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2025 January Update for the Starlink Packet Formats

Table 4 and 5 added.

In December 2022, SpaceX commenced launching its Starlink Version 2 spacecraft into orbit to which was added a VHF beacon package based on the Swarm SpaceBEE LoRa format [1 and 3] and operates in the same VHF band of 137-138 MHz. The Starlink VHF Beacon [2] provides early orbit telemetry, Tracking and command for the orbit raising phase.

The Starlink VHF Beacon transmits primarily on 137.055 MHz but do use 137.845 and 137.975 MHz occasionally. The transmission modulation is LoRa with a Spreading Factor of 8, a Coding Rate of 5 and Bandwidth of 41.666 kHz.

The Starlink VHF Beacon use packet lengths of 73, 81, 87 and 227-bytes with a packet structure of an 11-byte header followed by a variable length data zone. This zone has a two-byte header to inform the format type and remaining bytes.

Table 1 Starlink VHF Beacon 73-byte CC Format

Table 2 Starlink VHF Beacon 81-byte CC Format

Table 3 Starlink VHF Beacon 87-byte CC Format

Table 4 Starlink VHF Beacon 227-byte CC Format

Table 5 Starlink VHF Beacon 104-byte CC Format

Analysis of the data continues.

References:

1. Notes on the Swarm SpaceBEE Satellites <https://emitters.space/SpaceBEE.pdf>
2. Notes on the SpaceX Starlink VHF Beacon Satellites <https://emitters.space/Starlink.pdf>
3. All 175 operational SpaceBEEs have decayed by 19 November 2024

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Table 1 Starlink VHF Beacon 73-byte Format					
Segment	Byte Position	Parameter	Bytes	Data as little endian	Value
Header 11 bytes	1-3	Message Number	3	81828a	90773777
	4-5	Spacecraft ID	2	4a0b	2890
	6	Packet Type	2	cc	204
	7-8	Packet Seed	2	00 00	0 0
	9	Packet Source		d0	208
	10-11	Header CRC?	2	0c13	
Frame Header 2 bytes	12	Frame Length	1	3d	61
	13	Frame Format	1	04	4
Frame Data 1 19 bytes	14	?	1	00	0
	15-18	UTC Timecode	4	8dcb1c65	4 October 2023 02:18:53
	19-32	Semi-fixed TBD	14	53002450 fb340a00 21e204ba 7103	
Frame Data 2 41 bytes	33-34	GPS Week	2	ea08	
	35-36	GPS Week Seconds	4	2b3f9801	
	36-67	TBD	29	d0a621e6 86884111 d00d77e6 4128fcff 9aecf5ff c113fdff 1ee195e5 18	
	68-73	TBD	6	e16c1c 657262	

81828a 4a0b cc 0000 d0 0c13

3d 04 8dcb1c65 53002450fb340a0021e204ba7103

ea08 2b3f9801 d0a621e686884111d00d77e64128fcff9aecf5ffc113fdff1ee195e518 e16c1c657262

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Table 2 Starlink VHF Beacon 81-byte Format					
Segment	Byte Position	Parameter	Bytes	Data as little endian	Value
Header 11 bytes	1-3	Message Number	3	b98657	
	4-5	Spacecraft ID	2	2712	2890
	6	Packet Type	2	cc	204
	7-8	Packet Seed	2	00 00	0 0
	9	Packet Source		d0	208
	10-11	Header CRC?	2	d30b	
Frame Header 2 bytes	12	Frame Length	1	45	69
	13	Frame Format	1	05	4
Frame Data 1 19 bytes	14	?	1	02	2
	15-18	UTC Timecode	4	af 9a 77 66	23 June 2024 03:46:55
	19-32	Semi-fixed TBD	14	43 00 30 fa fb 34 0a 00 21 00 05 12 74 05	
Frame Data 2 49 bytes	33-34	GPS Week	2	10 09	2320
	35-38	GPS Week Seconds	4	60 cc 14 00	1363040/100
	39-81	TBD	43	58 bd 87 e5 8b ea d0 0f 74 9e 8c e6 2b 9b fc ff 33 b4 f5 ff b0 20 fd ff 22 08 68 18 05 00 00 00 00 00 00 90 8e c7 ff a6 ff fc ff 49 79	

b98657 2712 cc 0000 d0 d30b
 45 05
 02 af 9a 77 66
 43 00 30 fa fb 34 0a 00 21 00 05 12 74 05
 10 09 60 cc 14 00
 58 bd 87 e5 8b ea d0 0f 74 9e 8c e6 2b 9b fc ff 33 b4 f5 ff b0 20 fd ff 22 08 68 18 05 00 00 00 00 00
 00 90 8e c7 ff a6 ff fc ff 49 79

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Table 3 Starlink VHF Beacon 87-byte Format				
Segment	Parameter	Bytes	Data as little endian	Value
Header 11 bytes	Message Number	3	ae803e	4096174
	Spacecraft ID	2	5109	2385
	Packet Type	1	cc	
	Packet Seed	2	0000	
	Packet Source	2	D0	D = Starlink
	Unique	2	0eb4	
Frame Header 2 bytes	Frame Length	1	4b	75
	Frame Format	1	03	3 = Starlink 87-byte
Frame Data 1 39 bytes	UTC Timecode	4	6d765564	5 May 2023 21:34:37
	Latitude	4	313d06c2	-31.5597572 °
	Longitude	4	62100f43	143.064 °
	Altitude	4	19530600	414489 metres
	Semi-fixed TBD	23	0000 98a3 1400 0430 90fc 21ba 0403 0000 82ca 660e 0608 00	
Frame Data 2 35 bytes	GPS Week	2	d408	2260
	GPS Week Seconds	4	c0ba0903	5 May 2023 21:34:34
	TBD	29	18b6 01e5 8f2f 4b14	
			81d 8bce9 3eb3 fcff 2b74 f6ff 674a fbff 1e10 d2dc 07	

ae803e 5109 cc 0000 d0 0eb44b 03 6d765564 313d06c2 62100f43 19530600 0000 98a3 1400 0430
90fc 21ba 0403 0000 82ca 660e 0608 00 d408 c0ba0903 18b6 01e5 8f2f 4b14 81d 8bce9 3eb3 fcff
2b74 f6ff 674a fbff 1e10 d2dc 07

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Table 4 Starlink VHF Beacon 227-byte Format					
Segment	Byte Position	Parameter	Bytes	Data as little endian	Value
Header 11 bytes	1-3	Message Number	3	3802af	11469368
	4-5	Spacecraft ID	2	aa16	5802
	6	Packet Type	2	cc	204
	7-8	Packet Seed	2	0000	0
	9	Packet Source		d0	208
	10-11	Header CRC?	2	A664	
Frame Header 2 bytes	12	Frame Length	1	D7	215
	13	Frame Format	1	06	6
Frame Data Zone 1 19 bytes	14	Fixed	1	02	2
	15-18	UTC Timecode	4	994b5f67	15 Dec 2024 21:35:21
	19-32	Semi-fixed	14	5300 30f0 fb34 0a00 20ec 040a 6d07	
Frame Data Zone 2 35 bytes	33-34	GPS Week	2	2909	2345
	35-38	GPS Week Seconds	4	C79d9760	77736.39
	39-67		29	a5f4 a0e4 6d6b b711 fac0 02e9 2610 f8ff 7b4f f9ff b14a 0400 4243 2d18 02	15 Dec 2024 21:35:18
Frame Data Zone 3 160 Bytes	68-71	UTC Timecode	4	10265d67	14 Dec 2024 06:30:40
	72-227	39 x 32-bit signed	156	ffffd08a cfffed5ff f0ff8d1a 7ec904ef ae136f36 0000009a 99999999 bd8840e9 261042e5 7ac5428c 200a008c 200a008c 200a0015 040a8a83 22d5410e 00000000 00000000	

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				231a8cca 3b7b354a 75736bca de8fa2c5 cefb88c5 0dc42f45 a1a00000 ff7f5dff 7fd50700 d732d73e fc86fb3e 8151013f 85a8843d e150613d ab542b3e c468443e bf403f3e b3c7cf3f a91cce3f 9ab2cf3f 4052ce3f 06d4903f	
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3802af aa16 cc 0000 d0 a664 d7 06 02 994b5f67 530030f0fb340a0020ec040a6d07 2909 c79d7600
a5f4a0e46d6bb711fac002e92610f8ff7b4ff9ffb14a040042432d1802 10265d67 fffd08a cffed5ff
f0ff8d1a 7ec904ef ae136f36 0000009a 99999999 bd8840e9 261042e5 7ac5428c 200a008c 200a008c
200a0015 040a8a83 22d5410e 00000000 00000000 231a8cca 3b7b354a 75736bca de8fa2c5
cefb88c5 0dc42f45 a1a00000 ff7f5dff 7fd50700 d732d73e fc86fb3e 8151013f 85a8843d e150613d
ab542b3e c468443e bf403f3e b3c7cf3f a91cce3f 9ab2cf3f 4052ce3f 06d4903f

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Table 5 Starlink 104-byte encrypted message					
Segment	Parameter	Position	Bytes	LE Data	Value
1 st Header 11 bytes	Message Number	1 2 3	3	ae80b0	11567278
	Spacecraft ID	4 5	2	a506	5802
	Packet Type	6	1	ac	172
	Seed	7 8	2	6278	
	Source	9	1	B3	
	Unique	10 11	2	f1e8	
Length + 2 nd Header 12 bytes	Bytes remaining	12	1	5c	92
	Message number	13 14 15	3	0280b0	11567106
	SCID	16 17	2	a506	5802
	Encrypt Options	18	1	2c	44
	Seed	19 20	2	0000	
	Source	21	1	B4	
Length + Coded Data 81 bytes	Unique	22 23	2	2223	
	Bytes remaining	24	1	50	80
	Coded data	25 to 104	80	9c2cd6969d0bab59 7875e450287037d4 2a22f1ef9c29d358 f40ea73161dac9be f5ece1da0dbda93b 2e57f6613cace802 6a75f66830af5bd8 49bc2b69af8fb7f6 551bf2fb29cc3fb1 4d4a6ffd5905f6f2	

ae80b0 a506 ac 6278 6278 f1e8 5c 0280b0 a506 2c 0000b42223 50
9c2cd6969d0bab597875e450287037d42a22f1ef9c29d358f40ea73161dac9bef5ece1da0dbda93b2e5
7f6613cace8026a75f66830af5bd849bc2b69af8fb7f6551bf2fb29cc3fb14d4a6ffd5905f6f2