ORBEX

The Orbit Exchange Format

Draft Version 0.09

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1. THE PHILOSOPHY OF ORBEX

The International GNSS Service (IGS), formerly known as the International GPS Service, has been generating GPS precise orbits since its inception in 1994. The format used for these initial IGS orbits was the Standard Product 3 (SP3-a) format developed by Benjamin Remondi [Remondi 1989, Remondi 1991, Spofford and Remondi 1994]. In 1998, Werner Gurtner and Markus Rothacher defined an SP3-b format to allow for the combination of GPS and GLONASS orbits in a single file [IGEX Mail 0042, 27 Oct 1998]. At the 2000 IGS Analysis Center Workshop, it was suggested to further modify the SP3 format to include clock accuracy information, and to provide separate orbit accuracy information for both the observed and the predicted parts of the IGS ultra-rapid orbits. In 2004, the IGS switched to SP3-c for its combined GPS orbits, beginning with week 1285 for the rapid and ultra-rapid orbits, and week 1283 for the final orbits [Gendt 2004].

At the 2008 IGS Analysis Center Workshop in Miami Beach, it was suggested to create a new orbit format for the IGS called the ORBit EXchange format (ORBEX). This new format would also be usable for Low Earth Orbiting (LEO) satellites and would possess the following features:

- Unlimited number of satellites
- Unlimited number of comments
- Irregularly spaced data epochs
- Variable number of satellites at each epoch
- A more flexible, SINEX-like header
- 0.1 mm position precision (for GRACE, and other formation-flying satellites)
- Blank-space delimited fields (to allow for any size coordinate or precision)
- Attitude information.

All of these features have now been incorporated into this format document, along with the idea of allowing for a possible future extension of the length of the satellite ID, since already in 2019 there are plans to launch a 500-satellite GNSS-RO (Radio Occultation) constellation. By necessity, the main philosophy behind ORBEX is flexibility. But it is also important to avoid redundancy, especially when it can conflict with existing IGS authoritative sources (for example, the SVN and COSPAR numbers maintained in the ANTEX file). It is not the purpose of this document to try to predict all possible future record types or header blocks for ORBEX, but rather to describe the records that have been suggested now, and to set the ground rules that will allow users to create new header blocks and record types as new constellations and new kinds of satellite-related data become available.

In Section 2 below, the ORBEX format is introduced in general terms, using a very simple example. In Section 3, the lines in each mandatory and optional block are described in detail, including the column widths of each field and the various options/codes that can be used. In Section 4, the formats for the different record types used in the EPHEMERIS/DATA block are described, along with the optional flags used in columns 1 through 23 of each data record. Next come four example ORBEX files, which are presented in Section 5. The remaining sections, 6 through 8, contain acknowledgements, references, and the revision history for ORBEX. The

Table of Contents on page 2 provides an easy way for readers to quickly find the format description for any type of block or data record.

2. GENERAL FORMAT DESCRIPTION

Figure 1 below shows a very simple ORBEX example with one satellite and three epochs. This example will serve as a starting point to describe the five mandatory parts of any ORBEX file: the two header lines, the FILE/DESCRIPTION block, the SATELLITE/ ID_AND_ DESCRIPTION block, the EPHEMERIS/DATA block, and %END_ORBEX record. Note that in ORBEX, any line that begins with an asterisk in column 1 is a comment.

2.1 Header Lines

Each ORBEX file starts with two header lines. The first header line always begins with the characters '%=ORBEX' followed by the ORBEX version number (e.g., 0.09). The remaining columns on this line are reserved. Be aware that there can exist ORBEX 0.09 files that contain only satellite attitude information (i.e., ATT records) in the +EPHEMERIS/DATA block.

The second header line begins with the characters '%% '. The remaining columns on this line are likewise reserved for future use. See Section 3.1 for a detailed description of the header lines.

```
%=ORBEX  0.09
%%
+FILE/DESCRIPTION
 DESCRIPTION         EXAMPLE LEO ORBIT
 CREATED_BY          Dr. P. Caspian, Narnia AC
 CREATION_DATE       2010  2  8 12  0  0
 INPUT_DATA          p
 CONTACT             pc@igsac.narnia.gov
 TIME_SYSTEM         GPS
 START_TIME          2002 12 29  0  0  0.000000000000
 END_TIME            2002 12 29  0  0  2.000000000000
 EPOCH_INTERVAL      IRREGULAR
 COORD_SYSTEM        IGS00
 FRAME_TYPE          ECEF
 ORBIT_TYPE          FIT
 LIST_OF_REC_TYPES   POS
 ORBIT_XYZ_UNITS     METERS
 ORBIT_XYZ_REFERENCE CENTER-OF-MASS
-FILE/DESCRIPTION
*------------------------------------------------------------------------------
+SATELLITE/ID_AND_DESCRIPTION
*ID_    SATELLITE_DESCRIPTION_____________________________________________________
 L06    CHAMP
-SATELLITE/ID_AND_DESCRIPTION
*--------1---------2---------3---------4---------5---------6---------7----------
*2345678901234567890123456789012345678901234567890123456789012345678901234567890
+EPHEMERIS/DATA
*
## 2002 12 29  0  0  0.000000000000   1
*REC ID_    FLAGS_    N ________X_(m)___ ________Y_(m)___ ________Z_(m)___
 POS L06              3     1781848.9098     5968846.1797    -2704551.4098
## 2002 12 29  0  0  1.000000000001   1
 POS L06              3     1727998.7897     5780000.6581    -3119210.3412
## 2002 12 29  0  0  2.000000000003   1
 POS L06              3     1664504.1705     5565312.9920    -3519546.7577
-EPHEMERIS/DATA
%END_ORBEX
```

Figure 1. A very simple ORBEX example with one satellite and three epochs.

2.2 Header Blocks

In ORBEX, everything after the two header lines, and before the %END_ORBEX record, is a block (with the exception of comment lines, which can appear anywhere). There are two types of blocks: the blocks that come at the beginning of an ORBEX file (i.e., the header blocks), and the final block that stores the actual satellite positions, clock corrections, etc. (i.e., the EPHEMERIS/DATA block). In the future there may be other types of "data" blocks, but currently, the EPHEMERIS/DATA block is the only one. All of the various record types that are used to store satellite information (coordinates, velocities, clock corrections, clock rate-of-change, correlations, attitude information, etc.) can be found in the EPHEMERIS/DATA block. It is always the last block in an ORBEX file.

Since ORBEX is usable for any satellite, in many instances the file will be very simple like the example given above (although probably not as short). Header blocks that contain detailed information are optional within ORBEX, since for many applications they are not required. There are three mandatory blocks that are required for any satellite (or group of satellites). The first is the FILE/DESCRIPTION block, which lists: a description of the file, the name of the person/agency which created the file, the creation date, and various lines which describe how the file was created and which types of data records are present. The second is the SATELLITE/ID_AND_DESCRIPTION block, which defines the 3-character satellite ID(s) used throughout the file (the length of these satellite IDs may be extended in the future), and includes a description of each satellite. And finally, the EPHEMERIS/DATA block, which contains all of the actual ephemeris data. In the mandatory SATELLITE/ID_AND_DESCRIPTION block, it is required that the satellites be listed in numerical order for each constellation. The order of the constellations is arbitrary (i.e., the Galileo satellites can come before the GPS satellites, or vice-versa). All of the other optional SATELLITE blocks must use the same ordering for the satellite IDs as the SATELLITE/ID_AND_DESCRIPTION block. The FILE/DESCRIPTION block and the SATELLITE/ID_AND_DESCRIPTION block must always be the first and second blocks in an ORBEX file, respectively. The current list of ORBEX blocks is shown below.

The "mandatory" blocks are:

FILE/DESCRIPTION,
SATELLITE/ID_AND_DESCRIPTION,
EPHEMERIS/DATA

The "optional" header blocks are:

SATELLITE/STD_DEVS,
EPHEMERIS/MODELS,
SATELLITE/MANEUVER_INFO,
SATELLITE/ECLIPSE_INFO,
SATELLITE/EVENT.

The first two optional header blocks, the SATELLITE/STD_DEVS block and the EPHEMERIS/MODELS block, merit some further discussion since they were designed to replicate the functionality currently found in the SP3-c and SP3-d format. Similar to these formats, the SATELLITE/STD_DEVS block contains the standard deviations for position for each satellite. And as a new feature, it now lists the standard deviations for the clock corrections as well. The quoted errors should represent one standard deviation for the specified time span for each respective satellite (i.e., there can now be separate standard deviations for both the observed and predicted parts of the IGS combined ultra-rapid orbits. See example 2 in Section 5).

The EPHEMERIS/MODELS block stores the same model information that is currently stored in the four comment records of the SP3-c format for the IGS combined orbits: the name of the satellite PCV model used (e.g., igs05_1580.atx), the names of the ocean and atmospheric tidal loading models used and whether a center-of-mass correction was included in these models, and the origin definitions for the orbits and clocks [Gendt 2006]. Further details can be found in Section 3.5.

2.3 The EPHEMERIS/DATA Block

Recall that in the SP3 format, each epoch is required to have the same number of satellites, which match exactly the number of satellites given in the header. If a satellite is missing at an epoch, it is required to fill those fields with zeros (which signifies that the positions at those epochs are unknown). This can happen, for example, if a satellite has a maneuver and the last portion of the day is missing. For ORBEX, one is now allowed to have a variable number of satellites at each epoch. Also, each satellite may have a different number of record types; for example, if a file has both GNSS satellites and LEO satellites, the LEOs may have attitude information (ATT records) but not the GNSS satellites. Similarly, the GNSS satellites may have clock information (CLK records) but not the LEO satellites. And a file can have only satellite attitude information (i.e., quaternions stored in ATT records) and no satellite position or velocity information stored in the EPHEMERIS/DATA block.

In the EPHEMERIS/DATA block, the satellites at each epoch can come in any order. The various record types (see Figure 2 in section 4) can also come in any order and can even be separate from one another for the same satellite. There are two exceptions: a CPC record must always follow its corresponding PCS record, and a CVC record must always follow its corresponding VCS record. This is because both records together are required to build the 4-by-4 covariance matrix for the coordinates and clock correction (or the velocities and clock rate). Even though the satellites and record types are allowed to come in any order, for the sake of readability, it is “recommended” that the satellites follow the same order as the SATELLITE/ ID_AND_DESCRIPTION block, and that the record types for each satellite be kept together and follow the same general order shown in Figure 2.

The PCS record type, shown in Examples 1 and 2 in Section 5, stores the same information as the old P-record in the SP3-c format, namely: PRN/Slot number, X, Y, Z, satellite clock correction, and the standard deviations for these values. In the process of combining the orbits of several Analysis Centers (ACs) to make the IGS production orbits, standard deviations are

inserted at each SP3-c epoch based on the agreement between the ACs [Gendt 2004b]. The new POS record type in ORBEX stores only the X,Y,Z coordinates for the satellites, and the stand-alone CLK record type stores only the satellite clock correction. These two new record types give users the flexibility of providing CLK records at a more frequent interval than the POS records, if necessary.

For the records which appear in the EPHEMERIS/DATA block, the data values on each line come after column 23 and are separated by blank spaces. In columns 2 through 23, the record type label, satellite ID (the length of which may be extended in the future), event flags, maneuver flags, predicted flags, and the "number of data columns present" always follow a fixed-format. The actual number of values read in after column 23 will depend on the "number of data columns present" value stored in column 23. For example, there is a maximum of 8 data values for a PCS record, but if the user wishes to omit the standard deviations, then the number of data columns present will be 4 rather than 8. This saves time and space by not forcing users to pad missing data with 0.0 values. Obviously, if an absent value is embedded between two data values that are being used, then that value must be represented by a 0.0 so that the total set of data values can still be read as a free-formatted set of numbers, each separated by one or more blank spaces.

2.4 Additional Formatting Tips

The remaining paragraphs in this section discuss general guidelines for formatting an ORBEX file. All fields in the header blocks are designed to have a FIXED-FORMAT. The records types in the EPHEMERIS/DATA block, which are used to store: position, velocity, satellite clock corrections, clock-rate, correlation information, attitude information, etc. are FREE-FORMATTED after column 23. This gives users the flexibility to use larger numbers, or a greater number of decimal places, if necessary. The record type formats discussed in Section 4 do include "recommended" field widths and formats, and these should work well for most satellites (up to geostationary altitudes). For the header blocks, and for these "recommended" field widths, the following rules apply. Unless otherwise specified, all character strings are left-justified in their defined fields, and all integers and floating-point numbers are right-justified. The width of each field, and the precision of the floating point numbers, are represented using Fortran syntax (e.g., A3, I17, F16.7, etc.). This is similar to other IGS formats like RINEX, SINEX, ANTEX, etc. Hopefully, with the examples given here, this syntax will be easily understood even by those who program in other computer languages. When data items are not needed for certain types of files, those fields can be left blank.

All year values are 4-digit integers. No need to pad the month, day, hour, minute, or second fields with leading zeroes; the only field that is padded with leading zeroes is the one used for the satellite names (e.g., G02 or R09).

Comment lines always begin with an "*" in column 1, and can be used to provide column headings and to show units. These column headings can also use underscore characters to show the width of each field. All ORBEX files must end with the %END_ORBEX record.

3. FORMATS FOR HEADER BLOCKS

There are currently eight different blocks defined for ORBEX. The following section begins with the format specifications for the two header lines, and then provides the specifications for each of the nine different types of blocks.

3.1 Header Lines (Mandatory)

Description:

Each ORBEX file must begin with the two header lines described below. The first header line begins with the characters %=ORBEX followed by: the ORBEX version number.

The second line begins with the characters '%% '. The later columns are reserved for future use.

Contents:

FIRST HEADER LINE

Field	Description	Format	Cols
First Character	Single character '%' in column 1. No other character than '%' is allowed.	A1	1 to 1
Second Character	Single character '=' in column #2. No other character than '=' is allowed.	A1	2 to 2
Document Type	Five characters 'ORBEX' in cols 3 to 7. Indicates that this is an ORBit EXchange document.	A5	3 to 7
Format Version	Five digits indicating the version of ORBEX format used. ' 0.09' for this version.	1X,F5.2	8 to 13
RESERVED COLUMNS	The remaining columns are reserved for future use.		14 to 120
		Total 120	

SECOND HEADER LINE

Field	Description	Format	Cols
First Character	Single character '%' in column #1. No other character than '%' is allowed.	A1	1 to 1
Second Character	Single character '%' in column #2. No other character than '%' is allowed.	A1	2 to 2
Third	Single character ' ' in column #3.	A1	3 to 3

Character	No other character than ' ' is allowed.		
RESERVED COLUMNS	The remaining columns are reserved for future use.		4 to 120
		Total 120	

3.2 FILE/DESCRIPTION Block (Mandatory)

Description:

This block provides information on the purpose of the file, the person/agency creating the file, the date the file was created, the type of data used in creating the file, etc. For each type of information, the formats used in cols 21 through 120 will differ. See the NOTES section below to see how to format the information associated with each particular label. This block must always be the first block in an ORBEX file.

Contents:

FILE/DESCRIPTION DATA LINE			
Field	Description	Format	Cols
Information Type Labels	Describes the type of information present in the next field. May take on the following values: 'DESCRIPTION' - Description of the file contents. 'CREATED_BY' - Name of agency which created the file. 'CREATION_DATE' - The YMDHMS when the file was created. 'INPUT_DATA' - Brief description of the input used to generate this ephemeris file. 'CONTACT' - E-mail address of the relevant contact person. 'TIME_SYSTEM' - 3-char code used to specify the time system used in file. 'START_TIME' - The first epoch in the file (as YMDHMS). The time may also be optionally given as: (MJD,fracOfDay) and (GPS week, secsOfWk). 'END_TIME' - The last epoch in the file (as YMDHMS). The time may also be optionally given as: (MJD,fracOfDay) and (GPS week, secsOfWk). 'EPOCH_INTERVAL' - Number of seconds between each epoch time tag. For files with irregularly spaced epochs this field will be filled with the word “IRREGULAR”. 'COORD_SYSTEM'- 20-char label used to specify the reference frame used in file. (e.g. IGS05,ICRF,etc) 'FRAME_TYPE' - 20-char code denotes the frame type (e.g., ECEF, BCRS= Barycentric Ref.Sys.,	1X,A19	1 to 20

	ECI,etc.) 'ORBIT_TYPE' - 3-char code denotes the orbit type (e.g., FIT=Fitted, EXT=Extrapol./Pred., BRD=Broadcast, HLM= Fitted after applying a Helmert transf.). 'LIST_OF_REC_TYPES' - List of 3-char record types used in file. All of the above labels must be present and in the above order. When comment records are added to this block, it is recommended that an asterisk be placed in column 1 and columns 2 through 21 be left blank. --- All of the labels below are optional, but must come in this order, after the 'LIST_OF_REC_TYPES' line in the +FILE/DESCRIPTION block. 'ORBIT_XYZ_UNITS' – can be “METERS”, “KILOMETERS”, etc. (format is A99) 'ORBIT_XYZ_REFERENCE' – can be “CENTER-OF-MASS”, “ANTENNA-PHASE-CENTER”. etc. (format is A99) 'ORBIT_VEL_UNITS' – can be “METERS/SEC”, “DECIMETERS/SEC”, etc. (format is A99) 'SVCLK_UNITS' – can be “MICROSECONDS”, “NANOSECONDS”, etc. (format is A99) 'SVCLK_RATE_UNITS' – can be “NANOSECONDS/SECOND”, “PICOSECONDS/SECOND”, etc. (format is A99)		
Information	Relevant information for each label (see the detailed notes below).	1X,A99	21 to 120
		Total 120	

NOTES:

'DESCRIPTION' – A description of the file contents (i.e., the type of orbit and the types of satellites, purpose of the orbit file, etc.). The format is: A99

'CREATED_BY' – The name of the person or agency which created the file. The format is: A99

'CREATION_DATE' – Date and Time of creation (given to the nearest second). Use cols 22 to 40.
The YMDHMS format is: I4,5(1X,I2)
The format for the entire line would be: format(1x,a19,1x,i4,5(1x,i2))

'INPUT_DATA' – A description of the data that was used to compute the orbit. The format is: A99. Since it is important to have this information easily read by computer, the following codes can be used alone, or joined together with the ‘+’ sign, to represent the type(s) of data used for the orbit (and clock) determination:

u -- undifferenced carrier phase
du -- change in u with time

```
    s   -- 2-receiver/1-satellite carrier phase
    ds  -- change on s with time
    d   -- 2-receiver/2-satellite carrier phase
    dd  -- change in d with time

    U   -- undifferenced code phase (range observations)
    dU  -- change in U with time
    S   -- 2-receiver/1-satellite code phase (range observations)
    dS  -- change in S with time
    D   -- 2-receiver/2-satellite code phase (range observations)
    dD  -- change in D with time

    a   -- angular measurements
    p   -- position data (e.g, an orbit fitted to a GNSS kinematic navigation solution)
    o   -- Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) data
    L   -- Satellite Laser Ranging (SLR) observations
    x   -- Other (explain in one or more comment records). This is a lowercase x.
    +   -- type separator
```

For example, if a LEO satellite orbit was computed using GPS undifferenced phase and range, SLR, and DORIS measurements, it would have an input data code of “u+U+L+o". If there are measurements used that are not defined here, use “x” for “other” and describe the measurements using one or more comment records (recall that a comment record is any record that has an asterisk in column one). For files that are a combination of orbits from two or more sources, use the code ‘ORBIT’. This table is not final, suggestions are welcome.

'CONTACT' – The E-Mail address for the relevant contact person.
The format is: A99

‘TIME_SYSTEM’ – Examples: GPS, UTC(Universal Coordinated Time, BIPM), TAI(International Atomic Time), GAL(Galileo), GLO(GLONASS), ‘TT ‘(Terrestrial Time), etc. The format is: A20. For time systems like UTC and GLO that can be affected by leap seconds, the ORBEX file must be leap seconds free for its duration. For such files, the constant leap second offset used in the file (with respect to TAI) should listed after the TIME_SYSTEM code, for example:

```
UTC                LEAP_SECOND_OFFSET_(UTC-TAI):  -34.0
```

The format is A20,A29,F7.1, with the A29 field being the ‘LEAP_SECOND_OFFSET_(UTC-TAI):’ label.

'START_TIME' - Time of first ephemeris epoch. For YMDHMS use cols 22 to 53 with the format: I4,4(1X,I2),1X,F15.12
- For Modified Julian Date and fraction of day (this is optional) use cols 56 to 80 with the format: I5,1X,F19.17
- For GPS week and seconds of week (this is optional) use cols 83 to 106 with the format is: i4,1X,F19.12

Note: The different date/time formats are for the user’s convenience. They must all agree and be in the same TIME SYSTEM as specified above. The GPS week is a continuous count starting in 1980 (no modulo 1024, no Galileo week count). If all three types of times are given, the format for the entire line would be: format(1x,a19,1x,i4,4(1x,i2),1x,f15.12,2x,i5,1x,f19.17,2x,i4,1x,f19.12)

'END_TIME' - Time of last ephemeris epoch. For YMDHMS use cols 22 to 53 with the format: I4,4(1X,I2),1X,F15.12
- For Modified Julian Date and fraction of day (this is optional) use cols 56 to 80 with the format: I5,1X,F19.17
- For GPS week and seconds of week (this is optional) use cols 83 to 106 with the format: i4,1X,F19.12

Note: The different date/time formats are for the user’s convenience. They must all agree and be in the same TIME SYSTEM as specified above. The GPS week is a continuous count starting in 1980 (no modulo 1024, no Galileo week count). If all three types of times are given, the format for the entire line would be: format(1x,a19,1x,i4,4(1x,i2),1x,f15.12,2x,i5,1x,f19.17,2x,i4,1x,f19.12)

'EPOCH_INTERVAL' - The spacing (in seconds) between each ephemeris epoch. Cols 22 to 30. The format is F9.3 . For files with irregularly-spaced epochs, this field will be filled with the word “IRREGULAR” (A9).

‘COORD_SYSTEM’ and ‘FRAME_TYPE’ – To make these fields machine-readable, please use the codes listed in the table below. This table is not considered final, suggestions are welcome and new coordinate systems will be added as they are created or requested. For the ECEF coordinate systems listed below for the original IGS orbits, the reference Epoch time scale is GPS Time. For The quasi-inertial ECI frames, the time scale is usually Terrestrial Time (TT) where TT = TAI + 32.184 seconds and TAI is International Atomic Time. The format for both codes is A20.

COORD_SYSTEM	(Epoch)	(time span when this system was used by the IGS orbits)	FRAME_TYPE

ITRF92	1994.0	0000 January 9, 1994	until 2400 December 31, 1994.	ECEF
ITRF93	1995.0	0000 January 1, 1995	until 2400 June 29, 1996.	ECEF
ITRF94	1996.0	0000 June 30, 1996	until 2400 February 28, 1998.	ECEF
ITRF96	1997.0	0000 March 1, 1998	until 2400 July 31, 1999.	ECEF
ITRF97	1997.0	0000 August 1, 1999	until 2400 June 3, 2000.	ECEF
IGS97	1997.0	0000 June 4, 2000	until 2400 December 1, 2001.	ECEF
IGS00	1998.0	0000 December 2, 2001	until 2400 January 10, 2004.	ECEF
IGb00	1998.0	0000 January 11, 2004	until 2400 November 4, 2006.	ECEF
IGS05	2000.0	0000 November 5, 2006	until 2400 April 16, 2011.	ECEF
IGS08	2005.0	0000 April 17, 2011	until 2400 October 6, 2012.	ECEF
IGb08	2005.0	0000 October 7, 2012	until 2400 January 28, 2017.	ECEF
IGS14	2010.0	0000 January 29, 2017	until the present.	ECEF

COORD_SYSTEM	Reference Epoch	FRAME_TYPE
J2000 (EME2000)	1 January 2000 at 12:00:00.00 TT (JD 2451545.0)	ECI
B1950	31 December 1949 at 22:09:07.2 TT (JD 2433282.423)	ECI
M50	1 January 1950 at 12:00:00.00 TT (JD 2433283.0)	ECI
ICRF	J2000.0 = 1 January 2000 at 12:00:00.00 TT (JD 2451545.0)	BCRS
SPECIAL	(describe any “SPECIAL” COORD SYSTEM using a comment record)	
	(describe “OTHER” FRAME TYPE using a comment record)	OTHER

Note: For the combined IGS orbits, the FRAME TYPE will likely be an Earth-Centered, Earth-Fixed frame (ECEF). For cases where the user may want to use the ORBEX format to store satellite positions in an inertial frame, this label may be ‘BCRS’ (for the quasi-inertial Barycentric reference system) or ‘ECI’ for a quasi-inertial, Earth-Centered reference frame. Note that there are many ECI frames (GCRF, MOD, TOD, J2000 or EME2000, TEME, M50, etc.). Use “OTHER” for any frame type not listed here, and explain using one or more comment records. This table is not final, suggestions are welcome.

'ORBIT_TYPE' – The “type of orbit” is described using a three character label. The four orbit types currently defined are listed below. This list is not final, other labels may be added in the future. The format is A3.
FIT (fitted)
EXT (extrapolated or predicted)
BRD (broadcast)
HLM (fitted after applying a Helmert Transformation).

'LIST_OF_REC_TYPES' - A list of the record types one can expect to find in this ORBEX file. For example, a file with positions, clocks, and attitude information might use three types of records:
POS CLK ATT
These three digit codes are each separated by a blank space. Cols 22 to 117. The format is 24(A3,1X).

The labels listed below may be optional. They have been moved here from the two header lines because they are not mandatory for all files (e.g., for a file with only ATT records in the EPHEMERIS/DATA block). Only a few of these may be used to describe the EPHEMERIS/DATA, or none at all. If any of these labels appear in the FILE/DESCRIPTION block, they should appear in the same general order as shown below. They are required whenever the EPHEMERIS/DATA block includes position, clock, velocity, and/or clock-rate information.

'ORBIT_XYZ_UNITS' – Satellite position coordinates can be in units of “METERS”, “KILOMETERS”, etc. (format is A99).

'ORBIT_XYZ_REFERENCE' – The reference point for these satellite positions (and velocities) can be the satellite “CENTER-OF-MASS”, “ANTENNA-PHASE-CENTER”, etc. (format is A99).

'ORBIT_VEL_UNITS' – Satellite velocity vector components can be in units of “METERS/SEC”, “DECIMETERS/SEC”, etc. (format is A99).

‘SVCLK_UNITS' – The satellite clock corrections can be in units of “MICROSECONDS”, “NANOSECONDS”, etc. (format is A99).

‘SVCLK_RATE_UNITS' – The rate-of-change of the satellite clock corrections can be in units of ”NANOSECONDS/SECOND”, “PICOSECONDS/SECOND”, etc. (format is A99).

3.3 SATELLITE/ID_AND_DESCRIPTION Block (Mandatory)

Description:

This block provides the definitions for the 3-character satellite identification labels (IDs) that will be used throughout the file, in the various header blocks and in the main EPHEMERIS/DATA block. This block must always follow the FILE/DESCRIPTION block as the second header block in an ORBEX file. Each 3-character ID is followed by a 100-character description field. In addition to satellite names, this description field can also be used to store certain types of satellite-specific information. This can be especially useful for applications which might not have special header blocks already defined. For the 3-character IDs, it is recommended that the IGS-defined IDs be used (especially for GNSS and LEO applications). These follow the conventions set by associated formats like RINEX and ANTEX (see the NOTES section below). If no previous IGS-defined code(s) exist, then user-defined satellite IDs can be used and described via this SATELLITE/ID_AND_DESCRIPTION block.

Contents:

SATELLITE/ID_AND_DESCRIPTION DATA LINE			
Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Satellite ID	First character represents a constellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R09 for GLONASS). For LEOs see: http://cddis.nasa.gov/sp3c_satlist.html . Note: SV IDs like "G 2" or "R 9" or " 31" are not allowed. This is the unique satellite identifier for the entire file.	A1,I2.2	2 to 4
RESERVED COLUMN	Columns 5 to 7 are reserved for later use (in case longer SV IDs become necessary).	3X	5 to 7
Satellite Description	The type of satellite within the constellation (e.g., BLOCK IIR-B for GPS, or GLONASS-M for GLONASS) For LEOs, this can be the SV name (e.g., for L06 use "CHAMP"). For files with only GNSS SVs, these descriptions are optional (note that they do not appear in the older SP3 formats).	1X,A100	8 to 108
		Total 108	

NOTES:

As described previously in the Sp3-c format, and in RINEX, the IGS-defined satellite IDs are comprised of a one-character satellite system identifier followed by two-digit integer number (e.g., G02, G31, R03, R15, E02, C01, S22, L06, etc.). The satellite system identifier codes are:

- G : GPS
- R : GLONASS
- E : Galileo
- C : COMPASS
- L : Low Earth Orbiting satellite (LEO), see http://cddis.nasa.gov/sp3c_satlist.html
- S : Satellite-Based Augmentation System (SBAS)

The 2-digit integer numbers represent the following for each different type of constellation:

- PRN (for GPS, Galileo, and COMPASS)
- Slot number (for GLONASS)
- PRN-100 (for SBAS Geostationary)

If the integer number is less than 10, it should be padded with a leading zero (i.e., 'G01' not 'G 1'). All numbers must be >= 01 and <= 99; zero is not a valid satellite number.

There are codes for many different LEO satellites given at the CDDIS web page referenced above. If no IGS-defined code is available for a satellite (or group of satellites) the user can define new codes. It is recommended that the new codes not use any of the six letters listed above, to avoid any possible confusion regarding a satellite's identity.

For each constellation type, the satellite IDs must be listed in numerical order. The constellation types themselves can come in any order (e.g., in a file containing GPS and GLONASS satellites, the GLONASS satellites can come first in numerical order, followed by the GPS satellites in numerical order -- or vice-versa).

3.4 SATELLITE/STD_DEVS Block (Optional)

Description:

Similar to the older SP3-c format, this block lists: the standard deviation of the satellite positions for a given time period (in mm), and now the standard deviation of the satellite clock corrections (in picosecs). Also listed are the observed/predicted flags, and the Start/End Times. Since each line has its own start and stop time, additional lines can be added to give different position and/or clock standard deviations for specific time spans (e.g., for the predicted part of the IGS ultra-rapid orbit, or for periods when a satellite is known to have experienced a problem). If a position standard deviation is unknown leave the field blank; if it is greater than 100 meters, use the value 99999.99 mm in columns 50 to 57. If a clock correction standard deviation is unknown leave the field blank; if it is greater than 100 microseconds, use the value 99999999.999 psec in columns 59 to 70. The order of the satellite IDs in this block must match that used in the SATELLITE/ID_AND_DESCRIPTION block.

Contents:

SATELLITE/STD_DEVS DATA LINE

Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Satellite ID	First character represents a constellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R09 for GLONASS). For LEOs see: http://cddis.nasa.gov/sp3c_satlist.html . Note: SV IDs like "G 2" or "R 9" or " 31" are not allowed. This is the unique satellite identifier for the entire file.	A1,I2.2	2 to 4
RESERVED COLUMN	Columns 5 to 9 are reserved for later use (in case longer SV IDs become necessary).	3X	5 to 7
Standard Dev. for Positions	Standard Deviation for satellite positions, for the time period specified (one sigma, units = mm).	1X,F8.2	8 to 16
Standard Dev. for Satellite Clock Corrections	Standard Deviation for satellite clock corrections, for time period specified (one sigma, units = picoseconds).	1X,F12.1	17 to 29
Orbit Prediction Flag	A two-char Observed/Predctd. flag OB = orbit has been observed PR = orbit is predicted (for the time period specified).	1X,A2	30 to 32
Clock Corr. Prediction Flag	A two-char Observed/Predctd. flag OB = clock has been observed PR = clock is predicted (for the time period specified).	1X,A2	33 to 35

Start Time (YMDHMS)	First epoch for the time period specified for the standard devs, # epochs, and obs/predicted flag (time is to the nearest second).	1X,I4 1X,I2 1X,I2 1X,I2 1X,I2 1X,I2	36 to 55
End Time (YMDHMS)	Last epoch for the time period specified for the standard devs, # epochs, and obs/predicted flag (time is to the nearest second).	1X,I4 1X,I2 1X,I2 1X,I2 1X,I2 1X,I2	56 to 75
		Total 75	

3.5 EPHEMERIS/MODELS Block (Optional)

Description:

This block provides information on the various models used to calculate the satellite positions and satellite clock corrections in an ORBEX file. For the IGS combined orbit files, this might include the name of the satellite antenna Phase Center Variation (PCV) model, the name of the Ocean Tide Loading (OTL) model, the name of the Atmospheric Tide Loading (ATL) model, and whether or not the Earth Center-of-Mass Correction (CMC) was applied to the OTL and ATL models. IGS combined orbit files may also have model names and codes that describe the origin definition for the orbits and satellite clock corrections.

Contents:

EPHEMERIS/MODELS DATA LINES			
Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Model Type	Type of model being described.	A40	2 to 41
Model Description	Describe the file(s) used to implement each model, the options or parameters used to implement each model, or a particular name which describes the exact model that was used. See the ‘Notes:’ section below for examples.	1X, A60	42 to 102
		Total 102	

NOTES:

The following is an example of what an EPHEMERIS/MODELS block might look like for an IGS combined orbit file:

```
+EPHEMERIS/MODELS
*MODEL_TYPE_____________________________ DESCRIPTION_____________________________________________
 SATELLITE_ANTENNA_PCV_MODEL             igs05_1575.atx
 OCEAN_TIDE_LOADING_MODEL                FES2004 EARTH_CMC_APPLIED
 ATMOSPHERIC_TIDE_LOADING_MODEL          NONE NO_EARTH_CMC_APPLIED
 ECEF_ORIGIN_DEFINITION_ORBITS           CENTER_OF_NETWORK
 ECEF_ORIGIN_DEFINITION_CLOCKS           CENTER_OF_NETWORK
-EPHEMERIS/MODELS
```

SATELLITE_ANTENNA_PCV_MODEL:
The history of which satellite antenna offsets and PCVs were used to create a GNSS orbit (or an IGS combined orbit) is tracked by noting the week number in the name of the ANTEX file (e.g., igs05_wwww.atx, where wwww is the GPS week when the file was released). For current GPS and GLONASS satellites the DESCRIPTION field should be filled using the complete, lowercase ANTEX filename (e.g. igs05_1575.atx). If no satellite PCV model was used, use the label NONE.

OCEAN_TIDE_LOADING_MODEL:
For orbit determination, the site-dependent amplitude and phase values for the 11 main tides can be generated upon request by the Bos-Scherneck Ocean Tide Loading (OTL) service at the Onsala Space Observatory: http://www.oso.chalmers.se/~loading/ . As an option, these 66 coefficients can be corrected for the center-of-mass motion of the earth, for various OTL models such as FES2004: http://www.oso.chalmers.se/~loading/cmc.html
The model name for the Ocean Tide Loading model must be given at the beginning of the DESCRIPTION field. If no OTL model was used, use the label NONE. Then, separated by one blank space, the label 'EARTH_CMC_APPLIED' or the label 'NO_EARTH_CMC_APPLIED' is given to indicate whether or not the center-of-mass correction (CMC) was included in the model.

ATMOSPHERIC_TIDE_LOADING_MODEL:
In a similar fashion, the name of the Atmospheric Tide Loading (ATL) model should be given at the beginning of the DESCRIPTION field. If no ATL model was used, use the label NONE. Then, separated by one blank space, the label 'EARTH_CMC_APPLIED' or the label 'NO_EARTH_CMC_APPLIED' is given to indicate whether or not the center-of-mass correction (CMC) was included in the model.

ECEF_ORIGIN_DEFINITION_ORBITS:
The orbits generated by the Analysis Centers (ACs) of the IGS are usually given in an Earth-Centered, Earth-Fixed frame (ECEF). Usually this frame is the latest International Terrestrial Reference Frame (ITRF) or a realization of the ITRF. The origin definition for the orbit(s) is CENTER_OF_NETWORK (CoN) if the center-of-mass corrections (CMC) are applied to the tide loading models during generation of the orbits. If these corrections are NOT applied, then the origin for the orbits is CENTER_OF_MASS (CoM).

ECEF_ORIGIN_DEFINITION_CLOCKS:
The origin definition for the clock(s) is CENTER_OF_NETWORK (CoN) if the station coordinates are fixed to the ITRF during clock adjustment. If the ORBEX file is created using Analysis Center data where not all of the clock data was referenced to the same origin, then the label used should be COMBINATION (Gendt, 2006). If no clocks are provided for the satellite(s), use the label NOT_APPLICABLE. Thus the choices for the origin definition of the clocks (as used together with an ECEF orbit) are:
CENTER_OF_NETWORK
COMBINATION
NOT_APPLICABLE

This EPHEMERIS/MODELS block may also be used to store information about other types of models. It is recommended that software reading this block be designed to skip over any model types it might not recognize. Below is a generic example that includes some additional model types.

```
+EPHEMERIS/MODELS
*MODEL_TYPE_____________________________ DESCRIPTION_____________________________________________
 SATELLITE_ANTENNA_PCV_MODEL             igs05_1575.atx
 OCEAN_TIDE_LOADING_MODEL                FES2004  EARTH_CMC_APPLIED
 ATMOSPHERIC_TIDE_LOADING_MODEL          NONE  NO_EARTH_CMC_APPLIED
 ECEF_ORIGIN_DEFINITION_ORBITS           CENTER_OF_NETWORK
 NUTATION                                IAU1980
 PRECESSION                              IAU1976
 SOLAR_SYSTEM_EPHEMERIS                  DE403
 RELATIVITY                              POST_NEWTONIAN
 ATMOSPHERE_MODEL                        MSIS77
 SOLAR_RADIATION_PRESSURE                CODE_9PARAM
-EPHEMERIS/MODELS
```

3.6 SATELLITE/MANEUVER_INFO Block (Optional)

Description:

This block provides information on the start time and end time of a satellite maneuver, and the total resultant change in velocity after the maneuver, in the radial, along-track, and cross-track directions (as referenced to the inertial orbital plane). The Delta-V fields in columns 72 through 104 are optional; in some cases the actual velocity change will be unknown, but the start and stop times will still be important for avoiding bad data. If the end time (i.e., the duration) is unknown, columns 40 to 71 may be left blank. For those satellites that have had

maneuvers, the order of the satellite IDs in this block must match that used in the SATELLITE/ID_AND_DESCRIPTION block.

Contents:

SATELLITE/MANEUVER_INFO DATA LINE			
Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Satellite ID	First character represents a constellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R02 for GLONASS). For LEOs see: http://cddis.nasa.gov/sp3c_satlist.html .	A1,I2.2	2 to 4
RESERVED COLUMN	Columns 5 to 7 are reserved for later use (in case longer SV IDs become necessary).	3X	5 to 7
Start Time (YMDHMS)	Date/Time when the maneuver was known to begin.	1X,I4 4(1X,I2) 1X,F15.12	8 to 40
End Time (YMDHMS)	Date/Time when the maneuver ended. If the end time (duration) is not known, these fields may be left blank.	1X,I4 4(1X,I2) 1X,F15.12	41 to 73
Radial Delta-V	The resultant change in velocity in the radial direction (m/sec).	1X,F10.4	74 to 84
Along-Track Delta-V	Resultant change in velocity in the along-track direction (m/sec).	1X,F10.4	85 to 95
Cross-Track Delta-V	Resultant change in velocity in the cross-track direction (m/sec).	1X,F10.4	96 to 106
		Total 106	

3.7 SATELLITE/ECLIPSE_INFO Block (Optional)

Description:

This block provides information on the start and stop time of an eclipse period for a particular satellite. For those satellites that are in eclipse, the order of the satellite IDs in this block must match that used in the SATELLITE/ID_AND_DESCRIPTION block.

Contents:

SATELLITE/ECLIPSE_INFO DATA LINE			
Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Satellite ID	First character represents a constellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R02 for GLONASS). For LEOs see: http://cddis.nasa.gov/	A1,I2.2	2 to 4

	sp3c_satlist.html .		
RESERVED COLUMN	Columns 5 to 7 are reserved for later use (in case longer SV IDs become necessary).	3X	5 to 7
Start Time (YMDHMS)	Date/Time when the eclipse was known to begin.	1X,I4 4(1X,I2) 1X,F15.12	8 to 40
End Time (YMDHMS)	Date/Time when the eclipse was known to end.	1X,I4 4(1X,I2) 1X,F15.12	41 to 73
TYPE OF ECLIPSE	'EARTH' = the satellite is in the earth's shadow, 'MOON ' = the satellite is in the moon's shadow.	1X,A5	74 to 79
		Total 79	

3.8 SATELLITE/EVENT Block (Optional)

Description:

This block provides information on the start and stop times of any generic "event" for a particular satellite. These events might be related to the satellite "clock", "phase", "power", etc. A clock event is any event which causes a discontinuity in the satellite clock corrections (such as when a clock fails and the satellite must switch to using a different onboard clock). An example of a phase event might be when the phase of the signal for a satellite suddenly shifts, and then shifts back again (the actual phase shift may vary, if the details are known they can be included in the description field). An example of a power event might be something like boosting the signal power on one or more satellites. For those satellites that are in eclipse, the order of the satellite IDs in this block must match that used in the SATELLITE/ID_AND_DESCRIPTION block. The list of event types given below is not final, suggestions are welcome.

Contents:

SATELLITE/EVENT DATA LINE			
Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Satellite ID	First character represents a constellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R02 for GLONASS). For LEOs see: http://cddis.nasa.gov/sp3c_satlist.html .	A1,I2.2	2 to 4
RESERVED COLUMN	Columns 5 to 7 are reserved for later use (in case longer SV IDs become necessary).	3X	5 to 7
Event Type	The type of event being described: CLOCK PHASE POWER	1X,A10	8 to 18
Start Time (YMDHMS)	Date/Time when the satellite event was known to begin.	1X,I4 4(1X,I2) 1X,F15.12	19 to 51

End Time (YMDHMS)	Date/Time when the event ended. If the end time (i.e., duration) is unknown, columns 50 to 82 may be left blank.	1X,I4 4(1X,I2) 1X,F15.12	52 to 84
DESCRIPTION	65-char comment describing what caused the satellite event (e.g., “clock failure: switched from cesium to rubidium”).	1X,A65	85 to 150
		Total 150	

3.9 EPHEMERIS/DATA Block (Mandatory)

Description:

This block is always the last, and usually the largest, block since it contains all of the ephemeris data for the ORBEX file. The data for each epoch begins with a Time Tag Line which gives the Year, Month, Day, Hour, Minute, and Seconds for the epoch, plus the number of satellites which appear at that epoch. Each Time Tag Line starts with the characters "##" in columns one and two. The Time Tag Line is then followed by a series of data records, each of which begins with a blank character, followed by a 3-character record type, then another blank character, then a 3-character Satellite ID (note that the width of this satellite ID may be extended in the future, to allow for constellations with greater than 99 satellites). The discussion in Section 4 below describes the format of the Time Tag Line and also the different record types which are used to store orbital data. It is not required that all satellites have the exact same number of record types. For example, a file that has GPS, GLONASS, and a LEO satellite might have attitude information for the LEO (ATT records) but not for the GNSS satellites. The satellites at each epoch can come in any order, and the record types can come in any order. However, for the sake of readability, it is recommended that the satellites be written in the same order as the mandatory SATELLITE/ID_AND_DESCRIPTION block, and that the record types for each satellite be kept together and follow the general order outlined in Figure 2 below. While the order of most record types can be arbitrary, there are two exceptions: a CPC record must always follow its corresponding PCS record, and a CVC record must always follow its corresponding VCS record. This is because both records are needed to build the 4-by-4 covariance matrix for the coordinates and clock correction (or for the velocities and clock rate-of-change).

Similar to all other blocks, this block must start with a +EPHEMERIS/DATA line and end with a -EPHEMERIS/DATA line. Recall that the last line in any ORBEX file must always be the %END_ORBEX line.

4. FORMATS FOR RECORD TYPES

Figure 2, on the following page, shows an example for the time tag record that defines the start of each epoch, and an example for each of the different record types used in the EPHEMERIS/DATA block.

Figure 2. Examples of possible record types used in the EPHEMERIS/DATA block.

Example TIME TAG record:

```
## 2009  4  7  0  0  0.000000000000  51
```

Example PCS record:

```
*REC ID_    FLAGS_    N ________X_(m)___ ________Y_(m)___ ________Z_(m)___ __SVCLK_(usec)__ __STD_X __STD_Y __STD_Z ____STD_CLK
*                                                                              (mm)    (mm)    (mm)       (psec)
 PCS G02    EP  MP    8     1718903.5130    17055266.0040    20273390.0550      153.7291220     3.8     4.8     6.0      19.358
```

Example CPC record:

```
*REC ID_    FLAGS_    N ______xy_corr____ ______xz_corr____ ______xc_corr____ ______yz_corr____ ______yc_corr____ ______zc_corr____
 CPC G02              6   -23467890123456    43567892345123   -56723416544276    23456785432412   -76543567234234   -87452341567655
```

Example VCS record:

```
*REC ID_    FLAGS_    N ______VX_(m/s)__ ______VY_(m/s)__ ______VZ_(m/s)__ _CLKRATE_(ns/s)_ _STD_VX _STD_VY _STD_VZ ____STD_CLK
*                                                                             (um/s)  (um/s)  (um/s)      (fs/s)
 VCS G02              8    -2393.7383154    -1007.7310408     1004.8616286       -0.0002584     1.1     2.2     3.3   45.678901
```

Example CVC record:

```
*REC ID_    FLAGS_    N ____vxvy_corr____ ____vxvz_corr____ ____vxvc_corr____ ____vyvz_corr____ ____vyvc_corr____ ____vzvc_corr____
 CVC G02              6   -23467890123456    43567892345123   -56723416544276    23456785432412   -76543567234234   -87452341567655
```

Example POS record:

```
*REC ID_    FLAGS_    N ________X_(m)___ ________Y_(m)___ ________Z_(m)___
 POS G02     P  MP    3     1718903.5130    17055266.0040    20273390.0550
```

Example VEL record:

```
*REC ID_    FLAGS_    N ______VX_(m/s)__ ______VY_(m/s)__ ______VZ_(m/s)__
 VEL G02              3    -2393.7383154    -1007.7310408     1004.8616286
```

Example CLK record:

```
*REC ID_    FLAGS_    N __SVCLK_(usec)__
 CLK G02    E         1      153.7291220
```

Example CRT record:

```
*REC ID_    FLAGS_    N __SVCLKR(ns/s)__
 CRT G02              1       -0.0002584
```

Example ATT record:

```
*REC ID_    FLAGS_    N ___q0_(scalar)_____ ____q1__x__________ ____q2__y__________ ____q3__z__________
 ATT L06              4  0.9164178227001020  0.3553674926002010  0.1624720204001450 -0.0865746035002370
```

4.1 Time Tag Line

TIME TAG LINE

Field	Description	Format	Cols
First two characters	The '##' characters in columns one and two are meant to provide an easy to see marker that sets the time tags lines apart from all other record types.	A2	1 to 2
Epoch Date/Time (YMDHMS)	The Date/Time to which the data at this epoch pertains. Note that the seconds field has 12 decimal places to allow for future picosec precision (which is well beyond the 1 nanosec per day drift of the current hydrogen-maser clocks). All times are in the TIME SYSTEM specified in the FILE/DESCRIPTION block. All time tags must be in chronological order. No duplicate time tags are allowed.	1X,I4, 4(1X,I2), 1X,F15.12	3 to 35
Number of Satellites	The number of unique satellite IDs that appear at this epoch. (between 1 and 999). The integer zero is not allowed; if there are no data, then omit the time tag (integers are right-justified).	1X,I3	36 to 39
		Total 39	

4.2 PCS Record

PCS RECORD TYPE (POSITION, CLOCK, & STANDARD DEVIATIONS)

Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Record Type	The 3-character Record Type code (for this record type: PCS).	A3	2 to 4
RESERVED	The fifth column is left blank.	1X	5 to 5
Satellite ID	First character represents a constellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R02 for GLONASS). For LEOs see: http://cddis.nasa.gov/sp3c_satlist.html .	A1,I2.2	6 to 8
RESERVED	Columns 9 to 11 are reserved for later use (in case longer SV IDs become necessary).	3X	9 to 11
Satellite Event Flag	‘E’ = a satellite event has occurred (a CLOCK,PHASE,or POWER event) Blank means either no event has occurred, or it is unknown whether any event has occurred. See the NOTES section below.	1X,A1	12 to 13

Predicted Clock Flag	'P' = the satellite clock corr at this epoch is predicted. A blank means the clock corr is observed.	A1	14 to 14
RESERVED	Columns 13 and 14 are reserved for later use.	2X	15 to 16
Maneuver Flag	'M' = a maneuver has occurred. A blank means either no maneuver occurred, or it is unknown whether any maneuver occurred. See the NOTES section below.	A1	17 to 17
Predicted Orbit Flag	'P' = the satellite position at this epoch is predicted. A blank means the position is observed.	A1	18 to 18
RESERVED	Columns 19 to 21 are reserved for later use.	3X	19 to 21
Number Of Data Columns Present	Gives the number of data columns present on this line after column 23. Choices are 3, 4, 7, or 8.	1x,I1	22 to 23
X-coordinate	The X-coordinate for the position of the satellite (in the coordinate system specified in the FILE/DESCRIPTION block). Units = meters.	1X,F16.4	24 to 40
Y-coordinate	The Y-coordinate for the position of the satellite. Units = meters.	1X,F16.4	41 to 57
Z-coordinate	The Z-coordinate for the position of the satellite. Units = meters.	1X,F16.4	58 to 74
Satellite Clock Correction	The satellite clock correction in units of microseconds. Bad/absent clock values are set equal to 9999999.9999999. Units = microseconds.	1X,F16.7	75 to 91
Standard Dev. for X-coord.	The one-sigma standard deviation for the X-coordinate at this epoch (for the IGS combined orbits, see IGSMAIL-5008, 7 Sep 2004). If the sigma = 99999.9, it means the uncertainty for this coordinate is greater than 100 meters, or the orbit for this SV is unreliable. Units = millimeters.	1X,F7.1	92 to 99
Standard Dev. for Y-coord.	The one-sigma standard deviation for the Y-coordinate at this epoch If sigma = 99999.9, it means the uncertainty for this coordinate is greater than 100 meters, or the orbit for this SV is unreliable. Units = millimeters.	1X,F7.1	100 to 107
Standard Dev. for Z-coord.	The one-sigma standard deviation for the Z-coordinate at this epoch If sigma = 99999.9, it means the uncertainty for this coordinate is greater than 100 meters, or the orbit for this SV is unreliable.	1X,F7.1	108 to 115

	Units = millimeters.		
Standard Dev. for Satellite Clock Correction	The one-sigma standard deviation for the satellite clock correction at this epoch (for the IGS combined orbits, see IGSMAIL-5008, 7 Sep 2004). If sigma = 9999999.999, then the uncertainty for this clock corr is greater than 10 microsec, or this SV clock corr should not be used. Units = picoseconds.	1X,F11.3	116 to 127
		Total 127	

NOTES: For each PCS record used in the EPHEMERIS/DATA block, the data after column 23 must be read free-formatted (i.e., each data value is separated by one or more blank spaces). However, the 3-character record type code, the 3-character satellite ID, the satellite event flag, the predicted/observed flags, the maneuver flag, the good/bad flags, and the Number of Data Columns Present (i.e., all of the fields in columns 2 to 23) must be read according to the fixed formats given above.

The **Satellite Event Flag** in column 13 can be ‘E’ or blank. ‘E’ indicates that sometime between the previous epoch and the current epoch, or at the current epoch, a satellite event occurred. A blank means either no event occurred, or it is unknown whether any event occurred. The three types of satellite events currently defined are:
CLOCK event (e.g., a clock swap on a satellite),
PHASE event (e.g., a signal phase shift on a satellite),
POWER event (e.g., a power boost to one or more signals from a satellite).

This list is not final, suggestions are welcome. Additional details regarding a particular problem or event for a satellite can be placed into a SATELLITE/EVENT block, which must be positioned somewhere prior to the EPHEMERIS/DATA block.

The **Maneuver Flag** in column 15 can be ‘M’ or blank. ‘M’ indicates that sometime between the previous epoch and the current epoch, or at the current epoch, an orbit maneuver took place for this satellite. A maneuver is loosely defined as any planned or humanly-detectable thruster firing that changes the orbit of a satellite. A blank means either no maneuver occurred, or it is unknown whether any maneuver occurred. Additional details regarding start time, stop time (if known), and the delta V’s for a satellite can be placed in a SATELLITE/MANEUVER block, prior to the EPHEMERIS/DATA block.

The **Number of Data Columns Present** value in column 23 gives the number of data values that are actually listed for this satellite and this particular record type. The maximum number of data values will depend on the record type: 8 for (PCS,VCS), 6 for (CPC,CVC), 4 for (ATT), 3 for (POS,VEL), and 1 for (CLK,CRT). Since the data values are read in free-formatted, it is recommended that reading programs first initialize all values to zero, then read the line into a buffer first (so that data items are never accidentally read from the next line). When a data value is invalid but is embedded in between two valid data values, then because of the free-formatting, it must be represented as a 0.0 - which acts as a place holder (e.g., if a PCS record has no clock information, but does have the position standard deviations, then the clock correction field must have a 0.0000000 as a place holder).

4.3 VCS Record

VCS RECORD TYPE (VELOCITY, CLOCK RATE, & STANDARD DEVIATIONS)			
Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Record Type	The 3-character Record Type code (for this record type: VCS).	A3	2 to 4
RESERVED	The fifth column is left blank.	1X	5 to 5
Satellite ID	First character represents a con-	A1,I2.2	6 to 8

	stellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R02 for GLONASS). For LEOs see: http://cddis.nasa.gov/sp3c_satlist.html .		
RESERVED	Columns 9 to 11 are reserved for later use (in case longer SV IDs become necessary).	3X	9 to 11
RESERVED	Columns 10 to 17 are not utilized for the VCS record.	7X	12 to 18
RESERVED	Columns 19 to 21 are reserved for future use.	3X	19 to 21
Number Of Data Columns Present	Gives the number of data columns present on this line after column 23. Choices are 3, 4, 7, or 8.	1x,I1	22 to 23
X-component of the satellite velocity	The X-component of the satellite velocity (in the coordinate system specified in the FILE/DESCRIPTION block). Units = meters/second.	1X,F16.7	24 to 40
Y-component of velocity	The Y-component of velocity. Units = meters/second.	1X,F16.7	41 to 57
Z-component of velocity	The Z-component of velocity. Units = meters/second.	1X,F16.7	58 to 74
Rate-of-Change of satellite	The rate-of-change of the satellite clock correction. Bad/absent clock rate-of-change values are set equal to 9999999.9999999. Units = nanoseconds/second.	1X,F16.7	75 to 91
Standard Dev. for X-velocity	The one-sigma standard deviation for the X-velocity at this epoch. If sigma = 99999.9, it means the uncertainty for this velocity is greater than 1 decimeter/sec, or this SV’s orbit is unreliable. Units = micrometers/second.	1X,F7.1	92 to 99
Standard Dev. for Y-velocity	The one-sigma standard deviation for the Y-velocity at this epoch. If sigma = 99999.9, it means the uncertainty for this velocity is greater than 1 decimeter/sec, or this SV’s orbit is unreliable. Units = micrometers/second.	1X,F7.1	100 to 107
Standard Dev. for Z-velocity	The one-sigma standard deviation for the Z-velocity at this epoch. If sigma = 99999.9, it means the uncertainty for this velocity is greater than 1 decimeter/sec, or this SV’s orbit is unreliable. Units = micrometers/second.	1X,F7.1	108 to 115
Standard Dev. Rate-of-Change of SV Clk corr.	The one-sigma standard deviation for the Rate-of_Change of the SV clock correction at this epoch. If sigma = 9999999.999, then the uncertainty for this clock rate is > than 10 nanosec/sec, or this clock rate should not be used.	1X,F11.3	116 to 127

	Units = femtoseconds/second.		
		Total 127	

NOTES: For each VCS record used in the EPHEMERIS/DATA block, the data after column 23 must be read free-formatted (i.e., each data value is separated by one or more blank spaces). However, the 3-character record type code, the 3-character satellite ID, and the Number of Data Columns Present (i.e., all of the pertinent fields in columns 2 to 23) must be read according to the fixed formats given above. To avoid redundancy, the satellite event flag, the predicted/observed flags, and the maneuver flag, are not used for the VCS record.

The **Number of Data Columns Present** integer in column 23 gives the number of data values that are actually listed for this satellite and this particular record type. The maximum number of data values for the above VCS record is 8. The possible choices are: 3, 4, 7, or 8.

4.4 CPC Record

CPC RECORD TYPE (CORRELATION COEFFICIENTS FOR POSITION & CLOCK)

(this record can be used together with a PCS record to compute covariances)

Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Record Type	The 3-character Record Type code (for this record type: CPC).	A3	2 to 4
RESERVED	The fifth column is left blank.	1X	5 to 5
Satellite ID	First character represents a constellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R02 for GLONASS). For LEOs see: http://cddis.nasa.gov/sp3c_satlist.html .	A1,I2.2	6 to 8
RESERVED	Columns 9 to 11 are reserved for later use (in case longer SV IDs become necessary).	3X	9 to 11
RESERVED	Columns 10 to 17 are not utilized for the CPC record.	7X	12 to 18
RESERVED	Columns 19 to 21 are reserved for future use.	3X	19 to 21
Number Of Data Columns Present	Gives the number of data columns present on this line after column 23. Possible choices are 4 or 6.	1x,I1	22 to 23
XY CORRELATION Coefficient	The correlation coefficient between the X-coordinate and the Y-coordinate. The elements are in the order of the upper triangular part of the 4 x 4 correlation matrix. The covariance can be computed using this coeff and the std. devs. in the PCS record. Divide each 17-digit integer by 10**16 to obtain a correlation coeff between -0.9999999999999999 and +0.9999999999999999.	1X,I17	10 to 27

XZ CORRELATION Coefficient	The correlation coefficient between the X-coordinate and the Z-coordinate (divide by 10*16).	1X,I17	28 to 45
XC CORRELATION Coefficient	The correlation coefficient between the X-coordinate and the SV clock corr (divide by 10**16).	1X,I17	46 to 63
YZ CORRELATION Coefficient	The correlation coefficient between the Y-coordinate and the Z-coordinate (divide by 10**16).	1X,I17	64 to 81
YC CORRELATION Coefficient	The correlation coefficient between the Y-coordinate and the SV clock corr (divide by 10**16).	1X,I17	82 to 99
ZC CORRELATION Coefficient	The correlation coefficient between the Z-coordinate and the SV clock corr (divide by 10**16).	1X,I17	100 to 117
		Total 117	

NOTES: For each CPC record used in the EPHEMERIS/DATA block, the data after column 23 must be read free-formatted (i.e., each data value is separated by one or more blank spaces). However, the 3-character record type code, the 3-character satellite ID, and the Number of Data Columns Present (all of the pertinent fields in columns 2 to 23) must be read according to the fixed formats given above. To avoid redundancy, the satellite event flag, the predicted/observed flags, and the maneuver flag are not used for the CPC record.

The **Number of Data Columns Present** value in column 23 gives the number of data values that are actually listed for this satellite and this particular record type. The maximum number of data values for the above CPC record is 6. The possible choices are 4 or 6, as explained above.

4.5 CVC Record

CVC RECORD TYPE (CORRELATION COEFFICIENTS FOR VELOCITY & CLOCK-RATE) (this record can be used together with a VCS record to compute covariances)			
Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Record Type	The 3-character Record Type code (for this record type: CVC).	A3	2 to 4
RESERVED	The fifth column is left blank.	1X	5 to 5
Satellite ID	First character represents a constellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R02 for GLONASS). For LEOs see: http://cddis.nasa.gov/sp3c_satlist.html .	A1,I2.2	6 to 8
RESERVED	Columns 9 to 11 are reserved for later use (in case longer SV IDs become necessary).	3X	9 to 11
RESERVED	Columns 10 to 16 are not utilized for the CVC record.	7X	12 to 18

RESERVED	Columns 19-21 are reserved for future use.	3X	19 to 21
Number Of Data Columns Present	Gives the number of data columns present on this line after column 23. Choices are 4 or 6.	1x,I1	22 to 23
.. XY CORRELATION Coefficient correlation between the X-component of velocity & the Y-component of velocity	The correlation coefficient between X-dot and Y-dot (X & Y velocity components). Elements are in the order of the upper triangular part of the 4 x 4 correlation matrix. The covariance can be computed using this coeff and the std. devs. in the VCS record. Divide each 17-digit integer by 10**16 to obtain a correlation coeff between -0.9999999999999999 and +0.9999999999999999.	1X,I17	24 to 41
.. XZ CORRELATION Coefficient	The correlation coefficient between X-dot and Z-dot (divide by 10*16).	1X,I17	42 to 59
.. XC CORRELATION Coefficient	The correlation coefficient between the X-dot and the SV clock Rate-of-Change (divide by 10**16).	1X,I17	60 to 77
.. YZ CORRELATION Coefficient	The correlation coefficient between Y-dot and Z-dot (divide by 10**16).	1X,I17	78 to 95
.. YC CORRELATION Coefficient	The correlation coefficient between the Y-dot and the SV clock Rate-of-Change (divide by 10**16).	1X,I17	96 to 113
.. ZC CORRELATION Coefficient	The correlation coefficient between the Z-dot and the SV clock Rate-of-Change (divide by 10**16).	1X,I17	114 to 131
		Total 131	

NOTES: For each CVC record used in the EPHEMERIS/DATA block, the data after column 23 must be read free-formatted (i.e., each data value is separated by one or more blank spaces). However, the 3-character record type code, the 3-character satellite ID, and the Number of Data Columns Present (all of the pertinent fields in columns 2 to 23) must be read according to the fixed formats given above. To avoid redundancy, the satellite event flag, the predicted/observed flags, and the maneuver flag, are not used for the CVC record.

The **Number of Data Columns Present** integer in column 23 gives the number of data values that are actually listed for this satellite and this particular record type. The maximum number of data values for the above CVC record is 6. The possible choices are 4 or 6, as explained above.

4.6 POS Record

POS RECORD TYPE (X,Y,Z COORDINATES OF THE SATELLITE)			
Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Record Type	The 3-character Record Type code (for this record type: POS).	A3	2 to 4

RESERVED	The fifth column is left blank.	1X	5 to 5
Satellite ID	First character represents a constellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R02 for GLONASS). For LEOs see: http://cddis.nasa.gov/sp3c_satlist.html .	A1,I2.2	6 to 8
RESERVED	Columns 9 to 11 are reserved for later use (in case longer SV IDs become necessary).	3X	9 to 11
Satellite Event Flag	'E' = a satellite event has occurred (e.g.,CLOCK,PHASE,POWER). Blank means either no event has occurred, or it is unknown whether any event has occurred. See the NOTES section below.	1X,A1	12 to 13
RESERVED	Columns 12 to 14 are not utilized for the POS record.	3X	14 to 16
Maneuver Flag	'M' = a maneuver has occurred. A blank means either no maneuver occurred, or it is unknown whether any maneuver occurred. See the NOTES section below.	A1	17 to 17
Predicted Orbit Flag	'P' = the satellite position at this epoch is predicted. A blank means the position is observed.	A1	18 to 18
RESERVED	Columns 19 to 21 are reserved for future use.	3X	19 to 21
Number Of Data Columns Present	Gives the number of data columns present on this line after column 23. Only a choice of 3 make sense.	1x,I1	22 to 23
X-coordinate	The X-coordinate for the Center of Mass of the satellite (in the coordinate system specified in the FILE/DESCRIPTION block). Units = meters.	1X,F16.4	24 to 40
Y-coordinate	The Y-coordinate for the Center of Mass of the satellite. Units = meters.	1X,F16.4	41 to 57
Z-coordinate	The Z-coordinate for the Center of Mass of the satellite. Units = meters.	1X,F16.4	58 to 74
		Total 74	

NOTES: For each POS record used in the EPHEMERIS/DATA block, the data after column 23 must be read free-formatted (i.e., each data value is separated by one or more blank spaces). However, the 3-character record type code, the 3-character satellite ID, the satellite event flag, the predicted/observed flag, the maneuver flag, and the Number of Data Columns Present (i.e., all of the pertinent fields in columns 2 to 23) must be read according to the fixed formats given above.

The **Satellite Event Flag** in column 11 can be 'E' or blank. 'E' indicates that sometime between the previous epoch and the current epoch, or at the current epoch, a satellite event occurred.

A blank means either no event occurred, or it is unknown whether any event occurred. The three types of satellite events currently defined are:
CLOCK event (e.g., a clock swap on a satellite),
PHASE event (e.g., a signal phase shift on a satellite),
POWER event (e.g., a power boost to one or more signals from a satellite).

This list is not final, suggestions are welcome. Additional details regarding a particular problem or event for a satellite can be placed in a SATELLITE/EVENT block, prior to the EPHEMERIS/DATA block.

The **Maneuver Flag** in column 15 can be 'M' or blank. 'M' indicates that sometime between the previous epoch and the current epoch, or at the current epoch, an orbit maneuver took place for this satellite. A maneuver is loosely defined as any planned or humanly-detectable thruster firing that changes the orbit of a satellite. A blank means either no maneuver occurred, or it is unknown whether any maneuver occurred. Additional details regarding start time, stop time (if known), and the delta V's for a satellite can be placed in a SATELLITE/MANEUVER block, prior to the EPHEMERIS/DATA block.

The **Number of Data Columns Present** value in column 23 gives the number of data values that are actually listed for this satellite and this particular record type. The maximum number of data values will depend on the record type: 8 for (PCS,VCS), 6 for (CPC,CVC), 4 for (ATT), 3 for (POS,VEL), and 1 for (CLK,CRT). Since the data values are read in free-formatted, it is recommended that reading programs first initialize all values to zero, then read the line into a buffer (so that data items are never accidentally read from the next line). For the above POS record, the only possible choice is 3, since one would expect all three coordinates will always be valid or invalid together. If none of the coordinates are present, then obviously there would be no POS record included for this satellite.

4.7 VEL Record

VEL RECORD TYPE (X,Y,Z COMPONENTS FOR THE VELOCITY OF THE SATELLITE)

Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Record Type	The 3-character Record Type code (for this record type: VEL).	A3	2 to 4
RESERVED	The fifth column is left blank.	1X	5 to 5
Satellite ID	First character represents a constellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R02 for GLONASS). For LEOs see: http://cddis.nasa.gov/sp3c_satlist.html .	A1,I2.2	6 to 8
RESERVED	Columns 9 to 11 are reserved for later use (in case longer SV IDs become necessary).	3X	9 to 11
RESERVED	Columns 10 to 17 are not utilized for the VEL record.	7X	12 to 18
RESERVED	Columns 19 to 21 are reserved for future use.	3X	19 to 21
Number Of Data Columns Present	Gives the number of data columns present on this line after column 23. The only choice is 3.	1x,I1	22 to 23
X-component of the satellite velocity	The X-component of the satellite velocity (in the coordinate system specified in the FILE/DESCRIPTION block, for the SV Center-of-Mass) Units = meters/second.	1X,F16.7	24 to 40

Y-component of velocity	The Y-component of velocity. Units = meters/second.	1X,F16.7	41 to 57
Z-component of velocity	The Z-component of velocity. Units = meters/second.	1X,F16.7	58 to 74
		Total 74	

NOTES: For each VEL record used in the EPHEMERIS/DATA block, the data after column 23 must be read free-formatted (i.e., each data value is separated by one or more blank spaces). However, the 3-character record type code, the 3-character satellite ID, and the Number of Data Columns Present (i.e., all of the pertinent fields in columns 2 to 23) must be read according to the fixed formats given above. To avoid redundancy, the satellite event flag, the predicted/observed flags, and the maneuver flag, are not used for the VEL record.

The **Number of Data Columns Present** value in column 23 gives the number of data values that are actually listed for this satellite and this particular record type. The maximum number of data values for the above VEL record is 3. The only possible choice is 3.

4.8 CLK Record

CLK RECORD TYPE (SATELLITE CLOCK CORRECTION)			
Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Record Type	The 3-character Record Type code (for this record type: CLK).	A3	2 to 4
RESERVED	The fifth column is left blank.	1X	5 to 5
Satellite ID	First character represents a constellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R02 for GLONASS). For LEOs see: http://cddis.nasa.gov/sp3c_satlist.html .	A1,I2.2	6 to 8
RESERVED	Columns 9 to 11 are reserved for later use (in case longer SV IDs become necessary).	3X	9 to 11
Satellite Event Flag	'E' = a satellite event has occurred (e.g.,CLOCK,PHASE,POWER). Blank means either no event has occurred, or it is unknown whether any event has occurred. See the NOTES section below.	1X,A1	12 to 13
Predicted Clock Flag	'P' = the satellite clock corr at this epoch is predicted. A blank means the clock corr is observed.	A1	14 to 14
RESERVED	Columns 13 to 16 are not utilized for a CLK record.	4X	15 to 18
RESERVED	Columns 19 to 21 are reserved for future use.	3X	19 to 21
Number Of Data Columns	Gives the number of data columns present on this line after column	1x,I1	22 to 23

Present	23. The only choice is 3.		
Satellite Clock Correction	The satellite clock correction. Units = microseconds.	1X,F16.7	24 to 40
		Total 40	

NOTES: For each CLK record used in the EPHEMERIS/DATA block, the data after column 23 must be read free-formatted (i.e., the data value is separated by one or more blank spaces from col 23). However, the 3-character record type code, the 3-character satellite ID, the satellite event flag, the predicted-clock flag, and the number of data columns listed (i.e., all of the pertinent fields in columns 2 to 23) must be read according to the fixed formats given above. To avoid redundancy, the predicted-orbit flag, and the maneuver flag, are not used for the CLK record.

The **Satellite Event Flag** in column 11 can be 'E' or blank. 'E' indicates that sometime between the previous epoch and the current epoch, or at the current epoch, a satellite event occurred. A blank means either no event occurred, or it is unknown whether any event occurred. The three types of satellite events currently defined are:
CLOCK event (e.g., a clock swap on a satellite),
PHASE event (e.g., a signal phase shift on a satellite),
POWER event (e.g., a power boost to one or more signals from a satellite).
This flag should only be used for a CLK record if a CLOCK event occurs. Additional details regarding a particular clock event for a satellite can be placed in a SATELLITE/EVENT block, prior to the EPHEMERIS/DATA block.

The **Number of Data Columns Present** value in column 23 gives the number of data values that are actually listed for this satellite and this particular record type. The maximum number of data values for the above CLK record is 1. The only possible choice is 1.

4.9 CRT Record

CRT RECORD TYPE (RATE-OF-CHANGE OF THE SATELLITE CLOCK CORRECTION)			
Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Record Type	The 3-character Record Type code (for this record type: CRT).	A3	2 to 4
RESERVED	The fifth column is left blank.	1X	5 to 5
Satellite ID	First character represents a constellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R02 for GLONASS). For LEOs see: http://cddis.nasa.gov/sp3c_satlist.html .	A1,I2.2	6 to 8
RESERVED	Columns 9 to 11 are reserved for later use (in case longer SV IDs become necessary).	1X	9 to 11
RESERVED	Columns 10 to 17 are not utilized for the CRT record.	7X	12 to 18
RESERVED	Columns 19 to 21 are reserved for future use.	3X	19 to 21
Number Of Data Columns Present	Gives the number of data columns present on this line after column 23. Only possible choice is 1.	1x,I1	22 to 23

Rate-of-Change of satellite clock corr.	The rate-of-change of the satellite clock correction. Units = nanoseconds/second.	1X,F16.7	24 to 40
		Total 40	

NOTES: For each CRT record used in the EPHEMERIS/DATA block, the data after column 23 must be read free-formatted (i.e., the data value is separated by one or more blank spaces from col 23). However, the 3-character record type code, the 3-character satellite ID, and the Number of Data Columns Present (i.e., all of the pertinent fields in columns 2 to 23) must be read according to the fixed formats given above. To avoid redundancy, the satellite event flag, the predicted/observed flags, and the maneuver flag are not used for the CRT record.

The **Number of Data Columns Present** value in column 23 gives the number of data values that are actually listed for this satellite and this particular record type. The maximum number of data values for the above CRT record is 1. The only possible choice is 1.

4.10 ATT Record

ATT RECORD TYPE (SATELLITE ATTITUDE INFORMATION USING A QUATERNION)

Field	Description	Format	Cols
First Character	Single blank character in col one. No other character than ' ' is allowed.	1X	1 to 1
Record Type	The 3-character Record Type code (for this record type: ATT).	A3	2 to 4
RESERVED	The fifth column is left blank.	1X	5 to 5
Satellite ID	First character represents a constellation type. The last two are the PRN or slot number (e.g., G02 for GPS, or R02 for GLONASS). For LEOs see: http://cddis.nasa.gov/sp3c_satlist.html .	A1,I2.2	6 to 8
RESERVED	Columns 9 to 11 are reserved for later use (in case longer SV IDs become necessary).	3X	9 to 11
RESERVED	Columns 10 to 17 are not utilized for the ATT record.	7X	12 to 18
RESERVED	Columns 19 to 21 are reserved for future use.	3X	19 to 21
Number Of Data Columns Present	Gives the number of data columns present on this line after column 23. Only possible choice is 4.	1x,I1	22 to 23
q0 part of the quaternion	The q0 or scalar part of the quaternion. The four parts of the quaternion provide the transformation from spacecraft body frame coordinates to the frame specified by the COORD_SYSTEM label in the FILE/DESCRIPTION block. ORBEX will follow the quaternion notation (q0,q1,q2,q3) outlined in [Kuipers 1999] and [Montenbruck 2000].	1X,F19.16	10 to 29

q1 part of the quaternion	The q1 or x-component part of the quaternion.	1X,F19.16	30 to 49
q2 part of the quaternion	The q2 or y-component part of the quaternion.	1X,F19.16	50 to 69
q3 part of the quaternion	The q3 or z-component part of the quaternion.	1X,F19.16	70 to 89
		Total 89	

NOTES: For each ATT record used in the EPHEMERIS/DATA block, the data after column 23 must be read free-formatted (i.e., each data value is separated by one or more blank spaces). However, the 3-character record type code, the 3-character satellite ID, and the Number of Data Columns Present (i.e., all of the pertinent fields in columns 2 to 23) must be read according to the fixed formats given above. To avoid redundancy, the satellite event flag, the predicted/observed flags, and the maneuver flag are not used for the ATT record.

The **Number of Data Columns Present** value in column 23 gives the number of data values that are actually listed for this satellite and this particular record type. The maximum number of data values for the above ATT record is 4. The only possible choice is 4.

5. EXAMPLES

The following pages show some example ORBEX files.

Example 1. An example of an IGS final orbit with both GPS and GLONASS satellites. The three mandatory blocks are present: FILE/DESCRIPTION, SATELLITE/ID_AND_DESCRIPTION, and EPHEMERIS/DATA. The SATELLITE/STD_DEVS block and EPHEMERIS/MODELS block are also shown.

```
%=ORBEX  0.09
%%
*-------------------------------------------------------------------------------------------------------------------------
+FILE/DESCRIPTION
 DESCRIPTION          IGS FINAL GNSS ORBIT COMBINATION
 CREATED_BY           IGS Analysis Center Coordinator
 CREATION_DATE        2009  4 21 12  0  0
 INPUT_DATA           ORBIT
*                     Weighted Average of: cod emr esa gfz grz jpl mit ngs sio
 CONTACT              Jim.Ray@noaa.gov
 TIME_SYSTEM          GPS
 START_TIME           2009  4  7  0  0  0.000000000000  54928 0.00000000000000000  1526 172800.000000000000
 END_TIME             2009  4  7 23 45  0.000000000000  54928 0.98958333333333340  1526 258300.000000000000
 EPOCH_INTERVAL         900.000
 COORD_SYSTEM         IGS05
 FRAME_TYPE           ECEF
 ORBIT_TYPE           HLM
 LIST_OF_REC_TYPES    PCS
 ORBIT_XYZ_UNITS      METERS
 ORBIT_XYZ_REFERENCE  CENTER-OF-MASS
 SVCLK_UNITS          MICROSECONDS
-FILE/DESCRIPTION
*-------------------------------------------------------------------------------------------------------------------------
+SATELLITE/ID_AND_DESCRIPTION
*ID_    SATELLITE_DESCRIPTION_____________________________________________________________________________________
 G01    GPS BLOCK IIR-M
 G02    GPS BLOCK IIR-B
 G03    GPS BLOCK IIA
 G04    GPS BLOCK IIA
 .
 .
 .
 R21    GLONASS-M
 R22    GLONASS-M
 R23    GLONASS-M
 R24    GLONASS-M
-SATELLITE/ID_AND_DESCRIPTION
*-------------------------------------------------------------------------------------------------------------------------
+SATELLITE/STD_DEVS
*ID_    STDP(mm) STDCLK(psec) PS CL START_TIME_________ END_TIME___________
 G01    99999.99 99999999.999 OB OB 2009  4  7  0  0  0 2009  4  7 23 45  0
 G02        8.48       17.304 OB OB 2009  4  7  0  0  0 2009  4  7 23 45  0
 G03        6.06       18.410 OB OB 2009  4  7  0  0  0 2009  4  7 23 45  0
 G04        8.17       20.087 OB OB 2009  4  7  0  0  0 2009  4  7 23 45  0
 .
 .
 .
 R21        9.28 99999999.999 OB OB 2009  4  7  0  0  0 2009  4  7 23 45  0
 R22       21.41 99999999.999 OB OB 2009  4  7  0  0  0 2009  4  7 23 45  0
 R23       37.47 99999999.999 OB OB 2009  4  7  0  0  0 2009  4  7 23 45  0
 R24    99999.99 99999999.999 OB OB 2009  4  7  0  0  0 2009  4  7 23 45  0
-SATELLITE/STD_DEVS
*-------------------------------------------------------------------------------------------------------------------------
 .
 .
 .
```

```
*------ Example 1. (Continued) --------
 .
 .
 .
+EPHEMERIS/MODELS
*MODEL_TYPE_____________________________ DESCRIPTION_____________________________________________
SATELLITE_ANTENNA_PCV_MODEL               igs05_1567.atx
OCEAN_TIDE_LOADING_MODEL                  FES2004 EARTH_CMC_APPLIED
ATMOSPHERIC_TIDE_LOADING_MODEL            NONE NO_EARTH_CMC_APPLIED
ECEF_ORIGIN_DEFINITION_ORBITS             CENTER_OF_NETWORK
ECEF_ORIGIN_DEFINITION_CLOCKS             CENTER_OF_NETWORK
-EPHEMERIS/MODELS
*-------------------------------------------------------------------------------------------------------------------
+EPHEMERIS/DATA
## 2009  4  7  0  0  0.000000000000  51
*REC ID_    FLAGS_    N ________X_(m)___ ________Y_(m)___ ________Z_(m)___ __SVCLK_(usec)__ __STD_X __STD_Y __STD_Z ____STD_CLK
*                                                                            (mm)    (mm)    (mm)      (psec)
 PCS G01              8    15241224.1750     5058063.4240    21090756.8720   999999.9999990 99999.9 99999.9 99999.9 9999999.999
 PCS G02              8     1718903.5130    17055266.0040    20273390.0550      153.7291220     3.8     4.8     6.0      19.358
 PCS G03              8     2025829.2720   -19586169.2480   -17970607.2600      375.9727660     4.8     4.8     3.8      15.123
 PCS G04              8   -12801678.7490    10532088.7120    20686320.3260      -41.6910930     6.0     6.0     4.8      14.043
 .
 .
 .
 PCS R21              8    20532966.7170    -3759472.4100    14731291.7220     -143.9677080     9.3     7.5    14.6 9999999.999
 PCS R22              8    21498008.2120   -13433960.4000    -2117154.7760     -202.8994030    11.6    11.6    35.5 9999999.999
 PCS R23              8     9576520.8680   -15103940.2070   -18166054.9630     -197.7920690    44.4    22.7    28.4 9999999.999
 PCS R24              8    -8718012.6430    -7367533.1740   -22801114.6790   999999.9999990 99999.9 99999.9 99999.9 9999999.999
## 2009  4  7  0 15  0.000000000000  51
 .
 .
 .
## 2009  4  7 23 45  0.000000000000  51
 PCS G01              8    15082111.7680     4678373.3290    21287877.5780   999999.9999990 99999.9 99999.9 99999.9 9999999.999
 PCS G02              8     3240161.6440    17727180.8520    19527535.8950      153.7020930     4.8     7.5     4.8      36.786
 PCS G03              8      758191.5350   -18726043.1800   -18997681.4990      376.4280980     6.0     2.4     7.5      32.514
 PCS G04              8   -11249295.1630    11376440.6380    21110255.5670      -42.9485550     3.1     6.0     6.0      31.721
 .
 .
 .
 PCS R21              8     9302951.0330     7209196.0140    22641779.4470     -144.0841100    18.2     9.3     7.5 9999999.999
 PCS R22              8    21557124.6850    -4174991.1710    12912343.1810     -203.1429720     9.3    14.6     6.0 9999999.999
 PCS R23              8    21207051.6440   -13199848.5210    -5066697.5310     -197.3316280    11.6     7.5    35.5 9999999.999
 PCS R24              8     7307727.2270   -14059899.3810   -19941556.8550   999999.9999990 99999.9 99999.9 99999.9 9999999.999
-EPHEMERIS/DATA
%END_ORBEX
```

Example 2. An example of an IGS ultra-rapid orbit with only GPS satellites. The mandatory blocks are present: FILE/DESCRIPTION, SATELLITE/ID_AND_DESCRIPTION, and EPHEMERIS/DATA. The SATELLITE/STD_DEVS and EPHEMERIS/MODELS blocks are also shown. Note the separate standard deviations given for both the observed and the predicted parts of the ultra-rapid orbit.

```
%=ORBEX  0.09
%%
*-------------------------------------------------------------------------------------------------------------------------------
+FILE/DESCRIPTION
 DESCRIPTION          IGS ULTRA-RAPID ORBIT COMBINATION 15262_06
 CREATED_BY           IGS Analysis Center Coordinator
 CREATION_DATE        2009  4  7  9  0  0
 INPUT_DATA           ORBIT
*                     Weighted Average of: cou emu esu gfu gou siu usu
 CONTACT              Jim.Ray@noaa.gov
 TIME_SYSTEM          GPS
 START_TIME           2009  4  6  6  0  0.000000000000  54927 0.25000000000000000  1526 108000.000000000000
 END_TIME             2009  4  8  5 45  0.000000000000  54929 0.23958333333333320  1526 279900.000000000000
 EPOCH_INTERVAL         900.000
 COORD_SYSTEM         IGS05
 FRAME_TYPE           ECEF
 ORBIT_TYPE           HLM
 LIST_OF_REC_TYPES    PCS
 ORBIT_XYZ_UNITS      METERS
 ORBIT_XYZ_REFERENCE  CENTER-OF_MASS
 SVCLK_UNITS          MICROSECONDS
-FILE/DESCRIPTION
*-------------------------------------------------------------------------------------------------------------------------------
+SATELLITE/ID_AND_DESCRIPTION
*ID_     SATELLITE_DESCRIPTION_____________________________________________________________________________________________
 G02     BLOCK IIR-B
 G03     BLOCK IIA
 G04     BLOCK IIA
  .
  .
  .
 G29     BLOCK IIR-M
 G30     BLOCK IIA
 G31     BLOCK IIR-M
 G32     BLOCK IIA
-SATELLITE/ID_AND_DESCRIPTION
*-------------------------------------------------------------------------------------------------------------------------------
+SATELLITE/STD_DEVS
*ID_     STDP(mm) STDCLK(psec) PS CL START_TIME_________ END_TIME___________
 G02        13.79       52.972 OB OB 2009  4  6  6  0  0 2009  4  7  5 45  0
 G02        34.32      468.380 PR PR 2009  4  7  6  0  0 2009  4  8  5 45  0
 G03        11.73       64.290 OB OB 2009  4  6  6  0  0 2009  4  7  5 45  0
 G03        38.70     2039.349 PR PR 2009  4  7  6  0  0 2009  4  8  5 45  0
 G04        14.67       89.069 OB OB 2009  4  6  6  0  0 2009  4  7  5 45  0
 G04        42.07      780.508 PR PR 2009  4  7  6  0  0 2009  4  8  5 45  0
  .
  .
  .
 G29        15.16       71.813 OB OB 2009  4  6  6  0  0 2009  4  7  5 45  0
 G29        35.50      787.943 PR PR 2009  4  7  6  0  0 2009  4  8  5 45  0
 G30        13.84       62.461 OB OB 2009  4  6  6  0  0 2009  4  7  5 45  0
 G30        32.70     1495.816 PR PR 2009  4  7  6  0  0 2009  4  8  5 45  0
 G31        17.92       62.865 OB OB 2009  4  6  6  0  0 2009  4  7  5 45  0
 G31        61.38      418.036 PR PR 2009  4  7  6  0  0 2009  4  8  5 45  0
 G32        12.66       99.257 OB OB 2009  4  6  6  0  0 2009  4  7  5 45  0
 G32        40.31     1625.077 PR PR 2009  4  7  6  0  0 2009  4  8  5 45  0
-SATELLITE/STD_DEVS
*-------------------------------------------------------------------------------------------------------------------------------
  .
  .
  .
```

```
*-------- Example 2. (Continued) -------
 .
 .
 .

+EPHEMERIS/MODELS
*MODEL_TYPE_____________________________ DESCRIPTION_____________________________________________
SATELLITE_ANTENNA_PCV_MODEL               igs05_1567.atx
OCEAN_TIDE_LOADING_MODEL                  FES2004 EARTH_CMC_APPLIED
ATMOSPHERIC_TIDE_LOADING_MODEL            NONE NO_EARTH_CMC_APPLIED
ECEF_ORIGIN_DEFINITION_ORBITS             CENTER_OF_NETWORK
ECEF_ORIGIN_DEFINITION_CLOCKS             CENTER_OF_NETWORK
-EPHEMERIS/MODELS
*-------------------------------------------------------------------------------------------------------------------
+EPHEMERIS/DATA
## 2009  4  6  6  0  0.000000000000  31
*REC ID_    FLAGS_    N ________X_(m)___ ________Y_(m)___ ________Z_(m)___ __SVCLK_(usec)__ __STD_X __STD_Y __STD_Z ____STD_CLK
*                                                                            (mm)    (mm)    (mm)      (psec)
 PCS G02             8   -17033320.1300     1266609.1830   -20350817.7220      153.7494320     7.5    18.2     7.5     96.364
 PCS G03             8    19552874.2880     2683655.1740    17628511.1600      375.6269200     7.5    14.6     7.5    109.027
 PCS G04             8   -11296681.1130   -11706843.3750   -21072263.3550      -40.7402520    11.6    14.6     7.5    126.438
 .
 .
 .
 PCS G29             8     2378442.8870    22326932.6460   -14111601.6370        6.5393150    18.2     9.3     7.5    126.438
 PCS G30             8    -4952232.8610    15715395.1680   -21178818.5590      137.2970520    14.6     7.5     3.8    120.346
 PCS G31             8    11911757.1450     9229593.4540   -21650125.8680      -56.9138710     7.5    22.7     7.5     66.536
 PCS G32             8    22260699.0830    -7605906.2310   -11685545.2670      278.2352010     7.5    18.2     6.0     79.090
## 2009  4  6  6 15  0.000000000000  31
 .
 .
 .
## 2009  4  8  5 45  0.000000000000  31
 PCS G02     P   P    8   -17443243.7680     2212519.8080   -19898950.0300      153.6890110    22.7    44.4    14.6   1031.350
 PCS G03     P   P    8    19001074.7190     1865420.8380    18297835.3330      376.5320820    18.2    55.5    22.7   3724.322
 PCS G04     P   P    8   -11837973.7340   -10738247.1510   -21306552.4870      -43.2675070    35.5    44.4    18.2    825.831
 .
 .
 .
 PCS G29     P   P    8     2838117.4700    22894707.0100   -13088797.8310        7.2501730    55.5    22.7    28.4   1608.554
 PCS G30     P   P    8    -3904181.8360    15646108.4270   -21455788.1490      137.7760220    35.5    14.6    18.2   3724.322
 PCS G31     P   P    8    12445254.0340     8209420.4170   -21765377.7610      -57.0971120    55.5    86.7    22.7    529.495
 PCS G32     P   P    8    21618317.6930    -7720097.7270   -12742679.7990      277.4017030    28.4    44.4    28.4   2701.699
-EPHEMERIS/DATA
%END_ORBEX
```

Example 3. An example of an orbit with two GPS satellites and one LEO satellite. Several of the optional header blocks are present. Note also the record types being used: POS, VEL, CLK, and ATT.

```
%=ORBEX  0.09
%%
+FILE/DESCRIPTION
 DESCRIPTION          EXAMPLE GPS + LEO ORBIT
 CREATED_BY           Dr. P. Caspian
 CREATION_DATE        2009  4 21 12  0  0
 INPUT_DATA           d+p
*                     Global tracking data for G01 and G02, and data from the receiver on-board CHAMP
 CONTACT              pc@igsac.narnia.gov
 TIME_SYSTEM          GPS
 START_TIME           2002 12 29  0  0  0.000000000000  52637 0.00000000000000000  1199      0.000000000000
 END_TIME             2002 12 29 23 45  0.000000000000  52637 0.98958333333333340  1199  85500.000000000000
 EPOCH_INTERVAL       IRREGULAR
 COORD_SYSTEM         IGS05
 FRAME_TYPE           ECEF
 ORBIT_TYPE           FIT
 LIST_OF_REC_TYPES    POS VEL CLK ATT
 ORBIT_XYZ_UNITS      METERS
 ORBIT_XYZ_REFERENCE  CENTER-OF-MASS
 ORBIT_VEL_UNITS      METERS/SEC
 SVCLK_UNITS          MICROSECOND
-FILE/DESCRIPTION
*-------------------------------------------------------------------------------------------------------------------------
+SATELLITE/ID_AND_DESCRIPTION
*ID_    SATELLITE_DESCRIPTION_____________________________________________________________
 G02    GPS BLOCK IIR-B
 G03    GPS BLOCK IIA
 L06    CHAMP
-SATELLITE/ID_AND_DESCRIPTION
*-------------------------------------------------------------------------------------------------------------------------
+SATELLITE/STD_DEVS
*ID_    STDP(mm) STDCLK(psec) PF CL START_TIME_________ END_TIME___________
 G02        5.00       19.000 OB OB 2002 12 29  0  0  0 2002 12 29 23 45  0
 G03        4.00       15.000 OB OB 2002 12 29  0  0  0 2002 12 29 23 45  0
 L06       24.00              OB OB 2002 12 29  0  0  0 2002 12 29 23 45  0
-SATELLITE/STD_DEVS
*-------------------------------------------------------------------------------------------------------------------------
+EPHEMERIS/MODELS
*MODEL_TYPE_____________________________ DESCRIPTION_____________________________________________
 SATELLITE_ANTENNA_PCV_MODEL              igs05_1567.atx
 OCEAN_TIDE_LOADING_MODEL                 FES2004 EARTH_CMC_APPLIED
 ATMOSPHERIC_TIDE_LOADING_MODEL           NONE NO_EARTH_CMC_APPLIED
 ECEF_ORIGIN_DEFINITION_ORBITS            CENTER_OF_NETWORK
 ECEF_ORIGIN_DEFINITION_CLOCKS            CENTER_OF_NETWORK
-EPHEMERIS/MODELS
*-------------------------------------------------------------------------------------------------------------------------
+SATELLITE/MANEUVER_INFO
*ID_    MANEUVER_START_TIME_____________ MANEUVER_END_TIME_________________   DV_RADIA   DV_ALONG   DV_CROSS
 G03    2002 12 29 12 36 07.123456789012 2002 12 29 12 36 29.123456789012     1.2300   324.5000   -10.2340
-SATELLITE/MANEUVER_INFO
*-------------------------------------------------------------------------------------------------------------------------
 .
 .
 .
```

```
*-----Example 3. (Continued) -------
 .
 .
 .

+SATELLITE/ECLIPSE_INFO
*ID_    ECLIPSE_START_TIME_____________ ECLIPSE_END_TIME_______________ TYPE_
 G02    2002 12 29 01 48 30.123456789012 2002 12 29 02 42 30.123456789012 EARTH
-SATELLITE/ECLIPSE_INFO
*-------------------------------------------------------------------------------------------------------------------------------
+EPHEMERIS/DATA
*
## 2002 12 29  0  0  0.000000000000   3
*REC ID_    FLAGS_    N ________X_(m)___ ________Y_(m)___ ________Z_(m)___
 POS G02              3     4049646.6140    25594715.4960    -5815946.7980
*REC ID_    FLAGS_    N ______VX_(m/s)__ ______VY_(m/s)__ ______VZ_(m/s)__
 VEL G02              3         -353.5783         821.0842         2972.7179
*REC ID_    FLAGS_    N __SVCLK_(usec)__
 CLK G02              1      -39.2268190
 POS G03              3      992811.0780    16781981.6600   -20596776.8060
 VEL G03              3       -2362.6884        1126.0735         823.5752
 CLK G03              1       92.5224210
 POS L06              3     1781848.9098     5968846.1797    -2704551.4098
 VEL L06              3        -816.9472       -2926.5637       -7019.8869
*REC ID_    FLAGS_    N ___q0_(scalar)_____ ____q1__x__________ ____q2__y__________ ____q3__z__________
 ATT L06              4  0.9164178227001020  0.3553674926002010  0.1624720204001450 -0.0865746035002370
## 2002 12 29  0  0  1.000000000000   1
 POS L06              3     1727998.7897     5780000.6581    -3119210.3412
 VEL L06              3        -978.0014       -3365.6139       -6796.8063
 ATT L06              4  0.9264178234567890  0.3653674934567890  0.1724720345678901 -0.0965746045678901
## 2002 12 29  0  0  2.000000000000   1
 POS L06              3     1664504.1705     5565312.9920    -3519546.7577
 VEL L06              3       -1138.2837       -3787.6430       -6542.6599
 ATT L06              4  0.9364178245678901  0.3753674945678901  0.1824720456789012 -0.1165746056789012
 .
 .
 .
## 2002 12 29 23 45  0.000000000000   3
 POS G02              3     4304136.5610    24976241.1960    -7742704.1010
 VEL G02              3        -399.3729        1052.1896        2877.2689
 CLK G02              1      -39.7468990
 POS G03              3     2577521.6400    16060438.0370   -21042936.0520
 VEL G03              3       -2449.0774        1067.0806         533.4498
 CLK G03              1       92.7929170
 POS L06              3    -1761142.2643    -5848719.9669    -2970621.8193
 VEL L06              3        -998.0043       -3184.4734        6880.3132
 ATT L06              4 -0.5066930256001020 -0.2289786888002010  0.7772033941001450 -0.2945943349002370
-EPHEMERIS/DATA
%END_ORBEX
```

Example 4. An example of an IGS file with only satellite attitude information.
Note that the only record type being used is: ATT.

```
%=ORBEX  0.09
%%
+FILE/DESCRIPTION
 DESCRIPTION         Attitude quaternions for grg/grm products
 CREATED_BY          CNES-CLS IGS-AC
 CREATION_DATE       2019 05 02 12 34 54
 INPUT_DATA          u+U
 CONTACT             igs-ac@cls.fr
 TIME_SYSTEM         GPS
 START_TIME          2018 10 21 00 00  0.000000000000
 END_TIME            2018 10 21 23 59 30.000000000000
 EPOCH_INTERVAL         30.000
 COORD_SYSTEM        IGS14
 FRAME_TYPE          ECEF
 ORBIT_TYPE          FIT
 LIST_OF_REC_TYPES   ATT
-FILE/DESCRIPTION
+SATELLITE/ID_AND_DESCRIPTION
 E01
 E02
 E03
 R01
 R02
 G01
 G02
 G03
-SATELLITE/ID_AND_DESCRIPTION
+EPHEMERIS/DATA
*ATT RECORDS: TRANSFORMATION FROM TERRESTRIAL FRAME COORDINATES (T) TO SAT. BODY FRAME ONES (B) SUCH AS
*                              (0,B) = q.(0,T).trans(q)
*REC ID_              N ___q0_(scalar)_____ ____q1__x__________ ____q2__y__________ ____q3__z__________
## 2018 10 21 00 00  0.000000000000   8
 ATT E01              4  0.2796988739859625  0.0767732228075297  0.9535493300680007 -0.0813516273813716
 ATT E02              4 -0.0763832709942057  0.2798108239960775  0.0805438903508286  0.9536163696235584
 ATT E03              4  0.5051654088446309 -0.0123667305508339 -0.8608432558942428  0.0600321785688232
 ATT R01              4  0.3929179843903584  0.1771727389613362 -0.7035390216886975  0.5650293116935323
 ATT R02              4  0.1005541208221312  0.1166037923840662 -0.3880332242101842  0.9086928200973037
 ATT G01              4  0.4062502437634697 -0.0970122592581474 -0.8694030375664159 -0.2639843163258768
 ATT G02              4 -0.1496681237335243 -0.2530795077026955 -0.7371638931910669  0.6083910009972509
 ATT G03              4  0.3203878356598950 -0.0321052432048551 -0.9467398141198986  0.0021476685370511
## 2018 10 21 00 00 30.000000000000   8
 ATT E01              4  0.2794666584952466  0.0788926857131641  0.9532771962325394 -0.0832881628654021
 ATT E02              4 -0.0785052158963970  0.2795801729714974  0.0824831455053343  0.9533458914086921
 ATT E03              4  0.5041284994648602 -0.0141082233717651 -0.8615253227849633  0.0585622084698466
 ATT R01              4  0.3936182419914179  0.1754501671718069 -0.7054536941674464  0.5626873055227684
 ATT R02              4  0.1007699680301561  0.1175295119858701 -0.3895677507545111  0.9078927221470803
 ATT G01              4  0.4065921190368229 -0.0986582811099466 -0.8684206983132919 -0.2660730783950743
 ATT G02              4 -0.1496939903353548 -0.2526908562350616 -0.7384408338917909  0.6069960257479998
 ATT G03              4  0.3197072840913043 -0.0334593005685304 -0.9469253855505140  0.0002047057334085
## 2018 10 21 00 01  0.000000000000   8
 ATT E01              4  0.2792315418951427  0.0810077144798338  0.9529976390208150 -0.0852232141283546
 ATT E02              4 -0.0806227445862077  0.2793466020796836  0.0844209198940245  0.9530679709475965
 ATT E03              4  0.5030876207653896 -0.0158419216213776 -0.8622015285941634  0.0570999425730834
 ATT R01              4  0.3943114626522111  0.1737119189156034 -0.7073624054387999  0.5603401351139925
 ATT R02              4  0.1009931412040600  0.1184458879020473 -0.3911061152064730  0.9070870761492159
 ATT G01              4  0.4069287788973764 -0.1003018648871554 -0.8674315645499522 -0.2681622375124261
 ATT G02              4 -0.1497097542061216 -0.2523063427000890 -0.7397124347680939  0.6056021902026991
 ATT G03              4  0.3190254690192300 -0.0348094961213492 -0.9471050800871627 -0.0017367699695737
-EPHEMERIS/DATA
%END_ORBEX
```

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A list of identifiers for Low-Earth Orbiting satellites can be viewed at http://cddis.gsfc.nasa.gov/sp3c_satlist.html

8. REVISION HISTORY

12 May 2009:	Initial version written (0.01).
12 June 2009:	Additional text added (0.02).
10 July 2009:	Clarifications added for certain header blocks (0.03).
11 August 2009:	Modifications to ATT record type (0.04).
24 September 2009:	Shorten FILE/DESCRIPTION block, add flags (0.05).
27 November 2009:	Combine Origin/Def. and Center-of-Mass/Info blocks (0.06).
22 January 2010:	Moved examples to back. ":" marks where PCS flags begin (0.07).
7 May 2010:	Added good/bad flags, modified Sec. 1 & 2, added Fig 1. (0.08).
30 April 2019:	Removed good/bad flags, allowed for ATT-only files (0.09).