GPS signal structure

- Two services are available in the current GPS system:

- SPS: The Standard Positioning Service is an open service, free of charge for worldwide users. It is a single-frequency service in the frequency band L1.
- PPS: The Precise Positioning Service is restricted by cryptographic techniques to military and authorized users. Two navigation signals are provided in two different frequency bands, L1 and L2.
- The GPS uses the CDMA technique to send different signals on the same radio frequency, and the modulation method used is Binary Phase Shift Keying (BPSK)

- GPS employs sinusoidal signal with frequency 1575.42 and 1227.60 MHz as its two carriers.
- Each satellite transmits the same navigation signal at these two frequencies. They are coherently selected multiples of a 10.23-MHz master clock, derived from an atomic standard.

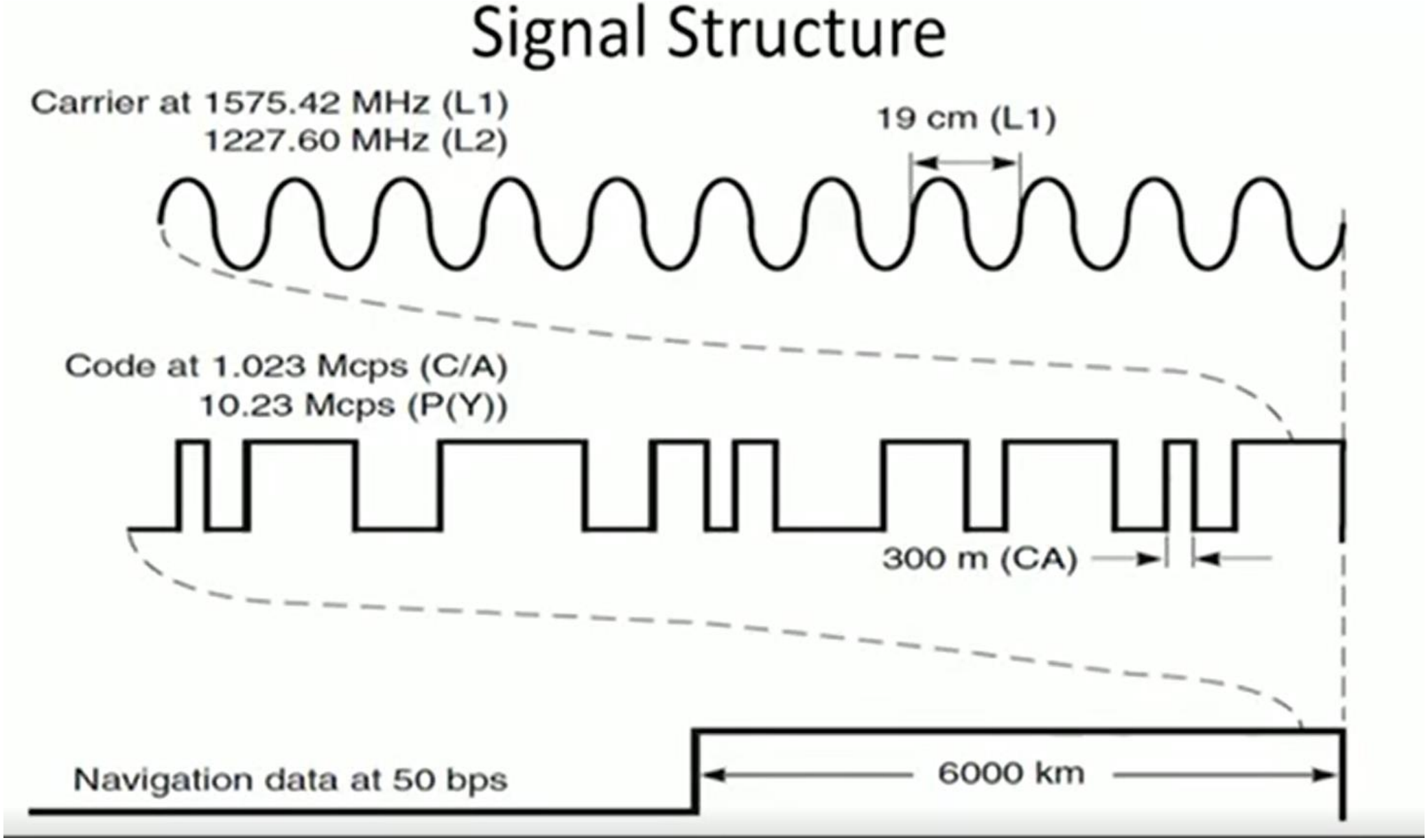
Components of GPS Signal

- Carrier
- Ranging Code
- Navigation Data

Carrier f(t)

Ranging Code C(t)

Navigation Data D(t)

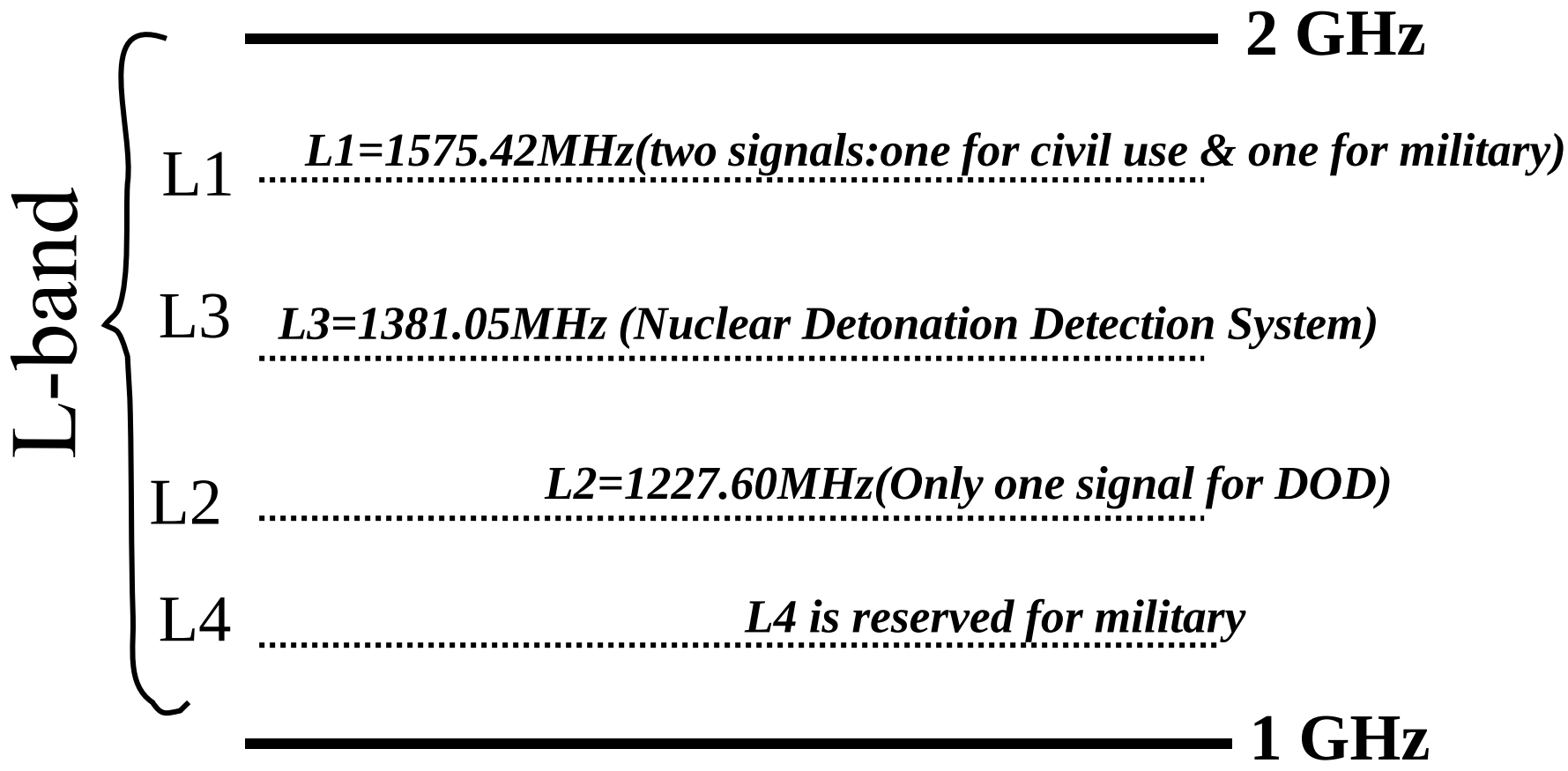


- Carrier: RF sinusoidal signal with frequency fL1 or fL2.
- Ranging code: PRN code assigned to each satellite allows receiver to determine signal transit time.
- Navigation data: a binary coded message consisting of data on the satellite health status, ephemeris, clock bias parameters, SVs constellation almanac etc.

Carrier frequency selection criteria

Performance parameter	UHF (300MHz-1GHz)	L-band (1-2GHz)	C-band (4-6GHz)
Path Loss for omni directional antenna $\sim f^2$	Lowest of three	**Acceptable**	Path loss≈10dB larger than at L-band
Ionospheric group delay $\Delta R \approx 1/f^2$	Large group delay,20-1500ns	**2-150ns at 1.5GHz**	≈0-15ns

Carrier


2 GHz
L-band
L1
L1=1575.42MHz(two signals:one for civil use & one for military)
L3
L3=1381.05MHz (Nuclear Detonation Detection System)
L2
L2=1227.60MHz(Only one signal for DOD)
L4
L4 is reserved for military
1 GHz

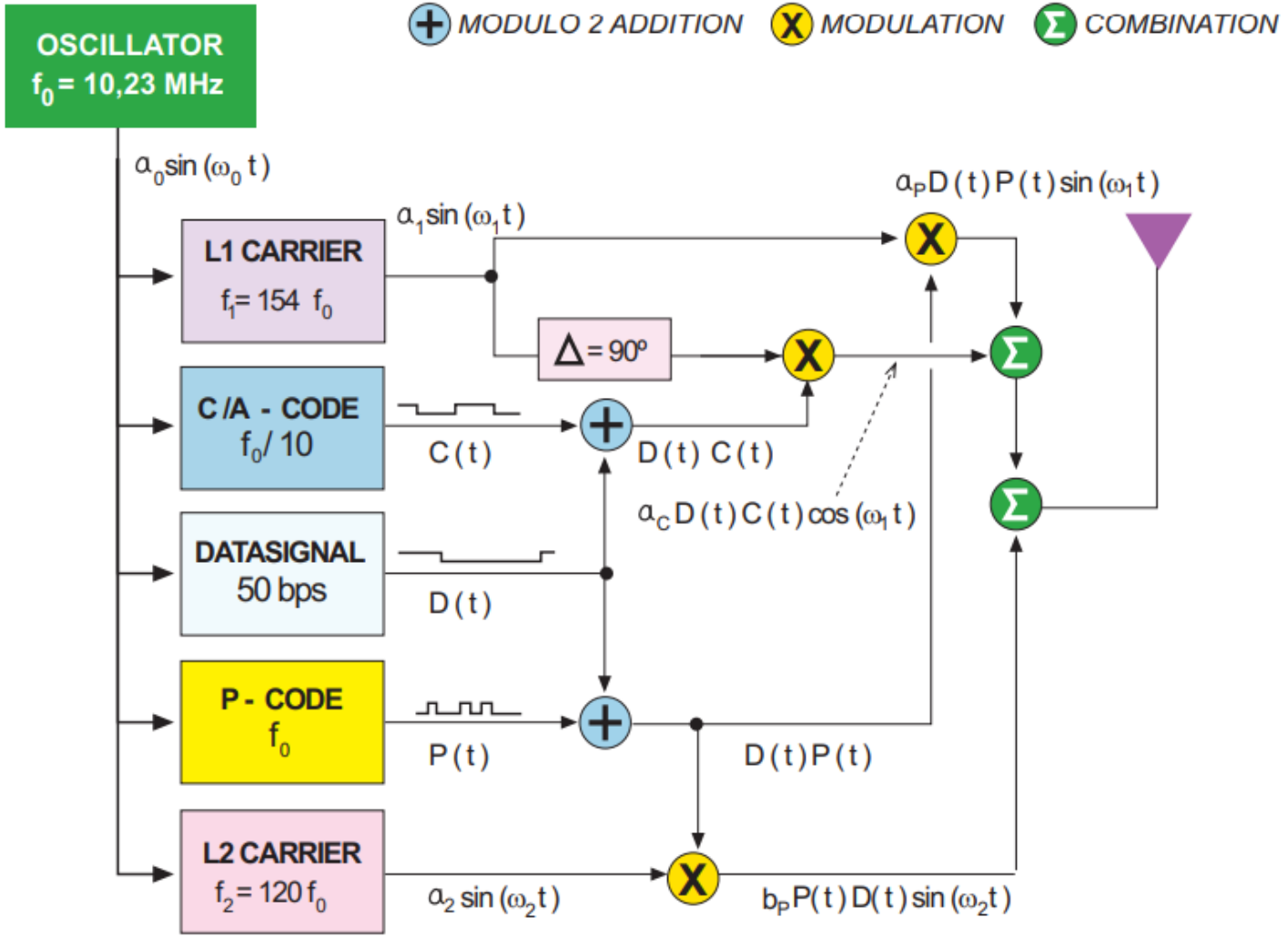


Figure 1: Legacy GPS signal structure (source [Seeber, 1993]).

Table 1: Legacy GPS signal structure

Atomic clock frequency	$f_0 = 10.23$ MHz
Frequency L1	$154 \times f_0$
	1575.420 MHz
Wavelength L1	19.03 cm
Frequency L2	$120 \times f_0$
	1227.600 MHz
Wavelength L2	24.42 cm
P code frequency (chipping rate)	$f_0 = 10.23$ MHz (Mbps)
P code wavelength	29.31 m
P code period	266 days, 7 days/satellite
C/A code frequency (chipping rate)	$f_0/10 = 1.023$ MHz
C/A code wavelength	293.1 m
C/A code period	1 ms
Navigation message frequency	50 bps
Frame length	30 s
Total message length	12.5 min

Ranging Codes (or) PRN Codes

C/A Code

- The C/A ranging codes are meant for civil users.
- These are short codes with a period of 1023 bits.
- The chip rate is 1.023 MHz, so sequence is of 1-ms duration.
- Short code permits rapid acquisition.
- Gold codes: formed by the products of two equal period 1023 bits PN codes.
- **chip λ= 300m**

P Code

- It is meant for authorized users only.
- It is a long code.
- Chip rate is 10.23 MHz, i.e., 10 times faster than C/A.
- It is a product of two PN codes, X1 and X2.
- X1 has a sequence of 15,345,000 chips and X2 has a sequence of 15,345,037 chips.
- The P code has a period of around 38 weeks.
- In GPS, P code is reset every Saturday/Sunday midnight, so that the period of truncated sequence is one week.
- The P code is difficult to acquire without acquisition aids.
- **Chip λ = 30m**

Navigation Data

Navigation data is formatted into:

a) **Master-frames**

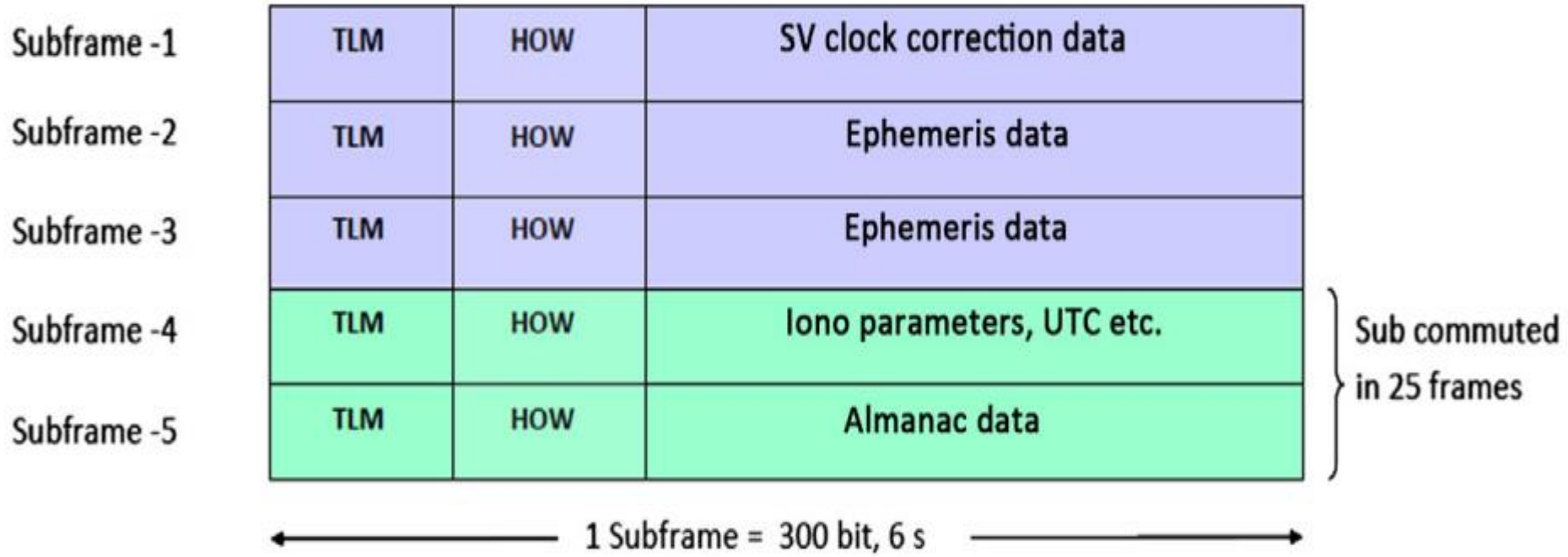
b) **Frames**

c) **Sub-frames**

- The duration of Master-Frame is 12.5 min (1500*25 bits).
- Each Master-Frame is subdivided into 25 Frames, each with 30 sec (1500 bits) duration.
- Each Frame is sub divided into 5 sub-frames, each of which lasts 6 sec (ten 30-bit words).

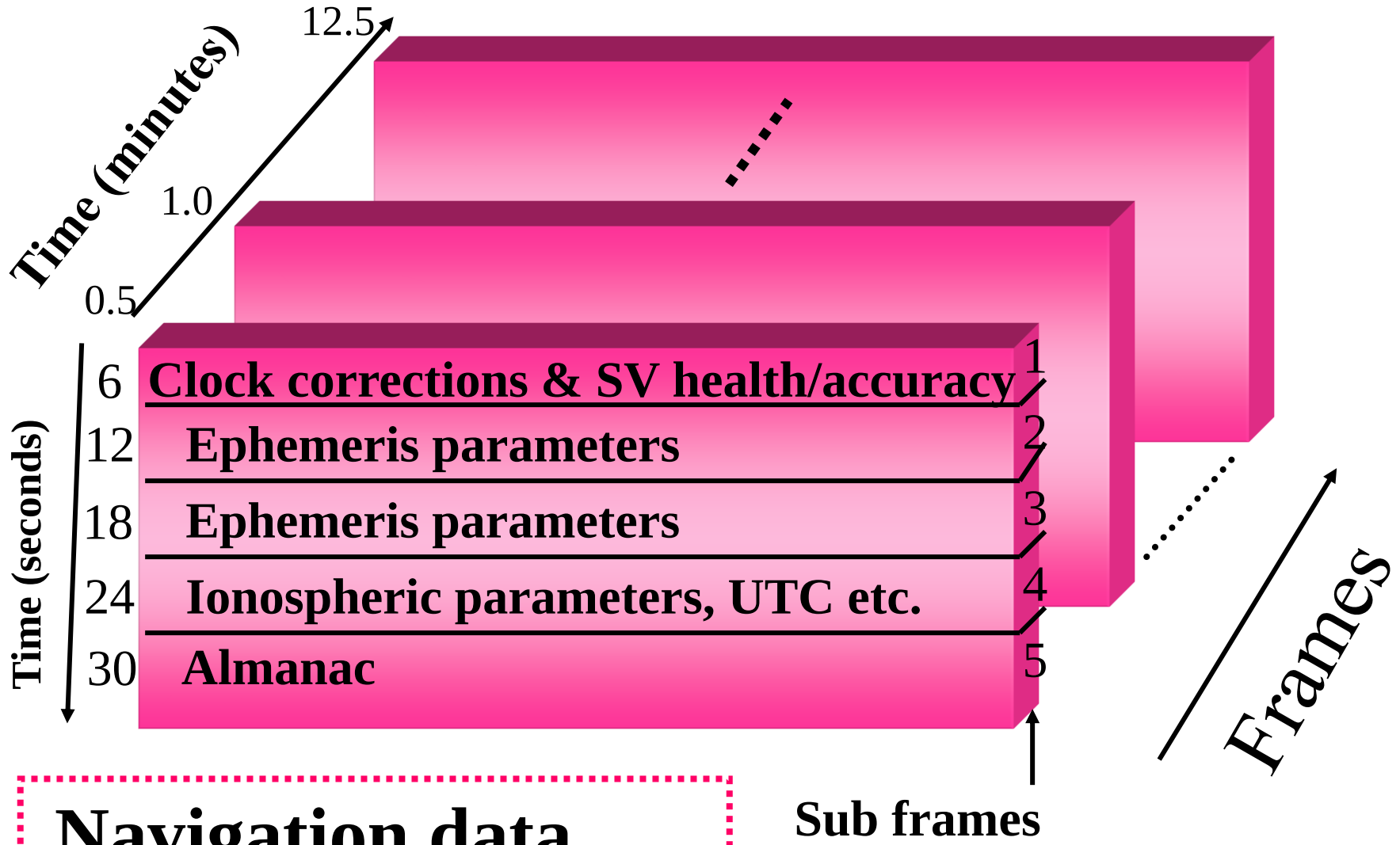
Navigation data

- Navigation data message rate is 50 bits/sec.
- Each bit is 20ms long.
- Subframes 1-3 repeat same info from frame to frame
- Subframes 4-5 contain different pages of the navigation message.
- It takes 25 frames (=One Master frame=12.5min) to transmit the complete navigation message.



- Word 1 and 2 have the same format in every subframe.
- Word 1 is the telemetry word. Its first 8 bits constitute the preamble 10,001,011 (8BH) and the rest is the telemetry data.
- Word 2 is the handover word and contains the truncated Z count that indicates the time of end of the subframe in quantum of 1.5 s.

- Sub frames 1,2 and 3 repeat every .5 min
- Sub frames 4 and 5 repeat every 12.5min.
- Sub frames 1,2 and 3 are specific to the transmitting satellites
- Sub frames 4 and 5 are common to all satellites.



Navigation data

Any Questions?