An Information Report by the
TMDD Steering Committee of

ITE and AASHTO

Version 1.0

TMDD & MS/ETMCC Guide

Standard for Functional Level
Traffic Management Data Dictionary (TMDD) and Message Sets
for External Traffic Management Center Communications

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- I-95 Corridor Coalition, New York State DOT
- Oregon DOT
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- Institute of Transportation Engineers

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ABSTRACT

Motivations Behind the Standards: Many of the initial efforts at deploying Intelligent Transportation Systems have traditionally used unique or proprietary definitions of transportation data to build specific applications to meet their immediate implementation needs. However, data described in such unique or proprietary ways, and messages between systems constructed using non-standardized data have in the past resulted in the following undesirable situations:

- Complicated system expansion with inclusion of desirable new features and functions,
- Restricted ability for different components and subsystems within an implementation to work together or to readily accept upgrades due to a "closed architecture", and
- Lessened ability to share data and/or exchange information among organizations and/or jurisdictions.

Addressing this lack of "interoperability" has been one of the driving motivations for establishing standards such as those discussed in this Guide.

Why the Standards are Needed: The Traffic Management Data Dictionary and Message Sets for External Traffic Management Center Communications Standards work together to provide a high level of interoperability among regional and local systems/centers. These Standards will:

- Help traffic agencies and emergency management agencies to more easily and clearly communicate during incident conditions, working to improve safety,
- Improve the potential of having effective traveler information systems with data and information that travelers want to know, and
- Enable public agencies and private companies to reduce system deployment costs and project delays while providing more effective public service and customer benefits.

What are the Standards and How They Work: The Traffic Management Data Dictionary Standard provides consistent names, definitions, and concepts similar to spelling and parts of speech to the word-like "data elements" in the Standard. The Traffic Management Data Dictionary enables concepts from traffic management to be defined and used in the same way by different systems and centers. However, the Standard also anticipates and provides for the use of locally unique data elements to recognize the individuality of each system or center. The Message Sets for External Traffic Management Center Communications Standard uses these data elements by combining them together in a sentence-like way in the sharing of data or pre-defined typical messages between systems or centers. That Standard also anticipates that every center will have their own unique messages they want to send and receive.

Relationship to other Standards Efforts and Lessons Learned: These two Standards provide a framework for interoperability that is consistent with the National ITS Architecture and work in conjunction with other standards, such as the Standard for Data Dictionaries. There are also complementary standards for other functional areas associated with Intelligent Transportation Systems, such as a similar data dictionary for Traveler Information Systems. There is a need to have a clear plan for migrating from current systems to those that are being planned, designed, and implemented to be in conformance with these two Standards.

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TMDD & MS/ETMCC Guide

1 FOREWORD

The Standards for Functional Level (Advanced) Traffic Management (System) Data Dictionary (TMDD) and for Message Sets for External Traffic Management Center Communication (MS/ETMCC) are receiving increasing attention as agencies seek to deploy elements of the National Intelligent Transportation System (ITS) Architecture. For ease of communication, this Guide refers to them separately as the TMDD Standard or MS/ETMCC Standard, and together as the TMDD & MS/ETMCC Standards or the "Traffic Management Information Standards".

The transportation community has long needed an ability to effectively, efficiently, and unambiguously exchange information electronically among:

- Traffic Management Centers (TMCs),
- Emergency Services Agencies and Centers,
- Information Service Providers and the traveling public, and
- Other transportation service providers such as transit agencies or airports

This transportation community consists of public agencies, private companies, and travelers each having general roles. Traffic Management Centers and systems are usually owned and operated by public sector agencies. Organizations that supply hardware, software, and/or system integration services to such centers and systems, as well as many users of information from them, are most often private sector companies. Individual travelers, business, and governmental agencies own the private vehicles and vehicle fleets that use the publicly owned and operated transportation facilities.

It is expected that the Traffic Management Information Standards will be widely embraced and specified in the deployment of new and upgraded ITS deployments. That will directly facilitate exchanges of data and information among these many involved and diverse public and private sector organizations and indirectly with individual travelers and shippers.

1.1 Purpose of the TMDD & MS/ETMCC Guide

The prime purpose of this Guide is to assist decision makers and practitioners to generally understand the nature, role, and benefits of using the Traffic Management Information Standards. To do that the Guide has the following five specific purposes:

- Provide a general awareness to decision makers and managers about the TMDD & MS/ETMCC Standards and serve as a basis for technology transfer and training,
- Improve understanding to support better resource allocation decision-making,
- Help identify requirements for new systems,

- Give a context to system design, and
- Develop insight for system implementation and operation.

This Guide provides general information and a context to the use of the TMMD & MS/ETMCC Standards. It is not a "how to" guide, or "users manual" style guide. These five specific purposes are reflected in the organization of the Guide, as discussed in the next subsection.

1.2 Organization of this TMDD & MS/ETMCC Guide

This Guide is being addressed to several audiences at the same time, where each audience is presumed to have a somewhat different set of interests and underlying knowledge base. However, it is recognized that the interests and knowledge base of any individual reader may differ from that of any one of the presumed audiences. Thus, while the Guide is organized and oriented primarily according to the intended audiences, there is also the expectation that each reader will delve into each Section of the Guide for their individual purposes. At different times, an individual reader may be more interested in one section of this Guide than another. The orientation of each Section named below is as follows:

> ***Abstract; Foreword; and Overview of the TMDD & MS/ETMCC Standards:*** Each of these Sections are intended principally for decision makers and managers such as a City Traffic Engineer or a Traffic Operations Engineer in charge of a regional or district office of a State transportation department as well as the staff that serve them. In particular, the Abstract for Decision Makers and Managers and the Overview to the TMDD & MS/ETMCC Standards Sections provide a quick synopsis of the Standards, motivations behind their use, the need for the Standards, as well as some of their key features. They also include a discussion of the relationship to other standards. Those sections also tend to have a broader, more statewide or regional emphasis.
>
> ***Understanding the TMDD & MS/ETMCC Standards:*** Section 3 of the Guide is intended principally for traffic and transportation engineers, transportation planners, and TMC managers. In addition, it will help decision makers and other managers better appreciate the importance of the Standards being used as well as some challenges that may be faced by their staff in deploying systems using them. This Section gives a general overview of the issues associated with using the TMDD & MS/ETMCC Standards in various applications. It also is a good starting point for anyone wishing to become better informed on the various concepts and technical aspects associated with using and applying a data dictionary. This section tends to have a regional or more local emphasis.
>
> ***Specifying Traffic Management System Improvements:*** Sections 4 and 7 are intended for writers specifying desired improvements to Traffic Management Systems or Centers using the TMDD Standard and the MS/ETMCC Standard, as well as for software system integrators and maintainers of the systems and centers. In many instances the public agencies needing to use the Standards are contracting out for professional System Engineering services to design and implement applications that rely upon the Standards.

Those two Sections are also intended to help agency or contractor project managers who will be setting directions and/or reviewing activities in developing the architecture for a given system.

The TMDD Standards consist of many data elements organized according to several Annexes. It is important that specification writers have a good grasp of the ways that the Annexes and Data Elements interrelate and would be appropriate for particular applications. Satisfying the user agency specifications in a TMDD deployment requires:

- Careful analysis and articulation of the agency's requirements,
- Careful mapping of the various TMDD & MS/ETMCC options to those requirements, and
- Specifications for services that are written with appropriate understanding of the Standards.

Designing with the TMDD & MS/ETMCC Standards: Sections 5 and 8 are intended for those designing the communications and data exchange elements of transportation systems. Those Sections include discussion on the relationship between the TMDD & MS/ETMCC Standards and application-specific data dictionaries, as well as the need for conformance between them. Those Sections also recognize that design may need to provide for migration alternatives to transition from various legacy systems to systems that are in full conformance. Relationships to the National ITS Architecture also need to be accounted for and considered.

Implementing and Operating with the TMDD & MS/ETMCC Standards: Sections 6 and 9 are intended principally for the various systems implementers and software system maintainers who will rely on the TMDD Standard and the MS/ETMCC Standard. Included are software maintainers who are expected to keep the systems running and work with modifications and updates. Since the TMDD Steering Committee guiding the preparation of this Guide consisted of many individuals involved in actual deployments of the new Standards, these sections are meant to provide the necessary insight often required to achieve successful deployment and operations. In particular, some of the lessons learned and common pitfalls encountered during actual deployments will be discussed, with suggested solutions. A process to update and revise the Standards will also be referenced.

The remainder of the Guide provides ancillary information in the following Sections:

(10) A glossary with a listing of nearly 100 terms, abbreviations, acronyms, and definitions that readers should refer to when they are not sure of the meaning of a word, abbreviation, or acronym used in the Guide,

(11) A bibliography of selected readings,

(12) The process for requesting an update or revision to the Standards,

(13) Selected examples of TMDD & MS/ETMCC Standards implementations, and

1.3 Disclaimers

These Standards will continue to evolve. The Steering Committee has provided a process for updates and revisions, given in Section 12 of this Guide. Thus, in implementing systems, users of the Standards need to be aware of possible changes that may have occurred since publication of the version of the Standards they are using. The Steering Committee anticipates that there would be changes to the Standards, especially during the first few years of implementation.

1.4 Additional Information

For more information about the TMDD & MS/ETMCC Standards, visit the TMDD Web Site at http://www.ite.org.tmdd. In order to obtain a printed summary of TMDD information, contact the TMDD Coordinator at the following address (starting in December 2000).

Standards Coordinator
Institute of Transportation Engineers
1099 14th Street, N.W.
Washington, D.C. 20005-3438

In preparation of the Functional Level TMDD & MS/ETMCC Standards, input of users and other interested parties was sought and evaluated. Additional written inquires, comments, and suggested revisions should be submitted to the TMDD Coordinator, at the above address, in the following form:

Document Name:
Version Number:
Section Number:
Paragraph:

Comment:

Please include your name, address, organization and contact information in your correspondence.

Additional material and procedures regarding requesting updates and revisions are given in Section 12 of this Guide.

In addition, there are a small number of documents associated with the TMDD and MS/ETMCC Standards, which consist of the actual Standards themselves, and this Guide.

2 OVERVIEW OF THE TMDD & MS/ETMCC STANDARDS

This Section of the Guide is intended principally for decision makers and managers such as a City Traffic Engineer or a Traffic Operations Engineer in charge of a regional or district office of a State transportation department, as well as the staff that serve them. This Section provides an overview of the TMDD & MS/ETMCC Standards, motivations behind their use, the need for the Standards, as well as their key features.

2.1 Introduction

Historically, transportation professionals and system integrators have used proprietary or unique definitions of transportation data to build their own applications and implementations. Data described in a proprietary or native fashion and subsequent messages constructed using such proprietary data have (1) restricted interoperability between various systems and (2) lessened the ability to exchange information among organizations and/or jurisdictions. For example, a message constructed using a definition of a roadway "Link Node" by one Traffic Management Center may not coincide with the definition of the same link node used by the Emergency Management Center in the same jurisdiction. In that example, ambiguity would be introduced in the basic message formation due to dissimilar data element definitions of the two agencies hindering interoperability and being contrary to the intent of the National ITS Architecture.

To facilitate the efficient, unambiguous, exchange of information in a manner that delivers desired ITS interoperability the Standards Development Organizations standardized the data elements, messages, and message sets using standards-based formats and templates. It was agreed that a Traffic Management Data Dictionary would contain data elements associated with the functional area of traffic management, from which messages can be constructed. As a result of this agreement, the TMDD Steering Committee was formed and has undertaken the two following related standards development efforts:

- ***Traffic Management Data Dictionary (TMDD):*** This Standard contains common data definitions called, *data elements*, which are used to transfer data between centers, for example roadway speed information being sent to an Information Service Provider. The Standard is organized in four separate sections and provides specific definition of selected data element currently in use and that are frequently needed to construct messages used by the ATMS applications. At present four sections have been developed into the following partitions:

    - Traffic Links and Nodes – the traffic network,
    - Events, Incidents and Notification Alarms – events perturbing the network,
    - Traffic Network, Traffic Signal Control, Traffic Detectors, Vehicle Probes, Ramp Metering, and Traffic Modeling – the traffic control devices, and
    - Closed Circuit Television, Dynamic Message Sign, Environmental Sensor Station, Gate, Highway Advisory Radio, and Parking – advanced information gathering or display devices

- ***Message Sets for External Traffic Management Center Communications (MS/ETMCC):*** This Standard contains common groupings of data organized into message sets for use in exchanging information between centers. It is a parallel standard to the TMDD Standard and focuses on the "traffic management" application messages used traditionally by transportation engineers. These messages are grouped based on the application needs and are organized to provide uniform information and interpretation throughout ITS deployment, both within the native system environment and with the external transportation management centers communications. The MS/ETMCC standard contains six message groups:

    - Roadway-Network,
    - Network-State,
    - Network-Events,
    - Traffic-Requests,
    - Traffic-Device-Status, and
    - Traffic-Control.

  These message sets provide for a near real-time data exchange between traffic management centers/ subsystems and the following types of transportation centers/ subsystems:

    - Information Service Providers (ISPs),
    - Transit Management,
    - Emergency Management,
    - Toll Administration, and
    - Emissions Management.

  Together the standards enable the effective exchange of data and information that are becoming increasingly necessary for system operations and management as recurring congestions levels and the pervasiveness of the effects of major incidents spread over larger areas.

Exhibit 2.1.1 illustrates a simple example of the basic relationships between data elements of the TMDD Standard and the MS/ETMCC Standard. Traffic Management Center 1 is represented by the set of boxes on the left side of Exhibit 2.1.1 while the boxes on the right side of the Exhibit represent Emergency Management Center 2. The TMDD & MS/ETMCC Standards are shown as previously being used by each of the centers in setting-up their internal database systems. Both Standards are indirectly used by Center 1 to send messages to Center 2. Both Standards are also indirectly used by Center 2 to receive and interpret the messages sent from Center 1.

Exhibit 2.1.1 shows that the TMDD Standards by themselves are necessary but not sufficient. The MS/ETMCC Standards are needed for the communication to occur in an interoperable fashion. Just using MS/ETMCC Standard may result in some communication but the content may not be understood at all without the TMDD Standard.

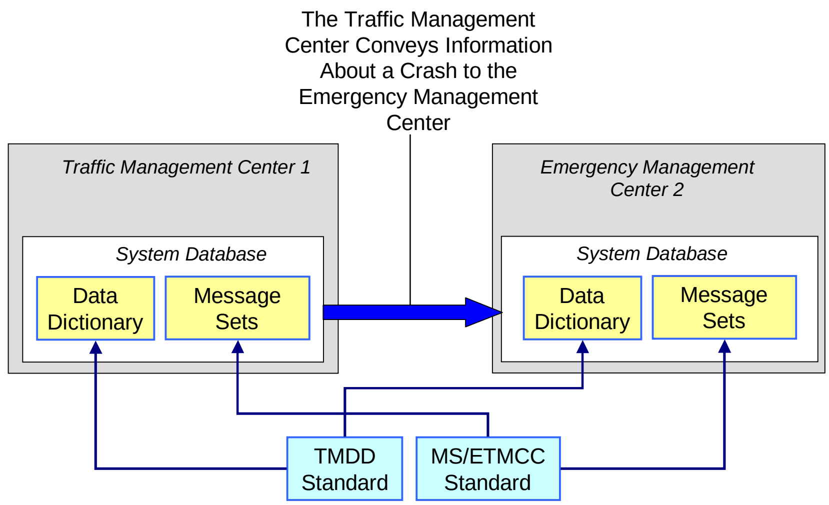


Exhibit 2.1.1: An Example Using Data Elements & Message Sets

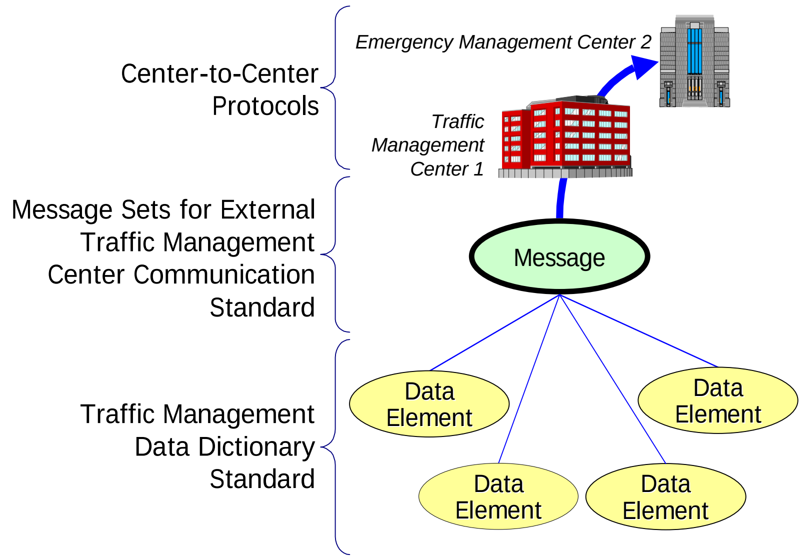


Exhibit 2.1.2: Functional Representation of the Example

Exhibit 2.1.2 shows the example from a functional perspective where a significant incident has just occurred and was detected by field devices of Traffic Management Center 1 who: (1) selects appropriate data elements describing the incident, (2) constructs one or more messages about the incident, and (3) transmits the message(s) to Emergency Management Center 2 using a center-to-center communication protocol. The message(s) then makes Emergency Management Center 2 aware of the incident and the information that Center 1 has about it. Center 2 would then use that information to carry out emergency responses that they deem appropriate.

2.2 What are the Functional Level TMDD & MS/ETMCC Standards?

ITE/AASHTO have jointly approved the following two related standards developed by the TMDD Steering Committee:

- ***TM 1.03, Functional Level Traffic Management Data Dictionary (TMDD)*** Standard is a set of agreed upon definitions and ways of formatting data for use by ITS systems that have the function of traffic management.

- ***TM 2.01, Message Sets for External Traffic Management Center Communications (MS/ETMCC)*** provides consistent ways for electronic communication messages to be exchanged among Traffic Management Centers, Traffic Management Systems, and other users and/or suppliers of traffic-related information.

These two Standards are built upon a data element format or base Standard 1489 issued by the Institute of Electrical and Electronics Engineers (IEEE). The IEEE 1489 Standard is also deployed by other Standards Development Organizations to develop their own standards-based data dictionaries for Intelligent Transportation Systems. For example, the Society of Automotive Engineers (SAE) is developing an Advanced Traveler Information Systems (ATIS) Data Dictionary. Minor revisions for the TMDD Standard are underway to have the TMDD Standard fully conform to the 1999 revisions of the IEEE 1489 Standard.

2.3 Why Do We Need the TMDD & MS/ETMCC Standards?

Transportation professionals increasingly rely on the use of Advanced Traffic Management Systems (ATMS) to carry out their management and operational responsibilities of providing for safe and efficient operation of traffic on the roadway network. Systems implemented using TMDD & MS/ETMCC Standards can facilitate coordination of ATMS functions and provide information exchanges that help in meeting their responsibilities. In particular, the TMDD & MS/ETMCC Standards can help with the following situations:

- **Regional Interoperability of Traffic Management:** It is often said that the end users of transportation, the network-traveler or driver does not care or recognize what agency in a region is responsible for providing smooth and effective traffic management functions – they just want whoever is in charge to make it work well. It is therefore necessary for jurisdictions to coordinate their services across boundaries. For example, two adjacent states can exchange data and traffic information about an Interstate Highway passing through their region in an unambiguous manner because the data elements and message sets used to convey pertinent information are standards-based.

- **Local Interoperability of Traffic Management:** Within many jurisdictions different agencies usually provide various transportation functions and services**.**

Whether it is a traffic control function, transit services, or incident management a state, county, or city transportation agency may have jurisdiction for part of the overall transportation system and they need to coordinate their services for each specific local area. For example, a local City TMC that has jurisdiction for traffic signal control and incident management services may have to quickly convey information about a specific incident on one of their roadways in real-time (1) to a Transit Operation Center regarding bus signal priority control status, as well as (2) to coordinate with the regional TMC operated by the state managing the adjacent freeway. In such a case, the TMDD and MS/ETMCC Standards make local interoperability possible for traffic control, transit management, and freeway management systems.

- **Incident Management:** Many jurisdictions across the country have recognized the benefits resulting from the deployment of the ITS devices to detect, clear and mange incidents on their roadways. They have implemented incident management programs that bring state and local police, fire, Emergency Management Services, and Transportation Operation Center personnel together to coordinate efforts in their jurisdictions. In this instance the Incident Management message sets follow ones developed by the IEEE P1512 Standard, with input from the other public sector participants. That Standard addresses the inter-agency communication needs for emergency management functions organized in terms of messages. The TMDD and MS/ETMCC Standards have been harmonized with those Incident Management Standards.

- **Traveler Information Coordination:** In recent years, travel information systems are being deployed across the country in close coordination with public sector detector and incident data and other real-time data collected by traveler information service providers. Systems and databases deployed by many agencies and organizations must be harmonized using standards-based data descriptions so that travelers receive the information, which is based on the uniform interpretation by all developers and service providers. The TMDD & MS/ETMCC standards are being coordinated with the similar data dictionaries and message sets for Advanced Traveler Information Systems. That will enable the traveler information systems to make more effective use of the data already collected for traffic management purposes.

- **Life-Cycle Cost Considerations:** Use of the TMDD & MS/ETMCC Standards will make it easier, more efficient and effective, for Traffic Engineers, Traffic Operations Engineers, and managers of Traffic Management Centers to carry out their responsibilities. In the short-run, the effort to incorporate these Standards may require some up-front investment. However, over time there will be longer-term cost reductions because data transfer interfaces will not have to be customized. The expectation, from a life-cycle costs perspective, is that early adoption and use of the TMDD and MS/ETMCC Standards will result in less overall costs as well as more effective communications and improved service among Traffic Management Centers.

2.4 How will the Standards be Used in Overall System Implementaion?

Local communities, cities, counties, and states have for decades been making investments in providing traffic control and more recently traffic management and transit management systems. The main purposes behind having such systems are to provide for the safe and efficient management of traffic and transit on arterial and freeway networks. The cumulative investment in such systems can be substantial. However, from time-to-time, wholesale replacement or incremental upgrading of various parts or of the overall traffic management system is needed. This is often necessary for two main reasons:

- Component parts and equipment in the centers can begin to operate less reliably and need to be replaced due to the wear and tear of their constant or heavy use, and

- Other times such hardware and software begin to become functionally obsolete as the rapid pace of improved technologies and more powerful and more cost effective control systems become available.

The decision makers and managers who review and approve such initiatives should also be sure that allowance for the use of the TMDD and MS/ETMCC Standards is included in the needs and requirements for the system upgrade or replacement. The Standards should be appropriately referenced in specifying the traffic management system improvements. The actual process of design should also account for the Standards.

A particular concern to be addressed as part of the implementation process is the need to provide for migration alternatives to transition between various legacy systems and a system that is in full conformance with the Standards. The TMDD Standard provides flexibility for local variations that can help in such transitions or migrations between systems. Such transitions can also be eased by the development of an application-specific data dictionary.

2.5 When are Standard Data Dictionaries and Message Sets Useful?

The discussion above outlined conditions for which the TMDD & MS/ETMCC Standards can be useful in helping to meet the responsibilities of the traffic and operations staff, particularly whenever they need to communicate from one center to another center. Those responsibilities include addressing the repetitive periodic daily, weekly, seasonal, and annual cycles of changing demand and periodic changes in system supply, such as reversible arterial lanes or freeway High Occupancy Vehicle lanes and busways. The TMDD & MS/ETMCC Standards contain many data elements and message sets that are useful in characterizing and communicating information about recurrent congestion conditions.

However, the responsibilities also include the monitoring and management of conditions associated with sporadic incidents and planned non-recurrent special events. Those incidents and events can also affect the demand for and/or supply of transportation, whenever such incidents and events occur. The MS/ETMCC Standard in particular is more oriented towards message sets that can be used in Incident Management. The Standards are also useful in characterizing the nature and effects of the incident so that messages can be communicated clearly, unambiguously, and quickly to groups such as incident management personnel or providers of traveler information. In the management of incidents, quick, effective communication is of paramount importance and can directly lead to the saving of lives, injury reduction, and the lessening of economic losses.

2.6 Who are the Expected Users of the TMDD & MS/ETMCC Standards?

The TMDD & MS/ETMCC Standards should be used by transportation, traffic, operations, and systems engineers who are involved with the development and management of traffic management systems. System software designers and application developers would also be typical users of the Standards.

The Standards can provide a way for staff, consultants, contractors and specialists to better communicate among themselves in the development and operation of traffic management systems. However, many of the actual TMC operating staff might never directly use the TMDD data elements in their daily activities. Rather, they would use an application-specific data element, in which the software translates into the proper functional data element. The range of typical responsibilities carried out by these staff include the following:

- Planning and program budgeting
- Design
- Specification
- Selection and procurement
- Installation, and
- Operation and maintenance of traffic management systems.

There are other direct and/or indirect users of the TMDD & MS/ETMCC Standards. Among them are the many different Public Safety, Police, Emergency Management System and Emergency Medical System groups who respond to incidents. These groups tend not to have standards like the TMDD or MS/ETMCC in operating their Computer Aided Dispatch systems. As such it can be expected that the TMDD & MS/ETMCC Standards may help increase their ability to developed more integrated emergency operations. The designers, developers, and operators of their systems will be increasingly interdependent with the ways in which items such as the location, nature, progress of managing, the effects, and records associated with incidents are defined and communicated. The TMDD & MS/ETMCC Standards can help foster increased interoperability of subsystems among all of the many groups involved with incident response and management.

Another group of indirect users will be the public agencies and private companies involved with various aspects of Advanced Traveler Information Systems. There will be interdependencies with (1) data and information needed in designing and operating such systems and services, and (2) the information they may be producing, such as short-term forecasts of likely future traffic conditions. The latter would be useful information for traffic management centers to have in carrying out their real-time operations and management responsibilities.

2.7 What Lessons have been Learned from the Use of the Standards?

These Standards are recently devised and adopted by the Standards Development Organizations. Very few TMCs have deployed the Standards into their systems. However, several deployments are underway across the country that will utilize these Traffic Management Information Standards. As a result there so far is little experience with implementing and using the TMDD & MS/ETMCC Standards upon which to draw a set of lessons learned. This sub-Section is here mainly as a placeholder that can be expanded in a later version of this Guide.

One lesson being learned from the limited initial experiences is referred to in sub-Section 2.4 above. That concerns the need to provide for a plan or way to migrate and transition between various legacy systems and the system that is being designed in accordance with the Standards. Further discussion about this need is given in Section 5.4 of this Guide.

2.8 Where to go for Further Information or Training on these and Other Standards?

There are several ways in which an interested person can get additional information, and soon training, about these two Standards. These include the following:

- A person can of course first refer to the Standards themselves. There is explanatory material prepared as part of the standards.

- ITE and AASHTO maintain web sites, which contain background information on the two Standards. The web sites can be found by starting respectively at: (www.ite.org) and (www.aashto.org). In addition, staff of the two organizations can be contacted at the addresses given on the cover.

- Both of the sponsoring organizations, in conjunction with other Standards Development Organizations and the United States Department of Transportation (U.S. DOT) are planning a series of training opportunities for these two and other standards, starting in Fall 2000. Please consult either of the two web sites mentioned above or that of the U.S. DOT at (www.its.dot.gov/standard/standard.htm). The address and telephone for the appropriate office in U.S. DOT are as follows:

  Federal Highway Administration
  ITS Joint Program Office, Room 3422, HOIT-1
  400 7th Street, S.W.
  Washington, D.C. 20590

  Phone: 202-366-2180
  Fax: 202-493-2027

3 UNDERSTANDING THE TMDD & MS/ETMCC STANDARDS

3.1 Introduction

This Section of the Guide is intended principally for traffic and transportation engineers, transportation planners, as well as managers of Traffic Management Centers (TMCs). This Section is also directed at helping decision makers better appreciate the importance of the Standards by covering some of the challenges that may be faced by their staffs in planning, designing, implementing, and maintaining systems using the Standards.

This Section presents a general overview of the issues associated with using the TMDD & MS/ETMCC Standards. This should be a good starting point for anyone wishing to become better informed on the various concepts and technical aspects associated with developing a data dictionary and using messages to communicate among systems. Readers can also refer to Section 10, Glossary and Definitions, of this Guide.

3.2 Analogies to Parts of Speech

People who study languages have developed conceptual approaches to distinguish among different aspects of communicating through spoken and written languages. Some of those approaches have analogous concepts in establishing systems and standards for communicating among TMCs. For example, as shown in Exhibit 3.2.1 and reading from the bottom to the top, the data elements of a data dictionary are like words, while message sets, which string together data elements and messages, are like sentences composed of words and phrases.

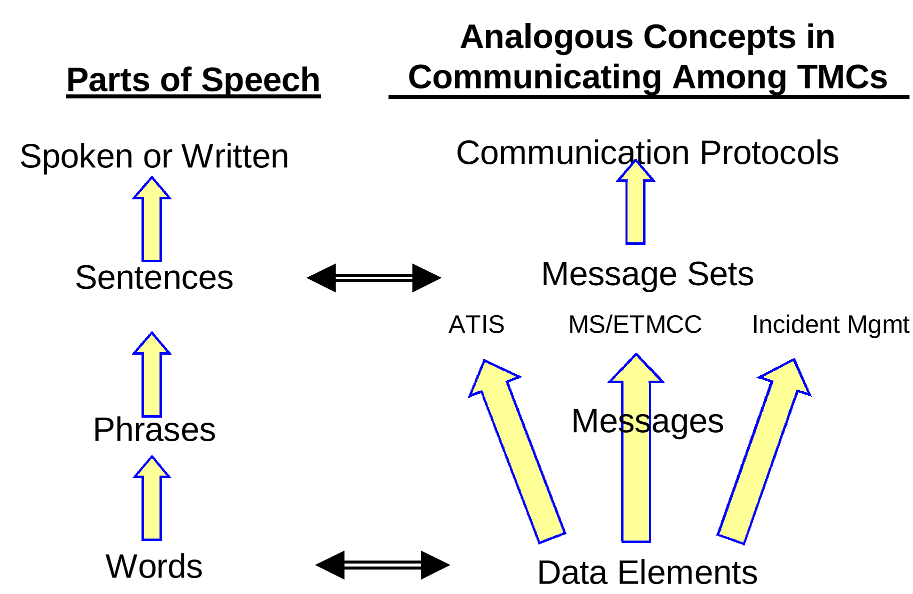


Exhibit 3.2.1: Analogy to Parts of Speech

The analogy to parts of speech is presented in Exhibit 3.2.1 to better illustrate the following concepts associated with the TMDD & MS/ETMCC Standards as well as how they are organized.

Data Elements: Material written about the ITS Standard for Data Dictionaries (IEEE 1489) notes that human communication relies on a vocabulary of words, each defined with a fixed meaning and spelling, and each usually understood the same way by those using the words in communication. Data elements are like a vocabulary of words used in communication among centers.

As defined in the TMDD Standard, a data element is “a syntactically formal definition and representation of:

- Some single unit of information of interest, (such as a fact, proposition, observation etc.), with
- A singular instance value at any point or period in time, about
- Some entity of interest (e.g. a person, place, process, property, object, concept, association, state, event).

A data element is considered indivisible in a certain context.”

Syntax refers to the structure of expressions in a language, and the rules governing the structure of a language.

Exhibit 3.2.2 shows one example of a data element defining a segment of roadway in a larger roadway network. Such segments of roadways are often referred to as links in a network, and where the ends of each link are referred to as nodes. In terms of the TMDD Standard, this data element for a link is referred to as “LINK_identifier_identifier”. This data element is defined as a unique numerical designation for a link within a network. Thus by using this data element, a TMC can uniquely designate each link in the networks they are monitoring or managing. By using the TMDD Standard another TMC would have the same data element name for the links in their networks, although the particular designated value might be different. In that case a table of correspondence between the values would be needed to facilitate the communication.

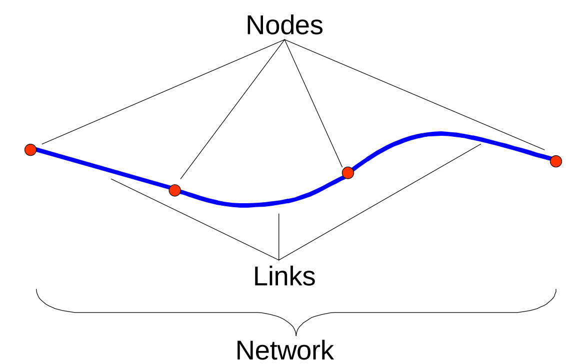


Exhibit 3.2.2: An Example of Links and Nodes in a Network

As noted above, data elements are considered as indivisible, building block "words" of data that are as small as they can get. However, several data elements can be combined to form a message. Communication protocols are then used to transmit messages using a standard such as the DATEX-ASN Standard for center-to-center communication and the National Transportation Communication for ITS Protocol (NTCIP) for center-to-field communication.

Data Dictionaries: Data dictionaries are a necessary component in the design and operation of modern computer based systems. Data dictionaries provide a full set of basic informational definitions upon which communications between systems depend – all the data element "words" that could be used by the system. Specifically, a data dictionary provides the informational definition (semantics) and specific format (syntax) for individual data elements. Each data element in a data dictionary is defined by a consistent set of attributes such as descriptive name, class name, data type, and valid value rules, for example. The full set of attributes for data elements using the TMDD semantics and syntax structure for data elements is given later in Section 4.3 below, in Exhibit 4.3.1.

A data dictionary with unambiguous definitions of the data elements is one of the necessary standards required to exchange messages between ITS Systems. Three different data dictionaries types are defined in the following:

- Functional-area Data Dictionary: This type of data dictionary contains standardizes data element meaning (semantics) and format (syntax) within and among the same ITS related functions, such as Traffic Management or Traveler Information. Thus, the title for this Standard refers to it as the Standard for Functional Level TMDD. A similar, functional-area data dictionary is being developed for Advanced Traveler Information Systems (ATIS) Data Dictionary (SAE J2353).

- Application-specific Data Dictionary: This type of data dictionary contains specific ITS applications, such as a specific local software application of a particular function.

- ITS Data Registry: The data registry is a single repository of all ITS data elements and concepts developed by all of the data dictionaries. It is intended to facilitate unambiguous data interchange and reuse among the ITS functional systems through their specific applications. It could also contain application-specific data elements that are not incorporated in a standard.

Messages and Message Sets: As referred to earlier, messages and message sets are like sentences in languages. Messages are groupings of data elements that include information about how the data elements are combined and used to convey information among ITS centers and systems. A message is "a grouping of data elements and message attributes used to convey information. … a message is an abstract description using a message set template; not a specific instance of transmission." A message set provides a series or set of individual messages (the semantics), and a strict format (the syntax), to handle individual information exchanges on specific topics – "a collection of messages referenced to a specific ITS function."

A key point to emphasize here is that message sets are the means by which one center communicates with another center. The message sets combine data elements from a data dictionary to form standardized messages that are then communicated.

An example of a message and a message set come from the Roadway-Network message group. Such Roadway-Network messages are one-way messages sent from a Traffic Management Center to another center based subsystem. These messages provide the ability to exchange a description of a specific traffic network as defined by a set of links and nodes. The messages can also be used to add or delete links or nodes or change specific characteristics. The Network-Identity message set identifies a specific traffic network by its identification number, name and jurisdiction, and specifies the list of links and nodes composing that network. In this example eight specific TMDD data elements comprise the message set, which include the following and is illustrated in Exhibit 3.2.3.

- Network-Id Number
- Network-Name
- Network-Section Count
- Organization-Contact-Organization Name
- Section-Link Count, and
- Section-Node Count
- Link-Id Number List
- Node-Id Number List

As with data elements, another set of standards is required to provide for the actual data exchange protocols for message sets, many of which are being defined by the NTCIP development process. Those standards describe how the messages and message sets are encoded for transmission and then transmitted and received by various parties.

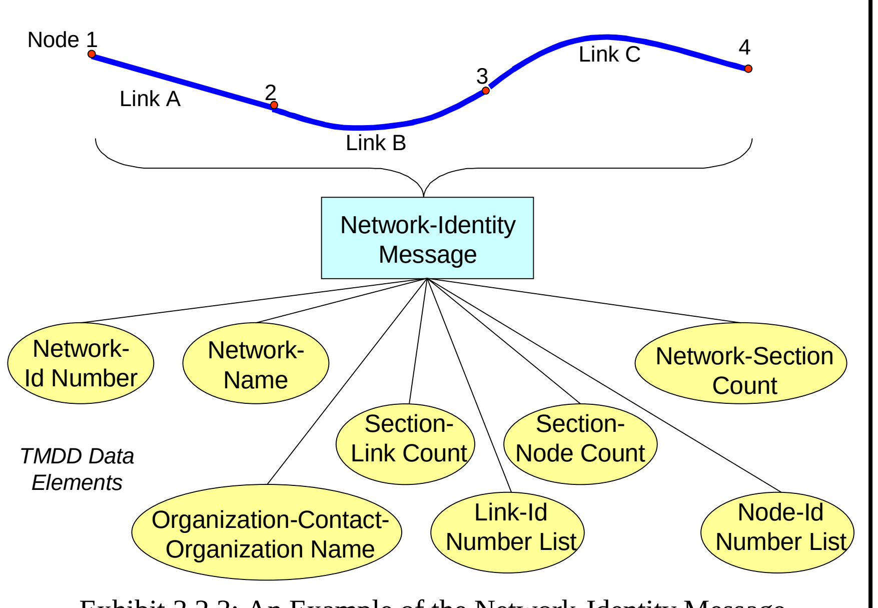


Exhibit 3.2.3: An Example of the Network-Identity Message

3.3 Scope of Data and Message Exchanges Supported by the Standards

The TMDD & MS/ETMMC Standards support a specific range of data flows to and from a traffic management system with those of other centers. The data elements and messages sets are intended to act as the core set that will be used by all ITS-based traffic management systems in exchanging near real-time data with other transportation center based systems.

The intention is for the scope of the data elements and message sets to be broad enough to be used in a wide-area network environment connecting a Traffic Management System with other publicly and privately operated transportation management center based systems. These other systems include managing transit service, transportation related emergencies, traffic related traveler information services, and others.

Working in a near real-time basis to exchange data elements and message sets is an important part of the scope needed to achieve many operational benefits of traffic management systems. The Standards need to recognize that the scope of many of the data elements and message sets being exchanged should facilitate providing data and information about events as soon as practical after they occur. Operators and managers of the traffic management centers need to make decisions at any moment, based upon as current data and information as possible. Those traffic management and control decisions then need to be communicated to other systems, devices, and personnel as soon as practical.

The scope of the TMDD & MS/ETMCC Standards may be augmented in specific applications with additional data elements and message sets. This may be necessary to support additional local functions or conventions not contained in the Standards. The Standards provide flexibility and a means of working with and supporting such local data elements and message sets. The general scope of the data flows that can be supported by these Standards are consistent with the data flows interfacing with a Traffic Management System in the Logical Architecture of the National ITS Architecture. (Reference ITS Architecture, Logical Architecture: Volume 1 – Description, June 1996; DFD 0 and lower layers for *Manage Traffic*)

It is recognized that it would be unlikely that the full scope of all data elements or message sets in the Standards will be used in any particular application. However, the scope of the data elements and message sets in the Standards need to be inclusive and broad enough to capture a wide range of needs nationally.

Returning to the language analogy, no one person is likely to know, let-alone use, all of the words listed in a dictionary. At the same time people know and use words that are different than those used by someone else. Thus, a word dictionary needs to be broad enough in scope to serve the needs of a large and diverse population, who collectively need the full scope of listed words. Such an analogy also applies to the scope of data elements and message sets supported by the Standards.

3.4 Structure and Interrelationships within the Standards Framework

The overall structure of the TMDD Standard is not directly analogous to a word dictionary, which is arranged alphabetically. The data elements of the Functional Level TMDD Standard have first been organized and grouped into 4 Sections and 17 Partitions as shown in Exhibit 3.4.1. Then within each Partition the data elements are listed alphabetically. The partitions are functional topic groupings. The Sections are convenient groupings of partitions, much like volumes and chapters of a book or encyclopedia.

Exhibit 3.4.1: Traffic Management Data Dictionary Sections and Partitions

Sections	Partitions
Section 1	Links Nodes
Section 2	Events Incidents Notification Alarm Organization *
Section 3	Traffic Network Traffic Signal Control Traffic Detectors Vehicle Probes Ramp Meter Traffic Modeling
Section 4	Closed Circuit Television Dynamic Message Sign Environmental Sensor Station Gate Highway Advisory Radio

* There are many data elements in this Section that relate to Organizations

Within each Partition area (i.e., Events of Section 2), a set of data elements necessary to support the exchange of information associated with that topic has been identified and described in the format of the IEEE 1489-1999 Standard.

Eighteen items are provided for each data element to allow for their unambiguous definition and use, which are identified and discussed below in Section 4.3. Data dictionaries are not necessarily complex or esoteric documents but rather can be relatively straightforward descriptions of important data terms. The TMDD Standard does not necessarily seek to identify data terms used only internally within a proprietary system or its database. In addition, it is important to emphasize that a data dictionary in itself does not seek to determine a database design, file structure or any method of internal data storage in a database system.

The message sets are applicable for implementing data flows between traffic management and other management center/subsystems including another traffic management center. The messages can be sent in a one-time request/reply sequence, at a regular updated interval, or in response to an event occurrence.

The MS/ETMCC Standard establishes six message groups, which provide the traffic management centers with the following data exchange functionality:

- **1. Roadway-Network:** provides ability to exchange a description of a specific traffic network as defined by a set of links and nodes. The messages can also be used to add or delete links or nodes or change specific characteristics.

- **2. Network-State:** provides a snapshot of current traffic performance for a specific traffic network. Messages can be used to update a complete network or a subset of links and nodes. Also used for predicted traffic performance; roadway specific environmental (weather and emissions) conditions; current conditions of parking facilities and traffic conditions on current priority routes.

- **3. Network-Events:** provides a description of all traffic related incidents and planned roadway events that are currently active in a specific traffic network. Also provides response plans and specific messages to address the updating of specific incidents or events. This includes a set of Event Report Message (ERM) messages that have been defined to harmonize with the data dictionary being established for Advanced Traveler Information Systems. (Please note that these ERM message sets have been approved by the TMDD Steering Committee and are awaiting balloting and adoption.)

- **4. Traffic-Request:** provides a center with the ability to request to use specific data elements that are contained in the TMDD. These requests are defined for specific categories of traffic information including: roadway network; network performance; traffic events and traffic control device parameters. This group also includes requests for specific types of control transfer.

- **5. Traffic-Device-Status:** provides a center with the ability to send traffic control device data after receiving a request for status. This message group implements a read-only capability.

- **6. Traffic-Control:** This message group provides a center with the ability to affect remote control over traffic control devices that are functionally controlled locally at another center. This message group implements a write capability for device specific control.

Exhibit 3.4.2 lists nineteen categories of message sets that are grouped by the six message groups. These are collections of message sets that address data communication for a single category of Traffic Management System functional application. Within each message set the individual messages are also given alphabetically, which is similar to the listing of TMDD data elements.

Exhibit 3.4.2: Message Groups and Sets for External TMC Communication

Message Group	Message Sets
1. Roadway-Network	1.1 – Roadway-Network-Description 1.2 - Roadway-Network Update
2 - Network-State	2.1 - Current-Network-State 2.2 - Predicted-Network-State 2.3 - Roadway-Network-Environment 2.4 - Current-Priority-Routes 2.5 - Current-Parking-State
3 - Network-Events	3.1 - Current-Network-Incidents 3.2 - Planned-Roadway-Events 3.3 - Event-Defined-Response 3.4 - Network-Incident-Update 3.5 - Roadway-Event-Update
4 - Traffic-Request	4.1 - Traffic-Status-Request 4.2 - Traffic-Control-Request 4.3 - Control-Response
5 - Traffic-Device-Status	5.1 - Field-Device-Status 5.2 - Surface-Street-Device-Status
6 - Traffic-Control	6.1 - Field-Device-Control 6.2 - Surface-Street-Control

3.5 Issues and Challenges to be Addressed in Planning to Use the Standards

In planning to use the TMDD & MS/ETMCC Standards it needs to be recognized that the Standards are not self-executing. Users of the Standards should anticipate that in their efforts to apply the Standards they might encounter various issues and challenges. However, such issues and challenges are not seen as limiting. Rather they are aspects that need to be addressed and dealt with at the appropriate time. Among some issues and challenges likely to be encountered are the following:

- **The need to use data dictionaries other than the TMDD:** The data elements included in the TMDD Standard are those most associated with Traffic Management Systems. However for example, if the function of a center also supports Incident Management, Advanced Traveler Information Systems, and Advanced Public Transportation Systems, then the data elements of the TMDD would be necessary but likely not sufficient for the needs of that center. As shown in Exhibit 3.5.1 the planning for that center will need to anticipate using data elements and message sets associated with other data dictionaries, particularly those for the functional-areas of incident management, traveler information, and public transportation.

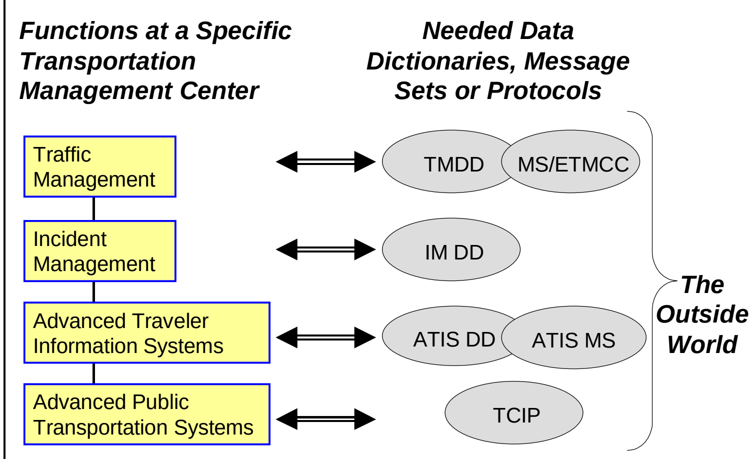


Exhibit 3.5.1: Need for Other Data Dictionaries

- **Aspects of the MS/ETMCC Standard are optional:** In planning to use the Standard, general decisions could be made about use of particular options so that the proper direction can be given to the specification and design processes. Alternatively, the planning should anticipate that as part of the specification and/or design process that an approach will be needed to address which options to use.

- **The need for using particular messages and message sets should drive which data elements are used:** The planning for an ITS application should recognize that the TMDD and MS/ETMCC Standards are a means to an end and not an end in themselves. The planning and visioning needs to select what functions, applications, and architectures would meet overall needs and requirements. That in turn should guide what types of messages and message sets will need to be communicated. Then, the appropriate data dictionaries with the needed data element "words" can be selected. Thus, which data elements are used will be driven by which particular messages and message sets are needed for communication among centers.

- **The number of data elements needed depend upon what ITS function are planned:** If the Traffic Management System of a center is planned to be a limited application, such as only sharing traffic related data with other centers, then an application-specific data dictionary for that center may only need to use a very limited number of the data elements from the TMDD Standard. Conversely, if a number of functions are planned, then the application-specific data dictionary may use many if not all of the data elements in the TMDD Standard. If broad or comprehensive sets of functions are planned for a center, then as noted above, there may be a need to rely on data dictionaries other than the TMDD.

- **The TMDD does not predetermine database structure:** The TMDD & MS/ETMCC Standards do not address or control how necessary databases within a center are designed and structured. Thus in planning to use the Standards, a separate effort to accomplish database design needs to be anticipated. However, it is noted that the standards associated with DATEX and CORBA do have requirements that structure databases and thus need to be anticipated in planning for the overall database design associated with the operations of a center. The discussion in the next section provides some additional information about how the TMDD & MS/ETMCC Standards interface with the two standardized communication protocols of DATEX-ASN and CORBA.

- **Concepts for Open, Interoperable Interfaces:** There is no universal definition of “interoperability”. Interoperability must be defined around specific functions that different systems agree must be performed in a cooperative manner. These agreements must focus on specific system interfaces. Interoperability requires both the technical aspects described below as well as institutional agreements and processes. In planning to use the Standards, a common understanding of ways to achieve open, interoperable interfaces is an issue for consideration. An evolving concept is that communications between ITS systems can be seen as requiring four levels of standardization to achieve interoperability, as illustrated by the interoperability pyramid given in Exhibit 3.5.2.

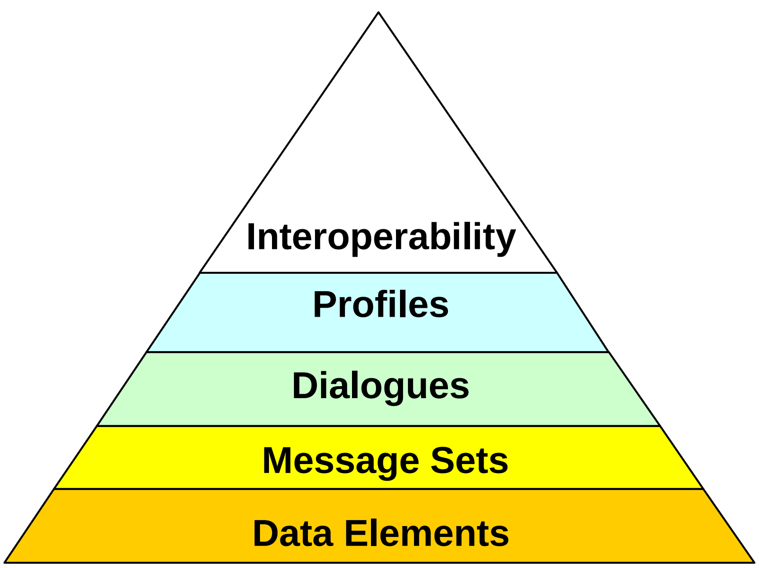


Exhibit 3.5.2: Interoperability Pyramid Requires Use of the Same Set of Definitions and Rules

All four levels are needed to actually achieve interoperability; standardizing only the lowest or base level is necessary, but not sufficient. In order for information to be exchanged in an implementation and for systems to actually work together and exchange information effectively, all four levels have to be defined, agreed upon, and standardized. Principles or rules of interoperability associated with these four levels of standardization need to be addressed beyond this standard. These principles or rules are, from the highest level at the top of the pyramid to the lowest level at the base, described by the following:

- **Profiles:** All systems must use the same protocols and protocol options (rules)
- **Dialogues:** All systems must agree upon and use the same set of sequences of messages for supported functions
- **Message Sets:** All systems must use the same set of messages (for both request and response messages) for supported functions
- **Data Elements and Objects:** All systems must use the same data elements and object definitions for supported system functions

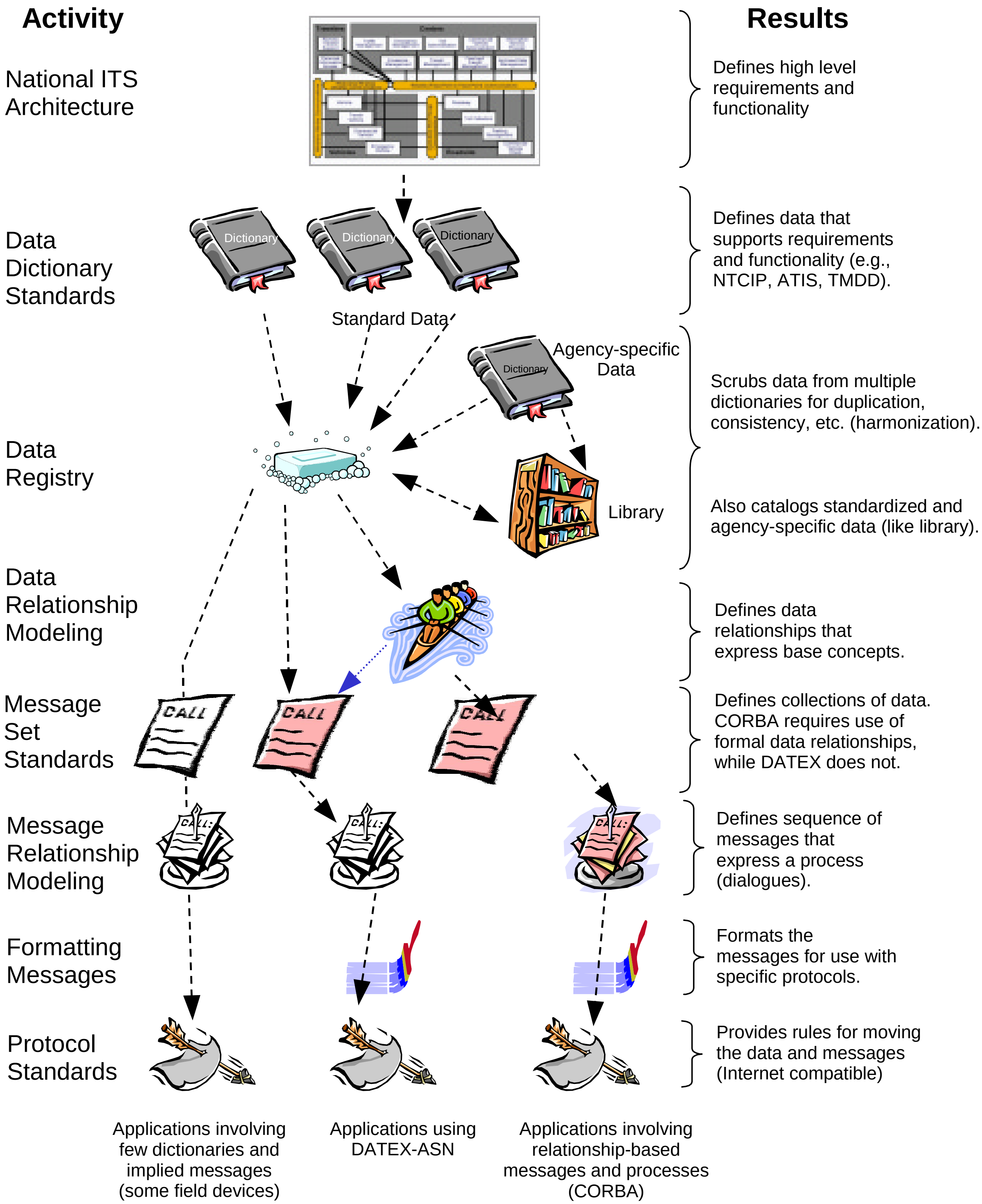
The ITS program has mostly focused on standardizing at the lower levels of the pyramid, data elements and message sets. The profiles level is largely addressed by existing information technology standards. However, since each of the four levels needs to be standardized for two systems to communicate, this tends to leave standardization of the dialogue level to proprietary specifications and pieced-together, one-time solutions. With a goal of implementing open systems, interoperability of an open system implies that all four levels of standardization should be based on open standards and not just open systems. When all definitions are open and standardized implementers for both requester and provider systems will know the syntax of the message requested, as well as the communication sequence required.

3.6 Relationship to the National ITS Architecture and other Standards

Exhibit 3.6.1 is an overview diagram related to the Standards Development Process that also shows relationships to the National ITS Architecture and other standards. The Exhibit depicts activities associated with the overall process, which are listed as the text in the left side of the Exhibit. The middle part of the Exhibit gives graphics that show the generally linear relationship among the several rows of activities identified in the left side of the Exhibit. The general results of each row of activity are given in the text in right side of the Exhibit in each row.

It is important to point out that in reading this diagram that the general top-to-bottom directions shown by the arrows are simplifications of what happens in reality. There are many iterative processes and feedback loops that are not shown in Exhibit 3.6.1 in order to reduce the complexity of the diagram.

The following discussion elaborates on some of the specific relationships associated with these various rows of activities identified in the left side of Exhibit 3.6.1, in the top-to-bottom order given there.



Source: Edward J. Seymour, Texas Transportation Institute

Exhibit 3.6.1 Standards Development Process Activities and Results

National ITS Architecture: One of the main reasons for developing the National ITS Architecture is to define ITS subsystems and help identify their interfaces to allow standards development organizations to standardize those interfaces. This is an initial step in the broader goal of deploying the National ITS Architecture, thereby providing ITS services and functions. The general scope of the message sets that can be supported by the MS/ETMCC Standards are consistent with the information exchange represented in the National ITS Architecture.

Data Dictionary Standards and Coordination: The National ITS Architecture can be a very complex subject and to date about 82 standards have been or are still being prepared as component parts of the overall development of the Architecture. Nearly a quarter of those standards efforts are data dictionaries, of which the TMDD Standard is only one. The high-level data dictionary did not define many of the particulars covered in the TMDD Standard, such as data type, specific names, valid values, etc.; that was left to individual standard developments. It is also noted that the Standards Development Organizations are working cooperatively with the U.S. DOT to monitor, track, help develop, and test the effectiveness of the standards.

As a general indication of relationships to other standards, and as noted in the TMDD Standard (Section on Development History), coordination with related standards development was closely maintained during the TMDD & MS/ETMCC development processes. Coordination mechanisms included regular participation in quarterly ITS America Council of Standards Organizations meetings plus specific involvement in selected standards activities that were deemed to be highly relevant to the TMDD and MS/ETMCC development. Specific examples included the following:

- IEEE Data Dictionary Format and Message Set Templates,
- SAE ATIS Data Dictionary and Message Sets,
- Transit Communications Interface Profiles (TCIP),
- National Transportation Communications for ITS Protocol (NTCIP), and
- IEEE Emergency Management Systems and Incident Management Message Set.

Joint formal coordination meetings with the associated steering committees were held in July and September 1997, April 1998, as well as in May and August 2000, the latter being with the SAE ATIS Standards Committee. Additional liaison and coordination was maintained by providing draft TMDD data element listings for inclusion in a national working data element database to support ITS data element development coordination, as well as in the ITS Data Registry.

ITS Data Registry: The ITS Data Registry, referred to in Exhibit 3.6.1 above, is a centralized data dictionary or repository for all ITS data elements and other data concepts that have been formally specified and established for use with the national ITS domain. It is intended to serve as a common or shared data reference for the national ITS domain. The primary objective of the ITS Data Registry is to support the unambiguous interchange and reuse of data and data concepts among functional-areas of ITS by recording unambiguous definitions of data concepts. It also provides a forum for harmonization of new data elements and messages.

Data Relationship Modeling: Data relationship modeling, referred to in Exhibit 3.6.1 above, defines data relationships that express base concepts. In particular it begins to establish logical connections between and among various individual data elements. Such relationship modeling begins to line-up individual data elements so that they figuratively are pulling together to express broader concepts, and start leading to the identification of messages and message sets.

Message Set Standards and Modeling: Message Set Standards, referred to in Exhibit 3.6.1, define collections of data elements that need to be transmitted in pre-defined and accepted patterns in order for effective communication to occur. The Message Relationship Modeling defines sequences of messages that express a process – in essence a dialogue between systems. Some modeling requires the use of formal data relationships, particularly the protocol of Common Object Request Broker Architecture (CORBA), while that of Data Exchange (DATEX) does not.

Formatting Messages and Protocol Standards: This part of the process formats the messages for use with specific protocols, such as CORBA or DATEX. The Protocol Standards provide rules for moving the data elements and message around such as by being Internet compatible.

Exhibit 3.6.2 below focuses back on the overall topic of the relationship of the TMDD & MS/ETMCC Standards to the National ITS Architecture and to other standards associated with the Architecture. The series of text boxes in the right hand column of Exhibit 3.6.2 shows how several selected standards relate to different parts of the National ITS Architecture. It specifically shows that the TMDD & MS/ETMCC Standards are clearly linked to the Traffic Management Subsystem within the Center Subsystems part of the Architecture.

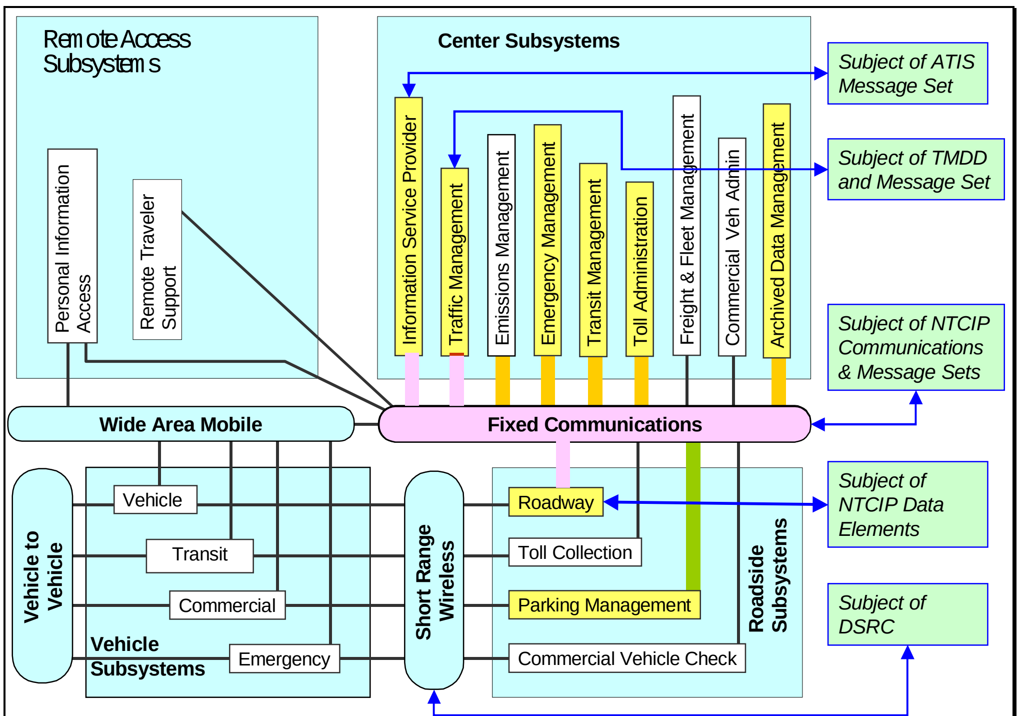


Exhibit 3.6.2: Relationship of the Architecture to Selected Standards

3.7 Benefits of Using the TMDD & MS/ETMCC Standards

To some extent the benefits of using the TMDD & MS/ETMCC Standards were covered in the discussion and responses given above in Section 2.3 of this Guide. Responses found in this section reflect more of the direct benefits to management and operations. This discussion focuses on some additional operational benefits as well as broader and secondary benefits to other activities:

- **Sharing control of field devices and coordination of information using center-to-center communications:** The TMDD & MS/ETMCC Standards can make it much easier and more feasible for adjacent jurisdictions to share control of field devices and coordinate information resulting in more efficient and cost effective operations. For example, as shown in Exhibit 3.7.1 by using TMDD based data elements and message sets based on the MS/ETMCC Standard a TOC of a county can request to coordinate information that a TMC of a state DOT is displaying on some of their Dynamic Message Signs (DMSs). A sequence of messages would be communicated back and forth to carry out such a coordination of information activity. A different set of messages and agreed to in advance procedures could enable one or the other of the TMC or TOC to share control of the others DMS field devices under appropriate circumstances. Without such Standards, the near instantaneous sharing of information and control of devices between and among centers can be very difficult, costly, and nearly impossible.

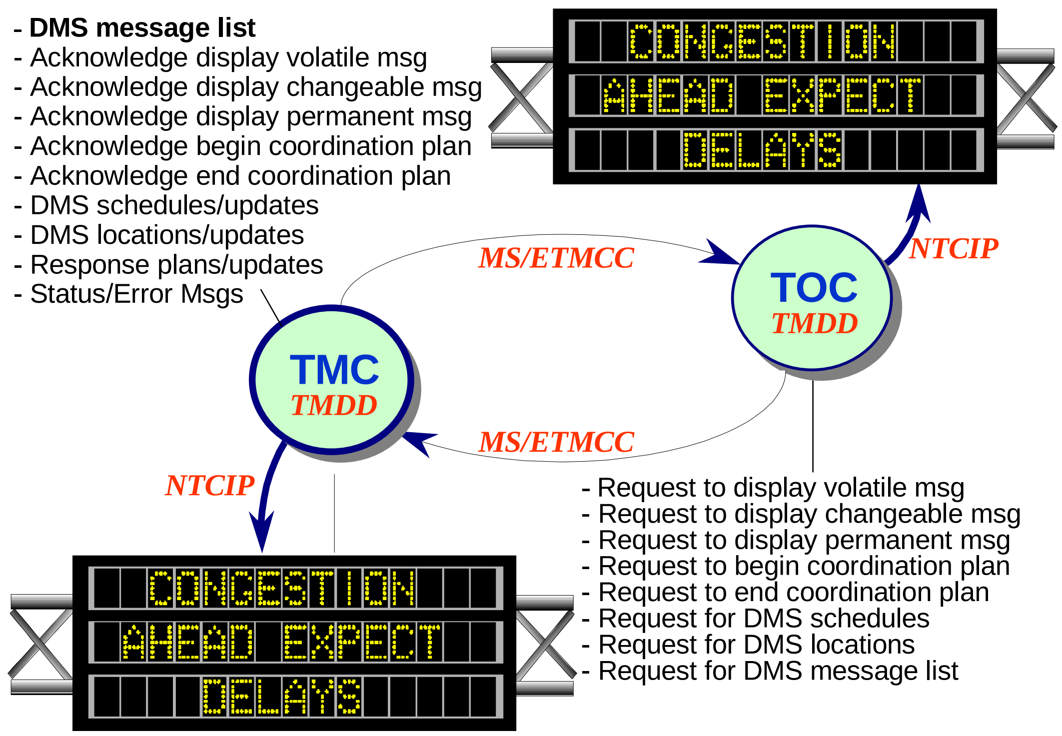


Exhibit 3.7.1: Coordination of Center-to-Center Communications

- **Facilitates phased investment and implementation:** The TMDD & MS/ETMCC Standards can facilitate the incremental phasing of additional ITS functions within a jurisdiction or among nearby jurisdictions. More "plug and play" ITS implementation functions can be relied on, which might enable funding availability or constraints to be less of an issue to the long-term success of the deployment of an overall program. This could also help in regional coordination, for example by enabling a TMC of one jurisdiction to use for a period of time the Dynamic Message Signs normally controlled of another nearby TMC until the first TMC can deploy their own signs.

- **Fostering of a multiple vendor environment:** The TMDD & MS/ETMCC Standards can reduce an agency's reliance on any specific type of implementation or specific vendor. The Standards will foster a multiple vendor environment as the issue of data definition and/or data communications does not predispose a single vendor solution.

- **Accelerates implementation that can lead to cost savings:** The TMDD & MS/ETMCC Standards can give an agency a head start in the design and shorten the time frame needed to implement appropriate features due to a lesser need for customized solutions. Given that "time is money", such items that accelerates implementation can result in both short-term and long-term cost savings. Having ITS systems up and running sooner than later also results in overall societal benefits from the investment in ITS user services being available sooner than they otherwise would be.

- **Monitoring traffic and travel and facilitating data archiving for use in transportation system performance measurement:** The TMDD & MS/ETMCC Standards will also make it easier for traffic and travel to be consistently monitored throughout regions, states, and perhaps nationally. That in turn will facilitate the ability to archive quality data on transportation system use and performance in sufficient quantity. The data can also be used by transportation agencies in their own programs for monitoring changes over time in the use and performance of the transportation system, as well as many other applications that can be derived from archived ITS related data.

4 SPECIFYING TRAFFIC MANAGEMENT SYSTEM IMPROVEMENTS USING THE TMDD STANDARD

4.1 Introduction

This and the two following Sections relate primarily to the TMDD Standard, while Sections 7, 8, and 9 relate primarily to the MS/ETMCC Standard.

This Section is intended principally for writers specifying desired improvements to traffic management systems or centers, as well as software system integrators and maintainers. This covers the process of identifying needs and requirements for systems as well as transforming those into requirements contained in request for proposals. In many instances public agencies are contracting out for professional system engineering services to design and implement applications. This Section is also intended to help agency or contractor project managers to develop system architectures for specific systems.

The TMDD Standards consist of many data elements organized according to several sections and partitions. It is important that specification writers have a good grasp of the ways that the sections, partitions and data elements interrelate and would be appropriate for particular applications.

4.2 Translating Systems Needs and Requirements to Specifications

The specifications for traffic management system improvements should begin with a clear understanding of the functional requirements of the system. If the vision for the system is to have it perform function “x” then, what is the data, “y”, which will be needed for the system to perform that function? The beginning point of specifying functional requirements is to understand the needs – what purpose should the system perform; what things are trying to be accomplished; what products or results are desired?

For example, if the purpose of the system improvement is to enable communications between a freeway management system and an arterial control system, then the number of data elements that may be required may not be that numerous. If however, the functionality needed also included device control, ramp metering, incident management, and dynamic message signs, then a much larger and more diverse number of data elements would need to be specified for use.

Thus, satisfying the user agency specifications in a TMDD deployment requires the following:

- Careful analysis and articulation of the agency’s requirements up front,
- Careful mapping of the TMDD Standard against those requirements, and then
- Well-written general specification for services that provides for appropriate use of the TMDD Standard and related concepts.

4.3 Specific Structure and an Example of the Data Element Formats

As noted above in Section 3.4, the overall structure of the TMDD Standard is organized and grouped into 4 sections and 16 partitions, and then within each partition the data elements are ordered alphabetically. The partitions are functional topic groupings, a set of data elements necessary to support the exchange of information associated with that topic. The nature of the entry for each data element is in itself in a structured format -- IEEE 1489-1999-1999. An example of a data element structure for LINK_Identifier_identifier is given next in Exhibit 4.3.1.

Exhibit 4.3.1: Example of the Structure of a Data Element

Traffic Management Data Dictionary Section 1 – Traffic Data Partition Entities: LINK, NODE Version 1.4	**October 30, 1998**
Descriptive Name:	LINK_Identifier_identifier
Descriptive Name Context:	Manage Traffic
Definition:	A unique numerical designation for the Link within the network
Class Name:	Traffic Data
Classification Scheme Name:	IEEE 1489-1999, Annex B
Classification Scheme Version:	19980706, V0.1.0
Keyword:	Link Identity
ASN1 Name:	Link-identifier
Data Type:	IA5 String
Representation Class Term:	Id
Value Domain:	Identifier
Valid Value Rule:	Any set of alphanumeric characters up to 32
Representation Layout:	SIZE (1..32)
Remarks:	V1.3 - Changed Descriptive Name from LINK_Id_number to LINK_Identifier_id. Removed ANSI X3.4 from Value Domain. Changed Data Type to IA5 String.
Data Concept Identifier:	3012
Data Concept Version:	V1.3
Submitter Organization Name:	TMDD
Last Change Date:	19981015

Three major pieces of information are specified to assure an unambiguous name and description of each data element, which are the following:

- Specific entity type (or "thing"), which generally is the name of the partition and is used in the first part of the naming convention. (i.e., "LINK" in this example of LINK_identifer_identifer),
- Specific property of the entity type to be described in the data element and is associated with the second part of the naming convention, and
- Specific and explicit representation class term format and permissible values, which is used in the third part of the naming convention.

Additional administrative information is provided to allow for the unambiguous identification, tracking and retrieval of data elements. These are identified and defined in the discussion in the next sub-Section on meta-data attributes.

4.4 Meta-data Attributes of Individual Data Elements

As noted in the TMDD Standard, information used to describe data elements is called *meta-data* (definition - data that describes other data). A standard set of eighteen meta-data attributes have been selected by the Steering Committee for the description of TMDD data elements. This meta-data set is consistent with the IEEE 1489-1999-1999 and includes all mandatory meta-data attributes, plus selected others prescribed for functional level data dictionaries.

More complete information including a listing, definition and description of all permissible data attributes including mandatory, optional, contingent and indicative data attributes are available in IEEE 1489-1999-1999. The list of these TMDD meta-data attributes and their definition includes the following:

- **Descriptive Name –** A descriptive word or group of words that labels a data concept. (The convention for descriptive names is specified in 1489-1999-1999 Annex A.). The TMDD Standard uses a three part descriptive name.
- **Descriptive Name Context –** Designation of an ITS functional area within which the descriptive name is relevant. (ITS functional areas are derived from the National ITS Architecture and include: Manage Traffic, Manage Transit, Manage Emergency, etc.)
- **Definition –** A statement in natural language text form that expresses the essential meaning of a data concept and assists humans in differentiating the data concept from all other data concepts.
- **Class Name –** The name of a group into which this Data Element can be meaningfully categorized. (Legal values for Class Name are listed in 1489-1999 Annex B.)
- **Classification Scheme Name –** The designator (e.g., the title or number) of a classification scheme that contains the Class Name.
- **Classification Scheme Version –** The version of the classification scheme that contains the class name.
- **Keywords –** Significant words that are useful for search and retrieval or indexing of a data concept.
- **ASN.1 Name –** The name of a Data Element expressed using ASN.1 syntax and naming conventions which is unique within the ITS community.
- **Data Type –** The type of the data for purposes of data interchange. The legal values shall be one of a dozen data types given in the TMDD Standard and whose formal definitions are given in ISO 8825-1:1998.

- **Representation Class Term –** The name of a type of Value Domain specified in 1489-1999 Annex C (used in the third part of the Naming Convention). A Representation Class Term can be represented with abbreviations. Fourteen different Value Domains are used, as given in the TMDD Standard.

- **Value Domain –** A specific and explicit physical representation form for data element or generic property domain values. This meta attribute shall be documented by providing a value domain reference (e.g., ISO 1000) or otherwise specifying the explicit format (e.g., cm). Recommended ITS value domain references are specified in 1489-1999 Annex C.

- **Valid Value Rule –** A natural language text definition of the rules by which permissible legal instances of a data element, generic property domain or value domain are identified within the constraints of applicable representation layout, data type, etc.

- **Representation Layout –** The size of the data field.

- **Remarks –** Comments or other information pertinent to the Data Element. The TMDD Standard sometimes uses this field to describe the Data Element development history.

- **Data Concept Identifier –** An Arabic numeral identifier assigned sequentially without any associated semantics beyond the notion of sequence.

- **Data Concept Version –** A reference to a revision or refinement of a data element that does not change its semantic content, or, if appropriate, its representational from. Note: Versions are normally established to record administrative or other minor, non-semantic/ representational changes to a data element.

- **Submitter Organization Name –** The name of the authority having responsibility for defining and submitting a data element. For the TMDD this is the TMDD Steering Committee.

- **Last Change Date –** The date of the last change to the data element meta-data.

4.5 Adapting the Functional-Area Data Dictionary to an Application-Specific Data Dictionary

The TMDD Standard anticipates that each specific application would have the option of having an application-specific data dictionary included in the specifications and then created for the application. For example, a tourist oriented Advanced Traveler Information System application such as in Branson, Missouri or for Yosemite, California might need to have data elements that are not provided for in the TMDD Standard. Alternatively, they might want to use a code for the "Valid Value Rule" that is tailored to their needs. The "0" and "1" values of the "Valid Value Rule" for many data elements in the TMDD Standard have been set aside to facilitate adding local options or values. This can be anticipated for by specification writers and then provided for in the design of specific applications.

Thus the TMDD Standard anticipates that additional data elements shall be permitted to support system specific functions or variations where the TMDD data elements do not exist. However, if the specifications are calling for the provision of some additional data elements, these system specific data elements should be developed in compliance with IEEE 1489-1999, as have the data elements in the TMDD Standard.

4.6 Additional Guidance for Specification Writers

In Section 4.2 above, this Guide stresses the importance of specification writers basing their proposed specifications on a soundly conceived set of needs and requirements. Additional items for consideration include the process for design of the database that will be used as well as the software platform and protocols for communication that could be specified.

Another approach that can be relied on, if practical, is that of working from a specification set previously developed for some other but similar application that has some similar needs and requirements. Such an approach might be a time saver and cost reducer, but also might have some pitfalls. Such an approach would be more like doing a design, but it should be done in an iterative manner to make sure that the specific needs and requirements for this application are indeed being addressed.

5 DESIGNING WITH THE TMDD STANDARD

5.1 Introduction

This Section is intended principally for those faced with the task of designing the communications and data exchange elements of transportation systems that utilize the TMDD Standard. This Section includes a discussion on the relationship between the TMDD Standard and application specific data dictionaries, as well as the need for conformance between them. This section also recognizes that the designs may need to provide for migration alternatives to transition between various legacy systems and systems that are in full conformance. Relationships to the National ITS Architecture also need to be accounted for here.

5.2 Creating an Application-Specific Data Dictionary using the TMDD

As noted in the previous section, the TMDD Standard anticipates that each specific system would have the option of having an application-specific data dictionary. An application-specific data dictionary is defined as the data dictionary used by a specific and actual installation of an ITS system.

Some perspective is also helpful here on the use of the term application-specific. An overall system might have associated with it several applications that would correspond to functions such as traffic signal management or transit management. Thus it may also be helpful to designers to think and plan their work more broadly in terms of a “project data dictionary”, which may contain several and even many application-specific data dictionaries and databases. If the concept of system life cycle is used to define an “implementation” of an overall project, then the design and development of application-specific data dictionaries and databases for the project can be addressed in a more modular and incremental fashion. That will especially be the case when the design is in conformance with the TMDD Standard.

One means to accomplish an application-specific data dictionary in the design is through the use of the codes for the “Valid Value Rule”, which have been provided in the TMDD Standard for just such a purpose. The “0” and “1” values of the “Valid Value Rule” for many data elements in the TMDD Standard can be used by designers of the databases. For example, the data element LINK_MedianType_code, which has a Data Concept Identifier of 3018, lists the following ten values for the Valid Value Rule:

- 0=Other, no additional information required,
- 1=Other, additional information required,
- 2=Curbed,
- 3=Concrete barrier,
- 4=Concrete barrier with visibility screen,
- 5=Guard rail,
- 6=Open grass,

- 7=Open sand,
- 8=Painted median no access,
- 9=Separate roadways, and
- 10=Unprotected

Through the use of the “other codes” of 0 and 1 in this example, the designer of the application-specific data dictionary and database can anticipate and provide for some unique local conditions in the design of a specific application. For further example, there might be a service, rest area in the median. Several links might be given a value of 1 as an alert in any message or message set using this data element, say for Incident Management activities related to this area, to indicate that additional information is required.

The design would then provide for the appropriate additional information to come in a text format selected by the designer. When this data element for the link in question is used in a message related to an incident, the value of 1 will be a flag to the receivers of the message that additional information is required. They then can send a message back requesting the appropriate additional information, or perhaps the system may have been designed to send it out concurrently in conjunction with the original message. Thus the TMDD Standard anticipates that during the process of database design that additional information may be added to supplement that associated with the Standard data elements.

5.3 Seeking Conformance Between Application-Specific Data Dictionaries and the TMDD

The TMDD Standard has a section on Conformance that makes the following three points about this topic:

- Conformance with this functional level TMDD Standard requires that an application-specific data dictionary shall use the TMDD specified data elements in all cases where they are applicable to the functions supported by the system.

- Conformance with this standard requires that individual data elements contained in the Annexes shall be used as specifically defined and described by the data element’s meta-attributes. No changes are permitted and required variants shall be separately described and established in compliance with IEEE 1489-1999 as additional application specific data elements.

- Additional data elements shall be permitted to support system specific functions or variations where the TMDD data elements do not exist. However, these system specific data elements shall be developed in compliance with IEEE 1489-1999.

Thus, if the specifications for a particular application and installation of an ITS system call for the design of the database and system to be in conformance with the TMDD Standard, then these three points need to be attended to by the designer.

An approach that can be used by designers to help them seek conformance to the TMDD Standard when working with application-specific data elements is to use the data element Descriptive Names of the Standard as the field names in the databases they are creating. If they also use the same Data Type and Representation Class Term, as defined in the meta-attributes of the TMDD Standard, then they can more easily model many of the data elements within the structure of the application-specific data dictionary and the project or application databases.

5.4 Providing Migration Alternatives for Transition Between Legacy Systems and an Application-Specific Data Dictionary

As noted above in Section 2.4, a particular concern to be addressed is the need to provide for migration alternatives to transition between various legacy systems and a system that is in full conformance with the TMDD Standard. The flexibility for local variations that the TMDD Standard provides can help in such transitions or migrations between systems. Such transitions can also be eased by the development of an application-specific data dictionary. There are a few other ways as well to account for this concern in the process of design.

The TMDD data elements and many aspects of their meta-attributes were based upon sample local data dictionaries that were already in use by many different implementations from throughout the country. Therefore, various legacy systems may already have many data elements and meta-attributes in common with the TMDD Standard. Others might have a moderate amount, while others still may have few, very few, or none. If the Descriptive Name for the data element is even at a slight variance in spelling or structure from those of the TMDD Standard, then the designer has the following alternatives to choose from:

- Change the application-specific data dictionary and databases, or
- Provide for a translation program to interrelate the data elements defined by the TMDD Standard with those being used locally.

The choice is a design decision that needs to be made locally and will depend upon many factors such as what degree of correspondence there is already between the TMDD Standard and the current application-specific data dictionary. Another factor that is increasingly coming into play is the desire by several larger states with multiple major metropolitan areas and/or significant rural applications to develop and maintain high degrees of consistency between ITS systems throughout their state.

The choice of a design solution needs to also account for short-term funding availability and long-term cost effectiveness. Many times funding availability and time constraints enable the designer to propose solutions that fit within short-term funding and are cost-effective over the life cycle of the application. However, with rapid changes in technology, increases in computational power, and declining hardware prices it is a challenge to accurately assess what will be the true long-term life cycle costs as well as what is the overall cost effective solution. Thus an approach that can be taken by designers is to provide for phased migration plans that provide for prototypes, conversions, and then final versions that have fully migrated.

5.5 Accounting for Unique Application-Specific Data Elements

The TMDD Standard can be adapted in the process of design of application-specific data dictionaries to account for unique application-specific data elements. Various techniques, such as entity relationship diagrams, can be used to design and model how the TMDD Standard data elements and application-specific data elements can be linked.

An example that illustrates the need to account for unique application-specific data elements is one related to a traffic control function application in New York City. The traffic control system there has some unique features due to the large number of signals, the overall complexity, and some unique hardware components and software. Those unique features were provided at the time to deal with the size and complexity requirements of the system. One such unique aspect is termed “CamChart data”, which describes the internal workings of vintage, electro-mechanical controllers. That term is used and understood by operators and other personnel. The TMDD Partition on Traffic Signal Control (Section 3) has several data elements that deal with timing plans, which is also the general type of data covered by this unique CamChart data. Thus in applying the TMDD Standard to a situation such as this, designers need to devise ways to account for such unique application-specific data elements.

Data flow diagrams from systems engineering are another tool that can be used by designers to account for unique application-specific data elements. If part of the system design anticipates the use of a relational database, then choosing which fields and associated data elements should be the common ones is a design decision that enables the tracking and linking between and among data sets and tables. By using a common data field based upon a data element from the TMDD Standard, such as LINK_Identifier_identifier (3012), or EVENT_Identifier_identifier (3215), a designer can tie together many specific tables, some of which might also contain unique application-specific data elements.

5.6 Recognition of Spatial Interdependencies Among Parts of the System

The National ITS Architecture is generally thought of as a logical architecture that is spatially independent with regard to its components, although there is a major component of the National ITS Architecture that represents a physical architecture. While the TMDD Standard can too be viewed as spatially independent, the design of application-specific data dictionaries needs to recognize spatial interdependencies among parts of the system. The TMDD Standard does however provide for six ways and many data elements that can be used to spatially locate the place that the other data elements are describing.

The TMDD Standard selected and supports six of the seven main “profiles” given in the Society of Automotive Engineers (SAE) Location Referencing Message Specification (LRMS) Information Report (SAE J2374). The LRMS describes sets or families of standard interfaces, each termed a profile, for transmission of location references among different components of ITS systems. The six location referencing profiles supported by the TMDD Standard are the following:

- **Point/Link Identification Interface Geometry Profile (Type: Link) -** contains referencing formats for locations based on fundamental spatial objects, such as points, links, and polygons;

- **Linear Referencing Profile (Type: Road Reference) –** intended for linear references, which identify a location on a network by an offset along network links from known locations on the network;

- **Address Profile –** uses an address that is a value unambiguously associated with a known location, such as a house or structure number;

- **Geographic Coordinate Profile (Type: Globally Referenced Point)** - contains record formats for the geographic coordinates of latitude, longitude, and altitude, expressed with reference to an established geometric datum;

- **Geographic Coordinate Profile (Type: Node Attribute)** - contains record formats for the geographic coordinates of latitude, longitude, and altitude, expressed with reference to an established node in the system; and

- **Cross Street Profile** - uses intersecting (crossing) street names and coordinates of intersections to identify nodes, rather than explicit node or link identifiers.

The designer of an application-specific data dictionary and the databases associated with a particular implementation needs to call upon one or more of these LRMS profiling methods provided for in the TMDD Standard in order to meet the needs and requirements specified for the particular ITS application. For example, a Traffic Management System may need data elements associated with (1) an Address Profile to support incident reporting on the arterial roadway network by emergency services personnel, (2) a Linear Referencing Profile for road maintenance and lane closure information, and (3) a globally referenced Geographic Coordinate Profile to serve a snowplowing program that is using Automatic Vehicle Location technology based on Global Positioning Systems.

One of the challenges in system design is to find ways to spatially locate events and incidents effectively when they are being reported or initially identified and are not yet specifically geographically referenced or spatially located.

5.7 Maintaining Consistency with the National ITS Architecture

As noted above in Section 3.6, the TMDD Standard was based upon the data flows for the “manage traffic” function as described in the National ITS Architecture. The general scope of the data flows that can be supported by the TMDD Standard are consistent with the data flows interfacing with a Traffic Management System and a Traffic Control System in the logical architecture. Therefore, if a designer is using the TMDD Standard for a particular ITS application, then the application-specific architecture will have a greater likelihood of being consistent with the National ITS Architecture.

A goal of the National ITS Architecture is to facilitate the defining of standards for interfaces for center-to-center communications as well as center-to-vehicle communications. If the designer is using data elements from the TMDD Standard, then the application will likely be capturing quite a few of the data flows of the National ITS Architecture and would be consistent with those aspects of it.

Another way for a designer to address this question is to look at the market packages associated with the National ITS Architecture. If the design of the overall ITS system has a high degree of similarity to one or more market packages, then the data flows and the needed and required data elements to support such data flows will likely be consistent with the National ITS Architecture.

5.8 Opportunities for Feedback to the TMDD Standard Process

In previous Sections of this Guide a general analogy to languages was used to help in the explanation and developing understanding about the TMDD Standard. The data elements of the TMDD Standard are like words in a regular dictionary. Regular dictionaries are not static entities, rather they evolve over time as usage and culture dictate and as people’s stories and communications needs establish new words to improve their ability to interact. Thus there is a feedback process of sorts that the developers and compilers of regular dictionaries pay attention to in order that their reference document is more relevant.

Similarly, there needs to be a feedback process to the on-going effort to have the TMDD Standard be fully relevant and useful to the ITS community. The TMDD Steering Committee has provided for such a process, which is described below in Section 12 of this Guide. However, for the feedback process to be effective implementers need to provide comments based upon their design experiences. Thus over time, the Traffic Management Data Dictionary should provide an even more rich and varied vocabulary to enable informative messages to be developed and exchanged.

6 IMPLEMENTION AND OPERATIONS USING THE TMDD STANDARD

6.1 Introduction

This Section is intended principally for systems implementers and operating agency staffs using the TMDD Standard on a day-to-day basis. Included would be software maintainers who are expected to keep the systems running and work with modifications and updates. The TMDD Steering Committee guiding the preparation of this Guide consists of many individuals involved in actual deployments of the new TMDD Standard. The TMDD Steering Committee as a whole is interested in encouraging successful implementation and operations using the TMDD Standard.

So far there are few lessons that have been learned from the limited number of the initial efforts to actually deploy the TMDD Standard. Guidance based upon those initial limited lessons learned are given here, including some pitfalls and how to avoid them. This Section also refers to a process established by the Steering Committee to consider requests to update and revise the TMDD Standard, which would be based upon future experiences with implementation and use of the Standard.

6.2 Implementing Systems in Accordance with Specifications and Designs

At the present time there has been limited opportunity to implement systems in accordance with specifications and designs based on the TMDD Standard. However, in the future there will be many new Traffic Management Systems implemented throughout the country. There are also many existing systems that will be evolving. Thus, it is expected that there will be many future opportunities to implement such Traffic Management Systems in accordance with specifications and designs based in part upon using the TMDD Standard. It is anticipated that the TMDD Standard will play an important role in the successful implementation and operation of such systems.

One general trend in software development may have some impact on implementing systems in accordance with specifications and design. The general approach of using of open source software, applied to Traffic Management System software, may help in the overall implementation process. One example of open source software is Linux, whose code is freely shared by the original developer. Other potential users of that software are encouraged to do their best to make the software better and more functional. They do so with a stipulation that they feedback and pass-on the improvements to the code back to the developer source so that other users can benefit by the improvement. By freely sharing code, innovations being made, and giving back to the developer, the net result is a better and more valuable product for the developer and for future users.

Some Traffic Management Systems are beginning to be used in a similar fashion. For example, the NaviGator™ System of the Georgia Department of Transportation, and the system operated by the Washington Department of Transportation have activities that have some similarities to this general open source software trend. Those agencies see benefits to themselves to share the software they have developed, including an expectation of getting back into their programs additional innovative ideas by others with whom they are sharing. It can be expected that some implementers of the TMDD Standard will also be using those two packages and will likely be implementing changes that incorporate the TMDD Standard in their software. As a result it can be expected that over time that those two systems, developed prior to the TMDD Standard, will have application-specific data dictionaries that use more and more of the data elements of the TMDD Standard.

It is possible that newer implementations of the Traffic Management Systems, which will be implemented in accordance with specifications and designs based in part upon using the TMDD Standard, might also take a similar open source approach to their effort. The sharing of approaches and code that adapt Traffic Management Systems to the TMDD Standard might make it easier for new Traffic Management Systems applications to be implemented in accord with the TMDD Standard. It may also make it easier for Traffic Management Systems that have been already implemented to refine and update their application-specific data dictionaries to be more consistent with the TMDD Standard.

6.3 Applying the TMDD Standard to Day-to-Day Operations

One of the purposes of developing the National ITS Architecture is to make it much more feasible for centers operated by different organizations to engage in the sharing of data or the day-to-day operation of devices. In many instances the design of the systems may make the use of the TMDD Standard appear invisible, behind the scenes with respect to the day-to-day operations performed by staff. In some instances the TMDD Standard can be applied to facilitate economies in the day-to-day operations. Some likely examples of the TMDD Standard affecting the day-to-day operations, whether visibly or invisibly, are the following:

Developing Short-lists for the Valid Value Range of Data Elements: A Traffic Management Center that has been operating for many years has implemented an upgrade that uses the TMDD Standard. The operators had been used to using specific, short pull down lists to code the characteristics of incidents into the incident log might encounter the following situation:

a) A number of the data elements in the TMDD Standard have a very large number, nearly 50, of coded values for their Valid Value Range, which several of the operators find to be very vexing to learn and slows down their entry into the log,

b) The operators do the following:

- Devise a short-list of values that is similar to their previous list of incident types that has the most common causes, and

- Prepare a secondary list that covers the remainder of the less frequently used codes,

c) When both lists are used together it enables the operators to regain their prior efficiency of operation.

Sharing of arterial signal controls: One example that could occur is when:

a) A significant incident is in the early stages of occurring on a freeway operated by a state's freeway Traffic Management Center,
b) High volumes of traffic are beginning to divert off the freeway onto some nearby parallel arterial roadways operated by a county public works department,
c) The state's center is operated 24 hours a day, seven days a week, while the county's center operates only from 6:00 am to 8:00 pm on weekdays, and
d) This incident is taking place during the busy shopping hours on Saturday.

The two organizations had previously worked out agreements and adapted their application-specific data dictionaries to enable the sharing and/or mutual control of devices by each using the same data elements from the TMDD standard. In this circumstance then, the operator managing the incident at the freeway management center of the state can do the following:

- Locate segments of the county operated arterial network that would likely be affected by the diversions, and
- Initiate changes in pre-designed signal timing plans prepared by the county, which were prepared in anticipation of such an occurrence, because the county operation center staff was not available at the time of the incident to do so directly.

Facilitating and Providing for On-call Operations: An operating consideration for a Traffic Management Center is what hours of operation should be provided, and how to maintain effective coverage during the hours when the center is not in operation. The following operation situations may occur.

a) Even though many of the centers that have been in operation for a number of years have around the clock operations, there will be many newer centers being operated in mid-sized and smaller-population-sized areas, where a higher proportion of them would probably only have needs or budgets that would allow for less than around-the-clock hours of operation.

b) One of the reasons that there are a large number of incident types coded in the TMDD Standard is that the numeric codes can facilitate a semi-automated operation of smaller centers.

c) Say during the hours that such centers are not in operation one of the operators could be on-call if a large incident was to occur and an operator is needed to manage.

d) The emergency service personnel also use the TMDD Standard codes, and when certain numeric codes are used for an incident type, as contrasted to a non-standard text based description of the incident, a message could automatically go out to the on-call operator to check and report in.

e) Such an arrangement, supported by the TMDD Standard, could result in cost savings for the Traffic Management Center as well as more cost effective incident management.

6.4 Maintaining the On-going Effectiveness of the Application-Specific Data Dictionary

The TMDD Steering Committee will be responsible for maintaining the effectiveness of the TMDD Standard. The TMDD Steering Committee also wants to help practitioners and operators by providing this guidance and thus indirectly assisting in maintaining the effectiveness of their application-specific data dictionaries. Maintaining the on-going effectiveness of the application-specific data dictionary needs to be attended to or else the benefits of making the effort to use the TMDD Standard can be eroded.

We can define effectiveness by answering the following questions:

- Does it continue to do the intended job?
- Does it continue to provide the same benefit or impact?
- Do others think that outcomes continue to be useful?

The Steering Committee is not thinking in its definition in terms of efficiency, which relates more to the effort going into performing the job or responsibility.

There can be many ways in which operating agencies and practitioners can gage and measure for themselves the on-going effectiveness of maintaining an application-specific data dictionary. The staff managing the operation should be able to readily assess items such as the following:

- The needs and requirements for the application have resulted in a subset of the data elements of the TMDD Standard being used as well as a number of application-specific data elements. How easy or difficult is it for additional data elements to be changed, modified, added, or deleted in the application-specific data dictionary when there is an addition or shift in the functions of the center?
- Was the initial application-specific data dictionary designed and implemented too tightly such that it is often necessary to initiate changes to the application-specific data dictionary?

- Was it organized in such a way that it seems to take an excessive amount of time to change, add or delete a data element and associated fields in the databases?

- Is adding in information and codes, about new types of devices, easy or hard to do?

- Has connection of a new center into the system resulted in the need to make no, few or many changes to the application-specific data dictionary so as to properly communicate with that center?

6.5 Lessons Learned from Initial Deployments Using the TMDD Standard

This sub-section of the Guide presents somewhat of a dilemma. The TMDD Standard is relatively new and it takes time to plan, specify, design, implement, and then operate with the new TMDD Standard. As of this time, the Steering Committee is aware of only a limited number of initial efforts that are beginning to deploy the TMDD Standard. As a result there is a very limited amount of information to call upon now from which lessons learned can be drawn and included here. However, guidance based upon such initial limited lessons learned is presented and discussed below.

The intent of the TMDD Steering Committee is that this sub-section will become more complete and thorough over time in subsequent updates of the Guide as more experience with using the TMDD Standard is obtained. Several initial examples are reported on here, where each is a response to a different set of functional needs and requirements. As a result each emphasizes use of different Sections of the TMDD Standard, as shown in Exhibit 6.5. More information is given about these initial deployments in Section 13 below.

Exhibit 6.5: Examples by Section of TMDD Standard being Emphasized

Application Examples	TMDD Standard Sections and Selected Partitions
New York Metropolitan ***TRANS****COM* Regional Architecture Database (RAD)	Section 1: Links and Nodes Section 2: Events, Incidents, Notification Alarms
Seattle, Washington North Seattle Advanced Transportation Management System	Section 3: Traffic Network, Traffic Signal Control, Traffic Detectors, Ramp Meter
Maryland CHART Dynamic Message Signs	Section 4: Dynamic Message Signs
Dallas-Fort Worth Center to Center Communications Project	Section 1: Links and Nodes Section 2: Events, Incidents, Notification Alarms Section 3: Traffic Network, Traffic Signal Control, Traffic Detectors, Ramp Meter

The following briefly describes two of the particular applications and discusses lessons learned to date. The two others are covered in Section 9.5 below, as they relate more to the MS/ETMCC Standard.

North Seattle Advanced Transportation Management System: This is a project of the Washington Department of Transportation. One of the main intents of the project was to develop a standardized approach that the Department could use in interrelating an arterial traffic control system with their Freeway Management System. The project started prior to the Traffic Management Data Dictionary Standard being developed. With the availability of the TMDD Standards, the focus of the project was shifted somewhat to develop a translation of data elements to those of the TMDD Standard, which was consistent with the intent of the project.

Technically the project is designed to collect data from local traffic controllers various operating characteristics on synchronization, splits, and offsets as well as system detector data such as volumes and occupancy. In developing the approach, the consultant took the existing definitions of the desired data elements and found the closest matching one from the TMDD Standard and that worked with the DATEX.ASN protocols. In total, about 25 to 30 data elements from the TMDD were used for the project approach, while a handful of data elements needed to be application-specific. The latter included cycle lengths for the controllers, offsets, phase data on the splits, the system clock, and alarms for the controllers, such as a door is open or the controller is in flash mode.

Some of the key lessons learned included the following:

- The need to develop these application-specific data elements, as contrasted to already having them provided for in the TMDD Standard, was viewed as a shortcoming of the TMDD Standard, rather than providing for local flexibility.

- There can be a long learning curve for the system developer to become sufficiently acquainted with the TMDD Standards with their first experience with it.

- It would have been useful to have a “check-list” or “how-to-do” guide in trying to figure out using the TMDD Standard.

- There is some concern and uncertainty about the actual way to do the implementation of data element transfers with the protocol standards of DATEX.ASN or with CORBA.

- The data elements for latitude and longitude where not specific or flexible enough regarding which projection system to reference, such as NAD 83, or one of the many other numerous projection systems.

CHART’s Dynamic Message Signs: The State Highway Administration of Maryland has a Freeway Management System termed CHART (Coordinated Highways Action Response Team), which has been undergoing a significant system upgrading. Among the purposes of the upgrading has been to migrate from a previous proprietary system to one with an open architecture, and to enable the more effective management of many detectors and an expanding set of Dynamic Message Signs (DMS). The timing was such that the use of the new TMDD Standard is being followed in the system upgrading. When one or more particular data elements are defined in the needs and requirements process that is being used, a check is made to see if there is a data element from the TMDD Standard that can meet the intended use. The work has progressed in a staged fashion, with an initial effort being given to the DMSs in Release 1, Build 1. The second build is focusing on incident events and Highway Advisory Radio (HAR) applications. There were several lessons learned, which include the following:

- It can be a challenge to interrelate the TMDD with the NTCIP protocols for device control. Careful effort is required to match data elements and concepts and to avoid redundancy and conflict.

- The documentation available with the TMDD Standard was not clear enough and required study and educated guesses in order to specify data elements in accordance with the TMDD Standard.

- The TMDD Standard appears to be written with flexibility in mind. In the initial work, only a few application-specific data elements seemed necessary, but more are being anticipated in the forthcoming phases of the work.

- If the client is very set on what particular types of data they want to use, the resulting needed data elements may not necessarily map well to the TMDD Standard.

- The availability of the TMDD Standard has been very helpful, describing data elements well. In addition the options that are available provides for needed flexibility

6.6 Accounting for Subsequent Revisions to the TMDD Standards

System implementers and operators of Traffic Management Systems should anticipate that revisions to the TMDD Standard are likely to occur. Here too the Committee has been dealing with some dilemmas.

The TMDD Steering Committee has been working on revisions even while the TMDD Standard was being balloted and approved. It is important that the TMDD Standard be thorough and well thought out, so that sufficient time needs to be taken to have a workable Standard. However, there is also a need to have useful and appropriate materials in the hands of practitioners as soon as feasible so that they have proper tools to better meet their responsibilities. Such an approach of moving forward with the TMDD Standard while still working on revisions has been taken as a way to address this dilemma.

There are various reasons that system implementers and operators also need to anticipate revisions to the TMDD Standard. As just discussed in the preceeding sub-section, the TMDD Standard has not yet been widely deployed nor field tested. The TMDD Standard may therefore be subject to future changes as a result of future operational deployments and real world field testing. Another reason to anticipate changes to the Standard is due to changes in associated standards, which is discussed in the next sub-section.

To help account for such potential subsequent revisions to the TMDD Standard users should periodically check the ITE (www.ite.org) and AASHTO (www.aashto.org) websites for information on the status on any such revisions.

6.7 Expectation of Future Changes in Associated Standards

System implementers and operators of Traffic Management Systems should also anticipate that associated standards might change in ways that will affect the TMDD Standard. The many ITS standards that are still under development are each like a moving target. While a system implementer or operator may pause to focus and aim on one, when they search for the next to deal with it, that standard may have moved relative to the first.

As noted in Section 13 below on relationships to other standards that the TMDD Standard has been totally dependent on the IEEE 1489-1999 Standard and has close interrelationships to several other standards, such as the ATIS Data Dictionary or the NTCIP Standard. Like the TMDD Standard, those standards will also likely go through their own maturation and development process. The net effect then will be that when those standards change they could either (1) definitely precipitate and require a change in the TMDD Standard, or (2) may or may not necessitate a change.

As an example of the former, the TMDD Standard has already been affected by changes and an update of the IEEE 1489-1999 Standard. The initial work done in developing the TMDD Standard relied on the IEEE 1489-1999 Standard at the time, which has been subsequently updated. Any further changes in that standard will precipitate associated changes in the TMDD Standard. Some of the revisions that are presently under consideration for the TMDD Standard have been done to respond to the changes to the IEEE 1489-1999 Standard. An example of the later may be changes to harmonize with work being done in developing the ATIS Data Dictionary.

7 SPECIFYING TRAFFIC MANAGEMENT SYSTEM IMPROVEMENTS USING THE MS/ETMCC STANDARD

7.1 Introduction

This and the two following Sections relate primarily to the MS/ETMCC Standard, while the three proceeding Sections, Sections 4, 5, and 6 relate primarily to the TMDD Standard. As a note to readers who have just covered the three previous Sections 4, 5, and 6 that some of the material here may appear to be repetitive. In particular, sub-Sections 7.1, 7.2, 7.5, and 7.6 repeat most of the concepts given above in sub-Sections 4.1, 4.2, 4.5, and 4.6, respectively. For those readers who already covered Section 4 they may wish to skim through these four identified sub-Sections of Section 7. Sub-sections 7.3 and 7.4 are specifically focused on the MS/ETMCC Standard.

This Section is intended principally for writers specifying desired improvements to traffic management systems or centers, as well as software system integrators and maintainers, who are involved with using the MS/ETMCC Standard. This covers the process of identifying needs and requirements for systems as well as transforming those into requirements contained in request for proposals. In many instances the public agencies needing to use the Standard are contracting out for professional system engineering services to design and implement applications that rely upon the Standard. This Section is also intended to help agency or contractor project managers who will be setting directions and/or reviewing activities to develop system architectures for specific systems.

The MS/ETMCC Standard consists of many messages organized by several message groups and many message sets. It is important that specification writers, usually consultants working under the direction of public agency personnel, have a good grasp of the ways that the message groups and message sets interrelate and would be appropriate for particular applications.

7.2 Translating Systems Needs and Requirements to Specifications

The specifications for communication and data sharing among centers should begin with a clear understanding of which specific centers and sub-systems the functional needs and requirements see as being connected. If the vision for the center-to-center communications and data sharing is to have it perform function “x” then, what are the messages, message sets, and message groups, “y”, which will be needed for communication and data sharing to enable the systems and centers to perform that function? The beginning point is the needs – what purpose should the system perform; what things are trying to be accomplished; what products or results are needed; and how does data sharing and communication of messages fit in?

For example, if the purpose of the system improvement is to enable communications between a freeway management system and an arterial control system, then the nature of which message groups and message sets that may be required may not be that numerous. If however, the functionality needed also includes device control, ramp metering, incident management, and dynamic message signs, then a much larger and more diverse number of message groups and message sets would need to be specified for use.

Thus, satisfying the user agency specifications in a MS/ETMCC deployment requires the following:

- Careful analysis and articulation of the agency's requirements up front,
- Careful mapping of the MS/ETMCC Standard to those requirements, and then
- Well-written specification for services.

7.3 Specific Structure of the Messages and Message Set Formats

As noted above in Section 3.4, the message sets are applicable for implementing data flows between traffic management and other management center/subsystems including another traffic management center. The messages can be sent in a one-time request/reply sequence, at a regular updated interval, or in response to an event occurrence. The MS/ETMCC Standard is structured according to six message groups, which are identified above in Section 3.4. An example of one of the six message groups is the Roadway-Network Message Group, which provides the ability to exchange a description of a specific traffic network as defined by a set of links and nodes. The messages in that group can also be used to add or delete links or nodes or to recognize changes that have occurred in some of their specific characteristics.

Each of the six message groups consists of several message sets. The Roadway-Network Message Group, for example, consists of the following two message sets:

- **Roadway-Network-Description Message Set:** This message set provides a complete description of a specific traffic network as defined by a set of connected links and nodes. The set consists of four messages:

    - Network-Identity,
    - Link-Identity,
    - Node-Description, and
    - Link-Description.

- **Roadway-Network-Update Message Set:** This message set provides an update of specific characteristics and features for specified links and/or nodes. The update is only for those specific links and nodes that have changed since the last complete update. This message set can be used to add or delete links or nodes or change specific characteristics. The set consists of three messages:

    - Network-Update,
    - Link-Update, and
    - Node-Update.

Exhibit 7.3.1 illustrates this general structure using the example of the Roadway-Network Message Group, which consists of two message sets, which in turn consist of a variable number of messages. In general each message set consists of a variable number of data elements, some of which could be in more than one message even in the same message set. Exhibit 7.3.1 does not attempt to show each of the specific data elements associated with the messages in each message set as it would have made this exhibit too complicated. Exhibit 3.2.3, given above, shows the eight data elements that comprise one of the messages shown in Exhibit 7.3.1, that of Network-Identity.

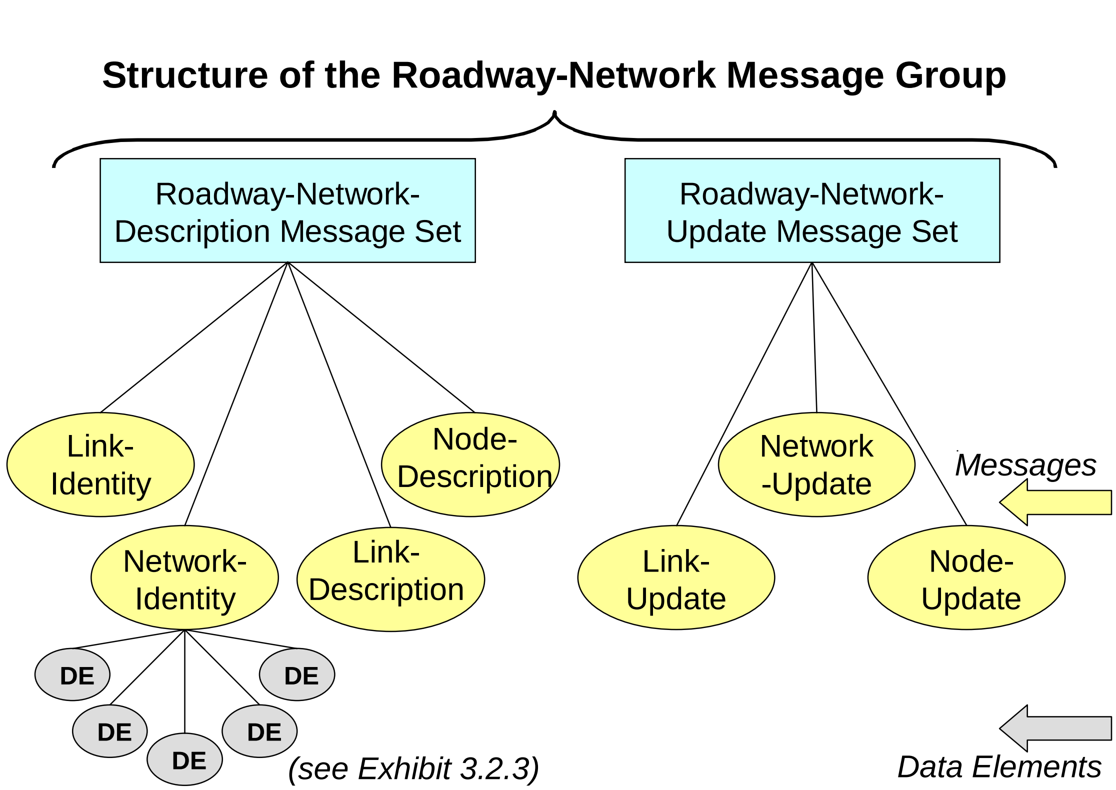


Exhibit 7.3.1: Example of the Roadway-Network Message Group

The MS/ETMCC Standard views the structure of such message sets as a list of data elements that make-up the message. For example, the Network-Identity Message is defined next and contains eight data elements, which are identified and referenced by their TMDD Standard data element (TMDD-DE) Data Concept Identifier, as follows:

> **Network Identity** is a message sent from a TMS to any other center based subsystem. It identifies a specific traffic network by identification Id, name and jurisdiction and specifies the list of links and nodes composing that network.

- **Network-Id Number:** uniquely identifies a traffic network by identification number (TMDD-DE 3411).

- **Network-Name:** Accepted name for specified network (TMDD-DE 3412).
- **Network-Section Count:** The number of sections in a network (TMDD-DE 3413).
- **Organization-Contact-Organization Name**: The organization that manages the network (TMDD-DE 3344).
- **Section-Link Count:** The current number of links in the specified network section (TMDD-DE 3422).
- **Section-Node Count:** The current number of nodes in the specified network sections in a network (TMDD-DE 3413).
- **Link-Id Number List:** A sequence of Identification Id numbers for the set of links included in the specified network by section (TMDD-DE 3012).
- **Node-Id Number List:** A sequence of Identification Id numbers for the set of nodes included in the specified network by section (TMDD-DE 3042).

7.4 Meta-data Attributes of Individual Messages and Message Sets

The MS/ETMCC Standard displays all of the messages for external TMC Communication written in ASN.1 syntax. This ASN.1 specification has been checked for conformance with the ASN.1 standard by the Open Systems Solutions ASN.1 Tools. Message templates are used to facilitate implementing the MS/ETMCC Standard. An example of such a template is that for the example used here of Network-Identity, and is shown in Exhibit 7.4.1.

Exhibit 7.4.1: Message Template for NETWORK-IDENTITY			
Message Group No. 1	**Message Group Name: ROADWAY-NETWORK**		
Message Set No. 1.1	**Message Set Name: ROADWAY-NETWORK-DESCRIPTION**		
Message No. 1.1.1	**Message Name: NETWORK-IDENTITY**		
Basic Message Attributes			
1.1	Message Identifier	M/M	NETWORK-IDENTITY: Shall be transmitted
1.2	Message Set Identifier	M/M	ROADWAY-NETWORK-DESCRIPTION: Shall be transmitted
1.3	Message Set Version	M/M	JD Version 2.0: Shall be transmitted
1.4	Message Group Identifier	M/O	No group: Shall not be transmitted
1.5	Message Name	M/O	NETWORK-IDENTITY: Shall not be transmitted
1.6	Message Description	M/O	This message describes the basic characteristics of the network: Shall not be transmitted
1.7	Meta Data Source	M/M	Direct (TMDD): Shall not be transmitted
1.8	Priority	M/O	Priority, Normal: Shall be transmitted
1.9	Frequency	M/O	Infrequent: Shall not be transmitted
2.4	Message Instance Identifier	O/C	Shall be transmitted
2.13	Time Stamp	O/C	Shall be used
2.14	Time stamped return receipt	O/O	Shall be used

Source: MS/ETMCC Standard, Table 5.1.1.1-1.

7.5 Adapting the MS/ETMCC Standard to a Specific Application

The MS/ETMCC Standard anticipates that each specific application would have the option of having an application-specific message set included in the specifications and then created for the application. An application-specific message set is a message set specific to a particular implementation of an ITS application, including all data dictionary definitions used by that application.

For example, a freeway oriented Traffic Management Center needs to frequently share data and communicate other messages with several adjacent and overlapping arterial traffic signal control oriented centers as well as many highway rail intersection at-grade-crossings and gates serving drawbridges over a canal/inland waterway. The various permutations and combinations of long trains coming through and long openings of the drawbridges may create needs and requirements for some application-specific message sets. This can be anticipated for by specification writers and then provided for in the design of specific applications.

The MS/ETMCC Standard anticipates that additional message sets shall be permitted to support system specific functions or variations where the MS/ETMCC message sets do not exist. However, if the specifications are calling for the provision of some additional message sets, these system specific data elements should be developed in compliance with IEEE P1488, the Standard for Message Set Templates for Intelligent Transportation Systems, as have the message sets in the MS/ETMCC Standard.

7.6 Additional Guidance for Specification Writers

In Section 7.2 above, this Guide stressed the importance of specification writers basing their proposed specifications on a soundly conceived set of needs and requirements. Additional items of consideration include the process for design of the database that will be used as well as the software platform. The MS/ETMCC, however, has been designed to be independent of any specific protocols for communication.

Another approach that can be relied on if practical is that of working from a specification set previously developed for some other but similar application that has some similar needs and requirements. Such an approach might be a time saver and cost reducer, but also might have some pitfalls. Such an approach would be more like doing a design, but it should be done in an iterative manner to make sure that the specific needs and requirements for this application are indeed being addressed.

8 DESIGNING WITH THE MS/ETMCC STANDARD

8.1 Introduction

This Section is intended principally for those faced with the task of designing the communications and data exchange elements of transportation systems that utilize the MS/ETMCC Standard. As a note to readers who have covered Sections 4, 5, and 6 above that some of the material here may appear to be repetitive. In particular, sub-Sections 8.1, 8.3, 8.4, 8.6, and 8.7 repeat most of the concepts given above in sub-Sections 5.1, 5.3, 5.4, 5.7 and 5.8, respectively. For those readers who already covered Section 5 they may wish to skim through these five identified sub-Sections of Section 8. Sub-sections 8.2 and 8.5 are specifically focused on the MS/ETMCC Standard.

This Section includes a discussion on the relationship between the MS/ETMCC Standard and application specific data dictionaries, as well as the need for conformance between them. This section also recognizes that design may need to provide for migration alternatives to transition between various legacy systems and a system that is in full conformance. Relationships to the National ITS Architecture also need to be accounted for here.

8.2 Creating Application-Specific Messages using the MS/ETMCC Standard

As noted in the previous section, the MS/ETMCC Standard anticipates that each specific application would have the option of having an application-specific message set designed for the application being developed. It is also noted that the MS/ETMCC has been designed to be independent of any specific communication protocols. If the communication medium is one that does not have a lot of bandwidth, then the question of which communication protocol to use could become an issue to be addressed during the design. Octet Based Encoding may require significantly more bandwidth than Packed Encoded Rules. Alternatively, SNMP, which is an Internet standard for routing devices to tell information about itself, may also be applicable in lowering bandwidth needs for some applications.

Thus the MS/ETMCC Standard anticipates that during the process of database design that additional information may be added to supplement that associated with the Standard message sets.

8.3 Seeking Conformance Between Application-Specific Messages using the MS/ETMCC Standard

The MS/ETMCC Standard has a section on Conformance that makes the following three points about this topic:

- "Conformance with this functional level message set standard requires that an application specific message set use the MS/ETMCC messages in all cases where they are applicable to the functions supported by the system. (An application specific message set is defined as the message set used by a specific and actual installation of an ITS system).

- Conformance with this standard requires that individual messages contained herein shall be used as specifically defined and described by the message and data element meta attributes. No changes are permitted and required variants shall be separately described and established in compliance with IEEE P1488 as additional application specific messages.

- Additional messages shall be permitted to support system specific functions or variations where the MS/ETMCC messages do not exist. However, these system specific messages shall be developed in compliance with IEEE P1488. "

Thus, if the specifications for a particular application and installation of an ITS system call for the design of the database and system to be in conformance with the MS/ETMCC Standard, then these three points need to be addressed by the designer.

8.4 Providing Migration Alternatives for Transition Between Legacy Systems and Message Sets

As noted above in Section 2.4, a particular concern to be addressed as part of the process of design and implementation of an application is the need to provide for migration alternatives to transition between various legacy systems and a system that is in full conformance with the MS/ETMCC Standard. The flexibility for local variations that the MS/ETMCC Standard provides can help in such transitions or migrations between systems. Such transitions can also be eased by the development of an application-specific message set. There are a few other ways as well to account for this concern in the process of design.

The message sets that were selected for inclusion in the MS/ETMCC Standard and many aspects of their meta-attributes were based upon sample local message sets that were already in use by many different implementations throughout the country. As a result, some legacy systems may already have many message sets and meta-attributes in common with the MS/ETMCC Standard. If the data elements included in the message set are even at a slight variance in spelling or structure from those of the MS/ETMCC Standard, then the designer has the following alternatives to choose from:

- Change the application-specific message set and databases, or
- Provide for a translation program to interrelate the message sets defined by the MS/ETMCC Standard with those being used locally.

The choice is a design decision that needs to be made locally and will depend upon many factors, such as what degree of correspondence is there already between the MS/ETMCC Standard and the current application-specific message sets. Another factor that is increasingly coming into play is the desire by several larger states with multiple major metropolitan areas and/or significant rural applications to develop and maintain high degrees of consistency between ITS systems through out their state.

One factor that will help in the migration from legacy systems is that if a lot of the communications between centers is being done through use of the Internet, then de facto a lot of it will be standardized due to TCP/IP protocols.

The choice of a design solution needs to also account for short-term funding availability and long-term cost effectiveness. Many times funding availability and time constraints enable the designer to propose solutions that fit within short-term funding and are cost-effective over the life cycle of the application. However, with rapid changes in technology, increases in computational power, and declining hardware prices it is a challenge to accurately assess what will be the true long-term life cycle costs as well as what is the overall cost effective solution. Thus an approach that can be taken by designers is to provide for phased migration plans that provide for prototypes, conversions, and then final versions that have fully migrated.

8.5 Accounting for Unique Application-Specific Message Sets

The MS/ETMCC Standard can be adapted in the process of design of application-specific message sets to account for unique application-specific message sets. Various techniques can be used to design and model how the MS/ETMCC Standard message sets and application-specific message sets can be tied and linked together.

An example that illustrates the accounting for unique application-specific message sets is one related to applying the MS/ETMCC Standard to an area in which extensive use is made of overhead lane control signals, such as in several of the major metropolitan areas in Texas. The MS/ETMCC Standard does not have a message set that relates to such devices and communicating with other TMCs or centers the status of the lane configuration at the present time. As such, in this example to be able to send messages out on the status of the overhead lane control signals, it would be necessary to develop one or more application-specific message sets.

Another example could relate to sending messages between TMCs and other centers related to air quality monitor readings and air quality alerts. In some metropolitan areas in the far west the issue of particulate matter is a critical area quality concern. However the MS/ETMCC Standard message set for Current_Roadside_Air Quality does not provide for messages related to particulate matter. Thus to support air quality objectives, the TMC might establish an application-specific message set and appropriate data elements in their application-specific data dictionary to have values for PM_{10}, a particular measure of particulate matter.

8.6 Maintaining Consistency with the National ITS Architecture

As noted above in Section 3.6, the MS/ETMCC Standard was based upon the data flows for the “manage traffic” function as described in the National ITS Architecture. The general scope of the data flows that can be supported by the MS/ETMCC Standard are consistent with the data flows interfacing with a Traffic Management System and a Traffic Control System in the logical architecture. Therefore, if a designer is using the MS/ETMCC Standard for a particular ITS application, then the application-specific architecture will have a greater likelihood of being consistent with the National ITS Architecture.

A goal of the National ITS Architecture was to facilitate the defining of standards for interfaces for center-to-center communications as well as center-to-vehicle communications. If the designer is using message sets from the MS/ETMCC Standard, then the application will likely be capturing quite a few of the data flows of the National ITS Architecture and would be consistent with those aspects of it.

Another way for a designer to address this question is to look at the market packages associated with the National ITS Architecture. If the design of the overall ITS system has a high degree of similarity to one or more market packages, then the data flows and the needed and required message sets to support such data flows will likely be consistent with the National ITS Architecture.

8.7 Opportunities for Feedback to the MS/ETMCC Standard Process

In previous Sections of this Guide a general analogy to languages was used to help in the explanation and developing understanding about the MS/ETMCC Standard. The message sets of the MS/ETMCC Standard are like sentences, which words in a regular dictionary with common meaning, and through which people communicate one with another. Such interpersonal communications are not static in their style, rather they evolve somewhat over time as usage and culture dictate and as people's stories and communications needs establish new ways to express themselves and to improve their ability to interact. Thus there is a feedback process of sorts that chroniclers of the usage of language pay attention to and note in their writings and commentaries.

Similarly, there needs to be a feedback process to the on-going effort to have the MS/ETMCC Standard be fully relevant and useful to the ITS community. The TMDD Steering Committee has provided for such a process, which is described below in Section 12 of this Guide. However, for the feedback process to be effective users need to provide comments and inputs based upon their design experiences. Thus over time, the Message Sets for External Communications Traffic Management Center Communications should provide an even more rich and varied sets of expressions to enable informative messages to be developed and exchanged.

9 IMPLEMENTION AND OPERATIONS USING THE MS/ETMCC STANDARD

9.1 Introduction

As a note to readers who have just covered Sections 4, 5, and 6 above that some of the material here may appear to be repetitive. In particular, sub-Sections 9.1, 9.2, 9.4, 9.6, and 9.7 repeat most of the concepts given above in sub-Sections 6.1, 6.2, 6.4, 6.6, and 6.7, respectively. For those readers who already covered Section 6 they may wish to skim through these five identified sub-Sections of Section 9. Sub-sections 9.3 and 9.5 are specifically focused on the MS/ETMCC Standard.

This Section is intended principally for the various systems implementers and operations staffs using the MS/ETMCC Standard on a day-to-day basis. Included would be software maintainers who are expected to keep the systems running and work with modifications and updates. The TMDD Steering Committee guiding the preparation of this Guide consists of many individuals involved in actual deployments of the new MS/ETMCC Standard. The TMDD Steering Committee as a whole is interested in encouraging successful implementation and operations using the MS/ETMCC Standard.

So far there are few experiences and lessons that have been learned from initial efforts to actually use the MS/ETMCC Standard in practice. Guidance based upon such initial limited lessons are given here. This Section also refers to a process established by the Steering Committee to consider requests to update and revise the MS/ETMCC Standard based upon future experiences with its implementation and use in operations.

9.2 Implementing Systems in Accordance with Specifications and Designs

There will be many new Traffic Management Systems implemented throughout the country in the coming years. There are also many existing systems that will be going through processes of being upgraded in various ways. It is expected that the MS/ETMCC Standard will be used extensively in the implementation of communications and data sharing among those systems.

Because the focus of the MS/ETMCC Standard is on the communication between and among centers and systems, as the number of such centers and systems increase and proliferate, the need for the MS/ETMCC will increase geometrically rather than arithmetically. Thus, there will be many opportunities to implement such Traffic Management Systems in accordance with specifications and designs based in part upon using the MS/ETMCC Standard. The need for it will become exceedingly important for the successful implementation and operation of such centers and systems.

In the discussion above in Section 6.2, a trend of sharing of software using an open source approach was noted. It is possible that newer implementations of the Traffic Management Systems, which will be implemented in accordance with specifications and designs based in part upon using the MS/ETMCC Standard, might also take a similar open source approach to their effort. The sharing of approaches and code that adapt Traffic Management Systems to the MS/ETMCC Standard might make it easier for new Traffic Management Systems applications to be implemented in accord with the MS/ETMCC Standard. It may also make it easier for Traffic Management Systems that have been already implemented to refine and update their application-specific message sets to be more consistent with the MS/ETMCC Standard.

9.3 Applying the MS/ETMCC Standard in Day-to-Day Operations

There will be many new Traffic Management Systems implemented throughout the country in the coming years, which will provide opportunity for operators to experience applying the MS/ETMCC Standard. One of the purposes of developing the National ITS Architecture was to make it much more feasible for nearby centers operated by different organizations to engage in sharing data or day-to-day operation of devices, such as Dynamic Message Signs. Other examples might relate to how the MS/ETMCC Standard can be adapted to facilitate some economy of operations. However, in many instances it is expected that the design of the systems may make the use of the MS/ETMCC Standard appear invisible, behind the scenes with respect to the day-to-day operations performed by staff. Some likely examples of the MS/ETMCC Standard affecting the day-to-day operations, whether visibly or invisibly, include the following:

Posting Messages on Another Organization's Dynamic Message Sign: An example could occur when:

a) For a multi-state corridor there is often a need to be able to inform long distance travelers and Commercial Vehicle Operators of major delays that might be caused by a number of situations, such as incident conditions, major road or bridge maintenance closures, or excessive congestion at toll plazas during holiday weekends.

b) If each of several adjacent Traffic Management Centers is using the MS/ETMCC Standard, and proper communications, protocols, and priorities have been established, then the operators of any one of the centers could post messages on the Dynamic Message Signs of the other centers, provided the pre-established priority of control permits. In this example, the interacting centers also need to have data elements that conform to the TMDD Standard in order to work together.

c) When conditions warrant and local message priorities elsewhere do not control, an operator at one center may post messages on signs in other jurisdictions to alert travelers moving toward the problem situation. Action by a single operator to post all the necessary messages will simplify the communication chain and ease the burden on the staff in several other centers.

Adding New Functions not Included in the MS/ETMCC Standard: In this example, staff of some TMCs that frequently interact could use the standard formats as a way to add additional message sets. If they find that some new function or feature of their operation requires them to frequently exchange messages, they could use the template used for the message sets to format a new message related to this new function or feature. For example, a few nearby centers may be interested in exchanging messages related to localized air quality particulate matter concentration readings from field devices. That is not presently included in the MS/ETMCC Standard, but by following the templates used for similar air quality emission concentrations, the TMC staffs can develop some application-specific messages with some marginal effort.

Allowing for Future Message Sets in Initial Acceptance Testing: The needs and requirements for a particular TMC may result in not initially needing all of the fields of the MS/ETMCC Standard. To facilitate future day-to-day operations it may be wise to provide for future use of additional likely messages and have them lay dormant in the message sets that are included in the initial acceptance testing of the system. Activating these dormant messages would be considerably easier than coding new messages in from scratch. On the other hand, if the messages were not included in the initial effort, future efforts to incorporate the un-tested messages would run a higher risk of errors and expensive troubleshooting.

Initializing Interrelated Systems on a Daily Basis: TMCs that frequently need to interact and are not operated on a 24 hours per day or 7 days per week schedule have a need to coordinate their start-up modes of operations each time they come back on-line. Message sets can be used to help in the coordinating and keeping in phase such interacting TMCs. By using the Network_Roadway_Network messages, the interacting TMCs can more easily coordinate their systems.

9.4 Maintaining the On-going Effectiveness of the Messages and Message Sets

The TMDD Steering Committee will be responsible for maintaining the effectiveness of the MS/ETMCC Standard. The TMDD Steering Committee also wants to help practitioners and operators by providing this guidance and thus indirectly assisting in maintaining the effectiveness of their application-specific message sets. Maintaining the on-going effectiveness of the application-specific message sets needs to be attended to or else the benefits of making the effort to use the MS/ETMCC Standard can be eroded.

As noted above in Section 6.4, one can define effectiveness by answering the following questions:

- Does it continue to do the intended job?
- Does it continue to provide the same benefit or impact?
- Do others think that outcomes continue to be as useful?

The Steering Committee is not thinking here in terms of efficiency, which relates more to the effort going into performing the job or responsibility.

There can be many ways in which practitioners can gage and measure for themselves the on-going effectiveness of maintaining an application-specific message set. The staff managing the operations should be able to easily and quickly make assess for themselves items such as the following:

- The needs and requirements for the application have resulted in a subset of the message sets of the MS/ETMCC Standard being used as well as a number of application-specific message sets. How easy or difficult is it for additional message sets to be changed, modified, added, or deleted in the application-specific message set when there is an addition or shift in the functions of the center or new centers who want to communicate or share data?

- Was the initial application-specific message set designed and implemented too tightly such that it is often necessary to initiate changes to the application-specific message set?

- Was it organized in such a way that it seems to take an excessive amount of time to change, add or delete a message set and associated fields in the databases?

- Does the connection of a new center into the system result in the need to make no, few or many changes to the application-specific message set so as to properly communicate with that center?

- Is adding in information and code about new centers easy or hard to do?

9.5 Lessons Learned from Initial Deployments of the MS/ETMCC Standard

Similar to the discussion above in Section 6.5, this sub-section of the Guide also presents somewhat of a dilemma. The MS/ETMCC Standard is relatively new and it takes time to plan, specify, design, implement, and then operate systems using the new MS/TEMCC Standard. As of this time, the Steering Committee is aware of only a small number of initial efforts to that are beginning to deploy the TMDD Standard and fewer yet that are beginning to use the MS/ETMCC Standard. As a result there is a very limited amount of information to call upon now from which lessons learned can be drawn and included here. However, limited guidance based upon such initial lessons learned is discussed here.

The intent of the TMDD Steering Committee is that this sub-section will become more complete and thorough over time in subsequent updates of the Guide as more experience with using the MS/ETMCC Standard is obtained.

The following briefly describes two of the particular applications and discusses lessons learned to date. A more complete summary of these examples is given in Section 13 below.

***TRANS**COM* **Regional Database Architecture:** ***TRANS**COM* is a coalition of sixteen transportation and public service agencies in the New York-New Jersey-Connecticut metropolitan area – the tri-state region. As a selected area for the Metropolitan Model Deployment Initiatives it is implementing a traveler information center that will make consolidated, multi-modal, multi-agency transportation information available to individual travelers. The application of the TMDD and MS/ETMCC Standards reported on here also relates to the effort to deploy the TRANSMIT system for managing incidents and traffic and the ***TRANS**COM* Regional Architecture (RA). The TRANSMIT system will be using Automatic Vehicle Identification (AVI) from toll tags to monitor traffic, detect incidents, and estimate travel times and speeds. The system will cover approximately 225 miles of freeways and parkways throughout the tri-state region.

To carry out its responsibilities to its constituent agencies ***TRANS**COM* is providing center-to-center communications among 47 Traffic Operations Centers (TOCs) with 52 workstations. The intent is to communicate messages about the tracking of incidents, construction closures, special events, and real-time traffic and transit conditions on the freeways, parkways, and transit facilities among all of the workstations. The RA effort focuses on the tracking of incidents, etc. and not on the management of responses to incidents or on traffic control. The RA was begun subsequent to initial efforts to integrate systems and data from the ***TRANS**COM* member agencies. The RA defines the particular communication flows that would be needed as well as the common databases and relational database links that enable effective communication and the sharing of data and information to occur among the many centers.

Without the availability of the Standards it is felt that the process would have taken much longer than it has. The desire of the ***TRANS**COM* member agencies to have a standards-based system made arriving at a design consensus easier and faster than would otherwise have been possible. The member agency buy-in process was greatly aided by the existence of the Standards. Also, the use of the Standards facilitated the main system developer in obtaining the cooperation of the other system development consultants working in the region. So far there have been several other lessons learned by this implementation, which included the following:

- The RA should have proceeded earlier than it did prior to efforts to physically connect-up many agencies, some of their vendors, and attempting to distribute information.

- Adequate and sufficient time is needed, particularly in a complex multi-agency situation, to review and address comments and concerns expressed by specific agencies. Because agency buy-in is a multi-year commitment to a specific set of operations tools, issues such as what information is needed, what screen layout to use, the content of GIS maps, and the specific site configurations can take a while to resolve.

- ***TRANS**COM* specified that only one software should be used in the center-to-center communications, which they commissioned to be developed. That has facilitated reducing the number of interfaces that need to be written to access the software. The software is owned by ***TRANS**COM* and they make it available to the constituent members free of charge.

Dallas/Fort Worth Center-to-Center Project: The State of Texas has a number of Traffic Management Centers (TMCs) either deployed or in final stages of development including ones in Dallas/Fort Worth (DalTrans and TransVISION). A Center-to-Center Communications Project was developed that would utilize ITS National Standards to allow traffic conditions information to be gathered and displayed and provide the capability to perform device command and control from dissimilar TMCs. The project is being implemented using the evolving Traffic Management Data Dictionary (TMDD) Standard as well as the MS/ETMCC Standard. The implementation approach is being performed in a phased manner with Phase 1 having an Internet based traffic map containing speed and incident information and a Graphical User Interface to provide that organizations with no TMC could inject incident information. Phase 2 includes exchange of device status information and device control capability between TMCs, where the devices include DMS and CCTV.

Regarding the specific technical approach, the project must interconnect several dissimilar traffic management systems. In order to create the center-to-center environment, interfaces to the existing systems are created. The data from these interfaces will communicate with the existing system in a “system specific” format. The data being deposited into the center-to-center environment will be converted to a standard format that is based on the TMDD Standard. This implementation also required the development of a number of custom applications in order to enable the interconnection and interface with specific proprietary infrastructure of a TMC or other center. In that customization, the data is converted in format to the standard ones of the TMDD Standard and MS/ETMCC Standard to enable transmission to other TMCs. In Phase 1 of the project several custom applications were developed related to the Standards. Phase 2 of the project added the ability using message sets to provide remote command/control of ITS devices (which includes DMS, LCS, and CCTV).

Regarding lessons learned, the ITS National Architecture is still a work in progress. Projects such as this one demonstrate that components of the architecture are mature and ready for deployment to operational TMCs. The center-to-center building blocks that were used provide a basic set of functionality that could be used in a number of environments where center-to-center communications needs to occur. While the initial cost of using standards is not trivial, a well-designed implementation should foster the reuse of source code and in the long run make center-to-center communications a reality for TMCs.

9.6 Accounting for Subsequent Revisions to the MS/ETMCC Standard

System implementers and operators of Traffic Management Systems should anticipate that revisions to the MS/ETMCC Standard will occur. Here too the Steering Committee has been dealing with some dilemmas.

The TMDD Steering Committee has been working on revisions even while the MS/ETMCC Standard was being balloted and approved. It is important that the MS/ETMCC Standard be thorough and well thought out, so that sufficient time needs to be taken to have a workable Standard. However, there is also a need to have useful and appropriate materials in the hands of practitioners as soon as feasible so that they have proper tools to better meet their responsibilities. Such an approach of moving forward with the MS/ETMCC Standard while still working on revisions has been taken as a way to address this dilemma.

There are various reasons that system implementers and operators also need to anticipate revisons to the MS/ETMCC Standard. As just discussed in the preceeding sub-section, the MS/ETMCC Standard has not yet been widely deployed nor field tested. The MS/ETMCC Standard may therefore be subject to future changes as a result of future operational deployments and real world field testing. Another reason to anticipate changes in the MS/ETMCC Standard is due to changes in associated standards, which is discussed in the next sub-section.

To help account for such potential subsequent revisions to the MS/ETRMCC Standard users should periodically check the ITE (www.ite.org) and AASHTO (www.aashto.org) websites for information on the status on any such revisions.

9.7 Expectation of Future Changes in Associated Standards

System implementers and operators of Traffic Management Systems should also anticipate that associated standards might change in ways that will affect the MS/ETMCC Standard. The many ITS standards that are still under development are each like a moving target. While a system implementer or operator may pause to focus and aim on one, when they search for the next to deal with it, that standard may have moved relative to the first.

As noted in Section 13 below on relationships to other standards, there are several other standards on which the MS/ETMCC Standard has been particularly dependent, such as IEEE P1488. Like the MS/ETMCC Standard, those standards will also likely go through their own maturation and development process. The net effect then will be that when those standards change they might necessitate or precipitate a change in the MS/ETMCC Standard.

As an example, the TMDD Standard has already been affected by changes and an update of the IEEE P1488 Standard. The initial work done in developing the MS/ETMCC Standard relied on the IEEE P1488 Standard at the time, which has been subsequently updated. Some of the revisions that are presently under consideration for the MS/ETMCC Standard have been done to respond to the changes to that other standard.

10 GLOSSARY AND DEFINITIONS

10.1 Abbreviations and Acronyms

Table 10.1 Glossary	
Abbreviation and Acronym	**Full Name**
AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standards Institute
APTS	Advanced Public Transportation Systems
ASC	Actuated Signal Controller
ASN.1	Abstract Syntax Notation One
ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management System
AVI	Automated Vehicle Identification
AVL	Automated Vehicle Location
CASE	Computer-Aided Software Engineering
CCTV	Closed-Circuit Television
COTS	Commercial Off-The-Shelf
CS	Conceptual Schema
CVISN	Commercial Vehicle Information Systems And Networks
CVO	Commercial Vehicle Operations
DBMS	Database Management System
DC	Data concept
DE	Data element
DEC	Data element concept
DMS	Dynamic Message Sign
DSRC	Dedicated Short Range Communications
E911	Enhanced 911
EDI	Electronic Data Interchange
EMMS	Emissions Management System
EMS	Emergency Management System or Emergency Medical Services
EPA	Environmental Protection Agency
ES	external schema
ESS	Environmental Sensor Station

Table 10.1 Glossary	
Abbreviation and Acronym	**Full Name**
ET	entity type
ETTM	Electronic Toll And Traffic Management
FGDC	Federal Geographic Data Committee
FMS	Fleet Management System
HAR	Highway Advisory Radio
GIS	Geographic Information System
GPD	Generic Property Domain
ID	Identification
IEEE	Institute of Electrical and Electronics Engineers
IRDS	Information Resource Dictionary System
IS	Internal Schema
ISO	International Organization for Standardization
ISP	Information Service Provider
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation System(s)
MS/ETMCC	Message Set for External Traffic Management Center Communication
NTCIP	National Transportation Communications for ITS Protocols
PR	Property
SAE	Society of Automotive Engineers
TCIP	Transit Communications Interface Profiles
TMC	Traffic Management Center
TMDD	(Advanced) Traffic Management (System) Data Dictionary
TMS	Traffic Management System
TrMC	Transit Management Center
TrMS	Transit Management System
TRSP	Traffic-Responsive
VD	value domain
VIN	Vehicle Identification Number

10.2 Definitions

The following table gives the terms and definitions that are used in the TMDD and/or MS/ETMMC Standards. The definitions from the TMDD Standard were based upon IEEE 1489-1999 Version 0.1.1. The user is referred to the IEEE Standard for more details as well as examples of some of the terms.

Table 10.2 Definitions

Term, Abbreviation or Acronym		Definition
7.2.1	Altitude	Elevation above or below a reference datum, the z-value in a spatial address. See also elevation.
7.2.2	Application-specific data dictionary	A data dictionary specific to a particular implementation of an ITS application, including all internal and external schema definitions used by that application.
7.2.3	Application-specific message set	A message set specific to a particular implementation of an ITS application, including all data dictionary definitions used by that application.
7.2.4	Area	A generic term for a bounded, continuous, two-dimensional object that may or may not include its boundary.
7.2.5	Artery	A heavily traveled signalized surface street. Generally includes multiple lanes, with complex intersection geometrics and traffic patterns. Major traffic flows generally found along artery. Minor flows at cross streets.
7.2.6	ATIS	Advanced Traveler Information Systems/Subsystem. An ITS functional area.
7.2.7	ATMS	Advanced Transportation Management Systems/Subsystem. An ITS functional area.
7.2.8	Attribute	Any describing characteristic of an entity.
7.2.9	Cartesian coordinates	A two-dimensional x,y location of a point on a plane in relation to two intersection straight lines (axes). If the axes are perpendicular to each other, the coordinates are rectangular; if no t, they are oblique. By convention, the x-axis measures the horizontal distance and the y-axis measures the vertical distance from the origin point of intersection. An x,y coordinate defines every point on the plane. Relative measures of distance, area and direction are constant throughout the Cartesian coordinate plane.
7.2.10	Classification scheme	A scheme for the arrangement or division of entities into groups based on properties that the entities have in common.
7.2.11	CCTV	Closed-Circuit television camera field device.
7.2.12	Concept	A unit of thought constituted through abstraction on the basis of characteristics common to a group of entities.
7.2.13	Controller	An electromechanical traffic device that can be used to control traffic signals and other field devices.
7.2.14	Coordinates	Pairs of numbers expressing horizontal distances along orthogonal axes; alternatively, triplets of numbers measuring horizontal and vertical distances.
7.2.15	Coordinate system	A reference system for the unique definition of a location of a point in n-dimensional space.

Table 10.2 Definitions

Term, Abbreviation or Acronym		Definition
7.2.16	Data	Representations of static or dynamic entities in a formalized manner suitable for communication, interpretation, or processing by humans or by machines.
7.2.17	Database	Collection of information structured in an organized way, typically held and maintained in a computer system.
7.2.18	Data concept	Any one of a group of data dictionary structures defined in IEEE 1489-1999, Version 0.0.7 (e.g., data element, data element concept, entity type, property, value domain) referring to physical objects that can be identified with explicit boundaries and meaning and whose properties and behavior all follow the same rules.
7.2.19	Data dictionary	An information construct for documenting, storing and retrieving the syntactical form (i.e., representational form) and some semantics of data elements.
7.2.20	Data element	A data item that is the basic building block of a data dictionary. A syntactically formal representation of some single unit of information of interest (such as a fact, proposition, observation, etc.) with a singular instance value at any point in time, about some entity of interest (e.g., a person, place, process, property, object, concept, association, state, event). A data element is considered indivisible in a certain context. Defined by a set of data descriptors found in IEEE 1489-1999, Version 0.0.7, Draft Standard for Data Dictionaries for Intelligent Transportation Systems, 9 Oct., 1997.
7.2.21	Data element concept	An expression of the inherent concept embodied in a data element without regard to the value domain(s) by which it can be physically represented.
7.2.22	Data registry	An advanced data dictionary that contains not only information about data elements in terms of their names, representational forms and usage in applications, but also about the semantics or meaning associated with the data elements as concepts that describe or provide information about real or abstract entities. A data registry may contain abstract data concepts that do not get directly represented as data elements in any application system, but which help in information interchange and reuse both from the perspective of human users and for machine-interpretation.
7.2.23	Data structure	Any construct (including data elements and data concepts) used to represent the contents of a data dictionary
7.2.24	Data type	A classification of the collection of letters, digits, and/or symbols used to encode values of a data element based upon the operations that can be performed on the data element.
7.2.25	Datum	A set of parameters and control points used to accurately define the three-dimensional shape of the Earth (e.g., as an ellipsoid). The corresponding datum is the basis for a planar coordinate system.
7.2.26	Detector	A traffic field device that indicates the presence or passage of vehicles or pedestrians.
7.2.27	Device	General nomenclature for any type of electromechanical field equipment including controllers, signals, dynamic message signs, highway advisory radios, etc.
7.2.28	Digital data	Data represented in a computer-compatible format.
7.2.29	Directed links	Links bounded by start and end points.
7.2.30	DMS	Dynamic Message Sign field device.
7.2.31	Elevation	A vertical distance below or above a reference surface. Terrain elevation is expressed with reference to mean sea level (MSL).

Table 10.2 Definitions		
Term, Abbreviation or Acronym		**Definition**
7.2.32	EMMS	Emissions Management System/Subsystem. An ITS functional area.
7.2.33	EMS	Emergency Management System/Subsystem. An ITS functional area.
7.2.34	Entity	Anything of interest (such as a person, place, process, property, object, concept, association, state, event, etc.) within a given domain of discourse (in this case within the ITS domain of discourse).
7.2.35	Entity type	The construct used to represent an entity in ITS data dictionaries.
7.2.36	ESS	Environmental Sensor Station – provides sensor measurements for roadway air quality and weather conditions
7.2.37	Event	A traffic element that represents the singular occurrence of any abnormal condition that adversely effects traffic operations. Events maybe unplanned (i.e. a multi-vehicle roadway accident) or planned, (i.e. a maintenance lane closure).
7.2.38	Foreign data dictionary	A data dictionary developed by a non-ITS community.
7.2.39	Functional-area data dictionary	A data dictionary that is intended to standardize data element syntax, and semantics, within and among application areas within the same functional area. NOTE—Functional-area data dictionaries contain among their contents refined or synthesized composites of the contents of application-specific data dictionaries, primarily in the form of logical application data elements.
7.2.40	Geodetic datum	A mathematical model of the earth's shape. A geometric set of five quantities that serve as a location reference or base for other quantities. The five quantities are the latitude and longitude of an initial point, the azimuth of a line from this point and two constants necessary to define the terrestrial spheroid.
7.2.41	Geographic coordinates	The quantities of latitude and longitude that define the position on the Earth with respect to the reference spheroid or ellipsoid.
7.2.42	HAR	Highway Advisory Radio field device.
7.2.43	Identifier	A means of designating or referring to a specific entity instance.
7.2.44	Incident	An unplanned randomly occurring traffic event that adversely effects normal traffic operations. For example, a multi-vehicle roadway accident is an incident.
7.2.45	Information Service Provider (ISP)	A public or private entity responsible for gathering, fusing, analyzing and reporting transportation related information motorists and other transportation users.
7.2.46	Instance	An individual occurrence of an entity that belongs to a particular type of entity.
7.2.47	Intersection	Two or more crossing roadways in a surface street network. Generally, an intersection involves conflicting traffic movements and active control devices.
7.2.48	Intelligent Transportation Systems (ITS)	Systems that apply modern technology to transportation problems. Another appropriate meaning of the ITS acronym is integrated transportation systems, which stressed that ITS systems will often integrate components and users from many domains, both public and private.
7.2.49	Interoperability	The ability to share information between heterogeneous applications and systems.
7.2.50	ITS Databus	An electronic implementation of a device layer where electronics components related to advanced vehicle functions can interoperate.
7.2.51	Linear referencing	Process of identifying location(s) on a transportation network or specific link in a network by specifying a start position, direction and distance along a particular route.
7.2.52	Link	A network element that represents the one-way network connection between two nodes. A link carries traffic in a one direction. For example, a link can represent the traffic flow between two interchanges on the mainline of a freeway.

Table 10.2 Definitions

Term, Abbreviation or Acronym		Definition
7.2.53	Link Id	An identifier assigned to a link. Link-Id may be arbitrary, or may be assigned by convention to assure that multiple occurrences of the same Id will not occur within one network or within the universe of similar networks or databases.
7.2.54	Link referencing	System that identifies a link in a network, and returns its Id value to an external application.
7.2.55	Location referencing system	System of determining the position of an entity relative to other entities or to some external frame of reference.
7.2.56	Map database	A collection of map data, possibly in digital form.
7.2.57	Message	A grouping of data elements and message attributes, used to convey information. For the purposes of this document, a message is an abstract description using a message set template; not a specific instance of transmission.
7.2.58	Message group	A collection of message sets referenced to a specific ITS functional area
7.2.59	Message set	A collection of messages referenced to a specific ITS function.
7.2.60	MS/ETMCC	Message Set for External Traffic Management Center Communication. This is a functional area message set.
7.2.61	Message set template	An abstract structure addressing the data and syntax used to specify the requirements and properties of ITS messages, as well as rules for producing message set standards.
7.2.62	Meta	A wording denoting a description that is one level of abstraction removed from the entity being described.
7.2.63	Meta attribute	In a data dictionary or data registry, a documenting characteristic of a data concept.
7.2.64	Meta data	Data that defines and describes other data.
7.2.65	Meta entity	In a data dictionary or data registry, a structure used to document a data concept.
7.2.66	Model Deployment Initiative	One of the joint public-private programs to implement and test integrated ITS systems and infrastructure in the U.S.
7.2.67	Name	An indexical term used by humans as a means of identifying data elements and other data concepts.
7.2.68	Network	A connected directed set of links and nodes that represent a physically connected set of roadways and intersections.
7.2.69	NTCIP	National Transportation Communications for ITS Protocols, A set of communication protocols, for data transfer, between an operation center and roadside devices.
7.2.70	Node	A network element that represents the starting and/or terminating location of any number of network links. For example, a node can represent a roadway intersection or the merge of two freeways.
7.2.71	Organization-contact	The traffic or transportation organization that has operational jurisdiction for a specific network of traffic highway and/or surface streets and/or combination.
7.2.72	Organization-resource	The public or private organization that has operational jurisdiction of transportation related equipment, facilities or vehicles.
7.2.73	Phase	The right-of-way, change and clearance intervals in a traffic signal cycle assigned to any independent movement of traffic.
7.2.74	Preempt	The transfer from a normal signal control mode to a special signal control mode at an intersection. Used for assigning a green phase to approaching priority vehicle.
7.2.75	Probe	A traffic field device that electronically reads the identification of a passing vehicle.

Table 10.2 Definitions

Term, Abbreviation or Acronym		Definition
7.2.76	Property	A documenting characteristic of an entity type that is used to group and differentiate individual entities.
7.2.77	Ramp meter	A traffic field device that directs entrance ramp vehicles to stop and proceed in accordance with metering rates.
7.2.78	Restricted maneuver	A prohibition of movement from one roadway (link) to another roadway (link) due to a physical impediment, regional restriction, one-way flow of traffic, or a posted restriction. There may be multiple restrictions pertaining to any link and these restrictions may be limited to a specific time of day and/or day of the week.
7.2.79	Route	An aggregation of sequentially connected links and nodes in a network typically denoting an intended or scheduled path of a transport vehicle. A single transversal of a route by a vehicle constitutes a trip.
7.2.80	Routing	The problem of calculating least-time, least-cost, or other optimized path (route) through a road network.
7.2.81	Schema	An abstract description of the structure of data.
7.2.82	Section	A surface street traffic sub-network of signalized intersections that are inter-connected and have a timing relationship between them.
7.2.83	Semantics	The meaning, including concept and use, associated with a given data element or message.
7.2.84	Spatial data	Information about the location, shape, relationships, and attributes of geographic features.
7.2.85	Street address location	Translating a user-oriented place specification (e.g., street address, intersection, vanity address, named place) to a specific object (node or link) in a database.
7.2.86	Street address range	The range of street numbers associated with a street or a particular name, usually within a given area.
7.2.87	Syntax	The structure of expressions in a language, and the rules governing the structure of a language. ITS message syntax is ASN.1 language.
7.2.88	Three-schema architecture	A structured way of organizing the contents of a data dictionary that allows for the separation of the meaning of data concepts from their internal physical implementations in storage media and their external presentation to users or application programs.
7.2.89	Timing plan	A set of cycle lengths, splits and offsets within a section of signals.
7.2.90	TMS	Traffic Management System/Subsystem. An ITS functional area.
7.2.91	TrMS	Transit Management System/Subsystem. An ITS functional area.
7.2.92	TRSP	Traffic-Responsive, A system in which a master controller either selects or computes signal timing based on the real-time demands of traffic as sensed by vehicle detectors.
7.2.93	Value domain	An expression of a specific and explicit representation of a data element within the ITS domain.

11 BIBLIOGRAPHY

11.1 Selected Reading List and References

Table 8.1 Selected Reading List and References

Subject	**Reference**
Normative References, for the TMDD Standard	IEEE 1489-1999 Version 0.1.0 Draft Standard for Data Dictionaries for Intelligent Transportation Systems. (Note – at the time of the TMDD balloting and formal standards approval by ITE and AASHTO, the IEEE 1489-1999 was still in ballot and revision to comments. The version used for the TMDD was the latest update available; but, it may vary slightly from the final version when formally approved by the IEEE).
Normative References for the MS/ETMCC Standard	IEEE P1488 Version 0.0.6 Draft Standard for Message Set Template for Intelligent Transportation Systems, 17 Oct. 1997.
Informative References, for the TMDD Standard	Strategic Plan for the Development of an ATMS Data Dictionary, Version 1.0, March 8, 1996, Institute of Transportation Engineers, 525 School Street SW, Suite 410, Washington, DC, 20024.
	ISO/IEC 11179 Information technology – Specification and standardization of data elements Part 1: Framework for the generation and standardization of data elements Part 2: Classification of concepts for the identification of domains Part 3: Basic attributes of data elements Part 4: Rules and guidelines for the formulation of data definitions Part 5: Naming and identification principles for data elements Part 6: Registration of data elements ISO/IEC Copyright Office, Case postale 56, CH-1211, Geneva 20, Switzerland
Informative References for the MS/ETMCC Standard	IEEE 1489-1999 Version 0.0.7 Draft Standard for Data Dictionaries for Intelligent Transportation Systems, 9 Oct. 1997.
	SAE-J2353, Revision 1.0.0, Data Dictionary for Advanced Traveler Information Systems (ATIS), 26 Feb. 1998.
	SAE-J2354 Revision 1.0.0, Message Sets for Advanced Traveler Information Systems (ATIS), 15 Dec. 1998.
	IEEE P1512 Version 0.0.2, Draft Standard for Incident Management Message Sets for Intelligent Transportation Systems, 18 May, 1998.
	ST-ITS-TCIP-SP, Transit Communications Interface Profiles Standard on Spatial Representation Objects, Version 1.0, 20 Feb. 1998.
	USDOT/FHWA, ITS National Architecture - Logical Architecture: Volume 1– Description, June 1996.
	Joint AASHTO/ITE/NEMA TS3. DATEX-199X, NTCIP Application Profile-Data Exchange-ASN.1, Drafter Ver. 98-01.02, 17 Feb. 1998, Part 3 – The DATEX-ASN Data Exchange Format.
	NEMA Standards Publications TS3.1-3.14; National Transportation Communication for ITS Protocol, Communication Standards and Device Object Definitions.
	Location Reference Message Specification (LRMS): Spatial Data Interoperability Protocol for ITS Rev. B. 5 May 1997.
	ISO/IEC 8824-1:1994, Abstract Syntax Notation One (ASN.1)

Table 8.1 Selected Reading List and References	
Subject	**Reference**
	ASN.1 Tool Set: Reference Manual for UNIX, VMS, OS/2 and MS-DOS, Open Systems Solutions Inc. June 1992.
	ASN.1 Tool Set: User’s Guide for UNIX, VMS, OS/2, Windows/NT and MS-DOS, Open Systems Solutions Inc., June 1994.

12 PROCESS FOR REQUESTING UPDATES AND REVISIONS

12.1 Purpose and Options

There will be a continuing need to answer questions, provide interpretations and clarifications, and revise or enhance the TMDD and MS/ETMCC. The steering committee needs a clearly defined process and timeline for these activities. In short, we need:

- A mechanism to make decisions on how to interpret the application of a standard,
- An arbitration process, and
- A mechanism to quickly exchange information and dynamically make changes to the standard.

We anticipate questions, comments, or requests in at least the following categories:

1. What was the rationale for selecting a particular approach in the TMDD or MS/ETMCC?

2. I have run into a particular problem implementing the TMDD or MS/ETMCC. Do you have any suggestions on how to approach this problem? Do you know anyone who has run into this situation and resolved it?

3. I don’t understand how to implement a particular data element or message set. Can you provide clarification?

4. I have found a problem with implementing the standard and suggest the following revision.

5. I have found a gap in the standard and suggest the following revision or addition.

The Steering Committee discussed three primary options for an approach to changing the TMDD or MS/ETMCC.

1. Filter questions, comments, and suggestions first by an ITE representative, an AASHTO representative, and a consultant expert. The process would include a mechanism to feed back the questions to the e-mail reflector.
2. Provide a reflector for submitting questions or suggested modifications, via a standard form, and have experts assigned to answer specific types of questions. The answers would go back out via the reflector so others could address answer.
3. A third approach would be to have a moderator that would pass the question to the expert(s) and the answer would be reflected.

The working group discussed these options, selected the third option and refined it.

12.2 Recommended Approach

The recommended approach is centered on a TMDD and MS/ETMCC website that includes:

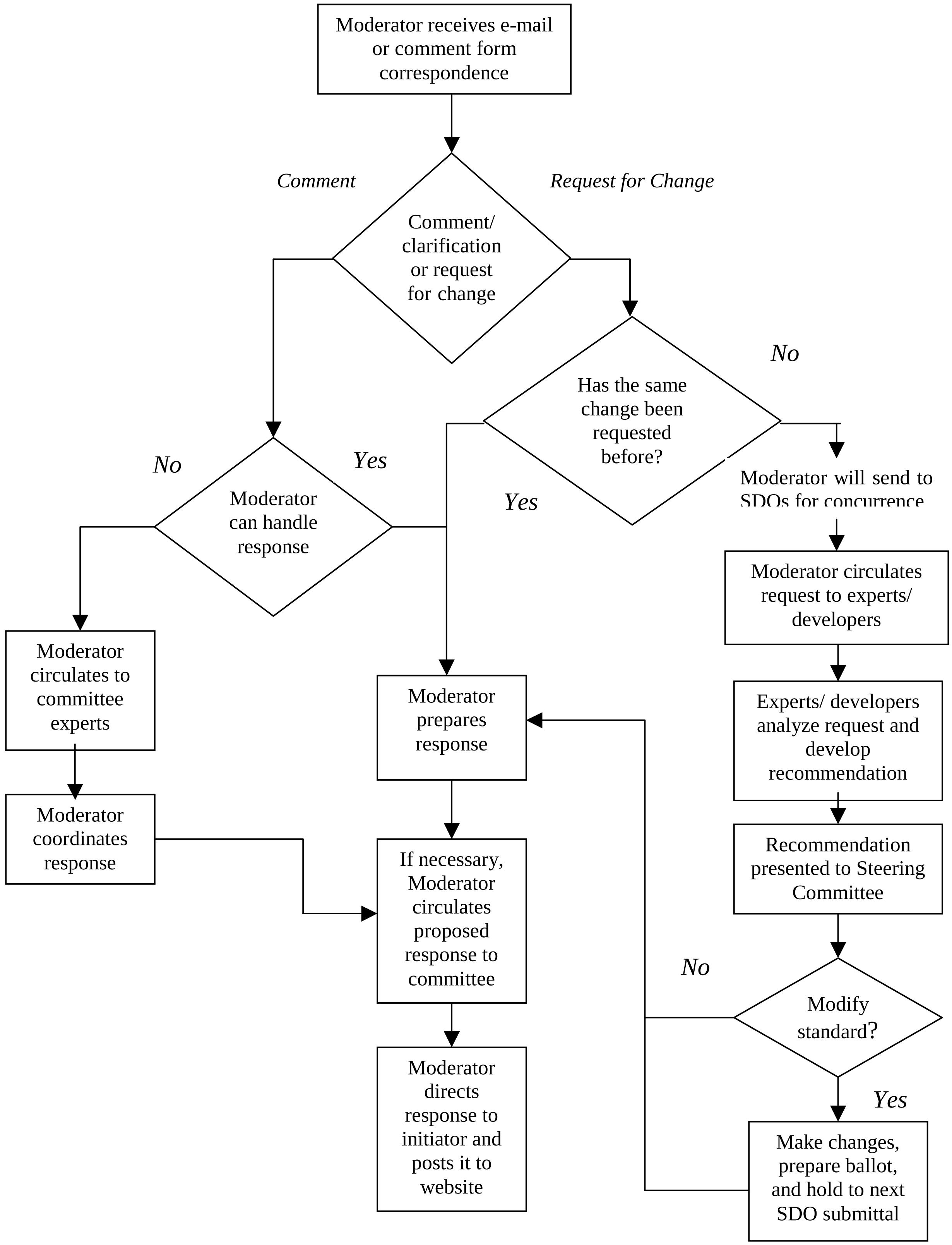
- Data dictionary and message set resources. Information that describes the effort and where to go to get the standards.
- Bulletin board function to post related information.
- Comment form to submit comments, questions, and suggested modifications.

There would also be a reflector established to facilitate discussion about TMDD and MS/ETMCC. The TMDD steering committee's consultant would moderate the reflector. The consultant would also receive the comment forms from the website. The moderator would be responsible to:

- Know who can address specific issues, distribute the comments and e-mail questions appropriately, and coordinate responses.
- Know what activity has been undertaken, what things have been proposed, and what things have been rejected and why. This will short-circuit some of the e-mail inquiries so that moderator can answer them directly.
- Post proposed changes to the website.

Finally, the work group proposes that the committee aims to officially pass changes on to the SDOs (ITE and AASHTO) for balloting once a year. (If the committee feels that an issue is time critical, there could be a ballot on a shorter time frame.) The work group recommends that the steering committee acts on individual changes as they arise and are resolved and hold the changes to be bundled into a ballot annually.

Exhibit 12.1: Recommended Process for Comments and Changes



13 EXAMPLE TMDD AND MS/ETMCC IMPLEMENTATIONS

This Section presents somewhat of a dilemma in that the TMDD & MS/ETMCC Standards are relatively still very new and it takes time to plan, specify, design, implement, and then operate for or with the new Standards. As of this time, the Steering Committee is aware of only a small number of initial efforts that are beginning to deploy the TMDD Standard and fewer still of the MS/ETMCC Standard. As a result there is a very limited amount of information to call upon now from which lessons learned can be drawn and included here. However, as best as can be done at this time guidance based upon those initial limited lessons learned is discussed, including when possible some pitfalls and how to avoid them.

The intent of the TMDD Steering Committee is that this Section will become more complete and thorough over time in subsequent updates of the Guide as more experience with using the TMDD & MS/ETMCC Standards are obtained.

Four of these initial examples are reported on here, where each is response to a different set of functional needs and requirements. As a result each is tending to emphasis use of different combinations of Sections of the TMDD & MS/ETMCC Standards, as shown in Exhibit 13.1.

Exhibit 13.1: Examples by Section of TMDD & MS/ETMCC Standards being Emphasized as of October, 2000

Application Examples	TMDD Standard Sections and Selected Partitions	MS/ETMCC Standard Groups and Selected Message Sets
New York Metropolitan ***TRANS****COM* Regional Architecture Database (RAD)	Section 1: Links and Nodes Section 2: Events, Incidents, Notification Alarms	Group 1. Roadway-Network Group 2. Network-State Group 3. Network-Events
Seattle, Washington North Seattle Advanced Transportation Management System	Section 3: Traffic Network, Traffic Signal Control, Traffic Detectors, Ramp Meter	
Maryland CHART Dynamic Message Signs	Section 4: Dynamic Message Signs	
Dallas-Fort Worth Center to Center Communications Project	Section 1: Links and Nodes Section 2: Events, Incidents, Notification Alarms Section 3: Traffic Network, Traffic Signal Control, Traffic Detectors, Ramp Meter	Group 1. Roadway-Network Group 3. Network-Events Group 6. Traffic –Control

The following briefly describes the particular applications and discusses any lessons learned to date. The discussion is organized by each application.

13.1 Transcom Regional Architecture Database

TRANS*COM* is a coalition of sixteen transportation and public service agencies in the New York-New Jersey-Connecticut metropolitan area. It was created in 1986 to provide a cooperative, coordinated approach to regional transportation management. ***TRANS****COM* was selected as one of the four Metropolitan Model Deployment Initiatives (MMDI) by the ITS Joint Program Office of the U.S. DOT. As a MMDI it is implementing a traveler information center and to make consolidated, multi-modal, multi-agency transportation information available to individual travelers. The application of the TMDD and MS/ETMCC Standards reported on here also relates to the effort to deploy the TRANSMIT system for managing incidents and traffic and the TRANSCOM Regional Architecture (RA). The TRANSMIT system will be using Automatic Vehicle Identification (AVI) from toll tags to monitor traffic, detect incidents and estimate travel times and speeds. This system will cover approximately 225 miles of freeways and parkways throughout the tri-state region.

To carry out its responsibilities to its constituent agencies ***TRANS****COM* is providing center-to-center communications among 47 Traffic Operations Centers (TOCs) with 52 workstations. That includes a number of state and county DOTs, bridge and tunnel authorities, police agencies, airports, and 6 major transit agencies. The intent of the Regional Architecture is to communicate messages about the tracking of incidents, construction closures, special events, and real-time traffic and transit conditions on the freeways, parkways and transit facilities among all of the workstations. The workstations are more than display terminals each having their own relational databases. There are also 8 servers that operate in a fully meshed fashion with all of the workstations. As of the fall of 2000 the servers were being deployed and a second round of agency testing was taking place. The workstation installation is expected to begin by the end of 2000.

The RA effort focuses on the tracking of incidents, etc. and not on the management of responses to them or on traffic control. The carrying out of such functions are a responsibility of the individual constituent agencies and are dealt with as necessary as part of each of their local architectures and systems.

This example is the most complex of the four implementations presented here and is probably among the most complex in the nation. The project managers and system developers chose to bring in the TMDD and MS/ETMCC Standards as soon as practical in order to effectively deal with the complexity resulting from needing to work with many agencies. The TMDD Section 1 on Links and Nodes and Section 2 on Events, Incident Notification, and Alarms were the ones most relied upon. The Message Set Groups most frequently used included Group1 on Roadway-Network, Group 2 on Network-State, and Group 3 on Network-Events, which emphasize incident and event tracking rather than the management of them

The RA project was begun subsequent to the initial efforts to integrate systems and data from the TRANSCOM member agencies. The RA project defines the data elements and message sets to use in the needed center-to-center communication. The RA project also defines the particular communication flows that would be needed as well as the common databases and relational database links that enable effective communication and the sharing of data and information to occur among the many centers.

Without the availability of the Standards it is felt that the process would have taken much longer than it has. The desire of the TRANSCOM member agencies to have a standards-based system made arriving at a design consensus easier and faster than would otherwise have been possible. The member agency buy-in process was greatly aided by the existence of the standards. Also, the use of the Standards facilitated the main system developer in obtaining the cooperation of the other system development consultants working in the region.

The implementation needed to develop supplemental sets of application-specific data elements and message sets, which included the following examples:

- In particular, the incident types needed to be expanded and a separate set was specified that better accounted for types of highway and transit incidents. The ***TRANS****COM* group had already logged over fourteen years of incident history prior to beginning to implement the Standards. They intend to suggest to the TMDD Steering Committee that consideration be given to having the Standards modified to recognize this expanded list of incident types.

- A supplemental set of generic messages were also developed that provided “Center-to-Center status” to enable the system to explicitly know that connections are not working.

- For some of the advanced traveler information system related information, it was necessary to add some message sets that conform to the Standards in order to stay consistent with messages that are typically used by the local operators.

- Other application-specific message sets dealt with generic alarms, static elements when adding in a new device, and geographic referencing for adding in links. The later in many systems is treated as a very static element, but their experience has been that needing to add in new links has been a very dynamic process.

These application-specific data elements and message sets were handled as supplemental, additional data elements or message sets above and beyond those included in the Standards. The intent was to stay true to the Standards yet have the benefit of more locally applicable data elements and message sets.

As noted above, to date two rounds of constituent operating agency reviews have taken place. The ***TRANS****COM* project manager and system developer have found the review comments and suggestions to be very good ones that when addressed have improved the overall implementation. These changes are in the process of being incorporated into a major system release for December of 2000.

There were several lessons learned by this implementation, which included the following:

- The RA should have proceeded earlier than it did prior to efforts to physically connect-up many agencies and some of their vendors and attempting to distribute information.

- Adequate and sufficient time is needed, particularly in a complex multi-agency situation, to review and address comments and concerns expressed by specific agencies. Because agency buy-in is a multi-year commitment to a specific set of operations tools, issues such as what information is needed, what screen layout to use, the content of GIS maps, and the specific site configurations can take a while to resolve.

- ***TRANS****COM* specified that only one software should be used in the center-to-center communications, which they commissioned to be developed. That has facilitated reducing the number of interfaces that need to be written to access the software. The software is owned by ***TRANS****COM* and they make it available to the constituent members free of charge.

The above information was gathered by personal interviews. For more information on the technical aspects of this implementation of the Standards, contact Sanjay Patel or Tom Batz of ***TRANS****COM* in Jersey City, New Jersey at 201-963-4033 or John C. Wintermute of PB Farradyne Inc. in Rockville, Maryland at 301-816-1837.

13.2 North Seattle Advanced Transportation Management System

The North Seattle Advanced Transportation Management System is a project being done for the Washington Department of Transportation. One of the main intents of the project was to develop a standardized approach that the Department could use in interrelating an arterial traffic control system with their Freeway Management System. The North Seattle area was a convenient test case of for developing such an approach. It was also seen as a test of using DATEX.ASN as the communication protocol standard.

The project started prior to the Traffic Management Data Dictionary Standard being developed. The project began using proprietary data elements and protocols of a vendor. With the availability of the TMDD Standards, the focus of the project was shifted somewhat to develop a translation of data elements to those of the TMDD Standard, which was consistent with the intent of the project to develop a standardized approach that could be used in interrelating arterial traffic control systems with the Freeway Management System. By the summer of 2000, the actual development of the approach, Phase I, has been completed and a system build test has been done prior to live deployment. Phase II is the delivery and Phase III will focus on the role of DATEX.ASN.

Technically the project is designed to collect data from local traffic controllers various operating characteristics on synchronization, splits, and offsets as well as system detector data such as volumes and occupancy. In developing the approach, the consultant took the existing definitions of the desired data elements and found the closest matching one from the TMDD Standard and that worked with the DATEX.ASN protocols. The “tool kit” to benchmark the DATEX.ASN protocol developed by the group that is now Iteris was used. There was also some expansion of the data elements to include some application-specific ones. One example was the need to have a time stamp based upon Greenwich Mean Time, which is not a data element in the TMDD Standard.

In total, about 25 to 30 data elements from the TMDD were used for the project approach, while a handful of data elements needed to be application-specific. The latter included cycle lengths for the controllers, offsets, phase data on the splits, the system clock, as noted above, and alarms for the controllers, such as the door is open or the controller is in flash mode. To some extent the need to develop these application-specific data elements, as contrasted to already having them provided for in the TMDD Standard, was viewed as a short-coming of the TMDD Standard, rather than providing for local flexibility.

There were several lessons learned by this implementation, which include the following:

- There can be a long learning curve for the system developer to become sufficiently acquainted with the TMDD Standards with their first experience with it. The categorizations of the data elements were not always grouped as expected and it was hard to figure out where to look for a particular concept. The consultant team found it necessary to call in staff from another office, who had direct experience in developing the TMDD Standard, in order to significantly short-cut the learning curve.

- It would have been useful to have a "check-list" or "how-to-do" guide in trying to figure out using the TMDD Standard. For example, it was not clear to the consultants that the message set standard was also being developed and they project wound up developing their own message sets for communication purposes by piecing together raw TMDD data elements.

- There is some concern and uncertainty about the actual way to do the implementation of data element transfers with the protocol standards of DATEX.ASN or with CORBA. The DATEX.ASN "tool kit", which was found to be very helpful may not continue to be supported and without it further development would be very difficult. While CORBA could be used, there are perceptions of problems with using that too.

- The data elements for latitude and longitude where not specific or flexible enough regarding which projection system to reference, such as NAD 83, or one of the many other numerous projection systems.

The above information was gathered using personal interviews. For more information on the technical aspects of this implementation of the Standards, contact Thomas Saul of PB Farradyne, Inc. in Seattle, Washington at 360-297-3821.

13.3 CHART's Dynamic Message Signs

The State Highway Administration of the Maryland Department of Transportation has a Freeway Management System that is termed CHART, which stands for Coordinated Highways Action

Response Team. CHART has been undergoing a significant system upgrading. Among the purposes of the upgrading has been to migrate from a previous proprietary system to one with an open architecture, and to enable the more effective management of many detectors and an expanding set of Dynamic Message Signs (DMS). The timing was such that the use of the new TMDD Standard is being followed in the system upgrading.

The system design and software consultants are using the TMDD Standard. When one or more particular data elements are defined in the needs and requirements process that is being used, a check is made to see if there is a data element from the TMDD Standard that can meet the intended use. The work has progressed in a staged fashion, with an initial effort being given to the DMSs in Release 1, Build 1. The second build is focusing on incident events and Highway Advisory Radio (HAR) applications. The deployment of a system of improved detectors and the establishment of a data archiving functionality are among the features being worked on for subsequent releases.

The specifications called for the upgrading to follow the National ITS Architecture, with no explicit task reference to the TMDD Standard. It was however referenced in the proposal by the consultant. As of the summer of 2000 the work associated with the upgrading has deployed the initial build, with work for Build 2 for incident events and HAR in the design phase.

There were several lessons learned by this implementation, which include the following:

- It can be a challenge to interrelate the TMDD with the NTCIP protocols for device control. Careful effort is required to match data elements and concepts and to avoid redundancy and conflict.

- The documentation available with the TMDD Standard was not clear enough and required study and educated guesses in order to specify data elements in accordance with the TMDD Standard.

- The TMDD Standard appears to be written with flexibility in mind. In the initial work, only a few application-specific data elements seemed necessary, but more are being anticipated in the forthcoming phases of the work. An example of an application-specific data element relates to tracking the organizational ownership and deployment of arrow boards and portable DMSs dispatched to an incident or construction site. It was necessary to refine the status and notification data elements to address that.

- If the client is very set on what particular types of data they want to use, the resulting needed data elements may not necessarily map well to the TMDD Standard. It is anticipated that the data elements that will be used for events and incidents may need to be significantly different from those provided for in the TMDD Standard.

- Regarding the development of message sets and the use of the MS/ETMCC Standard the CHART implementation is using CORBA protocols.

In general, the availability of the TMDD Standard has been very helpful, describing data elements well. In addition the options that are available provides for needed flexibility.

The above information was gathered using personal interviews. For more information on the technical aspects of this implementation of the Standards, contact John Schumitz of PB Farradyne, Inc. in Rockville, Maryland at 301-816-1852.

13.4 Dallas/Fort Worth Area Deployment Using the National ITS Architecture

The State of Texas has a number of Traffic Management Centers (TMCs) either deployed or in final stages of development. These include ones in Dallas/Fort Worth (DalTrans and TransVISION). Collectively, the TMCs in Texas have been developed utilizing variants of at least four distinctly different system architectures. In 1999, the Texas Department of Transportation (TxDOT), along with the United States Federal Highway Administration (FHWA) initiated a program to develop a Center-to-Center Communications Project that would utilize ITS National Standards to allow traffic conditions information to be gathered and displayed. Additionally, the project implemented the infrastructure necessary, again using standards, to provide the capability to perform device command and control from dissimilar TMCs. The goals of the project include:

- The transfer, storage, and display of traffic conditions data
- Development of a web site to display traffic conditions on a regional basis having the data being drawn from dissimilar TMCs.
- The exchange of device status, command, and control requests: Devices supported include: Dynamic Message Signs (DMS), Lane Control Signals (LCS), and Closed Circuit Television (CCTV) cameras.

The project is being implemented using the evolving Traffic Management Data Dictionary (TMDD) Standard as well as the MS/ETMCC Standard. The use of ITS standards is expected to create a system that is reusable in other ITS application areas and provide the Dallas/Ft. Worth Metroplex with a baseline system that can be cost effectively extended in the future. The project executes in a Microsoft Windows NT environment. The software utilizes TCP/IP and DATEX/ASN to communicate data between computers. The software is designed to operate in a distributed fashion that will support a variety of hardware configurations. The implementation approach is being performed in a phased manner.

- **Phase 1:** An Internet based Traffic map containing speed and incident information was developed and a Graphical User Interface based application was provided so that organizations with no TMC could inject incident information.

- **Phase 2:** Includes exchange of device status information and device control capability between TMCs. Devices include DMS, LCS, and CCTV. Video snapshots were also included.

- **Phase 3:** Includes interface to the ATMSs in other major Texas cities (e.g. San Antonio, Houston, and Austin) so that a "Texas View" of traffic conditions can be displayed.

Regarding the specific technical approach, the project must interconnect several dissimilar traffic management systems. In order to create the center-to-center environment, interfaces to the existing systems will be created. The data from these interfaces will communicate with the existing system in a "system specific" format. The data being deposited into the center-to-center environment will be converted to a standard format that is based on the TMDD Standard. The project is being created using a series of building blocks. These building blocks allow the software to be utilized in a number of configurations by simply altering the configuration parameters of the software. The building blocks being developed include:

- **Data Provider:** receives data from an ITS system in a system specific format and converts the data to TMDD format and then transmits the data to other blocks.

- **ATIS Data Server:** receives traveler information data (e.g., speed, incident, lane closure, screen snaps) from multiple sources in TMDD format and stores the data. Data Extractor blocks subscribe to this block to receive the stored data in TMDD format.

- **Data Extractor:** receives data from the ATIS Data Server block in TMDD format and converts it to a system specific format.

- **Command/Control Sender:** interfaces to an ITS system to transmit command/control requests for ITS equipment.

- **Command/Control Receiver:** interfaces to an ITS system to receive command/control requests for ITS equipment.

This implementation also required the development of a number of custom applications in order to enable the interconnection of these building blocks given above to interface with specific proprietary infrastructure of a TMC or other center. In that customization, the data is converted in format to the standard ones of the TMDD Standard and MS/ETMCC Standard to enable transmission to other TMCs. In Phases 1 of the project several custom applications were developed related to the Standards, including the following:

- **Fort Worth TransVISION Interface:** An application which extracts data from Fort Worth's database centric TMC and converts the data to TMDD based format for transmission to a data provider.

- **Dallas DalTrans Interface:** An application that extracts data from the Dallas TMC and converts the data to TMDD based format for transmission to a data provider.

- **Incident GUI:** An application that allows the manual entry of incident information. The information is then transmitted to a Data Provider building block.

- **Web Server Application:** An application which receives data from a Data Extractor block and interfaces with ESRI's Internet Map Server (IMS) to display graphical maps featuring travel speeds and incident information to users through Internet Web browsers.

Phase 2 of the project added the ability to provide remote command/control of ITS devices (which includes DMS, LCS, and CCTV). This command/control takes the form of one TMC sending a request message set (specifying a control command) to another TMC. The receiving TMC then must decide if the command can be implemented. The custom applications developed to support this include the following:

- **Fort Worth TransVISION Interface:** An application that allows command/control requests to be transmitted/received by the TransVISION system.

- **Dallas DalTrans Interface:** An application that that allows command/control requests to be transmitted/received by the DalTrans system.

- **Remote ATMS GUI:** An application that allows device command/control commands to be issued and submitted to an ATMS for execution. This GUI is a standalone application that can be executed without having the need to have an ATMS system to issue command/control requests.

This work involved developing some application-specific message sets related to the MS/ETMCC Standard. In several of the major metropolitan areas in Texas extensive use is made of overhead lane control signals. The MS/ETMCC Standard does not have a message set that relates to such devices and communicating to other TMCs or centers the status of the lane configuration at a given time. As such, this project needed to develop one or more application-specific message sets in order to send messages out on the status of the overhead lane control signals.

Regarding lessons learned, the ITS National Architecture is still a work in progress. Projects such as this one demonstrate that components of the architecture are mature and ready for deployment to operational TMCs. The center-to-center building blocks described in this paper provide a basic set of functionality that could be used in a number of environments where center-to-center communications needs to occur. While the initial cost of using standards is not trivial, a well-designed implementation should foster the reuse of source code and in the long run make center-to-center communications a reality for TMCs.

The above information was gathered from a paper presented at ITE 2000 and by using personal interviews. For more information on the technical aspects of this implementation of the Standards, contact Steven W. Dellenback, of the Southwest Research Institute in San Antonio, Texas at 210-522-3914.