

CHAPTER 24

Message Formats

Acronyms	24-iii
Chapter 24. Message Formats	24-1
24.1 Type-Length Value Structure	24-1
24.2 TmNSMessage	24-1
24.2.1 TmNSMessageHeader Structure.....	24-2
24.2.2 TmNSMessagePayload Structure.....	24-7
24.3 Radio Frequency Network Message	24-10
24.3.1 RFNM Header Structure.....	24-10
24.3.2 RFNM Payload Structure.....	24-11
24.4 TSS Messages	24-17
24.4.1 TSS Initialization Message Structure.....	24-17
24.4.2 TSS Data Message Structure.....	24-18
Appendix 24-A. Guidance for Using Chapter 11 Data Types	A-1
A.1. Introduction	A-1
A.1.a. Background	A-1
A.1.b. General Structure	A-1
A.1.b(1) Data Packaging.....	A-2
A.1.b(2) Data Delivery Characteristics.....	A-2
A.1.b(3) Data Typing.....	A-2
A.1.b(4) Identification Uniqueness.....	A-2
A.1.c. Data Correlation/Mapping	A-2
A.1.c(1) TmNS Message Mapping.....	A-3
A.1.c(2) TmNS Package Mapping.....	A-3
A.1.d. Packaging Data Types	A-4
A.1.d(1) TmNS Message w/Single Package.....	A-4
A.1.d(2) TmNS Message w/Multiple Packages.....	A-4

List of Figures

Figure 24-1. Type-Length-Value Structure.....	24-1
Figure 24-2. Multi-Value TLF Structure.....	24-1
Figure 24-3. TmNSMessage Structure.....	24-2
Figure 24-4. TmNSMessageHeader Structure.....	24-3
Figure 24-5. Option-Kind Message Structure.....	24-5

Figure 24-6. TmNSDataMessagePayload Structure..... 24-7
 Figure 24-7. Package Structure Containing PackageHeader and PackagePayload 24-8
 Figure 24-8. Standard PackageHeader Field Structure..... 24-9
 Figure 24-9. RFNM Structure..... 24-10
 Figure 24-10. RFNM Header Structure 24-11
 Figure 24-11. TSS Initialization Message Structure..... 24-18
 Figure 24-12. TSS Data Message Structure 24-19
 Figure 24-13. Algorithm For CRC Calculation (ANSI C Grammar)..... 24-20
 Figure A-1. Chapter 11 Packet Structures Mapped into TmNS Message Structures..... A-2
 Figure A-2. TmNS Message with Single Package A-4
 Figure A-3. TmNS Message with Multiple Packages A-5

List of Tables

Table 24-1. ApplicationDefinedFields “option-kind” List..... 24-6
 Table 24-2. RFNM TLVs..... 24-11
 Table 24-3. TxOp Assignment TLV 24-12
 Table 24-4. TxOp ID Acknowledgement Report TLV 24-13
 Table 24-5. MAC Queue Status Report TLV..... 24-13
 Table 24-6. Heartbeat TLV 24-14
 Table 24-7. Link Metric TLV..... 24-14
 Table 24-8. TE Queue Status Report TLV..... 24-15
 Table 24-9. Link Transmit Statistics Report TLV 24-17
 Table 24-10. TSS Initialization Message Codes 24-18

Acronyms

CINR	Carrier to Interference + Noise Ratio
CRC	cyclic redundancy check
DSCP	Diffserv Code Point
GHz	gigahertz
IOCTL	input/output control
IP	Internet Protocol
kHz	kilohertz
MAC	media access control
MDID	Message Definition Identifier
MDL	Metadata Description Language
PDID	Package Definition Identifier
PTP	Precision Time Protocol
RF	radio frequency
RFNM	radio frequency network message
RSSI	received signal strength indicator
TCP	Transmission Control Protocol
TE	Traffic Engineering
TAI	International Atomic Time
TLV	Type-Length-Value
TmNS	Telemetry Network Standard
TxOp	transmission opportunity

This page intentionally left blank.

CHAPTER 24

Message Formats

Application messages are message structures used to pass information between applications using an application layer protocol. The bit numbering, bit ordering, and byte ordering conventions used in this chapter are described in [Chapter 21 Appendix 21-B](#).

24.1 Type-Length Value Structure

The Type-Length-Value (TLV) message structure is depicted in [Figure 24-1](#).

TYPE	LENGTH	VALUE
------	--------	-------

Figure 24-1. Type-Length-Value Structure

The TLV field descriptions are provided below.

<u>Field Name</u>	<u>Field Length</u>	<u>Field Description</u>
Type	Fixed	Type of the TLV message, encoded as a binary value
Length	Fixed	Length, typically in bytes, of the entire TLV message (including Type and Length fields)
Value	Length = Length field value – (the length of the Type field + length of the Length field)	Data portion of the TLV message

For each defined TLV sequence, the Type and Length field sizes are fixed, a specific set of Types are defined, and each Value field may encode one or more pieces of information, as depicted in [Figure 24-2](#).

TYPE	LENGTH	VALUE
Type	Length	Value1 Value2 ... ValueN

Figure 24-2. Multi-Value TLF Structure

 NOTE	The following figure represents an ASCII message “ABCD” (0x41, 0x42, 0x43, 0x44) with a Type of 0xA97. The Type field is two bytes long and the Length field is one byte long.							
		Type		Length	Value			
	Byte Number	1	2	3	4	5	6	7
Data	0x0A	0x97	0x07	0x41	0x42	0x43	0x44	

24.2 TmNSMessage

A *TmNSMessage* shall contain a *TmNSMessageHeader* and may contain a *TmNSMessagePayload* as shown in [Figure 24-3](#).

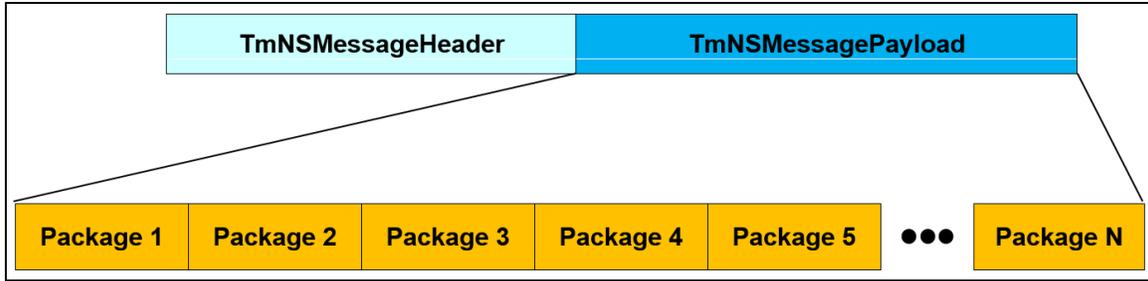


Figure 24-3. TmNSMessage Structure

All *TmNSMessageHeader* and *PackageHeader* fields in the *TmNSMessagePayload* shall use big-endian ordering as specified in [Chapter 21](#) Section B.3 and the bit numbering specified in [Chapter 21](#) Section B.2. *TmNSMessagePayload* fields (e.g., *PackagePayloads* fields described in MDL instance documents) are often based on acquisition data from non-Internet Protocol (IP)-network systems and, therefore, are not required to comply with the big-endian convention.

 <p>NOTE</p>	<p>The IP specification defines standard network byte order as big-endian for all numeric values in the IP packet headers. This standard maintains consistency with the IP specification by defining all numeric values in <i>TmNSMessageHeader</i> and <i>PackageHeader</i> fields of the <i>TmNSMessage</i> as following network byte order (i.e., big-endian).</p>
--	---

24.2.1 TmNSMessageHeader Structure

The *TmNSMessageHeader* shall contain the following fields and associated bit-widths as outlined in [Figure 24-4](#).

- MessageVersion – 4 bits
- OptionWordCount – 4 bits
- Reserved – 4 bits
- MessageType – 4 bits
- MessageFlags – 16 bits
- MessageDefinitionID – 32 bits
- MessageDefinitionSequenceNumber – 32 bits
- MessageLength – 32 bits
- MessageTimestamp – 64 bits
- ApplicationDefinedFields – variable (OptionWordCount * 32 bits)

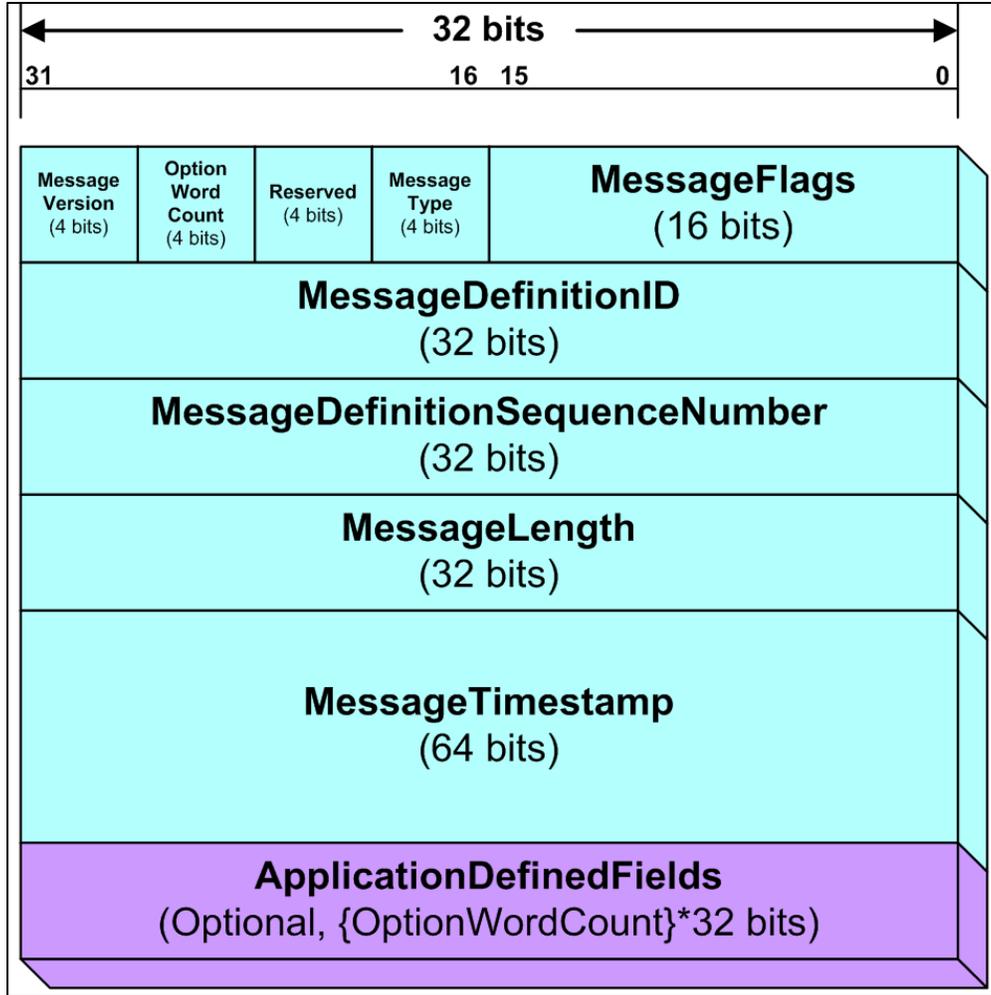


Figure 24-4. TmNSMessageHeader Structure

24.2.1.1 MessageVersion Field

The **MessageVersion** field specifies the version of the *TmNSMessage* protocol. This document defines Message Version 1 (i.e., 4'b0001)

24.2.1.2 OptionWordCount Field

The **OptionWordCount** field shall specify the number of 32-bit words in the **ApplicationDefinedFields**.

24.2.1.3 Reserved Field

This field is reserved for future use. All bits shall be set to zero (4'b0000) on transmission; ignored on reception.

24.2.1.4 MessageType Field

The **MessageType** field specifies the type of the *TmNSMessage*. This document defines the following message types:

- 4'b0000 – TmNSDataMessage

- 4'b0001 – TmNSDataMessage per [Appendix 24-A](#)

24.2.1.5 MessageFlags Field

The **MessageFlags** field shall provide indicators of *TmNSMessage* options and/or conditions. Using the bit-numbering convention specified in [Chapter 21](#) Appendix 21-B, the bits are defined as follows.

- **Reserved for Future Use** bits (bits 15-8). All bits shall be set to zero (8'h00) on transmission; ignored on reception.
- StandardPackageHeaderFlag bit (bit 7):
 - 1'b0 – At least one *Package* uses a *PackageHeader* completely described in an MDL instance document or at least one *Package* does not contain a *PackageHeader*
 - 1'b1 – All *Packages* use the Standard *PackageHeaders* (see Subsection [24.2.2.1.1](#))

For TmNSMessages that do not contain Packages, this bit shall be set to 1'b0.

- PlaybackDataFlag bit (bit 6):
 - 1'b0 – Live data (from source)
 - 1'b1 – Playback data
- MessageFragmentationFlags bits (bits 5-4):
 - 2'b00 – Complete *TmNSMessage*
 - 2'b01 – *TmNSMessage* with the first fragment
 - 2'b10 – *TmNSMessage* with a middle fragment
 - 2'b11 – *TmNSMessage* with the last fragment
 See [Chapter 26](#) Subsection 26.5.3 for more details.
- DataSourceAcquiredDataFlag bit (bit 3):
 - 1'b0 – Acquired data in this *TmNSMessage*
 - 1'b1 – Simulated data in this *TmNSMessage*
- DataSourceTimeLockFlag bit (bit 2):
 - 1'b0 – *DataSource* time locked to IEEE 1588 master clock
 - 1'b1 – *DataSource* time NOT locked to IEEE 1588 master clock
- DataSourceHealthFlag bit (bit 1):
 - 1'b0 – No error in the portion of the *DataSource* generating this *TmNSMessage*
 - 1'b1 – Error in the portion of the *DataSource* generating this *TmNSMessage*
- EndOfDataFlag bit (bit 0)
 - 1'b0 – Normal *TmNSMessage*
 - 1'b1 – End-of-data *TmNSMessage*
 See [Chapter 26](#) Subsection 26.4.2.2 for usage details of this bit.

See [Chapter 26](#) Subsection 26.5.4 for rules governing the merging of the **MessageFlags** field from multiple *TmNSDataMessages*.

24.2.1.6 MessageDefinitionID Field

The *MessageDefinitionID* field shall contain the *MessageDefinitionID* of the *TmNSMessage*.

24.2.1.7 MessageDefinitionSequenceNumber Field

The **MessageDefinitionSequenceNumber** field shall provide a non-negative integer that increments by one for each *TmNSMessage* instance in a sequence of *TmNSMessages*.

See [Chapter 26](#) Subsection 26.5.1 for additional **MessageDefinitionSequenceNumber** rules.

24.2.1.8 MessageLength Field

The **MessageLength** field shall provide the length (in bytes) of the *TmNSMessage* (or fragment), including the *TmNSMessageHeader* and *TmNSMessagePayload* (including padding).

Padding shall be used if a *TmNSMessage* does not fall on a 32-bit boundary.

24.2.1.9 MessageTimestamp Field (64 bits)

The **MessageTimestamp** field shall provide the message base time (in seconds and nanoseconds). The field shall use the lower 64 bits of the IEEE 1588-2008 specified time structure.

See [Chapter 26](#) Subsection 26.5.2 for additional **MessageTimestamp** rules.

24.2.1.10 ApplicationDefinedFields Field (OptionWordCount*32 bits)

ApplicationDefinedFields provide for optional header fields identified by the **option-kind** field (similar to Transmission Control Protocol [TCP] Options). [Figure 24-5](#) shows **ApplicationDefinedFields**.

<i>Field Name</i>	<i>Field Length</i>	<i>Field Description</i>
option-kind	1 byte	Indicates type of optional field
option-length	1 byte	Indicates length in bytes of particular option field + 2 bytes for the kind and length fields
option-data	0 to 58 bytes	Data associated with a particular option field

← option-length = option-data length + 2 bytes →		
TLV Type	TLV Length	TLV Value
option-kind (1 byte)	option-length (1 byte)	option-data (0 to 58 bytes)

Figure 24-5. Option-Kind Message Structure

Multiple **option-kind** fields may be included in the **ApplicationDefinedFields** as long as the total **ApplicationDefinedFields** size does not exceed 60 bytes. The **ApplicationDefinedFields** shall fall on a 32-bit boundary (i.e., length shall be an integer number of 32-bit words). For **option-kind** values between 8'h00 – 8'h7F inclusive, neither the **option-length** nor **option-data** fields are included resulting in a length of one byte. For **option-kind** values between 8'h80 – 8'hFF inclusive, both the **option-length** and **option-data** fields are included, resulting in an **option-data** length of **option-**

length – 2 bytes. [Table 24-1](#) defines each supported **option-kind** value along with their corresponding **option-length** and **option-data** values.

Table 24-1. ApplicationDefinedFields “option-kind” List				
option-kind	Type	option-length	option-data	Comment
8’h00	End of Options	N/A	N/A	Also used for padding to 32-bit boundary
8’h01	No Operation (NOP)	N/A	N/A	Allows individual options to be 32-bit aligned if needed (not required)
8’h02 – 8’h3F		N/A	N/A	Reserved for future allocation
8’h40 – 8’h7F		N/A	N/A	Reserved for implementation-specific or experimental use
8’h80				Reserved for future allocation
8’h81				Reserved for future allocation
8’h82	<i>DataSource Configuration</i>	3-32	An implementation-specific structure of configuration for the <i>DataSource</i> generating this <i>TmNSDataMessage</i>	
8’h83	<i>DataSource Error</i>	3-32	An implementation-specific structure of an error condition for the <i>DataSource</i> generating this <i>TmNSDataMessage</i>	
8’h84				Reserved for future allocation
8’h85	Destination Address	6 18	IPv4 address (unicast, multicast, broadcast) IPv6 address (unicast, multicast, broadcast)	
8’h86	Fragment Byte Offset	6	Byte offset of current fragment (32-bit length)	
8’h87	Package Count	6	Count of number of <i>Packages</i> in this message	
8’h88	Ingress Timestamp	8	Timestamp of when a message was most recently received. Timestamp format is 32-bit International Atomic Time (TAI) seconds field followed by 32-bit nanoseconds field.	This is the system time when the receiving entity received this message.

Table 24-1. ApplicationDefinedFields “option-kind” List				
option-kind	Type	option-length	option-data	Comment
8’h89	Egress Timestamp	8	Timestamp of when a message was most recently transmitted. Timestamp format is 32-bit TAI seconds field followed by 32-bit nanoseconds field.	This is the system time when the transmitting entity sent the message (e.g., local system time of recorder when it sends a message it received previously).
8’h8A –8’hBF				Reserved for future allocation
8’hC0 –8’hFF				Reserved for implementation-specific or experimental use

NOTE  The use of **ApplicationDefinedFields’ option-kind** value in the “implementation-specific or experimental use” range is permitted but does not ensure interoperability.

24.2.2 TmNSMessagePayload Structure

The *TmNSMessagePayload* is optional. If present, the *TmNSMessagePayload* shall include one or more *Packages* as illustrated in [Figure 24-6](#).

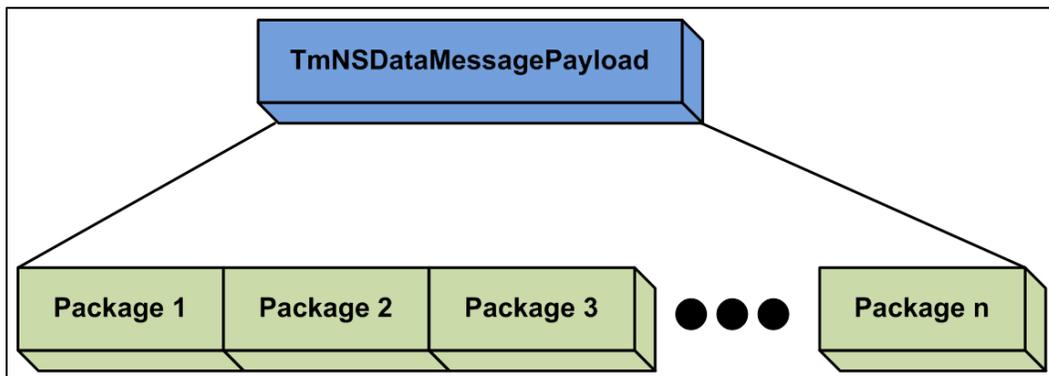


Figure 24-6. TmNSDataMessagePayload Structure

NOTE  The *MessageDefinitionID* specified in the *TmNSDataMessage* header serves as a reference to the structure, content, and ordering of *Package(s)* in the *TmNSDataMessage* payload. For details on how this information is described within an MDL instance document, refer to [Chapter 23](#).

Each *Package* shall include either a *PackageHeader*, a *PackagePayload*, or both. The case where both a *PackageHeader* and *PackagePayload* are present is illustrated in [Figure 24-7](#).

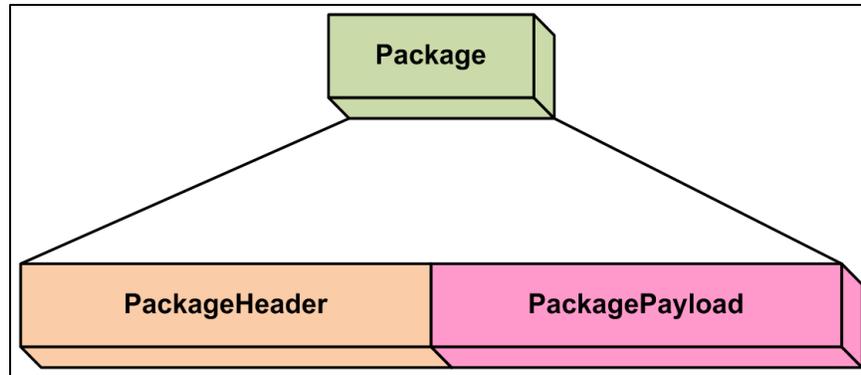


Figure 24-7. Package Structure Containing PackageHeader and PackagePayload

24.2.2.1 Package Header

The *PackageHeader* contains fields that describe the *PackagePayload*. When using a *PackageHeader*, *TmNSDataMessages* shall use either the standard *PackageHeader* or a *PackageHeader* completely described in an MDL instance document.

24.2.2.1.1 Standard PackageHeader

The standard *PackageHeader* shall contain the following fields.

- PackageDefinitionID – 32 bits
- PackageLength – 16 bits
- Reserved – 8 bits
- PackageStatusFlags – 8 bits
- PackageTimeDelta – 32 bits

[Figure 24-8](#) illustrates the standard *PackageHeader*. When using standard *PackageHeaders*, the *Package* shall start and end on 32-bit boundaries.

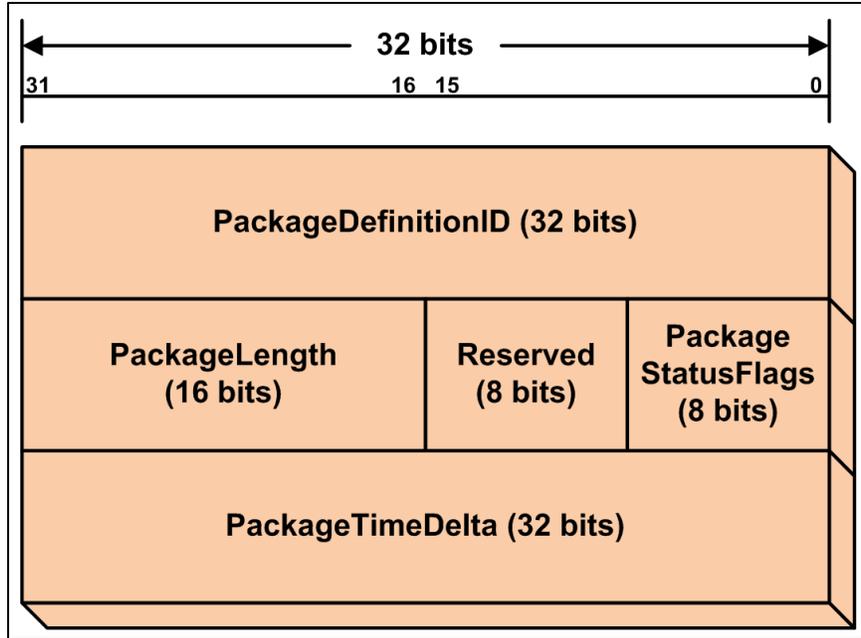


Figure 24-8. Standard PackageHeader Field Structure

24.2.2.1.1.1 *PackageDefinitionID Field*

The **PackageDefinitionID** field shall contain the *PackageDefinitionID* of the *Package*.

24.2.2.1.1.2 *PackageLength Field*

The **PackageLength** field shall specify the length, in bytes, of the entire *Package* (including *PackageHeader* and *PackagePayload*, but not including padding) to identify the end of bytes containing *MeasurementData* in the *Package*.

Padding shall be used to ensure a *Package* with a standard *PackageHeader* starts and ends on a 32-bit boundary.

24.2.2.1.1.3 *Reserved*

All bits shall be set to zero (8'h00) on transmission; ignored on reception.

24.2.2.1.1.4 *PackageStatusFlags Field*

The **PackageStatusFlags** field may provide indications on specific *MeasurementData* in a *Package* and/or error indications (e.g., parity, out of range, wrong frame size, etc.) of the *DataSource* producing the *MeasurementData*. These flags can be described by an MDL instance document. Each **PackageStatusFlags**' 1'b0 value shall be interpreted as a "no error" condition for that particular condition. Each **PackageStatusFlags** bit not described in an MDL instance document shall be set to 1'b0.

24.2.2.1.1.5 *PackageTimeDelta Field*

The **PackageTimeDelta** field shall provide the *Package* base time relative to the **MessageTimestamp** field in the *TmNSDataMessageHeader*. The value in the field shall be a non-negative integer that represents nanosecond resolution in the range of 0 to $2^{32} - 1$.

24.2.2.1.2 MDL-Described PackageHeader

A custom *PackageHeader* shall be used if the standard *PackageHeader* is not used for the *Package*. Custom *PackageHeaders* shall be completely described within the MDL instance document that contains the *Package* description.

24.2.2.2 Package Time Measurement Scoping Rules

The Telemetry Network Standard (TmNS) schema in [Chapter 23](#) defines the *MeasurementTimeRef* element, which is a measurement that is associated with another measurement. There shall be no *MeasurementTimeRef* elements that reference outside a single package instance within a single message instance.

24.3 Radio Frequency Network Message

There is one general structure for all radio frequency (RF) network messages (RFNMs). The structure consists of a common RFNM header followed by the RFNM payload. The payload consists of one or more TLVs.

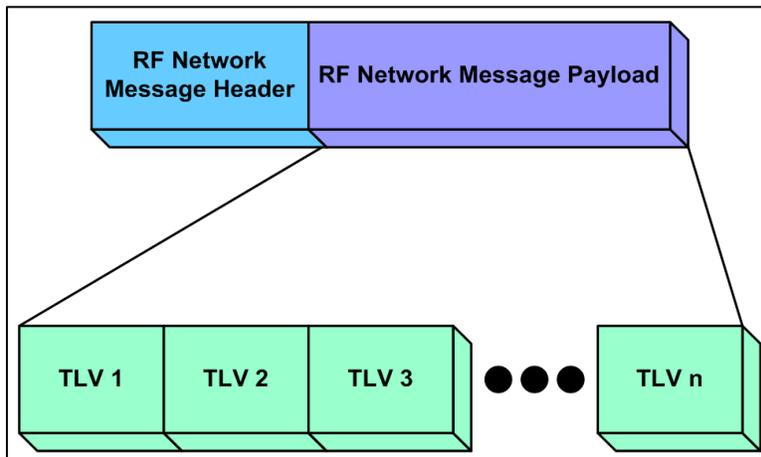


Figure 24-9. RFNM Structure

All fields in an RFNM shall use big-endian ordering as specified in [Chapter 21](#) Appendix 21-B.

24.3.1 RFNM Header Structure

An RFNM header shall contain the following fields shown in [Figure 24-10](#):

- Message Length – 16 bits
- Destination RF Media Access Control (MAC) address – 16 bits
- Source RF MAC Address - 16 bits
- Message Sequence Number – 32 bits

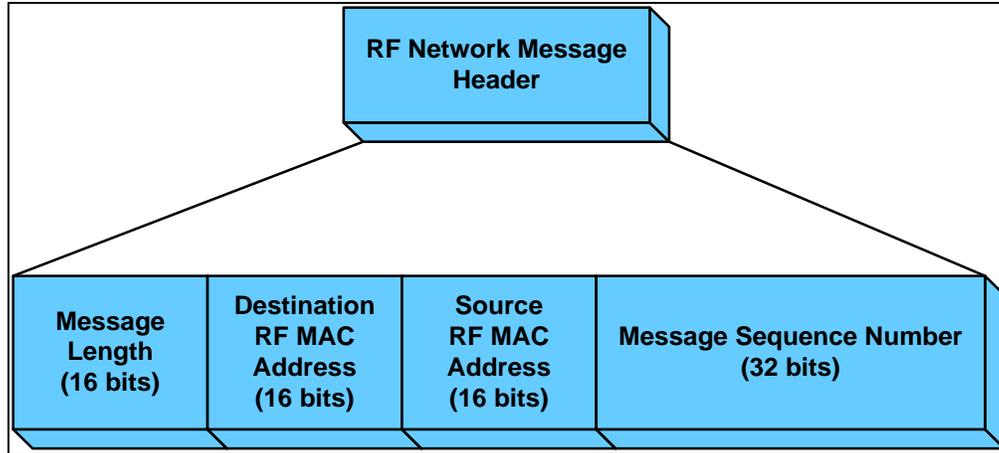


Figure 24-10. RFNM Header Structure

24.3.1.1 Message Length

This field indicates the remaining length in bytes of the RFNM. The size of the RFNM is the size of the Message Length field plus the value contained therein.

24.3.1.2 Destination RF MAC Address

This field contains the destination RF MAC address. The combination of the destination RF MAC address and the source RF MAC address identify a particular link for which the RFNM is associated

24.3.1.3 Source RF MAC Address

This field contains the source RF MAC address.

24.3.1.4 Message Sequence Number

The Message Sequence Number serves as an identifier of a particular RFNM. The sequence number shall be associated with the destination RF MAC address and source RF MAC address pair contained in the RFNM header. Entities that send RFNMs shall increment the sequence number associated with a particular destination RF MAC address and source RF MAC address pair after each RFNM is generated.

This value shall be initialized with 32'd0. The first RFNMs produced for a particular destination RF MAC address and source RF MAC address pair shall be 32'd0.

24.3.2 RFNM Payload Structure

The RFNM payload consists of one or more TLV structures. The defined TLVs are contained in [Table 24-2](#).

Table 24-2. RFNM TLVs		
TLV	Type	Descriptions
Transmission Opportunity (TxOp) Assignment	1	This TLV is used by the time-division multiple access scheduler to allocate a transmission opportunity on a radio link.

Table 24-2. RFNM TLVs		
TLV	Type	Descriptions
TxOp ID Acknowledgement Report	2	This TLV is used by a radio to report the acknowledgement of specific TxOps that have been received and processed and applied to the active schedule.
MAC Queue Status Report	3	This TLV is used by a radio to report MAC layer queue level.
Heartbeat	5	This TLV is used to establish a timeout value used by the radio to classify TxOps received from RF link management as stale.
Link Metric	6	This TLV contains an absolute time (converted to an internal representation) and link metric measurements pertaining to a specific radio link.
TE Queue Status Report	10	This TLV is used by a radio to report Traffic Engineering (TE) queue levels for each of the 8 TE queues associated with a particular link on the reporting radio.
Link Transmit Statistics Report	11	This TLV contains the count of IP packets transmitted over the specified RF link.

24.3.2.1 TxOp Assignment TLV

The TxOp Assignment TLV shall be used to allocate transmission opportunities on a radio for the link comprised of the destination RF MAC address and source RF MAC address in the RFNM header. The TxOp Assignment TLV is described in [Table 24-3](#).

Table 24-3. TxOp Assignment TLV			
Field	Width (bits)	Descriptions	Value/Range
Type	8	Type: Transmission Opportunity Assignment	1
Length	8	Length in bytes	13
Center Frequency	16	Carrier or operating frequency given in units of 250 kilohertz (kHz) (up to 16 gigahertz [GHz])	$[0, 2^{16}-1]$
Reserved	8	This field is reserved for future use. The value shall be set to 8'h80.	8'h80
TxOp ID	16	An identifier for the TxOp. If the value of this field is set to zero (16'h0000), no acknowledgement for the TxOp will be provided through the TxOp ID Ack Report TLV.	$[0, 2^{16}-1]$
TxOp Timeout	8	The value specifying the number of consecutive epochs for which this transmission opportunity is valid. Additionally, the value of 8'h0 is reserved to indicate that any existing TxOp with a non-zero remaining timeout value whose interval is wholly contained by Start and Stop Subseconds field of this message is deleted from all future epochs. The value of	$[0, 255]$

Table 24-3. TxOp Assignment TLV

Field	Width (bits)	Descriptions	Value/Range
		8'hFF is reserved to indicate that this TxOp has an infinite lifetime and will remain in effect until explicitly deleted or until the transmission heartbeat times out.	
TxOp Start Subseconds	20	The value specifying the fractional sub-seconds portion of a TxOp start time, measured in microseconds relative to the start of the epoch.	[0, 999,999]
TxOp Stop Subseconds	20	The value specifying the fractional sub-seconds portion of a TxOp stop time, measured in microseconds relative to the start of the epoch.	[0, 1,000,000]

24.3.2.2 TxOp ID Acknowledgement Report TLV

The TxOp ID Acknowledgement Report TLV shall be used to deliver one or more ID values of TxOps that have been applied to the transmission schedule of the transceiver. This TLV is not directly accountable to the link identified in the RFNM header of the message containing this TLV, thus a single RFNM may contain ID values from TxOps that were supplied to different links on the transceiver. Any TxOps whose ID value is set to zero (16'h0000) shall not be acknowledged. The TxOp ID Acknowledgement Report TLV is described in [Table 24-4](#).

Table 24-4. TxOp ID Acknowledgement Report TLV

Field	Width (bits)	Descriptions	Value/Range
Type	8	Type: TxOp ID Ack Report	2
Length	8	Length in bytes	2+2N, where 'N' is the number of TxOpIds being acknowledged in this TLV
TxOp ID 1	16	The TxOp ID of the first TxOp being acknowledged in this TLV. Required.	[1, 2 ¹⁶ -1]
... Optional.	...
TxOp ID N	16	The TxOp ID of the Nth TxOp being acknowledged in this TLV. Optional.	[1, 2 ¹⁶ -1]

24.3.2.3 MAC Queue Status Report TLV

The MAC Queue Status Report TLV shall be used to report the MAC layer queue level of the radio for the link comprised of the destination RF MAC address and source RF MAC address in the RFNM header. The MAC Queue Status Report TLV is described in [Table 24-5](#).

Table 24-5. MAC Queue Status Report TLV

Field	Width (bits)	Descriptions	Value/Range
Type	8	Type: MAC Queue Status Report	3

Table 24-5. MAC Queue Status Report TLV			
Field	Width (bits)	Descriptions	Value/Range
Length	8	Length in bytes	8
Reserved	2	Reserved	2'b00
Timestamp Seconds	6	The value specifying the seconds portion of a timestamp of when the MAC Queue Status was sampled, measured in seconds and corresponding to the least significant 6 bits of the seconds portion of TAI time.	[0, 63]
Reserved	4	Reserved	4'b0000
Timestamp Subseconds	20	The value specifying the fractional sub-seconds portion of when the MAC Queue Status was sampled, measured in microseconds relative to the timestamp Seconds field.	[0, 999,999]
MAC Queue Level	16	Amount of data (reported in units of 64 bytes, rounded up) buffered in transceiver, pending transmission	[0, 2 ¹⁶ -1]

24.3.2.4 Heartbeat TLV

The Heartbeat TLV shall be used to deliver an updated transmission heartbeat to a radio. The Heartbeat TLV is described in [Table 24-6](#).

Table 24-6. Heartbeat TLV			
Field	Width (bits)	Descriptions	Value/Range
Type	8	Type: Heartbeat	5
Length	8	Length in bytes	4
Timeout	16	Number of future epochs that this radio is authorized to execute TxOps. The value of 65,535 (16'hFFFF) is reserved to indicate a heartbeat that has an infinite lifetime and will remain in effect until explicitly changed.	[0, 2 ¹⁶ -1]

24.3.2.5 Link Metric TLV

The Link Metric TLV shall be used to deliver receiver statistics for the link comprised of the destination RF MAC address and source RF MAC address in the RFNM header. The Link Metric TLV is described in [Table 24-7](#).

Table 24-7. Link Metric TLV			
Field	Width (bits)	Descriptions	Value/Range
Type	8	Type	6
Length	8	Length in bytes	15
Timestamp	32	The time that this snapshot of Link Metric information was taken. This timestamp format consists of the following three subfields:	

Table 24-7. Link Metric TLV			
Field	Width (bits)	Descriptions	Value/Range
		Bits 31-26 - Reserved Bits 25-20 - seconds Time, in seconds, when snapshot was taken, corresponding to the least-significant 6 bits of the seconds portion of TAI time Bits 19-0 - microseconds The fractional sub-second portion of the timestamp, measured in microseconds.	6'b000000 [0-63] [0-999,999]
Center frequency	16	Indicates the center frequency where measurements are made. The center frequency is given in units of 250 kHz (up to 16 GHz)	[0, 2 ¹⁶ -1]
RSSI	8	Received signal strength indicator. This is a 2's compliment signed integer indicating the RSSI in 1-dBm step with a maximum range of -127 dBm to 127 dBm. The field is assigned -128 (hex 0x80) when RSSI measurement is not available.	[-128, 127]
CINR	8	Carrier to Interference + Noise Ratio. This is a 2's compliment signed integer indicating the CINR in 1-dB step with a maximum range of -127 dB to 127 dB. The field is assigned -128 (hex 0x80) when CINR measurement is not available.	[-128, 127]
Average channel bit error rate	8	This is an unsigned integer indicating the channel error rate in units of 1/2 ⁸ with a range of 1/2 ⁸ to 1-1/2 ⁸ . The field is assigned 0 when channel bit error rate measurement is not available.	[0, 2 ⁸ -1]
Received IP Packet Count	32	The number of IP packets that have been received over the RF link identified by the RFNM header.	[0, 2 ³² -1]

24.3.2.6 Traffic Engineering Queue Status Report TLV

The TE Queue Status Report TLV shall be used to report the queue levels of the eight different TE queues of the radio for the link comprised of the destination RF MAC address and source RF MAC address in the RFNM header. The TE Queue Status Report TLV is described in [Table 24-8](#).

Table 24-8. TE Queue Status Report TLV			
Field	Width (bits)	Descriptions	Value/Range
Type	8	Type: TE Queue Status Report	10
Length	8	Length in bytes	27
Reserved	2	Reserved	2'b00

Table 24-8. TE Queue Status Report TLV			
Field	Width (bits)	Descriptions	Value/Range
Timestamp Seconds	6	The value specifying the seconds portion of a timestamp of when the TE Queue Status was sampled, measured in seconds and corresponding to the least significant 6 bits of the seconds portion of TAI time.	[0, 63]
Reserved	4	Reserved	4'b0000
Timestamp Subseconds	20	The value specifying the fractional sub-seconds portion of when the TE Queue Status was sampled, measured in microseconds relative to the timestamp Seconds field.	[0, 999,999]
QoS Policy ID	32	Identifier for the QoS policy associated with this radio link	[0, $2^{32}-1$] Default: 0
Version	8	Unique identifier for this specific queue status report: TE Queue depth	0
DSCP Class 0 Queue Level	16	Amount of data (reported in units of 64 bytes, rounded up) in the queue(s) for Diffserv Code Point (DSCP) Class 0 (DSCP values 0 to 7)	[0, $2^{16}-1$]
DSCP Class 1 Queue Level	16	Amount of data (reported in units of 64 bytes, rounded up) in the queue(s) for DSCP Class 1 (DSCP values 8 to 15)	[0, $2^{16}-1$]
DSCP Class 2 Queue Level	16	Amount of data (reported in units of 64 bytes, rounded up) in the queue(s) for DSCP Class 2 (DSCP values 16 to 23)	[0, $2^{16}-1$]
DSCP Class 3 Queue Level	16	Amount of data (reported in units of 64 bytes, rounded up) in the queue(s) for DSCP Class 3 (DSCP values 24 to 31)	[0, $2^{16}-1$]
DSCP Class 4 Queue Level	16	Amount of data (reported in units of 64 bytes, rounded up) in the queue(s) for DSCP Class 4 (DSCP values 32 to 39)	[0, $2^{16}-1$]
DSCP Class 5 Queue Level	16	Amount of data (reported in units of 64 bytes, rounded up) in the queue(s) for DSCP Class 5 (DSCP values 40 to 47)	[0, $2^{16}-1$]
DSCP Class 6 Queue Level	16	Amount of data (reported in units of 64 bytes, rounded up) in the queue(s) for DSCP Class 6 (DSCP values 48 to 55)	[0, $2^{16}-1$]
DSCP Class 7 Queue Level	16	Amount of data (reported in units of 64 bytes, rounded up) in the queue(s) for DSCP Class 7 (DSCP values 56 to 63)	[0, $2^{16}-1$]

24.3.2.7 Link Transmit Statistics Report TLV

The Link Transmit Statistics Report TLV shall be used to report the number of IP packets transmitted by the transmitter over the link comprised of the destination and source RF MAC address in the RFSM header. [Table 24-9](#) describes the specifics of the link transmit statistics.

Table 24-9. Link Transmit Statistics Report TLV			
Field	Width (bits)	Description	Value/Range
Type	8	Type	11
Length	8	Length in bytes	10
Timestamp	32	The time that this snapshot of link transmission statistics was taken. This timestamp format consists of the following three subfields.	
		Bits 31-26 – reserved	6'b000000
		Bits 25-20 – seconds Time, in seconds, when snapshot was taken, corresponding to the least-significant 6 bits of the seconds portion of TAI time.	[0-63]
		Bits 19-0 – microseconds The fractional sub-second portion of the timestamp, measured in microseconds	[0-999,999]
Transmitted IP Packet Count	32	The number of IP packets that have been transmitted over the RF link identified by the RFSM header.	[0, 2 ³² -1]

24.4 TSS Messages

TmNS Source Selector (TSS) functionality is described in [Chapter 28](#), but the TSS messages are defined in this section. The TSS messages shall be exchanged between TSS interfaces. There are two types of TSS messages defined:

- TSS Initialization Message
- TSS Data Message

24.4.1 TSS Initialization Message Structure

After initial TCP socket connection is established, the TSS server (e.g., typically a radio) shall send 6 TSS initialization messages. The TSS initialization message structure shall contain the following fields as shown in [Figure 24-11](#).

- Interface Parameter Identifier – 4 bytes
- Interface Parameter – 32 bytes

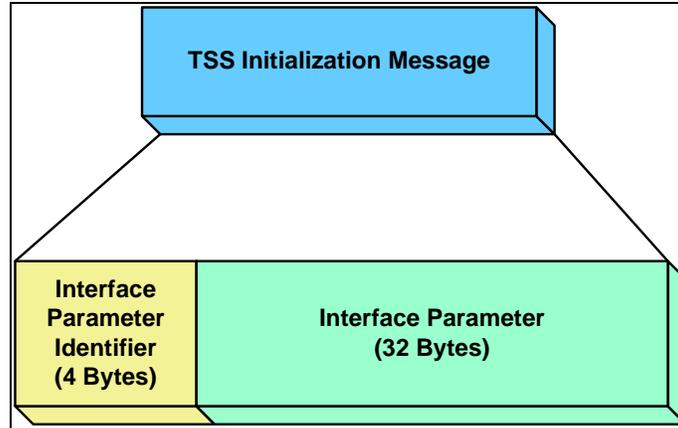


Figure 24-11. TSS Initialization Message Structure

24.4.1.1 Interface Parameter Identifier

The Interface Parameter Identifier field shall contain one of the six values shown in [Table 24-10](#). These values have been chosen to match Linux input/output control (IOCTL) names that are shown so as to ease Linux implementations. The six TSS initialization messages shall be sent in the order shown in [Table 24-10](#).

IOCTL Name	Description	Value
SIOCSIFHWADDR	MAC address of the interface	32'h00008924
SIOCSIFMTU	Maximum transfer unit of the interface	32'h00008922
SIOCSIFADDR	Interface IP address of the interface	32'h00008916
SIOCSIFDSTADDR	Destination IP address of the interface when point to point	32'h00008918
SIOCSIFBRDADDR	Broadcast IP address for the interface	32'h0000891a
SIOCSIFNETMASK	Network mask for the interface	32'h0000891c

24.4.1.2 Interface Parameter

The Interface Parameter field shall contain the value associated with the parameter.

24.4.2 TSS Data Message Structure

A TSS data message is a wrapper used to aid specialized routing of network traffic between TmNS networks over other networks. The structure of a TSS data message is shown shall contain the following fields as shown in [Figure 24-12](#).

- Message Length – 16 bits
- Cyclic Redundancy Check (CRC) – 32 bits
- Encapsulated Ethernet Frame – variable length

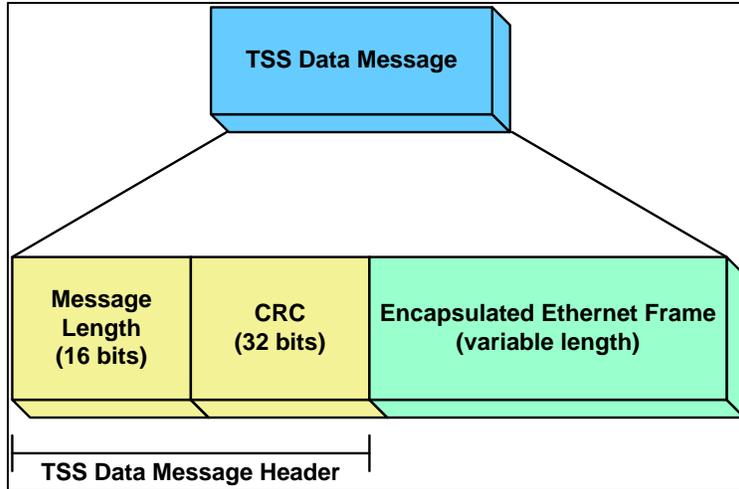


Figure 24-12. TSS Data Message Structure

24.4.2.1 Message Length

This field indicates the remaining length in bytes of the TSS data message. The size of the TSS data message is the size of the Message Length field plus the value contained therein.

24.4.2.2 Cyclic Redundancy Check (CRC)

The CRC field of the TSS data message serves as a message identifier for the TSS data message. The CRC calculation is performed on the entire Encapsulated Ethernet Frame of the message excluding the Ethernet header (e.g., offset by 14 bytes [6 dst + 6 src + 2 type]), with the result being stored in this field.

The polynomial to be used for CRC calculation shall be 32'h82608edb.

The algorithm for the CRC calculation shall be equivalent to that shown in [Figure 24-13](#). The constant POLY is defined as the polynomial listed above.

```

/*-----*/
/*-- get_crcByte - perform byte calculations for CRC process -----*/
/*-----*/
static inline uint32_t get_crcByte(int input)
{
    uint32_t val = input;
    int i;

    for (i=0; i<8; i++)
    {
        if (val & 1)
            val = (val >> 1) ^ POLY;
        else val >>= 1;
    }

    return val;
}

/*-----*/
/*-- get_crc32 - calculate the 32-bit CRC of the provided buffer -----*/
/*-----*/
static inline uint32_t get_crc32(unsigned char *data, int sz)
{
    uint32_t remainder, t1, t2;
    int bytes;

    remainder = 0;

    for (bytes = 0; bytes < sz; bytes++)
    {
        t1 = (remainder >> 8) & 0x0FFFFFFFL;
        t2 = get_crcByte(((int)remainder^(*(data+bytes)))&0xFF);
        remainder = t1^t2;
    }

    for (bytes = 0; bytes < sizeof(remainder); bytes++)
    {
        t1 = (remainder >> 8) & 0x0FFFFFFFL;
        t2 = get_crcByte(((int)remainder)&0xFF);
        remainder = t1^t2;
    }

    return remainder;
}

```

Figure 24-13. Algorithm For CRC Calculation (ANSI C Grammar)

NOTE

A reference implementation of TSS interfaces and functionality is available [here](#).

24.4.2.3 Encapsulated Ethernet Frame (Variable Length)

The Encapsulated Ethernet Frame field encapsulates an entire Ethernet frame so that it can be reproduced after transport.

APPENDIX 24-A

Guidance for Using Chapter 11 Data Types

A.1. Introduction

This appendix provides guidance for utilizing IRIG-106 Chapter 11 data types in TmNS networking applications with specific focus on implementing these data types into TmNS data messages. The intent is to establish a standardized implementation method for commonly used Chapter 11 data types within the TmNS data messages as part of the standardized network environment.

A.1.a. Background

There are various trades in operating in network environments relative to pure recording needs. Networking characteristics need to be balanced between data delivery and data recording. The TmNS was developed to leverage networking features and streamline movement of data through a flight-test data system network environment. The choices and trades made for TmNS were heavily driven by the need to increase test operational tempo and ensure interoperability between various test entities across DoD ranges. Chapter 11 was driven by the desire to document existing data formats for recording data into a large file structure for data storage.

Operating networks requires trade-offs between latency and throughput as well as providing mechanisms to allow for management of network resources and prioritization of users/nodes. The TmNS provides the mechanisms to achieve the desired functionality and performance based on open commercial standards for interoperability and reliability. On the aspect of time, the TmNS uses a time distribution method using Precision Time Protocol (PTP) to synchronize network nodes and, indirectly, other devices in a distributed fashion with absolute time. This makes the usage of the Relative Time Counter and the periodic time packets in Chapter 11 unnecessary. However, one can maintain the intra-packet timestamps if so desired to maintain the Chapter 11 Data Type characteristics.

Additionally, TmNS does not need to maintain a packet sync pattern as everything falls on a 32-bit boundaries and the network data transfer protocols ensure the frame integrity of the messages are maintained. Also, checksums are not necessary as the standard network delivery protocols for TmNS provide checksum verification.

The TmNS uses its MDL for describing generic characteristics of payloads to be used for processing and analysis of the data. The TmNS MDL can describe any payload, including the Chapter 11 data types; it can also rapidly describe/document any new formats. The MDL enables the ability to process any known data types, as the data structures are well known and only the data content needs to be described.

A.1.b. General Structure

The TmNS data message structure as described in Section [24.2](#) is composed of a message header and a package header that are used to facilitate the networking capabilities defined in the TmNS chapters. The TmNS message sizes are managed through the data delivery characteristics. The data types identified in Chapter 11 are composed of a packet header and a packet body for recording data into a large file structure.

A.1.b(1) Data Packaging

The Chapter 11 data types (or Packet Bodies) serve as data payloads within TmNS packages. One or more TmNS packages can be inserted into TmNS messages.

A.1.b(2) Data Delivery Characteristics

The TmNS provides the ability to control the size and shape of messages to manage data delivery characteristics to satisfy latency and throughput constraints. To achieve the maximum Chapter 11 packet size over the network, fragmentation bits are provided in the TmNS message header. Additionally, in a constrained network, the TmNS quality of service mechanisms may be required for data delivery.

A.1.b(3) Data Typing

The TmNS message and package structures are neutral to the data payloads. The TmNS uses its MDL for describing payloads in a more flexible data typing approach while Chapter 11 uses a more rigid data typing approach. Since MDL can describe any payload, it can describe all existing Chapter 11 data types.

A.1.b(4) Identification Uniqueness

The combination of TmNS Message Definition Identifier (MDID) and Package Definition Identifier (PDID) fields has a uniqueness constraint such that the combination within a measurement domain is unique to avoid multiple definitions/descriptions.

A.1.c. Data Correlation/Mapping

This section provides an explanation of the attribute mapping of the Chapter 11 fields into the TmNS data message structure. [Figure A-1](#) shows the Chapter 11 attributes identified by the red color font. The TmNS rules for messaging and packaging shall apply while the rules for the TmNS data payload are governed by Chapter 11.

31 (msb)				(lsb) 0	
Msg Ver (4 bits)	Opt. Word Count (4 bits)	Reserved (4 bits)	Msg Type (4 bits)	Message Flags (16 bits)	
Message Definition Identifier (32 bits)					
User Defined (16 bits)			Channel ID (16 bits)		
Message Definition Sequence Number (32 bits)					
Continuation (24 bits)				Sequence Number (8 bits)	
Message Length (32 bits) [Packet Length]					
Message Timestamp – PTP Seconds (32 Bits) [PTP Time]					
Message Timestamp – PTP Nanoseconds (32 Bits) [PTP Time]					
Package Definition Identifier (32 bits)					
User Defined (16 bits)			Data Type (8 bits)	Data Type Ver (8 bits)	
Package Length (16 bits) [Data Length]			Reserved (8 bits)	Package/Package Flags (8 bits)	
Package Timestamp Delta – Nanoseconds (32 Bits)					
[Packet Body] Data Payload (n words)					
Package Padding					

Figure A-1. Chapter 11 Packet Structures Mapped into TmNS Message Structures

A.1.c(1) TmNS Message Mapping

This section discusses the correlation between the TmNS message header structure and the Chapter 11 fields.

a. *MDID*

The Chapter 11 Channel ID is composed of 16 bits placed into the lower 16 bits of the MDID field. One can readily expand up 32-bit identifiers, if so desired. The upper 16 bits are user-defined and may be notionally represented by data source characteristics such as aircraft, component/box number, slot/module number, and port number. The importance is that the MDID must follow the TmNS uniqueness rules.

The MDIDs represent a collection of measurements within a measurement domain. The scope of the domain may contain messages from multiple sources. The user-defined field is used as a representation that can be changed to any value by the user without affecting operation of the hardware. No configuration information is encoded into the field.

b. *Message Definition Sequence Number*

The Chapter 11 Sequence Number is composed of 8 bits placed into the lower 8 bits of the message sequence field. One can readily continue the sequence up to 32-bit sequence number. Note that smaller messages delivered across the network drive the desire/need for a larger sequence number field.

c. *Message Length*

The Chapter 11 Packet Length is composed of 32 bits and maps directly into the message length field.

d. *Message Timestamp*

The packet timestamp accepts using PTP time as indicated in the secondary header and maps into the 64-bit message timestamp field. The Chapter 11 secondary header absolute time corresponds with the TmNS message timestamp.

e. *Optional Application Defined Fields (not shown)*

The optional application defined fields can be utilized to indicate which messages are Chapter 11 Data Types in a mixed networking environment, if so desired.

A.1.c(2) TmNS Package Mapping

This section discusses the correlation between TmNS package header structure and the Chapter 11 fields.

a. *PDID*

The Chapter 11 Data Type and Data Type Version map into the PDID field. The Data Type field is composed of 8 bits and maps into the second least significant byte of the PDID field. The Data Type Version field is composed of 8 bits and maps into the least significant byte of the PDID field. The upper 16 bits can be readily used to expand up to 32-bit identifiers, if so desired. The upper 16 bits are user-defined and may be notionally represented by data type characteristics such as sub-channel number.

b. *Package Length*

The Chapter 11 Data Length is composed of 32 bits but is limited to 16 bits of the package length field. When multiple TmNS packages are used in a TmNS message, the package length is limited to the length of the package itself.

c. *Package Flags*

The Chapter 11 Packet Flags field is composed of 8 bits and maps directly into the package flag field.

d. *Package Timestamp Delta*

The TmNS package timestamp delta is part of the TmNS structure; see Subsection [24.2.2.1.1.5](#) for more information.

e. *Package Payload*

The Chapter 11 Packet Body of the data type maps into the package payload and is governed by the Chapter 11 data type rules.

f. *Package Padding*

The package padding is used to align the package to the 32-bit boundary to ensure a package starts and ends on a 32-bit boundary.

A.1.d. Packaging Data Types

This section illustrates the packaging of Chapter 11 data types into the TmNS data message structure. The rules allow for one or more packages into a single message based on data delivery characteristics.

A.1.d(1) TmNS Message w/Single Package

[Figure A-2](#) shows how to place a single Chapter 11 data type into a TmNS data message utilizing a single package.

31 (msb)				(lsb) 0	
Msg Ver (4 bits)	Opt. Word Count (4 bits)	Reserved (4 bits)	Msg Type (4 bits)	Message Flags (16 bits)	
Message Definition Identifier (32 bits) [User Defined & Channel ID]					
Message Definition Sequence Number (32 bits) [Sequence Number]					
Message Length (32 bits) [Packet Length]					
Message Timestamp – PTP Seconds (32 Bits) [PTP Time]					
Message Timestamp – PTP Nanoseconds (32 Bits) [PTP Time]					
[User Defined & Data Type & Version] Package Definition Identifier (32 bits)					
Package Length (16 bits) [Data Length]			Reserved (8 bits)		Package/Package Flags (8 bits)
Package Timestamp Delta – Nanoseconds (32 Bits)					
[Packet Body] Data Payload (n words)					
Package Padding					

Figure A-2. TmNS Message with Single Package

A.1.d(2) TmNS Message w/Multiple Packages

[Figure A-3](#) shows how to place a single Chapter 11 data type into a TmNS data message using multiple data packages, if so desired.

31 (msb)				(lsb) 0
Msg Ver (4 bits)	Opt. Word Count (4 bits)	Reserved (4 bits)	Msg Type (4 bits)	Message Flags (16 bits)
Message Definition Identifier (32 bits) [User Defined & Channel ID]				
Message Definition Sequence Number (32 bits) [Sequence Number]				
Message Length (32 bits) [Packet Length]				
Message Timestamp – PTP Seconds (32 Bits) [PTP Time]				
Message Timestamp – PTP Nanoseconds (32 Bits) [PTP Time]				
[User Defined & Data Type & Version] Package Definition Identifier (32 bits) (Package 1)				
Package Length (16 bits) [Data Length]		Reserved (8 bits)		Package/Package Flags (8 bits)
Package Timestamp Delta – Nanoseconds (32 Bits)				
[Packet Body] Data Payload (n words)				
Package Padding (Package 1)				
[User Defined & Data Type & Version] Package Definition Identifier (32 bits) (Package m)				
Package Length (16 bits) [Data Length]		Reserved (8 bits)		Package/Package Flags (8 bits)
Package Timestamp Delta – Nanoseconds (32 Bits)				
[Packet Body] Data Payload (n words)				
Package Padding (Package m)				

Figure A-3. TmNS Message with Multiple Packages

Note: The TmNS Message Length field represents the aggregate length based on the number of packages. Additionally, the TmNS Message Definition Sequence Number field represents the sequences for all packages with the TmNS message.

This page intentionally left blank.

****** END OF CHAPTER 24 ******