THE FLORIDA DEPARTMENT OF TRANSPORTATION’S
STATEWIDE SPECIFICATION AND APPROVAL OF DYNAMIC
MESSAGE SIGNS

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ABSTRACT

The Florida Department of Transportation (FDOT) was among the first in the nation to
develop and implement statewide specifications for dynamic message signs (DMS) and other
intelligent transportation systems (ITS) devices commonly deployed on transportation
projects. The development of these specifications, their approval by the Federal Highway
Administration (FHWA), and subsequent publication and adoption on all projects within
Florida has produced numerous benefits for FDOT. These benefits include reduced
duplication of effort, improvements in the consistency and uniformity of project designs,
establishment of statewide purchasing agreements with competitive pricing that can be used
by other agencies, improvements in the consistency and repeatability of product approvals,
and improvements in DMS product performance and quality.

Key Words

Florida, Transportation, FDOT, Sign, DMS, Approval, APL, ITS, Specifications, Testing
INTRODUCTION AND EXECUTIVE SUMMARY

FDOT was among the first in the nation to develop and implement statewide specifications for DMSs and other ITS devices commonly deployed on transportation projects. The development of these specifications, their approval by the FHWA, and subsequent publication and adoption on all transportation projects within Florida has produced numerous benefits for FDOT. These benefits include reduced duplication of effort, improvements in the consistency and uniformity of project designs, establishment of statewide purchasing agreements with competitive pricing that can be used by other agencies, improvements in the consistency and repeatability of product approvals, and improvements in DMS product performance and quality.

The benefits of statewide specifications and centralized product evaluation for ITS equipment extends to a number of other traffic control products, including other commonly deployed ITS devices, such as cameras, Ethernet communications equipment, and vehicle detection systems. However, the scope of this paper is limited to sharing insight into Florida’s history with DMS specification development and product evaluation as well as ongoing development and refinement of these statewide minimum requirements. This paper also provides examples of issues uncovered and lessons learned during the course of DMS product evaluation by staff at FDOT’s Traffic Engineering Research Laboratory (TERL) in Tallahassee, Florida.

DEVELOPMENT AND PUBLICATION OF FLORIDA’S ITS SPECIFICATIONS

Responsibility for Statewide ITS Specification Development

FDOT is a decentralized agency with a large number of internal stakeholders dispersed throughout the state. FDOT is principally divided into seven Districts based on geographic area, plus Florida’s Turnpike Enterprise and the FDOT Central Office (in Tallahassee).

The Districts vary in organizational structure, but in general each has major divisions for administration, planning, production, and operations. As such, most of FDOT’s design and operational activities are undertaken and implemented regionally. One way in which the Central Office both guides and supports District project activities is through the establishment and promotion of statewide minimum functional requirements. These requirements are contained in the FDOT Standard Specifications for Road and Bridge Construction. A number of companion documents, including the FDOT Design Standards, Plans Preparation Manual, and Basis of Estimates are also developed and produced by the Central Office.

Central Office technical experts typically originate and coordinate development of new specifications or updates to existing content. However, new specifications and updates can also be introduced from local agencies, Districts, or other interested stakeholders. FDOT specifications for ITS equipment and other traditional traffic control devices, such as controllers, traffic cabinets, and traffic signals are usually initiated and managed by the FDOT Traffic Engineering and Operations Office in Tallahassee Central Office.

Need for Statewide ITS Specifications and Establishment of Guiding Principles
In 2004, as Florida’s ITS deployments gained significant momentum and continued to shift focus from planning to design and construction, FDOT’s Traffic Engineering and Operations Office ITS Program was tasked with developing statewide minimum requirements for a number of common ITS devices. Prior to this, the development and inclusion of minimum requirements for ITS equipment had been the responsibility of the Engineer of Record (EOR) for each individual project. Reducing effort on the EOR and reducing duplication of effort associated with this approach were among the many goals of the statewide specification development effort. Other goals included the desire to establish consistent minimum requirements that adopt national standards, foster the use of interoperable non-proprietary products and designs, align ITS specification development and refinement with systems engineering best practices, and ensure the quality and consistency of ITS devices installed in Florida.

Guiding principles were established as a framework to capture the general goals of the specification development effort and used regularly to ensure that content aligned with the desires and needs established by FDOT stakeholders. These principles were reduced to an informal list that was shared among staff involved with content development as a reminder of project goals and objectives. The summarized list essentially contained informal statements similar to those below:

- Focus on functionality over form
- Utilize current technology, shy from "bleeding edge"
- Adhere to applicable national standards where feasible (NTCIP, NEMA, AASHTO, etc.)
- Look for proven performance
- Consider interoperability and interchangeability
- Consider compatibility with statewide software systems
- Foster competition - maintain at least two viable sources for each device type
- Consider not only price, but best value
- Consider maintainability
- Consider practical application
- Consider quality and craft requirements around products with good track records
- Look for proven performance
- Only include requirements that are quantifiable, measurable, and defendable – TESTABLE!!!

Once the technical content for each ITS specification had been vetted through internal reviews, including review and comment by ITS Engineers throughout the state as well as product manufacturers and other industry stakeholders, they were finalized and transferred to the FDOT Central Specifications Office for further processing and eventual publication. FDOT’s specification development process is described in detail online at http://www.dot.state.fl.us/specificationsoffice/Development/Default.shtm.

The initial publication of multiple FDOT ITS specifications and standards occurred in 2006 and the entire set of ITS specifications are regularly reviewed and refined as required to reflect changes in needs, technology, and other factors. The DMS specifications were recently updated to address use of color and graphical sign technologies and other product evolutions.
DMS EVALUATION AT TERL

History and Mission of TERL

TERL was founded in 1997 to ensure that only safe and uniform traffic control devices (and subsequently ITS) are implemented on Florida’s streets and highways. Florida Statute 316.0745 requires that FDOT evaluate and certify all official traffic control signals and devices before their purchase and installation in the state of Florida. TERL is the centralized organization responsible for supporting this mandate.

More specifically, TERL supports this mandate by developing and updating standards, specifications, test procedures, and testing capabilities to evaluate and approve transportation equipment and quality management systems of these equipment suppliers. TERL’s staff ensures that equipment listed on the FDOT Approved Product List (APL) meets the required device specifications, is safe, and is of high quality prior to use in the state of Florida. In addition, TERL’s staff ensures that the quality management system of equipment suppliers meets the required FDOT quality assurance specification.

Organizationally, TERL is housed within the Traffic Systems section of the FDOT Traffic Engineering and Operations Office. Operationally, TERL consists of several components, each with staff, infrastructure, and equipment resources. Additional information about TERL can be found online at http://www.dot.state.fl.us/trafficoperations/Traf_Sys/Traf_Sys.shtm.

DMS Product Evaluation, Observations, and Lessons Learned

Early DMS product evaluation by TERL began as part of a joint research effort between FDOT and the Florida State University’s Electrical Engineering Department. TERL had long been considered FDOT’s technology lab, but had traditionally focused on the evaluation and approval of equipment for signalized intersections. However, multiple deployment and system integration difficulties with DMSs on ITS projects at the time were a perfect problem for engineers and associates at the lab to investigate. Many had backgrounds in electrical engineering and experience developing and testing a variety of software, hardware, and firmware.

Some of the issues occurring with DMS installations in the late 1990s and first years of the current millennium included: inconsistent specifications (often developed project-by-project), inconsistent compliance with specifications, inadequate testing, various product quality problems, and difficulties with implementing the (then relatively new) NTCIP.

Working with multiple end-user agencies throughout the state and DMS manufacturers in that time period (including Adaptive, Addco, Daktronics, Dambach, Mark IV, Skyline, and Vultron), the TERL team set out to find solutions to these problems, which would increase the success rate relating to deployment and use of DMS. It was quickly determined that a set of consistent, statewide minimum operational and material standards needed to be developed, followed by procedures and evaluation capabilities to verify compliance. Whenever possible, oversight or direct in-house evaluation by TERL would be used to ensure independence and impartiality of compliance testing.
The outcome of these early efforts was the development of: 1) Florida’s original requirements document for DMS entitled *Minimum Specifications for Permanent Mount Dynamic Message Signs*, 2) NTCIP testing procedures and testing capabilities at TERL, and 3) evaluation methods together with a program to evaluate and approve DMS manufacturers based on satisfying minimum requirements for implementation of internal quality assurance/quality control standards.

The early evaluation program consisted of three phases of evaluation and/or testing that manufacturers had to complete in order to provide DMSs on Florida projects. The first phase related to quality control and system evaluation; the second phase was DMS display properties testing; and the third phase was NTCIP compliance testing. These original core areas are still integral parts of Florida’s current DMS approval program, and have evolved and been refined over the years.

**Quality Control and System Evaluation**

The successful completion of a quality control and system evaluation is now a common prerequisite required by FDOT to list any device on the APL. This program was initiated and applied originally to DMS in order to stem the aforementioned issues encountered during deployment of signs in Florida’s initial ITS build-out. Based on this early success, the prerequisite for manufacturers to complete a pre-screening of their quality control system was expanded to other product categories listed on the APL.

For over a decade now, FDOT has used the quality control and system evaluation program as a proactive means to ensure a high level of quality for traffic control devices bought and used in Florida. In practice, the program has been an efficient and effective means of prescreening manufacturers prior to committing significant resources (from both the manufacturer and FDOT) to product evaluations. The program is based on industry standard practices for quality control, largely those prescribed by the International Organization for Standardization (ISO). By requiring manufacturers to demonstrate that they have implemented formal processes for quality control, including selection and evaluation of suppliers, in-house manufacturing and testing, and corrective/preventative actions, FDOT has found that 1) it is less likely to encounter significant issues with their products or services; and 2) there are processes in place to resolve any issues that may arise. Over the years, this has also resulted in several instances where manufacturers have passed the FDOT quality control evaluation and gone on with additional steps to become ISO 9001 certified in their own best interests. Currently, FDOT requires that manufacturers providing DMS to Florida are ISO 9001 certified. Manufacturers of other products on the APL must pass FDOT evaluation criteria (demonstrating compliance with ISO standards), but are not required to hold or present a current ISO certification as a condition of FDOT approval.

DMSs represent a significant capital investment and are also critical to timely dissemination of information to motorists for safe, efficient traffic operations and incident management. Agencies wishing to purchase and deploy DMSs should consider ISO prerequisites similar to those used by FDOT to minimize the likelihood that DMSs be sourced from entities without professional, formal measures in place to ensure quality, uniformity, reliability, and good customer service.

**Display Properties Testing**
Like the quality control system evaluation, testing DMS display properties is still performed as a step within FDOT’s current DMS certification program. However, unlike the early days of the program, DMS testing has been expanded to include on-site inspection and operation of the entire sign at TERL.

During the DMS approval program’s infancy, FDOT required manufacturers to submit only a DMS controller and a handful (minimum of three) of display modules. This served the primary goals at the time, as it allowed rudimentary operation of the controller and display components in order to confirm compliance with NTCIP standards for DMSs emerging at that time.

Testing at TERL has now evolved into operational system testing that requires manufacturers to deliver a complete sign to TERL following a desk-check of the technical submittal required as part of the APL process. The FDOT APL process is described in detail online at http://www.dot.state.fl.us/trafficoperations/Traf.Sys/terl/apl2.shtm. Whenever possible, DMS evaluations and delivery of DMSs to TERL (following successful submittal data review) are coordinated with the manufacturer to reduce costs and expenses that must be borne by the manufacturer. For instance, a sign may be detoured while in transit to a project site.

The TERL now conducts operational tests involving sign subsystems, such as airflow and ventilation systems, uninterruptable power systems, environmental sensors (photocells, thermostats, etc.), and physical inspection of the housing as well as display properties, pixel failure, and other diagnostic reporting. Many aspects of current evaluations also involve NTCIP testing and verifying compliance with the requirements of FDOT’s Standard Specifications for Road and Bridge Construction, FDOT’s Structures Manual, the National Electrical Manufacturers Association (NEMA) TS4 Hardware Standards for Dynamic Message Signs (DMS) with NTCIP Requirements, and the FHWA Manual on Uniform Traffic Control Devices (MUTCD).

**NTCIP Compliance Testing**

TERL DMS evaluators have experienced the evolution of NTCIP standards firsthand. TERL’s staff also participates in NTCIP working groups and committees. The development and refinement of the NTCIP standards, particularly those for DMSs has included technical challenges for those who have adopted and deployed signs over the years, particularly early products.

FDOT mandates that DMSs comply with NTCIP standards, though it does not forbid the use of vendor-specific communication protocols or vendor-specific NTCIP objects as long as they do not interfere with standard support of NTCIP or FDOT minimum requirements. FDOT strongly encourages and promotes adoption and use of NTCIP for all DMS systems and uses NTCIP for command and control of DMS in its SunGuide® software, Florida’s statewide advanced traffic management software.

**Past Experiences and Lessons Learned through DMS Product Evaluation**

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The evaluation of DMSs at TERL involves a variety of functional and physical inspections. Over the years, operational testing and inspection at TERL has generally illustrated the value of independent evaluation and verification with end-user operational insight. Manufacturers strive to build quality products that meet minimum requirements and often have a reasonable understanding of the operational and functional needs of roadway operators. However, it is nearly impossible for them to have access to a testing environment comprised of many other third-party components (including products from competitors), communication devices, and central control software that is capable of simulating deployment in a fully operational traffic management system.

In addition, the nature of business at TERL allows its staff to have deep and detailed exposure to multiple products from many vendors. This breadth and depth of firsthand experience with products of the same type from multiple vendors allows the lab to evaluate equipment from multiple perspectives. Foremost, they are evaluated against FDOT’s minimum functional requirements. However, the relative quality, design, and functionality of products within a product category also become apparent when one has such considerable exposure to multiple competing products.

Perhaps the greatest lesson learned and enabled by TERL is that a certain depth of firsthand operation and exposure to a variety of competing products is critical for setting agency expectations and establishing minimum requirements that govern devices. Product evaluations provide exposure and experience that directly contribute to continuous improvement of requirements and published specifications. Equally important to recognize is that device manufacturers also benefit from having a consistent, predictable, reliable, independent third party (in this case TERL) that is able to bridge gaps between multiple interpretations of requirements, clearly capture and articulate observations and recommendations, clarify requirements into real-world needs, and provide a working environment where solutions can be implemented and validated.

The following items illustrate some of the many issues and observations brought to light, characterized, and resolved during the course of numerous evaluations of various DMSs at TERL. In most cases, the resulting remedies were incorporated into the manufacturer’s standard product offerings, which are developed and sold nationwide. While TERL’s primary concern is ensuring that FDOT requirements are met, there is a secondary benefit to a much wider, national user community.

**NTCIP Implementation Issues**

Though NTCIP is now widely required and used by various departments of transportation, there are times when vendor implementations are either incorrect or interpreted in a manner that could compromise interoperability and interchangeability with other systems. While NTCIP standards are reasonably mature, they are not static and, in some cases, may not be fully implemented in certain products. For instance, many vendors and agencies are now migrating to NTCIP 1203v02. Any time such changes are implemented and device firmware is modified, there is the potential to introduce issues and even minor oversights.

There have been a few examples in the recent past with vendors encoding simple network management protocol values incorrectly. One example is the following excerpt from a TERL *Product Evaluation Activity Report* provided to the manufacturer by the TERL. TERL
activity reports present observations and issues discovered during the evaluation of a submitted product. The reports serve as a general record of events and a tool to facilitate conversation between TERL and the product manufacturer in order to resolve issues encountered during the evaluation.

“This issue was previously found on the [Manufacturer and product name removed for confidentiality] DMS and reported in the activity report for that device.

A Get-Request on the object communityNamesAccessMask.1 revealed the value for this object is encoded incorrectly. This object is defined with the Gauge syntax. The Gauge syntax is defined in RFC1155 as “[APPLICATION 2] IMPLICIT INTEGER (0…4294967295).”

Section 8.14.3 of ITU-T X.690 (ASN.1 encoding rules) states “If implicit tagging was used in the definition of the type, then:

a) the encoding shall be constructed if the base encoding is constructed, and shall be primitive otherwise, and

b) the contents octets shall be the same as the contents octets of the base encoding.”

This means the value for an object with a syntax of Gauge shall be encoded the same way as a value for an object with a syntax of Integer, which is a two’s complement binary number.

The device responded with the following message when a Get-Request for communityNameAccessMask.1 was performed.

```
30 82 00 3A 02 01 00 04 0D 61 64 6D 69 6E 69 73 74 72 61 74 6F 72 A2 82 00 24 02 01 24 02 01 00 02 01 00 02 01 30 19 30 17 06 0F 2B 06 01 04 01 89 36 04 02 06 05 03 01 03 01 42 04 FF FF FF FF FF.
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The section highlighted in red is encoded incorrectly. The correct encoding is 42 05 00 FF FF FF FF. Please encode the Gauge type the same way as the Integer type, but with the range specified for the Gauge type.

[Manufacturer name removed for confidentiality] Response: This has been corrected in the next firmware update.”

This following example illustrates an issue experienced with multiple manufacturers and DMS fan test activation.

“The climate control test does not appear to execute when activated using the dmsClimateCtrlTestActivation object. Power to fan 2 was removed when the temperature within the sign did not require the fans to activate. The objects dmsClimateCtrlTestActivation.2 (for RPM SENSOR 02) and dmsClimateCtrlTestActivation.6 (for FLOW SENSOR2) were both set to 3 (Test). Get-Requests were performed on these objects until the value was changed to 2 (noTest) by the sign. The objects dmsClimateCtrlErrorStatus.2 and dmsClimateCtrlErrorStatus.6 both reported 2 (noError), even though power was removed from the fan. When fanTestActivation.0 is used instead of dmsClimateCtrlTestActivation, the test runs, and the dmsClimateCtrlErrorStatus objects report the errors. Please ensure the climate control test activates and runs when dmsClimateCtrlTestActivation is used.

[Manufacturer name removed for confidentiality] Response: We agree with the FDOT recommendation for the behavior of the dmsClimateCtrlTestActivation object, the behavior will be changed to comply with the recommended operation and a firmware updated will be loaded on the [product name removed to sign controller.”

These are but a couple of many examples where TERL product evaluations have served to uncover and correct NTCIP implementations. Other NTCIP and controller functionality issues have included items, such as tables not being created properly or reporting correct status, display brightness reacting too quickly, and the order of MULTI tags negatively impacting displayed messages. For instance, in one case when a text rectangle tag was...
followed by a character spacing tag, half of the first character of the text message was not displayed.

Another important lesson learned was to require and ensure that a consistent set of default fonts is provided and installed on all DMSs. To do so, Florida has standardized on requiring at least one 5x7 font designed exactly as depicted in NEMA TS4-2005, Section 5.6.1. Many DMS manufacturers submitting products to FDOT provide a similar font, but with subtle variations in certain characters. Evaluators were surprised to discover this variability, particularly since uniformity and consistency is an important aspect of signage and the TS4 standard is very prescriptive and clear on the design of the standard font. Similarly, for uniformity and consistency, FDOT also requires that color DMSs with pixel pitch of 34mm or less be provided with a font that mimics the MUTCD Series E insofar as practical.

Other issues with DMS firmware have included excessively long message interruptions during pixel testing, user-programmable values (such as default colors) reverting back to factory defaults upon controller reset, and a host of other items that were typically uncovered as a result of comprehensive operational testing. These testing activities, while undertaken originally out of necessity as due diligence on behalf of FDOT, have also proven to be beneficial to manufacturers by further exercising their products and providing actionable information that can be used to detect and correct product issues prior to deployment. At this point, TERL has well-established working relationships with the major DMS manufacturers in the United States (US). The feedback, comments, and recommendations included in evaluation reports provided to DMS manufacturers during product evaluations are now rarely questioned. In almost all cases where the operation or functionality of a device is called into question, manufacturers generally acknowledge and concur with TERL’s evaluation team assessment and recommendations. This has not always been the case. It has taken years to establish a team with the right combination of multidisciplinary skills as well as the facilities and processes required to perform consistent, repeatable, and fair product evaluations. The lesson learned from this is that credibility and competency is established only over time through demonstrated ability and actions in multiple situations.

**Physical Inspection and Fabrication Issues**

DMS software, firmware, and electronics are housed in custom designed and fabricated enclosures available in a variety of configurations and sizes. Walk-in signs, front or rear access signs, and thin displays designed to be mounted to static panels are some major category types. All of these types involve mechanical design. From the outer skin and panels, to the fasteners and structural framing, the construction of these signs includes a great many components and an equal number of different approaches to fabrication. As one would expect, there are also different approaches to manufacturing and different levels of workmanship.

TERL staff is fortunate in that they are constantly exposed to similar products from competing manufacturers. TERL is also fortunate to have access to significant expertise and experience within other FDOT offices, such as the FDOT Structures Office that contributes structural and mechanical engineering support during DMS evaluations. Perspective and perceptions are largely shaped by firsthand experience, as are expectations. For years, black and white television was satisfying until color technologies were developed and broadly experienced. Color television was deemed to be better by most and black and white soon became less acceptable. Expectations were raised. Expectations are similarly set when one
witnesses varying levels of material quality and workmanship in products. Heavy gauge diamond tread floor panels exhibit a level of quality and workmanship higher than lesser gauge punched material that flexes and squeaks when stepped on. Large diameter fasteners, heavy gauge material, neatly laced wiring, and clean welds tend to illustrate manufacturing pride and commitment to quality that thin material, loose wires, and inconsistent welding do not. TERL has seen both.

While the latter may be good enough to barely exceed minimum requirements, it is important that these facets are experienced and considered. They are often the starting point for specification updates to ensure that lean manufacturing and economic pressures do not result in a manufacturer value engineering a product to an unacceptable level.

FDOT has learned that the exposure to these products and the experience gained through their inspection and evaluation is critical for setting expectation levels and reflecting those expectations in product requirements and specifications. Equally important is critical inspection and monitoring of products delivered to projects to ensure that quality is acceptable and consistent. Many manufacturers provide high-quality, well-designed, and well-crafted products at the start of the evaluation process; those who do not may need encouragement through tighter specifications and testing.

**CONCLUSION**

The consistent, predictable, repeatable, impartial, and thorough evaluation of any product, particularly products with the complexity of electronics such as traffic control devices, requires significant commitment and resources. It requires multidisciplinary technical staff, specialized tools and facilities, well-defined and efficient processes and procedures, effective communication, clear requirements, clearly documented results, and a team enthusiastic about their work.

FDOT recognizes that establishing a single entity responsible for centralized product evaluation yields benefits, such as uniformity and consistency, reduced duplication of effort, and improvements in product performance and quality. These benefits have been realized in several areas. Improvements in the performance and quality of DMSs, their ease of integration with existing statewide systems, and reduction of duplicate work involving specifications, factory acceptance testing, and other aspects are an example.

Other agencies and entities wishing to establish similar programs for other devices are encouraged to contact FDOT’s TERL in Tallahassee to establish a dialog for peer exchange. For DMSs, we encourage others to consider FDOT specifications and the products listed on the FDOT APL when selecting products for deployment. FDOT requirements are largely based on national standards for these devices and we are confident that, in most cases, they would be appropriate for any DMS deployment.

**ACKNOWLEDGEMENTS**

The authors wish to thank the management and staff of the Traffic Engineering and Operations Office (TEOO), the TEOO Intelligent Transportation Systems Program, and the Traffic Engineering Research Lab. Their commitment, support, and the culture of teamwork, professionalism, and quality that they have established in an enjoyable working environment are truly appreciated.
Thank you also to the manufacturers that have worked with us over the years, helped educate us regarding their products, showed us their best and worst, argued with us, agreed with us, subjected themselves to our criticisms, and received our accolades. Thank you, especially, to the manufacturers with products listed on the FDOT APL.
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