Jet Propulsion Laboratory
California Institute of Technology

In-Space Assembled Telescope (iSAT)

Steering Committee Telecon 3

June 1, 2018

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NASA Jet Propulsion Laboratory, California Institute of Technology

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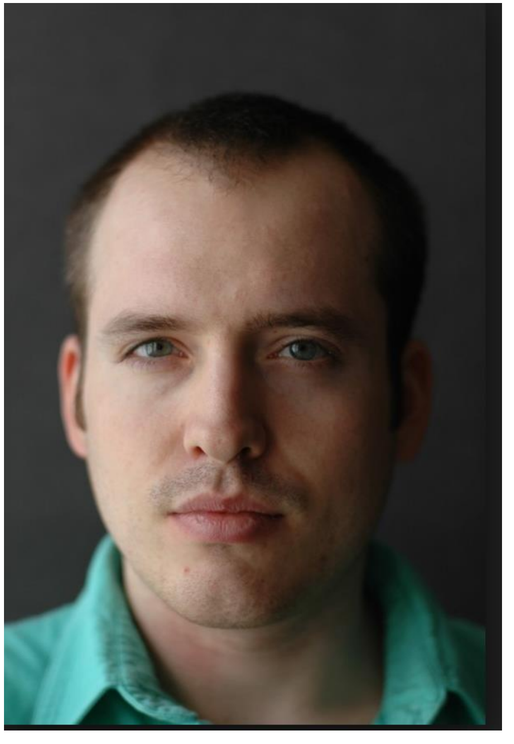
Today’s Agenda

1. Update on Study activities
2. Review of Study’s Reference Telescope, Initial Conditions, and Assumptions
3. Next Steps
4. Open Discussion

But first, any general questions?

Update on Study Activities

Upcoming Scientific American feature article on in-Space Assembly



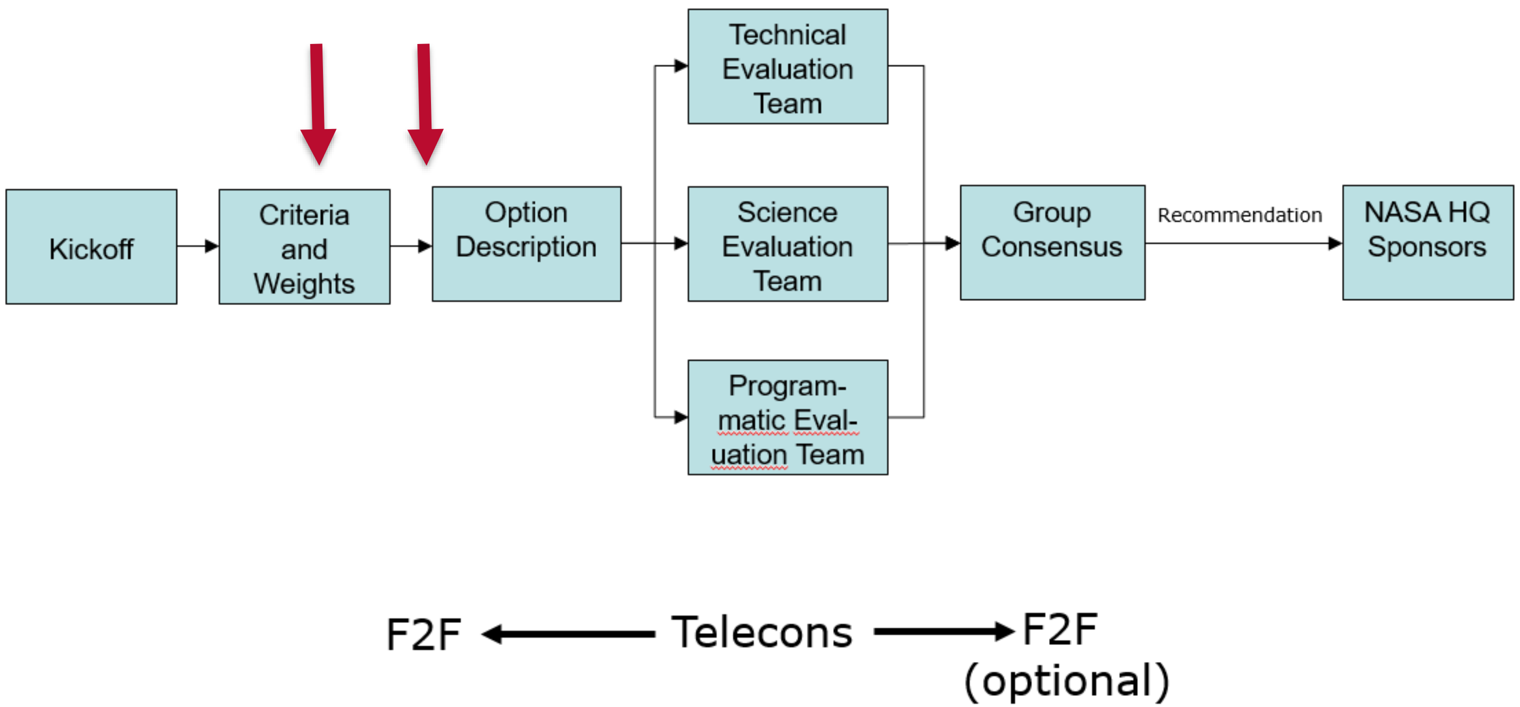
Lee Billings
Science Editor

New Additions to the Study Members

Name	Institution	Expertise
1. Ali Azizi	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	NASA 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. Tere Smith	NASA JPL	I&T
23. Paul Backes	NASA JPL	Robotics
24. Jim Breckinridge	UA	Optical Design
25. AllisonBarto	Ball	Optical SE/testing
26. Jeanette Domber	Ball	SE/Structures/Instruments
27. Joe Parrish	DARPA	Robotics
28. Acey Herrera	NASA GSFC	I&T

Name	Institution	Expertise
29. David Stubbs	Lockheed	Telescope Structures/Design
30. John Dorsey	NASA LaRC	Telescope Structures
31. Jeff Sokol	Ball	Mechanical/I&T
32. Brendan Crill	NASA ExEP	Technologist/Detectors
33. Dave Miller	MIT	Technologist
34. Atif Qureshi	SSL	Robotics Systems Engineering
35. Jason Tumlinson	STScI	Astrophysicist
36. Carlton Peters	NASA GSFC	Thermal
37. Paul Lightsey	Ball	Systems Engineering
38. Kim Mehalick	NASA GSFC	Optical Modeling/I&T
39. Bo Naasz	NASA GSFC	Systems Engineering
40. Eric Sunada	NASA JPL	Thermal
41. Keith Harvey	Harris	Telescopes
42. Babak Saif	NASA GSFC	Metrology

iSAT Study Process
(Activity 1a – Telescope Modularization)



Last Telecon's Next Steps

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

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

- **First Face-to-Face Workshop for the Working Group**

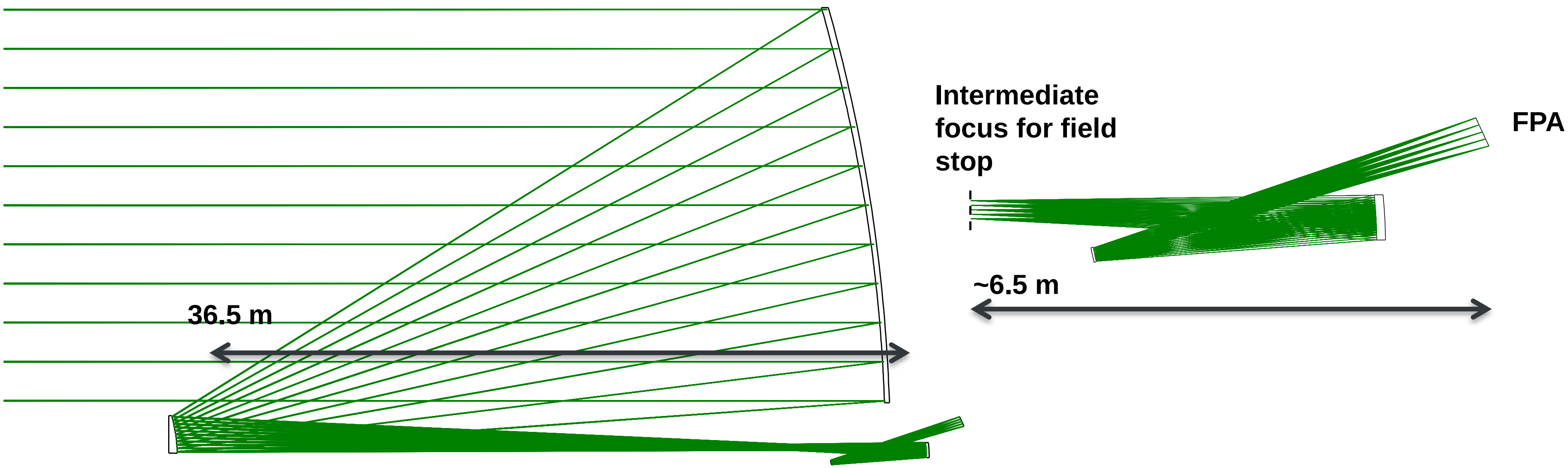
On track

  - June 5-7 at Caltech
  - Focus is on Activity 1a: Designing and Architecting a Modularized Telescope
  - Agenda completed
  - Presenters contacted
  - Breakout sessions "facilitators" selected
  - Note-takers selected
  - Dinner al fresco at Caltech after Day 1

Reference Telescope, Initial Conditions, and Assumptions

Candidate Reference Telescope Design

Off-Axis 20-Meter Optical Layout

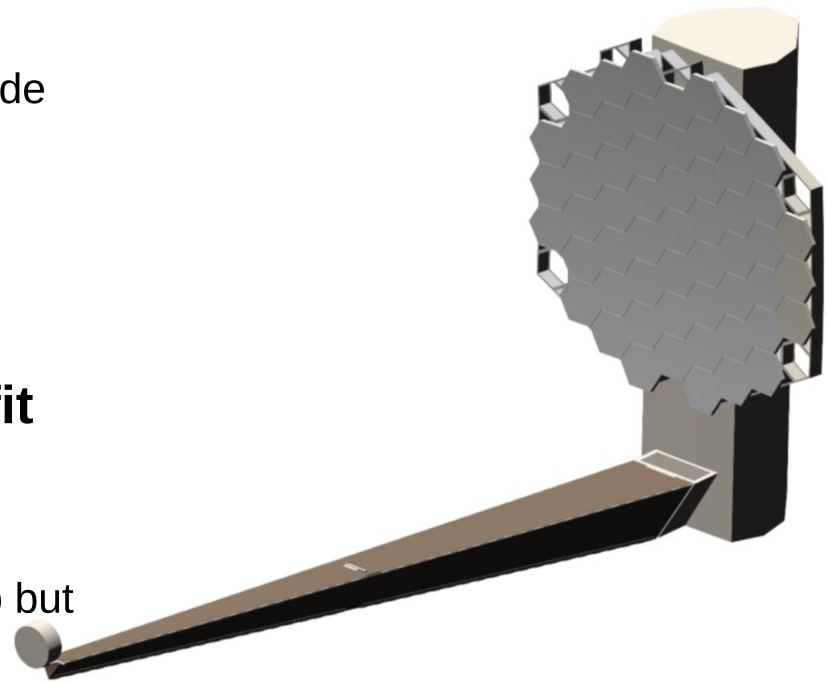


Parameter	Assumption
Entrance pupil diameter	20 meter
Field of View	3x3 arc-minute
Final F/#	F/30
Image size	530 x 530 mm (implied by EPD, F/#, and FOV)
Primary mirror ROC and F number	80 meter ; F/2.0
Primary-secondary spacing	36.5 meter
AOI, maximum on each mirror	16.0° primary; 17.5° secondary; 5.6° tertiary; 8.4° fold.
RMS WFE (nanometer)	18.6 maximum, 10.4 average

Generating Modularization Design Options

- **Trade space for <u>modularization</u> is very open**
  - Number of modules
  - Segment size, segment carriers, sun shade
  - Backplane architecture
  - Power, latching, harnessing
  - Instrument carriers, thermal

- **Do some telescope designs benefit from iSA more than others?**
  - Let's find out
  - Option generation starts at the Workshop but can continue after
  - Recommendation for Workshop Breakout sessions for Reference Telescopes:
    1) (a) 20 m off-axis and (b) 20 m off-axis with opportunities to move to a different configuration if benefits noted
    2) Max 5-m class fairings



Study Initial Conditions

1. 20-meter, filled-aperture, non-cryogenic telescope operating at UV/V/NIR
    - *We will examine parameterized designs so that we can also explore smaller apertures*
2. Off-axis secondary mirror (to assist coronagraph throughput and performance) but can diverge if clearly benefits telescope modularization (and therefore in-space assembly).
3. A high-contrast coronagraph will be an 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 (but identify benefits if a different number is selected)
5. Operational destination is Sun-Earth L2

Study Assumptions

1. Science goals developed from LUVOIR/HabEx concept studies; exoplanet science is the driving science on the reference telescope.
2. The Observatory must provide the stability requirements associated with coronagraphy of Earth-sized planets. These are expected to be on order of 10s of pm wavefront error stability over time periods of ~ 10 minutes.
   - At the end of the telescope modularization activity (Activity 1a) we may assess what would have been the impact if the coronagraph was not assumed but rather a starshade. A starshade would significantly reduce the stability requirements on the telescope as well as eliminate almost all of the active optics. In Kepner-Tregoe speak, we can capture this as an Opportunity.
3. Astronaut- and robotic-enabled assembly/servicing is available
4. ISS is available until 2028 (TBD)
5. The following missions can be assumed but each will carry its own level of capability and risk:
   a. DARPA's RSGS (Robotic Servicing & Geosynchronous Satellites) at GEO (contract with SSL already in place)
   b. NASA's Lunar-Orbital Platform - Gateway at cis-Lunar
   c. Orbital-ATK's Mission Extension Vehicle (MEV) at GEO (contracts in place)
   d. NASA's Restore-L at LEO

Next Steps

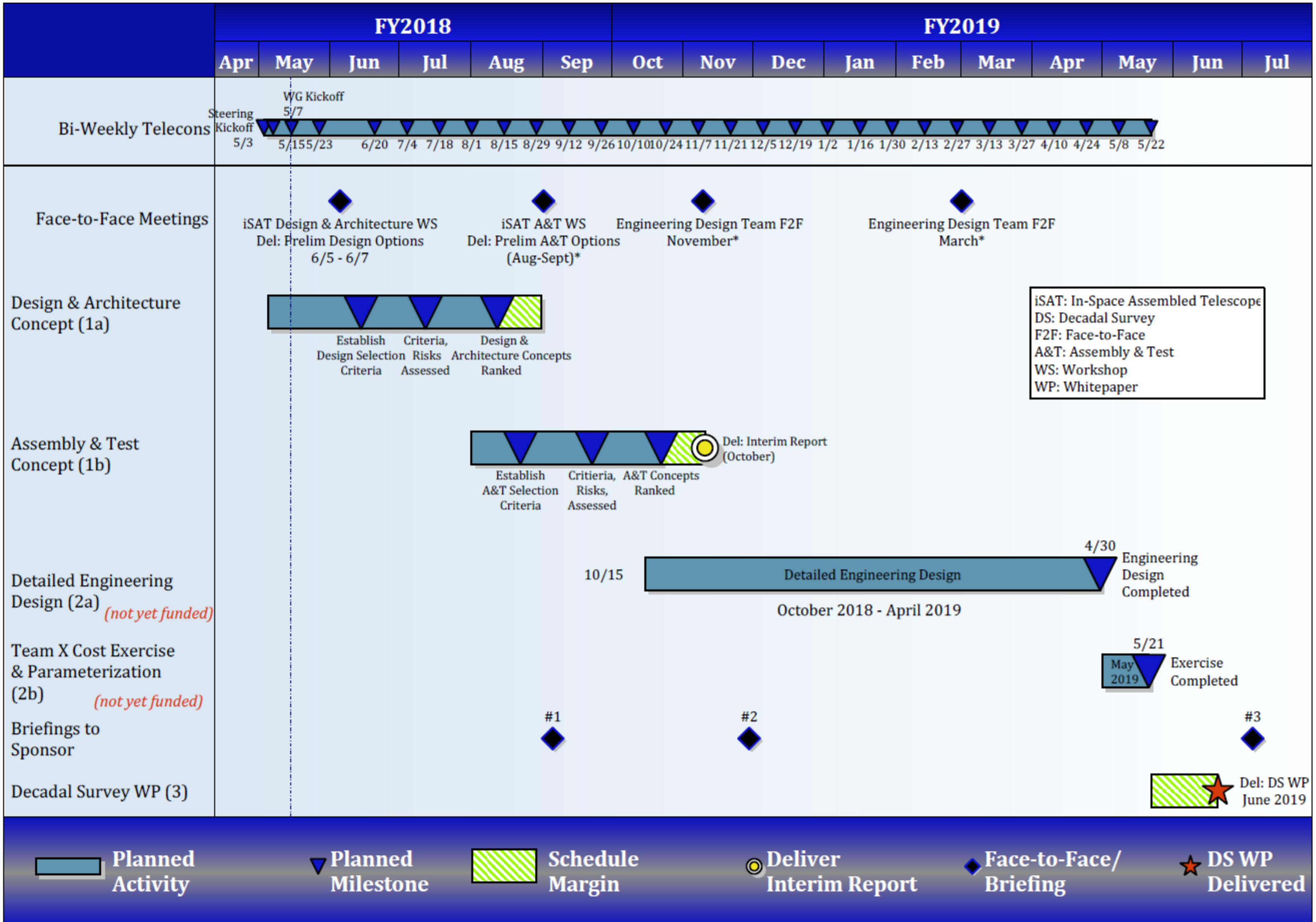
- **Advance Selection Criteria**
  - Next update today and will be sent out to the Working Group
  - Will continue advancing them at the Workshop and through telecons post-Workshop

- **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

Study Schedule

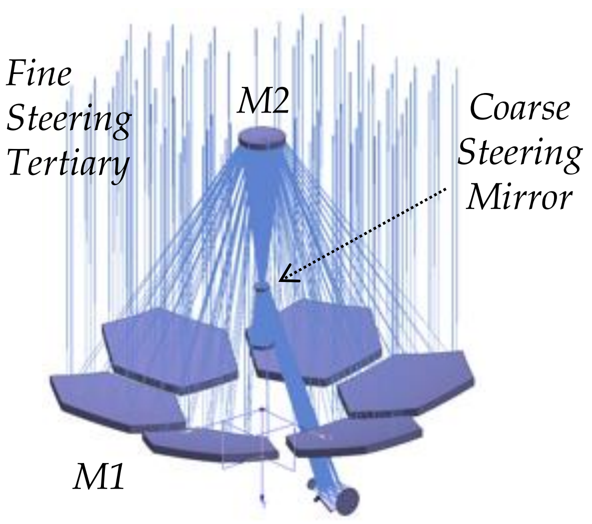


*tentative date

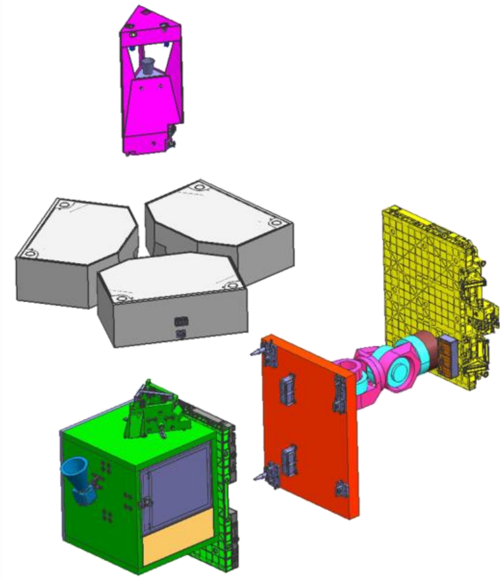
Activity 1a
Concept Design and Architecture for the iSAT

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)

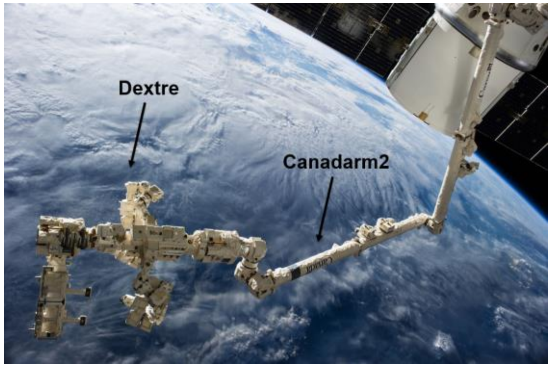


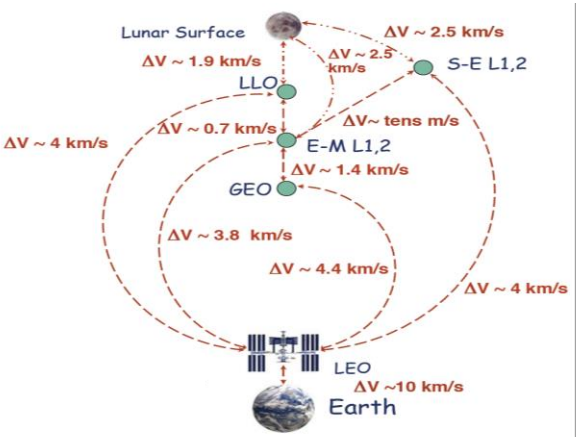
6 launch modules for assembly

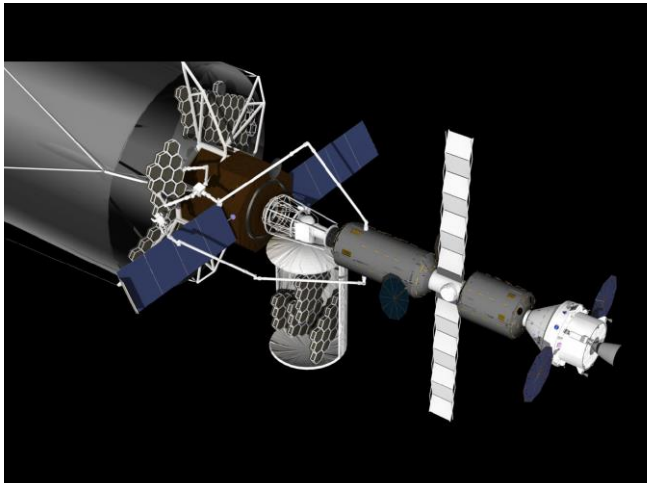
Activity 1b:

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

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)

Features of Kepner-Tregoe Decision Process

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					

plus Assumptions

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