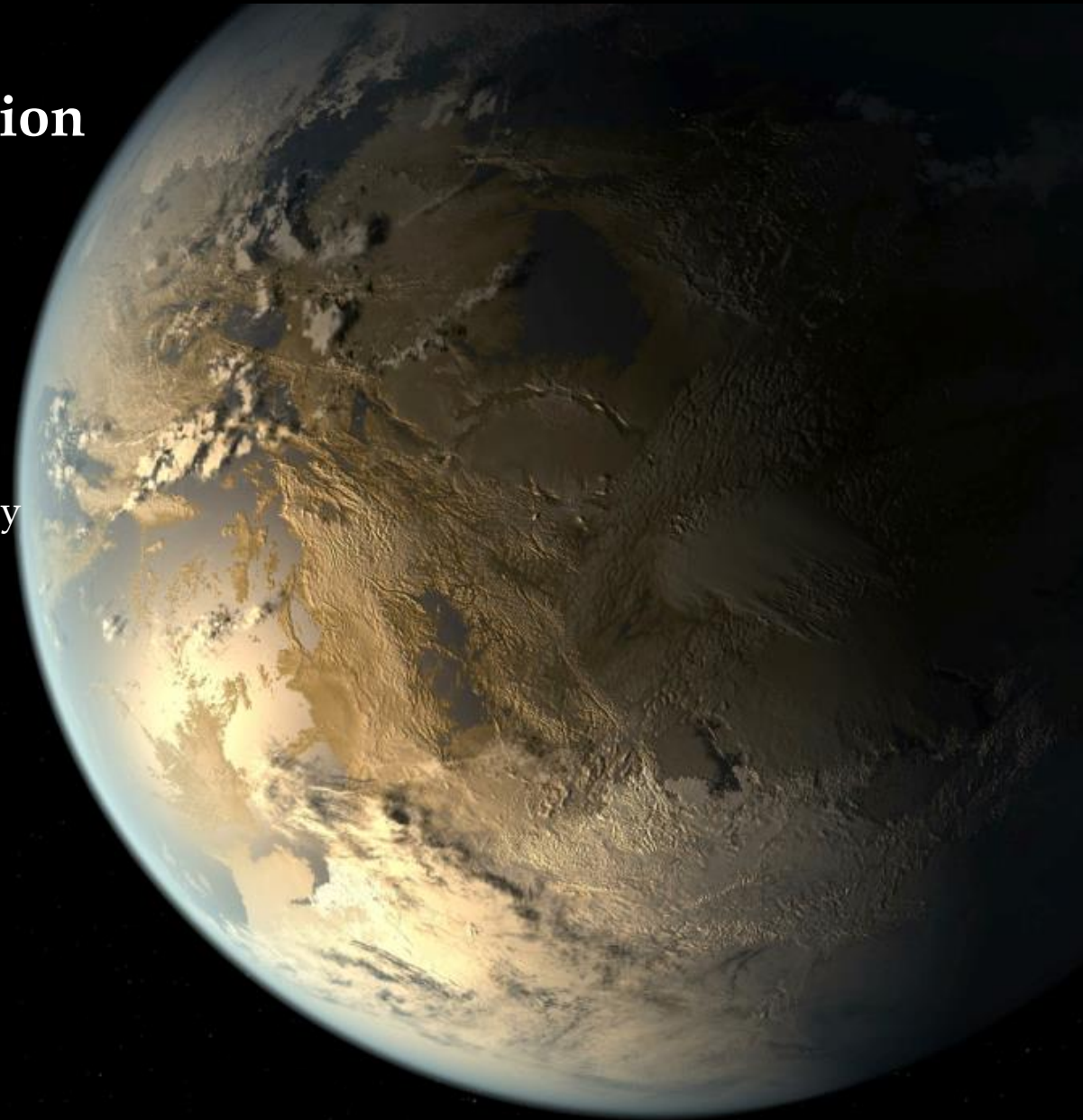


# Astrophysics Design Reference Mission

Rudranarayan Mukherjee Ph.D.  
Robotics Technologist  
Jet Propulsion Laboratory,  
California Institute of Technology  
&  
Co-Lead of the  
In-Space Assembled Telescope Study



Pre-Decisional Information -- For Planning and Discussion Purposes Only

# 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)

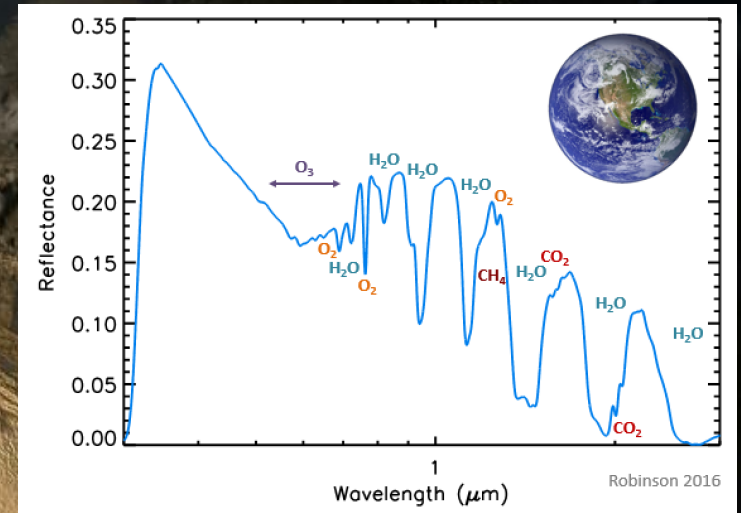
# We now know that in our Galaxy...

Planets are common  
( $> 1$  per star)

Planets with sizes  
0.5-2 times Earth  
are the most common

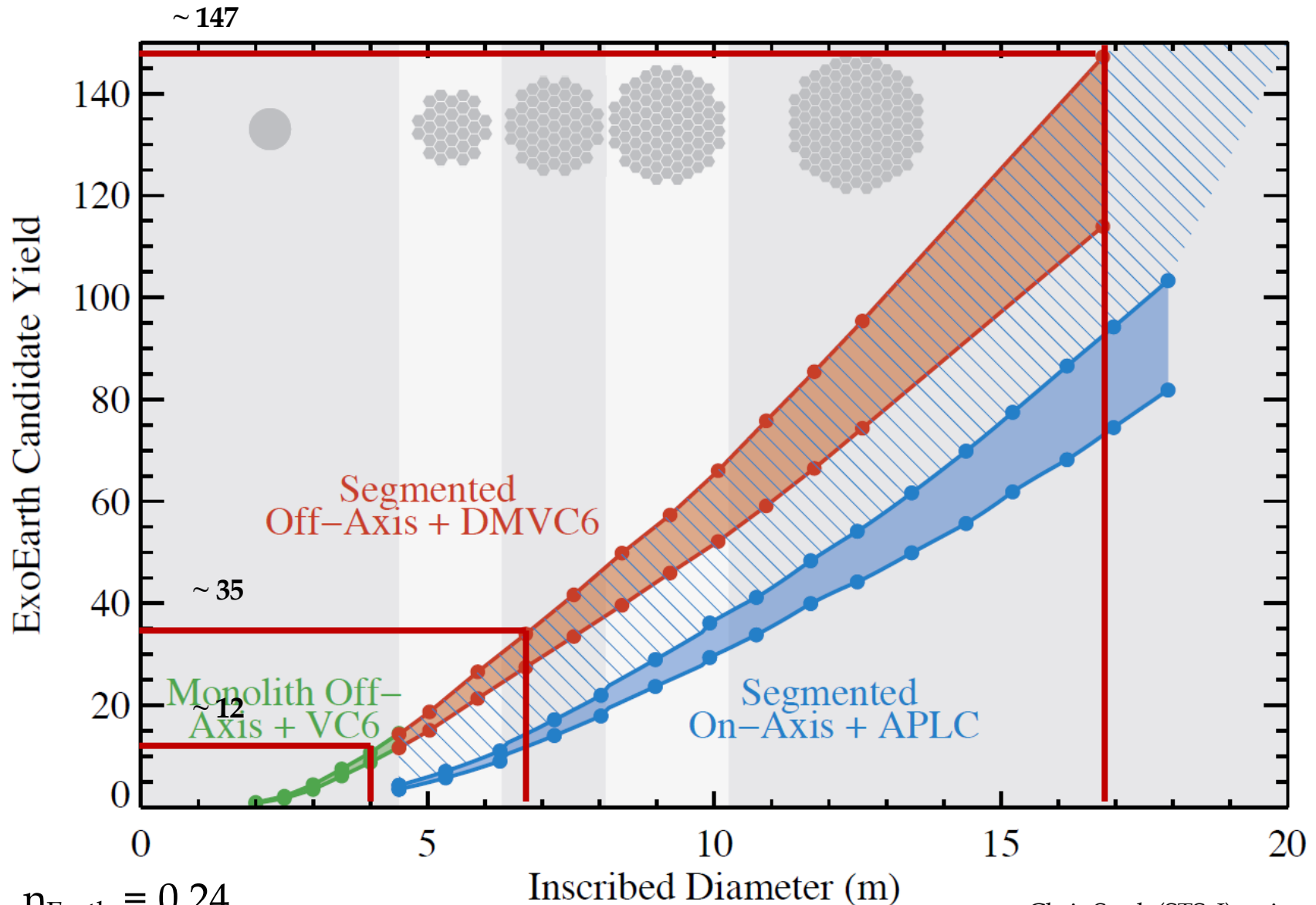
Earth-size planets in the  
Habitable Zone are  
common

...we're ready for the  
search for life



# Exo-Earth Model Predictions

As a function of telescope aperture size; coronagraph architecture





# In-Space Assembly and Servicing Workshop, GSFC Nov 2017



70+ participants from government, industry, and academia

## NASA In-Space Assembled Telescope (ISAT) Study

[https://exoplanets.nasa.gov/exep/technology/in-space-assembly/iSAT\\_study/](https://exoplanets.nasa.gov/exep/technology/in-space-assembly/iSAT_study/)



**Sponsor**  
**Dr. Paul Hertz**  
**Director**  
**Astrophysics Division**  
**NASA Headquarters**

**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.

In particular, the study must answer the question: *"When is it advantageous to assemble space telescopes in space rather than to build them on the Earth and deploy them autonomously from individual launch vehicles?"* The Study Charter (on the right) describes 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.

**Study Leads:**

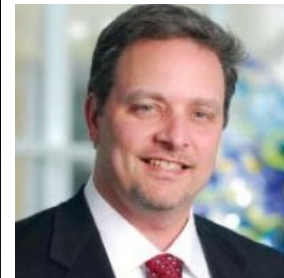
- Nick Siegler, NASA JPL
- Harley Thronson, NASA GSFC
- Rudra Mukherjee, NASA JPL

**Study Documents:**

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

**Study Workshops:**

- Telescope Design and Architecture Workshop June 5-7, Caltech (invite-only)
- Telescope Assembly and Testing Workshop October 2-4, NASA/Langley Research Center (invite-only)



**Sponsor**  
**Mike Seablom**  
**Chief Technologist**  
**Science Mission Directorate**  
**NASA Headquarters**

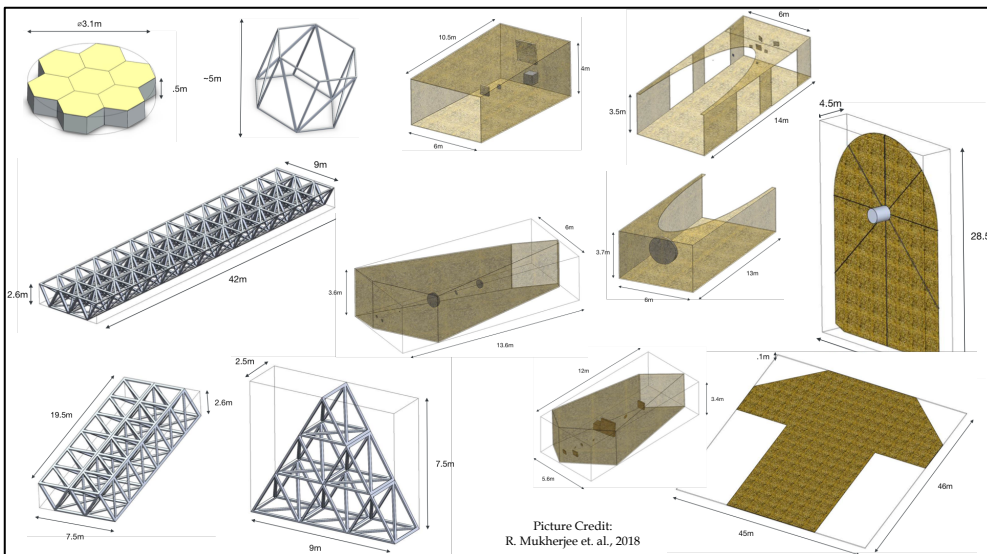
### Study Objective:

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

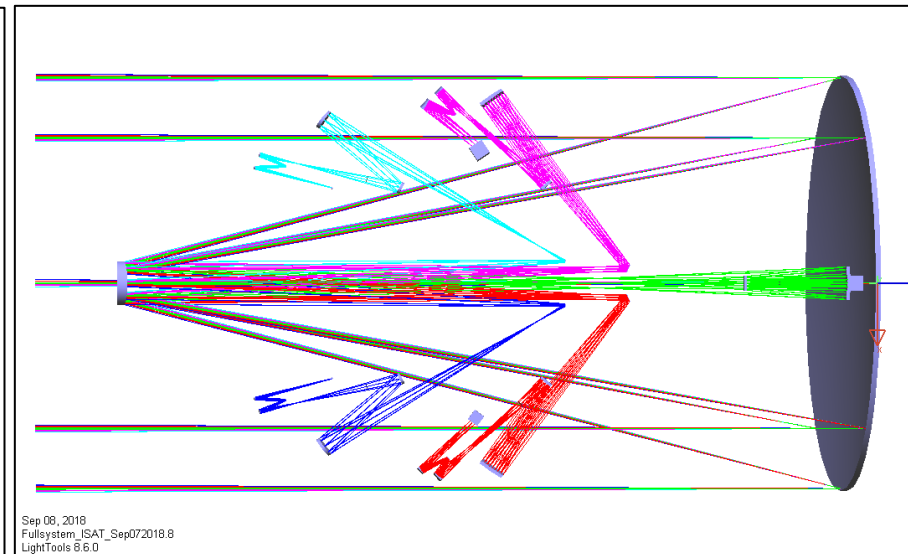
# Telescope Design and Architecture F2F Meeting I, Caltech, June 2018



47 Invited Participants from government, industry, and academia with primary expertise in astrophysics



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



Sep 08, 2018  
Fullsystem\_ISAT\_Sep072018.B  
LightTools 6.6.0

**A 20-meter, filled-aperture, non-cryogenic, serviceable telescope operating at UV/V/NIR with coronagraph**





DRM: A 20-meter, filled-aperture, non-cryogenic, serviceable telescope with coronagraph operating at UV/V/NIR assembled at Cis-Lunar environment using supervised autonomy robotics for >30 year operations at SE-L2

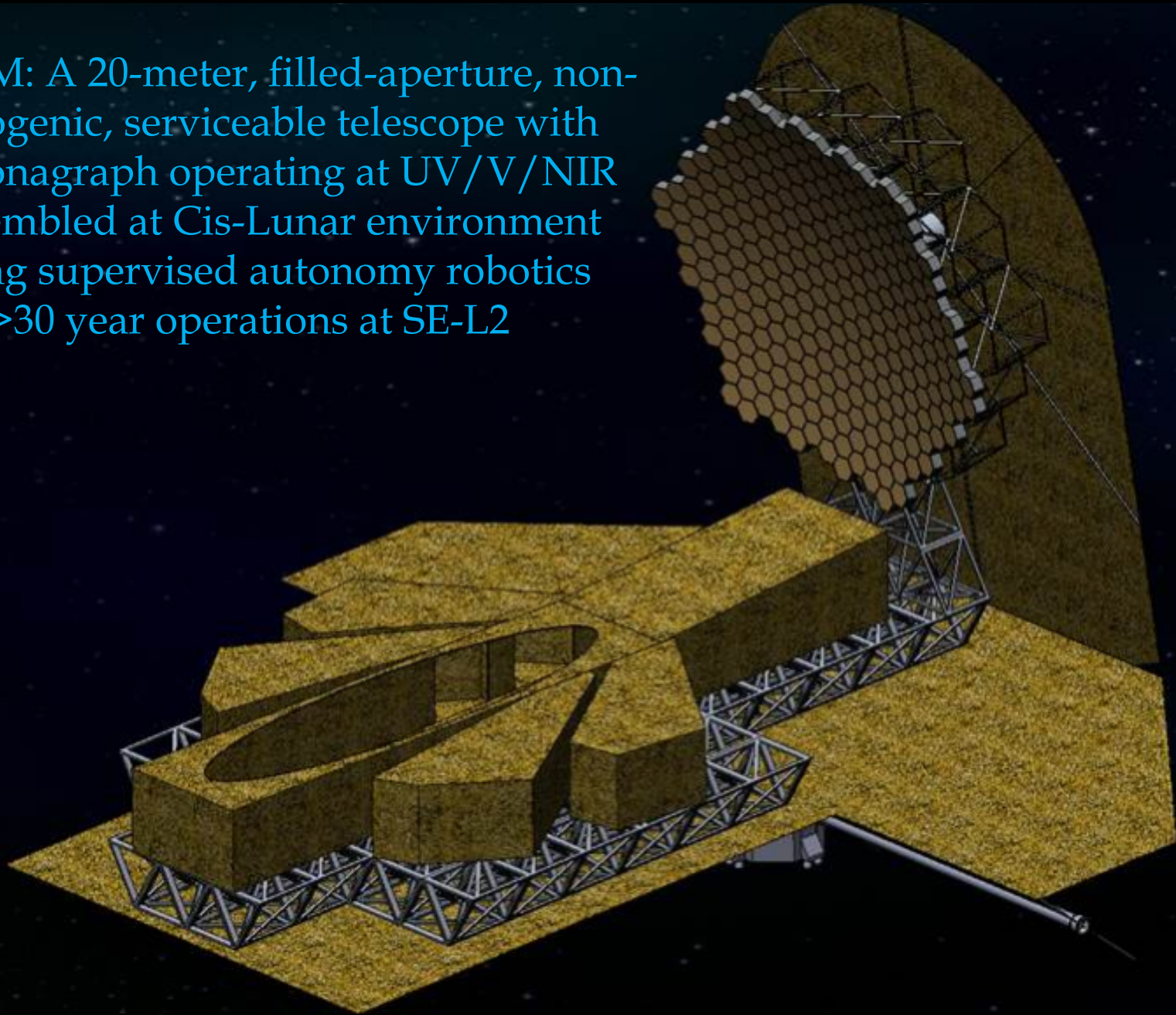


Image Credit: R. Mukherjee et. al. 2018