SERaero-TM

Telemetry Downlink Protocol ICD for NOVA USCT

Version 2.1
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Revision: 2.1.3

SERaero-TM Protocol Description

!THIS DOCUMENT IS A WORK IN PROGRESS!

SPECIFICATION DETAIL

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CHANGE LOG

Date of Change	Version	Paragraph Changed	Summary of Changes	Editor
09/08/17	Rev 01 draft 1		Original document created	JP
29/10/19	Rev 01 draft 2		9.6kbps adaption; Message ID adaption; Low RF data rate	JP
16/01/20	Rev 01 draft 3		Some ID adaptions and clearing	JP
29/03/21	Rev 02 V1		Add GPS Fix Type; new ID 413 definition	JP
22/06/21	Rev 2.1.3		New Display ID Data Type definitions	JP

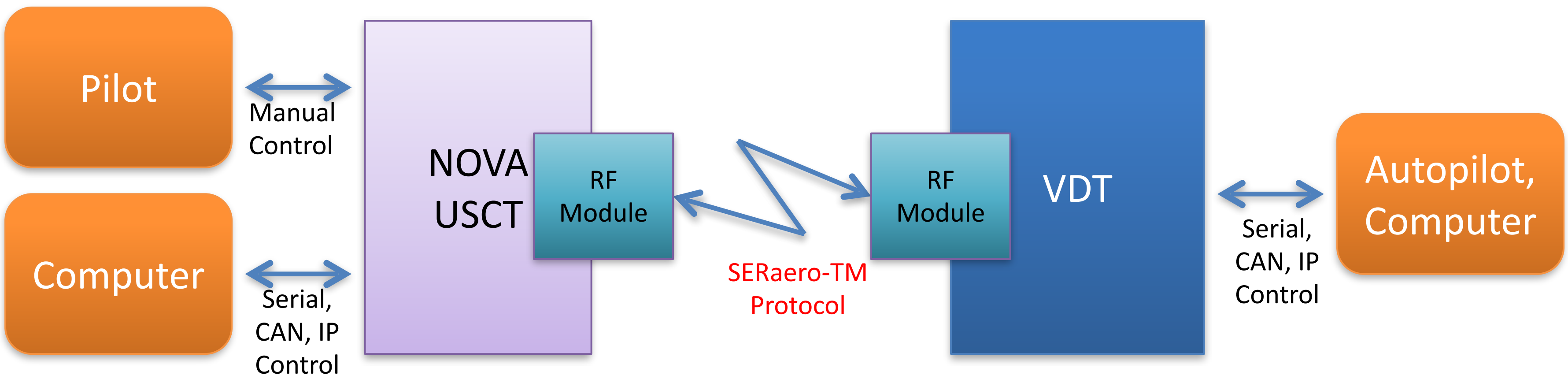
RELATED DOCUMENTS

- LikeAbird SERaero C2-8B ICD Specifications

NOVA USCT Overview

NOVA USCT – NOVA Unmanned Systems Control Transmitter

The NOVA USCT is Hetronic-LikeAbird's mobile ground control station, based on the Hetronic NOVA Touch, that serves as the pilot/operator's human machine interface to control small unmanned vehicle in a VLOS operational environment. The ground based NOVA USCT will be paired with the VDT (Vehicle Data Terminal) receiver unit installed in the remote controlled vehicle. Various RF Modules, from RC-grade to tactical-grade IP datalinks, can be used depending on the customer requirements. The NOVA USCT can also act as a ground gateway for computer based command & control applications.



SERaero-TM Protocol Description

SPECIFICATON DETAIL

This part of the document describes the SERaero-TM (telemetry) downlink protocol structure to support the Hetronic NOVA USCT rugged handheld radio control transmitter, as well as BVLOS data links based on industrial WiFi or public/private mobile network infrastructures (2G to 5G). The data protocol is referred to as SERaero-TM.

ELECTRICAL, TIMING AND PROTOCOL PARAMETERS

SERaero-TM is implemented by a 115.200 bit/s serial data stream and the data stream is generated by the remote vehicle data terminal (VDT) receiver unit. The receiver generates a data frame at a rate of 1 to 20 Hz, or it will send on a transmitter request only (single shot). The RF (air data rate) data rate will be variable between 9.600 to 115.200 bps. Each data frame consists of a header followed by a data section representing the telemetry data, and is concluded by a CRC checksum. The main electrical protocol parameters are:

- UART connection (TxD, RxD, Gnd) in TTL (5V) logic
- Serial Com Port parameters: 115.2 kbit/s, 8 data bits, 1 Stop bit, no parity
- Variable-Byte length data string transmitted at a update rate of 1 to 20 Hz, or single shot

SERaero-TM Data String Definition

The SERaero-TM is a “Vehicle Telemetry Status” protocol to inform periodically the ground transmitting device about the actual status of the remote vehicle, position, sensors, autopilot mode and aircraft functions settings, and to drive the correct LEDs (physical or virtual) on the transmitting device.

It is sent at an transmitter request or periodically at an update rate of 1 - 20 Hz and serves as a heartbeat signal also. The SERaero-TM uses a very similar data string definition as the CANaerospace protocol.

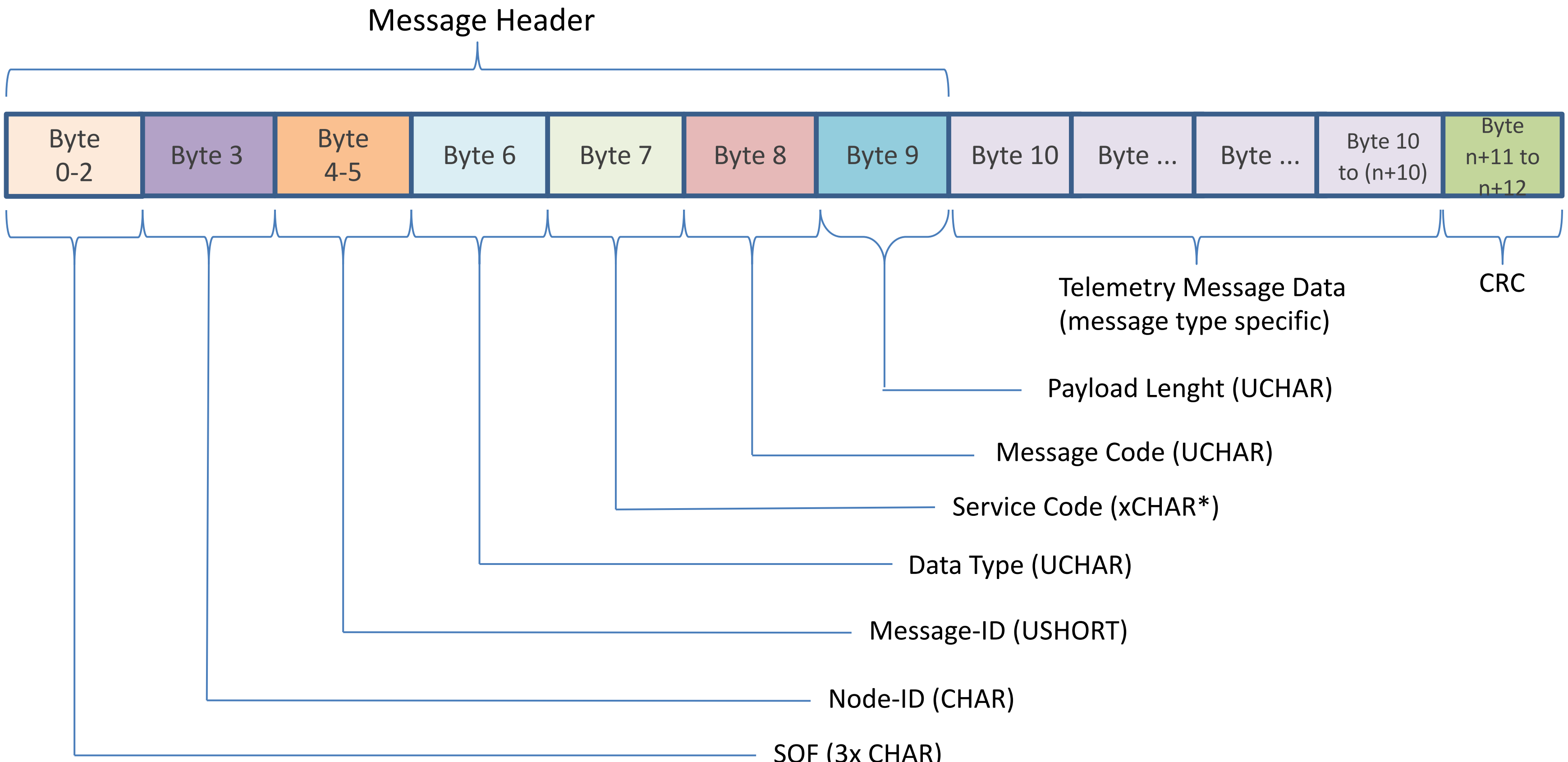
The protocol is able to transport data up 4 to 240 bytes of payload data. Payload data length depends on data link type, quality and data usage (real-time data, status report, protocol wrapper). The payload data length is always a multiple of 4. e.g 4, 8, 12, 16, etc. DEFAULT PAYLOAD DATA LENGTH IS 4 BYTES!

Byte Number	Parameter	Data Type	Range
0-2	Start of Frame (SOF) (ASCII “S-x”)	ASCII character	See Header definition for “x”
3	Node ID	Unsigned Character	0x00 – 0xFF
4-5	Message ID	Unsigned Short	0x0000 – 0xFFFF
6	Data Type	Unsigned Character	0x00 – 0xFF
7	Service Code	Unsigned Character	0x00 – 0xFF
8	Message Code or Internal Timer (CT)	Unsigned Character	0x00 – 0xFF
9	Payload Length (multiple of 4)	Unsigned Character	0x00 – 0xFF
10 to (n+10)	Payload Message Data (Default is 4)	Message Type Specific	n.a.
(n+11 to (n+12)	CRC (see*)	CRC16	n.a.

* CRC-16 polynomial 10000000 00000101

SERaero-TM Data String Layout

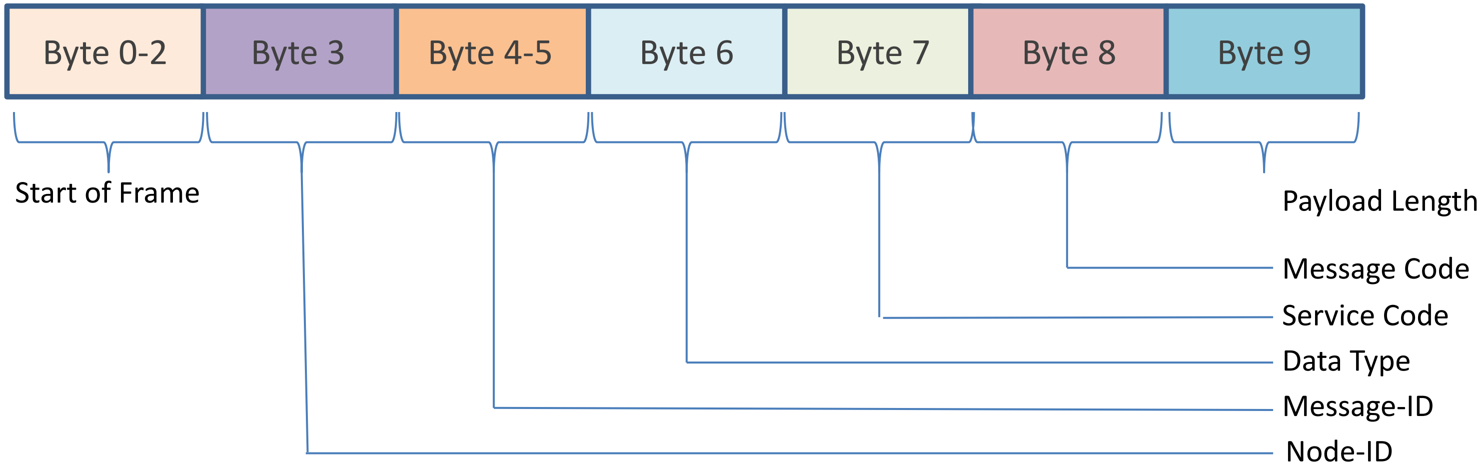
The SERaero-TM messages consist of 10 header bytes for node/message identification, data type, message code and service code and variable number of data bytes (payload) for the actual telemetry data. The minimum and default amount of payload bytes are 4. The string layout is a variable n+12 byte long string with final CRC checksum.



*: xCHAR may be CHAR, ACHAR, BCHAR or UCHAR

SERaero-TM Message Header Description

- **SOF** (Byte 0-2): The Start of Frame indicates a new start of a SERaero-TM data string.
- **Node-ID** (Byte 3): The Node-ID identifies the vehicle data terminal receiver unit. The Node-ID allows to send telemetry data, or to receive command & control data to/from a common ground control station. E.g. swarming and robotic cooperations.
- **Message-ID** (Byte 4-5): SERaero-TM defines an "identifier distribution" scheme addressing the most commonly used data for aerospace and unmanned systems applications. The scheme profiles reflect as much as possible the CANaerospace IDs.
- **Data Type** (Byte 6): The data type specifies the coding of the telemetry data transported with the corresponding message. The number is taken from a data type list.
- **Service Code** (Byte 7): The service code consists of 8 bits which may be used as required by the specific data (should be set to zero if unused). For node service data (NSL/NSH) messages, the service code contains the node service code for the current operation.
- **Message Code** (Byte 8): The message code is incremented by one for each message and may be used to monitor the sequence of incoming messages. The message code then rolls over to zero after passing 255. This feature allows any node in the network to determine the age of a signal and the proper sequence for monitoring purposes. For node service data (NSL/NSH) messages, however, the message code is used for extended specification of the service.
- **Payload Length** (Byte 9): The payload length specifies the number of used payload bytes. The minimum length is 4 bytes, the maximum length is 240 bytes.



SERaero-TM Message SOF

START OF FRAME (SOF) STRUCTURE

The SOF consits of 3 bytes:

- byte 1 signaling the start of frame (“S” -> 0x53)
- byte 2 acting as a constant separator (“-” -> 0x2D)
- byte 3 signaling the receiver status or protocol code trigger.

In version 1.0 of the SERaero-TM four receiver status values are defined:

“L”: valid and live data frame on 9.600 bps RF data rate

“M”: valid and live data frame on 57.600 bps RF data rate

“H”: valid and live data frame on 115.200 bps RF data rate

“!”: valid data frame with receiver in fail safe condition

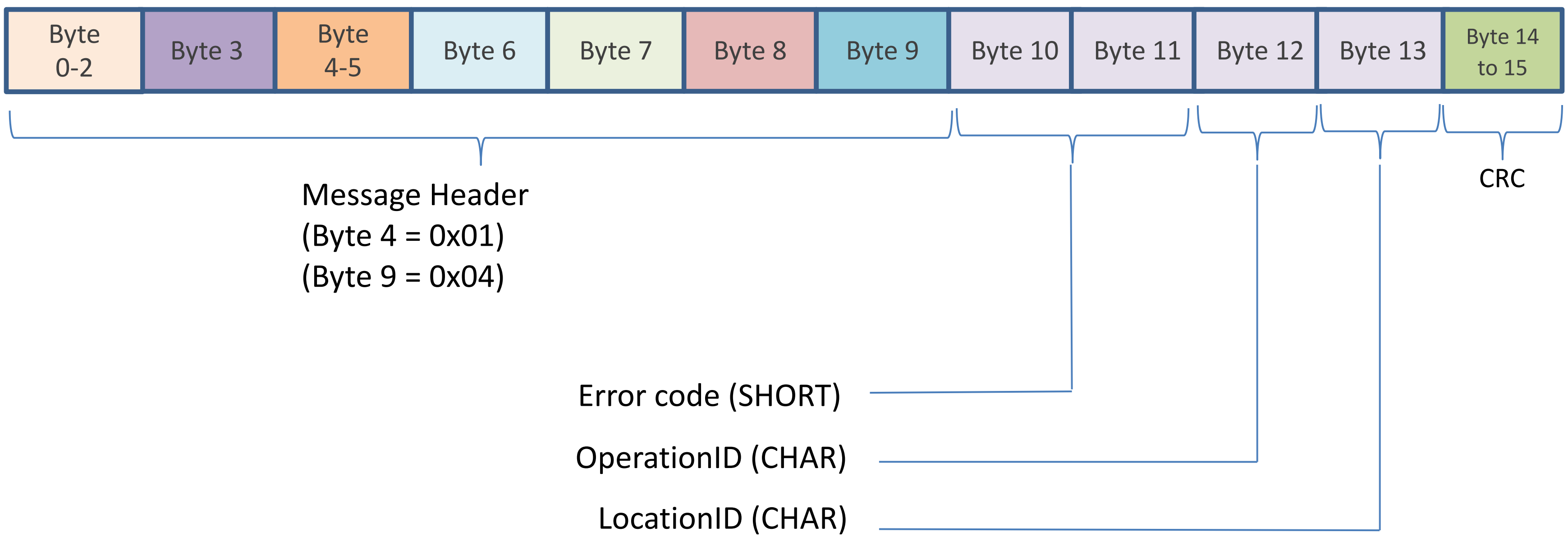
More receiver status values can be defined and added in further protocol evolvement, such as remote receiver unit configuration or MAVLink (or other) native messages.

SERaero-TM Message SOF Definition

Byte Number	Byte Name	Data Type	Byte Value	Remark
0	Start of Frame	ASCII character	0x53	“S”
1	Constant Separator	ASCII character	0x2D	“-”
2	Receiver Status	ASCII character	0x4C	“L” valid and live data frame at 9.600 bps RF data rate
2	Transmitter Status	ASCII character	0x4D	“M” valid and live data frame at 57.600 bps RF data rate
2	Transmitter Status	ASCII character	0x48	“H“valid and live data frame at 115.200 bps RF data rate
2	Transmitter Status	ASCII character	0x21	“!” valid data frame with transmitter in fail safe condition
2	Transmitter Status	ASCII character	other values	Values different to what defined above indicate an invalid data frame and should not be processed

SERaero-TM Emergency Event Data (EED)

Emergency Event Data (EED) is transmitted asynchronously by the affected unit whenever an error situation occurs. The corresponding data contains information about the location within the unit at which the error occurred, the offending operation and the error code:



SERaero-TM Message Types (Future Use)

The data format definition specifies 6 basic message types, which are used for different services. Each message type has an associated Message-ID range defining the message priority. Generally, the identifier distribution within the specified ranges is at the user's discretion.

A standard SERaero-TM identifier distribution addressing commonly used data objects and devices in aerospace applications is made in SERaero-TM Message IDs Summary section, however. The use of this standard distribution scheme is highly encouraged for interoperability reasons.

Message Type	Message-ID Range	Explanation
Emergency Event Data (EED)	0-127 (0x000 – 0x07F)	Transmitted asynchronously whenever a situation requiring immediate action occurs.
High Priority Node Service Data (NSH)	128-199 (0x080 – 0x0C7)	Transmitted asynchronously or cyclic with defined transmission intervals for operational commands.
High Priority User-Defined Data (UDH)	200-299 (0x0C8 – 0x12B)	Message/data format and transmission intervals entirely user-defined.
Normal Operation Data (NOD)	300-1799 (0x12C – 0x707)	Transmitted asynchronously or cyclic with defined transmission intervals for operational and status data.
Low Priority User-Defined Data (UDL)	1800-1899 (0x708 – 0x76B)	Message/data format and transmission intervals entirely user-defined.
Debug Service Data (DSD)	1900-1999 (0x76C – 0x7CF)	Transmitted asynchronously or cyclic for debug communication & software download actions.
Low Priority Node-Service Data (NSL)	2000-2031 (0x7D0 – 0x7EF)	Transmitted asynchronously or cyclic for test & maintenance actions.

SERaero-TM Data Types Definition

For data representation, the most commonly used basic data types are defined. Additionally, combined data types (i.e. two, three and four 16 bit and 8 bit data types in one SERaero message) and aggregate data types (64-bit double float) are supported. Other data types can be added to the type list as required. The type number in the range of 0-255 is used for data type specification as described in the next slides.

SERaero-TM Data Type Definition

Data Type	Range	Bits	Explanation	Type #
NODATA	n.a.	0	"No data" type	0 ($00)
ERROR	n.a.	32	Emergency event data type	1 ($01)
FLOAT	1-bit sign 23-bit fraction 8-bit exponent	32	Single precision floating-point value according to IEEE-754-1985	2 ($02)
LONG	-2147483647 to +2147483648	32	2's complement integer	3 ($03)
ULONG	0 to 4294967295	32	unsigned integer	4 ($04)
BLONG	n.a.	32	Each bit defines a discrete state. 32 bits are coded into four SERaero-TM data bytes	5 ($05)
SHORT	-32768 to +32767	16	2's complement short integer	6 ($06)
USHORT	0 to 65535	16	unsigned short integer	7 ($07)
BSHORT	n.a.	16	Each bit defines a discrete state. 16 bits are coded into two SERaero-TM data bytes	8 ($08)
CHAR	-128 to +127	8	2's complement char integer	9 ($09)
UCHAR	0 to 255	8	unsigned char integer	10 ($0A)
BCHAR	n.a.	8	Each bit defines a discrete state. 8 bits are coded into a single SERaero-TM data byte	11 ($0B)
SHORT2	-32768 to +32767	2x 16	2 x 2's complement short integer	12 ($0C)
USHORT2	0 to 65535	2x 16	2 x unsigned short integer	13 ($0D)
BSHORT2	n.a.	2x 16	2 x discrete short	14 ($0E)

SERaero-TM Data Type Definition

Data Type	Range	Bits	Explanation	Type #
CHAR4	-128 to +127	4x 8	4 x 2's complement char integer	15 ($0F)
UCHAR4	0 to 255	4x 8	4 x unsigned char integer	16 ($10)
BCHAR4	n.a.	4x 8	4 x discrete char	17 ($11)
CHAR2	-128 to +127	2x 8	2 x 2's complement char integer	18 ($12)
UCHAR2	0 to 255	2x 8	2 x unsigned char integer	19 ($13)
BCHAR2	n.a.	2x 8	2 x discrete char	20 ($14)
MEMID	0 to 4294967295	32	Memory ID for upload/download	21 ($15)
CHKSUM	0 to 4294967295	32	Checksum for upload/download	22 ($16)
ACHAR	0 to 255	8	ASCII character	23 ($17)
ACHAR2	0 to 255	2x 8	2 x ASCII character	24 ($18)
ACHAR4	0 to 255	4x 8	4 xASCII character	25 ($19)
CHAR3	-128 to +127	3x 8	3 x 2's complement char integer	26 ($1A)
UCHAR3	0 to 255	3x 8	3 x unsigned char integer	27 ($1B)
BCHAR3	n.a.	3x 8	3 x discrete char	28 ($1C)
ACHAR3	0 to 255	3x 8	4 xASCII character	29 ($1D)

SERaero-TM Data Type Definition

Data Type	Range	Bits	Explanation	Type #
DOUBLEH	1-bit sign 52-bit fraction 11-bit exponent	32	Most significant 32 bits of double precision floating-point value according to IEEE-754- 1985	30 ($1E)
DOUBLEL	1-bit sign 52-bit fraction 11-bit exponent	32	Least significant 32 bits of double precision floating-point value according to IEEE-754- 1985	31 ($1F)
RESVD	n.a.	xx	Reserved for future use	32-99 ($20- $63)
UDEF	n.a.	xx	User-defined data types	100- 255 ($64- $FF)

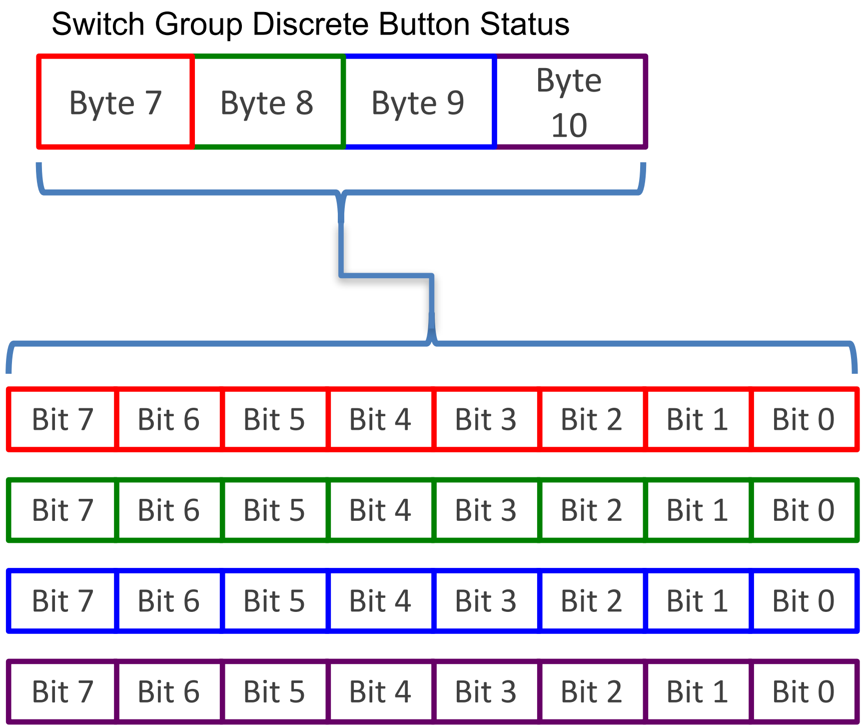
Note about 2's (Two's) Complement Data Type:
https://en.wikipedia.org/wiki/Two%27s_complement
https://technosoftmotion.com/en/knowledge-base/the-negative-numbers-representation-in-hex/

Online Binary to Decimal to Hex Converter:
https://www.mathsisfun.com/binary-decimal-hexadecimal-converter.html

SERaero-TM Remote Control Switch Group Status

SWITCH GROUP DISCRETE STATUS MESSAGE ENCODING

The SERaero TM discrete status messages provide feedback about switch position on the remote control device and consist of a data type „BLONG“. Each bit defines a discrete state. 32 bits are coded into four SERaero-TM data bytes.



SERaero-TM Default Identifier Scheme

By default, an identifier distribution scheme addressing the most commonly used data for aerospace applications has been specified. For this purpose, the available identifiers for normal operation data have been grouped for the various aircraft systems, thereby reserving the identifier range 300-1499. The identifiers from 1500-1799 are unassigned and may be used for other data at the user's discretion.

Parameters may support several data types if indicated in the "suggested data types" field. If this is the case, the user may select the appropriate type with respect to system requirements, processor performance, etc.

If analog parameters are transmitted as SHORT2 using this identifier distribution, the first SHORT variable contains the current value, while the second SHORT variable contains the maximum value of this parameter (to support parameter scaling for the receiving nodes) as described in the following example on next page.

SERaero-TM Default Identifier Scheme

Analog Data Example:

- Engine Temperature (ID 540) range: 0-450K
- AnalogScale = 450 ($01C2)
- AnalogFactor = 32767/450 = 72.81 - (32767 = signed 16-Bit integer value)
- AnalogValue = 16384 ($4000)
- SensorValue = 16384/72.81 = 225K

SensorValue = AnalogValue/(32767/AnalogScale)

AnalogFactor

„S“	$01	$021C	$0C	$00	$7E	$40	$00	$01	$C2	Byte 10-11

Message Header

AnalogValue (variable)

AnalogScale (constant)

CRC

SERaero-TM Message IDs Summary – v1.1

01 Flight state/air data:
- 311: Body pitch angle (deg)
- 312: Body roll angle (deg)
- 314: Altitude rate (m/s)
- 315: Indicated airspeed (m/s)
- 320: Baro corrected altitude (m)
- 321: Heading angle (deg)
- 322: Standard altitude (m)
- 324: Static air temperature (°C)
- 326: Static pressure (hPa)

02 Flight control data:
- 408: Feedback RC switch-group status 1
- 413: Feedback Flight Controller Status
- 441: Feedback RC switch-group status 2
- 442: Buzzer/shaker warning device

03 Vehicle engine/power supply system data:
- 500-503: Engine #n RPM for Channel A (1/min)
- 516-519: ESC #n temperatures for Channel A (°C)
- 524-527: ESC #n current rate for Channel A (Ah)
- 524-527: Engine #n fuel flow for Channel A (l/h)*
- 540-543: Engine #n temperature for Channel A (°C)
- 552-555: ESC #n power rating for Channel A (W)
- 556-560: Engine/ESC #n status bit encoding CH_A
- 564-567: Engine #n RPM for Channel B (1/min)
- 580-583: ESC #n temperatures for Channel B (°C)
- 588-591: ESC #n current rate for Channel B (Ah)
- 588-591: Engine #n fuel flow for Channel B (l/h)*
- 604-607: Engine #n temperature for Channel B (°C)
- 616-619: ESC #n power rating for Channel B (W)
- 620-623: Engine/ESC #n status bit encoding CH_B
- 624-627: Flight Battery #n single cell voltage CH_A
- 628-631: Flight Battery #n single cell voltage CH_B
- 660-663: Flight Battery #n current flow rate CH_A (mA/h)
- 664-667: Flight Battery #n current flow rate CH_B (mA/h)
- 660-663: Fuel pump #n flow rate (l/h) Channel A*
- 664-667: Fuel pump #n flow rate (l/h)Channel B*
- 668-671: Flight Battery #n capacity quantity CH_A (mA|%)
- 672-675: Flight Battery #n capacity quantity CH_B (mA|%)
- 668-671: Fuel tank #n quantity (kg) Channel A*
- 672-675: Fuel tank #n quantity (kg) Channel B*
- 676-679: Flight Battery #n temperature CH_A (°C)
- 680-683: Flight Battery #n temperature CH_B (°C)
- 676-679: Fuel tank #n temperature (°C) Channel A*
- 680-683: Fuel tank #n temperature (°C) Channel B*
- 684-687: Flight Battery #n voltage CH_A (V)
- 688-691: Flight Battery #n voltage CH_B (V)
- 692-695: Flight Battery #n current CH_A (A)
- 696-699: Flight Battery #n current CH_B (A)
- 700-703: Rotor #n RPM (Helicopter only) (1/min)

* Service code 0 = electric; Service code 1 = gas

SERaero-TM Message IDs Summary – v1.1

04 Electric system data:

- 920-929: DC system #n voltage (V)
- 930-939: DC system #n current (A)

05 Navigation system data:

- 1031: Distance to next waypoint (m)
- 1032: Time-to-go to next waypoint (min)
- 1036: GPS aircraft latitude (deg)
- 1037: GPS aircraft longitude (deg)
- 1038: GPS aircraft height above ellipsoid (m)
- 1039: GPS ground speed (m/s)
- 1048: GPS fix status
- 1069: Magnetic heading MH (deg)
- 1070: Radio height AGL (m)
- 1095: Direction and Distance from Home (deg, m)
- 1116: Transponder code

06 Miscellaneous data:

- 1175: Landing gear status
- 1200: UTC
- 1206: Date
- 1500: Rx RSSI (%)

SERaero-TM Low RF Data Rate Optimized IDs

To optimize telemetry values transmission over low RF data rates (9.600 bps), specific Message-IDs has been defined. This specific Message-IDs are a combination of various single Message IDs to lower the “Header-to-Payload” ratio (same amout of header bytes, increase of data bytes).

The specific Message IDs groups same categories data, such as engine data, flight state data, GPS data. It never groups single IDs from different categories. This allows the transmission of current, voltage, power and temperature data of an engine into a single Message ID.

The specific IDs use always a multiple of 4 payload data bytes (4, 8, 12, or 16) and all payload bytes must use the same data type defined in the header byte 6.

SERaero-TM Low RF Message IDs Summary – v1.1

01 Flight state/air data:

- 1300: Flight State 311/312/321
- 1301: Air Data 314/315/320/324

03 Vehicle engine/power supply system data:

- 1310: Engine/ESC #1 CH_A 500/516/524/540/552
- 1311: Engine/ESC #2 CH_A 501/517/525/541/553
- 1312: Engine/ESC #3 CH_A 502/518/526/542/554
- 1313: Engine/ESC #4 CH_A 503/519/527/543/555
- 1314: Encoding Bits CH_A 556-560
- 1315: Engine/ESC #1 CH_B 564/580/588/604/616
- 1316: Engine/ESC #2 CH_B 565/581/589/605/617
- 1317: Engine/ESC #3 CH_B 566/582/590/606/618
- 1318: Engine/ESC #4 CH_B 567/583/591/607/619
- 1319: Encoding Bits CH_B 620-623
- 1320: Flight Battery #1 CH_A 660/668/676/684
- 1321: Flight Battery #2 CH_A 661/669/677/685
- 1322: Flight Battery #3 CH_A 662/670/678/686
- 1323: Flight Battery #4 CH_A 663/671/679/687
- 1324: Flight Battery #1 CH_B 664/672/680/688
- 1325: Flight Battery #2 CH_B 665/673/681/689
- 1326: Flight Battery #3 CH_B 666/674/682/690
- 1327: Flight Battery #4 CH_B 667/675/683/691

05 Navigation system data:

- 1330: 1036/1037/1038/1039/1069

MESSAGE IDs

01: Message IDs – Flight State/Air Data

ID	Parameter Name	Data Type	Unit	Notes
311	Body pitch angle	FLOAT / SHORT2	deg	nose up: + // nose down: -
312	Body roll angle	FLOAT / SHORT2	deg	roll right: + // roll left: -
314	Altitude rate	FLOAT / SHORT2	m/s	Service code 0 = m // 1 = ft
315	Indicated airspeed	FLOAT / USHORT2	m/s	Service code 0 = m // 1 = ft
320	Baro corrected altitude	FLOAT / SHORT2	m	Service code 0 = m // 1 = ft
321	Heading angle	FLOAT / USHORT2	deg	0-360°
322	Standard altitude	FLOAT / SHORT2	m	Service code 0 = m // 1 = ft
324	Static air temperature	FLOAT / SHORT2	°C	Service code 0 = °C // 1 = °F
325	Differential pressure	FLOAT / SHORT2	hPa	
326	Static pressure	FLOAT / SHORT2	hPa	

02: Message IDs – Flight Control Data

ID	Parameter Name	Data Type	Unit	Notes
414-417	ESC/Engine Servo #n throttle setting for channel A	FLOAT / USHORT2	Norm -1/+1	
422-425	ESC/Engine Servo #n throttle setting for channel B	FLOAT / USHORT2	Norm -1/+1	
408	Feedback RC switch-group status 1	BLONG / BSHORT		
413	Feedback Autopilot status	UCHAR4		See ID description for details
441	Feedback RC switch-group status 2	BLONG / BSHORT		
442	Buzzer/shaker trigger (alarm/warning)	BLONG / BSHORT		Other function TBD

03: Message IDs – Flight Control Data

ID	Parameter Name	Data Type	Unit	Notes
500-503	Engine #n RPM for channel A	FLOAT / USHORT2	1/min	RPM
516-519	ESC #n temperature for channel A	FLOAT / SHORT2	°C	Service code 0 = °C // 1 = °F
524-527	Engine #n current rate for channel A Engine # fuel flow for channel A	FLOAT / USHORT2	ampere l/h	Service code 0 = electric Service code 1 = gas
540-543	Engine #n temperature for channel A	FLOAT / SHORT2	°C	Service code 0 = °C // 1 = °F
552-555	Engine #n power rating for channel A	FLOAT / USHORT2	watt	
556-560	Engine/ESC #n status bit encoding A	BLONG / BSHORT		bit encoding user defined
564-567	Engine #n RPM for channel B	FLOAT / USHORT2	1/min	RPM
580-583	ESC #n temperature for channel B	FLOAT / SHORT2	°C	Service code 0 = °C // 1 = °F
588-591	Engine #n current rate for channel B Engine # fuel flow for channel B	FLOAT / USHORT2	ampere l/h	Service code 0 = electric Service code 1 = gas
604-607	Engine temperature #n for channel B	FLOAT / SHORT2	°C	Service code 0 = °C // 1 = °F
616-619	Engine #n power rating for channel B	FLOAT / USHORT2	watt	
620-623	Engine/ESC #n status bit encoding B	BLONG / BSHORT		bit encoding user defined
624-627	Flight Battery #n single cell voltage CH_A	UCHAR	mV	1 cell/Byte -> 4-16 cells/batt
628-631	Flight Battery #n single cell voltage CH_B	UCHAR	mV	1 cell/Byte -> 4-16 cells/batt
660-663	Battery #n current flow rate channel A Fuel pump #n flow rate channel A	FLOAT / USHORT2	mA/h l/h	Service code 0 = electric Service code 1 = gas
664-667	Battery #n current flow rate channel B Fuel pump #n flow rate channel B	FLOAT / USHORT2	mA/h l/h	Service code 0 = electric Service code 1 = gas

03: Message IDs – Flight Control Data

ID	Parameter Name	Data Type	Unit	Notes
668-671	Battery #n capacity quantity channel A Fuel tank #n quantity channel A	FLOAT / USHORT2	mA|% g	Service code 0 = mA Service code 1 = % Service code 2 = gram
672-675	Battery #n capacity quantity channel B Fuel tank #n quantity channel B	FLOAT / USHORT2	mA|% g	Service code 0 = mA Service code 1 = % Service code 2 = gram
676-679	Battery #n temperature channel A Fuel tank #n temperature channel A	FLOAT / SHORT2	°C	Service code 0 = electric Service code 1 = fuel
680-683	Battery #n temperature channel B Fuel tank #n temperature channel B	FLOAT / SHORT2	°C	Service code 0 = electric Service code 1 = fuel
684-687				
688-691				
700-707	Rotor #n RPM	FLOAT / USHORT2	1/min	

04: Message IDs – Electric System Data

ID	Parameter Name	Data Type	Unit	Notes
920-929	DC system #n voltage	FLOAT / USHORT2	V	
930-939	DC system #n current	FLOAT / USHORT2	A	

05: Message IDs – Navigation System Data

ID	Parameter Name	Data Type	Unit	Notes
1031	Distance to next waypoint	FLOAT / USHORT2	m	Service code contains wpt #
1032	Time-to-go to next waypoint	SHORT	min	Service code contains wpt #
1036	GPS aircraft latitude	FLOAT / SHORT2	deg	
1037	GPS aircraft longitude	FLOAT / SHORT2	deg	
1038	GPS aircraft height above ellipsoid	FLOAT / USHORT2	m	
1039	GPS ground speed	FLOAT / USHORT2	m/s	Service Code 0: m/s Service Code 1: kph
1048	GPS fix status	UCHAR4		Byte 10 = GPS Status Byte 11 = Nr. Satellites
1069	Magnetic heading MH	FLOAT / USHORT2	deg	0 - 359°
1070	Radio height AGL	FLOAT / SHORT2	m	
1095	Direction and distance from home	USHORT2	deg|m	Service Code: 0 = m; 1 = km Bytes 10-11 = Direction Bytes 12-13 = Distance
1116	Transponder code	FLOAT / ACHAR4		

06: Message IDs – Miscellaneous Data

ID	Parameter Name	Data Type	Unit	Notes
1175	Landing gear status	BSHORT		
1200	UTC	UCHAR4		Format: 13h43min22s 13 43 22 00
1206	Date	UCHAR4		Format: 12. June 1987 12 06 19 87
1500 - 1503	RSSI #n	CHAR4	%|dB	Format: Rx RSSI 1,2,3,4 Service code 0 = % Service code 1 = dBm
1504	Ground Station Battery Status	USHORT2	V|%	Service code 0 = V Service code 1 = %

1500 - 1503 RSSI:
Byte 10/11/12/13: unsigned 0-100 if %
Byte 10/11/12/13: signed -128 to 127 if dBm

MESSAGE-ID 413 DESCRIPTION

“Feedback Flight Controller MODE” – Byte 10

Function	Feedback	Color	PX4	AP	Byte 10	Byte 11	Byte 12	Byte 13
MANUAL	DISPLAY	GREEN	x	x	0x01			
STABILIZED	DISPLAY	GREEN	x	x	0x02			
ALTITUDE HOLD	DISPLAY	GREEN	x	x	0x03			
POSITION HOLD	DISPLAY	GREEN	x	x	0x04			
AUTO/MISSION	DISPLAY	GREEN	x	x	0x05			
OFFBOARD	DISPLAY	YELLOW	x		0x06			
RETURN TO LAND/RTL	DISPLAY	YELLOW	x	x	0x07			
ACRO	DISPLAY	YELLOW	x	x	0x08			
FLIGHT TERMINATION	DISPLAY	RED			0x09			
TAKEOFF	DISPLAY	YELLOW	x	x	0x0A			
LAND	DISPLAY	YELLOW	x	x	0x0B			
FOLLOW ME	DISPLAY	YELLOW	x	x	0x0C			
HOLD/LOITER	DISPLAY	GREEN	x	x	0x0D			
RATTITUDE	DISPLAY	YELLOW	x		0x0E			
ORBIT/CIRCLE	DISPLAY	GREEN	x	x	0x0F			
GUIDED	DISPLAY	GREEN		x	0x10			
SMARTRTL	DISPLAY	YELLOW		x	0x11			
ZIGZAG	DISPLAY	GREEN		x	0x12			
SIMPLE/SUPER SIMPLE	DISPLAY	GREEN		x	0x13			
DRIFT	DISPLAY	GREEN		x	0x14			
SERIAL BRIDGE MODE	DISPLAY	YELLOW	INTERNAL USE		0x15			
STEERING	Display	GREEN		x	0x16			

MESSAGE-ID 413 DESCRIPTION

“Feedback Flight Controller MODE” – Byte 10

Function	Feedback	Color	PX4	AP	Byte 10	Byte 11	Byte 12	Byte 13
AUTOLAUNCH	DISPLAY	GREEN		x	0x17			
AVOID ADSB	DISPLAY	GREEN		x	0x18			

MESSAGE-ID 413 DESCRIPTION

“Feedback Autopilot Controller Type” – Byte 11 - 13

Function	Feedback	Color	---	---	Byte 10	Byte 11	Byte 12	Byte 13
AP_GENERIC	C12					0x00		
AP_ARDUPILOT	C12					0x03		
AP_PX4	C12					0x0C		
AP_EMBENTION	C12					0x04		
AP_UAVNAVIGATION	C12					0x05		
AP_MICROPILOT	C12					0x06		
FRAME_TYPE_UNDEF	C12						0x00	
FRAME_TYPE_UAV	C12						0x01	
FRAME_TYPE_UGV	C12						0x02	
FRAME_TYPE_USV	C12						0x03	
FRAME_TYPE_UUV*	C12						0x04	
* See next slide for clarification								

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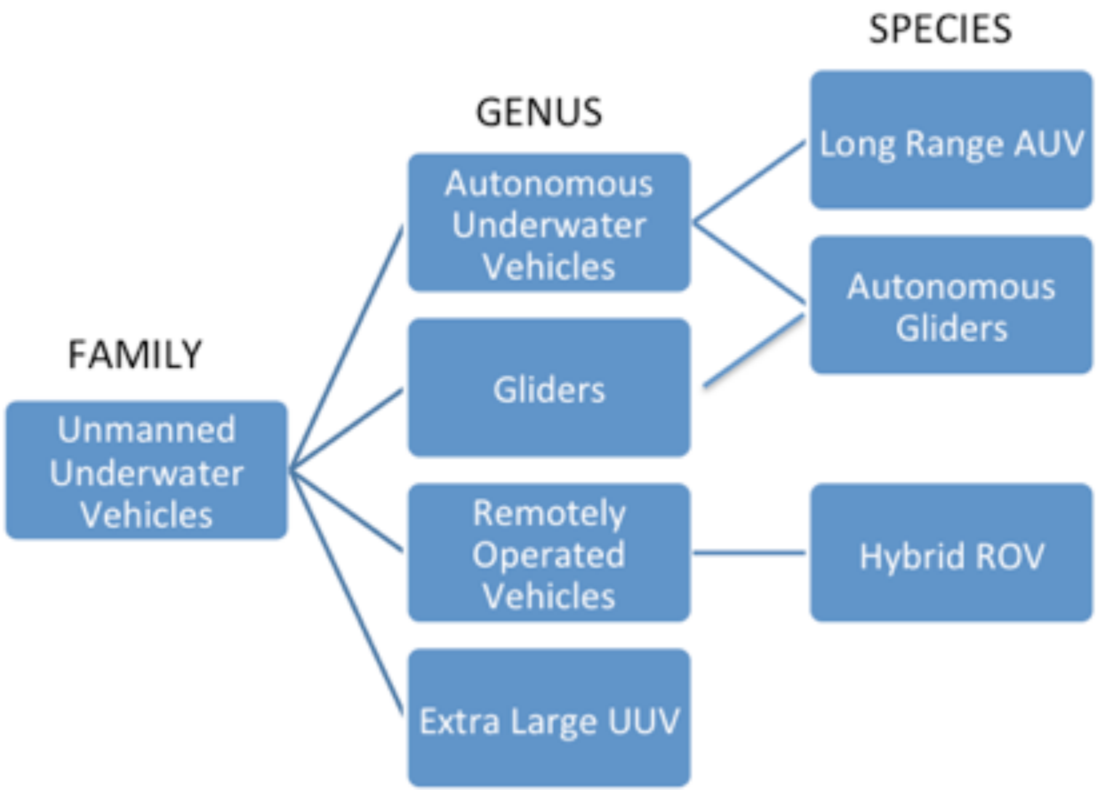
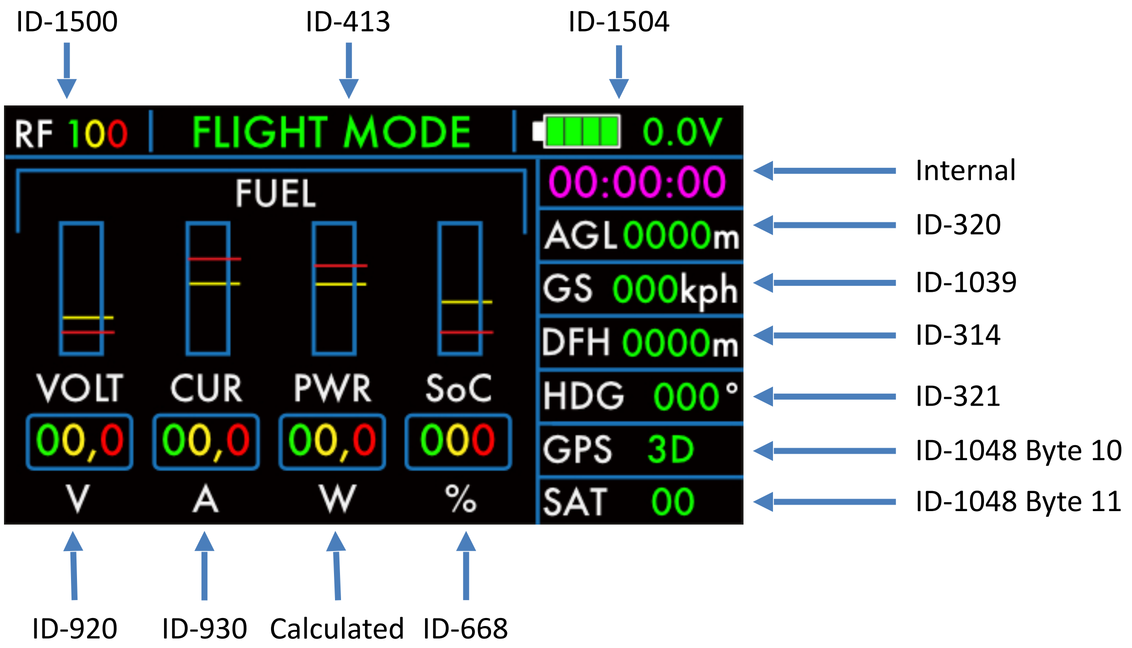


MESSAGE-ID 1048 DESCRIPTION

“SAT NO & GPS_FIX” – Byte 10 - 11								
Function	**Feedback**	**Color**	**PX4**	**AP**	**Byte 10**	**Byte 11**	**Byte 13**	**Byte 14**
NO	DISPLAY	RED	x	x	0x00			
NFIX	DISPLAY	RED	x	x	0x01			
2D	DISPLAY	YELLOW	x	x	0x02			
3D	DISPLAY	GREEN	x	x	0x03			
DGPS	DISPLAY	GREEN	x	x	0x04			
RTK1	DISPLAY	GREEN	x	x	0x05			
RTK2	DISPLAY	GREEN	x	x	0x06			
STAT	DISPLAY	GREEN	x	x	0x07			
PPP	DISPLAY	GREEN	x	x	0x08			
NUMBER OF SAT 0-5	DISPLAY	RED	x	x		0x0 – 0x5		
NUMBER OF SAT 6-9	DISPLAY	YELLOW	x	x		0x6 – 0x9		
NUMBER OF SAT 10 up	DISPLAY	GREEN	X	X		0x0A -		

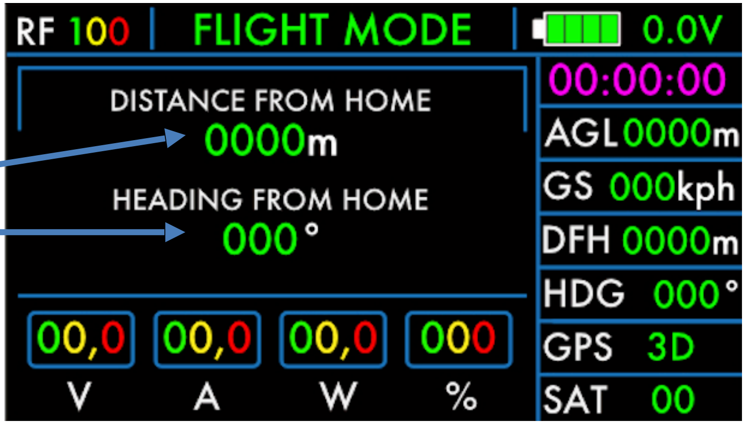
NOVA DISPLAY DESCRIPTION – MAIN SCREEN



NOVA DISPLAY DESCRIPTION – 2nd SCREEN

ID-314: Byte 10-11

ID-314: Byte 12-13



NOVA DISPLAY DESCRIPTION – MAIN SCREEN

LCD Display Customized Data Type Description

ID	Parameter Name	Data Type	Unit	Max Values
314	Distance From Home	USHORT (Byte 10-11)	m | km	0 - 9999m | 10 - 99,9km
320	Altitude above Ground Level	SHORT (Byte 10-11)	m	-000m to 9999m
321	Magnetic Heading	USHORT (Byte 10-11)	deg	0 - 359°
920	Flight Battery Voltage	USHORT2	V	0 - 99.9V
930	Flight Battery Current	USHORT2	A	0 - 99.9A | 100 - 999A
Calc.	Flight Battery Power	USHORT (Byte 10-11)	W	0 - 99.9W | 1 - 99.9kW
1039	GPS Ground Speed	USHORT (Byte 10-11)	kps | m/s	0 - 999kph | 0 - 999m/s
1048	GPS Fix / SAT Numbers	UCHAR2	-	See details on ID-1048 descr.
1500	RX RF Signal Level	CHAR (Byte 10)	% | dBm	0 - 100% | -127 - 127dBm
413	Flight Mode	UCHAR4	-	See details on ID-413 descr.
314	Heading From Home	USHORT (Byte 12-13)	deg	0 - 359°
668	Battery Capacity	USHORT2	%	0 - 100 %
1504	Ground Station Battery Status	USHORT2	V|%	Service code 0 = V Service code 1 = %

Note: Check Service Code options for ID-1039 and ID-1500

SERaero-TM CRC Description

CRC CALCULATION

CRC is a common method for detecting errors in transmitted messages or stored data. The CRC is a very powerful, but easily implemented technique to obtain data reliability.

This note describes the CRC-16 polynomial Cyclic Redundancy Check (CRC) calculation and implementation. The theory of a CRC calculation is straight forward. The data is treated by the CRC algorithm as a binary number. This number is divided by another binary number called the polynomial. The rest of the division is the CRC checksum, which is appended to the transmitted message.

The receiver divides the message (including the calculated CRC), by the same polynomial the transmitter used. If the result of this division is zero, then the transmission was successful. However, if the result is not equal to zero, an error occurred during the transmission.

The SERaero CRC is calculated taking Header and Data into account as is derived by the following algorithm:

SERaero CRC16 Algorithm

```
#define CRC16 0x8005
/********************************************************************************
*Function Name: gen_crc16
*Description: CRC16 calculation with Polynomial 0x8005
********************************************************************************/
uint16_t gen_crc16(const uint8_t *data, uint16_t size)
{
    uint16_t out = 0, crc;
    int bits_read = 0, bit_flag, i;
    int j = 0x0001;

    if(data == NULL)
        return 0;

    while(size > 0)
    {
        bit_flag = out >> 15;
        out <<= 1;
        out |= (*data >> bits_read) & 1;

        bits_read++;
        if(bits_read > 7)
        {
            bits_read = 0;
            data++;
            size--;
        }

        if(bit_flag)
            out ^= CRC16;
    }

    for (i = 0; i < 16; ++i) {
        bit_flag = out >> 15;
        out <<= 1;
        if(bit_flag)
            out ^= CRC16;
    }

    i = 0x8000;
    for (; i != 0; i >>=1, j <<= 1) {
        if (i & out) crc |= j;
    }

    return crc;
}
```

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