Concept of Operations:

Mitchell Hammock Road

Adaptive Traffic Signal Control System
Red Bug Lake Road from Slavia Road to SR 426
Mitchell Hammock Road from SR 426 to Lockwood Boulevard
Lockwood Boulevard from Mitchell Hammock Road to CR 419

Prepared by: City of Oviedo
Draft 1: June 2015

Document Approval Status

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<th>City of Oviedo Approval</th>
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1. **Scope**

This document addresses the system engineering needs for the Mitchell Hammock Road Adaptive Traffic Signal System. The signal system will make use of adaptive coordinated traffic signal technology to improve traffic conditions along the corridor of Red Bug Lake Road from Slavia Road to SR 426, Mitchell Hammock Rd from SR 426 to Lockwood Blvd, and Lockwood Boulevard from Mitchell Hammock Road to CR 419 as depicted in the illustration below.

![Figure 1 Corridor Map](image)

This Concept of Operations explains, at a high level, how the system will operate and defines the relative roles and responsibilities of the various participants in the system at each stage in the development of the project. The intended audience for the document includes both public and private sector partners responsible for planning, design, implementation, operations and maintenance of the system. This document is also intended to provide the required information for Federal and Florida Department of Transportation approval. Finally the document is expected to be used by the selected vendor as guidance for system design and implementation.
2. User-Oriented Operational Description

Overview
Adaptive traffic signal control technology makes use of sensors, communications and a control system to enable traffic signal timings to be in accordance with the variation in traffic flow. The system will also provide better support for public transit and emergency vehicle priority by minimizing disruption to coordination along the corridor in the event of a priority call. The overall effect of applying the technology will be to improve the reliability of travel times experienced through the corridor, reduce fuel consumption, reduce emissions and improve the driver experience by reducing the number of stops. The figure below shows a high level architecture description of the system.

![High Level System Architecture](image)

Figure 2 High Level System Architecture

The implementation will make use of existing traffic control hardware in order to preserve sunk investment in capital equipment and minimize implementation costs. Each intersection is currently equipped with the following equipment:

- NEMA ATC Controllers
- Conflict monitor / Malfunction Management Units
- Load switches
- Loop, Video, or Microwave Detection
- Fiber Optic Ethernet Based Network Switch
This will be supplemented through the acquisition of special purpose control hardware designed to support adaptive traffic signal control and the installation of traffic sensors at suitable locations along the corridor. Traffic signals will be controlled by on street controllers which in turn will be linked back to the regional traffic management center. This will allow traffic conditions to be monitored remotely from the regional traffic management center for special events to be managed remotely by operator intervention at the management center.

3. How the Existing System Works
The current system is connected back to the traffic management center via the fiber interconnect. This allows equipment monitoring and also plan selection. The current control strategy is based on Time of Day plan selection. Under the auspices of this control strategy different timing plans are selected based on the current time of day. The timing plans were developed based on snapshot traffic counts and do not reflect evolving traffic conditions.

4. Network Characteristics
The nature of the existing road network is arterial with major intersections with SR 426, SR 434 and CR 419 along with signalized ramp access for the SR 417 toll expressway. Land use along Red Bug Lake Road is primarily commercial. For Mitchell Hammock land use is primarily residential with some commercial uses. Commercial land uses consist of retail as well as business operations.

Table 1 provides a summary of the signalized intersections being addressed by the project. Table 2 provides a summary of the distances between intersections.

Table 1 List of Intersections

<table>
<thead>
<tr>
<th>Intersection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Bug Lake Road and Slavia Road</td>
</tr>
<tr>
<td>Red Bug Lake Road and Dovera Drive</td>
</tr>
<tr>
<td>Red Bug Lake Road and Oviedo Mall Boulevard</td>
</tr>
<tr>
<td>Red Bug Lake Road and SR 417 Southbound Ramp</td>
</tr>
<tr>
<td>Red Bug Lake Road and SR 417 Northbound Ramp</td>
</tr>
<tr>
<td>Red Bug Lake Road / Mitchell Hammock Road and SR 426</td>
</tr>
<tr>
<td>Mitchell Hammock Road and SR 434 (Alafaya Trail)</td>
</tr>
<tr>
<td>Mitchell Hammock Road and Clara Lee Evans Way / City Plaza Way</td>
</tr>
<tr>
<td>Mitchell Hammock Road and Oviedo Boulevard</td>
</tr>
<tr>
<td>Mitchell Hammock Road and Lake Rogers Boulevard / Kingsbridge Drive</td>
</tr>
<tr>
<td>Mitchell Hammock Road and Alafaya Woods Boulevard / Reformation Drive</td>
</tr>
<tr>
<td>Mitchell Hammock Road and Lockwood Boulevard</td>
</tr>
<tr>
<td>Lockwood Boulevard and CR 419</td>
</tr>
</tbody>
</table>
Table 2 Distances between intersections

<table>
<thead>
<tr>
<th>From Intersection</th>
<th>To Intersection</th>
<th>Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Bug Lake / Slavia</td>
<td>Red Bug Lake / Dovera</td>
<td>0.60</td>
</tr>
<tr>
<td>Red Bug Lake / Dovera</td>
<td>Red Bug Lake / Oviedo Mall</td>
<td>0.21</td>
</tr>
<tr>
<td>Red Bug Lake / Oviedo Mall</td>
<td>Red Bug Lake / SR 417 SB</td>
<td>0.25</td>
</tr>
<tr>
<td>Red Bug Lake / SR 417 SB</td>
<td>Red Bug Lake / SR 417 NB</td>
<td>0.14</td>
</tr>
<tr>
<td>Red Bug Lake / SR 417 NB</td>
<td>Red Bug Lake/M. Hammock / SR 426</td>
<td>0.31</td>
</tr>
<tr>
<td>Red Bug Lake/M. Hammock / SR 426</td>
<td>Mitchell Hammock / SR 434</td>
<td>1.08</td>
</tr>
<tr>
<td>Mitchell Hammock / SR 434</td>
<td>Mitchell Hammock / Clara Lee Evans</td>
<td>0.25</td>
</tr>
<tr>
<td>Mitchell Hammock / Clara Lee Evans</td>
<td>Mitchell Hammock / Oviedo</td>
<td>0.22</td>
</tr>
<tr>
<td>Mitchell Hammock / Oviedo</td>
<td>Mitchell Hammock / Lake Rogers</td>
<td>0.44</td>
</tr>
<tr>
<td>Mitchell Hammock / Lake Rogers</td>
<td>Mitchell Hammock / Alafaya Woods</td>
<td>0.28</td>
</tr>
<tr>
<td>Mitchell Hammock / Alafaya Woods</td>
<td>Mitchell Hammock / Lockwood</td>
<td>0.58</td>
</tr>
<tr>
<td>Mitchell Hammock / Lockwood</td>
<td>Lockwood / CR 419</td>
<td>0.24</td>
</tr>
<tr>
<td><strong>Total corridor length</strong></td>
<td></td>
<td><strong>4.6</strong></td>
</tr>
</tbody>
</table>

5. Traffic Characteristics

This roadway is a heavily trafficked arterial, with variable traffic flows. It features bidirectional peaks requiring a sophisticated approach to signal coordination. The corridor is a major arterial for the City of Oviedo.

6. Signal Grouping

The intersections are sufficiently close that they may be coordinated together under all traffic conditions. Since there are no groups of intersections that are separated by a sufficiently large distance it is recommended that all intersections are coordinated together.

7. Operating Agencies

The operating agency for the adaptive traffic control system will be Seminole County. The signal control equipment along the corridor will be connected using the existing Seminole County fiber Ethernet based network back to the Seminole County Traffic Management Center (TMC). The City of Oviedo will be provided a remote workstation for monitoring the operations of the signals under their jurisdiction. The relationship between the proposed system and the Central Florida Regional ITS Architecture is described in the following section.

8. Existing Architecture and Infrastructure

The following table summarizes the function and interfaces supported by the Seminole County TMC.
Table 3 Functions and Interfaces

<table>
<thead>
<tr>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinate emergency traffic signal control with the county EOC/warning points</td>
</tr>
<tr>
<td>Coordinate HRI signal adjustments, and provide track status information (e.g., blockage) to rail operators and local traffic operations</td>
</tr>
<tr>
<td>Coordinate traffic information and traffic control with the FDOT District 5 RTMC</td>
</tr>
<tr>
<td>Coordinate traffic information with the Seminole County TMC and the FDOT District 5 RTMC</td>
</tr>
<tr>
<td>Operate traffic signal systems, including CCTVs, signals, and sensors, for Seminole County and municipalities including City of Oviedo</td>
</tr>
<tr>
<td>Provide transit signal priority for regional transit providers using roadside devices</td>
</tr>
<tr>
<td>Information Dissemination for Central Florida Regional ITS Architecture</td>
</tr>
<tr>
<td>Coordinate emergency plans, incident responses, and resources with the county EOC/warning points</td>
</tr>
<tr>
<td>Coordinate evacuation and reentry plans with the county EOC/warning points</td>
</tr>
<tr>
<td>Provide traffic information to travelers using private companies; county and city public information systems; and the media</td>
</tr>
<tr>
<td>Receive AMBER Alerts and other wide area alert information from the county EOC/warning points</td>
</tr>
<tr>
<td>Incident Management (Traffic and Maintenance) for Central Florida Regional ITS Architecture</td>
</tr>
<tr>
<td>Perform network surveillance for detection and verification of incidents on County and City roads, and send traffic/incident information and traffic images to county fire/EMS/sheriff agencies, the FHP, the county EOC, and local fire/EMS/police agencies</td>
</tr>
<tr>
<td>Provide incident information to travelers using traffic information devices on county roads, and through local ISPs, Web sites, and the local media</td>
</tr>
<tr>
<td>Receive incident information, incident response status, and resource requests from the county EOC/warning points</td>
</tr>
</tbody>
</table>
The following block diagram shows how this system will fit within the Central Florida Regional ITS Architecture and the interfaces that are supported.

![Diagram](image)

**Figure 3 Fit with Central Florida Regional ITS Architecture**

Note that the gray box labeled “Seminole / Oviedo Field Equipment” is where the system will reside within the overall Central Florida Regional ITS Architecture. The operation of the traffic signals will be managed from the Seminole County TMC using a center to center communication link to City of Oviedo, with maintenance activities supported by Seminole County.

9. **What are the Limitations of the Existing System?**

Traffic signal control hardware along the corridor are serviceable. Existing traffic signal controllers are Naztec ATC Controllers current monitored and operated via central software. However due to traffic conditions it is necessary to implement an adaptive traffic control system. The corridor has been retimed several times in the past and yet progression is still limited. The variation in demand along the corridor require a more sophisticated solution. The current traffic controllers cannot support such a solution without the purchase of additional hardware and/or software.
10. How the System will be Improved
In broad terms, the general approach to improving the system is through the introduction of an adaptive coordinated capability to existing hardware along the corridor. This is to be achieved through the procurement of additional hardware and software that will work with existing controllers to support additional adapters and coordinated functionalities.

11. Statement of Objectives for the Improved System
This section is focused on describing the operational objectives that will be satisfied by the envisioned adaptive operation.

Operational objectives for the signals to be coordinated are as follows:

1. Smooth the flow of traffic along coordinated routes and improve travel time reliability
2. Maximize the throughput along the corridor by making the best use of available green time
3. Manage queues, to prevent excessive queuing from reducing efficiency
4. Preserve the legacy hardware and software to protect sunk investment in capital equipment
5. Enable traffic signal timings to be better aligned with variations in traffic flow
6. Minimize installation cost for adaptive control strategies through the reuse of existing hardware and software
7. Maximize the efficiency of the corridor under emergency and public transit priority situations through minimization of transition periods and the selection of the appropriate post priority traffic movements
8. The system must incorporate frequent pedestrian operation into routine adaptive operation
9. Operator training will be provided to enable effective and efficient operations and management of the system from the County TMC
10. Provide traffic and operational data
11. Equipment failure management

Smooth Flow
This objective seeks to provide a green band or pipeline along the corridor. For this particular corridor it is particularly important to achieve bidirectional coordination and to accommodate variable traffic flows. The corridor traffic exhibits bidirectional peaks and considerable variability. This will be achieved by ensuring that the relationship between the intersections and signal timings are such that once a platoon starts moving it rarely slows or stops. This may involve holding a platoon at one intersection until it can be released and not experience downstream stops. It may also involve operating non-coordinated phases at a high degree of saturation (by using the shortest possible green), within a constraint of preventing or minimizing phase failures and overflow of turn bays with limited length, and with spare time in each cycle generally reverting to the coordinated phases.
Maximize Throughput
This objective seeks to provide a broad green band along an arterial road, both directions, to provide the maximum throughput along the coordinated route without causing unacceptable congestion or delay side streets.

Manage Queues
The adaptive traffic signal control algorithm should also take account queue management requirements. This is particularly important for this corridor where most of the intersection spacing is less than 0.3 mile.

One of the primary objectives is to ensure that queues do not block upstream. This often requires constraints on phase lengths to ensure that a large platoon does not enter a short block if it must be stored within that block and wait for a subsequent green phase. The adaptive algorithm should have the ability to manage queues in such a manner.

Preserve legacy hardware and software
Existing hardware and software for traffic signal control is perfectly serviceable and does not require to be replaced. The current configuration can support adaptive coordinated traffic signal control. The desired implementation will make maximum use of existing hardware and software and superimpose appropriate capabilities to support adaptive traffic signal control. This will ensure that the cost of installation for adaptive traffic signal control is minimized.

Enable traffic signal timings to be better aligned with variations in traffic flow
The primary objective in implementing adaptive traffic signal control along this corridor is to better align traffic signal timings with variations in traffic flow. There are significant variations in traffic control along the corridor over the course of the day. Time-of-Day control strategies do not have the flexibility to optimize traffic signal control along the corridor.

Minimize installation costs
It is essential that sunk investment in traffic signal control equipment along the corridor is preserved. Therefore it is an important requirement of the project that existing hardware for traffic signal control be utilized in the new solution.

Maximize the efficiency of the corridor under emergency and public transit priority situations
The corridor currently features emergency vehicle and public transit vehicle priority equipment. This enables emergency and public transit vehicles to call for priority at each intersection. Under the current traffic signal control regime this introduces a loss of available green time due to the recovery period after priority has been granted. The objective is to minimize transitional green time losses.

Incorporate Frequent Pedestrian Calls
The system is to accommodate the incorporation of frequent pedestrian calls at any of the intersections.
Operator training will be provided to enable effective and efficient operations and management of the system from the TMC

Training will be provided to enable operators to conduct the following activities:

- Troubleshooting the system
- Preventive maintenance and repair of equipment
- System configuration
- Administration of the system
- System calibration

Training delivery shall include: printed course materials and references, electronic copies of presentations and references and delivered at the TMC.

Provide traffic and operational data

One of the major advantages of an adaptive coordinated traffic control system using the latest technology is the ability to collect a range of valuable data. This data can be used for operational management of the traffic signal system and also be used as input to a performance management system. The system will be expected to provide a range of traffic and operational data as specified in the requirements.

Existing Travel Time and Video Surveillance systems deployed within the corridor will be supplemented with additional equipment to provide enhanced monitoring of corridor operation.

Equipment failure management

The system will be expected to support a range of equipment failure management features. These will include failure of the adaptive processor, failure of the communication system and failure of other hardware and software. Failure management features will be expected to comply with those specified in requirements.
12. Description of Strategies to Be Applied by the Improved System

This section describes the adaptive coordination and control strategies that may be employed to achieve the operational objectives.

**Provide a Pipeline or green wave in both directions**

Providing a pipeline along a coordinated route will support the two objectives of minimizing stops along a route and maximizing throughput along the route. The provision of a pipeline along a coordinated route can be achieved by a system based on a common cycle length, and also by a system that provides coordination bands toward and away from a critical intersection without using a common cycle length. A non-cycle-length-based or non-sequential system is preferred. This will define the bandwidth of the pipeline to match the phase length of the coordinated phases at the critical intersection within a group. Phasing at other intersections will be timed so that green is provided on the coordinated route to accommodate the pipeline.

**Distribute Phase Splits**

To provide access equity, the demand for all phases will be handled equitably by serving all movements regularly and not providing preferential treatment to coordinated movements to the extent that delays and stops of other movements are significantly increased. To do this a system will be optimizing an objective function that seeks to balance individual vehicle delays or some surrogate measure proportional to delays.

**Manage Queues**

To manage queues, the system will allow the offsets between intersections to be set in order to allow queues to be cleared at the end of each phase in blocks that are required to store queues during a subsequent phase. It will provide a means to control the locations where queues are allowed to form.
13. Operational Needs
At the highest level the operational needs can be defined as follows:

- Increased efficiency
- Higher customer service
- Improved Safety

Each of these operational needs are defined in more detail as follows:

**Efficiency**
Efficiency is defined by a reduction in the number of stops and the reduction in the average travel time through the corridor. Note that the objective here is not to speed traffic but rather maintain traffic flow. Therefore this need will also be measured through a reduction in the number of stops achieved by better traffic signal coordination and better matching of signal timings to existing traffic flows.

**Customer Service**
The customer service operational need is defined as an improvement in the overall customer service experience with the corridor. This could be measured in terms of reduction in number of stops and reduction in delay. It can also be measured subjectively by surveying opinions of travelers who use the corridor, developing a satisfaction rating based on the survey results.

**Safety**
Safety needs can be defined in terms of reduction in the number and severity of accidents on the corridor.
14. Measuring Progress Towards Needs Satisfaction

The following table summarizes the performance measures that have been identified for measuring progress towards satisfying the needs described above. Note that some of the measures identified will not be measured directly, but inferred through the use of simulation modeling techniques such as Synchro.

Table 4 Performance Measures

<table>
<thead>
<tr>
<th>Needs</th>
<th>Performance measures</th>
<th>Efficiency</th>
<th>Customer Service</th>
<th>Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Of low severity accidents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. Of stops</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arterial delay</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side-street delay</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total network delay</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average travel time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variability in travel time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total fuel consumption</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

15. System Overview

The proposed implementation forms a component within the Seminole County traffic signal management system operated by Seminole County. The larger system consists of a number of on-street traffic controllers linked through a telecommunications network backbone (fiber Ethernet based interconnect) to Seminole County TMC. The system along this corridor is currently operated using a demand responsive strategy rather an adaptive one. This involves the creation of a number of predetermined timing plans which are brought into play depending on threshold traffic volumes measured by sensors along the network.

The proposed implementation will build on the success of the responsive system by adding further sophistication in the form of adaptive control. This will obviate the need for the development and maintenance of pre-determined timing plans. The traffic sensors will provide a continuous stream of data regarding traffic conditions and the special-purpose algorithms built into the firmware within the new hardware to be fitted the controllers will determine the appropriate traffic signal timings and communicate those to the controller. The overall system operation will be operated and monitored from the Seminole County TMC with a center to center communication link with the City of Oviedo TMC. This
will allow the opportunity for intervention to override automated signal timings should a special event occur.

16. Adaptive Operational Environment

This section describes the physical operational environment in terms of facilities, equipment, computing hardware, software, personnel and operational procedures necessary to operate the deployed system. It describes the personnel in terms of their expected experience, skills and training, typical work hours, and other activities that must be or may be performed concurrently.

To begin, the relative roles and responsibilities of each participating agency are defined. The matrix below summarizes roles and responsibilities for these participants at the various stages in the development of the project.

Table 5"Who Does What Matrix"

<table>
<thead>
<tr>
<th>Responsibility</th>
<th>Participant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>City of Oviedo / Seminole County</td>
</tr>
<tr>
<td>Design</td>
<td>City of Oviedo / Vendor</td>
</tr>
<tr>
<td>Implementation</td>
<td>Vendor</td>
</tr>
<tr>
<td>Operations</td>
<td>Seminole County</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Seminole County</td>
</tr>
</tbody>
</table>

The figure on the next page depicts the adaptive operational environment in terms of the new hardware and software to be installed within the overall context of the existing field system.
The system will be procured by City of Oviedo, with system operations and maintenance provided by Seminole County staff.

The operation of the adaptive system will be supported from the Seminole County TMC. This is an established traffic management center already conducting management and supervision for the corridor traffic signalized intersections. The new system will be operated under the auspices of the TMC. Therefore the system will be required to support a single interface from the field to the Seminole County TMC and a center to center communication link between the Seminole County TMC and City of Oviedo TMC will be established to facilitate monitoring of the system.

### 17. Operational Scenarios

To illustrate the operation of the system a number of operational scenarios have been defined. The overall operation of the system under each of the scenarios will be described as a means of illustrating the technical and organizational operational concept for the system. This will indicate how the hardware and software will operate and also illustrate the respective roles and responsibilities for each of the major participants in system operation and maintenance.

The following operational scenarios have been identified:

- Normal routine operating conditions
- Business Hours Operation
- Off-Peak Period Operation
- Major Events
- Minor Incident
- Major Incident
- Maintenance and Failure Scenarios
Each of these operational scenarios are described in more detail as follows

**Normal routine operating conditions**

It is expected that the system will operate under these conditions for the majority of the time. Under this scenario signal timings are automatically created and applied making use of the hardware and software enabling adaptive traffic signal control. While the operation of the automated system will be monitored remotely from the regional traffic management center is anticipated that there will be no requirement to intervene in system operations.

Normal routine operating conditions can also be subdivided into a number of more detailed scenarios as described below.

**Peak Periods – Unsaturated Conditions**

During typical peak periods (and other periods when traffic volumes are high), the system will select phases that minimize delay to all movements at all intersections. The system will compare the volumes traveling in each direction, and provide coordination in both directions. The coordination will be implemented in a manner that provides balanced progression as far as possible in the two directions.

Where leading and lagging left turn phases are used, the system will determine the optimal phase sequence in order to provide the best coordination. This would be linked to the direction of offset, such as providing a lagging left turn in the heavy, coordinated direction. If the green time required for a left turn phase is longer the time required to service a queue fully occupying the left turn bay, and the queue would overflow and block the adjacent lane, the operator will be able to specify the phase to operate twice per cycle in order to avoid queue overflow.

The entire corridor may be set by the operator to operate as one coordinated group, or the system may have the freedom to operate it as one group subject to user-specified criteria, such as volume of traffic in the peak direction exceeding a threshold.

**Peak Periods – Oversaturated Conditions**

During peak periods when one or more intersections are oversaturated, the primary objective of the system will be to maximize the throughput along the corridor in the peak direction. The system will determine the direction with peak flow and provide the maximum bandwidth possible. This will be subject to user-specified constraints, such as allowable phase sequences, and minimum and maximum phase times. As described in the unsaturated peak description, phase sequence of lead-lag phases, and the operation of left turn phases will be determined by the system. The entire corridor may be set by the operator to operate as one coordinated group, or the system may have the freedom to operate it as one group subject to user-specified criteria, such as similar required cycle lengths in different parts of the corridor are similar or the volume of traffic in the peak direction exceeds a threshold.

**Business Hours Operation**

During business hours, there will be two separate but complementary objectives: select signal timings that ensure all movements at all intersections are accommodated equitably, while providing reasonable coordination in both directions.
Off-Peak Period Operation
During early mornings, evenings and parts of the weekends when traffic is lighter than during the business hours, the coordination objectives will be similar to the business hours, although shorter green times may be applicable. If there are green times that would provide good two-way progression and accommodate all movements at all intersections equitably, but cannot accommodate all pedestrian movements on all phases and stay in coordination, the system will allow shorter green times through the following actions.

If protected/permitted left turn phasing is in operation, the protected phase can be omitted under user-specified conditions, such as very light volume or short queue lengths (determined by detector logic). The maximum green time may be set lower than the sum of pedestrian walk and clearance times, and still allow the pedestrian phase to operate by extending the green time when necessary without throwing the system out of coordination.

During normal weekend traffic conditions, the system may operate in the same manner as the business hours or as the off-peak periods.

Major Events
For this scenario it is assumed that a special event such as a sporting event is taking place requiring the special traffic signal timings and traffic handling be applied. In this case the TMC staff will adjust the time between green waves. The effect on traffic will be monitored making use of the sensors in the corridor and traffic data will be relayed back to the regional traffic management center to confirm the effectiveness of the timings and strategies being applied.

During major events, the traffic characteristics are often similar to the peak periods, either oversaturated or unsaturated. The system will behave in a similar fashion to those periods, and data from the detection system will determine whether unsaturated or oversaturated conditions prevail. If there is heavily directional traffic before or after an event, the system will determine the predominant direction and coordinate accordingly, with appropriate green times and offsets. If the event traffic is not as heavy as peak hours, but the traffic on the corridor is still highly directional, then the system will recognize this and provide coordination predominantly in the heaviest direction, even though the green times may be similar to business hours (with balanced flows) green times.

The entire corridor may be set by the operator to operate as one or more coordinated groups under this condition, or the system may have the freedom to operate it as one or more groups subject to user specified criteria, such as similar required green times in different parts of the corridor or the volume of traffic at key locations exceeds a threshold.

Minor Incident
Under the auspices of this scenario it is assumed that a minor incident has occurred along the corridor. This is defined as a traffic incident that is not severe enough to require Lane closure but is of such significance that traffic conditions have been affected along the corridor, for example a minor vehicle collision or a stalled vehicle. In this scenario it is expected that the automated traffic control system will be able to manage the signal timings automatically with the operation of the system being monitored remotely at the County TMC.
**Major Incident**

When a major incident occurs on I4, or at a location within the corridor, the traffic on the corridor will change in a manner that is difficult to predict, and the response required of the system will vary depending on the time of day, day of week and the current traffic conditions at the time the incident occurs. The system will detect any increase in traffic volume and take the following action. If the increased volume higher green times in order to continue to accommodate all movements at all intersections, it will increase the green times, but only up to the maximum permitted by the operator. If the diverted traffic results in a change in the balance of the direction of the traffic on the corridor, the progression will be changed to match the traffic. Typically the result of these actions will be to increase certain green times and provide a wide progression bandwidth in the direction of the diverted traffic. However, if the incident occurs at times of lower overall traffic volumes, and it does not result in oversaturated conditions on the corridor, the result may be that the system mimics a typical peak pattern or business hours pattern.

This type of incident will typically not result in a uniform increase in traffic in one direction for the entire length of the corridor. Therefore, it is expected that the response of the system will be different in each section of the corridor, depending on the location, nature and time of day of the incident. The architecture of the system will allow each section of the system to respond independently but in a consistent manner during incidents.

**18. Failure Scenarios**

A number of system failure scenarios have been defined as follows:

**Detector Failure**

Detector reliability is a very important part of successful adaptive operation. The system will recognize a detector failure and take appropriate action to accommodate the missing data. For a local detector failure, the local controller will place a soft recall or maximum recall (to be user-specified) on the appropriate phase, and issue an alarm. For a detector that influences the adaptive operation (e.g., a system detector), the system will use data from an alternate (user-specified) detector, such as in an adjacent lane or at an appropriate upstream or downstream location. If the number of detector failures within a specified group exceeds a user-specified threshold, the system will cease adaptive operation and go to a fallback mode of time-of-day operation or free operation. The fallback mode will be specified by the user based on location and time of day. All detector failure alarms will be automatically transmitted to maintenance and operations staff at the County TMC for appropriate attention.

**Communication Failure**

Communications failures will have varying effects on the operation of the system. If a communication failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation. The fallback mode will be specified by the user based on location and time of day. All communication failure alarms will be automatically transmitted to the County TMC operators for appropriate attention.
Adaptive System Failure

There are two possible types of adaptive system failures: failure of the server or equipment that operates the adaptive algorithms; and inability of the adaptive algorithms to accommodate current traffic conditions. If the equipment that operates the adaptive algorithms fails, the system will recognize the failure and place the operation in an appropriate, user-specified fallback mode, either time-of-day operation or free operation. The fallback mode will be specified by the user based and time of day.

The adaptive system will make its decisions based largely on detector data. Occasionally, as the result of an incident or other event outside the control of the system and outside the area covered by the system, congestion will propagate back into the adaptive control area and the measured traffic conditions will be outside the range of data that can be processed by the system. In locations where this is likely to occur, the intersection detectors, or queue detectors installed specifically for this purpose, will measure increased occupancy. In such cases, when user-specified signal timing and detector occupancy conditions are met, the system will recognize that its response to the input data may not be appropriate, and it will revert to an appropriate, user-specified fallback mode, either time-of-day operation or free operation. The fallback mode will be specified by the user based and time of day.

All adaptive system failure alarms will be automatically and immediately transmitted to Seminole County TMC and the City of Oviedo TMC operators for appropriate attention.