I-860 SMART CARPOOL LANE PROJECT
SYSTEM ENGINEERING MANAGEMENT PLAN

VERIFICATION (TEST) PLAN

PLAN SECTIONS:

1. GENERAL
2. ROLES AND RESPONSIBILITIES
3. TEST PLAN
4. EQUIPMENT ENVIRONMENTAL TESTING
5. FACTORY ACCEPTANCE TEST
6. ON-SITE INTEGRATION AND COMMISSIONING TEST
7. OPERATIONAL PERFORMANCE TEST

1. GENERAL

This document will present the I-860 Smart Lane electronic toll system (ETS) equipment and system verification testing process. It will outline the different types of tests that shall be conducted and identify the roles and responsibilities of each group that will be working on this project.

2. ROLES AND RESPONSIBILITIES

Based upon the recommended distributed responsibility for the successful implementation of test procedures to ensure that the delivered tolling system operates according to the Request for Proposal (RFP) and Contract requirements, the I-860 Smart Lane project engineering organization will have various roles and responsibilities. Listed below are recommended starting points for defining organizational responsibilities pertaining to the verification test activities that are required to ensure program success.

2.1 Joint Powers Agency (JPA) Personnel

1. The JPA Executive Director (ED) shall have full contractual responsibility for all of I-860 Smart Lane equipment and system verification testing activities and
will work closely with the Consultant staff to ensure that the testing is accomplished properly.

2.2 **Project Consultant Staff**

The JPA’s I-860 Smart Lane Program and tolling system consultant staff shall have the following roles and responsibilities:

1. Create and maintain all system verification and testing engineering related processes, policies and operating procedures for the Smart Lane project.
2. Participate in all facets of testing activities and provide recommendations to the JPA for verification testing related aspects of the project.
3. Provide technical assistance to the Integrator and JPA staff during the testing process.
4. Provide regulatory guidance for security-related requirements in conjunction with the JPA management staff.
5. Maintain a liaison with JPA and Integrator staff to incorporate additional testing procedures and ad hoc tests into the I-860 Smart Lane verification and testing process.

2.3 **Integrator Systems Engineering Staff**

The Integrator systems engineering personnel for the I-860 Smart Lane Project shall have the following roles and responsibilities:

1. Develop the various test scripts and procedures that are required to effectively support the I-860 Smart Lane verification and testing process.
2. Perform the various tests that are required and detailing to the JPA/Consultant group each procedure that is being conducted and why.
3. Ensure that the various system and equipment testing requirements and processes are properly flowed down from the RFP and the Contract documents by utilizing comprehensive requirements trace matrix.
4. Develop a detailed testing report that identifies all of the tests that were run, any problems that were discovered and how those problems would be corrected.
5. Perform any required re-testing activities that are identified by JPA and Consultant staff.

3. **TEST PLAN**

The Integrator shall prepare a detailed plan for testing all hardware, software and the full integration of the I-860 Smart Lane System. The test plan shall be developed to confirm
that the various functional requirements that are presented in the RFP, the system design
documentation and the other Contract documents are met by the equipment and/or system
operations. The Test Plan and subsequent testing activities shall be developed and
executed for three (3) distinct phases. Each test phase shall commence only upon the
successful completion of the previous phase. The three (3) test phases that will be
conducted by the Integrator, in the following order, are presented below:

1. Factory Acceptance Test (FAT);
2. On-site Integration and Commissioning Test; and
3. Operational Performance Test.

The Integrator shall be responsible to develop comprehensive test scripts and test plans to
ensure that the system development meets all of the system requirements that are presented
in the I-860 RFP and the other contract documents. The test scripts and plans will be
reviewed and approved by Joint Powers Agency staff or its designated representatives.
The test scripts and plans shall be closely adhered to during each phase of equipment and
system testing. At the completion of each test the Integrator shall submit final test results
to the JPA for final approval. The JPA ED, or designated staff/Consultant personnel, will
approve the test results.

Presented below in Figure 1 is a schematic that shows the three (3) distinct I-860 Smart
Lane Program testing phases and how each phase inter-relates with the others.

The JPA and their representatives will be permitted to participate in or otherwise observe
any and all of these tests at the JPA’s sole discretion. Tentative dates for conducting the
various tests shall be included in the Test Plan document that shall be submitted by the
Integrator during the system design phase of the Contract. Reasonable modifications to
these dates may be permitted during the course of the work by the JPA provided a written
request for such change is made at least two (2) weeks prior to the revised test date. The actual change approval must be granted, in writing, by the JPA.

4. EQUIPMENT ENVIRONMENTAL TESTING

As a preliminary effort prior to factory acceptance testing, the Integrator shall also provide test results, certified by a testing laboratory approved by the JPA, confirming that all proposed system equipment that is to be installed is suitable to operate within its respective environment. If certified test results are not available or the results are not satisfactory to the JPA, the Integrator shall arrange for such tests to be conducted or re-conducted at no additional cost to the JPA. The Integrator shall provide the JPA with certified test results for all equipment that is to be installed outside, or in any other non-environmentally controlled location. For equipment that is to be installed inside a building, cut sheets showing environmental operating requirements will be acceptable.

5. FACTORY ACCEPTANCE TEST (FAT)

The intent of the FAT, which will be held at the Integrator’s system development office, is to allow the Integrator to conclusively represent that the I-860 Smart Lane equipment, subsystems and overall system complies with the system functional requirements. Representatives from the JPA, the Consultant group, and possibly the TOLL AUTHORITY and/or SDOT are expected to be present at the FAT. The FAT shall be successfully completed, and accepted by the JPA, prior to commencement of on-site equipment installation, system integration and field testing. Equipment and/or system failures that are encountered during performance of the FAT shall be resolved, retested and acknowledged as being resolved by the JPA prior to issuance of FAT approval to the Integrator.

It is possible that certain components that comprise the overall I-860 Smart Lane System may not be available during factory testing. The Test Plan shall indicate those portions or components that will not be able to be verified during performance of the FAT. Where applicable, the Integrator shall attempt to simulate the missing components to represent a fully functioning system.

Components used in the FAT shall be production models, which would otherwise be suitable for installation in the I-860 Smart Lane System. Testing and careful evaluation of samples and prototypes shall be completed prior to the commencement of the FAT.

The FAT is the culmination of the design, development, fabrication and pre-test of the Smart Lane System equipment, subsystems and overall system. The FAT shall be
performed by the Integrator under the supervision of, and with the participation of, the JPA. Performance of the FAT shall be witnessed by the JPA, and their representatives, with acknowledgment of scenario success and/or failure by the JPA.

The Integrator shall prepare detailed test scripts that will be used as the basis for the FAT. FAT Scripts shall cover test set-up, step-by-step procedures and pre-determined expected results. FAT scripts shall be submitted and approved by the JPA prior to the commencement of the FAT. FAT scripts shall be submitted for review and approval no less than 60 days prior to scheduling of the factory test.

The following are recommended features of the Smart Lane System that are, at a minimum, to be demonstrated during the FAT:

- Equipment power up tests;
- Verify initialization;
- Verify data integrity (no loss of data);
- Verify diagnostic messages;
- Introduce failures and threats;
-Degraded mode performance;
-Verify diagnostic messages;
Normal transaction tests;
Tolling zone operational tests;
Proper association of vehicle and transponder;
Tolling zone stand-alone tests;
Operation of the Toll Data Center (TDC), including the dynamic pricing algorithms and the trip generation process;
Interface to the SDOT Traffic Management Center (TMC);
Integration between the TDC and the TOLL AUTHORITY Regional Customer Service Center (RCSC);
Communication link between the tolling zones and the TDC;
Generation of traffic, toll revenue and reconciliation reports;
Data analysis;
Integrity checking;
System audit; and
Others yet to be identified.

6. ON-SITE INTEGRATION AND COMMISSIONING TEST

The On-site Integration and Commissioning Test (OICT) shall be comprised of equipment, subsystem and system-wide testing of the Smart Lane System. The purpose of the OICT is
to provide both the Integrator and the JPA a mechanism for verifying and documenting successful system performance throughout the installation process up to the point of approval to Commission the lane. Testing procedures and scenarios, which will be developed by the Integrator and subject to JPA approval, shall be built upon the previously utilized FAT scripts and test steps.

At the subsystem and component level(s), the OICT shall cover installation check-out and performance verification at each applicable location throughout the I-860 Smart Lane System. At the system wide level, the OICT shall also cover end-to-end testing that represents a fully integrated and functional Smart Lane System with all subsystems and components successfully integrated on-site. The intent of end-to-end testing during the OICT phase is to ensure readiness for the subsequent Commissioning Test.

The Integrator shall prepare detailed test scripts for the OICT. OICT scripts shall be designed to verify the equipment installation and confirm that the subsystem and/or component(s) are ready for operation on the Smart Lane System and the Commissioning Test can then commence.

The tests to be performed shall be defined in the Integrator’s test plan and test scripts. The detailed test scripts and scenarios of the Test Plan shall be submitted and approved by the JPA prior to commencement of any of the specific tests. Performance of the various tests shall be witnessed by the JPA with acknowledgment of scenario success, failures or potential system or equipment threats.

The commissioning portion of the OICT will be conducted in order to represent the operational readiness of the system prior to deployment. Testing activities and scenarios during these tests shall include complete end-to-end testing of all functions and operations of the Smart Lane System. This testing will involve live traffic in the Smart Lane, both real traffic and test vehicles. To ensure that all of the stated RFP and Contract operating requirements are effectively met, the Integrator shall develop a comprehensive requirements trace matrix and confirm, in writing to the JPA, that the tolling system has met each and every stated requirement.

Any failures that are encountered during the Commissioning Test must be resolved, retested and acknowledged by the JPA before opening of the I-860 Smart Lane and commencement of the Operational Performance Test (OPT). The tests to be performed shall be similar to the tests in the FAT and shall be conducted under the supervision of, and with the participation of the JPA, and their representatives, in accordance with the test plan and test scripts that were previously approved. Testing results and corresponding documentation regarding the completion of the OICT shall be submitted to the JPA for
approval. Approval of the OICT must be granted prior to commencement of the Commissioning Test.

7. OPERATIONAL PERFORMANCE TEST

The final phase of testing of the I-860 Smart Lane System is the OPT. This test shall serve to closely monitor the performance of the Smart Lane under live traffic operating conditions once the Smart Lane is open to toll-paying vehicles. Activities during this period of testing will include all necessary scripted test documentation, unscripted ad-hoc tests as well as monitoring of day-to-day functions of the Smart Lane System, including the operation of the equipment at the three (3) tolling zones, the operation of the TDC, trip building functionality at the TDC, the interface to the TOLL AUTHORITY RCSC, etc.

The OPT shall be conducted over a 30-day continuous period without degradation in performance or failure in compliance with contract system requirements. Throughout the 30-day test period any system problems, errors, failures or malfunctions that are not in compliance with the contract requirements shall be categorized based on its level of severity. The typical four (4) levels of severity are:

- Severity 1 – Hardware or Software component or process that is critical to the operation of the Smart Lane that does not function and there is the possibility of loss of revenue and/or loss of data.
- Severity 2 – Hardware or software component or process that does not function. There is no risk of loss of revenue or data, however there is the possibility of negative impact to patron usage.
- Severity 3 – Hardware or software component or process that does not meet the design functionality and/or impedes the operation of the system but does not effect the collection of revenue or negatively impact the patron usage.
- Severity 4 – Hardware or software component or process that does not meet the design functionality and/or is “cosmetic” in nature. Failure is transparent in nature to both the patron and the JPA.

The success or failure of the 30-day OPT shall be determined by the number and type of severity levels encountered during the test. The following represents the impact of each of the severity levels on the eventual outcome of the test.

**Severity 1**

- Indicates a failure of the 30-day test.
The 30-day test is stopped. Once the problem is resolved, the 30-day test is restarted from Day 1.

Milestone payments regarding the 30-day test are withheld.

Warranty period will not begin until successful conclusion of the OPT.

Severity 2

- Does not indicate a failure of the 30-day test.
- The 30-day test is stopped. Once the problem is resolved, the 30-day test will resume from the date in which it left off. Once the problem is resolved the implemented fix shall operate without flaw for seven (7) consecutive days, which may extend the 30-day test period.
- Milestone payments regarding 30-day test will be withheld.
- Warranty period will not begin.
- Reoccurrence of the same problem that should have been resolved might raise the level of the issue to Severity 1.

Severity 3

- Does not indicate a failure of the 30-day test.
- The 30-day test is stopped. Once the problem is resolved, the 30-day test will resume from the point in which it left off. Once the problem is resolved the fix shall operate without failure for a minimum of seven (7) consecutive days, which may extend the 30-day test period.
- Milestone payments will continue to be paid to the Integrator.
- The Warranty Period will not begin.

Severity 4

- Does not indicate a failure of the 30-day test.
- The 30-day test is not stopped. The problem is resolved in a timely fashion.
- Milestone payments will continue to be paid.
- The Warranty Period will not begin.

All I-860 Smart Lane hardware and software will be carefully tested. Verification that all reported problems have been resolved will be obtained using several methods, including
event logs and service call logs and other additional information that can be gleaned from the Maintenance On-Line Management System maintained by the Integrator or other data sources approved by the JPA. Multiple meetings per week will be scheduled during the 30-day test to ensure that the JPA is fully aware of all system and equipment failures and the meetings will provide a forum in which JPA and Integrator staff can review system/equipment failures and classify the severity levels.

<p>| I-860 Smart Lane Project Document Revision History |
|---------------------------------|-----------------|-------------|</p>
<table>
<thead>
<tr>
<th>Rev</th>
<th>Revision Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>First Release – Verification (Test) Plan</td>
<td>4-14-06</td>
</tr>
<tr>
<td>2</td>
<td>Agency Review version</td>
<td>4-17-06</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Approval Person</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
</table>