CHARLOTTE	STATE

Figure 20: Area Map of Isolated Signals



Special Considerations

Existence of Interconnection/Coordination

Currently, there are a limited number of signal systems that are interconnected for communication/coordinatio n purposes. The interconnected systems are:

1. Main Street, Burlington/South Burlington (South Prospect Street to the Jughandle), Burlington/South Burlington
2. Shelburne Road (Home Ave. to I-189 Ramp C), Burlington/South Burlington
3. Dorset Street (Williston Road to Kennedy Drive), South Burlington
4. Exit 16 (Tigan Street to Watertower Hill), Winooski/Colchester
5. Susie Wilson Road/Kellogg Road, Essex
6. VT2A, Marshall Ave, Williston

A major advantage of interconnection is the potential to remotely download timing plans from a central location. Currently, the Main Street Grouping in Burlington and the Town of Williston Group have the hardware in place to enable this. As of the writing of this report, neither system is fully functional.

For the six interconnected systems, interconnection has been accomplished through a hardwire, which maintains a synchronous clock for each controller in the signal system. In the case of Susie Wilson Road, the Susie Wilson/Pinecrest Drive intersection sends a signal pulse to the VT15/Susie Wilson Road intersection, and this enables these two intersections to run in coordination. The Kellogg Drive intersections are hardwire interconnected. Time-based coordination has been attempted to link together the Kellogg Drive/Susie Wilson Road intersection with the other Susie Wilson Road intersections. Generally, a hardwire interconnect is not absolutely necessary to achieve good signal coordination, but it eliminates concerns about clocks in different controllers drifting over time. This time drift is important to minimize in order to maintain tight coordination.

Technology

Traffic signal controllers can be categorized into two main families: NEMA-type controllers and Type 170 controllers. In Chittenden County, the City of Burlington uses Type 170 controllers, and the remainder of the region uses NEMA-type controllers.

The sharpness of the coordination is improved if consistent hardware is used within each corridor or grouping. Connecting across controller types and different brands of the same type is not common. However, coordination can still be achieved under these circumstances. Mixing controller types increases the difficulty of achieving and maintaining good coordination. Coordination is possible if the clocks for the different controllers can be synchronized when new plans are implemented. For this reason, previous investments in a particular brand create significant inertia to continue investing in that brand of controller.

Manufacturers are always improving signal control technology. There are 3 important characteristics for the MPO to be aware of as it seeks to establish a signal maintenance program:

1. Spread Spectrum Radio interconnection – this technology can be used to interconnect signals without a hardwire. This technology is now gaining wider acceptance, and is less expensive in many cases when compared with wireline connections. Currently, installation/acquisition costs range from $2,000 to $5,000 per signal.

2. Microwave detection – this wireless detection technology is becoming less expensive as the technology matures. Its use enables more sophisticated use of detection at traffic signals, such as queue detection.

3. Increased functionality in signal controllers – signal controllers manufactured from the mid-1980s to the present are capable of storing multiple timing programs. These programs can be implemented by time of day, day of week, and week of year. In the great majority of cases, only 3-4 timing plans are implemented. The number of timing programs installed is typically limited by the amount of traffic data that is collected and analyzed. To gain high performance, this facet of the installed signal controllers must be exploited more fully.

Costs of Signal Timing Updates

Signal timing updates vary in cost. The main issue is whether a traffic signal operates in isolation or within a group that can be coordinated. Generally, coordination requires more technical analysis to determine timing plans and a greater investigation into hardware capabilities at the traffic signals within the coordinated system.

Table 19 shows a breakdown of tasks and labor efforts associated with retiming an isolated signal. The costs in Table 19 cover the creation of 4 timing plans. These would typically be: AM peak period, off peak, PM peak period, and weekend.

Table 19: Estimated Costs of Re-Timing an Isolated Intersection

Labor:		Senior Analyst	Technician		
Hourly Rate ->	public	$95.00	$55.00		
Task				Hrs/Task	$/Task
1. Traffic Count and Data Collection					
Hardware/Software Inventory		1	1	2	$150
12-hour Traffic Count		1	16	17	$975
Related Geometric/Operational Information		1	4	5	$315
SUBTOTAL		3	21	24	*$1,440*
2. Analysis					
Volume Adjustments		1	4	5	$315
Timing/Phasing Analysis		2	4	6	$410
Develop Timing Plans (4)		8	8	16	$1,200
SUBTOTAL		11	16	27	*$1,925*
3. Implementation					
Upload Plan into Controller		2	2	4	$300
Field Monitoring/Modification		8	8	16	$1,200
SUBTOTAL		10	10	20	*$1,500*
Total Labor		24	47	71	$4,865
Expenses	$300.00				
				TOTAL PROJECT COST	$5,165.00

As shown, retiming an isolated signal would involve an average cost of $5,165.

Table 20 shows estimated costs for coordinating a signal system involving 5 traffic signals. Included in the roughly $17,000 cost is development of a simulation model for simulating peak hour traffic flows. Four timing plans would be developed, of which two plans would be simulated (AM and PM peak periods). The overall cost of coordinated systems is not surprisingly higher than for isolated signals, but the cost per intersection is lower for coordinated systems.

Table 20: Estimated Costs of Re-Timing a Coordinated Signal System

Labor:		Senior Analyst	Technician		
	Hourly Rate -> public	$95.00	$55.00		
Task				Hrs/Task	$/Task
1. Traffic Count and Data Collection					
	Hardware/Software Inventory	4	8	12	$820
	12-Hour Turning Movement Counts	2	16	18	$1,070
	2-Week Tube Counts	1	8	9	$535
	SUBTOTAL	3	24	27	*$1,605*
2. Analysis					
	Volume Adjustments	4	12	16	$1,040
	Timing/Phasing Analysis	12	24	36	$2,460
	Develop/Refine Timing Plans (4)	8	16	24	$1,640
	Simulation	40	40	80	$6,000
	SUBTOTAL	64	92	156	*$11,140*
3. Implement Timing Plan					
	Upload Plan into Controller	2	4	6	$410
	Field Monitoring/Modification	8	8	16	$1,200
	SUBTOTAL	10	12	22	*$1,610*
Total Labor		77	128	205	$14,355

Expenses:	
turning movement counts	$1,800.00
tube counts	$1,000.00
other expenses	$225.00
Total	$3,025.00

TOTAL PROJECT COST	$17,380.00

Possible Funding Sources for Supporting an Ongoing Signal Maintenance Program

There are 3 funding sources for developing an ongoing signal maintenance program:

1. Ongoing investments from the CCMPO Transportation Improvement Plan.
2. Funding timing updates in a corridor through an existing capital commitment.
3. An impact fee system for funding signal timing changes.

Incorporating Signal Updates Through The CCMPO's Transportation Improvement Plan

Within the CCMPO's TIP, a signal update program would compete annually for capital funding of a variety of transportation projects. The anticipated annual cost of these updates is shown in Table 21.

Table 21: Signal Update Program and Estimated Costs

Phase	Signal Groups	Municipality(ies)	Estimated Cost, by Groupings (Timings Only)	Estimated Cost by Phase (Timings Only)
1	Main Street/Willliston Road	Burlington/South Burlington	$42,750	
	Battery Street	Burlington	$27,000	
	North Avenue	Burlington	$15,750	$105,750
	Old North End	Burlington	$15,750	
	Pine Street	Burlington	$4,500	
2	Shelburne Road	Burlington/South Burlington/Shelburne	$33,750	
	Williston Road	South Burlington	$15,750	$78,750
	Kennedy Drive-Swift Street	South Burlington	$13,500	
	Dorset Street	South Burlington	$15,750	
3	Pearl Street/Colchester Avenue	Burlington	$18,000	
	Colchester Avenue/Main Street	Burlington/Winooski	$18,000	$67,500
	Exit 16	Winooski/Colchester	$13,500	
	VT 15	Winooski/Colchester	$18,000	
4	Susie Wilson Road	Essex	$13,500	
	Essex Junction	Essex Junction	$18,000	$49,500
	Town of Essex	Essex	$18,000	
5	Town of Williston	Williston	$22,500	
	Town of Colchester	Colchester	$9,000	$40,500
	Isolated Signals	Various Municipalites	$9,000	
		Total Program Cost		$342,000
		Average Annual Cost		$68,400

The cost estimates are based on those provided in Table 19 and Table 20, with some consideration given to larger corridors (e.g. Shelburne Road corridor). The cost

analysis suggests an ongoing annual commitment of approximately $70,000 for the program.

In recent years, the categories of Federal Funds within ISTEA have been reduced to three: National Highway System (NHS), Congestion Mitigation Air Quality (CMAQ) and the Surface Transportation Program (STP). Other than NHS, signal timing and improvements are eligible activities under CMAQ and STP funds. Unfortunately, there is not a dedicated category just for signals. However, according to FHWA, many jurisdictions have used these categories, particularly CMAQ, for system and signal improvements. Before the Federal Funds can be used the project must be programmed in the State Transportation Improvement Program by the MPO. There is usually a 20% local match required when using Federal Funds. However, traffic control signalization projects are eligible for 100% Federal funds under Title 23, Section 120 of the US Code.

Funding Timing Updates In A Corridor Through An Existing Capital Commitment

FHWA typically allows signal retimings to be included within construction costs on highway projects to which it contributes. Recent examples of this type of funding include the Shelburne Road Reconstruction and the Main Street Reconstruction Project. In both cases, signal timing plans were devised as part of the overall engineering design of the corridor.

Not surprisingly, signal timing costs are very minor in comparison with overall construction costs. Funding signal timing improvements in this way is typically considered affordable and easily incorporated into overall project costs. The one drawback to this type of funding is that there is often a significant lag time between engineering and construction, such that 3 or more years might pass between the time the plans are devised and when they are implemented. Thus, the plans are based on estimates of traffic that may not be accurate when compared to the actual traffic levels that occur after capacity improvements are in operation. Ideally, project costs could include the initial timing plans performed to meet construction specifications and an updated timing plan to be performed 6 months following opening of the facility.

An Impact Fee System For Funding Signal Timing Changes

This method holds considerable promise for supporting ongoing signal maintenance costs within Chittenden County. The concept is to assess impact fees specifically targeted to signal timing updates. The impact fees could be assessed in local or state land use permitting. Such fees would go into a Signal Timing Fund.

Mitigating traffic impacts is very expensive. If mitigation involves any type of significant capacity increases, such as a new road/street, or an intersection reconstruction, such costs can be so high as to ruin the economics of a private development.

It is far more affordable to pay a fee targeted to updating traffic signals at the intersections affected by a proposed development after the development is open and operating. Such fees could be assessed to multiple developments through the permitting process, and the costs could be shared proportionately according to relative impact (# of trips).

The development community may be receptive to this concept simply because the alternative – no permit or excessive mitigation costs – is not workable.

To make this funding option work, a public entity would need to be the recipient of the impact fees, and such fees would need to be earmarked for signal timing improvements. Within Chittenden County it makes sense for an operating committee to oversee management of the Signal Timing Fund. The operating committee should consist of representatives from VTrans, the CCMPO, and municipal public works departments.

Recommended Procedures For Updating Signal Timing Plans

Updating signal timing plans should begin with an inventory of the intersection geometry, existing timing/phasing plans, and controller hardware (and related detection). A hardware checklist should be assembled, including the following items:

? Detectors – location and type

? Controller – model and type (including whether a Master Controller exists)

? Extent and type of interconnection

The controller information is important for understanding the limitations of the system and for specifying any hardware upgrades that will need to occur to achieve certain levels of performance (e.g. whether interconnection is necessary, the presence of a Master Controller).

Signal timing/phasing plans should be based upon the most recent traffic data possible. Generally, it is recommended that 12-hour turning movement counts be acquired for a mid-week weekday (Tuesday, Wednesday, Thursday). Turning movement data should be acquired for each intersection involved in the coordinated system.

In addition, link segment counts over a 2-week period are extremely useful for identifying the extents of peak periods, as well as for specifying weekend timing plans.

Traffic count data should be adjusted to reflect average peak hour conditions. These adjustments are made using Continuous Traffic Counter data. After the turning movement counts are adjusted to reflect average peak hour conditions, they should be further adjusted by the peak hour factor to reflect peak volume flow.

There are several software packages that are useful for developing preliminary timing plans. Each package has particular strengths depending on the situation being modeled. For example, Synchro and Transyt7 are particularly good for coordinated traffic systems. Passer2 has a specialty module for evaluating diamond interchange signal systems.

For coordinated systems it is extremely useful to combine the volume data and preliminary timing plans into a traffic simulation using either CORSIM or SimTraffic. This step is critical for visually checking progression and for determining whether system constraints such as limited vehicle stacking are concerns with the new timing plan. Developing a traffic simulation model will add $5,000 - $12,000 to the cost of the signal timing upgrade.

Typically, signal plan updates are submitted to the state (VTrans) or municipality, whichever entity owns and maintains the traffic signal. Signal plans are reviewed and any comments are integrated into a final timing plan. Once final approval is obtained, the new timings can be programmed in the field. Response of the traffic stream to the new timing plans should be monitored immediately on the day the timing plans are implemented. Ideally, field visits should occur once every week for 3-4 weeks following initial implementation to refine the plans. Field visits should coincide with the key time periods addressed by the timing plans – peak periods, off peak, weekends, and any other special plans.

Recommended Program For Updating Signal Timing Plans/Technologies

A total of 20 signal timing groups have been identified in Chittenden County. It would be reasonable to update the timing plans of each group once every 5 years to account for traffic changes. A sample program is shown in Table 22. The collections of signal groups are designed to handle traffic flow within related travel blocks in the region. Thus, beginning with Phases 1 and 2, the major and minor arterials within Burlington and South Burlington would be retimed. The phasing continues through to Phase 5, where the signals in the outer communities and the isolated signals would be retimed.

Each phase of the program would contain at least one major coordinated arterial that would require a more extensive analysis.

Table 22: Recommended Schedule of Signal Timing Updates

Phase	Signal Groups	Municipality(ies)
1	Main Street/Willliston Road	Burlington/South Burlington
	Battery Street	Burlington
	North Avenue	Burlington
	Old North End	Burlington
	Pine Street	Burlington
2	Shelburne Road	Burlington/South Burlington/Shelburne
	Williston Road	South Burlington
	Kennedy Drive-Swift Street	South Burlington
	Dorset Street	South Burlington
3	Pearl Street/Colchester Avenue	Burlington
	Colchester Avenue/Main Street	Burlington/Winooski
	Exit 16	Winooski/Colchester
	VT 15	Winooski/Colchester
4	Susie Wilson Road	Essex
	Essex Junction	Essex Junction
	Town of Essex	Essex
5	Town of Williston	Williston
	Town of Colchester	Colchester
	Isolated Signals	Various Municipalites

As of the date of this memorandum, four signal groupings have either been retimed, or have updated plans that are ready for implementation. These are:

1. Main Street/Williston Road
2. Susie Wilson Road
3. Shelburne Road
4. Exit 16