Industry perspective on use of the 2.4m telescope for AFTA WFIRST

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Ball Aerospace & Technologies Corp.
ITT EXELIS
Space Telescope Science Institute
Topics for today’s discussion

1. The focal plane array suggested for the wide-field visible and NIR imager is technically feasible.

2. A polar, sun-synchronous orbit and a geosynchronous orbit are both attractive, and reachable with a Falcon 9.

3. Alternative implementation approaches can reduce costs.
We know that the telescope with an aft-optics system can provide the field of view and spatial resolution desired for the WFIRST surveys.
The field of view allows efficient tiling with large Focal Plane Arrays.
Scalability offered by a modular design is very advantageous

- H4RG-10 NIR HgCdTe + Sidecars
- These can cover the $0.6\mu m < \lambda < 2\mu m$ region with only one type of detector.
- 9 modules per FPA x 3 = 27 modules
- 150 Mpx per FPA
- 453 Mpx total for 3 FPAs
- 0.11 arc sec / pixel
H4RG detector feasibility is encouraging, but with some development needed

- Analyses undertaken by our team have not uncovered any major technical risks
  - Packaging approach, size, mass, 20cm x 17cm x 5cm, 16 kg
  - Operating temperature, passive cooling with external radiator
  - Power, 11 watts, includes heaters
  - Data rate, volume, compression, management
  - Radiation issues at candidate orbits
  - I&T requirements, facilities, flow
  - Cost and schedule issues are understood, 48 months

- Can we use the Strategic Astrophysics Technology programs to raise the TRL?
  - Imaging performance of individual detectors
  - Yield and schedule concerns
  - Packaging and operational parameters for maximum stability
  - Packaging for modularity to enable in-orbit replacement
# Topic 2

Orbit possibilities allow lower cost launch and operations

<table>
<thead>
<tr>
<th></th>
<th>Orbit Options</th>
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<th>Comment</th>
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<tbody>
<tr>
<td></td>
<td>LEO Sun-Synch</td>
<td>GEO-Synch</td>
<td>Comment</td>
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<tr>
<td>Example Mission</td>
<td>WISE</td>
<td>SDO</td>
<td></td>
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<tr>
<td>NGP Visibility</td>
<td>33%</td>
<td>68%</td>
<td>LEO limited by Earth avoidance</td>
</tr>
<tr>
<td>Galactic plane vis</td>
<td>50%</td>
<td>75%</td>
<td></td>
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<tr>
<td>Downlink</td>
<td>TDRSS (Real-Time)</td>
<td>Ka-Band (Real-Time)</td>
<td>Existing NASA capabilities Reduced on-board storage</td>
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<tr>
<td>Launch Vehicle</td>
<td>Falcon 9</td>
<td>Falcon 9H Atlas V</td>
<td>5.2-meter Falcon 9 faring 5-meter Atlas V fairing</td>
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<tr>
<td>LV Cost</td>
<td>Modest</td>
<td>Higher</td>
<td></td>
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<tr>
<td>Serviceable</td>
<td>Yes</td>
<td>Yes</td>
<td>Human or Robotic</td>
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New WFIRST in Falcon 9

5.2-meter fairing
Solar Dynamics Observatory is a good example for GEO option

Atlas V 401 launch
Geosynchronous orbit
28° inclination

18m Ka band antennas at White Sands
Mission Operations at NASA Goddard

130 Mbits/s science data rate
1.5 Terabits/day
Topic 3
Alternative implementation approaches can reduce costs

“NASA Productivity Study” identified factors that affect cost and recommended pathways to lower cost missions.

Relative Cost vs. Complexity of Imaging Systems

DoD & NASA Efficiencies are Similar but Much Less Than Commercial
Two commercial examples at Ball were less costly than NASA’s QuickCost model would have predicted.
Falcon 9 is another example
Using the existing telescope “as is” offers many cost-saving benefits

- Cost of design, fabrication, testing, etc.
- Schedule
- Interfaces are well known
- Instrument accommodations can be made accessible and serviceable
How can we actually achieve the lower cost?

1. Interface definition and control
2. Stability of requirements
3. Stability of funding
4. Early technical maturity
5. Level of programmatic oversight
There are specific programmatic items that affect the cost

<table>
<thead>
<tr>
<th>Technical Complexity Attributes</th>
<th>NASA REFERENCE MISSION (Kepler)</th>
<th>Commercial #1 (Proposed)</th>
<th>Commercial #2 (Proposed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting TRL</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
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<tr>
<td>New Development</td>
<td>Medium/High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Average Complexity %</td>
<td>48</td>
<td>52 (1)</td>
<td>50 (2)</td>
</tr>
<tr>
<td>System Testing Complexity</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Requirement Stability @ ATP</td>
<td>High/Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Aperture Size</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
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</table>

| Acquisition Complexity Attributes | Customer Oversight | # of Approved CDRLS | External Consultants | PMRs /year | Major Reviews w/Customer (3) | On-site customer reps | Customer access to vendors | Contractual Incentive (Profit/Science) | Funding Stability | Procurement Process | MA Oversight | System Requirements |
|-----------------------------------|---------------------|---------------------|----------------------|------------|-----------------------------|----------------------|--------------------------|-----------------|-------------------|-------------|---------------------|
|                                   | Selective Oversight | Selective Oversight |                      |            | Follows LCGM                | Yes (3 reps)         | Controlled                | CPIF (Science)   | Excellent (assumed)| FFP (Sole Source) | High                | Prescriptive (4)   |
|                                   |                     |                     |                      |            |                             |                      |                          | FFP (Profit)      |                   | FFP (Profit) |          |
|                                   |                     |                     |                      |            |                             |                      |                          |                 |                   | FFP (Sole Source) |                     |                  |
|                                   |                     |                     |                      |            |                             |                      |                          |                 |                   | Best Industry Practice |                     |                  |
|                                   |                     |                     |                      |            |                             |                      |                          |                 |                   | Best Industry Practice |                     |                  |

(1) COBRA based on QuickBird 2 evaluation
(2) Similarity to WV2 by extension
(3) Typical LGCM Major review set: SRR, PDR, CDR, IIR, PSR
(4) Prescriptive requirements influence development and production specifications, reliability, and test.
Much of the total mission cost may be amenable to fixed price acquisition

• Space elements
  – Telescope refurbishment
  – Instruments and focal planes
  – Spacecraft bus
  – Launch vehicle

• Ground elements
  – Observatory I&T facility
  – SOC & MOC facilities
The End