Satellite Orbit Simulation for Sensor Calibration/Validation

David Liu
Mentors: Yan Bai, Dr. Xi Shao, Dr. Changyong Cao

Objective/Motivation

- Understanding satellite orbit and orbit prediction
- Learning how TLEs and the SGP4 propagation model are used to predict satellite positions
- Evaluate / investigate orbital simulation tools for visualization and analysis

Major Accomplishments

- Studied TLEs, perturbations, and their impact on prediction accuracy
- Conducted surveys on web-based orbit satellite simulation tools, compared Zerua with STK
- Application of Zerua to simulate JPSS mission and COSMIC tools

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Introduction

What is Satellite Orbit and What Determines it?

- Curved path followed by spacecraft as it moves around Earth or other celestial body
- Orbit results from balance between gravitational acceleration pulling satellite inwards and tangential velocity carrying it forward
- Two-line Elements

Epoch (year/day of year)

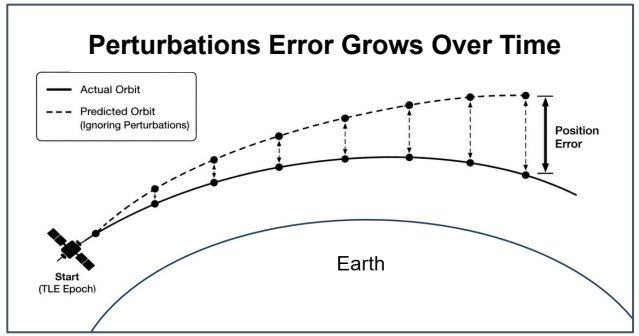
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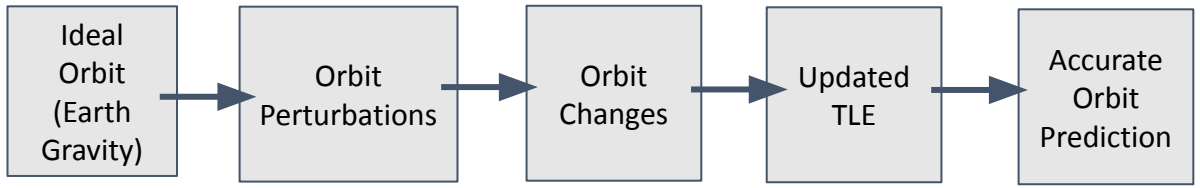
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What are Perturbations and Why are They important?

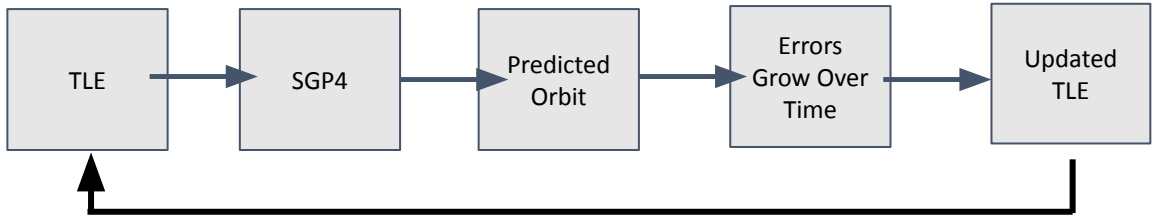
Major Perturbations:

- Earth's non spherical gravity
- Atmospheric drag
- Solar radiation pressure
- Earth and ocean tides
- Third-body gravity
- Spacecraft maneuvers and attitude





How Do Orbit Predictions Work?



- A TLE provides a snapshot of a satellite's orbit at a specific epoch.
- SGP4 (Simplified General Perturbations 4) is the standard orbit propagation model used with TLEs to predict a satellite's future position and velocity.
- SGP4 models Earth's gravity and the major orbital perturbations to estimate the satellite's future orbit.
- As perturbations continuously change the orbit, the TLE must be updated regularly to maintain prediction accuracy.

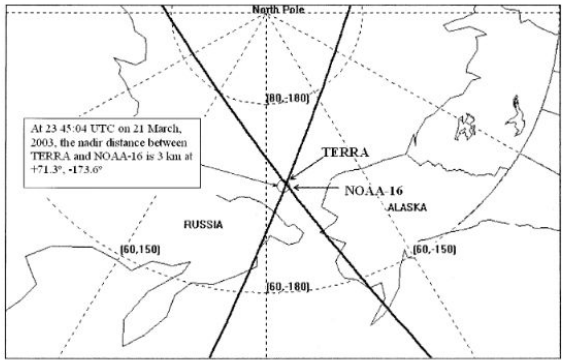


FIG. 1. Simultaneous (1 s) nadir overpass (SNO) between *NOAA-16* and *Terra*.

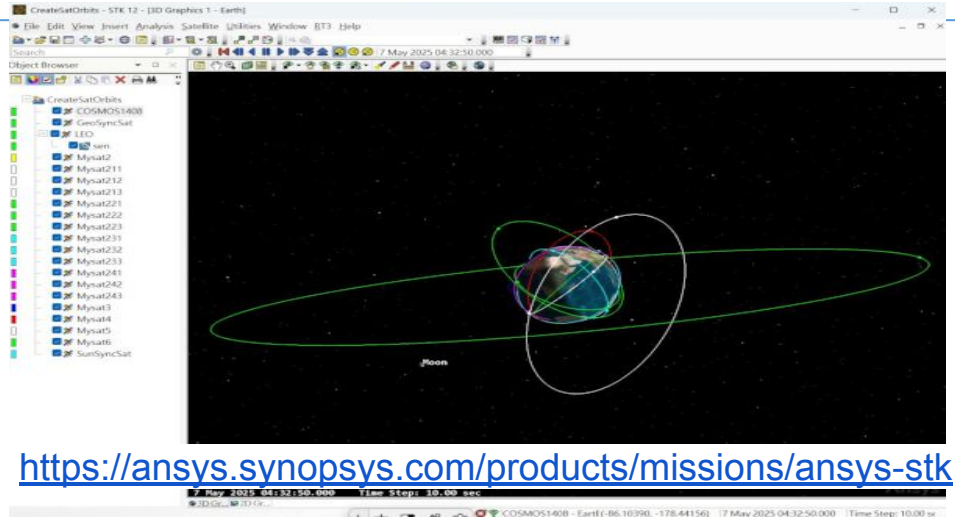
Example of Simultaneous Nadir Overpass (SNO) between NOAA-16 and Terra. (From Cao et al., 2004, J. Atmos. Oceanic Technol.)

Reference: Cao, C., Weinreb, M., & Xu, H. (2004). Predicting Simultaneous Nadir Overpasses among Polar-Orbiting Meteorological Satellites for the Intersatellite Calibration of Radiometers. J. Atmos. Oceanic Technol., 21, 537–542.

Orbit Simulation Tools

STK

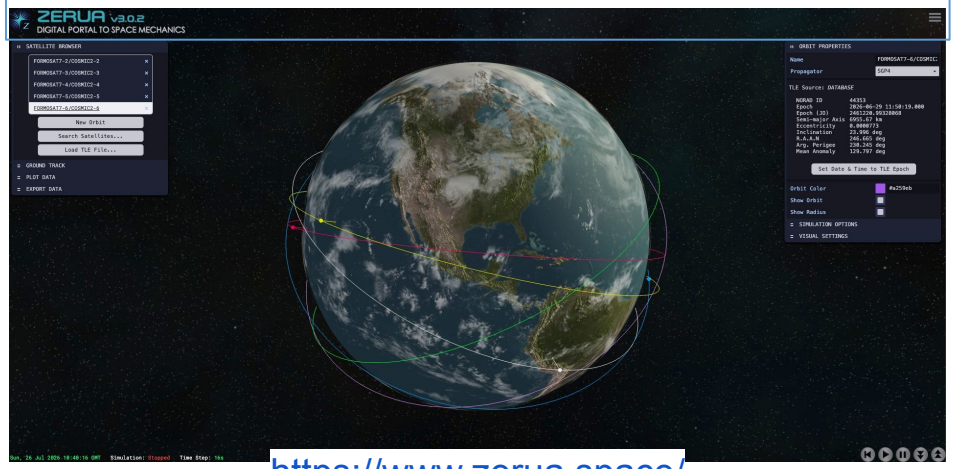
Pros	Cons
High-fidelity orbit modeling	Steep learning curve
Many advanced analysis tools	Advanced features can be expensive
Strong reporting and export options	Requires installation and paid access
Widely used in the aerospace industry	Can be excessive for simple tasks



https://ansys.synopsys.com/products/missions/ansys-stk

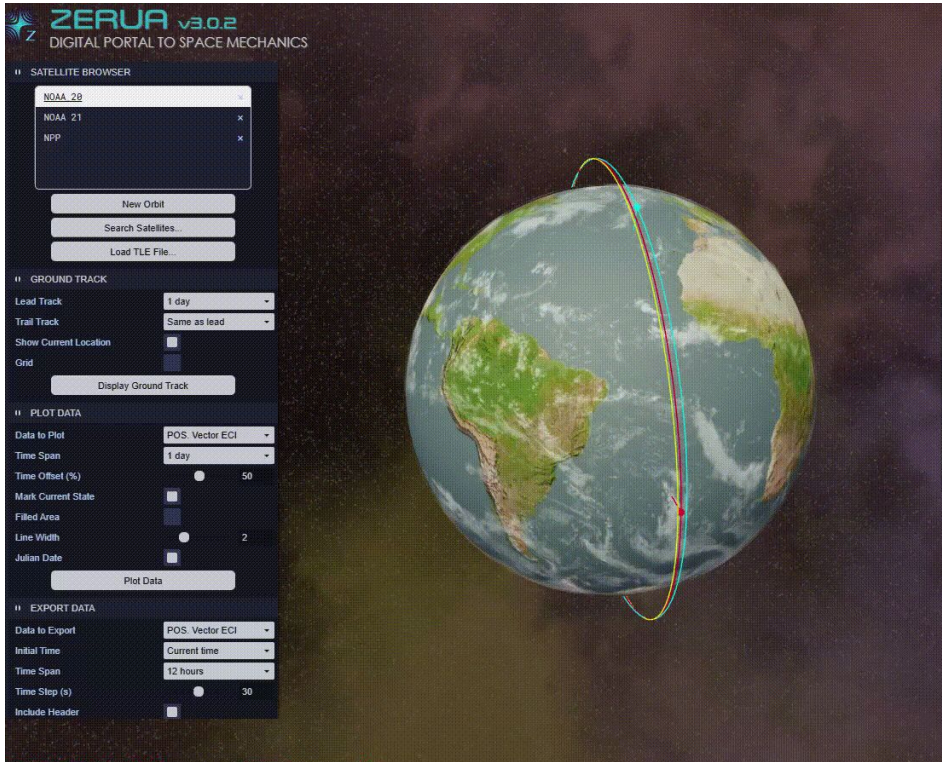
Zerua

Pros	Cons
Easy to learn and use	Fewer advanced analysis tools
Runs in a web browser & free	Less detailed orbit modeling
Fast 3D orbit visualization	Limited propagator options
Simple TLE input	No direct animation export



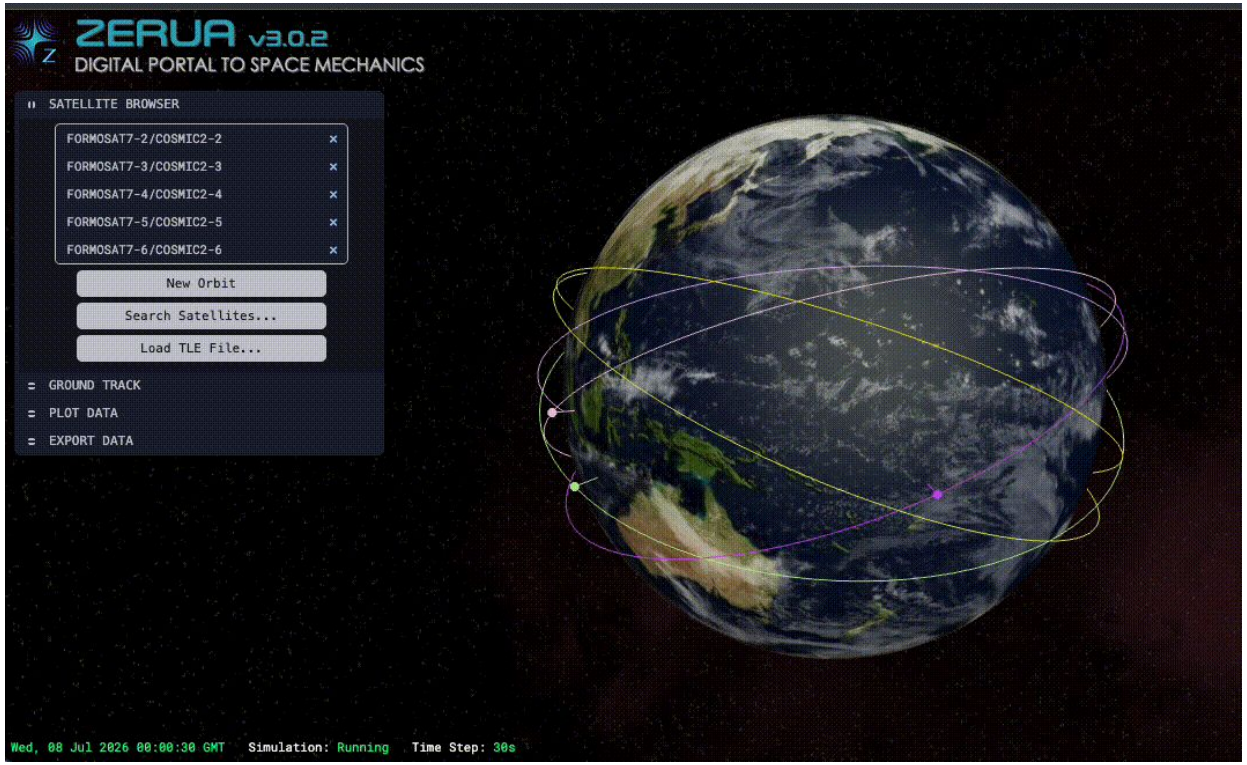
https://www.zerua.space/

JPSS and COSMIC2



NPP, NOAA20, NOAA21

https://ansys.synopsys.com/products/missions/ansys-stk



FORMOSAT7-1/COSMIC2-1,
FORMOSAT7-2/COSMIC2-2,
FORMOSAT7-3/COSMIC2-3

FORMOSAT7-4/COSMIC2-4,
FORMOSAT7-5/COSMIC2-5
FORMOSAT7-6/COSMIC2-6

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