



NMRA Standard	
Layout Command Control™ (LCC) Firmware Upgrade	
Apr 25, 2021	S-9.7.4.4

## Adopted as a NMRA Standard

The OpenLCB Standard document appended to this cover sheet has been formally adopted as a NMRA Standard by the NMRA Board of Directors on the date shown in the *Adopted* column in the *Version History* table below.

## Version History

Date	Adopted	Summary of Changes
Feb 8, 2016		Initial version submitted for public comment
Apr 25, 2021	<b>July 2, 2021</b>	Changed LCC logo to include the ® symbol Changed “Layout Command Control” to have the ™ symbol Added the NMRA Legal Disclaimer fine-print Changed the OpenLCB license to “Creative Commons Attribution-ShareAlike 4.0 International”

# 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

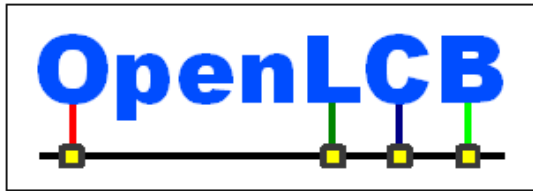
Users of NMRA Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any NMRA Standards document does not constitute compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the 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.



<b>OpenLCB Standard</b>	
<b>Firmware Upgrade</b>	
<b>Apr 25, 2021</b>	<b>Adopted</b>

## 1 Introduction (Informative)

This Standard defines a method for using OpenLCB protocols for upgrading the firmware of an OpenLCB node. This Standard is agnostic to the physical layer.

## 2 Intended Use (Informative)

- 5 This method is expected to be implemented in common Configuration Tool (CT) software packages. Any hardware device that is able to follow the interactions defined here and thereby receive a firmware upgrade through this method will be able to be updated using commonly available CT software. This reduces the burden of the manufacturers in that they don't need to develop and provide tools and user interface for firmware upgrade capability, as well as
- 10 increases user satisfaction, because the user does not have to acquire and learn to use a new tool for each hardware manufacturer, but can use a tool they are already familiar with to update all conforming hardware nodes.

- 15 This Standard does not define new protocols, but identifies a specific subset of the OpenLCB protocol stack that is necessary for the firmware upgrade to function, and defines the exact sequence of operations that are expected to happen during a firmware upgrade.

The intended use of this subset is to allow manufacturers to supply their hardware with dual firmware, consisting of a “firmware upgrade” component with the minimum required support for firmware update, as well as a replaceable “production” firmware for full node operation.

## 3 References and Context (Normative)

- 20 For more information on format and presentation, see:

- OpenLCB Common Information Technical Note

For information on OpenLCB message transport and OpenLCB communications, see:

- 25
- OpenLCB Message Network Standard. That Standard also defines the Uninitialized state and the Node Initialization Complete message, as well as the Protocol Support protocol messages.

Firmware upgrade relies on commands and messages defined in the following standards:

- OpenLCB Memory Configuration Standard, which defines, among others, the commands “Freeze”, “Unfreeze”, “Write” and “Stream Write”.

- 30
- OpenLCB Stream Transport Draft Standard, which defined how streams are opened, data transferred, aborted with error, and completed.

## 4 Message Formats (Normative)

This Standard does not define any messages.

### States (Normative)

A powered-on hardware node may be in one of the following two states:

- 35
- Firmware Upgrade state. In this state the node supports a writable Memory Space under the number of the Firmware Space to receive the firmware upgrade data, as defined in the firmware upgrade interaction. The hardware is not expected to perform any of its regular operations. The OpenLCB node shall still be standards compliant.
  - Operating state. In this state the node performs its desired function. The node in Operating state must not export a writable Memory Space under the number of the Firmware Space.
- 40

## 5 Interactions (Normative)

### 5.1 Definitions

There are two nodes involved in the firmware upgrade process:

- 45
- The **Configuration Tool** (CT) is the node with a user interface that is in possession of the new manufacturer-supplied firmware data file.

The **Target Node** is the node whose firmware is being updated.

### 5.2 State transitions

A node may not transition between Firmware Upgrade state and Operating state without returning to Uninitialized state, as defined by the OpenLCB Message Network standard.

- 50
- At power-up a hardware node shall start up in Operating state by default, unless one of the following conditions hold:
- Regular operation is impossible due to the lack of a working firmware. In this case the Target Node may, but is not required to, emit a Producer-Consumer Event Report (PCER) message with the Well-Known Event ID “Firmware Corrupted” after reaching Initialized state.
  - The user has requested firmware upgrade mode using a hardware switch, if one is available. In this case, the Target Node may, but is not required to, emit a PCER message with the Well-Known Event ID “Firmware Upgrade Requested by Hardware Switch” after reaching Initialized state.
- 55

- 60
- To request a Target Node to transition from Firmware Upgrade state to Operating state, the Configuration Tool shall send a Memory Configuration protocol “Unfreeze” command for the memory

space designated as Firmware Space. The Target Node shall acknowledge the completion of the state transition by sending a Node Initialization Complete message.

65 To request a Target Node to transition to Firmware Upgrade state (from either Firmware Upgrade or Operating state), a Configuration Tool shall send a Memory Configuration protocol “Freeze” command for the memory space designated as Firmware space. The node shall acknowledge the completion of the state transition by sending a Node Initialization Complete message.

### 5.3 State identification

A Target Node that supports the Firmware Upgrade Standard shall set the following bit(s) in the Protocol Support Reply message depending on its state:

State	Protocol bit (Normative)	Bit value (Informative)
Operating state	Firmware Upgrade Protocol	0x00 00 20
Firmware Upgrade state	Firmware Upgrade Active	0x00 00 10

70

### 5.4 Data Transfer

#### 5.4.1 Streaming transfer

75 If the Target Node, while in Firmware Upgrade state, sets the “Stream Protocol” bit in the Protocol Support Reply packet, then the Configuration Tool shall transfer the manufacturer-supplied firmware data by performing a Memory Configuration protocol Stream Write to the memory space of Firmware Space, with a starting offset of zero (0). The stream data bytes are the unmodified, uninterpreted, exact sequence of the manufacturer-supplied firmware upgrade file.

The Target Node being upgraded may, but is not required to, throttle the incoming data on the stream by means allowed by the Stream protocol.

80 After transferring all the bytes in the manufacturer-supplied firmware data file, the CT shall wait until it would be allowed to send more data according to the Stream protocol. Then the CT shall close the stream as defined in the Stream protocol. Afterwards the CT shall initiate a transition of the Target Node to Operating state by sending the Unfreeze command.

#### 5.4.2 Datagram transfer

85 If the Target Node, while in Firmware Upgrade state, does not set the “Stream Protocol” bit in the Protocol Support Reply packet, the Configuration Tool shall transfer the manufacturer-supplied firmware data by performing a sequence of Memory Configuration protocol Write commands, starting at offset 0, with exactly 64 bytes of payload in each datagram except the last, and the datagrams' offsets increasing by 64 bytes after each. The concatenated payloads of the Write messages sent shall be are  
90 the unmodified, uninterpreted, exact sequence of the manufacturer-supplied firmware upgrade file.

The Target Node being upgraded may, but is not required to, throttle the incoming data on the stream by means allowed by the Datagram protocol and Memory Configuration Protocol.

After transferring all the bytes in the manufacturer-supplied firmware data file, the CT shall wait until the last datagram is responded to as the Memory Configuration Protocol requires. Afterwards the CT shall initiate a transition of the Target Node to Operating state.

### 5.4.3 Aborting and Re-trying the transfer

If the node being upgraded encounters an error, it may abort the data transfer by aborting the stream with an error code when using the Stream protocol, or, respectively, returning a Datagram Reject with an error code or a Write Response Failed Memory Configuration datagram. If the transfer is aborted, the node is required to stay in Firmware Upgrade state. If the CT re-tries the transfer, it shall do so from offset zero again. If the Target Node aborted the transfer, it is not required to be able to return to Operating state until the transfer is re-tried and successfully completed; however, it is required to be able to boot after a power cycle and return to Firmware Upgrade state, able to accept a new firmware upgrade attempt.

## 5.5 Full sequence of firmware upgrade

For a more detailed description of the messages transferred, please see the Firmware Upgrade Technical Note.

1. The CT sends a Memory Configuration datagram command “Freeze” with an argument of Firmware Space. Note that a Datagram Received OK reply message is not always returned to this request.
2. The CT waits for a Node Initialization Complete message from the Target Node.
3. The CT sends a Protocol Support Inquiry to the Target Node to check whether it supports Stream protocol.
4. The CT performs the Data Transfer.
5. The CT resets the Target Node using a Memory Configuration datagram command “Unfreeze” with an argument of Firmware Space.

## 6 Allocations (Normative)

This section describes the numerical values that were referenced in earlier sections and are not defined in their respective standards.

### 6.1 Memory Space numbers

0xEF	Firmware Space
------	----------------

### 6.2 Error Codes

The Target Nodes may, but are not required to, use the following error codes to denote specific conditions relating to the firmware upgrade process.

0x2088	Temporary error, Transfer error. The firmware written has failed checksum.
0x1088	Permanent error, invalid arguments. The firmware data is incompatible with this hardware node.
0x1089	Permanent error, invalid arguments. The firmware data is invalid or corrupted.

### 6.3 Well-Known Event IDs

01.01.00.00.00.00.06.01      Firmware Corrupted

01.01.00.00.00.00.06.02      Firmware Upgrade Requested by Hardware Switch

130

## Table of Contents

1 Introduction (Informative).....	1
2 Intended Use (Informative).....	1
3 References and Context (Normative).....	1
4 Message Formats (Normative).....	2
States (Normative).....	2
5 Interactions (Normative).....	2
5.1 Definitions.....	2
5.2 State transitions.....	2
5.3 State identification.....	3
5.4 Data Transfer.....	3
5.4.1 Streaming transfer.....	3
5.4.2 Datagram transfer.....	3
5.4.3 Aborting and Re-trying the transfer.....	4
5.5 Full sequence of firmware upgrade.....	4
6 Allocations (Normative).....	4
6.1 Memory Space numbers.....	4
6.2 Error Codes.....	4
6.3 Well-Known Event IDs.....	5