SATELLITE CLOSE APPROACH ANALYSIS

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A LITTLE ABOUT ME

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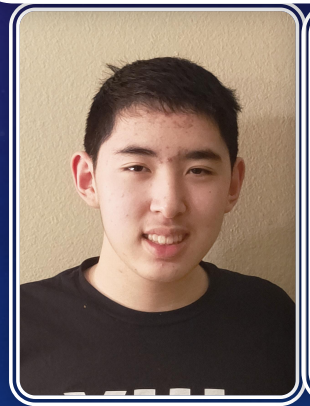
Aspiring Software Engineer

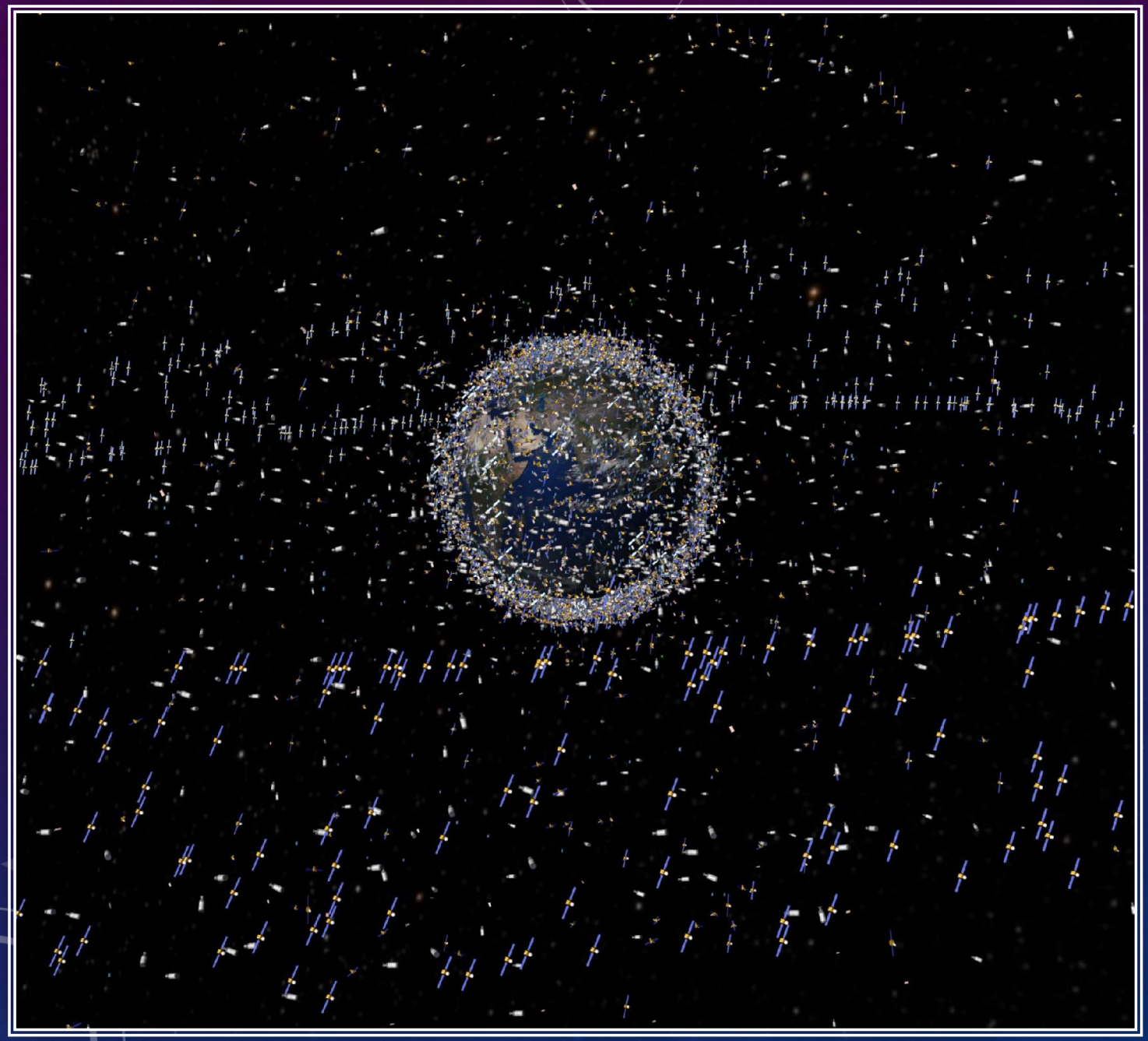
Software Mentors: Megumi Telles and Bryce Ockerman

Project Mentor: Galen Stevens

Hobbies:

- Programming
- Cybersecurity
- Chess
- Video Games





THE PROBLEM

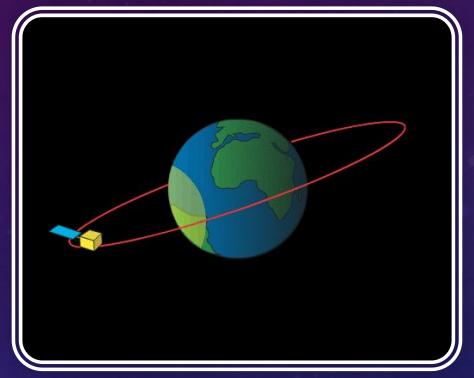
- There are over 30,000 objects orbiting around earth
- Operational satellites provide essential functions, are expensive, and very prone to damage
- Collisions are very possible, lots of financial loss, causes more space debris

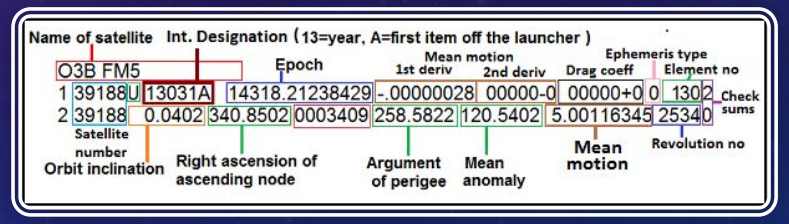
A FEW DEFINITIONS

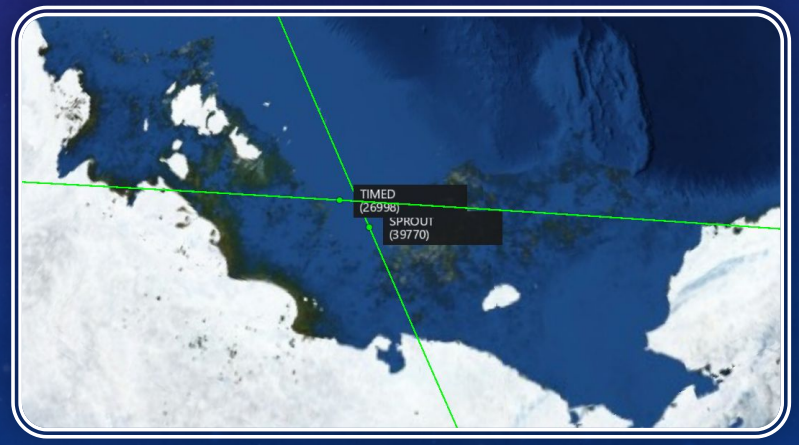
- Propagate – predict the trajectory of an object in motion. In this case, the objects in question are satellites.

- Two-Line Element (TLE) – a set of parameters that define the orbital motion of a satellite. Each Two-Line Element, or TLE represents a single satellite.

- Close Approach – when two satellites come into relatively (~10 km) close proximity with each other







PROJECT ASSIGNMENT

GOAL: propagate the paths of thousands of satellites over a period, and detect all the close approaches

INPUT: a text file containing satellites represented by TLEs

OUTPUT: a readable log file containing all close approaches between satellite pairs

Advantages:

Parameters such as the starting date, the danger threshold, and duration are all configurable

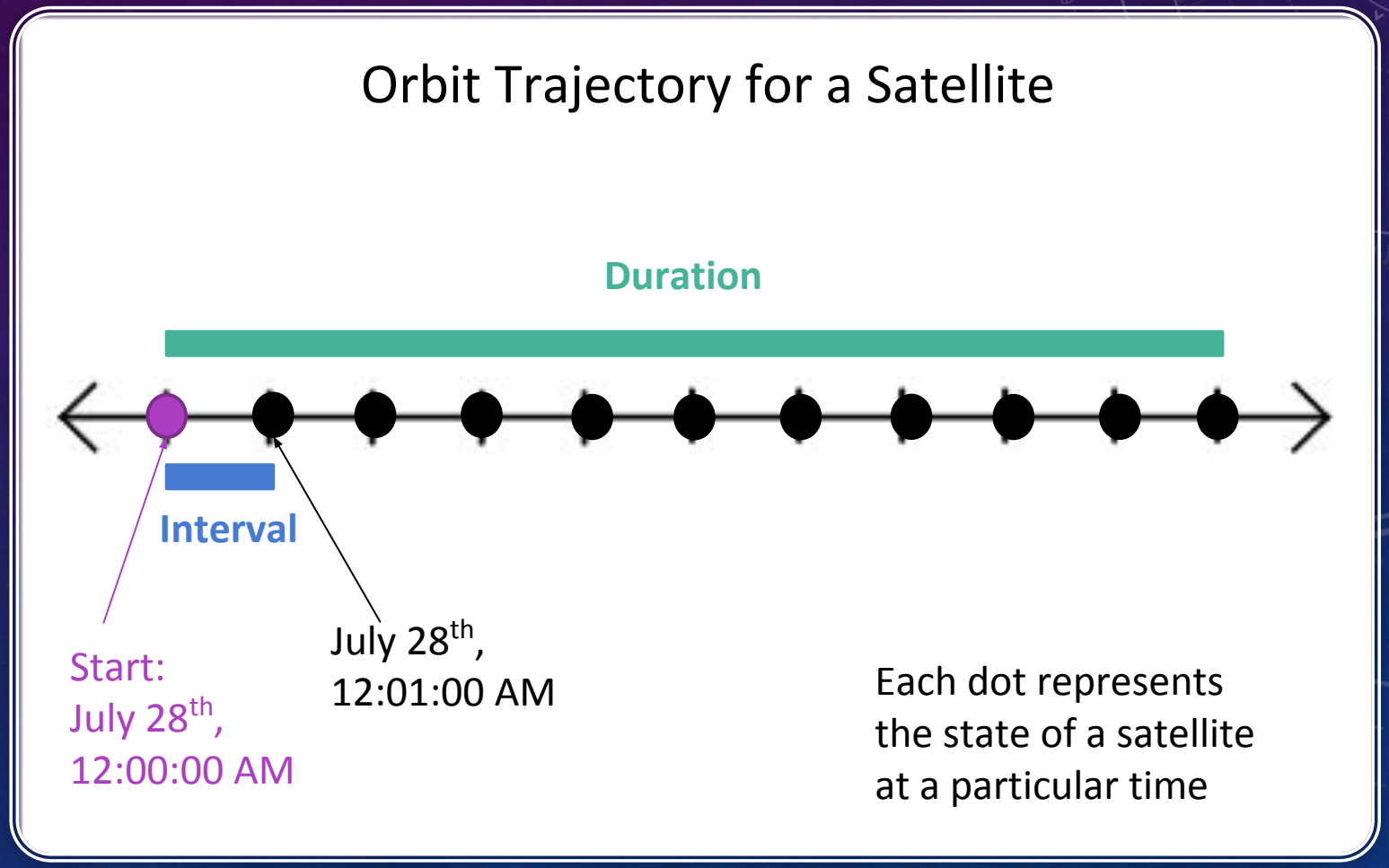
```
threshold=10000
interval=60
duration=7
durationUnit=days
startDate=2021-07-28
```

The program outputs a log file that is both readable for humans, and can be analyzed by computers

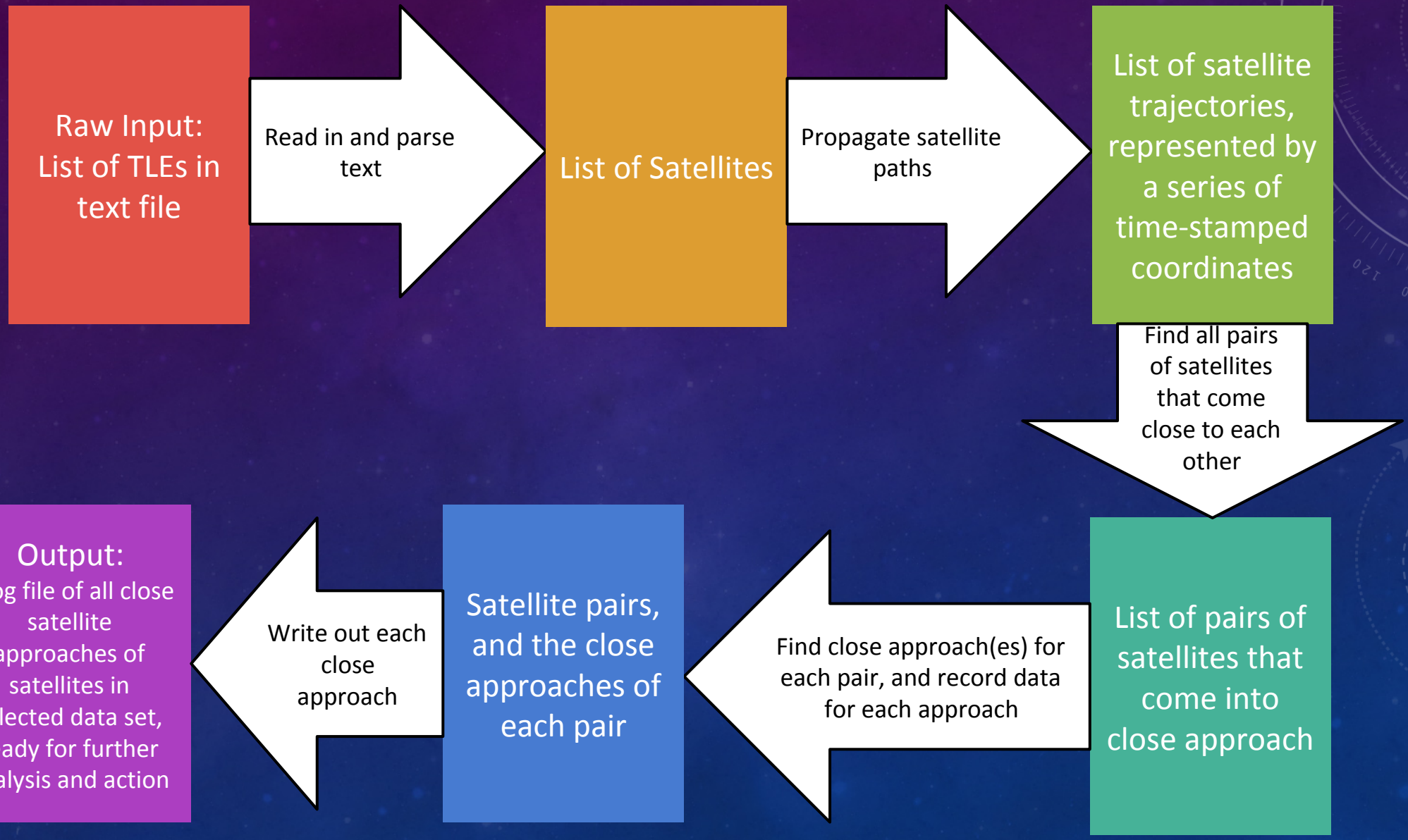
```
First 2 Close approach(es) between FENGYUN 2G and THURAYA-3.
Close approach from 2021-07-28T09:03:00.000 to 2021-07-28T09:05:00.000
Closest distance is 9455.421087, occurs at time 2021-07-28T09:04:11.000
At this time, position of A compared to B is:{-5,810.8441160172; -7,458.2688959755; -115.3414850942}
---
Close approach from 2021-07-30T20:54:00.000 to 2021-07-30T20:56:00.000
Closest distance is 1610.440457, occurs at time 2021-07-30T20:55:02.000
At this time, position of A compared to B is:{263.4384825081; 1,588.001202811; 48.6909933222}
---
```

CONFIGURABLE PARAMETERS

```
threshold=10000
interval=60
duration=7
durationUnit=days
startDate=2021-07-28
```



THE DATA FLOW



OREKIT

(ORBITS EXTRAPOLATION KIT)

- Set of pre-built functions and data structures that were built to work with satellites and orbits
- Abstracted away a lot of complexity, making it easier to focus on higher level data processing

HOW OREKIT COMES INTO PLAY: PROPAGATION WITH OREKIT

Our satellites in TLE format

List of satellite pathways, represented by a series of time-stamped coordinates

Takes care of all the complex calculations

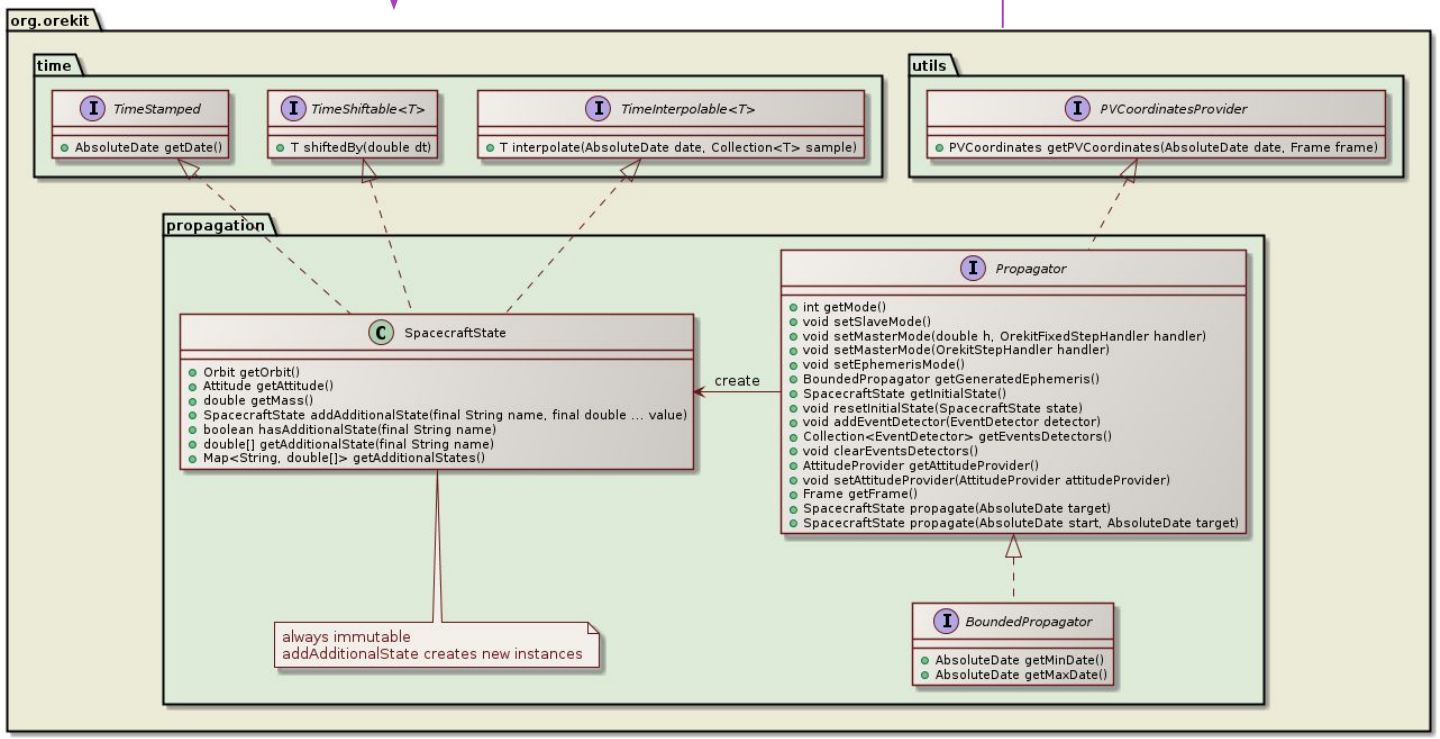
Provides useful data structures that make storing the output of the propagation easier

HOW OREKIT COMES INTO PLAY: BEHIND THE SCENES

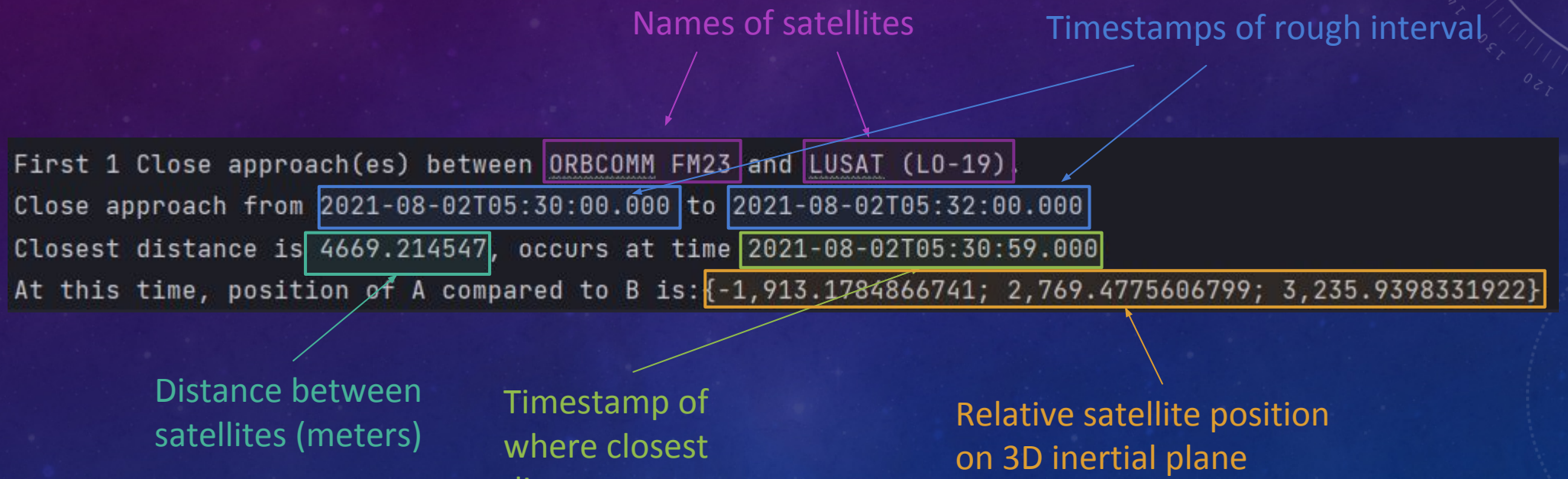
Our satellites in TLE format

List of satellite pathways, represented by a series of time-stamped coordinates

Diagram courtesy of OREKIT

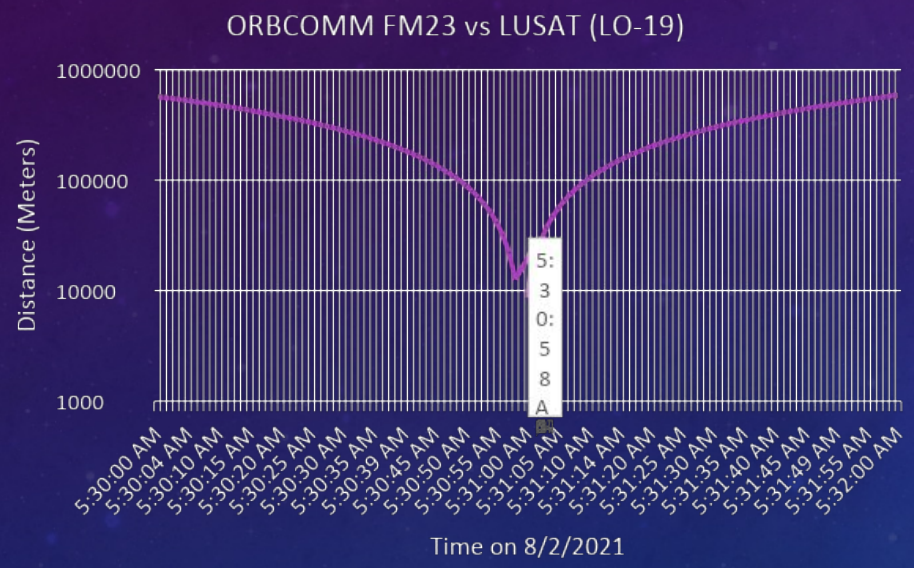


SAMPLE LOG ENTRY



SAMPLE PROJECT OUTPUT

Distance Between Two Satellites Graphed over Time (log 10)



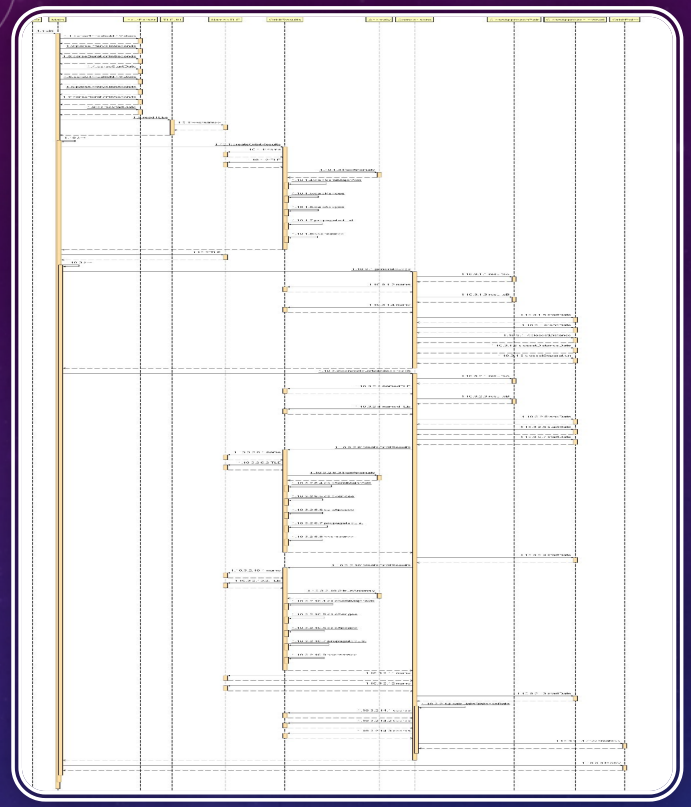
Spreadsheet Data (1 Second Interval)

Date and Time	Distance in Meters	X Difference	Y Difference	Z Difference
5:30:00 AM	575244.4175	325863.2945	424022.2795	211953.6733
5:30:01 AM	565542.9921	320314.8446	416891.1818	208420.2937
5:30:02 AM	555840.9597	314766.0353	409759.6338	204886.6955
5:30:03 AM	546138.3313	309216.8726	402627.6434	201352.8827
5:30:04 AM	536435.1179	303667.3626	395495.2181	197818.8592
5:30:05 AM	526731.3308	298117.5113	388362.366	194284.6287
5:30:06 AM	517026.981	292567.3248	381229.0946	190750.1952
...	...	...	...	...
5:30:59 AM	**4669.214547**	**-1913.178487**	**2769.477561**	**3235.939833**

Timestamp and distance of closest approach

CHALLENGES

- Complex structures and dependencies
- Learning how to use a build tool
- Performance and memory issues



Project run structure

THANK YOU!

QUESTIONS?