Elysium Radio Networking Layer - Space Packet Protocol

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Contents

List of Figures

List of Tables

1 Overview

The Space Packet Protocol (CCSDS Recommended Standard 133.0-B-1) is a network layer standard used by many NASA and ESA missions.

Packets of the Space Packet Protocol are routed using Application Process Identifiers (APIDs). The SrcAddr register will be interpreted as an APID assigned to the Elyisum radio. All packets containing this APID will be routed to the Elysium radio.

The Space Packet Protocol also makes a distinction between telemetry (or reporting) packets and telecommand (or requesting) packets. With the exception of packets containing the APID of the Elysium radio, all telemetry packets are routed over the radio link, while all telecommand packets are routed over the UART interface.

More details of address translation and routing can be found in Section 2.

Registers associated with the SPP Network Layer subsystem can be found in Section 3. Channels, Errors, and Events associated with the SPP Network Layer subsystem can be found in Section 4, Section 5, and Section 6, respectively.

2 Routing

In order to receive Space Packets, the Elysium must have a valid APID. This APID is derived from the value of the SrcAddr register by taking the least significant 11 bits. Translations of APIDs into Reply Addresses is performed by left-padding the APID into a 16-bit value.

Routing decisions are made by examining the Packet Type and APID of the Packet Primary Header. If the Packet Type is Telecommand and the APID does not match the Elysium APID, the packet is routed out the UART interface. If the Packet Type is Telemetry and the source of the packet is not the Elysium, the packet is passed to the Data Link Layer for transmission over the RF interface.

When Packet Type is Telemetry and the source of the packet is the Elysium, the packet must be inspected further in order to determine its destination. If the APID matches the value stored in the GroundAPID register, the packet is passed to the Data Link Layer for transmission over the RF interface - otherwise the packet is routed out the UART interface.

As a small amount of framing is required to transmit Space Packets over the UART link, the END and ESC bytes from the Serial Line Internet Protocol are used. An END byte (0xC0) indicates the end of a Space Packet (and thus the start of a new one). An ESC byte is used to escape an END byte (with the sequence 0xDB 0xDC) or an ESC byte (with the sequence 0xDB 0xDD) found in the Packet.

3 Registers

This section defines the registers in Table 1, which apply to the Space Packet Protocol Network Layer.

Table 1: SPP Registers

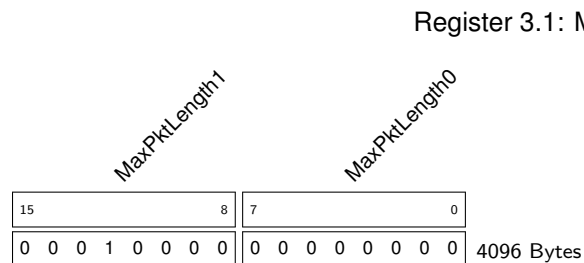| Address	Name	Description
0x80	MaxPktLength0	Maximum Packet Length LSB
0x81	MaxPktLength1	Maximum Packet Length MSB
0x82	GroundAPID0	Ground APID LSB
0x83	GroundAPID1	Ground APID MSB
0x84	PktName0	Packet Name LSB
0x85	PktName1	Packet Name MSB
0x86	Options	General Configuration Bitfields
0x87	PVNErrLvl	Invalid PVN Error Reporting Level
0x88	PktLengthLvl	Packet Length Mismatch Error Reporting Level
0x89	SPPErrRpt	SPP Error Reporting Bitfields

3.1 MaxPktLength[0-1]

Address: 0x80

Data Type: uint16_t

Description: The MaxPktLength register contains the maximum length of a Space Packet as a 16-bit unsigned integer in bytes.

Diagram:

Register 3.1: MAXPKTLENGTH (0x80)

MaxPktLength1								MaxPktLength0								
15							8	7							0	
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4096 Bytes

Fields:

- MaxPktLength1 - MSB - 0x81

- MaxPktLength0 - LSB - 0x80

Recommended Value: 2048 bytes

Notes: The valid range for this register is from 7 to 4096 bytes.

The number of packets capable of being stored in the on-board buffer is directly proportional to this value. The buffer is 8192 bytes deep and is divided into slots of length MaxPktLength, with excess bytes remaining
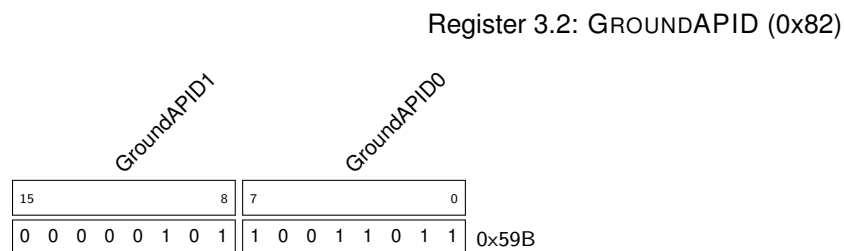
unused.

3.2 GroundAPID[0-1]

Address: 0x82

Data Type: uint16_t

Description: The GroundAPID register contains the APID used to identify the ground station when sending Telemetry packets from the Elysium itself.

Diagram:

Register 3.2: GROUNDAPID (0x82)

Fields:

- GroundAPID1 - MSB - 0x83
- GroundAPID0 - LSB - 0x82

Recommended Value: N/A

Notes: The valid range for this register is from 0 to 2047 (0x000 to 0x7FF). A value over 0x7FF will be masked with 0x7FF to produce a legal value.

This value will be used to determine when Elysium responses should be routed over the radio to the ground station. Because all Elysium response packets are Telemetry packets, this APID is required to determine the routing destination for such packets. All other packets are routed in a pass-through fashion as described in Section 2.
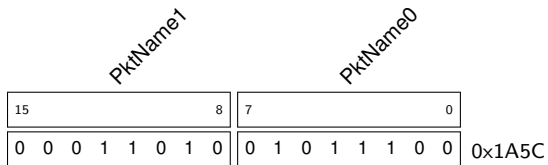
3.3 PktName[0-1]

Address: 0x84

Data Type: uint16_t

Description: The PktName register contains the Packet Name used in place of the Packet Sequence Count if configured in the Packet Name field of the Options register.

Diagram:

Register 3.3: PKTNAME (0x84)

Fields:

- PktName1 - MSB - 0x85

- PktName0 - LSB - 0x84

Recommended Value: Use of this option is not recommended.

Notes: The valid range for this register is from 0 to 16383 (0x000 to 0x3FFF). A value over 0x3FFF will be clipped to 0x3FFF.
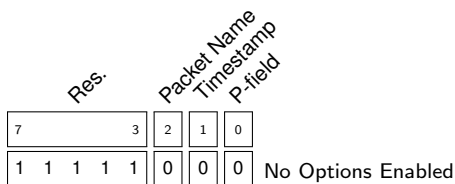
3.4 Options

Address: 0x86

Data Type: Bitfields

Description: The Options register contains a number of bitfields which configure the use of optional features of the Space Packet Protocol.

Diagram:

Register 3.4: OPTIONS (0x86)

Fields:

- Res. - Reserved. These bits are ignored. - 0x86.3

- Packet Name - Packet Name enable field - 0x86.2

- Timestamp - Timestamp enable field - 0x86.1

- P-Field - P-Field enable field - 0x86.1

Recommended Value: In general, none of these options are needed, however if the Timestamp option is used the P-field option should also be used.

Notes: The reserved bits are ignored and may be safely set to any value.

The Packet Name field enables the use of the optional Packet Name function of the Space Packet Protocol, which replaces the Packet Sequence Count with a user-specified identifier (specified in the Packet Name register).

The Timestamp field enables the use of the optional Time Code Field of the Space Packet Protocol. The Time Code Field is an optional field in the Packet Secondary Header which describes the time at which a packet was sent in one of several formats. When this bit is set, all Telemetry packets sent by the Elysium will contain in the Time Code Field the current Mission Time as a 32-bit signed integer. See the Elysium User Manual for more information.

The P-Field field enables the use of the optional P-Field portion of the Time Code Field of the Space Packet Protocol. When this bit is set, a P-Field is prepended to the 4-byte timestamp value to describe it as using an unsegmented time code with an Agency-defined epoch and using 4 bytes for the basic time unit and 0 bytes for the fractional time unit. This corresponds to a P-field value of 00101100 or 0x2C.

The Ancillary Data Field of the Space Packet Protocol is not supported by the Elysium.
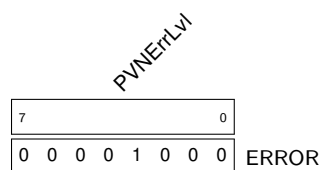
3.5 PVNErrLvl

Address: 0x87

Data Type: Priority Enumeration

Description: The PVNErrLvl register controls the priority level of invalid PVN errors, if enabled by the PVNErrRpt bit of the SPPErrRpt register.

Diagram:

Register 3.5: PVNErrLvl (0x87)

7							0	
0	0	0	0	1	0	0	0	ERROR

Fields:

- PVNErrLvl - Priority level of invalid PVN errors - 0x87

Recommended Value: ERROR

Notes: The acceptable values for this register are the valid values of the Priority Enumeration data type, a one-hot encoding using bits 0 through 4.
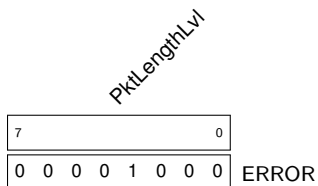
3.6 PktLengthLvl

Address: 0x88

Data Type: Priority Enumeration

Description: The PktLengthLvl register controls the priority level of packet length mismatch errors, if enabled by the PktLengthRpt bit of the SPPErrRpt register.

Diagram:

Register 3.6: PKTLENGTHLVL (0x88)

PktLengthLvl

7							0
0	0	0	0	1	0	0	0	ERROR

Fields:

- PktLengthLvl - Priority level of invalid PVN errors - 0x88

Recommended Value: ERROR

Notes: The acceptable values for this register are the valid values of the Priority Enumeration data type, a one-hot encoding using bits 0 through 4.
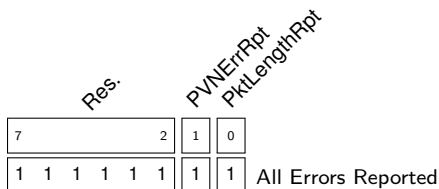
3.7 SPPErrRpt

Address: 0x89

Data Type: Bitfields

Description: The SPPErrRpt register contains a number of bitfields controlling the reporting of errors within the SPP Networking Layer.

Diagram:

Register 3.7: SPPERRRPT (0x89)

Res.   PVNErrRpt PktLengthRpt

7					2	1	0
1	1	1	1	1	1	1	1	All Errors Reported

Fields:

- Res. - Reserved. These bits are ignored. - 0x89.6

- PVNErrRpt - Enables reporting of invalid PVN errors - 0x89.1

- PktLengthRpt - Enables reporting of packet length mismatch errors - 0x89.0

Recommended Value: If the spacecraft contains a flight computer which is capable of taking action to correct errors, in general all errors should be reported.

Notes: The reserved bits are ignored and may be safely set to any value.

When the PVNErrRpt bit is set, anytime a Space Packet is received with an invalid Packet Version Number, an error will be reported with the priority level defined in the PVNErrLvl register.

When the PktLengthRpt bit is set, anytime a Space Packet is received which consists of a different number of bytes than that specified in the Packet Data Length field, an error will be reported with the priority level defined in the PktLengthLvl register.

4 Channels

Table 2: Channels

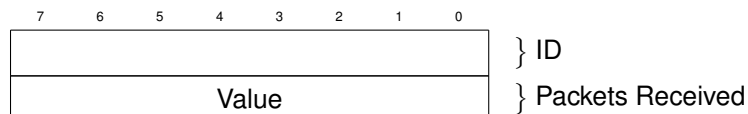| ID	Name	Data Type
0x60	Packets Received	uint8_t
0x61	Packets Sent	uint16_t
0x62	Packets Relayed	uint8_t

4.1 Packets Receieved

Channel ID: 0x60

Data Type: uint8_t

Description: The Packets Received Channel reports the number of Telecommand packets received by the Elysium firmware.

Format:

7	6	5	4	3	2	1	0	
								} ID
			Value					} Packets Received

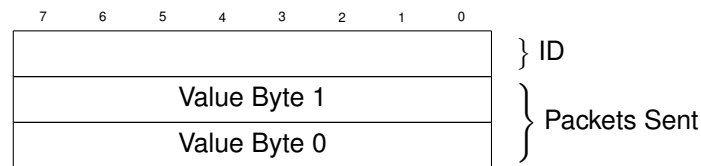**Notes:** This counter increases monotonically until it rolls over from 255 to 0.

4.2 Packets Sent

Channel ID: 0x61

Data Type: uint16_t

Description: The Packets Sent Channel reports the number of Telemetry packets sent by the Elysium firmware.

Format:

7	6	5	4	3	2	1	0	
								} ID
Value Byte 1								}
Value Byte 0								} Packets Sent

Notes: This value corresponds with the value to be placed in the Packet Sequence Count field of the next Space Packet sent by the Elysium (or the value that would be placed there if the Packet Name bit of the Options register were not set). As such, it is limited to 14 bits, or the range from 0 to 16383.

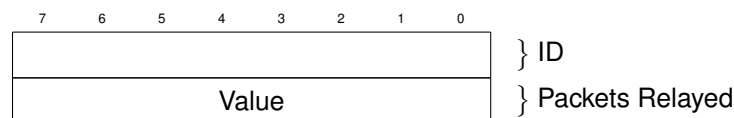This counter increases monotonically until it rolls over from 16383 to 0.

4.3 Packets Relayed

Channel ID: 0x62

Data Type: uint8_t

Description: The Packets Relayed Channel reports the number of both Telemetry and Telecommand packets relayed through the Elysium, without being received by or sent from the Elysium firmware.

Format:

7	6	5	4	3	2	1	0	
								} ID
Value								} Packets Relayed

Notes: This value is incremented whenever a packet is passed through the Elysium without interacting with the Elysium firmware, in either direction.

This counter increases monotonically until it rolls over from 255 to 0.

5 Errors

Table 3: Errors

ID	Error
0xA0	PVN Mismatch
0xA1	Packet Length Mismatch

5.1   PVN Mismatch

Error ID: 0xA0

Description: The PVN Mismatch error indicates that the Elysium firwmare has received a Space Packet with a Packet Version Number (PVN) other than '000'.

Fault Response? Packet discarded.

Recommended Priority: ERROR

Priority Register: PVNErrLvl

5.2   Packet Length Mismatch

Error ID: 0xA1

Description: The Packet Length Mismatch error indicates that the Elysium firwmare has received a Space Packet with a Packet Data Length field which indicates either more or fewer bytes than the number of bytes available in the packet.

Fault Response? Packet discarded.

Recommended Priority: ERROR

Priority Register: PktLengthLvl

6   Events

Table 4: Events

ID	Event
0xE0	Packet Received
0xE1	Packet Sent
0xE2	Packet Relayed

6.1 Packet Received

Event ID: 0xE0

Description: The Packet Received Event indicates that the Elysium firmware has received a Telecommand packet.

Notes: The total number of received packets can be retrieved from the Packets Received channel.

6.2 Packet Sent

Event ID: 0xE1

Description: The Packet Transmitted Event indicates that the Elysium firmware has sent out a Telemetry packet.

Notes: The total number of sent packets can be retrieved from the Packets Sent channel.

6.3 Packet Relayed

Event ID: 0xE2

Description: The Packet Relayed Event indicates that the Elysium has relayed a Space Packet.

Notes: The total number of relayed packets can be retrieved from the Packets Relayed channel.

A   Revision History

1. Initial release