

6 IMPLEMENTATION 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 NaviGatorTM 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 <i>TRANSCOM</i> 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 were 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 preceding 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 preceding 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.

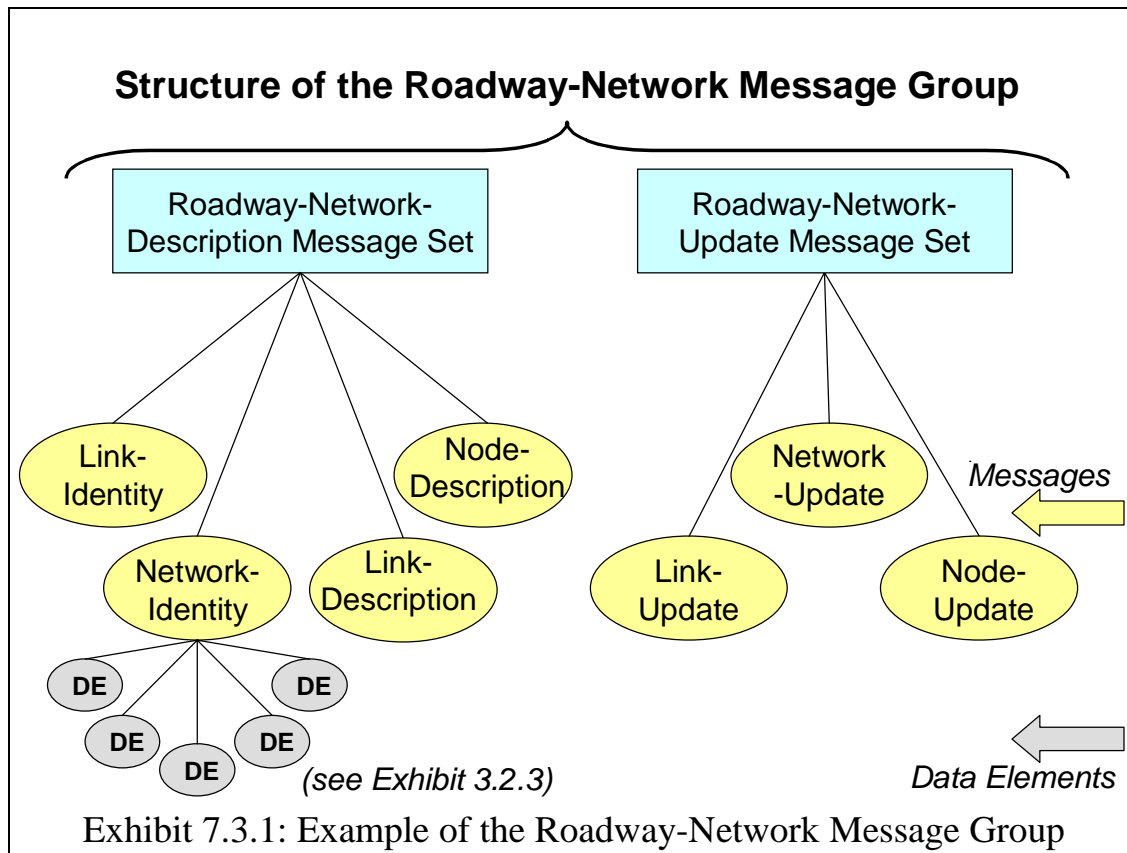
7.3 Specific Structure of the Messages and Message Set Formats

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.



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 PM₁₀, 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 IMPLEMENTATION 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 gauge and measure for themselves the ongoing 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/ETMCC 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.

TRANSCOM Regional Database Architecture: *TRANSCOM* 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 *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. 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 *TRANSCOM* 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 *TRANSCOM* 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 *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. 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.
- *TRANSCOM* 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 *TRANSCOM* 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 revisions to the MS/ETMCC Standard. As just discussed in the preceding 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/ETMCC 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.