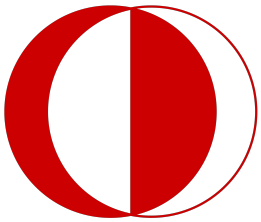

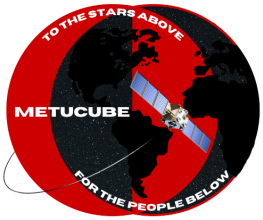

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CCSDS Based Telecommand Processing Guide

July 13, 2025

Contents

1 CCSDS TM/TC Application

For the telecommand and telemetry applications of METUCube, **CCSDS 133.0-B-1/2** protocol will be established. Mentioned protocol is well used in space industry, and CCSDS protocols in general are used by NASA cFS too, which is the main software framework for METUCube OBC.

CCSDS 133.0-B-1/2 consists of 3 main fields, as follows.

- PACKET PRIMARY HEADER
- PACKET SECONDARY HEADER (OPTIONAL)
- USER DATA FIELD - PAYLOAD

The last two items are named as PACKET DATA FIELD. The PACKET PRIMARY HEADER is made up of 6 octets, where PACKET DATA FIELD is made up of up to 65536 octets by design, but this maximum number is open to modification. This can be seen in Figure 1, which is explained in [1].

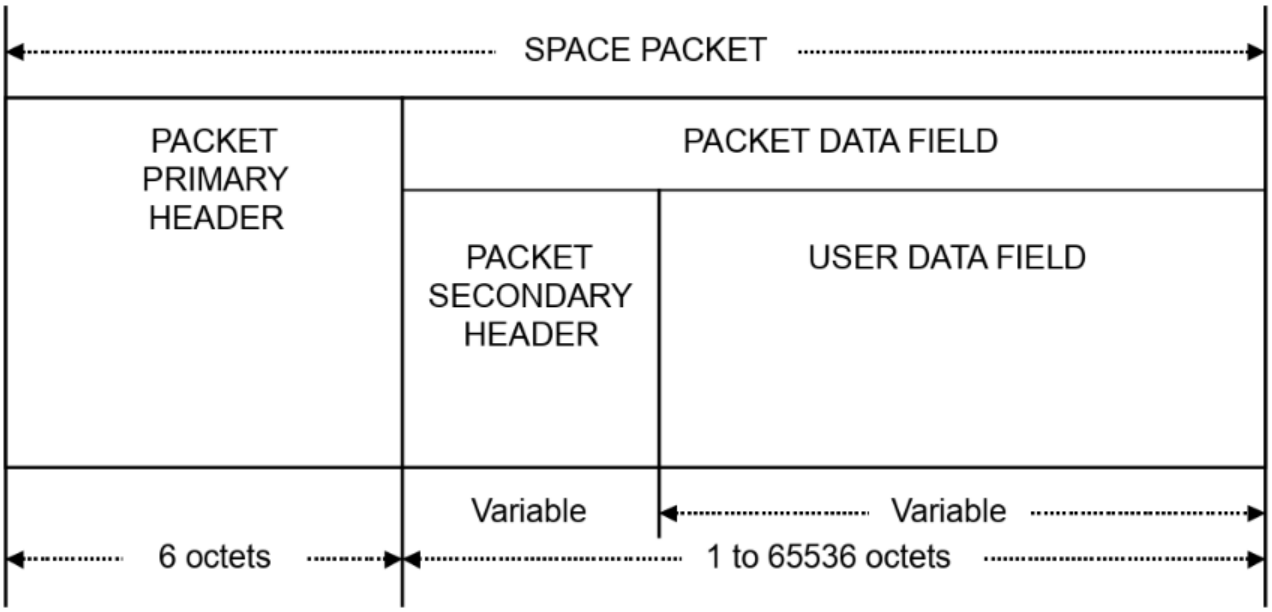

Figure 1: CCSDS 133.0-B-1/2 Data Structural Components

1.1 Primary Header Structure

Total of 48 bits are pre-defined for this packet. Size allocation is as follows.

- 3 bits - Packet CCSDS Version

- 13 bits - Packet Identification
  - 1 bit - Type (0 for TM and 1 for TC)
  - 1 bit - 1 if Secondary Header presents, else 0
  - 11 bits - APID (Application Process ID)
- 16 bits - Packet Sequence Control
  - 2 bits - Sequence control (00 for Continuation, 01 for First, 10 for Last, 11 for Unsegmented)
  - 14 bits - Packet Sequence Count
- 16 bits - Packet Data Length in bytes(Payload + Secondary Header - 1)

Details of these allocated items are explained in Section 4.1.3 of [1].

1.2 Secondary Header Structure

Consists of TIME CODE FIELD and ANCILLARY DATA FIELD. Use cases for METUCube will be explained in later chapters.

1.3 User Data Field Structure

Consists of PAYLOAD. Use cases for METUCube will be explained in later chapters. Should be placed right after secondary header without any gaps, provided octets for secondery header structure is pre-determined.

2 METUCube CCSDS TM/TC Integration

METUCube will follow a same trend as the CCSDS, but with couple changes. All the necessary fields will be explained in this document. Following that, this integrated protocol will be named as MCLink. Unless otherwise specified, this document will explain MCLink version 1.0.0.

2.1 MCLink Header Structure

Total of 64 bits are pre-defined for this packet. Size allocation is as follows.

- 3 bits - Packet MCLink Version
- 13 bits - Packet Identification
  - 1 bit - Type (0 for TM and 1 for TC)
  - 12 bits - MTID (Message Type ID)
- 16 bits - Packet Sequence Control
  - 2 bits - Sequence control (00 for Continuation, 01 for First, 10 for Last, 11 for Unsegmented)
  - 14 bits - Packet Sequence Count
- 32 bits - Packet Data Length in bytes(Payload + Secondary Header)

2.1.1 Packet MCLink Version

For this document, it is specified as version 1.0.0, and corresponding binary is **100**.

2.1.2 Packet Identification

In regular CCSDS implementation, there was a secondary header flag here, but MCLink always assumes there will be a secondary header for MCLink.

2.1.2.1 Packet Type

If it is a Telemetry, corresponding binary is **0**. If it is a Telecommand, corresponding binary is **1**.

2.1.2.2 Message Type ID (MTID)

12 bits are reserved for this MTID. This is an unsigned integer, and processes will explained in detail in the later versions of this report.

2.1.3 Packet Sequence Control

2.1.3.1 Sequence Control Type

If it is the First communication packet, corresponding binary is **01**. If it is a continuation packet, corresponding binary is **00**. If it is the last packet, corresponding binary is **10**. If packet is unsegmented, corresponding binary is **11**.

If file transmission is desired, it is recommended for first payload to be a metadata for the file. Standards for this metadata will be explained later.

2.1.3.2 Packet Sequence Count

If packet is segmented, unsigned int for the packet sequence count starting from 0. Packet 0 is recommended to be the header.

2.1.4 Packet Data Length

Total length of the payload + secondary header, in terms of bytes. Unsigned int.

2.2 MCLink Secondary Header Structure

Total of 64 bits. 32 bit for the timestamp, and 32 bit for the CRC-32 encryption.

2.2.1 Timestamp

Unsigned UNIX timestamp with 32 bits will be used. Note that this approach will cause overflow around year 2161 :)

2.2.2 CRC-32 Encryption

Only the payload will be encrypted with CRC-32 method, and the result will be added to secondary header as a 32 bit unsigned int.

2.3 Payload

It was recommended from CCSDS that payload and second header have total size of 4294967296 bytes. This constraint is issued by the 32 bit packet size field. The secondary header takes 8 bytes, so the maximum payload length is **4294967288 bytes**. There is no end or start flag, since size of this payload is pre-defined in the header.

3 Header For File Transmission via MCLink

It consists of 384 bits, mostly taken by SHA256.

- 32 bits - File Data ID
- 32 bits - Unique File ID
- 32 bits - File Data Length in Bytes
- 256 bits - SHA256 of File
- 16 bits - Number of PDUs
- 16 bits - PDU Data Length in Bytes

3.1 File Data ID

This defines the file type. 32 bit unsigned int.

- 0 : Housekeeping Data
- 1 : Payload Imagery Data

3.2 Unique File ID

32 bit unsigned int. Defines an unique ID for the file to be sent. It has to be generated from the sender.

3.3 File Data Length in Bytes

32 bit unsigned int.

3.4 SHA256 of File

SHA256 encrypted key of the file content.

3.5 Number of PDUs

16 bit unsigned int. Number of pieces that data will be sent as.

3.6 PDU Data Length in Bytes

16 bit unsigned int.

4 Minimal TM to Emit

COMMMC_APP_MINIMAL_TM_MTID is 0. Message will be sent each 60 seconds. The example receiver code can be found here.

4.1 Minimal TM from ADCS

Total 512 bits.

- Quaternion, 4 floats, 128 bits
- Angular Velocity, 3 floats, 96 bits
- Velocity, 3 floats, 96 bits
- Position Vector, 3 floats, 96 bits
- RW Speeds in RPM, 3 uint32s, 96 bits

4.2 Minimal TM from ADCSTT

Same as ADCS, defined in subsection 4.1.

4.3 Minimal TM from Power

Total 64 bits.

- Battery Percentage, 1 uint32, 32 bits
- Battery Health, 1 uint32, 32 bits

5 Telecommand Structure

Telecommands will follow the header structure mentioned. The TC can identify itself using Packet Identification - MTID field. Note that payload is optional in the case of Telecommand. A TC can be sent that requires satelitte to emit some TM, and this can be expressed using MTID. The following MTIDs will be used.

- 0: Stream the message in payload
- 1: Send last HK file
- 2: Delete last HK file to save space
- 10: Uploading Table File

5.1 Stream the Message Payload and Process

Payload consists of:

- Buffer to be streamed

5.2 Table Uploading Payload and Process

Will be explained in later versions.

References

[1] Consultative Committee for Space Data Systems (CCSDS). *Space Packet Protocol*. Blue Book 133.0-B-2. Recommendation for Space Data System Standards. CCSDS, Sept. 2020. URL: https://ccsds.org/Pubs/133x0b2e2.pdf.