

# ITS Standards Impacting the Maintenance Community

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## INTRODUCTION

Intelligent Transportation Systems (ITS) apply advanced technologies to surface transportation networks in order to improve roadway operations and safety. Standards facilitate the integration of various ITS components to achieve the interoperability required for such systems to function consistently between agencies and across the nation. The U.S. Department of Transportation (DOT) ITS Standards Program promotes extensive use of open, non-proprietary standards. ITS standards, which are developed by industry consensus, define how elements of a system operate within the framework of the National ITS Architecture. These standards ensure that equipment and systems purchased from different vendors are capable of exchanging data automatically, consistently, and reliably. The use of standards also promotes competition among system developers, resulting in cost-savings over the life of public (e.g., State DOT) investments.

This paper provides an overview of ITS standards and the development process: highlighting the ways in which standards are important to the maintenance community, identifying relevant standards, and describing resources for technical support. The paper focuses primarily on the Environmental Sensor Station (ESS) standard and related standards that facilitate use of ESS data in Road Weather Information Systems (RWIS) and other systems.

## OVERVIEW OF ITS STANDARDS

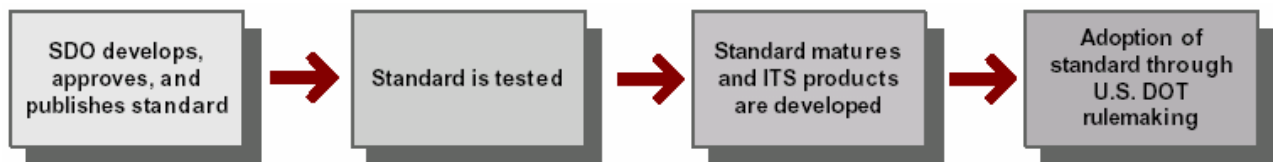
ITS standards allow different technologies and system components to interact and exchange information. Various standards for different applications (e.g., maintenance management, traffic management, traveler information) address interfaces in the National ITS Architecture. This section outlines the standards development process and introduces the standards architecture.

### Standards Development Process

ITS standards are developed through cooperative agreements between the U.S. DOT ITS Standards Program and the following Standards Development Organizations (SDOs):

- American Association of State Highway and Transportation Officials (AASHTO)
- American Public Transportation Association (APTA)
- American Society for Testing and Materials (ASTM)
- Institute of Electrical and Electronics Engineers (IEEE)
- Institute of Transportation Engineers (ITE)
- National Electrical Manufacturers Association (NEMA)
- Society of Automotive Engineers (SAE)

The four-step standards development process, depicted in Figure 1, includes publication, testing, deployment, and adoption. Publication begins with identification of needs and analysis of technical requirements by an SDO. These requirements are documented in draft standards, which are then sent to ballot. During balloting, working group members assess the draft standard and either reject or approve it. Approved standards are published and can be purchased from the lead SDO. Then the standard is tested in early deployments. Lessons learned from deployments result in revision to the standard. When sufficient standards-compliant products are available and the standard is widely deployed, the U.S. DOT will consider rulemaking.



**Figure 1 – Life Cycle of ITS Standards**

As of November 2003, 82 ITS standards had been approved and 73 of these were published. Five standards were in ballot, or being voted upon by a working group, and 28 were under development.

### **National ITS Architecture**

The National ITS Architecture is the overall structure used to plan, configure, and integrate Intelligent Transportation Systems. The architecture helps transportation agencies define system stakeholders and their relationships in order to facilitate integration of systems locally, regionally, and nationally. As shown in Figure 2, the architecture defines subsystems, which is where functions occur, and the data flows that connect subsystems to form an integrated system. Figure 2, also known as the “sausage diagram”, is a high-level view of the National ITS Architecture that illustrates where Maintenance and Construction Management fits into the overall ITS operational concept.

As seen in the figure, subsystems are grouped into four classes: centers, field, vehicles, and travelers. The lines in Figure 2 represent four types of architecture flows or interfaces between subsystems: wireline communications (i.e., fixed-point to fixed-point), wide area wireless communications (i.e., mobile), dedicated short-range communications, and vehicle-to-vehicle communications. *These architecture flows indicate where interoperability is needed and where ITS standards are required.*

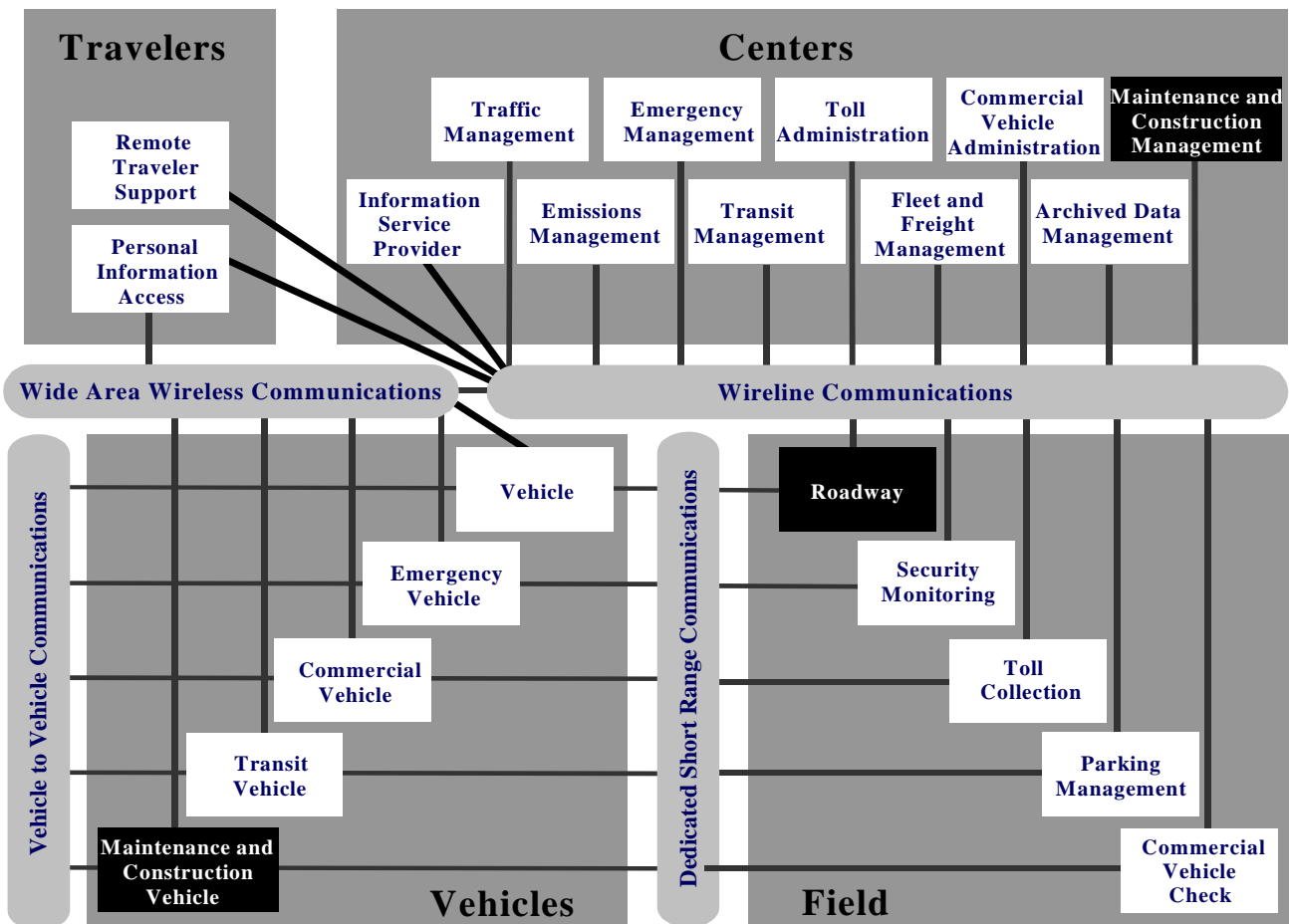


Figure 2 – High-Level View of the National ITS Architecture

## THE IMPORTANCE OF ITS STANDARDS TO THE MAINTENANCE COMMUNITY

ITS standards are valuable because they allow maintenance personnel to deploy equipment and integrate systems that operate consistently across technical, jurisdictional, and institutional boundaries. ITS standards can reduce agency costs and increase competition by prompting vendors to provide implementers with more product and service alternatives. Although using standards may increase initial project costs, total life cycle cost (i.e., procurement, maintenance, and expansion costs) will be minimized. Transportation projects employing ITS standards are also eligible for federal funding through the Highway Trust Fund. The benefits of using ITS standards will increase as more interfaces are standardized for the road maintenance community.

By allowing systems to exchange data in a standard format and syntax, ITS standards facilitate interchangeability and interoperability, reducing dependence on proprietary equipment and software. Interchangeability allows devices of the same type, made by different vendors, to be substituted for one another and interact on the same communication channel. For example, an agency could deploy Environmental Sensor Stations from three manufacturers in a statewide RWIS. With ITS standards, maintenance managers could use one central system to access data

from all of the Environmental Sensor Stations. Interoperability is the ability of systems or devices to provide information to, and receive information from, other systems or devices such that they effectively operate as a single system. For example, an interoperable system would allow a maintenance garage to send road weather data to a Traffic Management Center (TMC) and receive traffic flow data from the TMC, regardless of the equipment manufacturer, and without multiple data conversion steps.

Applicable standards for road maintenance cover two types of architecture flows: center-to-field (e.g., between a maintenance garage and an ESS) and center-to-center (e.g., between a maintenance garage and a TMC). Currently, no ITS standards are available for center-to-vehicle architecture flows applicable to road maintenance. Standards for these flows may be developed in the future.

### **Center-to-Field Standards**

Maintenance managers utilize center-to-field standards to configure, control, and collect data from multiple field devices from a central computer. Architecture flows between the Maintenance and Construction Management center and the Roadway subsystem are covered by center-to-field standards. These architecture flows, which are the most relevant for the maintenance community, include:

- environmental sensors control
- environmental conditions data
- roadway treatment system control
- roadway treatment system status
- roadway information system data



These are the architecture flows that apply to managing Environmental Sensor Stations, observing weather and pavement conditions, monitoring water levels, controlling and monitoring automated anti-icing systems, and disseminating road weather information via Dynamic Message Signs (DMS). There are several standards associated with these architecture flows, and multiple standards may apply to any one of these flows. All of these standards have been developed under an umbrella effort entitled *National Transportation Communication for ITS Protocol*, also known as NTCIP. The associated standards are:

- NTCIP 1201 – Global Object Definitions
- NTCIP 1203 – Object Definitions for Dynamic Message Signs
- NTCIP 1204 – Object Definitions for Environmental Sensor Stations
- NTCIP Center-to-Field Standards Group – a group of standards which address a wide range of communications protocols between centers and field devices

**NTCIP 1201 – Global Object Definitions:** Global Object Definitions cover data elements that are common to many different types of ITS devices. At an early stage, the NTCIP SDOs wisely decided that for the purposes of configuration control, it would be best to put common data elements used by multiple equipment standards in a single “global” standard of elements. This allows commonly used elements to be updated across the entire set of center-to-field standards.

The SDOs approved the first version of NTCIP 1201 in 1997 and approved an amendment in 2001. A second version was recommended for ballot and approved in 2002.

NTCIP 1203 – Object Definitions for Dynamic Message Signs: Data elements for three types of DMS are defined in the Object Definitions for Dynamic Message Signs standard. NTCIP 1203 was initially approved as a recommended standard in 1997 and amended in 2002. This is the most mature and widely-deployed ITS standard. The first version of the standard has been deployed in several states including Arizona, Georgia, Illinois, Virginia, and Washington State. Version 2, which reflects lessons learned from early deployments, is currently going through the approval process. The second version includes a concept of operations (i.e., user needs), functional requirements, traceability between the needs to the interface specifications, and expanded functionality (e.g., use of graphics). A recommended standard is expected by fall 2004.

NTCIP 1204 – Object Definitions for Environmental Sensor Stations: The standard that defines data elements for environmental monitoring, pavement treatment systems, and RWIS is entitled Object Definitions for Environmental Sensor Stations. The first version of NTCIP 1204 was approved and published by SDOs in 1998 and amended in 2001. This standard has been implemented by DOTs in Alaska, Minnesota, Washington State, and Wisconsin. Case studies of Minnesota DOT and Washington State DOT have documented how this standard has been used in their deployments. The Minnesota DOT used NTCIP 1204 to avoid pitfalls associated with proprietary systems and sole-source vendors. Over 70 NTCIP-compatible stations and numerous legacy stations were seamlessly integrated into a single RWIS. The Washington State DOT used the standard to facilitate communication between ESS made by one vendor and a central server from another vendor. This allowed the DOT to manage environmental data from a single platform and reduce procurement costs by nearly 50 percent due to increased competition between vendors.

A second version of NTCIP 1204, which incorporates lessons learned from early deployments and testing, is currently under development. Version 2 will also include a concept of operations (i.e., user needs) and requirements that explicitly trace to specific interface specifications (i.e., data elements and dialogs). A user comment draft is expected to go to ballot in fall 2004 and a recommended standard is anticipated in December.

NTCIP Center-to-Field Standards: These are a family of lower level protocol profile standards that specify how data will be sent over various communications media (e.g., dial-up telephone lines, fiber optic cables). These protocols are common across all center-to-field interfaces, apply to a wide range of communications requirements, and are implemented in various combinations based upon user needs. Some of these standards are mutually exclusive. All of the standards in the group would not be deployed in a particular system. Appropriate standards are selected based on the communication media. Details on the Center-to-Field Standards Group can be found at <http://itsarch.iteris.com/itsarch/html/standard/ntcip2f.htm>.

For the center-to-field architecture flows identified above, Object Definitions standards would be used in conjunction with the Global Objects standard and selected center-to-field communications profile standards.

## Center-to-Center Standards

Because many events can be related (e.g., increased congestion during rainfall, more frequent crashes on icy pavement), sharing information on weather events (e.g., winter storms and hurricanes) and mitigation strategies with managers in neighboring jurisdictions can foster institutional coordination. Center-to-center standards facilitate communication between two or more management centers and allow road weather data to be integrated with Advanced Traveler Information Systems (ATIS) and Advanced Traffic Management Systems. These standards allow maintenance managers to interface with traffic management and other personnel, inform operators of weather-related conditions affecting traffic flow and road safety, and increase the operational efficiency of all center managers.

Architecture flows between the Maintenance and Construction Management center and the Traffic Management center are covered by center-to-center standards. These architecture flows, which can also be used to communicate with another Maintenance and Construction Management center or an Information Service Provider center, include:

- road weather information
- roadway maintenance status



These architecture flows are utilized to send weather data, road condition information, and the status of maintenance fleet operations from a maintenance division to other transportation system operators. The center-to-center standards associated with these flows are:

- ITE Traffic Management Data Dictionary
- ITE Message Sets for External TMC Communication
- SAE J2354 – Message Sets for Advanced Traveler Information Systems
- NTCIP 1301 – Weather Report Message Set for Environmental Sensor Stations
- NTCIP Center-to-Center Standards Group – a group of standards which address a wide range of communications protocols between two centers

ITE Traffic Management Data Dictionary and ITE Message Sets for External TMC Communication: The center-to-center standard that is most important to maintenance managers is the Traffic Management Data Dictionary (TMDD). All management centers that share information can use this standard, regardless of their function. Version 1 of the TMDD standard is organized into four sections that define elements for the traffic network (i.e., links and nodes), events disrupting the network (i.e., events, incidents, and notification alarms), traffic control devices (e.g., signals, detectors, ramp meters), and information gathering or dissemination devices (i.e., ESS, DMS, Closed-Circuit TV, Highway Advisory Radio). The TMDD and Message Sets for External TMC Communication (MS/ETMCC) standards are used together to provide interoperability. The MS/ETMCC combines TMDD data elements into messages for transmission between management centers. Version 1 of the MS/ETMCC standard contains six message groups: roadway network, network state, network events, traffic request, traffic device status, and traffic control. The MS/ETMCC has been implemented by the Texas DOT and in

over 30 centers in New York, New Jersey and Connecticut as part of TRANSCOM, a coalition of transportation and public safety agencies.

Version 1 of the TMDD standard and Version 2 of the MS/ETMCC standard were published in 2003. The SDOs are currently developing a new version that will combine the TMDD and MS/ETMCC into one standard. The new version will provide a concept of operations, functional requirements, dialogs, and traceability to updated messages and data elements. The TMDD and MS/ETMCC standards are being coordinated with similar ATIS standards to make effective use of data collected for other applications and to provide uniform interpretation across ITS deployments.

SAE J2354 – Message Sets for Advanced Traveler Information Systems: The Message Sets for Advanced Traveler Information Systems standard provides traveler information messages, including road condition messages, in both Abstract Syntax Notation 1 (ASN.1) and eXtensible Mark-up Language (XML) formats. SAE J2354 was originally published in 1999 and revised in 2004. It can be used to support data dissemination to the public via ATIS, such as agency web sites and 511—the national traveler information telephone number. The SAE J2354 standard includes weather information, either by road segment or by larger geographic area, as transmitted to Information Service Provider centers. Maintenance managers can use the standard to disseminate road weather information (e.g., hazardous winter road conditions) to the public via this type of center. The City of San Francisco and the Gary-Chicago-Milwaukee Corridor have deployed the SAE J2354 standard.

The MS/ETMCC and SAE J2354 standards have been harmonized and therefore have overlapping content with regards to traveler information. Managers should select one of the standards based upon specific operational needs. The MS/ETMCC standard is designed for information exchange between centers, while the SAE J2354 standard is intended primarily for disseminating traveler information to end users, usually via an Information Service Provider.

NTCIP 1301 – Weather Report Message Set for Environmental Sensor Stations: Another standard that is being considered, but is not yet developed, is the Weather Report Message Set for Environmental Sensor Stations. If deemed necessary, this standard will define message sets for exchange of environmental data between centers. Currently, the operational concept for NTCIP 1301 is being compared to functions in the MS/ETMCC to determine if there is a need for a separate standard solely for weather-related messages.

NTCIP Center-to-Center Standards: These are a family of lower level protocol profile standards that specify how data will be transmitted (e.g., dial-up telephone lines, fiber optic cables) between centers. These protocols are common across all center-to-center interfaces, apply to a wide range of communications requirements, and are implemented in various combinations based upon user needs. Some of these standards are mutually exclusive. All of the standards in the group would not be deployed in a particular system. Appropriate standards are selected based on the communication media. Details on the Center-to-Field Standards Group can be found at <http://itsarch.iteris.com/itsarch/html/standard/ntcip2c.htm>.

## Center-to-Vehicle Standards

In the future, center-to-vehicle standards will allow maintenance managers to monitor mobile environmental sensors and track the location and operational status (e.g., plow up/down, chemical application rate) of maintenance vehicles that use different technologies. These standards will allow managers to communicate with a single vehicle, a group of vehicles, or all vehicles, independent of the brand of equipment installed, as they travel along their designated routes.

Architecture flows between the Maintenance and Construction Management center and Maintenance and Construction Vehicles would be covered by center-to-vehicle standards. These architecture flows, which are candidates for future standardization, include:

- maintenance and construction dispatch information
- maintenance and construction vehicle location data
- maintenance and construction vehicle operational data
- environmental probe data



## **ITS STANDARDS RESOURCES**

Deploying standards can seem overwhelming at first. For this reason, a host of resources have been developed to assist maintenance personnel in implementing ESS and other ITS standards. As a start, the FHWA Road Weather Management Program created a brochure that describes communications standards, siting standards, and calibration standards for RWIS applications. This resource can be accessed on the program web site at [www.ops.fhwa.dot.gov/weather/Publications/RWIS\\_brochure.pdf](http://www.ops.fhwa.dot.gov/weather/Publications/RWIS_brochure.pdf). Many other resources provide more detailed assistance, as described below.

An ITS Standards Advisory on ESS highlights standards development, testing, and deployment activities. It also includes guidance on working with ESS vendors, information on the ESS Working Group, and a table of Standards Applicable to ESS Deployments. The advisory is available at [www.standards.its.dot.gov/Documents/ess\\_advisory.pdf](http://www.standards.its.dot.gov/Documents/ess_advisory.pdf).

An ESS Specification Guide is currently under development by the FHWA Joint Program Office to assist deployers with procurement of NTCIP-conformant ESS and RWIS. Specifications for RWIS that reference NTCIP standards can be found on the Aurora Program web site, [www.aurora-program.org/matrix.cfm](http://www.aurora-program.org/matrix.cfm).

The NTCIP Specification Guide (i.e., NTCIP 9001v03.02) was accepted as a recommended information report in October 2002. The guide is organized into 10 chapters including an “Executive Summary” for decision makers, “Understanding NTCIP” for system planners, “Procuring NTCIP” for specification writers, “Designing NTCIP” for communications engineers, and “Implementing NTCIP” for hardware and software developers and system

integrators. The other chapters discuss applications for center-to-field and center-to-center communications, as well as other issues such as intellectual property rights, legacy and system migration issues, testing and conformity, and configuration management. A copy of the guide can be downloaded from [www.ntcip.org/library/guide.asp](http://www.ntcip.org/library/guide.asp).

### **Training and Software**

Training and support tools are available for transportation agencies that are planning, deploying, or upgrading ITS. The National ITS Architecture Team (i.e., Iteris, Inc. and Lockheed Martin) created Turbo Architecture, an interactive software tool to help system designers identify the data flows and associated standards needed to achieve desired functionality. For more information on Turbo Architecture, visit <http://www-mctrans.ce.ufl.edu/> and select “Featured Software.”

The NTCIP SpecWizard software can assist with creation of NTCIP-compatible procurement specifications by eliminating vague and indistinct language. Currently, the SpecWizard specification tool guides users through a series of questions to select those data objects needed to support a particular implementation. SpecWizard currently contains modules for ESS, DMS, and signal controllers. In the near future, it is anticipated that the SpecWizard software will be updated to support procurement based on user needs and requirements for additional modules. The software can be obtained by visiting [www-mctrans.ce.ufl.edu/featured/SpecWizard/](http://www-mctrans.ce.ufl.edu/featured/SpecWizard/) or by calling McTrans at 800-226-1013.

Transportation agencies can also receive guidance through the Integrating NTCIP Compliant Hardware (INCH) Project that teaches managers how to specify, purchase, deploy, and test NTCIP-conformant hardware. Information on the INCH Project can be found online at [www.enterprise.prog.org/inch3.htm](http://www.enterprise.prog.org/inch3.htm).

### **Technical Assistance**

The ITS Standards Field Support Team ([www.its-standards.net/Documents/FSTflyer.pdf](http://www.its-standards.net/Documents/FSTflyer.pdf)) provides intensive consultation to aid state and local transportation agencies with a wide range of issues including system assessment, specification development, contract advice and review, test plan design, compliance evaluation, and other technical issues. Through the ITS Peer-to-Peer Program, deployers also can request assistance from peers, in the public and private sectors, who have successfully overcome the challenges of designing and implementing various types of Intelligent Transportation Systems. Peer-to-Peer Program information can be obtained by calling 1-888-700-PEER or visiting [www.its.dot.gov/peer/peer-t.htm](http://www.its.dot.gov/peer/peer-t.htm).

## **CONCLUSION**

Over 80 ITS standards have been developed by SDOs for use by transportation agencies that deploy and integrate various technologies to create interoperable management systems. ITS standards are organized in the framework of the National ITS Architecture, which groups

subsystems into four categories: centers, field, vehicles, and travelers. Architecture flows denote areas where ITS standards are required to achieve interoperability.

Three types of architecture flows are important to the maintenance community: center-to-field, center-to-center, and center-to-vehicle. Center-to-field architecture flows between a garage and a roadside device (or more broadly described as between Maintenance and Construction Management centers and Roadway subsystems) are critical for monitoring data from ESS, controlling anti-icing systems, and distributing road weather information to travelers. Four center-to-field standards that are associated with these flows were identified and described.

Architecture flows between Maintenance and Construction Management centers and other centers, such as Traffic Management and Information Service Providers, are used to share road weather data and maintenance fleet status information. Center-to-center standards allow transportation managers to interface and coordinate operational responses to inclement weather and other conditions. Five center-to-center standards relevant for maintenance activities were highlighted. In the future, emerging communications standards will support center-to-vehicle applications.

Numerous resources are available to assist maintenance personnel with implementation of ITS standards. Documents, training courses, software and other technical assistance can be used to guide state DOTs as they deploy and integrate ITS components. Using ITS standards in RWIS applications will ultimately support a nationwide road weather observing system that will benefit local, state, and regional transportation agencies, and the traveling public.

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