

**ITS Standards:
Tools for A Simplified Approach To Conformance**

**ITE Annual Meeting 2002
Philadelphia, Pennsylvania**

Raymond D. Chong, P.E.
City of Camarillo
601 Carmen Drive
Camarillo, Ca 93010
(805) 388-5381; (805) 388-5387 FAX
rchong@ci.camarillo.ca.us

and

Kevin G. Aguigui, P.E.
Principal
DKS Associates
1956 Webster Street, Suite 300
Oakland, CA 94612
(510) 763-2061; (510) 268-1739 (FAX)
kga@dksassociates.com

ABSTRACT

As public agencies increasingly deploy Advanced Traffic Management Systems (ATMS) throughout the United States, system integrators and vendors must comply with the national ITS Standards. However, they face the difficult challenge to obtain conformance of their ATMS with them. A national ITS Standards Testing Program by United States Department of Transportation has the primary responsibility to determine ITS Standards conformance for ATMS, but to date it has only tested a few systems. The Program investigates ITS Standards performance and validates field deployments. The Program is an excellent independent verification and validation (IV&V) test of ATMS with the ITS Standards. However, public agencies require a preliminary determination of ITS Standards conformance for their ATMS if they are unable to qualify for testing under this Program. Many public agencies want to evaluate the National Transportation Communications for ITS Protocol (NTCIP).

This paper will describe the basic technical issues that public agencies face when they determine conformance of their ATMS with ITS Standards. It will identify the tools and appropriate methodology to utilize to initially evaluate an ATMS on conformance with ITS Standards. The technical issues include: applicable ITS Standards; mandatory, optional and vendor-specific elements of the ITS Standards; and field devices installation. Methods include Protocol Information Conformance Statements (PICS), conformance levels and data object testers to meet the criteria of the Program. Public agencies will know expectations of system integrators and vendors who claim to be compliant with the ITS Standards. It will differentiate the elements of ITS Standards from an open architecture system.

INTRODUCTION

The Intelligent Transportation System (ITS) Standards are standards that define how system components operate within a consistent framework. The ITS Standards are based on a consensus from the transportation industry. The framework is known as the National ITS Architecture. By specifying how systems and components interconnect, the standards promote interoperability.

To expedite deployment of nationally interoperable ITS elements and services, the United States Department of Transportation supports specific ITS Standards initiatives, especially in areas that have significant public benefit.

The ITS Standards Program is working toward the widespread use of standards to encourage the interoperability of ITS systems. Through cooperative agreements with five standards development organizations (SDOs), the Standards Program is accelerating development of about 100 non-proprietary, industry-based, consensus ITS Standards, and is encouraging public-sector participation in the development process.

The Standards Program is maturing from a primarily standards development program to a standards deployment program by rapidly moving into standards deployment support. Such support includes helping to build credibility in the standards through testing and case studies,

providing standards resource information, supporting training and technical assistance to deployers, developing deployment experience-based guidance such as “lessons learned,” and assessing the readiness of standards for deployment. In addition, the program is coordinating U.S. ITS Standards efforts with international standardization activities.

Testing is an important step toward interoperable ITS systems because it provides information to potential users on the reliability, interoperability, functionality, and performance of systems based upon the standards. The objective of ITS Standards testing activities is to “prove” the standards in real transportation settings and build confidence in the standards. The U.S. DOT’s program to test ITS Standards is being carried out by the Battelle Memorial Institute.

The six standards tested were assessed and evaluated as suitable, effective and as contributing positively to the interoperability and interchangeability of NTCIP DMS subsystems. There were exceptions that are presented in the findings stated of the report. The conclusion of the testing was that the DMS-specific standards 2101 and 2103 are mature enough to have enabled two independent vendors to create fully functional subsystems for DMS. Since the actual deployment was not tested, it was concluded that these two subsystems have the ‘potential’ to be fully interoperable and interchangeable in a mixed-product operational environment.

CONFORMANCE

Due to the level of development of the many ITS Standards, the predominant issue associated with the deployment of such standards is to what level does each vendor conform to the standards as written. There are many interpretations on the definition of conformance with the standards, with each entity providing their own definition. Discussed below are the different perspectives of the standards and the general feeling towards the issue of conformance.

While many ITS Standards have been published, there has not been a standard method or approach to testing the implementation of these standards. It has been a common practice to “self-proclaim” one’s conformance with the standards without the benefit of any formalized acceptance testing. While it is relatively simple to specify that a product or system shall conform to the National ITS Standards, or be “NTCIP-compliant”, there is currently nor formal process to confirm this requirement. Furthermore, there is no testing process to ensure interoperability using the ITS Standards amongst different system vendors. The following section provides a brief discussion on the options available to users for performing their own acceptance tests.

CURRENT TESTING PROCESS

This section discusses the different approaches to testing software for conformance to the ITS Standards. In particular, the testing is performed for the development of the software and not the implementation.

Data Testers

While there is a national testing program for the development of the ITS Standards, there are other potential avenues that one could explore to test the relative integrity of a software for

conformance. These tools include software testers that are readily available from software developers. Those that are commercially available include TrafficView by Klos Technologies, SimpleTester from SimpleSoft and Frontline Test System (FST) from Trevilon. Each of these tools monitors the data flowing over the communications channels and reports on the protocols being used based on the packet structure of the data.

One tool that that was utilized in the City of Cupertino was a data object tester developed by Naztec, Inc. of Sugar Land, Texas. Their tester performed queries on the system software for data objects located within a management information base (MIB). The objects that were queried are those defined in the ITS Standards. If a specific data object could not be found, a flag was returned. The query run was then documented for review and comparison against those objects hat are mandatory, optional or proprietary.

National Test Site

Another way to test a system for conformance is to become a test site. This would be under the ITS Standards testing program being conducted by Battelle Memorial Institute. There are rigorous standards to be met should an agency decide to become a test site. Table 1 below is taken from a list prepared by The Battelle Group on the status of the testing sites. While this table may already be out of date, it illustrates that limited locations that have been utilized as test sites for testing of the different standards. In some cases, the testing is left up to the vendors.

Table 1 ITS Standards Testing Progress				
Lead SDO	Document Number	Standard Title	To be tested?	Comments
AASHTO	NTCIP 1207	NTCIP - Object Definitions for Ramp Meter Control	Yes	
AASHTO	NTCIP 1205	NTCIP - Object Definitions for Closed Circuit Television Camera Control	Yes	
AASHTO	NTCIP 2303	NTCIP - File Transfer Protocol - Application Profile	Yes	
AASHTO	NTCIP 1204	NTCIP - Object Definitions for Environmental Sensor Stations	Yes	
AASHTO	NTCIP 2302	NTCIP - Trivial File Transfer Protocol - Application Profile	Yes	
AASHTO	NTCIP 2305	NTCIP - Application Profile - CORBA	TBD	On hold indefinitely; standard will be tested only if objects are defined.
AASHTO	NTCIP 1101	NTCIP - Simple Transportation Management Framework (STMF)	Yes	Successfully tested; March 2000. DMS test with Illinois State Toll Highway Authority.
	NTCIP 2001	NTCIP - Class B Profile	Yes	Successfully tested; March 2000. DMS test with Illinois State Toll Highway Authority.
	NTCIP 1201	NTCIP - Global Object Definitions	Yes	Successfully tested; March 2000. DMS test with Illinois State Toll Highway Authority.
	NTCIP 1202	NTCIP - Object Definitions for Actuated Traffic Signal Controller	Yes	
	NTCIP 1203	NTCIP - Object Definitions for Dynamic Message Signs	Yes	Successfully tested; March 2000. DMS test with Illinois State Toll Highway Authority.

Protocol Implementation Conformance Statement

One passive method of confirming the conformance of a vendor's system software is to require the submittal of a Protocol Implementation Conformance Statement (PICS). While this does not replace any conformance testing, it documents the claims of conformance from a system vendor, and provides the user with a sense that some effort has been expended to back up this claim.

CONFORMANCE OF ITS STANDARDS IN THE CITY OF CUPERTINO

The City of Cupertino in California is deploying several ITS applications that meet National ITS Standards. The City has successfully implemented an Advanced Traffic Management System (ATMS) that manages its traffic signals on arterials. The results of this implementation included construction of new Traffic Operations Center (TOC), a central software and hardware system known as Naztec *StreetWise*, and comprehensive replacement of field devices.

The scope of work for the work included:

- Installation of ATMS software in the TOC.
- Installation of NEMA TS-2 advanced traffic signal controllers (33 each) in conformance with the National Transportation for ITS Protocol (NTCIP) standards.
- Upgrade of the communication network in conformance of NTCIP.

The *StreetWise* central system software is a flexible and modular system that was selected for implementation as it best matched all of the City's needs and requirements. The system has interfaces to the *Synchro* software optimization tool, will operate as a centralized system or a fully distributed system, It utilizes much of the industry standard software protocols such as the Transmission Control Protocol/Internet Protocol (TCP/IP). It has multiple architecture TCP/IP client/server application and NTCIP center to center and center to controller.

The City's ATMS consists of multiple implementation phases, with each subsequent phase implementing extension tools for the system. The initial system consists of the TOC, new central system and new traffic signal controllers and cabinets. The City already has a comprehensive communications network of copper wire interconnect. Separate dial-up links will be used for remote access from the City's Traffic Signal Shop to the central server. The various phases of the Project are prioritized in such a way that initial phases will implement the base infrastructure that has been designed to accommodate the expansion of the system.

The figure below illustrates the overall architecture of the system including the future enhancements to the system.

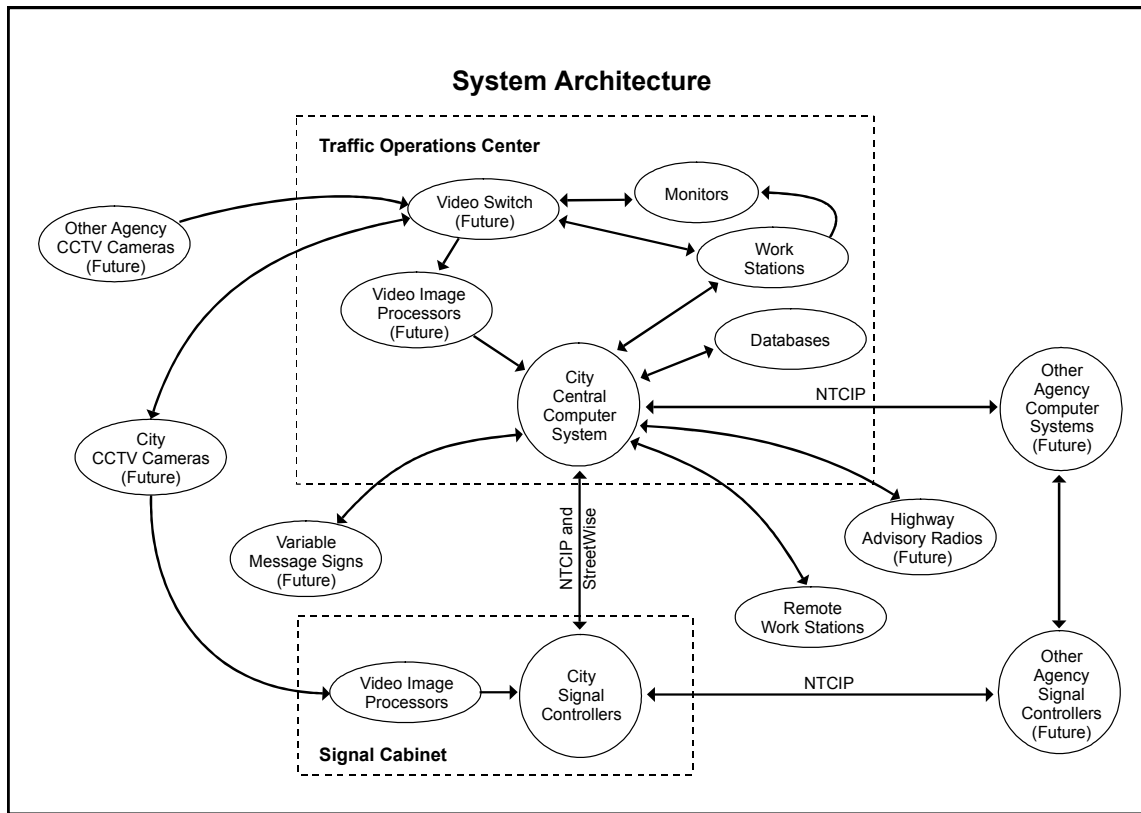


Figure 1 - System Architecture

The new system meets all of the City's current needs, with the expansion elements to be integrated as those projects are started. The figure below illustrates the communications configuration network of the system that includes the central system and field devices.

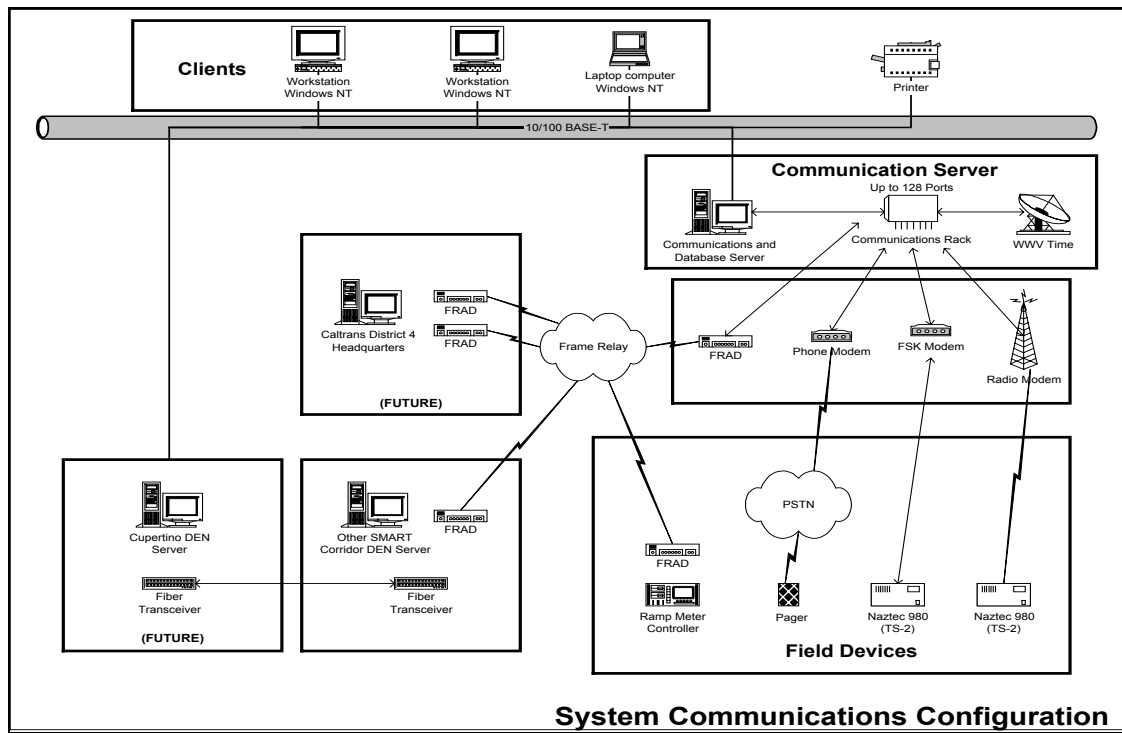


Figure 2 - System Communications Configuration

The system has the ability to implement the NTCIP standards. The software has been modified to implement the TS-3.3, Class B Profile with an RS232-E interface. In addition, the software will implement all of the mandatory and optional objects of the Conformance Groups as defined in NEMA TS-3.4, Global Object Definitions and NEMA TS-3.5, Actuated Signal Controller Object Definitions. Naztec has also prepared a comprehensive set of objects in their proprietary MIB, which will be implemented.

The City has implemented central to field communications using the NTCIP Class B Profile. New NTCIP central software and controller software versions were implemented in the field. Utilizing FLASH memory in the controllers, the City updated the controller software at several controllers within a channel. The interconnect lines have already been conditioned to produce data rates up to 9600 baud.

Naztec's Object Tester Software has tested 12,855 NTCIP objects and proprietary MIB's in *StreetWise* in Cupertino. It was the first ATMS in the nation to fully conform NTCIP as a complete system. Naztec fully supports NTCIP as the communications and database standard for all ITS field devices. Naztec has made a major investment in developing and testing NTCIP for all TS-2 products and the emerging 2070 controller line. The Protocol Analyzer and Object Tester built into the Naztec *StreetWise* ATMS ensure compatibility with the 12,855 NTCIP

objects and MIB's currently implemented in the Naztec family of ITS devices. Naztec also will ensure that future enhancements to the NEMA standards and it's own MIB objects are fully tested and supported.

In 1996, Naztec upgraded their TS-1 controller line to TS-2 and the 16-phase / 16-overlap TxDOT specifications. During the same period, NEMA began finalizing the NTCIP protocol. NTCIP became part of the design process as Naztec moved from the TS-1 controller (16-bit 8 MHz processor, 256K memory) to the TS-2 controller (32-bit 16 MHz processor, 4 meg memory). Naztec chose to incorporate the NTCIP object definitions into the database of the new TS-2 controller rather than write controller software to translate the old TS-1 database to NTCIP. This one-to-one match between the controller database and the byte definitions of the NTCIP objects helps insure compatibility with the intent of the NEMA specifications. Naztec's implementation of the NTCIP protocol fully supports SNMP, STMP and dynamic objects. In addition, the Naztec 2070 controller software supports both asynchronous communication (NTCIP 2101 - PMPP/RS232 Sub-Network Profile) and IP connectivity (NTCIP 2104 - Ethernet Sub-Network Profile). However, NTCIP has proved superior to the other protocols after Naztec developed block transfers to increase the data packet size and minimize the overhead of the protocol. Naztec controllers also support baud rates up to 56K Baud which also improve data throughput.

Naztec developed a block transfer method to enhance the communication throughput of NTCIP. This enhancement maintains all NTCIP packet structures and will not interfere with other NTCIP messages broadcasted from other ITS devices that do not support block transfers. Naztec field devices can communicate with the ATMS at a much higher data rate because the block transfer method increases the data packet size when communication environment is stable. This minimizes the overhead of the header information required by NTCIP for each data packet. An analogy between the block transfer method and the standard NTCIP packet size is the difference between carrying a load of cargo with a semi tractor-trailer and a 4-wheel drive jeep. The semi would obviously allow you to minimize the haul time for a large amount of cargo. However, if you had to carry the load to the top of a mountain, you would use the 4-wheel drive vehicle but make far more trips. In a similar way, the block transfer method increases the data packet size when the communication path is free of errors and reduces the data block back to the NTCIP packet size when the communication path is noisy and error prone. The following example illustrates the speed improvement achieved with Naztec's block transfers enhancement to the NTCIP protocol.

Protocol	Mode	Data bytes (per message)	Total Messages (Bytes)	Total Time (Minutes)
Standard NTCIP		1	18,432	61.0
Naztec TS-1 Protocol		16	1,152	3.8
Naztec NTCIP With Block Transfers	Mode 1	16	1,152	4.8
	Mode 2	32	576	2.6
	Mode 3	64	288	1.7
	Mode 4	128	144	1.2
	Mode 5	256	72	0.9
	Mode 5	512	36	0.8
	Mode 7	1024	18	0.6

Table 2 - Example: Volume/Occupancy Report - 24 hours of data (18,432 bytes) at 9600 Baud

Currently there are no standardized tests for the NTCIP objects. Even when standard tests become available, each manufacturer will need to test proprietary MIB's that not included in the NTCIP objects. Therefore, Naztec has developed an NTCIP Protocol Analyzer and Object Tester as part of the *StreetWise* ATMS software. The Naztec Protocol Analyzer is built into the *StreetWise* Communication Server and is capable of intercepting all NTCIP messages transmitted over the serial ports to the ITS field devices.

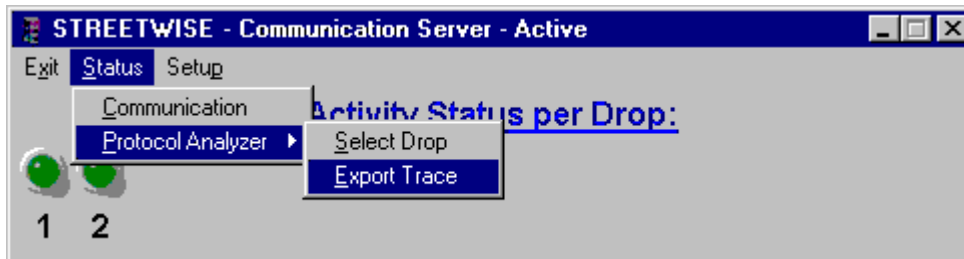


Figure 3 - Communication Server

The Protocol Analyzer provides the ability to capture and trace all NTCIP data between *StreetWise* and the field devices. The trace capture is a byte-by-byte definition of the protocol transmitted (TX) and received (RX) from the field. These byte definitions agree with the byte definitions required by the NTCIP objects in the NEMA protocol.

```

trace.txt - Notepad
File Edit Search Help

TX Sat Oct 14 14:31:41.240 2000
(Bytes 46)7e 5 13 c1 30 26 2 1 0 4 6 70 75 62 6c 69 63 a0 19 2 2 1 ad 2 1 0 2 1 0 30 d 30 b
RX Sat Oct 14 14:31:41.360 2000
(Bytes 47)7e 5 13 c1 30 27 2 1 0 4 6 70 75 62 6c 69 63 a2 1a 2 2 1 ad 2 1 0 2 1 0 30 e 30 c

```

Figure 4 - Trace

The Naztec Object Tester is built into the *StreetWise* client as shown below:

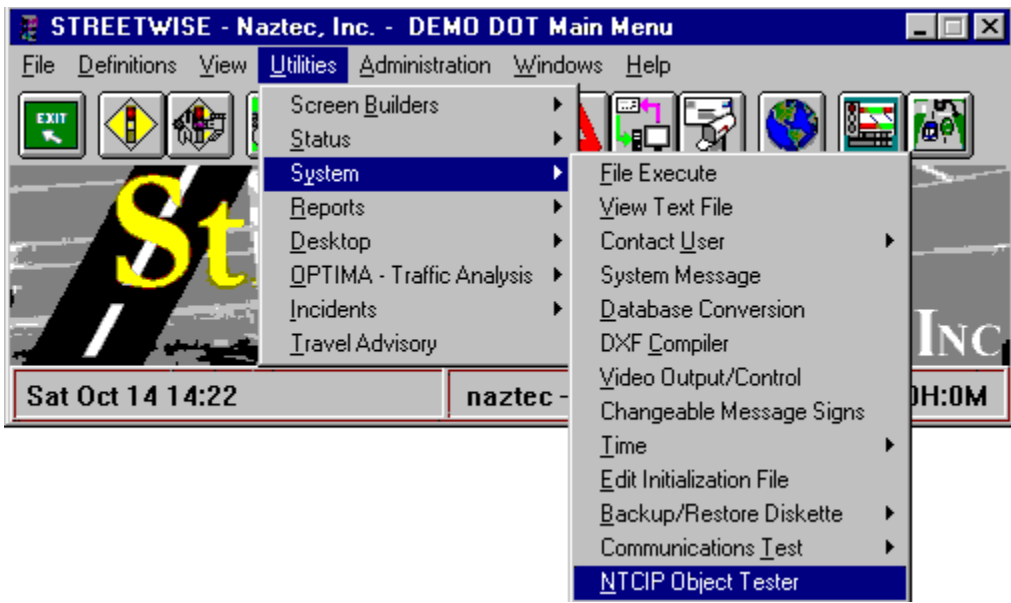


Figure 5 - NTCIP Object Tester in *StreetWise*

The Naztec Object Tester exercises and tests 12,855 NTCIP objects including all Naztec proprietary MIB's defined in *StreetWise* the 970, 980 and 981 family of controllers as shown below. The Object Tester is also being used to develop NTCIP based software for Naztec's 2070 controller line. The Object Tester insures that all communications software developed by Naztec for NTCIP is systematically tested for compliance with the NEMA specifications.

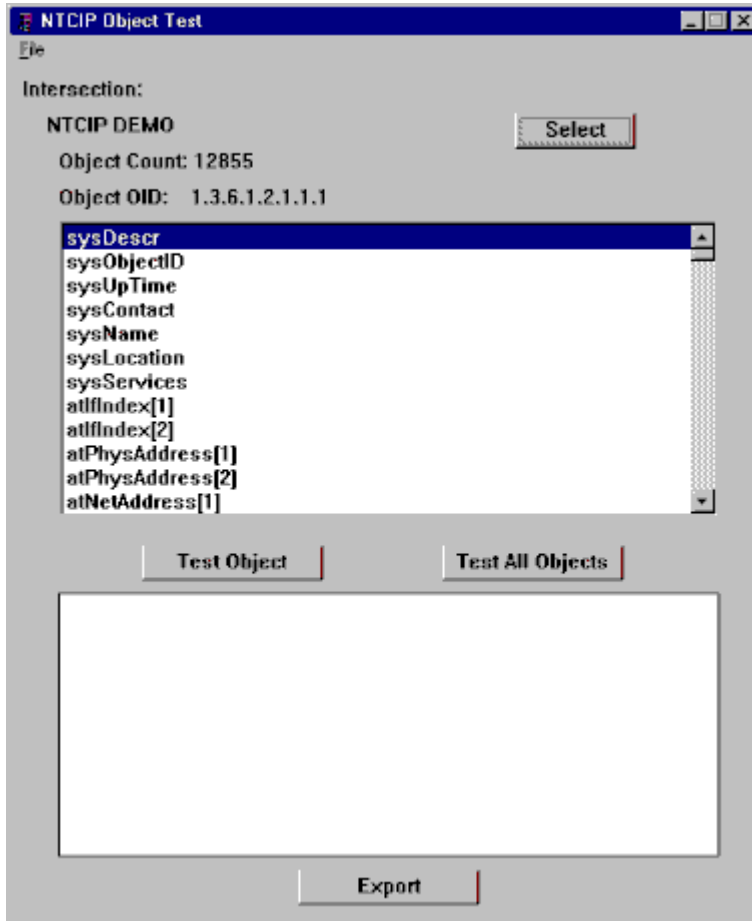


Figure 6 - NTCIP Object Test

The screen below illustrates the progress of the Naztec Object Tester while testing all 12,855 objects - a process that takes over 3 hours to complete.

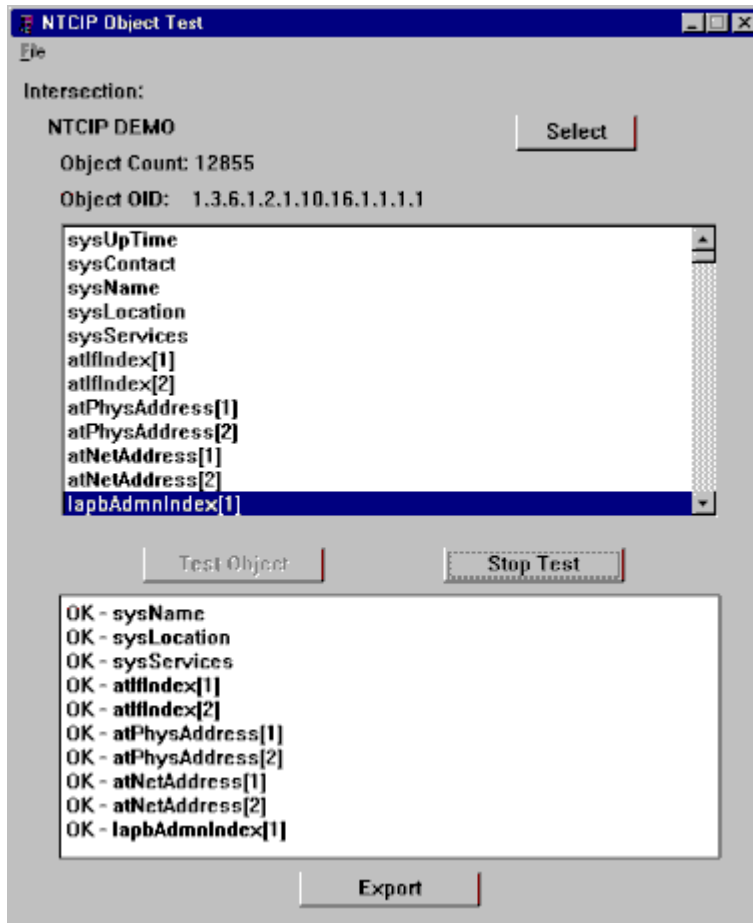


Figure 7 - NTCIP Object Test

As each object is tested, the Object Tester indicates an OK or fail message.

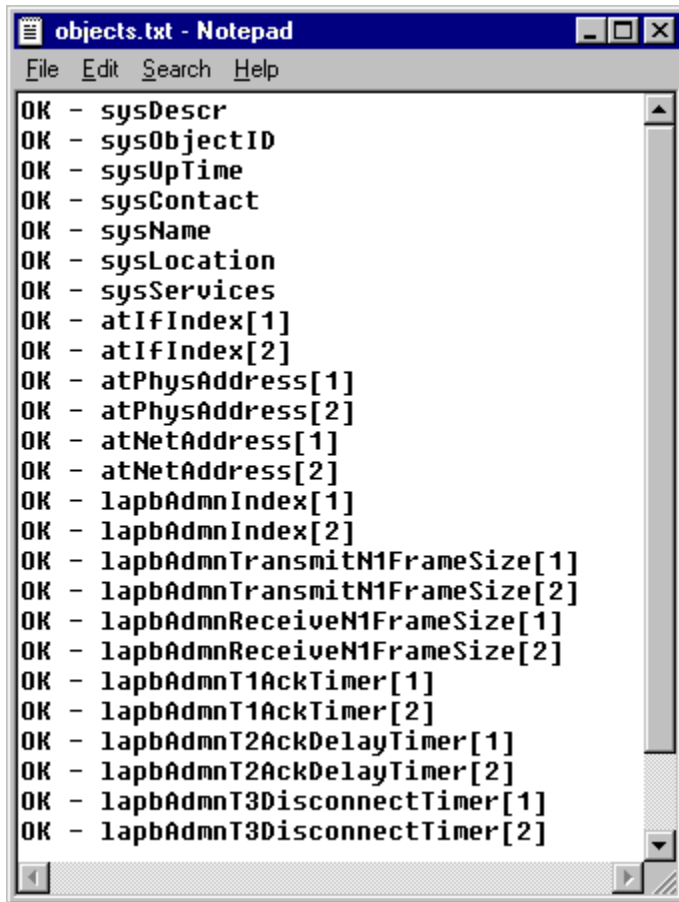


Figure 8 - Objects

Naztec has provided a NTCIP Conformance Statement on their conformance with NTCIP and all subsequent amendments. It covers NEMA TS-3.1 (NTCIP – Overview), NEMA TS-3.2 (Simple Transportation Management Framework), NEMA TS-3.3 (Class B Profile), NEMA TS-3.4 (Global Object Definitions) and TS-3.5 (Object Definitions for Actuated Traffic Signal Controller Units) and Naztec’s proprietary MIB. DKS Associates of Oakland, California, conducted preliminary tests to confirm Naztec’s validity of their conformance statement. They tested data objects and block transfers on *StreetWise*.

CALL TO ACTION

The National ITS Standards have been under development for many years now. In all this time, there has not been a single standard that has been tested for actual field deployment and interoperability. However, the deployment of transportation systems that claim to be “conformance” standards have increased. For the end users, there are no distinct procedures on how to test the different software for conformance with the standards. This has led to confusion for many different users who are seeking to deploy open architecture systems. For this reason, there has to be more active movement on the testing front of all systems for conformance with

the ITS Standards. Listed below are some of the suggestions for actions that can occur to move in that direction.

Formulate a Testing Body – this would establish a group whose sole purpose is to test the standards for each ITS component within different vendor’s systems. This testing would be for the standards and the deployment of the components using the standards. While similar in nature to what Battelle Memorial Institute is doing, this group will test the interoperability of different manufacturer’s components, preferably in a field environment.

Allocate Funding – In order to conduct this testing, adequate funds must be allocated to the process by the United States Department of Transportation.

Provide Incentives – It will be necessary to provide incentives to the system vendors to have them go through the conformance testing process. This could include international recognition of systems or products that successfully complete conformance testing or making the delivery of conformance test documents a condition of deployment of systems or products.

Test Actual Field Deployments – The testing program has only focused to date on the integrity of the ITS Standards themselves. It will be important to begin to test the actual field deployments of systems that have deployed the standards. In particular, testing of interoperability of different elements of each system will be necessary.

REFERENCES:

Chong, Raymond D., Aguigui, Kevin G., (June 2000), “City of Cupertino: A Cooperative Implementation of an Advanced Traffic Management System.”
DKS Associates, March 2001, “Cupertino Advanced Traffic Management System” Project Summary Report.
Naztec, TecNote 1000 - The Naztec NTCIP Protocol.

INFORMATION ABOUT THE AUTHORS:

Raymond D. Chong, P.E., is the City Traffic Engineer for the City of Camarillo, California. He received his bachelor’s degree from the University of Southern California and a master’s degree from San Jose State University. He is a registered professional engineer in civil and traffic engineering in the state of California, and a registered Professional Traffic Operations Engineer. Mr. Chong has served as the City Traffic Engineer for Cupertino between October 1996 and April 2001.

Kevin G. Aguigui, P.E. is a Principal with DKS Associates. He has over 13 years of experience in the design and implementation of Advanced Transportation Management Systems including adaptive and transit priority systems. A registered civil and traffic engineer, he has a certificate in Telecommunications and Network Engineering from the University of California at Berkeley.