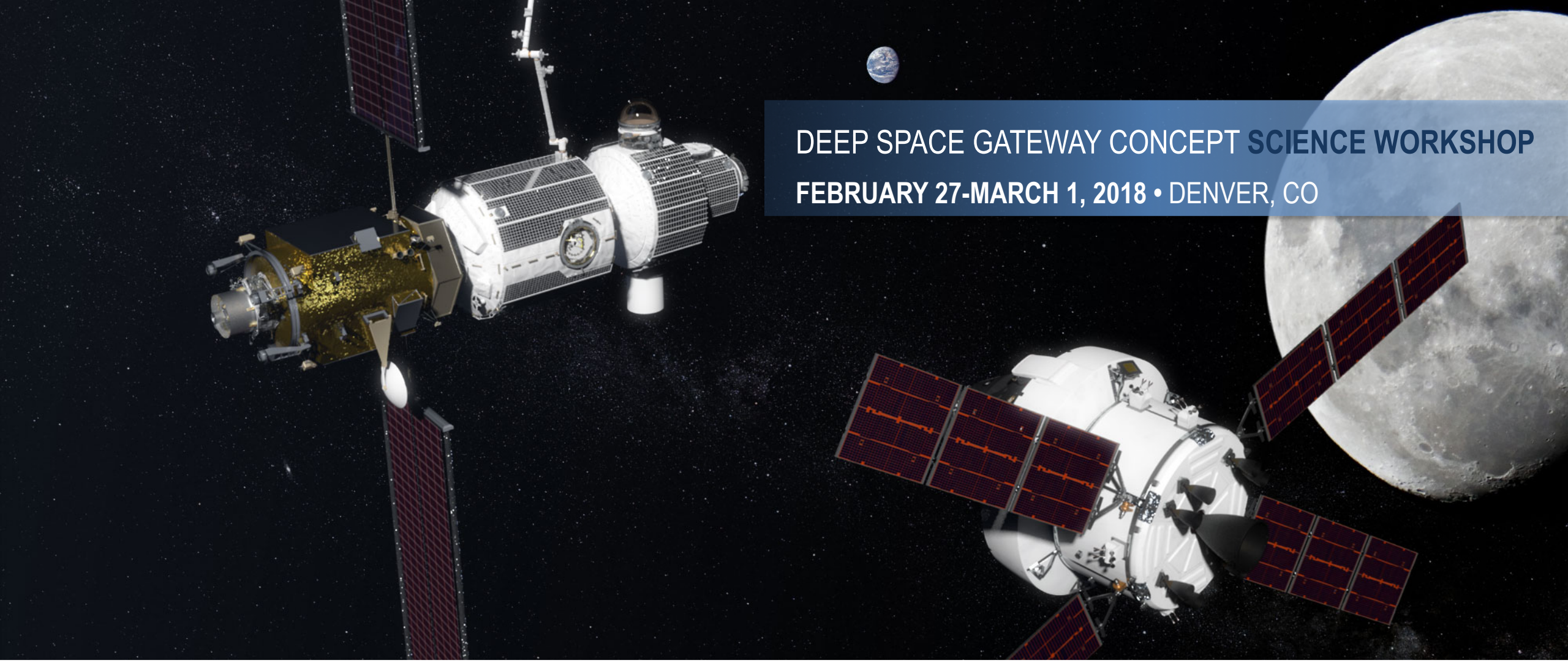
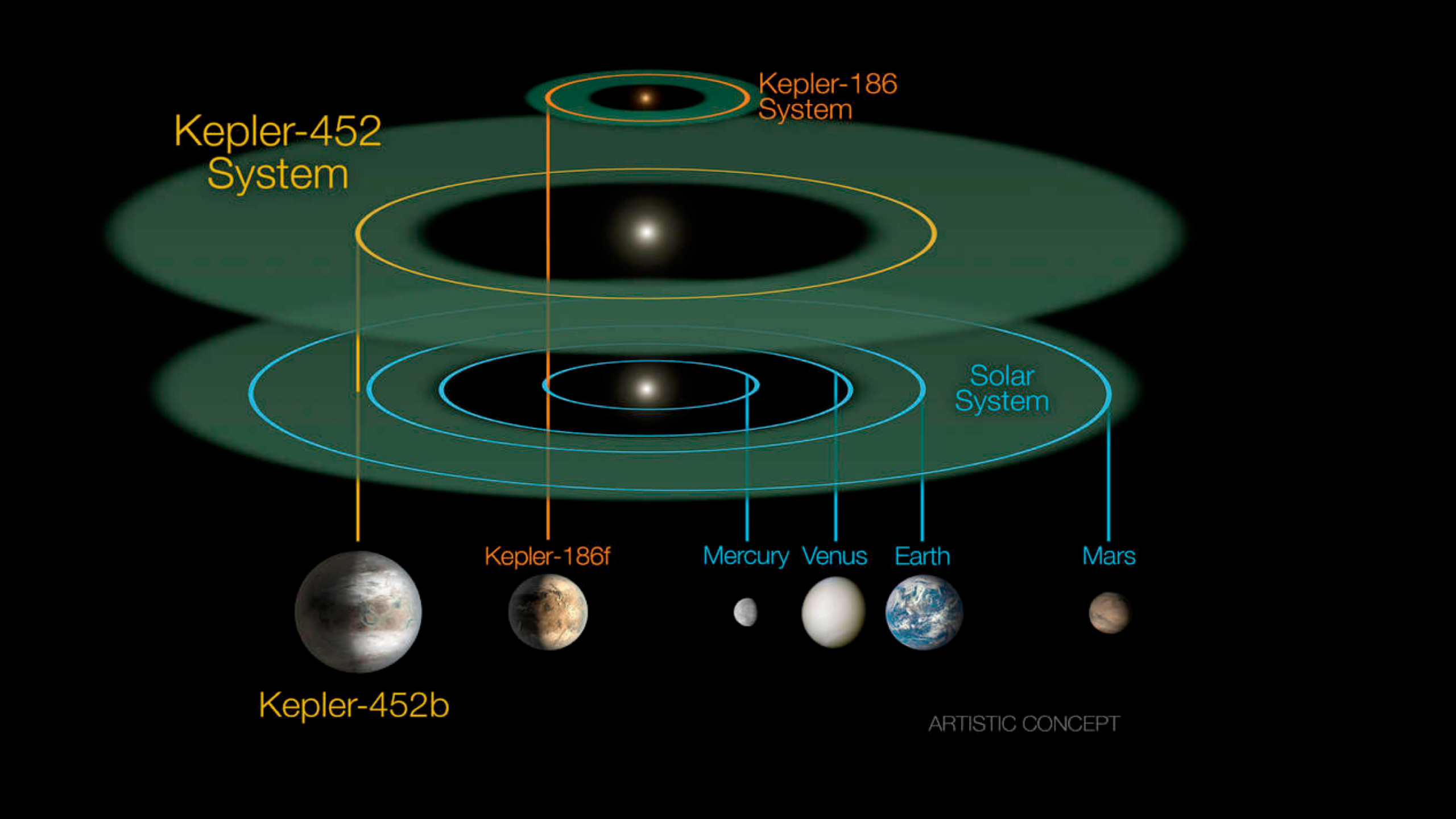


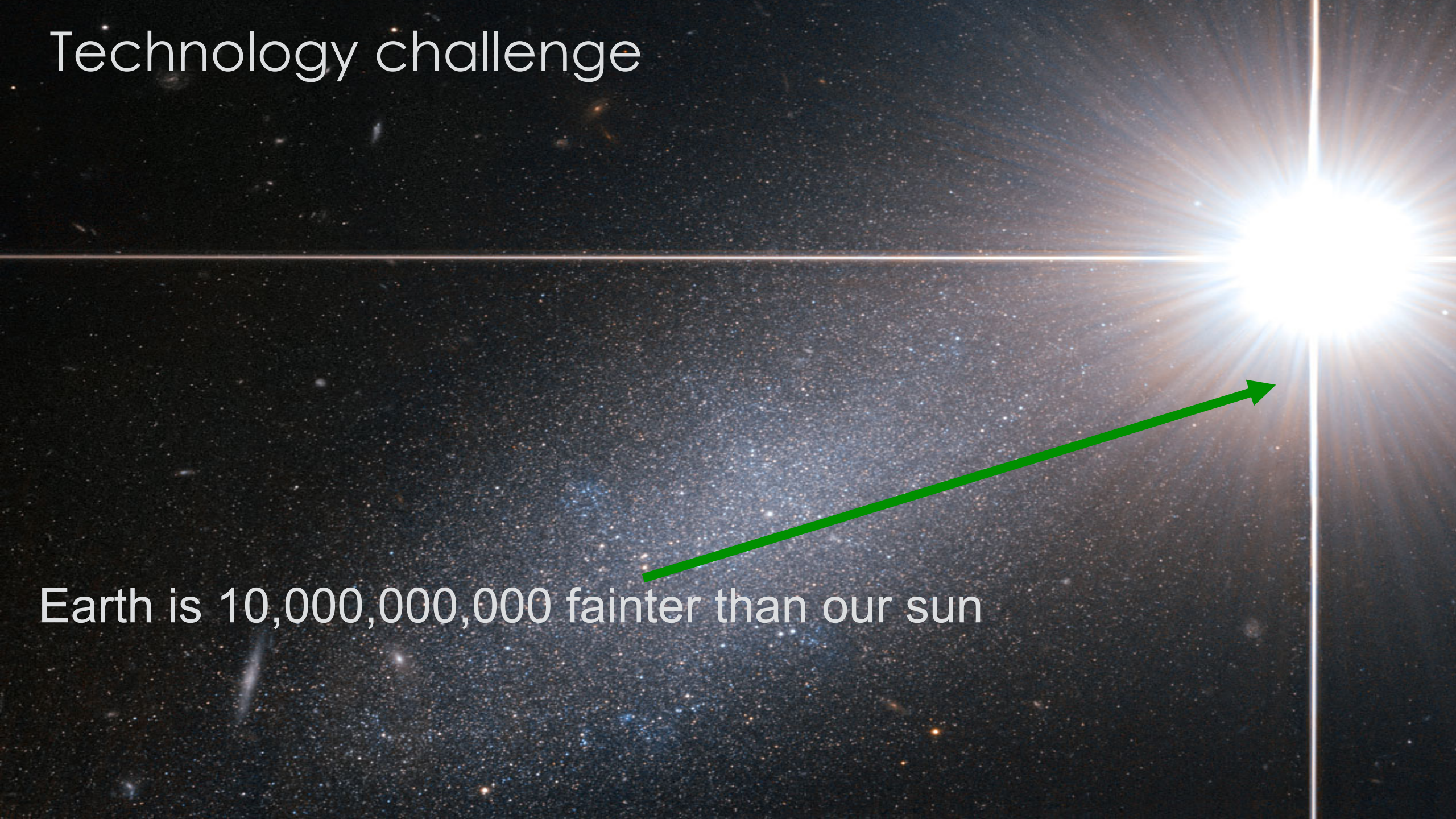
Starshade Assembly Enabled by the Deep Space Gateway Architecture

28 February 2018

John Mace Grunsfeld, Astrophysicist/Astronaut, NASA GSFC (Emeritus),
Nick Siegler, and Rudra Mukherjee, NASA JPL/Caltech.


Kepler-186
System
Kepler-452
System
Solar
System
Kepler-186f
Mercury
Venus
Earth
Mars
Kepler-452b
ARTISTIC CONCEPT

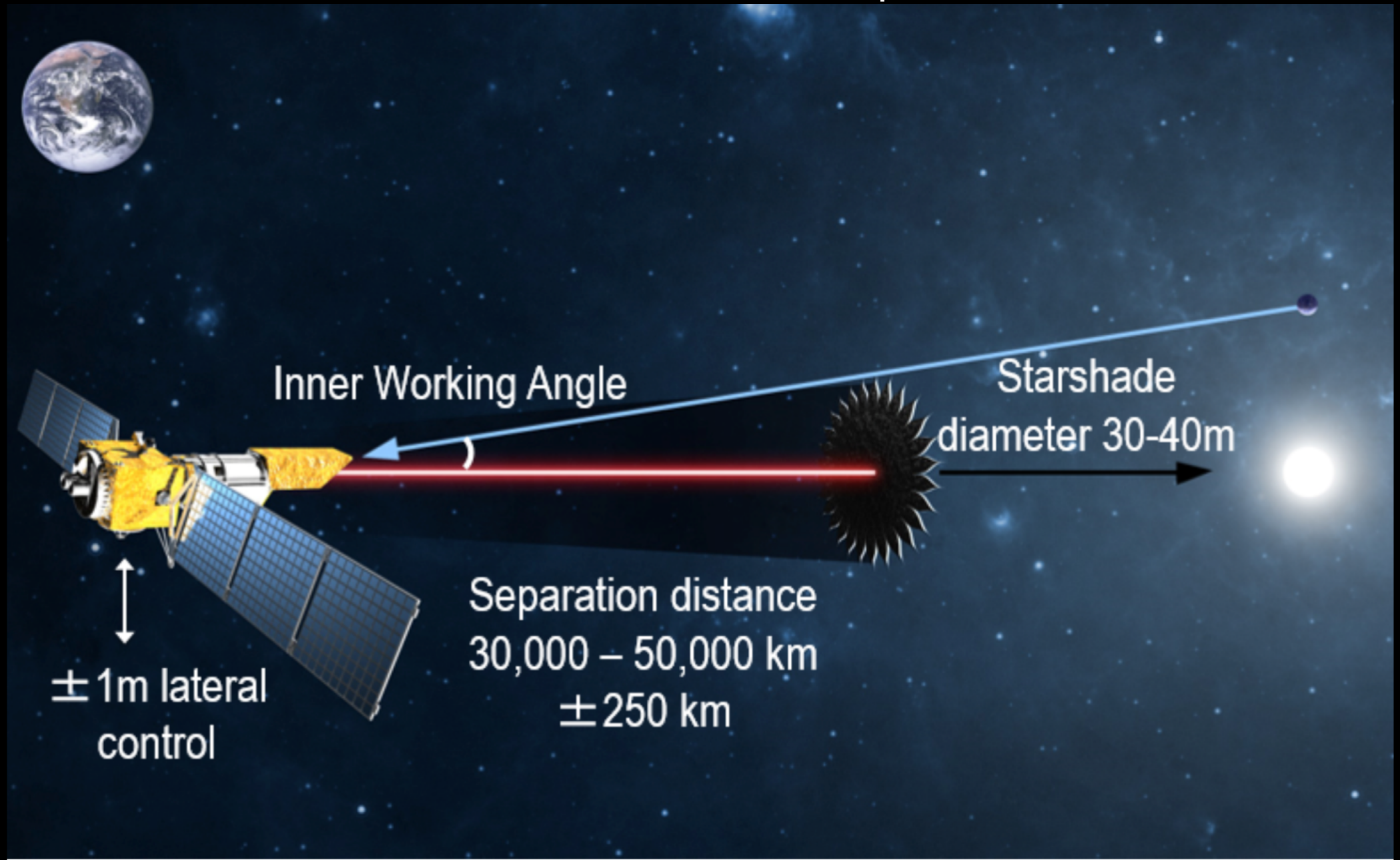
Technology challenge



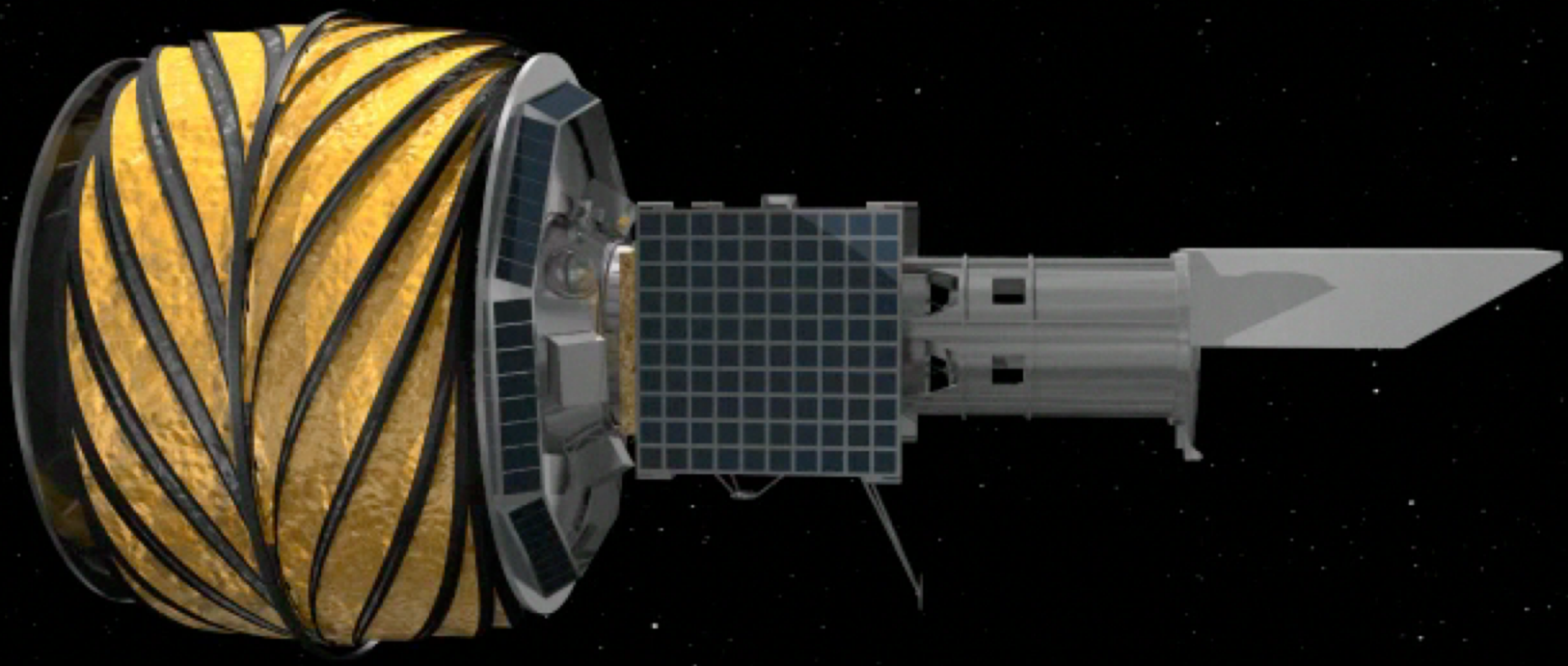
Earth is 10,000,000,000 fainter than our sun

Need to block out the starlight

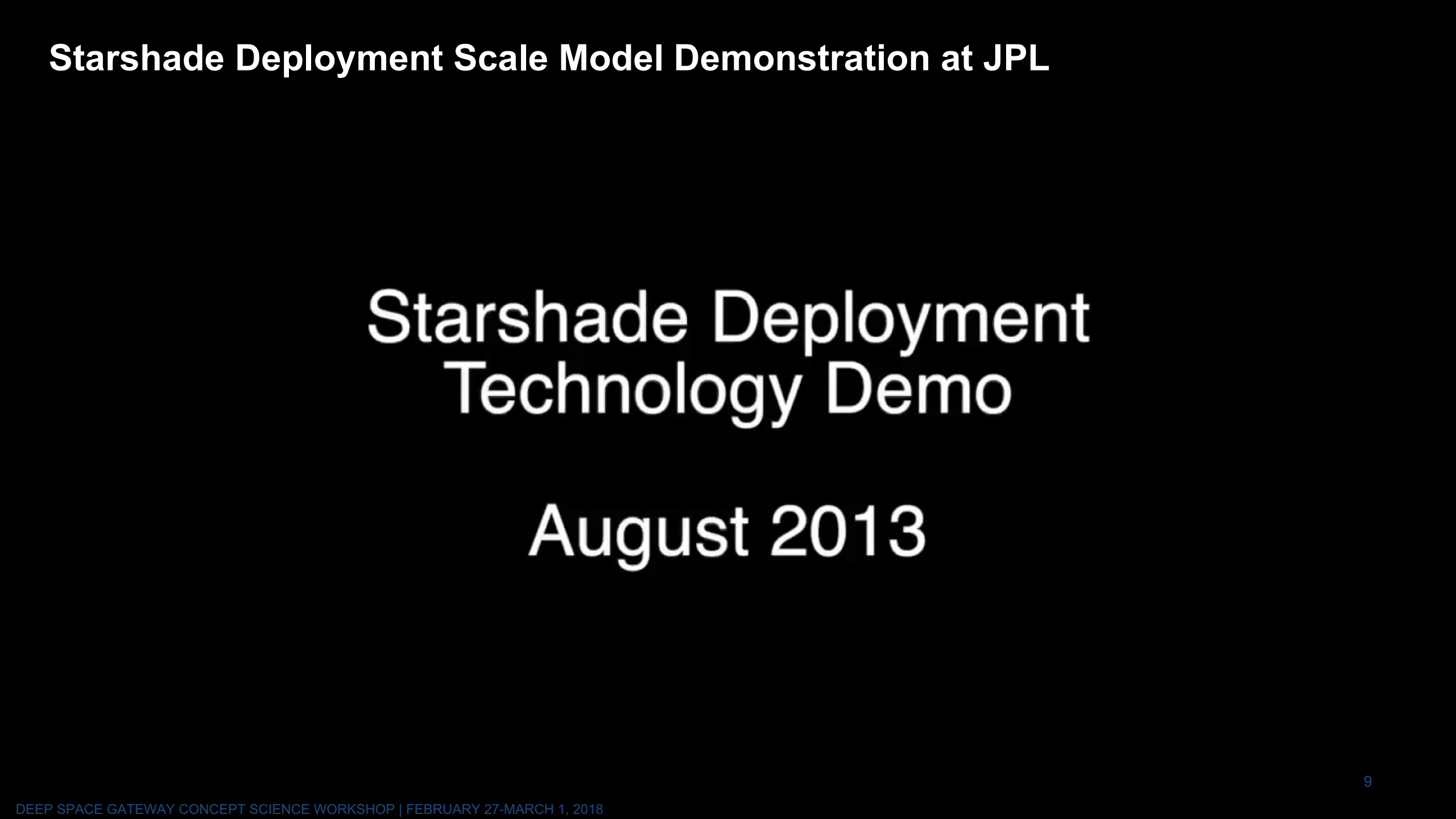
Starshade Concept



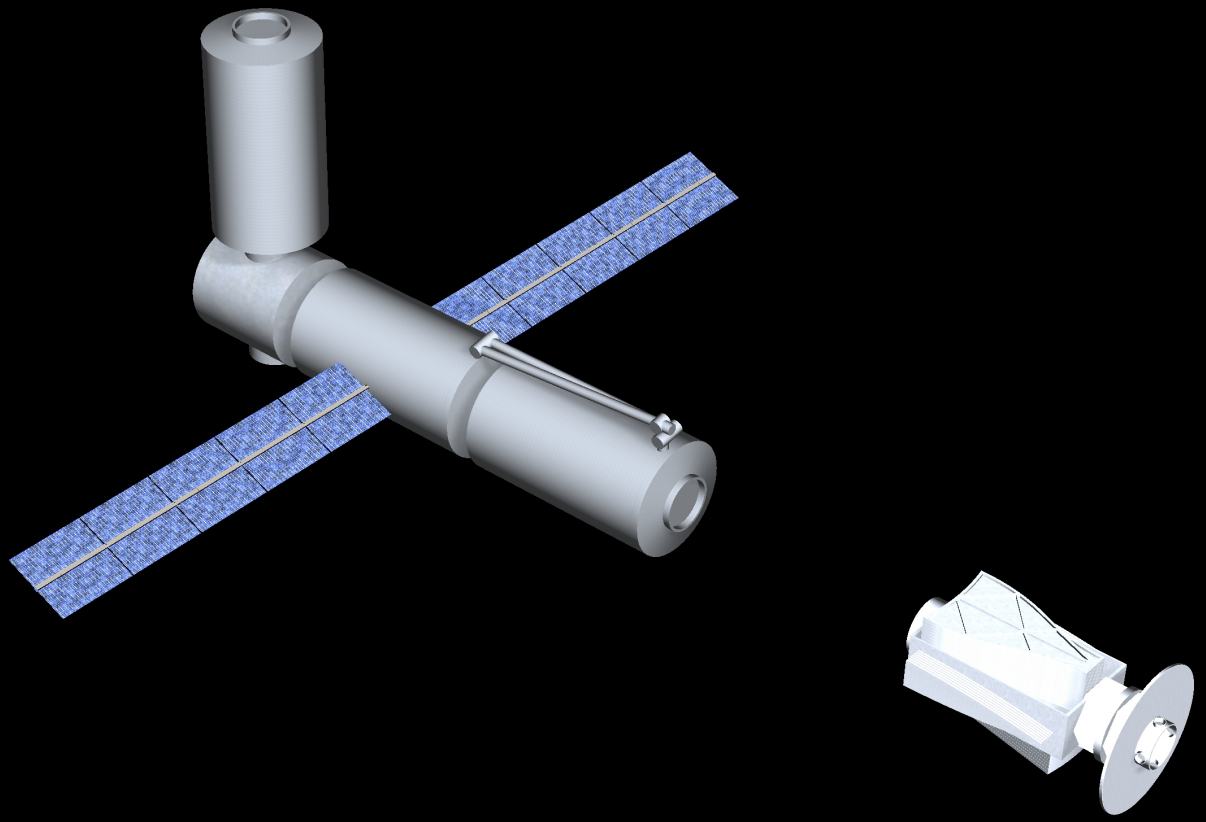
Starshade Deployment – Current Origami Concept



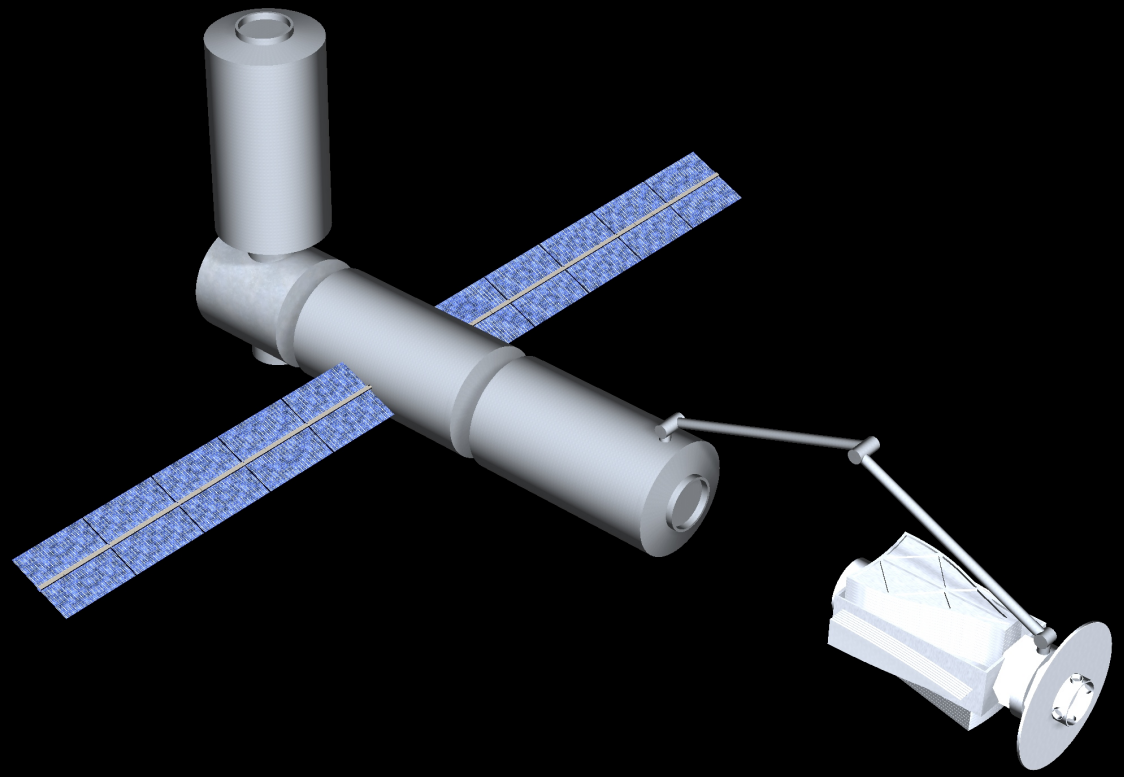
Starshade Deployment Scale Model Demonstration at JPL



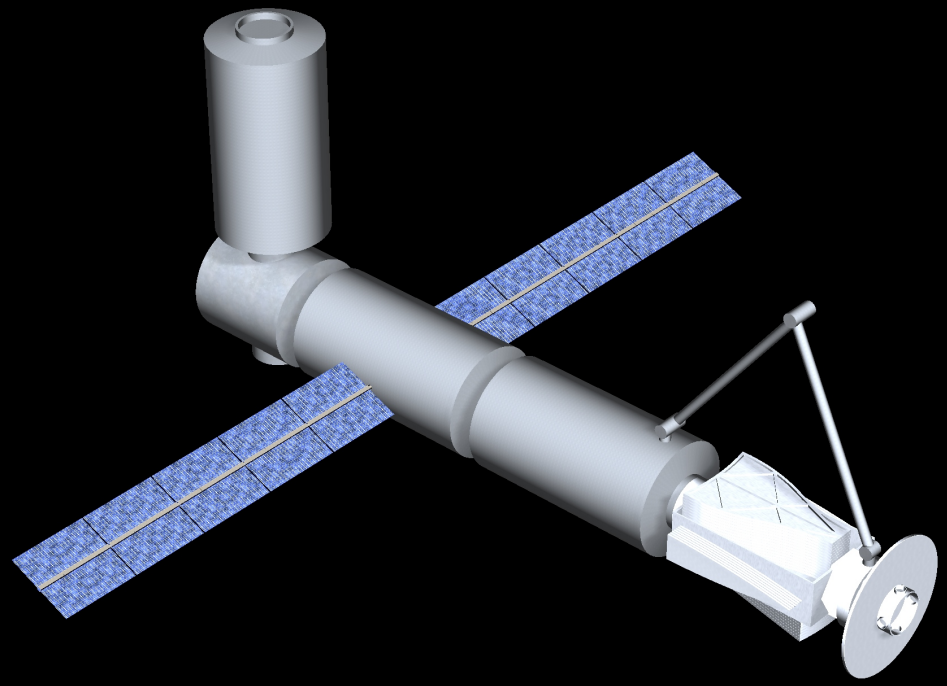
Spacecraft approaching the DSG



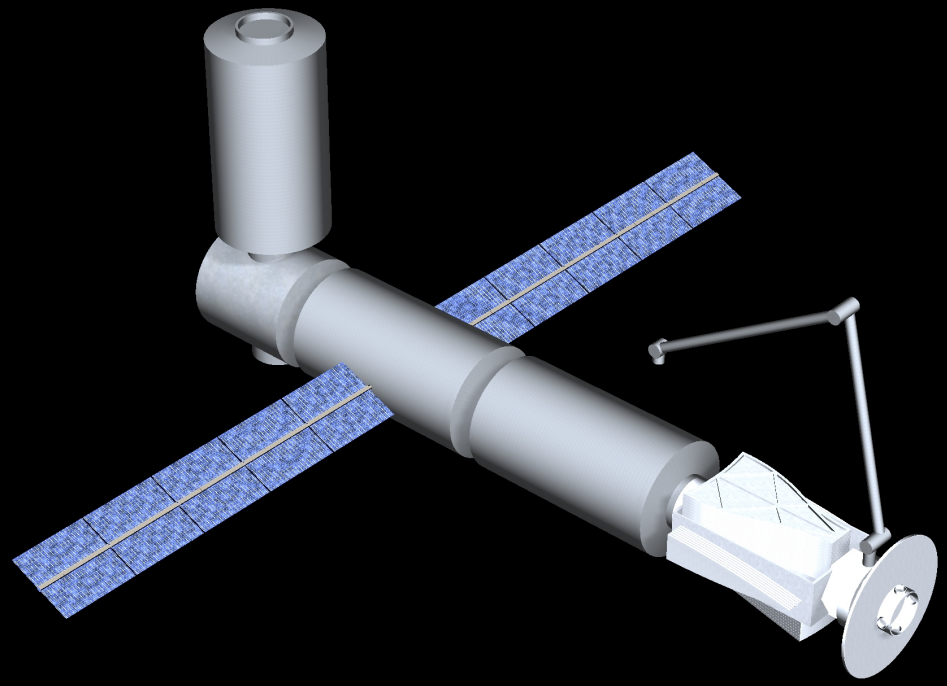
Grapple



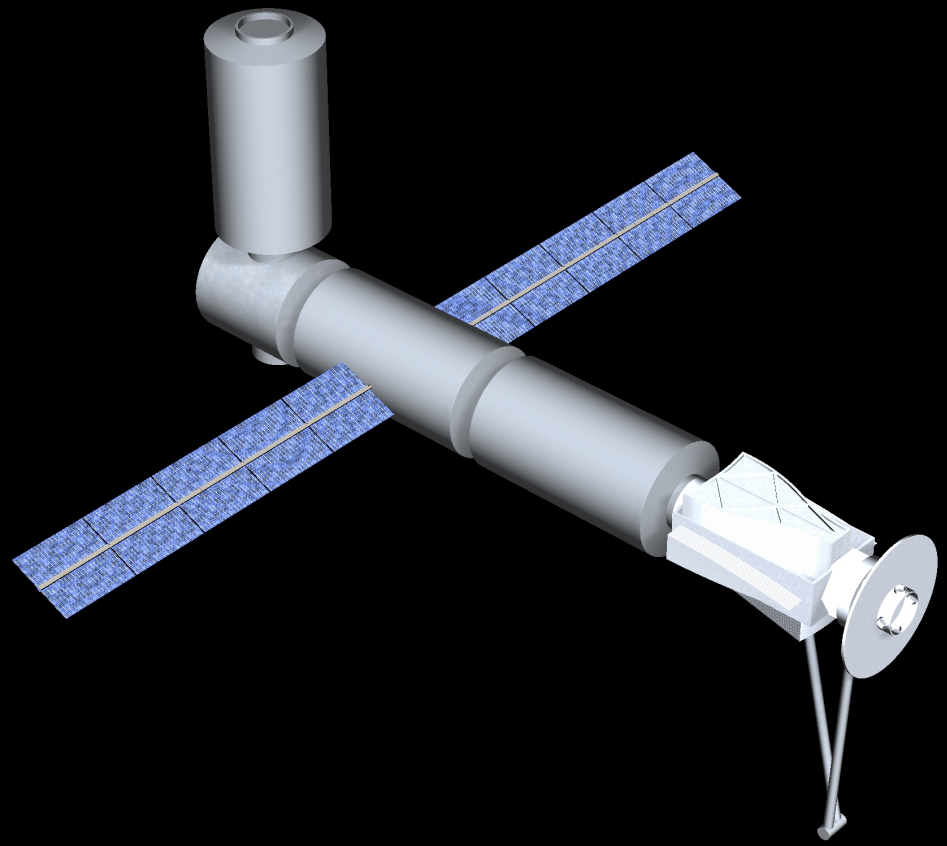
Berthed



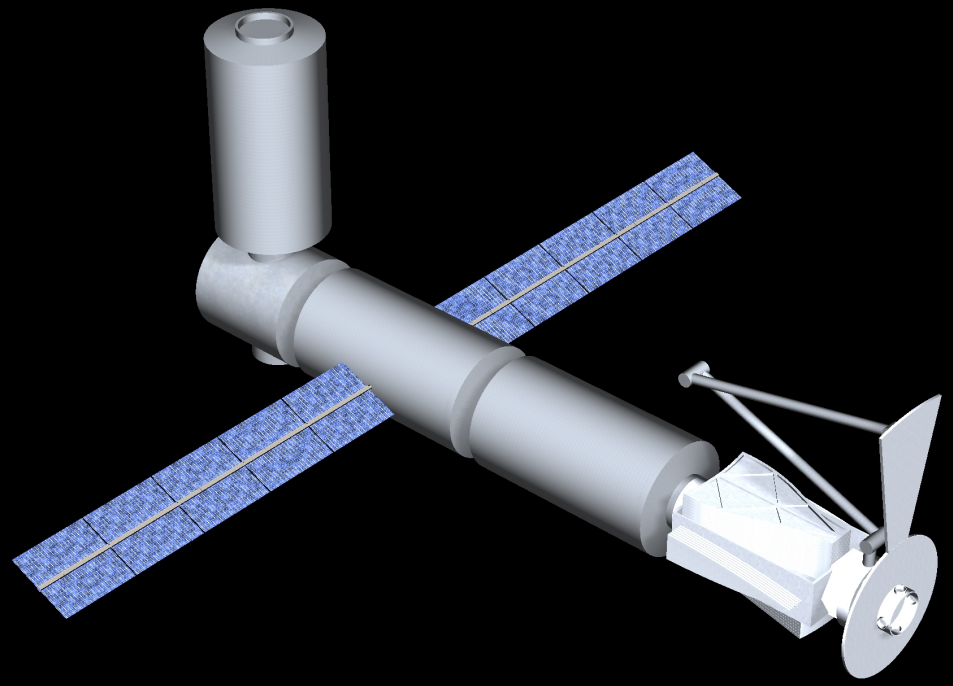
Arm Walk Off to Starshade Spacecraft



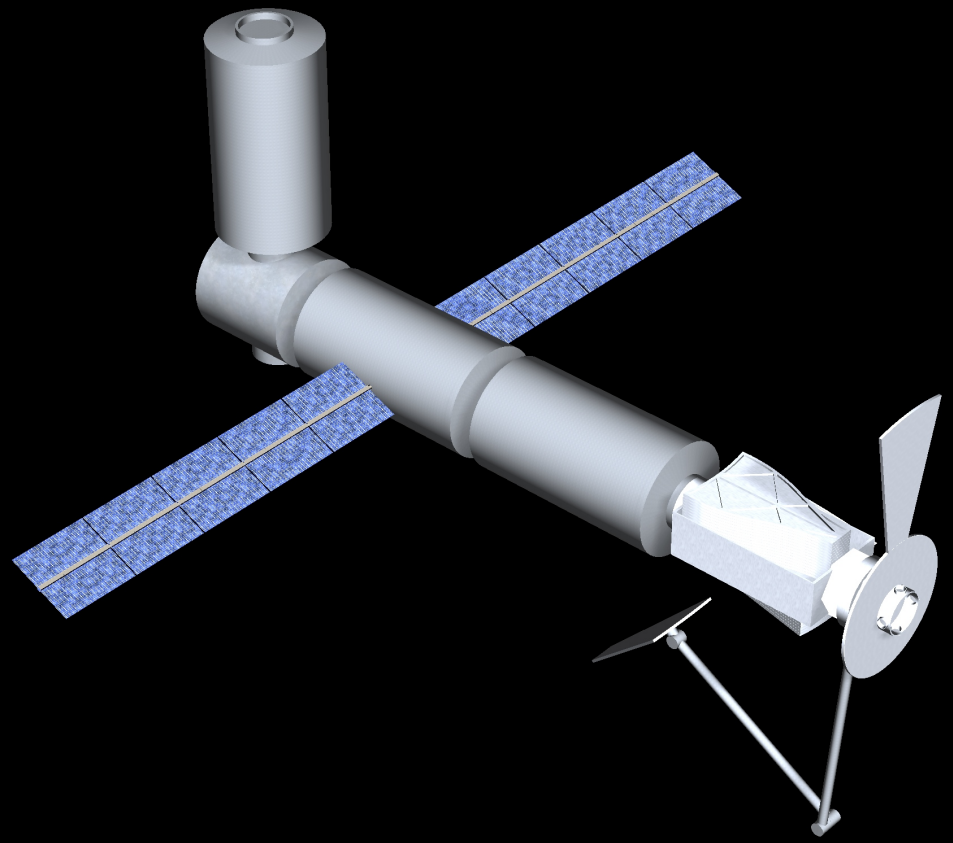
Grab Panel



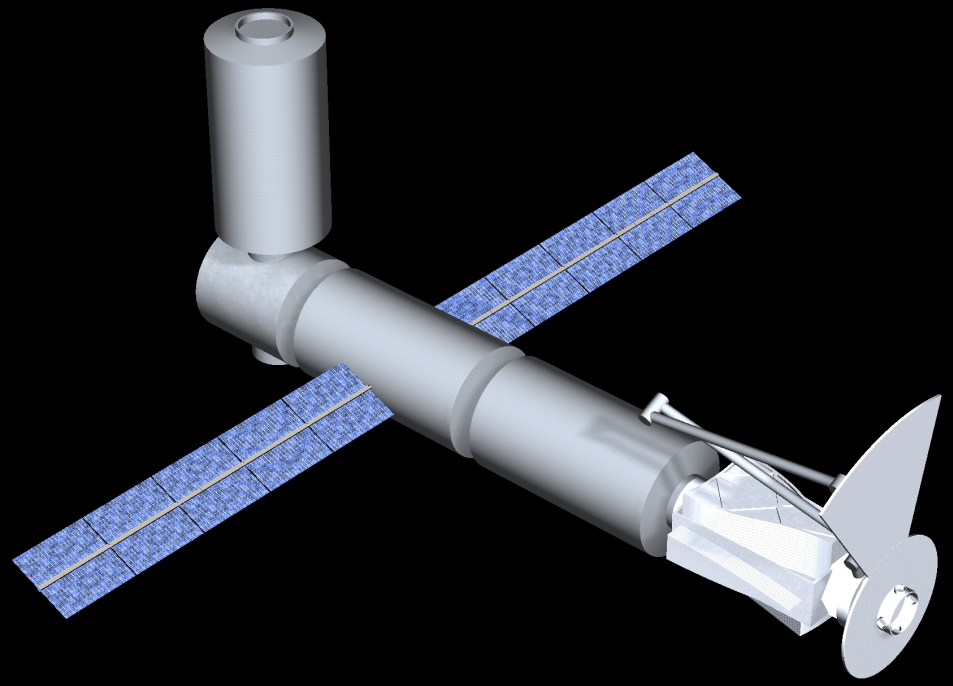
Place First Panel



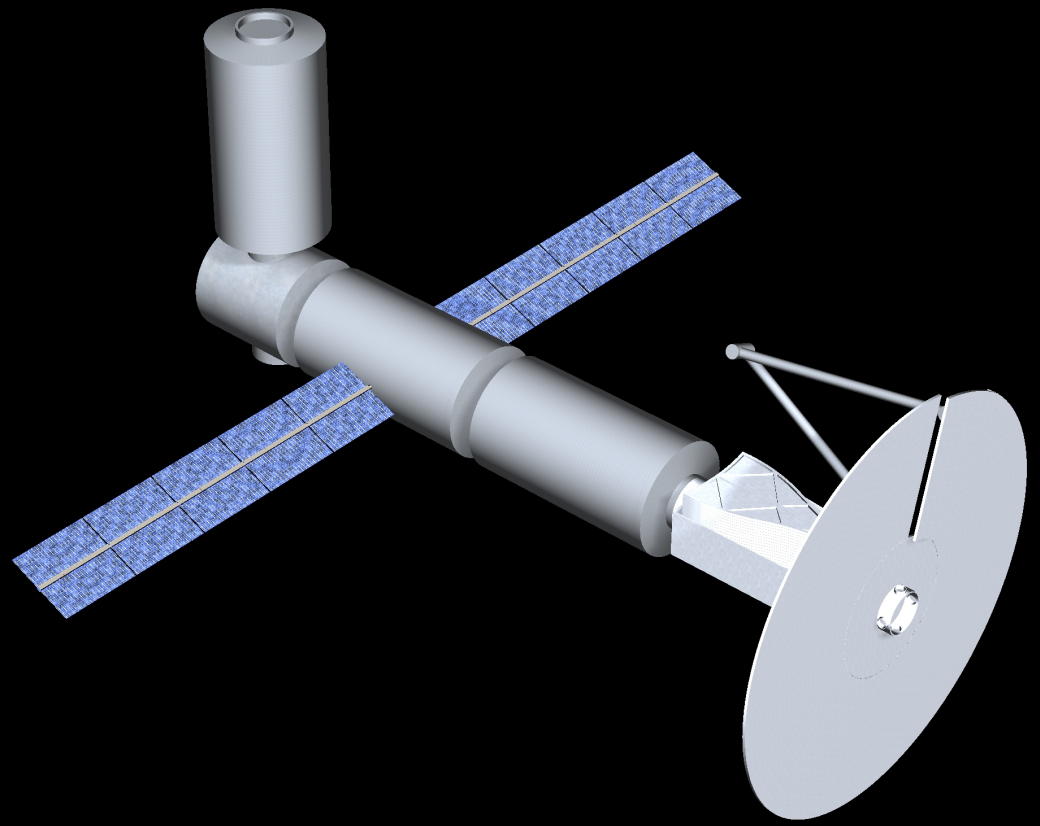
Second Panel



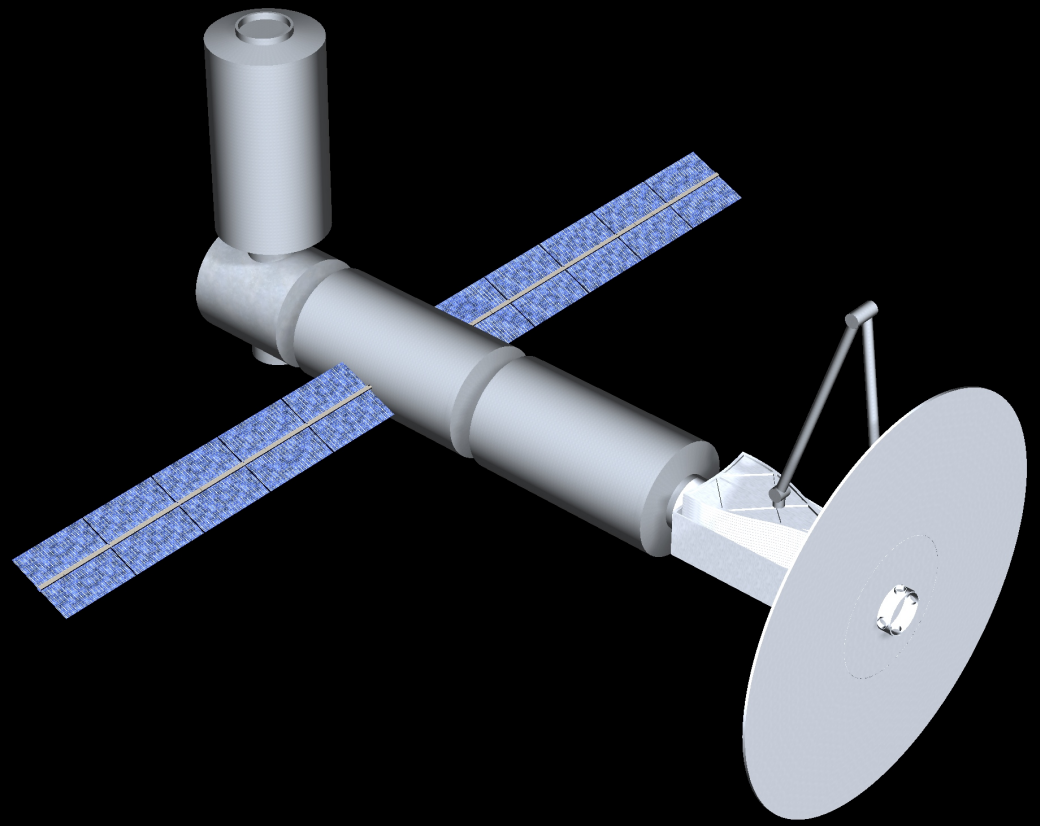
Place Second Panel



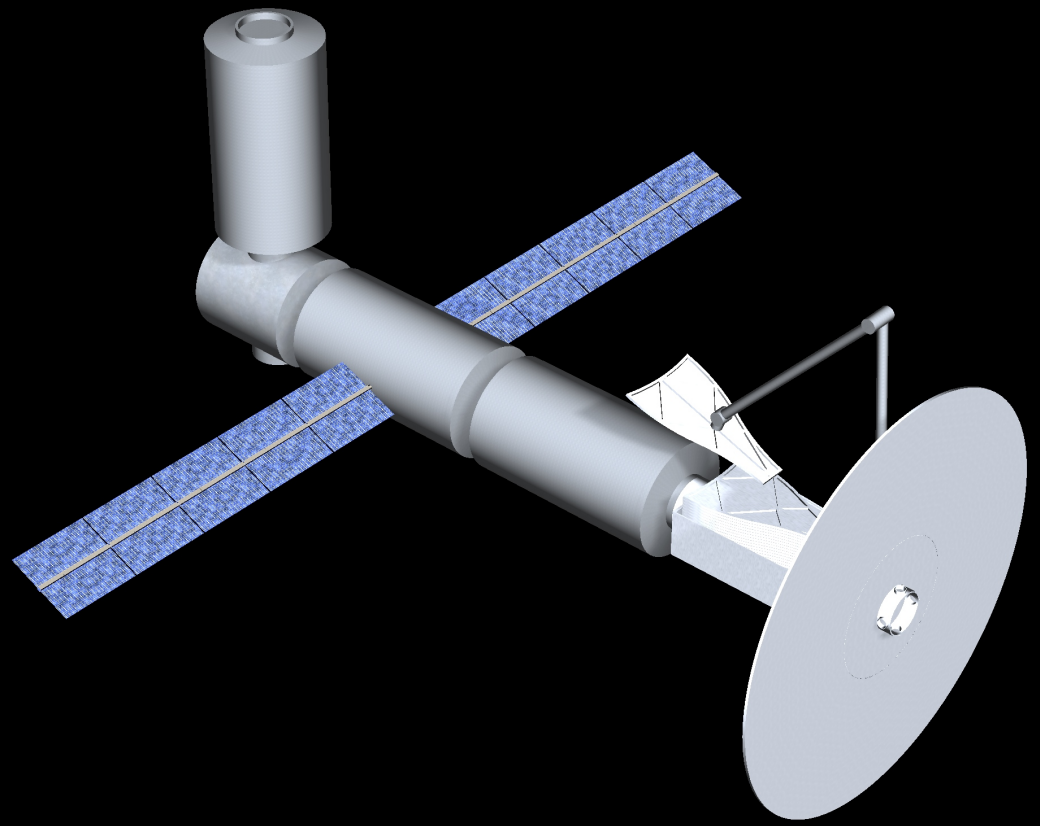
Complete Inner Ring



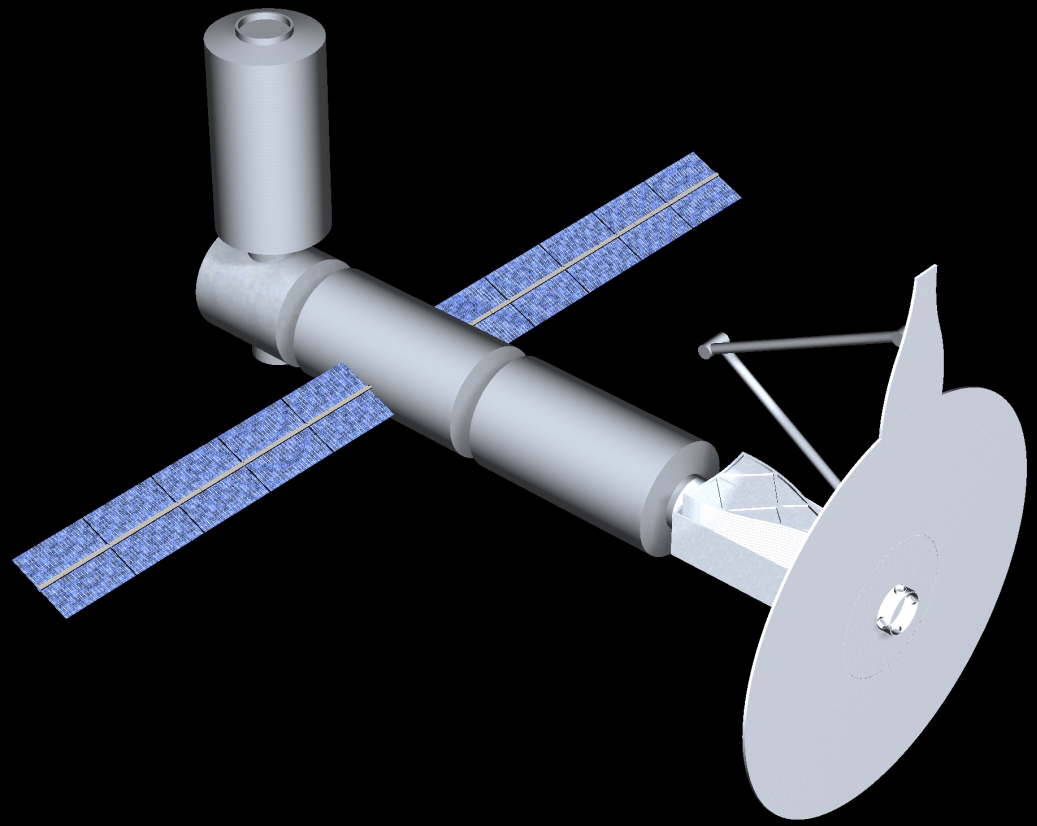
Begin Second Ring



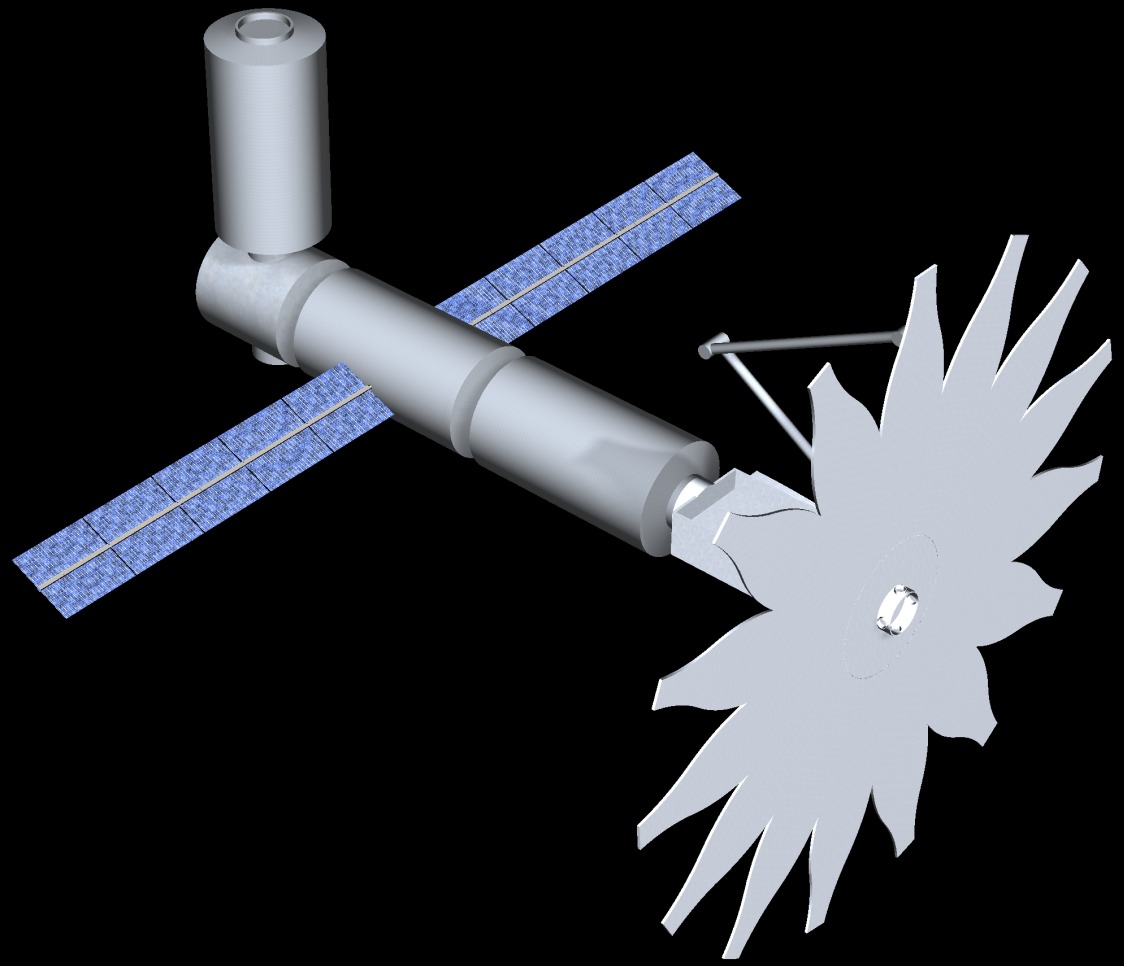
Move Second Ring Pedal



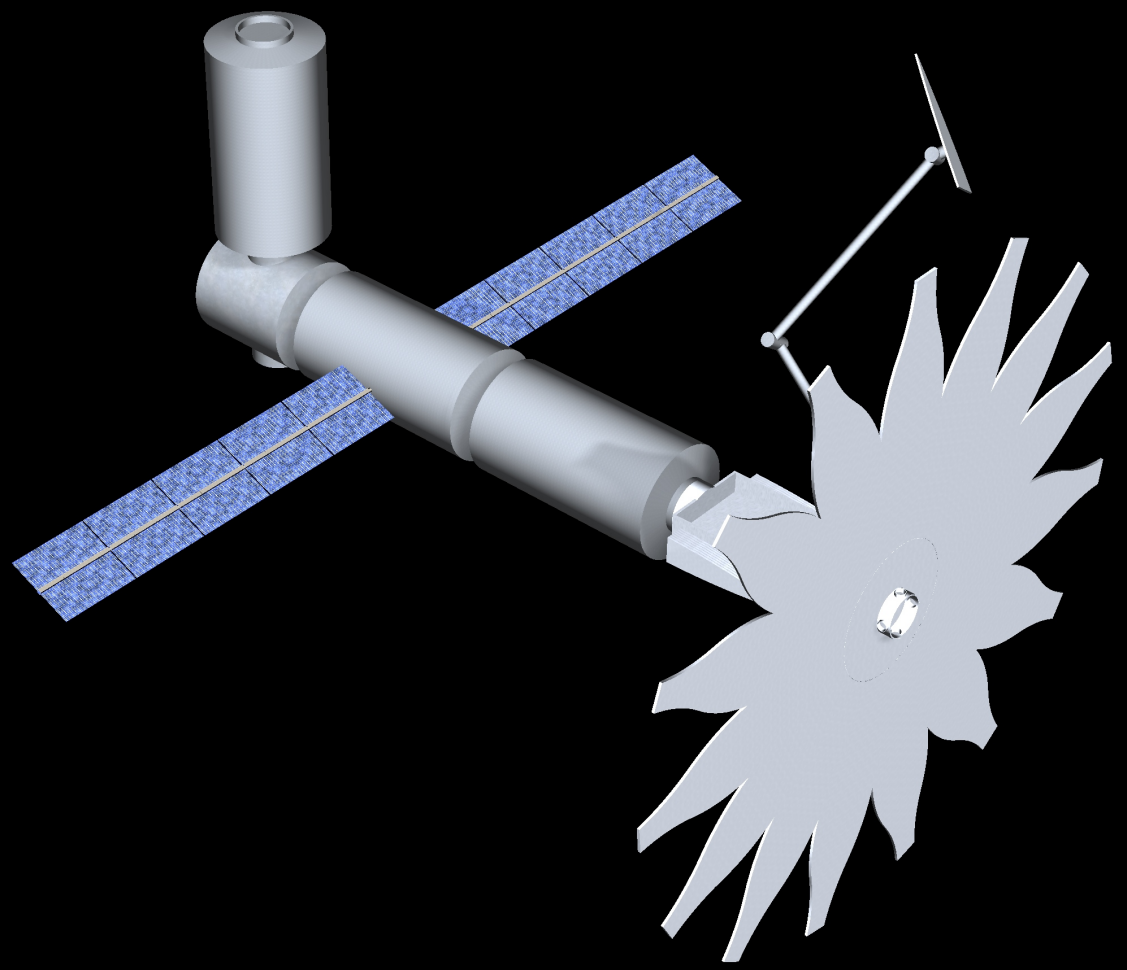
Place Pedal



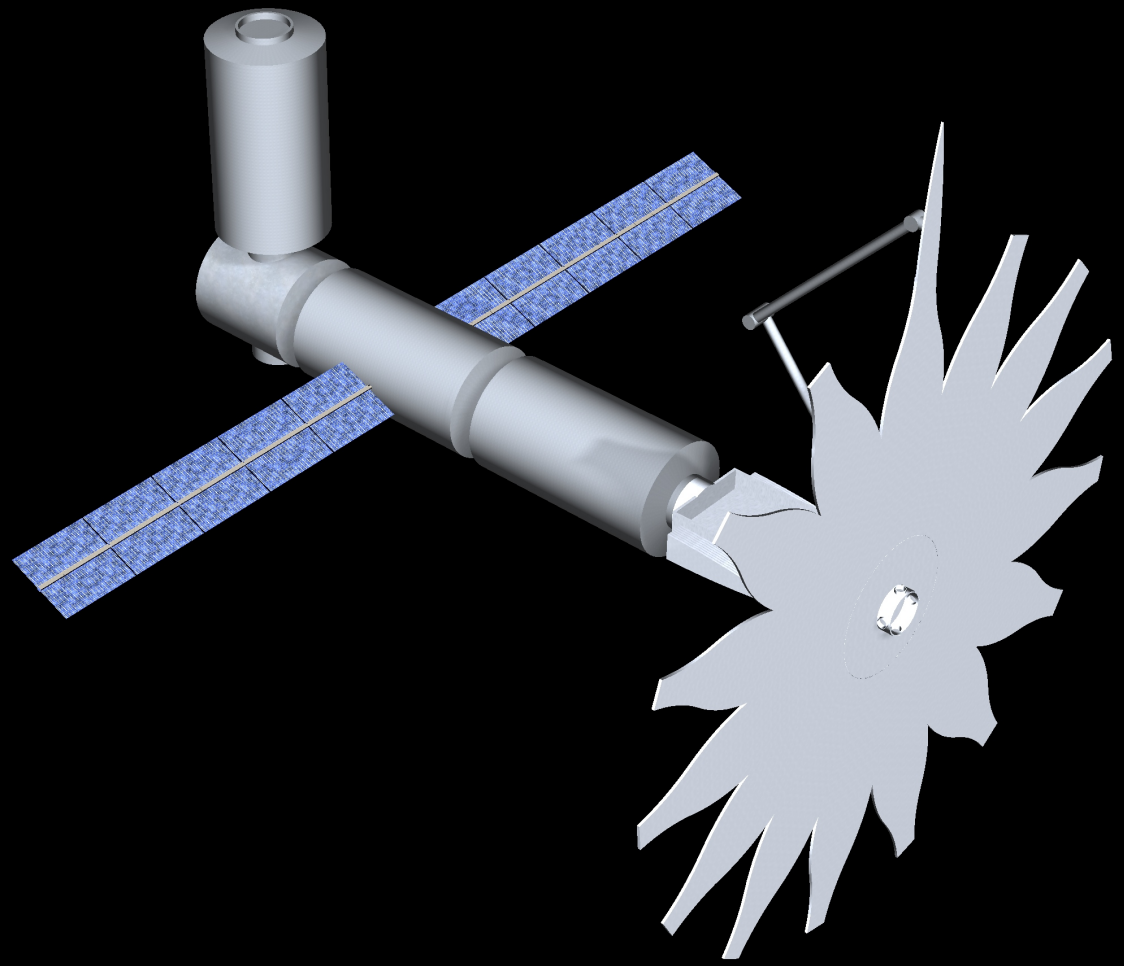
Pedals Complete



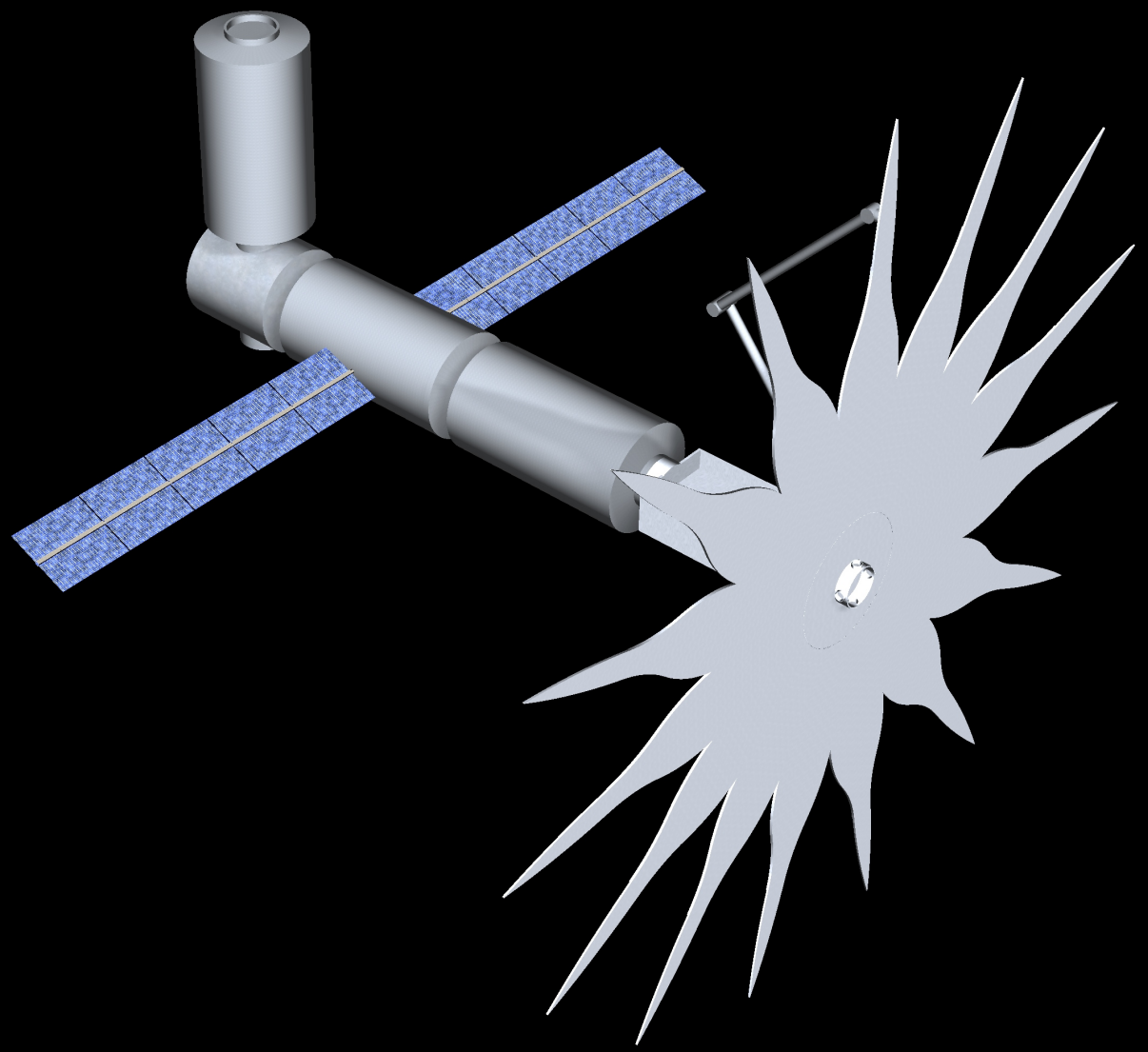
Third Ring Tip Move



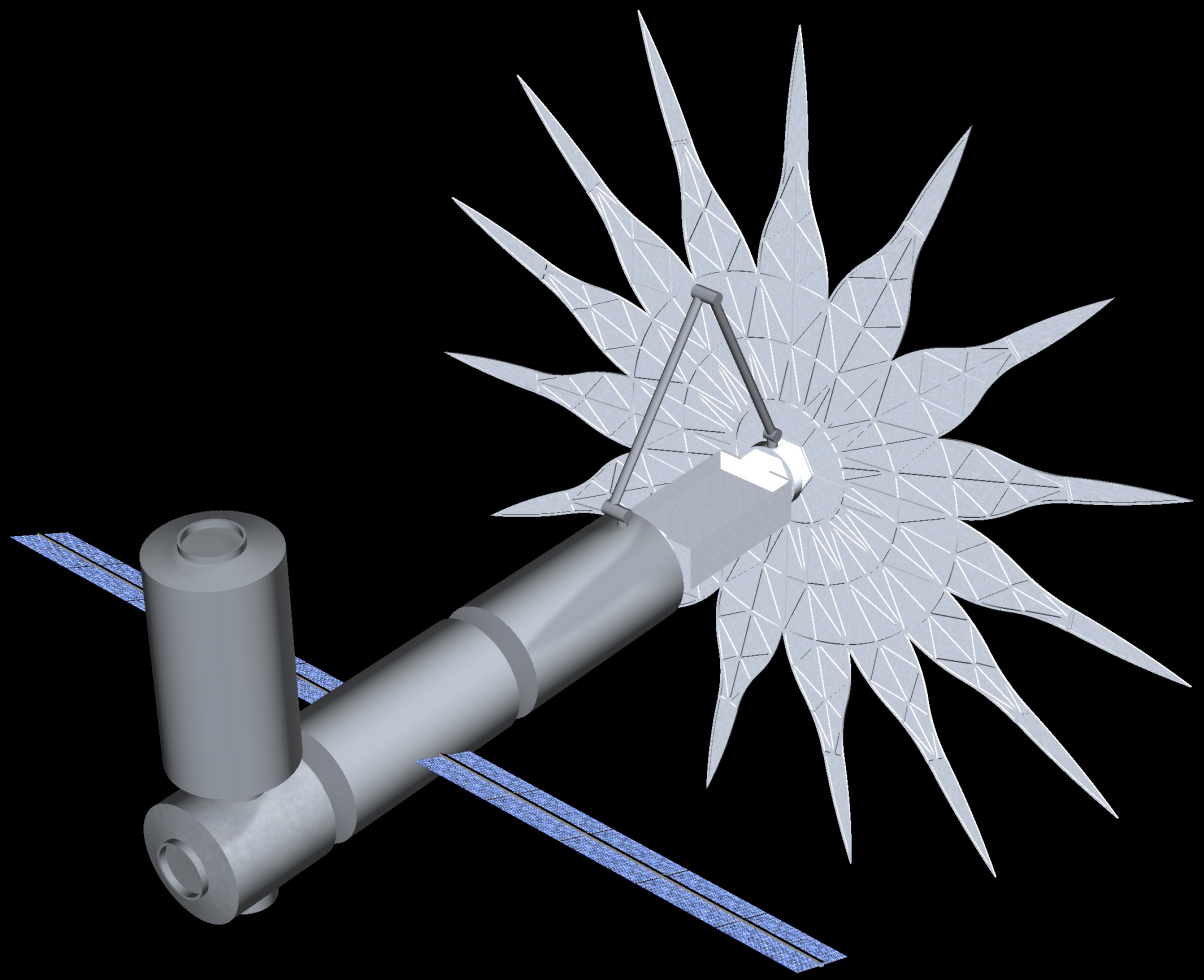
Tip Place



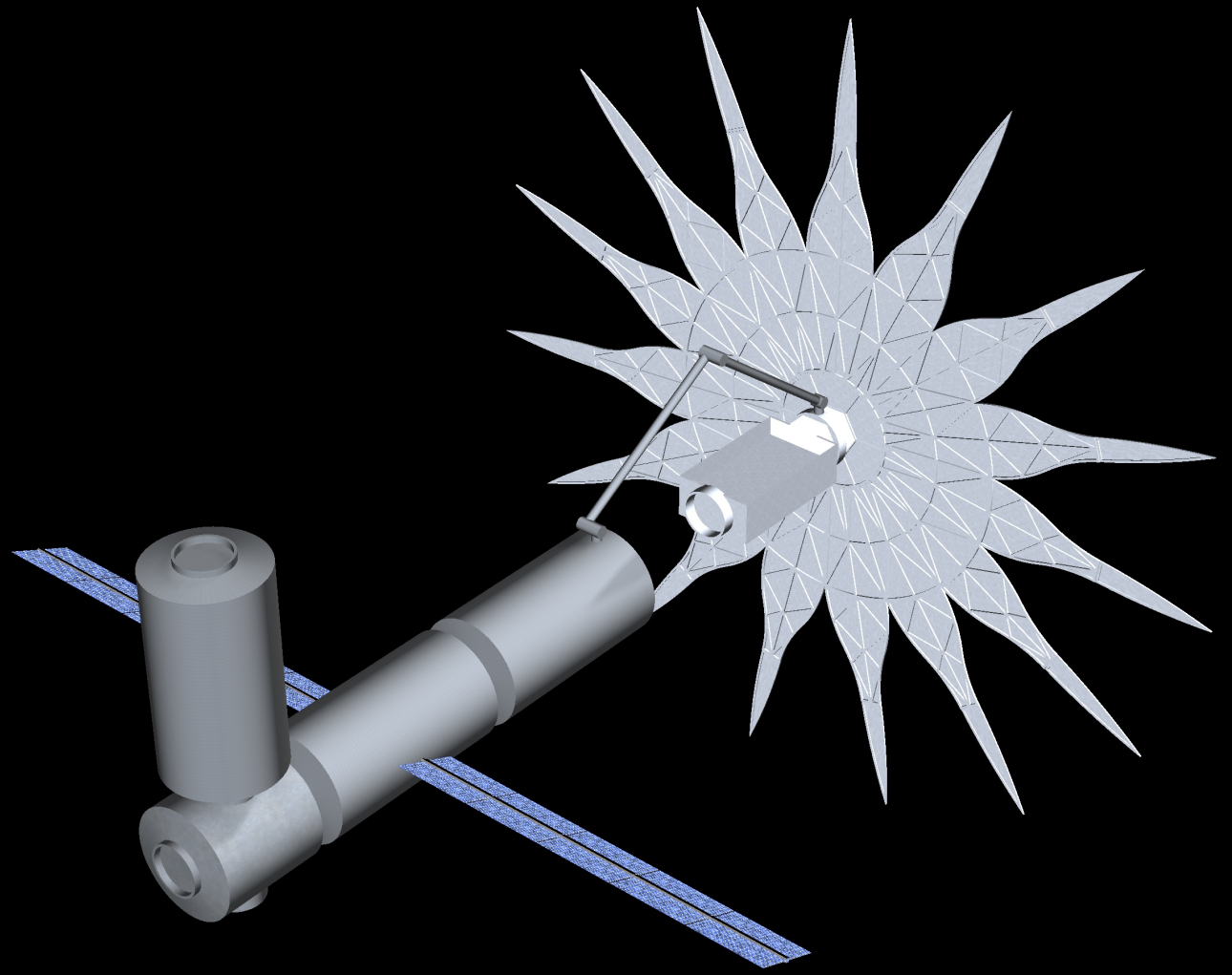
Tips Complete



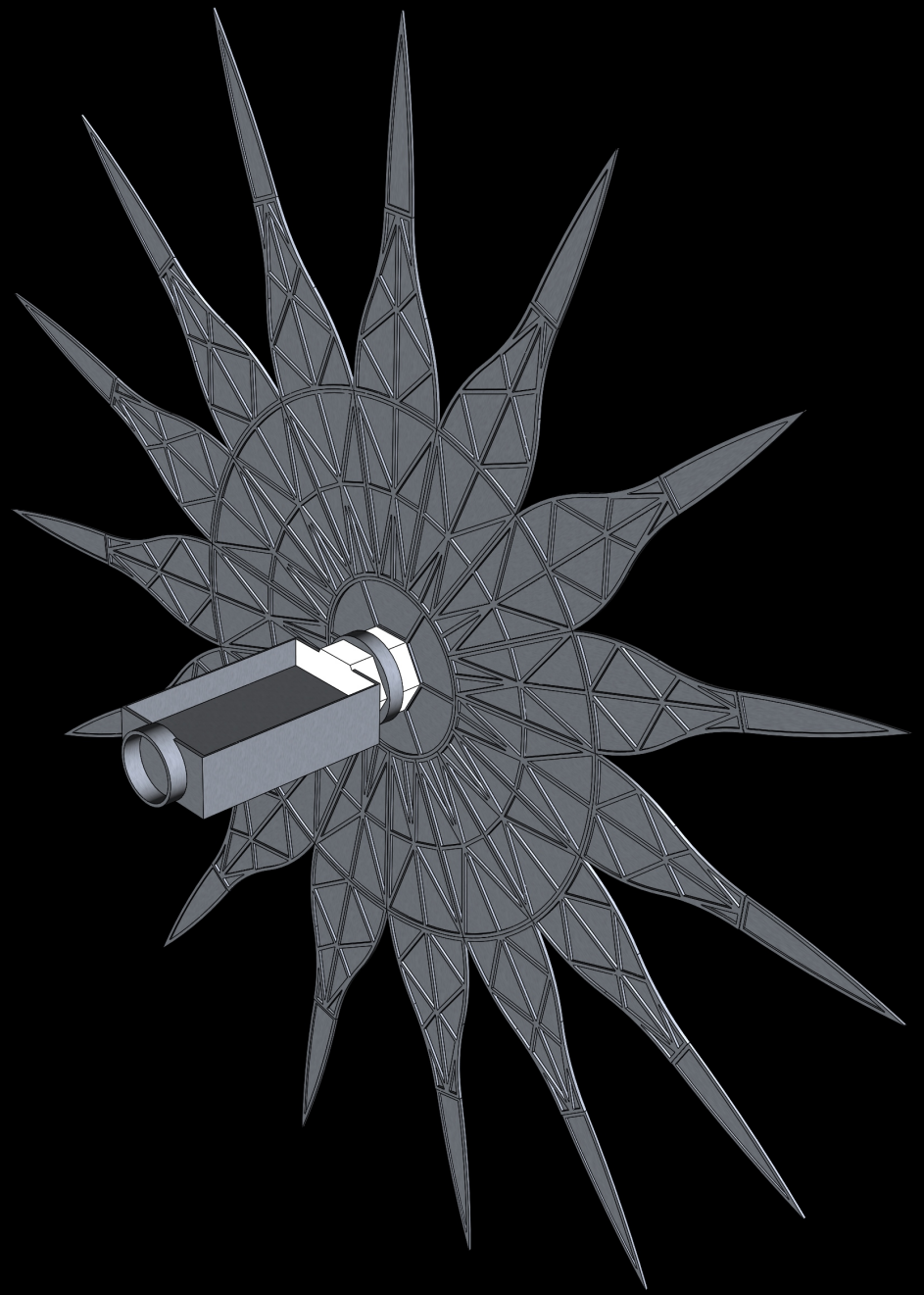
Stow Robotic Arm



Unberth



Deployed



Advantages of Assembly at DSG

- Starshade completely assembled and validated on Earth, match drilled to maintain tolerances
- Material (Carbon fiber rib-reinforced face sheet) strong, light and stiff
- Assembly removes risk and complexity of deployments that cannot be tested in 1-g
- Lower Cost (excluding DSG)
- DSG orbit is amenable to low delta-V transfer to Earth-Sun L2 orbit (~10's m/s)

imagine the moment...

References and Status of Work in this Field

https://exoplanets.nasa.gov/

https://exoplanets.nasa.gov/exep/technology/in-space-assembly

In-Space Servicing and Assembly

Our Vision: ***Enable NASA to realize the capabilities of assembling and servicing future spacecraft in space to solve the deepest scientific mysteries of the Cosmos.***

Instrument Function Statement and Gateway Usage

STATEMENT	INSTRUMENT/CONCEPT DETAILS
FUNCTION STATEMENT Use of the Deep Space Gateway as a platform for robotic assembly of a Starshade. Makes use of telerobotic capabilities and potential astronaut intervention for construction of a starshade from modular components delivered on the starshade spacecraft.	A spacecraft containing the component pieces of the starshade is delivered to the DSG and docked to the International Docking Adapter. The DSG robotic arm is then used to assemble the starshade structure, previously assembled and validated on the ground before disassembly for launch. After assembly the spacecraft departs for deep space to work in tandem with a space telescope.
WHY IS THE GATEWAY THE OPTIMAL FACILITY FOR THIS INSTRUMENT/RESEARCH? The Deep Space Gateway offers the infrastructure to enable the assembly of a 30m+ starshade. The DSG orbit then allows a low delta-V transfer to the target location in deep space near Earth-Sun L2	The DSG offers all the infrastructure required, and a desirable orbit to assemble the starshade. LEO/GTO are not suitable. Without the DSG the telerobotics would be be required to be carried by the starshade spacecraft for assembly. Using the DSG eliminates the need for the infrastructure costs significantly reducing costs.

Basic Instrument Parameters

PARAMETER	INSTRUMENT ESTIMATE & ANY COMMENTS
MASS (KG)	<1000kg (only temporarily mounted to DSG before deployment)
VOLUME (M)	Externally mounted to international docking adapter
POWER (W)	Self powered by solar arrays with option for 400W keep alive power
THERMAL REQUIREMENTS	No active thermal required. May have pointing requirements for passive thermal
DAILY DATA VOLUME	self contained telemetry
CURRENT TRL	TRL 3-6 depending on subsystem method
WAG COST & BASIS	~>$250M based on similarity analysis (WAG), not including launch
DURATION OF EXPERIMENT	5 days
OTHER PARAMETERS	Requires ~10m robotic arm 6-7 DOF

Instrument Gateway Usage

USAGE	INSTRUMENT REQUIREMENTS & COMMENTS
ORBIT CONSIDERATIONS	Any
FIELD OF VIEW REQUIREMENTS	none
REQUIRES USE OF AIRLOCK	no
CREW INTERACTION REQUIRED?	crew robotics optional, ground telerobotic control required
WILL ASTRONAUT PRESENCE BE DISRUPTIVE?	no
DOES THE INSTRUMENT PRESENT A RISK TO THE CREW	no
OTHER CONSUMABLES REQUIRED	none
SPECIAL SAMPLE HANDLING REQUIREMENTS	no
NEED FOR TELEROBOTICS?	yes
OTHER REQUIREMNTS OF THE GATEWAY?	Arm End Effector Custom Tool (already on ISS)