National Aeronautics and Space Administration

ACESat: Heliocentric Orbit Design

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Agenda

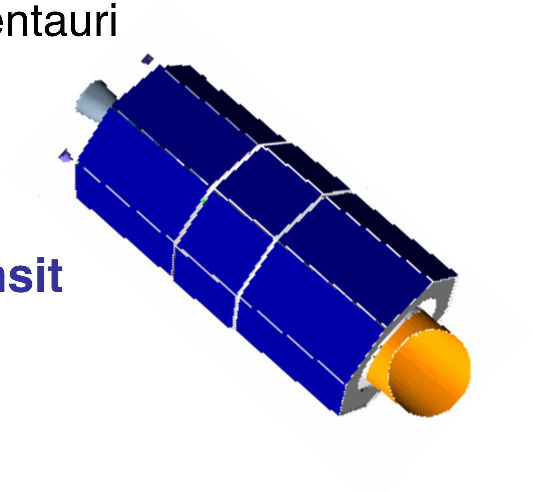
- ACESat Overview
- Heliocentric Orbit Benefits
- Proposed Mission Requirements
- Heliocentric Orbital Design
- Launch Opportunities
- Orbit Optimization
- Summary

What is ACESat?

Alpha Centauri Exoplanet Satellite

Look for exoplanets around local binary star system, Alpha Centauri

Led by Rus Belikov and Eduardo Bendek



Payload

Coronagraph to directly image spectra of exoplanet

- **Exoplanets missions (Kepler and TESS) use transit photometry**

Why Alpha Centauri?

Close proximity to Earth

- **Current candidates are too far away to use foreseeable technology to detect biomarkers**

Recent Kepler data suggests a 40-50% chance one of the aCEN stars supports habitable exoplanet

Uninterrupted stare time

Coronagraph needs to have >90% access duration total mission duration

- **Heliocentric orbit would be best option**

Benefit of Heliocentric Orbits

Pros:

- Has continuous, uninterrupted access to science target
- Provides stable thermal environment
- Requires little propulsion
  - **Does not require station keeping/decommissioning dV**
  - **Can be obtained via single orbit insertion maneuver**
    - Good for instrument sensitivity
- DSN network for comms system

Cons:

- Eventually will drift away from Earth
  - **Comm requirement**
- Only 50% launch availability from GTO

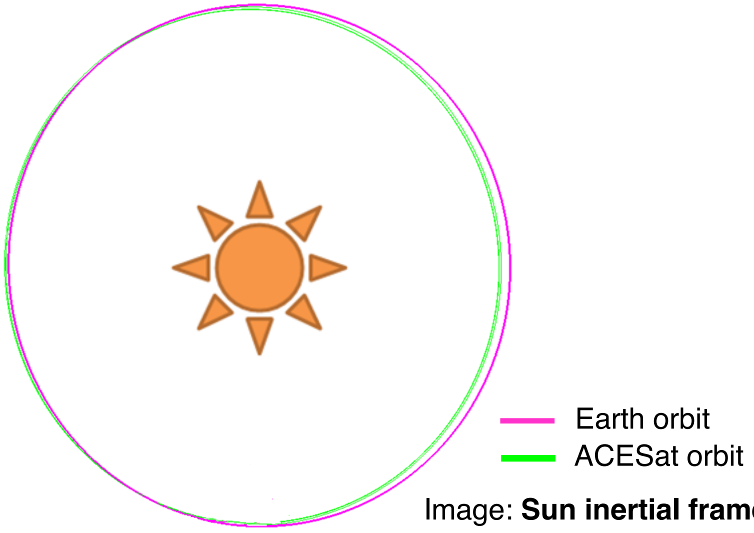


Image: **Sun inertial frame**

Proposed Mission Requirements

Fall 2020 launch

2 year mission lifetime

Falcon 9 launch vehicle

- Could fit on Evolved Expendable Launch Vehicle (EELV)

Secondary payload integrated with SSL 1300 communications satellite

- Released in Geostationary Transfer Orbit

Earth Trailing Heliocentric Orbit Design

Launch opportunity

Sufficient launch opportunities occur during 50% of possible GTO hours

Leave from GTO

35786 x 300 km, 28.5 deg

Launch = Fall 2020

Falcon 9 launch vehicle

Single Orbit Insertion maneuver

Total dV = 800 m/s at Perigee of GTO

Bi propellant

Earth Trailing Heliocentric Orbit

367 day period

1.025 x 0.94 AU, 23.43 deg

e = 0.042

SC drift rate = 0.12 AU/year

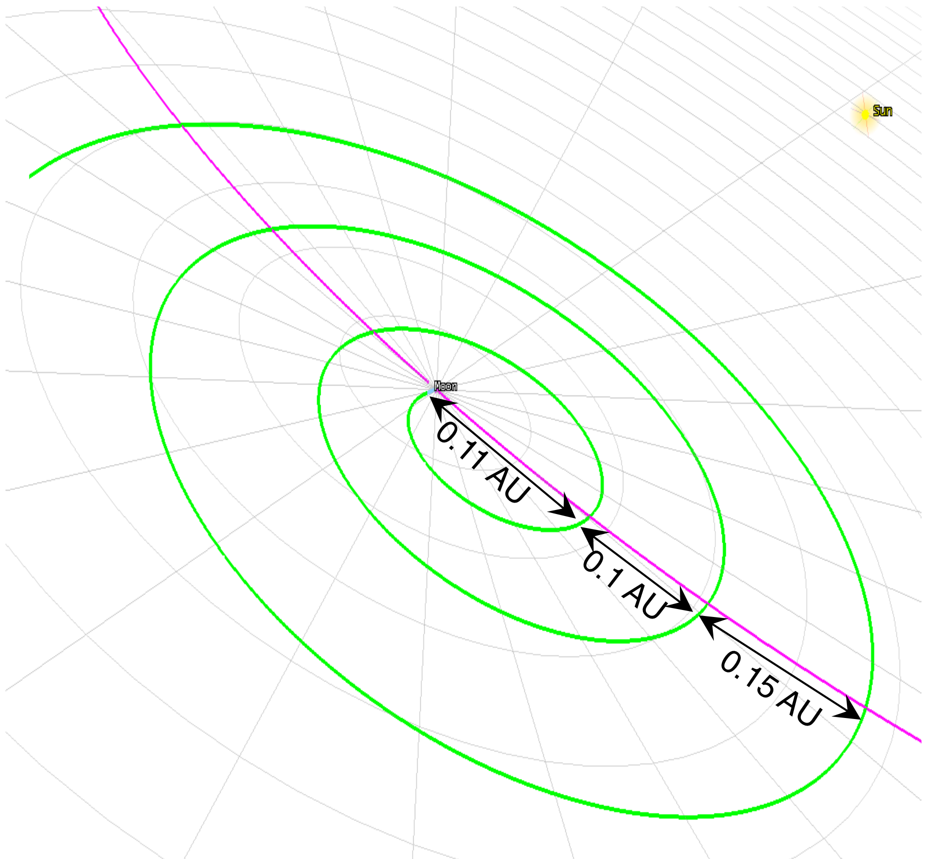
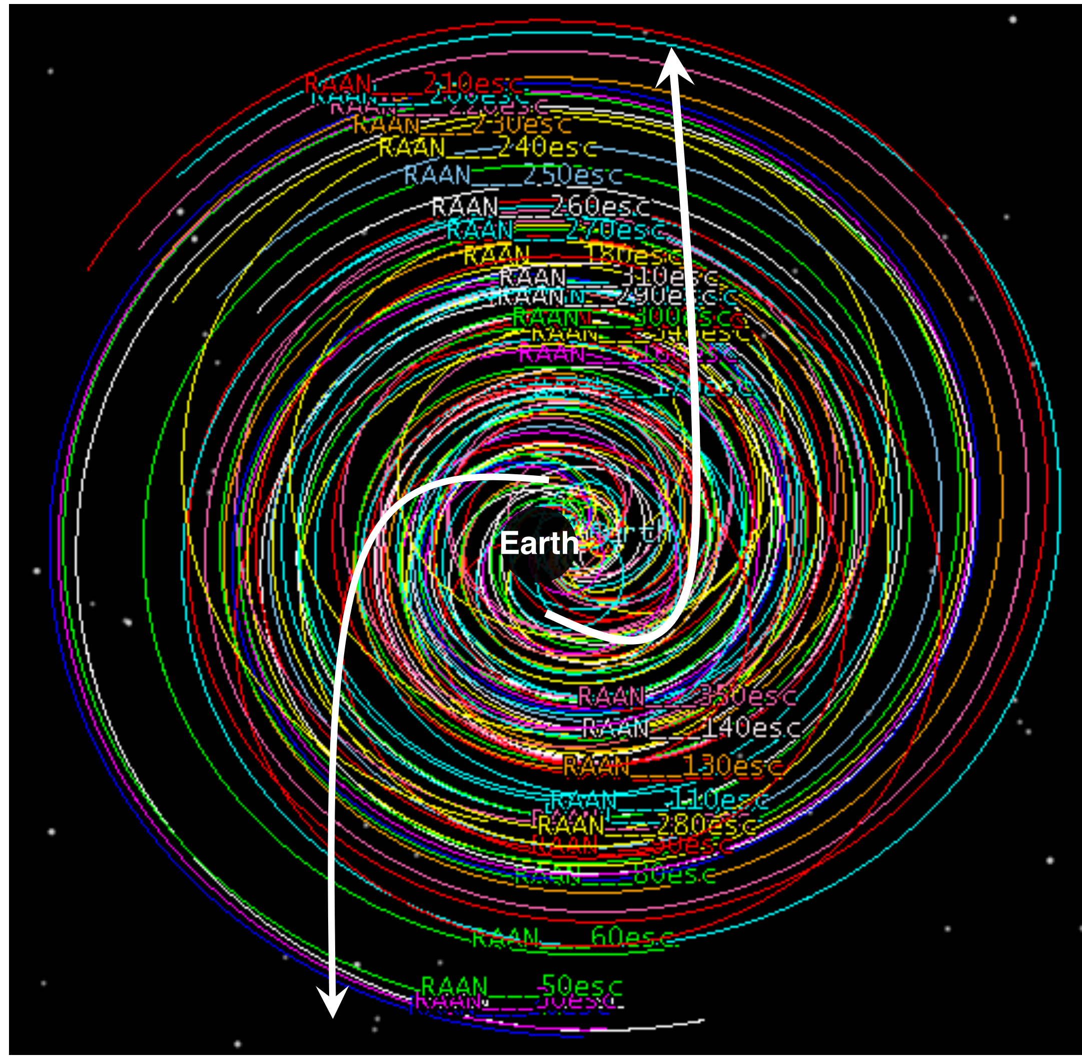


Image: **Earth inertial frame**
Earth orbit
ACESat orbit

Leading vs Trailing Injection Points

Injection Design for Trailing vs Leading Orbit

- Midnight – 12 noon = Leading
- 12 noon – midnight = Trailing



Launch Opportunity

Earth Trailing Orbit design satisfies 50% of possible GTO launch hours

Two launch windows

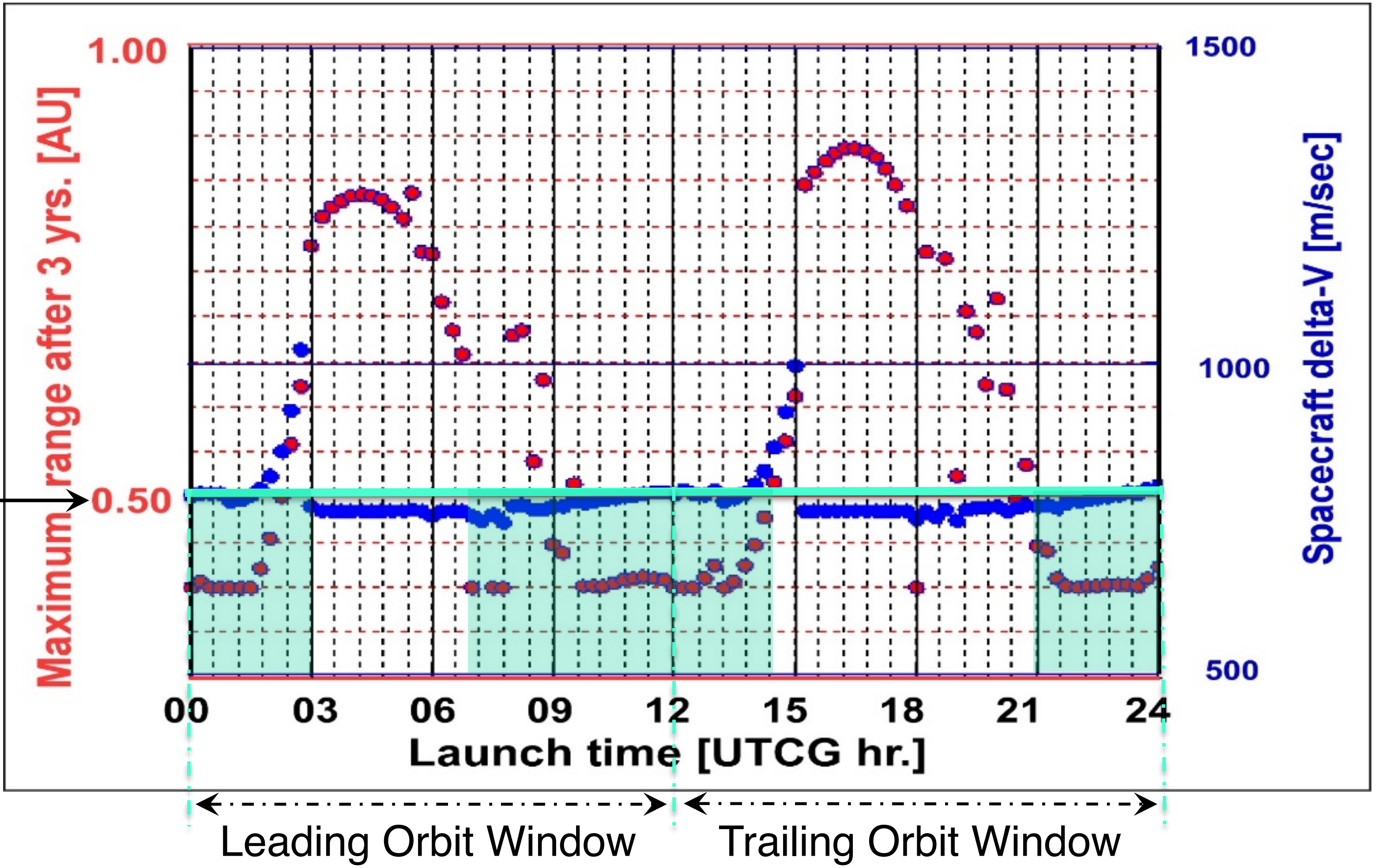
- Leading orbit (midnight – 12 noon)
- Trailing orbit (12 noon – midnight)

Worst case ACESat can orbit in a WSB for up to 3 mo for RAAN optimization

- Will not cost more dV
- Out of radiation belts

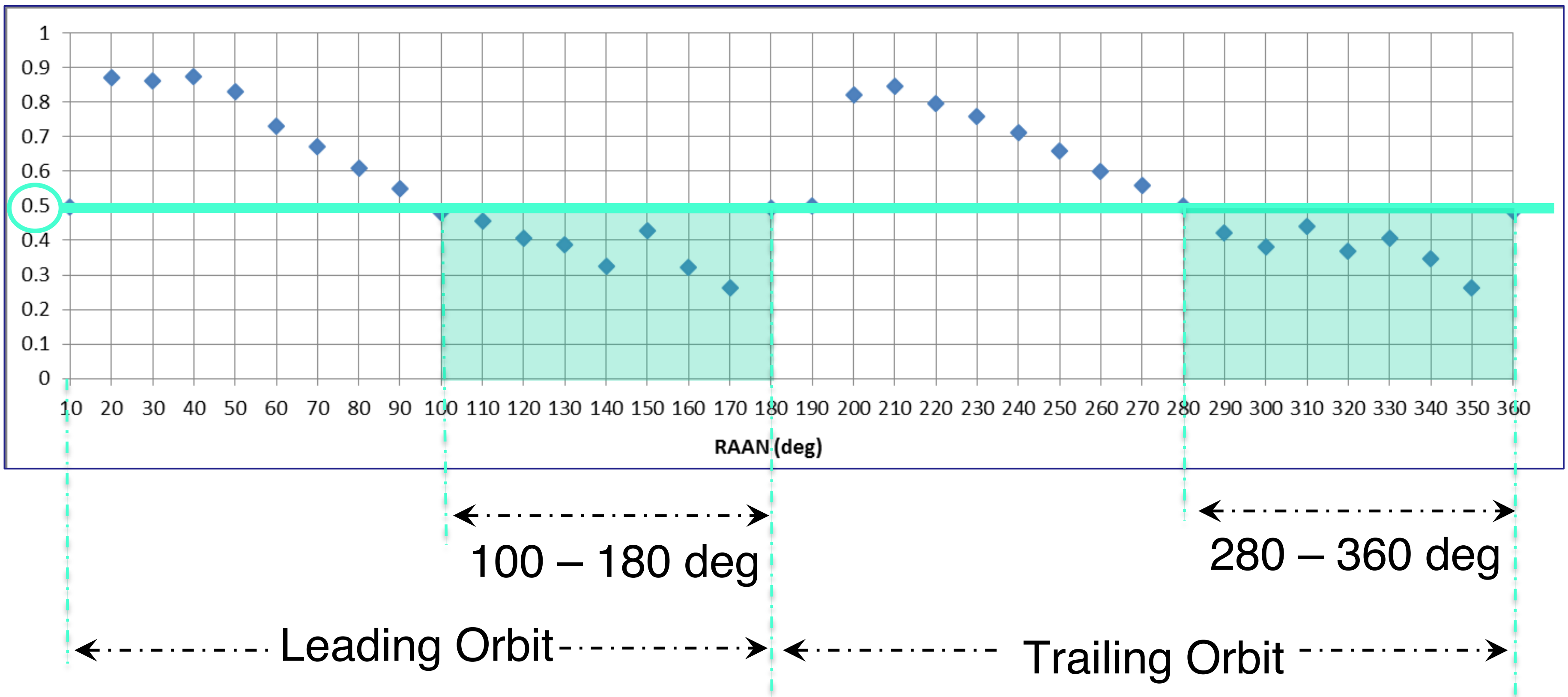
Two Launch Windows

Threshold for max Earth-SC range and max dV for single orbit insertion maneuver



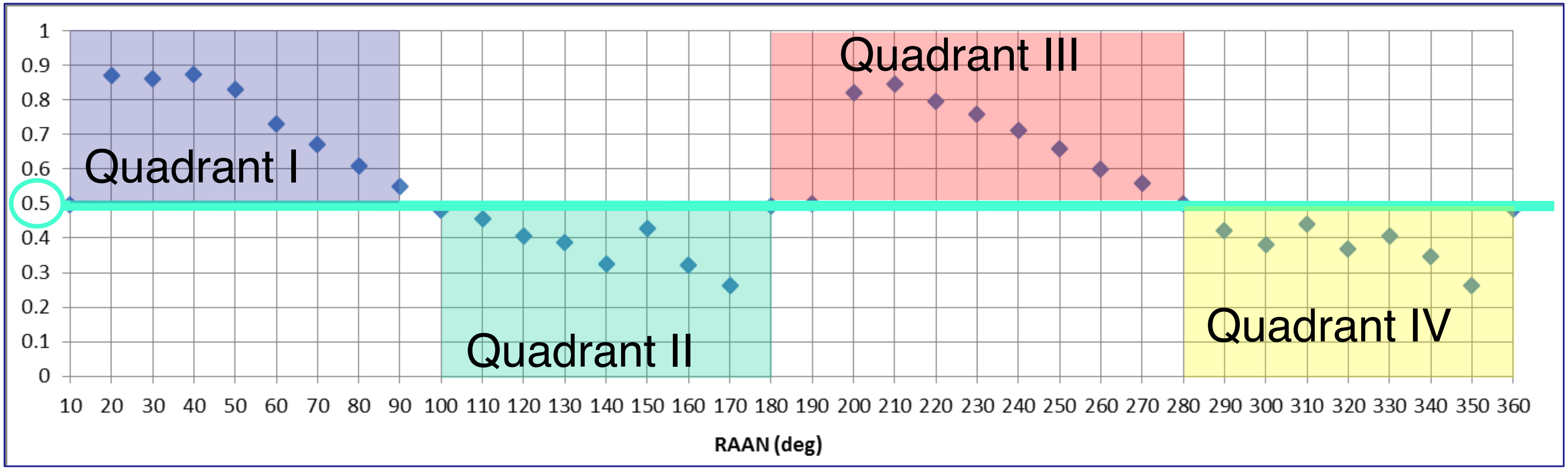
Optimal Heliocentric Orbit is highlighted

RAAN Sweet Spots vs Earth-SC Range



0.5 AU is max Earth-SC range after mission lifetime

RAAN Sweet Spots vs Earth-SC Range

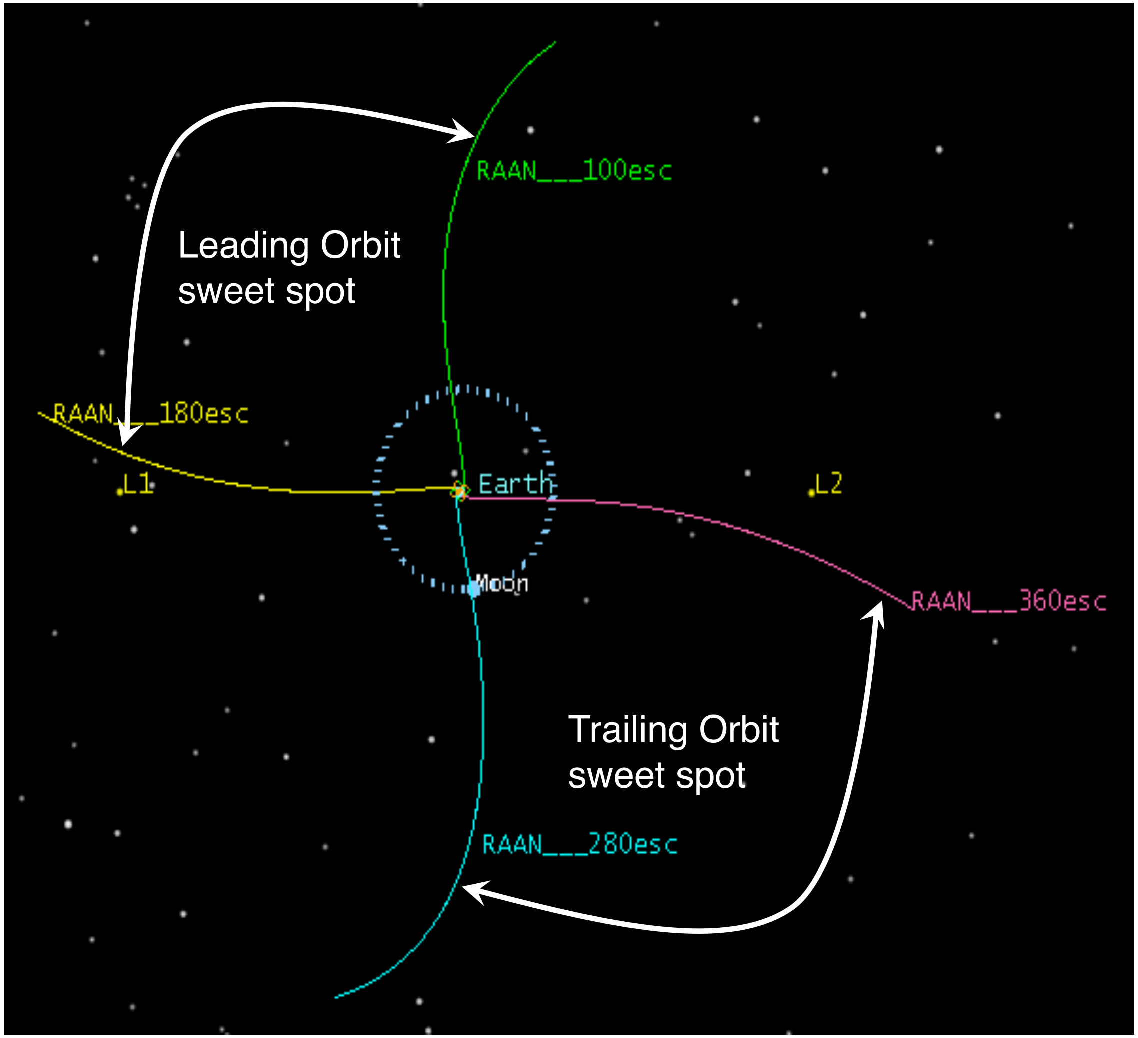


Earth escape trajectories can be thought of as being broken into 4 RAAN quadrants

Available RAAN Quadrants

Sun's position and Earth rotation changes RAAN values ~once every 3 months

Can change escape trajectory by allowing RAAN precession

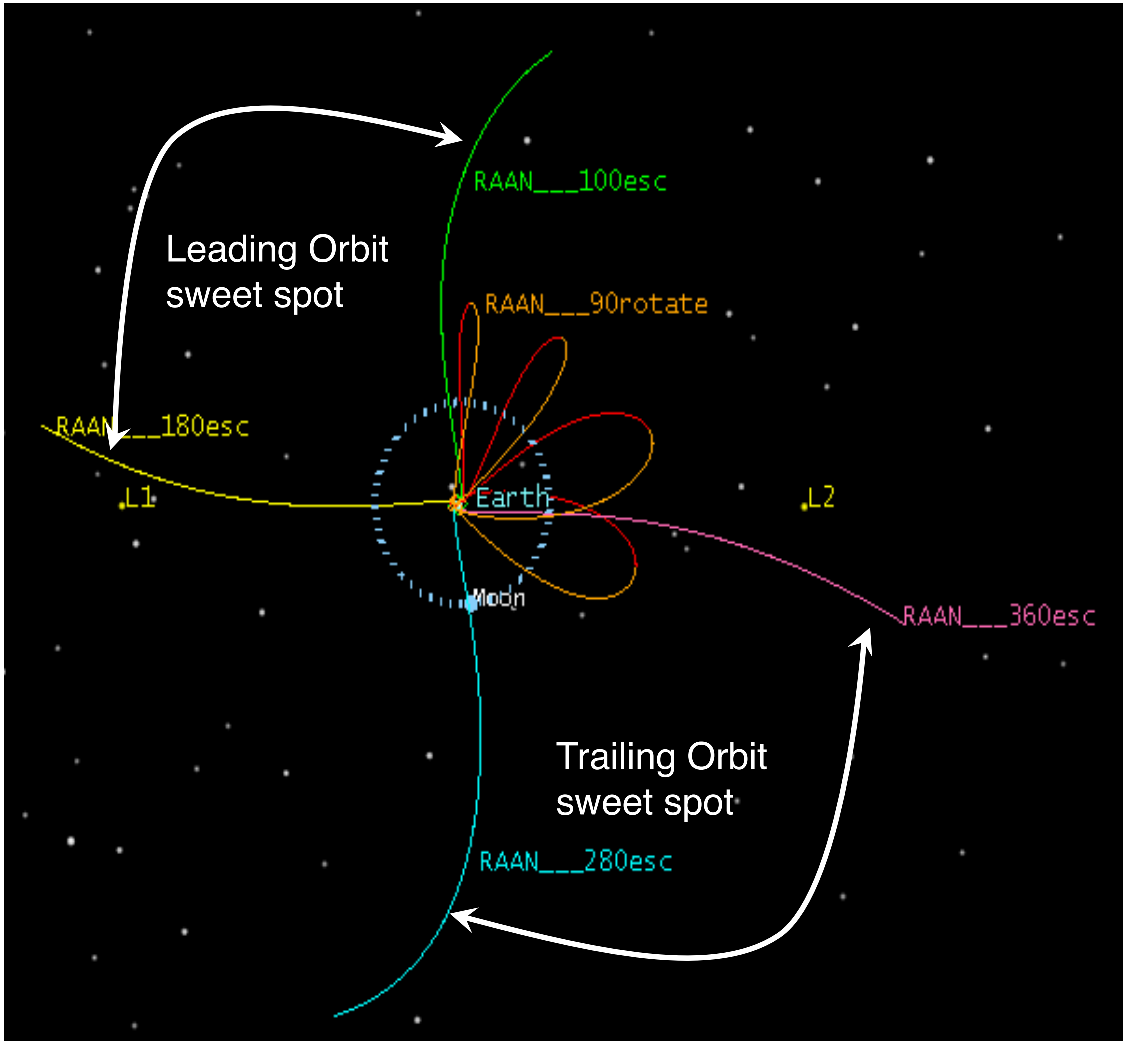


Worst Case Launch Option

Apply maneuver to raise apogee

Orbit for 3 months then use rest of propellant to escape

- Insert into Heliocentic orbit



Orbit Optimization

Propulsion system

Raise periapsis/lower apoapsis to match Earth's heliocentric orbit

- **PROS: Decrease drift rate which is easier for data volume budget, smaller antennaes**
- **CONS: require minimum of 1 km/s dV, minimum of 2 burns over course of a year which may result in perturbing instrument pointing**

Launch Opportunity

Find an different rideshare other than to GTO

- **Where strategy does not involve waiting period**
- **Circular LEO parking orbit**

Summary

Potentially easiest next step in searching for Earth-like exoplanets may be to look around Alpha Centauri

Closest star system utilizing foreseeable technology

- **Kepler findings are too far to directly image**

ACESat would be the first mission to perform direct imaging science around Alpha Centauri

The orbit of such a mission needs to go through iterations and satisfy all instrument/mission requirements

Current orbit to be optimized in Phase A

Acknowledgements

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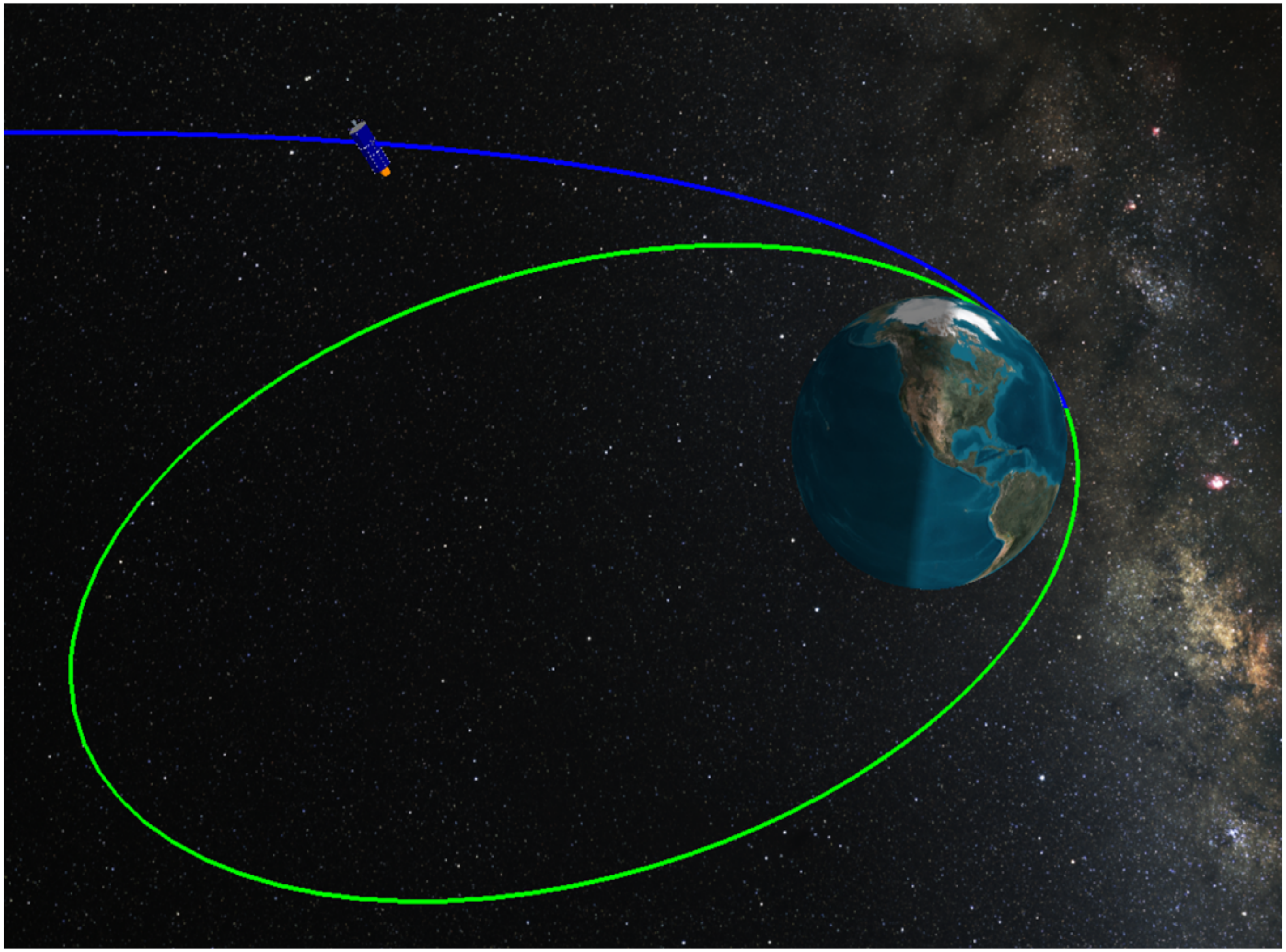

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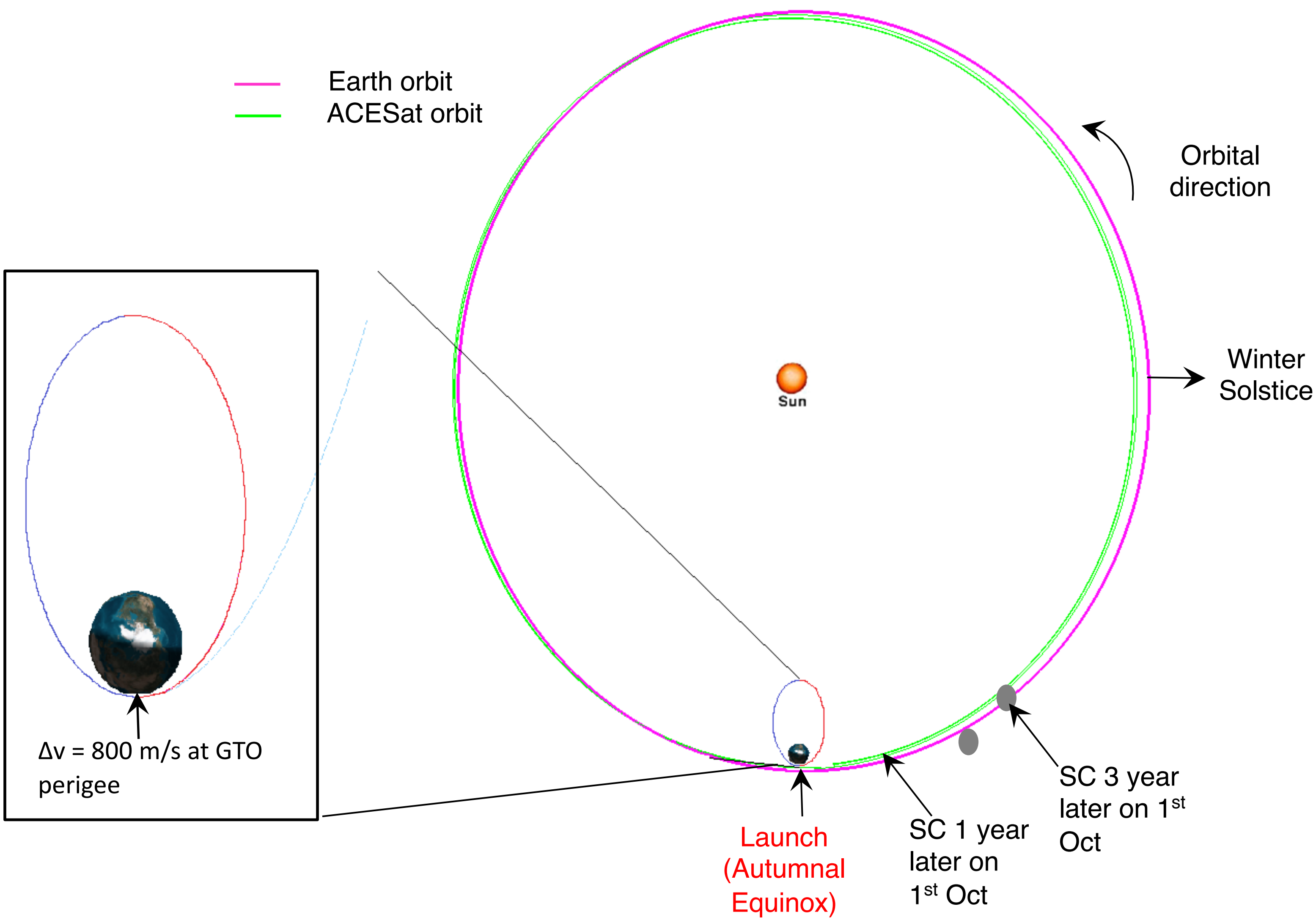
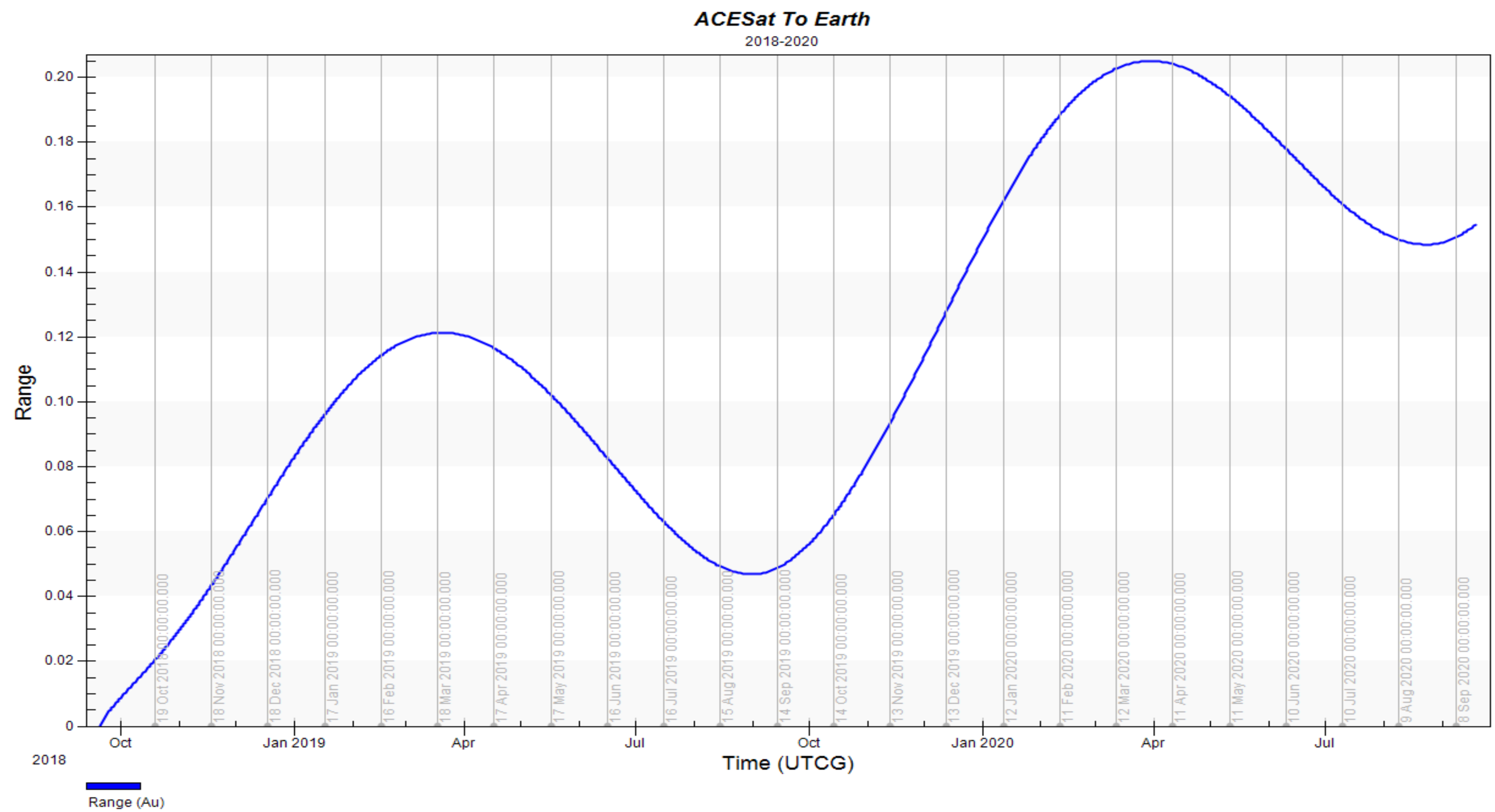
BACKUP SLIDES

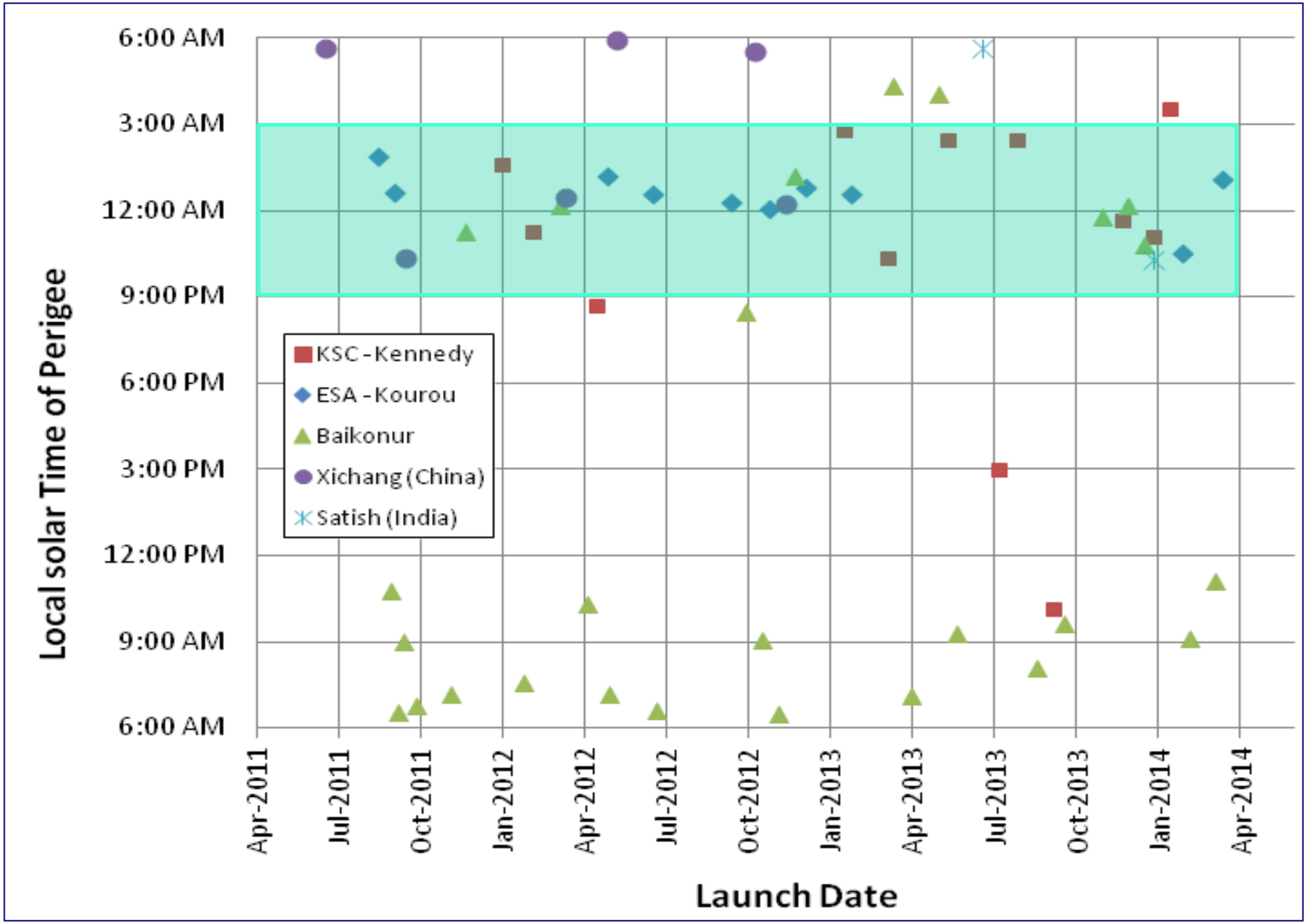
Earth Trailing Heliocentric Orbit



Range btwn Earth and ACESat



the SC is about **0.28 AU from Earth after 2 yrs**


6:00 AM
3:00 AM
12:00 AM
9:00 PM
6:00 PM
3:00 PM
12:00 PM
9:00 AM
6:00 AM
Local solar Time of Perigee
KSC - Kennedy
ESA - Kourou
Baikonur
Xichang (China)
Satish (India)
Apr-2011
Jul-2011
Oct-2011
Jan-2012
Apr-2012
Jul-2012
Oct-2012
Jan-2013
Apr-2013
Jul-2013
Oct-2013
Jan-2014
Apr-2014
Launch Date