



Designing a Software Architecture for the Precision Assembly of Space Structures

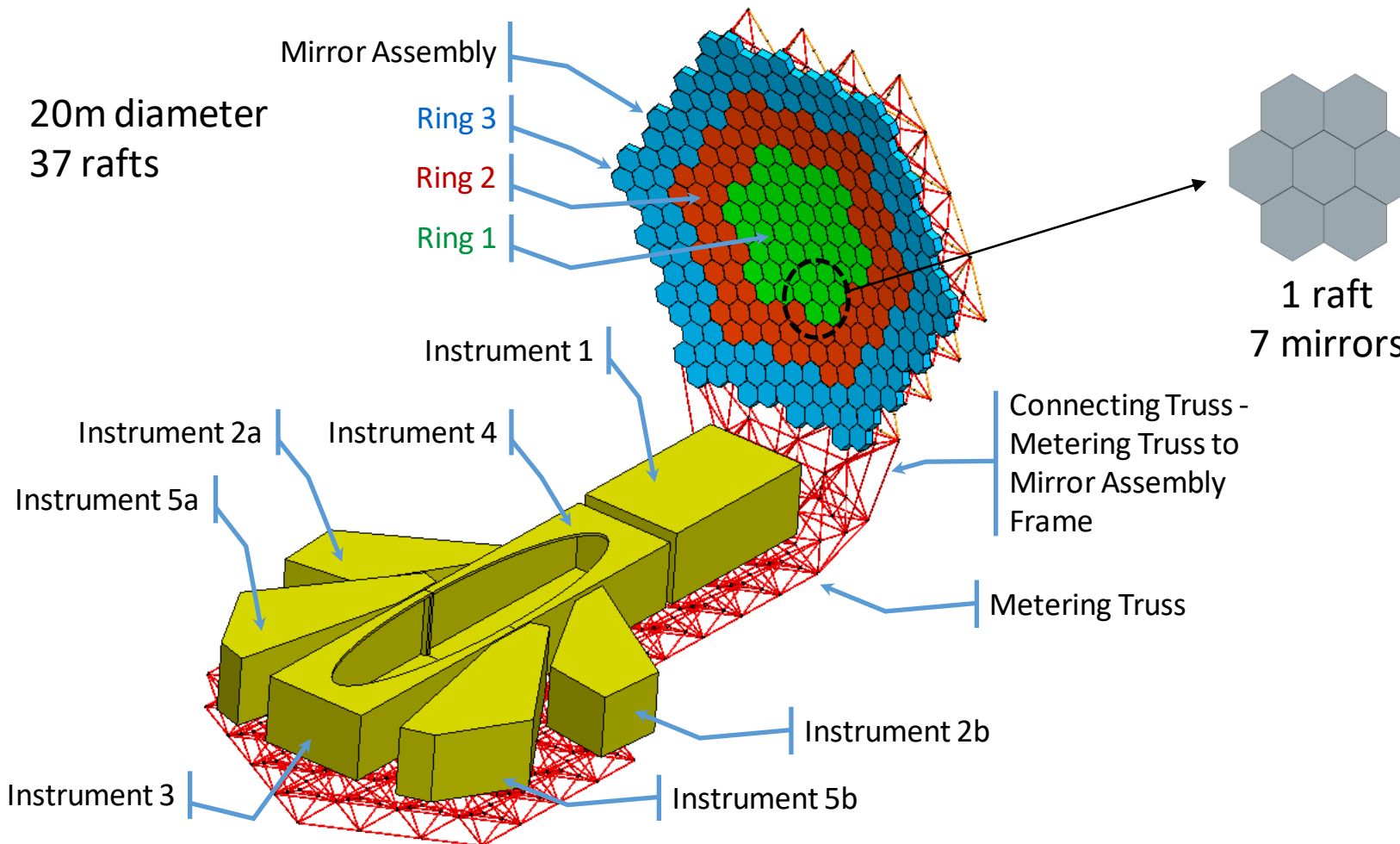
Benjamin N. Kelley, John R. Cooper, Javier Puig Navarro,
Matthew P. Vaughan, Walter J. Waltz, B. Danette Allen, and William R. Doggett

NASA Langley Research Center, Hampton, VA, 23681, USA

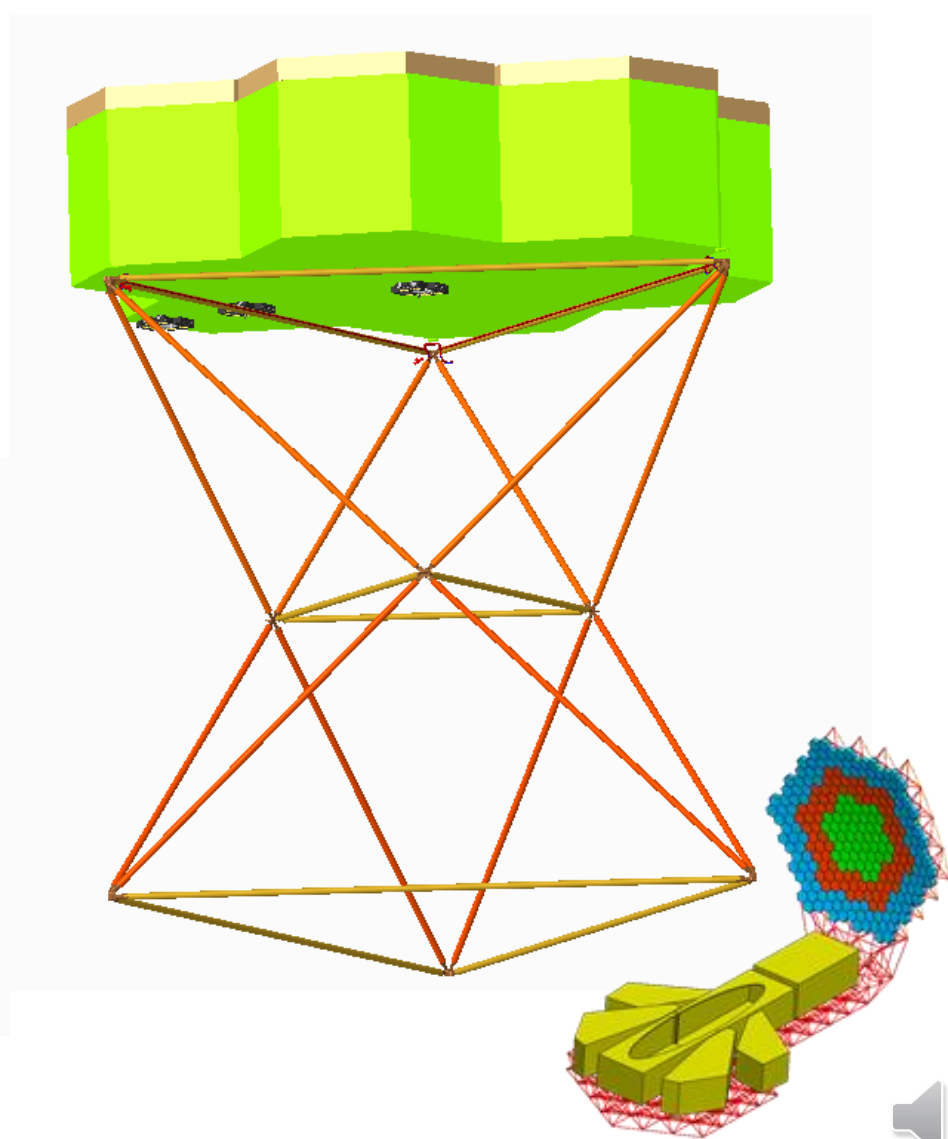
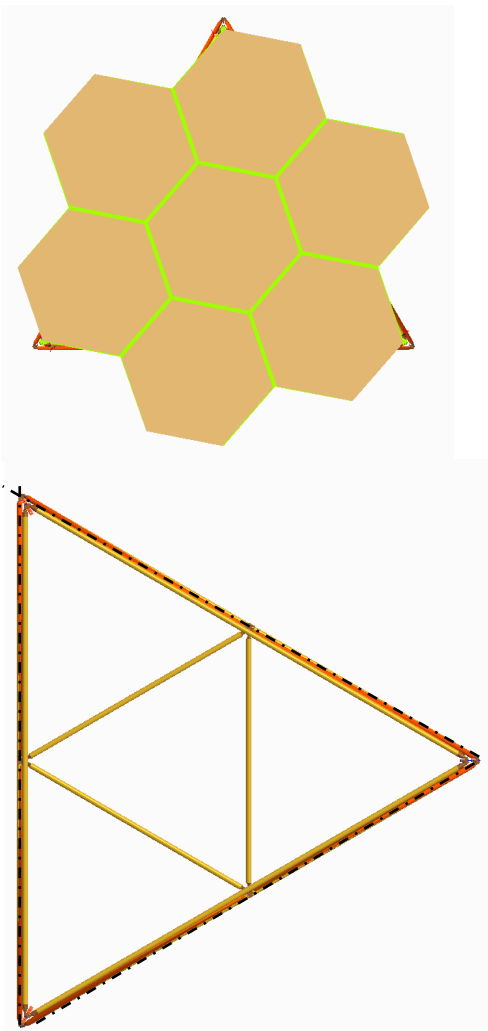
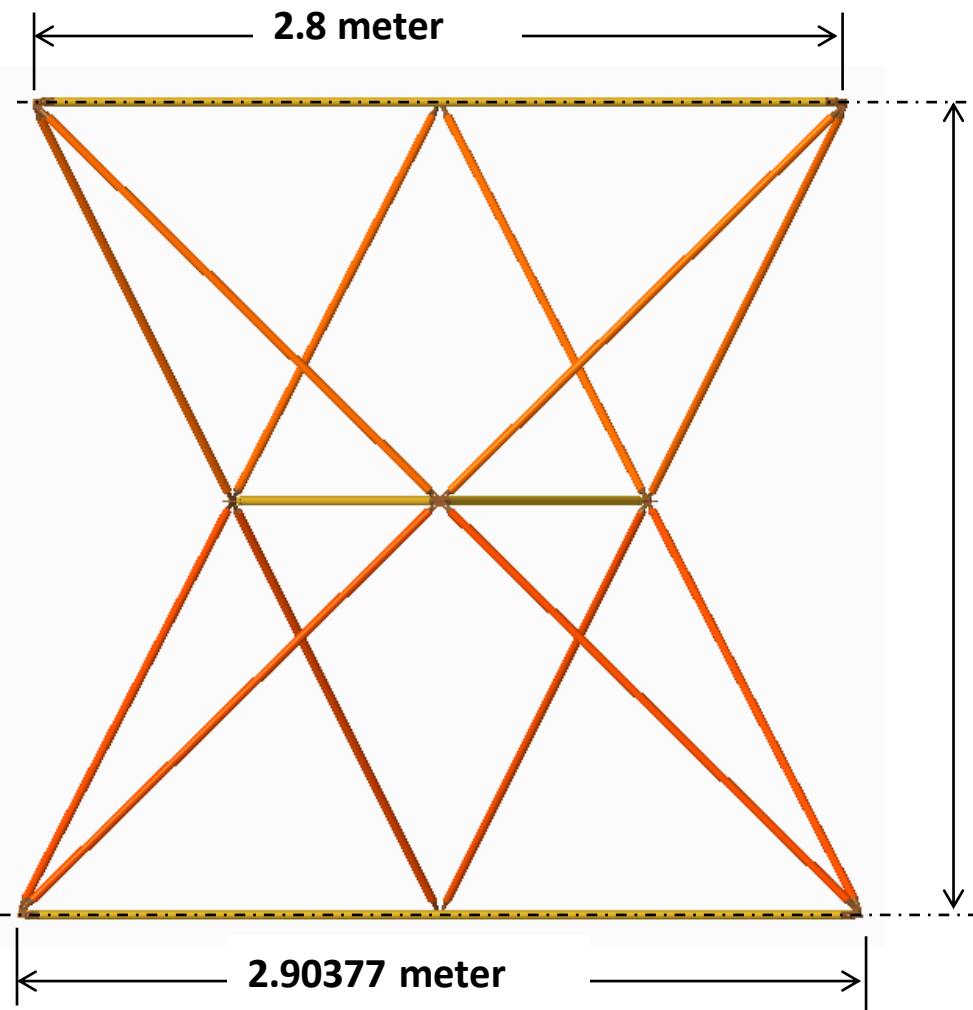
Thea V. Avila, A. Kyle McQuarry, Andrew Miloslavsky,
Sherif A. Shazly, Robert M. Slick, and Ralph A. Williams

Analytical Mechanics Associates Inc., Hampton, VA, 23666, USA

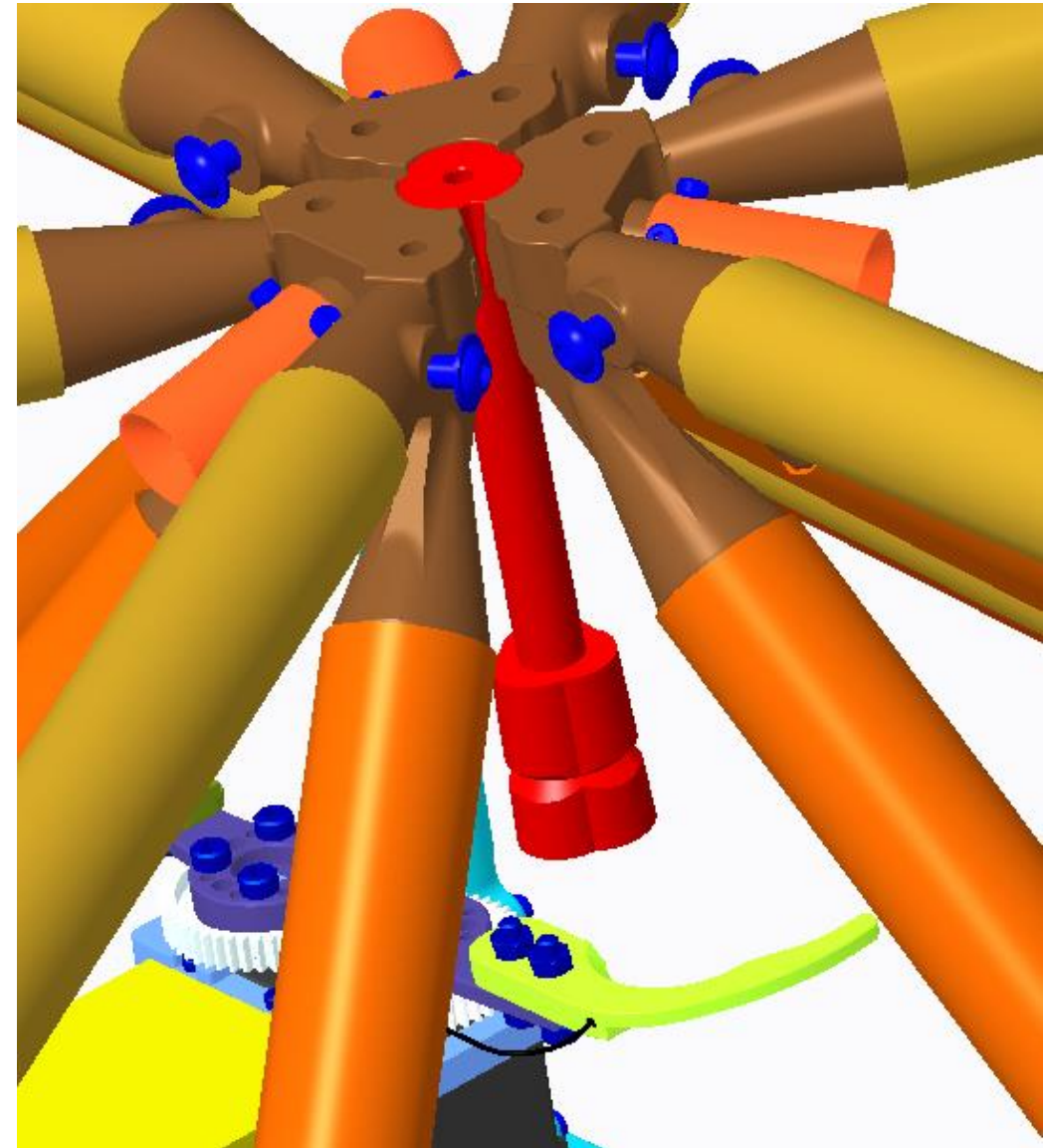
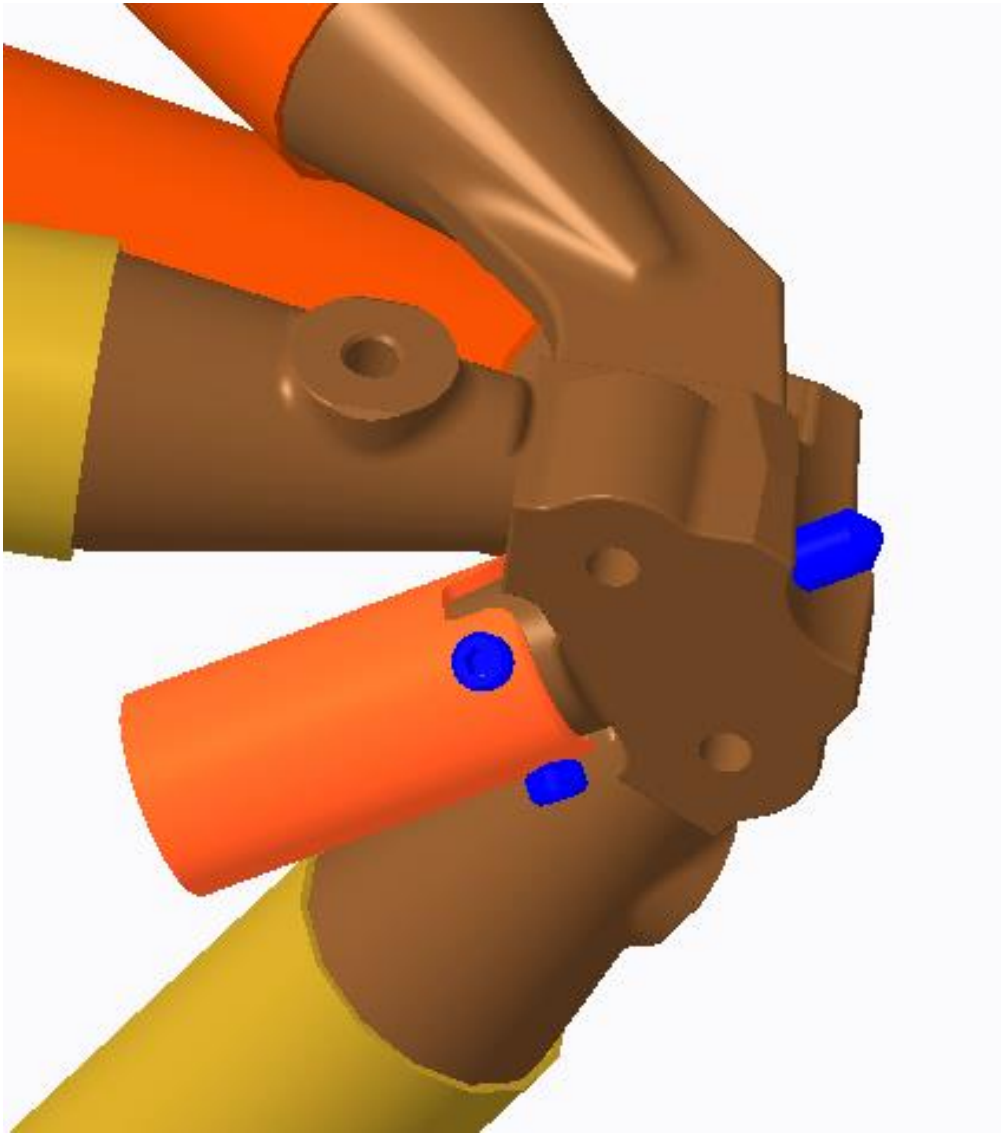
iSAT 20m class Instrument



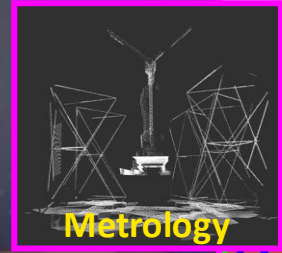
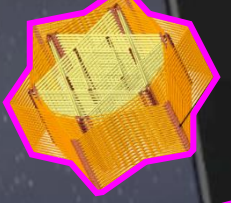
Tri-Truss



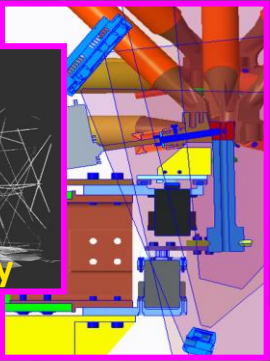
Tri-Truss Connection



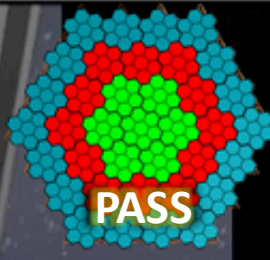
Truss Deployment



Metrology

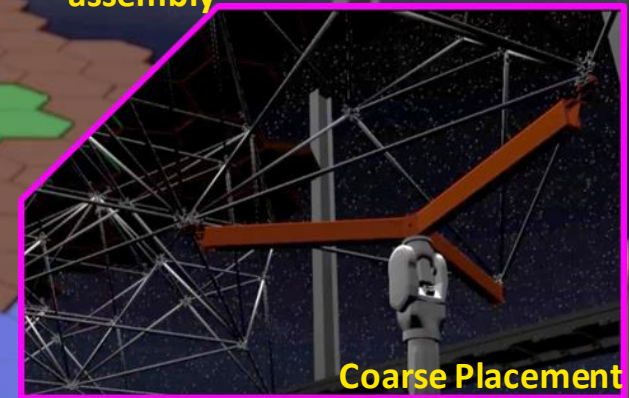


Fine Placement and assembly

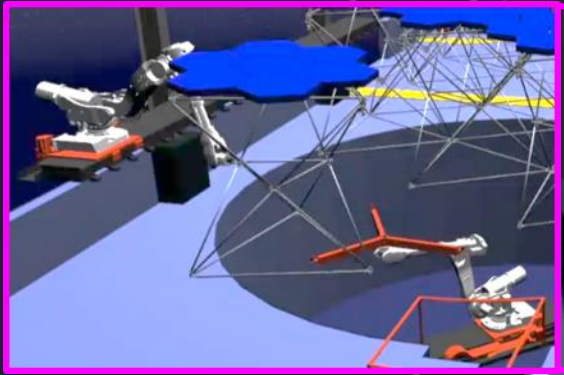


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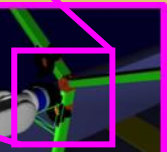
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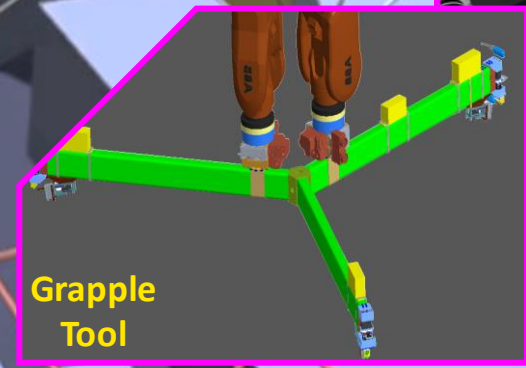
Coarse Placement



Collaborative handoff to Coarse Placement Agent



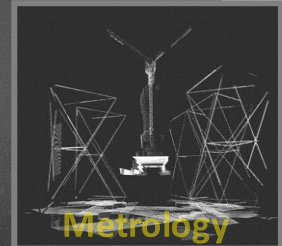
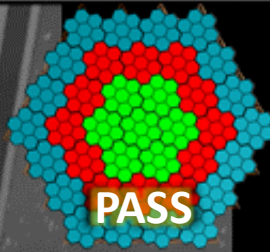
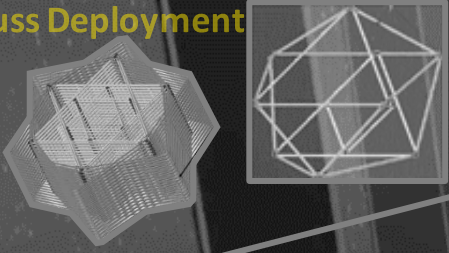
Quick Change



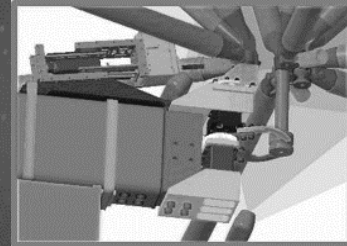
Grapple Tool



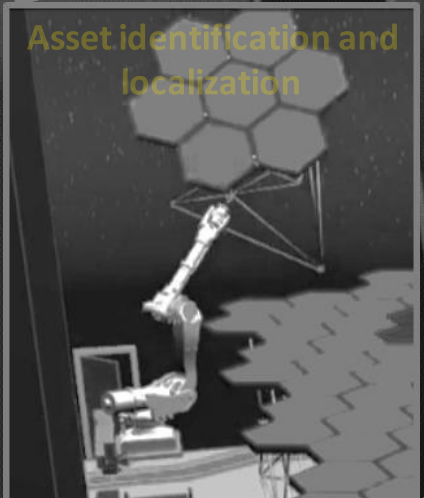
Truss Deployment



Metrology



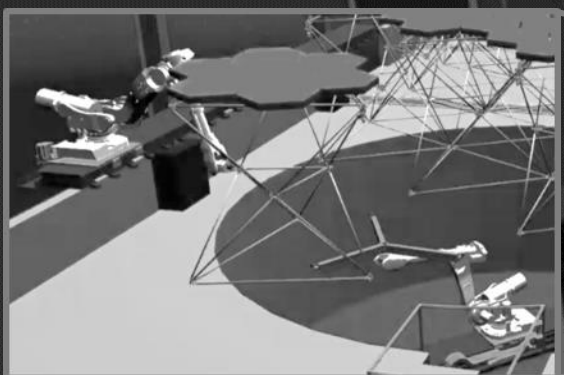
Fine Placement and assembly



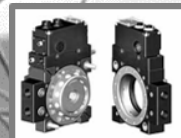
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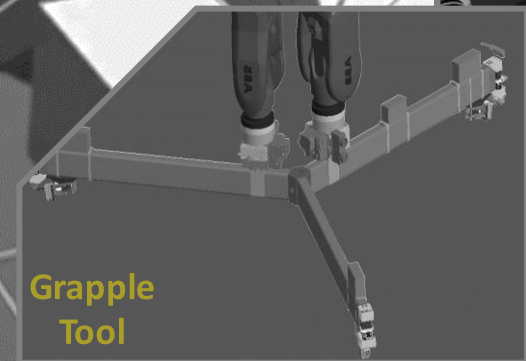
Coarse Placement



Collaborative handoff to Course Placement Agent

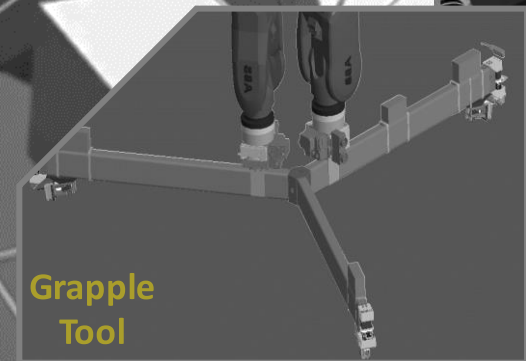
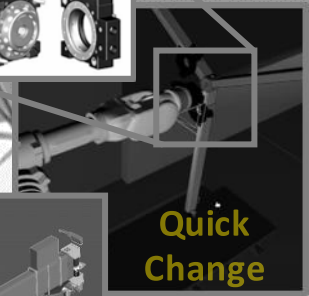
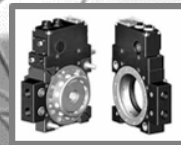
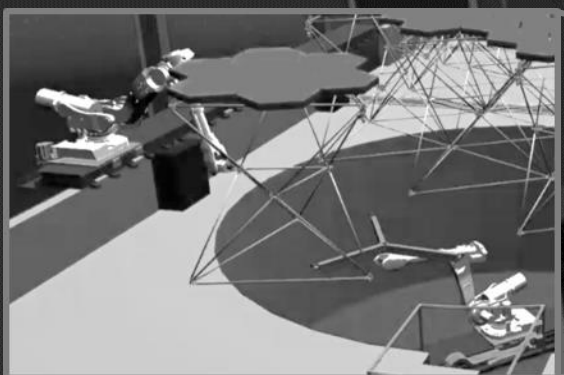
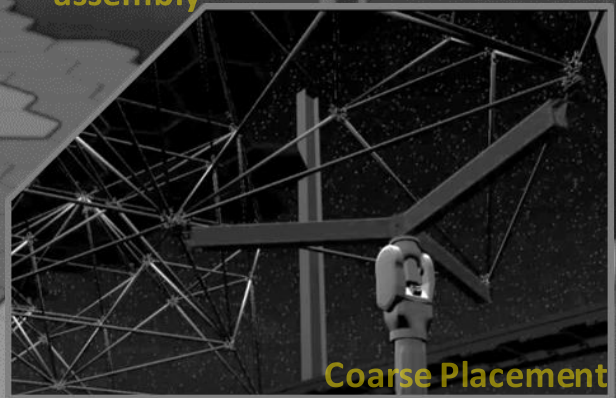
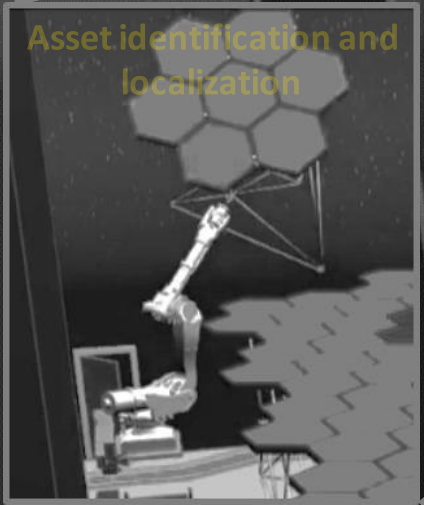
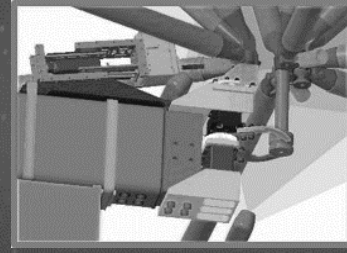
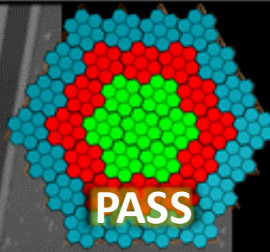
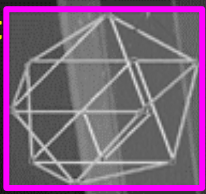
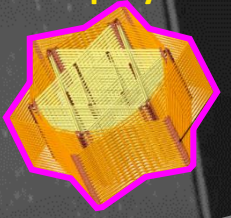


Quick Change

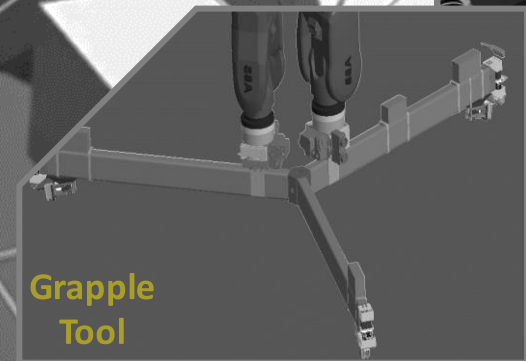
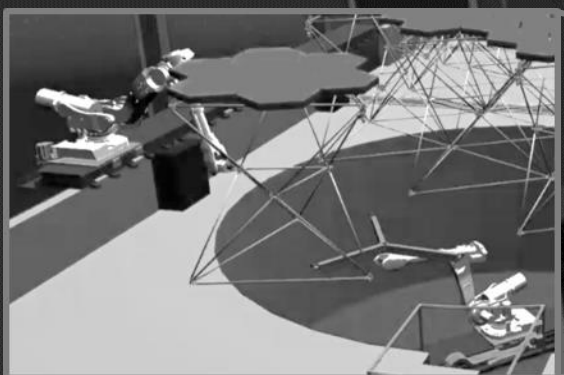
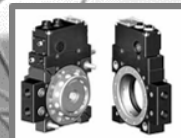
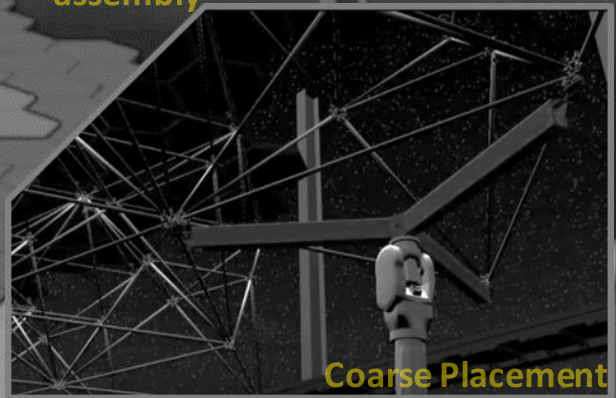
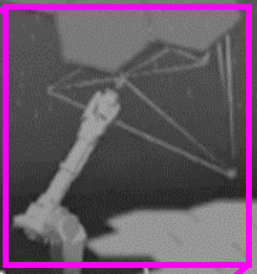
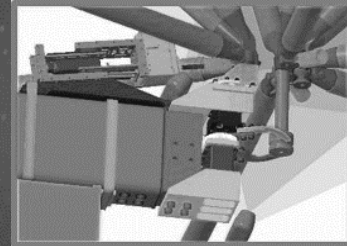
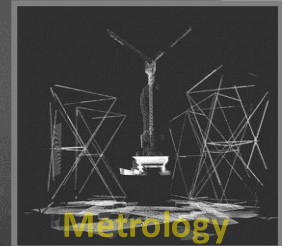
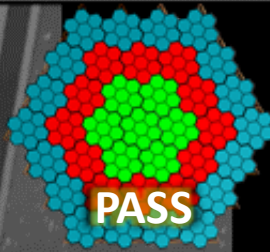
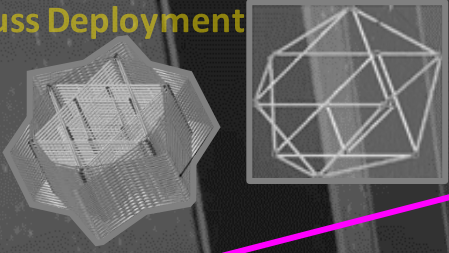


Grapple Tool

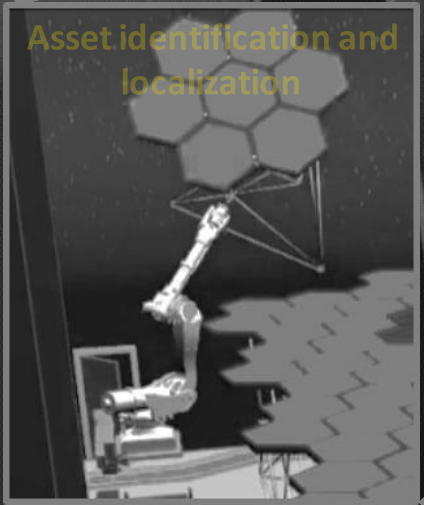
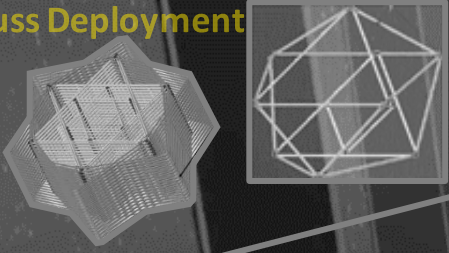
Truss Deployment



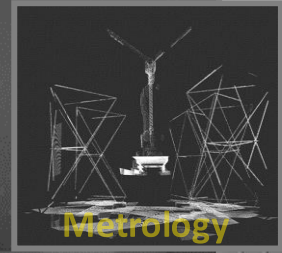
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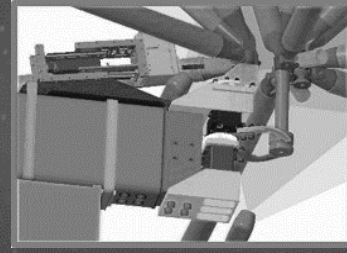
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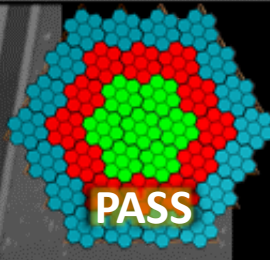
Asset identification and localization



Metrology



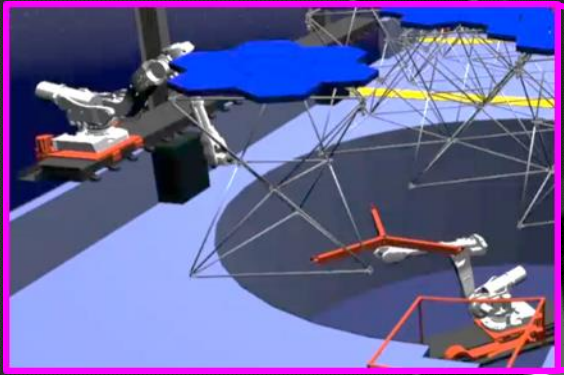
Fine Placement and assembly



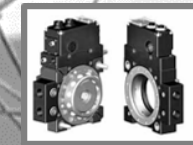
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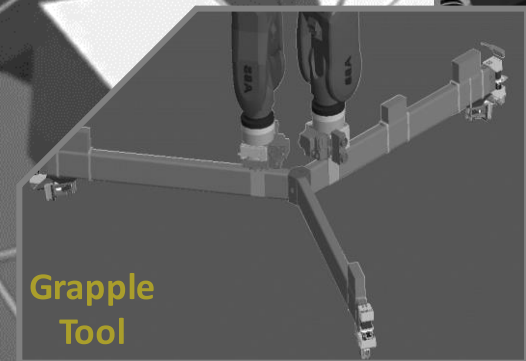
Coarse Placement



Collaborative handoff to Course Placement Agent



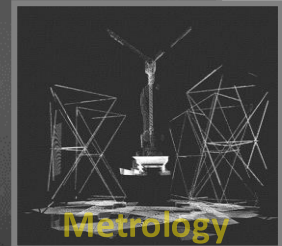
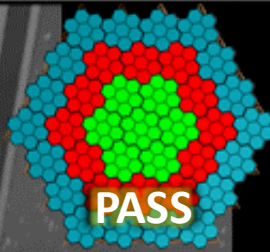
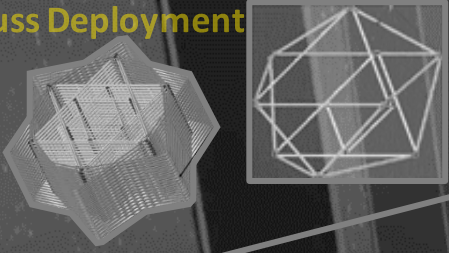
Quick Change



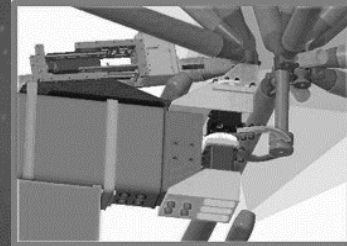
Grapple Tool



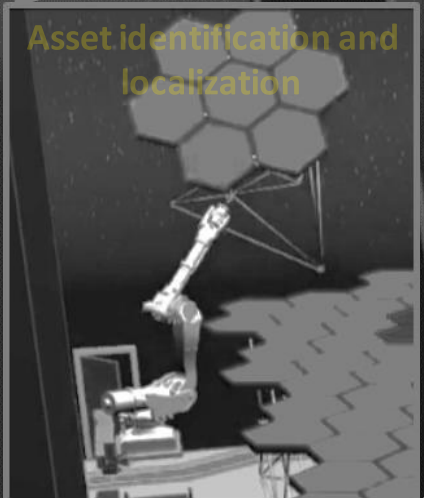
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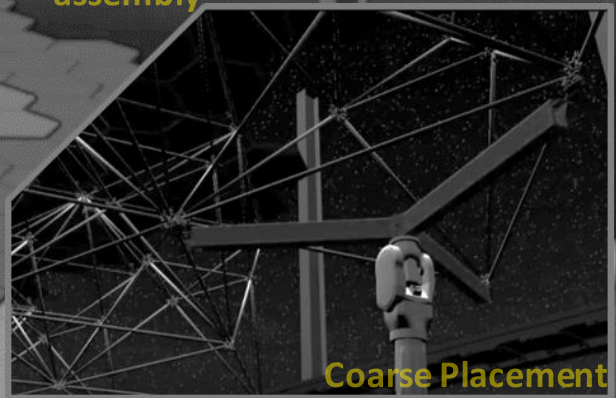
Metrology



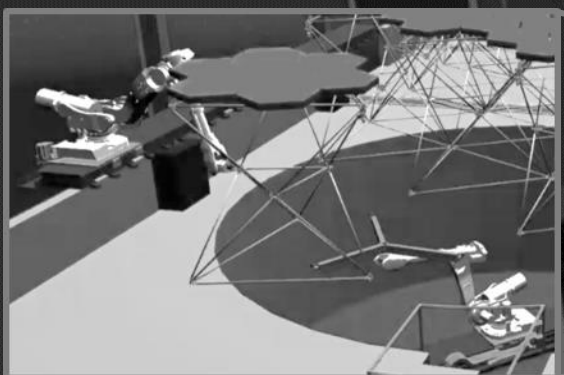
Fine Placement and assembly



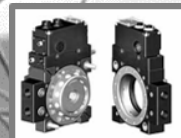
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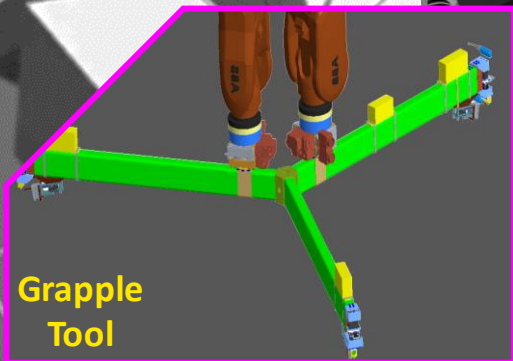
Coarse Placement



Collaborative handoff to Course Placement Agent



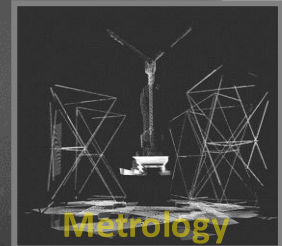
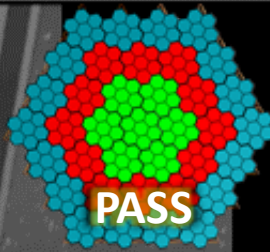
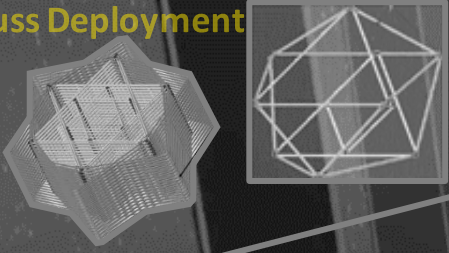
Quick Change



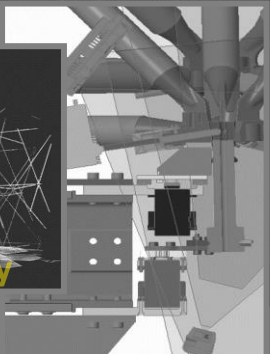
Grapple Tool



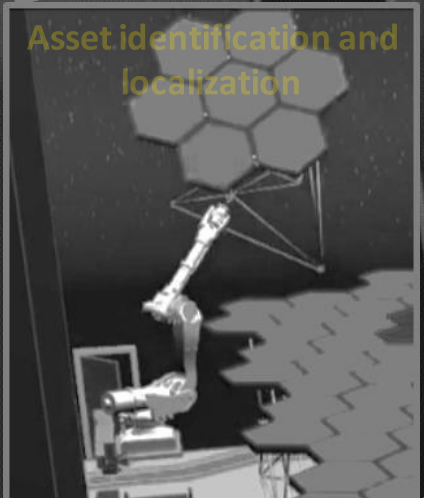
Truss Deployment



Metrology



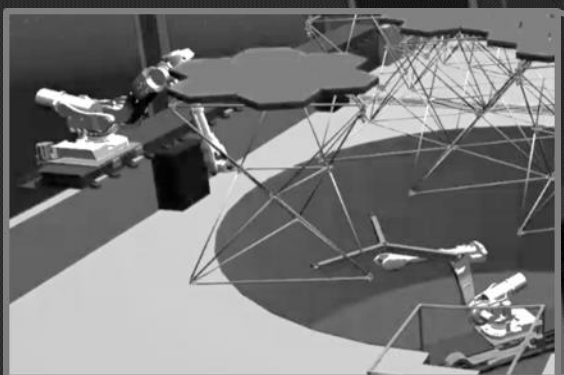
Fine Placement and assembly



Asset identification and localization



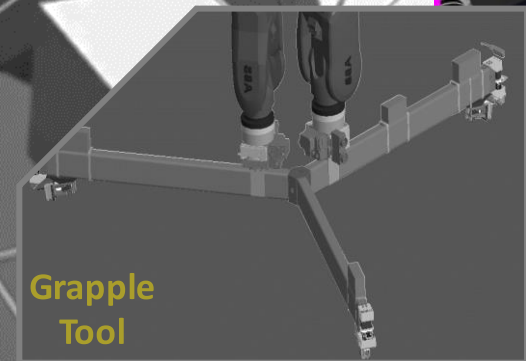
Coarse Placement



Collaborative handoff to Course Placement Agent



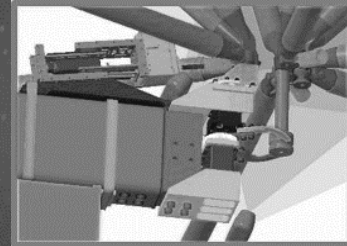
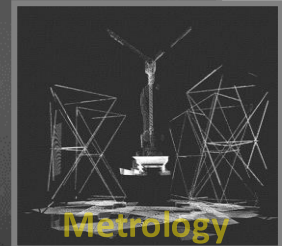
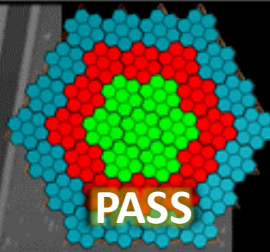
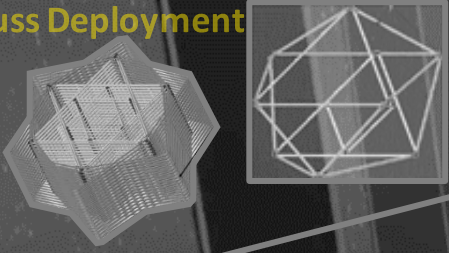
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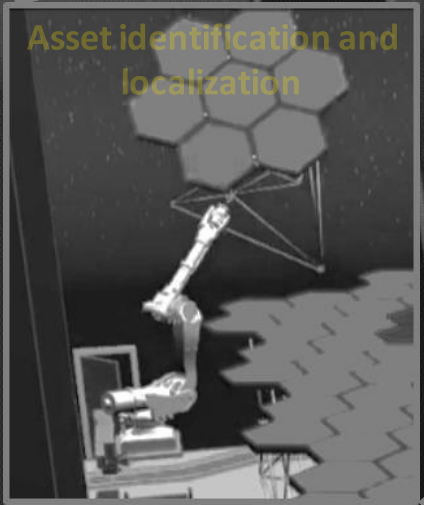
Grapple Tool



Truss Deployment



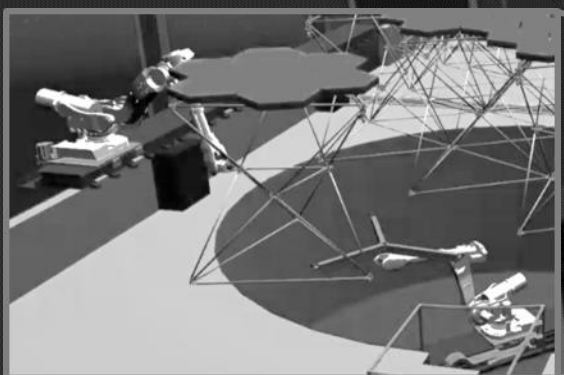
Fine Placement and assembly



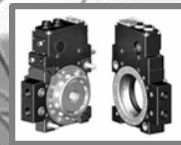
Asset identification and localization



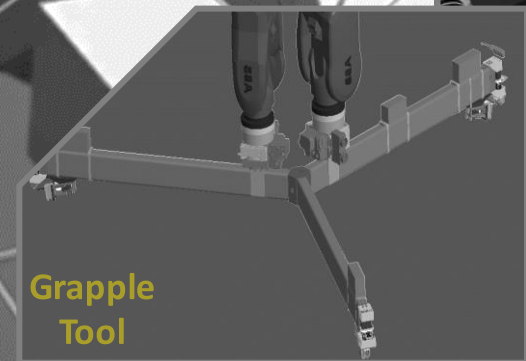
Coarse Placement



Collaborative handoff to Coarse Placement Agent

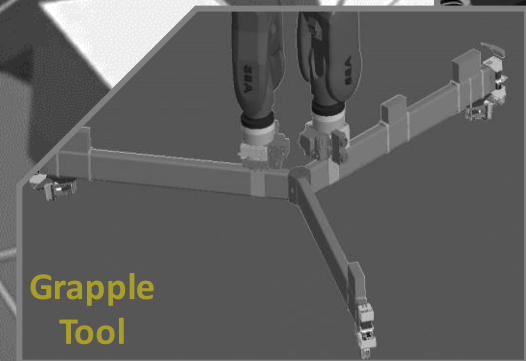
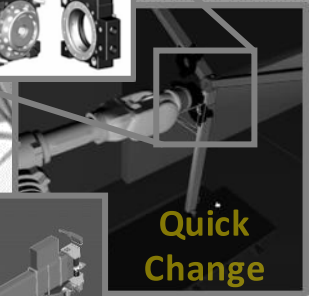
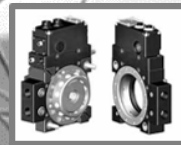
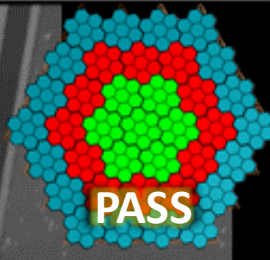
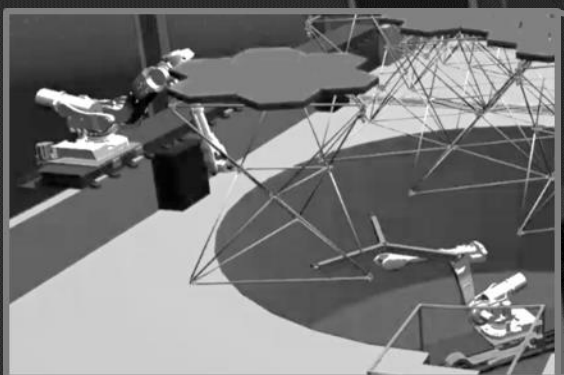
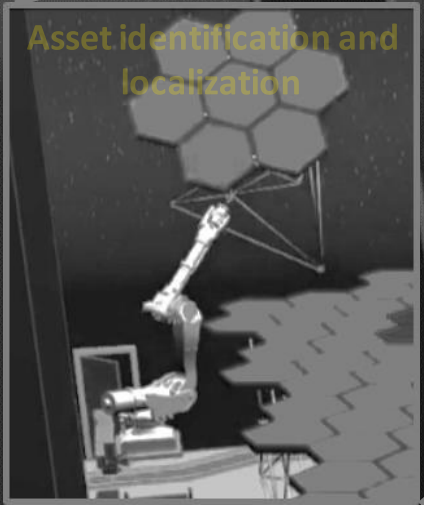
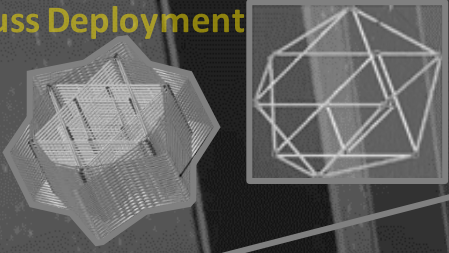


Quick Change

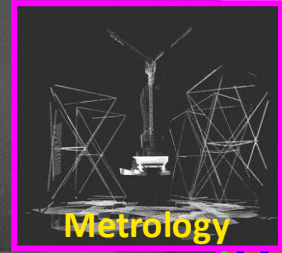
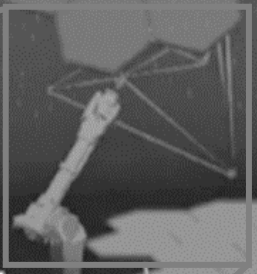
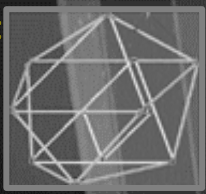
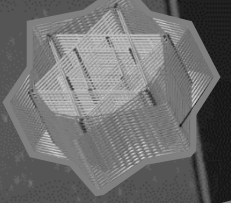


Grapple Tool

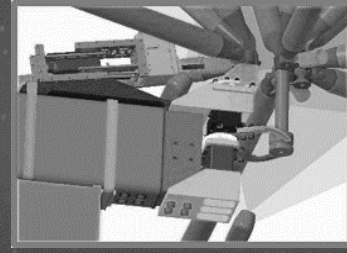
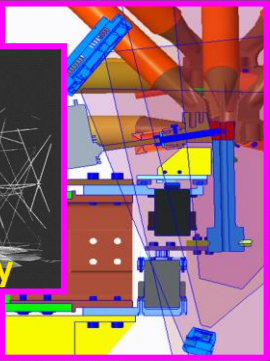
Truss Deployment



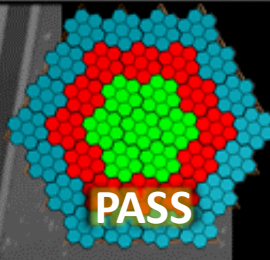
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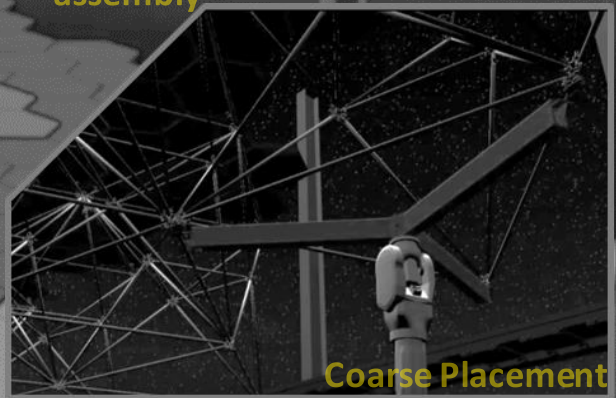
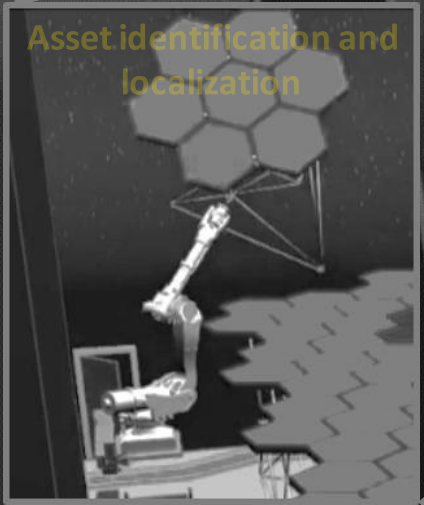
Metrology



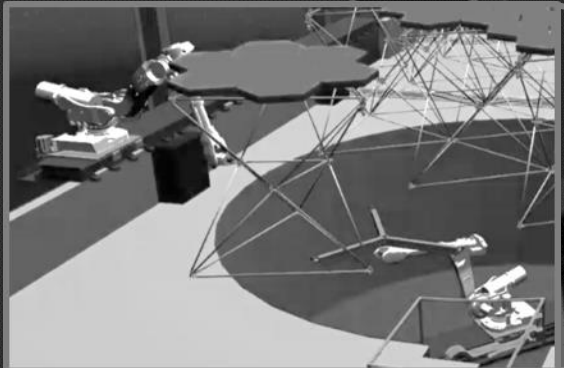
Fine Placement and assembly



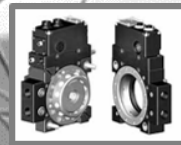
Asset identification and localization



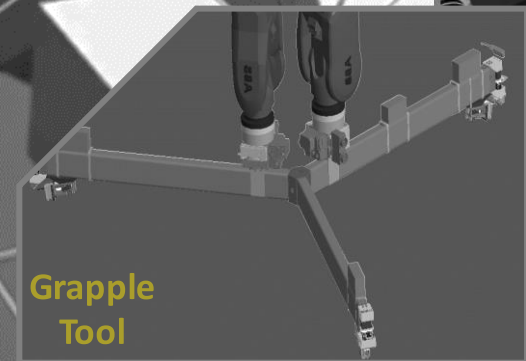
Coarse Placement



Collaborative handoff to Course Placement Agent

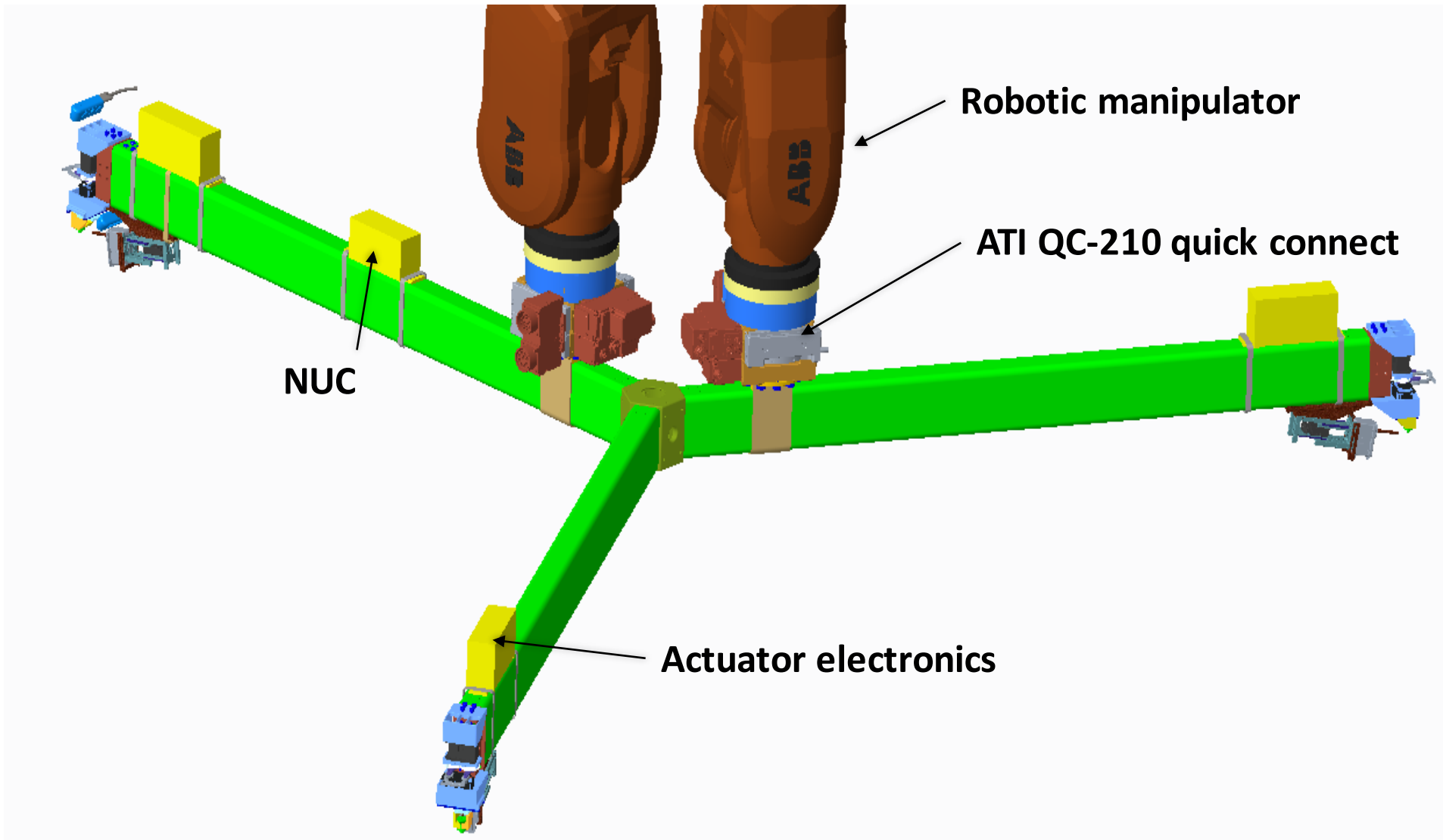


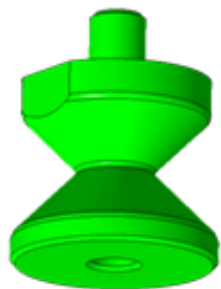
Quick Change



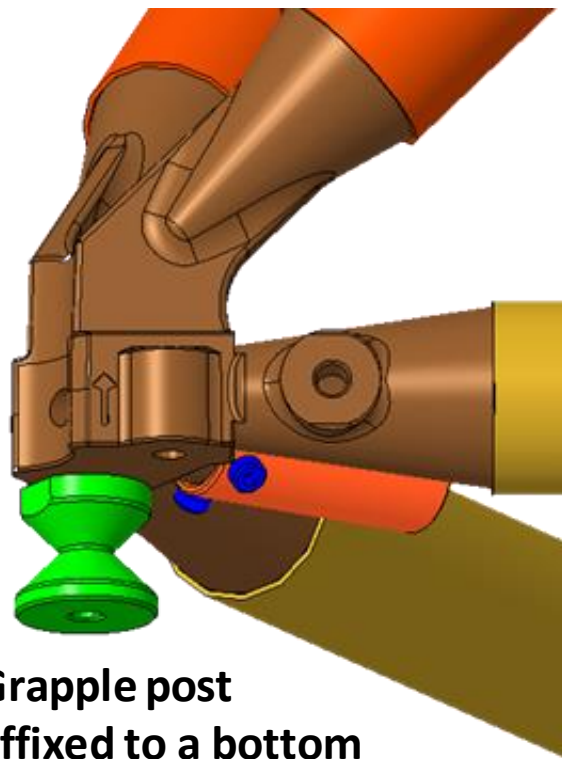
Grapple Tool

Grapple Mechanism



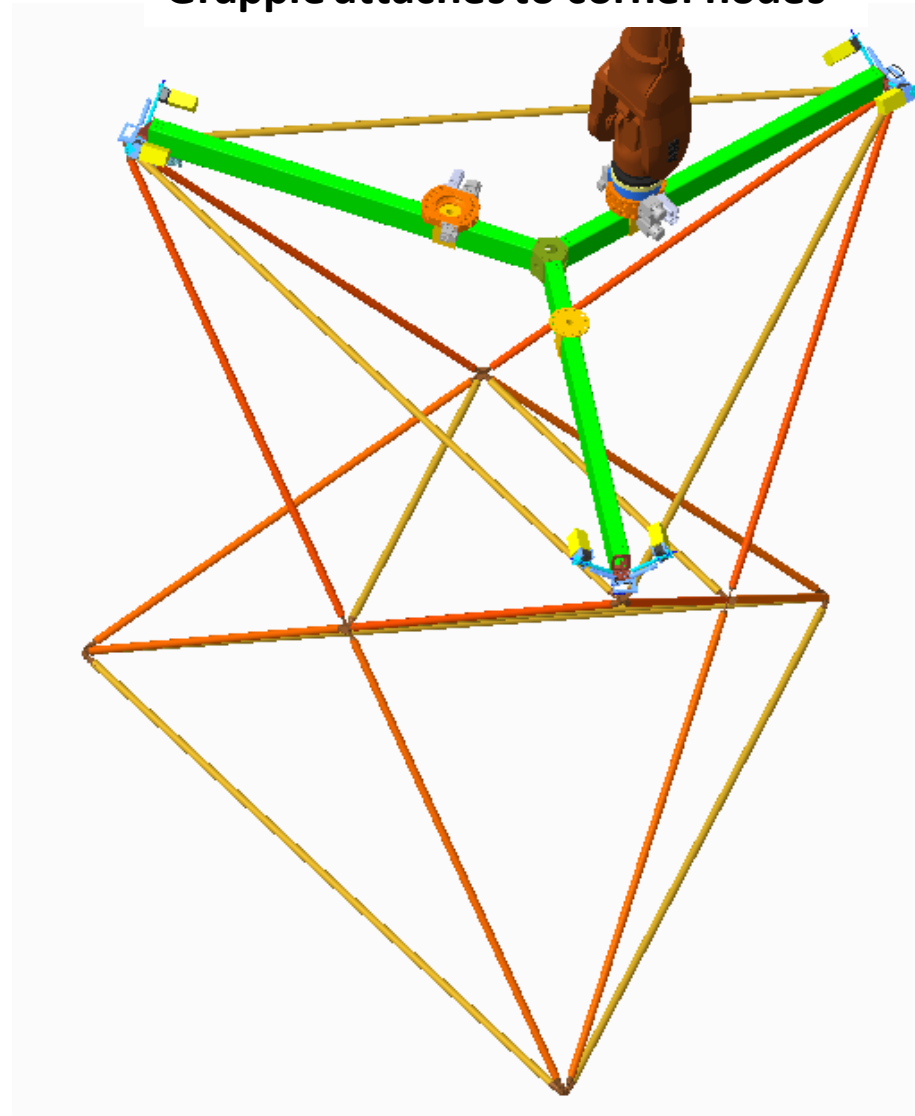


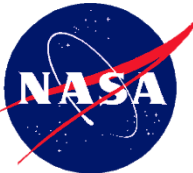
Grapple post



Grapple post affixed to a bottom corner of tri-truss

Grapple attaches to corner nodes

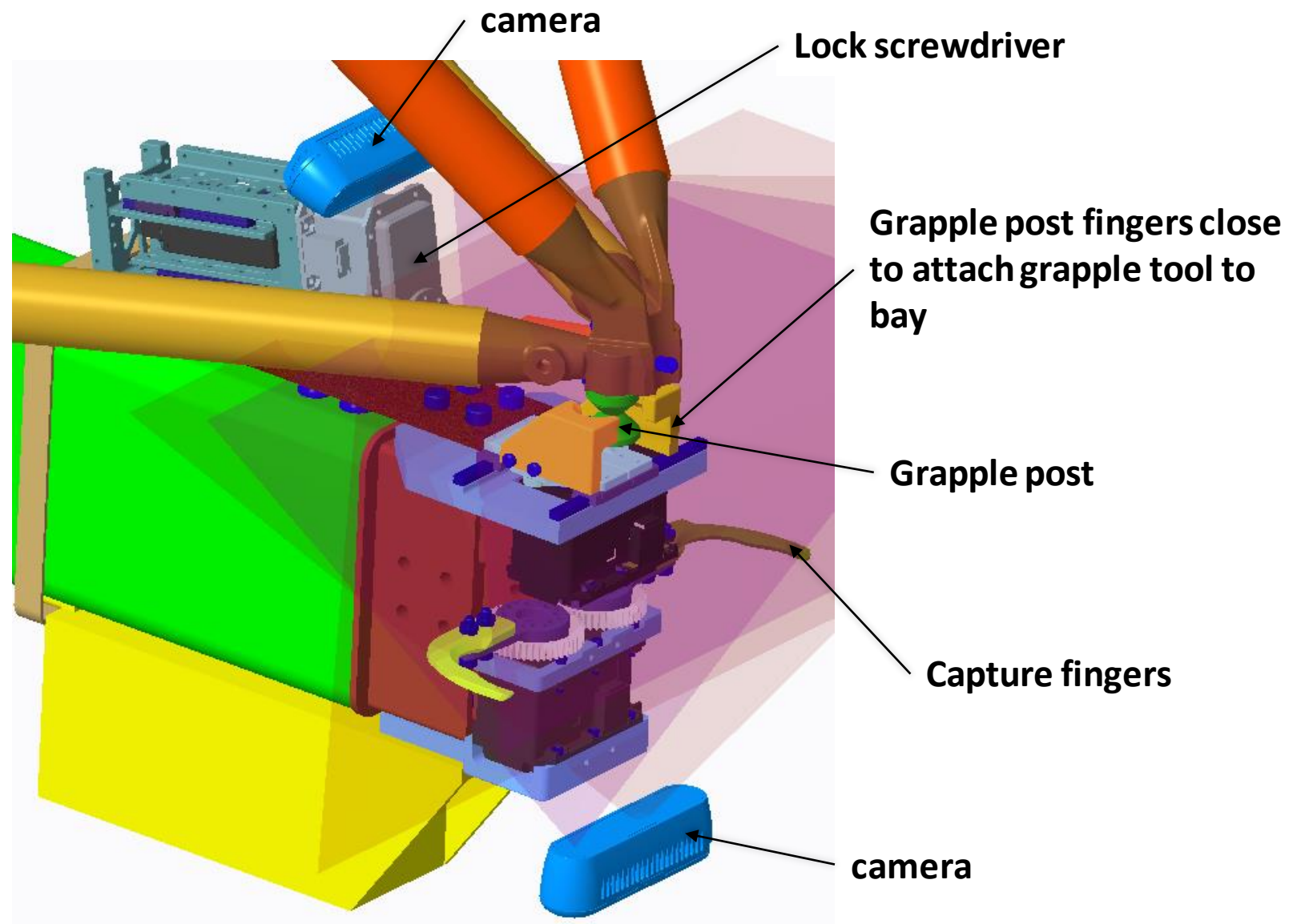




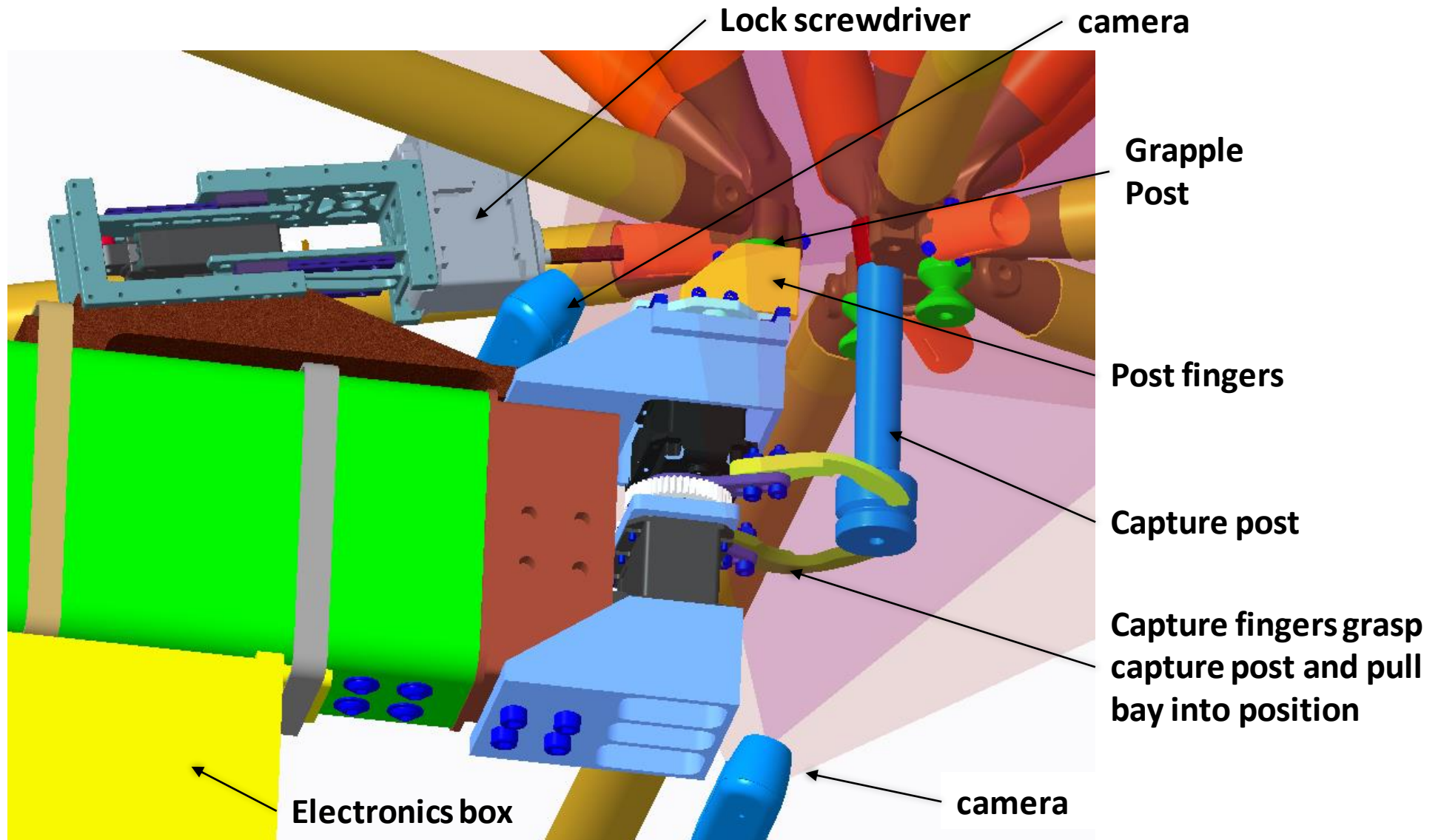
Grapple Mechanism: End Spoke Payload

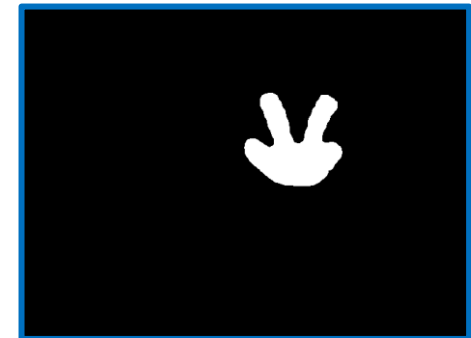
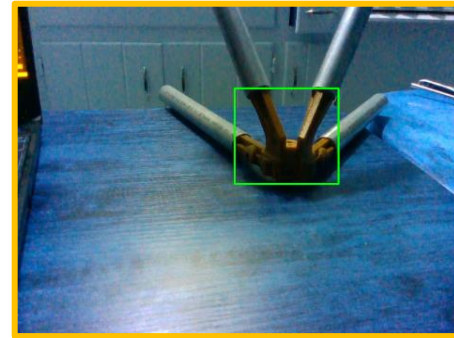
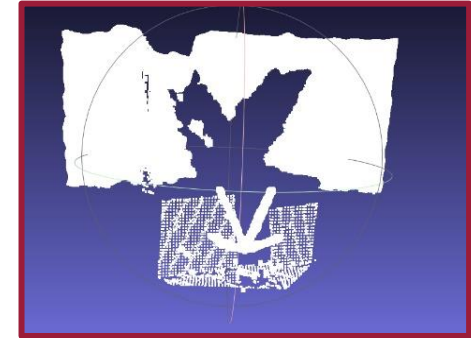
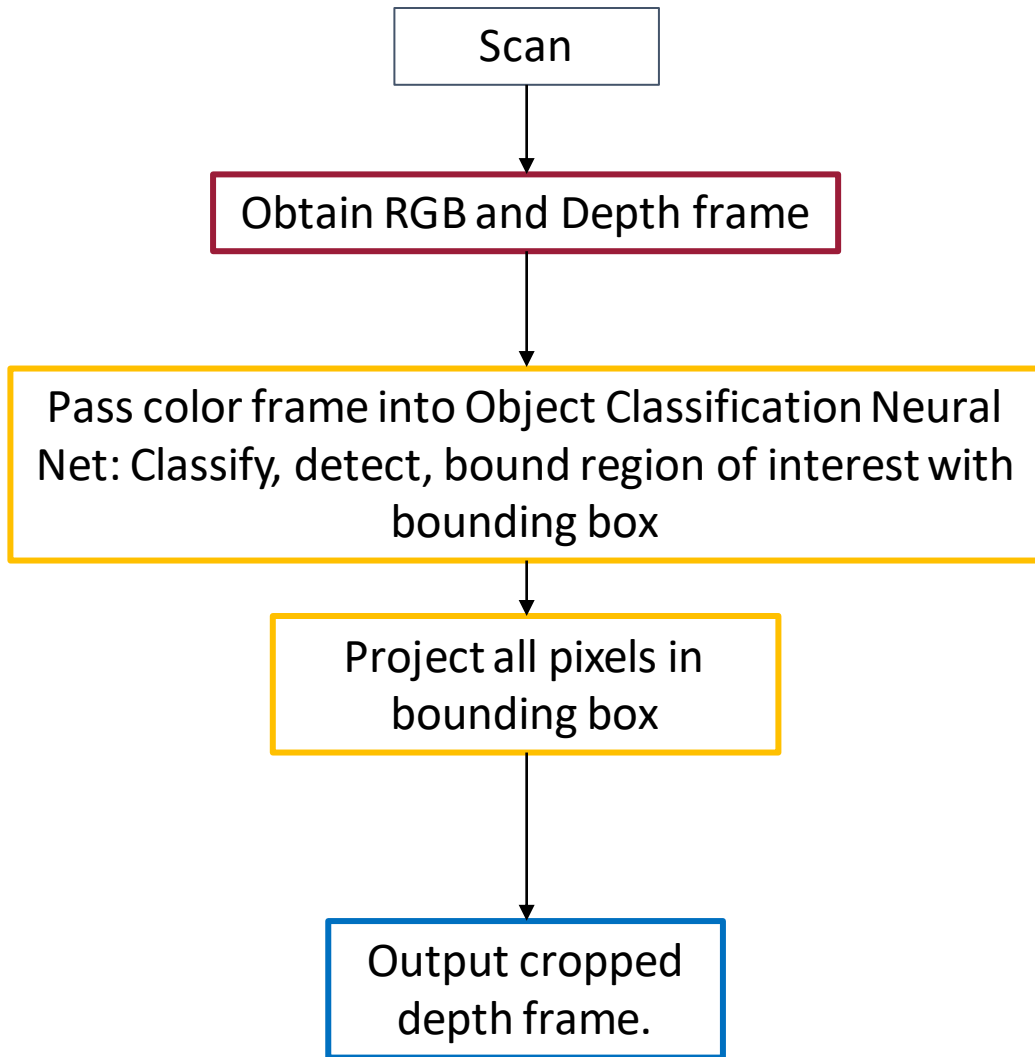


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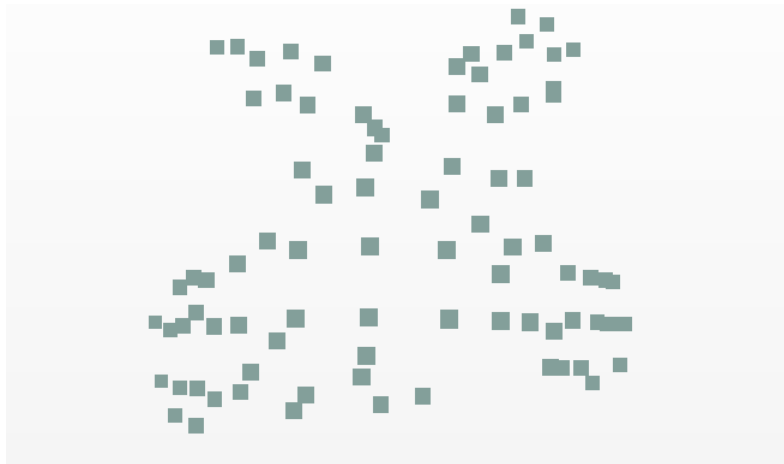


Grapple Mechanism: Metrology





- Develop a set of point cloud representations of the object at different rotations either manually or using a pan-tilt
- Using fitness score provided by registration, select the best fit scan from the model set
- Apply transform from Iterative Closest Point (ICP) to the model to align it within scene
- Return pose



Point Cloud Model of Node

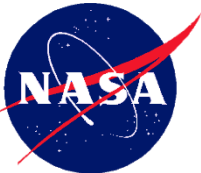
Align? →



Captured Scene Scan

Pose Estimation: Visualization

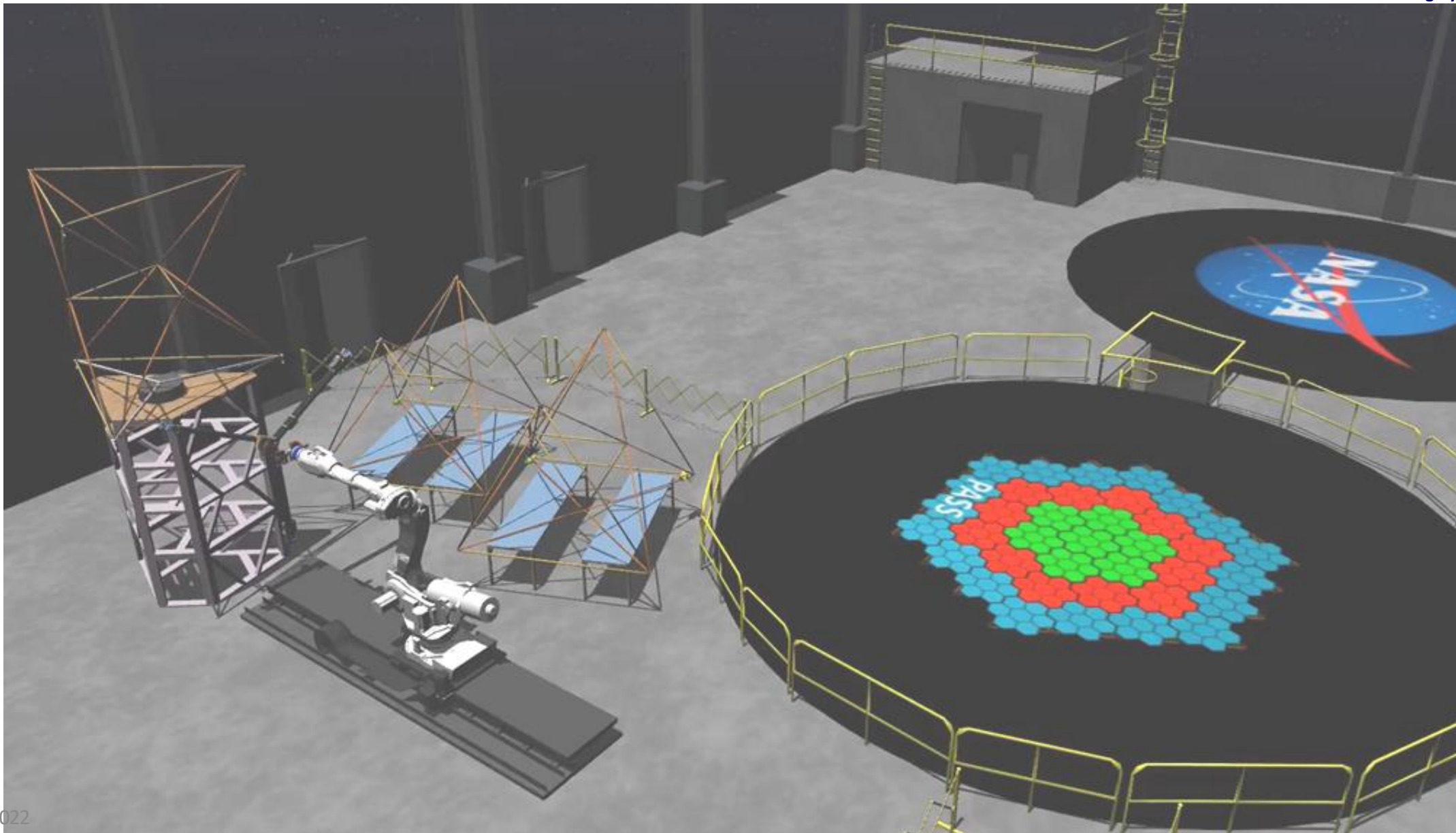


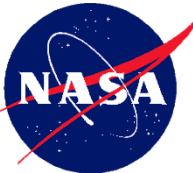


Phase 1 Assembly



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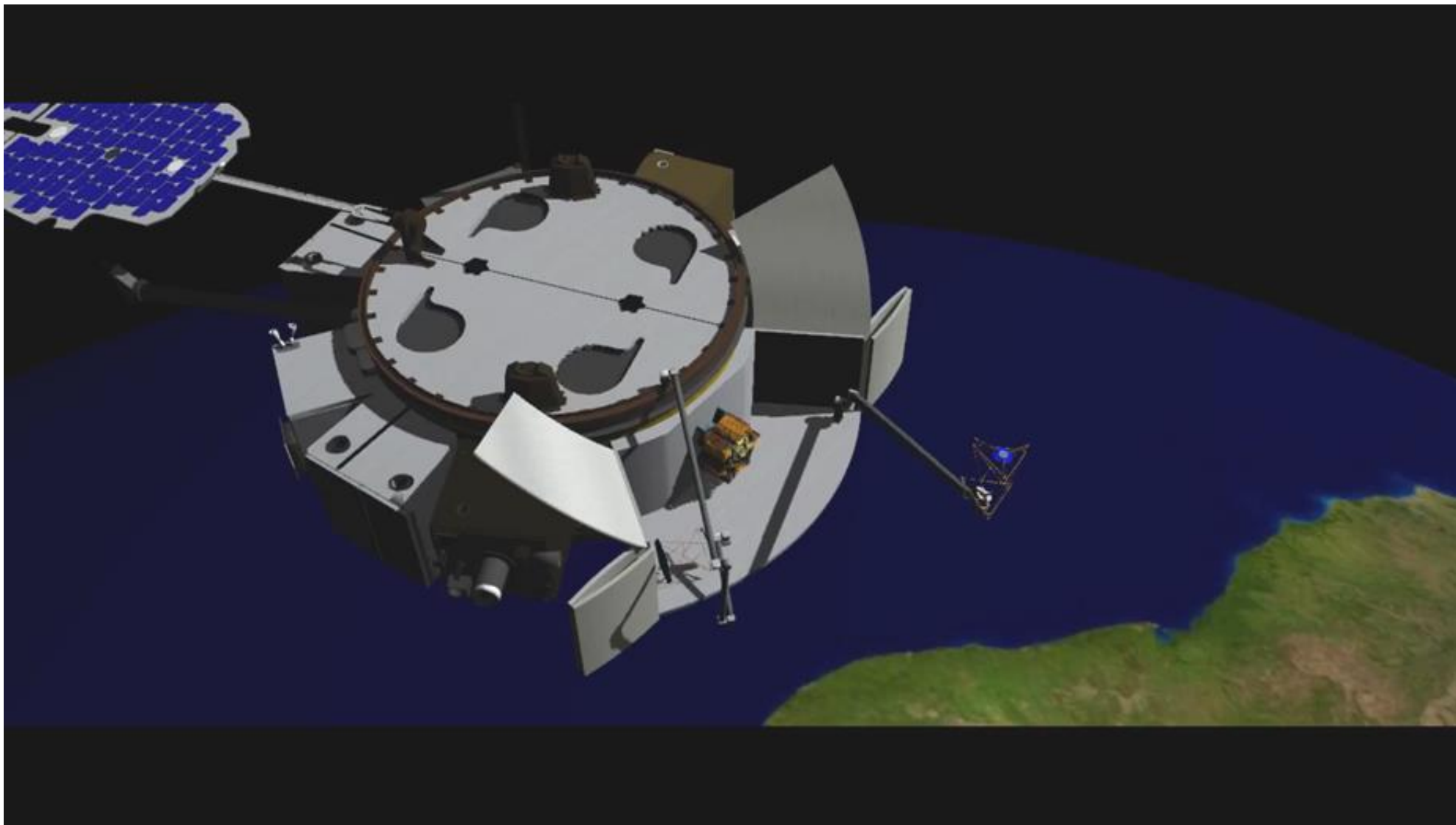




Future Work: ESPA TriTruss Ring Assembly



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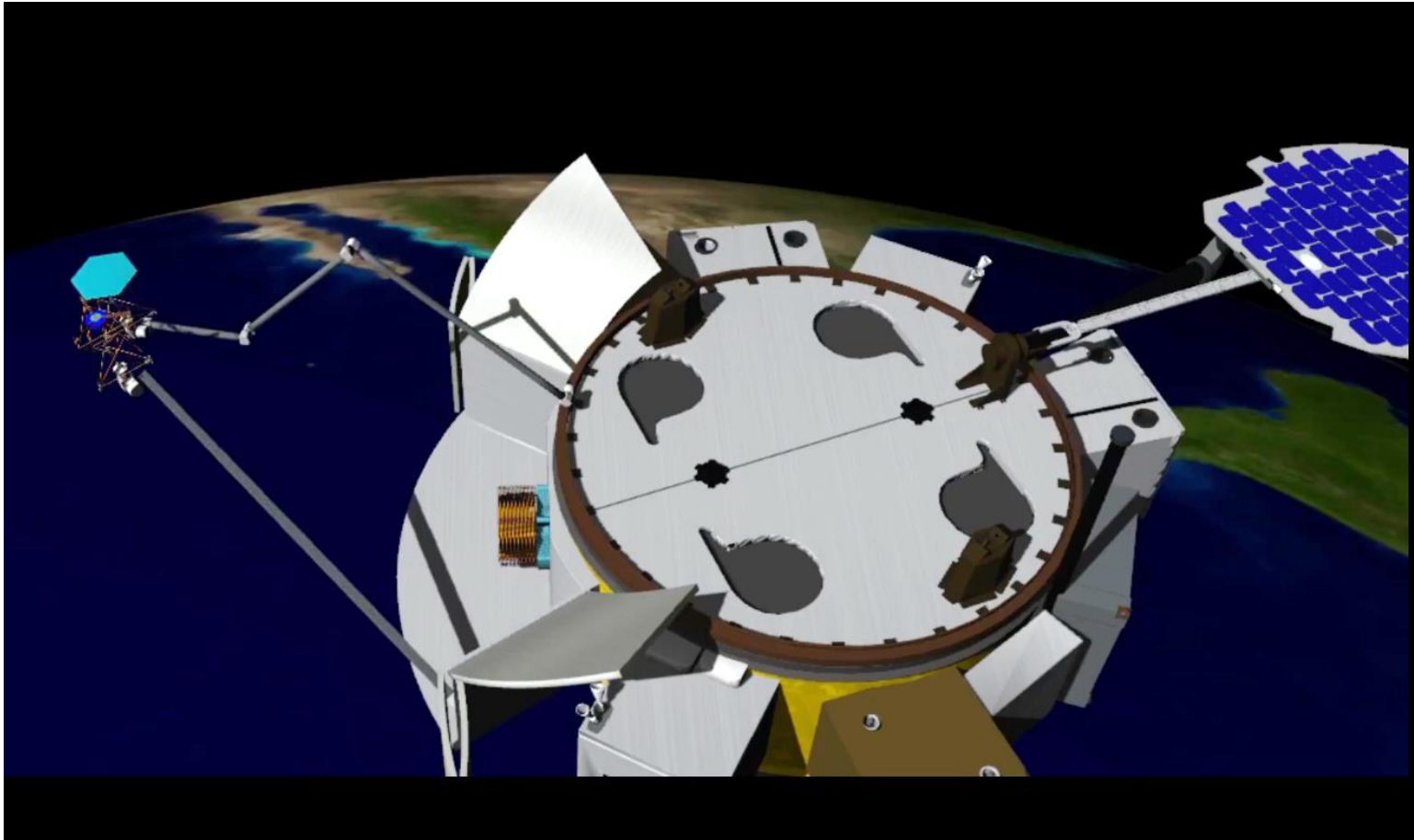




Thank You



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AIAA SciTech, January 2022

