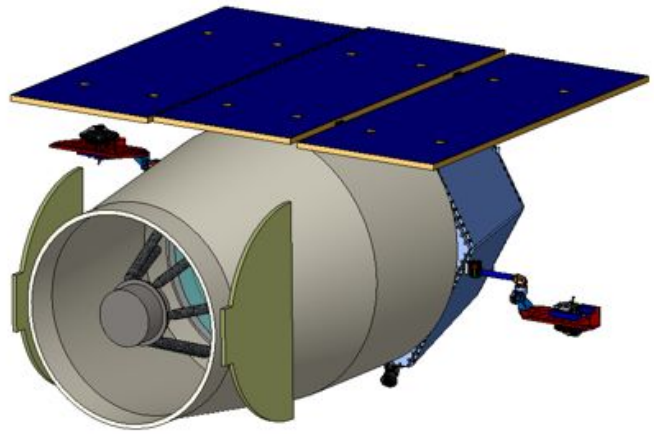

Industry perspective on use of the 2.4m telescope for AFTA WFIRST

January 10, 2013

Ball Aerospace & Technologies Corp.
ITT EXELIS
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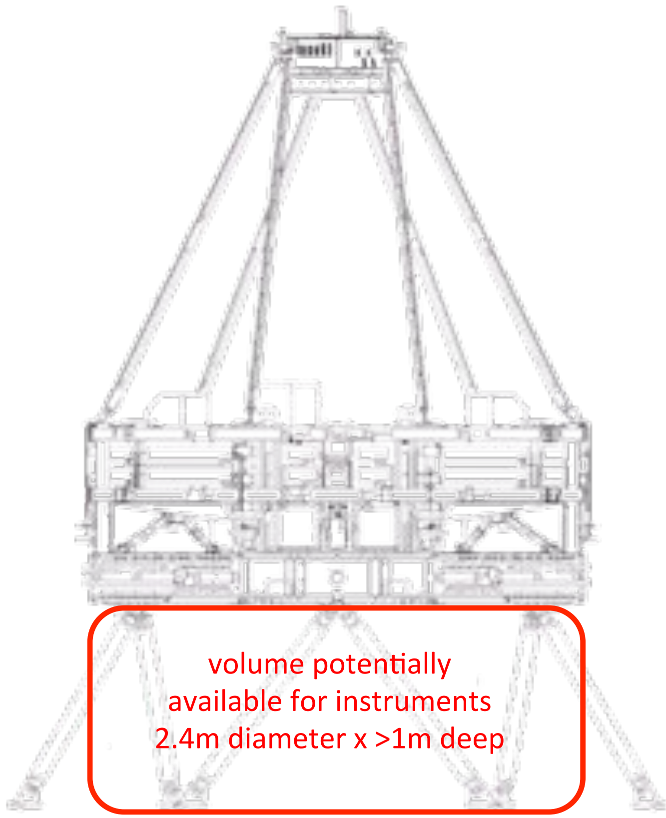
Topics for today's discussion

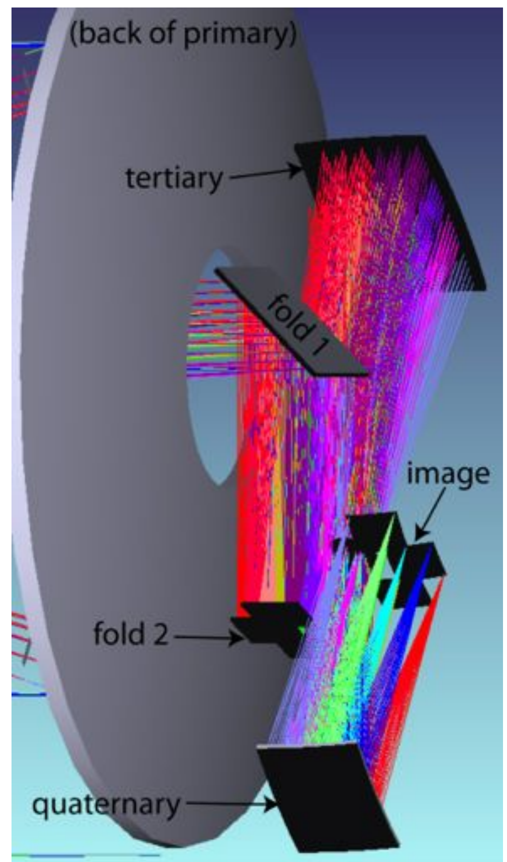
1. The focal plane array suggested for the wide-field visible and NIR imager is technically feasible.
2. A polar, sun-synchronous orbit and a geosynchronous orbit are both attractive, and reachable with a Falcon 9.
3. Alternative implementation approaches can reduce costs.

Topic 1
Focal plane for the Wide Field Imager

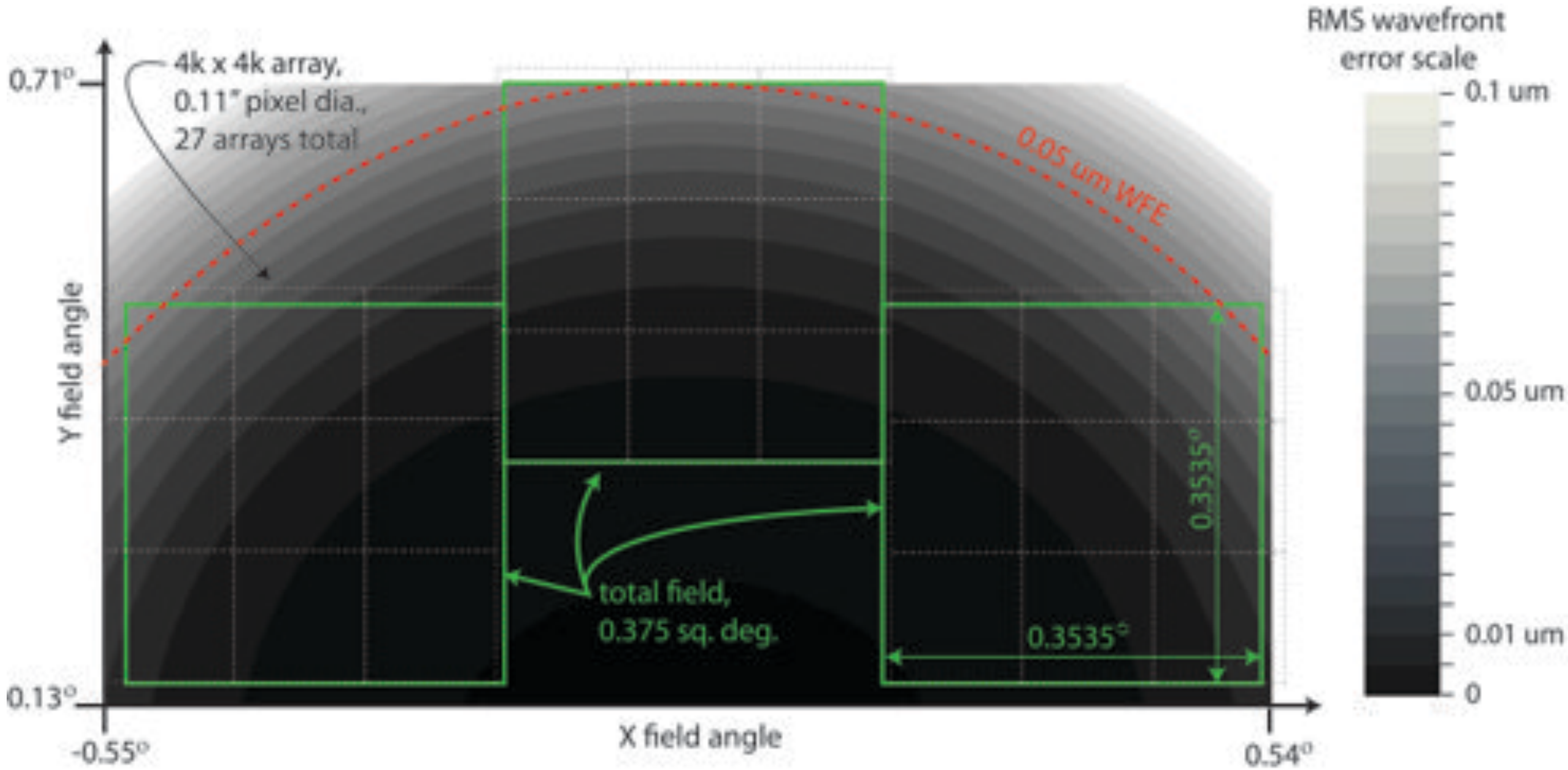
We know that the telescope with an aft-optics system can provide the field of view and spatial resolution desired for the WFIRST surveys.



Layout of a telescope similar to the delivered units.

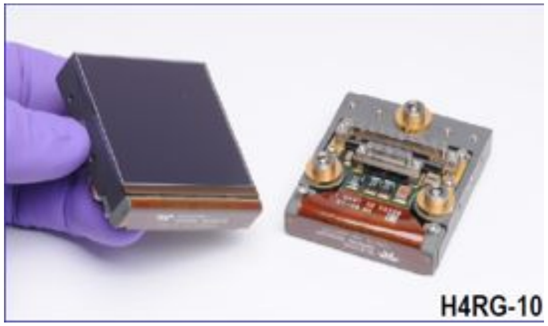


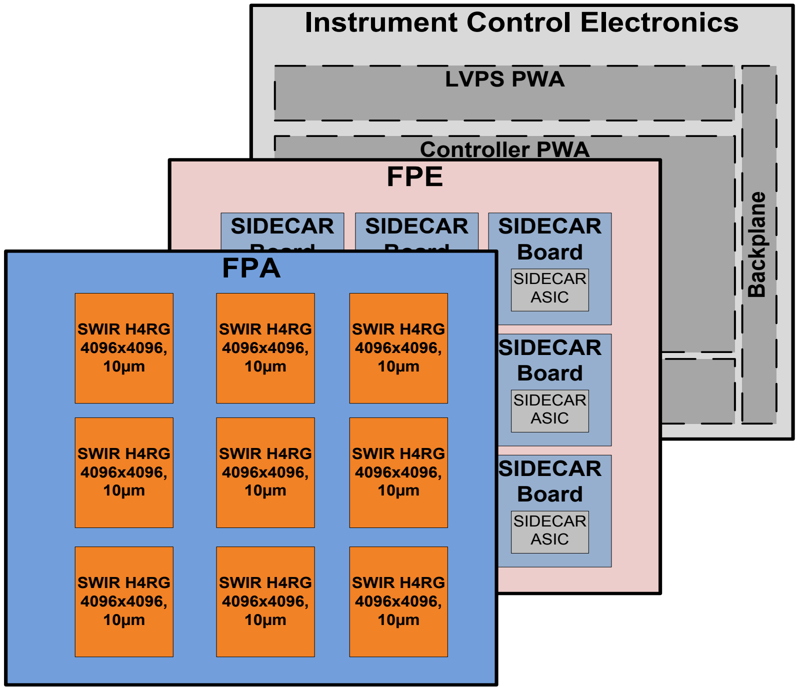
The field of view allows efficient tiling with large Focal Plane Arrays



Scalability offered by a modular design is very advantageous

- H4RG-10 NIR HgCdTe + Sidecars
- These can cover the 0.6μm < λ < 2μm 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



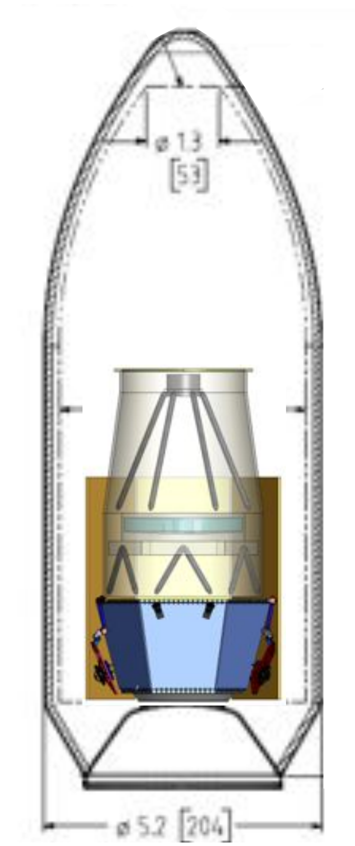


H4RG detector feasibility is encouraging, but with some development needed

- 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

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



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

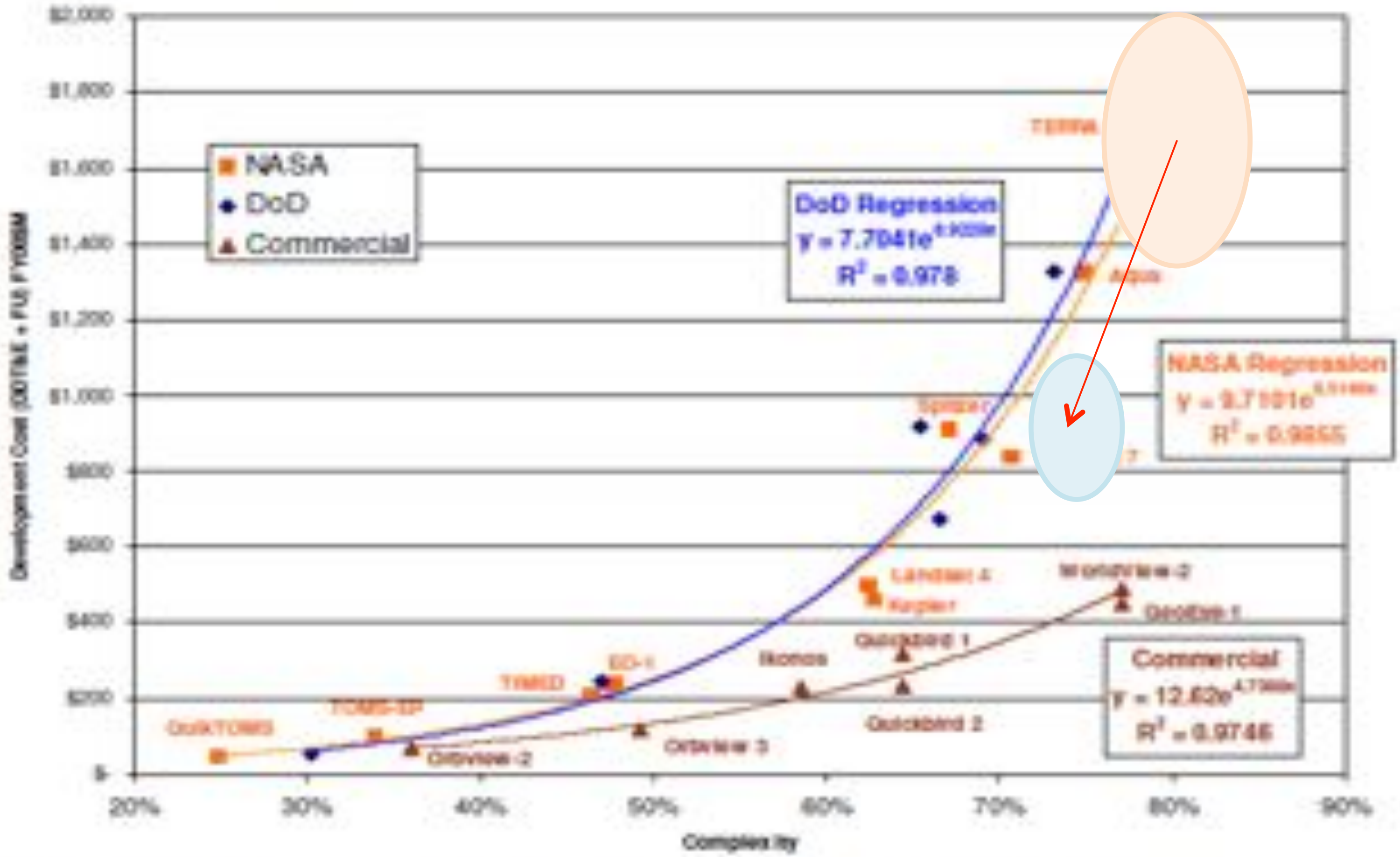
130 Mbits/s science data rate
1.5 Terabits/day

Topic 3
Alternative implementation approaches can reduce costs

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

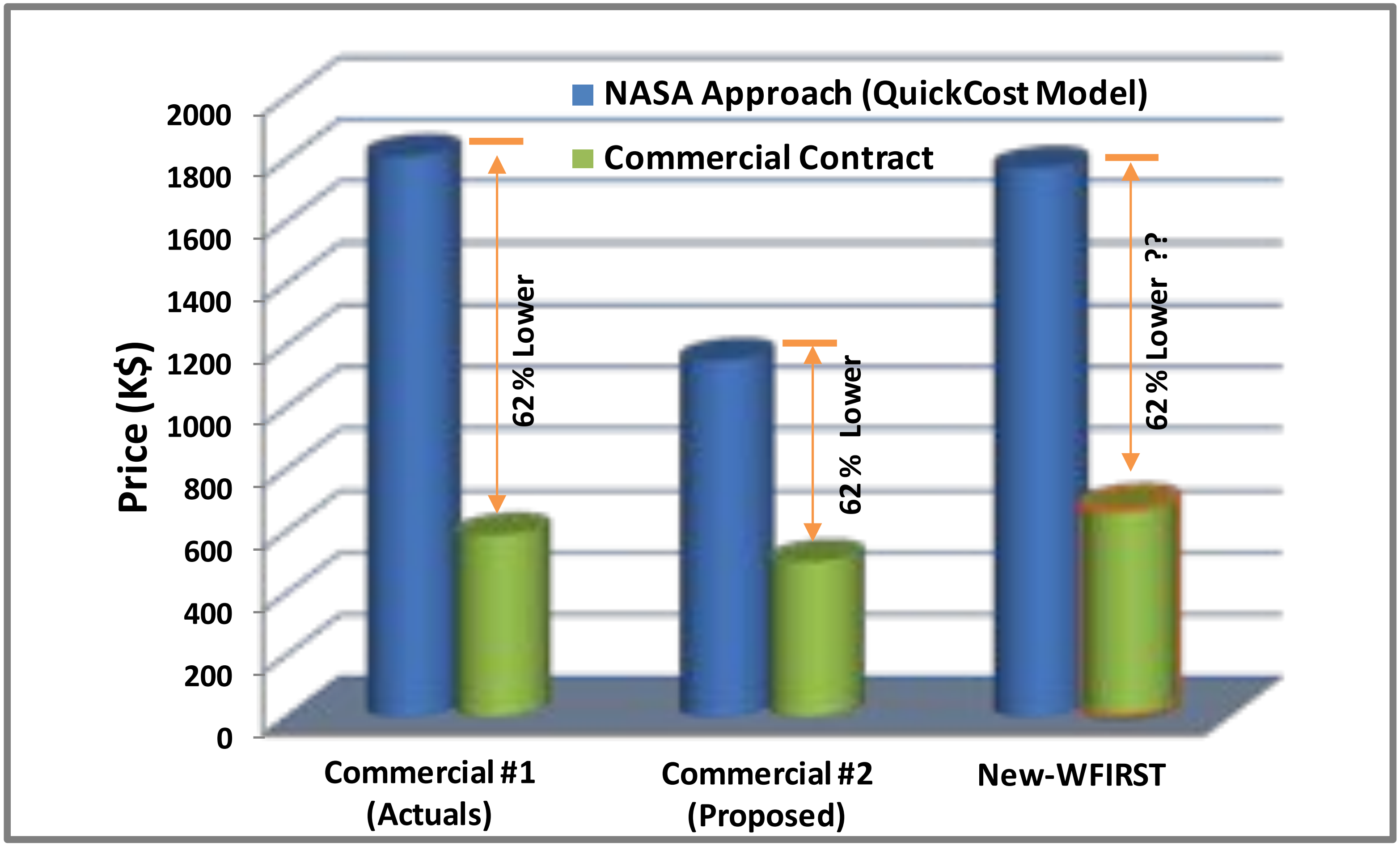
Coonce, T., Bitten, R., Hamaker, J. and Hertzfeld, H. "NASA Productivity." Journal of Cost Analysis and Parametrics 3:1 (2010): 50-78

Relative Cost vs. Complexity of Imaging Systems

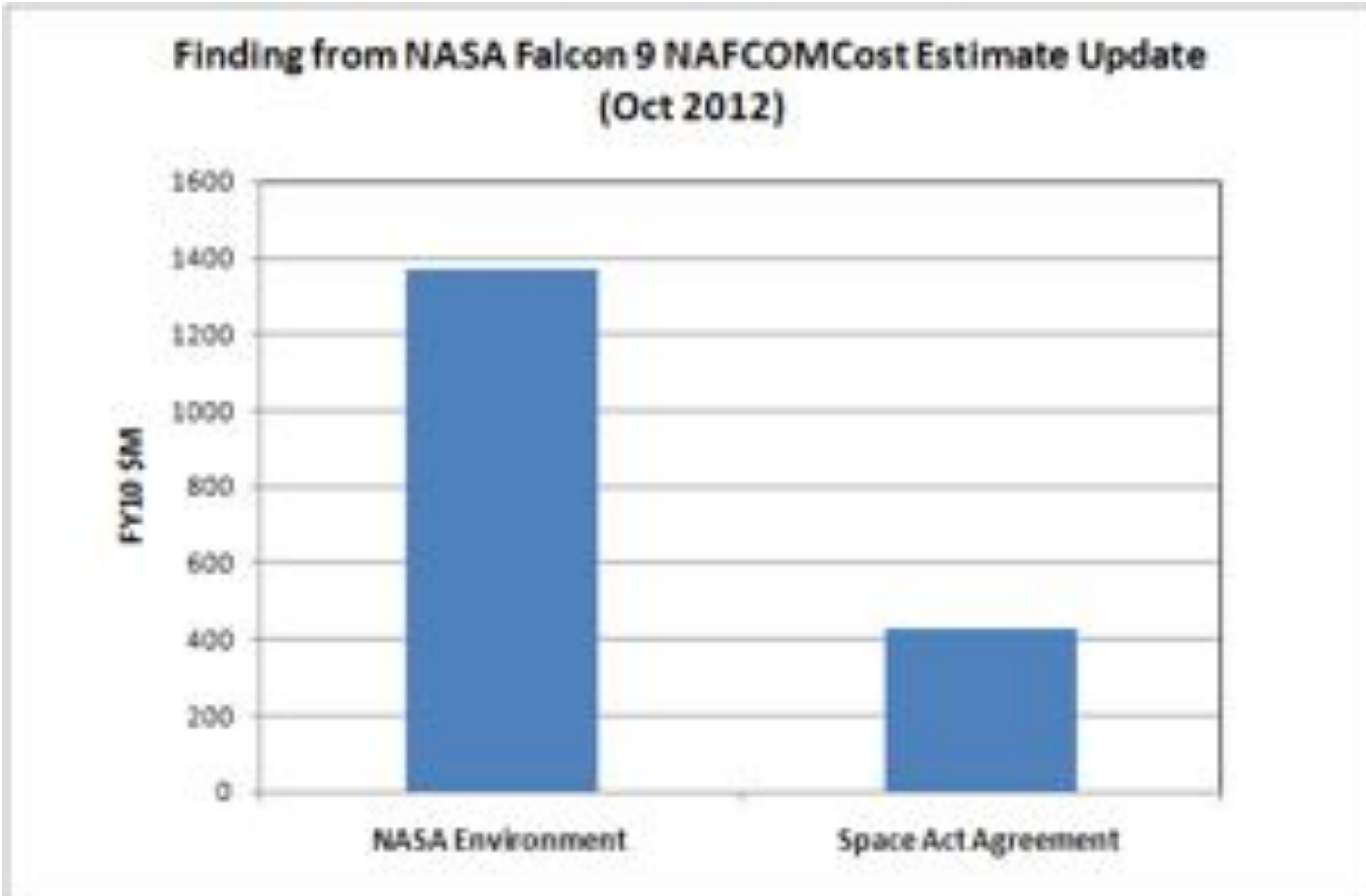


DoD & NASA Efficiencies are Similar but Much Less Than Commercial

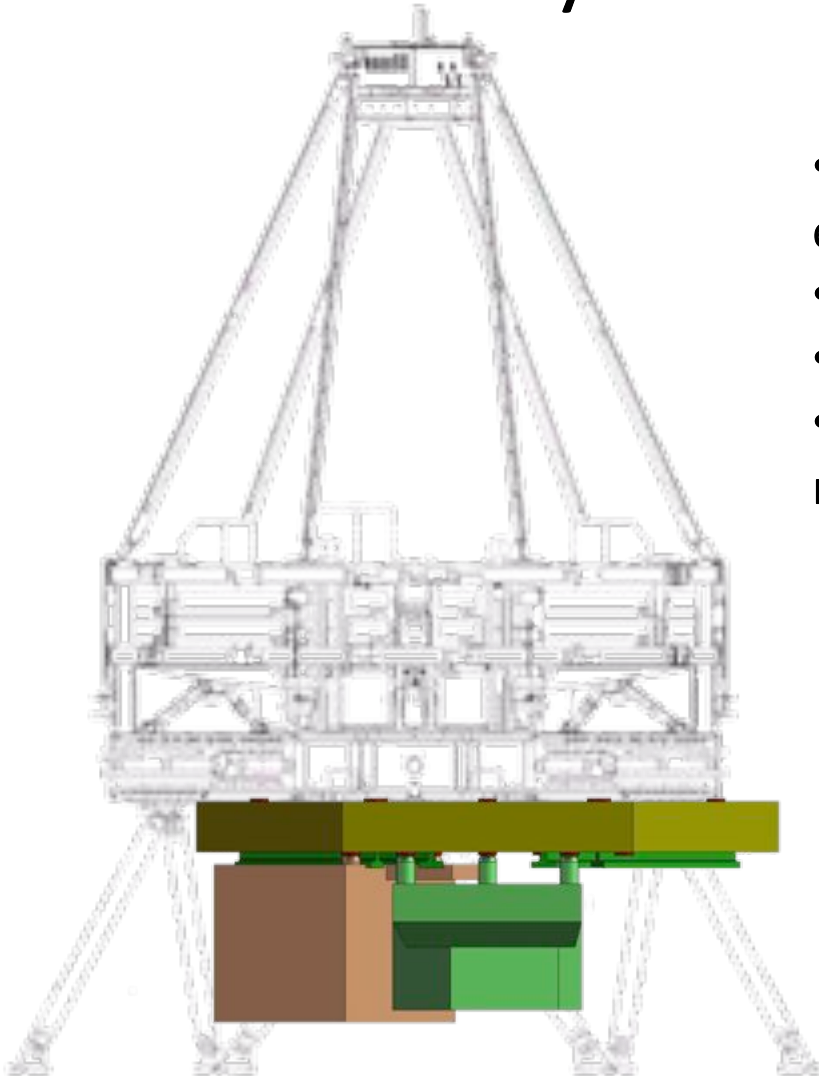
Two commercial examples at Ball were less costly than NASA's QuickCost model would have predicted



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

Mission Price Reduction →

		NASA REFERENCE MISSION (Kepler)	Commercial #1	Commercial #2 (Proposed)
Technical Complexity Attributes	Starting TRL	Medium	High	High
	New Development	Medium/High	Low	Low
	Average Complexity %	48	52 (1)	50 (2)
	System Testing Complexity	High	Medium	Medium
	Requirement Stability @ ATP	High/Medium	High	High
	Aperture Size	Medium	Medium	Medium
Acquisition Complexity Attributes	Customer Oversight	Multiple NASA Centers. Extensive Peer to peer.	Selective Oversight	Selective Oversight
	# of Approved CDRLS	Medium	Medium	Medium
	External Consultants	No	No	No
	PMRs /year	12	12	12
	Major Reviews w/Customer (3)	Follows LCGM	Follows LCGM	Follows LCGM
	On-site customer reps	Yes (3 reps)	Yes (3 reps)	Yes (2 reps)
	Customer access to vendors	On-demand	Controlled	Controlled
	Contractual Incentive (Profit/Science)	CPIF (Science)	FFP (Profit)	FFP (Profit)
	Funding Stability	Poor	Excellent	Excellent (assumed)
	Procurement Process	Competitive RFP	FFP (Sole Source)	FFP (Sole Source)
	MA Oversight	High	Best Industry Practice	Best Industry Practice
	System Requirements	Prescriptive (4)	Performance	Performance

(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 influnece development and production specifications, reliability, and te

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

With mature and stable requirements

The End