1.1 cube-wheel-2-control-program-4

1.1.1 Telecommands

Table 1: List of Telecommands

ID	Name	Description	Length (bytes)
General			
1	Reset	Perform a soft reset - Table 2	1
2	Current Unix time	Current Unix time - Table 4	8
3	Error Log Index	Describes the index of the error log that will be read when calling GetErrorLogEntry - Table 5	5
4	Error Log Entry	Error Log Entry - Table 7	8
5	Error Log Clear	Clear the Error Log - Table 8	0
6	Error Log Settings	Error Log Settings - Table 9	1
7	Persist Config	Writes volatile config items to flash - Table 12	0
60	Motor Power	Switch motor power on/off - Table 13	1
61	Backup Gain	Backup speed controller gain values - Table 14	12
62	Clear Errors	Clear the processor error flags - Table 15	0
63	Wheel Reference Torque	Set torque reference for wheel - Table 16	4
64	Wheel Reference Speed	Set momentum wheel reference speed - Table 17	4
66	Backup Wheel Mode	Set the back-up wheel mode - Table 18	1
67	Main Gain	Main speed controller gain values - Table 19	12
68	PWM Gain	General PWM gain - Table 20	4
69	Wheel Reference Distance	Drive rover for defined distance and max speed. - Table 21	8
70	Wheel Reference Speed Ramp Rate Limit	Set ramp rate limit for wheel speed reference - Table 22	4

Table 2: Reset Command Format

ID	1		**Parameters Length (bytes)**	1	
Description	Perform a soft reset				
Parameters	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	8	Reset Type	ENUM	The type of reset to perform. Possible values are in Table 3

Table 3: ResetVal Enumeration Values

Numeric Value	Name	Description
0	Do Nothing	Dummy Value
55	Soft	Performs a list of final() operations before resetting
66	Hard	Performs reset immediately

Table 4: Current Unix time Command Format

ID	2		**Parameters Length (bytes)**		8
Description	Current Unix time				
Parameters	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	32	Current Unix seconds	UINT	Current Unix time s. (Unit of measure is [s])
	32	32	Current Unix Nanoseconds	UINT	Current Unix time ns. (Unit of measure is [ns])

Table 5: Error Log Index Command Format

ID	3		**Parameters Length (bytes)**		5
Description	Describes the index of the error log that will be read when calling GetErrorLogEntry				
Parameters	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	8	Error Log Index Reference	ENUM	0 = Head, 1 = Tail. Possible values are in Table 6
	8	16	Error Log Index Value	UINT	Error Log Index Value ~ Relative to ErrorLogIndexReference
	24	16	Error Log Entries	UINT	Number of Error Log Entries Present

Table 6: ErrorLogSearch Enumeration Values

Numeric Value	Name	Description
0	ReferenceHead	ReferenceHead
1	ReferenceTail	ReferenceTail

Table 7: Error Log Entry Command Format

ID	4		**Parameters Length (bytes)**		8
Description	Error Log Entry				
Parameters	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	32	Error Log Entry Timestamp	UINT	Timestamp of this Error Log Entry
	32	32	ErrorLogEntryErrorCode	UINT	ErrorCode of this Error Log Entry

Table 8: Error Log Clear Command Format

ID	5	**Parameters Length (bytes)**	0
Description	Clear the Error Log		

Table 9: Error Log Settings Command Format

ID	6		**Parameters Length (bytes)**		1
Description	Error Log Settings				
Parameters	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	1	Active State	ENUM	Error Logging Enabled state. Possible values are in Table 10
	1	1	Buffer Full Action	ENUM	Action to take when log is full. Possible values are in Table 11
	2	6	Reserved	PADDING	Reserved.

Table 10: ActiveState Enumeration Values

Numeric Value	Name	Description
0	Enabled	Logging is disabled
1	Disabled	Logging is enabled

Table 11: BufferFullAction Enumeration Values

Numeric Value	Name	Description
0	Ignore	Ignore new entries when buffer is full
1	Erase	Erase log and add new entry when buffer is full

Table 12: Persist Config Command Format

ID	7	**Parameters Length (bytes)**	0
Description	Writes volatile config items to flash		

Table 13: Motor Power Command Format

ID	60		**Parameters Length (bytes)**		1
Description	Switch motor power on/off				
Parameters	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	1	Motor Power Switch	BOOL	Switch motor power switch on/off

Table 14: Backup Gain Command Format

ID	61		**Parameters Length (bytes)**		12
Description	Backup speed controller gain values				
Parameters	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	32	Kp	FLOAT	Proportional gain
	32	32	Ki	FLOAT	Integrator gain
	64	32	Kd	FLOAT	Feedback gain

Table 15: Clear Errors Command Format

ID	62	**Parameters Length (bytes)**	0
Description	Clear the processor error flags		

Table 16: Wheel Reference Torque Command Format

ID	63		**Parameters Length (bytes)**		4
Description	Set torque reference for wheel				
Parameters	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	32	Reference Torque	FLOAT	Wheel reference Torque. (Unit of measure is [mNm])

Table 17: Wheel Reference Speed Command Format

ID	64		**Parameters Length (bytes)**		4
Description	Set momentum wheel reference speed				
Parameters	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	32	Reference Speed	FLOAT	Wheel reference speed. (Unit of measure is [RPM])

Table 18: Backup Wheel Mode Command Format

ID	66		**Parameters Length (bytes)**		1
Description	Set the back-up wheel mode				
Parameters	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	1	BackupMode	BOOL	Enable the back-up mode

Table 19: Main Gain Command Format

ID	67	**Parameters Length (bytes)**	12
Description	Main speed controller gain values		

Parameters	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	32	Kp	FLOAT	Proportional gain
	32	32	Ki	FLOAT	Integrator gain
	64	32	Kd	FLOAT	Feedback gain

Table 20: PWM Gain Command Format

ID	68		Parameters Length (bytes)		4
Description	General PWM gain				
Parameters	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	32	K	FLOAT	Main gain

Table 21: Wheel Reference Distance Command Format

ID	69		Parameters Length (bytes)		8
Description	Drive rover for defined distance and max speed.				
Parameters	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	32	Reference Speed	FLOAT	Wheel reference speed. (Unit of measure is [RPM])
	32	32	Reference Distance	INT	Wheel reference distance. (Unit of measure is [Rot])

Table 22: Wheel Reference Speed Ramp Rate Limit Command Format

ID	70		Parameters Length (bytes)		4
Description	Set ramp rate limit for wheel speed reference				
Parameters	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	32	Ramp Rate Limit	FLOAT	Maximum speed reference increment during 1ms period. This limits the max torque of the motor.. (Unit of measure is [RPM/ms])

1.1.1 Telemetry

Table 23: List of Telemetry Frames

ID	Name	Description	Length (bytes)
		General	
128	Identification	Identification information for this node (Legacy definition - use Identification2 instead) - Table 24	8
129	Serial Number	Unique serial number of the CubeSpace Component - Table 27	70
130	Error Log Index	Describes the index of the error log that will be read when calling GetErrorLogEntry - Table 30	5
131	Error Log Entry	Error Log Entry - Table 31	8
132	Error Log Settings	Error Log Settings - Table 32	1
133	Current Unix time	Current Unix time - Table 33	8
134	Persist Config Diagnostics	Diagnostics data for config persistence - Table 34	6
135	Communication Status	Communication Status - Table 37	32
136	Version	Firmware Version - Table 38	22
137	Boot Status	State information about the device boot process - Table 40	3
138	Telecommand Acknowledge	Used with the I2C protocol to receive Telecommand Ack/Nack - Table 43	4
139	Common Error Codes	Error codes common to all applications - Table 45	16
140	Identification2	Identification information for this node - Table 46	21
183	Wheel Position Data	Complete wheel data - Table 47	15
184	Wheel Model	Get the wheel model - Table 49	1

185	Wheel Torque	Wheel Torque measurement - Table 51	5
186	Wheel Reference Torque	Set torque reference for wheel - Table 52	4
187	Control Mode	Get the motor control mode - Table 53	1
188	Wheel Speed	Wheel speed measurement - Table 55	5
189	Health Telemetry	Health telemetry for CubeWheel - Table 56	17
190	Wheel Data	Complete wheel data - Table 57	15
191	PWM Gain	General PWM gain - Table 58	4
192	Backup Gain	Backup speed controller gain values - Table 59	12
193	Main Gain	Main speed controller gain values - Table 60	12
194	Status and Error Flags	Processor status and error flags - Table 61	1
195	Wheel Duty Cycle	Motor commanded PWM control signal - Table 62	4
196	Wheel Reference Speed	Set momentum wheel reference speed - Table 63	4
197	Motor Power	Switch motor power on/off - Table 64	1
198	Backup Wheel Mode	Set the back-up wheel mode - Table 65	1
199	Stator Data	Data related to the motor stator windings - Table 66	8
200	Wheel Reference Speed Ramp Rate Limit	Set ramp rate limit for wheel speed reference - Table 67	4

Table 24: Identification Telemetry Format

ID	128		**Frame Length (bytes)**		8
Description	Identification information for this node (Legacy definition - use Identification2 instead)				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	4	Node type identifier	ENUM	Node type identifier. Possible values are in Table 25
	4	4	Program type identifier	ENUM	Program type identifier. Possible values are in Table 26
	8	8	Interface version	UINT	Interface version
	16	8	Firmware version (Major)	UINT	Firmware version (Major)
	24	8	Firmware version (Minor)	UINT	Firmware version (Minor)
	32	16	Runtime (seconds)	UINT	Seconds since processor start-up
	48	16	Runtime (milliseconds)	UINT	Milliseconds (after the integer second) since processor start-up

Table 25: NodeTypeLegacy Enumeration Values

Numeric Value	Name	Description
0	Invalid	Invalid Node Type
1	CubeComputer	CubeComputer Type - version independant
2	CubeSense	CubeSense Type - version independant
3	CubeWheel	CubeWheel Type - version independant
4	CubeIr	CubeIR Type - version independant
5	CubeMag Deploy	CubeMag Deploy Type - version independant
6	CubeMag Compact	CubeMag Compact Type - version independant
7	CubeStar	CubeStar Type - version independant
8	CubeAuriga	CubeAuriga Type - version independant
9	CubeNode	CubeNode General Type - version independant
10	CubeNode-SLT	CubeNode SLT Type - version independant
11	CubeNode-PST3S	CubeNode PST3S Type - version independant
12	CubeNode-NSSRWL	CubeNode NSSRWL Type - version independant
15	NodeTypeLegacyExtended	Marks the end of the 4-bit legacy enum - Make use of a different telemetry that uses the NodeType enum (Identification2)

Table 26: ProgramType Enumeration Values

Numeric Value	Name	Description
0	Invalid	Invalid Program Type
1	control-program	control-program primary product application

4	flash-bootloader	cube-computer flash-bootloader Bootloader application
7	health-check	health-check Health Check application

Table 27: Serial Number Telemetry Format

ID	129		**Frame Length (bytes)**		70
Description	Unique serial number of the CubeSpace Component				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	256	OTP Serial	STRING	OTP ASCII string of chars denoting the serial number of this module
	256	256	Config Serial	STRING	Config ASCII string of chars denoting the serial number of this module
	512	8	Node type identifier	ENUM	Node type identifier sourced from active serial. Possible values are in Table 28
	520	32	Serial Integer	UINT	Integer representation of the integer portion the serial number of this module sourced from active serial
	552	8	Active Serial Number	ENUM	Which area the serial number (OTP/Config) is being used internally. Possible values are in Table 29

Table 28: NodeType Enumeration Values

Numeric Value	Name	Description
0	Invalid	Invalid Node Type
1	CubeComputer	CubeComputer Type - version independant
2	CubeSense	CubeSense Type - version independant
3	CubeWheel	CubeWheel Type - version independant
4	CubeIr	CubeIR Type - version independant
5	CubeMag Deploy	CubeMag Deploy Type - version independant
6	CubeMag Compact	CubeMag Compact Type - version independant
7	CubeStar	CubeStar Type - version independant
8	CubeAuriga	CubeAuriga Type - version independant
9	CubeNode	CubeNode General Type - version independant
10	CubeNode-SLT	CubeNode SLT Type - version independant
11	CubeNode-PST3S	CubeNode PST3S Type - version independant
12	CubeNode-NSSRWL	CubeNode NSSRWL Type - version independant
16	CubeNodeQuad	CubeNodeQuad General Type - version independant
17	CubeNodeQuad-PST3S	CubeNodeQuad PST3S Type - version independant
18	CubeNodeQuad-NSSRWL	CubeNodeQuad NSSRWL Type - version independant
19	CubeNodeQuad-LITEFUFORS	CubeNodeQuad LITEFUFORS Type - version independant

Table 29: SerialSource Enumeration Values

Numeric Value	Name	Description
0	OTP	Serial number sourced from OTP
1	Config	Serial number sourced from Config

Table 30: Error Log Index Telemetry Format

ID	130		**Frame Length (bytes)**		5
Description	Describes the index of the error log that will be read when calling GetErrorLogEntry				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**

	0	8	Error Log Index Reference	ENUM	0 = Head, 1 = Tail. Possible values are in Table 6
	8	16	Error Log Index Value	UINT	Error Log Index Value ~ Relative to ErrorLogIndexReference
	24	16	Error Log Entries	UINT	Number of Error Log Entries Present

Table 31: Error Log Entry Telemetry Format

ID	131		**Frame Length (bytes)**		8
Description	Error Log Entry				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	32	Error Log Entry Timestamp	UINT	Timestamp of this Error Log Entry
	32	32	ErrorLogEntryErrorCode	UINT	ErrorCode of this Error Log Entry

Table 32: Error Log Settings Telemetry Format

ID	132		**Frame Length (bytes)**		1
Description	Error Log Settings				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	1	Active State	ENUM	Error Logging Enabled state. Possible values are in Table 10
	1	1	Buffer Full Action	ENUM	Action to take when log is full. Possible values are in Table 11
	2	6	Reserved	PADDING	Reserved.

Table 33: Current Unix time Telemetry Format

ID	133		**Frame Length (bytes)**		8
Description	Current Unix time				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	32	Current Unix seconds	UINT	Current Unix time s. (Unit of measure is [s])
	32	32	Current Unix Nanoseconds	UINT	Current Unix time ns. (Unit of measure is [ns])

Table 34: Persist Config Diagnostics Telemetry Format

ID	134		**Frame Length (bytes)**		6
Description	Diagnostics data for config persistence				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	8	State	ENUM	Config Persistence Task State. Possible values are in Table 35
	8	8	Last Result	ENUM	Config Persistence Last Result. Possible values are in Table 36
	16	32	Timestamp	UINT	Timestamp of last result. (Unit of measure is [s])

Table 35: ConfigPersistState Enumeration Values

Numeric Value	Name	Description
0	Idle	Config Persist task is IDLE
1	Busy	Config Persist task is BUSY

Table 36: ConfigPersistResult Enumeration Values

Numeric Value	Name	Description
0	None	No result yet for config persist
1	Success	Config Persist SUCCESSFUL
2	Error Param Lock	Config Persist failed due to a parameter mutex timeout
3	ErrorFlash	Config Persist failed due to faillure during flash operations

Table 37: Communication Status Telemetry Format

ID	135		**Frame Length (bytes)**		32
Description	Communication Status				
Channels	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	16	UART Telecommand counter	UINT	UART No. of telecommands received
	16	16	UART Telemetry request counter	UINT	UART No. of telemetry requests received
	32	16	UART Errors reported in SW checks	UINT	UART Errors reported in SW checks
	48	16	UART Errors reported by HW Flags	UINT	UART Errors reported by HW Flags
	64	16	UART2 Telecommand counter	UINT	UART2 No. of telecommands received
	80	16	UART2 Telemetry request counter	UINT	UART2 No. of telemetry requests received
	96	16	UART2 Errors reported in SW checks	UINT	UART2 Errors reported in SW checks
	112	16	UART2 Errors reported by HW Flags	UINT	UART2 Errors reported by HW Flags
	128	16	CAN Telecommand counter	UINT	CAN No. of telecommands received
	144	16	CAN Telemetry request counter	UINT	CAN No. of telemetry requests received
	160	16	CAN Errors reported in SW checks	UINT	CAN Errors reported in SW checks
	176	16	CAN Errors reported by HW Flags	UINT	CAN Errors reported by HW Flags
	192	16	I2C Telecommand counter	UINT	I2C No. of telecommands received
	208	16	I2C Telemetry request counter	UINT	I2C No. of telemetry requests received
	224	16	I2C Errors reported in SW checks	UINT	I2C Errors reported in SW checks
	240	16	I2C Errors reported by HW Flags	UINT	I2C Errors reported by HW Flags

Table 38: Version Telemetry Format

ID	136		**Frame Length (bytes)**		22
Description	Firmware Version				
Channels	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	8	Firmware version (Major)	UINT	Firmware version (Major)
	8	8	Firmware version (Minor)	UINT	Firmware version (Minor)
	16	16	Firmware version (Patch)	UINT	Firmware version (Patch)
	32	8	System version (Major)	UINT	System version (Major)
	40	8	System version (Minor)	UINT	System version (Minor)
	48	16	System version (Patch)	UINT	System version (Patch)

	64	8	Git Branch	ENUM	The git branch of the firmware build. Possible values are in Table 39
	72	32	Git Hash	UINT	Git has for the firmware build
	104	32	Build Hash	UINT	Build hash
	136	32	Build Time (seconds)	UINT	Timestamp of the firmware build. (Unit of measure is [s])
	168	8	Hardware version (Minor)	UINT	Hardware version (Minor)

Table 39: GitBranch Enumeration Values

Numeric Value	Name	Description
0	Master	master branch
1	Release	release branch
2	Other	all other informal/development branches - not expected for software bundle firmware

Table 40: Boot Status Telemetry Format

ID	137		**Frame Length (bytes)**		3
Description	State information about the device boot process				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	8	State	ENUM	Boot State. Possible values are in Table 41
	8	8	Reset Reason	ENUM	Cause of the last reset. Possible values are in Table 42
	16	1	Shared Params Error	BOOL	CRC check of shared parameters from bootloader failed - app will use its own config values
	17	1	Port Validation Error	BOOL	Port validation failed. Only applicable to CubeComputer.
	18	1	Port Discovery Error	BOOL	Auto-Discovery failed. Only applicable to CubeComputer.
	19	1	OTP Serial Number Error	BOOL	OTP serial number is invalid
	20	1	Config Serial Number Error	BOOL	Config serial number is invalid
	21	1	Serial Number Mismatch Error	BOOL	OTP/Config serial numbers do not match
	22	1	Config invalid error	BOOL	Set if the applications config is invalid and the default configuration is being used (if available).

Table 41: BootState Enumeration Values

Numeric Value	Name	Description
0	Application Initializing	Application is busy booting and initializing
1	Port Validation	CubeComputer control-program is running and performing port validation of connected nodes. Only applicable to CubeComputer
2	Auto-discovery	CubeComputer control-program is running and performing node auto discovery of connected nodes. Only applicable to CubeComputer
3	Application Running	Application is running after successful bootloader execution and initialization
4	ASSERT Error	Application has triggered an ASSERT and will immediately. This is transitory and is not expected to be read as the state. It will be reflected in the reset reason.

Table 42: BootResetReason Enumeration Values

Numeric Value	Name	Description
0	Unkown	Reset reason is unknown
1	Firewall	Firewall (Unused)
2	Option bytes reload	Option-byte reset. This will have a dedicated reset reason if commanded, otherwise, is signals that the bootloader reloaded option bytes automatically before exitting.
3	EXT Pin	External Pin reset (Unused)
4	Brown Out	Brown Out reset
5	Soft Reset	Software reset
6	WatchDog	WatchDog Reset
7	Low Power	Low Power Reset
8	ASSERT error	The running application triggered an ASSERT and reset - check error log for error code

Table 43: Telecommand Acknowledge Telemetry Format

ID	138		**Frame Length (bytes)**		4
Description	Used with the I2C protocol to receive Telecommand Ack/Nack				
Channels	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	8	TCTLM ID	UINT	Last TcTlm ID
	8	8	Error	ENUM	Last TcTlm Error. Possible values are in Table 44
	16	8	ErrorIndex	UINT	Buffer index of error
	24	1	Read	BOOL	Flag indicating if this acknowledgement has been read sinc the last TCTLM

Table 44: TcTlmError Enumeration Values

Numeric Value	Name	Description
0	Ok	No Error
1	Invalid ID	Invalid TcTlm ID
2	Invalid Length	Invalid Length
3	Invalid Parameter	Invalid Parameter
4	CRC	CRC Check Failed
5	Not Implemented	TCTLM not implemented
6	Busy	Busy
7	Sequence	Error in sequence of commands
8	Internal	Internal error
9	Passthrough Timeout	Passthrough node timeout error
10	Passthrough Target	Passthrough target is invalid (passthrough is disabled)

Table 45: Common Error Codes Telemetry Format

ID	139		**Frame Length (bytes)**		16
Description	Error codes common to all applications				
Channels	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	32	Slave Service - CAN	UINT	Tctlm comms slave service error code for CAN interface (OBC comms).
	32	32	Slave Service - UART	UINT	Tctlm comms slave service error code for UART interface (OBC comms).
	64	32	Slave Service - I2C	UINT	Tctlm comms slave service error code for I2C interface (OBC comms).
	96	32	Error Log Service	UINT	Error-log service error code.

Table 46: Identification2 Telemetry Format

ID	140		**Frame Length (bytes)**		21
Description	Identification information for this node				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	8	Node type identifier	ENUM	Node type identifier. Possible values are in Table 28
	8	8	Program type identifier	ENUM	Program type identifier. Possible values are in Table 26
	16	32	Serial Integer	UINT	Integer representation of the integer portion the serial number of this module sourced from active serial
	48	8	Interface version	UINT	Interface version
	56	8	Firmware version (Major)	UINT	Firmware version (Major)
	64	8	Firmware version (Minor)	UINT	Firmware version (Minor)
	72	16	Firmware version (Patch)	UINT	Firmware version (Patch)
	88	8	System version (Major)	UINT	System version (Major)
	96	8	System version (Minor)	UINT	System version (Minor)
	104	16	System version (Patch)	UINT	System version (Patch)
	120	8	Hardware version (Minor)	UINT	Hardware version (Minor)
	128	16	Runtime (seconds)	UINT	Seconds since processor start-up
	144	16	Runtime (milliseconds)	UINT	Milliseconds (after the integer second) since processor start-up
	160	8	Reserved	PADDING	Reserved.

Table 47: Wheel Position Data Telemetry Format

ID	183		**Frame Length (bytes)**		15
Description	Complete wheel data				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	32	Wheel Position	FLOAT	Wheel positiion. (Unit of measure is [Rotations])
	32	32	Wheel Speed	FLOAT	Wheel speed measurement in rpm. (Unit of measure is [RPM])
	64	32	Wheel Reference	FLOAT	Wheel reference speed in rpm. (Unit of measure is [RPM])
	96	16	Battery Current	UINT	Battery current measurement. (Unit of measure is [mA])
	112	8	Wheel Data Status	ENUM	Wheel data status. Possible values are in Table 48

Table 48: WheelErrorState Enumeration Values

Numeric Value	Name	Description
0	Data Valid	Data is valid
1	Encoder No Response	No response from encoder
2	Hall Sensor Encoder Mismatch	Mismatch between speed reported from hall sensors vs that of encoder
3	Speed Not Reached Timeout	Speed setpoint not reached within allocated time period
4	Maximum Speed Limit Reached	Speed setpoint at or near the software limit

Table 49: Wheel Model Telemetry Format

ID	184		Frame Length (bytes)		1
Description	Get the wheel model				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	8	Wheel type	ENUM	The model type of the motor. Possible values are in Table 50

Table 50: WheelTypeEnum Enumeration Values

Numeric Value	Name	Description
0	Generic Wheel	Default Generic Wheel
1	CubeWheel 0017	Node is a CubeWheel 0017 type
2	CubeWheel 0057	Node is a CubeWheel 0057 type
3	CubeWheel 0162	Node is a CubeWheel 0162 type
4	CubeWheel 0500	Node is a CubeWheel 0500 type
5	CubeWheel 1200	Node is a CubeWheel 1200 type
6	CubeWheel 2500	Node is a CubeWheel 2500 type
7	CubeWheel 5000	Node is a CubeWheel 5000 type
8	CubeWheel Rover1	Node is a CubeWheel Rover 1 type
9	CubeWheel 10k	Node is a CubeWheel 10k type
10	CubeWheel 40k	Node is a CubeWheel 40k type

Table 51: Wheel Torque Telemetry Format

ID	185		Frame Length (bytes)		5
Description	Wheel Torque measurement				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	32	Wheel Torque	FLOAT	Wheel Torque measurement in mNm. (Unit of measure is [mNm])
	32	8	Wheel Error State	ENUM	Wheel error state. Possible values are in Table 48

Table 52: Wheel Reference Torque Telemetry Format

ID	186		Frame Length (bytes)		4
Description	Set torque reference for wheel				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	32	Reference Torque	FLOAT	Wheel reference Torque. (Unit of measure is [mNm])

Table 53: Control Mode Telemetry Format

ID	187		Frame Length (bytes)		1
Description	Get the motor control mode				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	8	Control Mode	ENUM	Control mode of motor. Possible values are in Table 54

Table 54: ControlModeVal Enumeration Values

Numeric Value	Name	Description
0	No Control	No control mode
1	Speed Controller	Speed controller mode
2	Torque Controller	Torque controller mode

Table 55: Wheel Speed Telemetry Format

ID	188		Frame Length (bytes)		5
Description	Wheel speed measurement				
Channels	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	32	Wheel Speed	FLOAT	Wheel speed measurement in rpm. (Unit of measure is [RPM])
	32	8	Wheel Error State	ENUM	Wheel error state. Possible values are in Table 48

Table 56: Health Telemetry Telemetry Format

ID	189		Frame Length (bytes)		17
Description	Health telemetry for CubeWheel				
Channels	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	16	Battery Current	UINT	Battery current measurement. (Unit of measure is [mA])
	16	16	Battery Voltage	UINT	Battery voltage measurement at input. (Unit of measure is [mV])
	32	16	Driver Voltage	UINT	Battery voltage measurement at driver. (Unit of measure is [mV])
	48	16	Digital Current	UINT	Total 3.3V Current. (Unit of measure is [mA])
	64	32	MCU Temperature	FLOAT	MCU temperature measurement. (Unit of measure is [C])
	96	40	Watchdog Counters	ARRAY	Bitmask representing virtual watchdog region warning counters.

Table 57: Wheel Data Telemetry Format

ID	190		Frame Length (bytes)		15
Description	Complete wheel data				
Channels	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	32	Wheel Speed	FLOAT	Wheel speed measurement in rpm. (Unit of measure is [RPM])
	32	32	Wheel Backup Speed	FLOAT	Wheel backup speed measurement in rpm. (Unit of measure is [RPM])
	64	32	Wheel Reference	FLOAT	Wheel reference speed in rpm. (Unit of measure is [RPM])
	96	16	Battery Current	UINT	Battery current measurement. (Unit of measure is [mA])
	112	8	Wheel Data Status	ENUM	Wheel data status. Possible values are in Table 48

Table 58: PWM Gain Telemetry Format

ID	191		Frame Length (bytes)		4
Description	General PWM gain				
Channels	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	32	K	FLOAT	Main gain

Table 59: Backup Gain Telemetry Format

ID	192		Frame Length (bytes)		12
Description	Backup speed controller gain values				
Channels	Offset (bits)	Length (bits)	Name	Data Type	Description

	0	32	Kp	FLOAT	Proportional gain
	32	32	Ki	FLOAT	Integrator gain
	64	32	Kd	FLOAT	Feedback gain

Table 60: Main Gain Telemetry Format

ID	193		**Frame Length (bytes)**		12
Description	Main speed controller gain values				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	32	Kp	FLOAT	Proportional gain
	32	32	Ki	FLOAT	Integrator gain
	64	32	Kd	FLOAT	Feedback gain

Table 61: Status and Error Flags Telemetry Format

ID	194		**Frame Length (bytes)**		1
Description	Processor status and error flags				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	1	Invalid Telemetry	BOOL	An invalid telemetry request was received
	1	1	Invalid Telecommand	BOOL	An invalid telecommand was received
	2	1	Encoder Error	BOOL	Encoder indicates an error
	3	1	Uart Error	BOOL	Error in UART protocol
	4	1	I2C Error	BOOL	Error in I2C protocol
	5	1	CAN Error	BOOL	Error in CAN protocol
	6	1	Configuration Error	BOOL	Configuration load error
	7	1	Speed Error	BOOL	Speed measurements indicates an error

Table 62: Wheel Duty Cycle Telemetry Format

ID	195		**Frame Length (bytes)**		4
Description	Motor commanded PWM control signal				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	32	Duty Cycle	FLOAT	Duty cycle of motor PWM control signal. The torque provided by the motor will be proportional to the PWM signal. (Unit of measure is [%])

Table 63: Wheel Reference Speed Telemetry Format

ID	196		**Frame Length (bytes)**		4
Description	Set momentum wheel reference speed				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	32	Reference Speed	FLOAT	Wheel reference speed. (Unit of measure is [RPM])

Table 64: Motor Power Telemetry Format

ID	197		**Frame Length (bytes)**		1
Description	Switch motor power on/off				
Channels	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	1	Motor Power Switch	BOOL	Switch motor power switch on/off

Table 65: Backup Wheel Mode Telemetry Format

ID	198		Frame Length (bytes)		1
Description	Set the back-up wheel mode				
Channels	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	1	BackupMode	BOOL	Enable the back-up mode

Table 66: Stator Data Telemetry Format

ID	199		Frame Length (bytes)		8
Description	Data related to the motor stator windings				
Channels	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	32	Coil current	FLOAT	Current applied to motor coils. (Unit of measure is [mA])
	32	32	Stator temperature	FLOAT	Temperature of the coil windings. (Unit of measure is [C])

Table 67: Wheel Reference Speed Ramp Rate Limit Telemetry Format

ID	200		Frame Length (bytes)		4
Description	Set ramp rate limit for wheel speed reference				
Channels	Offset (bits)	Length (bits)	Name	Data Type	Description
	0	32	Ramp Rate Limit	FLOAT	Maximum speed reference increment during 1ms period. This limits the max torque of the motor.. (Unit of measure is [RPM/ms])

1.1.1 Configuration Messages

Table 68: List of Configuration Messages

Set ID	Get ID	Name	Description	Length (bytes)

1.1.1 Events

Table 69: List of Events

ID	Name	Description	Class
		Info	
254	Reset Commanded	Soft reset has been commanded - Table 70	Info
253	Unix Time Change Commanded	Unix time change has been commanded - Table 71	Info
252	Config Persisted	Volatile config items were written to flash - Table 72	Info
		WarnMajor	
251	Config Persist Error	Error occured while writing config items to flash - Table 73	WarnMajor
250	Virtual Watchdog Warning	A service protected by the virtual watchdog did not check in in time. - Table 74	WarnMajor
		Critical	
249	Virtual Watchdog Error	A service protected by the virtual watchdog did not check for three successive warnings. - Table 75	Critical

Table 70: Reset Commanded Event Format

ID	254	Class	Info
Description	Soft reset has been commanded		

Table 71: Unix Time Change Commanded Event Format

ID	253		**Class**		Info
Description	Unix time change has been commanded				
Parameters	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	32	New Unix seconds	UINT	New Unix time s. (Unit of measure is [s])
	32	32	New Unix Nanoseconds	UINT	New Unix time ns. (Unit of measure is [ns])

Table 72: Config Persisted Event Format

ID	252	**Class**	Info
Description	Volatile config items were written to flash		

Table 73: Config Persist Error Event Format

ID	251		**Class**		WarnMajor
Description	Error occured while writing config items to flash				
Parameters	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	8	Persist Result	ENUM	Config Persistence Last Result. Possible values are in Table 36
	8	32	Error Code	UINT	Config Persistence Error Code

Table 74: Virtual Watchdog Warning Event Format

ID	250		**Class**		WarnMajor
Description	A service protected by the virtual watchdog did not check in in time.				
Parameters	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	40	Region Mask	ARRAY	Bitmask representing the warning count of each region, if a flag is set, the region that was not refreshed. Please consult with CubeSpace as to the service that uses the specified region

Table 75: Virtual Watchdog Error Event Format

ID	249		**Class**		Critical
Description	A service protected by the virtual watchdog did not check for three successive warnings.				
Parameters	**Offset (bits)**	**Length (bits)**	**Name**	**Data Type**	**Description**
	0	40	Region Mask	ARRAY	Bitmask representing the warning count of each region, if a flag is set, the region that was not refreshed repeatedly and is presumed dead. Please consult with CubeSpace as to the service that uses the specified region