QZSS Early Warning System (EWS)

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Background Information

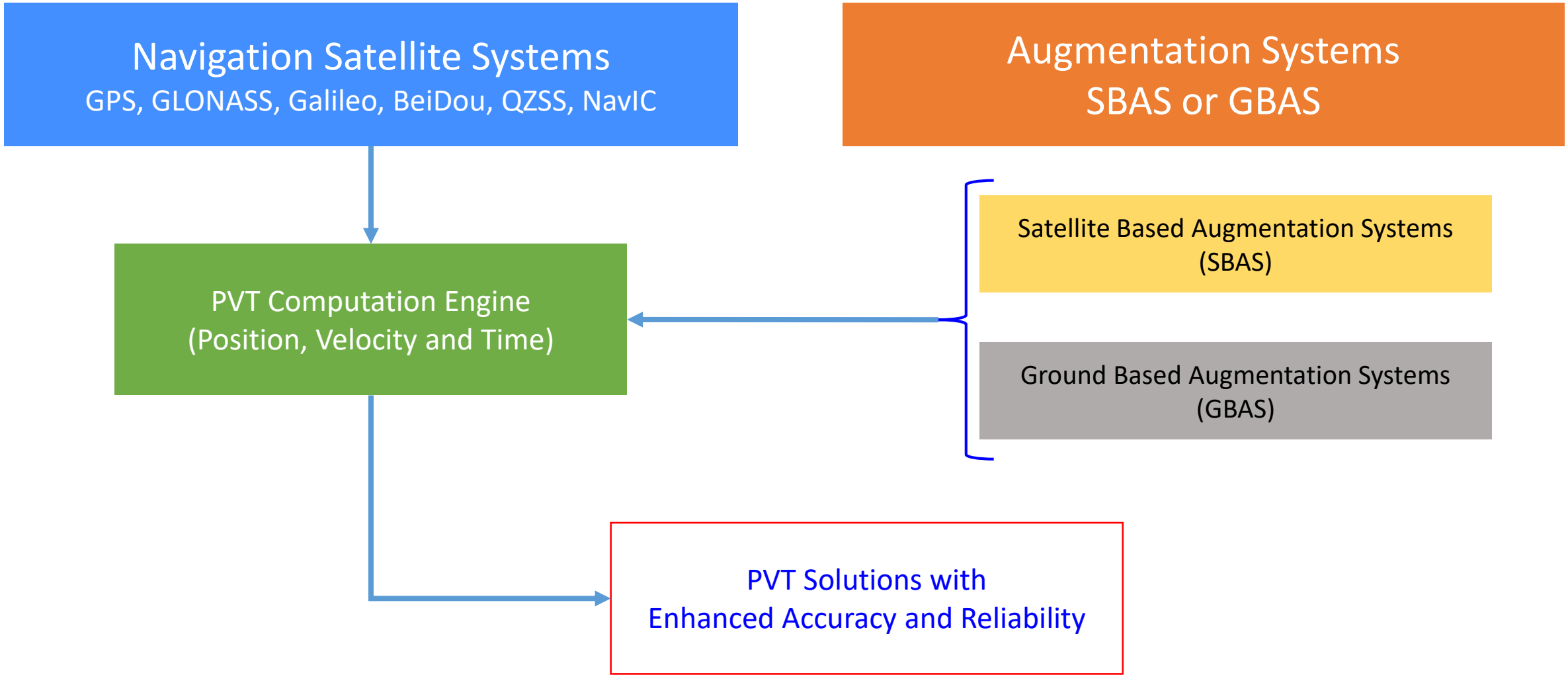
QZSS EWS message is broadcasted using QZSS L1S signal structure that uses signal structure similar to SBAS signal. EWS also requires knowledge about Navigation Message structure. So, some background information on SBAS signals, GPS and SBAS navigation messages are provided.

GNSS

Global Navigation Satellite System (GNSS) is the standard generic term for all navigation satellites systems like GPS, GLONASS, GALILEO, BeiDou, QZSS, NAVIC.

- Global Constellation
  - GPS, USA
  - GLONASS, Russia
  - Galileo, Europe
  - BeiDou (COMPASS) / BDS, China
- Regional Constellation
  - QZSS, Japan
  - NAVIC (IRNSS), India

Systems Related with Navigation



Satellite Based Augmentation System (SBAS)

- Satellite Based Augmentation System (SBAS) are used to augment GNSS Data
  - Provide Higher Accuracy and Integrity
  - Correction data for satellite orbit errors, satellite clock errors, atmospheric correction data and satellite health status are broadcasted from satellites
- SBAS Service Providers
  - WAAS, USA (131,133,135,138)
  - MSAS, Japan (129,137)
  - EGNOS, Europe (120,121,123,124,126,136)
  - BDSBAS, China (130,143,144)
  - GAGAN, India (127,128,132)
  - SDCM, Russia (125,140,141)
  - KASS, Korea (134), Also Navigation System
  - AUS-NZ, Australia (122)
  - NSAS, Nigeria, (147)
  - ASAL, Algeria (148)

PRN code numbers are given in the bracket

GPS L1C/A Signal Structure

- Carrier Signal
  - It defines the frequency of the signal
  - For example:
    - GPS L1 is 1575.42MHz, L2 is 1227.60MHz and L5 is 1176.45MHz
- PRN Code
  - Used to identify satellite ID in CDMA
  - Requires to modulate the data
  - Should have good auto-correlation and cross-correlation properties
- Navigation Data
  - Includes satellite orbit related data (ephemeris data)
  - Includes satellite clock related information (clock errors etc)

GPS Signals

Band	Frequency, MHz	Signal Type	Code Length msec	Chip Rate, MHz	Modulation Type	Data / Symbol Rate, bps/sps	Notes
L1	1575.42	C/A	1	1.023	BPSK	50	Legacy Signal
		C_{Data}	10	1.023	BOC(1,1)	50 / 100	From 2014
		C_{Pilot}	10	1.023	TMBOC	No Data	BOC(1,1) & BOC(6,1)
		P(Y)	7 days	10.23	BPSK		Restricted
L2	1227.60	CM	20	0.5115	BPSK	25 / 50	Modulated by TDM of (L2CM xor Data) and L2CL
		CL	1500	0.5115		No Data	
		P(Y)	7days	10.23	BPSK		
L5	1176.45	I	1	10.23	BPSK	50 / 100	Provides Higher Accuracy
		Q	1			No Data	

QZSS Signals and PRN ID

PRN	SVN	Satellite	Launch Date (UTC)	Orbit	Positioning Signals
193	J001	QZS-1	2010/9/11	QZO	L1C/A, L1C, L2C, L5
183					L1S
193					L6
194	J002	QZS-2	2017/6/1	QZO	L1C/A, L1C, L2C, L5
184					L1S
196					L5S
194					L6
199	J003	QZS-3	2017/8/19	GEO	L1C/A, L1C, L2C, L5
189					L1S
197					L5S
137					L1Sb
199					L6
-					Sr/Sf
195	J004	QZS-4	2017/10/9	QZO	L1C/A, L1C, L2C, L5
185					L1S
200					L5S
195					L6

Source: https://qzss.go.jp/technical/satellites/index.html

QZSS Signals and PRN ID

QZS-1R was launched on 2021/10/26. 1R represent replacement for SVN 1.

PRN	SVN	Satellite Name	Launch Date (UTC)	Orbit	Positioning Signals
196	J005	QZS-1R	2021/10/26	QZO	L1C/A, L1C, L2C, L5
186					L1S
186					L5S
196					L6

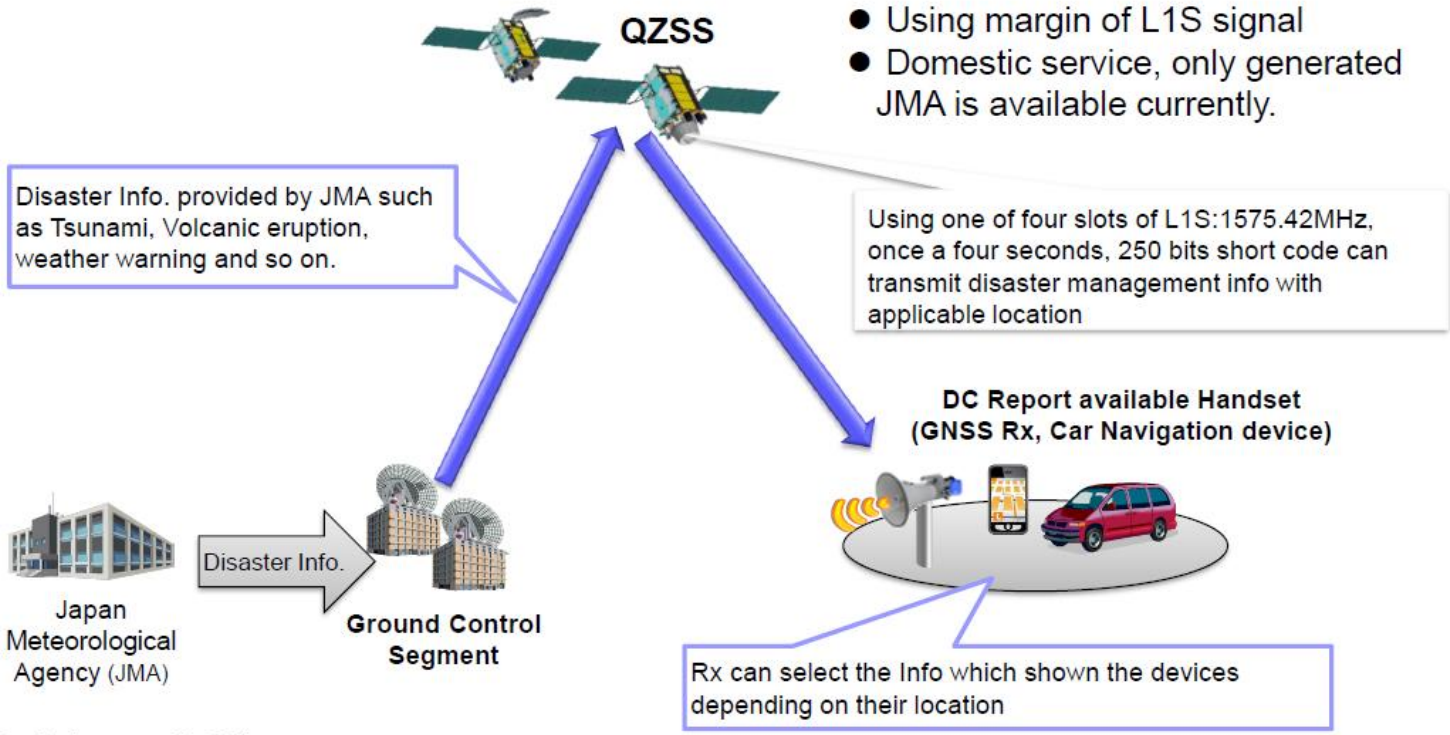
Source: https://qzss.go.jp/technical/satellites/index.html

QZSS EWS

1. QZSS Overview -Current Services-

Messaging Services outline

Satellite Report for Disaster and Crisis Management (DC Report)



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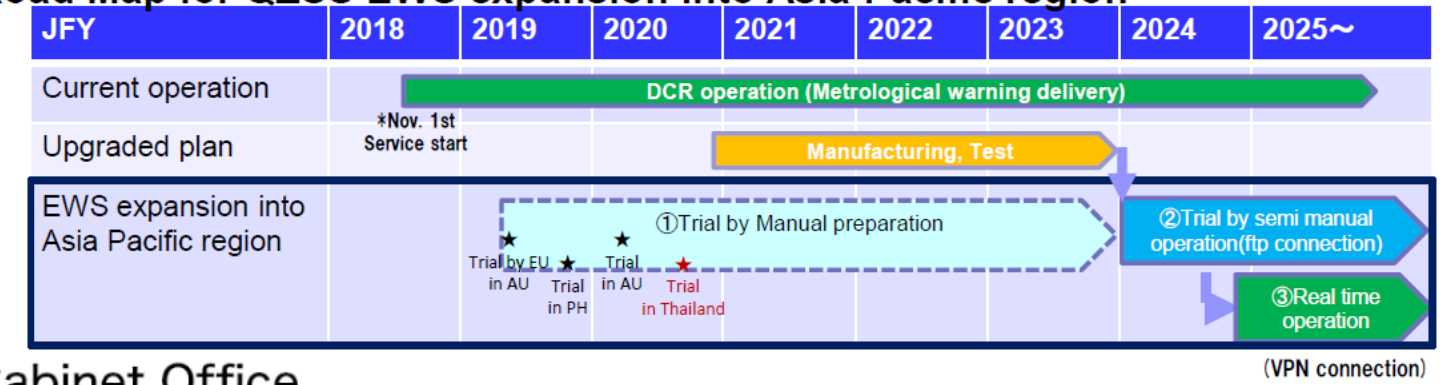
Slide from QZSS Presentation by S. Kogure, UTokyo/ICG GNSS Training, 11 – 14 January 2022

2. QZSS 7SV Constellation Design
Latest Updates -Early Warning Service (EWS)-

- QZSS L1S signal is sharing 250 bps data stream with SLAS and Disaster and Crisis Report service.
- DCR service is currently providing weather information generated by JMA for Japanese domestic users.
- Common EWS format is being investigated in collaboration with EC.
- QZSS ground segment will be upgraded to support EWS in 2024-2025 and distribute EWS once every 4 seconds through QZS-1 to 4 satellites.

Signal	Service Name	Center freq.	Modulation	Bit Rate
L1S	Sub-meter Level Augmentation Service (SLAS)	1575.42MHz	BPSK	250bps
	DC Report Service			

Road Map for QZSS EWS expansion into Asia Pacific region



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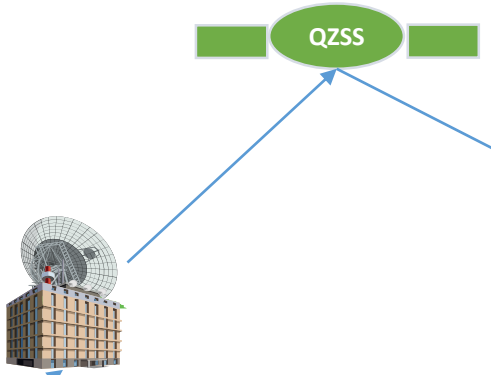
This slide is taken from presentation slides of S. Kogure, Introduction to Michibiki and EWS, presented on 13th July 2021

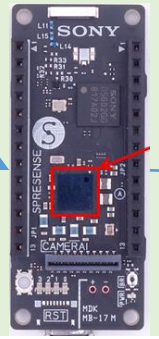
EWS System Architecture



QZSS Control Office
Japan

Send by e-mail

1 **EWS Test Message**
Teams generate sample EWS message
See documents: EWS_Format.pdf
EWS_Message_Example.pdf



SPRESENSE Device

2 Coding
Display EWS
Message

EWS Message
Decoding

GNSS
(Pos. Vel.,Time)

Coding Interface

NB-IoT

WiFi / BLE

3 NB-IoT
WiFi/BT

4

Alarm, Evacuation
Guidance

5

Flashing light

6

Wailing siren

7

Showing message
on signage display

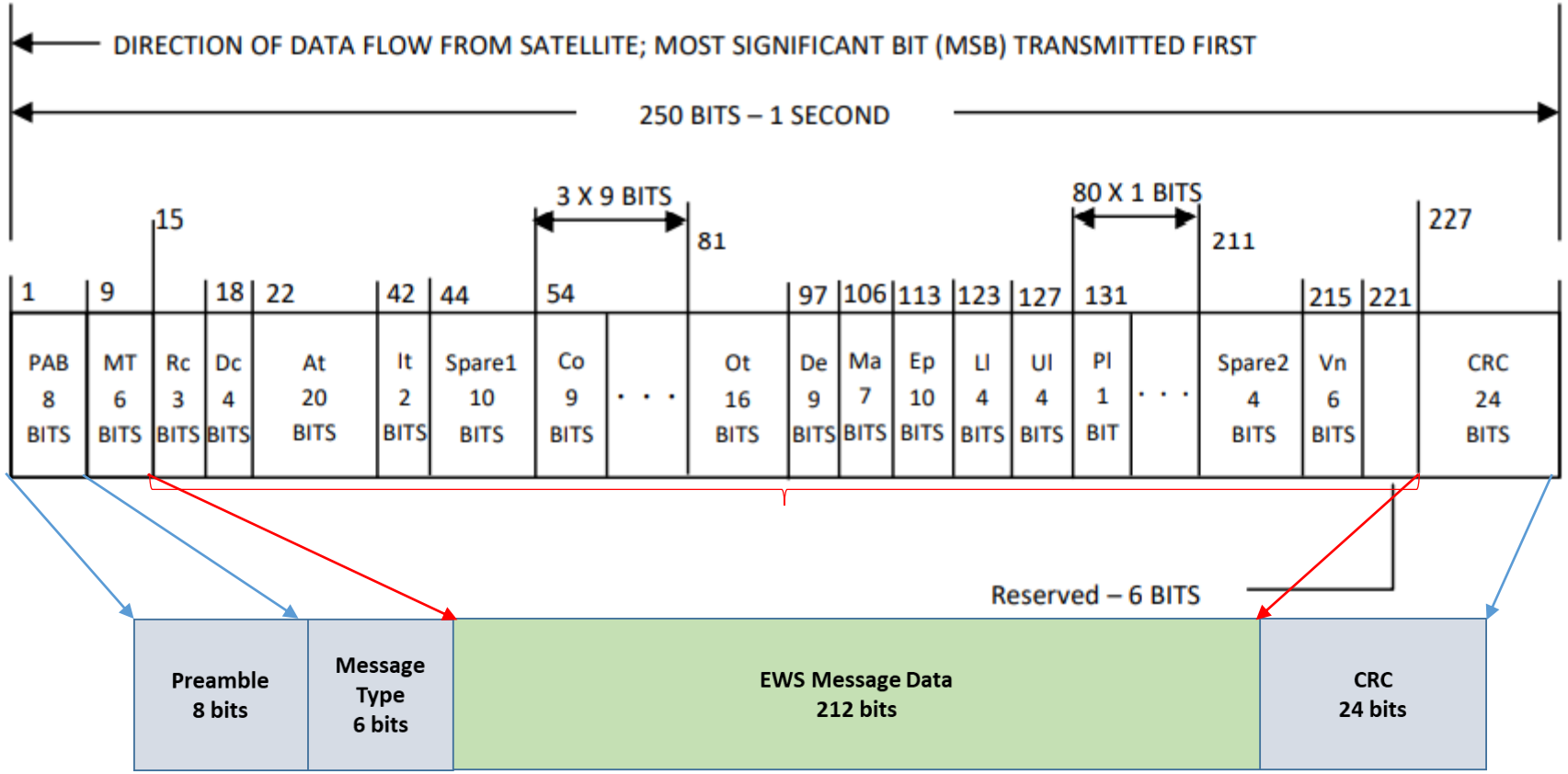
Minimum Requirement as MVP (Minimum Viable Product) for PoC level Prototype:
Item (1) : Generate sample test EWS message
Item (2) : Read EWS message from Spresense device and display in a PC

SBAS / EWS Message Format

EWS Message: Early Warning System Message
DC Report: Disaster Crisis Report, QZSS uses the term DC Report instead of EWS.

Data Rate : 250bps
Symbol Rate : 500sps (1/2 rate FEC)

Earthquake Early Warning Message Format



https://qzss.go.jp/en/technical/ps-is-qzss/is_qzss_dcr_008_agree.html

https://qzss.go.jp/en/technical/ps-is-qzss/ps-is-qzss.html

Earthquake Early Warning Message Format

Table 4.1.2-5 Parameter Definitions (Earthquake Early Warning) (1/2)

Parameter	Description	Effective Range	Number of Bits	LSB	Units
-	PAB and MT See Section 4.1.2.2.	-	-	-	-
Rc	Report Classification 1: Maximum priority 7: Training/Test	1,7	3	-	-
Dc	Disaster Category 1: 防災気象情報(緊急地震速報)	1	4	1	-
At AtMo	Report Time The UTC time when JMA issued the information.	1-12	4	1	month
At AtD		1-31	5	1	day
At AtH		0-23	5	1	hour
At AtMi		0-59	6	1	minute
It	Information Type 0: Issue: 発表 2: Cancellation: 取消	0, 2	2	-	-
Spare1	Spare1 Fix to "0" for spare.	-	10	-	-
Co_1	Notification on Disaster Prevention (Information 1) See Table 4.1.2-6.	0, 101-500	9	1	-
:					
Co_3	Notification on Disaster Prevention (Information 3) See.Table 4.1.2-6.	0, 101-500	9	1	-
Ot D_1	Occurrence Time of Earthquake The UTC time when the earthquake occurred.	1-31	5	1	day
Ot H_1		0-23	5	1	hour
Ot M_1		0-59	6	1	minute
De	Depth of Seismic Epicenter The depth kilometers of hypocenter. It is "501" if the depth is more than 500 km, and "511" if the depth is unknown. It is "10" if Ma is "10".	0-501, 511	9	1	km
Ma	Magnitude 0.1 unit of the magnitude. It is "101" if the magnitude is more than 10.0, and "127" if the magnitude is unknown. It is "10" if JMA issue Earthquake Early Warning by assumptive hypocenter.	1-101, 127	7	0.1	-
Ep	Seismic Epicenter See Table 4.1.2-7.	11-1000	10	-	-

Table 4.1.2-5 Parameter Definitions (Earthquake Early Warning) (2/2)

Parameter	Description	Effective Range	Number of Bits	LSB	Units
Il	Seismic Intensity Lower Limit See Table 4.1.2-8.	1-15	4	-	-
Ul	Seismic Intensity Upper Limit See Table 4.1.2-9.	1-15	4	-	-
Pl_1	Forecast Region_Earthquake Early Warning (Region 1) See Table 4.1.2-10.	0-1	1	-	-
:					
Pl_80	Forecast Region_Earthquake Early Warning (Region 80) See Table 4.1.2-10.	0-1	1	-	-
Spare2	Spare2 Fix to "0" for spare.	-	4	-	-
Vn	Version Number "1" The version number of JMA-DC Report, which is used to judge whether JMA-DC Report can be used or not. JMA-DC Report can be used only if the receiver supports the version showed in this section. JMA-DC Report shall be transmitted in upward compatible. Set a transitional period if upward compatibility is not available.	0-63	6	1	-
Reserved	Reserved	-	6	1	-
-	CRC See Section 4.1.1.3.	-	-	-	-
Display example	防災気象情報(緊急地震速報) 緊急地震速報 Co 発表時刻：AtMo 月 AtD 日 AtH 時 AtMi 分 震央地名：Ep 地震発生時刻：D_1 日 H_1 時 M_1 分 深さ(km)：De マグニチュード：Ma 震度(下限)：Il 震度(上限)：Ul Pl				

DC Report message output from a receiver

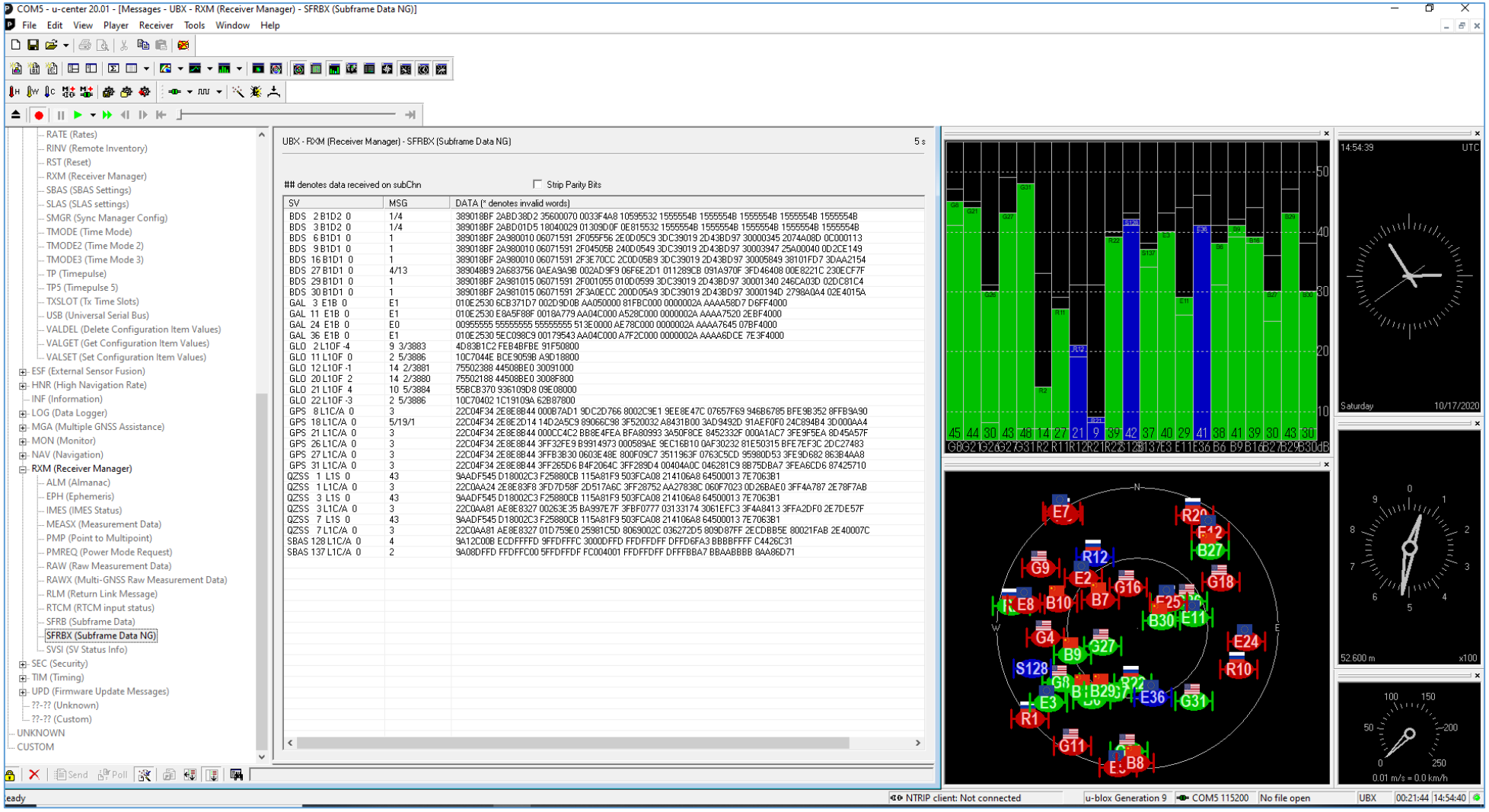
- DC (Disaster Crisis) Report message output format
  - QZSS uses the term “DC” instead of EWS.
  - All output data shall be interpreted as ASCII characters
  - The beginning of the sentence is message header "$QZQSM“
  - Satellite ID is 6 LSB of the 8 bit which represented PRN of the L1S
    - PRN 183 ➔0xB7➔ 10110111_b ➔ 110111_b (Take 6LSBs) ➔ 55_{10}
    - PRN 183 corresponds to 55
  - 250bit DC Report Message are added two binary data "00" at end of a message to make 252 bit data
  - A carriage return code (CR) and a linefeed code (LF) are added at the end of a sentence

GNSS Navigation Data Bits

denotes data received on subChn ☐ Strip Parity Bits

SV	MSG	DATA (* denotes invalid words)
BDS 2 B1D2 0	1/4	389018BF 2ABD38D2 35600070 0033F4A8 10595532 1555554B 1555554B 1555554B 1555554B 1555554B
BDS 3 B1D2 0	1/4	389018BF 2ABD01D5 18040029 01309D0F 0E815532 1555554B 1555554B 1555554B 1555554B 1555554B
BDS 6 B1D1 0	1	389018BF 2A980010 06071591 2F055F56 2E0D05C9 3DC39019 2D43BD97 30000345 2074A08D 0C000113
BDS 9 B1D1 0	1	389018BF 2A980010 06071591 2F04505B 240D0549 3DC39019 2D43BD97 30003947 25A00040 0D2CE149
BDS 16 B1D1 0	1	389018BF 2A980010 06071591 2F3E70CC 2C0D05B9 3DC39019 2D43BD97 30005849 38101FD7 3DAA2154
BDS 27 B1D1 0	4/13	389048B9 2A683756 0AEA9A9B 002AD9F9 06F6E2D1 011289CB 091A970F 3FD46408 00E8221C 230ECF7F
BDS 29 B1D1 0	1	389018BF 2A981015 06071591 2F001055 010D0599 3DC39019 2D43BD97 30001340 246CA03D 02DC81C4
BDS 30 B1D1 0	1	389018BF 2A981015 06071591 2F3A0ECC 200D05A9 3DC39019 2D43BD97 3000194D 2798A0A4 02E4015A
GAL 3 E1B 0	E1	010E2530 6CB371D7 002D9D0B AA050000 81FBC000 0000002A AAAA58D7 D6FF4000
GAL 11 E1B 0	E1	010E2530 E8A5F88F 0018A779 AA04C000 A528C000 0000002A AAAA7520 2EBF4000
GAL 24 E1B 0	E0	00955555 55555555 55555555 513E0000 AE78C000 0000002A AAAA7645 07BF4000
GAL 36 E1B 0	E1	010E2530 5EC098C9 00179543 AA04C000 A7F2C000 0000002A AAAA6DCE 7E3F4000
GLO 2 L1OF -4	9 3/3883	4D83B1C2 FEB4BFBE 91F50800
GLO 11 L1OF 0	2 5/3886	10C7044E BCE9059B A9D18800
GLO 12 L1OF -1	14 2/3881	75502388 44508BE0 30091000
GLO 20 L1OF 2	14 2/3880	75502188 44508BE0 3008F800
GLO 21 L1OF 4	10 5/3884	55BCB370 936109D8 09E08000
GLO 22 L1OF -3	2 5/3886	10C70402 1C19109A 62B87800
GPS 8 L1C/A 0	3	22C04F34 2E8E8B44 000B7AD1 9DC2D766 8002C9E1 9EE8E47C 07657F69 946B6785 BFE9B352 8FFB9A90
GPS 18 L1C/A 0	5/19/1	22C04F34 2E8E2D14 14D2A5C9 89066C98 3F520032 A8431B00 3AD9492D 91AEF0F0 24C894B4 3D000AA4
GPS 21 L1C/A 0	3	22C04F34 2E8E8B44 000CC4C2 BB8E4FEA BFA80993 3A50F8CE 8452332F 000A1AC7 3FE9F5EA 8D45A57F
GPS 26 L1C/A 0	3	22C04F34 2E8E8B44 3FF32FE9 B9914973 000589AE 9EC16B10 0AF30232 81E50315 BFE7EF3C 2DC27483
GPS 27 L1C/A 0	3	22C04F34 2E8E8B44 3FFB3B30 0603E48E 800F09C7 3511963F 0763C5CD 95980D53 3FE9D682 863B4AA8
GPS 31 L1C/A 0	3	22C04F34 2E8E8B44 3FF265D6 B4F2064C 3FF289D4 00404A0C 046281C9 8B75DBA7 3FEA6CD6 87425710
QZSS 1 L1S 0	43	9AADF545 D18002C3 F25880CB 115A81F9 503FCA08 214106A8 64500013 7E7063B1
QZSS 1 L1C/A 0	3	22C0AA24 2E8E83F8 3FD7D58F 2D517A6C 3FF28752 AA27838C 060F7023 0D26BAE0 3FF4A787 2E78F7AB
QZSS 3 L1S 0	43	9AADF545 D18002C3 F25880CB 115A81F9 503FCA08 214106A8 64500013 7E7063B1
QZSS 3 L1C/A 0	3	22C0AA81 AE8E8327 00263E35 BA997E7F 3FBF0777 03133174 3061EFC3 3F4A8413 3FFA2DF0 2E7DE57F
QZSS 7 L1S 0	43	9AADF545 D18002C3 F25880CB 115A81F9 503FCA08 214106A8 64500013 7E7063B1
QZSS 7 L1C/A 0	3	22C0AA81 AE8E8327 01D759E0 25981C5D 8069002C 036272D5 809D87FF 2ECDBB5E 80021FAB 2E40007C
SBAS 128 L1C/A 0	4	9A12C00B ECDFFFFD 9FFDFFFC 3000DFFD FFDFFDFF DFFD6FA3 BBBBFFFF C4426C31
SBAS 137 L1C/A 0	2	9A08DFFD FFDFFC00 5FFDFFDF FC004001 FFDFFDFF DFFFBBA7 BBAABBBB 8AA86D71

U-blox Screen Shot



QZSS Navigation Message Data Bits

SV	MSG		DATA (* denotes invalid words)	
QZSS 1	L1S	0	43	9AADF545 D18002C3 F25880CB 115A81F9 503FCA08 214106A8 64500013 7E7063B1
QZSS 1	L1C/A	0	3	22C0AA24 2E8E83F8 3FD7D58F 2D517A6C 3FF28752 AA27838C 060F7023 0D26BAE0 3FF4A787 2E78F7AB
QZSS 3	L1S	0	43	9AADF545 D18002C3 F25880CB 115A81F9 503FCA08 214106A8 64500013 7E7063B1
QZSS 3	L1C/A	0	3	22C0AA81 AE8E8327 00263E35 BA997E7F 3FBF0777 03133174 3061EFC3 3F4A8413 3FFA2DF0 2E7DE57F
QZSS 7	L1S	0	43	9AADF545 D18002C3 F25880CB 115A81F9 503FCA08 214106A8 64500013 7E7063B1
QZSS 7	L1C/A	0	3	22C0AA81 AE8E8327 01D759E0 25981C5D 8069002C 036272D5 809D87FF 2ECDBB5E 80021FAB 2E40007C

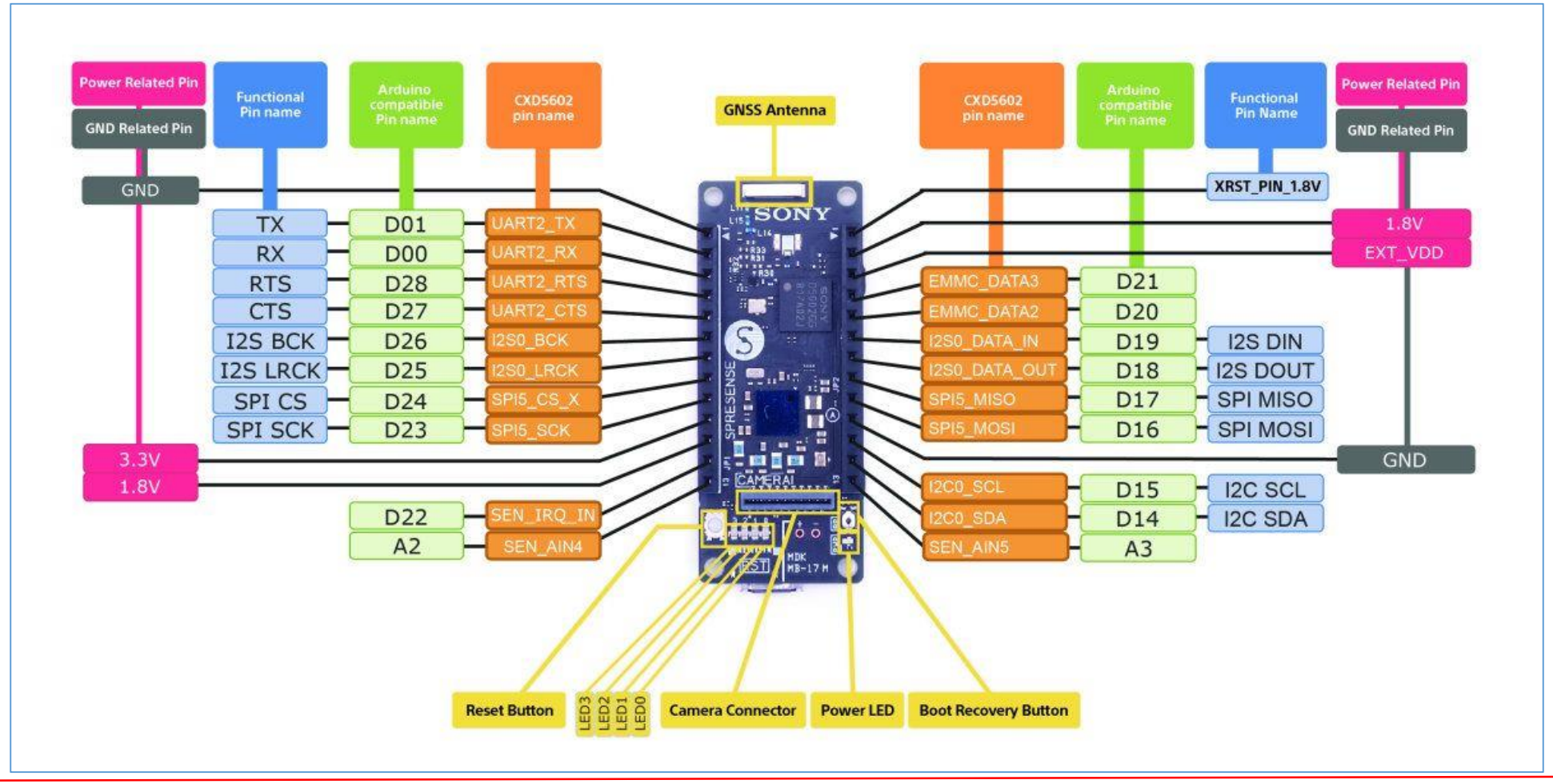
DC Report message output from a receiver

Table 4.3.1-1 Sentence format

Field	Value	Number of character
Message header	$QZQSM	6
Field delimiter	,	1
Satellite ID	55,56,57,61(PRN183,184,185,189)	2
Field delimiter	,	1
DC Report Message		63
Field delimiter	*	1
Checksum		2

Example : $QZQSM, 55, 53AC12345 · · · · · · · 9ABCDEFC*1F

SPRESENSE Main Board



Sample NMEA Output Data from Spresense Device

$QZQSM,56,53ADF6105400050FB4A1F7D4403A880C51022A2711450028A2D00010E28E564*05
$QZDCM,Message Type,14
$GPGGA,072433.00,3554.1824,N,13956.3583,E,2,09,1.2,54.3,M,39.3,M,,*52
$GPGSV,3,1,09,03,09,310,38,12,05,050,37,16,07,235,36,22,11,288,,0*69
$GPGSV,3,2,09,25,37,046,44,26,42,252,45,29,48,089,46,31,59,329,47,0*6B
$GPGSV,3,3,09,32,63,180,51,,,,,,,,,,,,0*55
$GQGSV,2,1,05,56,86,275,48,01,45,189,44,02,86,275,47,03,22,167,40,0*6B
$GQGSV,2,2,05,07,46,201,39,,,,,,,,,,,,0*5D
$GNRMC,072433.00,A,3554.1824,N,13956.3583,E,0.0,22.2,041221,,,D,V*05
$GNVTG,22.2,T,,M,0.0,N,0.0,K,D*24
$GPGGA,072434.00,3554.1824,N,13956.3583,E,2,09,1.2,54.3,M,39.3,M,,*55
$GPGSV,3,1,09,03,09,310,38,12,05,050,37,16,07,235,36,22,11,288,,0*69
$GPGSV,3,2,09,25,37,046,44,26,42,252,45,29,48,089,45,31,59,329,47,0*68
$GPGSV,3,3,09,32,63,180,51,,,,,,,,,,,,0*55
$GQGSV,2,1,05,56,86,275,48,01,45,189,44,02,86,275,46,03,22,167,39,0*64
$GQGSV,2,2,05,07,46,201,38,,,,,,,,,,,,0*5C
$GNRMC,072434.00,A,3554.1824,N,13956.3583,E,0.0,22.2,041221,,,D,V*02
$GNVTG,22.2,T,,M,0.0,N,0.0,K,D*24

Sample NMEA Output Data from Spresense Device

$GPGGA,072436.00,3554.1824,N,13956.3583,E,2,09,1.2,54.3,M,39.3,M,,*57
$GPGSV,3,1,09,03,09,310,38,12,05,050,36,16,07,235,37,22,11,288,,0*69
$GPGSV,3,2,09,25,37,046,43,26,42,252,46,29,48,089,45,31,59,329,46,0*6D
$GPGSV,3,3,09,32,63,180,51,,,,,,,,,,,,0*55
$GQGSV,2,1,05,56,86,275,48,01,45,189,44,02,86,275,46,03,22,167,41,0*6B
$GQGSV,2,2,05,07,46,201,38,,,,,,,,,,,,0*5C
$GNRMC,072436.00,A,3554.1824,N,13956.3583,E,0.0,22.2,041221,,,D,V*00
$GNVTG,22.2,T,,M,0.0,N,0.0,K,D*24
$QZQSM,56,9AADF6104F000283F2507F8A106961F92C406588AD40FF282080000111573F9C*74
$QZDCM,Message Type,14
$GPGGA,072437.00,3554.1824,N,13956.3583,E,2,09,1.2,54.3,M,39.3,M,,*56

Demo:
EWS Message from Spresense Device

If you want to access EWS message from Spresense device, please send request e-mail to me.