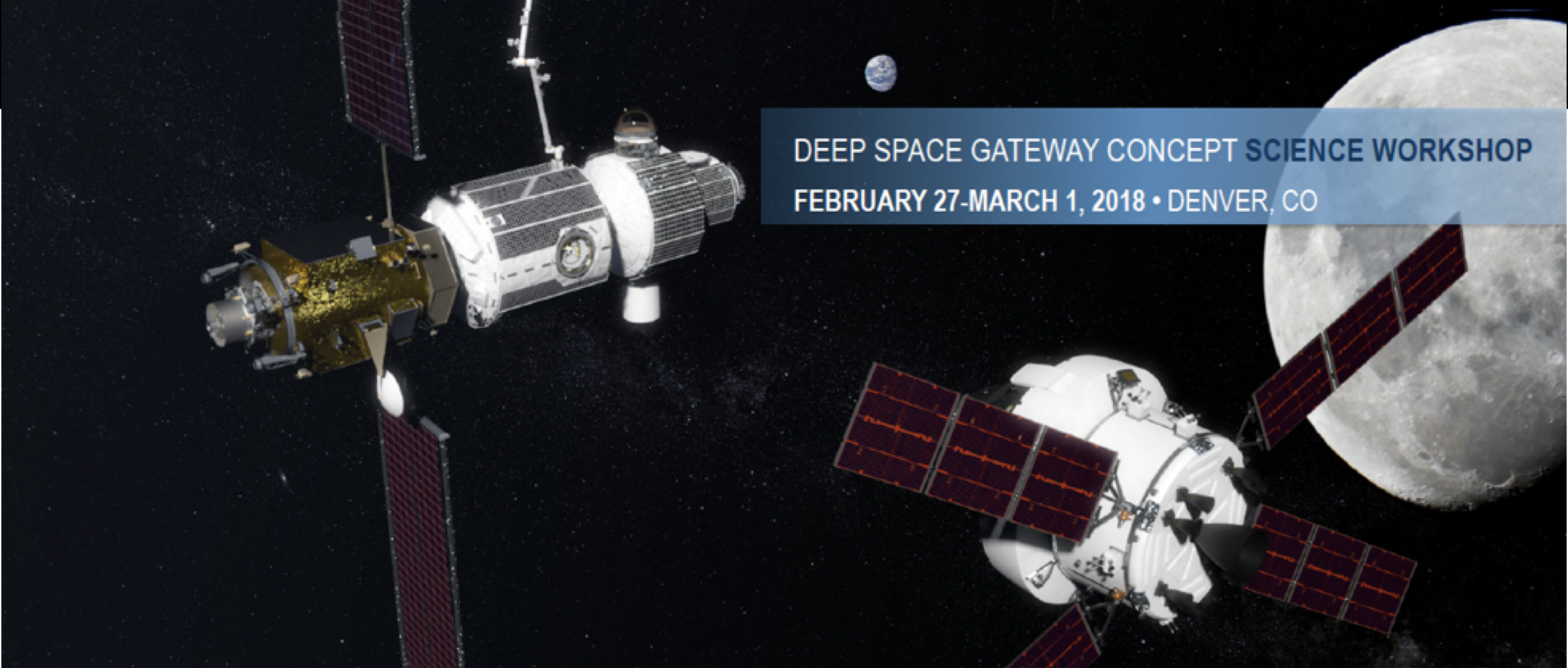


In-Space Servicing and Assembly: Infrastructure Needs

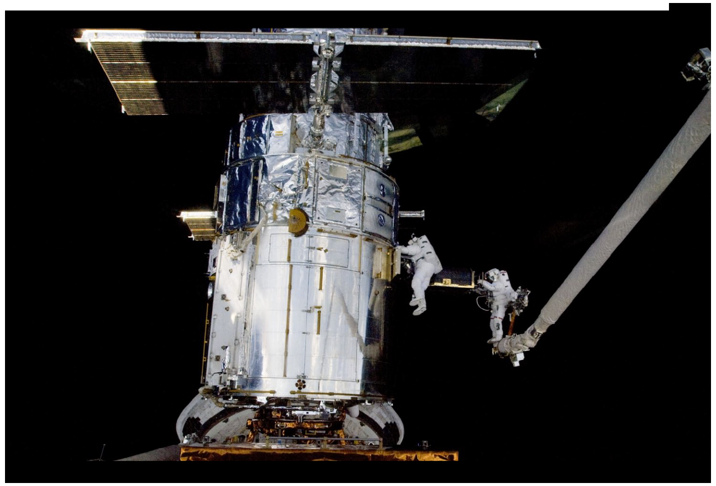
St. David's Day, 2018

Harley Thronson, Senior Scientist for Advanced Astrophysics Mission Concepts,
NASA Goddard Space Flight Center

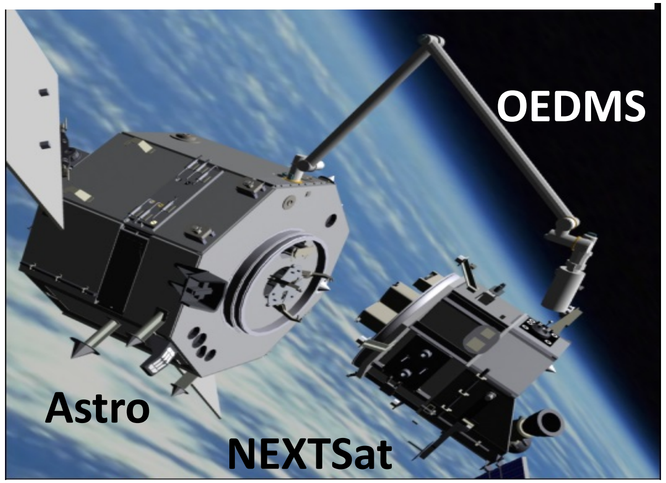
Space Servicing: Required by Congress for most of a Decade

Purely robotic servicing activities are accelerating with government and commercial involvement. This seems likely to be a capability available without DSG.

NASA - HST

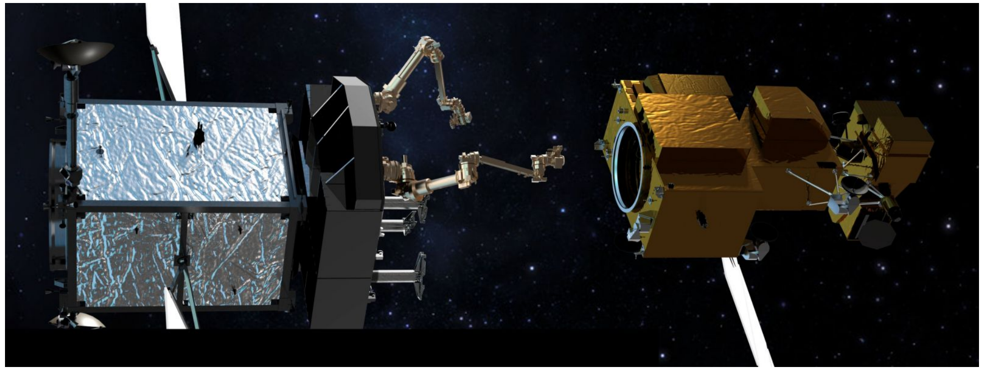


DARPA - Orbital Express

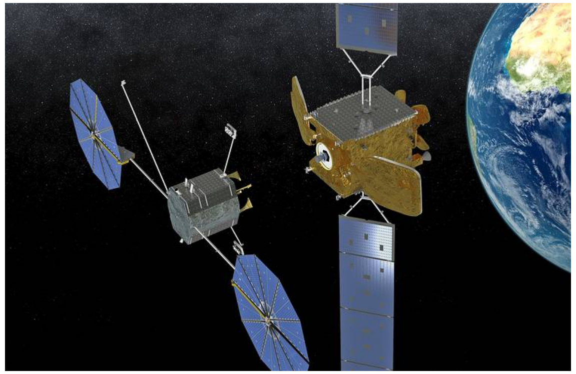


DARPA/SSL - Robotic Servicing of Geosynchronous Satellites

NASA - RESTORE-L



Orbital ATK - Mission Extension Vehicle

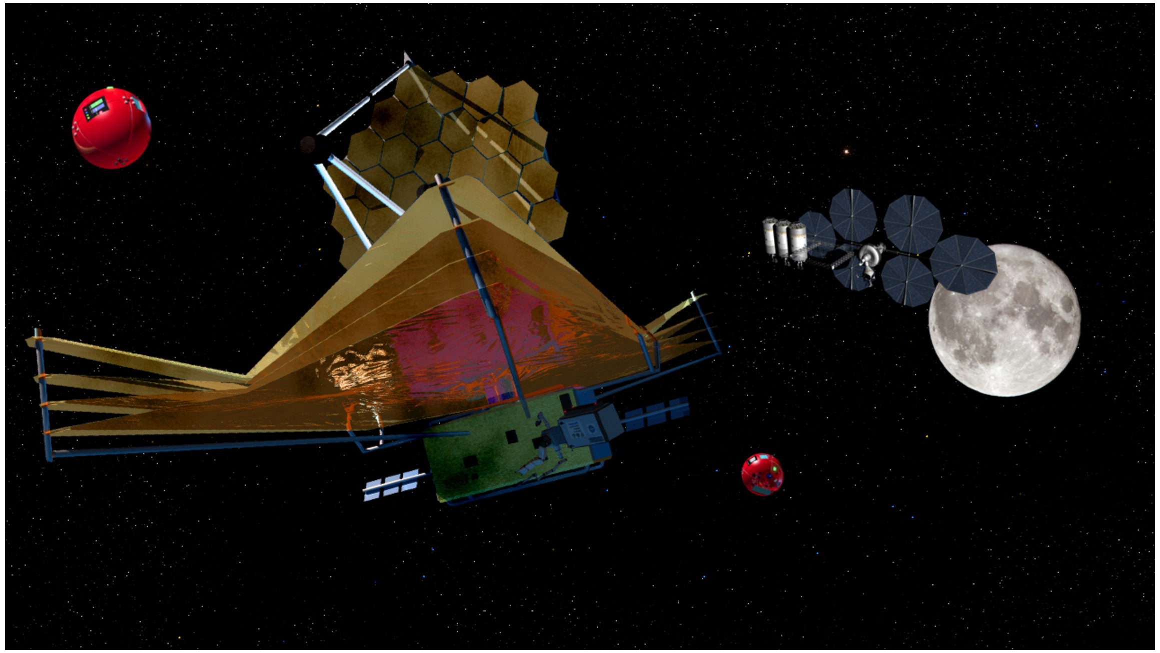


Servicing with DSG Available Offers Multiple Advantages

Even with future advanced robotics, the availability of a DSG – with or without astronauts – offers considerable advantages.

Advantages of a DSG

- Astronauts on site to supervise and/or for contingent EVA
- High data-rate comm
- Multiple imaging systems, especially for detailed inspection
- Aggregation site for replacement units, fuel
- On-site repair, if possible
- On-site manufacturing TBD

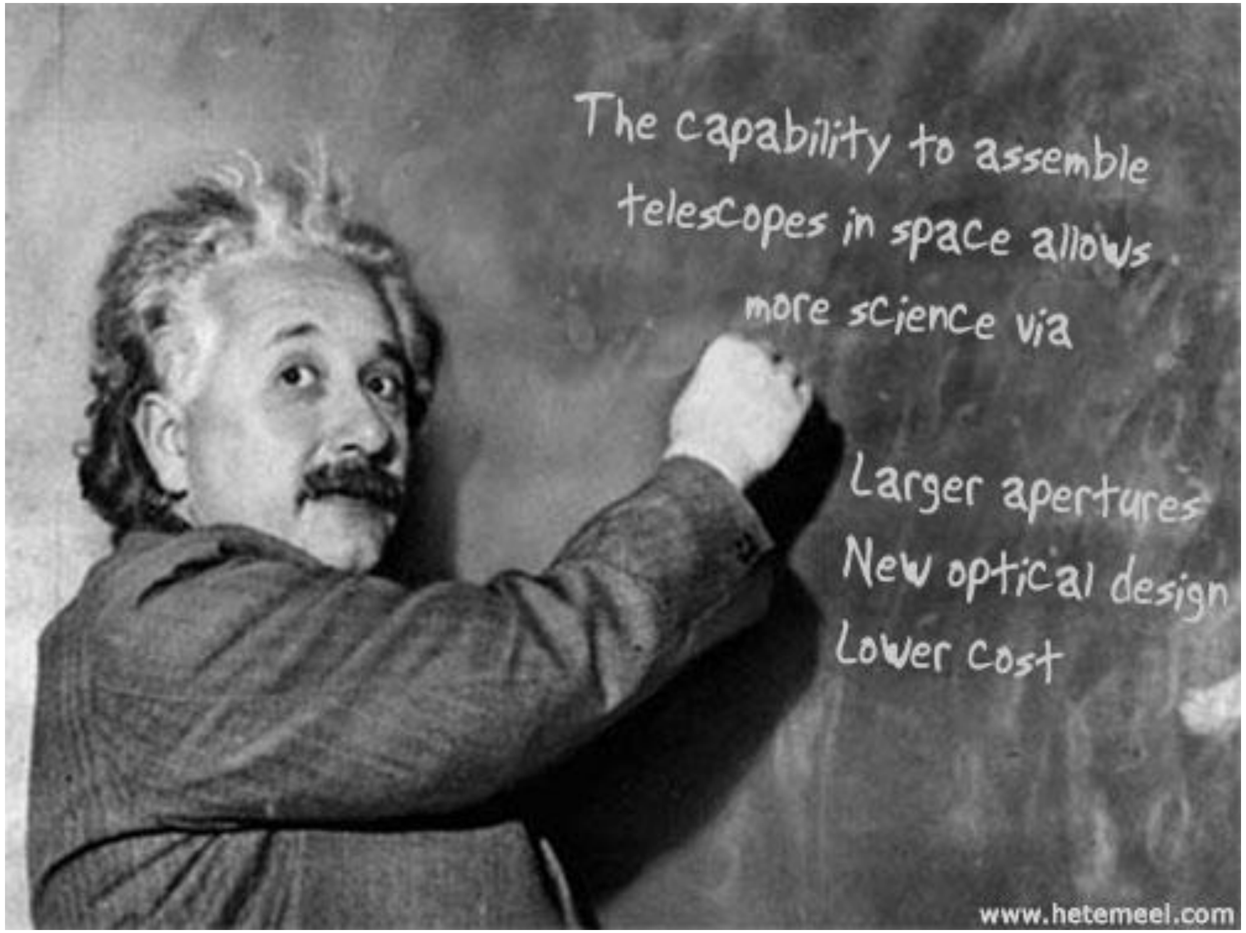


"Flagship" observatory, accompanied by escort-bots, returns to EM L2 Gateway for instrument upgrade.
[Credit: Future In-Space Operations Working Group (2008)]

DSG Requirements

- Airlock, EVA suits, etc.
- High-data rate systems
- Stereo, multi-band, and microscopic imaging systems
- Berthing points for replacement units
- Rendezvous, approach, and proximity operations capabilities [Docking TBD]
- Telerobots and operations systems
- Test and repair equipment in a small volume? May be sent to DSG in advance of rendezvous

Assembly in Space: An Inevitable Future for Space Astronomy



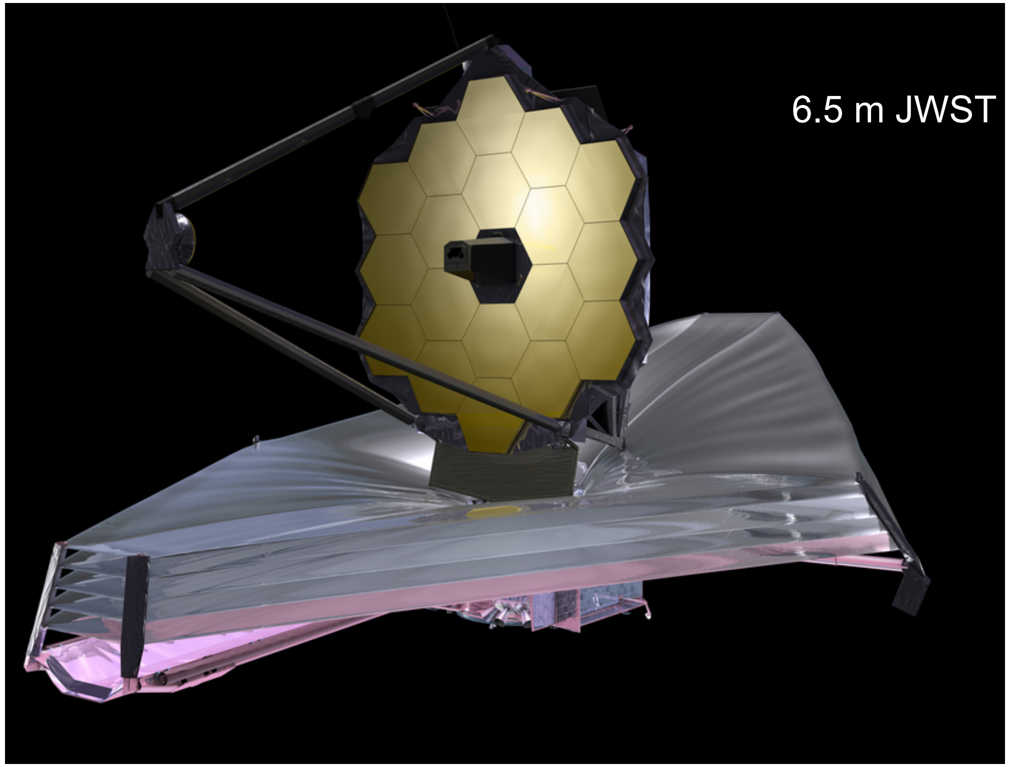
Telescopes larger than those currently under early consideration almost certainly will require space assembly.

Even before that time is reached, space assembly should be evaluated as insurance in the event that "all up" launch and autonomous self-deployment is not feasible or cost-effective.

Current Conundrum: Telescope Diameter Currently Limited by LV

Since science performance depends upon telescope diameter as $D^2 \Rightarrow D^4$, science results in the current design paradigm are fundamentally limited by LV fairing.

JWST in Ariane 5 (4.6 m fairing)



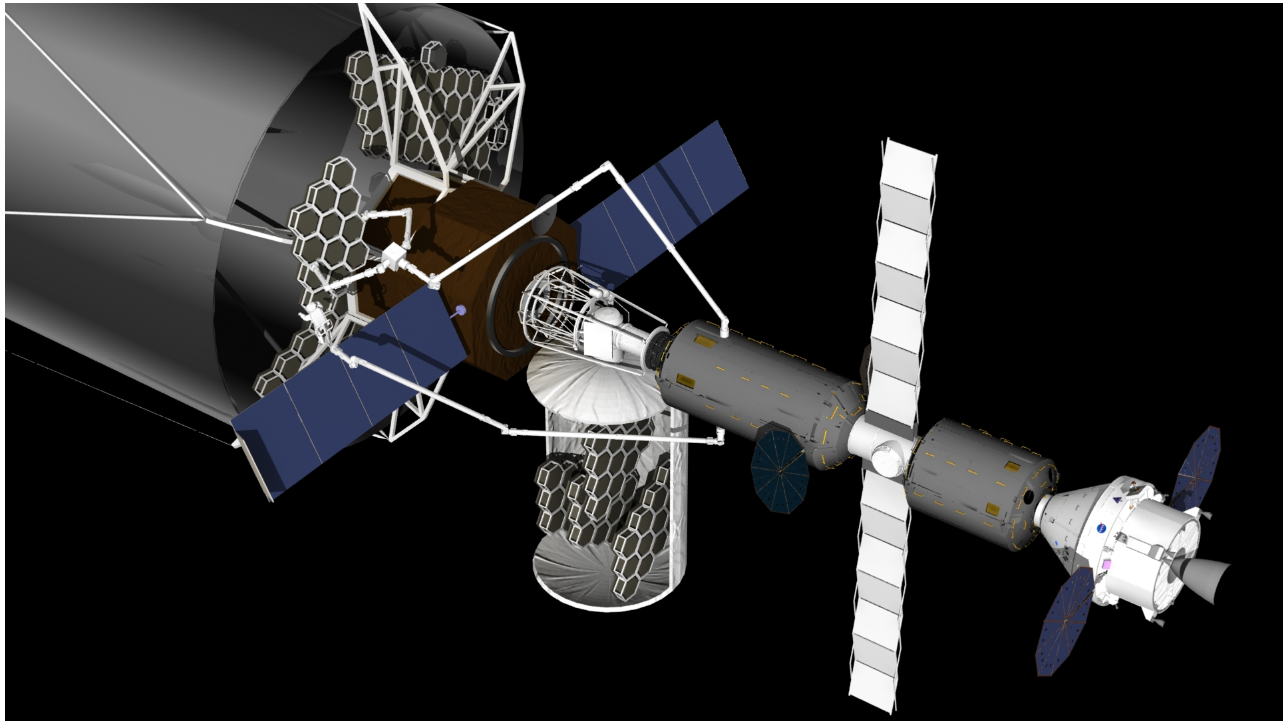
Falcon Heavy (5.2 m fairing) – 9 m telescope
SLS Block I (8 m fairing) – 12 m telescope
SLS Block II (10 m fairing) – 15 m telescope
? – ≥ 20 m telescope

Notional Capability Needs of the Gateway for Space Assembly

Rendezvous and proximity operations (docked during assembly; not docked during servicing)

Autonomous and dexterous external robotic arms capable of assembling and servicing

Birthing points for unpressurized containers for telescope elements



Gateway-based assembly of 20+ meter telescope
[Credit: NASA GSFC (ca. 2012)]

Telerobotic operations from both Earth and the DSG

Astronaut EVAs

Defined power, propulsion, attitude control

Quiescent environment

Extensive photogrammetry capabilities

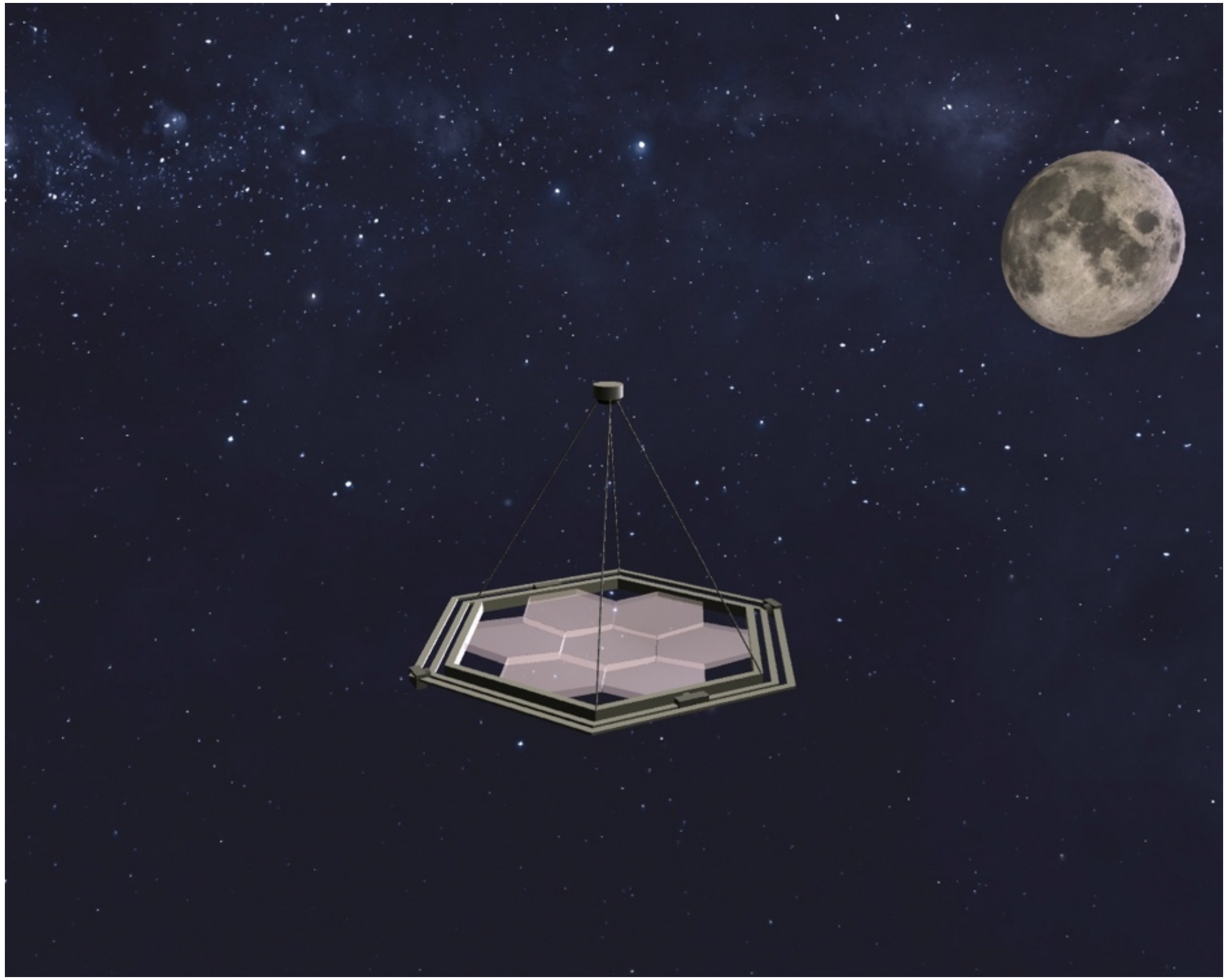
In-Space Manufacturing: A Unique Optical System Design

Unique, modular design

- Optical/Near-Infrared
- Telescope array with ultra light-weight ~5 m unit telescopes
- Modular design with *few unique elements*
- Multi-order Diffractive Optical Element: Engineered Material Lenses (MOD-EML)
- High image quality with nearly achromatic images
- Option: MOD-EML molded in space from low melting point glass

Capabilities

- 40 telescopes, each with 7x light-collecting power of the Hubble Space Telescope
- Equivalent to light-collecting power of 26 m telescope



A Single Module in Orbit
[Daniel Apai *et alia* at this workshop]

Servicing and/or Assembly: Notional Priority Cross-Cutting Capabilities

Top Three Cross-Cutting Capabilities Required for Servicing and/or Assembly

Astronauts on site with EVA capability (only contingency?)

Telerobotics from the DSG and Earth

Rendezvous and proximity operations (including inspection). Docking TBD

Current Space Servicing & Assembly Studies, Presentations, and Archives

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

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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.***

Above: Concepts for servicing and in-space assembly of future large space telescopes. Left: Deep Space cis-Lunar Gateway (NASA). Center: Polidan et al (2016) Evolvable Space Telescope. Right: Lee et al. (2016)

Welcome to the NASA Exoplanet Exploration Program's in-Space Servicing & Assembly (iSSA) website. We are actively exploring the benefits of assembling future large telescopes in space rather than autonomously deploying them. One day NASA will want to launch a telescope or interferometer whose size and/or mass exceeds the launch capability of our largest rockets. Additionally, the deployment schemes may be very complicated and perhaps carry too much risk of something going wrong. In those cases, assembling these structures in space will be the

In-Space Servicing and Assembly Technical Interchange Meeting Nov 1-3, 2017

View Summary PDF

Links

NASA GSFC Satellite Servicing Projects Division

Decadal Planning Team HSF + science architecture based on cis-lunar Gateway (1999 – 2001): https://history.nasa.gov/DPT/DPT.htm
FISO working group & seminars: Gateway-based servicing, assembly, lunar exploration (2007 – present): http://fiso.spiritastro.net/archivelist.htm
Galveston Workshop on Human Capabilities and Operations in Cis-Lunar Space (2011): https://www.nasa.gov/pdf/603258main_Scimemi-Findings-Cis-lunar-space-workshop.pdf