The research conducted under this project was performed between September 2003 and September 2004 and initially reported to AASHTO in December 2004. However, due to the premature death of the principal investigator, Curtis Herrick, the posting of the report was delayed. For additional information please contact:

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Background

This project was intended to serve as a foundation for demonstrating how an independent testing facility can serve as a linkage between standards development, implementation, and deployment. In essence, the concept of a testing lab can be used to resolve issues related to the implementation of a standard, thereby enhancing the quality of the standard and increasing the likelihood of a successful field deployment.

The goals of this project were to develop test plans and procedures for assessing the implementation of the NTCIP standards by different traffic signal controller manufacturers; and to apply those tests on actual equipment to assess the effectiveness of the NTCIP standards to promote interoperability. Further, it was our intent to provide feedback to the standards developers on any issues encountered with the standards themselves.

Four traffic signal controller manufacturers participated in the project. These four manufacturers represent over half of the U.S. marketplace in traffic signal controllers. These manufacturers provided equipment for testing and worked with the Texas Transportation Institute (TTI) to resolve implementation issues encountered during testing that were related to the NTCIP Traffic Actuated Signal Controller standard. As part of our agreement with the manufacturers, test results on their equipment are being kept confidential.

Deliverables

This document and a CD represented the final report and project deliverables for this project. The project deliverables on the CD included the following:

- The test cases and test procedures that were used in testing the traffic signal controllers.
- SimpleSoft ® SimpleTester for NTCIP scripts for automating the testing procedures.

In addition to the CD, the test procedures and the SimpleSoft® SimpleTester for NTCIP scripts are posted on the TTI Interoperability Test Lab website (www.itstestlab.org) under the Testing and In House menu options.

Lessons Learned

Lessons learned throughout the course of this project include the following:

- Laboratory testing can serve to resolve interoperability issues associated with the implementation of ITS standards. A third party test lab offers an opportunity to work directly with manufacturers to resolve interoperability issues in an environment that is outside the constraints and limitations of a typical agency construction project. In addition, laboratory testing can help identify ambiguities in a standard and such information can be fed back to the appropriate standards developers.

- Substantial work has been done by the traffic signal controller manufacturers participating in this project towards the implementation of NTCIP standards. However, additional work is needed to provide for interoperability for the full array of features defined in the NTCIP standards. No manufacturer that participated in the project has fully implemented the latest version of the NTCIP ASC standard—some manufacturers have chosen to implement most all of an older version of the standard, while others offer only limited implementations of an even older version of the standard. The minimum level of support encountered was only the mandatory objects found in the NTCIP ASC standard.

- The internal functional software design varies between traffic signal controller manufacturers and this can lead to interoperability problems. Since manufacturers have often developed their own management application software so that it is closely tied to the software of their local controller, reliance on a known local controller software functional design can lead to communication failures when attempting to communicate with devices that have a different internal functional software design. Examples include
the expectation that a prescribed number of phases will be uploaded or downloaded, and
the use of an internal phase check to determine when a phase has an outstanding call for
service. In addition, requirements need to be defined for management applications.

- Substantial time can be saved with the use of automated test scripts. Manual testing
  using any one test procedure may take on the order of 2 to 10 hours each time it is
  executed, depending on the length of the test procedure. Those same test procedures
  can be executed using an automated test script in less than 15 minutes, on average, with
  many tests being automatically executed in about 5 minutes and the longest test taking
  about 45 minutes. Considering the many times that test procedures will be executed at
  various agencies across the country, significant testing costs can be reduced through an
  investment in the development of automated testing scripts and associated automated
  testing tools. Using test procedures from this project, and leveraging funding resources
  from other projects, the TTI Interoperability Test Lab has developed some automated test
  scripts for the traffic signal controller. However, automated test scripts are needed for
  other NTCIP devices and the existing test scripts need to be refined, augmented and
  maintained.

- There needs to be a set of minimum values and string sizes defined for devices
  conforming to the NTCIP standards. Supporting data element range values less than the
  maximum permissible values, called subranging is allowable for index values in the
  NTCIP standards. Examples of where subranging is used are things like the number of
  phases supported by a traffic signal controller, or the length of text string values. In order
  to facilitate a minimum level of interoperability, a set of minimum values and string sizes
  that all devices conforming to the standard must accept need to be defined for each
  NTCIP standard.

- NTCIP testing requires the use of a variety of NTCIP specific testing tools. Some tools
  tend to be better than others at performing some tests, while other tools perform better on
  other tests. This problem is further exacerbated when developing automated testing
  scripts. Not all NTCIP testing tools support standards-based scripting languages and
  those that do, tend to support different languages. The automated scripts created to-date
  by the TTI Interoperability Test Lab were developed using a standard Tool Command
  Language (TCL) scripting language supported by the SimpleSoft® SimpleTester for
  NTCIP testing tool. This tool was selected because of the extent of its scripting
  capabilities. Other NTCIP testing tools will need to support a common TCL scripting
  language in order to make use of the scripts.

- Automated test scripts need to support all possible error conditions in order to be
effective in their use. The development of comprehensive test scripts is not a trivial task,
but it is an important task.

- Some standards have removed deprecated objects from the standard Management
  Information Base (MIB) and this causes problems when support is needed for multiple
  versions of a standard. Deprecated objects need to be added back to the standard
  because their support is required when dealing with devices that support an older version
  of a standard.

- The development of test procedures from a standard that does not incorporate systems
  engineering documentation was relatively straightforward. However, it is noted that not
  all status and control variables have defined state charts that show exactly how to place
  the device into every allowable state. Ultimately, this means that additional
  documentation in the standard is necessary in order to define the state charts. It should
  be noted that state charts are only a small piece of the systems engineering
  documentation that is now being required for NTCIP standards.

Recommendations

Based upon the lessons learned from this project, the following recommendations are made:

- Laboratory testing should be an integral part of the implementation and deployment of an
  ITS standard.
Automated test scripts should be developed for all test procedures created for the ITS standards. In addition, consideration should be given to fully-automating the testing process using a hardware-in-the-loop to also exercise device functionality.

Once created, test procedures and automated test scripts should be refined, augmented and maintained.

The lessons learned from this project should be fed back to the appropriate NTCIP working group(s) in an effort to resolve any ambiguities that may exist in the standards. The working groups should also consider defining a set of minimum values and string sizes that all devices conforming to a standard must accept, in order to facilitate a minimum level of interoperability.

Training should be offered to those who will be tasked with interpreting the test procedures, using appropriate test tools, and applying the automated test scripts.

While this project dealt specifically with NTCIP center-to-field communications for an actuated traffic signal controller, additional work should be considered for the development of test procedures and automated test scripts for other NTCIP center-to-field devices. In addition, consideration should be given to the testing needs for center-to-center communications.

In summary, a series of test cases and test procedures have been created and used during the execution of the NTCIP Laboratory Testing for Actuated Signal Controllers Project. TTI has been able to create automated test scripts for many of the test procedures. The automated test scripts that have been developed to-date are being provided to AASHTO and placed in the public domain.