

The background features a dark blue gradient with a subtle pattern of white dots. Overlaid on the left side are several concentric circular patterns and arcs. Some of these arcs are marked with degree values: 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, and 260. There are also dashed lines and arrows indicating a clockwise direction of movement or rotation.

SATELLITE CLOSE APPROACH ANALYSIS

STEVEN SHI

A LITTLE ABOUT ME

Student at Redondo Union High School

Aspiring Software Engineer

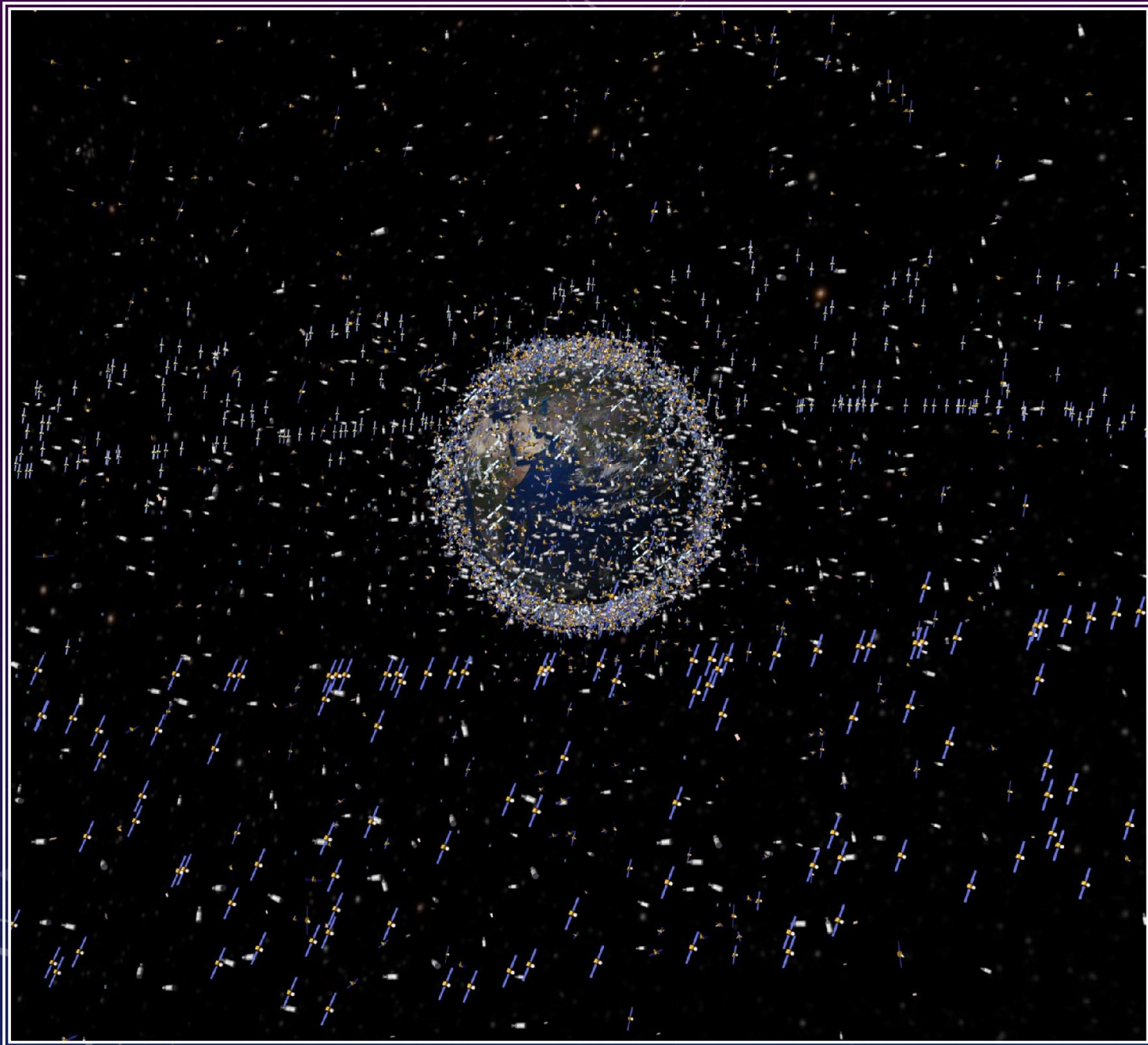
Software Mentors: Megumi Telles and Bryce Ockerman

Project Mentor: Galen Stevens

Hobbies:

- Programming
- Cybersecurity
- Chess
- Video Games



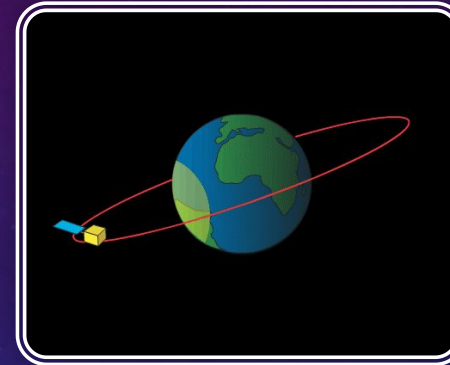


THE PROBLEM

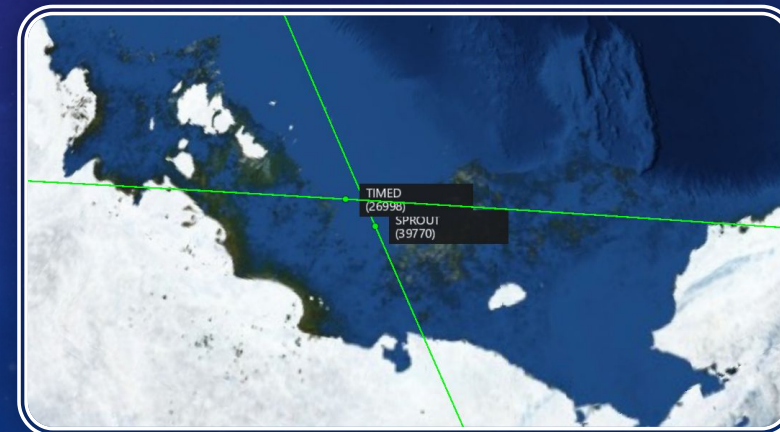
- There are over 30,000 objects orbiting around earth
- Operational satellites provide essential functions, are expensive, and very prone to damage
- Collisions are very possible, lots of financial loss, causes more space debris

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



Name of satellite	Int. Designation (13=year, A=first item off the launcher)	Epoch	Mean motion 1st deriv	Mean motion 2nd deriv	Drag coeff	Ephemeris type	Element no
O3B FM5	13031A	14318.21238429	-0.00000028	0.00000-0	0.00000+0	0	1302
1 39188U	0.0402 340 8502	0003409	258.5822	120.5402	5.00116345	25340	Check sums
2 39188							
Satellite number	Orbit inclination	Right ascension of ascending node	Argument of perigee	Mean anomaly	Mean motion	Revolution no	



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

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

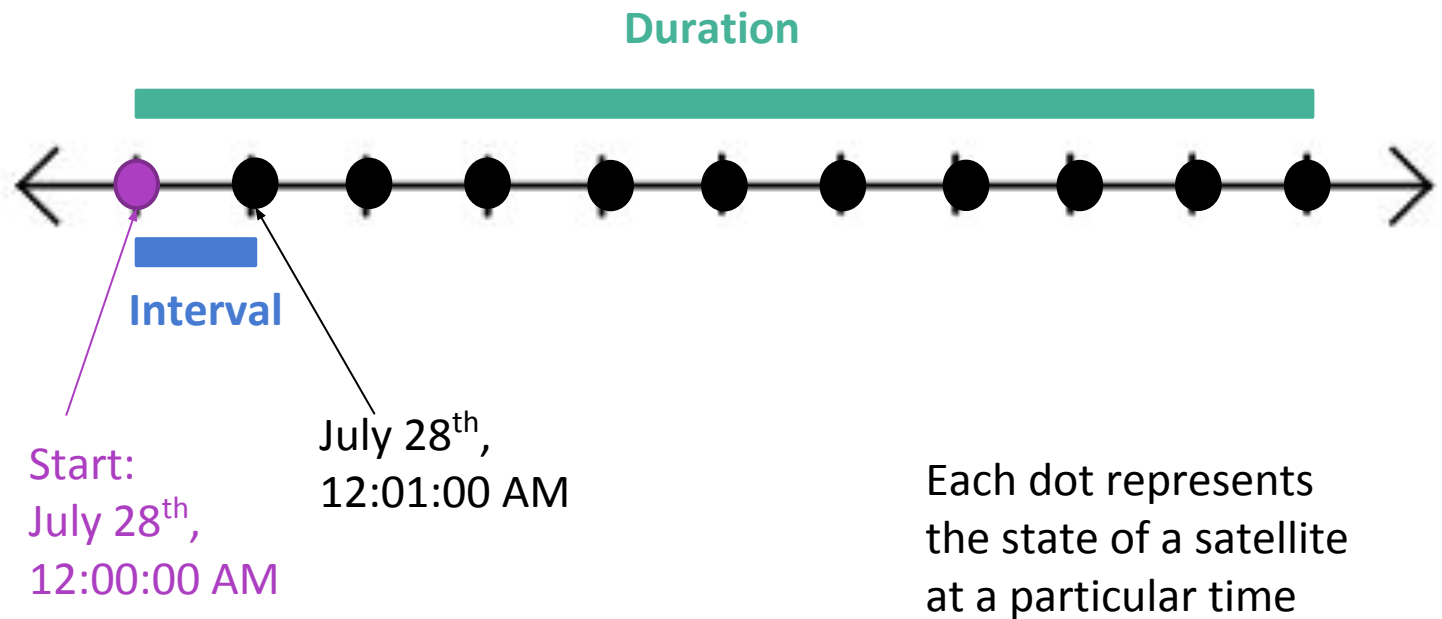
```
threshold=10000
interval=60
duration=7
durationUnit=days
startDate=2021-07-28
```

```
First 2 Close approach(es) between FENGYUN 26 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}
---
```

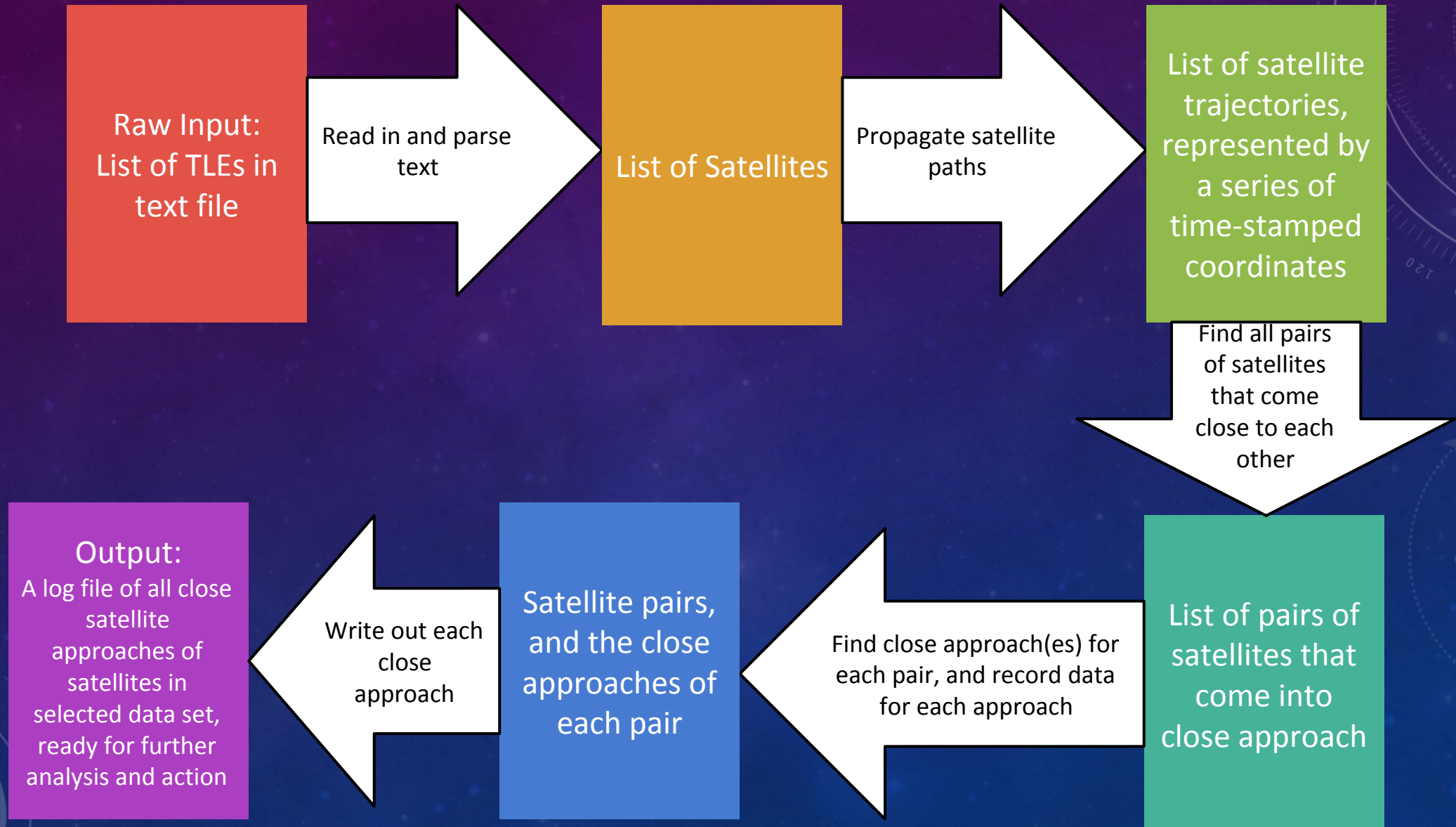

CONFIGURABLE PARAMETERS

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

Orbit Trajectory for a Satellite



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

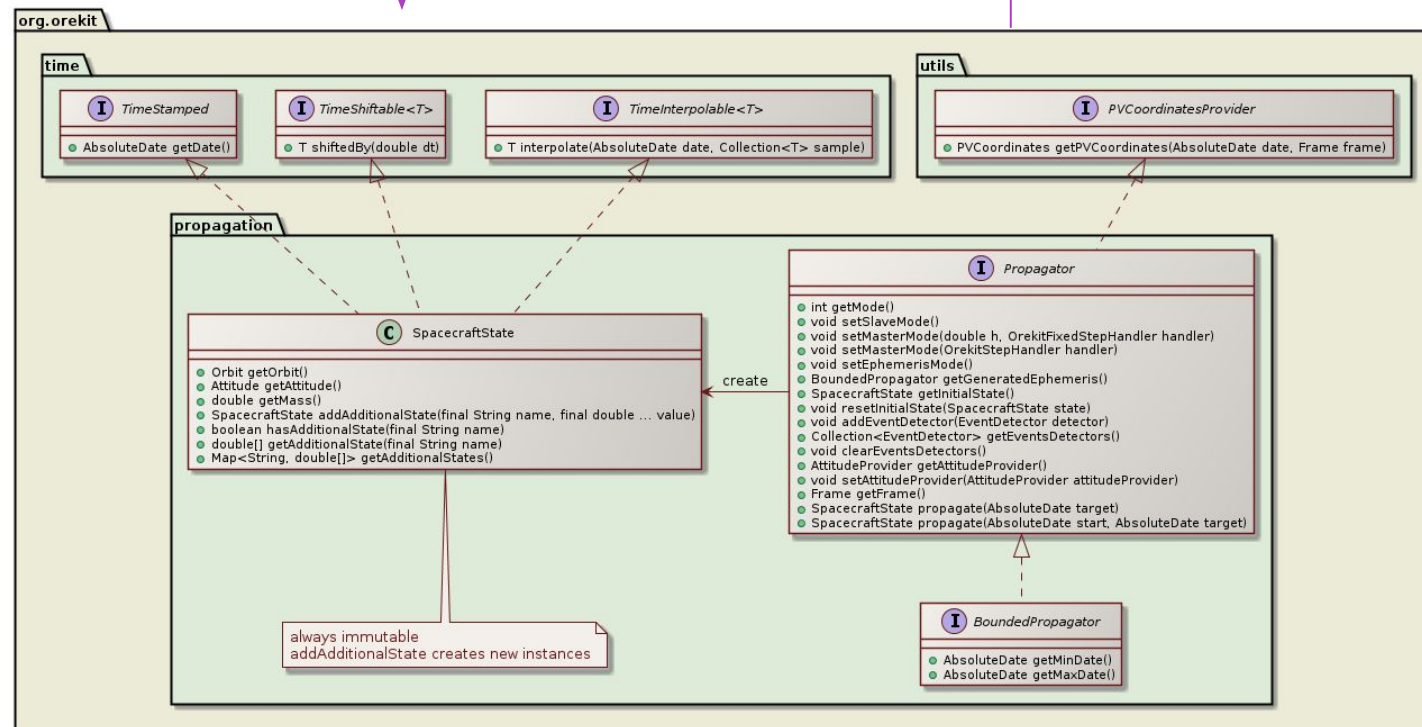
Provides useful data structures that make storing the output of
the propagation easier

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

First 1 Close approach(es) between **ORBCOMM FM23** and **LUSAT (LO-19)**
Close approach from **2021-08-02T05:30:00.000** to **2021-08-02T05:32:00.000**
Closest distance is **4669.214547**, occurs at time **2021-08-02T05:30:59.000**
At this time, position of A compared to B is: **{-1,913.1784866741; 2,769.4775606799; 3,235.9398331922}**

Names of satellites

Timestamps of rough interval

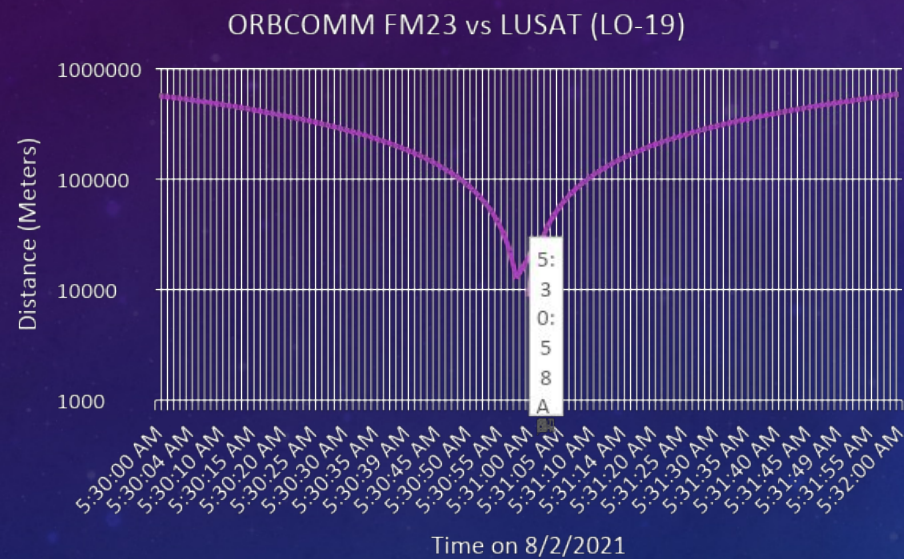
Distance between
satellites (meters)

Timestamp of
where closest
distance occurs

Relative satellite position
on 3D inertial plane

SAMPLE PROJECT OUTPUT

Distance Between Two Satellites Graphed over Time
(log 10)



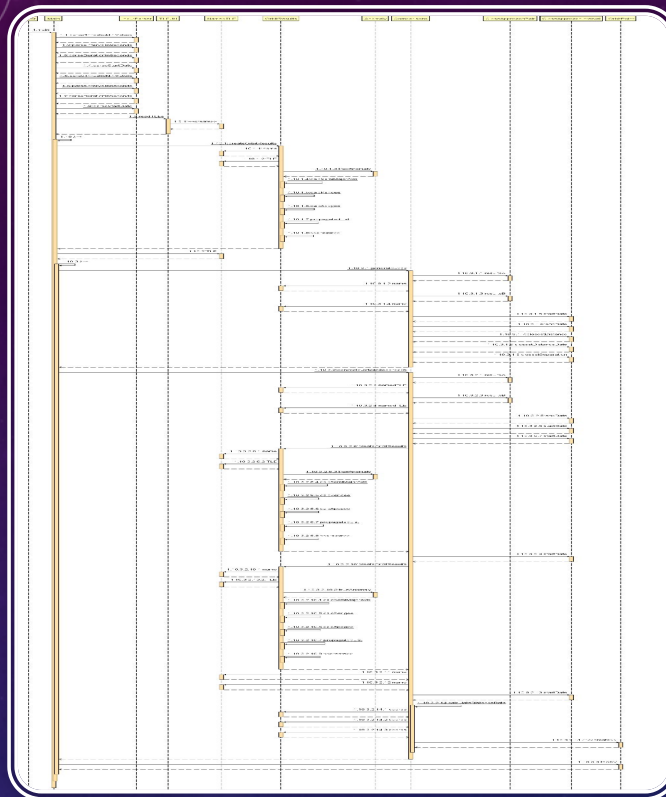
Spreadsheet Data
(1 Second Interval)

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



 IntelliJ IDEA (6)	100% CPU	83% Memory
	95.9%	6,156.6 MB



THANK YOU!

QUESTIONS?