City of New Britain

Traffic Signal Management & Operations Plan

Adopted by the City of New Britain Board of Public Works on February 6, 2017
Adopted by the City of New Britain Board of Police Commissioners on February 21, 2017
Adopted by the Common Council of the City of New Britain on March 9, 2017
Preface

Traffic signals are ideally installed because other forms of traffic control devices are not as effective at efficiently moving traffic throughout the day. Working from this perspective, establishing specific objectives for managing the City's traffic signal infrastructure is critical for ensuring that signals are operating at their most efficient levels. Efficiency at its core is: performing or functioning in the best possible manner with the least waste of time and effort. How should this translate to the City's signals?

What the typical driver expects for signal operations fall into a few central themes:

“I want signal timings to be as responsive as possible to changing patterns”.

“I'm okay with waiting at a traffic signal, but not if traffic is nonexistent on the other approaches”.

“During peak times, I’m okay with not making it through one full cycle, but not two”.

“I expect the impact on my travel to be predictable”.

Similarly, the expectations of the typical pedestrian are:

“I expect the traffic signal to be responsive to my desire to safely cross the street”.

“At busy intersections I want all the traffic to stop for the pedestrian phase so I can safely cross”.

“I should not have to wait more than one cycle”.

And for the typical cyclist:

“I expect to be treated the same as a motor vehicle/driver with similar expectations”.

“I want a green indication for my phase even if there are no motor vehicles present on the same approach”.

Distilled down, the majority of the traveling public desires to be treated equitably, consistently, and in a manner that appears to make sense when they encounter traffic signals.

The goal of this document is to identify what constitutes good basic service to our citizens, and what we need to do to ensure that we provide that good basic service. Objectives need to touch on all aspects of traffic signals from intersection control assessment through design, construction, timing development, operations, and maintenance. Traffic signal management by objectives will guide the City toward the vision of treating the traveling public in the most fair and efficient manner possible.

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1 Improving Traffic Signal Management and Operations: A Basic Service Model
http://www.ops.fhwa.dot.gov/publications/fhwahop09055/sigopsmgmt_v.htm
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Executive Summary

The purpose of this Traffic Signal Management and Operations Plan (TSMOP) is to provide a framework for delivery of high quality service to the public through an efficient and well-maintained traffic signal system. The plan describes the objectives of traffic signal management within the context of the City of New Britain’s Vision Statement and program goals and sets out strategies to guide the maintenance, design and operation of the traffic signal system. It also defines appropriate measures of performance to determine the extent to which the objectives are being met, and verification reporting to confirm that the defined strategies continue to be appropriately implemented on an ongoing basis.

There are two primary audiences for this TSMOP. For City management and the public, the document shows how all the system management activities support the City’s vision, transportation and related goals, and defines specific objectives for traffic signal management. For City staff, the document describes in detail the strategies they will employ while maintaining, designing and operating the system. In addition, the approach to customer service is defined, plus additional enabling strategies that must be implemented by other groups within the City to support the traffic signal management. The relationships between the goals, objectives and strategies are illustrated here.

The TSMOP Action Plan is intended to define the appropriate steps to:

1. Fully implement the TSMOP and
2. Keep it relevant and updated.

Finally, a schedule is included for the phased implementation of the plan and routine review.
1. INTRODUCTION

1.1. Purpose of this document

The purpose of this document is to:

- Provide a framework for sustainable maintenance, design and operation of the traffic signal system.
- Describe how the traffic signal system within New Britain supports the transportation and mobility goals of the City of New Britain, our neighbors and the Capital region.
- Provide a basis for funding future operations.
- Provide a basis for succession planning.

1.2. Approach to preparation of this document

This document has been prepared collaboratively by staff members responsible for planning, designing, operating and maintaining New Britain’s traffic signal system. The team proceeded through the following steps:

1. Collect and collate relevant planning and management documents that guide the programs and activities related to the traffic signal system.

2. Critically examine all the activities currently undertaken by staff in planning, operating and maintaining the traffic signal system, and in managing the staff and programs.

3. Confirm the linkages between program goals, objectives and strategies, and the activities of staff managing the traffic signal system, to ensure that:
   - All activities undertaken are essential to support the goals and objectives, and
   - There are no relevant goals or objectives that are not supported by appropriate activities.

4. Assemble the entire team to verify the institutional knowledge is consistent with the written goals and policies.

The hierarchy of vision, goals, objectives and strategies adopted for the Traffic Signal Management and Operation Plan (TSMOP) is illustrated in Exhibit 1.

1.3. Future of this document

This Traffic Signal Management and Operations Plan is expected to be a living document that will constantly guide future activities but also be modified as the City’s goals and objectives change to meet the changing demands of our stakeholders. It has been structured so that the activities of staff are described in appendices, mainly through policies and procedures that already exist and are either referenced or compiled in this document for completeness. As these procedures change to match changing technologies and administrative structures, the relevant appendices may be changed accordingly, without the need for major revisions to the document. More significant changes, such as when regional and local policies, goals and objectives change, will periodically require updates to the body of this plan. This document will also be evaluated at regular intervals to ensure it is in alignment with the City’s goals.
Exhibit 1 – Hierarchy of vision, goals, objectives and strategies

- Overall City Vision
  - Transportation & Related Mobility Goals
    - Traffic Signal Management Goals
      - Traffic Signal Management Objectives
        - System Management
          - Operational Strategies
          - Maintenance Strategies
          - Customer Service
          - Continuous Evaluation & Improvements
            - Design Strategies
            - Enabling Strategies
2. GOALS AND OBJECTIVES

2.1. Background

New Britain is centrally located in Connecticut between the cities of Hartford, Middletown, Meriden, Waterbury and Bristol. Interstate 84, CT Route 9 and CT Route 72 expressways, various state routes, connections with the comprehensive central Connecticut bus transit network, multiple railroad rights-of-way, as well as the evolution of the historic city center and numerous neighborhoods have all shaped New Britain’s current transportation system. New Britain boasts plentiful north-south and east-west connections. Although the City lacks any passenger rail connections of its own, it contains a varying degree of railroad stock, from abandoned right-of-way to the well-traveled Amtrak corridor along its south-eastern border.

The roadway system within New Britain is comprised of a series of interconnected corridors with varying levels of roadway functional classification. According to CTDOT, as of 2009, New Britain was served by 220.2 miles of public roadway, 81% of which were City roads (178.3 miles) and the balance (41.9 miles) were State roads. New Britain’s downtown street network consists of multiple east-west routes separated by CT Route 72 dividing downtown. Several north-south streets connect the split downtown with Main Street being the primary north-south vehicular route through downtown. New Britain currently owns and maintains 67 signalized intersections. A map of signalized locations is provided in Appendix A.

CTDOT also owns and operates 45 traffic signals in the City on State owned arterial routes and freeway ramps including: CT 71 (Elm St/Martin Luther King Dr/Stanley St/Hartford Rd); CT 174 (East Main St/Newington Av); CT 175 (Allen St/East St); CT 372 (West Main St/Corbin Av); CT 9 and 72 ramps; and I-84 ramps.

Public transit in New Britain currently consists of a local and regional bus system. No passenger rail service exists in the City at this time. However, 19 bus routes travel within New Britain, and form part of a larger area-wide bus system that spans multiple towns and cities. These bus routes operate seven days a week. Most of the local routes have weekday service from about 5:00 A.M. through midnight, and generally less extensive service on Saturdays and Sundays. While five of the routes provide primarily intra-city service, the remaining routes extend well beyond New Britain where they make connections with CTtransit Hartford, CTtransit Bristol, CTtransit Meriden and Middletown Area Transit. Downtown serves as the hub for all bus routes. Frequency of service varies between the bus routes, with headways as often as 25 to 30 minutes on some routes out of Downtown during weekday morning and afternoon commuter periods. Most run hourly on weekdays and Saturdays and Sundays.

CTfastrak is a bus rapid transit service with a dedicated guideway running from a terminal in Downtown New Britain to Hartford’s Asylum Street, and connecting service on local roads. The guideway extends along a 9.4 mile corridor of abandoned and active rail line. A five mile multi-use trail runs along the Busway from Downtown New Britain to
Newington Junction. Eleven transit stations serve busway users with three stops in New Britain (Downtown, East Main Street and East Street). There are four local CTfastrak routes that go through New Britain and an additional four express routes. CTfastrak offers faster travel times when compared with automobiles, since the dedicated guideway bypasses heavily travelled arterial streets and congestion on nearby highways and expressways. CTfastrak also offers frequent service, with headways of less than five minutes during peak periods. This major infrastructure investment provides residents, commuters and visitors reduced travel time for employment, recreational, residential and commercial opportunities throughout the region.

The configuration of the network and the pattern of development lead to the following travel patterns:

Peak weekday periods of heavy traffic on roadways connecting to the interstates and arterial routes connecting to downtown; and

Off-peak periods where origin and destinations among land uses within the city tend to govern the traffic patterns.

The City supports a complete streets program and has made efforts to create and encourage the use of bike and pedestrian facilities on the local road network. The Complete Streets Master Plan for Downtown New Britain was developed to serve as a guide for creating a more pedestrian-friendly, attractive and livable environment throughout the downtown area. With the terminus station of CTfastrak located in the center of downtown New Britain, the City’s goal is to maximize transit-oriented development and employment opportunities downtown, as well as support bus ridership, and improve the quality of life for those who live and work in New Britain.

The Traffic Signal Management and Operations Plan is another step in fostering a more livable environment through its effort to meet the basic service objectives of the City’s constituents.

2.2. City’s Vision and Guiding Principles

New Britain’s Plan of Conservation and Development (POCD) provides the context within which the City operates. The POCD has articulated certain overall principles to guide the community. These principles include:

- **A Community of Neighborhoods:** Priority must be given to strengthening the neighborhoods including the business areas located along corridors within neighborhoods.

- **A Regionally Central Location:** This central location should be enhanced through improved local and regional transportation linkages including the New Britain to Hartford Busway to supports its attractiveness as both a place to reside and to conduct business.
• A “Green” Community: This is reflected by the number and quality of its parks. These parks must be maintained and improved as needed to serve the community.

• A Traditional Employment Center: New Britain has strength in the growing employment sectors of healthcare and education. These economic engines should be supported moving into the next decade.

• An Affordable Place to Live: New Britain should strive to provide a diversity of housing. Part of this strategy should be to increase the supply of workforce housing serving the economic growth sectors of healthcare and education as well as the region. This role as a regional workforce housing resource will be enhanced by the New Britain-Hartford Busway.

• A Regional Culture Center: These cultural attractions are supported by the classic architecture found in the downtown and surrounding neighborhoods. These resources should be supported and enhanced through the enactment of design standards and review procedures.

• Comprehensive Infrastructure: This should be used to support smart growth principles including higher density development and adaptive reuse at strategic locations including, but not limited to areas accessed by the Busway and the Route 9 / Route 72 corridors.

• Downtown Center of Activity: The downtown will be the location for cultural activity, workforce housing and the expansion of educational and healthcare economic base sectors.

2.3. Transportation Goals

The Plan of Conservation and Development also articulates goals to guide the community specifically in development of its transportation network. Past goals have focused on the movement of people and goods within the City as well as into and out of the City. While still an important goal, more recent planning efforts have identified other transportation objectives that play a significant part in achieving economic development, housing and livable community goals, such as creating “interesting and secure pedestrian environments” in the Downtown CBD. Building upon past goals, existing conditions and recent planning efforts, a comprehensive program of transportation improvements and recommendations to encourage multi-modal travel, improve pedestrian and traffic circulation, mitigate congestion, and reduce accidents is described. Articulated goals that are relevant to management of the traffic signal system are:

• Encourage and promote use of the New Britain-Hartford Busway
  o Pedestrian, bicycle and vehicle circulation at and around the three proposed busway stations should be optimized.
  o Intelligent Transportation System (ITS) technology such as allowing buses priority at traffic signals and installing real-time traveler information sign displays at bus stops could be part of this.

• Seek ways to connect the Downtown with the larger City and region
  o The City needs to find ways to better link and physically connect Downtown New Britain with the Broad Street and East Street neighborhoods.
  o Pedestrian linkages along sidewalks over the expressways between Downtown and surrounding areas should be improved from an aesthetic and streetscape standpoint through lighting, landscaping and other design elements.
- **Encourage the use of alternative modes of transportation**
  - The City’s overall pedestrian infrastructure should be improved upon in areas lacking coverage or in disrepair.
- **Improve upon New Britain’s existing road network where necessary**
  - Although roadway capacity for vehicle travel is not currently a large issue within the City, select areas that regularly experience problems should be addressed. This generally includes areas where roadway widening or restriping would improve vehicle flows and reduce instances of long vehicle queuing and delays.
  - Devise strategies to reduce traffic accidents, especially in areas that experience high crash rates. Techniques such as improving signal timing, combining driveways, adjusting roadway widths, and restricting turning movements should be evaluated as opportunities arise.
  - Continually utilize and update Capital Improvement programs to implement projects addressing roadway safety and capacity constraints.
  - Continually standardize and update traffic control elements such as roadway signage and traffic signals.

2.4. **Traffic Signal Management Objectives**

Objectives for management of the traffic signal system that are consistent with the City’s Vision, POCD, and departmental program goals are expressed in the following terms (see Exhibit 2). These have been crafted specifically to explain why the activities that currently support the traffic signal system will continue to be essential for satisfying our customers’ needs.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Operate traffic signal system efficiently to provide good basic service within the context of a balanced, multimodal operation and realistic resource allocation, as described in current operational policies.</td>
</tr>
<tr>
<td>2</td>
<td>Keep the signal operation appropriate for the current traffic conditions (e.g. congested or uncongested) and consistent with current operational policies.</td>
</tr>
<tr>
<td>3</td>
<td>During weekday peak-hours, smooth flow of traffic on the main streets to and from the interstate and other State highways, as well as arterial routes in and out of downtown. Minimize main street stops, but when stops must occur, make them brief, within the context of safe operation.</td>
</tr>
<tr>
<td>4</td>
<td>Maximize vehicle throughput on the main street and manage vehicle queue lengths to minimize their effect on the overall corridor during congested periods.</td>
</tr>
<tr>
<td>5</td>
<td>Minimize queue length and cycle failures during uncongested off-peak periods. By doing this, access to various land uses is maximized.</td>
</tr>
<tr>
<td>6</td>
<td>Use versatile timing plans that operate well over a range of vehicle flows and patterns.</td>
</tr>
<tr>
<td>7</td>
<td>Consider pedestrians and bicyclists in the transportation network as part of complete streets. Provide reasonable accommodations in design and operations of traffic signals and related infrastructure.</td>
</tr>
<tr>
<td>8</td>
<td>Maintain a traffic signal infrastructure that is appropriate for accommodating current mobility goals of all users including those with disabilities.</td>
</tr>
<tr>
<td>9</td>
<td>Maximize the percentage of time that motorists encounter what we expect them to encounter (i.e. are timing plans and equipment running as we expect).</td>
</tr>
</tbody>
</table>

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4 A cycle failure is when a vehicle waiting at a red light is not able to make it through on a single green indication. Traffic Signal Timing Manual [http://ops.fhwa.dot.gov.arterial_mgmt/tstmanual.htm](http://ops.fhwa.dot.gov.arterial_mgmt/tstmanual.htm)
Develop traffic operations plans that can be responsive to traffic conditions beyond typical patterns (e.g. diversion route plans). Institute procedures and provide traffic control system infrastructure to support these plans.

Design traffic signal system elements that are sustainable in a fiscally responsible manner.

 Undertake maintenance in a cost-effective manner.

 Simplify hardware and software needs when possible.

 Keep the community and other stakeholders fully informed and educated about the development and operation of the traffic signal system so they understand what we do, why we do what we do, and the challenges we face, so they can judge for themselves how well we are satisfying their needs.

 Cooperatively coordinate with neighbor agencies to develop and implement regional solutions to traffic problems related to regional issues.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Performance Measure</th>
<th>Measurement Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2</td>
<td>Number of signal timing adjustments required to address reported or observed issues</td>
<td>Monthly statement</td>
</tr>
<tr>
<td>1, 3</td>
<td>Percentage arrivals in green on coordinated routes</td>
<td>Continuous data collection and reporting using ITS equipment at locations in system*</td>
</tr>
<tr>
<td>1, 3</td>
<td>Arrivals in green at applicable intersections</td>
<td>Continuous data collection and reporting using ITS equipment at locations in system*</td>
</tr>
<tr>
<td>1, 3, 6</td>
<td>Travel time along coordinated routes</td>
<td>Periodic floating car studies</td>
</tr>
<tr>
<td>4</td>
<td>Vehicle throughput at congested intersections</td>
<td>Continuous data collection and reporting using ITS equipment at locations in system*</td>
</tr>
<tr>
<td>4, 5</td>
<td>Residual queue length at critical intersections within established criteria (target values)</td>
<td>Continuous data collection and reporting using ITS equipment at locations in system* Where available, use queue length calculations from video detection. Occupancy of appropriate local or system detectors may be a proxy for queue length. Visual observation may be used where otherwise not instrumented.</td>
</tr>
<tr>
<td>7</td>
<td>Percentage of signals at which crosswalks and signals provide for all desired pedestrian movements</td>
<td>Annual review</td>
</tr>
<tr>
<td>7</td>
<td>Percentage of signals at which all desired bicycle movements are accommodated</td>
<td>Annual review</td>
</tr>
<tr>
<td>7</td>
<td>Percentage of intersections and phases with operational bicycle detection</td>
<td>Annual report</td>
</tr>
</tbody>
</table>

In each of the following chapters, strategies that will support each of these objectives are described.

**2.5. Performance Measures**

The following measures of performance will answer the question, “Are the strategies we have implemented having the desired effect?” Exhibit 3 indicates what performance measures may be applicable to each objective, and appropriate methods of obtaining each performance metric.
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Reporting Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Percentage of intersections with unserved pedestrian movements</td>
<td>Annual report</td>
</tr>
<tr>
<td>8</td>
<td>Percent of signals with Accessible Pedestrian Signals</td>
<td>Annual report</td>
</tr>
<tr>
<td>11, 12</td>
<td>Annual operating and maintenance costs of signals</td>
<td>Annual report</td>
</tr>
<tr>
<td>9</td>
<td>Number/percentage of intersections where annual preventative maintenance is performed</td>
<td>Annual report</td>
</tr>
<tr>
<td>9</td>
<td>Percentage of units unserviceable, by unit type</td>
<td>Annual report</td>
</tr>
<tr>
<td>9</td>
<td>Percentage of time communications is fully operational</td>
<td>Monthly report, automatically generated from central system software*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quarterly report at locations with closed loop interconnection</td>
</tr>
<tr>
<td>9, 12</td>
<td>Maintenance performance statistics, such as: Time to respond to fault report Time to repair fault</td>
<td>Annual report</td>
</tr>
<tr>
<td>11, 12</td>
<td>Total cost of maintenance activities per intersection</td>
<td>Quarterly statement, Annual report</td>
</tr>
<tr>
<td>11, 12</td>
<td>Cost to repair, by fault type</td>
<td>Quarterly statement, Annual report</td>
</tr>
<tr>
<td>13</td>
<td>Perform system engineering analysis for any new installation or upgrade</td>
<td>Annual report</td>
</tr>
<tr>
<td>13</td>
<td>Number of different major equipment or software items (brands, models, revisions, etc.) supported</td>
<td>Annual report</td>
</tr>
<tr>
<td>14</td>
<td>Traffic dashboard of useful performance data that correlate to stakeholder goals</td>
<td>Annual report</td>
</tr>
<tr>
<td>15</td>
<td>Maintain current incident management plans with traffic signal response to incidents on freeways</td>
<td>Annual review</td>
</tr>
</tbody>
</table>

*Requires traffic signal system
3. DESIGN

This chapter describes design strategies that will be employed as appropriate to implement one or more of the objectives, to ensure the installed signal system will have the capabilities to operate as required and to be maintained in the manner required. In addition, this chapter lays out the minimum steps to be taken when implementing new automated systems for either traffic signal operation or management (such as signal trouble call tracking).

3.1. Design Strategies

These strategies ensure that all the elements included in traffic signal designs are required to support:

a) operational strategies described in the operations chapter;

b) maintenance strategies described in the maintenance chapter; and

c) do not create inefficiencies or difficulties for both maintenance and operations staff.

3.1.1. Operations Support

1. Establish design criteria to be utilized for all new signal installations to ensure consistency and compatibility with existing field equipment.

2. Prior to the installation of any new traffic signals or the upgrade or replacement of any existing traffic signals, evaluate if they are warranted per the Manual of Uniform Traffic Control Devices. Do not install and consider removal if not warranted. Consider alternative traffic control, such as installing a roundabout, using life cycle cost analysis.

3. Design signals to allow application of versatile operational strategies to suit varying traffic conditions and changing community expectations.

4. Design adhering to the current MUTCD and CTDOT requirements for signal head location. Where discretion is allowed, provide consistency. (e.g., primary signal heads should be placed directly over centerlines of all approaches to provide consistency for drivers, especially to assist with orientation of lanes when snow events occur).

5. Design for pedestrian push buttons on all pedestrian phases to allow for maximum flexibility of timing plan development. Pedestrian signal heads are required for all phases where push buttons are utilized. Guidance from the MUTCD and ADA shall be utilized in placement of push buttons.

6. Design detection suitable to satisfy anticipated operational strategies with consideration focusing the best resources at the locations of critical need to address congestion. Where there is lesser demand, accommodate the more limited operational needs with detection that requires less operational and maintenance resources.

7. Use robust detection installation that will be less affected by pavement deterioration, road maintenance or construction activities.

8. Design system elements that automate performance measurement as much as possible to assist operations and management of traffic.

9. Design the communications system to have bandwidth, communication speed, reliability and availability, suitable to accommodate operational requirements. Apply sound system engineering principles to all communications technology decisions to ensure that they support anticipated activities of the agency.

10. Routinely review existing traffic signal installations to ensure their design is still appropriate for the prevailing conditions (e.g., appropriate number of phases, appropriately accommodate pedestrians and bicycles, the need for the signal is still valid).

11. Design system to allow efficient setup, fine tuning, monitoring, and performance measurement by operations staff.
3.1.2. Maintenance Support

1. The current Public Works design criteria will be utilized for all new signal installations. This ensures consistency, and compatibility with existing field equipment.

2. Design plans should incorporate span pole and mast arm configurations that minimize the amount of infrastructure to be maintained (e.g. at T-intersections can a single mast arm assembly oriented diagonally adequately serve all approaches). Ensure that pole locations do not encroach on sidewalks if possible, but if unavoidable, ADA access requirements to curb ramps must be met.

3. The use of detection that is non-intrusive to the road pavement is preferred (video, microwave, etc.) to allow for future flexibility of zone set-ups, and minimize pavement damage for reduced repair costs and minimal disruption to travel resulting from lane required closures. However, this should not be at the expense of achieving operational goals. If other detection technology decreases maintenance needs and meets operation goals, these should be utilized. Detection zones should be limited to what is necessary to meet operational needs. Limitations of detector technology should be understood for all conditions (sightlines, night and day light conditions). When using video detection, the manufacturer should be consulted regarding placement for best functionality.

4. Specify detection systems that have a proven record of high performance and reliability, and are maintainable at a high level of availability.

5. Design the traffic signal system to allow a high level of efficiency and cost-effectiveness of maintenance and operation activities.

6. Specify materials to minimize deterioration of performance and appearance that would require continued maintenance or early replacement.

7. Design system to automatically detect and report faults.

8. Design system to minimize failure rates of equipment units.

9. Design signals to minimize risk of damage due to crashes and vandalism.

10. Design system to allow fast and efficient response by maintenance staff.

11. Design communications system to self-diagnose and report faults.

12. Design communications system to minimize damage by others.

3.1.3. Multimodal Accommodations

1. Provide accessible pedestrian signals (APS) at locations where known support facilities for visually impaired citizens are nearby, or when requested by citizens during the planning stages when signalized locations are on a route currently used by visually impaired citizens.

2. Provide a high level of accessibility of traffic signals to all road users (e.g., facilities accommodating pedestrians, cyclists, transit passengers).

3. Provide crosswalks for all reasonable pedestrian movements at traffic signals.

4. Provide push buttons for all pedestrian phases.

5. Provide bicycle detection for actuated phases where there is expected bike demand.

6. Upgrade intersection elements to current ADA standards and include APS when significant modifications or construction work are undertaken in the vicinity of the intersection.

3.1.4. Regional Coordination and Compatibility

1. Design should conform to regional or statewide ITS architecture standards.

2. Design should consider coordination between City signals and State or abutting town signals where necessary to maintain smooth flow or manage congestion.

3.1.5. Miscellaneous

1. Follow systems engineering principles for all new system elements and when considering major changes to the system.
2. Maintain a design review checklist to identify all elements that must be included in a design and the appropriate standard or specification.

3. Design system to share high bandwidth communications with other departments and agencies where it will be feasible and cost-effective.

3.2. Systems Engineering
The following minimum steps should be utilized when systems such as signal system software changes, tracking, or infrastructure management systems are updated or procured. These steps assist with a consistent systems engineering approach to ensure that the City obtains what it truly needs. The City’s objectives and high level requirements must be kept at the forefront when assessing new projects, and applications using these steps. This is a top down assessment approach. All relevant stakeholders should be involved in the process to be most effective. For all projects using State or Federal aid a System Engineering Analysis Form (SEAFORM) that documents the system engineering process must be completed and approved by CTDOT. The system engineering approach supports the concept of providing good basic service, which focuses the City’s resources on doing what is most important based on the stated goals and evaluating outcomes. The system engineering “V” diagram illustrates this. Notice the symmetry in the model. This symmetry reflects the relationship between the plans developed on the left driving the processes on the right. The connections between the steps indicated by the arrows provide the continuity between the beginning and end of project development and ensure that the engineers are focused on the completion of the project from the beginning.\(^5\)

During the formative stage of the project, as the feasibility and concept is explored, the portion of the regional and statewide ITS architecture\(^6\) that is related to the project is identified. If the project does not conform to the architecture CTDOT must be advised so that the architecture can be updated.

**Needs Assessment and Concept of Operations:** Needs are identified that address how to achieve the stated City’s goals and objectives. Thorough needs must be established if federal funding is used. Routine replacement or repair of an existing system does not in of itself constitute a need\(^7\).

The Concept of Operations is a non-technical description of how the system be used and by whom and for what purposes. This provides a bridge between the often vague needs that

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motivated the project to begin with and the specific technical requirements. The development of the Concept of Operations helps to:

- Identify the stakeholders and get their agreement to describe how the system is to be operated and maintained, who is responsible for what, and what the lines of communication are;
- Define the high-level capabilities of the system;
- Define the environment in which the system will operate;
- Derive high-level requirements, especially user requirements;
- Provide scenarios and criteria to be used for validation (via the Validation Plan) of the completed system.

Staff should write this document when possible to best think through the needs. If a consultant writes this document, the Engineering Division should be the primary audience. The focus of this step needs to be on what will be done with the new system, and not what features are desired. This step provides a model of the activities of the City staff, in detail, including how staff receives and responds to citizen complaints, how the signal timing database is managed, how the operation of the system is monitored, how future operations are evaluated, and so on. These activities should describe each step taken by staff, and the activities, taken together, describe the needs in detail. These needs will become the basis for requirements used to evaluate systems alternatives. The Engineering Division will confirm that the model of their activities as described in any proposed system Concept of Operations is accurate and representative of intentions.

Requirements: The activities described above will lead to requirements. For example, if staff intends to be responsive to the reporting of critical faults on a 24-hour full-time basis, that activity will lead to a requirement to provide a portable device that a person can carry anywhere and be notified of specific critical fault information. These requirements will become the standard for evaluating design and technology alternatives, and therefore the requirements themselves will be independent of design and technology prescriptions. Each requirement must be linked to a corresponding need described in the Concept of Operations. If a requirement cannot be traced to a statement of need then the Concept of Operations must be revised (so its readers will clearly understand why the requirement exists), or the requirement should be deleted.

The requirements will also be written to be easily and directly tested so that designers are able to efficiently demonstrate that their design is complete and correct, and so that staff is able to efficiently conduct verification and validation. The types of requirements typically needed to define a proposed system are described below, although they need not be differentiated into these categories in the requirements document:

- Functional requirements: What the system is to do;
- Performance requirements: How well it is to perform;
- Non-functional requirements: Under what conditions will it conform;
- Enabling requirements: What other actions must be taken in order for the system to become fully operational;
- Interface requirements: Definitions of the interfaces between sub-systems or with external systems;
- Data requirements: Definition of data flows between sub-systems or external systems.

When developing requirements constraints (the limitations within which you must work) will be identified. It is very important to distinguish between constraints and requirements. The requirements should be related entirely to the manner in which the system is to operate and how operators interact with the system based on identified needs and not be artificially restricted. Each identified constraint should be carefully evaluated to determine whether it can be overcome or whether it will affect the design. If after examining the trade-offs it is decided to accept the constraint, it will then become a non-functional requirement.

**Design:** A system design is created based on the system requirements including a high-level design that defines the overall framework for the system. Subsystems of the system are identified and decomposed further into components. Requirements are allocated to the system components, and interfaces are specified in detail. Detailed specifications are created for the hardware and software components to be developed, and final product selections are made for off-the-shelf components.

**Implementation and Testing:** System components are procured, installed, and tested. This can be an interactive process, particularly if a custom software installation is involved.

**Verification:** This step will require the designer to demonstrate how each element of the design fulfills the requirements. It should also describe how the system will be tested to prove it conforms to the design. This can also be an interactive process as components of the system are integrated and verified against the requirements using the verification plan.

**Validation:** During this phase, the system’s owner and stakeholders assess the system’s performance against the intended needs, goals, and expectations documented in the Concept of Operations and the Validation Plan. System validation may also measure how satisfied the users are with the system. This can be assessed through surveys, interviews, reviews and direct observation. It is important that this validation takes place as early as possible in order to assess its strengths, weaknesses, and new opportunities. As a result of validation, new needs and requirements may be identified. This evaluation sets the stage for the next evolution of the system. In addition, deficiencies of the project development should also be reviewed at this time. A “lessons learned” review can be very valuable for future projects. Measurement of the system’s performance should not stop after the system validation phase. Performance measurements should be collected throughout the life of the system to determine when the system becomes less effective.
3.3. Implementation Verification

The following measures in Exhibit 4 will verify, through periodic assessment, the extent to which the design strategies have been successfully implemented.

<table>
<thead>
<tr>
<th>Design Performance Measure</th>
<th>Target</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Document number of signals meeting current New Britain design standards</td>
<td>100%</td>
<td>Annual review</td>
</tr>
<tr>
<td>Document number of signals with full communications capability</td>
<td>Downtown plus primary routes</td>
<td>Annual review</td>
</tr>
<tr>
<td>Confirm specifications consistent with needs of all operations and maintenance</td>
<td></td>
<td>Annual review</td>
</tr>
<tr>
<td>Confirm all required details are in design review checklist</td>
<td></td>
<td>Annual review</td>
</tr>
<tr>
<td>Report design exceptions, variations from standards and design review checklist</td>
<td></td>
<td>Annual review</td>
</tr>
</tbody>
</table>
4. OPERATIONS
This chapter describes operational strategies that will be employed as appropriate to implement one or more of the objectives, from the point of view of how the signals will control and facilitate movement of traffic and other road users.

This chapter discusses both the operational approach to the City's traffic signals along with the evaluation to be undertaken for purposes of meeting the following key requirements:

1. Smooth flow during weekday peak periods must minimize main street stops and delays to travel time.
2. Versatile timing plans that operate well over a range of vehicle flows and patterns.
3. Minimize queue length and cycle failures during uncongested off-peak periods.
4. Maximize vehicle throughput on the main street, and
5. Manage vehicle queue lengths to minimize their effect on the overall corridor during congested periods.

4.1. Current Resources and Capabilities
The Engineering Division of Public Works is responsible for the traffic design and operations of the City's traffic signal infrastructure. The Engineering staff, led by the City Engineer, consists of eight staff members. One of the two project managers assumes the Traffic Engineer role and dedicates a large portion of time to traffic matters.

Traffic signal design is often supported by consultants' services via a qualified selection process for major projects or on-call engineering services contracts for smaller assignments. Operations are supported by on-call services provided by the City's primary traffic signal equipment vendor. Both engineering and operations functions are also supported by the University of Connecticut T2 Center Traffic Signal System Circuit Rider.

4.2. Operational Strategies
The following operational strategies should be used when they are appropriate. Some are mutually exclusive and cannot be implemented concurrently. Decisions on when to employ each strategy should be documented and regularly reviewed by supervisors for continued applicability.

4.2.1. System Efficiency
1. Install hardware and software to continually monitor performance under all conditions to which the operational strategies are being applied, and report the quality of that performance.
2. Automatically monitor traffic conditions and review signal timing whenever conditions change beyond a pre-determined amount.
3. Operate signals in a mode that suits current traffic conditions (e.g., separate time of day timing plans or coordinated).
4. Review and revise, as appropriate, coordinated signal timing at least once every year.

4.2.2. Signal Coordination
1. Optimize cycle lengths, splits, and offsets of individual timing plans that are developed toward achieving the key requirements listed above.
2. Strive for timing plan versatility such that the number of timing plans is kept to a minimum while still achieving the key requirements listed above.
3. When needed to accommodate demand, provide a “pipeline” along arterial roads, to maximize flow on the coordinated route while keeping side street delay to an acceptable level.
4. While accommodating demand, as far as possible, coordinate signals along arterial roads to minimize stops along the arterial, while keeping side street delay to an acceptable level.
5. Away from major arterials, distribute phase splits to balance delays on all approaches.
6. Where protected/permissive left turns are provided, allow the protected phase to be excluded from the signal pattern when the permissive phase will provide sufficient capacity to safely accommodate all left turns without carryover queues.
7. When providing coordination, include consideration of “complete street” policies.

4.2.3. Multimodal Safety and Efficiency
1. Utilize phase clearance (yellow change plus red clearance) times and pedestrian walk and clearance times calculated to comply with the latest revision of the Connecticut Department of Transportation, Traffic Control Signal Design Manual and other applicable standards.
2. Provide adequate phase green and clearance times for bicycles on each traffic signal phase, using relevant national standards.
3. Utilize pedestrian detection (push button or detection zones) to activate pedestrian phases to broaden ability to optimize splits.
4. Depending on the area, optimum synchronization of vehicular traffic may be compromised to accommodate pedestrian, bicycle and transit needs.

4.2.4. Intersection Efficiency
1. Review signal timing at applicable traffic signals whenever a policy related to timing is modified.
2. Use signal timings and flexible phasing arrangements to prevent queues exceeding critical lengths in left turn bays, in short blocks on arterial roads and on freeway off-ramps.
3. Utilize stop bar detection for side street approaches (excluding dedicated right turn lanes) and dedicated left turn lanes on main streets if protected left turn phases are warranted. The desired headway (greater than saturation headway) should be assessed for these movements to establish the appropriate detection length and passage time using the formula:

$$\text{passage} = h-\frac{(L_v + L_d)}{v}$$

Where: 
- passage is the unoccupied detector time
- $h$ = desired headway (seconds) (greater than saturation flow headway)
- $L_v$ = vehicle length (feet) (default to passenger car design length – 19 feet)
- $L_d$ = detection zone length (feet)
- $v$ = vehicle speed (feet/second)

The passage time may vary by time of day in order to meet the respective key objectives.

4. Minimize the use of protected left turning phases to increase intersection efficiency and reduce interference with arterial street progression. The left-turn movement should be treated as a minor intersection maneuver and should be provided the minimum traffic control necessary to accommodate traffic without unnecessarily long delays and safety problems while adequately providing for the other major intersection through movements. Utilize guidance found in CTDOT Traffic Signal Design Manual and Appendix B (Castle Rock Left Turn Phase Strategy).

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9 NCHRP Synthesis 225, page 1
5. Utilize shorter cycle lengths when appropriate. Shorter cycle lengths can reduce overall pedestrian wait time as well as side street delay and can help to reduce the variability of travel speeds in a corridor\(^{10}\) increasing safety and reducing the likelihood of crashes. Under congested conditions shorter cycle lengths can be more effective than overly long cycle lengths and they can be advantageous to queue management\(^{11}\).

4.2.5. Regional Coordination and Compatibility

1. Participate in regular operations coordination meetings with adjacent agencies.
2. Coordinate signals to accommodate traffic diverted by freeway incidents.

4.3. Implementation Verification

The following measures in Exhibit 5 will verify, through periodic assessment, the extent to which the operational strategies have been successfully implemented. The following evaluation strategies are described in more detail below.

1. Conduct an annual report of accidents on city-owned public streets and intersections, and use statistical modeling to assess whether infrastructure issues may be a contributing factor to accidents.
2. Conduct floating car travel time studies to measure average number of stops and average delay during weekday AM and PM peak hours. If funding becomes available, use of blue tooth technology\(^{12}\) or high-resolution controller event data\(^{13}\) should be considered to supplement or replace the floating car method.
3. Field assess each corridor during off peak periods to determine the dominant flow patterns. All signal corridors will be assessed once/year with a minimum of six months between assessments. Reviews should try to cover all four quarters of the year in alternating years. Both weekday and weekend off peak periods should be assessed.

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Target</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial volume (throughput)</td>
<td></td>
<td>Monthly report for locations that have appropriate detection</td>
</tr>
<tr>
<td>Accidents on City streets and intersections</td>
<td></td>
<td>Annual report</td>
</tr>
<tr>
<td>Minor phase max-out</td>
<td></td>
<td>Monthly report</td>
</tr>
<tr>
<td>Number of stops, weighted by volume</td>
<td># stops per mile</td>
<td>Periodic floating car studies</td>
</tr>
<tr>
<td>Frequency queue exceeds limit</td>
<td>Zero blockages</td>
<td>Continuous detection</td>
</tr>
<tr>
<td>Number of intersections with bicycle timing</td>
<td>All intersections</td>
<td>Annual report</td>
</tr>
</tbody>
</table>

\(^{10}\) NACTO Urban Street Design Guide http://nacto.org/publication/urban-street-design-guide/intersection-design-elements/traffic-signals/signal-cycle-lengths/


\(^{12}\) http://www.trafficcast.com/products/view/blue-toad/

5. MAINTENANCE

These activities make sure the system continues in a good state of repair, and deviations are corrected in a timely manner. This chapter lays out the City’s approach to the maintenance of City owned traffic signals. This chapter includes a clear explanation of how available staff and financial resources will be maximized to maintain existing equipment. This chapter outlines the strategies to meet the key requirement of “Maximizing the percentage of time that motorists encounter what we expect them to encounter”.

5.1. Current Resources and Capabilities

The Traffic Division of Public Works is responsible for maintaining the City’s traffic signals. There are two full-time Traffic Maintainers that work under the direction of the General Foreperson and Streets Foreperson. The Field Services personnel work closely with the Engineering Division and Traffic Division of the New Britain Police Department. The Field Services Traffic Division is also responsible for maintaining the City’s signage, setting up temporary traffic control devices and minor pavement marking installations. The Traffic Maintainers utilize two bucket trucks, a utility truck and have access to a number of other resources when needed.

The Annual Traffic Budget (as of FY2016) is $23,000 for operations, maintenance, repairs, supplies, and outside contractor services. The Traffic Budget covers all traffic signal, signage and pavement markings expenditures except full-time salaries.

5.2. Maintenance Strategies

5.2.1. Proactive Maintenance

These strategies ensure that:

a) components of the traffic signal system that have a limited service life are regularly cleaned, replaced, recalibrated or tuned to prevent equipment failures; and

b) information that will prevent damage by others is provided in a timely manner.

1. Maintain accurate as-built records of all elements of the traffic signal system.
2. Make as-built records available in a timely fashion to anyone who needs them in order to prevent damage to the traffic signal system.
3. Visit every intersection once every year and undertake all required preventive maintenance activities, according to relevant procedure. (e.g., change filters, vacuum dust, remove insects and rodents, replace defective signal displays, test MMU, and check condition of cables and connectors). Use checklist found in Appendix C. A comparison of the number of trouble calls versus preventative maintenance frequencies should assist with optimizing a preventative maintenance schedule and tasks. Examples include: 1) is current preventative maintenance schedule too lean, or excessive, 2) is more detail required for existing checklists.
4. Maintain comprehensive log of all tests, maintenance and repair activities.
5. Regularly confirm that signal timing parameters are correct (e.g., controller settings match master database).
6. Mark underground equipment in a timely manner when requested.
7. Continue to maintain all underground signal infrastructure with the State’s call before you dig locate request center to minimize repair costs associated with damage from contractor digs.
8. Semi-annual visits to each signal by City staff to observe video detection quality and operations. If possible, visits should cover varying light, and weather conditions.
9. Conduct regular program upload and comparisons of all traffic signals to ensure correct timing plans are running. Ensure the traffic signal equipment vendor has a process to maintain traffic signal timings and procedures for timing change notification to the Traffic Engineering Division associated with maintenance activities.

10. Reduce the number of future signal installations to minimize equipment inventory by assessing alternative controls, such as roundabouts, during engineering reviews of unsignalized intersections.

5.2.2. Reactive Maintenance

These strategies ensure efficient and effective response when equipment fails and an emergency response is required to restore operation.

1. Maintain at least two standard traffic control cabinets, controllers and conflict monitors to restore full operation. Maintain non-standard cabinets (pedestal mounted) as feasible. Additional contractor resources shall be available to assist in the installation of critical components. Response to equipment failure shall be as outlined in the Traffic Signal Response Plan.

2. Maintain a sufficient number of spare safety-critical equipment parts. This includes items such as signal indications, relays and load switches. Response to equipment failure shall be as outlined in the Traffic Signal Response Plan.

3. Provide a sufficient number of traffic maintainers on duty and available for call-ins during off-hours to ensure safety-critical issues can be addressed as outlined in the Traffic Signal Response Plan.

4. Utilize the City’s Purchasing Department to retain contractors’ services when repairs are too complex and/or extensive to be undertaken by City personnel. Contractor expenses are included in the Annual Traffic Budget.

5.2.3. Maintenance Administration

1. Train all staff to be proficient in all the activities to which they are assigned.

2. Analyze maintenance logs and report effectiveness and efficiency (monthly, annually, etc.).

3. Proceed cautiously to ensure new equipment can be maintained cost effectively.

4. Provide staff with the flexibility to work non-standard hours when required to accommodate emergency or unusual maintenance circumstances.

5. Track all emergency maintenance call-ins.

5.3. Implementation Verification

The following measures in Exhibit 6 will verify, through periodic assessment, the extent to which the maintenance strategies have been successfully implemented.

<table>
<thead>
<tr>
<th>Exhibit 6 – Maintenance performance measures</th>
<th>Target</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to respond to emergency calls</td>
<td>Varies by type of reported fault</td>
<td>Report quarterly</td>
</tr>
<tr>
<td>Time to provide requested information (e.g., mark underground facilities)</td>
<td>Three days</td>
<td>Report monthly</td>
</tr>
<tr>
<td>Number of staff trained to maintain equipment, by type</td>
<td>Varies by type of equipment</td>
<td>Report annually</td>
</tr>
<tr>
<td>Time to clear failures, by type</td>
<td>Varies by type of fault</td>
<td>Report monthly</td>
</tr>
<tr>
<td>Detector status report</td>
<td>Fix detection problems before public notices</td>
<td>Report monthly</td>
</tr>
<tr>
<td>Tabulation of maintenance work orders</td>
<td>Fix detection problems before public notices</td>
<td>Report monthly</td>
</tr>
<tr>
<td>Report equipment and spares inventory, actual vs planned</td>
<td>Zero variance</td>
<td>Report quarterly</td>
</tr>
<tr>
<td>Report staff status actual vs planned</td>
<td>Zero variance</td>
<td>Annual report</td>
</tr>
</tbody>
</table>
6. MANAGEMENT AND ADMINISTRATION
These activities make sure the system continues in a good state of repair, and deviations are corrected in a timely manner.

6.1. Enabling Strategies
The following strategies will assist in creating and maintaining an environment within the City of New Britain that will allow the maintenance, design and operations strategies to be effectively and sustainably implemented.

6.1.1. Personnel Strategies
1. Provide a well-trained group of staff with sufficient resources to handle staff changes and temporary fluctuations without compromising the performance of the traffic signal system.
2. Coordinate the activities of all relevant staff involved in planning, designing, operating and maintaining the traffic signal system.
3. Develop and implement a succession plan for each staff position.
4. Document procedures to the extent necessary for a new or temporarily assigned staff member to be able to efficiently complete the duties of the position.
5. Define qualifications appropriate for all staff and a policy to ensure staff remain appropriately qualified.

6.1.2. Inter-department Coordination Strategies
1. Conduct monthly Traffic Coordination Meetings with personnel from Engineering, Field Services and NBPD Traffic Division.
2. Define when and how to coordinate planning reviews with operations and maintenance staff.
3. Define when and how to coordinate Capital Improvement Projects development, grant applications and internal budgeting.
4. Define how to handle design reviews.

6.1.3. Budget and Programming
1. Maintain a list of intersections that require upgrade or improvement when modifications are proposed by others (e.g., developer of adjacent property). List should be based on regular assessment of intersection operations, maintenance history, obsolete, substandard or defective equipment.
2. Maintain a plan to avoid obsolescence as current equipment ceases to be supported by vendors.
3. Regularly review new technology developments beyond traffic signals that will require modifications to existing equipment and practices (e.g., connected vehicles).

6.2. Customer Service Strategies
Clear, direct, honest communications is the essential vehicle by which the City’s values are demonstrated. This is the foundation of our interaction not only with the Mayor, City Council, boards, commissions, and staff, but the public as well. The following strategies will support the City’s customer service objective:

1. All signal questions or comments received should be responded to in kind (phone calls with phone calls, emails with emails, etc.).
2. All initial contacts should be initially returned by phone or email within two business days to notify a person that their question or comment has been received. This initial contact should be by the person managing the review or response.
3. The Engineering Project Manager should personally answer all questions associated with traffic signal issues that are not malfunctions.

4. All contacts from the media regarding traffic signals shall be directed to the Public Works Director. The Director may assign the Engineering Project Manager or City Engineer to respond or coordinate with the Mayor’s Office.

5. The Engineering Project Manager should be responsible for preparing all presentations and reports to City officials, boards, and commissions regarding signal procurement, installation, removal, and operations.

6. An annual report will be prepared for the Public Works Director for the proceeding year’s efforts and following year’s objectives.

7. Empower all employees to be ambassadors of the City by providing them with a good understanding of the traffic signal system, and training them to recognize when it is appropriate to discuss with customers and when to refer to a more qualified staff member.

8. Measure and report our performance in responding to complaints.

9. Tell customers ahead of time what to expect (e.g., normal operations, planned events such as community events and lane closures, and expected incidents such as weather events).

10. Provide timely information in response to unplanned and unexpected incidents and emergencies.

11. Report regularly to officials, show where the traffic signal management plan is leading and how it is responding to the City’s goals and objectives.

12. Engender pride in the traffic signal system.

13. Provide procedures and standards to all staff for customer service activities, such as:

   ✓ Accepting and responding to trouble calls
   ✓ Accepting and responding to requests to modify the way the traffic signal system is designed or operates
   ✓ Dealing with media requests
   ✓ Reporting system performance to City Council

6.3. Implementation Verification

The following measures will verify, through periodic assessment, the extent to which the management activities have been successfully implemented.

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Target</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to respond to customer</td>
<td>Initial response – 2 days</td>
<td>Quarterly report</td>
</tr>
<tr>
<td>Time to close out request</td>
<td>Closeout – four weeks</td>
<td>Quarterly report</td>
</tr>
<tr>
<td>Types of inquiries</td>
<td></td>
<td>Quarterly report</td>
</tr>
<tr>
<td>Percentage of inquiries satisfied</td>
<td></td>
<td>Quarterly report</td>
</tr>
</tbody>
</table>
Appendix A – City of New Britain Signalized Locations
Appendix B – Castle Rock Left Turn Phase Strategy

Protected left turn phasing may be beneficial if some or all of the following conditions exist:

1. Volumes:

<table>
<thead>
<tr>
<th># of Opposing Lanes</th>
<th>If</th>
<th>Left Turn Should Exceed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(Q_o(C/g) &lt; 1000)</td>
<td>(770(g/C) - 0.634Q_o)</td>
</tr>
<tr>
<td></td>
<td>(1000 &lt; Q_o(C/g) &lt; 1350)</td>
<td>(480(g/C) - 0.348Q_o)</td>
</tr>
<tr>
<td></td>
<td>(Q_o(C/g) &lt; 1000)</td>
<td>(855(g/C) - 0.500Q_o)</td>
</tr>
<tr>
<td></td>
<td>(1000 &lt; Q_o(C/g) &lt; 1350)</td>
<td>(680(g/C) - 0.353Q_o)</td>
</tr>
<tr>
<td></td>
<td>(1350 &lt; Q_o(C/g) &lt; 2000)</td>
<td>(390(g/C) - 0.167Q_o)</td>
</tr>
<tr>
<td>2</td>
<td>(Q_o(C/g) &lt; 1000)</td>
<td>(900(g/C) - 0.448Q_o)</td>
</tr>
<tr>
<td></td>
<td>(1000 &lt; Q_o(C/g) &lt; 1350)</td>
<td>(735(g/C) - 0.297Q_o)</td>
</tr>
<tr>
<td></td>
<td>(1350 &lt; Q_o(C/g) &lt; 2400)</td>
<td>(390(g/C) - 0.112Q_o)</td>
</tr>
</tbody>
</table>

\(Q_o\) = opposing traffic volume, \(C\) = Cycle Length, \(g\) = effective green time

Note: Use judgement as to whether or not dedicated right turn lane and associated volume should be included in calculation.

2. Delay:
   a. Total estimated delay of all left turning volume in hour > 2 hours
   b. Min of 2 left turning vehicles/cycle
   c. Average delay for left turn vehicle is > 35 seconds

3. Accidents:
   a. Single approach: 4 accidents/year, or 6 in two years
   b. 2 opposing approaches: 6/year, or 10 in two years

4. Sight Distance: When opposing left turns cannot see past one another to be able to observe safe gaps in opposing through traffic.

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14 Town of Castle Rock, CO Traffic Signal Management and Operations: A Basic Service Plan
Appendix C – City of New Britain Preventative Maintenance Checklist

City of New Britain
Department of Public Works
Traffic Control Signal Maintenance Checklist

rev.2015-12-28

Intersection (number / major street / minor street): | Performed By: | Date:
---|---|---

**CABINET**

Controller Information
- [ ] Naztec  Model/Part No: ___________________ Manufacturing Date: ___________________
- [ ] Econolite  Serial No: ___________________ Program No (Econolite): ___________________
- [ ] Vacuum Cabinet
- [ ] Check for insects / animals
- [ ] Check seal at base  [ ] Good Condition  [ ] Re-Caulk  [ ] Water/Moisture in Cabinet
- [ ] Check ground rod, clamps & wire
- [ ] Check wiring for loose wires and/or corrosion
- [ ] Check / replace duct sealant at conduits
- [ ] Check fan
- [ ] Check / replace lamp
- [ ] Check and record current at circuit breaker: ___________________
- [ ] Check / replace load switches and relays
- [ ] Check detector amplifiers: Note approaches not working properly: ___________________
- [ ] Lubricate hinges and lock
- [ ] Replace filter  filter size: ___________________
- [ ] Remove spare parts (relays, load switches, etc)
- [ ] Check for graffiti on cabinet exterior  [ ] no graffiti  [ ] wash off graffiti  [ ] repaint cabinet
- [ ] Remove / Trim brush vegetation

**HANDBOLES**

- [ ] Check cover (including screws)
- [ ] Check integrity of the splices
- [ ] Check ground clamps and wire
- [ ] Check for abnormal amount of water

**MAST ARM ASSEMBLIES / SPAN POLES / PEDESTIALS**

- [ ] Check overall mast arm / span pole  [ ] pole leaning  [ ] repaint pole
- [ ] Inspect anchor bolts for rust and tightness  [ ] excessive rust  [ ] missing cover(s)
- [ ] Inspect poles at base plate  [ ] excessive rust  [ ] sections of steel rotted through
- [ ] Inspect poles/arms for rust and corrosion  [ ] excessive rust  [ ] dents
## Traffic Control Signal Maintenance Checklist

### SIGNAL HEADS

- Check alignment
- Lamp type: [ ] All LED  [ ] Incandescent & LED (list all non-LED lamps: approach – left/right – R/Y/G/arrow)

- Check / replace lamps
- Check wires, connections and terminals
- Check gasket for water infiltration and deterioration
- Check for cracks and/or rust on signal heads
- Check hoods, wing nuts and hinges
- Check signal head attachment hardware (including clevis pin) for wear, loose or rust
- Check for wear on spanwire
- Shake/twist heads to simulate heavy wind loading
- Recheck signal head attachment hardware
- Clean lenses and signs

### PEDESTRIAN PUSH BUTTONS & SIGNAL HEADS

- Check each push button call to controller
- Check push button signs: secure, clean or replace
- Check audible signal (if installed)
- Check signal head alignment
- Pedestrian signal type: [ ] Incandescent  [ ] LED (non-countdown)  [ ] LED (countdown)

- Check / replace lamps
- Check wires, connections and terminals
- Check gasket for water infiltration and deterioration
- Check for cracks and/or rust on signal heads
- Check hoods, wing nuts and hinges
- Check signal head attachment hardware (including banding) for wear, loose or rust
- Clean lenses and signs

**Other Issues / Potential Issues Noticed:**

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