

## Key Technology Capability Roadmaps: Performance, Products, and Using Missions vs. Time

Time Horizon	Now	5 Years	10 Years	25 Years
Advanced Structures Deployment and Control	<ul style="list-style-type: none"> <li>Many low to moderate precision deployments already occurring</li> <li>First flight test of aerodynamics of deployable structures</li> <li>10<sup>-3</sup> deg C CTE of composite structures</li> </ul>	<ul style="list-style-type: none"> <li>Flight deployment of 2-4-meter diameter structures</li> <li>Shape control to 25<math>\mu</math> RMS</li> <li>NGST Inflatable sun shield flight experiment</li> <li>5% structural damping to less than 20 modes</li> <li>Enabling for Origins and SEU missions</li> </ul>	<ul style="list-style-type: none"> <li>Flight deployment to 10m diameter structures</li> <li>Control structure to 25<math>\mu</math> RMS</li> <li>10<sup>-3</sup> deg C CTE of composite structures</li> <li>Enabling for Origins and SEU missions</li> </ul>	<ul style="list-style-type: none"> <li>Flight deployment of 20m to 25m diameter ultra light structures</li> <li>Control shape to one micron RMS error for 25m diameter ultra light structures</li> <li>10<sup>-3</sup> deg C CTE of composite structures</li> <li>Enabling for Origins missions</li> </ul>
Communications	<ul style="list-style-type: none"> <li>Path finder: 10kbps from Mars to high-resolution color imaging</li> <li>30cm X-band S/C antenna</li> <li>70m ground antenna</li> </ul>	<ul style="list-style-type: none"> <li>1Mbps from Mars for HDTV</li> <li>30cm optical S/C telescope</li> <li>Lightweight, low-power, robust communication electronics</li> <li>Lightweight antenna materials</li> <li>Enhancing technology for all missions</li> </ul>	<ul style="list-style-type: none"> <li>100Mbps from Mars approaching IMAX quality</li> <li>50cm optical S/C telescope</li> <li>10m ground receiving telescope</li> <li>Lightweight, low-power, robust communication electronics</li> <li>Lightweight antenna materials</li> <li>Enhancing technology for all missions</li> </ul>	<ul style="list-style-type: none"> <li>10Gbps from Mars for Mars trunk line integrating orbiter, lander and rover data</li> <li>100cm optical S/C telescope</li> <li>10m ground receiving telescope</li> <li>Lightweight, low-power, robust communication electronics</li> <li>Lightweight antenna materials</li> <li>Enhancing technology for all missions</li> </ul>
Design Tools Spacecraft Operability	<ul style="list-style-type: none"> <li>Skunk works</li> <li>Co-located teams</li> <li>HWSW breadboard and test</li> </ul>	<ul style="list-style-type: none"> <li>Collaborative engineering</li> <li>Tele-engineering</li> <li>Model-based design</li> <li>Benefits all missions</li> </ul>	<ul style="list-style-type: none"> <li>3-D real-time model-based design</li> <li>Design visualization</li> <li>Distributed engineering</li> <li>Benefits all missions</li> </ul>	<ul style="list-style-type: none"> <li>S/C design synthesis</li> <li>Quick turn-around design</li> <li>Formal verifications</li> <li>Benefits all missions</li> </ul>
Lightweight Optics	<ul style="list-style-type: none"> <li>HST mirror at 1250kg/m<sup>2</sup></li> <li>SIRTF prototype at 25kg/m<sup>2</sup></li> <li>Segmented optical systems of 0.3-2m at 15kg/m<sup>2</sup></li> <li>Shell x-ray mirrors, 15 arc-sec HPD, 1,300kg, 0.7m diameter</li> </ul>	<ul style="list-style-type: none"> <li>Segmented optical systems of 2m-4m diameter</li> <li>Precision optical control to 150nm</li> <li>Large lightweight mirrors 612m diameter at 15kg/m<sup>2</sup></li> <li>Enabling for Origins missions</li> </ul>	<ul style="list-style-type: none"> <li>Segmented optical systems of 8 to 10m diameter</li> <li>Precision optical control to 50nm</li> <li>Large lightweight mirrors of 4m diameter at 15kg/m<sup>2</sup></li> <li>Enabling for Origins missions</li> <li>Enabling for NGST</li> <li>X-ray mirror detectors, 5 arc-sec HPD, large area, lightweight, medium resolution, enabling for Constellation-X</li> </ul>	<ul style="list-style-type: none"> <li>Thin-film transmissive optics of 224m aperture</li> <li>Segmented optical systems of 220m diameter</li> <li>Inflatable reflective optics of 225m aperture</li> <li>Precision optical control to 30nm</li> <li>Large lightweight mirrors of 4m diameter at 1kg/m<sup>2</sup></li> <li>RMS figure good enough for optical imaging</li> <li>Enabling for Origins and SEU missions</li> </ul>
Metrology	<ul style="list-style-type: none"> <li>Lab testbeds at one micron absolute and 250pm relative precision over 1-meter lengths</li> </ul>	<ul style="list-style-type: none"> <li>Image-based wavefront sensors for infrared telescopes</li> <li>50pm relative metrology over 10m lengths</li> <li>Enabling for Origins missions</li> </ul>	<ul style="list-style-type: none"> <li>Image-based wavefront sensors for visible telescopes</li> <li>50pm relative metrology over 100m lengths</li> <li>Enabling for Origins missions</li> </ul>	<ul style="list-style-type: none"> <li>50pm relative metrology over tens of km lengths</li> <li>Enabling for Origins missions</li> </ul>