Brief Introduction To TLEs And Satellite IDs

Keplerian or Two-Line Element Sets (TLEs) are distributed in the form shown in the example below:

THOR ABLESTAR R/B 1
1 00047U 60007C 96198.95303667 -.00000008 +00000-0 +24803-4 005026 2
2 00047 066.6626 011.9766 0252122 190.4009 169.1818 14.34618735877842

Line 0 (the top line) provides the **catalog and/or common name** of the satellite object. Not all TLEs have common names associated with them, but they are an additional enhancement provided by some TLE distributors to allow the tracking program to provide a common name for the satellite in addition to the Satellite Catalog Number and/or International ID. Note, "R/B is an acronym for "rocket body".

The **epoch date** is the third element **(96198.95303667)** in line 1 of the TLE. The epoch is the sequential calendar date when the satellite crossed the equator in an ascending (northerly) direction subsequent to a series of observations that were made to calculate the elements. In the above example, observations were made near the time on which the satellite was calculated to have crossed the equator on calendar date 198.95303667 in the year 1996. Universal Time (UT), formally known as Greenwich Mean Time (GMT), is the time standard used. Jim Varney explains the concept in a response to a question found in the SeeSat-L e-mail archive.

Specifically, the equatorial crossing was calculated for day 198 of the year 1996 at 22:52 UT [24 (hours) x 0.95303667 = 22.87288 hours, and 60 (minutes) x 0.87288 = 52.3728 minutes]. Most tracking programs will inform the user how old the element is by using the epoch date element. This tells the user if an old and possibly unreliable TLE is being used.

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The first element in line 1 **(00047U)** and in line 2 **(00047)** is the **Satellite Catalog Number** assigned by USSPACECOM. The **"U"** designates the element as unclassified or for public distribution. The official title for this identifier is "Satellite Catalog Number". However, many acronyms are used because of their brevity and past history of use. These include NORAD (North American Air Defense), NSSC (NORAD Space Surveillance Center), Cat # (Catalog Number), Object Number, USSPACECOM (US Space Command) number, and so on.

Thus the satellite in the example TLE was 47th satellite ever cataloged by the USSPACECOM.

"Satellite Catalog Number" comes from the early days of satellite identification done at Hanscom Field, Massachusetts, USA in the late 1950's, where they kept track of the satellites they identified, by giving them the next ascending number in a log that began with the number 00001 for the Sputnik launch. When NORAD took over the responsibility for tracking, they continued using the sequence. Now USSPACECOM continues the assignment.

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The second element in line 1 **(60007C)** indicates the **International Designation** and corresponds to the numerical format designation of 60-007C. This indicates a launch in 1960 and it was the 7th successful orbital launch for that year. "C" designates the third object catalogued for that launch. Launches in 2000, 2001, 2002 and later start with 00-xxxx, 01-xxxx, 02-xxxx while launches from 1957 and later until the year 2000 start with the numbers 57 to 99. The International Designation is also described by terms such as International ID, COSPAR (COmmittee for SPAce Research) number, and COSPAR/WWAS (COSPAR World Warning Agency for Satellites) number. The World Warning Agency (WWAS) is the body authorized by the United Nations to issue the International ID. WWAS issues the International Designation for the payload but not for any of the other objects placed in orbit as a result of the launch. Subsequent International Designations for non-payload objects are normally assigned by USSPACECOM using the same designation as the payload, but using the next higher English letter in the alphabet.

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The second element in Line 2 **(066.6626)** is the **inclination** of the orbit which is measured counter-clockwise from true East to true West . The values of inclination can be from 0 to 180 degrees. Thus, this satellite will be seen moving in a NNE direction as it crosses the Earth's equator going in an ascending direction (south to north).

An inclination of less than 90 degrees would mean that the satellite is in an orbit less than polar and is in a prograde orbit. That is, the satellite moving in an easterly direction takes advantage of the Earth's easterly rotation and requires less energy to be placed into orbit. The minimum energy needed to place a satellite into orbit would be a launch from the equator in a due easterly direction. Such a launch would have the satellite have an inclination of 0 degrees. Additional energy must be expended by the rocket to maneuver a satellite into an orbital inclination of zero degrees if launched from a latitude other than zero degrees.

An inclination of 90 degrees would mean the satellite crosses the Earth's equator at a right angle and crosses both poles in one orbit.

An inclination of greater than 90 degrees would mean that the satellite is in less than a polar orbit and is in what is called a retrograde orbit. Part of the motion of the satellite is in the opposite direction of rotation of the Earth.

Breakdown of Orbital Elements

Standard Two-Line Elements (TLE) Format

```
25107 Iridium 48
1 25107U 97082D   98151.26839894 -.00007632  00000-0 -27359-2 0  1321
2 25107  86.3970 282.3520 0003565  65.4476 294.7132 14.34205441 23251
```

Breakdown of a Two Line Element Set

Line 0= "25107 Iridium 48", provides the NORAD catalog number and/or possibly other information such as the common name assigned to the satellite.

```
!>Line Number 1
!   !>Catalog Number (NORAD)
!   !  !>Security Classification for this Element Set
!   !  !    !>International Identification for this Object (COSPAR)
!   !  !    !     !>Two Digit Year
!   !  !    !     !  !>Day of Year
!   !  !    !     !  !     !>Fraction of 24 Hour Day
!   !  !    !     !  !     !     !>Sign of 1st Time Derivative
!   !  !    !     !  !     !     !    !>1st Time Derivative
!   !  !    !     !  !     !     !    !     !>Sign of 2nd Time Derivative
!   !  !    !     !  !     !     !    !     !  !>2nd Time Derivative
!   !  !    !     !  !     !     !    !     !  !  !>Sign of exponent
!   !  !    !     !  !     !     !    !     !  !   !>Exponent 2ndTimeDerivative
!   !  !    !     !  !     !     !    !     !  !     !>Sign of BSTAR drag term
!   !  !    !     !  !     !     !    !     !  !     !  !>BSTAR/Drag Term
!   !  !    !     !  !     !     !    !     !  !     !  !  !>Sign of Exponent
!   !  !    !     !  !     !     !    !     !  !     !  !  !!>Exponent BstarDrg
!   !  !    !     !  !     !     !    !     !  !     !  !  !! !>Ephemeris Type
!   !  !    !     ! ---    !     !    !     !  !     !  !  !! ! !>Element No.
! -----! -------- --|||--------- !--------- !-----   !-----!! ! ----!>Checksum
1 25107U 97082D   98151.26839894 -.00007632  00000-0 -27359-2 0  1321 = Line 1
2 25107 086.3970 282.3520 0003565 065.4476 294.7132 14.34205441 23251 = Line 2
123456789012345678901234567890123456789012345678901234567890123456789 = columns
! ----- ---.---- ---.---- ------- ---.---- ---.---- --.--------|||||!>Checksum
!   !   Incl     RAAN     Ecc     AoP      MA       RpD        -----
!   !   !        !        !       !        !        !          !>Rev # @ Epoch
!   !   !        !        !       !        !        !>MeanMotion(Revolutions/Day)
!   !   !        !        !       !        !>Mean Anomaly
!   !   !        !        !       !>Argument of Perigee
```

```
!   !   !        !        !>Eccentricity, with assumed decimal point leading
!   !   !        !>Right Ascension of Ascending Node
!   !   !>Inclination
!   !>Catalog Number (NORAD)
!>Line Number 2
```

Line 0 provides the catalog number and/or possibly other information such as the common name assigned to the satellite.

Line 1

Column Numbers First	Last	Number of Characters	Description
1	1	1	Line No. Identification
3	7	5	Catalog No.
8	8	1	Security Classification
10	17	8	International Identification
19	32	14	YRDOY.FODddddd
34	34	1	Sign of first time derivative
35	43	9	1st Time Derative
45	45	1	Sign of 2nd Time Derivative
46	50	5	2nd Time Derivative
51	51	1	Sign of 2nd Time Derivative Exponent
52	52	1	Exponent of 2nd Time Derivative
54	54	1	Sign of Bstar/Drag Term
55	59	5	Bstar/Drag Term
60	60	1	Sign of Exponent of Bstar/Drag Term
61	61	1	Exponent of Bstar/Drag Term
63	63	1	Ephemeris Type
65	68	4	Element Number
69	69	1	Check Sum, Modulo 10

Line 2

Column Numbers First	Last	Number of Characters	Description
1	1	1	Line No. Identification
3	7	5	Catalog No.
9	16	8	Inclination
18	25	8	Right Ascension of Ascending Node
27	33	7	Eccentricity with assumed leading decimal
35	42	8	Argument of the Perigee
44	51	8	Mean Anomaly
53	63	11	Revolutions per Day (Mean Motion)
64	68	5	Revolution Number at Epoch
69	69	1	Check Sum Modulo 10

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