PCOS Technology Needs Identification and Prioritization Process

For discussion with PhysPAG
AAS Long Beach, CA
January 6, 2013

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Agenda

• How the PhysPAG can help

• Quick summary of last two year’s PCOS technology needs identification and prioritization process

• Consideration for change to our process

• Open discussion
The 2012 PCOS PATR

The PCOS PATR can be downloaded from https://pcos.gsfc.nasa.gov
How the PhysPAG Can Help

• Provide feedback on technology identification and prioritization process
• Continue to collect and consolidate technology needs inputs for Program Office (PO) prioritization
  • Focus on achieving uniform definition of technology needs
  • Narrow needs down to what PAG sees as appropriate for consideration for strategic technology development
• Provide PO with needs list by the end of June
• Continue feedback dialogue – thank you!
Annual Technology Needs Identification and Prioritization

• A Program technology needs identification and prioritization process has been implemented for PCOS and COR for the last 2 years

• The objectives of this process are to:
  • Identify technology needs that are applicable and relevant to Program science objectives
  • Then prioritize these needs with respect to a published set of criteria

• The outcome of this process is used to:
  • Inform the Program’s call for SAT proposals and other technology development Program planning (SBIR and other OCT activities)
  • Inform technology developers of the Program needs
  • Guide the selection of technology awards to be aligned with Program goals and science objectives

• This process is designed to:
  • Improve the transparency and relevance of Program technology investments
  • Inform the community about and engage it in our technology development process
  • Leverage the technology investments of external organizations by defining needs and a customer
Overview of the Technology Needs Identification and Prioritization Process

• The community identifies technology needs each summer by working with the PAG or through direct individual submission to the Program Office’s website.

• The Program Technology Management Board (TMB) reviews and vets community identified technology needs, defines their priorities, and recommends investment consideration.
  • TMB membership includes senior members of the Program at NASA HQ and in the Program Office, and when needed, subject matter expert(s) from the community.

• The TMB prioritizes the technology needs based on a published set of criteria that includes an 11-point assessment that addresses scientific priorities (Decadal Survey), benefits and impacts, timeliness, risk reduction and effectiveness of investment.

• The technology needs and the resulting priorities are published each year in the Program Annual Technology Report (PATR).
Prioritization Criteria Address ...

• STRATEGIC ALIGNMENT- Aligns with scientific and/or programmatic priorities as determined by the Decadal Review, other community-based review or study, other peer review, or programmatic assessment

• BENEFIT/IMPACT- Degree of unique or enabling/enhancing capability the technology provides. Impact of the technology on the science, the implementation and the schedule. How many mission concepts can benefit from this technology? (cross-cutting)

• TIMELINESS of the technology investment. Time available before the technology is needed to be at TRL6.

• RISK REDUCTION- Reduction of risk profile (technical or programmatic (cost, schedule))

• EFFECTIVENESS- How well defined is the required technology. Is there a clear description of what is sought? Are there other sources of funding to mature this technology? Are there credible providers/developers of this technology?
## Technology Needs Prioritization Criteria

<table>
<thead>
<tr>
<th>#</th>
<th>Criterion</th>
<th>Weight Score (0-4)</th>
<th>Weighted Score</th>
<th>General Description/Question</th>
<th>Score Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scientific Ranking of Applicable Mission Concept</td>
<td>4</td>
<td>4</td>
<td>Scientific priority as determined by the Decadal Review, other community-based review, other peer review, or programmatic assessment. Captures the importance of the mission concept which will benefit from the technology.</td>
<td>Highest ranking, Medium rank, Low rank, Not ranked by the Decadal, No clear applicable mission concept</td>
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<tr>
<td>2</td>
<td>Overall Relevance to Applicable Mission Concept</td>
<td>4</td>
<td>4</td>
<td>Impact of the technology on the applicable mission concept. Captures the overall importance of the technology to the mission concept.</td>
<td>Critical key enabling technology - required to meet mission concept goals, Highly desirable technology - reduces need for critical resources and/or required to meet secondary mission concept goals, Desirable - offers significant benefits but not required for mission success, Minor implementation improvements, No implementation improvement</td>
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<tr>
<td>3</td>
<td>Scope of Applicability</td>
<td>3</td>
<td>4</td>
<td>How many mission concepts could benefit from this technology? The larger the number, the greater the reward from a successful development.</td>
<td>The technology applies to multiple mission concepts across multiple NASA programs and other agencies, The technology applies to multiple mission concepts across multiple NASA programs or other agencies, The technology applies to multiple mission concepts within a single NASA program, The technology applies to a single mission concept, No known applicable mission concept</td>
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<tr>
<td>4</td>
<td>Time To Anticipated Need</td>
<td>3</td>
<td>4</td>
<td>When does the technology need to be ready for implementation?</td>
<td>4 to 8 years (this decade), 9 to 14 years (early 2020s), 15 to 20 years (late 2020s), Greater than 20 years (2030s), No anticipated need</td>
</tr>
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<td>5</td>
<td>Scientific Impact to Applicable Mission Concept</td>
<td>2</td>
<td>4</td>
<td>Impact of the technology on the scientific harvest of the applicable mission concept. How much does this technology affect the scientific harvest of the mission?</td>
<td>Needed for applicable mission concept, Major improvement (&gt; ~2x) to primary scientific goals, Only enables secondary scientific goals, Minor scientific improvement, No scientific improvements</td>
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<td>6</td>
<td>Implementation Impact to Applicable Mission Concept</td>
<td>2</td>
<td>4</td>
<td>Impact of the technology on the implementation efficiency of the applicable mission concept. How much does this technology simplify the implementation or reduce the need for critical resources?</td>
<td>Needed for applicable mission concept, Enables major savings in critical resources (e.g., smaller launch vehicle, longer mission lifetime, smaller spacecraft bus, etc.) or reduces a major risk, Enables minor savings in critical resources or reduces a minor risk, Minor implementation improvement, No implementation improvements</td>
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<td>7</td>
<td>Schedule Impact to Applicable Mission Concept</td>
<td>2</td>
<td>4</td>
<td>Impact of the technology on the schedule of the applicable mission concept. How much does this technology simplify the implementation to bring in the schedule?</td>
<td>Technology is likely to drive the applicable mission schedule, Technology is likely to drive the schedule for a major subsystem/ component of the applicable mission concept, Technology is likely to drive the schedule for a minor applicable mission concept, Technology is less likely to be a factor for the schedule of the applicable mission concept, Technology will not be a factor for the schedule of the applicable mission concept</td>
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<tr>
<td>8</td>
<td>Risk Reduction to Applicable Mission Concept</td>
<td>2</td>
<td>4</td>
<td>Ability of the technology to reduce risks by providing an alternate path for a high risk technology that is part of the applicable mission concept.</td>
<td>Technology is a direct alternative to a key technology envisioned for the applicable mission concept. At least one other known alternate technology, Technology is a direct alternative to a secondary technology envisioned. At least one other known alternate technology, Technology is a direct alternative to a secondary technology envisioned. The technology is already part of the applicable mission concept, No risk benefits or technology is already part of the applicable mission concept</td>
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<tr>
<td>9</td>
<td>Definition of Required Technology</td>
<td>1</td>
<td>4</td>
<td>How well defined is the required technology? Is there a clear description of what is sought?</td>
<td>Exquisitely defined, Well defined, but some vagueness, Well defined, but some conflicting goals not clarified, Not well defined, lacking in clarity, Poorly defined, not clear at all what is being described</td>
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<tr>
<td>10</td>
<td>Other Sources of Funding</td>
<td>1</td>
<td>4</td>
<td>Are there other sources of funding to mature this technology? If funding is expected to be available from other sources, this will lower the prioritization.</td>
<td>No, the Program is the only viable source of funding, Interest from other sources can be developed during the development time of the technology, Interest from other sources is likely during the development time of the technology, Moderate investments (relative to the potential level for a NASA investment) in the technology are already being made by other programs, agencies, or countries, Major investments (relative to the potential level for a NASA investment) in the technology are already being made by other programs, agencies, or countries.</td>
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<td>11</td>
<td>Availability of Providers</td>
<td>1</td>
<td>4</td>
<td>Are there credible providers/developers of this technology? Where providers are scarce, there may be a compelling need to maintain continuity for the technology in the event there are no replacement technologies.</td>
<td>Potential providers/developers have insufficient capabilities to meet applicable mission concept needs, Potential providers/developers have uncertain capability relative to applicable mission concept needs, Single competent and credible provider/developer known, Two competent and credible providers/developers known, Multiple competent and credible providers/developers known</td>
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</tbody>
</table>
Changes in Consideration

• Technology needs list is unwieldy (>90 inputs) given that we can only afford to invest in ~5 SATs
  • Plan to reduce inputs for consideration. Options include:
    ➢ Focus on technologies associated with NWNH
    ➢ Focus on short and medium term needs in mid TRL (3-5) i.e. those with well defined, quantifiable paths to TRL 6.
    ➢ Should we provide inputs to APRA for needs where current TRL is ~1-3
    ➢ Remove matured technology needs (TRL >/= 6), engineering needs, duplications and similar needs statements
    ➢ Focus on technologies for program objectives (launch vehicle, rover, avionics, spacecraft systems are best assess by OCT)
    ➢ Emphasis on uniform description of technology need inputs

• Prioritization criteria can be reduced from 11 to 4
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<thead>
<tr>
<th>#</th>
<th>Criterion</th>
<th>Weight</th>
<th>Score</th>
<th>General Description/Question</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Strategic Alignment</td>
<td>4</td>
<td>4</td>
<td>Technology enables or enhances a mission concept that is prioritized by the Decadal Review, other community-based review or study, other peer review, or programmatic assessment.</td>
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<td>4</td>
<td>4</td>
<td>Highest ranking</td>
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<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>Not ranked by the Decadal but has applicable mission concept</td>
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<td></td>
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<td>0</td>
<td>0</td>
<td>No clear applicable mission concept</td>
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<tr>
<td>2</td>
<td>Benefits and Impacts</td>
<td>10</td>
<td>4</td>
<td>Impact of the technology on the applicable mission concept. Degree of unique or enabling/enhancing capability the technology provides toward the science objective and the implementation of the mission.</td>
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<td>4</td>
<td>4</td>
<td>Critical and key enabling technology - required to meet mission concept objective(s)</td>
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<td>Desirable - offers significant science or implementation benefits but not required for mission success</td>
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<td>0</td>
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<td>No science impact or implementation improvement</td>
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<td>3</td>
<td>Scope of Applicability</td>
<td>3</td>
<td>4</td>
<td>How cross-cutting is the technology. How many mission concepts could benefit from this technology?</td>
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<td>4</td>
<td>4</td>
<td>The technology applies to multiple mission concepts across multiple NASA programs and other agencies</td>
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<td>0</td>
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<td>Minor science impact or implementation improvements</td>
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<td>0</td>
<td>0</td>
<td>No science impact or implementation improvement</td>
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<tr>
<td>4</td>
<td>Time To Anticipated Need</td>
<td>3</td>
<td>4</td>
<td>When does the technology need to be ready for a decision point or implementation?</td>
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<td></td>
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<td>4</td>
<td>4</td>
<td>Decision point is now or overdue, and implementation is needed within 7 years (this decade)</td>
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<td></td>
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<td>0</td>
<td>0</td>
<td>Decision point is 5 - 10 years away, or implementation is needed 18 years or later (2030's)</td>
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<td>0</td>
<td>0</td>
<td>No anticipated need</td>
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</table>
Discussion
Back-up
## PCOS Technology Needs Prioritization From 2012 PATR (top 2 of 4 priorities)

<table>
<thead>
<tr>
<th>Priority</th>
<th>PCOS Technology Needs</th>
<th>Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Large format Mercury Cadmium Telluride CMOS IR detectors, 4K x 4K pixels</strong></td>
<td>Dark Energy</td>
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<td></td>
<td><strong>High-resolution X-ray microcalorimeter: central array (~1,000 pixels): 2.5 eV FWHM at</strong></td>
<td>X-ray</td>
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<td>6 keV; extended array: 10 eV FWHM at 6 keV.</td>
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<td><strong>Dimensionally stable optical telescope: stringent length (pm) and alignment (nrad)</strong></td>
<td>Gravitational</td>
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<td>stability with low straylight</td>
<td>Wave</td>
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<td></td>
<td><strong>Metrology laser: 10 yr life, frequency-stabilized, 2W, low noise, fast frequency and</strong></td>
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<td></td>
<td>power actuators</td>
<td>Gravitational</td>
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<tr>
<td></td>
<td><strong>Lightweight, replicatable x-ray optics</strong></td>
<td>Wave</td>
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<td></td>
<td><strong>High resolution X-ray gratings (transmission or reflection)</strong></td>
<td>X-ray</td>
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<td></td>
<td><strong>Large format (1,000-10,000 pixels) arrays of CMB polarimeters with noise below the</strong></td>
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<td></td>
<td>CMB photon noise and excellent control of systematics</td>
<td>Inflation</td>
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<td></td>
<td><strong>Micronewton thrusters: 10 yr. life, low contamination, low thrust noise</strong></td>
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<td></td>
<td><strong>Lightweight precision mirror mounting structure</strong></td>
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<td>2</td>
<td><strong>High throughput anti-reflection coatings with controlled polarization properties</strong></td>
<td>Inflation</td>
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<td></td>
<td><strong>Stable and continuous sub-Kelvin coolers for detectors</strong></td>
<td>Inflation</td>
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<tr>
<td></td>
<td><strong>High-throughput, light, low-cost, cold, mm-wave telescope operating at low backgrounds</strong></td>
<td>Inflation</td>
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<tr>
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<td><strong>Polarization modulating optical elements</strong></td>
<td>Inflation</td>
</tr>
</tbody>
</table>
### PCOS Technology Needs Prioritization

From 2012 PATR (priority 3 of 4)

<p>| 3 | Gigapixel X-ray active pixel sensors | X-ray |
| 3 | Very large format (&gt;10^5 pixels) FPA with background-limited performance and multi-color capability | FarIR |
| 3 | Molecular clocks/cavities with 10E-15 precision over orbital period; 10E-17 precision over 1-2 year experiment. | Fundamental Physics |
| 3 | Cooled atomic clocks with 10E-18 to 10E-19 precision over 1-2 year experiment | Fundamental Physics |
| 3 | Cryocooler &lt;100 mK with 1 mK stability (IXO heritage) | X-ray |
| 3 | Large throughput, cooled mm-wave to far IR telescope operating at background limit | FarIR |
| 3 | Cooling to 50-300 mK | FarIR |
| 3 | Megapixel microcalorimeter array | X-ray |
| 3 | Coupling of ultra-stable lasers with high-finesse optical cavities for increased stability | Fundamental Physics |
| 3 | Lightweight adjustable optics to achieve 0.1 arcsec high resolution grating spectrometer | X-ray |</p>
<table>
<thead>
<tr>
<th>Technology Need</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coded aperture imaging</strong>: ~5 mm thick W and ~2.5 mm holes; ~0.5 mm W and ~0.2 mm holes</td>
<td>X-ray</td>
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<tr>
<td>Wavefront sensing with cold atoms</td>
<td>Gravitational Wave</td>
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<tr>
<td>Cooled Ge</td>
<td>Gamma</td>
</tr>
<tr>
<td>Arrays of Si, CZT or CdTe Pixels</td>
<td>Gamma</td>
</tr>
<tr>
<td>Finely pixelated CZT detectors for hard X-rays</td>
<td>X-ray</td>
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<tr>
<td>ASIC on each ~20x20 mm crystal</td>
<td>X-ray</td>
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<tr>
<td>Arcsecond attitude control to maintain resolution</td>
<td>X-ray</td>
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<tr>
<td>Hard X-Ray grazing incidence optics with multi-layer coatings with at least 5&quot; angular resolution</td>
<td>X-ray</td>
</tr>
<tr>
<td>Loop Heat Pipe to radiators for ~30 deg (Si) and ~5 deg (CZT) over large areas</td>
<td>X-ray</td>
</tr>
<tr>
<td>Low CTE materials</td>
<td>Gravitational Wave</td>
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<tr>
<td>Large area atom optics</td>
<td>Gravitational Wave</td>
</tr>
<tr>
<td>Long booms or formation flying</td>
<td>Gamma</td>
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<tr>
<td>High rate X-ray Si detector (APS).</td>
<td>X-ray</td>
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<tr>
<td>Compton telescope on single platform</td>
<td>Gamma</td>
</tr>
<tr>
<td>1 m precision optics (1/1,000)</td>
<td>Gravitational Wave</td>
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<tr>
<td>Sun-shield for atom cloud</td>
<td>Gravitational Wave</td>
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<tr>
<td>Active cooling of germanium detectors</td>
<td>Gamma</td>
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<tr>
<td>Passive cooling of pixel arrays</td>
<td>X-ray</td>
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<tr>
<td>Low power ASIC readouts</td>
<td>X-ray</td>
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<tr>
<td>Scintillators, cooled Ge</td>
<td>Gamma</td>
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<tr>
<td>No optics; source isolation by collimator</td>
<td>X-ray</td>
</tr>
<tr>
<td>ASIC readouts</td>
<td>Gamma</td>
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<tr>
<td>Piezoelectric Adjustable X-ray Optics</td>
<td>X-ray</td>
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<tr>
<td>Quadrant photodetector: low noise</td>
<td>Gravitational Wave</td>
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<tr>
<td>ADC: 10 yr life, low noise (amplitude and timing)</td>
<td>Gravitational Wave</td>
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<tr>
<td>Priority</td>
<td>Technology Need</td>
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</tr>
<tr>
<td>1</td>
<td>Depth graded multilayer coatings for hard X-ray optics</td>
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<td>2</td>
<td>Laser interferometer ~1 kWatt laser</td>
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<td>3</td>
<td>Extendable optical bench to achieve 60 m focal length</td>
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<td>4</td>
<td>Active cooling of germanium detectors</td>
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<td></td>
<td>&gt;3 m^2 Si (or CZT or CdTe) pixel arrays or hybrid pixels -- possibly deployable</td>
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<td>Broadband X-ray Polarimeter</td>
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<td>10 W near IR, narrow line</td>
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<td></td>
<td>Finely pixelated detectors for high angular resolution hard X-ray imaging.</td>
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<td>Gravity Reference Unit (GRU) with ~100x lower noise</td>
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<td>Focusing elements (e.g., Laue lens) on long boom or separate platform</td>
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<td>Photocathodes, microchannel plates, crossed grid anodes</td>
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<td>3 m precision optics</td>
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<td>Low-frequency, wide-bandwidth, low-mass science antennas</td>
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<td>Thin lightweight X-ray concentrator</td>
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<td>Point source optimized X-ray concentrator</td>
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<td>Lightweight, high throughput Fresnel optics</td>
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<td>Advanced scintillators and readouts for gamma-ray detection</td>
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<td>Lobster eye X-ray optics for all-sky monitors</td>
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<td>Megapixel CCD camera</td>
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<td>Ultra-low power, temperature resistant, radiation tolerant analog electronics</td>
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<tr>
<td></td>
<td>Ultra-low power, temperature resistant, radiation tolerant digital electronics</td>
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<tr>
<td></td>
<td>Autonomous low-power generation and storage</td>
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<td></td>
<td>Thermal stability/control less than 10E-8 K variation</td>
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<td></td>
<td>Low-cost launch vehicles for single payloads with few months mission durations</td>
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</tbody>
</table>