

NSF Science Working Group

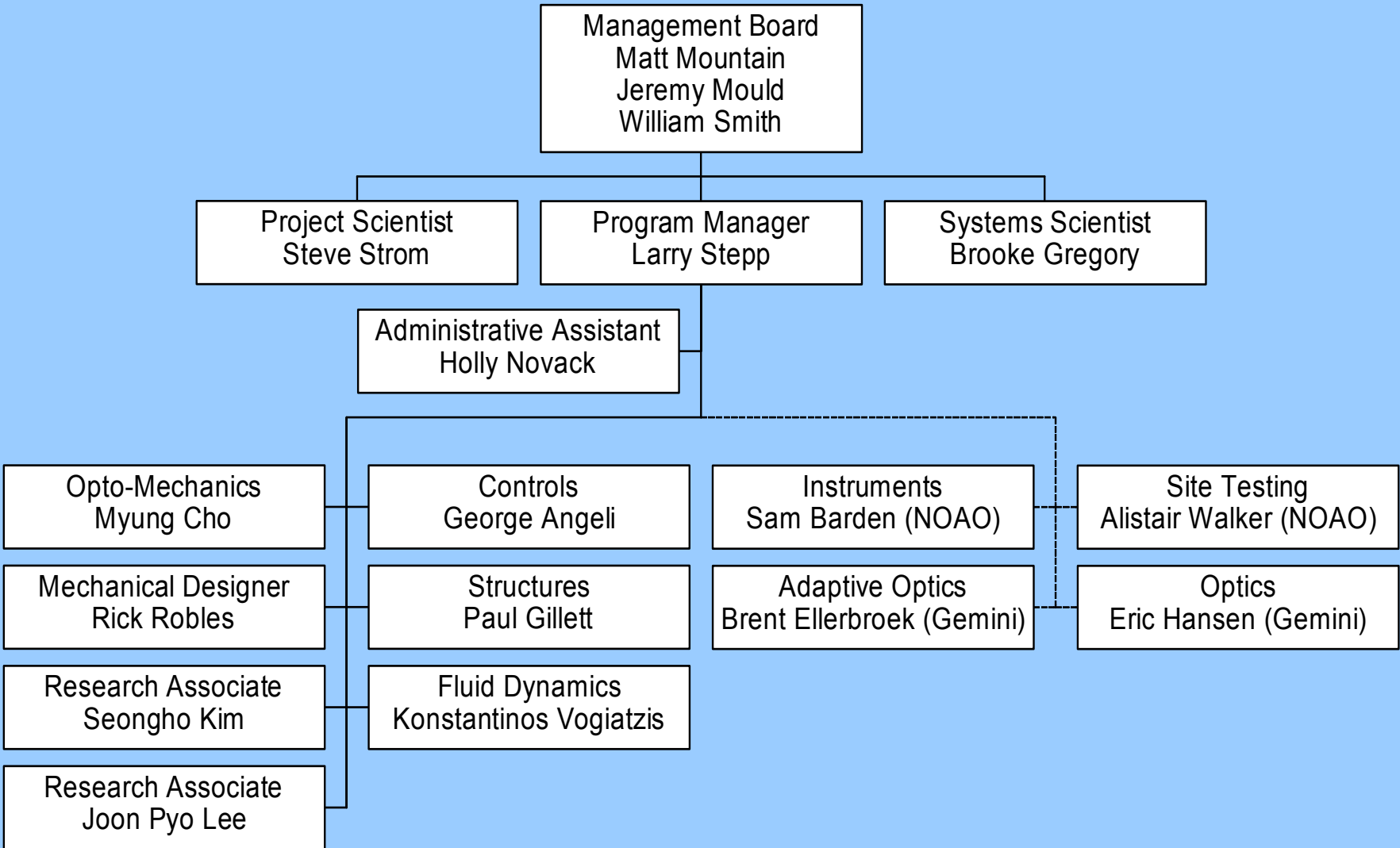
Support Available from AURA NIO

- Available Personnel
- Current Activities & Next Steps
- Maximizing Scientific Value

GSMT SWG Meeting

L. Stepp, July 30, 2002

Available Personnel



Planned Additions to NIO Core Staff

- Three full-time positions focused on integrated modeling:
 - Optical engineer
 - Adaptive optics engineer
 - Software engineer
- Personnel requisitions approved for these positions

Personnel in 2003 NIO Plan

NIO Staff		Position / Expertise
George Angeli	85%	Principal Controls Engineer
Myung Cho	75%	Principal Opto-mechanical Engineer / FEA; mirror supports
Paul Gillett	55%	Principal Structural Engineer / site construction manager
Holly Novack	80%	Administrative Assistant
Rick Robles	50%	Mechanical Designer
Larry Stepp	100%	NIO Manager / opto-mechanical engineer; large optics
Konstantinos Vogiatzis	100%	Computational Fluid Dynamics Post-doc
AO Engineer	100%	
Optical Engineer	80%	
Software Engineer	100%	
Intern	25%	
Gemini Staff		
Brent Ellerbroek	15%	Gemini Adaptive Optics Group Manager
Eric Hansen	20%	Gemini Systems Engineering Manager / opto-mechanical engineer
Dwain Jacobsen	50%	Site Testing Technician
Eric James	10%	Opto-mechanical Engineer / adaptive optics
Mike Sheehan	20%	Gemini Mechanical Engineering Manager / structural engineer

Personnel in 2003 NIO Plan (cont.)

NOAO Staff

Sam Barden	35%	NIO Instrument Scientist
Bob Blum	13%	Scientist
Arjun Dey	5%	Scientist
Dave DeYoung	5%	Scientist
Brooke Gregory	66%	NIO Systems Scientist
Ming Liang	10%	Optical Engineer
Julie McLaughlin	10%	Technical Editor
Knut Olsen	10%	Scientist
Joan Najita	30%	Scientist
Hugo Schwarz	10%	Scientist
Steve Strom	33%	NIO Project Scientist
Nick Suntzeff	3%	Scientist
Andrei Tokovinin	20%	Scientist
Alistair Walker	18%	Scientist / site testing manager
Chile Site Testing Technician	TBD	
Total FTEs	12.3	

Current Activities & Next Steps

NIO Technology Studies Described in GSMT Book

- Site Testing and Selection
- Sodium Layer Testing
- Cost Effective Mirror Fabrication
- Characterization of Wind Loading
- Adaptive Optics
- Design-to-Cost

These studies are continuing

Recent/Ongoing Activities

- Studies

- Beowulf cluster for AO simulation
- AMEC study of enclosure designs
- SG&H telescope structure cost estimate
- Univ. of Durham study on “Million-Element” IFU Spectrograph
- Site testing program on Mauna Kea
- Remote sensing site characterization: MK & SW USA + Mexico
- TSU CFD study of 30-m geometries

- Workshops

- Segment Fabrication
- Site Testing II

Next Steps

- Support key technology studies
- Develop methodology to maximize science value
- Evaluate cost-effectiveness of proposed ELT concepts
- Develop collaborations to accelerate ELT developments

Planned NIO Technology Studies

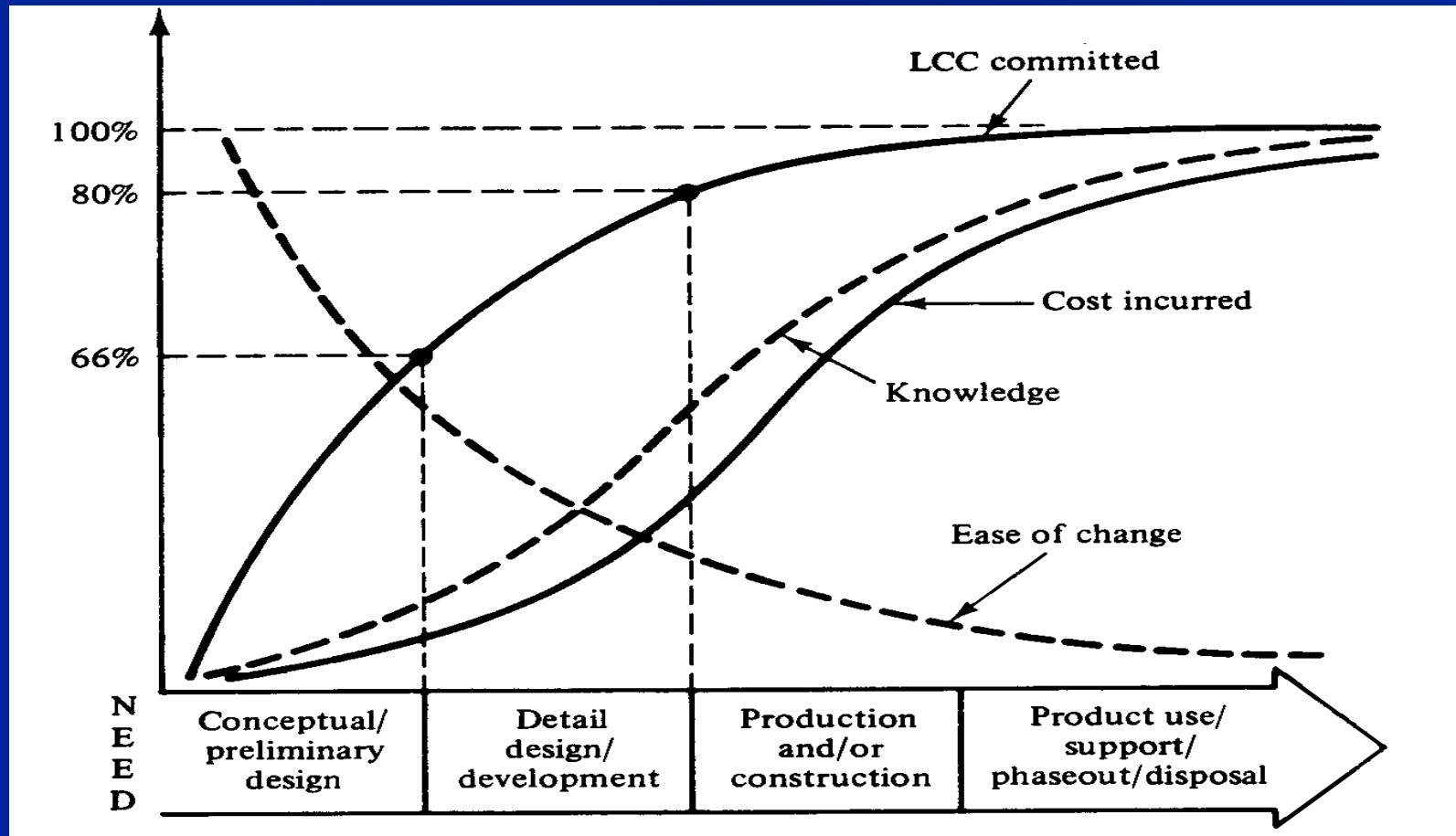
- Adaptive secondaries
- AO systems and components
- Segment fabrication and polishing
- Sensors and actuators
- Instrument concept studies
 - Advance key technologies (e.g. gratings; detectors; optics)

Maximizing Science Value

Design-to-Cost Approach

- ELTs will be very expensive to build and operate
 - Must consider life-cycle costs:
 - Design
 - Construction
 - Operation
- Design-to-cost approach is essential to maximize “science value” per dollar.
- Essential to apply design-to-cost protocol early in project

Cost Leverage Through Project Life Cycle



From Joe Hamacker, NASA MSFC

Design to Cost

- Used to maximize value while controlling cost
- Requires:
 - Tools to quantify scientific value:
 - *Science merit functions*
 - Tools to evaluate end-to-end performance
 - *Integrated modeling*
 - Tools to evaluate cost drivers
 - *Parametric cost estimating*
 - Flexibility to find optimum trades among design parameters
 - *Culture shift away from rigid requirements*

Science Merit Functions

- Scientific value = $\sum_i [W_i \times T_i \times MF_i(p_k)]$

where:

W_i = weight assigned to i th science program

T_i = time fraction assigned to i th science program

$MF_i(p_k)$ = merit function for i th science program

- Function of parameters p_k , for example:
 - Throughput
 - Available time
 - Emissivity
 - Degree of Multiplexing
 - Resolution
 - Sky coverage
 - Strehl ratio
 - Scattered light
 - Field of view
 - Isoplanatism

- Developing merit functions should be straightforward
 - Controversy comes in assigning weights and time fractions
- SMFs become part of project systems engineering

Science Merit Functions

- During conceptual design phase:
 - SMFs used to evaluate proposed telescope concepts
- During preliminary design phase:
 - SMFs used to optimize design relative to cost
- During construction phase:
 - SMFs used to guide decisions as conditions change

Tools to Evaluate End-to-End Performance

- Model system response to disturbances
 - Use an *Integrated Modeling* approach
- Conduct trade studies for different design approaches
 - Example: Fast primary active control vs adaptive secondary
- Build up modeling capability in modular stages

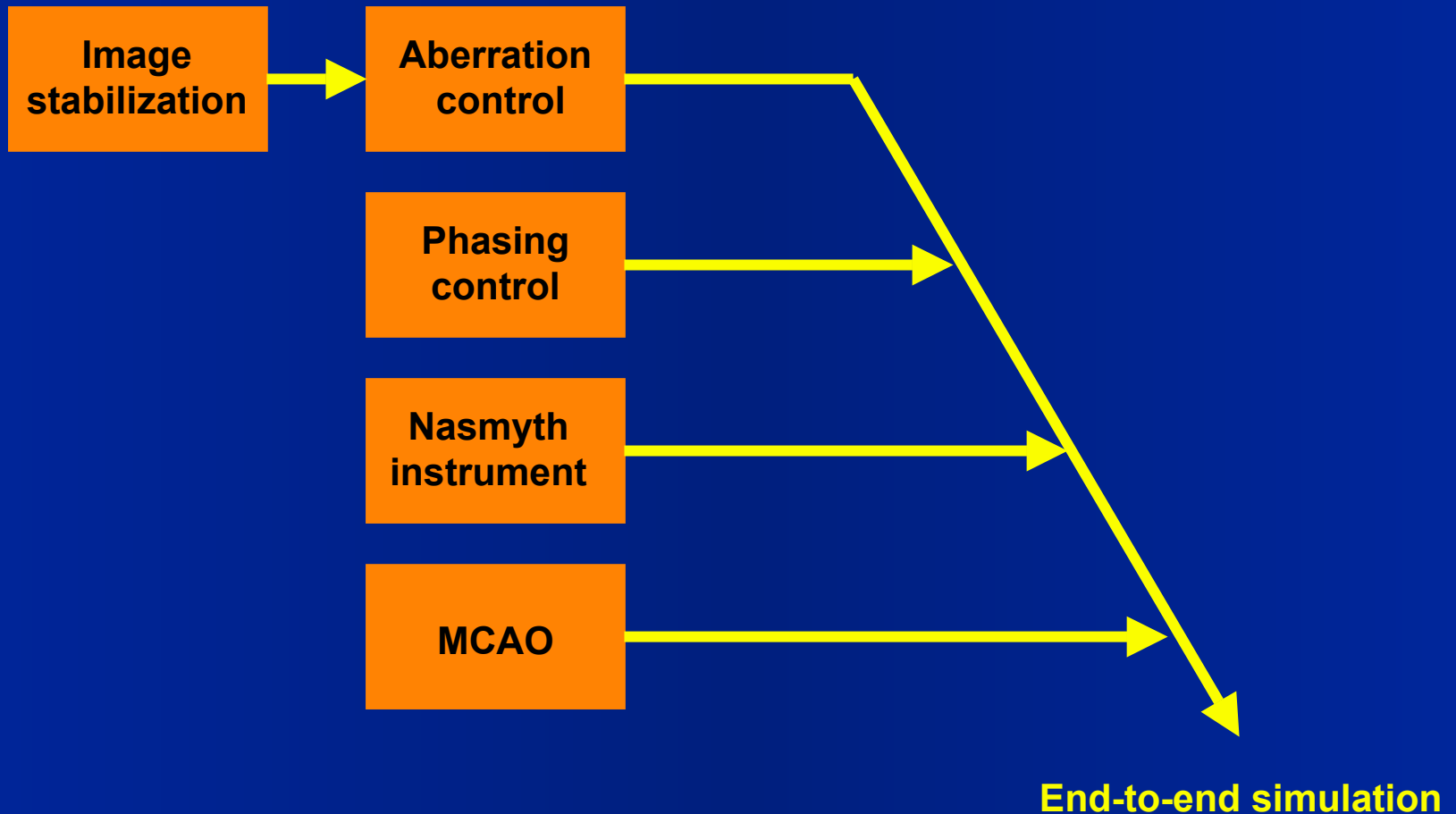
Integrated Modeling: a Modular Approach

1. Image stabilization
 - 1.1. Using main drives
 - 1.2. Using tip-tilt secondary
2. Aberration control
 - 2.1. Using M2 rigid body motion
 - 2.2. Using adaptive secondary
 - 2.3. Using M1 segment position control
3. Segment phasing control
 - 3.1. Quasi static
 - 3.2. Dynamic
4. Instrument performance
 - 4.1. Cassegrain instrument
 - 4.2. Nasmyth instrument
5. AO performance
 - 5.1. Adaptive Secondary
 - 5.2. MCAO
6. End-to-end performance
 - 6.1. Adaptive Secondary + Cassegrain Instrument
 - 6.2. MCAO + Nasmyth instrument

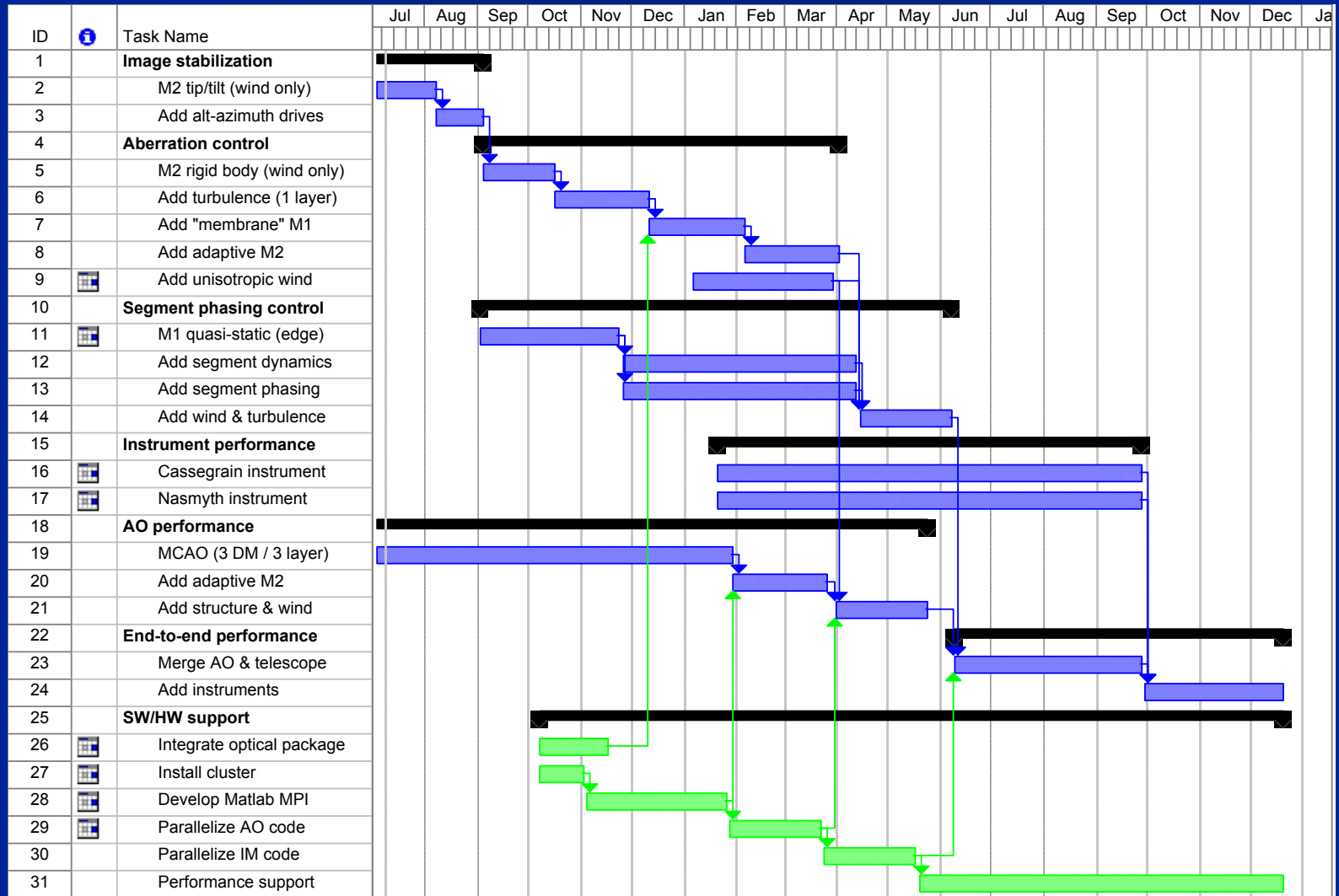
Integrated Modeling

		Actuators						Sensors					Disturbances					
		Main axes	M2 tip/tilt	M2 rigid body	M2 deformable	M1 "deformable"	M1 segmented	Pointing sensor	Low order WFS	High order WFS	Instrument WFS	Edge sensor	Isotropic wind	Unisotropic wind	Gravitation	Thermal load	Single layer	Multiple layers
Image Stabilization	Alt-azimuth	■						■					■					
	M2 tip/tilt	■	■					■					■				■	
Aberration Control	Low order	■	■	■				■	■			■					■	
	High order	■	■	■	■		■	■	■	■		■	■				■	
Segment Phasing Control	M1 quasi-static						■					■		■	■			
	M1 dynamic	■	■	■			■	■	■	■		■	■	■	■	■	■	
Instrument Performance		■	■								■						■	
AO Performance		■	■	■	■				■	■		■						■
End-To-End Performance	Cassegrain inst.	■	■	■	■		■		■	■	■	■	■	■	■			■
	Nasmyth inst.	■	■	■	■		■		■	■	■	■	■	■	■			■

Build Complexity by Adding Modules



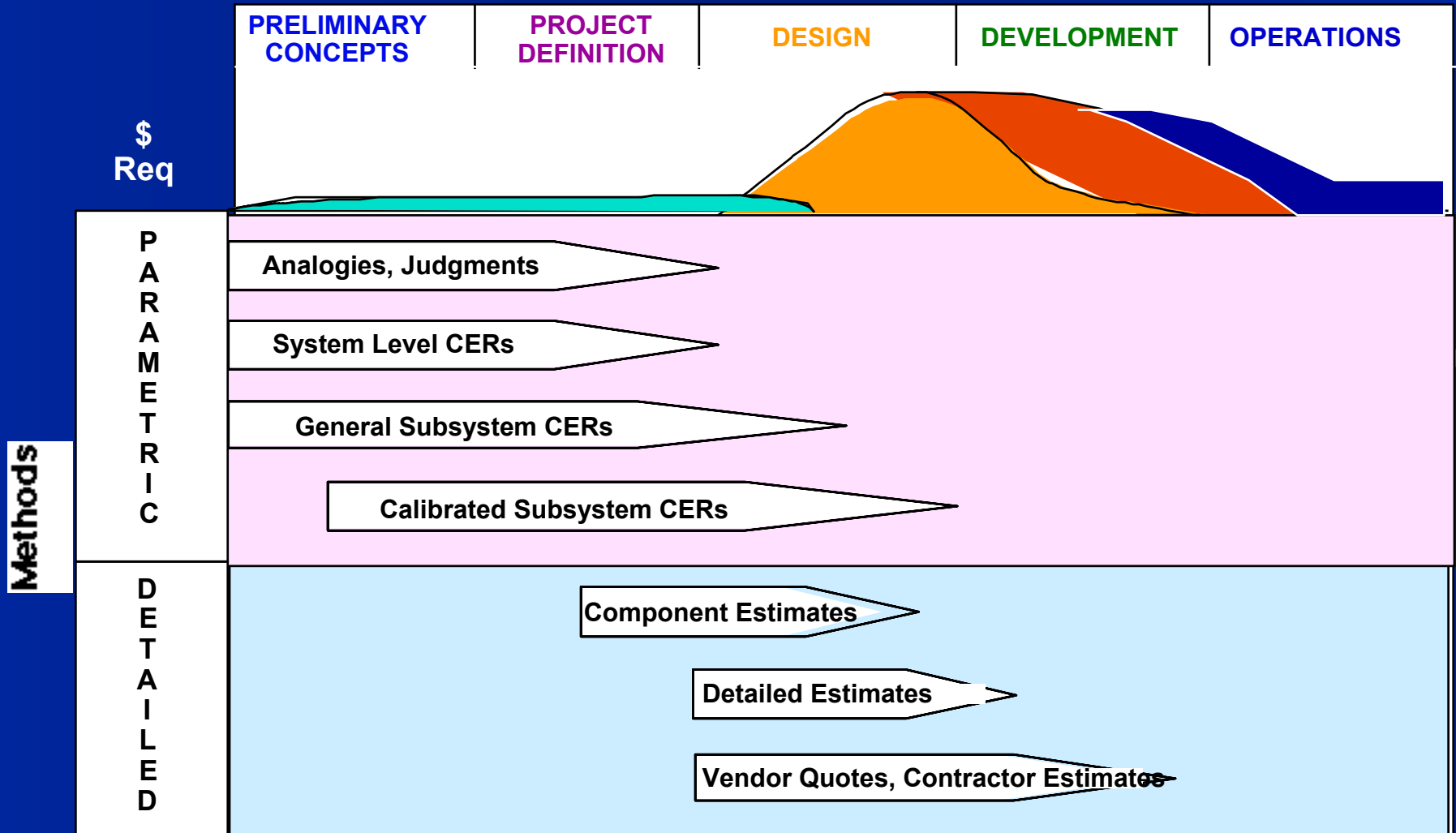
Modeling Sequence



Cost Estimating Dilemma

- Cost decisions most important during conceptual phase
- Difficult to estimate costs without detailed design
 - Design changes dynamic
 - Need to consider large number of variations

Cost Estimating Approaches Over Project Life Cycle



Parametric Cost Estimation

- Develop cost estimating relationships for major subsystems
 - Use current estimates and historical data as starting points
 - Involve potential contractors
 - Some studies may require significant funding
 - Possible focus for collaborative efforts by ELT groups
 - Calibrate models against existing facilities for which costs are known
- Apply PCE to multiple ELT concepts
 - Use point designs as test cases
 - Evaluate cost of alternate ELT designs
 - Potential value to multiple ELT groups

Example: Enclosure Cost

- Cost Estimating Relationship based on:
 - Historical enclosure costs from Gemini, Keck, etc.
 - AMEC GSMT enclosure cost estimates: 30m scale
 - AMEC XLT enclosure cost estimates: 20m scale
 - Euro 50 enclosure cost study: 25m, 50m, 75m & 100m scales
- Identify key cost parameters, including:
 - Weight
 - Diameter
 - Acceleration requirements
 - Site characteristics
 - Operational factors

