Cal Poly Spacecraft Design 20-21

Mission Concept Of Operations

Phase 0
Pre-Launch

The launch services will transport and prepare each launch vehicle to be ready for a launch window around **October 9, 2029 and January 3, 2030.** The ground system (GS) will be prepared for launch by staffing the necessary personnel and creating software for the mission. Each S/C will also be integrated into each launch vehicle.

Phase 1
Launch

The mission will launch separately out of KSC using the launch services provided by SpaceX using **two Falcon Heavy Expendables**. During launch, the GS will monitor the telemetry of the S/C. This phase will conclude when the S/C detumbles after separation from the second stage of the launch vehicle.

Phase 2
Orbital Insertion

After separation from the launch vehicle, each S/C will detumble and begin communication with the ground system. The mission shall have **each S/C complete two gravity assists around Earth to increase inclination**. The final PP orbits of the spacecraft will be a circular, heliocentric orbit at **1 AU with 21 degrees of inclination, and 90 degree RAAN difference**.

Phase 3
PP Orbit Waiting Period

Each of the S/C will be commanded by the GS to complete secondary objective campaigns until an ISO is pursued. **The secondary objectives attempted in this phase include remote observation platform (B.3), and exoplanet platform (B.5)**. Each S/C will be in orbit and ready to conduct objectives before 12/31/2030.

Phase 4
Navigation to ISO

Upon detection of an ISO, **the S/C chosen to pursue will be commanded by the GS to leave its PP orbit on a trajectory towards an Earth gravity assist**. This S/C will then be designated as the Encounter S/C with the other S/C as the Secondary S/C. The mission will use OpNav on the way to the ISO and switch to Autonomous Optical Navigation at a distance of 55,000 km to the ISO.

Phase 5
ISO Flyby

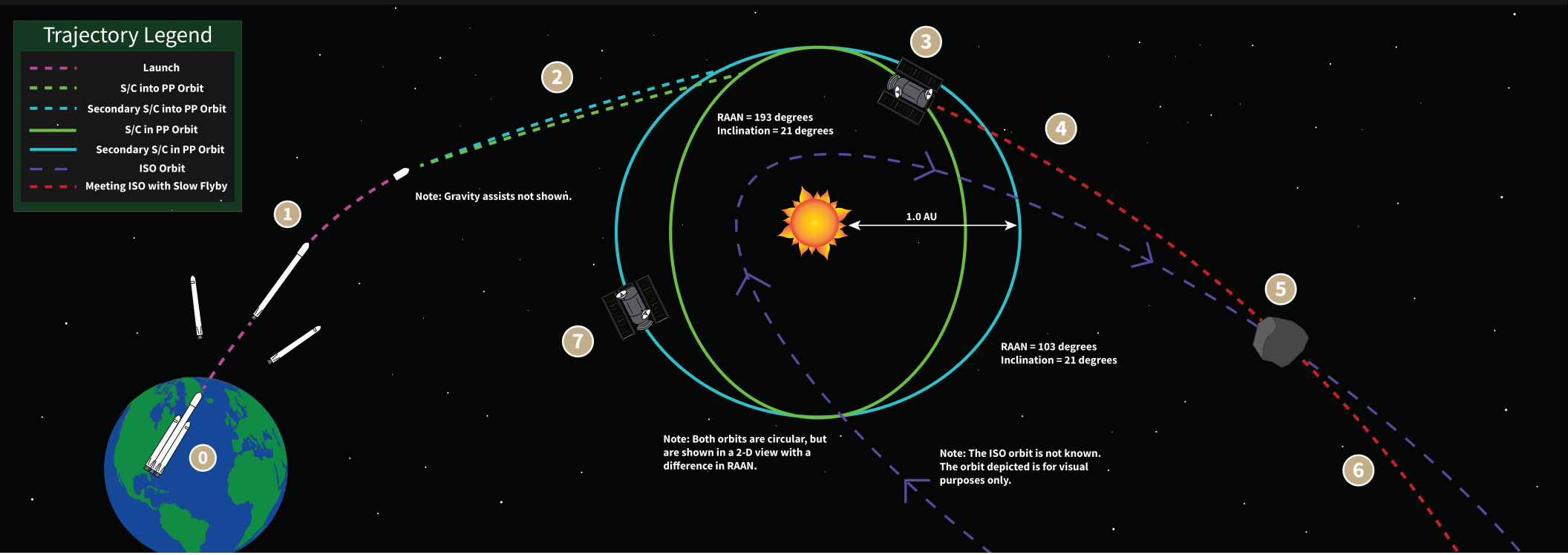
As Autonomous Optical Navigation begins, the flyby of the ISO will begin with a closest approach distance of **400 km and a maximum relative velocity of 13 km/s**. During this phase, the S/C will complete all primary objectives as well as **partial completion of the secondary objective of Advanced Object Definition (B.1).**

Phase 6
Downlink Data

Once the ISO is out of range of the S/C, **data taken during the encounter will begin to be downlinked to the GS.** All of the data must be downlinked before nine months after flyby of the ISO have elapsed. The GS will receive the data and begin processing. Once processed, the data will be made available to the customer.

Phase 7
Decommission

After the primary science data has been downlinked back to the GS, the **Encounter S/C will enter the decommision phase** to be prepared for shutoff. During this time, the GS will monitor the Encounter S/C trajectory to ensure a safe graveyard orbit. The **Secondary S/C will remain in its PP orbit for a minimum of 20 years** since emplaced until decommision.



Launch to Orbital Insertion: Phase 1 and 2

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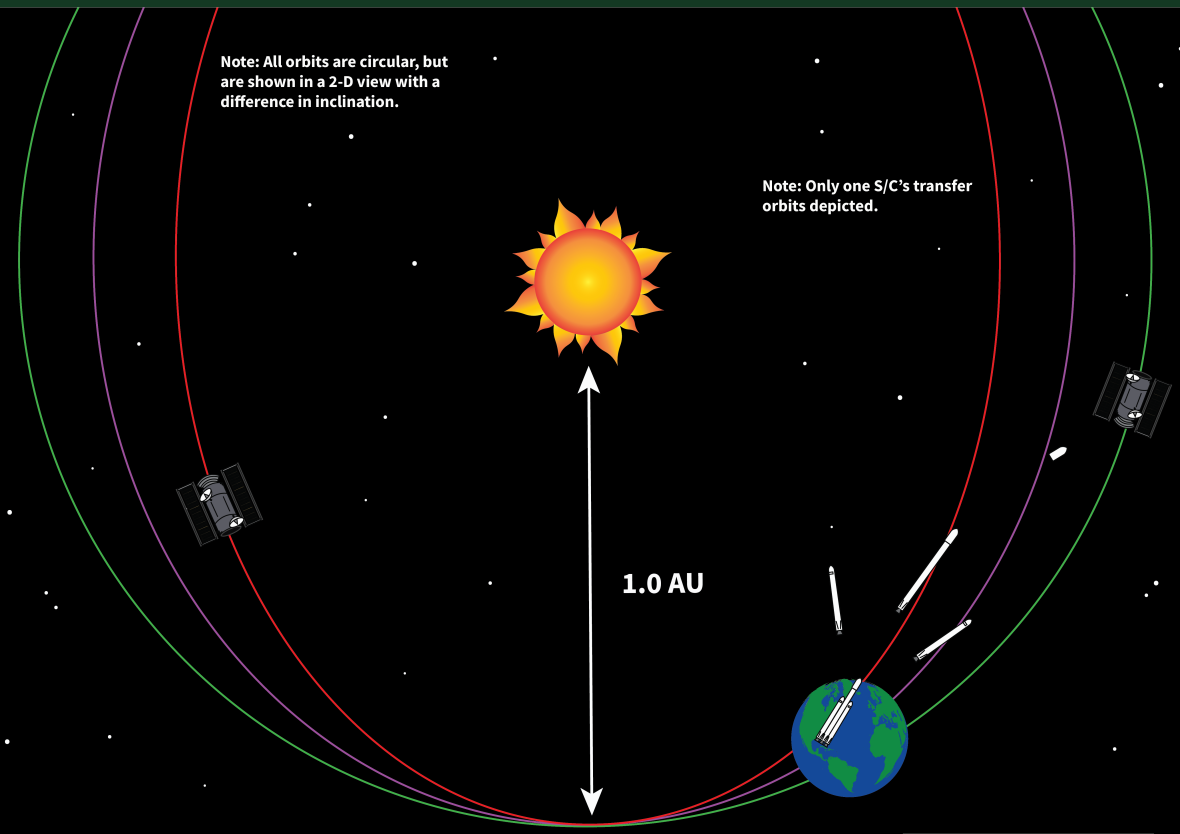

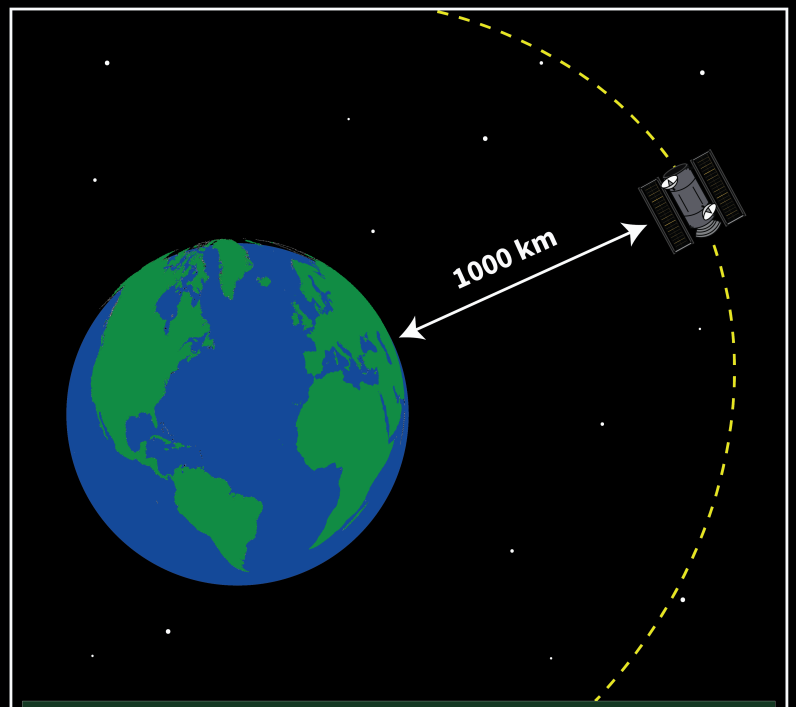

Phase 1: Launch

Two identical S/C will be launched out of KSC three months apart **using Space X's Falcon Heavy Expendable** each time. Each launch will **direct inject into a circular, heliocentric orbit at 1 AU and an inclination of 2.5 degree**s. The first S/C launched will have a **RAAN of 193 degrees and an Argument of Periapsis of 270 degrees while the second S/C launched will have a RAAN of 103 degrees and an Argument of Periapsis of 0 degrees.** This phase will conclude with the detumble of the S/C after separation.

Legend

- Final PP Orbit
- Transitional PP Orbit
- Initial PP Orbit
- Gravity Assist Trajectory

Phase 2: Gravity Assists

Each S/C will complete two gravity assists around Earth on the way to the final prepositioned orbits to increase inclination. The **gravity assists are bounded at a minimum altitude of 1000 km with each launch achieving a C3 of 2 km/s**.

Final PP Orbit Parameters

S/C	Semi-Major Axis	Eccentricity	RAAN	Inclination	Argument of Periapsis
A	1 AU	0.0167	193°	21°	270°
B	1 AU	0.0167	103°	21°	0°

Prepositioned Orbit Waiting Period: Phase 3

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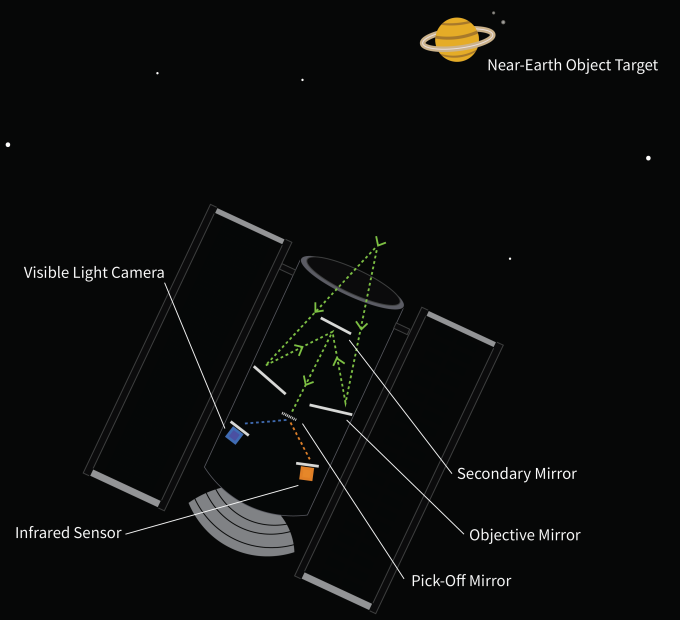
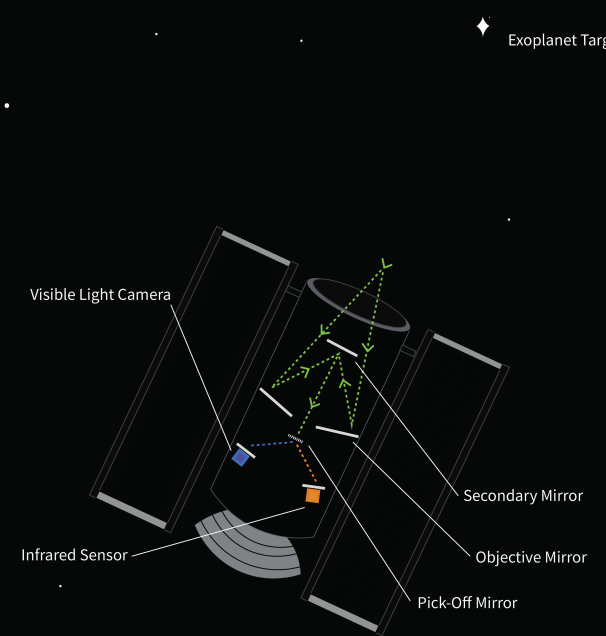
B.3 Remote Observation Platform

To meet B.3 Remote Observation Platform, the **S/C will observe objects for 2-4 weeks at a time.** These will be follow-up observations, and will alternate with B.5 Exoplanet Platform campaigns. Images will be acquired with the primary telescope so that **the target is observable with an SNR greater than or equal to 2.5**, based off of known near earth objects or heliocentric orbiting bodies. These observations will provide further knowledge of the targets to the scientific community, potentially used to derive spin rates or see how their orbits change over time. The campaigns pursued will be determined by the customer.



B.5 Exoplanet Platform

To complete B.5 Exoplanet Platform, each spacecraft will perform **follow-up science on known exoplanets for 2-4 weeks at a time, acquiring images every 30 minutes to build light curves** that will be analyzed on the ground to look for exoplanet transits. Targets will be selected based on known exoplanets with **apparent magnitude of their stars brighter than Magnitude 14.43 to ensure the transits are observable**. This follow-up science will provide greater knowledge of these exoplanets and their orbital characteristics. Again, the campaign pursued will be determined by the customer.



Encounter Strategy: Phase 5

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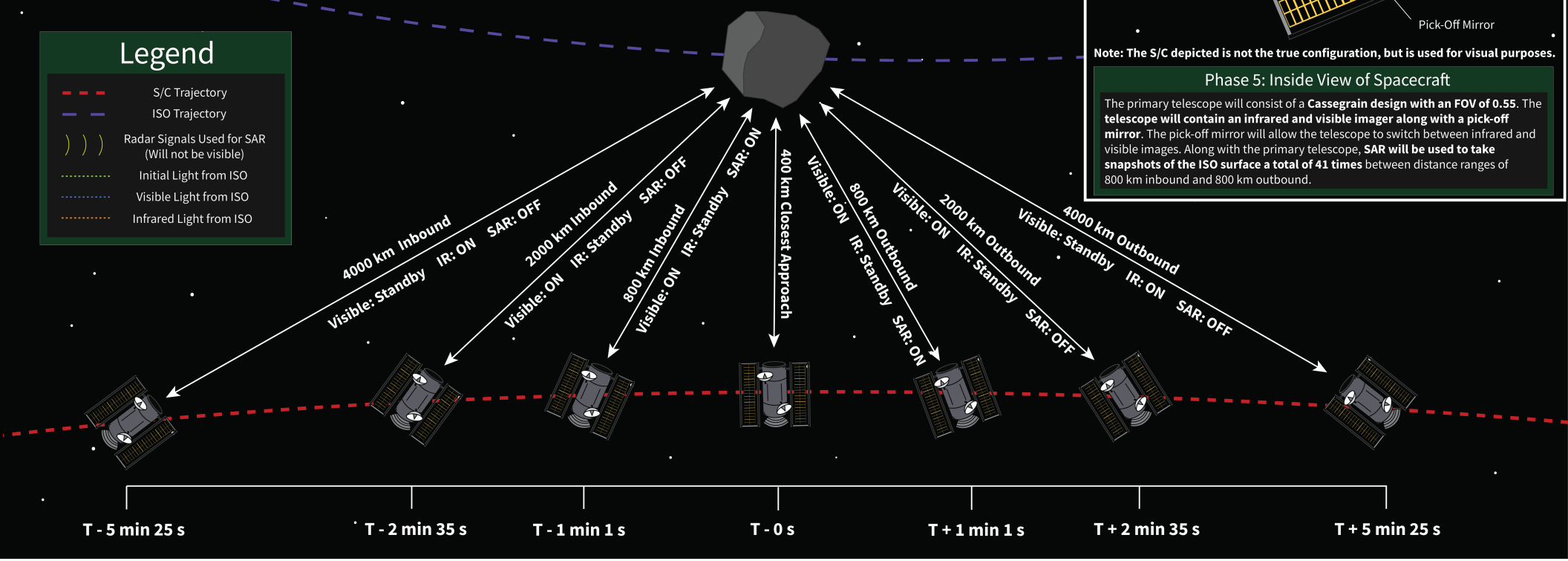
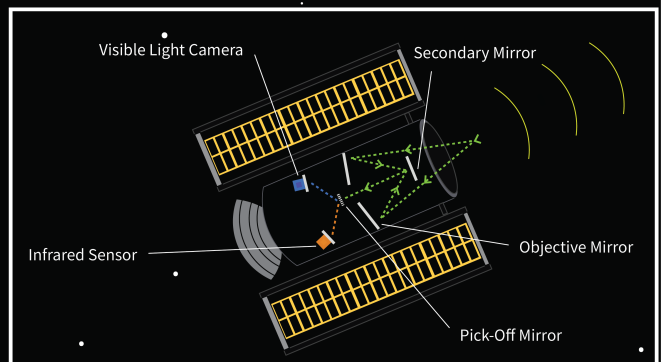
Phase 5

The Encounter S/C will begin Autonomous Optical Navigation at 55,000 km away from the ISO on the inbound trajectory. At **4000 km away from the ISO, the IR imager will begin taking images** of the ISO surface. Once the **S/C is 2000 km away from the ISO, visible imaging will begin**. **At 800 km away, the SAR system will begin** taking snapshots. The **closest approach will be 400 km** away. The **Encounter S/C will stop collecting primary science data at 4000 km** away on the outbound trajectory.



Legend

- S/C Trajectory
- ISO Trajectory
- Radar Signals Used for SAR (Will not be visible)
- Initial Light from ISO
- Visible Light from ISO
- Infrared Light from ISO



Note: The S/C depicted is not the true configuration, but is used for visual purposes.

Phase 5: Inside View of Spacecraft

The primary telescope will consist of a **Cassegrain design with an FOV of 0.55**. The **telescope will contain an infrared and visible imager along with a pick-off mirror**. The pick-off mirror will allow the telescope to switch between infrared and visible images. Along with the primary telescope, **SAR will be used to take snapshots of the ISO surface a total of 41 times** between distance ranges of 800 km inbound and 800 km outbound.