CHANGE NOTICE

Affected Document:	IRN/SCN Number	Date:
IS-GPS-705 Rev F	IRN-IS-705F-003	25-SEP-2019
Authority:	**Proposed Change Notice**	**Date:**
RFC-00395	PCN-IS-705F_RFC395	12-APR-2019

CLASSIFIED BY: N/A
DECLASSIFY ON: N/A

Document Title: NAVSTAR GPS Space Segment/User Segment L5 Interfaces

RFC Title: 2019 Public Documents Proposed Changes

Reason For Change (Driver):

1. IS-GPS-705 identifies dual frequency users as “L1/L2” and “L1/L5 (recommended)”. Users may interpret frequency pair (L2/L5) as a viable dual frequency; that is not recommended.
2. The user implementation community has identified equations in the Elements of Coordinates Systems tables in documents ICD-GPS-700 (non-public), IS-GPS-200, IS-GPS-705, and IS-GPS-800 that can benefit from an improvement.
3. ~~Documents IS-GPS-200, IS-GPS-705, IS-GPS 800, and ICD-GPS-700 (non-public) are not consistent in their definition of when to broadcast CNAV UTC data. These documents need to be made consistent.~~
4. ICD-GPS-870 Appendices 1-6 currently define an ASCII format for public release GPS products, the legacy format. The ICD states that modernized formats in XML will be defined. The ICD does not specifically call the current format legacy nor does it have placeholders for the modernized formats. Stakeholders could incorrectly assume that the ASCII format is the modernized format.
5. ICD-GPS-870 Appendices OCX provides a utility to convert modernized GPS products to the legacy, AEP-formatted GPS products. The legacy formats are characterized with default filenames, which are important for the public user community to interpret and process the GPS products. However, these default filenames are not described in ICD-GPS-870.
6. Public documents need clarification and clean-up, as identified in past Public ICWGs and as newly-identified changes of administrative nature.
7. Currently the Operational Advisories (OAs) that are published and archived contain plane/slot descriptions that are not in the constellation definition provided to the public in the SPS Performance Standard as well as the data provided by the National Geospatial-Intelligence Agency (NGA) (refer to http://earth-info.nga.mil/GandG/sathtml/satinfo.html). The OA does not have the capability to correctly publish information regarding fore/aft position since moving to the 24+3 constellation with three expanded slots. (Moved from RFC-374)

Description of Change:

1. In IS-GPS-705, state operational use of the group of signals (L2/L5) is at the users own risk.
2. Recommend a different, less complicated kinematic formulation that improves the equations in the Elements of Coordinate Systems tables in the Signal in Space (SiS) documents.
3. No change was needed.
4. Deferred for future RFC.
5. ICD-GPS-870 stakeholders are relying on the default filenames used by AEP for their equivalent files. ICD-GPS-870 does not capture the default filenames. Need to document the default filenames to support stakeholders.
6. Provide clarity and clean up identified administrative changes in all public documents.
7. This topic was originally addressed in RFC-374 but needs to be re-addressed in order to update ICD-GPS-870 such that OCX produces an OA with section one set to the original data or set to “RESERVED.”

Authored By: RE: Anthony Flores **Checked By: RE: Jennifer Lemus**

AUTHORIZED SIGNATURES	REPRESENTING	DATE
	GPS Directorate Space & Missile Systems Center (SMC) – LAAFB	

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CODE IDENT 66RP1

IS705-13 :

Section Number :
2.1.0-4

WAS :
Other Publications

IS-GPS-200 current issue	Navstar GPS Space Segment / Navigation User Interfaces
GP-03-001 current issue	GPS Interface Control Working Group (ICWG) Charter

Redlines :
Other Publications

IS-GPS-200 current issue	Navstar GPS Space Segment / Navigation User Interfaces
GP-03-001 current issue	~~GPS Interface Control Working Group (ICWG) Charter~~ GPS Adjudication Working Group (AWG) and Rough Order of Magnitude (ROM)/ Impact Assessment (IA) Charter

IS :
Other Publications

IS-GPS-200 current issue	Navstar GPS Space Segment / Navigation User Interfaces
GP-03-001 current issue	GPS Adjudication Working Group (AWG) and Rough Order of Magnitude (ROM)/ Impact Assessment (IA) Charter

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IS705-54 :

Section Number :
3.3.1.6.0-2

WAS :
The GPS III SV shall provide L5 signals with the following characteristic: the L5 off-axis relative power (referenced to peak transmitted power) shall not decrease by more than 2 dB from the Edge-of-Earth (EOE) to nadir, and no more than 18 dB from EOE to 26 degrees off nadir; the power drop off between EOE and ±26 degrees shall be in a monotonically decreasing fashion.

Redlines :
The GPS III and GPS IIIF SV shall provide L5 signals with the following characteristic: the L5 off-axis relative power (referenced to peak transmitted power) shall not decrease by more than 2 dB from the Edge-of-Earth (EOE) to nadir, and no more than 18 dB from EOE to 26 degrees off nadir; the power drop off between EOE and ±26 degrees shall be in a monotonically decreasing fashion.

IS :
The GPS III and GPS IIIF SV shall provide L5 signals with the following characteristic: the L5 off-axis relative power (referenced to peak transmitted power) shall not decrease by more than 2 dB from the Edge-of-Earth (EOE) to nadir, and no more than 18 dB from EOE to 26 degrees off nadir; the power drop off between EOE and ±26 degrees shall be in a monotonically decreasing fashion.

IS705-56 :

Section Number :
3.3.1.6.0-6

WAS :
Table 3-III.

SV	Signal	
	I5	Q5
Block IIF	-157.9 dBW	-157.9 dBW
GPS III	-157.0 dBW	-157.0 dBW

Redlines :
Table 3-III.

SV	Signal	
	I5	Q5
Block IIF	-157.9 dBW	-157.9 dBW
GPS III/IIIF	-157.0 dBW	-157.0 dBW

IS :
Table 3-III.

SV	Signal	
	I5	Q5
Block IIF	-157.9 dBW	-157.9 dBW
GPS III/IIIF	-157.0 dBW	-157.0 dBW

IS705-1586 :

Section Number :
3.3.1.6.1.0-2

WAS :
Table 3-IV. Space Service Volume (SSV) Received Minimum RF Signal Strength for GPS III and Subsequent Satellites over the Bandwidth Specified in 3.3.1.1 – GEO Based Antennas

Redlines :
Table 3-IV. Space Service Volume (SSV) Received Minimum RF Signal Strength for GPS III, GPS IIIF, and Subsequent Satellites over the Bandwidth Specified in 3.3.1.1 – GEO Based Antennas

IS :
Table 3-IV. Space Service Volume (SSV) Received Minimum RF Signal Strength for GPS III, GPS IIIF, and Subsequent Satellites over the Bandwidth Specified in 3.3.1.1 – GEO Based Antennas

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IS705-119 :

Section Number :
6.2.2.2.0-1

WAS :
The operational satellites are designated Block IIA, Block IIR, Block IIRM, Block IIF and GPS III SVs. Characteristics of these SVs are provided below. These SVs transmit configuration codes as specified in paragraph 20.3.3.5.1.4 of IS-GPS-200. The navigation signal provides no direct indication of the type of the transmitting SV.

Redlines :
The operational satellites are designated Block IIA, Block IIR, Block IIRM, Block IIF, GPS III, and GPS ~~III~~IIIF SVs. Characteristics of these SVs are provided below. These SVs transmit configuration codes as specified in paragraph 20.3.3.5.1.4 of IS-GPS-200. The navigation signal provides no direct indication of the type of the transmitting SV.

IS :
The operational satellites are designated Block IIA, Block IIR, Block IIRM, Block IIF, GPS III, and GPS IIIF SVs. Characteristics of these SVs are provided below. These SVs transmit configuration codes as specified in paragraph 20.3.3.5.1.4 of IS-GPS-200. The navigation signal provides no direct indication of the type of the transmitting SV.

IS705-129 :

Section Number :
6.2.2.2.6.0-1

WAS :
See paragraph 6.2.2.2.6 of IS-GPS-200. The III operational SVs do broadcast the L5 signal.

Redlines :
See paragraph 6.2.2.2.6 of IS-GPS-200. The GPS III and GPS IIIF operational SVs do broadcast the L5 signal.

IS :
See paragraph 6.2.2.2.6 of IS-GPS-200. The GPS III and GPS IIIF operational SVs do broadcast the L5 signal.

IS705-1521 :

Section Number :
6.2.8.1-2

WAS :
Table 6-I-1.

Symbol	Parameter Name	Message
$\dot{A}$	Change Rate in Semi-major Axis	10
ΔA	Semi-major Axis Difference at Reference Time	10
Δn_0	Mean Motion Difference from Computed Value at Reference Time	10
$\Delta \dot{n}_0$	Rate of Mean Motion Difference from Computed Value	10
ω	Argument of Perigee	10
e	Eccentricity	10
ISF	Integrity Status Flag NOTE1	10
(L1/L2/L5)	Signal Health (3 bits)	10
M_0	Mean Anomaly at Reference Time	10
URA_{ED}	Elevation Dependent User Range Accuracy	10
WN_n	Week Number	10
t_{oe}	Time of Ephemeris	10, 11
t_{op}	CEI Data Sequence Propagation Time of Week	10, 30-37
$\dot{\Omega}$	Rate of Right Ascension	11
Ω_0	Longitude of Ascending Node of Orbit Plane at Weekly Epoch	11
C_{ic}	Amplitude of the Cosine Harmonic Correction Term to the Angle of Inclination	11
C_{is}	Amplitude of the Sine Harmonic Correction Term to the Angle of Inclination	11
C_{rc}	Amplitude of the Cosine Harmonic Correction Term to the Orbit Radius	11
C_{rs}	Amplitude of the Sine Correction Term to the Orbit Radius	11
C_{uc}	Amplitude of Cosine Harmonic Correction Term to the Argument of Latitude	11
C_{us}	Amplitude of Sine Harmonic Correction Term to the Argument of Latitude	11
i_0	Inclination Angle at Reference Time	11
$i_{0\text{-}n}$-DOT	Rate of Inclination Angle	11
$ISC_{L1C/A}$	Inter-signal Correction	30
ISC_{L2C}	Inter-signal Correction	30

Symbol	Parameter Name	Message
ISC_{L5I5}	Inter-signal Correction	30
ISC_{L5Q5}	Inter-signal Correction	30
T_{GD}	Group Delay Differential	30
a_{f0}	SV Clock Bias Correction Coefficient	30-37
a_{f1}	SV Clock Drift Correction Coefficient	30-37
a_{f2}	Drift Rate Correction Coefficient Index	30-37
t_{oc}	Time of Clock	30-37
URA_{NED0}	NED Accuracy Index	30-37
URA_{NED1}	NED Accuracy Change Index	30-37
URA_{NED2}	NED Accuracy Change Rate Index	30-37
Alert	Alert Flag [NOTE1]	All

NOTE1: Parameters so indicated are for CEI Refinement – not limited to curve fit. Parameters not indicated are needed for/limited to curve fit.
Updates to parameters in table shall prompt changes in t_{oe}/t_{oc}. Any parameter marked with NOTE1 may be changed with or without a change in t_{oe}/t_{oc}.

Redlines :
Table 6-I-1.

(See Week Number)

Symbol	Parameter Name	Message
$\dot{A}$	Change Rate in Semi-major Axis	10
ΔA	Semi-major Axis Difference at Reference Time	10
Δn_0	Mean Motion Difference from Computed Value at Reference Time	10
$\Delta \dot{n}_0$	Rate of Mean Motion Difference from Computed Value	10
ω	Argument of Perigee	10
e	Eccentricity	10
ISF	Integrity Status Flag NOTE1	10
(L1/L2/L5)	Signal Health (3 bits)	10
M_0	Mean Anomaly at Reference Time	10
URA_{ED}	Elevation Dependent User Range Accuracy	10
$WN_{\text{~~n~~}}$	Week Number	10
t_{oe}	Time of Ephemeris	10, 11
t_{op}	CEI Data Sequence Propagation Time of Week	10, 30-37
$\dot{\Omega}$	Rate of Right Ascension	11
Ω_0	Longitude of Ascending Node of Orbit Plane at Weekly Epoch	11
C_{ic}	Amplitude of the Cosine Harmonic Correction Term to the Angle of Inclination	11
C_{is}	Amplitude of the Sine Harmonic Correction Term to the Angle of Inclination	11
C_{rc}	Amplitude of the Cosine Harmonic Correction Term to the Orbit Radius	11
C_{rs}	Amplitude of the Sine Correction Term to the Orbit Radius	11
C_{uc}	Amplitude of Cosine Harmonic Correction Term to the Argument of Latitude	11
C_{us}	Amplitude of Sine Harmonic Correction Term to the Argument of Latitude	11
i_0	Inclination Angle at Reference Time	11
$i_{0\text{-}n}$-DOT	Rate of Inclination Angle	11
$ISC_{L1C/A}$	Inter-signal Correction	30
ISC_{L2C}	Inter-signal Correction	30
ISC_{L5I5}	Inter-signal Correction	30
ISC_{L5Q5}	Inter-signal Correction	30
T_{GD}	Group Delay Differential	30
a_{f0}	SV Clock Bias Correction Coefficient	30-37

Symbol	Parameter Name	Message
a_{f1}	SV Clock Drift Correction Coefficient	30-37
a_{f2}	Drift Rate Correction Coefficient Index	30-37
t_{oc}	Time of Clock	30-37
URA_{NED0}	NED Accuracy Index	30-37
URA_{NED1}	NED Accuracy Change Index	30-37
URA_{NED2}	NED Accuracy Change Rate Index	30-37
Alert	Alert Flag NOTE1	All
NOTE1: Parameters so indicated are for CEI Refinement – not limited to curve fit. Parameters not indicated are needed for/limited to curve fit. Updates to parameters in table shall prompt changes in t_{oe}/t_{oc}. Any parameter marked with NOTE1 may be changed with or without a change in t_{oe}/t_{oc}.		

IS :
Table 6-I-1.

Symbol	Parameter Name	Message
$\dot{A}$	Change Rate in Semi-major Axis	10
ΔA	Semi-major Axis Difference at Reference Time	10
Δn_0	Mean Motion Difference from Computed Value at Reference Time	10
$\Delta \dot{n}_0$	Rate of Mean Motion Difference from Computed Value	10
ω	Argument of Perigee	10
e	Eccentricity	10
ISF	Integrity Status Flag [NOTE1]	10
(L1/L2/L5)	Signal Health (3 bits)	10
M_0	Mean Anomaly at Reference Time	10
URA_{ED}	Elevation Dependent User Range Accuracy	10
WN	Week Number	10
t_{oe}	Time of Ephemeris	10, 11
t_{op}	CEI Data Sequence Propagation Time of Week	10, 30-37
$\dot{\Omega}$	Rate of Right Ascension	11
Ω_0	Longitude of Ascending Node of Orbit Plane at Weekly Epoch	11
C_{ic}	Amplitude of the Cosine Harmonic Correction Term to the Angle of Inclination	11
C_{is}	Amplitude of the Sine Harmonic Correction Term to the Angle of Inclination	11
C_{rc}	Amplitude of the Cosine Harmonic Correction Term to the Orbit Radius	11
C_{rs}	Amplitude of the Sine Correction Term to the Orbit Radius	11
C_{uc}	Amplitude of Cosine Harmonic Correction Term to the Argument of Latitude	11
C_{us}	Amplitude of Sine Harmonic Correction Term to the Argument of Latitude	11
i_0	Inclination Angle at Reference Time	11
$i_{0\text{-}n}$-DOT	Rate of Inclination Angle	11
$ISC_{L1C/A}$	Inter-signal Correction	30
ISC_{L2C}	Inter-signal Correction	30
ISC_{L5I5}	Inter-signal Correction	30
ISC_{L5Q5}	Inter-signal Correction	30
T_{GD}	Group Delay Differential	30
a_{f0}	SV Clock Bias Correction Coefficient	30-37

Symbol	Parameter Name	Message
a_{f1}	SV Clock Drift Correction Coefficient	30-37
a_{f2}	Drift Rate Correction Coefficient Index	30-37
t_{oc}	Time of Clock	30-37
URA_{NED0}	NED Accuracy Index	30-37
URA_{NED1}	NED Accuracy Change Index	30-37
URA_{NED2}	NED Accuracy Change Rate Index	30-37
Alert	Alert Flag NOTE1	All
NOTE1: Parameters so indicated are for CEI Refinement – not limited to curve fit. Parameters not indicated are needed for/limited to curve fit. Updates to parameters in table shall prompt changes in t_{oe}/t_{oc}. Any parameter marked with NOTE1 may be changed with or without a change in t_{oe}/t_{oc}.		

IS705-138 :

Section Number :
6.3.2.0-1

WAS :
As an aid to user equipment receiver designers, plots are provided (Figure 6-1 and Figure 6-2) of a typical GPS Block IIF and GPS III phase noise spectral density for the un-modulated L5 carrier.

Redlines :
As an aid to user equipment receiver designers, plots are provided (Figure 6-1 and Figure 6-2) of a typical GPS Block IIF, GPS III, and GPS ~~III~~IIIF phase noise spectral density for the un-modulated L5 carrier.

IS :
As an aid to user equipment receiver designers, plots are provided (Figure 6-1 and Figure 6-2) of a typical GPS Block IIF, GPS III, and GPS IIIF phase noise spectral density for the un-modulated L5 carrier.

IS705-1576 :

Section Number :
6.3.2.0-5

WAS :
Figure 6-2 Typical GPS III L5 Carrier Phase Noise Spectral Density

Redlines :
Figure 6-2 Typical GPS III and GPS IIIF L5 Carrier Phase Noise Spectral Density

IS :
Figure 6-2 Typical GPS III and GPS IIIF L5 Carrier Phase Noise Spectral Density

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IS705-141 :

Section Number :
6.3.3.0-1

WAS :
As an aid to user equipment receiver designers, a table is provided (Table 6-I) of a typical GPS Block IIF and GPS III ellipticity as a function of off-boresight angle.

Redlines :
As an aid to user equipment receiver designers, a table is provided (Table 6-I) of a typical GPS Block IIF, GPS III, and GPS ~~III~~IIIF ellipticity as a function of off-boresight angle.

IS :
As an aid to user equipment receiver designers, a table is provided (Table 6-I) of a typical GPS Block IIF, GPS III, and GPS IIIF ellipticity as a function of off-boresight angle.

IS705-1386 :

Section Number :
20.3.2.0-3

WAS :
Block IIF SVs have the capability of storing at least 48 hours of CNAV navigation data, with current memory margins, to provide CNAV positioning service without contact from the CS for that period. GPS III SVs have the capability of providing up to 60 days of CNAV positioning service without contact from the CS. The timeframe is defined by the CS.

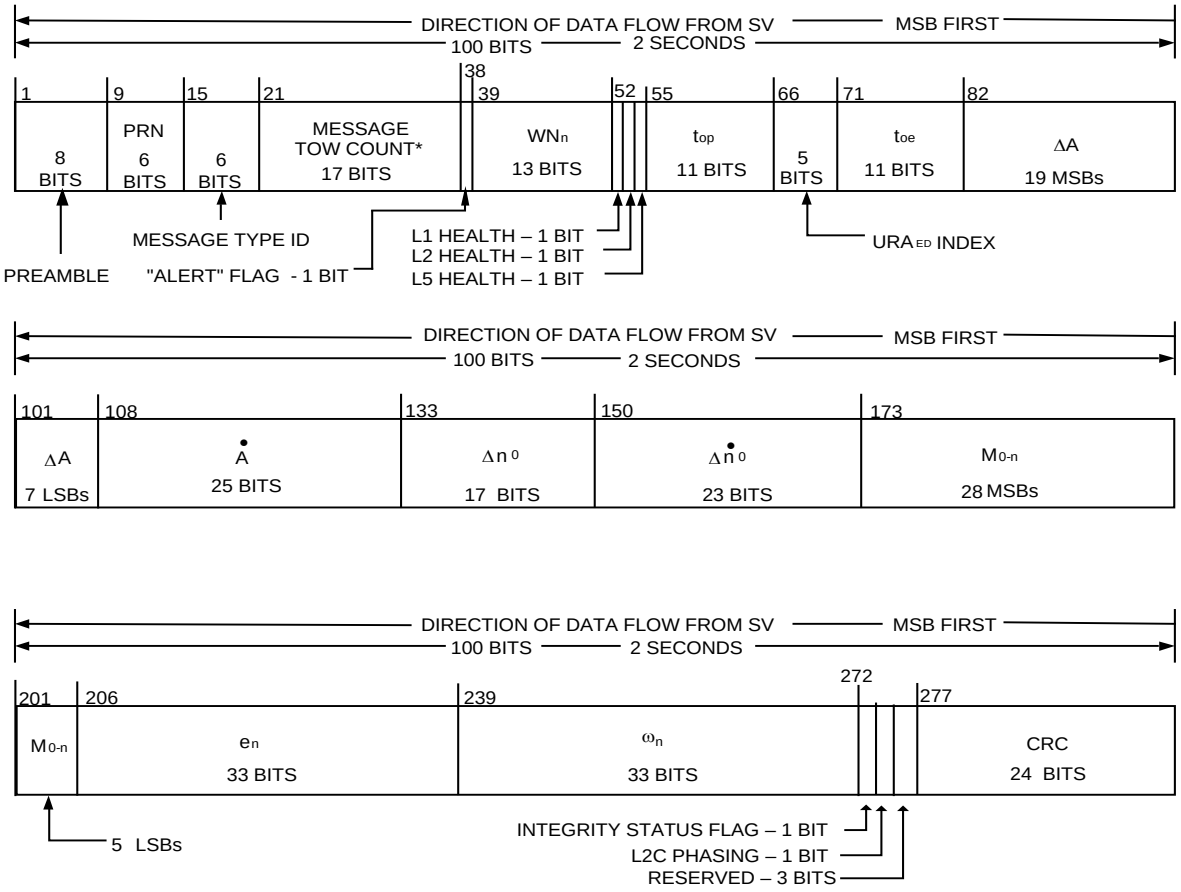
Redlines :
Block IIF SVs have the capability of storing at least 48 hours of CNAV navigation data, with current memory margins, to provide CNAV positioning service without contact from the CS for that period. GPS III and GPS IIIF SVs have the capability of providing up to 60 days of CNAV positioning service without contact from the CS. The timeframe is defined by the CS.

IS :
Block IIF SVs have the capability of storing at least 48 hours of CNAV navigation data, with current memory margins, to provide CNAV positioning service without contact from the CS for that period. GPS III and GPS IIIF SVs have the capability of providing up to 60 days of CNAV positioning service without contact from the CS. The timeframe is defined by the CS.

IS705-198 :

Section Number :
20.3.3.0-2

WAS :



* MESSAGE TOW COUNT = 17 MSB OF ACTUAL TOW COUNT AT START OF NEXT 6 SECOND MESSAGE

Figure 20-1. Message Type 10 - Ephemeris 1

Redlines :

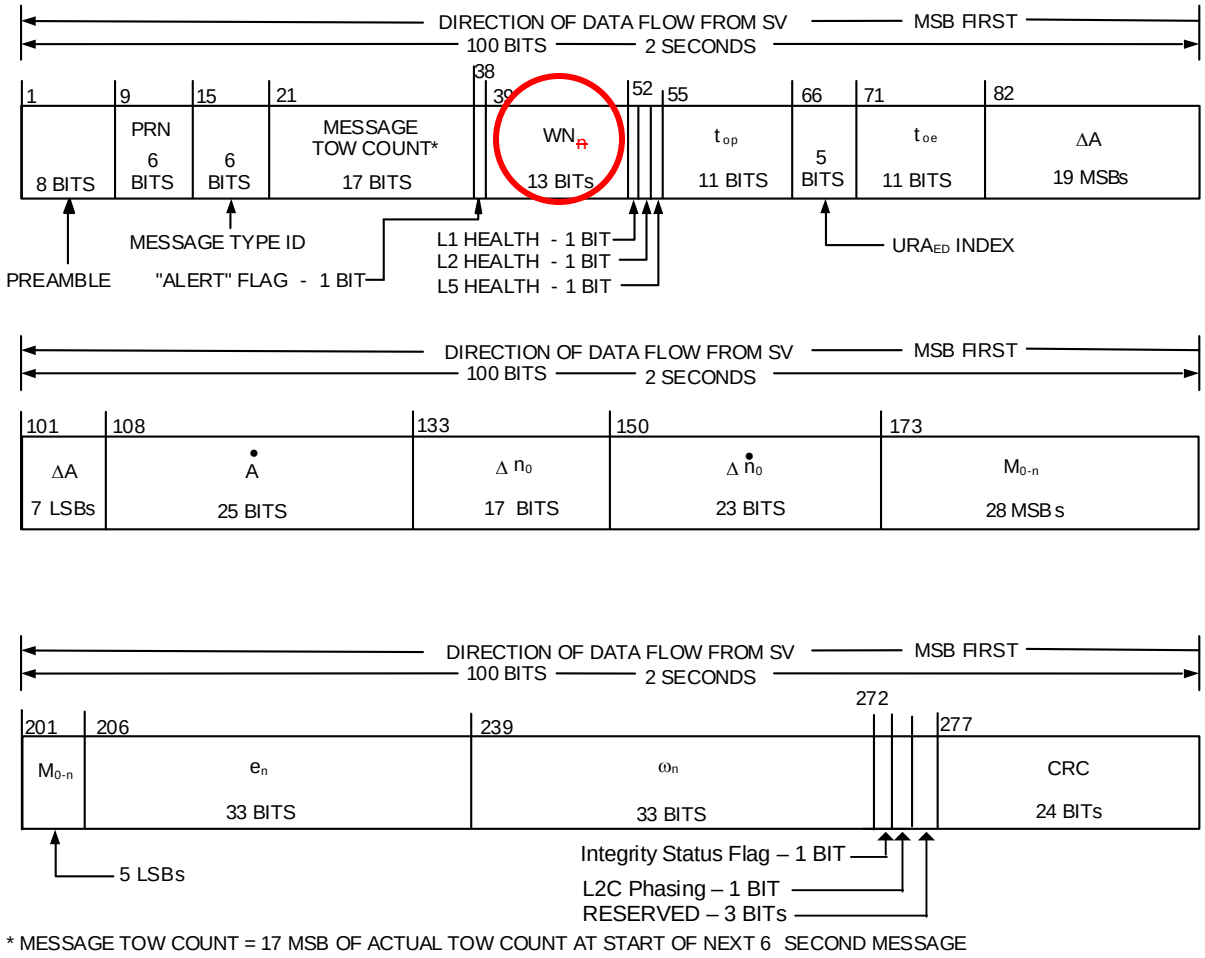
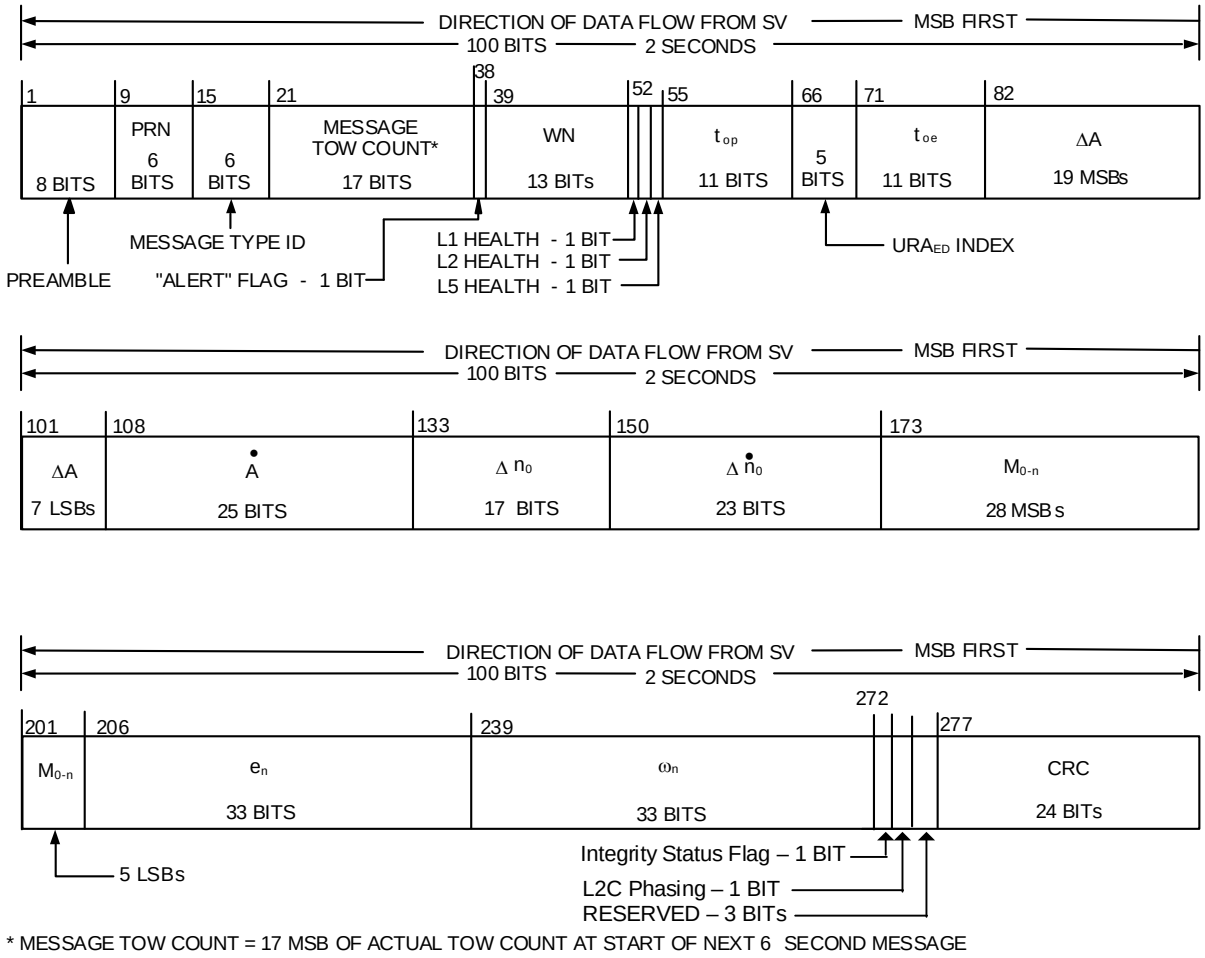


Figure 20-1. Message Type 10 - Ephemeris 1

IS :



* MESSAGE TOW COUNT = 17 MSB OF ACTUAL TOW COUNT AT START OF NEXT 6 SECOND MESSAGE

Figure 20-1. Message Type 10 - Ephemeris 1

IS705-216 :

Section Number :
20.3.3.1.1.0-4

WAS :
Any change in the message type 10 and 11 ephemeris data will be accomplished with a simultaneous change in the t_{oe} value. The CS (Block IIF) and SS (GPS III) will assure that the t_{oe} value, for at least the first CEI data set transmitted by an SV from a new CEI data sequence propagation, is different from that transmitted from the prior CEI data sequence propagation. (reference paragraph 20.3.4.5)

Redlines :
Any change in the message type 10 and 11 ephemeris data will be accomplished with a simultaneous change in the t_{oe} value. The CS (Block IIF) and SS (GPS III and GPS IIIF) will assure that the toe value, for at least the first CEI data set transmitted by an SV from a new CEI data sequence propagation, is different from that transmitted from the prior CEI data sequence propagation. (reference paragraph 20.3.4.5)

IS :
Any change in the message type 10 and 11 ephemeris data will be accomplished with a simultaneous change in the t_{oe} value. The CS (Block IIF) and SS (GPS III and GPS IIIF) will assure that the toe value, for at least the first CEI data set transmitted by an SV from a new CEI data sequence propagation, is different from that transmitted from the prior CEI data sequence propagation. (reference paragraph 20.3.4.5)

IS705-239 :

Section Number :
20.3.3.1.3.0-1

WAS :
The user shall compute the ECEF coordinates of position for the SV's antenna phase center (APC) utilizing a variation of the equations shown in Table 20-II. The ephemeris parameters are Keplerian in appearance; the values of these parameters; however, are produced by the CS (Block IIF) or the SV (GPS III) via a least squares curve fit of the propagated ephemeris of the SV APC (time-position quadruples; t, x, y, z expressed in ECEF coordinates). Particulars concerning the applicable coordinate system are given in Sections 20.3.3.4.3.3 and 20.3.3.4.3.4 of IS-GPS-200.

Redlines :
The user shall compute the ECEF coordinates of position for the SV's antenna phase center (APC) utilizing a variation of the equations shown in Table 20-II. The ephemeris parameters are Keplerian in appearance; the values of these parameters; however, are produced by the CS (Block IIF) or the SV (GPS III and GPS IIIF) via a least squares curve fit of the propagated ephemeris of the SV APC (time-position quadruples; t, x, y, z expressed in ECEF coordinates). Particulars concerning the applicable coordinate system are given in Sections 20.3.3.4.3.3 and 20.3.3.4.3.4 of IS-GPS-200.

IS :
The user shall compute the ECEF coordinates of position for the SV's antenna phase center (APC) utilizing a variation of the equations shown in Table 20-II. The ephemeris parameters are Keplerian in appearance; the values of these parameters; however, are produced by the CS (Block IIF) or the SV (GPS III and GPS IIIF) via a least squares curve fit of the propagated ephemeris of the SV APC (time-position quadruples; t, x, y, z expressed in ECEF coordinates). Particulars concerning the applicable coordinate system are given in Sections 20.3.3.4.3.3 and 20.3.3.4.3.4 of IS-GPS-200.

IS705-1598 :
Insertion after object IS705-239

The user shall compute the ECEF coordinates of position for the SV's antenna phase center (APC) utilizing a variation of the equations shown in Table 20-II. The ephemeris parameters are Keplerian in appearance; the values of these parameters; however, are produced by the CS (Block IIF) or the SV (GPS III) via a least squares curve fit of the propagated ephemeris of the SV APC (time-position quadruples; t, x, y, z expressed in ECEF coordinates). Particulars concerning the applicable coordinate system are given in Sections 20.3.3.4.3.3 and 20.3.3.4.3.4 of IS-GPS-200.

Section Number :
20.3.3.1.3.0- 2

WAS :
N/A

Redlines :
<INSERTED OBJECT>

IS :
The user can compute velocity and acceleration for the SV utilizing a variation of the equations, as required, shown in Table 20-II Part 3 and 4.

IS705-1537 :

Section Number :
20.3.3.1.3.0-8

WAS :
Table 20-II. Elements of Coordinate System (Part 1 of 2)

Redlines :
Table 20-II. ~~Elements of~~Broadcast ~~Coordinate~~Navigation ~~System~~User Equations (~~Part~~sheet 1 of ~~2~~4)

IS :
Table 20-II. Broadcast Navigation User Equations (sheet 1 of 4)

IS705-243 :

Section Number :
20.3.3.1.3.0-9

WAS :
Table 20-II.

Element/Equation	Description
$\mu = 3.986005 \times 10^{14}$ meters^3/sec^2	WGS 84 value of the earth's gravitational constant for GPS user
$\dot{\Omega}_e = 7.2921151467 \times 10^{-5}$ rad/sec	WGS 84 value of the earth's rotation rate
$A_0 = A_{REF} + \Delta A$ *	Semi-Major Axis at reference time
$A_k = A_0 + (\dot{A})\, t_k$	Semi-Major Axis
$n_0 = \sqrt{\frac{\mu}{A_0^{\,3}}}$	Computed Mean Motion (rad/sec)
$t_k = t - t_{oe}$ **	Time from ephemeris reference time
$\Delta n_A = \Delta n_0 + \frac{1}{2}\, \dot{\Delta n}_0\, t_k$	Mean motion difference from computed value
$n_A = n_0 + \Delta n_A$	Corrected Mean Motion
$M_k = M_0 + n_A\, t_k$	Mean Anomaly
$M_k = E_k - e_n \sin E_k$	Kepler's equation for Eccentric Anomaly (radians) (may be solved by iteration)
$\nu_k = \tan^{-1} \left\{ \frac{\sin \nu_k}{\cos \nu_k} \right\}$	True Anomaly
$= \tan^{-1} \left\{ \frac{\sqrt{1-e_n^{\,2}} \sin E_k \,/\, (1 - e_n \cos E_k)}{(\cos E_k - e_n) / (1 - e_n \cos E_k)} \right\}$	
$g = \cos^{-1} \left\{ \frac{e_n + \cos \nu_k}{1 + e_n \cos \nu_k} \right\}$	Eccentric Anomaly

* A_{REF} = 26,559,710 meters

** **t** is GPS system time at time of transmission, i.e., GPS time corrected for transit time (range/speed of light). Furthermore, is shall be the actual total 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.

Redlines :

Table 20-II.

Element/Equation	Description
$\mu = 3.986005 \times 10^{14}$ meters^3/sec^2	WGS 84 value of the earth's gravitational constant for GPS user
$\dot{\Omega}_e = 7.2921151467 \times 10^{-5}$ rad/sec	WGS 84 value of the earth's rotation rate
$A_0 = A_{REF} + \Delta A$ *	Semi-Major Axis at reference time
$A_k = A_0 + (\dot{A})\, t_k$	Semi-Major Axis
$n_0 = \sqrt{\frac{\mu}{A_0^{\,3}}}$	Computed Mean Motion (rad/sec)
$t_k = t - t_{oe}$ **	Time from ephemeris reference time
$\Delta n_A = \Delta n_0 + \frac{1}{2}\, \dot{\Delta n}_0\, t_k$	Mean motion difference from computed value
$n_A = n_0 + \Delta n_A$	Corrected Mean Motion
$M_k = M_0 + n_A\, t_k$	Mean Anomaly
~~$M_k = E_k - e_n \sin E_k$~~	~~Kepler's equation for Eccentric Anomaly (radians) (may be solved by iteration)~~
	Kepler's equation ($M_k = E_k - e \sin E_k$) may be solved for Eccentric anomaly (E_k) by iteration:
$E_0 = M_k$	– Initial Value (radians)
$E_j = E_{j-1} + \frac{M_k - E_{j-1} + e \sin E_{j-1}}{1 - e \cos E_{j-1}}$	– Refined Value, minimum of three iterations, (j=1,2,3)
$E_k = E_j$	– Final Value (radians)
~~$v_k = \tan^{-1}\left\{\frac{\sin v_k}{\cos v_k}\right\}$~~	~~True Anomaly~~
~~$= \tan^{-1}\left\{\frac{\sqrt{1 - e_n^2}\sin E_k / (1 - e_n \cos E_k)}{(\cos E_k - e_n)/(1 - e_n \cos E_k)}\right\}$~~	
$v_k = 2 \tan^{-1}\left(\sqrt{\frac{1+e}{1-e}} \tan \frac{E_k}{2}\right)$	True Anomaly (unambiguous quadrant)
~~$E_k = \cos^{-1}\left\{\frac{e_n + \cos v_k}{1 + e_n \cos v_k}\right\}$~~	~~Eccentric Anomaly~~

* A_{REF} = 26,559,710 meters

** **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 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.

IS :

Table 20-II.

Element/Equation	Description
$\mu = 3.986005 \times 10^{14}$ meters^3/sec^2	WGS 84 value of the earth's gravitational constant for GPS user
$\dot{\Omega}_e = 7.2921151467 \times 10^{-5}$ rad/sec	WGS 84 value of the earth's rotation rate
$A_0 = A_{REF} + \Delta A$ *	Semi-Major Axis at reference time
$A_k = A_0 + (\dot{A})\, t_k$	Semi-Major Axis
$n_0 = \sqrt{\frac{\mu}{A_0^{\,3}}}$	Computed Mean Motion (rad/sec)
$t_k = t - t_{oe}$ **	Time from ephemeris reference time
$\Delta n_A = \Delta n_0 + \frac{1}{2}\, \dot{\Delta n}_0\, t_k$	Mean motion difference from computed value
$n_A = n_0 + \Delta n_A$	Corrected Mean Motion
$M_k = M_0 + n_A\, t_k$	Mean Anomaly
	Kepler's equation ($M_k = E_k - e \sin E_k$) may be solved for Eccentric anomaly (E_k) by iteration:
$E_0 = M_k$	– Initial Value (radians)
$E_j = E_{j-1} + \frac{M_k - E_{j-1} + e \sin E_{j-1}}{1 - e \cos E_{j-1}}$	– Refined Value, minimum of three iterations, (j=1,2,3)
$E_k = E_j$	– Final Value (radians)
$\nu_k = 2 \tan^{-1}\left(\sqrt{\frac{1+e}{1-e}} \tan \frac{E_k}{2} \right)$	True Anomaly (unambiguous quadrant)

*	A_{REF} = 26,559,710 meters
**	**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 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.

IS705-1538 :

Section Number :
20.3.3.1.3.0-10

WAS :
Table 20-II. Elements of Coordinate System (Part 2 of 2)

Redlines :
Table 20-II. ~~Elements~~Broadcast ~~of~~Navigation ~~Coordinate~~User ~~System~~Equations (~~Part~~sheet 2 of ~~2~~4)

IS :
Table 20-II. Broadcast Navigation User Equations (sheet 2 of 4)

IS705-1593 :
Insertion after object IS705-244
Table 20-II part 2

Element/Equation *	Description
$\Phi_k = \nu_k + \omega_n$	Argument of Latitude
$\delta u_k = C_{us\text{-}n}\sin 2\Phi_k + C_{uc\text{-}n}\cos 2\Phi_k$	Argument of Latitude Correction (Second Harmonic Perturbations)
$\delta r_k = C_{rs\text{-}n}\sin 2\Phi_k + C_{rc\text{-}n}\cos 2\Phi_k$	Radial Correction (Second Harmonic Perturbations)
$\delta i_k = C_{is\text{-}n}\sin 2\Phi_k + C_{ic\text{-}n}\cos 2\Phi_k$	Inclination Correction (Second Harmonic Perturbations)
$u_k = \Phi_k + \delta u_k$	Corrected Argument of Latitude
$r_k = A_k(1 - e_n \cos E_k) + \delta r_k$	Corrected Radius
$i_k = i_{o\text{-}n} + (\dot{i}_{o\text{-}n})t_k + \delta i_k$	Corrected Inclination
$x_k' = r_k \cos u_k$ $y_k' = r_k \sin u_k$	Positions in orbital plane
$\dot{\Omega} = \dot{\Omega}_{REF} + \Delta\dot{\Omega}$ ***	Rate of Right Ascension
$\Omega_k = \Omega_{0\text{-}n} + (\dot{\Omega} - \dot{\Omega}_e)\, t_k - \dot{\Omega}_e t_{oe}$	Corrected Longitude of Ascending Node
$x_k = x_k' \cos\Omega_k - y_k' \cos i_k \sin\Omega_k$ $y_k = x_k' \sin\Omega_k + y_k' \cos i_k \cos\Omega_k$ $z_k = y_k' \sin i_k$	Earth-fixed coordinates of SV antenna phase center

Section Number :
20.3.3.1.3.0-12

WAS :
N/A

Redlines :
<INSERTED OBJECT>

IS :
Table 20-II. Broadcast Navigation User Equations (sheet 3 of 4)

IS705-1594 :
Insertion after object IS705-1593 (See previous)

Section Number :
20.3.3.1.3.0-13

WAS :
N/A

Redlines :
<INSERTED OBJECT>

IS :
Table 20-II part 3

Element/Equation	Description
SV Velocity	
$\dot{E}_k = n/(1 - e\cos E_k)$	Eccentric Anomaly Rate
$\dot{v}_k = \dot{E}_k \sqrt{1-e^2}/(1 - e\cos E_k)$	True Anomaly Rate
$(di_k / dt) = (IDOT) + 2\dot{v}_k (c_{is}\cos 2\phi_k - c_{ic}\sin 2\phi_k)$	Corrected Inclination Angle Rate
$\dot{u}_k = \dot{v}_k + 2\dot{v}_k (c_{us}\cos 2\phi_k - c_{uc}\sin 2\phi_k)$	Corrected Argument of Latitude Rate
$\dot{r}_k = eA\dot{E}_k \sin Ek + 2\dot{v}_k (c_{rs}\cos 2\phi_k - c_{rc}\sin 2\phi_k)$	Corrected Radius Rate
$\dot{\Omega}_k = \dot{\Omega} - \dot{\Omega}_e$	Longitude of Ascending Node Rate
$\dot{x}'_k = \dot{r}_k \cos u_k - r_k \dot{u}_k \sin u_k$	In- plane *x* velocity
$\dot{y}'_k = \dot{r}_k \sin u_k + r_k \dot{u}_k \cos u_k$	In- plane *y* velocity
$\dot{x}_k = -x'_k \dot{\Omega}_k \sin\Omega_k + \dot{x}'_k \cos\Omega_k - \dot{y}'_k \sin\Omega_k \cos i_k - y'_k(\dot{\Omega}_k \cos\Omega_k \cos i_k - (di_k/dt)\sin\Omega_k \sin i_k)$	Earth- Fixed *x* velocity (m/s)
$\dot{y}_k = x'_k \dot{\Omega}_k \cos\Omega_k + \dot{x}'_k \sin\Omega_k + \dot{y}'_k \cos\Omega_k \cos i_k - y'_k(\dot{\Omega}_k \sin\Omega_k \cos i_k + (di_k/dt)\cos\Omega_k \sin i_k)$	Earth- Fixed *y* velocity (m/s)
$\dot{z}_k = \dot{y}'_k \sin i_k + y'_k (di_k/dt)\cos i_k$	Earth- Fixed *z* velocity (m/s)

IS705-1592 :
Insertion after object IS705-1594 (See Previous)

Section Number :
20.3.3.1.3.0-14

WAS :
N/A

Redlines :
<INSERTED OBJECT>

IS :
Table 20-II. Broadcast Navigation User Equations (sheet 4 of 4)

IS705-1591 :
Insertion after object IS705-1592 (See Previous)

Section Number :
20.3.3.1.3.0-15

WAS :
N/A

Redlines :
<INSERTED OBJECT>

IS :
Table 20-II part 4

Element/Equation	Description
SV Acceleration	
R_E = 6378137.0 meters	WGS 84 Earth Equatorial Radius
J_2 = 0.0010826262	Oblate Earth Gravity Coefficient
$F = -(3/2)\, J_2\, (\mu / r_k^2)\, (R_E / r_k)^2$	Oblate Earth acceleration Factor
$\ddot{x}_k = -\mu\,(x_k / r_k^3) + F\,[(1 - 5\,(z_k / r_k)^2)(x_k / r_k)] + 2\dot{y}_k\dot{\Omega}_e + x_k\dot{\Omega}_e^2$	Earth- Fixed x acceleration (m/s^2)
$\ddot{y}_k = -\mu\,(y_k / r_k^3) + F\,[(1 - 5\,(z_k / r_k)^2)(y_k / r_k)] - 2\dot{x}_k\dot{\Omega}_e + y_k\dot{\Omega}_e^2$	Earth- Fixed y Acceleration (m/s^2)
$\ddot{z}_k = -\mu\,(z_k / r_k^3) + F\,[(3 - 5\,(z_k / r_k)^2)(z_k / r_k)]$	Earth- Fixed *z* Acceleration (m/s^2)

IS705-270 :

Section Number :
20.3.3.3.1.1.0-1

WAS :
The group delay differential correction terms, T_{GD}, $ISC_{L1C/A}$, ISC_{L2C} are contained in bits 128 through 166 of message type 30. See paragraph 30.3.3.3.1.1 of IS-GPS-200. The bit lengths, scale factors, ranges, and units of these parameters are given in Table 20-IV. These group delay differential correction terms are also used for the benefit of single frequency L5-I5 and L5-Q5 users and dual frequency L1/L5 and L2/L5 users.

Redlines :
The group delay differential correction terms, T_{GD}, $IS_{CL1C/A}$, ISC_{L2C} are contained in bits 128 through 166 of message type 30. See paragraph 30.3.3.3.1.1 of IS-GPS-200. The bit lengths, scale factors, ranges, and units of these parameters are given in Table 20-IV. These group delay differential correction terms are also used for the benefit of single frequency L5-I5 and L5-Q5 users and dual frequency L1/L5 ~~and L2/L5~~ users.

IS :
The group delay differential correction terms, T_{GD}, $ISC_{L1C/A}$, ISC_{L2C} are contained in bits 128 through 166 of message type 30. See paragraph 30.3.3.3.1.1 of IS-GPS-200. The bit lengths, scale factors, ranges, and units of these parameters are given in Table 20-IV. These group delay differential correction terms are also used for the benefit of single frequency L5-I5 and L5-Q5 users and dual frequency L1/L5 users.

IS705-271 :

Section Number :
20.3.3.3.1.1.1

WAS :
L1/L2 Inter-Signal Group Delay Differential Correction.

Redlines :
<DELETED OBJECT>

IS :
<DELETED OBJECT>

IS705-272 :

Section Number :
20.3.3.3.1.1.1.0-1

WAS :
See paragraph 30.3.3.3.1.1.1 of IS-GPS-200.

Redlines :
<DELETED OBJECT>

IS :
<DELETED OBJECT>

IS705-274 :

Section Number :
20.3.3.3.1.2.0-1

WAS :
The group delay differential correction terms, $T_{GD,}$ ISC_{L5I5} and ISC_{L5Q5}, for the benefit of single frequency L5-I5 and L5-Q5 users and dual frequency L1/L5 and L2/L5 users are contained in bits 128 through 140 and 167 through 192 of message type 30 (see Figure 20-3 for complete bit allocation). The bit lengths, scale factors, ranges, and units of these parameters are given in Table 20-IV. The bit string of "1000000000000" shall indicate that the group delay value is not available. The related algorithms are given in paragraphs 20.3.3.3.1.2.1, 20.3.3.3.1.2.2, and 20.3.3.3.1.2.3.

Redlines :
The group delay differential correction terms, T_{GD}, ISC_{L5I5} and ISC_{L5Q5}, for the benefit of single frequency L5-I5 and L5-Q5 users and dual frequency L1/L5 ~~and L2/L5~~ users are contained in bits 128 through 140 and 167 through 192 of message type 30 (see Figure 20-3 for complete bit allocation). The bit lengths, scale factors, ranges, and units of these parameters are given in Table 20-IV. The bit string of "1000000000000" shall indicate that the group delay value is not available. The related algorithms are given in paragraphs 20.3.3.3.1.2.1, 20.3.3.3.1.2.2, and 20.3.3.3.1.2.3.

IS :
The group delay differential correction terms, $T_{GD,}$ ISC_{L5I5} and ISC_{L5Q5}, for the benefit of single frequency L5-I5 and L5-Q5 users and dual frequency L1/L5 users are contained in bits 128 through 140 and 167 through 192 of message type 30 (see Figure 20-3 for complete bit allocation). The bit lengths, scale factors, ranges, and units of these parameters are given in Table 20-IV. The bit string of "1000000000000" shall indicate that the group delay value is not available. The related algorithms are given in paragraphs 20.3.3.3.1.2.1, 20.3.3.3.1.2.2, and 20.3.3.3.1.2.3.

IS705-282 :

Section Number :
20.3.3.3.1.2.3

WAS :
L2/L5 Ionospheric Correction.

Redlines :
<DELETED OBJECT>

IS :
<DELETED OBJECT>

IS705-283 :

Section Number :
20.3.3.3.1.2.3.0-1

WAS :
The dual-frequency (L2 C and L5 I5) user shall correct for the group delay and ionospheric effects by applying the relationship:

$$PR = \frac{(PR_{L5I5} - \gamma_{25} PR_{L2C}) + c(ISC_{L5I5} - \gamma_{25} ISC_{L2C})}{1 - \gamma_{25}} - cT_{GD}$$

Redlines :
<DELETED OBJECT>

IS :
<DELETED OBJECT>

IS705-284 :

Section Number :
20.3.3.3.1.2.3.0-2

WAS :
The dual-frequency (L2 C and L5 Q5) user shall correct for the group delay and ionospheric effects by applying the relationship:

$$PR = \frac{(PR_{L5Q5} - \gamma_{25} PR_{L2C}) + c(ISC_{L5Q5} - \gamma_{25} ISC_{L2C})}{1 - \gamma_{25}} - cT_{GD}$$

where

PR = g corrected for ionospheric effects,
g = pseudorange measured on the channel indicated by the subscript,
ISC_i = inter-signal correction for the channel indicated by the subscript (see paragraph 20.3.3.3.1.2),

T_{GD} = see paragraph 20.3.3.3.3.2 of IS-GPS-200,
c = speed of light (see paragraph 20.3.4.3).

and where, denoting the nominal center frequencies of L2 and L5 as f_{L2} and f_{L5} respectively.

$\gamma_{25} = (f_{L2}/f_{L5})^2 = (1227.6/1176.45)^2 = (24/23)^2$

Redlines :
<DELETED OBJECT>

IS :
<DELETED OBJECT>

IS705-287 :

Section Number :
20.3.3.3.1.3.0-2

WAS :
The ionospheric data shall be updated by the CS at least once every six days while the CS is able to upload the SVs. If the CS is unable to upload the SVs, the ionospheric data transmitted by the SVs may not be accurate. During extended operations or in the Autonav mode, if the CS is unable to upload the SVs, the use of this model will yield unpredictable results.

Redlines :
The ionospheric data shall be updated by the CS at least once every six days while the CS is able to upload the SVs. If the CS is unable to upload the SVs, the ionospheric data transmitted by the SVs may not be accurate. During extended operations ~~or in the Autonav mode~~, if the CS is unable to upload the SVs, the use of this model will yield unpredictable results.

IS :
The ionospheric data shall be updated by the CS at least once every six days while the CS is able to upload the SVs. If the CS is unable to upload the SVs, the ionospheric data transmitted by the SVs may not be accurate. During extended operations, if the CS is unable to upload the SVs, the use of this model will yield unpredictable results.
