Jet Propulsion Laboratory
California Institute of Technology

# In-Space Assembled Telescope (iSAT)

## Steering Committee Telecon 2

**May 16, 2018**

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NASA Jet Propulsion Laboratory, California Institute of Technology

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# Today's Agenda

1. Update on Study activities
2. New Steering Committee and Study Members added
3. Review of Study's Initial Conditions and Assumptions
4. Review Workshop Agenda
5. Review Schedule
6. Next Steps
7. Open Discussion

*But first, any general questions?*

# Role of the Steering Committee

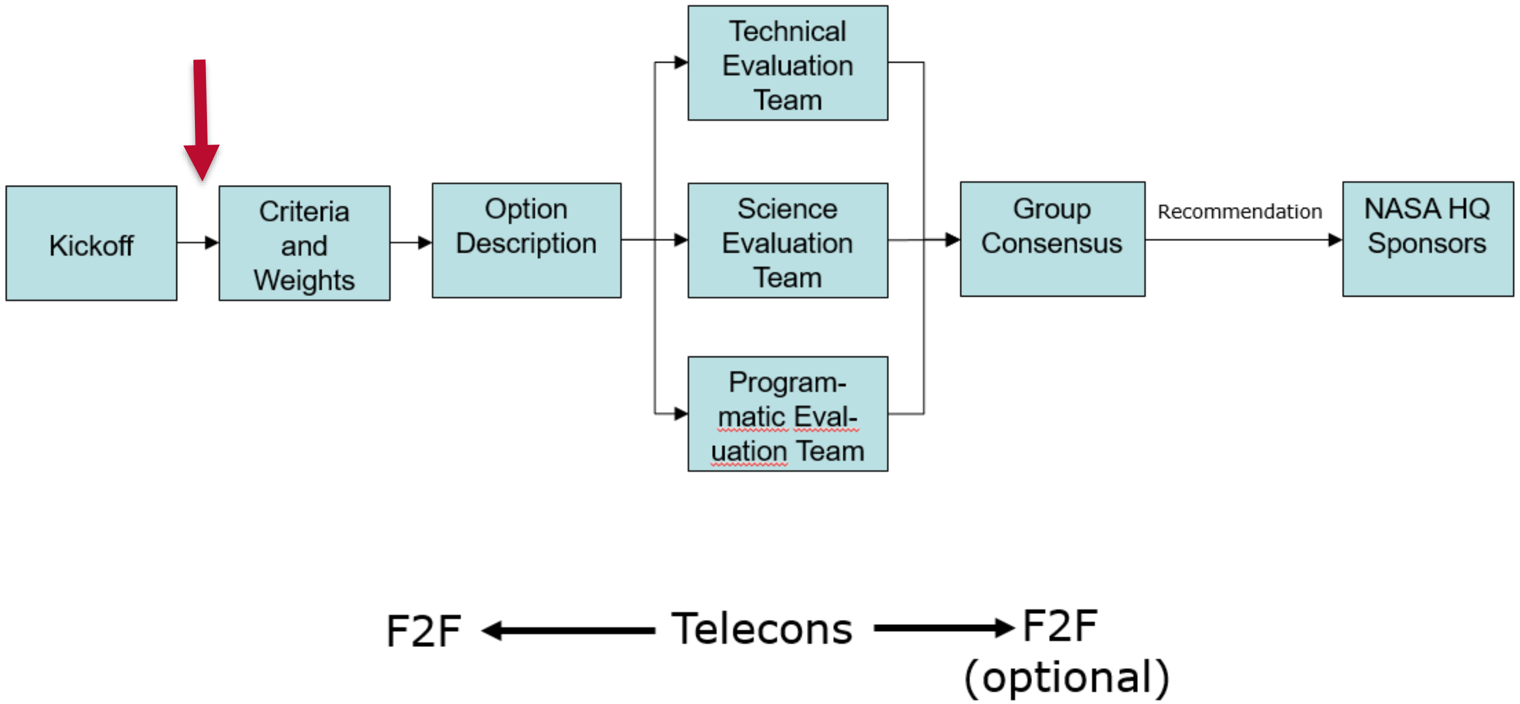
1. **Recommend membership in the Study Working Group**
   – Ensuring they are well represented in terms of expertise.

2. **Advise the Study Leads, providing feedback at key junctions of the Study regarding its progress and direction in moving the work forward.**

3. **Provide input regarding the Study's Assumptions and Initial Conditions.**

# Update on Study Activities

# iSAT Study Process



# Last Week's Next Steps

- **Kick-Off Telecon with the entire Working Group**
  - Monday and Tuesday (5/7 and 5/8)

- **Subsequent Telecons with the entire Working Group**
  - Bi-weekly cadence
  - Advancing work

**5/17, 5/18, 5/22, 5/24**

- **First Face-to-Face Workshop for the Working Group**
  - June 5-7 at Caltech
  - Focus is on Activity 1a: Designing and Architecting a Modularized Telescope
  - Draft Agenda completed being sent out today
  - Breakout sessions

**On track**

New website

# NASA in-Space Assembled Telescope (iSAT) Study

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.

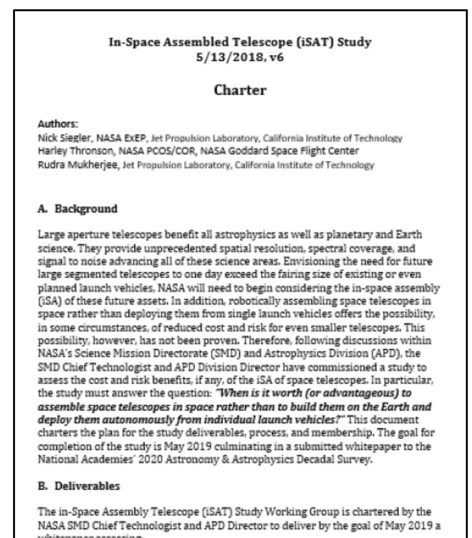
**Study Leads:**

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

**Study Documents:**

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

Charter matured (out for signature)



**In-Space Assembled Telescope (iSAT) Study**
**5/13/2018, v6**

**Charter**

Authors:
Nick Siegler, NASA ExEP, Jet Propulsion Laboratory, California Institute of Technology
Harley Thronson, NASA PCOS/COR, NASA Goddard Space Flight Center
Rudra Mukherjee, Jet Propulsion Laboratory, California Institute of Technology

**A. Background**

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. In particular, the study must answer the question: ***"When is it worth (or advantageous) to assemble space telescopes in space rather than to build them on the Earth and deploy them autonomously from individual launch vehicles?"*** This document charters the plan for the study deliverables, process, and membership. The goal for completion of the study is May 2019 culminating in a submitted whitepaper to the National Academies' 2020 Astronomy & Astrophysics Decadal Survey.

**B. Deliverables**

The in-Space Assembly Telescope (iSAT) Study Working Group is chartered by the NASA SMD Chief Technologist and APD Director to deliver by the goal of May 2019 a whitepaper assessing:

# KISS Think Tank

# New Participants

# A New Addition to the Steering Committee

**Steering Committee**

| | | | |
|---|---|---|---|
| 1. | Dave Redding | NASA JPL | Study Member (mirrors, WFSC) |
| 2. | Joe Pitman | consultant | Study Member (opto-mech struct) |
| 3. | Scott Knight | Ball | Study Member (optical design) |
| 4. | Bill Doggett | NASA LaRC | Study Member (telescope struct) |
| 5. | Matt Greenhouse | NASA GSFC | Study Member (astrophysicist) |
| 6. | Joanne Hill-Kittle | NASA GSFC | |
| 7. | Ron Polidan | consultant | Study Member (telescopes) |
| 8. | John Grunsfeld | NASA (ret) | |
| 9. | Keith Belvin | NASA STMD | |
| 10. | Brad Peterson | STScI/OSU | Study Member (astrophysicist) |
| 11. | Florence Tan | NASA SMD | |
| 12. | Ray Bell | Lockheed | Study Member (telescope systems) |
| 13. | Nasser Barghouty | NASA APD | |
| 14. | Eric Smith | NASA JWST/APD | |
| 15. | Keith Warfield | NASA ExEP | Study Member (systems) |

# New Additions to the Study Members

| Name | Institution | Expertise |
|---|---|---|
| 1. TBD | NASA JPL | Metrology |
| 2. Gary Matthews | Consultant | Mirror Segments |
| 3. Fang Shi | NASA JPL | WF Sensing/Control |
| 4. Larry Dewell | Lockheed | Pointing/Stability/Control |
| 5. Oscar Salazar | NASA JPL | Pointing/Stability/Control |
| 6. Phil Stahl | NASA MSFC | Telescope Architecture |
| 7. Jon Arenberg | Northrop | Telescope Architecture |
| 8. Doug McGuffey | NASA GSFC | Systems Engineering |
| 9. Kim Aaron | NASA JPL | Systems Eng/Structures |
| 10. Sharon Jeffries | NASA LaRC | Systems Engineering |
| 11. Al Tadros | SSL | Robotics |
| 12. Joel Burdick | Caltech | Robotics |
| 13. Bob Hellekson | Orbital-ATK | Telescope Systems |
| 14. Gordon Roesler | DARPA | Robotics |
| 15. Michael Rodgers | ASA JPL | Optical Design |
| 16. Hsiao Smith | NASA GSFC | Robotics |
| 17. Eric Mamajek | NASA ExEP | Astrophysicist |
| 18. Shanti Rao | NASA JPL | Optical Design |
| 19. Ray Ohl | NASA GSFC | Optical Alignment/Test |
| 20. Joe Howard | NASA GSFC | Optical Design |
| 21. Sergio Pellegrino | Caltech | Telescope Structures |
| 22. Cal Ablanalp | Harris | Telescope Design |
| 23. Tere Smith | NASA JPL | I&T |
| 24. Paul Backes | NASA JPL | Robotics |
| 25. Jim Breckenridge | UA | Optical Design |
| 26. AllisonBarto | Ball | Optical SE/testing |
| 27. Jeanette Domber | Ball | SE/Structures/Instruments |
| 28. Joe Parrish | DARPA | Robotics |

| Name | Institution | Expertise |
|---|---|---|
| 29. Acey Herrera | NASA GSFC | I&T |
| 30. David Stubbs | Lockheed | Telescope Structures/Design |
| 31. John Dorsey | NASA LaRC | Telescope Structures |
| 32. David Yanatis | Harris | Optical Systems |
| 33. Jeff Sokol | Ball | Mechanical/I&T |
| 34. Brendan Crill | NASA ExEP | Technologist/Detectors |
| 35. Dave Miller | MIT | Technologist |
| 36. Atif Qureshi | SSL | Robotics Systems Engineering |
| 37. Jason Tumlinson | STScI | Astrophysicist |
| 38. Carlton Peters | NASA GSFC | Thermal |
| 39. Paul Lightsey | Ball | Systems Engineering |
| 40. Kim Mehalick | NASA GSFC | Optical Modeling/I&T |

# Initial Conditions and Assumptions

# Study Initial Conditions

- We need to select a reference telescope that we can use to explore the benefits of iSA (cost, risk, opportunities enabled).
  - *Size, operating wavelength, aperture, operational temperature, etc.*
  - *“Parameterizable”*
- So it doesn’t matter which telescope is selected as long as we don’t select one that is very unlikely or atypical.
- And we don’t want to design the telescope in this Study.
- Hence the need for Initial Conditions:

1. 20-meter, filled-aperture, non-cryogenic telescope operating at UV/V/NIR
   a. *We will examine parameterized designs so that we can also explore smaller apertures*
2. Off-axis secondary mirror (to assist coronagraph throughput and performance)
3. A high-contrast coronagraph will be the observatory instrument tasked to directly image and spectrally characterize Earth-sized planets. The coronagraph will have the capability to actively sense and control input light wavefront errors due to all reasonable disturbance sources.
4. f/(>2) to reduce polarization effects to coronagraph performance
5. Operational destination is Sun-Earth L2

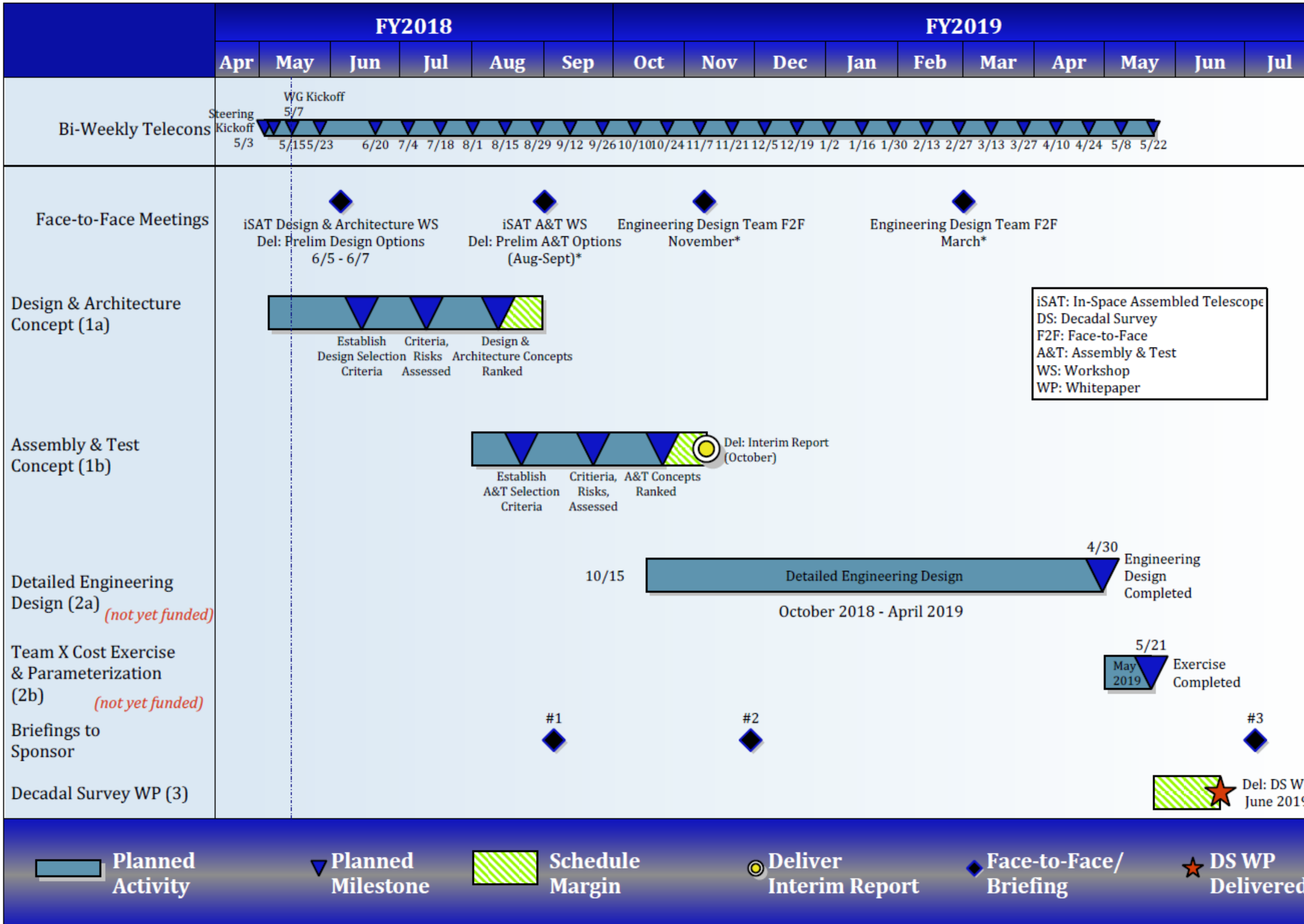
# Study Assumptions

1. Science goals developed from LUVOIR/HabEx concept studies
2. Telescope structure and wavefront error stability requirements associated with coronagraphy of Earth-sized planets will work to the requirements: 10s of pm wavefront error stability over time periods of ~ 10 minutes.
    - This assumption is to keep the focus of this Study on iSA and associated aspects of space activities such as I&T, V&V, robotics, robotic platform, orbit, launch vehicles, and delta-V transfer among assembly and operations orbits
3. Robotic assembly system is a donated asset
4. Astronaut-enabled assembly/servicing to be considered as time and resources permit
5. ISS is available until 2025 (TBD)
6. The following planned missions can be assumed but each will carry its own level of risk if assumed:
    - DARPA's RSGS (Robotic Servicing & Geosynchronous Satellites) at GEO (contract with SSL already in place)
    - NASA's Lunar-Orbital Platform - Gateway at cis-Lunar
    - Orbital-ATK's Mission Extension Vehicle (MEV) at GEO (contracts already in place)
    - NASA's Restore-L at LEO
    - Or other assets to be brought up

# Agenda

https://exoplanets.nasa.gov/internal_resources/865

# Study Schedule




*tentative date

# Next Steps

- **Telecons with the entire Working Group**
  - This week and next week
  - Agreeing on reference telescope
  - Advancing Selection Criteria

| Decision Statement | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | | | | *Option 1* | | *Option 2* | | *Option 3* | |
| | *Feature 1* | | | | | | | | |
| | *Feature 2* | | | | | | | | |
| | *Feature 3* | | | | | | | | |
| **Evaluation** | **Musts** | | | | | | | | |
| | *M1* | | | ✔ | | ✔ | | ✔ | |
| | *M2* | | | ✔ | | **?** | | **?** | |
| | *M3* | | | ✔ | | ✔ | | ✗ | |
| | **Wants** | *Weights* | | | | | | | |
| | *W1* | *w1%* | | *Rel score* | | *Rel score* | | *Rel score* | |
| | *W2* | *w2%* | | *Rel score* | | *Rel score* | | *Rel score* | |
| | *W3* | *w3%* | | *Rel score* | | *Rel score* | | *Rel score* | |
| | | *100%* | Wt sum => | *Score 1* | | *Score 2* | | *Score 3* | |
| | **Risks** | | | C | L | C | L | C | L |
| | *Risk 1* | | | M | L | M | L | | |
| | *Risk 2* | | | H | H | M | M | | |
| **Final Decision, Accounting for Risks** | | | | | | | | | |
| C = Consequence, L = Likelihood | | | | | | | | | |

# Next Steps

- **First Face-to-Face Workshop for the Working Group**
  - June 5-7 at Caltech
  - Focus is on Activity 1a: Designing and Architecting a Modularized Telescope
  - Draft Agenda completed being sent out today
  - Breakout sessions

# Open Discussion

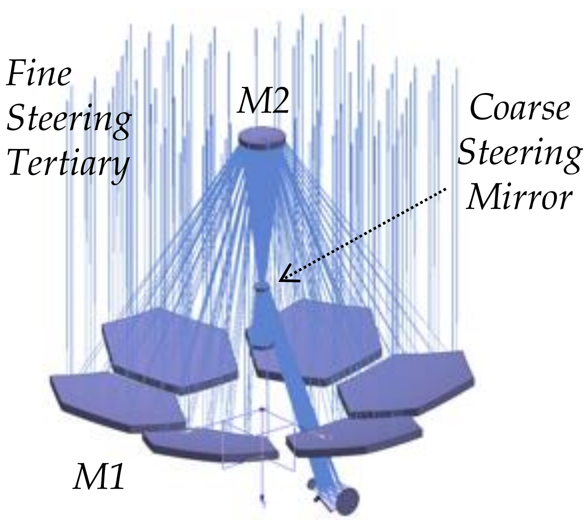
# Additional Slides

# Activity 1a

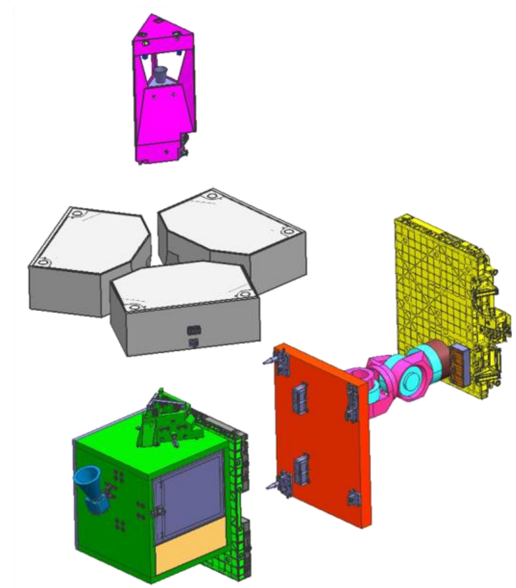
# Concept Design and Architecture for the iSAT

**Select a reference <u>design and architecture</u> concept for a 20 m, filled aperture, non-cryogenic space telescope to be assembled and tested in space.**

- Paradigm shift in architecture: Modularization
- An example, from the 2012 OpTIIX study (NASA JSC/GSFC/JPL/STScI):



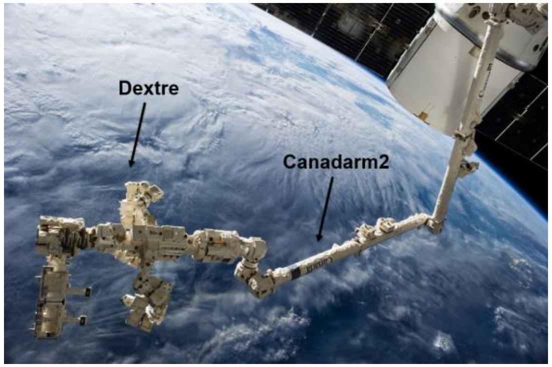

**3 Mirror Anastigmat Telescope (1.45 m aperture)**

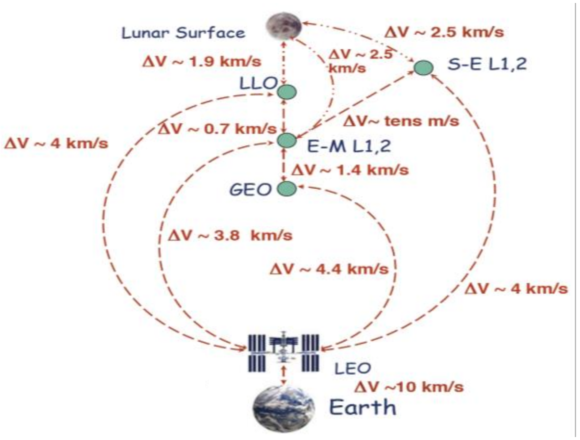


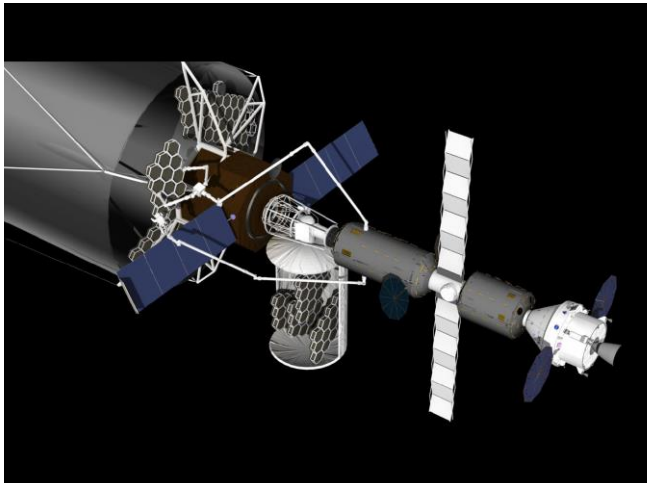
**6 launch modules for assembly**

# Activity 1b:
# Concept for Assembling and Testing the ISAT

**Select a reference in-space <u>assembly and testing concept</u> for the "assemble-able" space telescope architecture, defining robotics, orbit, launch vehicle, and assembly platform.**



# Activities 2a and 2b

## Detailed Engineering Design and Costed

**Activity 2a: Advance the engineering fidelity of the concepts sufficiently so that they can be costed.**

a) Inputs from Activity 1a and 1b
b) Select a team of NASA engineers, academia, government labs, and commercial companies to conduct the work.
c) Needs funding

**Activity 2b: Estimate, through an independent body, the cost of designing, architecting, assembling, and testing the reference 20 m space telescope?**

a) Input design from Activity 2a
b) Identify risks
c) Parameterize the cost to smaller apertures

# Activity 3
## Deliver Final Whitepaper

**Write and deliver the Final Whitepaper**

a) Submit to APD Director who submits to 2020 Decadal Survey

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California Institute of Technology