TFAWS
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Power and Propulsion Element Steerable High Gain Antenna Lunar Transit Thermal Analysis Tracking Methodology

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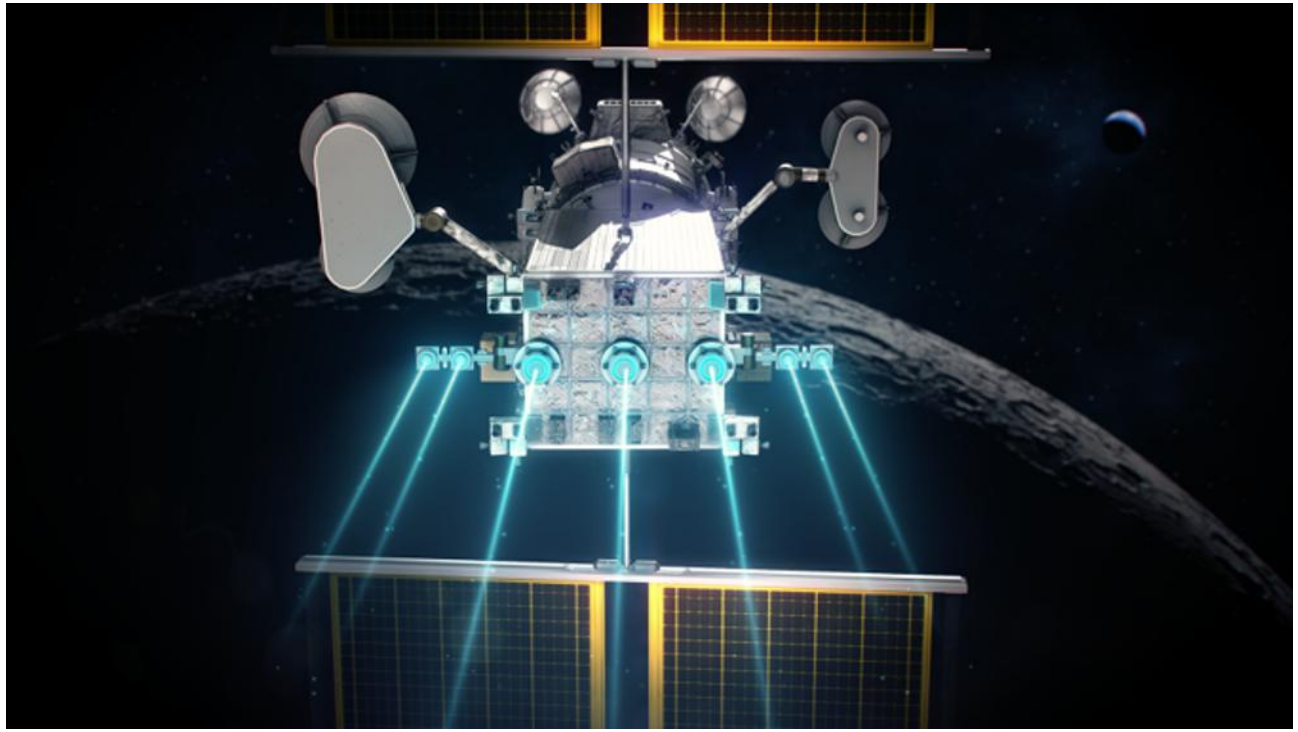
Background

- NASA has been developing the Power and Propulsion Element (PPE) as one of the first two elements of a Lunar Gateway space station.
- The spacecraft coupled with the Habitation and Logistics Outpost (HALO) was to fly an approximately one-year electric orbit raising (EOR) spiral Earth phase prior to orbiting the Moon.
- Communication for the spacecraft utilized 2 sets of Steerable High Gain Antennas (SHGAs) that allowed multi-axis rotation control for pointing.

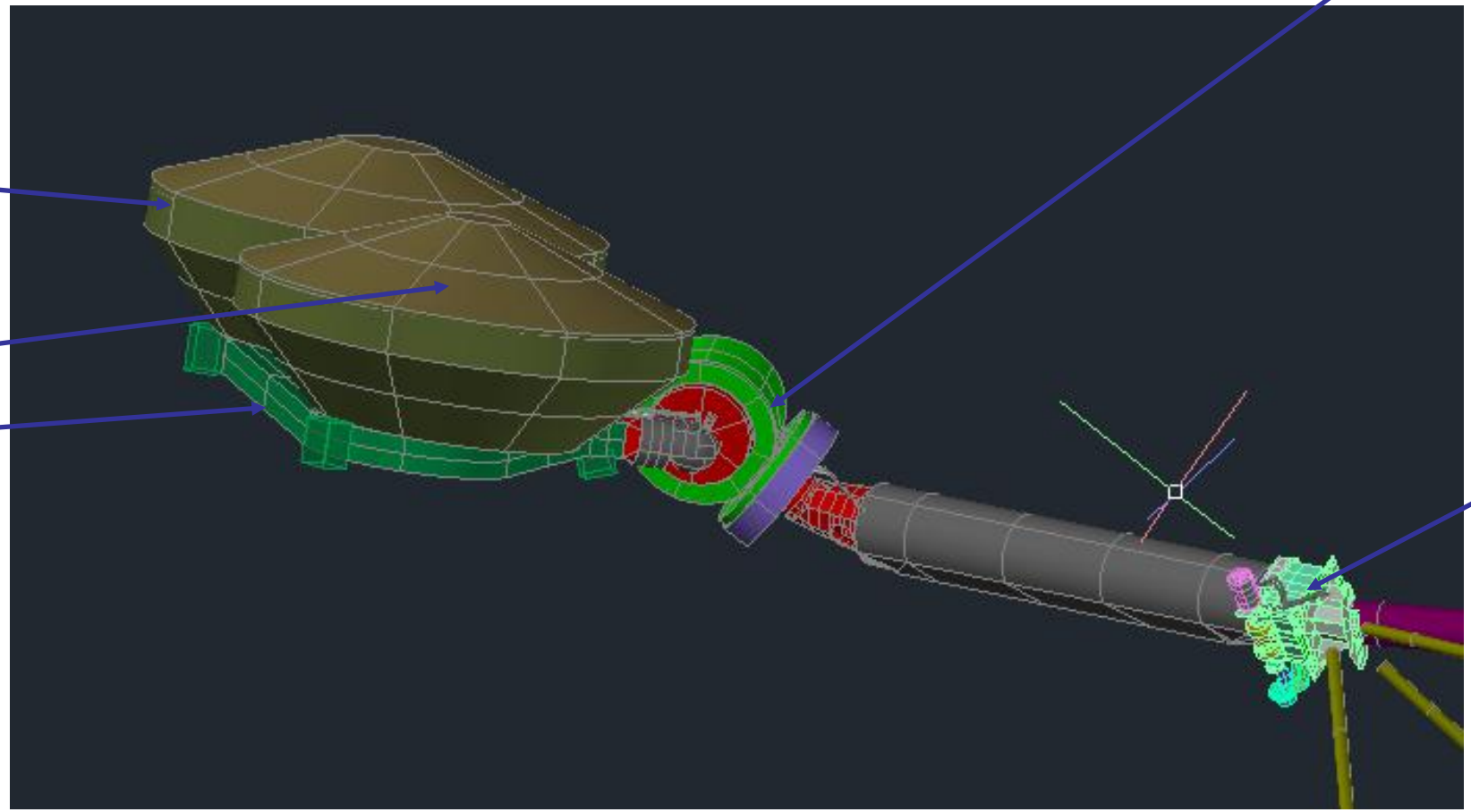


"Gateway Full Configuration." *NASA*, National Aeronautics and Space Administration, 2022, https://www.nasa.gov/missions/artemis/gateway/a-powerhouse-in-deep-space-gateways-power-and-propulsion-element/

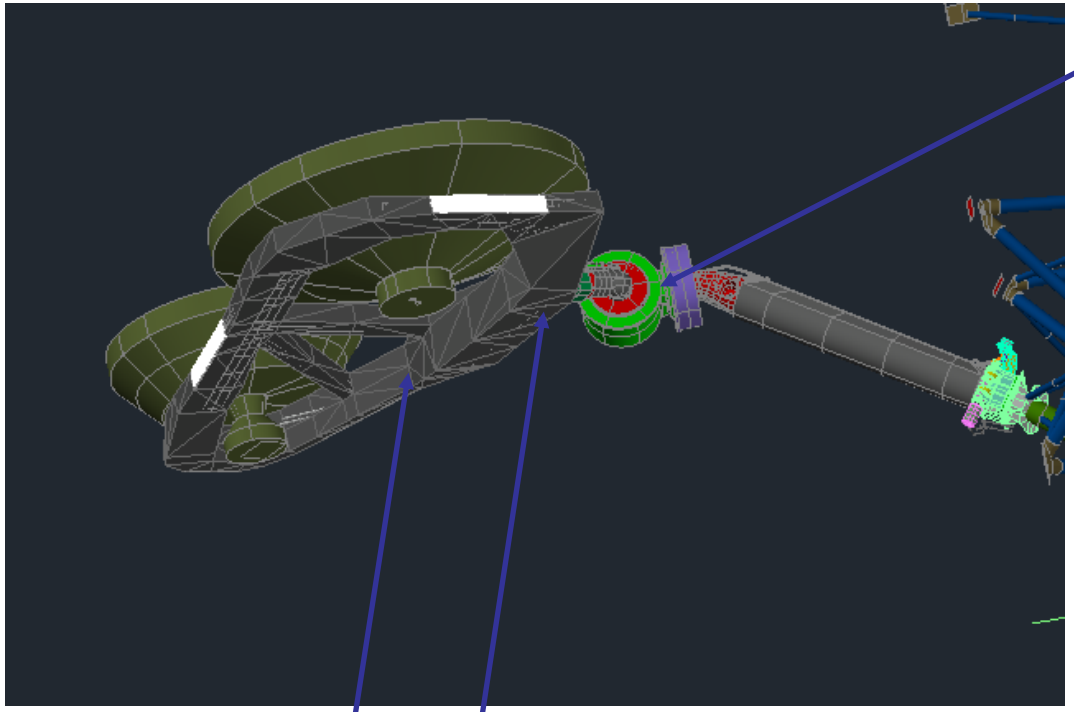
Background - Continued

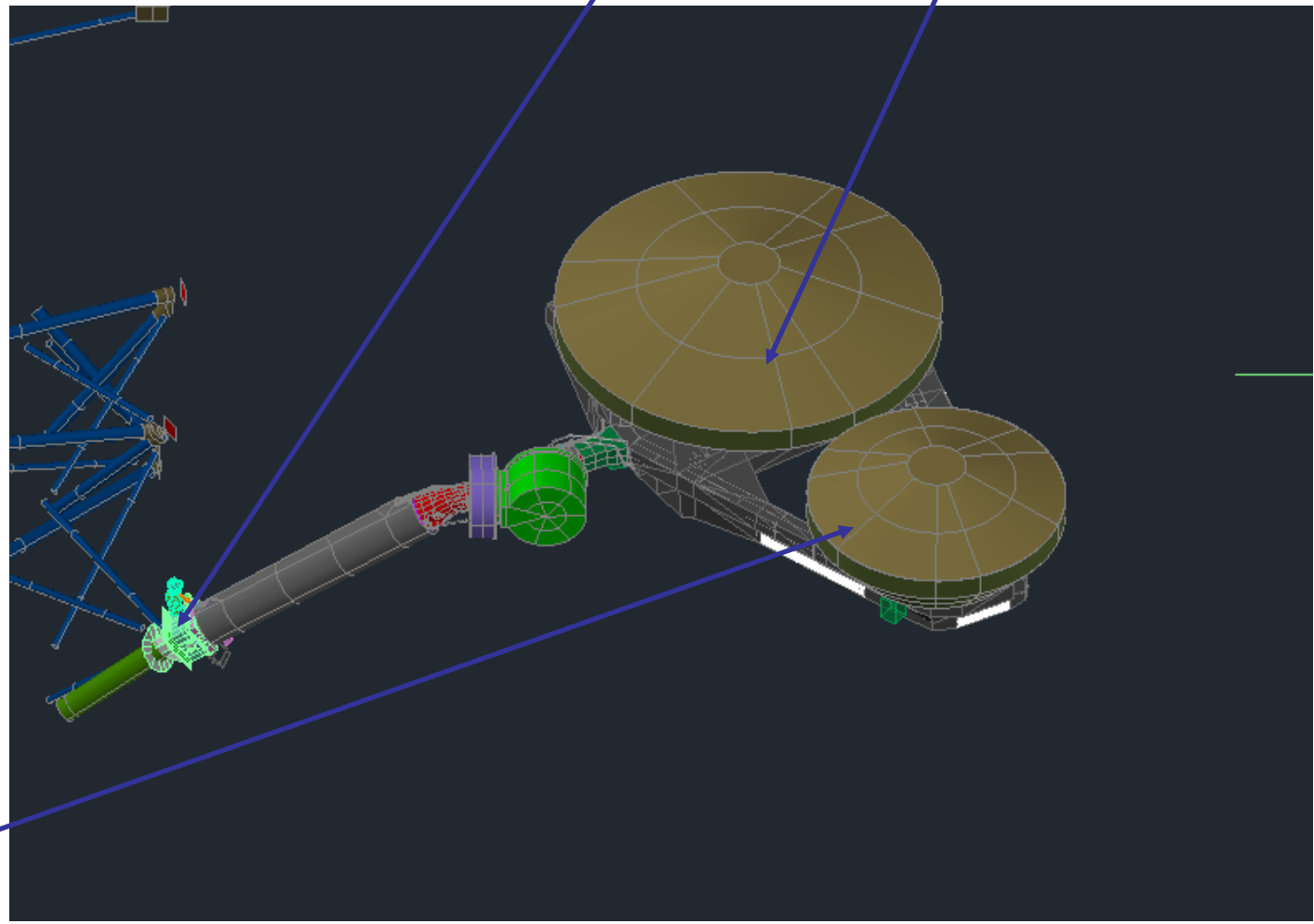
- Thermal control system constraints for communication concept of operations (ConOps) requires accurate celestial body rotations to account for position sensitive radiative heat transfer.
- As of April-2026, PPE has been reutilized to be an element of Space Reactor-1 Freedom (SR-1), the work presented in this presentation was completed prior to the program change.

SHGA Direct to Earth (DTE), +Y S/C Side



SHGA Direct to Earth (DTE)/Lunar, -Y S/C Side





Two Axis Gimbal (TAG) Assembly

Hinge Assembly

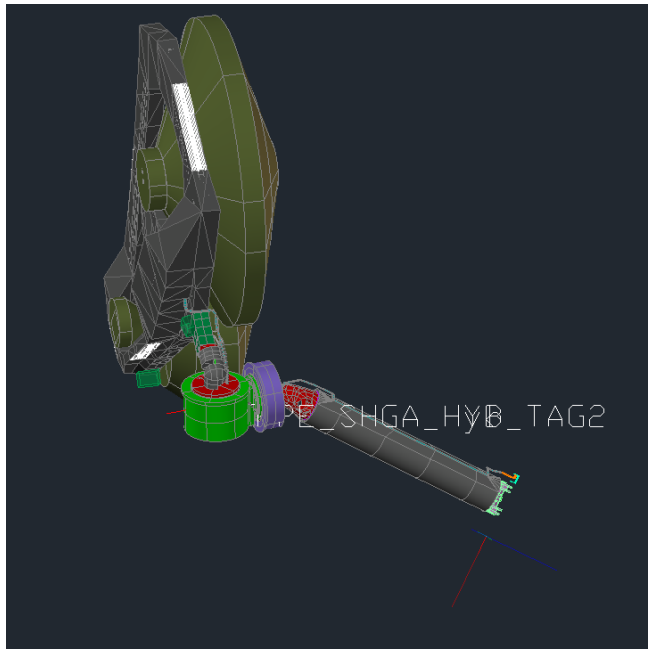
Ka-Band Hybrid

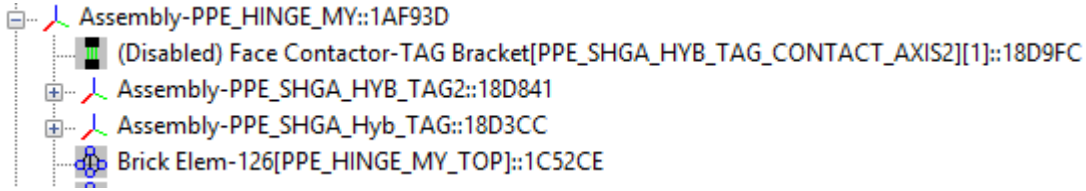
Radiator Pallet

Radio Frequency (RF) Unit, Blanketed

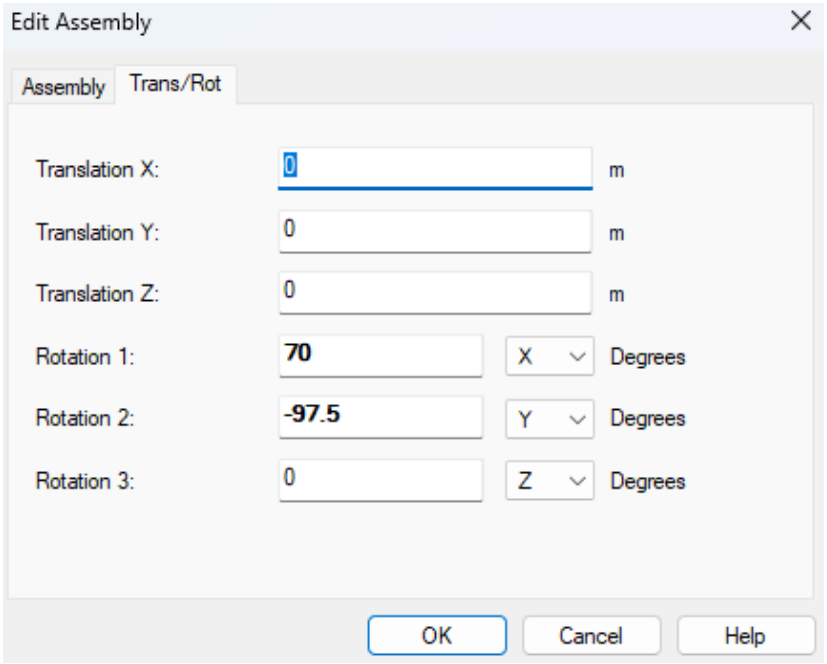
X-Band Hybrid

Original Model Methodology





Model Browser Tree for Assembly Parent/Child Relationship

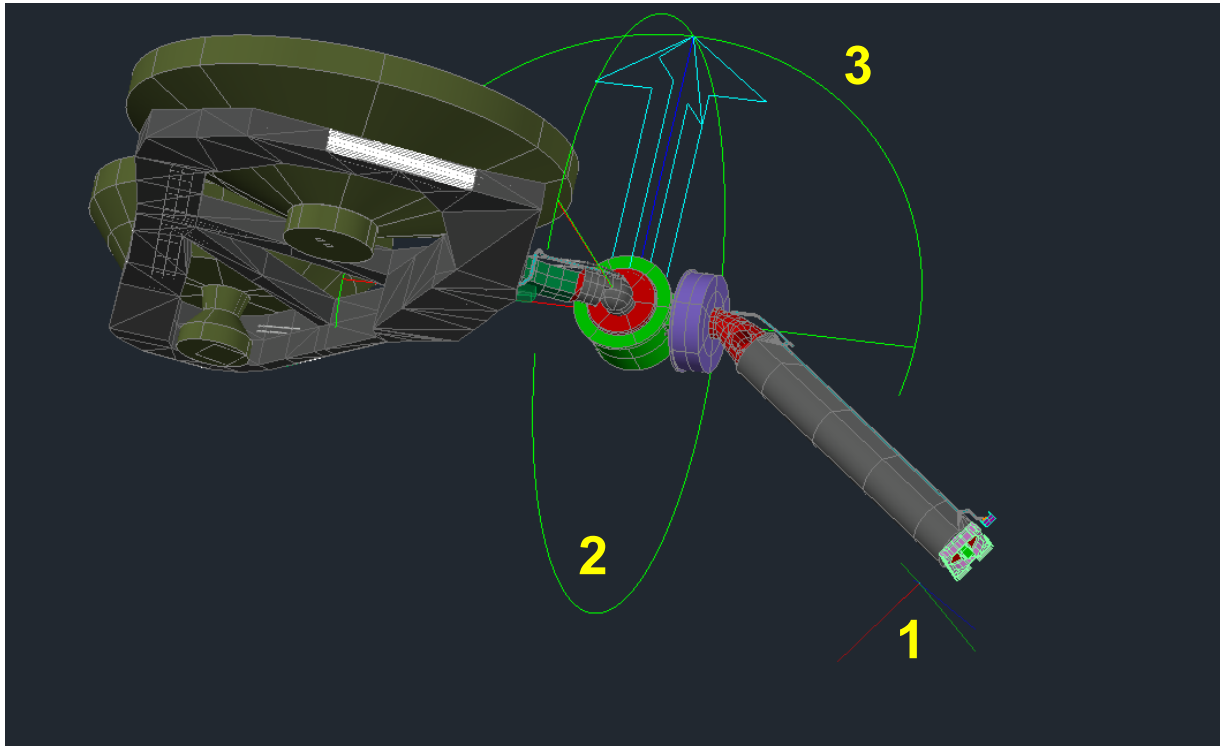


Assembly Articulator Edit Dialog for PPE_SHGA_HYB_TAG2

- Assembly – PPE_HINGE_MY – Controls deployment of the antenna.
- Assembly – PPE_SHGA_HYB_TAG2 – Controls antenna hardware for two axis rotations outside of the TAG.
- Assembly – PPE_SHGA_Hyb_TAG – Controls single axis rotation of the TAG hardware.

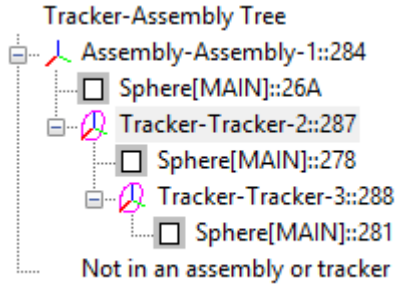
Does not allow for exact pointing.

New Model Methodology



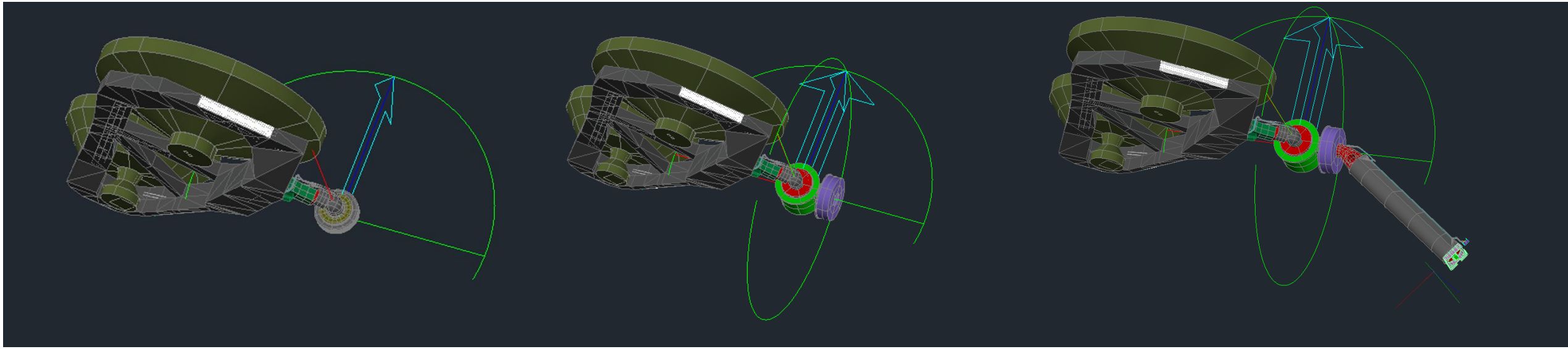
- Trackers only allow for single axis pointing, so 3 articulators are needed.
- Surfaces/Solids may only be attached to one articulator at a time.

- 1 – An assembly articulator that controls all hardware to deploy, is parent to everything.
- 2 – A tracker that is nested in 1 and rotates all hardware past the boom on the first axis.
- 3 – Since this is nested within 2, when 2 rotates it also rotates all attached objects. The rotation on this tracker rotates the objects for the second axis.



Example Model Browser Tree of Nesting Articulators

New Model Methodology - Continued

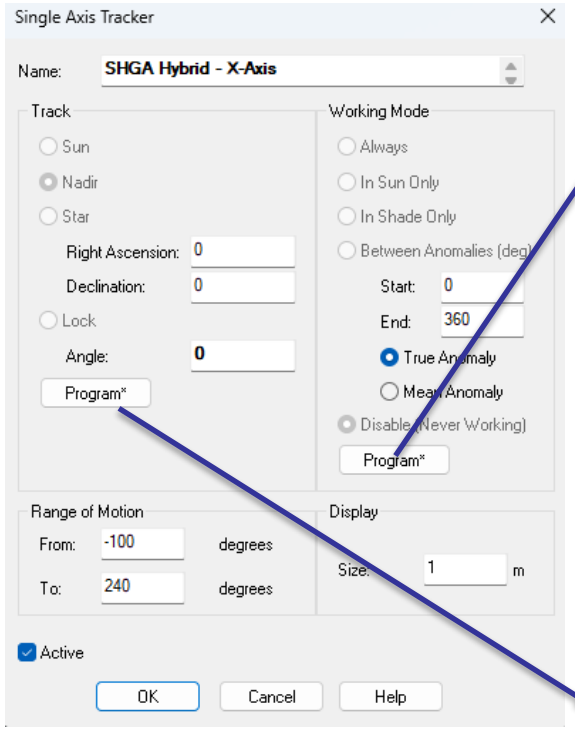


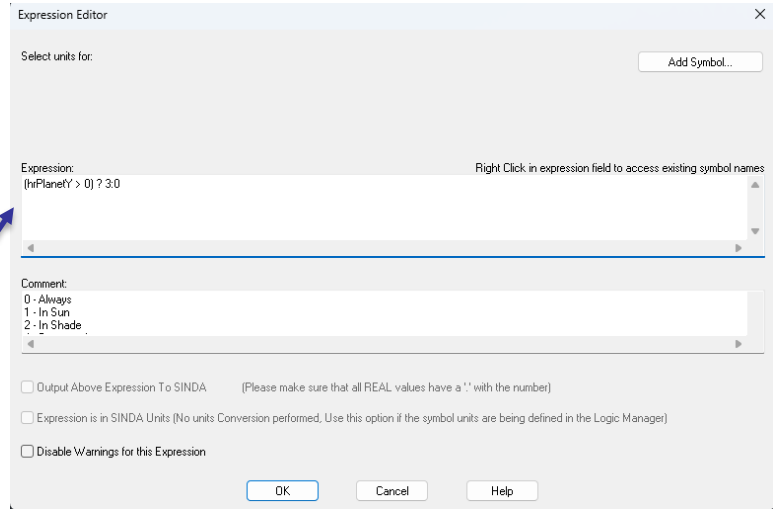
1. Surface/Solids shown are attached to one tracker and will track on 2-axis and rotate for deployment.

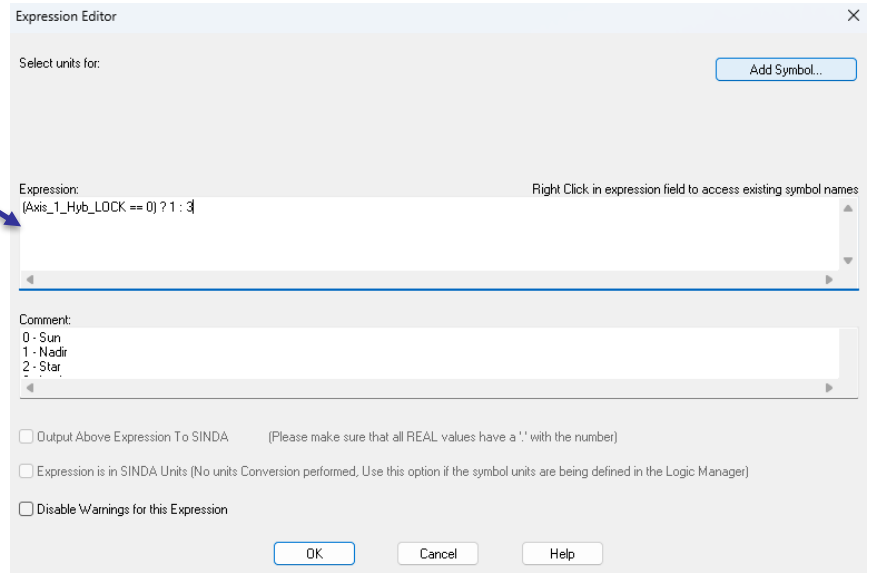
2. A new tracker is added in which the tracker from the previous step is attached. Additional Surface/Solids that will only rotate on one axis are also attached to the new tracker. Components at this step also rotate for deployment.

3. An assembly articulator is inserted where the tracker added in step 2 is attached. Lastly Surface/Solids that will only rotate for deployment but not track are attached to this assembly articulator.

New Model Methodology - Continued



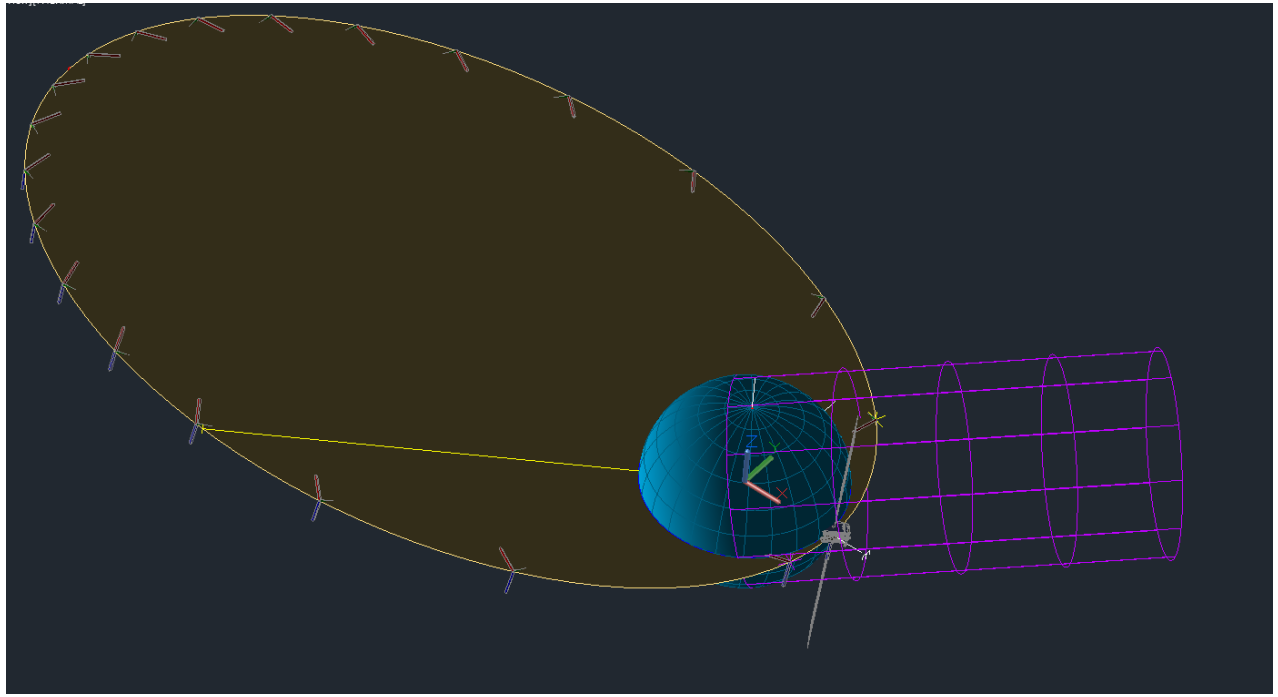




- Thermal Desktop generates system variables hrPlanetX, Y, and Z.
- Depending on what side of the vehicle was facing the Earth determines if the “working mode” is active or not, if not active the antenna does not track and returns to a default position.
- To maintain the ability to manual set rotation position, a SINDA symbol was added to lock the axis.
- The range of motion depends on the TAG hardware limits.

Test Orbit

- A test orbit was simulated to verify the model logic responded as intended in different positions.
- Antenna tracking successfully turned off when solar vector from spacecraft is opposite to DTE/Hybrid, -Y/+Y respectively.
  - Antenna returned to a nominal parked position.



PPE in a Multi-Position Test Orbit Around Earth

Allows for exact pointing.

Conclusion

- The PPE SHGA thermal model generated in Thermal Desktop was successfully modified to switch from exact rotation angles to accurate Earth nadir pointing for the EOR mission phase.
- Additional symbols were added to maintain baseline functionality.
- The new model was used to proceed with EOR thermal analysis.

Questions

Thank you for your attention!

Acknowledgements

- Analysis software used was Thermal Desktop, Version 6.3 published and developed by Ansys.
- The original thermal model was generated by Intuitive Machines formerly known as Maxar.