Table 2-3. Subframe 1 Reserved Data Fields

Word	Bits
3	11-12
4	1-24
5	1-24
6	1-24
7	1-16

2.4.4 Subframes 2 and 3 - Satellite Ephemeris Data

Subframes 2 and 3 contain the ephemeris representation parameters of the transmitting satellite.

2.4.4.1 Ephemeris Parameters

Table 2-4 gives the definition of the orbital parameters using terminology typical of Keplerian orbital parameters; it is noted, however, that the transmitted parameter values are expressed in a coordinate system which allows the best trajectory fit in Earth fixed coordinates for each specific fit interval. The user will not interpret intermediate coordinate values as pertaining to any conventional or stable coordinate system.

For each parameter contained in subframe 2 and 3, the number of bits, the scale factor of the LSB (which is the last bit received), the range, and the units are as specified in Table 2-5.

Table 2-4. Ephemeris Data Definitions

M_0	Mean Anomaly at Reference Time
Δn	Mean Motion Difference from Computed Value
e	Eccentricity
$(A)^{1/2}$	Square Root of the Semi-Major Axis
$(OMEGA)_0$	Longitude of Ascending Node of Orbit Plane at Weekly Epoch
i_0	Inclination Angle at Reference Time
ω	Argument of Perigee
OMEGADOT	Rate of Right Ascension
IDOT	Rate of Inclination Angle
C_{uc}	Amplitude of the Cosine Harmonic Correction Term to the Argument of Latitude
C_{us}	Amplitude of the Sine Harmonic Correction Term to the Argument of Latitude
C_{rc}	Amplitude of the Cosine Harmonic Correction Term to the Orbit Radius
C_{rs}	Amplitude of the Sine Harmonic Correction Term to the Orbit Radius
C_{ic}	Amplitude of the Cosine Harmonic Correction Term to the Angle of Inclination
C_{is}	Amplitude of the Sine Harmonic Correction Term to the Angle of Inclination
t_{oe}	Reference Time Ephemeris
IODE	Issue of Data (Ephemeris)

2.4.4.2 Issue of Data, Ephemeris

The Issue of Data, Ephemeris (IODE) is an 8 bit number equal to the 8 LSBs of the 10 bit IODC of the same data set. The issue of ephemeris data (IODE) term will provide the user with a convenient means for detecting any change in the ephemeris representation parameters. The IODE is provided in both subframes 2 and 3 for the purpose of comparison with the 8 LSBs of the IODC term in subframe 1. Whenever these three terms do not match, a data set cutover has occurred and new data must be collected. The transmitted IODE will be different from any value transmitted by the satellite during the preceding six hours.

Table 2-5. Ephemeris Parameters

Parameter	No. of Bits	Scale Factor (LSB)	Effective Range***	Units
IODE	8			(see text)
C_{rs}	16*	2^{-5}		meters
Δn	16*	2^{-43}		semi-circles/sec
M_0	32*	2^{-31}		semi-circles
C_{uc}	16*	2^{-29}		radians
e	32	2^{-33}	0.03	dimensionless
C_{us}	16*	2^{-29}		radians
$(A)^{1/2}$	32	2^{-19}		$\text{meters}^{1/2}$
t_{oe}	16	2^4	604,784	seconds
C_{ic}	16*	2^{-29}		radians
$(\text{OMEGA})_0$	32*	2^{-31}		semi-circles
C_{is}	16*	2^{-29}		radians
i_0	32*	2^{-31}		semi-circles
C_{rc}	16*	2^{-5}		meters
ω	32*	2^{-31}		semi-circles
OMEGADOT	24*	2^{-43}		semi-circles/sec
IDOT	14*	2^{-43}		semi-circles/sec

* Parameters so indicated are two's complement, with the sign bit (+ or -) occupying the MSB;
** See Figure 2-8 for complete bit allocation in subframe;
*** Unless otherwise indicated in this column, effective range is the maximum range attainable with indicated bit allocation and scale factor.

Any change in the subframe 2 and 3 data will be accomplished in concert with a change in both IODE words. Cutovers to new data sets will occur only on hour boundaries except for the first data set of a new upload. The first data set may be cut-in (reference paragraph 2.4.1.1) at any time during the hour and therefore may be transmitted by the satellite for less than one hour. Additionally, the t_{oe} value, for at least the first data set transmitted by an satellite after an upload, will be different from that transmitted prior to the cutover.

2.4.4.3 Spare and Reserved Data Fields

Table 2-6 provides the locations of spare and reserved data fields within subframe 2. All spare and reserved data fields support valid parity within their respective words. Contents of spare data fields are alternating ones and zeros until they are allocated for a new function. Users are cautioned that the contents of spare data fields can change without warning.

Table 2-6. Subframe 2 Spare and Reserved Data Fields

Word	Bits	Status
10	17	Reserved
10	18-22	Spare

2.4.5 Subframes 4 and 5 - Support Data

Both subframes 4 and 5 are subcommutated 25 times each; the 25 versions of these subframes are referred to as pages 1 through 25 of each subframe. With the possible exception of "spare" pages and explicit repeats, each page contains different data in words three through ten. As shown in Figure 2-8, the pages of subframe 4 use six different formats, while those of subframe 5 use two.

A brief summary of the various data contained in each page of subframes 4 and 5 is as follows:

Table 2-15. Elements of Coordinate Systems

$A = \left(\sqrt{A}\right)^2$	Semi-major axis
$n_0 = \sqrt{\dfrac{\mu}{A^3}}$	Computed mean motion - rad/sec
$t_k = t - t_{oe}$*	Time from ephemeris reference epoch
$n = n_0 + \Delta n$	Corrected mean motion
$M_k = M_0 + nt_k$	Mean anomaly
$M_k = E_k - e \sin E_k$	Kepler's equation for eccentric anomaly (may be solved by iteration) - radians
$\nu_k = \tan^{-1}\left\{\dfrac{\sin\nu_k}{\cos\nu_k}\right\} = \tan^{-1}\left\{\dfrac{\sqrt{1-e^2}\sin E_k \,/\, (1 - e\cos E_k)}{(\cos E_k - e) \,/\, (1 - e\cos E_k)}\right\}$	True anomaly
$E_k = \cos^{-1}\left\{\dfrac{e + \cos\nu_k}{1 + e\cos\nu_k}\right\}$	Eccentric anomaly
$\Phi_k = \nu_k + \omega$	Argument of latitude
	<u>Second Harmonic Perturbations</u>
$\delta u_k = C_{us} \sin 2\Phi_k + C_{uc} \cos 2\Phi_k$	Argument of latitude correction
$\delta r_k = C_{rc} \cos 2\Phi_k + C_{rs} \sin 2\Phi_k$	Radius correction
$\delta i_k = C_{ic} \cos 2\Phi_k + C_{is} \sin 2\Phi_k$	Correction to inclination
$u_k = \Phi_k + \delta u_k$	Corrected argument of latitude
$r_k = A(1 - e\cos E_k) + \delta r_k$	Corrected radius
$i_k = i_0 + \delta i_k + (\text{IDOT})\, t_k$	Corrected inclination
$\left.\begin{array}{l} x_k' = r_k \cos u_k \\ y_k' = r_k \sin u_k \end{array}\right\}$	Positions in orbital plane
$\Omega_k = \Omega_0 + \left(\dot{\Omega} - \dot{\Omega}_e\right) t_k - \dot{\Omega}_e t_{oe}$	Corrected longitude of ascending node
$\left.\begin{array}{l} x_k = x_k' \cos\Omega_k - y_k' \cos i_k \sin\Omega_k \\ y_k = x_k' \sin\Omega_k + y_k' \cos i_k \cos\Omega_k \\ z_k = y_k' \sin i_k \end{array}\right\}$	Earth-Centered, Earth-Fixed coordinates

* t is GPS system time at time of transmission, i.e., GPS time corrected for transit time (range/speed of light). Furthermore, t_k shall be the actual total time difference between the time t and the epoch time t_{oe}, and must account for beginning or end of week crossovers. That is, if t_k is greater than 302,400 seconds, subtract 604,800 seconds from t_k. If t_k is less than -302,400 seconds, add 604,800 seconds to t_k.