



NMRA Standard	
21MTC Decoder Interface	
Dec 1, 2020	S-9.1.1.3 Draft

# 1 General

## 1.1 Introduction and Intended Use (Informative)

This standard defines a uniform multi-pole interface for vehicles for safe and quick installation or exchange of electronic modules (vehicle and function decoder or SUSI module, herein after referred to as decoder) for the purpose of control via Digital Command Control systems.

## 1.2 References

This standard should be interpreted in the context of the following NMRA Standards, Technical Notes, and Technical Information.

### 1.2.1 Normative

- S-9.1.1 DCC Interfaces, which specifies general DCC interface requirements

### 1.2.2 Informative

- TN-9.1.1.3 21MTC Decoder Interface, which provides commentary on the 21MTC decoder interface.
- TI-9.1.1 Sources for Connectors for DCC, which provides a list of manufacturer part numbers for DCC interface connectors.
- TI-9.2.3 Serial User Standard Interface for DCC, which provides information on SUSI
- RCN-121 Decoder Interface 21MTC, with which this standard is intended to be in harmony
- NEM 660 Electrical Interface 21MTC, with which this standard is intended to be in harmony.

### 1.2.3 Description of the Interface

The interface supports the connection of a motor, and a baseline of 8 function outputs, 2 input sensors and data bus expansion with options allowing up to 12 function outputs. The installation space and the size of the decoder are part of the interface. Vehicles with a factory-installed interface and decoder with the interface according to this standard must be clearly marked with the Logo 21MTC on the packaging.



The interface is defined for plugging the decoder directly into the vehicle. A connection via cable is not provided and such a design does not correspond to this standard.

## 1.3 Terminology

Term	Definition
Vehicle	Mobile model railroad device. This includes locomotives and other rolling stock.
Decoder	DCC receiver for controlling vehicle animation.
System Board	Electronic circuit board that is considered part of the vehicle which a decoder is intended to be plugged into. Also sometimes called a motherboard.
Train Bus	Serial User Standard Interface (SUSI)

## 1.4 Requirements

- 35 To meet this standard all mechanical and electrical values mentioned must be met and respected, unless otherwise noted. It is not necessary to implement all connections of the interface. The connections belonging to unimplemented features must remain unconnected. This applies to vehicles as well as for other devices that use this interface.

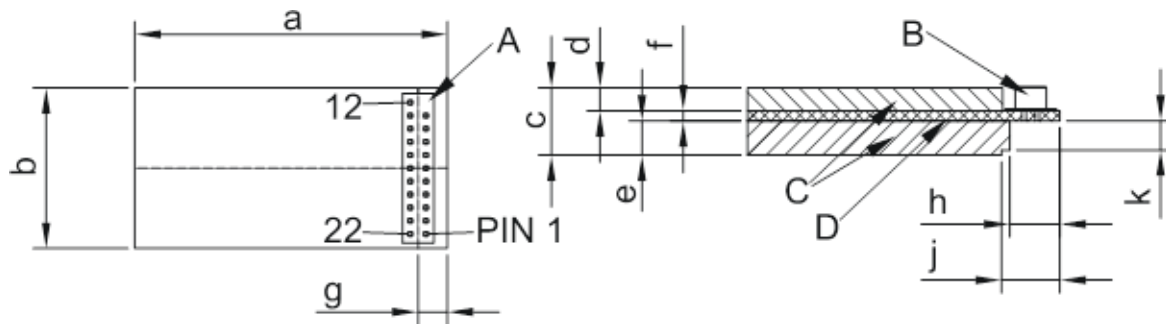
## 2 Mechanical Properties

- 40 On the vehicle side, the interface consists of a 22-pin, two-row strip of pins with a grid dimension of 1.27 mm and on the decoder side of the matching socket strip. To assure proper orientation Pin 11 is omitted and the associated socket is blocked. The pins have a length of 3 mm and either a square profile with an edge length of 0.40 mm or a round profile with a diameter of 0.43 mm. Pins  
45 and sockets have a gold-plated contact surface and a contact load capacity of max. 1 A.

### 2.1 Requirements for the decoder

- The dimensions of the decoder are a maximum of 30 (length) x 15.5 (width) x 6.5 (height) mm. The maximum assembly height on the side with the socket strip, hereinafter referred to as the top, is  
50 2.2 mm. On the side opposite the socket strip, hereinafter referred to as the underside, the maximum fitting height is 3.3 mm. The maximum thickness of the board is 1 mm. The center line of the socket strip is 2.8 mm away from the one short edge of the decoder. The socket strip is to be installed symmetrically to the decoder width. Drill holes must be provided in the circuit board, which allow the pin header to be inserted through the circuit board from below. A 4.8 mm wide strip of  
55 components must be kept free from the edge of the decoder on the underside where the socket connector is located. At a distance of 5.8 mm from the edge, the equipment height is limited to 2.8 mm. There is no need to drill a hole in the board at position Pin 11 of the socket strip. In order to ensure that there is no mix-up when installing the rotated variant (see Section 4), the position Socket 11 must also be completely sealed.

60



**Figure 1:** Decoder plan view (top visible) and a side view for compact plug variant.

A = index position Pin 11

C = components on the top and bottom

B = socket

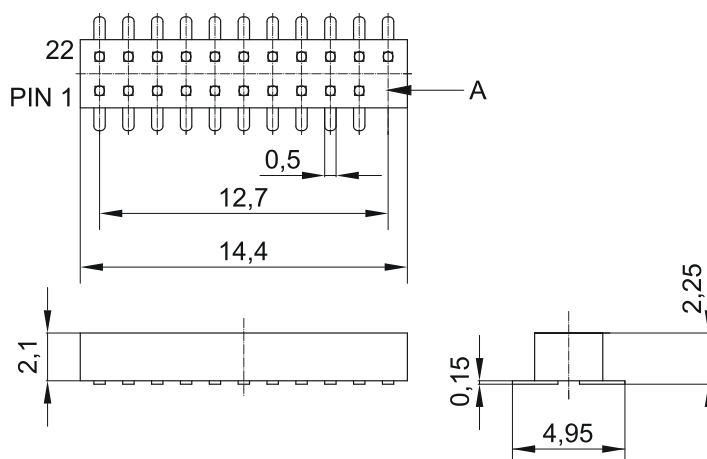
D = decoder board

The lower-case letters in Table 1 correspond to the following dimensions. Unless otherwise stated, all values are maximum dimensions.

#	Description	Measure
a	Length	30.0 mm
b	Width	15.5 mm
c	Total height	6.5 mm
d	Equipment height above	2.2 mm
e	Assembly height below	3.3 mm
f	Thickness of the board	1.0mm
G	Distance between the center of the socket strip and the edge	2.8 mm
H	Area to be kept clear on the underside	4.8 mm
j	Area with reduced equipment height	5.8
k	Reduced assembly height	2.8

**Table 1:** 21MTC Physical Dimensions

70 The following picture shows a typical example of a socket connector.



A = Index position Pin 11

**Figure 2:** Typical socket connections for decoders

2.2 Requirements for the vehicle

The installation space in the vehicle must be such that a decoder with maximum dimensions can be inserted without constraint. There should also be enough space be provided that the decoder can be pulled without tools.

The following image shows a typical example of a pin header.

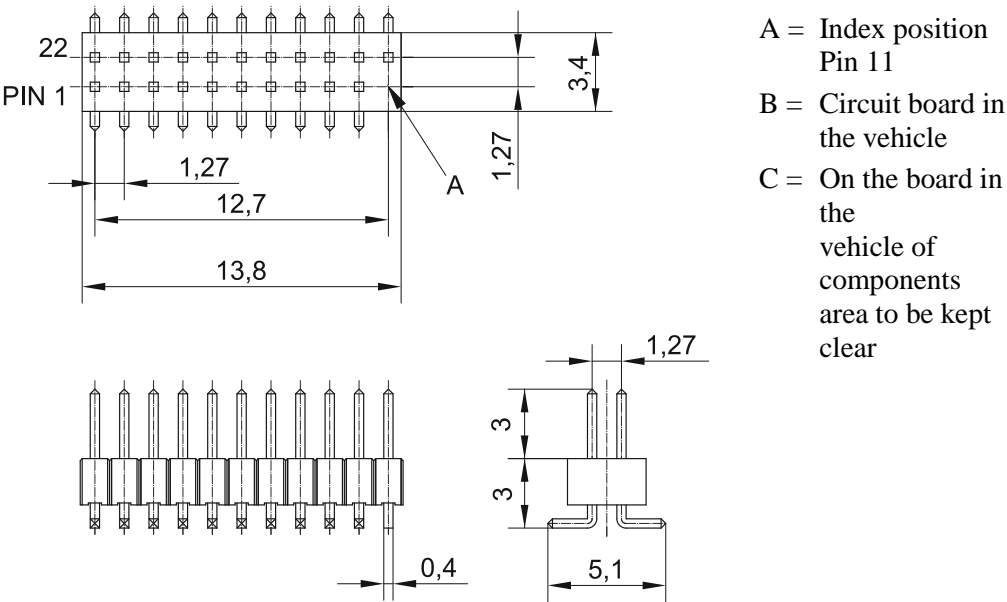


Figure 3: Typical pin header for vehicles

Installation in the vehicle is permitted in two variants.

2.3 Compact variant

The compact variant results in the lowest possible overall height. Here the decoder is inserted with the socket facing up. The pins of the connector are inserted through the board of the decoder. The decoder sits on the board in the vehicle. On the circuit board in the vehicle, the area of the decoder - apart from the pin header - must be kept free of components and be electrically isolated.

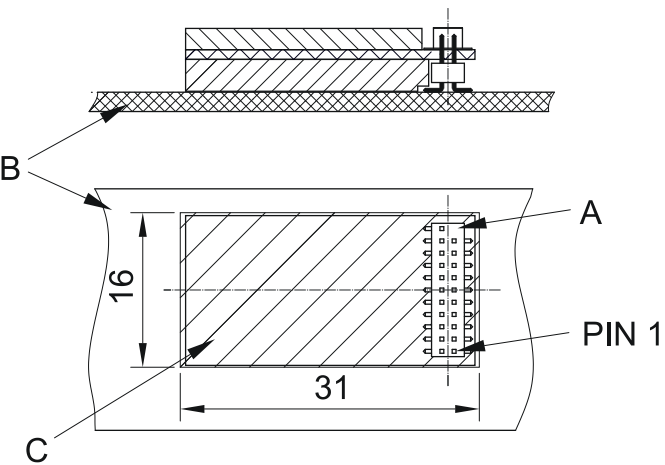
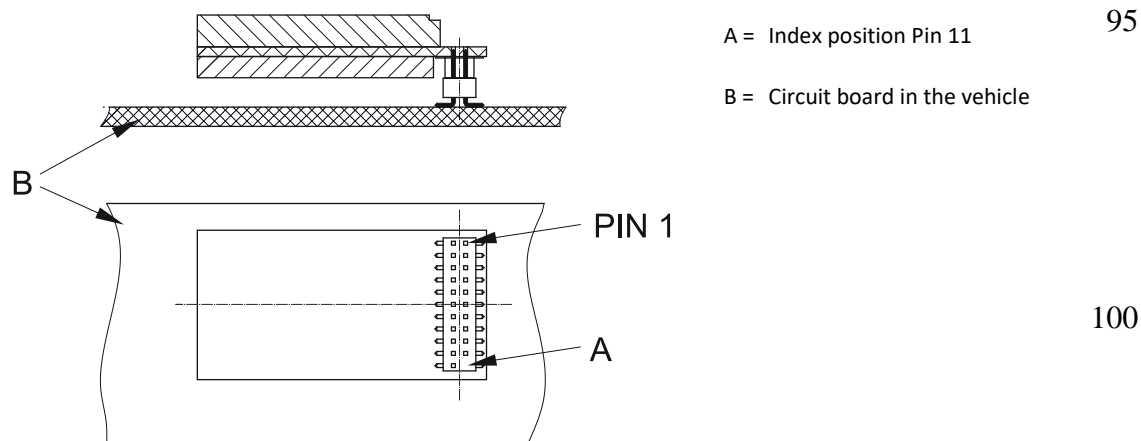


Figure 4: Installation in a compact version

## 2.4 Rotated variant

If there is enough height, but no space for the free space on the vehicle board, the vehicle manufacturer can use the rotated variant. The decoder is plugged in with the socket facing downwards (towards the vehicle circuit board). The assignment of the connector on the vehicle circuit board must be mirrored in the axis of pin 6/17. The maximum assembly height on the circuit board in the vehicle in the area of the decoder is - apart from the pin header - 3.3 mm and must be electrically isolated from the decoder.



**Figure 5:** Installation in a rotated variant

## 3 Electrical Characteristics

Manufacturer of this decoder must specify the maximum current allowed to be drawn for each output and input. In case the decoder utilizes a flat ribbon cable with a connector at the remote end, following the wire color specification is optional. For standalone extension cables and interface cables, with connectors at both ends, wire color coding is mandatory.

### 3.1.1 Pin Assignments

The pin assignments for 21MTC are defined in Table 2:

Pin	Name	Description	Group
1	Input1	Sensor-Input 1, alternate AUX7	4
2	Input2	Sensor-Input 2, alternate AUX8	4
3	AUX6	Output 6	8
4	AUX4	Output 4	8
5	ZBCLK	Train Bus Clock, alternate AUX9	7
6	ZBDTA	Train Bus Data (TxD, RxD), alternate AUX 10	7
7	F0r	Light direction rear	5
8	F0f	Light direction forward	5
9	LS/A	Speaker Connection A	6
10	LS/B	Speaker Connection B	6
11	Index	Not used, Orientation	
12	Vcc	Internal Decoder-Voltage 1.8 – 5.7 Volt	2
13	AUX3	Output 3	8
14	AUX2	Output 2	5
15	AUX1	Output 1	5
16	V+	Decoder Plus, referenced at rectifier, port storage capacitors	
17	AUX5	Output 5	8
18	Motor2	Motor-connection #2 minus / direction rear	3
19	Motor1	Motor-connection #1 plus / direction forward	3
20	GND	Decoder GND, Referenced at rectifier	
21	Track left	Track left in direction forward	1
22	Track right	Track right in direction forward	1

**Table 2:** Contact assignment and function descriptions

### 3.1.2 Description of Signals

**Group 1:** When supplied with AC-Motors Pin 21 is connected to the outer rails und Pin 22 to the middle rail.

**Group 2:** Pin 12 is not mandatory. It is recommended to use this connection only for the access bus interface.

**Group 3:** Pin 19 is field coil A; Pin 18 is field coil B for AC-Motors.

**Group 4:** Pin 1 and 2 are open collector inputs and are switched to GND. The input resistance should be approx. 100k $\Omega$ . Sensor input 1 should be used for wheel synchronization on steam locomotives. These connections can also be used as function outputs with logic level.

**Group 5:** When switched on, these outputs are connected to GND on the decoder side. The voltage for the switched load results from the track voltage at V+. If the rear lights are connected separately from the headlights in the vehicle, the rear lights of Driver's Cab 1 are switched with AUX1 (Pin 15) and those of Driver's Cab 2 with AUX2 (Pin 14).

**Group 6:** The effective impedance of the speaker(s), as observed by the decoder, is 4 $\Omega$  - 8 $\Omega$  and must be documented by the decoder manufacturer. Impedance of factory installed speakers must be documented by the vehicle manufacturer.

- 135
- Group 7:

The microcontroller-pins of the train bus are connected through a serial resistor with a maximum of 470 Ohm. The levels correspond to those of the logic level in Group 8 (Table 3). These connections can also be used as function outputs with logic level.
- Group 8:

Outputs are defined as TTL/LVTTL logic-level according to Table 3, maximum load 0.5 mA
- 140

	Voltage Level Decoder Output	Input Load Switch
Function Switched Off	<= 0.4 Volt	<= 0.8 Volt
Function Switched On	>= 2.4 Volt	>= 2.0 Volt

Table 3: Logic Level Values

145

It should be noted that when the decoder processor is started, uncontrolled states including a high-resistance state at the outputs with logic level can occur for a short time. Critical hardware on the locomotive board must be secured accordingly.

## 4 Operation without Decoder

150

When operating without a decoder, a jumper plug must be used, which connects at least the connections of Track 1 (Pin 22) with Motor 1 (Pin 19) and Track 2 (Pin 21) with Motor 2 (Pin 18). If the vehicle lighting is available, F0f (Pin 8) must also be connected to Track 2 (Pin 21) and F0r (Pin 7) to Track 1 (Pin 22). The connection V + (Pin 16) is to be supplied via two diodes from the track connections.

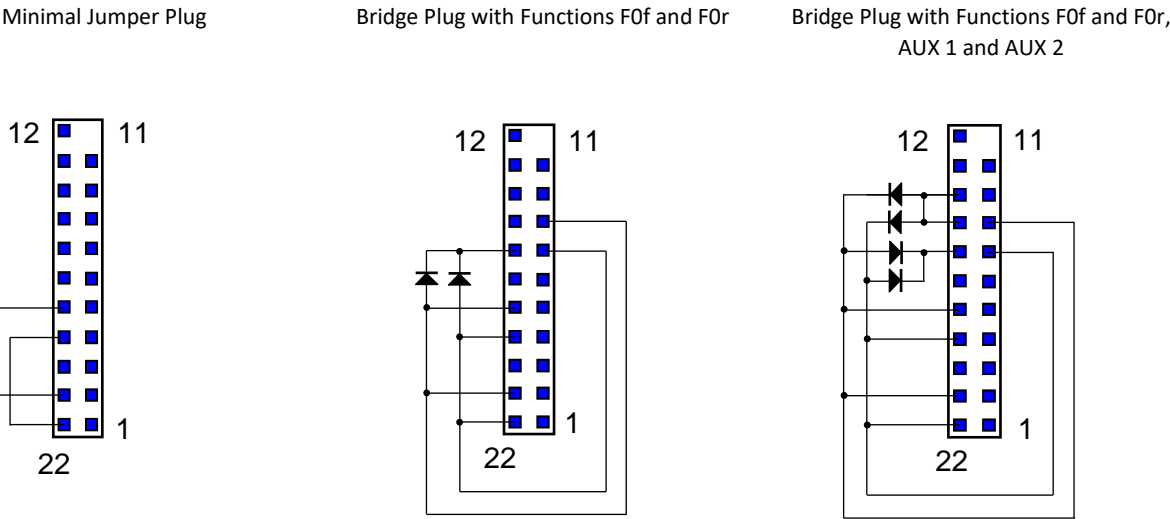


Figure 6: Typical Jumper Plugs

155

Depending on the wiring of the function outputs in the vehicle, the vehicle manufacturer can produce a jumper plug specific to the vehicle that connects other outputs. In the middle picture the outputs F0f and F0r are controlled depending on the direction; In the right picture, the functions

160

AUX1 and AUX2 are also always switched on.

## Use of Interface with SUSI

This interface can also be used as a SUSI interface according to TI-9.2.3. In this case, only four signals may be used:

1. GND (Pin 21)
2. V+ (Pin 16)
3. Train Bus Clock (Pin 5)
4. Train Bus Data (Pin 6)

In particular, the track connections are not to be used when wired as a SUSI interface. All other connections can be used for functions of the SUSI module.

## 6 Document History

Date	Description
Dec 1, 2020	First Revision of S.9.1.1.3, supporting the latest 21MTC proposed feature additions. Added additional clarifying text for the speaker requirements.



# Important Notices and Disclaimers Concerning NMRA Standards Documents

The Standards (S), Recommended Practices (RP), Technical Note (TN), and Technical Information (TI) documents of the National Model Railroad Association ("NMRA Standards documents") are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading "Important Notices and Disclaimers Concerning NMRA Standards Documents."

## Notice and Disclaimer of Liability Concerning the Use of NMRA Standards Documents

NMRA Standards documents are developed within the Standards and Conformance Department of the NMRA in association with certain Working Groups, members, and representatives of manufacturers and sellers. NMRA develops its standards through a consensus development process, which brings together volunteers representing varied viewpoints and interests to achieve the final product. NMRA Standards documents are developed by volunteers with modeling, railroading, engineering, and industry-based expertise. Volunteers are not necessarily members of NMRA, and participate without compensation from NMRA.

NMRA does not warrant or represent the accuracy or completeness of the material contained in NMRA Standards documents, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard or recommended practice, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, NMRA disclaims any and all conditions relating to results and workmanlike effort. In addition, NMRA does not warrant or represent that the use of the material contained in NMRA Standards documents is free from patent infringement. NMRA Standards documents are supplied "AS IS" and "WITH ALL FAULTS."

Use of NMRA Standards documents is wholly voluntary. The existence of an NMRA Standard or Recommended Practice does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the NMRA Standards documents. Furthermore, the viewpoint expressed at the time that NMRA approves or issues a Standard or Recommended Practice is subject to change brought about through developments in the state of the art and comments received from users of NMRA Standards documents.

In publishing and making its standards available, NMRA is not suggesting or rendering professional or other services for, or on behalf of, any person or entity, nor is NMRA undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any NMRA Standards document, should rely upon their own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given NMRA Standards documents.

IN NO EVENT SHALL NMRA BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: THE NEED TO PROCURE SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD OR RECOMMENDED PRACTICE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

## Translations

NMRA's development of NMRA Standards documents involves the review of documents in English only. In the event that an NMRA Standards document is translated, only the English version published by NMRA is the approved NMRA Standards document.

## Official Statements

A statement, written or oral, that is not processed in accordance with NMRA policies for distribution of NMRA communications, or approved by the Board of Directors, an officer or committee chairperson, shall not be considered or inferred to be the official position of NMRA or any of its committees and shall not be considered to be, nor be relied upon as, a formal position of NMRA.

## Comments on Standards

Comments for revision of NMRA Standards documents are welcome from any interested party, regardless of membership. However, **NMRA does not provide interpretations, consulting information, or advice pertaining to NMRA Standards documents.**

Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since NMRA standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, NMRA, its departments, Working Groups or committees cannot provide an instant response to comments, or questions except in those cases where the matter has previously been addressed. For the same reason, NMRA does not respond to interpretation requests. Any person who would like to participate in evaluating comments or in revisions to NMRA Standards documents may request participation in the relevant NMRA working group.

## Laws & Regulations

Users of NMRA Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any NMRA Standards document does not constitute compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. NMRA does not, by the publication of NMRA Standards documents, intend to urge action that is not in compliance with applicable laws, and NMRA Standards documents may not be construed as doing so.

## Copyrights

NMRA Standards documents are copyrighted by NMRA under US and international copyright laws. They are made available by NMRA and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of modeling, structural and engineering practices and methods. By making NMRA Standards documents available for use and adoption by public authorities and private users, NMRA does not waive any rights in copyright to the NMRA Standards documents.

## IMPORTANT NOTICE

NMRA Standards documents do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other systems, devices or networks. NMRA Standards documents development activities consider research and information presented to the standards development group in developing any safety recommendations. Other information about safety practices, changes in technology or technology implementation, or impact by peripheral systems also may be pertinent to safety considerations during implementation of the standard. Implementers and users of NMRA Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.