



Technology Development Strategy for NGST Wavefront Sensing and Control

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Near Term Wavefront Sensing and Control Goal



- Demonstrate all relevant phases of wavefront sensing and control for the Next Generation Space Telescope
- Include aspects of
 - Scale
 - Complexity
 - Environment
 - Traceable Hardware
 - Traceable Algorithms
 - Traceable Operations
- Achieve "Technology Readiness Level 6":

System/subsystem model or prototype demonstration in relevant environment (ground or space)

- Strategy is a piecemeal approach to Technology Readiness Level 6
- Merge with Prime Contractor's strategy post-selection

Technology Demonstration by Device



Next Generation Space Telescope

NGST

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NGST Wavefront Control Test Matrix, August 16, 2002
Testing Issue / Objective Test Facilities

Testing Issue / Objective	WFT-1		PRC/ Small optics	WFT-2		PRC/ UoTA	PRC/ Ball AMSD	PRC/ UK AMSD	PRC/ BEG AMSD	PRC/ cryo PRC	AMSD-2 mirror		WFT-4 cryoPRC	NGST ETU	NGST test
	WFT-1	WFT-2		WFT-3	WFT-4						PRC	PRC			
WFS&C Control Modes	5.5	7		2	2		2	2	2	1	6	7	7	7	7
Demonstrate Coarse Alignment	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1
Demonstrate Coarse Phasing	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1
Demonstrate telescope alignment	0	■	0	0	0	0	0	0	0	0	1	1	1	1	1
Demonstrate WF Sensing	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Demonstrate WF Control	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
Demonstrate PSF Monitoring (IPO)	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1
Demonstrate Prime Contractor WFS&C	0.5	■	0	0	0	0	0	0	0	0	0	1	1	1	1
Optical Fidelity	4	5		2	2		2	2	2	1	3.6	5	5	5	5
Number of segments	0.5	■	0	0	0	0	0	0	0	0	0.3	1	1	1	1
Optical quality	0.7	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Number of control DOFs	0.8	■	1	1	1	1	1	1	1	0	0.3	1	1	1	1
Filled segmented aperture	■	1	0	0	0	0	0	0	0	0	1	1	1	1	1
Adjacent edges	■	1	0	0	0	0	0	0	0	0	1	1	1	1	1
System Fidelity	0.9	0.9		1	3		3	3	3	0	5.5	0.9	6	6	6
Large optics	0	0	■	1	1	1	1	1	1	0	1	0	1	1	1
Jitter	0.7	0.7	0	0	0	0	0	0	0	0	■	0.7	1	1	1
Higher order dynamics	0.2	0.2	0	0	0	0	0	0	0	0	■	0.2	1	1	1
Vacuum Optics	0	0	0	■	1	1	1	1	1	0	1	0	1	1	1
Cryo Optics	0	0	0	■	1	1	1	1	1	0	1	0	1	1	1
System Complexity	0	0	0	0	0	0	0	0	0	0	■	0	1	1	1
Control System fidelity	2.4	3.8		1.6	2.1		2.1	2.1	2.1	3	4	5.5	9	11	11
Tractable actuators	0.1	0.5	0.5	■	1	1	1	1	1	0	1	0.5	1	2	2
Vacuum Camera	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Cryo Camera	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Tractable camera focal plane	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0	1	1	2	2
Segment RB control	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1
Segment deformation control	0	0	■	0	1	1	1	1	1	0	1	0	1	1	1
Quaternary DM	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1
Controllable SM	0	■	0	0	0	0	0	0	0	0	0	0	1	1	1
Segment RoC control	0	0	0	■	0	0	0	0	0	0	1	0	1	1	1
Verification and Validation	1	1		2	2		2	2	2	2	2	1	1	2	2
Independent measurement	0	0	1	1	1	1	1	1	1	1	1	0	0	1	1
PSF metric	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Approximate Date	1999	2000	2001	2002	2003	2002	2002	2002	2002	2003	2004	2005	2006	2008	
Total score for each facility	6.9	11.9	4.1	13.8	17.7	8.6	11.1	11.1	11.1	7	21.1	19.4	28	31	
Estimated cumulative TRL	4	4	4	4	5	5	6	6	6	6	5	6	6	7	7

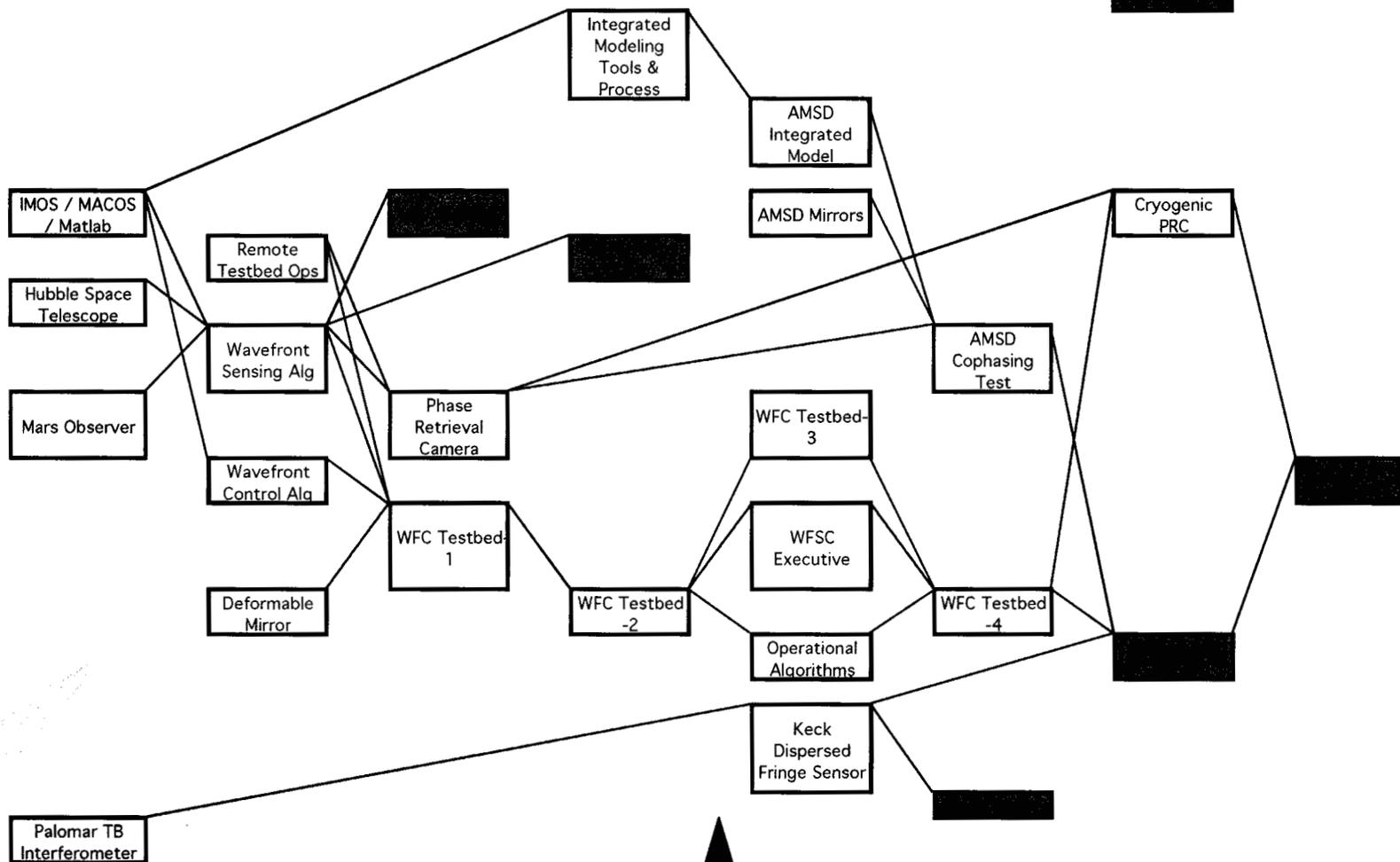
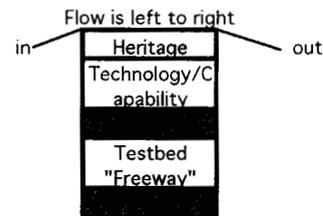
■ completed ■ first application □ high value testbed

Technology Flow (Roadmap)



Next Generation Space Telescope

Wavefront Sensing and Control Technology Roadmap through NAR - Core



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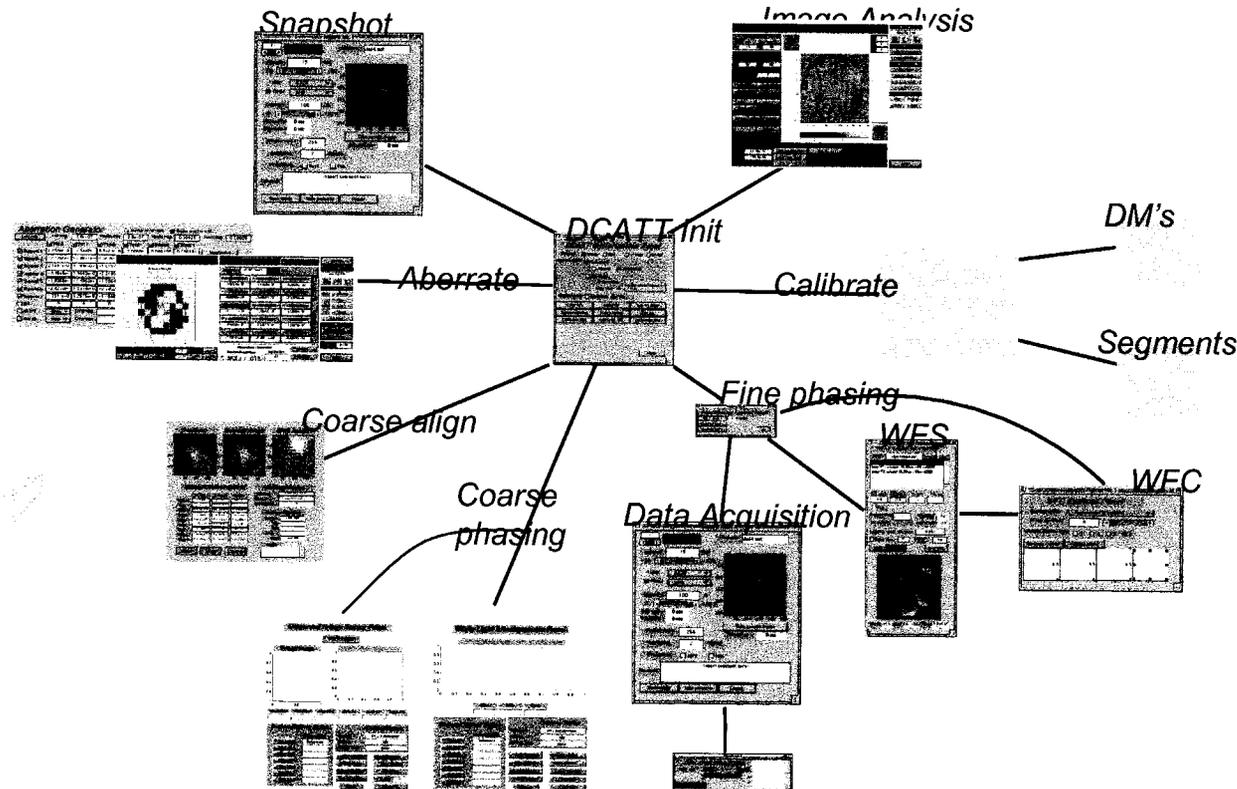
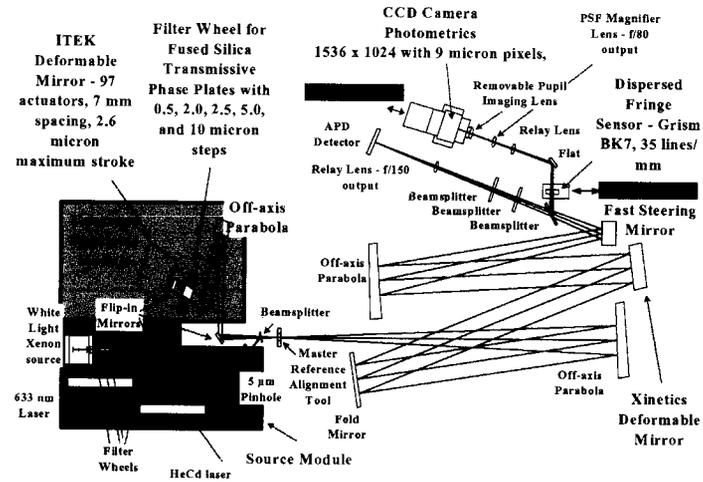
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Wavefront Control Testbed 1



Next Generation Space Telescope

- Wavefront sensing
- Wavefront control
- Deformable mirror
- In-focus PSF optimization
- PSF metrics



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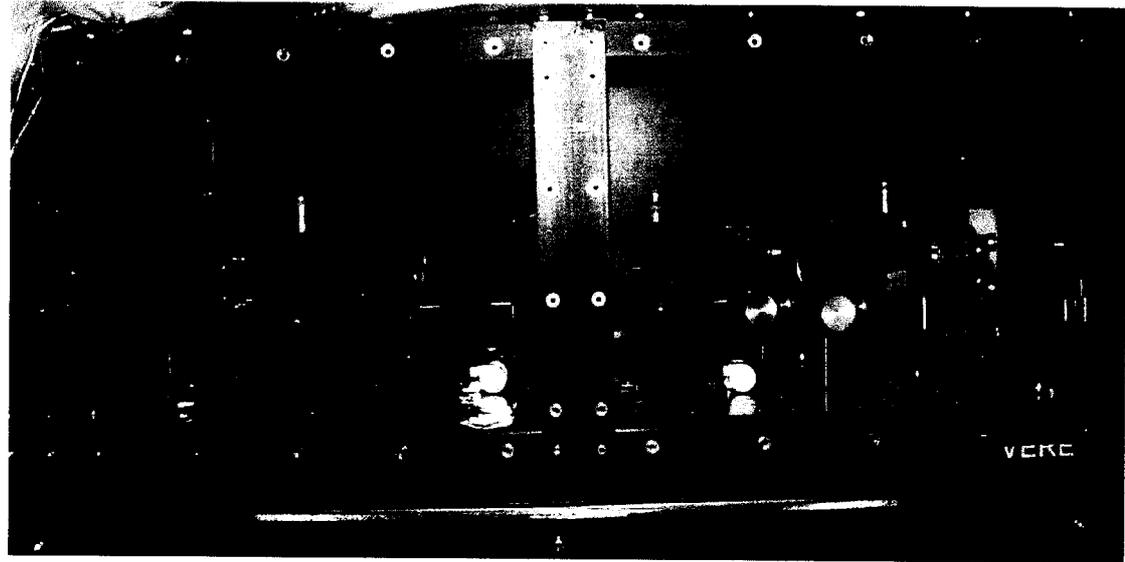
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Wavefront Control Testbed 2



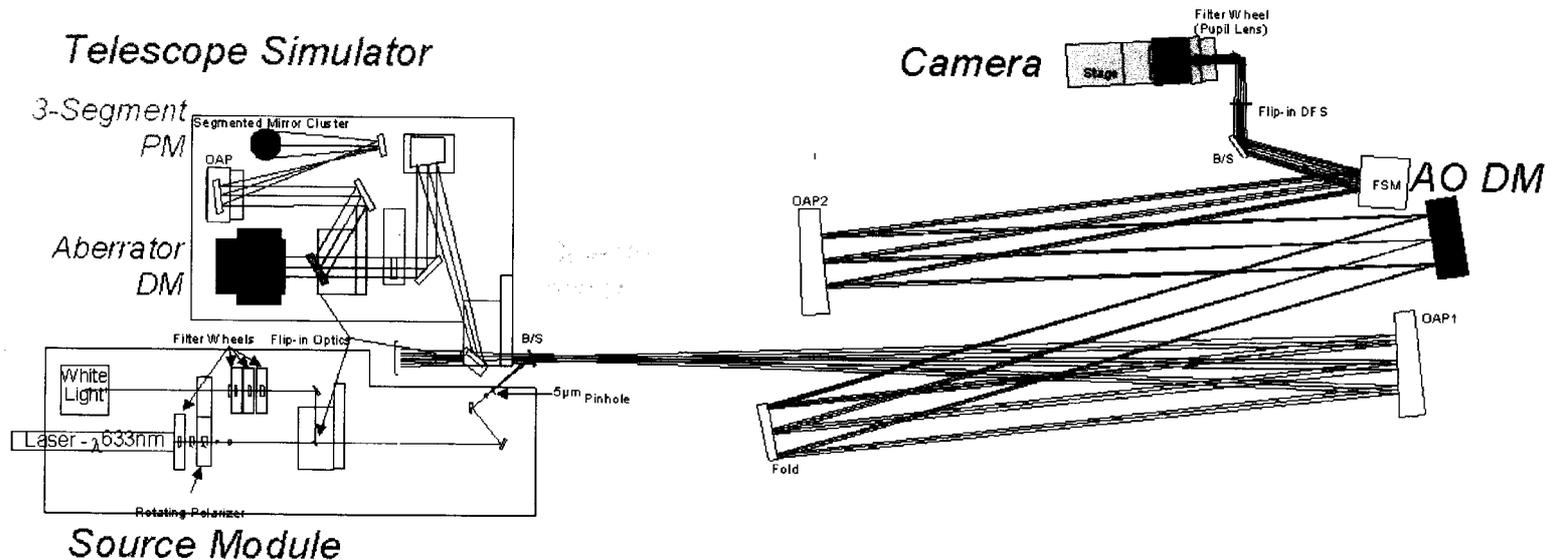
Next Generation Space Telescope

- Segmented optic
- Alignment
- Phasing
- In-focus PSF optimization
- Segment rigid body control



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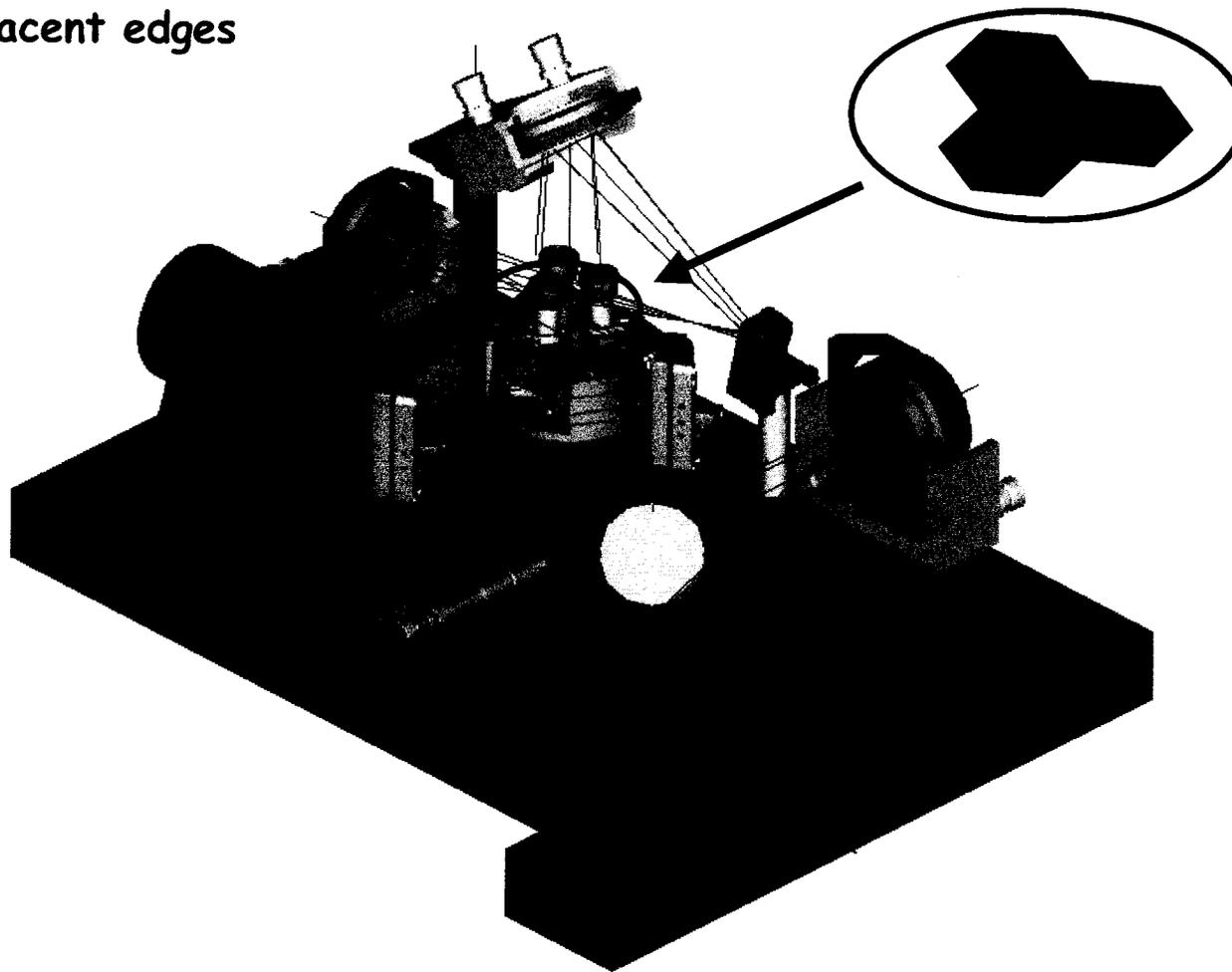
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Wavefront Control Testbed 3



- Filled aperture
- Adjacent edges



Upgrade WCT-2 telescope simulator with adjacent hexes

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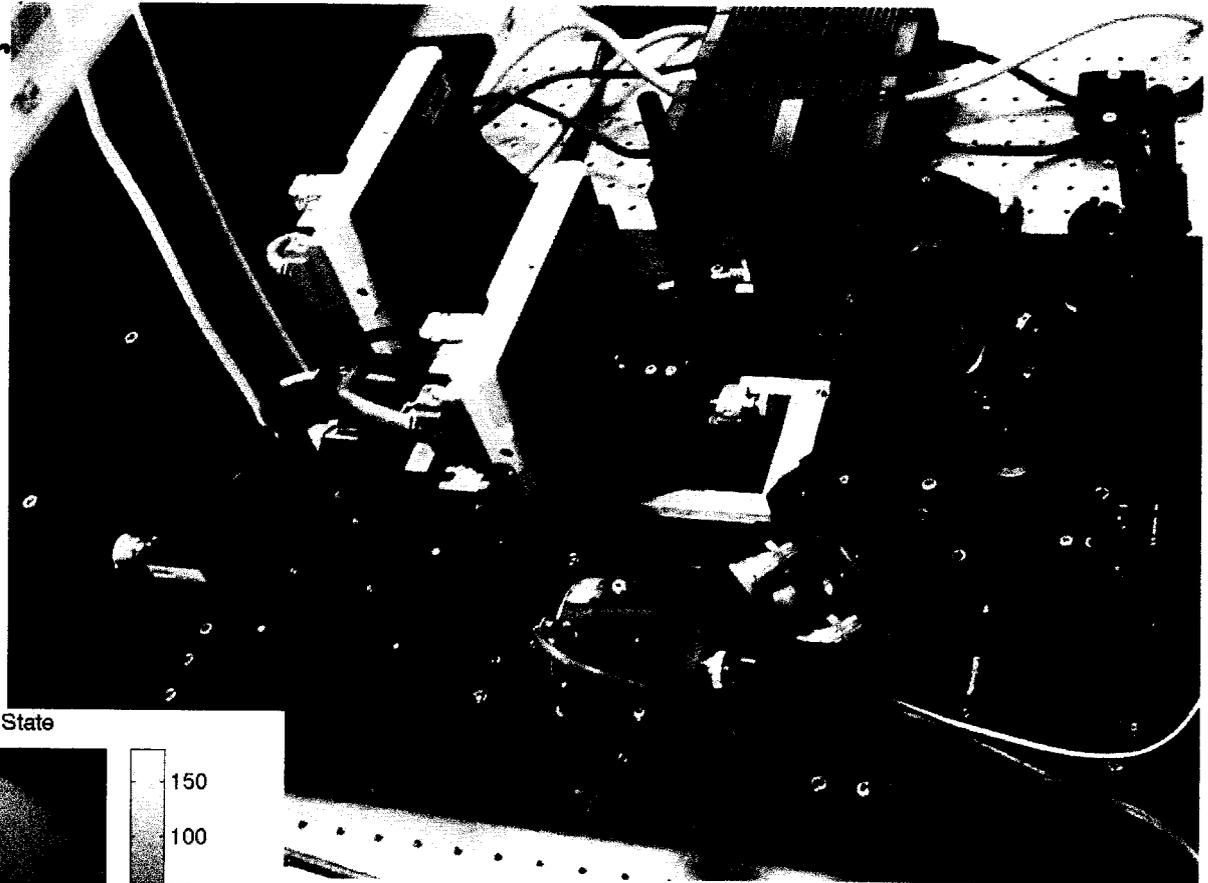
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Phase Retrieval Camera

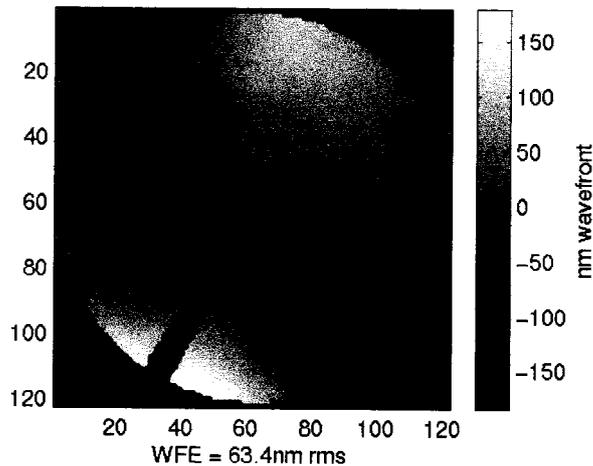


Next Generation Space Telescope

- Portable wavefront sensor
- Jitter-tolerant
- Validated against Zygo interferometer



Test Optic OPD in Final State



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Wavefront Control Testbed 4

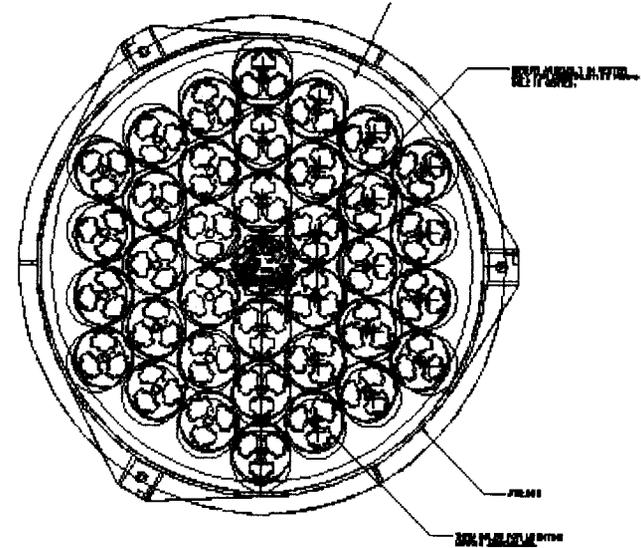


Next Generation Space Telescope

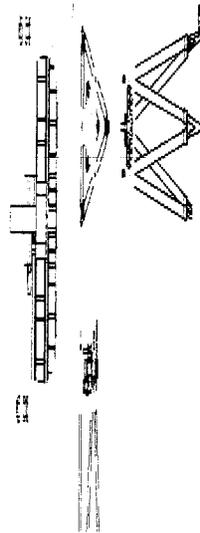
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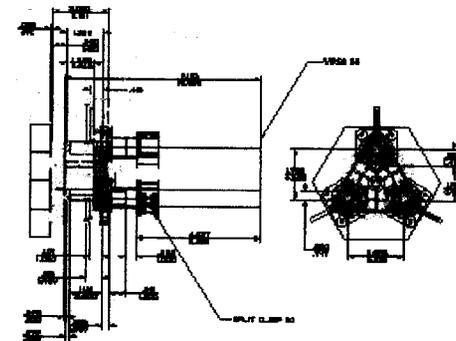
- Telescope alignment
- Operations timeline
- Comparable number of segments
- Comparable number of control degrees of freedom
- Controlable secondary mirror
- Traceable algorithms



Primary mirror assembly



Secondary tower



Actuated segment assembly

Integrated Modeling



- Multidisciplinary
- End-to-end performance modeling
- Nanometric precision
- Explore requirements
- Optimize design

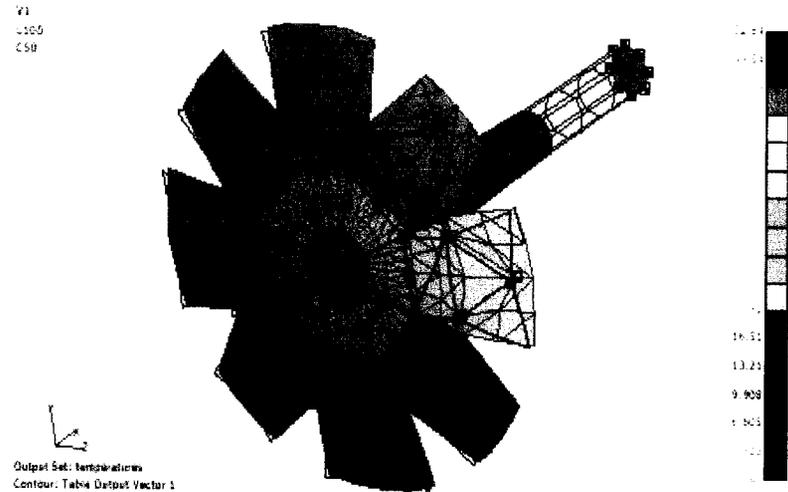
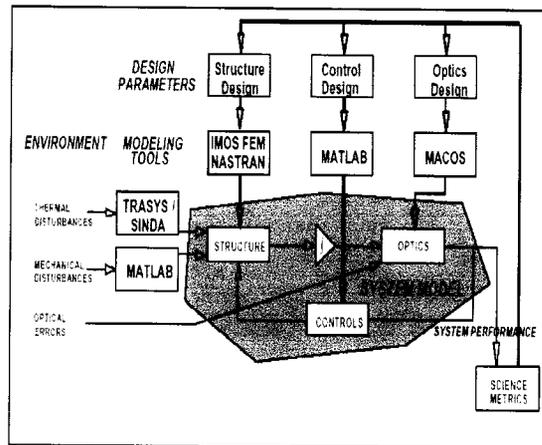
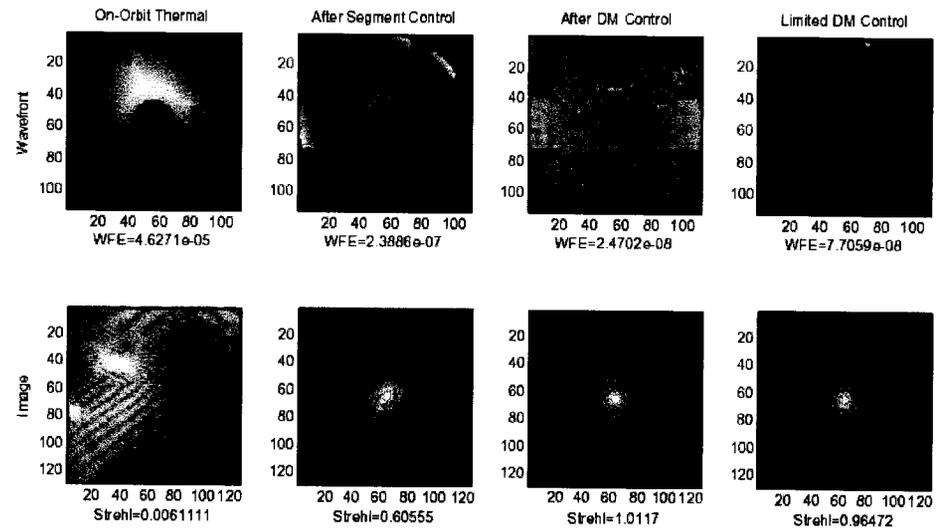


Figure 6-1 OTA steady-state temperatures



NGST integrated modeling environment



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Wavefront Sensing and Control Executive



- Testbed operations
- Remote operations
- Hosts wfsc algorithms
- Gathers experiment metrics
- Archives testbed data

