Manual
for
Radio-Amateurs

for receiving and decoding telemetry data from the PEGASUS satellite

Revised version
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DOCUMENT CHANGE RECORD	
Project: PEGASUS - Communication	
Change Status Log:	
V0.5, 22. 5. 2017, MT	Document created from previous documents
V1.0, 24. 5. 2017, MT	CRC, FEC, description added, O-Beacon explained
V1.1, 22. 9. 2021, PCR	Q numbering system explained, cosmetic changes.
V1.2, 27. 2. 2023, PCR	Included source code for the CRC, Stacie Voltage and O-beacon geographical coordinates. Clarified S-beacons bytes 7 and 8, added terms of E-beacon byte 23 to glossary. Ammended O2 beacons comments, included 02 beacon timestamp parsing, minor corrections.

Abbreviations

ADCS	Attitude Control System
AID	Address Identifier
CALL	Call Sign (Ham Radio Call Sign) of the satellite
CRC	Cyclic Redundancy Checksum
E-Beacon	EPS-Beacon
EPS	Electrical Power System
FEC	Forward Error Correction (RS Code)
GPS	Global Positioning System
GS	Ground Station
IARU	International Amateur Radio Union
ILEOP	Initial Launch and Early Orbit Phase
LEOP	Launch and Early Orbit Phase
MCC	Mission Control Center
OBC	Onboard Computer
O-Beacon	OBC-Beacon
PCB	Printed Circuit Board
PID	Protocol Identifier
RBF	Raw Binary File
RS	Reed Solomon
RSSI	Received Signal Strength Indication
RTC	Real Time Clock
S-Beacon	STACIE-Beacon
SDC	Space Data Center
Side-P	Side Panels
STG	Space Tech Group
STACIE	Space Telemetry And Command InterfacE
TRX	Transceive, Transceiver
Ttc	UART chip, part of STACIE
TT-64	Thomas Turetschek 64 byte protocol
TX	Transmit, Transmitter
WOD	Whole Orbit Data[1]
µPPT	

1 Whole Orbit Data are sent every minute (except if the I2C fails). They are a requirement of the QB50 project.

1 Radio Engineering Parameter of Pegasus

The Pegasus satellite is a 2U CubeSat with 2 redundant TRX modules on one PCB. Each of the two communications modules (called STACIE) uses one of the two independent dipole antennas built at a 90º angle of each other. STACIE draws power from two independent buses to the satellite main power. The end result is a redundant and reliable communications system.

Downlink Frequency	436,670 MHz
TX power max	30dBm, 1W
Modulation	GFSK
Polarisation	Linear
Protocol	TT-64

2 TT-64 Protocol

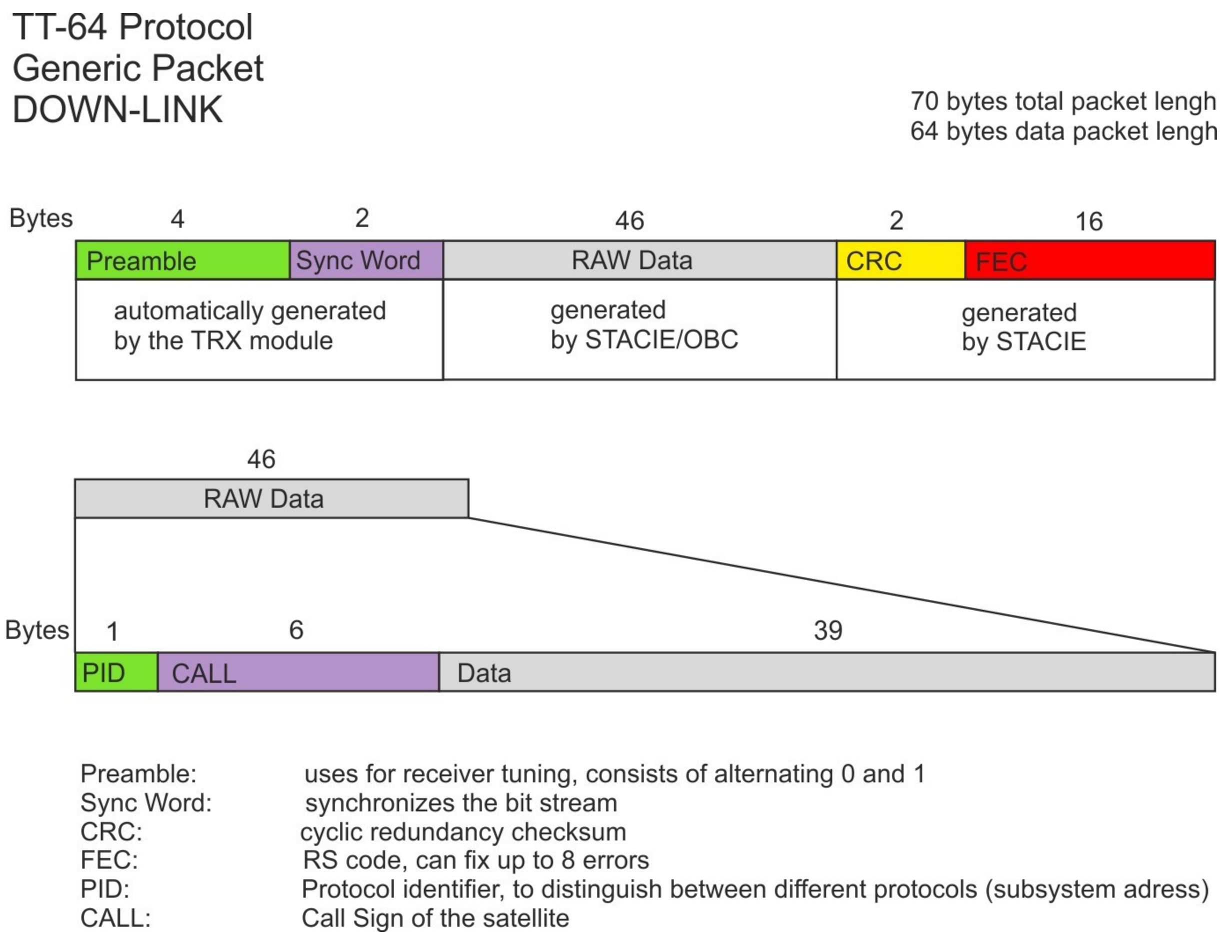
The TT-64 protocol regulates the data transfer between the satellite and the GS in both directions (air interface). The TT-64 protocol supports the time division multiplex method (semi duplex communication).

A complete data packet consists of a 70 bytes string. The first 6 bytes are created automatically for synchronizing and receiver tuning. The remaining 64 bytes are data bytes, divided into 46 data bytes and 18bytes used for CRC and FEC.

2.1 Down-Link

From the 46 bytes of data the first byte must be the PID and the next 6 bytes the CALL.

The CALL is the official call sign of the satellite.



2.2 PID Regulation

The PID indicates which subsystem is sending the data packet and the type of packet called beacon).

Thanks to the PID it is possible to distinguish between the different beacons and route them to the appropriate decoding operations.

Assigned PIDs

Content	hex	binary
S Beacon	0xC0	11000000
E Beacon	0xC1	11000001
O Beacon 1/2	0x53	01010011
O Beacon 2/2	0x56	01010110

2.3 CALL

The assigned call sign of the satellite PEGASUS is ON03AT. The call sign is encoded using the ASCII standard.

Symbol	O	N	0	3	A	T
Hex	0x4F	0x4E	0x30	0x33	0x41	0x54
Binary	01001111	01001110	00110000	00110011	01000001	01010100

2.4 FEC and CRC

The FEC and CRC are not necessary for receiving and decoding the beacons. Their function is to provide error detection and error correction in the raw data.

CRC
The Cyclic Redundancy Checksum (CRC) is a standard CRC16 Checksum.

FEC
The Forward Error Correction (FEC) is a Reed Solomon (RS) code with the following Specifications:

RS (n=64, k=48)

Generator-polynomial-coefficients:

79	44	81	100	49	183	56	17	232	187	126	104	31	103	52	118

With this technique it is possible to repair eight errors per 64bit packet.

3 Beacon description

Pegasus can send three types of beacons or packets, designated by their initial, the EPS beacon, the STACIE beacon and the OBC beacon.

Formats used

(W = whole bits, F = Fractional bits)
UFix W.F

Unsigned Fixed point arithmetic using the AMD-style Q number format. This means that the W bits (left of the fixed point) should be read as an unsigned int. The F bits (for Fractional, right of the fixed point) are not to be read as an int, but as a fraction of the total. For instance: Ufix 7.1 would mean a fixed point integer that can go as far as 2^7 for the whole part, and has two possible fractional parts: 0 (if the LSB is 0) or 0.5 (if the LSB is 1). Ufix 6.2 would have a maximum whole value of 2^6 and four possible fractions: 0, 0.25, 0.5 and 0.75, etc.etc.

Fix W.F

Signed Fixed point arithmetic using AMD-style Q number format. The most significant bit represents the sign.
Note that the whole part is expressed in one's complement unless indicated otherwise.

3.1 E-Beacon

The E-Beacon consists of the Electrical Power System telemetry. STACIE collects this telemetry from the EPS over I^2C interface between the EPS and STACIE. The OBC is not involved in this action. The E-Beacon is only sent if the OBC operation status does not allow sending O-Beacons. The PID is 0xC1

Data sequence of the E-Beacon

Byte #	Name	Unit	Format	Bits	Description
0	PID			8	0xC1 (EPS-Beacon ID)
1	CALL			8	0x4F (O)
2	CALL			8	0x4E (N)
3	CALL			8	0x30 (0)
4	CALL			8	0x33 (3)
5	CALL			8	0x41 (A)
6	CALL			8	0x54 (T)
7	I_PV2_5V	A	Fix 3.4	8	Current through FET3-2 between PV2-bus and 5V converter
8	I_PV1_5V	A	Fix 3.4	8	Current through FET3-1 between PV1-bus and 5V converter[2]

2 Please see Annex A

9	V_PV2	V	UFix 3.5	8	Voltage at PV2-bus, Solarbus 2
10	V_5V_IN	V	UFix 3.5	8	Voltage at the input of the 5V converter measured at FET3-1
11	I_PV1_3V3	A	Fix 3.4	8	Current through FET5-1 between PV1-bus and 3V3 converter
12	I_PV2_3V3	A	Fix 3.4	8	Current through FET5-2 between PV2-bus and 3V3 converter
13	V_PV1	V	UFix 3.5	8	Voltage at PV1-bus, Solarbus 1
14	V_3V3_IN	V	UFix 3.5	8	Voltage at the input of the 3V3 converter measured at FET52
15	Temp_BAT1SW	°C	Fix 7.0	8	Temp near BAT1 switches
16	Temp_5V	°C	Fix 7.0	8	Temp near 5V converter
17	I_PV1_HV	A	Fix 3.4	8	Current through FET4-1 between PV1-bus and HV supply
18	I_PV2_HV	A	Fix 3.4	8	Current through FET4-2 between PV2-bus and HV supply
19	V_3V3_OUT	V	UFix 3.5	8	Voltage at the output of the 3V3 converter
20	V_HV	V	UFix 3.5	8	Voltage at the output of the HV supply to the PPTs measured at FET4-2
21	I_PV2_BAT1	A	Fix 3.4	8	Current through FET1-2 between PV2-bus and battery 1
22	I_PV1_BAT1	A	Fix 3.4	8	Current through FET1-1 between PV1-bus and battery 1
23	V_5V_OUT	V	UFix 3.5	8	Voltage at the output of the 5V converter
24	V_BAT1	V	UFix 3.5	8	Voltage of the battery 1
25	I_PV2_BAT2	A	Fix 3.4	8	Current through FET2-2 between PV2-bus and battery 2
26	I_PV1_BAT2	A	Fix 3.4	8	Current through FET2-1 between PV1-bus and battery 2
27	Version of EPS			8	Versions Number of EPS
28	STACIE 0/1		boolean	LSB	E-Beacon send by STACIE 0/1 (A/C)
29	V_BAT2	V	UFix 3.5	8	Voltage of the battery 2
30	Temp_BAT1	°C	Fix 7.0	8	Temp of BAT1 on the battery holder
31	Temp_BAT2	°C	Fix 7.0	8	Temp of BAT2 on the battery holder
32	Status 1	-	boolean	8	**B7 (MSB)**: 3V3-1 on, **B6**: 3V3-2 on, **B5**: 3V3-3 on, **B4**: 3V3Backup on, **B3**: 5V-1 on, **B2**: 5V-2 on, **B1**: 5V-3 on, **B0 (LSB)**: 5V-4 on.
33	Status 2	-	boolean	8	**B7 (MSB)**: Low Power Warning (EPS will enter in Power Down Mode soon after this warning), **B6**: Bat1 connected to PV1, **B5**: Bat2 connected to PV2, **B4**: 3V3 on, **B3**: 5V on, **B2-B0 (LSBs)**: 000 Debug Mode, 001 Boot Mode, 010 Flight Mode, 011 Power Down Mode, 100 Safe Mode.
34	Status 3	-	boolean	8	**B7 (MSB)**: 3V3 Burst Mode on, **B6**: 5V Burst Mode on, **B5**: Bat1 connected to PV2, **B4**: Bat2 connected to PV1, **B3**: Temperature warning flag, **B2**: CC1

					connection okay flag, **B1**: CC2 connection okay flag, **B0 (LSB)**: RBF
					Unconnected
36	Beacon Count S		uint	8	Beacon Count of STACIE Beacons
37	Reboot_MC	-	UFix 8.0	8	Number of reboots since last change of the RBF of the main controller
38	Reboot_CC1	-	UFix 8.0	8	Number of reboots since last change of the RBF of the first communication controller
39	Reboot_CC2	-	UFix 8.0	8	Number of reboots since RBF of the second communication controller
40	Vcc_CC1	V	UFix 3.5	8	Supply voltage of CC1
41	Temp_CC1	°C	Fix 7.0	8	Temperature of the internal sensor of CC1
42	Vcc_CC2	V	UFix 3.5	8	Supply voltage of CC
43	Temp_CC2	°C	Fix 7.0	8	Temperature of the internal sensor of CC2
44	Status_CC1	-	boolean	8	**B7 (MSB)-B6**: CC Mode: 00 Boot Mode, 01 Flight Mode, 10 Safe Mode, 11 CC1 unavailable, **B5**: mcTimeoutFlag, **B4**: RBF (CC1 only), **B3**: EN_I2C, **B2**: Bat1 connected to PV1, **B1**: Bat2 connected to PV2, **B0 (LSB)**: 3V3-Backup on
45	Status_CC2	-	boolean	8	**B7 (MSB)-B6**: CC Mode: 00 Boot Mode, 01 Flight Mode, 10 Safe Mode, 11 CC2 unavailable, **B5**: mcTimeoutFlag, **B4**: TBD **B3**: EN_I2C, B2: Bat1 connected to PV1, **B1**: TBD, **B0 (LSB)**: 3V3-Backup on
	CRC			16	
	FEC			128	

3.2 S-Beacon

The S-Beacon consists of the STACIE telemetry. The telemetry is generated and stored in the communication subsystem STACIE and immediately available by internal storage. The OBC is not involved in this action. The S-Beacon is only sent if the OBC operation status does not allow sending O-Beacons. If O-Beacons or other packets from the OBC are sent, an S-Beacon is sent after around every 30th packet sent by the OBC.

The PID is 0xC0

Data Packet

Bytes	1	6	39	2	16
	PID	CALL	Data	CRC	FEC

Data sequence of the S-Beacon

Byte #	Name	Byte length	Notes	Unit	Description
0	PID	1	0xC0		Stacie Beacon ID
1	Call Sign	6	0x4F		O
2	Call Sign		0x4E		N
3	Call Sign		0x30		0
4	Call Sign		0x33		3
5	Call Sign		0x41		A
6	Call Sign		0x54		T
7	USP	2	Low Byte		Supply Voltage of Stacie in mV
8			High Byte		(See Annex A)
9	TRX Temp	1		Int	Temperature of Stacie‘s array.
10	Idle RSSI	1	-132dBm + value	Ufix 7.1	Received Signal Strength Indication, without TRX
11	RX RSSI	1	-132dBm + value	Ufix 7.1	Received Signal Strength Indication, during RX
12	Antenna Deployment	1		Boolean	0= not deployed, 1=deployed For Antenna 1, 2, 3, 4
13	Stacie OP	1			Operational Mode: 0=Normal, 2=Sleep, 3=Beacon, 4=Deployment, 8=Shutdown
14	T-Comp On/Off	1		Boolean	Temperature Compensation On/Off (1=on, 0=off)
15	Reset Counter	2	Low Byte		Reset after last mP-Flash
16			High Byte		

17	Uplink Error	1			Uplink Error rate (increases by 1 if CRC check fails).
18	OBC Sent Packet counter between S-Beacons	1			Packets send between 2 Stacie Beacons
19	Beacon Interval	2	Low Byte		Stacie Beacon interval in seconds
20			High Byte		
21	Reserved	8			
22-28	Reserved				
29	SID	1		boolean	0=STACIE A, 1=STACIE C
30	TxSelReason	1			Weight why Stacie is Master
31	reason remote	1			Weight of partner-stacie, 0=No answer
32	sTime	4	Byte 0		Stacie Up-Time in mseconds since last reset
33			Byte 1		
34			Byte 2		
35			Byte 3		
36	Reserved	1			
37	BeaconCount	1			Number of Beacons send from Stacie
38-45	Reserved				
	CRC	2			
	FEC	16			

3.3 O-Beacon

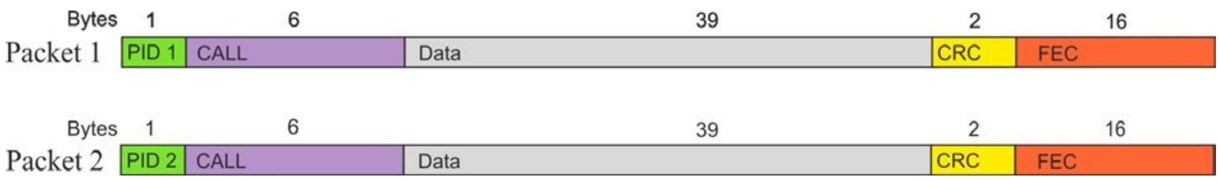
The O-Beacon consists of OBC, STACIE, EPS, μPPT, GPS and ADCS telemetry. The OBC collects and stores the telemetry of the mentioned subsystems. The OBC sends the collected data in two packets to STACIE, which is adds the CRC and the FEC before transmission

Each packet has its own PID, so it can be decrypted even if the other is lost. The PID of the first packet is 0x53 and of the second packet, 0x56.

Telemetry marked with WOD (Whole Orbit Data) in the comments field is telemetry required by QB50. The WOD telemetry is also displayed in the public area of the MCC. The table contains information about what information comes from what subsystem.

O-Beacon nº 1 consists of the EPS telemetry and some telemetry from STACIE and the OBC. O-Beacon nº 2 consist of the GPS data, ADCS and Side Panels data and a sizeable amount of OBC status parameters, expressed in boolean.

Data Packets



	OBC BEACON 1/2					
#	Name	Unit	Format	Bit	Comments	Sub-system
0	PID			8	0x53 (OBC-Beacon 1 ID)	
1	CALL			8	0x4F (O)	
2	CALL			8	0x4E (N)	
3	CALL			8	0x30 (0)	
4	CALL			8	0x33 (3)	
5	CALL			8	0x41 (A)	
6	CALL			8	0x54 (T)	
7	V_PV1	V	UFix 3.5	8	WOD	EPS
8	V_PV2	V	UFix 3.5	8	WOD	EPS
9	V_5V_IN	V	UFix 3.5	8		EPS
10	V_3V3_IN	V	UFix 3.5	8		EPS
11	V_5V_OUT	V	UFix 3.5	8	WOD	EPS
12	V_3V3_OUT	V	UFix 3.5	8	WOD	EPS
13	I_PV1_5V	A	Fix 3.4	8	WOD as I_5V	EPS
14	I_PV2_5V	A	Fix 3.4	8	WOD as I_5V	EPS
15	I_PV1_3V3	A	Fix 3.4	8	WOD as I_3V3	EPS
16	I_PV2_3V3	A	Fix 3.4	8	WOD as I_3V3	EPS
17	Temp_BAT1SW	°C	Fix 7.0	8	WOD as Temp_EPS	EPS
18	Temp_5V	°C	Fix 7.0	8	WOD as Temp_EPS	EPS

19	V_HV	V	UFix 3.5	8		EPS
20	I_PV1_BAT1	A	Fix 3.4	8	WOD as I_Bat1	EPS
21	I_PV2_BAT1	A	Fix 3.4	8	WOD as I_Bat1	EPS
22	I_PV1_BAT2	A	Fix 3.4	8	WOD as I_Bat2	EPS
23	I_PV2_BAT2	A	Fix 3.4	8	WOD as I_Bat2	EPS
24	V_BAT1	V	UFix 3.5	8	WOD	EPS
25	V_BAT2	V	UFix 3.5	8	WOD	EPS
26	Vcc_CC2	V	UFix 3.5	8		EPS
27	Vcc_CC1	V	UFix 3.5	8		EPS
28	Temp_BAT1	°C	Fix 7.0	8	WOD (as Temp Bat)	EPS
29	Temp_BAT2	°C	Fix 7.0	8	WOD (as Temp Bat)	EPS
30	Status 1	-	boolean	8		EPS
31	Status 2	-	boolean	8		EPS
32	Status 3	-	boolean	8		EPS
33	Status_CC1	-	boolean	8		EPS
34	Status_CC2	-	boolean	8		EPS
35	Reboot_MC	-	boolean	8		EPS
36	Reboot_CC1	-	boolean	8		EPS
37	Reboot_CC2	-	boolean	8		EPS
38	Temp A	°C		8	WOD (Temp TT&C), STACIE A temperature	STACIE
39	Temp C	°C		8	WOD (Temp TT&C), STACIE C temperature	STACIE
40	RSSI A (X+)		-132dBm + (value/2)	8	Receive Signal Strength Indicator of STACIE A	STACIE
41	RSSI C (X-)		-132dBm + (value/2)	8	Receive Signal Strength Indicator of STACIE C	STACIE
42	STACIE Mode A			4 MSB	operating mode of STACIE A	STACIE
42	STACIE Mode C			4 LSB	operating mode of STACIE C	STACIE
43	state machine			8	WOD (OBC Status) **Bit 7**: SU Script active (1 if science script is running or waiting for next time table entry/next day) **Bit 6**: SU Powered (1 if Science Unit is active and powered on) **Bit 5**: ADCS enabled (1 if	OBC

					enabled 0 if disabled) **Bit 4**: n.u. **Bit3..0**:"OBC Mission State" (0 – Standby)	
44	CmdCnt			8	OBC Mission Counter	OBC
45	CmdCnt			8	OBC Mission Counter	OBC
	CRC			16		
	FEC			128		

	OBC BEACON	2/2				
#	Name	Unit	Format	Bits	Comment	Sub-system
0	PID			8	0x56 (OBC-Beacon 2 ID)	
1	CALL			8	0x4F (O)	
2	CALL			8	0x4E (N)	
3	CALL			8	0x30 (0)	
4	CALL			8	0x33 (3)	
5	CALL			8	0x41 (A)	
6	CALL			8	0x54 (T)	
7	Date		ddmmyy	14	Date of GPS data (when fix is 1, RTC, no fix, time since last OBC reset)	GPS
	Time		hhmmss	17	Time of GPS data (when fix is 1, RTC, no fix, time since last OBC reset)	GPS
	Fix		Bool	1		GPS
	Number of Satellites seen		Uint?	4		GPS
	Lattitude		9000.0000N	28	**Bits:** 1 sign, 7 deg, 7 mins int ,13 mins fract	GPS
	Longitude		18000.0000 W	29	**Bits:** 1 sign, 8 deg, 7 mins int ,13 mins fract	GPS
	Altitude			20	in m	GPS
				7	Fill bits	GPS
22	ADCS Status			8		ADCS
23	ADCS Angle Dev			8		ADCS

	OBC Status states				
	Byte 24		Bit #		
24	Crystal oscillator in use	Bool	0	1... Crystal oscillator operational	OBC
24	power_source	Bool	1	0... 3.3V_SPA, 1... V_Backup	OBC
24	last_reset_source1	Bool	2	Two bits showing the last reset source	OBC
24	last_reset_source2	Bool	3	**POR:** 0b00, **EXTR:** 0b01, **WDTR:** 0b10, **BODR:** 0b11(see Annex A)	OBC
24	eps_cc_used	Bool	4	0...CC1, 1... CC2	OBC
24	obc_power saving mode	Bool	5	OBC controller is in power saving mode mode	OBC
24	obc_3v3_spa_enabled	Bool	6	This is the standard power supply rail of the OBC!	OBC
24	task_sensors_running	Bool	7	Main sensor task is running	OBC

	Byte 25		Bit #		
25	task_maintenance_running	Bool	0	Mandatory maintenance task is running	OBC
25	statemachine_initialized	Bool	1	Statemachine task is initialized	OBC
25	rtc_synchronized	Bool	2	RTC time and date is up to date	OBC
25	i2c0_initialized	Bool	3	I2C interface is operational	OBC
25	i2c1_initialized	Bool	4	I2C interface is operational	OBC
25	i2c2_initialized	Bool	5	I2C interface is operational	OBC
25	ssp0_initialized	Bool	6	SSP interface is operational	OBC
25	ssp1_initialized	Bool	7	SSP interface is operational	OBC

	Byte 26		Bit #		
26	supply_switches_initialized	Bool	0	GPIOs for power supply switching are initialized	OBC
26	i2c_switches_initialized	Bool	1	I2C switches are initialized	OBC
26	rtc_initialized	Bool	2	Real time clock is operational	OBC
26	adc_initialized	Bool	3	Adc is operational	OBC
26	uart_gps_initialized	Bool	4	UART interface operational	OBC
26	uart_ttc2_initialized	Bool	5	UART interface operational	OBC
26	uart_mnlp_initialized	Bool	6	UART interface operational	OBC
26	uart_ttc1_initialized	Bool	7	UART interface operational	OBC

	Byte 27		Bit #		
27	timer0_initialized	Bool	0	Timer initialized	OBC
27	watchdog_initialized	Bool	1	Watchdog initialized	OBC
27	timer1_initialized	Bool	2	Timer initialized	OBC
27	eps_cc1_operational	Bool	3	Eps CC1 communication ok	OBC
27	eps_cc2_operational	Bool	4	Eps CC2 communication ok	OBC
27	eeprom1_initialized	Bool	5	Eeprom initialized	OBC
27	eeprom2_initialized	Bool	6	Eeprom initialized	OBC
27	eeprom3_initialized	Bool	7	Eeprom initialized	OBC

	Byte 28		Bit #		
28	mag_bp_initialized	Bool	0	Mag BP communication ok	OBC
28	mag_bp_boom_initialized	Bool	1	Magnetometer on boom initialized	OBC
28	gyro1_initialized	Bool	2	Low rate gyro initialized	OBC
28	gyro2_initialized	Bool	3	Low rate gyro initialized	OBC
28	msp_initialized	Bool	4	Msp JTAG programmer initialized	OBC
28	onboard_mag_initialized	Bool	5	Onboard magnetometer operational	OBC
28	onboard_tmp100_initialized	Bool	6	Onboard TMP100 temp sensor operational	OBC
28	mpu_initialized	Bool	7	Mpu gyro initialized	OBC

	Byte 29		Bit #		
29	flash1_initialized	Bool	0	External flash storage initialized	OBC
29	flash2_initialized	Bool	1	External flash storage initialized	OBC
29	spa_initialized	Bool	2	Side panel operational	OBC
29	spb_initialized	Bool	3	Side panel operational	OBC
29	spc_initialized	Bool	4	Side panel operational	OBC
29	spd_initialized	Bool	5	Side panel operational	OBC
29	sa_initialized	Bool	6	Science adapter operational	OBC
29	bp_initialized	Bool	7	Bottom panel operational	OBC

	Byte 30		Bit #		
30	gps_initialized	Bool	0	Gps initialized	OBC
30	ttc1_initialized	Bool	1	Ttc initialized	OBC
30	ttc2_initialized	Bool	2	Ttc initialized	OBC
30	science_module_initialized	Bool	3	Science MODULE comms. operational	OBC
30	spa_vcc_on	Bool	4	SPA Power supply enabled	OBC
30	spb_vcc_on	Bool	5	SPB Power supply enabled	OBC
30	spc_vcc_on	Bool	6	SPC Power supply enabled	OBC
30	spd_vcc_on	Bool	7	SPD Power supply enabled	OBC

	Byte 31		Bit #		
31	bp1_vcc_on	Bool	0	Power supply of Bottom panel 1 enabled	OBC
31	bp2_vcc_on	Bool	1	Power supply of Bottom panel 2 (boom) enabled	OBC
31	sa_vcc_on	Bool	2	Power supply science adapter enabled	OBC
31	i2c_sw_a_on	Bool	3	I2C of SPA is connected	OBC
31	i2c_sw_b_on	Bool	4	I2C of SPb is connected	OBC
31	i2c_sw_c_on	Bool	5	I2C of SPC is connected	OBC
31	i2c_sw_d_on	Bool	6	I2C of SPD is connected	OBC
31	onboard_mag_powersafe	Bool	7	Onboard magnetometer is in power saving mode	OBC

	Byte 32		Bit #		
32	gyro_powesafe	Bool	0	Low rate gyro is in power saving mode	OBC
32	mpu_powersafe	Bool	1	MPU is in power saving mode	OBC
32	tmp100_powersafe	Bool	2	TMP100 is in power saving mode	OBC
32	mag_bp_power saving mode	Bool	3	Magnetometer on bottom panel is in power saving mode	OBC
32	mag_bp_boom_power saving mode	Bool	4	Magnetometer on boom is in power saving mode	OBC
32	mnlp_5v_enabled:	Bool	5	5V power supply for MNLP is enabled	OBC
32	rtc_oscillator_error	Bool	6	oscillator of RTC not operational	OBC
32	eeprom_page_cycle_overflow	Bool	7	At least one EEPROM page has > 1e6 cycles	OBC

	Byte 33		Bit #		
33	ssp0_frequent_errors	Bool	1	SSP interface produces errors frequently	OBC
33	ssp1_frequent_errors	Bool	1	SSP interface produces errors frequently	OBC
33	i2c0_frequent_errors	Bool	1	I2C interface produces errors frequently	OBC
33	i2c1_frequent_errors	Bool	1	I2C interface produces errors frequently	OBC
33	i2c2_frequent_errors	Bool	1	I2C interface produces errors frequently	OBC
33	timer0_running	Bool	1	Timer is operational and running	OBC
33	timer1_running	Bool	1	Timer is operational and running	OBC
33	default_config_used	Bool	1	Default configuration of OBC is used	OBC

#	Name	Format	Bits	Comment	Sub-system
34	error_code;	uint8_t	8	Hardware error code	OBC
35	error_code_before_reset	uint8_t	8	Last hardware error code before reset	OBC
36	resets counter	uint32_t	8	Reset counter since mission start	OBC
40	Temp SP X-		8	temperature sidepanel X-	SideP
41	Temp SP X+		8	temperature sidepanel X+	SideP
42	Temp SP Y-		8	temperature sidepanel Y-	SideP
43	Temp SP Y+		8	temperature sidepanel Y+	SideP
44	Script Slots		8	**bit 7:** Cmd Scrip Slot 1(8) loaded **bits 6..0:** Science Script Slots 7,6,5,4,3,2,1 loaded	OBC
45	Script Slot		8	**bits 7..4:** n.u. **bits 3..0:** Cmd Script Slot 5(12),4(11), 3(10),2(9) loaded	OBC
	CRC		16		
	FEC		128		

OBC Beacon 1/2

CmdCnt: Counter of received and processed commands, even if they had no impact.

OBC Beacon 2/2

GPS Time and Date: as long as the GPS has no fix, the RTC Date and -Time of the OBC since the last reset is recorded in these telemetry sections. (Epoche Time 1.1.2015) If the GPS is reporting a fix, the RTC is UTC.

Annex A

Code

S-beacon bytes 7 and 8 – Parsing of the Voltage value

PHP code

```
function stacie_usp($byte1,$byte2)  // returns  Volt
{
  $w = (ord($byte2)*256 + ord($byte1) );
  return( $w /1023 * 2 * 3.3  );
}
```

O2 beacon bytes 7-10, parsing of the timestamp

This python code parses the 02 date. Note that first_byte refers to byte 7, and fourth, to byte 10.

```
# Year
year_value = ((first_byte & 0x1f) + 2000)

# Month
month_value = ( (first_byte >> 5) | (( second_byte & 0x01 ) << 3))

# Day
day_value = (( second_byte & 0x3E) >> 1 )

# Seconds
seconds_value = ((second_byte >> 6) | ((third_byte & 0x0F) << 2 ))

# Minutes
minutes_value = (((third_byte & 0x0F ) >> 4) | ((fourth_byte & 0x03 ) << 4))

# Hours
hours_value = ((fourth_byte & 0x07C) >> 2 )
```

O2-beacon, byte 24, bits 2 and 3

<u>Reset sources:</u>

POR: Power-on reset
EXTR: External signal
WDTR: Watchdog timer
BODR: Brown-out detector reset

Annex B

Operation of the CRC

PHP code

```
function crc_calc($data, $length)
{
    $checksum = 0;

    # while ($length > 0)
    for ($i = 0; $i < $length; $i++)
    {
        $checksum = crc_update($data[$i], $checksum);
    }

    return $checksum;
}

function crc_update($data, $checksum)
{
    $checksum = $checksum ^ ord($data);
    for ($i= 0; $i < 8; $i++) {
        if ($checksum & 1) {
            $checksum = ($checksum >> 1) ^ 0xA001;
        }
        else {
            $checksum = ($checksum >> 1);
        }
    }
  return($checksum);
}
```

O-beacon, byte 7, longitude and latitude

```
$year = (ord($B[7])) & 0x1f;
  $month = (ord($B[7]) >> 5) | ((ord($B[8]) & 0x01) << 3);
  $day = (ord($B[8]) & 0x3E) >> 1;
  $sec = ((ord($B[8])) >> 6) | ((ord($B[9]) & 0x0F) << 2);
  $min = ((ord($B[9]) & 0xF0) >> 4) | ((ord($B[10]) & 0x03) << 4);
  $hour = (ord($B[10]) & 0x7C) >> 2;
  $D->fix = (ord($B[10]) & 0x80);
  $D->tis = sprintf("%4d-%02d-%02d %02d:%02d:%02d",$year +2000,$month,$day,
$hour,$min,$sec );

  $D->tit = "<TR><TD>" . helpinfo('O2','07-10') ."</TD><TD>GPS
Time</TD><TD>" .$D->tis . " [" . $D->fix."]</TD></TR>";

  if ($D->fix) # Base 13 -> 11// 2 weniger als Robert
  {
       $D->NrOfSatelites = ord($B[11]) & 0x0f;
       $D->latMinFract = ((ord($B[11]) & 0xf0) >> 4) |
                                  ((ord($B[12])) << 4) |
                                  ((ord($B[13]) & 0x01) << 12);
       $D->latMin = (ord($B[13]) & 0xfE) >> 1;
       $D->LatMin = $D->latMin + 0.0001 * $D->latMinFract;
       $D->LatDeg = ord($B[14]) & 0x7F;
                if ((ord($B[14]) & 0x80) > 0)
                {
                    $D->LatDeg = $D->LatDeg * (-1);
                }

        $D->lonMinFract = ord($B[15]) | ((ord($B[16]) & 0x1F) << 8);
        $D->lonMin = ((ord($B[16]) & 0xE0) >> 5) |
                              (ord($B[17]) & 0x0F) << 3;
        $D->LonMin = $D->lonMin + 0.0001 * $D->lonMinFract;
        $D->LonDeg = (ord($B[17]) & 0xF0) >> 4 | (ord($B[18]) & 0x0F) << 4;
                if ((ord($B[18]) & 0x10) > 0)
                {
                    $D->LonDeg = $D->LonDeg * (-1);
                }


        $D->alt = (ord($B[18]) & 0xE0) >> 5 | (ord($B[19])) << 3 |
(ord($B[20])) << 11 | (( ord($B[21])) & 0x01) << 19;

        # MyLocation = new GeoCoordinate((Double)(LatDeg ?? 0) +
((Double)latMin / 60.0) + (0.0001 * (Double)latMinFract / 60.0),
        #              (Double)(LonDeg ?? 0) + ((Double)lonMin / 60.0) +
(0.0001 * (Double)lonMinFract / 60.0),alt);
     $D->geos =  sprintf("S: %d // %d deg %6.2f min %d deg %6.2f min //
%8.3f km",$D->NrOfSatelites ,$D->LonDeg, $D->lonMin, $D->LatDeg ,$D-
>latMin , $D->alt/1000);
     $D->geot = "<TR><TD>" . helpinfo('O2','11-21') ."</TD><TD>GeoLocation:
Sat/Lon/Lat/Alt</TD><TD>". $D->geos ."</TD></TR>";
   }
   else
   {
     $D->NrOfSatelites = ord($B[11]) & 0x0f;
     $D->geos = "Na";
     $D->geot = "<TR><TD>" . helpinfo('O2','11-21')
."</TD><TD>GeoLocation:</TD><TD>No Fix. //
Sats:".$D->NrOfSatelites."</TD></TR>";
   }
```