**Table of Contents**

<table>
<thead>
<tr>
<th>SECTION</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>3</td>
</tr>
<tr>
<td>I-90 GATE OPERATIONS SYSTEM</td>
<td>3</td>
</tr>
<tr>
<td>TRAFFIC MANAGEMENT SUBSYSTEM</td>
<td>4</td>
</tr>
<tr>
<td>DETECTION &amp; SENSOR SUBSYSTEM</td>
<td>9</td>
</tr>
<tr>
<td>COMMUNICATIONS SUBSYSTEM</td>
<td>12</td>
</tr>
<tr>
<td>CONTROL &amp; MONITOR SUBSYSTEM</td>
<td>16</td>
</tr>
<tr>
<td>ASSEMBLY &amp; IMPLEMENTATION</td>
<td>19</td>
</tr>
<tr>
<td>TESTING &amp; TRAINING</td>
<td>19</td>
</tr>
<tr>
<td>SCHEDULE</td>
<td>20</td>
</tr>
</tbody>
</table>
I. INTRODUCTION

A. Purpose. The purpose of this document is to provide a detailed description and implementation procedure for the I-90 Gate Operations System.

B. Task Description. The work plan task description is based on the results of Task 2. The purpose of the work plan is to provide a functional specification for the installation and implementation of the I-90 Gate Operations solution for the US71 and I-90 intersection near Jackson, Minnesota. The work plan includes a detailed description and implementation procedure of the following subsystems:

- Type of gate(s) (outcome of task 2)
- Video detection system
- Changeable message sign and warning sign interface with the gate system
  Note: This is part of Mankato and Rochester ITS projects RFP that is in process.
- Communications
- Monitor and control
- Remote user interface

This document was prepared using Microsoft Word and does not exceed 20 pages. This document will be an appendix to the final report.

II. I-90 GATE OPERATIONS SYSTEM

A. System & Subsystems. The I-90 Gate Operations solution is comprised of four subsystems. Figure 1 provides a block diagram illustration of the four subsystems and their components.
B. Communications & Control Overview. The I-90 Gate Operations system is designed to be installed at existing intersections without extensive cable trenching and landline connectivity. Thus, maximum use of wireless communications is employed. Each of the frequency bands have been chosen to ensure adequate bandwidth, throughput, and range is employed to meet the various communications requirements.

Figure 2 provides an illustration of the communications and connectivity from the control center at the District 7B office in Windom to each of the four gate/detection subsystems at the intersection. The Jackson Truck Station will be used as the host end control point. The system is designed for all control and monitor functions to be performed at the District 7B office using a web browser and the ThomTech graphical user interface. The system operator logs onto the internet, proceeds to the intersection URL where a control and video screen appears. Signals are sent to the web server and database controls to operate the gates and signal the advanced warning signs. The video feeds provide a quad view of all four cameras. A more detailed description is provided in the discussion for the Control & Monitor Subsystem.
Each subsystem is discussed and illustrated below. Because the subsystems are interrelated, many of the diagrams and graphics contain elements of several of the subsystems. These are added for clarity.

C. Intersection Overview. The intersection is located in Jackson, Minnesota where Interstate 90 and US Highway 71 intersect. Figure 3 provides an aerial view block diagram of the gates, light poles, and locations for the detection and sensor subsystem. At present, the electrical power infrastructure for the light poles provides power only during the hours of darkness switched on and off by a photo cell. The Electrical Services Section of Mn/DOT and ThomTech are coordinating the installation of electrical power at selected light poles in order to power the subsystems installed at the intersection. These include the Traffic Management Subsystem (gates), the Detection & Sensor Subsystem, and the Communications Subsystem. The photograph below provides a glimpse of the electrical access panel to provide electrical power to the light poles. A power cable will be extended from the nearby light pole to the existing gate pole.

III. TRAFFIC MANAGEMENT SUBSYSTEM

A. General. The traffic management subsystem consists of the gates and the advanced warning signs. The photograph at the left illustrates the existing gate assembly.

B. Gates. The gate subassembly that will be used is the existing gate and gate arm that is presently installed at the I-90/US-71 intersection. ThomTech will purchase the components of an existing gate and modify as needed to install the remote controlled actuator to raise and lower the gate (this gate assembly will be known as the test gate). The overall gate will be manufactured by
ThomTech’s parent company – FORCE America. The photograph below provides a view of the I-90 & US-71 intersection. The view is facing north from the southbound lane of US-71. The second photograph below is shows the front entrance to the Mn/DOT District 7B Office spaces.

The test gate assembly will be used to design and test subassembly components and for the Jackson Truck Station test. Figure 4 provides an illustration of the ramp gate. The ramp gates are installed on the left side of the entrance ramps. Figure 5 provides an illustration of the mainline gate. The mainline gates are installed on the right side of the interstate highway.

The cable wench that is on the gates will be removed and an electric linear actuator will be added to raise and lower the gate arm. The actuator has a heater and will be activated by a switch triggered from a signal from the 900 MHz radio. The actuator can be mounted at the base of the pole or above the gate arm. Both will be tested during the subassembly test phase. The gate power is provided from a nearby light pole and is overheaded to the gate pole.

The gate subsystem will also have a weather proof box mounted on the gate pole that will house the 900 MHz radio, the switching mechanism, and the power connections.
This figure illustrates an aerial view of I-90 Gate Operations system at the US71 & I-90 interchange.

Figure 3: Aerial View Block Diagram
C. **Advanced Warning Signs.** There will be one advanced warning sign per ramp gate installed prior to the entrance ramp on US-71. There will be two advanced warning signs per mainline, one at 100 feet and another at 200 feet. The advanced warning signs are purchased and installed separate from this project. The signaling (activation & deactivation) will be accomplished by the I-90 Gate Operations System. The exact sign configuration, electrical power, and activation means are still in design. ThomTech has selected a candidate communications mechanism for signaling the signs. It is a 900MHz radio system. This is the same signaling means that will be used for the gates.

An example of an advanced warning sign solution for the flashing light and power portion is provided in the following specification. The unit is a solar powered assembly consisting of a 12” flashing LED, 2-80 watt solar panels, two battery back up, enclosure, pole, FHWA pedestal base, mounting brackets, helix metal foundation and bolts. These specifications were determined from a similar application being used in the state of Utah.

The specifications are: 12 VDC crystalline silicon solar panel, ventilated, lockable, weatherproof aluminum enclosure for batteries and control electronics, meets ITE visibility standards, low voltage disconnect protects batteries from overcharging. Pedestal base is FHWA breakaway approved. Pole, brackets, and hardware all meet applicable ASTM standards. Metal screw foundation capable of supporting unit. To complete the advanced warning sign, a 900 MHz radio with on/off switch and a metal sign needs to be added. Proposed sign message is “Freeway Closed when Flashing.”

![Figure 4: Ramp Gate](image-url)
IV. DETECTION & SENSOR SUBSYSTEM

A. General. The autoscope solo pro will be used to sense violations from motorists that elect to go around or through the lowered gate arm. The autoscopes with pan/tilt will be installed on existing light poles as shown in Figure 6. Two autoscopes are not configured with pan/tilt and they will be installed on existing light poles as shown in Figure 7.
B. Mounting. The pan/tilt platforms and autoscopes will mount under the light pole arm, balanced by the wireless radio equipment, mounted on top of the light pole arm. Figure 8 illustrates the detection and sensor subsystem.

C. Autoscope. The new autoscope solo pro with video compression will be used to provide digital video feeds to the web server. A photograph of an autoscope solo pro is provided to the left. The autoscope detects movement based on image comparison techniques and creates an alarm when a violation occurs by a motorist driving around or through the closed gate arm. The alarm signal will appear on the District 7B workstation screen.

D. Pan/Tilt. Two of the light poles (the mainline autoscopes) will have pan/tilt platforms. These are ultra rugged, heated units that provide precise return to detection position. The units are manufactured by QuickSet. A photograph is provided at the left. The units have metal housing and gear train construction for lasting durability and reliability. The units have slow and high speed operation, 435 degree pan, heater, and have automatic return to default position for detection purposes with 0.5 degree accuracy.
Figure 8: Detection Subsystem
V. COMMUNICATIONS SUBSYSTEM

A. General. The purpose of the communications subsystem is to provide reliable communication links between the other subsystems. The I-90 Gate Operations system relies heavily on spread spectrum wireless radio links. This is based on two underlying principles inherent to overlaying video, sensor detection, remote control, and gate arm operations on top of an existing rural intersection.

First, the communications subsystem must use wireless technology because the cost and time constraints of installing fiberoptic or even twisted pair within the intersection or to the district office are prohibitive.

Second, the use of spread spectrum allows the use of radio frequency spectrum without applying for FCC licenses. Thus, the project provides a good vehicle for applying the latest wireless technology, state-of-the art web site & database design, while operating in a rural, harsh weather environment. The needs of the communications subsystem are provided in Figure 9.

![Figure 9: Requirements of the Communications Subsystem](image)

B. Four Components. The communications subsystem consists of four components – video, data & control, gates & signs, and internet access.

1. Video. The digital video signal from the autoscope to the host end at the truck station will be transmitted and received by a Motorola spread spectrum broadband multi-point to point system. The four video feeds will be terminated at the communications server which will translate the digital video to the I-90 Gate Operations web site. The video streams can be viewed by the system operator one at a time or all four in the quad mode.

2. Data & Control. The data and control signals to the autoscopes and the pan/tilt platform will use the same spread spectrum radio signal that will act in point to multi-
point mode. The base station will send and receive signals from the detection and sensor subsystem. The signals are controlled by the communications server.

3. Gates & Advanced Warning Signs. The gates and signs are turned on and off using a 900MHz spread spectrum radio system. The radios provide a signal to activate/deactivate the on/off switch for the gate and/or sign. Each are individually activated and addressed for opening and closing the gates one at a time.

4. Internet access. The system uses two internet access points. Both locations (Jackson Truck Station & District 7B office) use Southwest Wireless as the Internet Service Provider (ISP). The units use 2.4GHz spread spectrum 256K DSL connections to the internet. The speed of the video (frames/second) will be determined by the speed of the internet connection.

Figure 10 provides a summary of the communications paths for each of the four components of this subsystem.

![Diagram](image)

**Figure 10: Four Subsystem Components and Associated Communications Paths**

The communications subsystem is illustrated in Figures 11 and 12. Figure 13 provides a detailed description of the communications connectivity as it relates to all four subsystems.

C. Equipment. The equipment selected for transmitting the digital video, data, and control is the Motorola 5.0 GHz broadband radio. The 900 MHz radios used to control the gates and the signs are made by Intuicom. The option to change radio equipment vendors based on delivery and price is still open. The wireless internet connections for Windom and Jackson will be provided by Southwest Wireless. Their office is in Windom.

The test gate and a complete communications subsystem will be lab tested at ThomTech’s office and then field tested at one of the gate location at the intersection in Jackson before installing the complete system at the I-90/US-71 intersection.
Communications Subsystem:

Each of the four remote sites at the gates include three types of transmission means.
1. Video - 5.8 GHz point to point
2. Data (control & sensing) - 2.4 GHz point to multi-point
3. Signal (gates & signs) - 900 MHz point to multi-point

All three transmission means terminate at the truck station where the signals are connected to the communications server.

The communications server and the video server are connected directly to the web server. The web server is connected to the internet via a wireless DSL connection. This is used as the primary source for control & monitoring at the Windom District 7A Office. The backup connection uses a 56K frame relay line between Windom & Jackson. The backup system does not have video capability.

Figure 11: Communications Subsystem for Video & Detection
Signal subsystem:

Signal subsystem is part of the communications subsystem and consists of the wireless connections to signal the gates to close/open and the advanced warning signs to turn on/off.

The mainline signs are enclosed in an arrow pointing east and west to signify that the figure is not to scale.

Signalling is accomplished using a 900 MHz wireless radio system.

Figure 12: Communications Subsystem for Gates & Signs
Figure 13: Communications Connectivity Diagram
VI. **CONTROL & MONITOR SUBSYSTEM**

**A. General.** The control and monitor subsystem is also illustrated in Figure 9. Figure 10 provides an initial web site design for the control and monitoring of the I-90 Gate Operations system. The system is designed to be operated from the District 7B office in Windom. The system operator enters the internet, goes to the designated web site as shown in Figure 10. The system will require a login name and password for entrance.

![Diagram of Control & Monitor Subsystem]

**Figure 9: Control & Monitor Subsystem**

**B. Servers.** The heart of the control and monitor subsystem will be installed at the Jackson Truck Station. The complete subsystem is being designed with housing this subsystem in a traffic control cabinet at the intersection. Because of the “pilot project” nature of this system implementation, the environmentally controlled truck station offers the ideal opportunity for adjusting, troubleshooting, and exercising the various implementation options posed by this project. Thus, the web, communications, and the video servers are separate units of desktop configuration.
C. Web Site Operation. The web site used to control and monitor the I-90 Gate Operations system will reside on the web server at the truck station in Jackson. Access to the web site is controlled by a user name and password. Once the system operator has successfully entered the web site, they will have access to the control panel (see Figure 10). The operator can view the video stream from one or all of the autoscopes by selecting a particular view or the quad view. The pan/tilt and zoom features are controlled using the virtual “joystick” in the upper left hand side of the screen. The pan, tilt, or zoom features are presented as slow or high speed arrow buttons. Thus, by clicking the mouse on the larger arrow, the feature moves faster than when clicking on the smaller arrow. By pressing the HOME or RESET button the autoscope camera is returned to the default/detection position.

The closing/opening of each of the gates is executed by the buttons in the lower left hand side of the screen. The advanced warning signs are turned on when the gate arm closing is initiated. In the same manner, the signs are turned off when the gate arm is raised. As presently configured, each gate arm is opened and/or closed one at a time.

The alarm and snapshot retrieval screen is not shown. However, the operator will see a visual alarm window open when a violation has occurred. The alarm will notify the operator which gate the autoscope detected a violation and provide the operator with a snapshot from the video feed for that camera/autoscope.

Figure 10: Graphical User Interface
VII. ASSEMBLY & IMPLEMENTATION

A. Assembly. The implementation plan begins by ordering the selected hardware, accepting equipment delivery, and performing initial acceptance tests. In parallel, the software application development occurs. The initial subsystem tests will occur at ThomTech’s Burnsville facility. The gate components are being purchased to assemble a test gate in Burnsville. The picture at left illustrates the wench that requires removal. Also, the access panel at the base of the gate pole is where the access to electrical power occurs. There will be an override on/off switch at the gate for authorized personnel to raise and lower the gate arm manually when needed. Once a system test is complete, a field test at the Jackson truck station will be conducted. After that, the system will be installed at the intersection.

B. Initial Evaluation. During the first phase of implementation, an evaluation of the wireless internet connections will be conducted at the District 7B offices. A complete set of hardware with desktop PC and browser will be installed and connected to the internet to assess the connection speed, reliability, and ease of use. In addition, the backup 56K frame relay line will be tested from the District 7B office and the Jackson truck station.

VIII. TESTING & TRAINING

The system testing and training phase will occur after installation. The training consists of two parts, operation training and maintenance training. The operation training consists of the operation of the system through the web site. This includes the camera controls, alarm features, operating the gate and sign mechanisms and entering and leaving the web site.

The maintenance training includes the changing of passwords, database and information retrieval tasks, detailed use of the pan/tilt/zoom control features, and other tasks.

Training documentation will be provided as well as operations and maintenance users manuals.
IX. SCHEDULE

The implementation schedule is provided in Figure 14.

<table>
<thead>
<tr>
<th>Task</th>
<th>9/01</th>
<th>10/01</th>
<th>11/01</th>
<th>12/01</th>
<th>1/02</th>
<th>2/02</th>
<th>3/02</th>
<th>4/02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Plan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Order Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software Design &amp; Integration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subsystem Assembly &amp; Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Power Installed at Poles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation at Intersection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training &amp; Testing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation &amp; Evaluation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 14: Implementation Schedule*