In-Space Assembled Telescope (iSAT)

Study Members Telecon 3  
May 22/24, 2018

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NASA Jet Propulsion Laboratory, California Institute of Technology
Today’s Agenda

1. Quick Review of Study Goals and Activities
2. Advance Selection Criteria

Telecon #1, #2 presentation slides:
https://exoplanets.nasa.gov/exep/technology/in-space-assembly/iSAT_working_group_telecons/

Study Charter:
https://exoplanets.nasa.gov/internal_resources/864
Review of Study Goals and Activities
Telescope Modularization Workshop
June 5-7, Caltech, Pasadena, CA

• Goal:
  – Generating concepts for a 20 m modularized telescope

• Draft Agenda:
  – https://exoplanets.nasa.gov/exep/technology/in-space-assembly/iSAT_study_workshops/

• A block of rooms is available at the Marriott Residence Inn Old Town Pasadena
  – Deadline to book is May 18th
  – https://exoplanets.nasa.gov/exep/technology/in-space-assembly/iSAT_study_workshops/

• Logistics questions:
  – Jennifer Gregory (jgregory@jpl.nasa.gov)
Study Objective and Deliverables

• Study Objective:
  – “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?”

• Deliverables:
  A whitepaper by May 2019 assessing:
  1. the telescope size at which iSA is necessary (an enabling capability)
  2. the telescope size at which iSA is cheaper or lower risk with respect to traditional launch vehicle deployment (an enhancing capability)
  3. the important factors that impact the answers (e.g., existence of HEO-funded infrastructure, architecture of space telescope (segments or other), cryogenic or not, coronagraph capable (stability) or not, etc.)
  4. A list of technology gaps and technologies that may enable in-space assembly

The intention of the whitepaper is to inform NASA and the 2020 Decadal Survey of the cost and risk benefits of the iSA of telescopes.
Activity 1a
Concept Design and Architecture for the iSAT

Select a reference design and architecture 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
• LUVOIR A: 15 m on-axis
  – On-axis JWST-derived configuration
  – Shielded from the Sun, then optics heated to 270K
  – Gimballed telescope

• LUVOIR B: 8 m off-axis
  (preliminary)
  – Off-axis config is better for coronagraphy
  – Primary mirror f/2.7: 20 m PM-SM separation
# Features of Kepner-Tregoe Decision Process

## Decision Statement

<table>
<thead>
<tr>
<th>Description</th>
<th>Feature 1</th>
<th>Feature 2</th>
<th>Feature 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Musts</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>M2</td>
<td>✔</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>M3</td>
<td>✔</td>
<td>✔</td>
<td>✗</td>
</tr>
<tr>
<td><strong>Wants</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W1</td>
<td>w1%</td>
<td>Rel score</td>
<td>Rel score</td>
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<tr>
<td>W2</td>
<td>w2%</td>
<td>Rel score</td>
<td>Rel score</td>
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<tr>
<td>W3</td>
<td>w3%</td>
<td>Rel score</td>
<td>Rel score</td>
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<tr>
<td>100% Wt sum =&gt;</td>
<td>Score 1</td>
<td>Score 2</td>
<td>Score 3</td>
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<tr>
<td><strong>Risks</strong></td>
<td>C</td>
<td>L</td>
<td>C</td>
</tr>
<tr>
<td>Risk 1</td>
<td>M</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>Risk 2</td>
<td>H</td>
<td>H</td>
<td>M</td>
</tr>
</tbody>
</table>

## Final Decision, Accounting for Risks

C = Consequence, L = Likelihood

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plus Assumptions
Advance Selection Criteria Concurrence

(switch to Excel)
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
  – Breakout sessions
Additional Slides
## Off-Axis 20-Meter Optical Layout

Candidate conceptual design

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Assumption</th>
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</thead>
<tbody>
<tr>
<td>Entrance pupil diameter</td>
<td>20 meter</td>
</tr>
<tr>
<td>Field of View</td>
<td>3x3 arc-minute</td>
</tr>
<tr>
<td>Final F/#</td>
<td>F/30</td>
</tr>
<tr>
<td>Image size</td>
<td>530 x 530 mm (implied by EPD, F/#, and FOV)</td>
</tr>
<tr>
<td>Primary mirror ROC and F number</td>
<td>80 meter ; F/2.0</td>
</tr>
<tr>
<td>Primary-secondary spacing</td>
<td>36.5 meter</td>
</tr>
<tr>
<td>AOI, maximum on each mirror</td>
<td>16.0° primary; 17.5° secondary; 5.6° tertiary; 8.4° fold.</td>
</tr>
<tr>
<td>RMS WFE (nanometer)</td>
<td>18.6 maximum, 10.4 average</td>
</tr>
</tbody>
</table>
Activity 1b: Concept for Assembling and Testing the ISAT

Select a reference in-space assembly and testing concept for the "assemble-able" space telescope architecture, defining robotics, orbit, launch vehicle, and assembly platform.
Activities 2a and 2b
(Not Yet Funded)
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
Example of a Completed Trade Matrix

**Decision Statement:** Recommend one Primary and one Backup coronagraph architecture (option) to focus design and technology development.

<table>
<thead>
<tr>
<th>Name</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
<th>Option 4</th>
<th>Option 5</th>
<th>Option 6</th>
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<td>HLC</td>
<td>VVC</td>
<td>VNC-DA</td>
<td>VNC-PO</td>
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<td>No</td>
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<td>M3</td>
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<td>Yes</td>
<td>Yes</td>
<td>U</td>
<td>No</td>
<td>U</td>
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<td>M4</td>
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<td>Yes</td>
<td>Yes</td>
<td>U</td>
<td>No</td>
<td>No</td>
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<tr>
<td>M5</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>U</td>
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**Weights**

<table>
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<tr>
<td>Technical</td>
<td>40</td>
<td>30</td>
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</tr>
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</table>

**Risks**

- Technical risk in meeting TRL gate: M
- Schedule or Cost risk in meeting TRLS Gate: M
- Risk of not meeting at least threshold science: M
- Risk of mfr tolerances not meeting 8L science: M
- Risk that wrong architecture is chosen due to assumption that all jitter >2Hz is only tip/tilt: M
- Risk that wrong architecture is chosen due to any assumption made for practicality/simplicity: M
- Risk that ACWG simulations (by JK and BM) overestimate the science yield due to model fidelity: M

**Opportunities**

- Possibility of Science gain for 0.2msec jitter, x30: M

**Final Decision, Accounting for Risks and Opportunities:**

- C = Consequence, L = Likelihood, B=Benefit
- **DCL = Dave Content Interface List**
- Indicates those few areas where consensus was not achieved on consensus achieved on balance of matrix.