In-Space Assembled Telescope (iSAT) Study

Nick Siegler
Chief Technologist
NASA Exoplanet Exploration Program
Jet Propulsion Laboratory/California Institute of Technology

AAS Seattle
January 9, 2019

Exoplanet Science Strategy Report

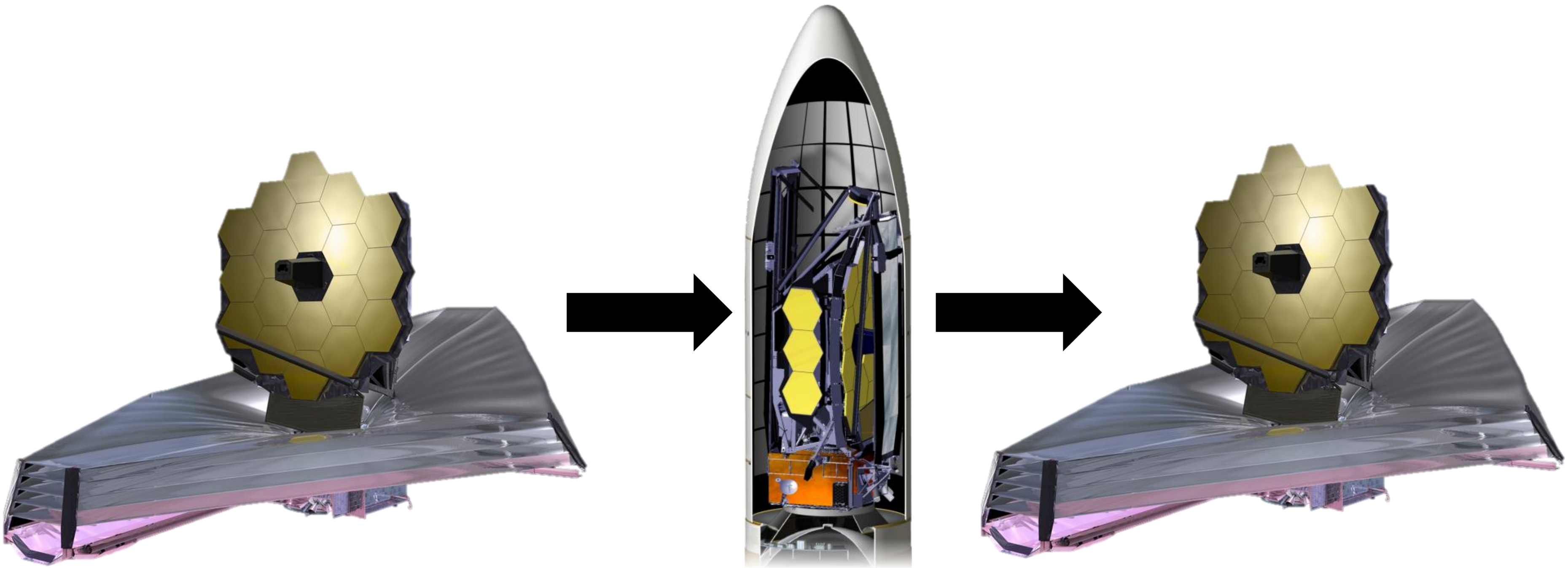
Released September 5, 2018 by the National Academies

Recommendation #1:

NASA should lead a large strategic direct imaging mission capable of measuring the reflected-light spectra of temperate terrestrial planets orbiting Sun-like stars.

David Charbonneau (Harvard)   Scott Gaudi (Ohio State University)

The Current Paradigm



volume and mass constraints

- **Currently, no existing rockets to fly an 8 m segmented telescope**
  - Not even a 4 m monolith
  - Launch vehicles are in the works by NASA, SpaceX, and Blue Origins

$$$

- 40 deployable structures
- 178 release mechanisms

Study Objective:

- ***When is it worth assembling space telescopes in space rather than building them on the Earth and deploying them autonomously from single launch vehicles?***

Deliverables:

A whitepaper by June 2019 assessing:

1. When is iSA an **enabling** capability? *(i.e. only viable approach)*
2. When is iSA an **enhancing** capability*? (i.e. cheaper or lower risk with respect to traditional launch vehicle deployment)*

Is iSA enhancing? Lots of anecdotal support:

- Eliminate complex folding and deployment operations
- Drastically reduce mass constraints and heavy light-weighted designs; can use simpler FEM models
- Reduce need for ruggedizing the system and its interfaces to survive launch environment (*design for operational env't instead)*
- Reduce need for new and unique ground test facilities
- Reduce need for a large standing army during I&T
- Leverage existing and less-costly medium-lift launch vehicles
- Does not require next-generation launch vehicles
- Launch failure need not be equivalent to mission failure

iSAT Study Activities

Activity 1: **Select a reference telescope mission concept**

Activity 2: **Estimate the costs and assess the risks of the concept**

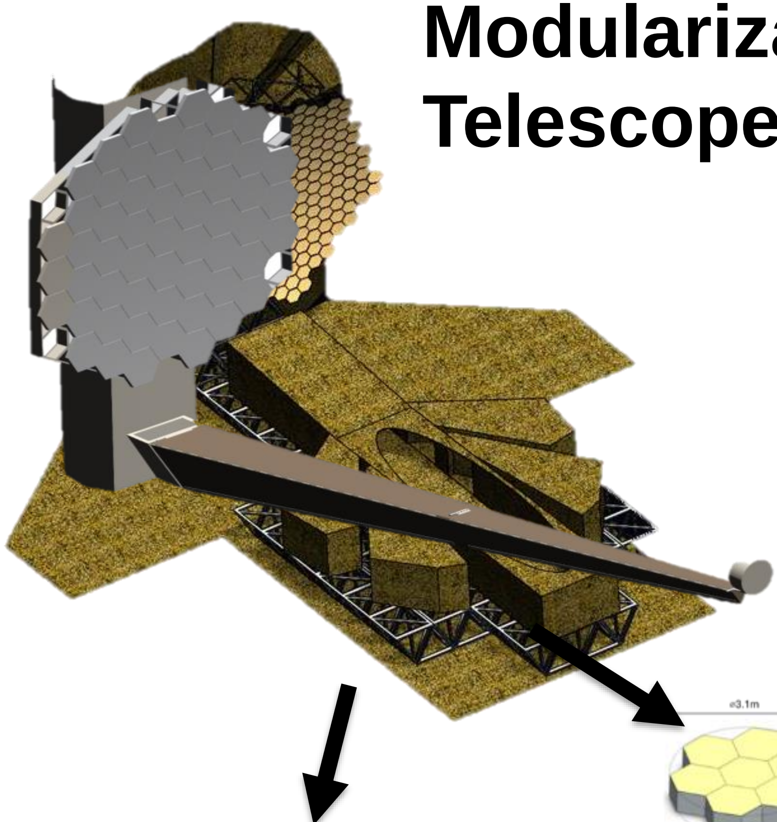
Study Participants

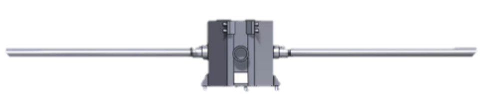
Name	Institution	Expertise
1. Ali Azizi	NASA JPL	Metrology
2. Gary Matthews	Consultant	Mirror Segments
3. Larry Dewell	Lockheed	Pointing/Stability/Control
4. Oscar Salazar	NASA JPL	Pointing/Stability/Control
5. Phil Stahl	NASA MSFC	Telescope Architecture
6. Jon Arenberg	Northrop	Telescope Architecture
7. Doug McGuffey	NASA GSFC	Systems Engineering
8. Kim Aaron	NASA JPL	Systems Eng/Structures
9. Bill Doggett	NASA LaRC	Robotics
10. Al Tadros	SSL	Robotics
11. Bob Hellekson	Orbital-A	
12. Gordon Roesler	DARPA	
13. Eric Mamajek	NASA ExE	
14. Shanti Rao	NASA JPL	
15. Ray Ohl	NASA GSF	
16. Sergio Pellegrino	Caltech	
17. Tere Smith	NASA JPL	
18. Paul Backes	NASA JPL	
19. Jim Breckinridge	UA	
20. Allison Barto	Ball	
21. Joe Parrish	DARPA	
22 Dave Redding	NASA JPL	Telescopes
23. David Stubbs	Lockheed	Telescope Structures/Design
24. John Dorsey	NASA LaRC	Telescope Structures
25. Jeff Sokol	Ball	Mechanical/I&T
26. Brendan Crill	NASA ExEP	Technologist/Detectors
27. Dave Miller	MIT	Technologist
28. Atif Qureshi	SSL	Robotics Systems Engineering
29. Jason Tumlinson	STScI	Astrophysicist
30. Carlton Peters	NASA GSFC	Thermal
31. Paul Lightsey	Ball	Systems Engineering
32. Kim Mehalick	NASA GSFC	Optical Modeling/I&T
33. Bo Naasz	NASA GSFC	Systems Engineering
34. Eric Sunada	NASA JPL	Thermal
35. Keith Havey	Harris	Telescopes

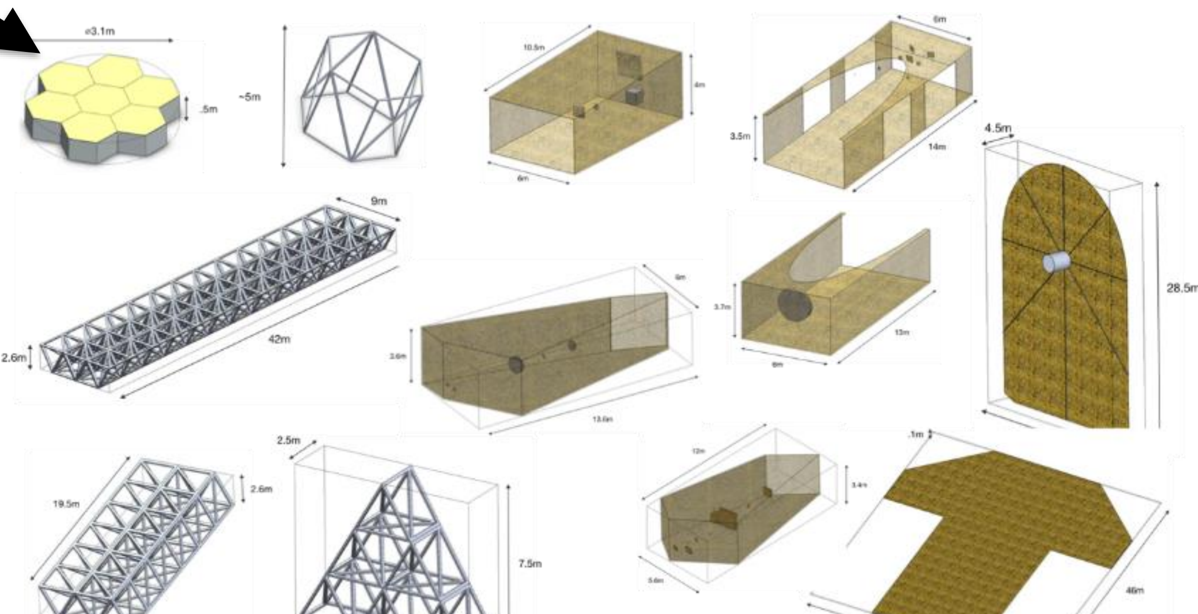
- **73 individuals**
- **6 NASA Centers**
- **14 private companies**
- **4 gov't agencies**
- **5 universities**

36. Lynn Allen	Harris	Optics
37. Ben Reed	NASA GSFC	Robotic Servicing
38. Scott Knight	Ball	Optics
39. Jason Hermann	Honeybee	Robotics
40. John Lymer	SSL	Robotics
41. Glen Henshaw	NRL	Robotics
42. Gordon Roesler	ex-DARPA	Robotic Assembly
43. Rudra Mukherjee	NASA JPL	Robotics
44. Mike Renner	DARPA	Robotics
45. Mike Fuller	Orbital-ATL	Robotics/Gateway
46. Ken Ruta	NASA JSC	Robotics
47. Kim Hambuchen	NASA JSC	Robotics
48. Dave Miller	MIT	System Assembly
49. Joe Pitman	Sensor Co	Structures
elvin	NASA STMD	Structures
hupe	LMC	Gateway
Jeffries	NASA LaRC	Systems Eng
lsperman	Boeing	Gateway
olta	NASA GSFC	Orbital Dynamicist
Vhitley	NASA JSC	Orbital Dynamicist
ange	NASA JSC	RPO
odgers	NASA OCT	Programmatic
owman	NASA LaRC	Programmatic
runsfeld	ex-NASA	Astronaut
60. Alison Nordt	LMC	Programmatic
61. Hosh Ishikawa	NRO	Programmatic
62. Kevin Foley	Boeing	Programmatic
63. Richard Erwin	USAF	Programmatic
64. Bill Vincent	NRL	Programmatic
65. Diana Calero	KSC	Launch Vehicles
66. Brad Peterson	OSU	Astrophysicist
67. Kevin DiMarzio	Made in Space	Fabrication
68. Matt Greenhouse	NASA GSFC	Astrophysicist
69. Max Fagin	Made in Space	Fabrication
70. Bobby Biggs	LMC	Fabrication
71. Alex Ignatiev	U Houston	Coatings
72. Rob Hoyt	Tethers	Fabrication
73. Scott Rohrbach	NASA GSFC	Scattered Light

Modularization of a 20 m Space Telescope







Picture Credit:
R. Mukherjee et. al., 2018

Any 5 m Fairing Size Rocket

Two currently existing in the US

ULA's Delta IV Heavy

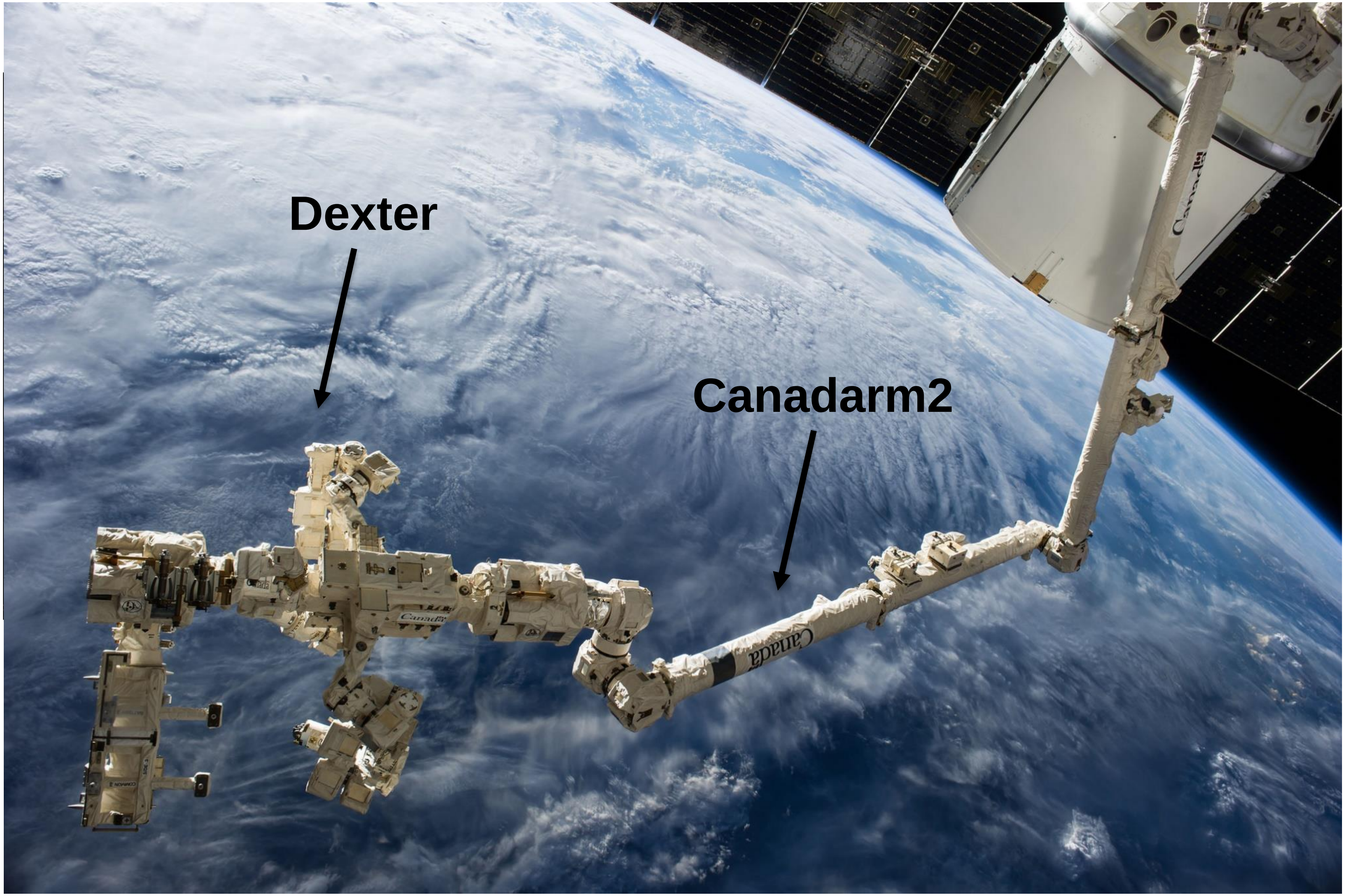
Photo: United Launch Alliance

SpaceX's Falcon Heavy

Photo: SpaceX

Long-Reach Robotic Arms

Mounted on the spacecraft bus, a separate module, or on the telescope



Long-Reach Robotic Arms

Mounted on the spacecraft bus, a separate module, or on the telescope

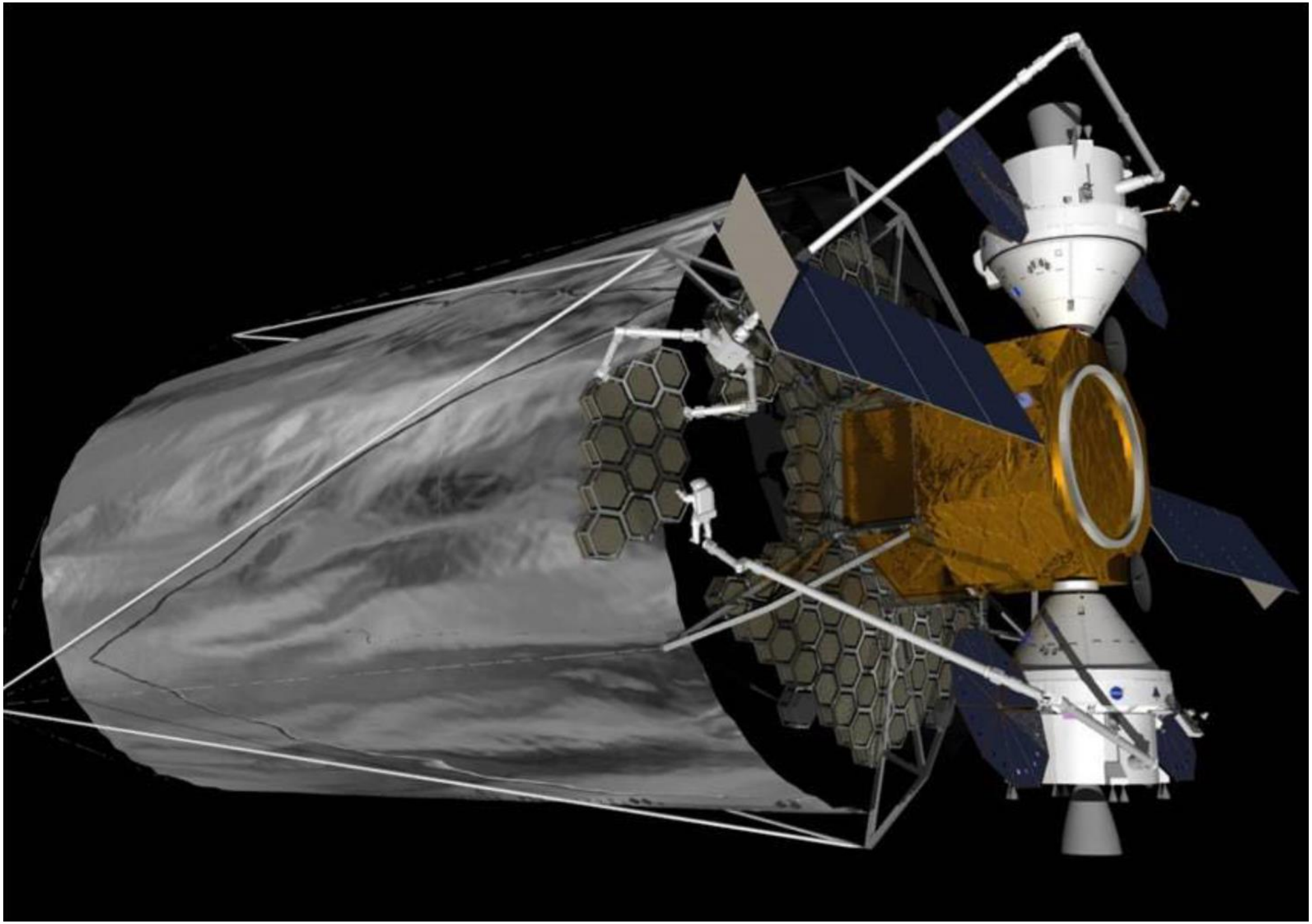


Illustration: NASA

Orbit Trade: Cislunar vs Sun-Earth L2

Cislunar

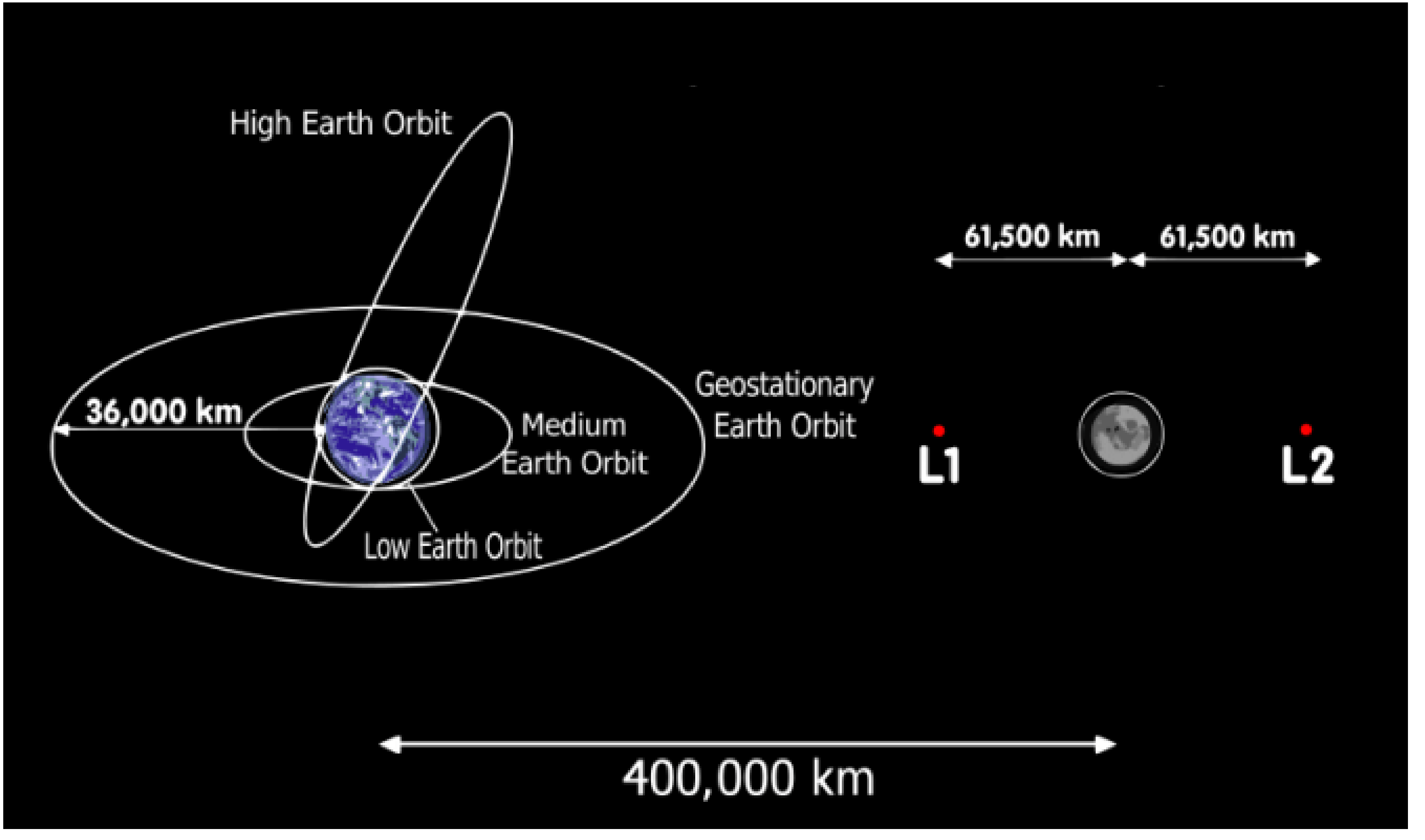


Illustration: NASA

Orbit Trade: Cislunar vs Sun-Earth L2

Sun-Earth L2

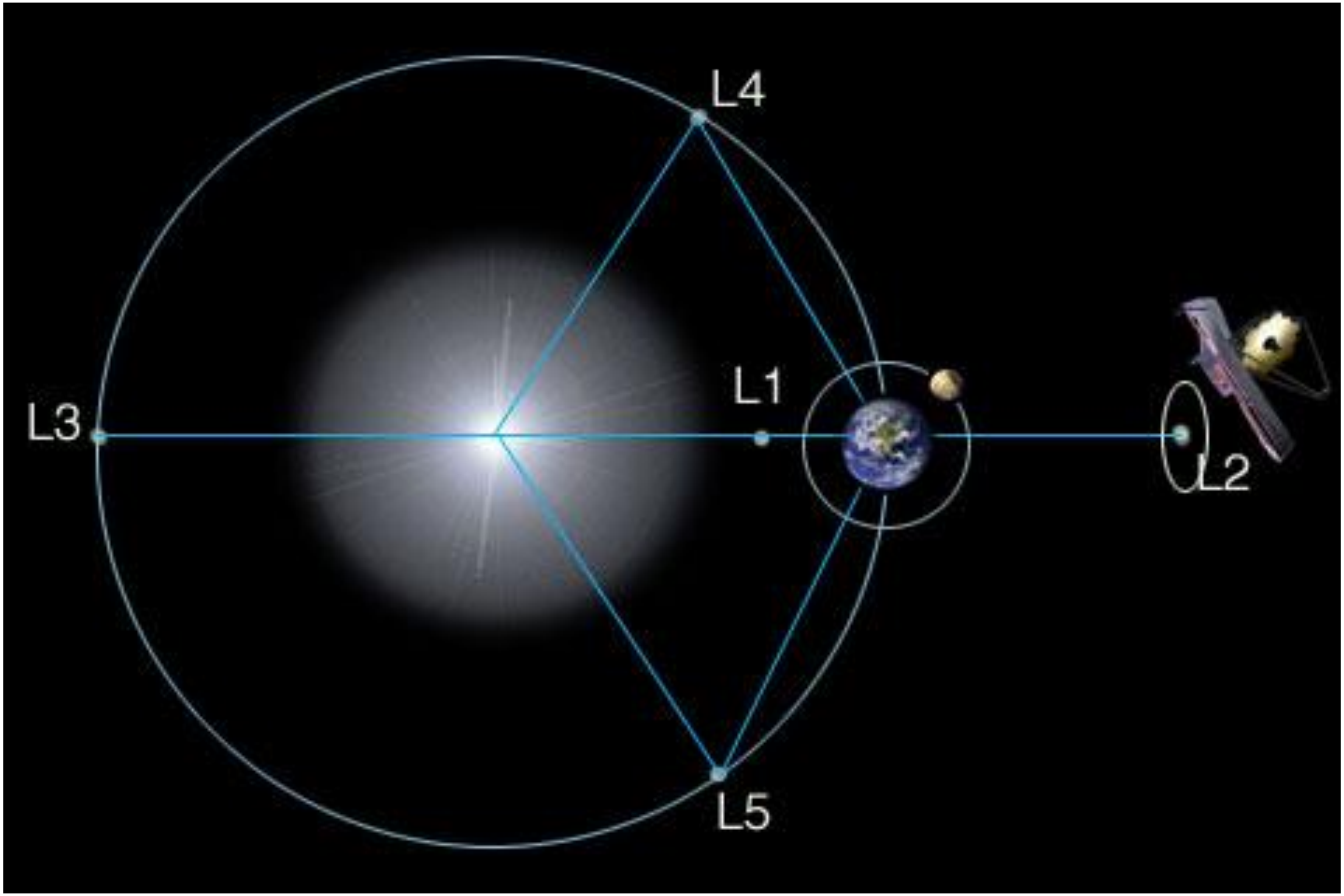


Illustration: NASA

Costing activities underway

iSAT Website

NASA in-Space Assembled Telescope (iSAT) Study

NASA in-Space Assembled Telescope (iSAT) Study | Steering Committee | Study Workshops and F2F Meetings | Study Member Telecons

Large aperture telescopes benefit all astrophysics as well as planetary and Earth science. They provide unprecedented spatial resolution, spectral coverage, and signal to noise, advancing all of these science areas. Envisioning the need for future large segmented telescopes to one day exceed the fairing size of existing or even planned launch vehicles, NASA will need to begin considering the in-space assembly (iSA) of these future assets. In addition, robotically assembling space telescopes in space rather than deploying them from single launch vehicles offers the possibility, in some circumstances, of reduced cost and risk for even smaller telescopes. This possibility, however, has not been proven. Therefore, following discussions within NASA's Science Mission Directorate (SMD) and Astrophysics Division (APD), the SMD Chief Technologist and APD Division Director have commissioned a study to assess the cost and risk benefits, if any, of the iSA of space telescopes.

Study Leads:

- Nick Siegler, NASA JPL
- Harley Thronson, NASA GSFC
- Rudra Mukherjee, NASA JPL

Study Documents:

- iSAT Charter
- iSAT Assumptions and Initial Conditions (in process)

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

Jet Propulsion Laboratory
California Institute of Technology