PROPOSED INTERFACE REVISION NOTICE (PIRN)

Note: This Cover Page is not intended for signature. It is to be used during the document update (pre-ICWG) process.

Affected ICD/IS: IS-GPS-705 Rev D	**PIRN Number:** PIRN-IS-705D-003
Authority: RFC-00312	**PIRN Date:** 22-JUN-2016

CLASSIFIED BY: N/A

DECLASSIFY ON: N/A

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

Reason For Change (Driver): To remove ambiguity in contractor interpretation, the definition of the parameter Time of Predict (T_op) and other timing parameters must be clarified in the GPS technical baseline documentation.

Description of Change: Process the proposed changes with the correct stakeholders and update IS-GPS-705 Rev D for accurate implementation.

Prepared By: John Buckley **Checked By: Drew Sapp**

Req ID : IS705-1496

WAS :

AFMC	-	Air Force Materiel Command
AFSPC	-	Air Force Space Command
ASCII	-	American Standard Code for Information Interchange
bps	-	bits per second
BPSK	-	Bi-Phase Shift Key
C/A	-	Course/Acquisition
CDC	-	Clock Differential Correction
CNAV	-	Civil Navigation
CRC	-	Cyclic Redundancy Check
CS	-	Control Segment
dB	-	Decibel
dBc	-	Power ratio of a signal to a (unmodulated) carrier signal, expressed in decibels
dBi	-	Decibels with respect to isotropic antenna
dBW	-	Decibels with respect to 1 Watt
DC	-	Differential Correction
DoD	-	Department of Defense
ECEF	-	Earth-Centered, Earth-Fixed
ECI	-	Earth Centered Inertial
EDC	-	Ephemeris Differential Correction
EOL	-	End of Life
FEC	-	Forward Error Correction
GGTO	-	GPS/GNSS Time Offset
GNSS	-	Global Navigation Satellite System
GPS	-	Global Positioning System
GPSW	-	Global Positioning System Wing
Hz	-	Hertz
I5	-	In-phase Code on L5 Signal

ICC	-	Interface Control Contractor
ID	-	Identification
IODC	-	Issue of Data, Clock
IS	-	Interface Specification
ISC	-	Inter-Signal Correction
LSB	-	Least Significant Bit
MSB	-	Most Significant Bit
NAV	-	Navigation
NSI5	-	Non-Standard I-Code
NSQ5	-	Non-Standard Q-Code
OCS	-	Operational Control System
PIRN	-	Proposed Interface Revision Notice
PRN	-	Pseudo-Random Noise
P(Y)	-	Precise (Anti-Spoof) Code
Q5	-	Quadraphase code on L5 Signal
RF	-	Radio Frequency
RHCP	-	Right Hand Circular Polarization
RMS	-	Root Mean Square
SBAS	-	Satellite Based Augmentation System
sps	-	Symbols per Second.
SIS	-	Signal In Space
SS	-	Space Segment
SSV	-	Space Service Volume
SV	-	Space Vehicle
TBD	-	To Be Determined
TBS	-	To Be Supplied
TOW	-	Time Of Week
URA	-	User Range Accuracy
US	-	User Segment
USNO	-	US Naval Observatory

UTC	-	Coordinated Universal Time
WGS 84	-	World Geodetic System 1984
WN	-	Week Number
WN_e	-	Extended Week Number

IS :

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GGTO	-	GPS/GNSS Time Offset

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GPS	-	Global Positioning System
GPSW	-	Global Positioning System Wing
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ICE		Integrity/Clock/Ephemeris
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RMS	-	Root Mean Square
SBAS	-	Satellite Based Augmentation System
sps	-	Symbols per Second.
SIS	-	Signal In Space
SS	-	Space Segment
SSV	-	Space Service Volume
SV	-	Space Vehicle

TBD	-	To Be Determined
TBS	-	To Be Supplied
TOW	-	Time Of Week
URA	-	User Range Accuracy
US	-	User Segment
USNO	-	US Naval Observatory
UTC	-	Coordinated Universal Time
WGS 84	-	World Geodetic System 1984
WN	-	Week Number
WN_e	-	Extended Week Number

Req ID : IS705-1514

WAS : N/A

IS : **Integrity/Clock/Ephemeris (ICE) Data Set.**

Req ID : IS705-1515

WAS : N/A

IS : An Integrity/Clock/Ephemeris (ICE) data set is the collection of SV-specific URA parameters, clock correction polynomial parameters, ephemeris parameters, and related parameters (health flags, time tags, etc.) needed to use the SV's broadcast signal(s) in the positioning service. ICE data is sometimes also known as the user's 'hot start' data for the SV. Before modernization, an ICE data set was sometimes called a "Subframe 1-2-3 data set".

Req ID : IS705-1516

WAS : N/A

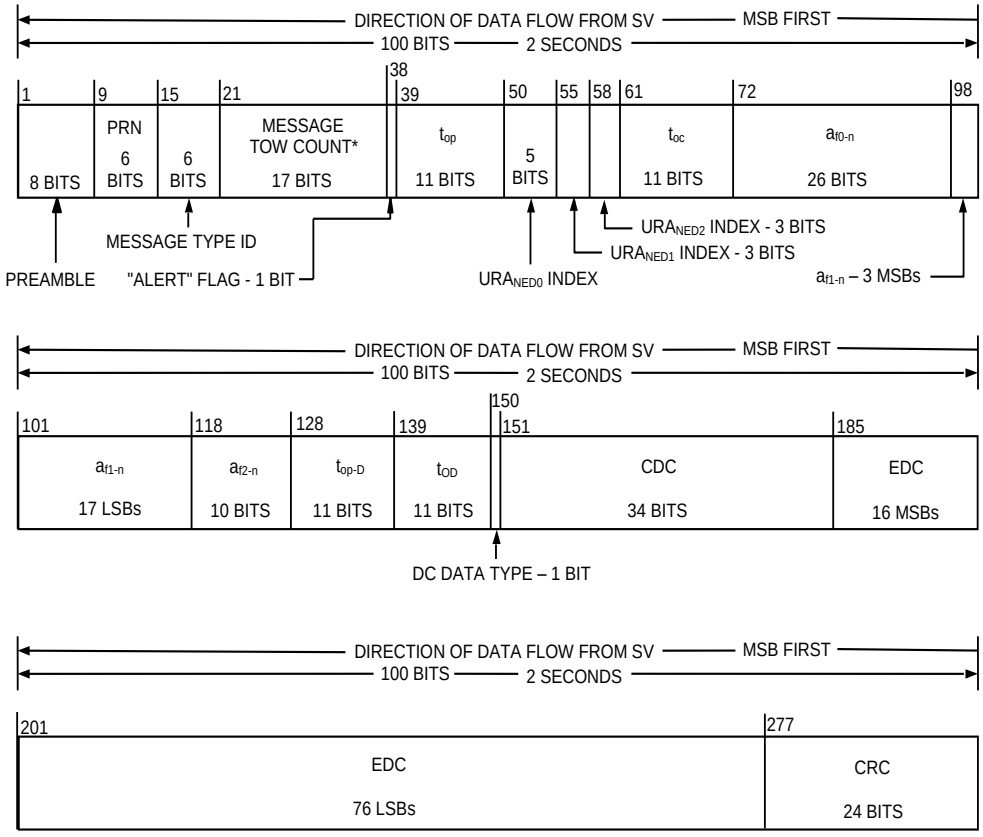
IS : **ICE Data Projection Sequence.**

Req ID : IS705-1517

WAS : N/A

IS : A related time-ordered sequence of ICE data sets in which each successive ICE data set is a time projection of the preceding ICE data set. Special provisions apply to alert users to discontinuities separating one ICE data projection sequence from another ICE data projection sequence (e.g., after an upload occurs). Before modernization, an ICE data projection sequence was sometimes called an “uploaded sequence of Subframe 1-2-3 data sets”. Beginning with the Next Generation Operational Control System (OCX), an upload may include multiple, disjoint but contiguous ICE data projection sequences.

Req ID : IS705-204

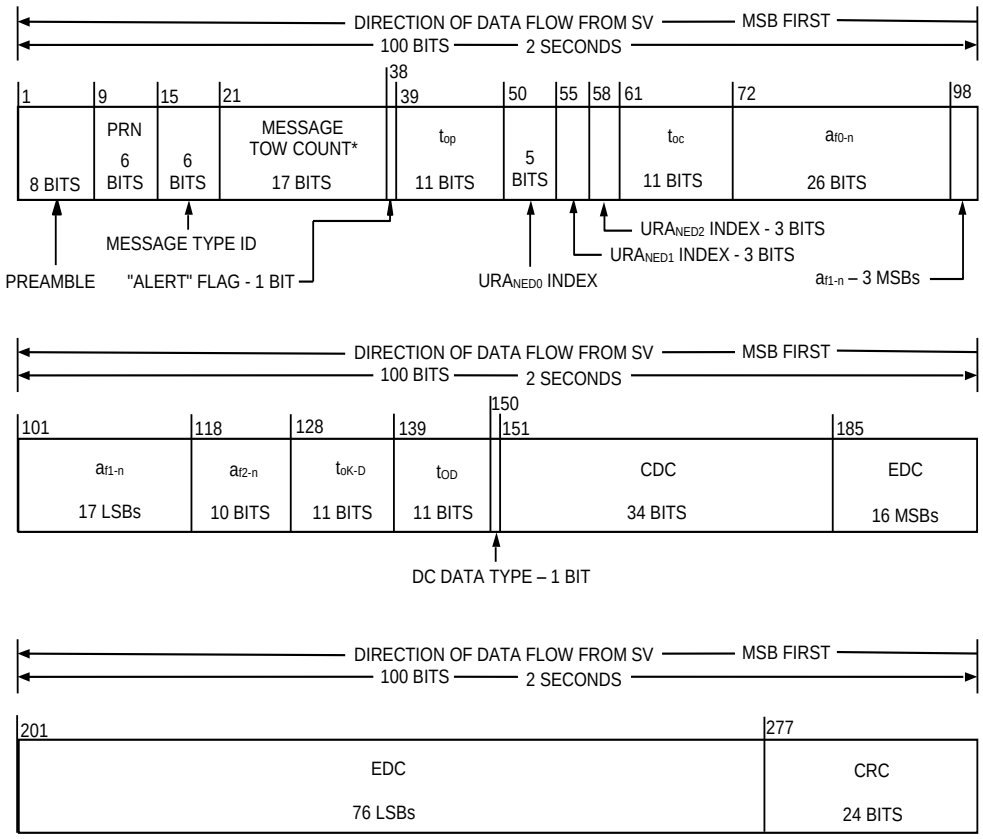


* MESSAGE TOW COUNT = 17 MSB OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

CDC = Clock Differential Correction
EDC = Ephemeris Differential Correction

WAS :

Figure 20-7. Message type 34 - Clock & Differential Correction



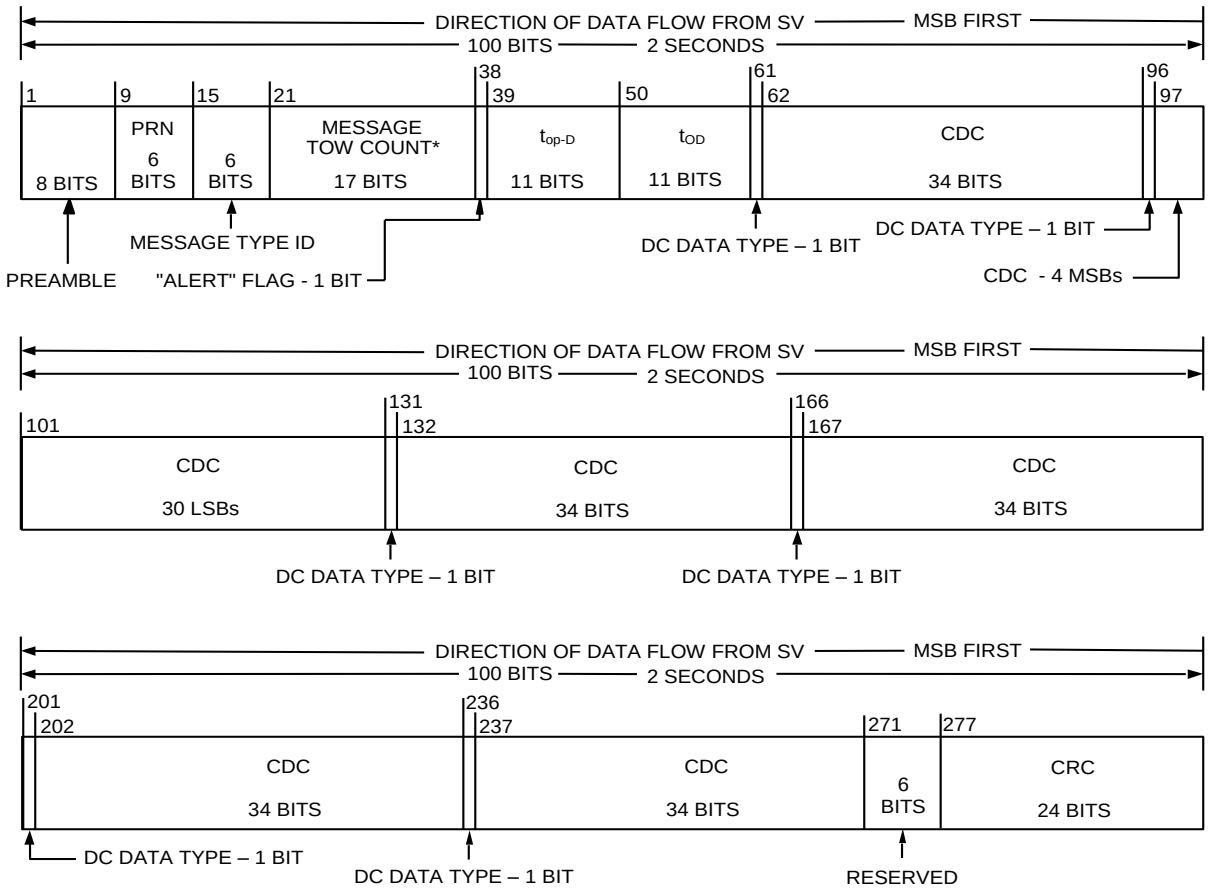
* MESSAGE TOW COUNT = 17 MSB OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

CDC = Clock Differential Correction
EDC = Ephemeris Differential Correction

IS :

Figure 20-7. Message type 34 - Clock & Differential Correction

Req ID : IS705-209

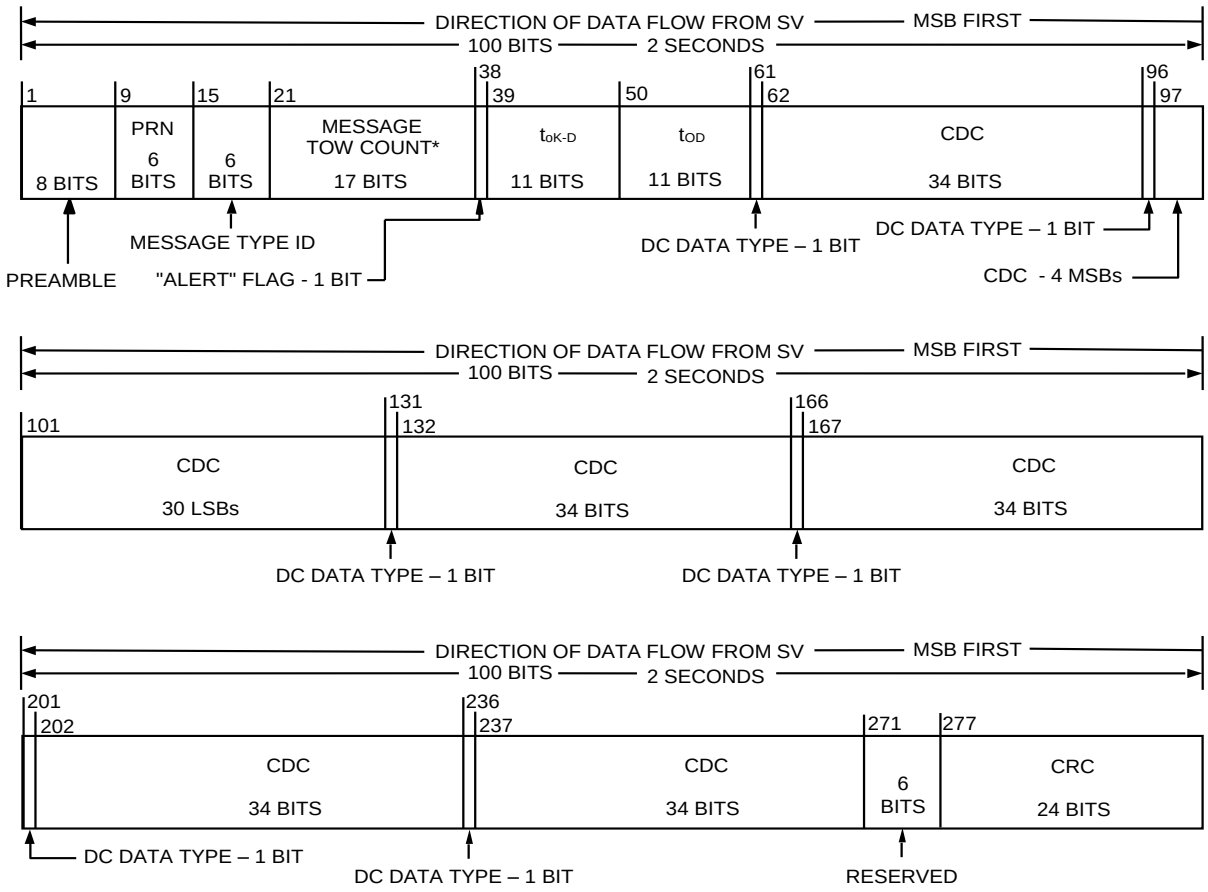


* MESSAGE TOW COUNT = 17 MSBs OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

CDC = Clock Differential Correction

WAS :

Figure 20-12. Message type 13 - Clock Differential Correction



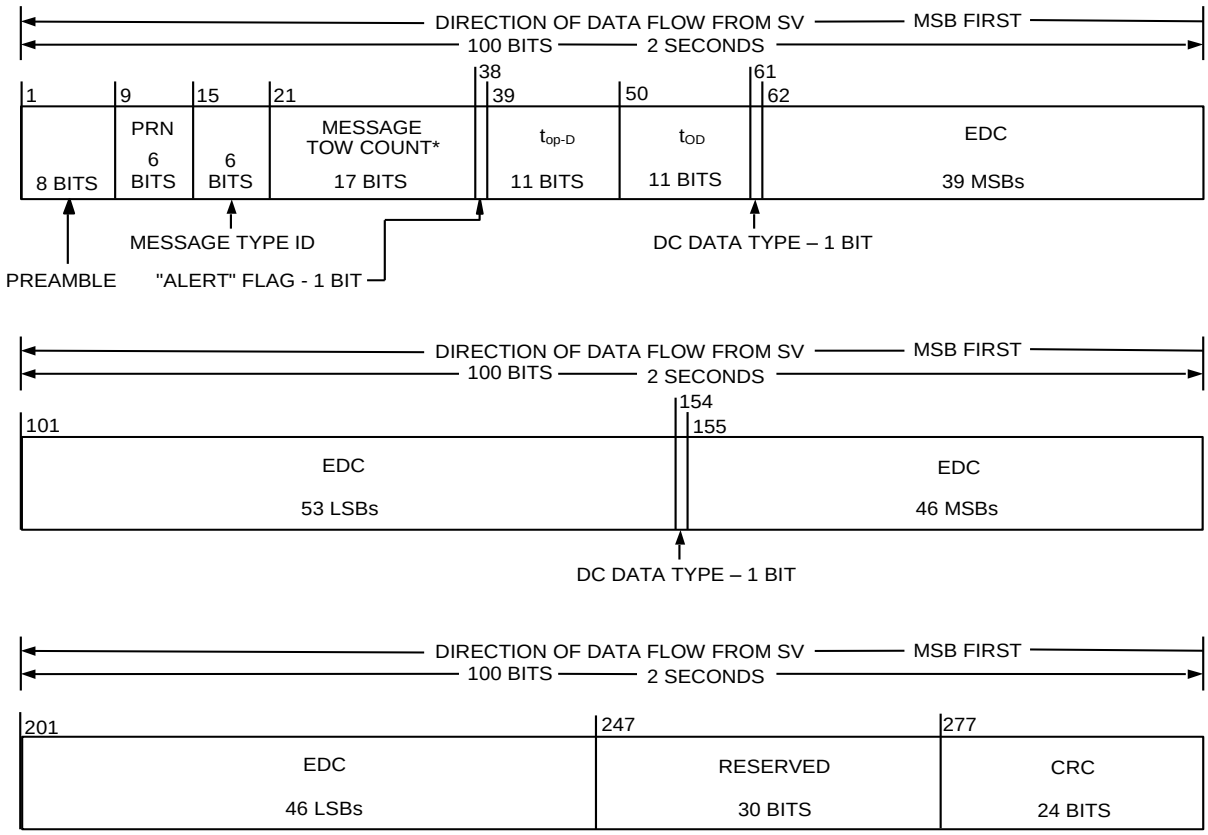
* MESSAGE TOW COUNT = 17 MSBs OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

CDC = Clock Differential Correction

IS :

Figure 20-12. Message type 13 - Clock Differential Correction

Req ID : IS705-210

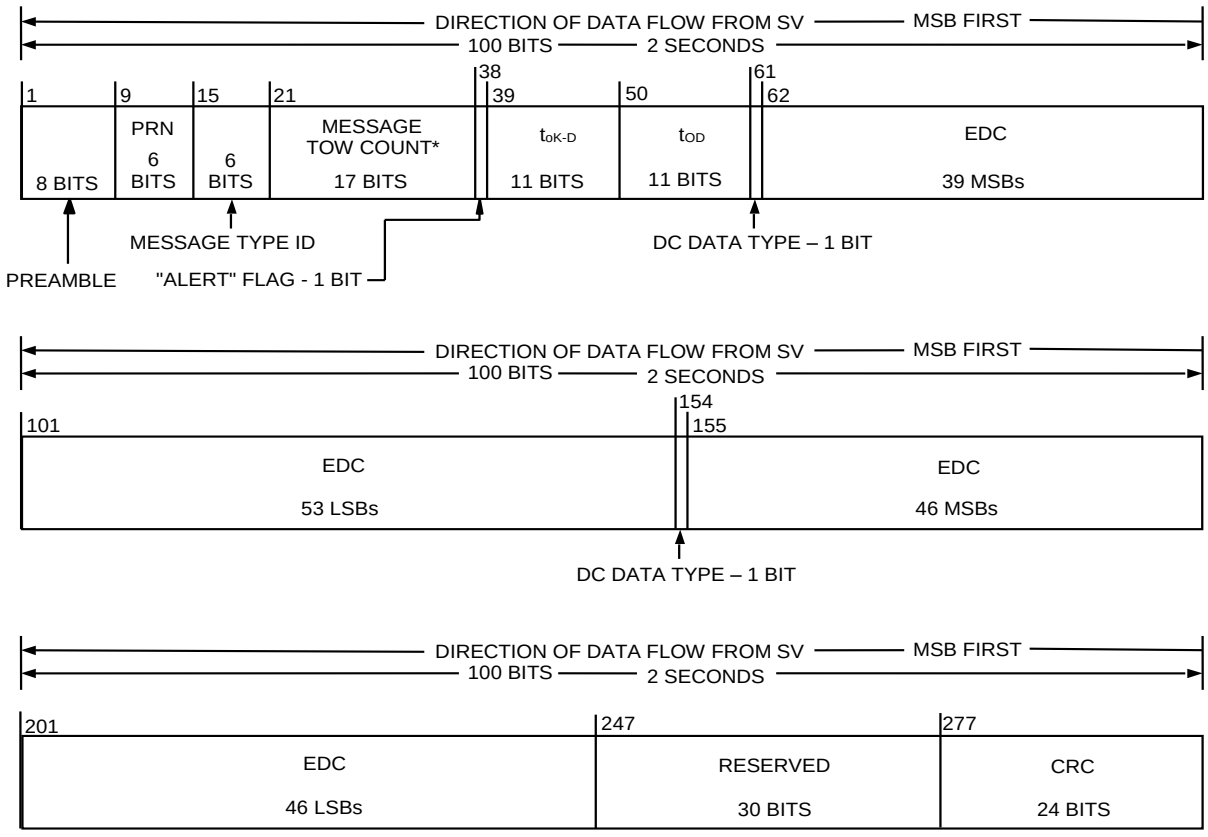


* MESSAGE TOW COUNT = 17 MSBs OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

EDC = Ephemeris Differential Correction

WAS :

Figure 20-13. Message type 14 - Ephemeris Differential Correction



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

EDC = Ephemeris Differential Correction

IS :

Figure 20-13. Message type 14 - Ephemeris Differential Correction

Req ID : IS705-216

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 will assure the t_{oe} value for Block IIR-M/IIF and SS will assure the t_{oe} value for GPS III, for at least the first data set transmitted by an SV after an upload, is different from that transmitted prior to the cutover. See Section 20.3.4.5 for additional information regarding t_{oe}.

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 II/Block IIA/IIR/IIR-M/IIF) and SS (GPS III) shall assure that the t_{oe} value, for at least the first data set transmitted by an SV from a new ICE data projection sequence, is different from that transmitted from the prior ICE data projection sequence (reference paragraph 20.3.4.5).

Req ID : IS705-227

WAS : **Data Predict Time of Week.**

IS : **ICE Data Projection Sequence Time of Week.**

Req ID : IS705-228

WAS : Bits 55 through 65 of message type 10 shall contain the data predict time of week (t_{op}). The top term provides the epoch time of week of the state estimate utilized for the prediction of satellite quasi-Keplerian ephemeris parameters.

IS : Bits 55 through 65 of message type 10 shall contain the ICE data projection sequence time of week (t_{op}). The t_{op} term provides the epoch time of week of the state data utilized for the projection of satellite ICE data quasi-Keplerian ephemeris parameters. Users are cautioned to avoid using this parameter to compute age of data for any SV.

Req ID : IS705-239

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 predicted 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) via a least squares curve fit of the projected 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.

Req ID : IS705-241

WAS :

Table 20-I. Message Types 10 and 11 Parameters (1 of 2)

Parameter Symbol	Parameter Description	No. of Bits**	Scale Factor (LSB)	Effective Range***	Units

WN	Week No.	13	1		weeks
URA_{ED} INDEX	ED accuracy	5*			(see text)
Signal health (L1/L2/L5)		3	1		(see text)
t_{op}	Data predict time of week	11	300	604,500	seconds
ΔA ****	Semi-major axis difference at reference time	26*	2^{-9}		meters
$\dot{A}$	Change rate in semi-major axis	25*	2^{-21}		meters/sec
Δn_0	Mean Motion difference from computed value at reference time	17*	2^{-44}		semi-circles/sec
$\dot{\Delta n}_0$	Rate of mean motion difference from computed value	23*	2^{-57}		semi-circles/sec^2
M_{0-n}	Mean anomaly at reference time	33*	2^{-32}		semi-circles
e_n	Eccentricity	33	2^{-34}	0.03	dimensionless
ω_n	Argument of perigee	33*	2^{-32}		semi-circles

* Parameters so indicated are two's complement, with the sign bit (+ or -) occupying the MSB;

** See Figure 20-1 for complete bit allocation in message type 10;

*** Unless otherwise indicated in this column, effective range is the maximum range attainable with indicated bit allocation and scale factor.

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

IS :

Table 20-II. Message Types 10 and 11 Parameters (1 of 2)

Parameter Symbol	Parameter Description	No. of Bits**	Scale Factor (LSB)	Valid Range***	Units

WN	Week No.	13	1		weeks
URA_{ED} INDEX	ED accuracy	5*			(see text)
Signal health (L1/L2/L5)		3	1		(see text)
t_{op}	ICE Data projection sequence time of week	11	300	0 to 604,500	seconds
ΔA ****	Semi-major axis difference at reference time	26*	2^{-9}		meters
$\dot{A}$	Change rate in semi-major axis	25*	2^{-21}		meters/sec
Δn_0	Mean Motion difference from computed value at reference time	17*	2^{-44}		semi-circles/sec
$\dot{\Delta n_0}$	Rate of mean motion difference from computed value	23*	2^{-57}		semi-circles/sec^2
M_{0-n}	Mean anomaly at reference time	33*	2^{-32}		semi-circles
e_n	Eccentricity	33	2^{-34}	0.0 to 0.03	dimensionless
ω_n	Argument of perigee	33*	2^{-32}		semi-circles

* Parameters so indicated are two's complement, with the sign bit (+ or -) occupying the MSB;

** See Figure 20-1 for complete bit allocation in message type 10;

*** Unless otherwise indicated in this column, valid range is the maximum range attainable with indicated bit allocation and scale factor.

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

Req ID : IS705-251

WAS : **Data Predict Time of Week.**

IS : **ICE Data Projection Sequence Time of Week.**

Req ID : IS705-252

WAS : Bits 39 through 49 of message types 30 through 37 shall contain the data predict time of week (top). The top term provides the epoch time of week of the state estimate utilized for the prediction of SV clock correction coefficients.

IS : Bits 39 through 49 of message types 30 through 37 shall contain the ICE data projection sequence time of week (top). The top term provides the epoch time of week of the state data utilized for projecting the SV clock correction coefficients forward in time. Users are cautioned to avoid using this parameter to compute age of data for any SV.

Req ID : IS705-257

WAS :

Table 20-III. Clock Correction and Accuracy Parameters

Parameter Symbol	Parameter Description	No. of Bits**	Scale Factor (LSB)	Effective Range***	Units
t_{oc}	Clock Data Reference Time of Week	11	300	604,500	seconds
URA_{NED0} Index	NED Accuracy Index	5*			(see text)
URA_{NED1} Index	NED Accuracy Change Index	3			(see text)
URA_{NED2} Index	NED Accuracy Change Rate Index	3			(see text)
a_{f2-n}	SV Clock Drift Rate Correction Coefficient	10*	2^{-60}		sec/sec^2
a_{f1-n}	SV Clock Drift Correction Coefficient	20*	2^{-48}		sec/sec
a_{f0-n}	SV Clock Bias Correction Coefficient	26*	2^{-35}		seconds

* Parameters so indicated are two's complement, with the sign bit (+ or -) occupying the MSB;
** See Figures 20-3 through 20-10 for complete bit allocation in message types 30 to 37;
*** Unless otherwise indicated in this column, effective range is the maximum range attainable with indicated bit allocation and scale factor.

IS :

Table 20-III. Clock Correction and Accuracy Parameters

Parameter		No. of Bits**	Scale Factor (LSB)	Valid Range***	Units
t_{op}	ICE Data Projection Sequence Time of Week	11	300	0 to 604,500	seconds
t_{oc}	Clock Data Reference Time of Week	11	300	0 to 604,500	seconds
URA_{NED0} Index	NED Accuracy Index	5*			(see text)
URA_{NED1} Index	NED Accuracy Change Index	3			(see text)
URA_{NED2} Index	NED Accuracy Change Rate Index	3			(see text)

a_{f2-n}	SV Clock Drift Rate Correction Coefficient	10*	2^{-60}		sec/sec^2
a_{f1-n}	SV Clock Drift Correction Coefficient	20*	2^{-48}		sec/sec
a_{f0-n}	SV Clock Bias Correction Coefficient	26*	2^{-35}		seconds
* Parameters so indicated are two's complement, with the sign bit (+ or -) occupying the MSB; ** See Figure 20-3 through 20-10 for complete bit allocation in Message types 30 to 37; *** Unless otherwise indicated in this column, valid range is the maximum range attainable with indicated bit allocation and scale factor.					

Req ID : IS705-1500

WAS : **Data Predict Week Number.**

IS : **ICE Data Projection Sequence Week Number.**

Req ID : IS705-1502

WAS : Bits 257-264 of Message Type 30 shall indicate the Data Predict Week Number (WN_{OP}) to which the Data Predict Time of Week (t_{op}) is referenced (see 20.3.3.1.1.3 and 20.3.3.2.1.2). The WN_{OP} term consists of eight bits which shall be a modulo 256 binary representation of the GPS week number to which the t_{op} is referenced. The user must account for the truncated nature of WN_{op} in all calculations in which WN_{op} is used.

IS : Bits 257-264 of Message Type 30 shall indicate the ICE Data Projection Sequence Week Number (WN_{op}) to which the t_{op} is referenced (see 20.3.3.1.1.3 and 20.3.3.2.1.2). The WN_{OP} term consists of eight bits which shall be a modulo 256 binary representation of the GPS week number to which the t_{op} is referenced. The user must account for the truncated nature of WN_{op} in all calculations in which WN_{op} is used.

Req ID : IS705-339

WAS : Each DC data packet contains: corrections to SV clock polynomial coefficients provided in any one of the message types 30 to 37 of the corresponding SV; corrections to quasi-Keplerian elements referenced to t_{OD} of the corresponding SV; User Differential Range Accuracy (UDRA) and $\dot{UDRA}$ indices that enable users to estimate the accuracy obtained after corrections are applied. Each DC packet is made up of two different segments. The first segment contains 34 bits for the CDC parameters and the second segment contains 92 bits of EDC parameters totaling 126 bits. The CDC and EDC parameters form an indivisible pair and users must utilize CDC and EDC as a pair. Users must utilize CDC and EDC data pairs of the same t_{op-D} (t_{op-D} =DC data predict time of week) and of the same t_{OD}.

IS : Each DC data packet contains: corrections to SV clock polynomial coefficients provided in any one of the message types 30 to 37 of the corresponding SV; corrections to quasi-Keplerian elements referenced to t_{OD} of the corresponding SV; User Differential Range Accuracy (UDRA) and $\dot{UDRA}$ indices that enable users to estimate the accuracy obtained after corrections are applied. Each DC packet is made up of two different segments. The first segment contains 34 bits for the CDC parameters and the second segment contains 92 bits of EDC parameters totaling 126 bits. The CDC and EDC parameters form an indivisible pair and users must utilize CDC and EDC as a pair. Users must utilize CDC and EDC data pairs of the same $t_{oK\text{-}D}$ ($t_{oK\text{-}D}$ =DC data predict time of week) and of the same t_{OD}.

Req ID : IS705-340

WAS : **Differential Correction Data Predict Time of Week.**

IS : **Differential Correction Data Kalman Time of Week.**

Req ID : IS705-341

WAS : The DC data predict time of week ($t_{op\text{-}D}$) provides the epoch time of week, in increments of 300 seconds (i.e. five minutes), at which the prediction for the associated DC data was performed.

IS : The DC data Kalman time of week ($t_{oK\text{-}D}$) provides the epoch time of week, in increments of 300 seconds (i.e. five minutes), at which the kalman estimation for the associated DC data was performed.

Req ID : IS705-349

WAS : The SV PRN code phase offset, uncorrected by clock correction coefficient updates, is given by equation 2 in 20.3.3.3.3.1 of IS-GPS-200 (see paragraph 20.3.3.2.3). If the matched pair of DC data for the subject SV is available, the user may apply clock correction coefficient update values by;

$\Delta t_{sv} = (a_{f0} + \delta a_{f0}) + (a_{f1} + \delta a_{f1})(t - t_{oc}) + a_{f2}(t - t_{oc})^2 + \Delta t_r$

where δa_{f0} and δa_{f1}, (see Table 20-X), are given in message types 34 or 13, and all other terms are as stated in 20.3.3.3.3.1 of IS-GPS-200. Clock-related DC data shall not be applied to any SV transmitting clock correction parameters message(s) containing a t_{op} value greater than the t_{op-D} value of messages types 34 or 13 containing the clock-related DC data.

IS : The SV PRN code phase offset, uncorrected by clock correction coefficient updates, is given by equation 2 in 20.3.3.3.3.1 of IS-GPS-200 (see paragraph 20.3.3.2.3). If the matched pair of DC data for the subject SV is available, the user may apply clock correction coefficient update values by;

$\Delta t_{sv} = (a_{f0} + \delta a_{f0}) + (a_{f1} + \delta a_{f1})(t - t_{oc}) + a_{f2}(t - t_{oc})^2 + \Delta t_r$

where δa_{f0} and δa_{f1}, (see Table 20-X), are given in message types 34 or 13, and all other terms are as stated in 20.3.3.3.3.1 of IS-GPS-200. Clock-related DC data shall not be applied to any SV transmitting clock correction parameters message(s) containing a t_{op} value greater than the t_{oK-D} value of messages types 34 or 13 containing the clock-related DC data.

Req ID : IS705-351

WAS : The DC data packet includes corrections to parameters that correct the state estimates for ephemeris parameters transmitted in the message types 10 and 11 (broadcast by the SV to which the DC data packet applies). The user will update the ephemeris parameters utilizing a variation of the algorithm expressed in the following equations. The user will then incorporate the updated quasi-Keplerian element set in all further calculations of SV position, as represented by the equations in Table 20-II (see para. 20.3.3.1.3). Ephemeris-related DC data shall not be applied to any SV transmitting message types 10 and 11 containing a t_{op} value greater than the t_{op-D} value of message types 34 or 14 containing the ephemeris-related DC data.

IS : The DC data packet includes corrections to parameters that correct the state estimates for ephemeris parameters transmitted in the message types 10 and 11 (broadcast by the SV to which the DC data packet applies). The user will update the ephemeris parameters utilizing a variation of the algorithm expressed in the following equations. The user will then incorporate the updated quasi-Keplerian element set in all further calculations of SV position, as represented by the equations in Table 20-II (see para. 20.3.3.1.3). Ephemeris-related DC data shall not be applied to any SV transmitting message types 10 and 11 containing a t_{op} value greater than the t_{oK-D} value of message types 34 or 14 containing the ephemeris-related DC data.

Req ID : IS705-356

WAS : For any time, t_k, other than t_{op-D}, UDRA is found by,

$$UDRA = UDRA_{op-D} + \dot{UDRA}(t_k - t_{op-D})$$

IS : For any time, t_k, other than $t_{oK\text{-}D}$, UDRA is found by,

$$UDRA = UDRA_{op\text{-}D} + \dot{UDRA}\,(t_k - t_{oK\text{-}D})$$

Req ID : IS705-1477

WAS : The t_{oe} shall be equal to the toc of the same CNAV data set. The following rules govern the transmission of toe and t_{oc} values in different data sets: (1) The transmitted t_{oc} will be different from any value transmitted by the SV during the preceding seven days; (2) The transmitted t_{oe} will be different from any value transmitted by the SV during the preceding six hours.

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 20.3.4.1) at any time during the hour and therefore may be transmitted by the SV for less than one hour.

The start of the transmission interval for each data set corresponds to the beginning of the curve fit interval for the data set. Each data set remains valid for the duration of its transmission interval, and nominally also remains valid for the duration of its curve fit interval. A data set is rendered invalid before the end of its curve fit interval when it is superseded by the SV cutting over to the first data set of a new upload.

Normal Operations. The message type 10, 11, and 30-37 data sets are transmitted by the SV for periods of two hours. The corresponding curve fit interval is three hours.

IS : The t_{oe} shall be equal to the t_{oc} of the same CNAV data set. The following rule governs the transmission of t_{oe} and t_{oc} values in different data sets: The transmitted t_{oe}/t_{oc} will be different from any value transmitted by the SV during the preceding seven days.

Cutovers to new data sets will occur only on hour boundaries except for the first data set of a new ICE data projection sequence. The first data set may be cut-in (reference paragraph 20.3.4.1) at any time during the hour and therefore may be transmitted by the SV for less than one hour.

The start of the transmission interval for each data set corresponds to the beginning of the curve fit interval for the data set. Each data set remains valid for the duration of its transmission interval, and nominally also remains valid for the duration of its curve fit interval. A data set is rendered invalid before the end of its curve fit interval when it is superseded by the SV cutting over to the first data set of a new ICE data projection sequence.

Normal Operations. The message type 10, 11, and 30-37 data sets are transmitted by the SV for periods of two hours. The corresponding curve fit interval is three hours.