All About TLE

L0	`ISS (ZARYA)`
L1	`1 25544U 98067A   06052.34767361  .00013949  00000-0  97127-4 0  3934`
L2	`2 25544  051.6421 063.2734 0007415 308.6263 249.9177 15.74668600414901`
L3	`000000000111111111122222222223333333333444444444455555555556666666666`
L4	`123456789012345678901234567890123456789012345678901234567890123456789`

L0 - L2 : Actual TLE
L3 - L4 : Reference column number

Line 0

Column 1-24

Common Name

Common name for the object based on information from the Satellite Catalog

Line 1

Column 1

Line Number 1

Column 3-7

NORAD Catalogue Number

5 digit satellite identification number used since first satellite was launched in 1957

Sometime referred to as NASA #, SCC #, or SSC #

Column 8

Satellite Classification Designation

U - Unclassified

C - Classified

S - Secret

Column 10-17

International Designator

Coded to inform reader of the year and order of the launch within the year

Ex: 98067A

98 - launch year of 1998

067 - 67th launch in year 1998

A - primpary payload

This subsequent lettering indicates secondary payloads and rockets that were directly involved in the launch process. Debris detected from the original object is catalogued as a subsequent letter (B, C, D, etc.) in order of when they were detected. Some satellites have broken up into hundreds and even thousands of pieces, each having its own International designator number. Debris can exceed the 26 letter alphabet, and so two (or more) letters can be used (AA, AB, AC, etc.).

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```

Column 19-32

Epoch

UTC time when the TLE's indicated orbit elements were true
Columnn 19-20 - epoch year, ("57"-"99" = 1957 to 1999 and "00"-"56" = 2000 to 2056)
Column 21-23 - epoch's integer day (001 to 365, or 001 to 366 in a leap year)
Column 24-32 - decimal (fraction) days
Ex: 06052.34767361
06 - 2006
052 - February 21
.34767361 - 08:20:39 U.T.C.

Column 34-43

Mean Motion Dot $\dot{n}$

Half of the first time derivative of the Mean Motion
Measured in (orbits/day^2)
Defines how the Mean Motion changes from day to day so that some orbit propagation software can continue to predict the location of the satellite accurately over longer periods of time from the TLE Epoch.
This value can be negative or positive. Not all orbit propagators read or use this value.

Column 45-52

Mean Motion Double Dot $\ddot{n}$

One sixth the second time derivative of the Mean Motion
Measured in (orbits/day^3)
Defines the rate of change of the Mean Motion Dot from day to day so that some orbit propagation software can continue to predict the location of the satellite accurately.
The Mean Motion Double Dot is normally zero unless the satellite is being maneuvered or is undergoing orbit decay.
Ex: $\underbrace{-12345\text{-}6 = -0.12345 \times 10^{-6}}$ Not from ISS example above

Column 54-61

B-Star Drag Term B^*

Used for SGP4 type propagator and estimates effecs of atmospheric drag on satellite's motion
Measured in units of (EarthRadii^-1)
Ex: $97127\text{-}4 = +0.97127 \times 10^{-4}$ Earth Radii^{-1}

$$B^* = \frac{\rho_0 C_D A}{2m}$$

B^* = B-star drag term
ρ_0 = atmospheric density
C_D = drag coefficient
A = cross-sectional area of satellite
m = mass of satellite

```
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```

Column 63

Internal Use

Air Force Space Command uses this value to indicate the orbit model used to generate a TLE.
In practice, this value is set to 0 for all external viewing.
No external orbit propagators read or use this value.

Column 65-68

Element Set Number

Used to distinguist a specific satellite TLE from its predecessors and successors
Whenever new TLE is generated for a particular satellite, this number for that satellite is incremented
Ex: 393 - 393rd TLE generated for a specific satellite

Column 69

Line 1 Checksum

Determined by adding all previous numbers in Line 1 and taking the last digit in the final sum
All letters, periods, and plus signs are taken as 0
Negative signs are take as 1
Manly used to verify Line 1's authenticity and/or its integrity upon receipt
Many orbit propagators do not read or use this value

From ISS Example above: 1+2+5+5+4+4+(U)+9+8+0+6+7+(A)+0+6+0+5+2+(.)+3+4+7+6+7+3+6+1+(.)
+0+0+0+1+3+9+4+9+0+0+0+0+0+(-)+0+9+7+1+2+7+(-)+4+0+3+9+3 = 174

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```

Line 2

Column 1

Line number 2

Column 3-7

NORAD catalogue number

Column 9-16

Inclination i

Measured in degrees
Angle of satellite's orbit plane measured from Earth's equatorial plane
Inclination between 0 to 90 deg is called prograde orbit (satellite orbits around Earth in same direction as Earth's rotation)
Inclination between 90 and 180 is called a retrograde orbit (satellite oribts around Earth in opposite direction as Earth's rotation)
Ex: 051.6421 - 51.6421 degrees above Earth's equatorial plane

Column 18-25

Right Ascension of Ascending Node (RAAN) Ω

Measured in degrees
Geocentric Right Ascension of a satellite as it intersects the Earth's equatorial plane traveling nortward (ascending)
Ranges between 0 to 360 degrees
Ex: 063.2734 - 63.2734 degrees from the First Point of Aries at the specified Epoch in the TLE

Column 27-33

Eccentricity e

Unitless
Ratio of the satellite orbit's focus distance to the orbit's semi-major axis
Defines how elliptical the orbit is
Ranges between 0 (perfectly circular orbit) to 1 (parabolic orbit)
Ex: 0007415 - 0.0007415

$e = 0$ (circle)
$e < 1$ (ellipse)
$e = 1$ (parabola)
$e > 1$ (hyperbola)

Column 35-42

Argument of Perigee ω

Measured in degrees
Defined as the angle within the satelllite orbit plane that is measured from the Ascending Node to the perigee point along the satellite's direction of travel
Ranges between 0 to 360 degrees
Ex: 308.6263 - 308.6263 degrees from the satellite orbit's Ascending Node to its perigee point

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Column 44-51

Mean Anomaly M_0

Measured in degrees

Indicates where the satelllite was located within its orbit at the specified Epoch

Ranges between 0 to 360 degrees

Ex: 249.9177 - 249.9177 degrees

Mean Anomaly at any time t, $M(t)$

$M(t) = M_0 + n(t - t_0)$

$M(t)$ - Mean Anomaly at time t

n - satellite orbit's Mean Motion

t - chosen prediction time

t_0 - Epoch time

For perfectly circular orbits (eccentricity of 0), Mean Anomaly is exactly equal to True Anomaly throughout the orbit

Column 53-63

Mean Motion n

Measured in orbits per solar days

Defined as number of orbits (revolutions) the satellite completes about the Earth in exactly 24 hours (one solar day)

Theoretically, this number can range anywhere between 0 and 17 orbits per solar day

Ex: 15.74668600 - 15.74668600 orbits per day

Column 64-68

Orbit Number

Number of orbits that the satellite has completed from launch to the specified TLE Epoch

Ex: 41490 - ISS has completed 41,490 orbits between launch and the TLE epoch

Column 69

Line 2 Checksum

Determined by adding all previous numbers in Line 2 and taking the last digit in the final sum

All letters, periods, and plus signs are taken as 0

Negative signs are take as 1

Mainly used to verify Line 2's authenticity, or its successful transmission to another party

From ISS Example above: 2+2+5+5+4+4+0+5+1+$\overset{=0}{(.)}$+6+4+2+1+0+6+3+$\overset{=0}{(.)}$
+2+7+3+4+0+0+0+7+4+1+5+3+0+8+$\overset{=0}{(.)}$+6+2+6+3+2+4+9+$\underset{=0}{(.)}$+9+1+7+7+1+5+$\underset{=0}{(.)}$
+7+4+6+6+8+6+0+0+4+1+4+9+0 = 211

Reference

http://castor2.ca/03_Mechanics/03_TLE/index.html