

## Astromechanics

### 11. Two Line Element Sets (TLES)

Two line element sets are a standard format for providing orbital information about satellites and other cataloged space items. Detailed information can be found at the web site <celestrak.com>. The essence of that information is presented here. The format is two lines of data, each line containing 69 characters. As an example we have the International Space Station TLES for a recent observation. ISS (ZARYA)

```
1 25544U 98067A 01331.21823275 .00051000 00000-0 56502-3 0 7634
2 25544 51.6415 348.6383 0010541 24.6992 52.9180 15.62395971172522
```

#### Line 1

Field	column	description	example
1.1	1	Line number	1
1.2	3-7	Satellite Number (NORAD catalog number)	25544
1.3	8	Classification (U, S) U= unclassified	U
1.4	10-11	Int. Designator (last two digits of launch year)	98
1.5	12-14	Int. Designator (launch number of year)	067
1.6	15-17	Int. Designator (Piece of the launch)	A
1.7	19-20	Epoch year (last two digits)	01
1.8	21-32	day of Epoch year (Universal time, UT)	331.21823275
1.9	34-43	(first time derivative of mean angular rate)/2 (rev/day <sup>2</sup> )	.00051000
1.10	45-52	(Second time derivative of mean angular rate)/6 (rev/day <sup>3</sup> ) (leading decimal point assumed)	00000-0
1.11	54-61	$B^* = C_D A \rho_0 / (2 m) (\text{earth radii})^{-1}$ (leading decimal assumed) a measure of drag	56502-3
1.12	63	Ephemeris Type (always 0 - use SGP4/SGD4 model)	0
1.13	65-68	Element set number	763
1.14	69	Checksum	4

## Line 2

Field	Column	Description	Example
2.1	1	line number	2
2.2	3-7	satellite number	25544
2.3	9-16	inclination (deg)	51.6415
2.4	18-25	right ascension of ascending node (deg)	348.6383
2.5	17-33	eccentricity (leading decimal assumed)	0010541
2.6	35-42	argument of perigee (deg)	24.6992
2.7	44-51	mean anomaly (deg)	52.9180
2.8	53-63	mean motion (rev/day)	15.62395971
2.9	64-68	revolution number at epoch	17252
2.10	69	checksum	2

The day of the year starts with January 1 being day number 1. Hence day 01001.0000 is midnight of New Years eve. (Not 01000.0000). The mean angular rate is given in revolutions/day where one day has 24 hours (a solar day). Time of epoch is in Universal time (UT).

The epoch time can be determined from the day fraction as follows:

Given the time as 331.21823275, we strip off the day number to get:

$$0.21823275 \times 24 \text{ hrs} = \underline{5.237586} \text{ hrs}$$

Then, strip off the hours to get:

$$0.237586 \times 60 \text{ min} = \underline{14.25516} \text{ min}$$

Then strip off the minutes to get:

$$0.25516 \times 60 \text{ sec} = 15.3096 \text{ sec}$$

The epoch of the data is:

November 27, 2001 (day 331)  
5 hrs 14 min 15.3096 sec = 5:14:15.3096 UT