



Libration Orbit Selection Methods and Formulations to Meet Mission Requirements

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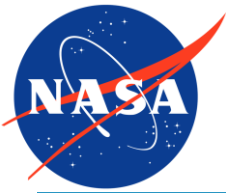
University of Maryland Baltimore County

^{*}**NASA Goddard Space Flight Center**

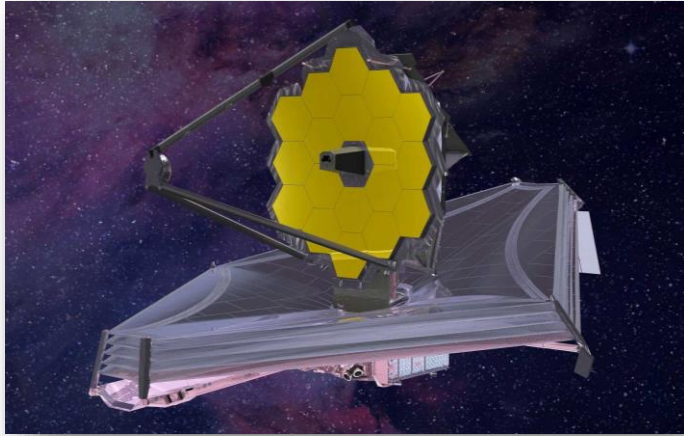
Code 595 Navigation and Mission Design Branch

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Mission Requirement



JWST science orbit requirements:

- Mission orbit must not exceed $\pm 832,000\text{km}$ in the RLPY and $\pm 520,000\text{km}$ in the RLPZ
- The Mission Orbit must avoid all Earth and Moon shadows



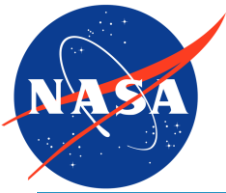
SWFO science orbit requirements:

- The Mission Orbit Sun-Earth-Vehicle (SEV) angle must remain between 4 and 13 degrees for at least 5 years



RST science orbit requirements:

- Operational Mission Orbit Extent: the Operational Mission Orbit must maintain the L2-Earth-Vehicle (LEV) angle between 0.51 and 36 degrees
- Orbit Coverage: the Operational Mission Orbit to have a minimum access time of 7 hours each day from White Sands Ground Station.

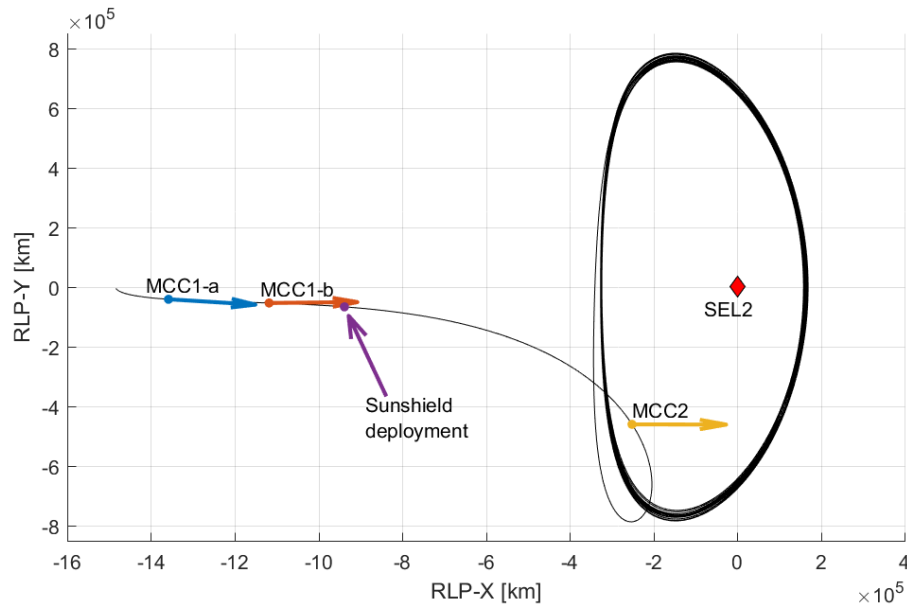


James Webb Space Telescope (JWST)

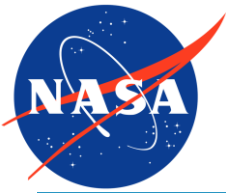


■ JWST science orbit requirements:

1. Mission orbit must not exceed $\pm 832,000\text{km}$ in the RLPY and $\pm 520,000\text{km}$ in the RLPZ.
 2. Avoid shadows with from the Earth and the Moon.
- JWST Launch Window is defined by continuous time intervals between 11:30 UTC and 14:00 UTC each day of the year (some days are discarded due to large Moon perturbations).
 - JWST mission baseline is very flexible as it allows for a wide range of science orbits.



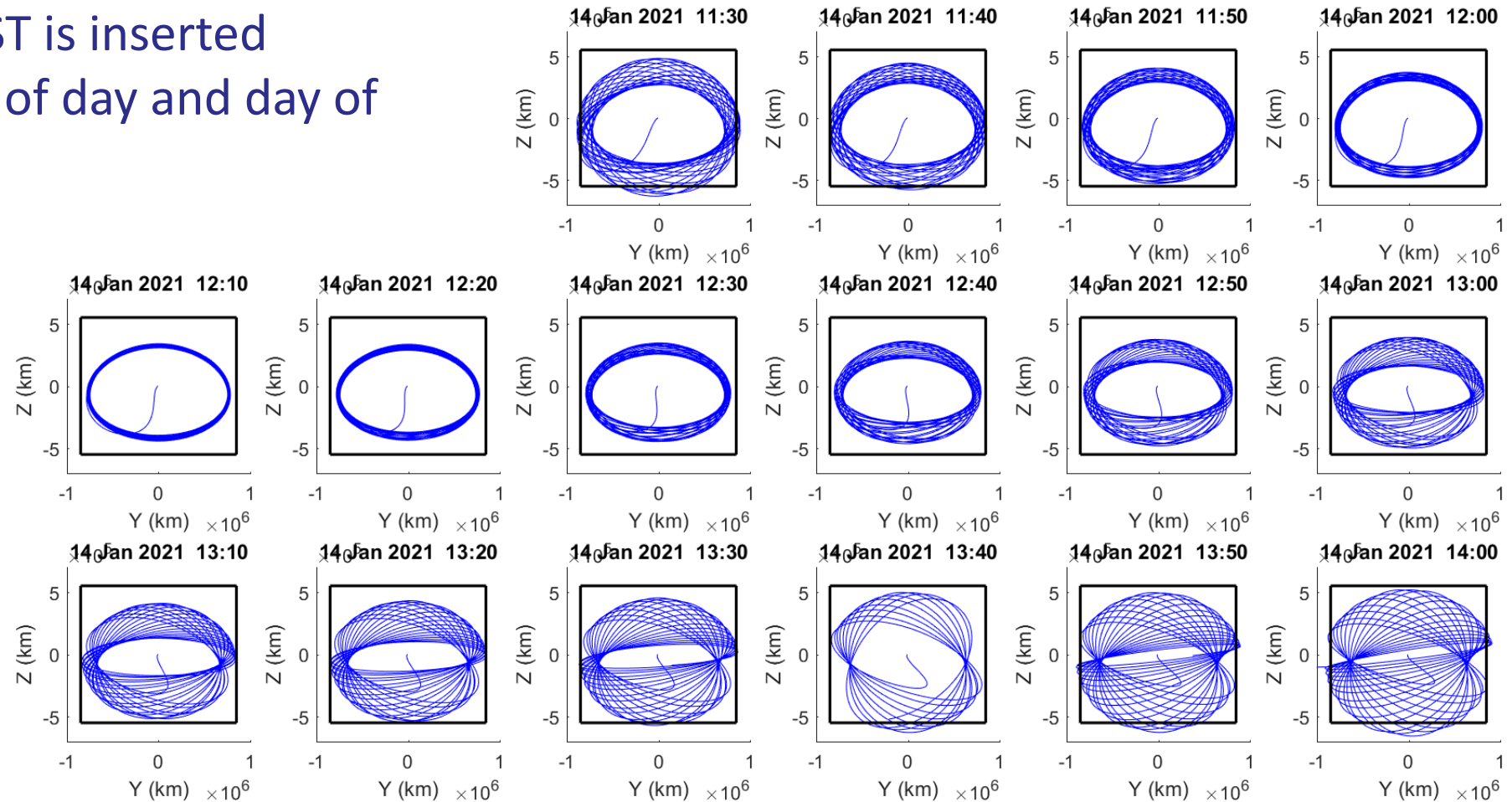
Maneuver Id	Time	Performance
MCC1-a	+12.5 hours after launch	Perform 93%
MCC1-b	+2.5 days after launch	Perform 93%
Sunshield deployment	+5 days after launch	SRP starts to play a role
MCC2	+29 days after launch	Perform 100% (1 st station keeping maneuver)
Station-Keeping	Every 21 days during mission lifetime	Perform 100%

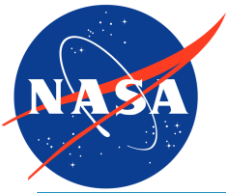


James Webb Space Telescope (JWST)



The type of orbit JWST is inserted depends on the time of day and day of year it is launched.



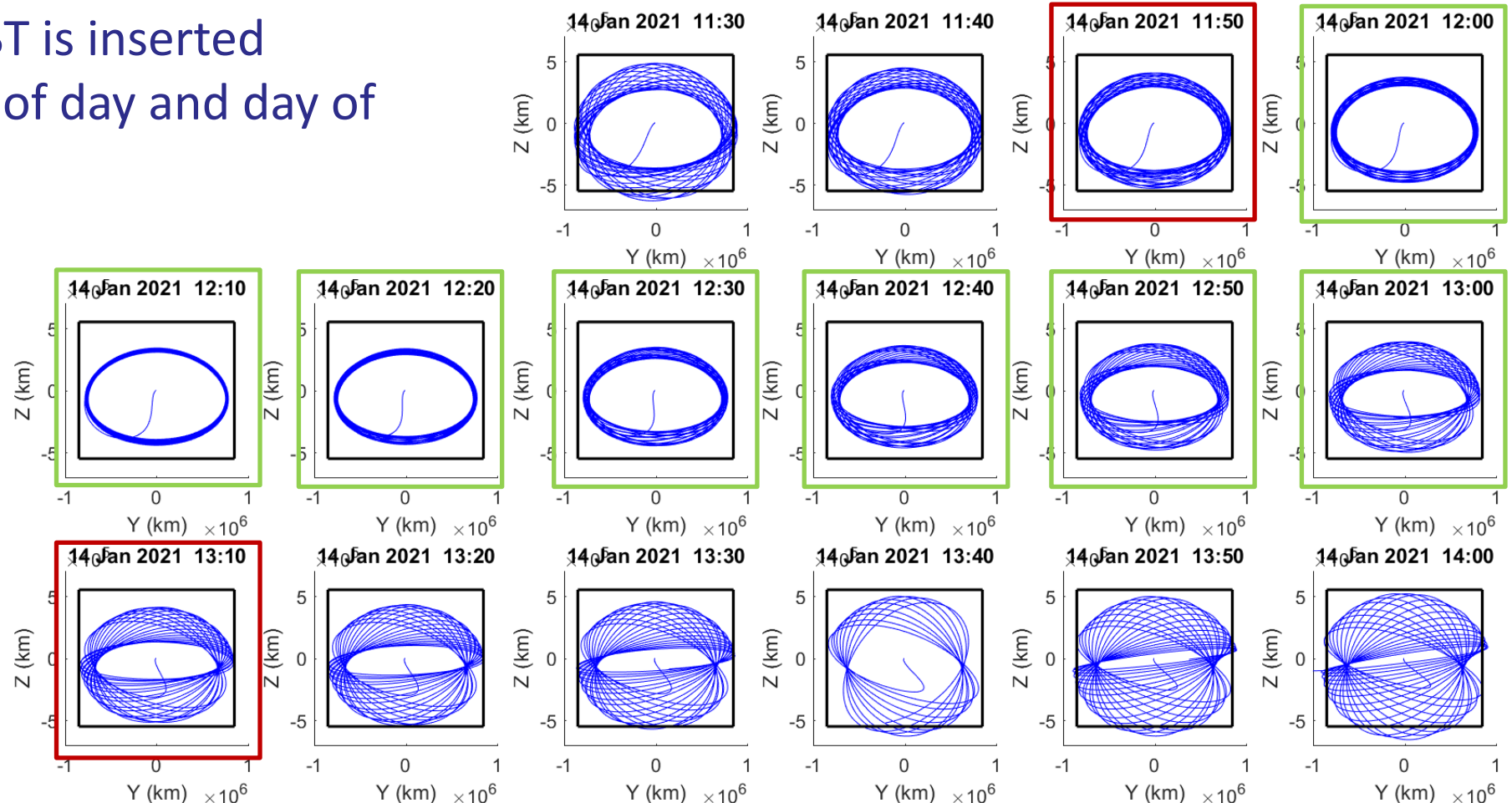


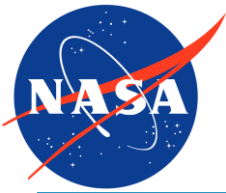
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For each launch date, we select the times when the mission orbit meets the requirement



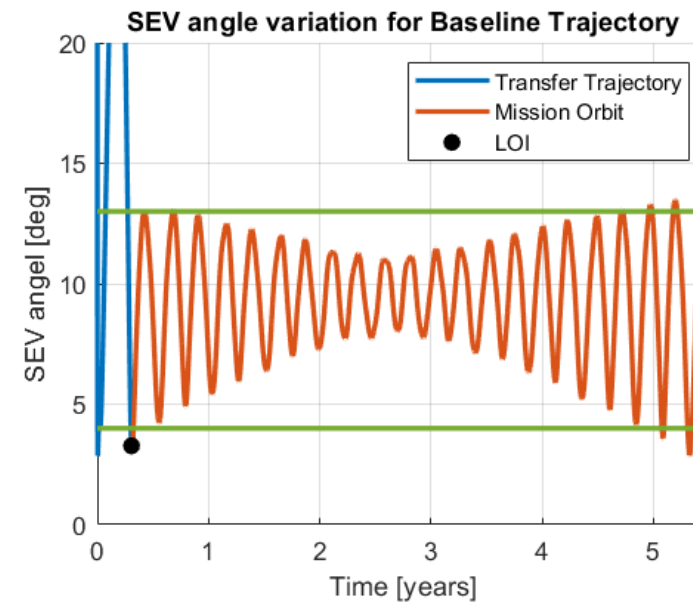
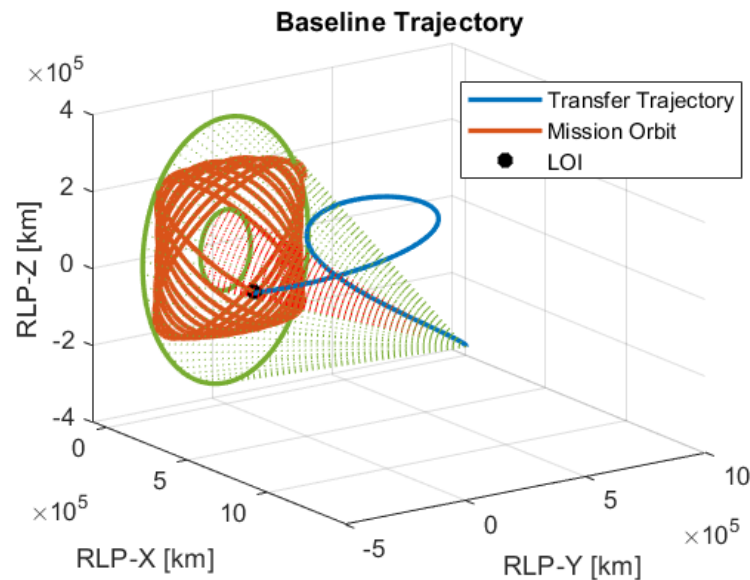


Space Weather Follow-On L1 (SWFO-L1)



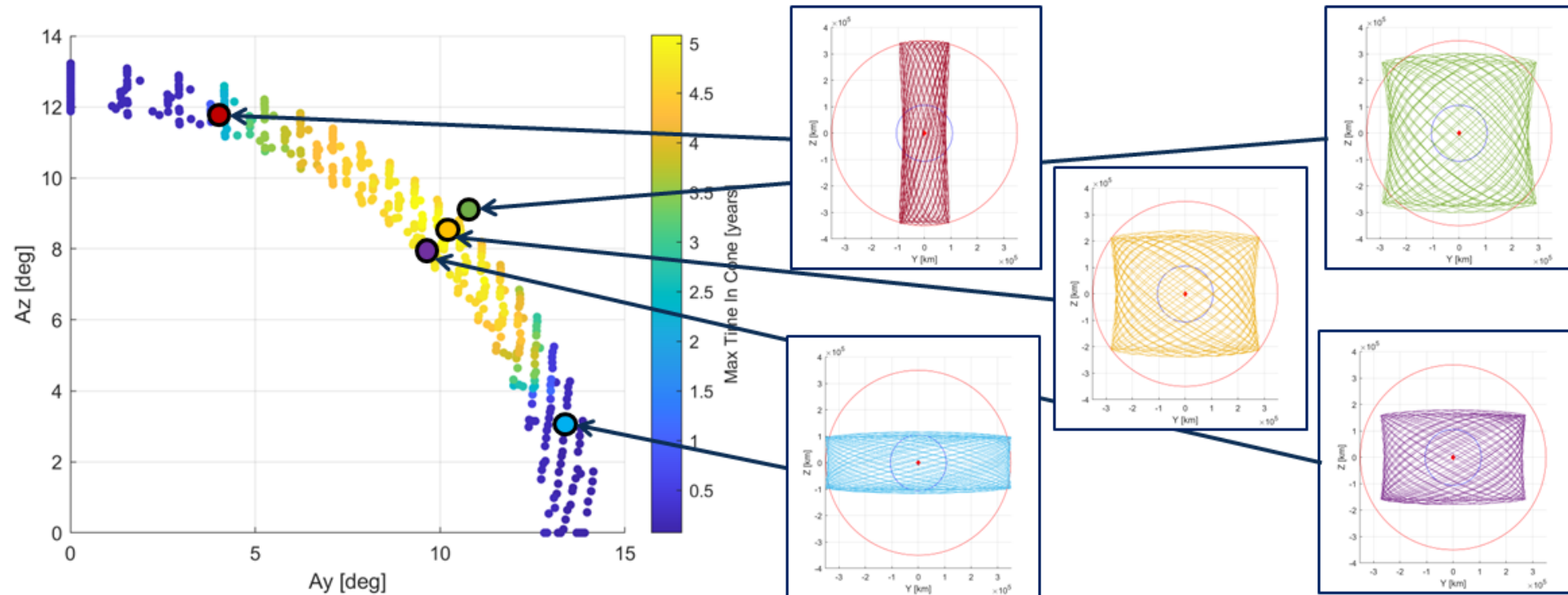
■ SWFO science orbit requirements:

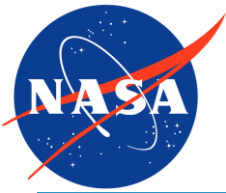
- The Mission Orbit Sun-Earth-Vehicle (SEV) angle must remain between 4 and 13 degrees for at least 5 years.
- In the Launch Window we must select a mission orbits that meet the orbit requirements.



Step 1: Orbit Selection in CRTBP (Circular Restricted Three Body Problem)

- Scan Lissajous orbits in the CRTBP and check SEV angle.
- Select one orbit that meets requirement and refine in the full ephemeris model for each synodic month.

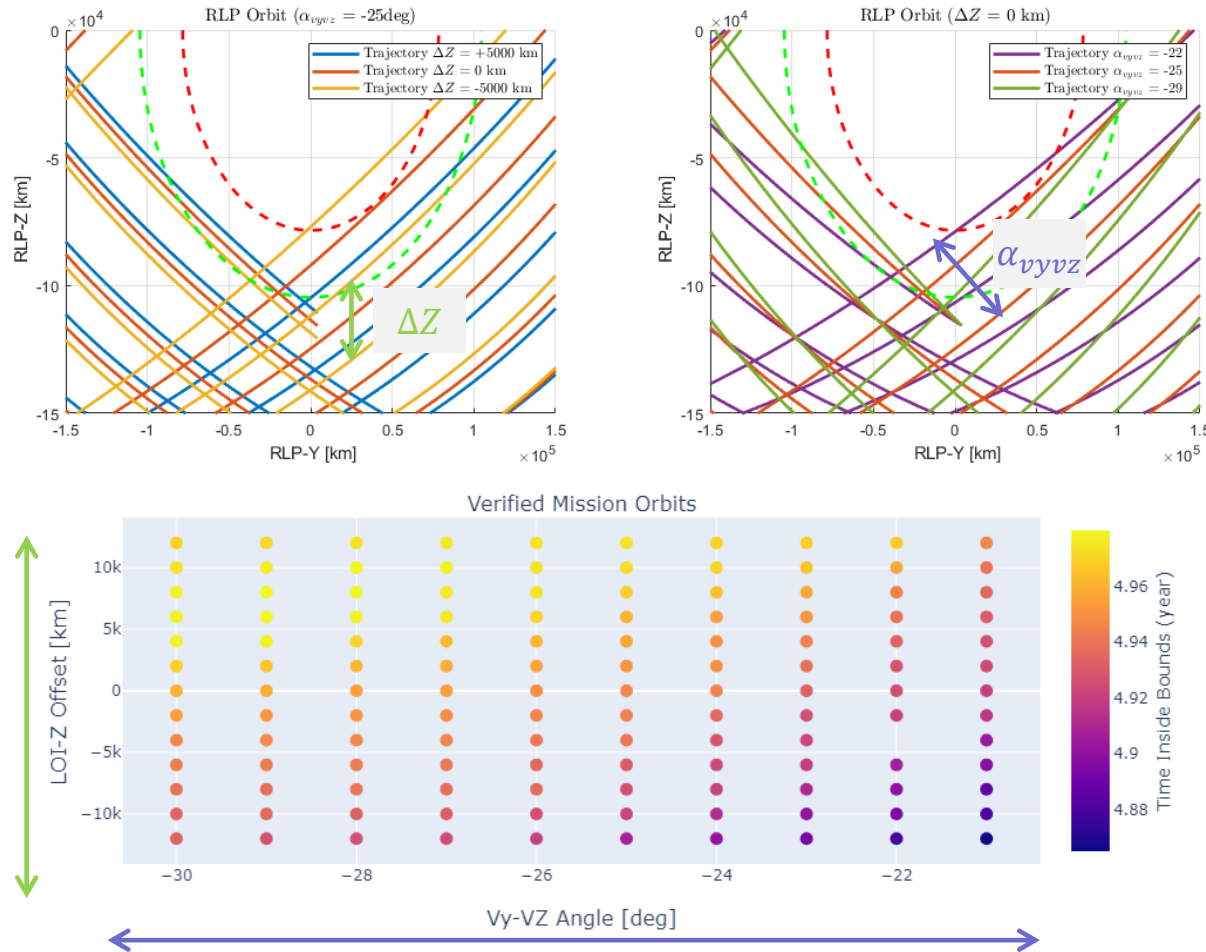




Space Weather Follow-On L1 (SWFO-L1)

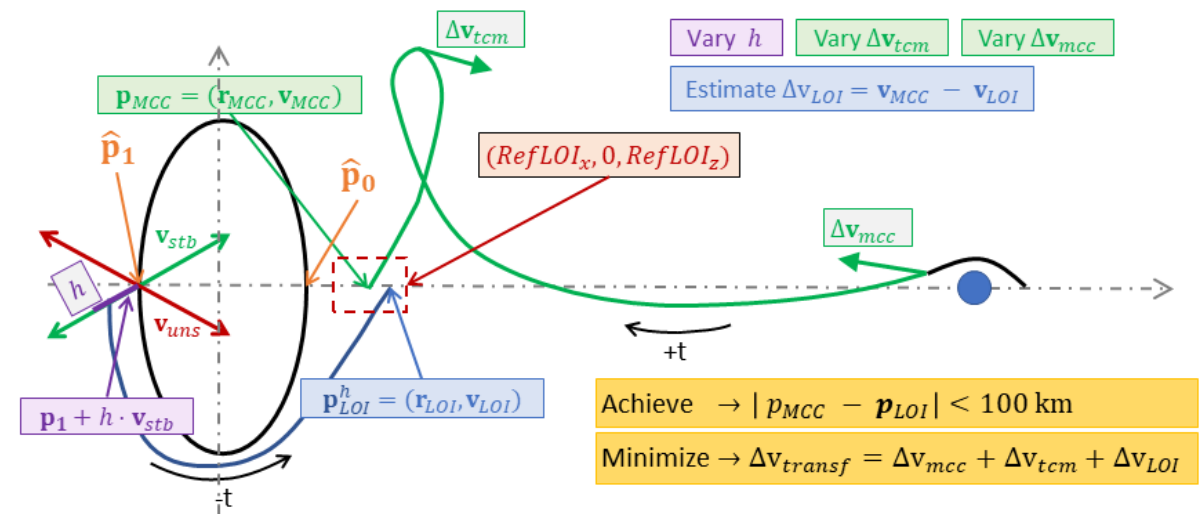


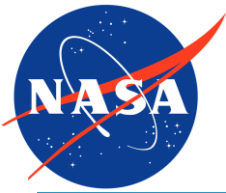
Step 2: Scan family in the full Ephemeris



Step 3: Find Insertion Point

For each orbit we find an MCC, LOI and insertion point using an optimization method.



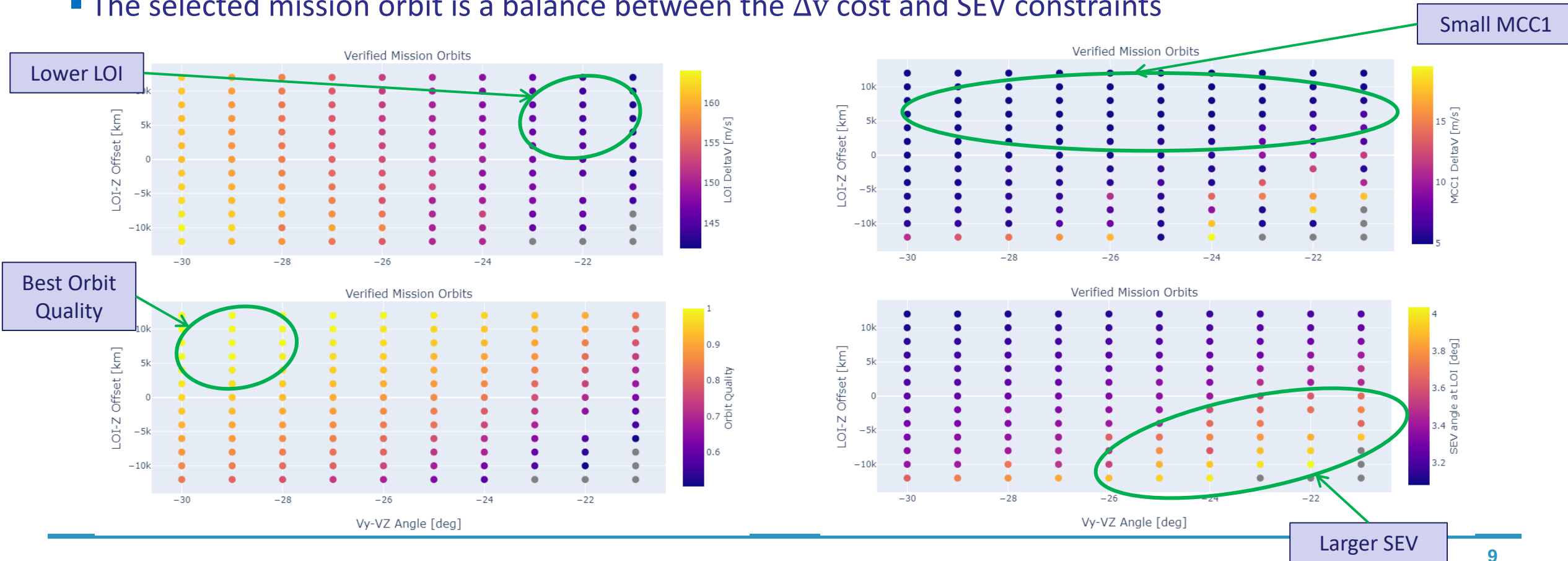


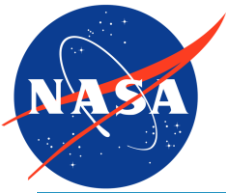
Space Weather Follow-On L1 (SWFO-L1)



Step 4: Trade Study (Sep 23rd, 2025 launch date)

- We can perform trade studies looking at the MCC-1, LOI, SEV and Orbit Quality Indicator for each orbit
- The selected mission orbit is a balance between the Δv cost and SEV constraints



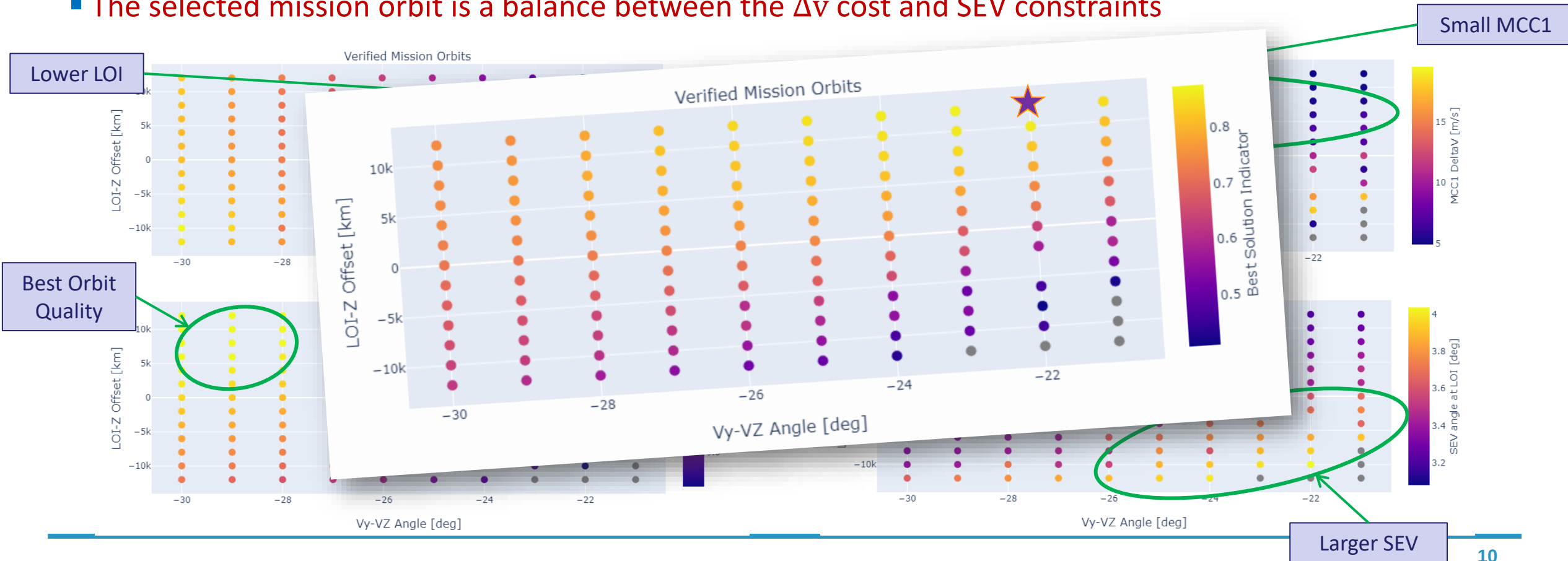


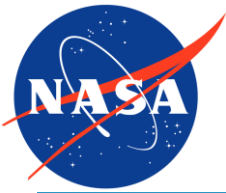
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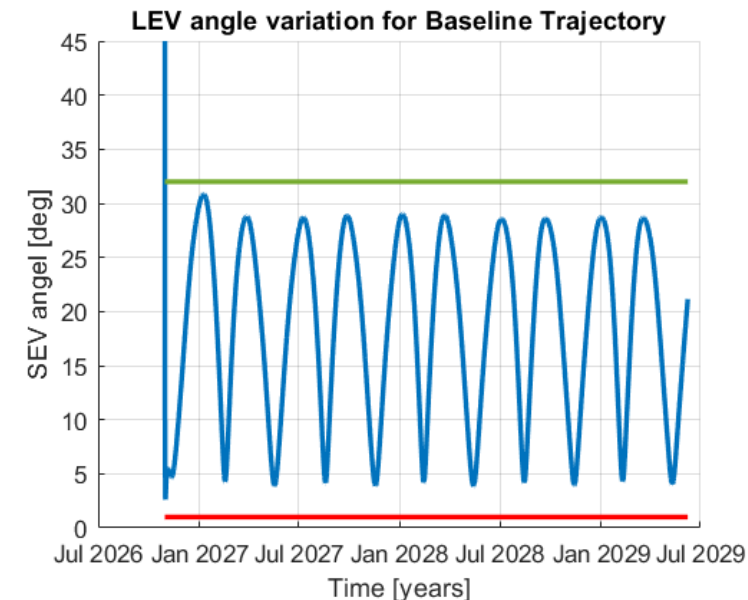
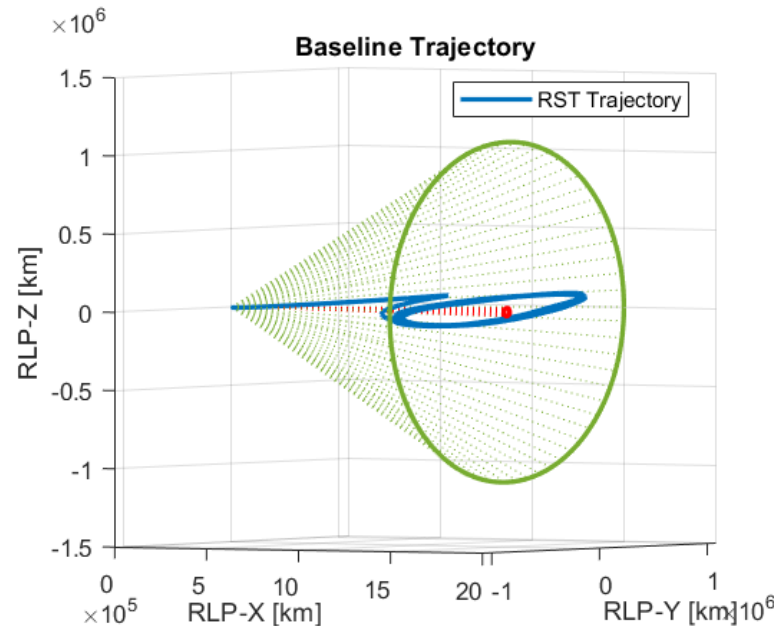


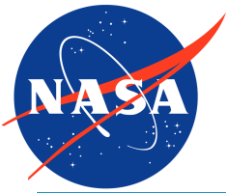
Roman Space Telescope (RST)



■ RST science orbit requirements:

- Operational Mission Orbit Extent: the Operational Mission Orbit must maintain the L2-Earth-Vehicle (LEV) angle between 0.51 and 36 degrees.
- Orbit Coverage: the Operational Mission Orbit shall have a minimum access time of 7 hours each day from White Sands Ground Station.

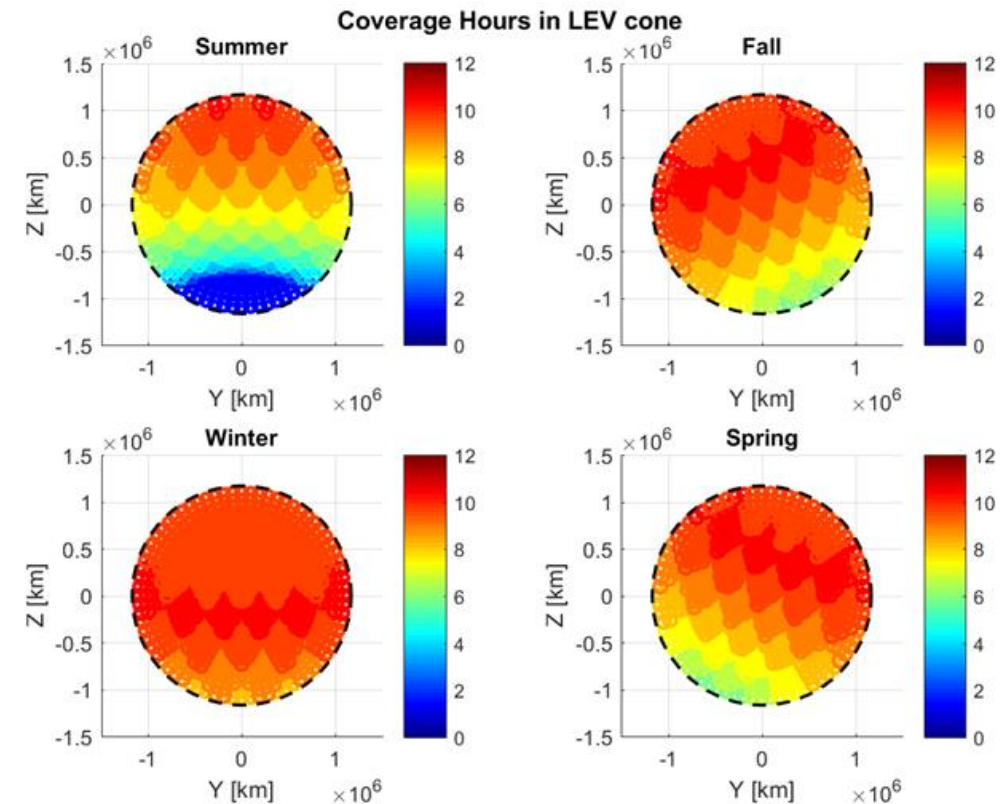
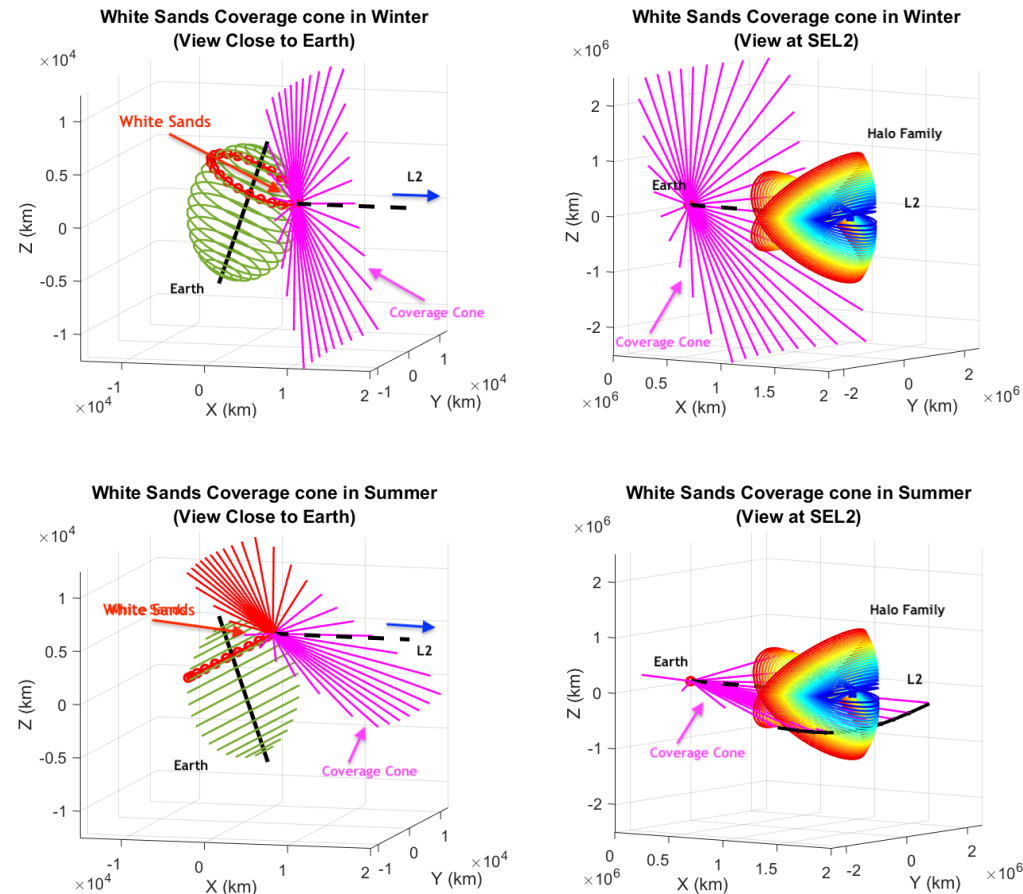




Roman Space Telescope (RST)



- The 7 hours of access time from White Sands Ground Station is the main driver of the mission orbit selection. The size of the orbit will also depend on the launch date.



- We performed scans for each synodic month to determine bounds for the Libration Orbit Insertion location

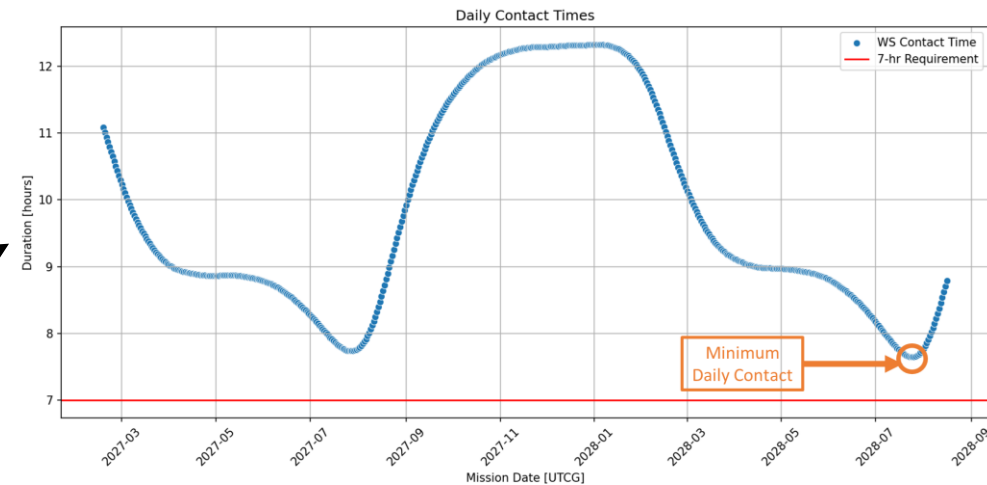
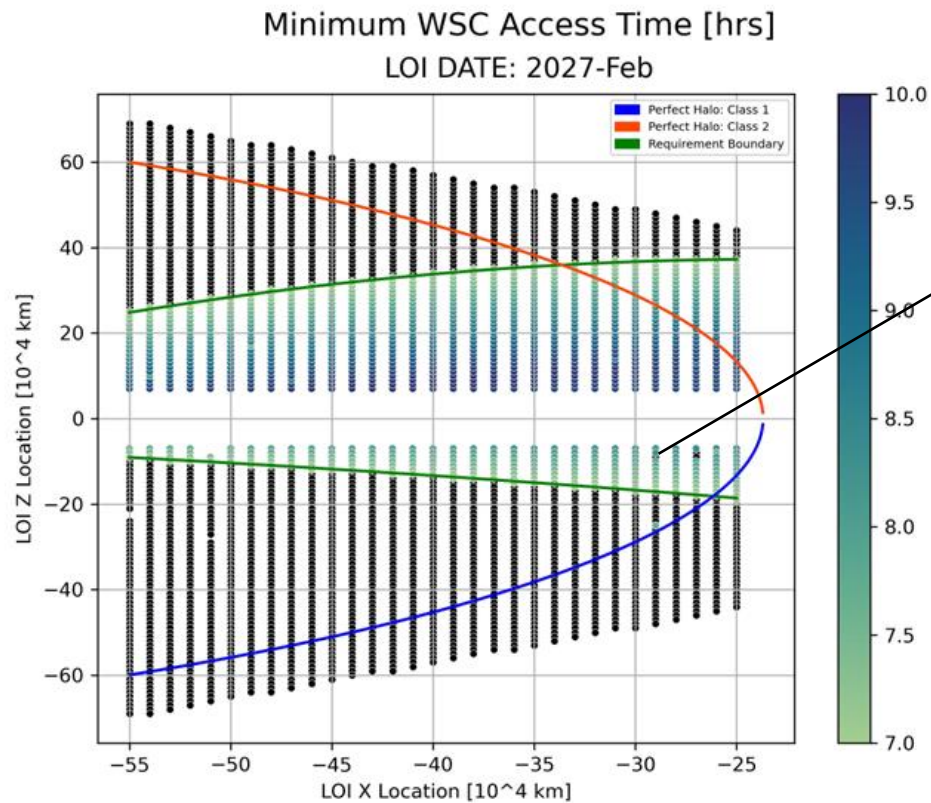
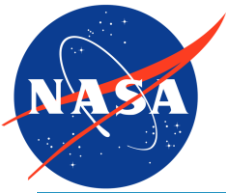


Table 1. Monthly Z Bounds for Class 1 and Class 2 Orbits

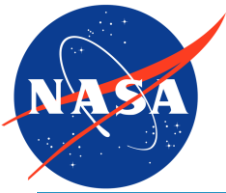
Launch Month	Class 1 Z bound	Class 2 Z bound	Launch Month	Class 1 Z bound	Class 2 Z bound
Jan.	-18×10^4 km	13×10^4 km	Jul.	-20×10^4 km	12×10^4 km
Feb.	-12×10^4 km	26×10^4 km	Aug.	0×10^4 km	15×10^4 km
Mar.	0×10^4 km	44×10^4 km	Sep.	-11×10^4 km	47×10^4 km
Apr.	-17×10^4 km	47×10^4 km	Oct.	-11×10^4 km	34×10^4 km
May	0×10^4 km	12×10^4 km	Nov.	-9×10^4 km	8×10^4 km
Jun.	-10×10^4 km	0×10^4 km	Dec.	-16×10^4 km	6×10^4 km



Conclusions



- We have seen that the strategies used to select the mission orbit are different depending on the mission requirements
- Both SWFO and RST searched a specific location in the SEL1/SEL2 vicinity to perform the insertion maneuver
- Translating the requirements into the CRTBP can help do rapid trades and use info on natural dynamics to plan transfer and insertion maneuvers



Questions ?



Thank you for your attention

