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GIOVE-A

NAVIGATION SIGNAL-IN-SPACE

INTERFACE CONTROL DOCUMENT

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TABLE OF CONTENTS

1 INTRODUCTION

1.1 Scope

The GIOVE-A Navigation Signal in Space Interface Control Document provides a description of the Galileo navigation signals transmitted by the GIOVE-A spacecraft in the bands E1, E6, and E5.

These GIOVE-A signals are representative for the future Galileo navigation signals in terms of spreading code chip rates, spreading symbols, spectrum shape, and data rates of the non-PRS signals. Future Galileo signals can be different especially w.r.t. actual spreading codes, navigation message format and detailed content.

1.2 Introduction

Galileo is the European global navigation satellite system, providing a highly accurate, guaranteed global positioning service under civilian control. It is inter-operable with GPS and GLONASS, the two other currently available global satellite navigation systems.
The fully deployed Galileo system consists of 30 satellites (27 operational + 3 spares), positioned in three circular Medium Earth Orbit (MEO) planes at a nominal average orbit semi-major axis of 29601.297 km, and at an inclination of the orbital planes of 56 degrees with reference to the equatorial plane. Once this is achieved, the Galileo navigation signals provide a good coverage even at latitudes up to 75 degrees north and 75 degrees south.

Figure 1 specifies the RF air interface between the space and user segment. Three independently usable signals are permanently transmitted by all Galileo satellites: E5, E6 and E1. The E5 link is further sub-divided into two RF links denoted E5a and E5b.

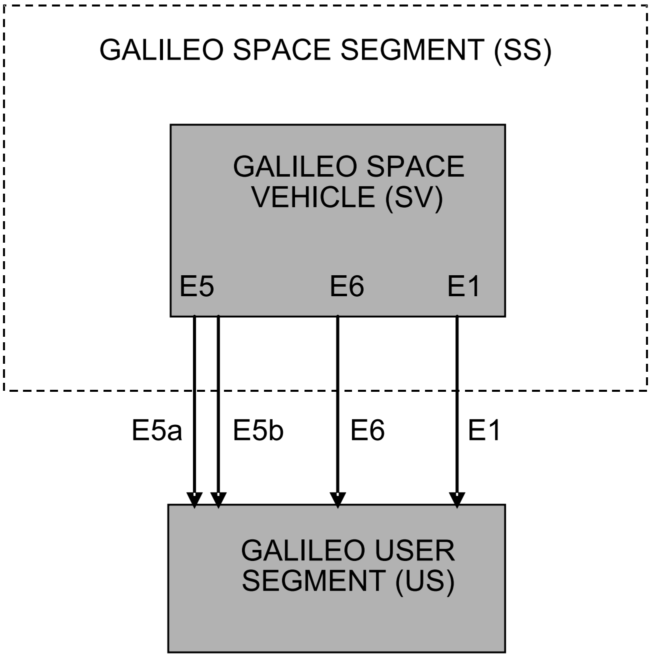

Figure 1: Space Vehicle / Navigation User Interface

The GIOVE-A s/c as part of the GSTB-V2 activity provides signals on two out of the three carriers E5, E6, and E1 of figure 1 at a time, in the combinations E1-E5 or E1-E6. The transmission schedule will be published on the GIOVE web site

http://www.giove.esa.int

together with status and monitoring information.

The nominal GIOVE-A orbit parameters are fitting to the Galileo constellation parameters as shown in table 1 below, except for the semi-major axis of GIOVE-A which is typically approximately 30km above the nominal value.

Table 1: Main Galileo Constellation Parameters

Parameter	**Value**
Constellation parameters	Walker(27,3,1) plus 3 spares
Nominal orbit eccentricity	0
Nominal orbit inclination	56°
Nominal orbit semi-major axis	29600 km

Detailed orbit estimations generated by the GIOVE-A ground segment (GIOVE Processing Center, GPC) will be published on the GIOVE Web site. GIOVE-A TLE information can also be obtained from the Celestrak web site (http://www.celestrak.com/NORAD/elements/galileo.txt).

Wherever possible, definitions and nomenclatures used in this document are following the conventions used in [RD 1] Galileo OS SIS ICD.

2 GENERAL TERMS AND ABBREVIATIONS

2.1 General terms and definitions

2.1.1 Signal definitions

2.1.1.1 Carrier and frequency channel

A frequency channel is the transmission band covered by a navigation signal including all its components and is denoted as [X channel] where X can be equal to E1, E6, E5, E5a, or E5b.

A carrier is the unmodulated centre frequency of a frequency channel and is denoted as [X carrier], where X can equal to E1, E6, E5, E5a, or E5b.

2.1.1.2 Carrier component

A carrier component is the in-phase or quadrature modulation signal of a modulated carrier.

2.1.1.3 [Navigation] signal

A nominally modulated carrier X is denoted as [X navigation signal] or [X signal], with X equal to one of E1, E6, E5, E5a, or E5b.

2.1.1.4 [Navigation] signal component

A [navigation] signal component is one of the spreading sequences modulated onto one common carrier, and is denoted as [X-Y navigation signal component] or [X signal component] with X one of E1, E6, E5, E5a, or E5b, and Y one of I, Q, or A, B, C. The I, Q notation is usually applied if only two signal components are multiplexed onto one carrier.

Each [navigation] signal component has its own spreading code and can carry its own data modulation.

A signal component carrying data modulation can be denoted as [X-Y data channel]. Signal components that do not contain data modulation can be denoted as [X-Y pilot].

2.1.2 Signal modulation definitions

Pulse Shaping [1] $\mathrm{rect}_{Tc}(t)$ is the rectangular chip pulse shaping transmission response, defined as

$$\mathrm{rect}_{T_c}(t) = \begin{cases} 1 \ \text{ for } 0 \le t \le T_c \\ 0 \ \text{ elsewhere} \end{cases}$$

before Tx band limiting.

Table 2: Symbols used within the signal descriptions

Parameter	**Explanation**	**Unit**
f_X	Carrier frequency	Hz
P_X	RF-Signal power of carrier X	W
$L_{X\text{-}Y}$	Ranging code repetition period	chips
$T_{C,X\text{-}Y}$	Ranging code chip duration	s
$T_{S,X\text{-}Y}$	Subcarrier period	s
$T_{D,X\text{-}Y}$	Navigation message symbol duration	s
$R_{C,X\text{-}Y}$	$= 1 / T_{C,X\text{-}Y}$; code chip rate	cps
$R_{S,X\text{-}Y}$	$= 1 / T_{S,X\text{-}Y}$; sub carrier frequency	Hz
$R_{D,X\text{-}Y}$	$= 1 / T_{D,X\text{-}Y}$; navigation message symbol rate	sps
$S_X(t)$	Signal pass-band representation	
$C_{X\text{-}Y}(t)$	Binary (NRZ modulated) ranging code signal	
$D_{X\text{-}Y}(t)$	Binary (NRZ modulated) navigation message signal	
$sc_{X\text{-}Y}(t)$	Binary (NRZ modulated) sub carrier	
$e_{X\text{-}Y}(t)$	Binary NRZ modulated navigation signal component including code, sub-carrier (if applicable) and navigation message data (if applicable).	
$s_X(t)$	Normalized baseband signal ($= s_{X\text{-}I}(t) + j \cdot s_{X\text{-}Q}(t)$) with unit mean power	
$c_{X\text{-}Y,k}$	'k^{th}' Chip of the ranging code	
$d_{X\text{-}Y,k}$	'k^{th}' Symbol of the navigation message	
$DC_{X\text{-}Y}$	$= T_{D,X\text{-}}^{\;Y} / T_{C,X\text{-}}^{\;Y}$, number of code chips per symbol	
$\lvert i \rvert_L$	'i' modulo L	
$\lfloor i \rfloor_{DC}$	Integer part of i/DC	
$rect_T(t)$	Function "rectangle", which is equal to 1 for $0 < t < T$, and equal to 0 elsewhere	

---

[1] Pulse shaping is affected by on-board filtering for meeting out-of-band emissions.

2.2 Abbreviations

AltBOC	Alternative BOC
ARNS	Aeronautical Radio Navigation Service
BOC	Binary Offset Coding (with sine phased sub carrier)
BOCc	Binary Offset Coding with Cosine phased subcarrierCCF Cross Correlation Function
CDMA	Code Division Multiple Access
CL	Correlation Loss
cps	Chips per second
CRC	Cyclic Redundancy Check
FEC	Forward Error Correction
GIOVE	Galileo In-Orbit Verification Experiment
GSTB	Galileo Signal Test Bed
ICD	Interface Control Document
LFSR	Linear Feedback Shift Register
LSB	Least Significant Bit
MSB	Most Significant Bit
OB	On Board (generated data)
OS	Open Service
PGCNT	Page Count Field
RHCP	Right hand circular polarized
RMS	Root Mean Square
RNSS	Radio Navigation Satellite System
S/C	Spacecraft
SAR	Search and Rescue
SNF	Satellite Navigation Field
SOL	Safety Of Life service
sps	Symbols per second
SVID	Space Vehicle Identifier
TOT	Time of transmission
UINT	Unsigned Integer
UL	Uplinked (bentpiped data)

3 REFERENCE DOCUMENTS

[RD 1] Galileo Open Service Signal-in-Space Interface Control Document, GAL OS SIS ICD/D.0, issue Draft 0, 19.05.2006

4 FREQUENCY PLAN

The GIOVE-A frequency plan is identical the original frequency plan presented in [RD 1]. The Galileo Navigation Signals are transmitted in the frequency bands indicated in blue in figure 2. These frequency bands are: the E5a and E5b bands, E6 band and L1 band.

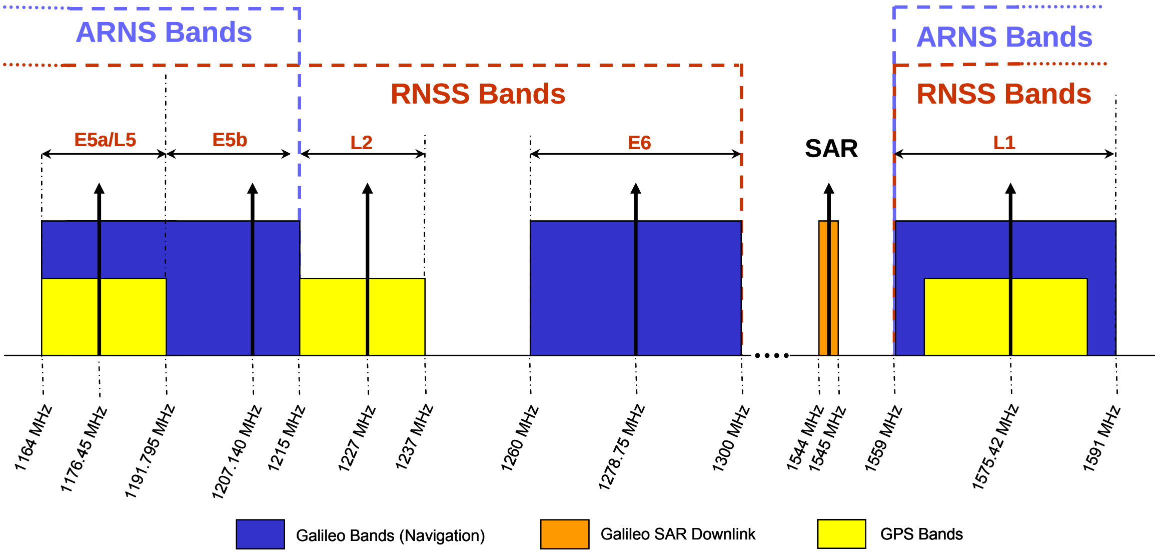

Figure 2: Galileo Frequency Plan

The frequency bands have been selected in the allocated spectrum for Radio Navigation Satellite Services (RNSS) and in addition to that, E5a, E5b and L1 bands are included in the allocated spectrum for Aeronautical Radio Navigation Services (ARNS), employed by Civil-Aviation users, and allowing dedicated safety-critical applications. Galileo carrier frequencies are shown in table 3.

Table 3: Carrier Frequency per Signal

Signal	Carrier Frequency
E5 (E5a+E5b)	1191.795 MHz
E5a	1176.450 MHz
E5b	1207.140 MHz
E6	1278.750 MHz
E1	1575.420 MHz

All GIOVE-A signals are CDMA type spread spectrum signals, being compatible with the set of Galileo navigation signals as described in [RD 1]. The GIOVE-A spread spectrum signals are transmitted including different ranging codes per signal component on each carrier and per carrier frequency.

5 NAVIGATION SIGNALS

5.1 *Transmit polarization and Rx reference bandwidth*

All emitted GIOVE-A navigation signals are RHCP. The Rx reference bandwidths are specified in table 4, and are to be interpreted as minimum Rx bandwidth required to provide the service, covering all signal components of each carrier.

Table 4: GIOVE-A Navigation SIS Rx Reference Bandwidth

Signal	Rx Reference Bandwidth
E5	51.150 MHz
[E5a	20.460 MHz]
[E5b	20.460 MHz]
E6	40.920 MHz
E1	32.736 MHz

The brackets around the entries for E5a and E5b indicate that these signals are part of the E5 signal in its full bandwidth. Tx bandwidth limitation is applied only to the E5 wideband signal in total.

5.2 *GIOVE-A Navigation Signal Parameters*

At each time, GIOVE-A provides signals on two out of the possible carrier frequencies E1, E6, E5. The combination of carriers is subject to the mission planning and will change with time. Possible combinations are E1-E5 and E1-E6.
The nominal emitted signals will follow the definition given in the following chapters. Note that for experimental purposes, transmission of non-nominal modulations not described in this SIS ICD is possible for limited times.

5.2.1 Nominal navigation signals

Table 5: Primary GIOVE-A Navigation Signal Parameters

Signal	Components	Modulation Type	Chip Rate $R_{C,X-Y}$ [Mcps]	Sub Carr. R_{SX-Y} [MHz]	Symbol Rate $R_{D,X-Y}$ [sps]	User min. rec. power level (1)	Power sharing(2)
E5	E5a-I data	AltBOC(15,10)	10.23	15.345	50	-155.0 dBW	21%
	E5a-Q pilot				N/A		21%
	E5b-I data				250		21%
	E5b-Q pilot				N/A		21%
E6	E6-A	BOCc(10,5)	5.115	10.230	100	-153.8 dBW	44%
	E6-B data	BPSK(5)	5.115	n/a	1000		22%
	E6-C pilot				N/A		22%
E1	E1-A	BOCc(15,2.5)	2.5575	15.345	100	-155.7 dBW	44%
	E1-B data	BOC(1,1)	1.023	1.023	250		22%
	E1-C pilot				N/A		22%

(1) User minimum received power level is given for terrestrial users at the output of a (hypothetical) ideally matched and isotropic 0 dBi RHCP receiver antenna with unobstructed line of sight to the source, and excluding propagation effects (multipath, shadowing, atmospheric and ionospheric attenuation). The signal source (spacecraft) is assumed to be above 10° elevation angle of the receiver antenna. The satellite is assumed to transmit the nominal navigation signal-in-space.

(2) Power in percent of the total power of the channel, for the ideal signal before band limiting. The remainder to the full 100% per carrier covers power of eventual inter-modulation products used to approximate constant envelope modulation. Tx and Rx bandwidth limitation will further affect the power ratio between the signal components.

5.2.2 Navigation signals for extended experimentation

All parameters as e.g. user received power that are listed in this document are valid for the nominal navigation SIS configuration described herein. Additional configurations of transmitted signals are possible for experimental purposes. These configurations are not described within this GIOVE-A SIS ICD. If being used, their details can be provided together with the mission planning on the GIOVE website.

5.3 User received power

GIOVE-A minimum received power levels as received at the output of a hypothetic 0 dBic RHCP lossless user antenna, for elevations above 10° and on earth surface, are defined by table 5. Note that these values also assume zero dB losses due to propagation effects.
Maximum received power levels are

E5	Minimum received power (table 5) plus 4.5dB
E6	Minimum received power (table 5) plus 3dB
E1	Minimum received power (table 5) plus 3dB

6 SIGNAL GENERATION SCHEME

In the following sections, modulation expressions are given for the power normalized complex envelope (i.e. base-band version) *s*(*t*) of a modulated (band-pass) signal *S*(*t*). Both are described in terms of its in-phase and quadrature components by the following generic expressions in eq. (1)

$$\begin{aligned} S_X(t) &= \sqrt{2\cdot P_X}\cdot\left[s_{X-I}(t)\cdot\cos(2\pi f_X t) - s_{X-Q}(t)\cdot\sin(2\pi f_X t)\right], \\ s_X(t) &= s_{X-I}(t) + j\cdot s_{X-Q}(t) \end{aligned} \qquad (1)$$

with parameters according to table 2.

6.1 E5 signal

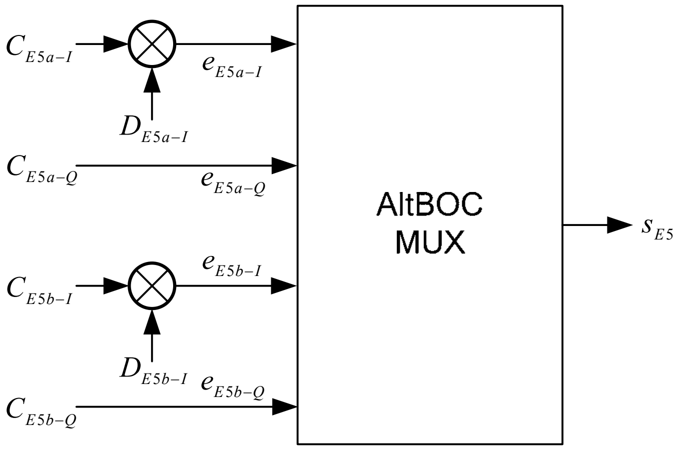

Figure 3: E5 Modulation scheme

The respective definitions are following the definition equation (2) below, using the chip rates and data rates as from table 5:

$$
\begin{aligned}
e_{E5a-I}(t) &= \sum_{i=-\infty}^{+\infty}\left[c_{E5a-I,|i|_{L_{E5a-I}}}\cdot d_{E5a-I,[i]_{DC_{E5a-I}}}\, rect_{T_{C,E5a-I}}\left(t-i\cdot T_{C,E5a-I}\right)\right] \\
e_{E5a-Q}(t) &= \sum_{i=-\infty}^{+\infty}\left[c_{E5a-Q,|i|_{L_{E5a-Q}}}\cdot rect_{T_{c,E5a-Q}}\left(t-i\cdot T_{C,E5a-Q}\right)\right] \\
e_{E5b-I}(t) &= \sum_{i=-\infty}^{+\infty}\left[c_{E5b-I,|i|_{L_{E5b-I}}}\cdot d_{E5b-I,[i]_{DC_{E5b-I}}}\, rect_{T_{C,E5b-I}}\left(t-i\cdot T_{C,E5b-I}\right)\right] \\
e_{E5b-Q}(t) &= \sum_{i=-\infty}^{+\infty}\left[c_{E5b-Q,|i|_{L_{E5b-Q}}}\cdot rect_{T_{C,E5b-Q}}\left(t-i\cdot T_{C,E5b-Q}\right)\right]
\end{aligned}
\tag{2}
$$

The wideband E5 signal is then generated using the AltBOC modulation with side-band sub-carrier rate $R_{S,E5} = 1/T_{S,E5}$ from table 5 according to

$$
\begin{aligned}
s_{E5}(t) = {} & \frac{1}{2\sqrt{2}}\left(e_{E5a-I}(t)+j\,e_{E5a-Q}(t)\right)\left[sc_{E5-S}(t)-j\,sc_{E5-S}\left(t-T_{s,E5}/4\right)\right] \\
& +\frac{1}{2\sqrt{2}}\left(e_{E5b-I}(t)+j\,e_{E5b-Q}(t)\right)\left[sc_{E5-S}(t)+j\,sc_{E5-S}\left(t-T_{s,E5}/4\right)\right] \\
& +\frac{1}{2\sqrt{2}}\left(\bar{e}_{E5a-I}(t)+j\,\bar{e}_{E5a-Q}(t)\right)\left[sc_{E5-P}(t)-j\,sc_{E5-P}\left(t-T_{s,E5}/4\right)\right] \\
& +\frac{1}{2\sqrt{2}}\left(\bar{e}_{E5b-I}(t)+j\,\bar{e}_{E5b-Q}(t)\right)\left[sc_{E5-P}(t)+j\,sc_{E5-P}\left(t-T_{s,E5}/4\right)\right]
\end{aligned}
\quad . \tag{3}
$$

The respective dashed signal components $\bar{e}_{E5a-I}$, $\bar{e}_{E5a-Q}$, $\bar{e}_{E5b-I}$ and $\bar{e}_{E5b-Q}$ are product signals as described in equation (4).

$$
\begin{aligned}
\bar{e}_{E5a-I} &= e_{E5a-Q}\, e_{E5b-I}\, e_{E5b-Q} & \qquad \bar{e}_{E5b-I} &= e_{E5b-Q}\, e_{E5a-I}\, e_{E5a-Q} \\
\bar{e}_{E5a-Q} &= e_{E5a-I}\, e_{E5b-I}\, e_{E5b-Q} & \qquad \bar{e}_{E5b-Q} &= e_{E5b-I}\, e_{E5a-I}\, e_{E5a-Q}
\end{aligned}
\tag{4}
$$

The parameters $sc_{E5\text{-}S}$ and $sc_{E5\text{-}P}$ represent the four valued sub-carrier functions for the single signals and the product signals respectively,

$$sc_{E5-S}(t) = \sum_{i=-\infty}^{\infty} AS_{|i|_8} \cdot rect_{T_{S,E5}/8}\left(t - i\frac{T_{s,E5}}{8}\right)$$

and (5)

$$sc_{E5-P}(t) = \sum_{i=-\infty}^{\infty} AP_{|i|_8} \cdot rect_{T_{S,E5}/8}\left(t - i\frac{T_{s,E5}}{8}\right)$$

with the coefficients AS_i and AP_i according to table 6 below.

Table 6: AltBOC subcarrier coefficients

i	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
$2\ AS_i$	$\sqrt{2}+1$	1	-1	$-\sqrt{2}-1$	$-\sqrt{2}-1$	-1	1	$\sqrt{2}+1$
$2\ AP_i$	$-\sqrt{2}+1$	1	-1	$\sqrt{2}-1$	$\sqrt{2}-1$	-1	1	$-\sqrt{2}+1$

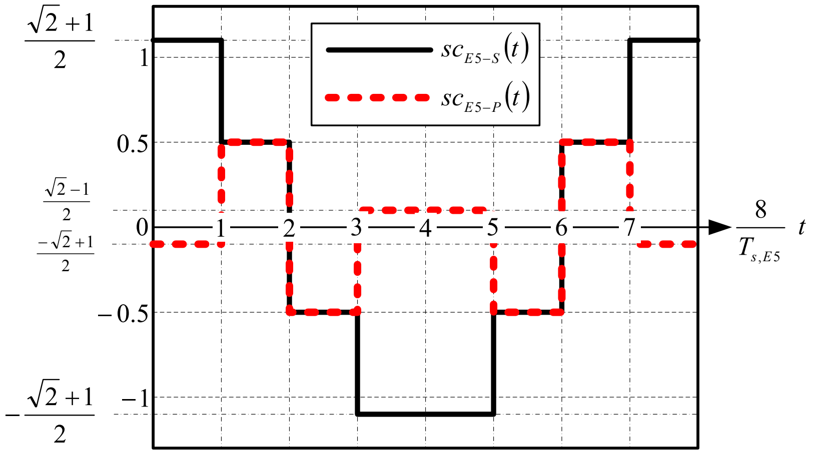

Figure 4: One period of the two AltBOC sub carrier functions $sc_{E5\text{-}S}$ and $sc_{E5\text{-}P}$

The relative power of the product-signals within the unfiltered base-band signal $s_{E5}(t)$ is

$$\left[\left(\sqrt{2}-1\right)^2+1\right]\Big/8 \approx 15\%$$

Equivalently, the AltBOC complex baseband signal $s_{E5}(t)$ can be described as an 8-PSK signal,

$$s_{E5}(t) = \exp\left(j\frac{\pi}{4}k(t)\right) \quad \text{with} \quad k(t) \in \{1,2,3,4,5,6,7,8\} \qquad \textbf{(6)}$$

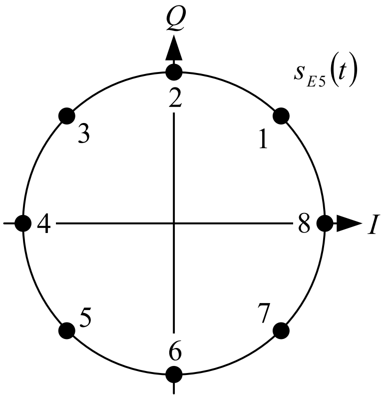

Figure 5: 8-PSK phase-state diagram of E5 AltBOC signal

The relation of the 8 phase states to the 16 different possible states for the quadruple $e_{E5a\text{-}I}(t)$, $e_{E5a\text{-}Q}(t)$, $e_{E5b\text{-}I}(t)$, and $e_{E5b\text{-}Q}(t)$ depends also on time. Therefore, time is partitioned first in sub-carrier intervals $T_{s,E5}$ and further sub-divided in 8 equal sub-periods. The index i_{Ts} of the actual sub-period is defined as

$$i_{Ts} = \text{integer part}\left[\frac{8}{T_{s,E5}} \cdot \left(t \;\text{ modulo }\; T_{s,E5}\right)\right] \quad \textit{with} \quad i_{Ts} \in \{\,0,1,2,3,4,5,6,7\,\} \tag{7}$$

and determines which relation between input quadruple and phase states has to be used. The dependency of phase-states from input-quadruples and time is shown in table 7 below.

Table 7: Look-up table for AltBOC phase states as function of input quadruples and time

		Input Quadruples															
$e_E5_{a\text{-}I}$		-1	-1	-1	-1	-1	-1	-1	-1	1	1	1	1	1	1	1	1
$e_E5_{b\text{-}I}$		-1	-1	-1	-1	1	1	1	1	-1	-1	-1	-1	1	1	1	1
$e_E5_{a\text{-}Q}$		-1	-1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1	1
$e_E5_{b\text{-}Q}$		-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1
$t' = t$ modulo $T_{s,E}5$		k (according to $s_{E5}(t) = \exp(jk\pi/4)$)															
i_{Ts}	t'																
0	$[0, T_{s,E}5/8[$	5	4	4	3	6	3	1	2	6	5	7	2	7	8	8	1
1	$[T_{s,E}5/8, 2\cdot Ts_{,E}5/8[$	5	4	8	3	2	3	1	2	6	5	7	6	7	4	8	1
2	$[2\cdot T_{s,E}5/8, 3\cdot T_{s,E}5/8[$	1	4	8	7	2	3	1	2	6	5	7	6	3	4	8	5
3	$[3\cdot T_{s,E}5/8, 4\cdot T_{s,E}5/8[$	1	8	8	7	2	3	1	6	2	5	7	6	3	4	4	5
4	$[4\cdot T_{s,E}5/8, 5\cdot T_{s,E}5/8[$	1	8	8	7	2	7	5	6	2	1	3	6	3	4	4	5
5	$[5\cdot T_{s,E}5/8, 6\cdot T_{s,E}5/8[$	1	8	4	7	6	7	5	6	2	1	3	2	3	8	4	5
6	$[6\cdot T_{s,E}5/8, 7\cdot T_{s,E}5/8[$	5	8	4	3	6	7	5	6	2	1	3	2	7	8	4	1
7	$[7\cdot T_{s,E}5/8, T_{s,E}5\ [$	5	4	4	3	6	7	5	2	6	1	3	2	7	8	8	1

6.2 E6 Signal

The E6 signal is generated from the $D_{E6\text{-}A}$ and $D_{E6\text{-}B}$ navigation data streams and the $C_{E6\text{-}A}$, $C_{E6\text{-}B}$, and $C_{E6\text{-}C}$ ranging code signals, to form the baseband signal s_{E6} which is then modulated onto the E6 carrier. The modulation parameters are to be found in table 5.

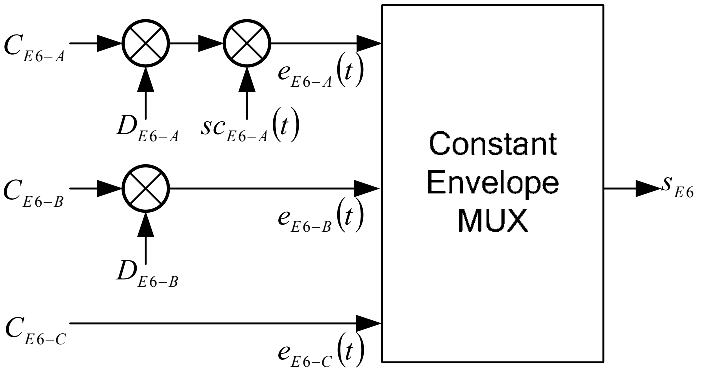

Figure 6: E6 Modulation Scheme

The mathematical description using the symbols as defined in table 2 can be written as

$$s_{E6}(t) = \frac{1}{3}\left(\sqrt{2}\left(e_{E6-B}(t) - e_{E6-C}(t)\right) + j\left(2\, e_{E6-A}(t) + IM_{E6}(t)\right) \right) \tag{8}$$

$$\begin{aligned}
e_{E6-A}(t) &= \sum_{i=-\infty}^{+\infty} c_{E6-A,|i|_{L_{E6-A}}} \, d_{E6-A,[i]_{DC_{E6-A}}} \, rect_{T_{C,E6-A}}\left(t - i\,T_{C,E6-A}\right) \operatorname{sign}\left(\cos\left(2\pi\, R_{s,E6-A}\, t\right)\right) \\
e_{E6-B}(t) &= \sum_{i=-\infty}^{+\infty} c_{E6-B,|i|_{L_{E6-B}}} \, d_{E6-B,[i]_{DC_{E6-B}}} \, rect_{T_{C,E6-B}}\left(t - i\,T_{C,E6-B}\right) \\
e_{E6-C}(t) &= \sum_{i=-\infty}^{+\infty} c_{E6-C,|i|_{L_{E6-C}}} \, rect_{T_{C,E6-C}}\left(t - i\,T_{C,E6-C}\right)
\end{aligned} \tag{9}$$

The inter-modulation product $IM_{E6}(t)$ is generated on board and is used to approximate constant envelope modulation of the signal before HPA. Before transmit bandwidth limitation, typically about 11% of the total transmit power of the E6 modulated carrier belong to $IM_{E6}(t)$.

6.3 E1 Signal

The generation of the E1 baseband signal $s_{E1}(t)$ uses the same principle as the E6 signal generation. Table 5 provides the parameters required for the signal generation.

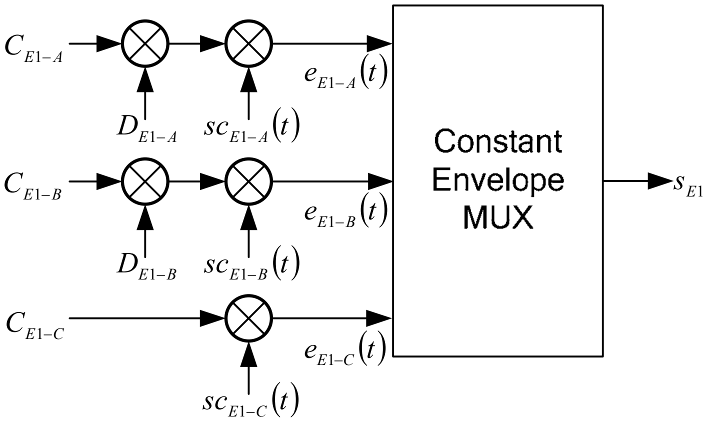

Figure 7: E1 Modulation Scheme

The complementing mathematical description using the symbol notation as defined in table 2 is as below:

$$s_{E1}(t) = \frac{1}{3}\left(\sqrt{2}\left(e_{E1-B}(t) - e_{E1-C}(t)\right) + j\left(2\, e_{E1-A}(t) + IM_{E1}(t)\right) \right) \tag{10}$$

$$\begin{aligned}
e_{E1-A}(t) &= \sum_{i=-\infty}^{+\infty} c_{E1-A,|i|_{L_{E1-A}}}\, d_{E1-A,[i]_{DC_{E1-A}}}\, rect_{T_{C,E1-A}}\left(t - i\,T_{C,E1-A}\right)\operatorname{sign}\left(\cos\left(2\pi\, R_{s,E1-A}\, t\right)\right) \\
e_{E1-B}(t) &= \sum_{i=-\infty}^{+\infty} c_{E1-B,|i|_{L_{E1-B}}}\, d_{E1-B,[i]_{DC_{E1-B}}}\, rect_{T_{C,E1-B}}\left(t - i\,T_{C,E1-B}\right)\operatorname{sign}\left(\sin\left(2\pi\, R_{s,E1-B}\, t\right)\right) \\
e_{E1-C}(t) &= \sum_{i=-\infty}^{+\infty} c_{E1-C,|i|_{L_{E1-C}}}\, rect_{T_{C,E1-C}}\left(t - i\,T_{C,E1-C}\right)\operatorname{sign}\left(\sin\left(2\pi\, R_{s,E1-C}\, t\right)\right)
\end{aligned} \qquad (11)$$

The inter-modulation product $IM_{E1}(t)$ is generated on board and is used to approximate constant envelope modulation of the signal before HPA. Before transmit bandwidth limitation, typically about 11% of the total transmit power of the E1 modulated carrier belong to $IM_{E1}(t)$.

7 SPREADING CODE CHARACTERISTICS

GIOVE-A spreading codes consist of a primary spreading sequence (primary code) and a secondary code used for pilots and for signals with low data rate. The secondary code is used to modulate the primary code like a deterministic data modulation, to generate a total code length that is multiple of the primary code length.

Primary spreading codes are generated as truncated combined M-sequences that can be implemented using linear feedback shift register (LFSR) techniques. Secondary codes are short memory stored pseudo random sequences.

7.1 Code length

Table 8: Spreading code lengths

Signal Component	**Full Tiered Code period (ms)**	**Code length (chips)**	
		Primary	**Secondary**
E5a-I	20	10230	20
E5a-Q	100	10230	100
E5b-I	4	10230	4
E5b-Q	100	10230	100
E6-A	10	51150	1
E6-B	1	5115	1
E6-C	100	10230	50
E1-A	10	25575	1
E1-B	4	4092	1
E1-C	200	8184(*)	25

(*) The primary code of the E1-C pilot has twice the length of the primary code on E1-B. The chip rate of the secondary code of the E1-C pilot channel is half of the symbol rate of the E1-B data channel.

7.2 Spreading code generation

When considering a primary code with length N chips and an associated secondary code with length N_S chips, then the resulting combined (Tiered) code will follow the description in figure 8 below.

Code generation for all signal components:

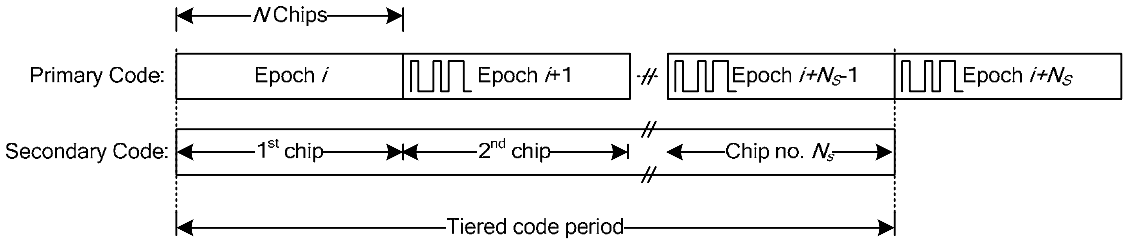

Figure 8: Code construction principle and synchronization

Primary codes, secondary codes are combined by using exclusive-or logic. If applicable, data modulation is applied to the full code again using the exclusive-or combination of code and data symbol(s).

7.3 Primary code parameters and assignment of secondary codes

GIOVE-A primary codes are generated using LFSR pairs. The LFSR parameters are shown in table 9, together with the reference to the secondary code (see table 10). The primary code generation process starts with the register initialization values specified in table 9. After generation of the required number of chips (see table 8), the registers are reset to the initialization value and the generation is restarted.

Table 9: Primary code parameters and assigned secondary codes (see table 8 for code lengths)

Signal Component	Register spec (octal)	Register Spec (Feedback Taps)	Register Length R	Register initialization values (octal)	Secondary code
E5a-I					CS20b
Base register 1	40503o	[1,6,8,14]	14	All cells logical 1	
Base register 2	50661o	[4,5,7,8,12,14]	14	35277o	
E5a-Q					CS100b
Base register 1	40503o	[1,6,8,14]	14	All cells logical 1	
Base register 2	50661o	[4,5,7,8,12,14]	14	15452o	
E5b-I					CS4a
Base register 1	64021o	[4,11,13,14]	14	All cells logical 1	
Base register 2	51445o	[2,5,8,9,12,14]	14	34242o	
E5b-Q					CS100d
Base register 1	64021o	[4,11,13,14]	14	All cells logical 1	
Base register 2	51445o	[2,5,8,9,12,14]	14	30004o	
E6-A					-
Base register 1	200000011o	[3,25]	25	All cells logical 1	
Base register 2	200005535o	[2,3,4,6,8,9,11,25]	25	100000000o	
E6-B					-
Base register 1	22441o	[5,8,10,13]	13	All cells logical 1	
Base register 2	34003o	[1,11,12,13]	13	5340o	
E6-C					CS50a
Base register 1	44103o	[1,6,11,14]	14	All cells logical 1	
Base register 2	40635o	[2,3,4,7,8,14]	14	15035o	
E1-A					-
Base register 1	204000051o	[3,5,20,25]	25	All cells logical 1	
Base register 2	204204057o	[1,2,3,5,11,16,20,25]	25	100000000o	

Signal Component	Register spec (octal)	Register Spec (Feedback Taps)	Register Length R	Register initialization values (octal)	Secondary code
E1-B					-
Base register 1	23261o	[4,5,7,9,10,13]	13	All cells logical 1	
Base register 2	30741o	[5,6,7,8,12,13]	13	15603o	
E1-C					CS_{25a}
Base register 1	20033o	[1,3,4,13]	13	All cells logical 1	
Base register 2	23261o	[4,5,7,9,10,13]	13	14603o	

The interpretation of the octal notation is explained in figure 9.

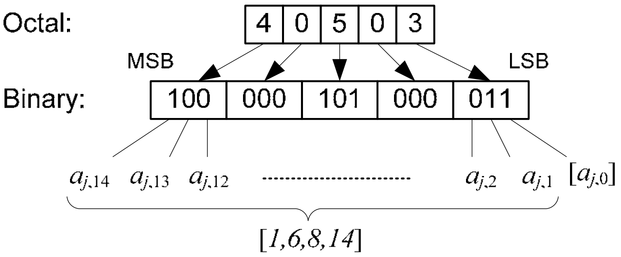

Figure 9: Octal notation example

An example implementation to generate the LSFR codes could use the structure shown in figure 10 with the coefficients determined according to figure 9.

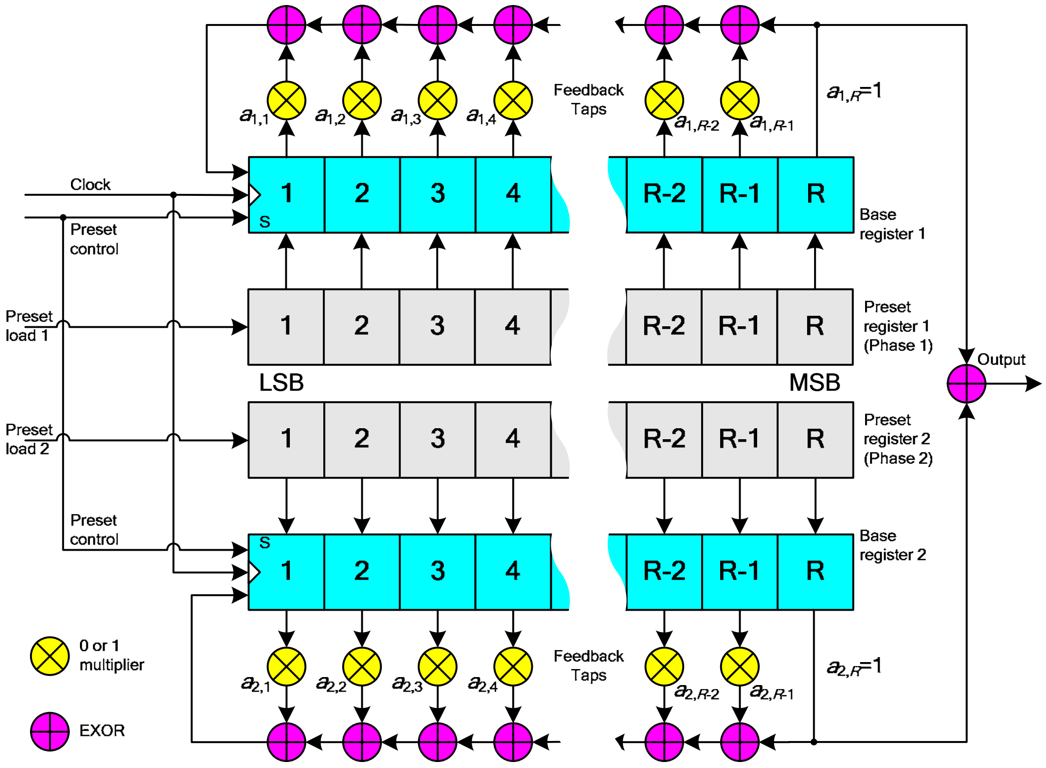

Figure 10: Primary Ranging Code Generation Topology

7.4 Secondary Codes

Secondary codes are implemented as memory codes. Table 10 lists them in octal notation, starting from left with the MSB which is transmitted first.

Table 10: Secondary Codes

Identifier	Code Length	Sequence [octal]
CS4a	4	16o
CS20b	20	2 041 351o
CS25a	25	34 012 662o
CS50a	50	31 353 022 416 630 457o
CS100b	100	1 736 526 276 160 463 054 356 046 605 322 257o
CS100d	100	1 017 667 551 661 733 412 501 077 343 115 434o

8 NAVIGATION MESSAGE

8.1 *Navigation Message Validity Signature*

During payload, satellite or system startup, until valid navigation data is available the navigation message data is “empty”, that is, it does not contain information useable for positioning. This “empty” default value can be identified by verifying two indicators:

- Check the satellite health (chapter 8.3.7) for invalidity of the navigation message.
- Check the value of the ephemeris (chapter 8.3.5) square root semimajor axis $(A)^{1/2}$ to be equal to zero.

If at least one of these two parameters is indicating an invalid message, the message will consist of test data and is not to be used for positioning.

8.2 *Navigation Message Structure and Protection*

8.2.1 Navigation Message Data Page Format

The Navigation Message Data Page Format forms a packet structure. It includes as a minimum:

- Navigation Message Data Page Sync Field (SYNC)
- Navigation Message Data Page Count Field (PGCNT)
- Satellite Navigation Field (SNF)
- Navigation Message Data (NAVDATA) basically consisting of Sub-Fields (dependant on Service):
  - Satellite Data
  - Constellation Data
- Navigation Message Data Page CRC Field (CRC)
- Navigation Message Data Page Tail Field (TAIL)

Note: GIOVE-A does not provide the following types of data: integrity data, Search&Rescue data.

Figure 11 summarizes the overall format of a Navigation Message Data Page.

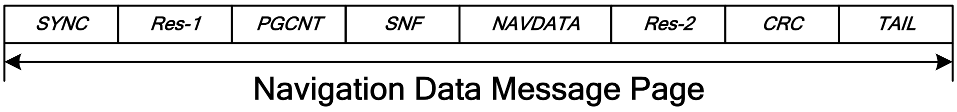

Figure 11: Navigation Message Data Page Structure

8.2.1.1 Navigation Message Data Page Sync Field (SYNC)

Each Navigation Message Data Page commences with a fixed “Sync Word” synchronization pattern.

Table 11: Navigation Message Page Sync field

Signal	Sub Signal	Length *L_SYNC* [No. of bits]	Pattern
E5a	I	12	101101110000
	Q	N/A	N/A
E5b	I	10	0101100000
	Q	N/A	N/A
E6	A	10	0101100000
	B	16	1011011101110000
	C	N/A	N/A
E1	A	10	0101100000
	B	10	0101100000
	C	N/A	N/A

8.2.1.2 Reserved fields (Res-1 and Res-2)

This field is reserved (present but not for use) within the GIOVE-A Navigation Message Page.

Table 12: Reserved fields

Signal	Sub signal	Length of Res-1 *L_RES1* [No. of bits]	Length of Res-2 *L_RES2* [No. of bits]	Format
E5a	I	N/A	N/A	N/A
	Q	N/A	N/A	N/A
E5b	I	1	24	Reserved
	Q	N/A	N/A	N/A
E6	A	1	24	Reserved
	B	N/A	N/A	N/A
	C	N/A	N/A	N/A
E1	A	1	24	Reserved
	B	1	24	Reserved
	C	N/A	N/A	N/A

8.2.1.3 Navigation Message Data Page Count Field (PGCNT)

Each Navigation Message Data Page includes a Navigation Message Data Framing Field with the following format:

Table 13: Page count field

Signal	Sub signal	Length *L_PGCNT* [No. of bits]	Format
E5a	I	6	Page No. within Stream, UINT
	Q	N/A	N/A
E5b	I	10	Page No. within Stream, UINT
	Q	N/A	N/A
E6	A	10	Page No. within Stream, UINT
	B	7	Page No. within Stream, UINT
	C	N/A	N/A
E2L1E1	A	10	Page No. within Stream, UINT
	B	10	Page No. within Stream, UINT
	C	N/A	N/A

UINT = Unsigned Integer

The page count *PGCNT* is reset to one at the first page of each frame, then incremented by one for each following page.

8.2.1.4 Satellite Navigation Field (SNF)

Each Navigation Message Data Page includes a Satellite Navigation Field with the following format:

Table 14: SNF field

Signal	Sub signal	Length *L_SNF* [No. of bits]	Format
E5a	I	3	UINT
	Q	N/A	N/A
E5b	I	3	UINT
	Q	N/A	N/A
E6	A	3	UINT
	B	3	UINT
	C	N/A	N/A
E1	A	3	UINT
	B	3	UINT
	C	N/A	N/A

UINT = Unsigned Integer.
The SNF is generated as described in chapter 8.3.6.2.

8.2.1.5 Navigation Message Data Packet (NAVDATA)

Each Navigation Message Data Page contains Navigation Message Data with the following format:

Table 15: Navigation Message Data

Signal	Sub signal	Length *L_NAV* [No. of bits]	Format
E5a	I	217	See section 8.3
	Q	N/A	N/A
E5b	I	64	See section 8.3
	Q	N/A	N/A
E6	A	64	See section 8.3
	B	464	See section 8.3
	C	N/A	N/A
E1	A	64	See section 8.3
	B	64	See section 8.3
	C	N/A	N/A

with

$$L\_NAV = (L\_INTER/2) - (L\_RES1 + L\_PGCNT + L\_SNF + L\_RES2 + L\_CRC + L\_TAIL)$$

8.2.1.6 Navigation Message Data Page CRC Field (CRC)

Each Navigation Message Data Page includes a Cyclic Redundancy Check derived from all other page data **except SYNC and TAIL**.

Table 16: CRC Parameters

Signal	Sub signal	Length *L_CRC* [No. of bits]
E5a	I	12
	Q	N/A
E5b	I	12
	Q	N/A
E6	A	12
	B	12
	C	N/A
E1	A	12
	B	12
	C	N/A

CRC computation is defined in chapter 8.2.2.1.

8.2.1.7 Navigation Message Data Page Tail Field (TAIL)

Each Navigation Message Data Page is completed, after CRC is applied and before FEC encoding, with 6 zero-valued tail bits. The transmitted FEC encoded symbol stream contains the symbols generated for these tail bits, to allow the FEC decoder of the receiver to completely decode the useful page content.

8.2.2 Navigation Message Page Error Protection

8.2.2.1 Navigation Message Data Page Cyclic Redundancy Check

The CRC is calculated according to the following generator polynomial:

12 bit CRC: $P(X) = 1 + X + X^2 + X^3 + X^5 + X^7 + X^{11} + X^{12}$ or

$$P(X) = (1 + X) \cdot (1 + X^2 + X^5 + X^6 + X^{11}) \text{ (Factors decomposition)}$$

8.2.2.2 Navigation Message Data Page Convolutional Encoding

Each Navigation Message Data Page includes Forward Error Correction (FEC) in form of Convolutional Encoding applied to all page data **except SYNC**. The Navigation Message Data Page Convolutional Encoding is generated in accordance to the following table:

Table 17: FEC Parameters

Code Parameter	Value
Coding Rate	1/2
Coding Scheme	Convolution
Constraint Length	7
Generator Polynomials	$G_1 = 171$ (octal), $G_2 = 133$ (octal)
Encoding Sequence	*G*1, *G*2

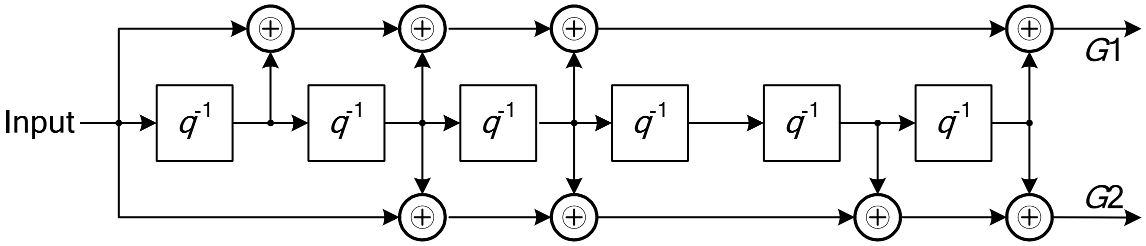

Figure 12: Convolutional Encoding Scheme

The Navigation Message Data Page Convolutional Encoding is reset (register values in figure 12 initialized to zero before clocking in the first data bit) at the start of every page.

8.2.2.3 Navigation Message Data Page Interleaving

Each Navigation Message Data Page includes Page Interleaving following FEC, and applied to all page symbols **except SYNC**. The Navigation Message Data Page Interleaving uses page sizes of [***n·k***] bits, where a (***n·k***) Block Interleaver takes (***n·k***) symbols and fills a matrix having ***k*** rows and ***n*** columns column by column and symbols are then transmitted row by row:

Table 18: Block Interleaving Scheme

Signal	Sub signal	No. of Columns N	No. of Rows k	Block Interleave Length L_INTER [No. of symbols]
E5a	I	61	8	488
	Q	N/A	N/A	N/A
E5b	I	30	8	240
	Q	N/A	N/A	N/A
E6	A	30	8	240
	B	123	8	984
	C	N/A	N/A	N/A
E1	A	30	8	240
	B	30	8	240
	C	N/A	N/A	N/A

8.2.2.4 Navigation Message Data Page Timing

Each Navigation Message Data Page has the following transmission periods *T_PG* and lengths *L_PG*:

Table 19: Navigation Message Data Page Period

Signal	Sub signal	Period *T_PG* (s)	Length *L_PG* [No. of symb]
E5a	I	10	500
	Q	N/A	N/A
E5b	I	1	250
	Q	N/A	N/A

Signal	Sub signal	Period *T_PG* (s)	Length *L_PG* [No. of symb]
E6	A	2.5	250
	B	1	1,000
	C	N/A	N/A
E1	A	2.5	250
	B	1	250
	C	N/A	N/A

Each Navigation Message Data Page is aligned to the 1 PPS epoch as shown in figure 13.

8.2.3 Navigation Message Data Sub-frame Format

8.2.3.1 Sub-frame Format and Timing

Each Navigation Message Sub-frame consists of *N_PGinSF* Navigation Message Data Pages:

Table 20: Message Sub-frame Format and Timing

Signal	Sub signal	No. of Pages *N_PGinSF*	Period *T_SF* (s)	Length *L_SF* [No. of symb]
E5a	I	5	50	2,500
	Q	N/A	N/A	N/A
E5b	I	25	25	6,250
	Q	N/A	N/A	N/A
E6	A	10	25	2,500
	B	15	15	15,000
	C	N/A	N/A	N/A
E1	A	10	25	2,500
	B	25	25	6,250
	C	N/A	N/A	N/A

with

- Transmission Period $T\_SF = T\_PG \cdot N\_PGinSF$
- Transmission Lengths $L\_SF = L\_PG \cdot N\_PGinSF$

Each Navigation Message sub-frame is aligned to the 1 PPS epoch.

8.2.4 Navigation Message Data Stream Format

8.2.4.1 Navigation Message Data Frame Format and Timing

Each Navigation Message Data Frame consists of N_BL Navigation Message Sub-frames:

Table 21: Navigation Message Data Frame Format and Timing

Signal	Sub signal	No. of Sub-frames *N_SFinFR*	No. of Pages *N_PGinFR*	Period *T_FR* (s)	Length *L_FR* [No. of symb]
E5a	I	12	60	600	30,000
	Q	N/A	N/A	N/A	N/A
E5b	I	24	600	600	150,000
	Q	N/A	N/A	N/A	N/A

Signal	Sub signal	No. of Sub-frames *N_SFinFR*	No. of Pages *N_PGinFR*	Period *T_FR* (s)	Length *L_FR* [No. of symb]
E6	A	24	240	600	60,000
	B	8	120	120	120,000
	C	N/A	N/A	N/A	N/A
E1	A	24	240	600	60,000
	B	24	600	600	150,000
	C	N/A	N/A	N/A	N/A

with

- Transmission Period $T\_FR = T\_SF \cdot N\_SFinFR$
- Transmission Length $L\_FR = L\_SF \cdot N\_SFinFR$
- Pages per frame $N\_PGinFR = N\_PGinSF \cdot N\_SFinFR$

Navigation Message Data Frames are aligned to the 1 PPS epoch. Navigation Message Data Frames are synchronized, independent from Page or Sub-frame counts, and across Sub signals, according to the following layout:

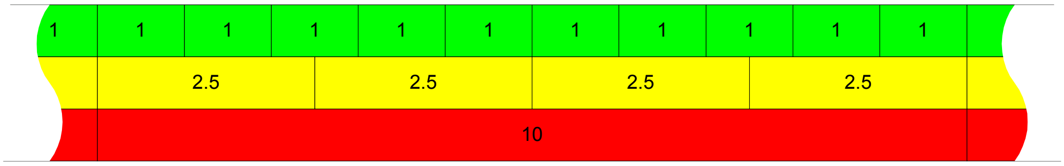

Figure 13: Navigation Message Data Page Synchronization

with:

- Green (top): 1 Second Period Navigation Message Data Pages (E5b-I, E1-B, E6-B)
- Yellow (middle): 2.5 Second Period Navigation Message Data Pages (E6-A,E1-A)
- Red (bottom): 10 Second Period Navigation Message Data Pages (E5a-I)

The Navigation Message Data Frames are generated from MSB (transmitted first) to LSB (transmitted last).

All Navigation Message Data Frames are synchronized with week transitions: Each frame starts with its first Navigation Message Data Page (*PGCNT* = 1) at the week transition.

8.2.4.2 Navigation Message Data Stream Generation Scheme

All Navigation Message Data Streams are generated according to the scheme outlined in figure 14

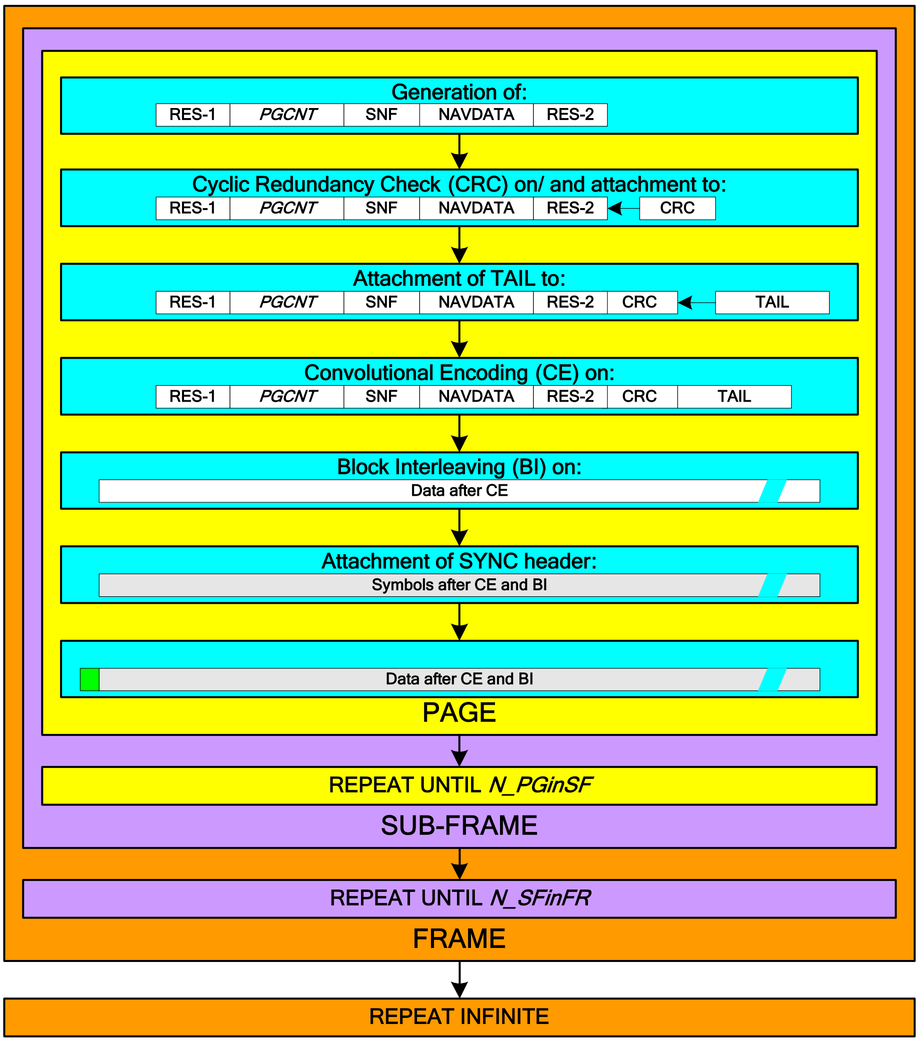

Figure 14: Navigation message Data Frame generation scheme

8.3 Navigation Message Data Content

8.3.1 GIOVE-A Galileo System Time (GST) and Week Number

The GST is given as 30-bit (OB) binary number composed of two parts as follows:

- The Week Number is an integer counter that gives the sequential week number from the origin of the Galileo Time. This parameter is coded on 10 bits, which covers 1024 weeks. Then the counter is reset to zero to cover additional weeks with week number modulo 1024.
- The Time of Week (TOW) is defined as the number of seconds that have occurred since the transition from the previous week. The TOW shall cover an entire week from 0 to 604799 seconds and is reset to zero at the end of each week.

Time stamps are inserted in the navigation message at regular intervals by the broadcasting satellite to identify the GST in multiples of 1 second.

Table 22: GIOVE GST Parameters

Parameter	Definition	Bits	Scale factor	Unit
WN	Week Number	10 (MSB)	1	week
TOW	Time of Week	20 (LSB)	1	s
	Galileo System Time	**30**		

The GIOVE GST start epoch shall be 00:00 UT on Sunday January 06 1980 (midnight between January 05th and 06th). At the start epoch, GIOVE GST shall be synchronous with UTC.

The GIOVE-A broadcast GST value refers to the time of the transmission (TOT) of the first Navigation Message Data Page (PGCNT = 1) at the start of the Navigation Message Data Frame containing the TOW, and there to the leading edge of the first chip of the first code sequence of the first page symbol (first symbol of the SYNC field).

8.3.2 Satellite Clock Correction Parameters

The difference between system GST and the time of the on-board physical clock, measured at the antenna phase centre and for the dual frequency combination $(X) = (f_1,f_2)$, is called satellite clock correction term $\Delta t_{SV}(X)$. This term is approximated by the following 2nd order polynomial:

$$\Delta t_{SV}(X) = a_{f0}(X) + a_{f1}(X)(t - t_{0c}(X)) + a_{f2}(X)(t - t_{0c}(X))^2 + \Delta t_r$$

where $a_{f0}(X)$, $a_{f1}(X)$ and $a_{f2}(X)$ are the polynomial correction coefficients corresponding to phase error, frequency error and rate of change of frequency error, and t is the time in GST. Terms of higher order than 2 have been omitted. The parameter $t_{0c}(X)$ is a reference time (in sec) for the clock correction relative to end/start of week transition.
Δt_r is a relativistic correction term, given by

$$\Delta t_\gamma = F\, e\, A^{1/2} \sin(E) \qquad [\mathrm{s}]$$

with the orbital parameters (e, $A^{1/2}$, E) from the ephemeris (chapter 8.3.5) and F the constant:

$$F = -2\frac{\sqrt{\mu}}{c^2} = -4.442807309 \cdot 10^{-10} \quad \mathrm{s/m^{1/2}}$$

Consequently, the coefficients a_{f0}, a_{f1}, a_{f2}, and t_{0c} are being transmitted in the Navigation Message Data according to the following format:

Table 23: Clock Correction Parameters

Parameter	Definition	Bits	Scale factor	Unit
t_{0c}	Reference Time	16	2^{4}	Seconds
a_{f0}	First Polynomial Correction Coefficient	26 (*)	2^{-31}	Seconds
a_{f1}	Second Polynomial Correction Coefficient	16 (*)	2^{-43}	Sec/sec
a_{f2}	Third Polynomial Correction Coefficient	12 (*)	2^{-70}	Sec/sec^2
	Total	70 (UL)		Bits

(*) Parameters so indicated are two's complement with the sign bit occupying the MSB

All GIOVE-A navigation messages transmitted at the same time provide the same clock correction. Which clock correction out of the possible combinations of navigation signal components is being provided is signaled within the navigation data health section of the satellite health flags (chapter 8.3.7).

8.3.3 Estimated Group Delay Differential (T_{GD})

Equipment group delay is defined as the delay between the L-band radiated output of each individual ranging signal from the S/C (measured at the antenna centre of phase) and the output of that S/C's on-board signal generation source. The delay consists of a bias term and an uncertainty. The induced effect of the equipment group delay is an error in the GST estimated by the user.

Common mode equipment group delays of frequency pairs are covered by the corresponding on board clock correction. Differences in equipment group delay between different carriers are identified within the group delay differential or Bias Group Delay (*BGD*) T_{GD}, provided in the navigation message. The BGD is coded in a **16 bit** (1 low byte + 1 high byte) field with a scale factor of 2^{-32}.

Parameter	Definition	Bits	Scale factor	Unit
T_{GD}	Bias Group Delay	16 (*)	2^{-32}	Seconds

(*) Parameters so indicated are two's complement with the sign bit occupying the MSB

It represents the differential group delay parameter referenced to a specified pair of carrier frequencies.

$$T_{GD}(X,Y)=\frac{1}{1-\gamma_{X,Y}}\left(t_X-t_Y\right)\quad[\mathrm{sec}]\qquad \text{with}\quad X,Y\in\left\{\mathrm{E1\text{-}A, E1\text{-}B/C, E5}, E\mathrm{5a, E5b, E6\text{-}A\ or\ E6\text{-}B/C}\right\}$$

where:

$$\gamma_{X,Y}=\left(\frac{f_X}{f_Y}\right)^2$$

and t_X and t_Y are the GIOVE-A System Time of Transmissions of the navigation signal components X and Y from the S/C antenna phase centre. These differential group delay parameters allow deriving the appropriate S/C clock correction value for alternative signal combinations from the transmitted clock correction parameters.

Only one BGD value T_{GD} is transmitted within all GIOVE-A navigation messages. Which BGD out of the possible combinations of navigation signal components is being provided is signaled within the navigation data health section of the satellite health flags (chapter 8.3.7).

For illustration, the following table shows example configurations. In this example the dual frequency s/c clock correction $\Delta t_{SV}(X,Y)$ is calculated according to section 8.3.2, using the broadcast clock correction coefficients a_{f0}, a_{f1}, a_{f2} that are computed by the ground segment based on E1-BC/E5a dual frequency measurements as signaled in the navigation data health information. The dual frequency clock correction is then modified using T_{GD} to compute the single frequency clock correction $\Delta t_{SV}(Z)$ with $Z\in\{X,Y\}$.

Table 24: Example computation for satellite single frequency clock correction

Used signals	Clock Correction Computation
E1 (Single frequency)	$\Delta t_{SV}(\mathrm{E1-BC})=\Delta t_{SV}(\mathrm{E1\text{-}BC,E5a})-T_{GD}(\mathrm{E1\text{-}BC,E5a})$
E5a (Single frequency)	$\Delta t_{SV}(\mathrm{E5a})=\Delta t_{SV}(\mathrm{E1\text{-}BC,E5a})-\gamma_{\mathrm{E1,E5a}}T_{GD}(\mathrm{E1\text{-}BC,E5a})$

8.3.4 Computation of the Time of Transmission in GST

The estimated satellite signal time of transmission TOT_C in GST can be computed for the signal combination using these time correction data according to

$$TOT_C(X) = TOT_m(X) - \Delta t_{SV}(X),$$

where

- $(X) = (f_1, f_2)$ is the dual frequency combination f_1 and f_2 to correct for ionospheric path delay.
- $TOT_C(X)$ is the corrected satellite TOT in GST, for the signal combination X
- $TOT_m(X)$ is the physical satellite TOT for the signal combination X as derived from the navigation message and the dual frequency code phase measurements.

If a receiver performs single frequency measurements on the signal component Z, then the dual frequency clock correction $\Delta t_{SV}(X)$ is to be replaced by the appropriate single frequency correction $\Delta t_{SV}(Z)$ as defined in chapter 8.3.3.

8.3.5 Ephemeris Parameters

Note: *The IDOT information transported on E5a-I is being used for experimental purposes. The nominal data format is outlined below, but the actual transmitted data in E5a-I is different and is not to be used until removal of this note within a future up-issue of this ICD.*

The GIOVE-A ephemeris is composed by 15 parameters (6 Keplerian parameters, 6 harmonic coefficients, inclination and LAN rates plus mean motion correction). The parameter t_{0e} is the reference time (in sec) for the ephemeris relative to end/start of week transition.

Table 25: Ephemeris Parameters

Parameter	Definition	Bits	Scale factor	Unit
M_0	Mean Anomaly at Reference Time	32 (*)	2^{-31}	Semi-circ.
Δn	Mean Motion Difference From Computed Value	16 (*)	2^{-43}	Semi-circ./s
e	Eccentricity	32	2^{-33}	N/A
$(A)^{1/2}$	Square Root of the Semi-Major Axis	32	2^{-19}	Meters$^{1/2}$
$(OMEGA)_0$	Longitude of Ascending Node of Orbit Plane at Weekly Epoch	32 (*)	2^{-31}	Semi-circ.
i_0	Inclination Angle at Reference Time	32 (*)	2^{-31}	Semi-circ.
ω	Argument of Perigee	32 (*)	2^{-31}	Semi-circ.
$OMEGADOT$	Rate of Right Ascension	24 (*)	2^{-43}	Semi-circ./s
$IDOT$	Rate of Inclination Angle	14 (*)	2^{-43}	Semi-circ./s
C_{uc}	Amplitude of the Cosine Harmonic Correction Term to the Argument of Latitude	16 (*)	2^{-29}	Radians
C_{us}	Amplitude of the Sine Harmonic Correction Term to the Argument of Latitude	16 (*)	2^{-29}	Radians
C_{rc}	Amplitude of the Cosine Harmonic Correction Term to the Orbit Radius	16 (*)	2^{-5}	Meters
C_{rs}	Amplitude of the Sine Harmonic Correction Term to the Orbit Radius	16 (*)	2^{-5}	Meters
C_{ic}	Amplitude of the Cosine Harmonic Correction Term to the Angle of Inclination	16 (*)	2^{-29}	Radians
C_{is}	Amplitude of the Sine Harmonic Correction Term to the Angle of Inclination	16 (*)	2^{-29}	Radians
t_{0e}	Reference Time Ephemeris	16	2^{4}	Seconds
Total (one satellite)		358 (UL)		Bits

(*) Parameters so indicated are two's complement with the sign bit occupying the MSB

The user computes the ECEF coordinates of the SV's antenna phase centre position at GST time *t*, utilizing the equations shown in table 26 or a variant thereof. The algorithm uses the ephemeris parameters defined in table 25 and constants μ and ω_E defined below. Due to the extreme sensibility of the SV's antenna phase centre position to small perturbations in the ephemeris parameters, also a defined value for π shall be used.

Constant	Description
π = 3.1415926535898	ratio of a circle's circumference to its diameter
μ = 3.986004418 · 10^{14} m^3/s^2	geocentric gravitational constant
ω_E = 7.2921151467 · 10^{-5} rad/s	mean angular velocity of the earth
c = 299792458 m/s	Speed of light

Table 26: User Algorithm for Ephemeris Determination

Computation	Description
$A = (A^{1/2})^2$	Semi-major axis
$n_0 = \sqrt{\frac{\mu}{A^3}}$	Computed mean motion (rad/s)
$t_k = t - t_{0e}$	Time from ephemeris reference epoch[2]
$n = n_0 + \Delta n$	Corrected mean motion
$M = M_0 + n\, t_k$	Mean anomaly
$M = E - e \sin(E)$	Kepler's Equation for Eccentric Anomaly (may be solved by iteration)
$\nu = \tan^{-1}\left\{\frac{\sin\nu}{\cos\nu}\right\}$	True Anomaly
$= \tan^{-1}\left\{\frac{\sqrt{1-e^2}\sin E / (1-e\cos E)}{(\cos E - e)/(1-e\cos E)}\right\}$	
$\Phi = \nu + \omega$	Argument of Latitude
$\delta u = C_{us}\sin 2\Phi + C_{uc}\cos 2\Phi$	Argument of Latitude Correction
$\delta r = C_{rs}\sin 2\Phi + C_{rc}\cos 2\Phi$	Radius Correction
$\delta i = C_{is}\sin 2\Phi + C_{ic}\cos 2\Phi$	Inclination Correction
$u = \Phi + \delta u$	Corrected Argument of Latitude
$r = A(1 - e\cos E) + \delta r$	Corrected Radius
$i = i_0 + \delta i + (IDOT)\, t_k$	Corrected Inclination
$\left.\begin{aligned} x' &= r\cos u \\ y' &= r\sin u \end{aligned}\right\}$	Position in orbital plane
$\Omega = OMEGA_0 + (OMEGADOT - \omega_E)t_k - \omega_E\, t_{0e}$	Corrected longitude of ascending node
$\left.\begin{aligned} x &= x'\cos(\Omega) - y'\cos(i)\sin(\Omega) \\ y &= x'\sin(\Omega) + y'\cos(i)\cos(\Omega) \\ z &= y'\sin(i) \end{aligned}\right\}$	GTRF coordinates of the SV antenna phase center position at time *t*

---

[2] *t* is Galileo System Time. Furthermore, t_k shall be the actual total time difference between the time *t* and the epoch time t_{0e} (t_{0a} for the almanacs) and must account for beginning or end of week crossovers.

8.3.6 Issue of Data

Note: *The IOD information in the navigation message of all GIOVE-A data channels is being used for experimental purposes. The nominal data format is outlined below, but the actual transmitted data can be different and is not to be used until removal of this note within a future up-issue of this ICD.*

For GIOVE-A a System Issue of Data (SIOD) of 9 bits total is maintained within the system. A change in the SIOD value indicates one or more changes in ephemeris, clock correction, almanac, UTC data of the navigation message provided by the Galileo ground segment for broadcast. Note that these modifications of the navigation message content are also associated to appropriate updates of the reference times t_{0c}, t_{0e}, t_{0a}, t_{0t}, but these reference times are transmitted only within a subset of the affected Navigation Message Pages.

SIOD counters are also used to indicate data set cutover on board. Counter reset is enabled relative to end/start of week transitions. The nominal validity interval (fit interval) for the GIVOE-A ephemeris and clock correction is 4 hours minimum (TBC/A). The nominal validity interval for the GIVOE-A almanac is typically 2 days.

8.3.6.1 IOD Index

The broadcast IOD in Navigation Message Data Page (ephemeris page 1) equals to the SIOD (UL) 6 MSB.

8.3.6.2 SNF Index

A specific field is used in the Navigation Message Data Page structure (figure 11) to support data integrity and to improve reacquisition performance. The purpose of this SNF is to allow rapid determination of changes in the Satellite Navigation data (ephemeris, clock, almanac), to support Navigation Message Data base maintenance.

For data rate limitation reason, only 3 bits are used to code the SNF value. The SNF equals the SIOD (UL) 3 LSB:

$$\text{SNF} = \text{SIOD mod } 7$$

8.3.7 Satellite Health

The satellite health is currently used also for experimental purposes. As long as this is the case, the description below is to be understood as advance information. The transmitted data can not be used with the description below until, in an upissue of this ICD, this note is removed. As a supportive means, message data validity can be identified by checking the value of the ephemeris square root semimajor axis $(A)^{1/2}$ *to be different from zero.*

Transmitted health data consists of 13 (UL) bits referring to the transmitting S/C, separated in two blocks:

Table 27: Satellite Health

Parameter	Definition	Bits	Scale Fact.	Unit	Values
Signal Health					
Carrier Status	One bit per carrier E1, E5, E6, see table 28 below	3	n/a	dimensionless	bit field
Reserved	Reserved	7	n/a	dimensionless	bit field
Nav. Data Health	Navigation data status, see table 29	3	n/a	dimensionless	UINT

The detailed interpretation of the Carrier Status and Navigation Data Health bits is given in tables 29 below.

Table 28: Carrier Status

Carrier Status bit no.	Definition
0	if ==1 then carrier E1 is useable
1	if ==1 then carrier E6 is useable
2	if ==1 then carrier E5 is useable

Note: "Carrier useable" refers to the full availability of all navigation signal components of the carrier (for E5, both E5a and E5b with I and Q) as described in chapter 6.

Table 29: Navigation Data Health

Nav. Data Health value	Definition	
0	Nav. data invalid	
1	Nav. data valid,	Message provides T_{GD} and clock correction for (E1-B, E5b)
2	Nav. data valid,	Message provides T_{GD} and clock correction for (E1-B, E5a)
3	Nav. data valid,	Message provides T_{GD} and clock correction for (E1-A, E6-A)
4	Nav. data valid,	Message provides T_{GD} and clock correction for (E1-B, E5)
5	Nav. data valid,	Message provides T_{GD} and clock correction for (E1-A, E5b)
6	Nav. data valid,	Message provides T_{GD} and clock correction for (E1-A, E5)
7	Nav. data valid,	Message provides T_{GD} and clock correction for any other component pair

Note: If the Navigation Data Health indicates a carrier pair that is different from the GIOVE-A actual transmitted pair of carriers, then the clock correction and the T_{GD} value transported in the message may be invalid.

Note: If the Navigation Data Health indicates "…for any other component pair", the precise application of the transported clock correction and T_{GD} value can not be defined without further system internal information from sources outside the navigation message. A standalone user can not use the provided clock model and BGD parameters.

8.3.8 Space Vehicle Identifier (SVID)

The SVID is coded with 6 (UL) bits, unsigned integer.

Parameter	Definition	Bits	Scale Factor	Unit	Values
SVID	Satellite Identification	6	N/A	Dimensionless	1 … 64

All bits zero are equivalent to SVID = 1 decimal.

GIOVE-A is assigned to SVID 1 within the GIOVE-A navigation message.

Note: SVID = 1 will be reused after GIOVE-A decommissioning and during Galileo nominal operation, by satellites emitting signals according to [RD 1].

8.3.9 Ionosphere Corrections

Note: The Ionosphere correction model provided by the GIOVE-A navigation message is expected not to reach the accuracy of the final Galileo ionosphere correction at this time, because the number of ground reference stations is still significantly lower than foreseen for the full Galileo configuration.

The NeQuick model is being used for ionosphere modeling. GIVOE-A provides the model with a total data size of **40 (UL) bits**.
The Ionosphere model parameters include:

- the broadcast coefficients a_{i0}, a_{i1} and a_{i2} used to compute the Effective Ionization Level Az

- the "Ionosphere Disturbance Flag" (also referred as "model storm flag" or "storm flag"), given for five different regions

Table 30: Ionosphere Correction Parameters

Param.	Definition	Bits	Scale factor	Unit
a_i0	Effective Ionization Level 1st order parameter	11	2^{-2}	sfu(**)
a_i1	Effective Ionization Level 2nd order parameter	11(*)	2^{-8}	sfu(**)/degree
a_i2	Effective Ionization Level 3rd order parameter	13(*)	2^{-15}	sfu(**)/degree2
*SF*1	Ionosphere Disturbance Flag (or storm flag) for region 1	1	N/A	dimensionless
*SF*2	Ionosphere Disturbance Flag (or storm flag) for region 2	1	N/A	dimensionless
*SF*3	Ionosphere Disturbance Flag (or storm flag) for region 3	1	N/A	dimensionless
*SF*4	Ionosphere Disturbance Flag (or storm flag) for region 4	1	N/A	dimensionless
*SF*5	Ionosphere Disturbance Flag (or storm flag) for region 5	1	N/A	dimensionless
	Total ionosphere bits	**40**		

(*) Parameters so indicated are two's complement, with the sign bit (+ or -) occupying the MSB.
(**) 'sfu' (solar flux unit) is not a SI unit but can be converted as: 1 sfu = 10^{-22} W/(m^2*Hz)

The effective ionization level shall be computed according to

$$Az = a_{i0} + a_{i1} \cdot \mu + a_{i2} \cdot \mu^2$$

where μ is the modified dip latitude "MODIP".

The "Ionosphere Disturbance Flag" (also referred to as "model storm flag" or "storm flag") shall have the following values: 0…No disturbance / 1…Disturbance in the region, where the regions are defined as:

- Region 1: for the northern region (60° < MODIP < 90°)
- Region 2: for the northern middle region (30° < MODIP < 60°)
- Region 3: for the equatorial region (-30° < MODIP < 30°)
- Region 4: for the southern middle region (-60° < MODIP < -30°)
- Region 5: for the southern region (-90° < MODIP < -60°)

The "Ionosphere Disturbance Flag" indicates whether *Az*, and by this the Ionosphere model, is applicable (flag value 0) for the relevant regions or not.

8.3.10 Almanac

The almanac data are reduced-precision subsets of the Ephemeris and Clock parameters.

Table 31: Almanac

Parameter	Definition	Bits	Scale factor	Unit
$(A)^{1/2}$	Square Root of Mean Semi-Major Axis	24	2^{-11}	Meters$^{1/2}$
e	Eccentricity	16	2^{-21}	N/A
δ_i	Inclination Angle at Reference Time (relative to $i_0 = 56^o$)	16(*)	2^{-19}	Semi-circ.
ω	Argument of Perigee	24(*)	2^{-23}	Semi-circ.
OMEGADOT	Rate of change of Longitude of Right Ascension Node at weekly epoch	24(*)	2^{-38}	Semi-circles/s
M_0	S/C Mean Anomaly at Reference Time	24(*)	2^{-23}	Semi-circ.

Parameter	Definition	Bits	Scale factor	Unit
A_{f0}	S/C Clock Correction Bias "Truncated"	15(*)	2^{-20}	Seconds
A_{f1}	S/C Clock Correction Linear Term "Truncated"	11(*)	2^{-38}	Sec/Sec
t_{0a}	Almanac Reference Time	8	3600	Seconds
WN_a	Almanac Reference Week Number	8	1	week

(*) Parameters so indicated are two's complement with the sign bit occupying the MSB

Note: The almanac reference time t_{0a} is referenced to the almanac reference week WN_a. The WN_a term consists of **8 (UL) bits** which is a Modulo 256 binary representation of the GST week number *WN*.

Note: The Almanac contains no SVID entries. The assignment is established by the Almanac slot number being set equal to the SVID reduced by one (slot 0 corresponds to SVID 1).

8.3.10.1 Almanac S/C Health Status

Additionally to the orbit and clock parameters data provided in the almanacs, a predicted S/C health status is provided for each of the S/Cs, giving indications on the S/Cs signal health and S/C's NAV data health. The Health Status contains **11 (UL) bits**.

Table 32: Almanac S/C Health field

Parameter	Definition	Bits	Scale Factor	Unit	Values
S/C health	Satellite health == 0 is satellite not active or unhealthy, == 1 if s/c active and healthy	1	n/a	n/a	{0,1}
Reserved	Value may vary, standard value is all bits = 0	10	n/a	n/a	bit field

The almanac s/c health status is intended as an *indication* for the receiver, to support signal search. It can be overridden by the more up to date ephemeris health information, and by operational events. In principle a satellite can be inactive (e.g. due to a failure, before almanac update) despite of the almanac transmitting an active status, and vice versa (since the system will attempt for maximum availability).

8.3.10.2 Empty almanac entries

The almanac message for any non-operational satellite contains all bits of M_0, a_{f0}, a_{f1} and almanac s/c health (section 8.3.10.1) set to zero.

8.3.11 UTC/GST Conversion

Note: The UTC/GST Conversion fields of the GIOVE-A navigation message(s) are being used for experimental purposes. At the time of this ICD they can not be used for positioning or timing services. The field descriptions below are given for completeness of the message definition, to describe a possible future use.

The conversion between GIVOE-A GST and Universal Time Co-ordinated (UTC) uses the navigation message parameters described in table 33 below.

Table 33: Parameters for GST-UTC Conversion

Parameter	Definition	Bits	Scale factor	Unit
A_1	Rate of change (in seconds per second) of the offset Δt_{UTC} between GST and UTC time scales	24 (*)	2^{-50}	Sec/sec
A_0	Constant term (in seconds) of polynomial describing the offset Δt_{UTC} between GIVOE-A System and UTC time scales at the time t_E, that is the GIOVE-A System Time as estimated by the user on the basis of correcting $t_{S/C}$ for the satellite clock offset and relativity terms as well as for ionospheric effects	32 (*)	2^{-30}	Seconds
Δt_{LS}	Offset due to the integer number of seconds between GST and UTC	8 (*)	1	Seconds
t_{0t}	Time of validity of the UTC offset parameters	8	2^{12}	Seconds
WN_t	UTC reference week number	8	1	Weeks
WN_{LSF}	Week number for the leap second adjustment	8	1	Weeks
DN	Day number for the leap second adjustment (becomes effective at the end of the day)	8	1	Days
Δt_{LSF}	Is the offset due to the introduction of a leap second at WN_{LSF} and DN	8 (*)	1	Seconds
	Total	104 (UL)		**Bits**

(*) Parameters so indicated are two's complement with the sign bit occupying the MSB

The UTC time t_{UTC} is computed through 3 different cases, depending on the epoch of a possible leap second adjustment (scheduled future or recent past) given by *DN*, the day at the end of which the leap second becomes effective, and week number WN_{LSF} to which *DN* is referenced. "Day one" of *DN* is the first day relative to the end/start of week and WN_{LSF} is the Galileo week number modulo 256.
Define furthermore

- t_E GST as estimated by the user through its GST determination algorithm,
- *WN* week number to which t_E is referenced, modulo 256.

Case a:
Whenever the leap second adjustment time indicated by WN_{LSF} and *DN* is not in the past (relative to the user's present time), and the user's present time does not fall in the time span which starts six hours prior to the effective time (=*DN*+3/4) and ends six hours after the effective time at (=*DN*+5/4), t_{UTC} is computed according to the following equations:

$$\Delta t_{UTC} = \Delta t_{LS} + A_0 + A_1 \cdot \left(t_E - t_{ot} + 604800 \cdot \left(WN - WN_t\right)\right) \text{ [s]} \qquad ,$$

and UTC time can be calculated from t_E (GST, estimated) as:

$$t_{UTC} = \left(t_E - \Delta t_{UTC}\right) \qquad \{\text{modulo } 86400 \text{ seconds}\}$$

Case b:
Whenever the user's current time falls within the time span of six hours prior to the effective time to six hours after the effective time, t_{UTC} is computed according to the following equation:

$$t_{UTC} = W \qquad [\text{Modulo } (86400 + \Delta t_{LSF} - \Delta t_{LS})]$$

where

- $W = (t_E - \Delta t_{UTC} - 43200)$ [Modulo 86400] + 43200
- and Δt_{UTC} is as in case a.

Case c:

Whenever the effectivity time of the leap second event, as indicated by the WN_{LSF} and DN values, is in the "past" (relative to the user's current time) and the user's present time does not fall in the time span which starts six hours prior to the effective time and ends six hours after the effective time, t_{UTC} is computed according to the following equation:

$$t_{UTC} = \left(t_E - \Delta t_{UTC}\right) \qquad \text{[Modulo 86400]}$$

where Δt_{UTC} is computed as: $\Delta t_{UTC} = \Delta t_{LSF} + A_0 + A_1 \cdot \left(t_E - t_{ot} + 604800 \cdot \left(WN - WN_t\right)\right)$

8.3.12 GPS to GIOVE-A Galileo System Time Offset (GGTO)

Note: The GGTO Conversion fields of the GIOVE-A navigation message(s) are currently under preparation. At the time of this ICD they can not be used for positioning or timing services. The field descriptions below are given for completeness of the message definition, to describe a possible future use.

The GPS to GIOVE-A Galileo System Time Offset (GGTO) parameters shall be formatted according to the values stated in the following table.

Table 34: Parameters for the GPS time to GST offset computation

Parameter	Definition	Bits	Scale factor	Units
GGTOval	Validity flag, '1' indicates valid GGTO	1	n/a	n/a
A_{0G}	Constant term of the offset $\Delta t_{systems}$	20 (*)	2^{-32}	s
A_{1G}	Rate of change of the offset $\Delta t_{systems}$	12 (*)	2^{-51}	s/s
t_{0G}	GGTO data reference Time of Week	8	3600	s
WN_{0G}	GGTO data reference Week Number	6	1	week
	GPS Time to GST Offset Parameters	**47**		

* Parameters so indicated are two's complement, with the sign bit occupying the MSB

In case GGTO is not available or not valid, the *GGTOval* flag will signal a logical '0'.
Note that the possible range of offsets A_{0G} is up to ±122µs. This is required due to a speciality of the GIOVE-A time scale, which is, after a coarse initial synchronisation and different to the final Galileo time scale, free running over the operational time of the s/c or until the range of A_{0G} is exceeded.

The user evaluates the difference between the GIOVE-A Galileo and the GPS time scales by the expression

$$\Delta t_{Systems} = A_{0G} + A_{1G}\left(TOW - t_{0G} + 604800 \cdot \left(\left(WN - WN_{0G}\right) \bmod 64\right)\right)$$

with

$\Delta t_{Systems}$	offset GST minus GPS time (seconds)
TOW	GIOVE-A GST TOW (seconds)
WN	GIOVE-A GST Week Number corresponding to GST TOW (week)

and A_{0G}, A_{1G}, t_{0G} and WN_{0G} according to table 34.

8.3.13 Spare data

If not explicitly defined differently, spare data bits are set to a random format, or to a series of alternating 0/1. Spare data may be re-defined and change at any time during system operation. The user is expected not to evaluate spare data.

8.4 *Navigation Message Data Page Format*

8.4.1 E5a-I Navigation Data Pages

Table 35: E5a-I Navigation Data Pages

E5a-I

Data Packet	Applicability	Content	Bits	Page No.
Ionosphere & UTC Conversion	System	$SVID$	6	1
		Ionosphere corr. a_{i0}	11	
		Ionosphere corr. a_{i1}	11	
		Ionosphere corr. a_{i2}	13	
		Ionosphere corr. $SF_1 \dots SF_5$	5	
		Spare	40	
		A_1	24	
		A_0	32	
		Δt_{LS}	8	
		t_{0t}	8	
		WN_t	8	
		WN_{LSF}	8	
		DN	8	
		Δt_{LSF}	8	
		Spare	27	
		Total	217	

E5a-I

Data Packet	Applicability	Content	Bits	Page No.
Ephemeris, Clock correction	Broadcasting s/c	M_0	32	2
		Δn	16	
		e	32	
		$(A)^{1/2}$	32	
		$(OMEGA)_0$	32	
		i_0	32	
		ω	32	
		$IDOT$ (9 MSB)	9	
		Total	217	
		$IDOT$ (5 LSB)	5	3
		$OMEGADOT$	24	
		C_{uc}	16	
		C_{us}	16	
		C_{rc}	16	
		C_{rs}	16	
		C_{ic}	16	
		C_{is}	16	
		t_{0e}	16	
		IOD	6	
		$t0_c$	16	
		a_f0	26	
		a_f1	16	
		a_f2	12	
		Total	217	

E5a-I

Data Packet	Applicability	Content	Bits	Page No.
GST, S/C health, BGD, GGTO	Broadcasting s/c, System	Estimated T_{GD}, low byte	8	4
		Spare	8	
		S/C Health	13	
		t_{0a}	8	
		WN_a	8	
		GST WN	10	
		GST TOW	20	
		Estimated T_{GD}, high byte	8	
		$GGTOval$	1	
		A_{1G}	12	
		A_{0G}	20	
		t_{0G}	8	
		WN_{0G}	6	
		Spare	87	
		Total	217	

E5a-I

Data Packet	Applicability	Content		Bits	Page No.
Slow repeptition data (Almanac)	System	s/c k	M_0	24	page 5 with k=0
			Clock corr. A_{f0}, A_{f1}	26	
			Health	11	
		s/c k+1	M_0	24	page 25 with k=12
			Clock corr. A_{f0}, A_{f1}	26	
			Health	11	
		s/c k+2	M_0	24	page 45 with k=24
			Clock corr. A_{f0}, A_{f1}	26	
			Health	11	
		Mean square root SMA $(A)^{1/2}$ for s/c $k\ldots k+11$		24	
			Spare	10	
			Total	217	

E5a-I

Data Packet	Applicability	Content		Bits	Page No.
Slow repeptition data (Almanac)	System	s/c k+3	M_0	24	page 10 with k=0
			Clock corr. A_{f0}, A_{f1}	26	
			Health	11	
		s/c k+4	M_0	24	page 30 with k=12
			Clock corr. A_{f0}, A_{f1}	26	
			Health	11	
		s/c k+5	M_0	24	page 50 with k=24
			Clock corr. A_{f0}, A_{f1}	26	
			Health	11	
		Eccentricity e for s/c $k\ldots k+11$		16	
		Delta inclination δ_i for s/c $k\ldots k+11$		16	
			Spare	2	
			Total	217	

E5a-I

Data Packet	Applicability	Content		Bits	Page No.
Slow repeption data (Almanac)	System	s/c $k+6$	M_0	24	page 15 with $k=0$
			Clock corr. A_{f0}, A_{f1}	26	
			Health	11	
		s/c $k+7$	M_0	24	page 35 with $k=12$
			Clock corr. A_{f0}, A_{f1}	26	
			Health	11	
		s/c $k+8$	M_0	24	page 55 with $k=24$
			Clock corr. A_{f0}, A_{f1}	26	
			Health	11	
		Argument of perigee ω for s/c $k \ldots k+11$		24	
			Spare	10	
			Total	217	

E5a-I

Data Packet	Applicability	Content		Bits	Page No.
Slow repeption data (Almanac)	System	s/c $k+9$	M_0	24	page 20 with $k=0$
			Clock corr. A_{f0}, A_{f1}	26	
			Health	11	
		s/c $k+10$	M_0	24	page 40 with $k=12$
			Clock corr. A_{f0}, A_{f1}	26	
			Health	11	
		s/c $k+11$	M_0	24	page 60 with $k=24$
			Clock corr. A_{f0}, A_{f1}	26	
			Health	11	
		OMEGADOT for s/c $k \ldots k+11$		24	
			Spare	10	
			Total	217	

8.4.2 E1-B/E5b-I and E1-A/E6-A Navigation Data Pages

Table 36: E1-B/E5b-I and E1-A/E6-A Navigation Data Pages

E5b-I
E1-B

E6-A
E1-A

Data Packet	Applicability	Content	Bits	Page No.
Ephemeris, (packets 1…4)	Broadcasting s/c	*IOD*	6	1
		ω	32	
		Δn	16	
		SVID	6	
		Spare	4	
		Total	64	
		e	32	2
		$(A)^{1/2}$	32	
		Total	64	
		$(OMEGA)_0$	32	3
		t_0	32	
		Total	64	
		M_0	32	4
		IDOT	14	
		Spare	18	
		Total	64	

	Data Packet	Applicability	Content	Bits	Page No.
E5b-I	Ephemeris, Clock correction, Ionosphere corr. (packets 5…8)	Broadcasting s/c, System	$OMEGADOT$	24	25+1
E1-B			C_{uc}	16	
			C_{us}	16	
			$SVID$	6	
			Spare	2	
E6-A			Total	64	
E1-A			t_{0e}	16	25+2
			C_{rc}	16	
			C_{rs}	16	
			C_{ic}	16	
			Total	64	
			t_{0c}	16	25+3
			C_{is}	16	
			Ionosphere correction a_{i0}	11	
			Ionosphere correction a_{i1}	11	
			Ionosphere corr. a_{i2} (8 MSB)	8	
			Spare	2	
			Total	64	
			a_{f0}	26	25+4
			a_{f1}	16	
			a_{f2}	12	
			Ionosphere corr. a_{i2} (5 LSB)	5	
			Ionosphere corr. $SF1 ... SF_5$	5	
			Total	64	

	Data Packet	Applicability	Content	Bits	Page No.
E5b-I	Time ref. + etc (packet 1 + 2)	System	GST (WN, TOW)	30	5
E1-B			A_0	32	
			Spare	2	
E6-A			Total	64	
E1-A			A_1	24	6
			Δt_{LS}	8	
			t_{0t}	8	
			WN_t	8	
			WN_{LSF}	8	
			Spare	8	
			Total	64	

	Data Packet	Applicability	Content	Bits	Page No.
E5b-I	Time ref., health, GGTO (packet 3 + 4)	Broadcasting s/c & System	DN	8	5
E1-B			Δt_{LSF}	8	
			Estimated T_{GD}, low byte	8	
E6-A			t_{0a}	8	
E1-A			WN_a	8	
			S/C health	13	
			Estimated T_{GD}, high byte	8	
			Spare	3	
			Total	64	
			$GGTOval$	1	6
			A_{1G}	12	
			A_{0G}	20	
			t_{0G}	8	
			WN_{0G}	6	
			Spare	17	
			Total	64	

E5b-I
E1-B

E6-A
E1-A

Data Packet	Applicability	Content	Bits	Page No.
Orbital parameters, plane *n*	System	$(A)^{1/2}$	24	See add. description
		e	16	
		δ_i	16	
		Spare	8	
		Total	64	
		OMEGADOT	24	See add. description
		ω	24	
		Spare	16	
		Total	64	

E5b-I
E1-B

E6-A
E1-A

Data Packet	Applicability	Content	Bits	Page No.
Almanac S/C *k*	System	A_{f0}	15	See add. description
		A_{f1}	11	
		M_0	24	
		Almanac S/C Health	11	
		Spare	3	
		Total	64	

8.4.3 E6-B Navigation Data Pages

Table 37: E6-B Navigation Data Pages

E6-B

Data Packet	Applicability	Content	Bits	Page No.
Ephemeris, Clock correction	Broadcasting s/c	M_o	32	1
		Δn	16	
		e	32	
		$(A)^{1/2}$	32	
		$(OMEGA)_0$	32	
		i_0	32	
		ω	32	
		IDOT	14	
		OMEGADOT	24	
		C_{uc}	16	
		C_{us}	16	
		C_{rc}	16	
		C_{rs}	16	
		C_{ic}	16	
		C_{is}	16	
		t_{0e}	16	
		t_{0c}	16	
		a_{f0}	26	
		a_{f1}	16	
		a_{f2}	12	
		SVID	6	
		IOD	6	
		Spare	24	
		Total	464	

E6-B

Data Packet	Applicability	Content	Bits	Page No.
Ionosphere & UTC Correction, BGD, Almanac reference time GGTO	System & Broadcasting s/c	GST (WN, TOW)	30	2
		A_1	24	
		A_0	32	
		Δt_{LS}	8	
		t_{0t}	8	
		WN_t	8	
		WN_{LSF}	8	
		DN	8	
		Δt_{LSF}	8	
		Ionosphere corr. a_{i0}	11	
		Ionosphere corr. a_{i1}	11	
		Ionosphere corr. a_{i2}	13	
		Ionosphere corr. $SF_1 \ldots SF_5$	5	
		Spare	40	
		S/C health	13	
		S/C T_{GD} low byte	8	
		WNa	8	
		$t0a$	8	
		S/C T_{GD} high byte	8	
		$GGTOval$	1	
		A_{1G}	12	
		A_{0G}	20	
		t_{0G}	8	
		WN_{0G}	6	
		Spare	158	
		Total	464	

E6-B

Data Packet	Applicability	Content		Bits	Page No.
Almanac data (packet 1)	System	Plane 1	$(A)^{1/2}$	24	3
			e	16	
			δ_i	16	
			$OMEGADOT$	24	
			ω	24	
		Plane 2	$(A)^{1/2}$	24	
			e	16	
			δ_i	16	
			$OMEGADOT$	24	
			ω	24	
		Plane 3	$(A)^{1/2}$	24	
			e	16	
			δ_i	16	
			$OMEGADOT$	24	
			ω	24	
		Spare		152	
		Total		464	

E6-B

Data Packet	Applicability	Content		Bits	Page No.
Almanac data (packet 2…7)	System	s/c i+0	Clock corr. A_{f0}	15	18 with i=0 33 with i=6 48 with i=12 63 with i=18 78 with i=24 93 with i=30
			Clock corr. A_{f1}	11	
			M_0	24	
			s/c health	11	
		s/c i+1	Clock corr. A_{f0}	15	
			Clock corr. A_{f1}	11	
			M_0	24	
			s/c health	11	
		s/c i+2	Clock corr. A_{f0}	15	
			Clock corr. A_{f1}	11	
			M_0	24	
			s/c health	11	
		s/c i+3	Clock corr. A_{f0}	15	
			Clock corr. A_{f1}	11	
			M_0	24	
			s/c health	11	
		s/c i+4	Clock corr. A_{f0}	15	
			Clock corr. A_{f1}	11	
			M_0	24	
			s/c health	11	
		s/c i+5	Clock corr. A_{f0}	15	
			Clock corr. A_{f1}	11	
			M_0	24	
			s/c health	11	
		Spare		98	
		Total		464	

8.5 *Navigation Message Data Frame Format*

8.5.1 E5a-I Frame Format

Table 38: E5a-I Navigation Message Data Stream Format

0s			*50s*			*550s*	
Time	Page #	Subframe 1	Page #	Subframe 2		Page #	Subframe 12
0 s	1	Ionospere, UTC conversion	6	Ionospere, UTC conversion		56	Ionospere, UTC conversion
10 s	2	Ephemeris, Clock correction	7	Ephemeris, Clock correction		57	Ephemeris, Clock correction
20 s	3		8			58	
30 s	4	GST, Health, BGD, GGTO	9	GST, Health, BGD, GGTO		59	GST, Health, BGD, GGTO
40 s	5	Slow repetition data (packet 1)	10	Slow repetition data (packet 2)		60	Slow repetition data (packet 12)
		One frame on E5a-I			…		

8.5.2 E5b-I Frame Format

Table 39: E5b-I Navigation Message Data Frame Format

0s			*25s*		*550s*		*575s*	
Time	Page #	Subframe 1	Page #	Subframe 2	Page #	Subframe 23	Page #	Subframe 24
0 s	1	Ephemeris (packets 1…4)	26	Ephemeris, Clock correction, Iono correction (packets 5…8)	551	Ephemeris (packets 1…4)	576	Ephemeris, Clock correction, Iono correction (packets 5…8)
1 s	2		27		552		577	
2 s	3		28		553		578	
3 s	4		29		554		579	
4 s	5	Time ref + etc (packets 1 + 2)	30	Time ref + etc (packets 3 + 4)	555	Time ref + etc (packets 1 + 2)	580	Time ref + etc (packets 3 + 4)
5 s	6		31		556		581	
6 s	7	Spare	32	Spare	557	Spare	582	Spare
7 s	8		33		557		583	
…	…	…	…	…	…	…	…	…
18 s	19		44		569		594	
19 s	20		45		570		595	
20 s	21	See additional descritiption	46	See additional description	571	See additional descritiption	596	See additional description
21 s	22		47		572		597	
22 s	23		48		573		598	
23 s	24		49		574		599	
24 s	25		50		575		600	
		One frame on E5b-I		…				

Table 40: Additional description to table 39

Page #	Subframe 1	Page #	Subframe 2	Page #	Subframe 3	Page #	Subframe 4
21	Orbital Parameters Plane 1	46	Orbital Parameters Plane 2	71	Almanac S/C 1	96	Almanac S/C 4
22		47	Orbital Parameters Plane 3	72	Almanac S/C 2	97	Almanac S/C 5
23	Orbital Parameters Plane 2	48		73	Almanac S/C 3	98	Almanac S/C 6
24	Spare	49	Spare	74	Spare	99	Spare
25	Spare	50	Spare	75	Spare	100	Spare
	Subframe 5		Subframe 6		Subframe 7		Subframe 8
121	Almanac S/C 7	146	Almanac S/C 10	171	Almanac S/C 13	196	Almanac S/C 16
122	Almanac S/C 8	147	Almanac S/C 11	172	Almanac S/C 14	197	Almanac S/C 17
123	Almanac S/C 9	148	Almanac S/C 12	173	Almanac S/C 15	198	Almanac S/C 18
124	Spare	149	Spare	174	Spare	199	Spare
125	Spare	150	Spare	175	Spare	200	Spare
	Subframe 9		Subframe 10		Subframe 11		Subframe 12
221	Almanac S/C 19	246	Almanac S/C 22	271	Almanac S/C 25	296	Almanac S/C 28
222	Almanac S/C 20	247	Almanac S/C 23	272	Almanac S/C 26	297	Almanac S/C 29
223	Almanac S/C 21	248	Almanac S/C 24	273	Almanac S/C 27	298	Almanac S/C 30
224	Spare	249	Spare	274	Spare	299	Spare
225	Spare	250	Spare	275	Spare	300	Spare
	Subframe 13		Subframe 14		Subframe 15		Subframe 16
321	Almanac S/C 31	346	Almanac S/C 34	371	Spare	396	Spare
322	Almanac S/C 32	347	Almanac S/C 35	372	Spare	397	Spare
323	Almanac S/C 33	348	Almanac S/C 36	373	Spare	398	Spare
324	Spare	349	Spare	374	Spare	399	Spare
325	Spare	350	Spare	375	Spare	400	Spare
	Subframe 17		Subframe 18		Subframe 19		Subframe 20
421	Spare	446	Spare	471	Spare	496	Spare
422	Spare	447	Spare	472	Spare	497	Spare
423	Spare	448	Spare	473	Spare	498	Spare
424	Spare	449	Spare	474	Spare	499	Spare
425	Spare	450	Spare	475	Spare	500	Spare
	Subframe 21		Subframe 22		Subframe 23		Subframe 24
521	Spare	546	Spare	571	Spare	596	Spare
522	Spare	547	Spare	572	Spare	597	Spare
523	Spare	548	Spare	573	Spare	598	Spare
524	Spare	549	Spare	574	Spare	599	Spare
525	Spare	550	Spare	575	Spare	600	Spare

8.5.3 E6-A Frame Format

Table 41: E6-A Navigation Message Data Frame Format

0s			*25s*			*550s*		*575s*	
Time	Page #	Subframe 1	Page #	Subframe 2		Page #	Subframe 23	Page #	Subframe 24
0.0 s	1	Ephemeris (packets 1…4)	11	Ephemeris, Clock correction, Iono correction (packets 5…8)		221	Ephemeris (packets 1…4)	231	Ephemeris, Clock correction, Iono correction (packets 5…8)
2.5 s	2		12			222		232	
5.0 s	3		13			223		233	
7.5 s	4		14			224		234	
10.0 s	5	Time ref + etc (packets 1 + 2)	15	Time ref + etc (packets 3 + 4)		225	Time ref + etc (packets 1 + 2)	235	Time ref + etc (packets 3 + 4)
12.5 s	6		16			226		236	
15.0 s	7	See additional descritiption	17	See additional description		227	See additional descritiption	237	See additional description
17.5 s	8		18			228		238	
20.0 s	9		19			229		239	
22.5 s	10		20			230		240	
		One frame on	**E6-A**		…				

Table 42: Additional description to table 41

Page #	Subframe1	Page #	Subframe 2	Page #	Subframe 3	Page #	Subframe 4
7	Orbital Parameters Plane 1	17	Orbital Parameters Plane 2	27	Almanac S/C 1	37	Almanac S/C 4
8		18	Orbital Parameters Plane 3	28	Almanac S/C 2	38	Almanac S/C 5
9	Orbital Parameters Plane 2	19		29	Almanac S/C 3	39	Almanac S/C 6
10	Spare	20	Spare	30	Spare	40	Spare
	Subframe 5		Subframe 6		Subframe 7		Subframe 8
47	Almanac S/C 7	57	Almanac S/C 10	67	Almanac S/C 13	77	Almanac S/C 16
48	Almanac S/C 8	58	Almanac S/C 11	68	Almanac S/C 14	78	Almanac S/C 17
49	Almanac S/C 9	59	Almanac S/C 12	69	Almanac S/C 15	79	Almanac S/C 18
50	Spare	60	Spare	70	Spare	80	Spare
	Subframe 9		Subframe 10		Subframe 11		Subframe 12
87	Almanac S/C 19	97	Almanac S/C 22	107	Almanac S/C 25	117	Almanac S/C 28
88	Almanac S/C 20	98	Almanac S/C 23	108	Almanac S/C 26	118	Almanac S/C 29
89	Almanac S/C 21	99	Almanac S/C 24	109	Almanac S/C 27	119	Almanac S/C 30
90	Spare	100	Spare	110	Spare	120	Spare
	Subframe 13		Subframe 14		Subframe 15		Subframe 16
127	Almanac S/C 31	137	Almanac S/C 34	147	Spare	157	Spare
128	Almanac S/C 32	138	Almanac S/C 35	148	Spare	158	Spare
129	Almanac S/C 33	139	Almanac S/C 36	1149	Spare	159	Spare
130	Spare	140	Spare	150	Spare	160	Spare
	Subframe 17		Subframe 18		Subframe 19		Subframe 20
167	Spare	177	Spare	187	Spare	207	Spare
168	Spare	178	Spare	188	Spare	208	Spare
169	Spare	179	Spare	189	Spare	209	Spare
170	Spare	180	Spare	190	Spare	200	Spare
	Subframe 21		Subframe 22		Subframe 23		Subframe 24
207	Spare	217	Spare	227	Spare	237	Spare
208	Spare	218	Spare	228	Spare	238	Spare
209	Spare	219	Spare	229	Spare	239	Spare
210	Spare	220	Spare	230	Spare	240	Spare

8.5.4 E6-B Frame Format

Note: The information transported on E6-B is for at the time being used for experimental purposes. The nominal frame format is outlined below, but the actual transmitted data in E6-B will deviate from the nominal frame, sub-frame and page content and is not to be used until removal of this note within a future up-issue of this ICD.

Table 43: E6-B Navigation Message Data Frame Format

0s			15s			90s		105s	
Time	Page #	Subframe 1		Subframe 2			Subframe 7		Subframe 8
0s	1	Ephemeris & Clock corr	16	Ephemeris & Clock corr		91	Ephemeris & Clock corr	106	Ephemeris & Clock corr
1s	2	Ionospheric & UTC con.	17	Ionospheric & UTC con.		92	Ionospheric & UTC con.	107	Ionospheric & UTC con.
2s	3	Almanac data (1)	18	Almanac data (2)		93	Almanac data (7)	108	
3s	4	Spare	19	Spare		94	Spare	109	Spare
4s	5		20			95		110	
5s	6		21			96		111	
6s	7		22			97		112	
7s	8		23			98		113	
8s	9		24			99		114	
9s	10		25			100		115	
10s	11		26			101		116	
11s	12		27			102		117	
12s	13		28			103		118	
13s	14		29			104		119	
14s	15		30			105		120	
		One Frame on E6-B			...				

8.5.5 E1-A Frame Format

Table 44: E1-A Navigation Message Data Frame Format

0s			*25s*			*550s*		*575s*	
Time	Page #	Subframe 1	Page #	Subframe 2		Page #	Subframe 23	Page #	Subframe 24
0.0 s	1	Ephemeris (packets 1…4)	11	Ephemeris, Clock correction, Iono correction (packets 5…8)		221	Ephemeris (packets 1…4)	231	Ephemeris, Clock correction, Iono correction (packets 5…8)
2.5 s	2		12			222		232	
5.0 s	3		13			223		233	
7.5 s	4		14			224		234	
10.0 s	5	Time ref + etc (packets 3 + 4)	15	Time ref + etc (packets 1 + 2)		225	Time ref + etc (packets 3 + 4)	235	Time ref + etc (packets 1 + 2)
12.5 s	6		16			226		236	
15.0 s	7	See additional description	17	See additional description		227	See additional description	237	See additional description
17.5 s	8		18			228		238	
20.0 s	9		19			229		239	
22.5 s	10		20			230		240	
		One frame on		**E1-A**	…				

Table 45: Additional description to table 44

Page #	Subframe 1	Page #	Subframe 2	Page #	Subframe 3	Page #	Subframe 4
7	Almanac S/C 31	17	Almanac S/C 34	27	Spare	37	Spare
8	Almanac S/C 32	18	Almanac S/C 35	28	Spare	38	Spare
9	Almanac S/C 33	19	Almanac S/C 36	29	Spare	39	Spare
10	Spare	20	Spare	30	Spare	40	Spare
	Subframe 5		Subframe 6		Subframe 7		Subframe 8
47	Spare	57	Spare	67	Spare	77	Spare
48	Spare	58	Spare	68	Spare	78	Spare
49	Spare	59	Spare	69	Spare	79	Spare
50	Spare	60	Spare	70	Spare	80	Spare
	Subframe 9		Subframe 10		Subframe 11		Subframe 12
87	Spare	97	Spare	107	Spare	117	Spare
88	Spare	98	Spare	108	Spare	118	Spare
89	Spare	99	Spare	109	Spare	119	Spare
90	Spare	100	Spare	110	Spare	120	Spare
	Subframe 13		Subframe 14		Subframe 15		Subframe 16
127	Orbital Parameters Plane 1	137	Orbital Parameters Plane 2	147	Almanac S/C 1	157	Almanac S/C 4
128		138	Orbital Parameters Plane 3	148	Almanac S/C 2	158	Almanac S/C 5
129	Orbital Parameters Plane 2	139		1149	Almanac S/C 3	159	Almanac S/C 6
130	Spare	140	Spare	150	Spare	160	Spare
	Subframe 17		Subframe 18		Subframe 19		Subframe 20
167	Almanac S/C 7	177	Almanac S/C 10	187	Almanac S/C 13	207	Almanac S/C 16
168	Almanac S/C 8	178	Almanac S/C 11	188	Almanac S/C 14	208	Almanac S/C 17
169	Almanac S/C 9	179	Almanac S/C 12	189	Almanac S/C 15	209	Almanac S/C 18
170	Spare	180	Spare	190	Spare	200	Spare
	Subframe 21		Subframe 22		Subframe 23		Subframe 24
207	Almanac S/C 19	217	Almanac S/C 22	227	Almanac S/C 25	237	Almanac S/C 28
208	Almanac S/C 20	218	Almanac S/C 23	228	Almanac S/C 26	238	Almanac S/C 29
209	Almanac S/C 21	219	Almanac S/C 24	229	Almanac S/C 27	239	Almanac S/C 30
210	Spare	220	Spare	230	Spare	240	Spare

8.5.6 E1-B Frame Format

Table 46: E1-B Navigation Message Data Frame Format

0s			*25s*			*550s*		*575s*	
Time	Page #	Subframe 1	Page #	Subframe 2		Page #	Subframe 23	Page #	Subframe 24
0 s	1	Ephemeris (packets 1…4)	26	Ephemeris, Clock correction, Iono correction (packets 5…8)		551	Ephemeris (packets 1…4)	576	Ephemeris, Clock correction, Iono correction (packets 5…8)
1 s	2		27			552		577	
2 s	3		28			553		578	
3 s	4		29			554		579	
4 s	5	Time ref + etc (packets 3 + 4)	30	Time ref + etc (packets 1 + 2)		555	Time ref + etc (packets 3 + 4)	580	Time ref + etc (packets 1 + 2)
5 s	6		31			556		581	
6 s	7	Spare	32	Spare		557	Spare	582	Spare
7 s	8		33			557		583	
…	…	…	…	…		…	…	…	…
18 s	19		44			569		594	
19 s	20		45			570		595	
20 s	21	See additional descritption	46	See additional description		571	See additional descritption	596	See additional description
21 s	22		47			572		597	
22 s	23		48			573		598	
23 s	24		49			574		599	
24 s	25		50			575		600	
		One frame on E1-B			…				

Table 47: Additional description to table 46

Page #	Subframe 1	Page #	Subframe 2	Page #	Subframe 3	Page #	Subframe 4
21	Almanac S/C 31	46	Almanac S/C 34	71	Spare	96	Spare
22	Almanac S/C 32	47	Almanac S/C 35	72	Spare	97	Spare
23	Almanac S/C 33	48	Almanac S/C 36	73	Spare	98	Spare
24	Spare	49	Spare	74	Spare	99	Spare
25	Spare	50	Spare	75	Spare	100	Spare
	Subframe 5		Subframe 6		Subframe 7		Subframe 8
121	Spare	146	Spare	171	Spare	196	Spare
122	Spare	147	Spare	172	Spare	197	Spare
123	Spare	148	Spare	173	Spare	198	Spare
124	Spare	149	Spare	174	Spare	199	Spare
125	Spare	150	Spare	175	Spare	200	Spare
	Subframe 9		Subframe 10		Subframe 11		Subframe 12
221	Spare	246	Spare	271	Spare	296	Spare
222	Spare	247	Spare	272	Spare	297	Spare
223	Spare	248	Spare	273	Spare	298	Spare
224	Spare	249	Spare	274	Spare	299	Spare
225	Spare	250	Spare	275	Spare	300	Spare
	Subframe 13		Subframe 14		Subframe 15		Subframe 16
321	Orbital Parameters Plane 1	346	Orbital Parameters Plane 2	371	Almanac S/C 1	396	Almanac S/C 4
322		347	Orbital Parameters Plane 3	372	Almanac S/C 2	397	Almanac S/C 5
323	Orbital Parameters Plane 2	348		373	Almanac S/C 3	398	Almanac S/C 6
324	Spare	349	Spare	374	Spare	399	Spare
325	Spare	350	Spare	375	Spare	400	Spare
	Subframe 17		Subframe 18		Subframe 19		Subframe 20
421	Almanac S/C 7	446	Almanac S/C 10	471	Almanac S/C 13	496	Almanac S/C 16
422	Almanac S/C 8	447	Almanac S/C 11	472	Almanac S/C 14	497	Almanac S/C 17
423	Almanac S/C 9	448	Almanac S/C 12	473	Almanac S/C 15	498	Almanac S/C 18
424	Spare	449	Spare	474	Spare	499	Spare
425	Spare	450	Spare	475	Spare	500	Spare
	Subframe 21		Subframe 22		Subframe 23		Subframe 24
521	Almanac S/C 19	546	Almanac S/C 22	571	Almanac S/C 25	596	Almanac S/C 28
522	Almanac S/C 20	547	Almanac S/C 23	572	Almanac S/C 26	597	Almanac S/C 29
523	Almanac S/C 21	548	Almanac S/C 24	573	Almanac S/C 27	598	Almanac S/C 30
524	Spare	549	Spare	574	Spare	599	Spare
525	Spare	550	Spare	575	Spare	600	Spare

8.6 Message Mapping to Navigation Signal Components

Table 48: Message Mapping

GIOVE		Message Data Content
Nav. signal component		*Navigation*
E5b-I	E1-B	✓
E6-B		✓ (GIOVE-A specific)
E6-A	E1-A	✓