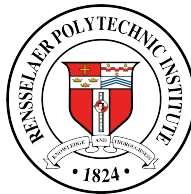


**TRACKING OF SPACE DEBRIS FROM PUBLICLY
AVAILABLE DATA
THINK OF A BETTER TITLE
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Approved by: People



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0.1 Acknowledgments

Thank lots of people here

Mom, dad, David, P Anderson John B for git and PHP Paul McKee for latex

0.2 Abstract

The goal of this project is to get access to the orbital information of space debris.

This is for the initial stage of the project: get data from NORAD into a useable format. Should this be accomplished in a timely manner more work will be done on the orbital dynamics of OSCAR getting to said debris.

0.3 Introduction

Talk more about project. one or two paragraph here

0.3.1 Space Debris

Space Debris is bad

0.3.2 CubeSats

talk about cube sats here

0.3.3 OSCAR

Unsure if talking about oscar? Yes not

0.3.4 NORAD /Space Track

0.4 Two Line Elements

A Two Line Element (TLE) is a data format that encodes a list of orbital elements for an Earth-orbiting object for a given point in time [\[Re do this\]](#)

An example is given below. The line under the dashes is the reference number line.

ISS (ZARYA)

```
1 25544U 98067A 04236.56031392 .00020137 00000-0 16538-3 0 9993
2 25544 51.6335 344.7760 0007976 126.2523 325.9359 15.70406856328906
```

```
-----
123456789012345678901234567890123456789012345678901234567890
1           2           3           4           5           6           7
```

Table 1[1] describes the example TLE.

Table 1: Description of TLE

Line 0		
Columns	Example	Description
1-24	ISS (ZARYA)	The common name for the object based on information from the Satellite Catalog.
Line 1		
Columns	Example	Description
1	1	Line Number
3-7	25544	Satellite Catalog Number
8	U	Elset Classification
10-11	98	International Designator (Last two digits of launch year)
12-14	067	International Designator (Launch number of the year)
15-17	A	International Designator (Piece of the launch)
19-32	04	Epoch Year (last two digits of year)
21-32	236.56031392	Epoch (day of the year and fractional portion of the day)
34-43	.00020137	1st Derivative of the Mean Motion with respect to Time
45-52	00000-0	2nd Derivative of the Mean Motion with respect to Time (decimal point assumed)
54-61	16538-3	B* Drag Term
63	0	Element Set Type
65-68	999	Element Number
69	3	Checksum
Line 2		
Columns	Example	Description
1	2	Line Number
3-7	25544	Satellite Catalog Number
9-16	51.6335	Orbit Inclination (degrees)
18-25	344.7760	Right Ascension of Ascending Node (degrees)
27-33	0007976	Eccentricity (decimal point assumed)
35-42	126.2523	Argument of Perigee (degrees)
44-51	325.9359	Mean Anomaly (degrees)
53-63	15.70406856	Mean Motion (revolutions/day)
64-68	32890	Revolution Number at Epoch
69	6	Checksum

Of the terms given in table 1 the B^* term is the least heard of. It is a way of modeling drag on orbiting objects in propagation models. Aerodynamic drag is given by the following equation:

$$F_D = \frac{1}{2} \rho C_d A v^2 \quad (1)$$

Where A is the area, C_d is the drag coefficient, v the velocity, and ρ is the fluid density. From Newton's second law

$$F = m \times a \quad (2)$$

the acceleration due to the force of drag is

$$a_D = \frac{F_D}{m} = \frac{\rho C_d A v^2}{2m} = \frac{C_d A}{m} \times \frac{\rho v^2}{2} \quad (3)$$

The ballistic coefficient is given by the following equation:

$$B = \frac{C_d A}{m} \quad (4)$$

The *starred* ballistic coefficient is then

$$B^* = \frac{\rho_0 B}{2} = \frac{\rho_0 C_d A}{2m} \quad (5)$$

This turns the equation for acceleration due to drag into [2]

$$a_D = \frac{\rho}{\rho_0} B^* v^2 \quad (6)$$

to do here, add more details on what the checksum and stuff liek that is

0.4.1 SatCat?

0.5 NORAD Space-Track

Describe the site describe the SATCAT, then the TLE query

0.5.1 Space-Track Query

0.6 Code Overview

0.6.1 VarStore.m

This is a file where a few imporant variables are stored. Depening on how the code is reformatted, it might get deleted. **COME BACK TO THIS**

0.6.2 UserPass.m

at This file is where the username and password for space-track.org are stored.

0.6.3 MASTER_TLE.m

This file is the master file for the Two Line Element MATLAB files. Running it will run all of the associated MATLAB files. These MATLAB files take some time to run, so it may be convenient to toggle the files run by the MASTER_TLE.m

0.6.4 get_SATCAT.m

Get_SATCAT.m is the MATLAB file that gets the satellite catalog numbers of all orbital debris launched after a given year and with the “RCS_SIZE” value equal to “SMALL”. The Launch Year can be set by the values given by the user in VarStore.m The default launch year is set to 1990. Note that an earlier launch year will provide more data, and thus it will take more time to process. This may cause a time out error. Should this happen the timeOutVal in VarStore.m should be adjusted to be longer.

Once the SATCAT csv file has been acquired the file then formats it. The quotation marks that are around every entry are removed. The debris that have already deorbited are also removed. Finally the debris is sorted by NORAD Catoluge Id, and saved as a .mat file.

0.6.5 get_Multiple_TLE_from_Id.m

This file takes the Ids given in the .mat file and then obtains the Two Line Element files associated with the debris. It does this by saving the TLEs in .txt files. The number of TLEs grabbed at a time and saved in a .txt file is set by the user. It is not advised to go above 400, as that causes time out errors.

Withing MASTER_TLE.m, this code is surrounded by a a loop and a try/catch error. The loop runs through all the different blocks of TLEs. In the case of a time out the the try/catch will attempt to download the TLEs a second time.

At this point in the code the space debris has had it's Two Line Element files saved to .txt files. This is the longest part of the code to run, but also with the .txt files saved, these functions need only be run once every few days.

0.6.6 readTLE_txt.m

This MATLAB file reads the .txt files and then converts the TLE format to the standard orbital elements stored in a .mat file.

0.6.7 check_TLE_Edit_TLE.m

0.7 Conclusion

Bibliography

- [1] Space Track. Basic description of the two line element (tle) format, 2013.
- [2] By Dr. T.S. Kelso. Frequently asked questions: Two-line element set format, 1998.

Appendix 1 - MATLAB code