Dual Anamorphic Reflector Telescope (DART)

Large Aperture Technology Element

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Outline

- Need for large, lightweight apertures
- Previous approaches
- Introduction to DART
- Membrane candidates
- Conclusion

Need for Large Apertures

- space science requiring increased sensitivity and angular resolution
- higher resolution observations of earth
- permit work at higher orbits allowing better coverage with fewer satellites

Limited by launch vehicle capabilities:

- as apertures increase - mass density must decrease
- as apertures increase - must be packagable and deployable

Limited also by manufacturing time

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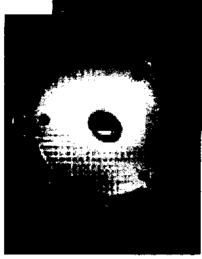
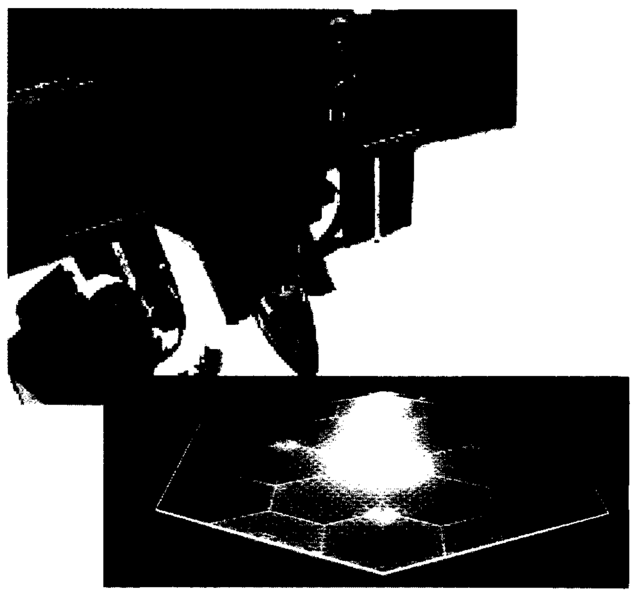
Large Aperture Technology Approaches

- Monolithic mirror have been lightweighted, but still have increasing mass density with diameter
- Segmented mirrors have lower masses, but follow similar scaling trends
- Membranes look promising, but surface figure has been a challenge

Monolithic

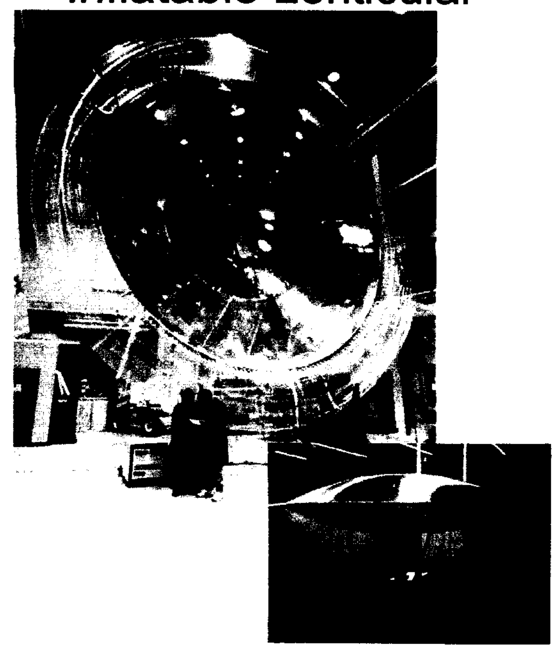


Hubble Primary



Segmented

Inflatable Lenticular



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Pictures: JPL, NASM, *Mark Lake, IEEE, 2001, Kodak AMSD mirror, AFRL, L'Garde

Introduction to the Dual Anamorphic Reflector Telescope (DART)

- DART represents a fundamental shift in telescope architecture; enabling for large (10-40m) aperture missions
- Instead of one 3-dimensional dish shaped reflector there are two cylindrical parabolic reflectors
- Since the 2-dimensional arrangement is more natural for membranes, problems associated with 3-d membrane dish manufacture and shaping are avoided
- DART development at JPL concentrates on demonstration of a telescope architecture which is scalable to large (~10s of m) sizes and very low (~kg/m^2) mass densities with a focus on a SAFIR (4K, 10m IR telescope) mission architecture

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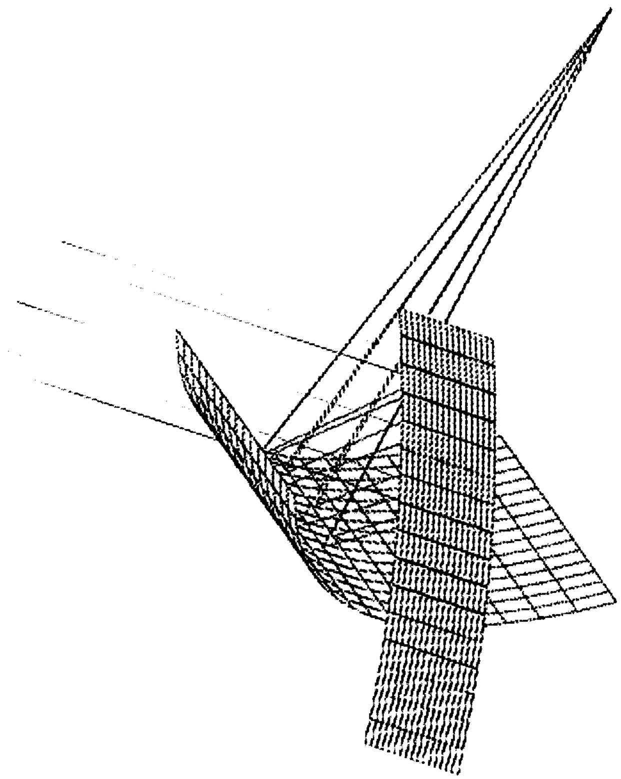
Optical Configuration

Dual Two-Dimensional Parabolas



This ray trace shows DART's fundamental optical concept, two cylindrical reflectors oriented perpendicular to each other with slightly different focal lengths (hence the *anamorphic* in the acronym) so that both focus at the same point.

- completely unobstructed aperture
- wide field of view with 100 x 100 fully sampled diffraction limited pixels
- optical performance degrades gently with increasing misalignment

Ideal for observations of low contrast sources such as the CMB, CIB, and dim objects near bright sources

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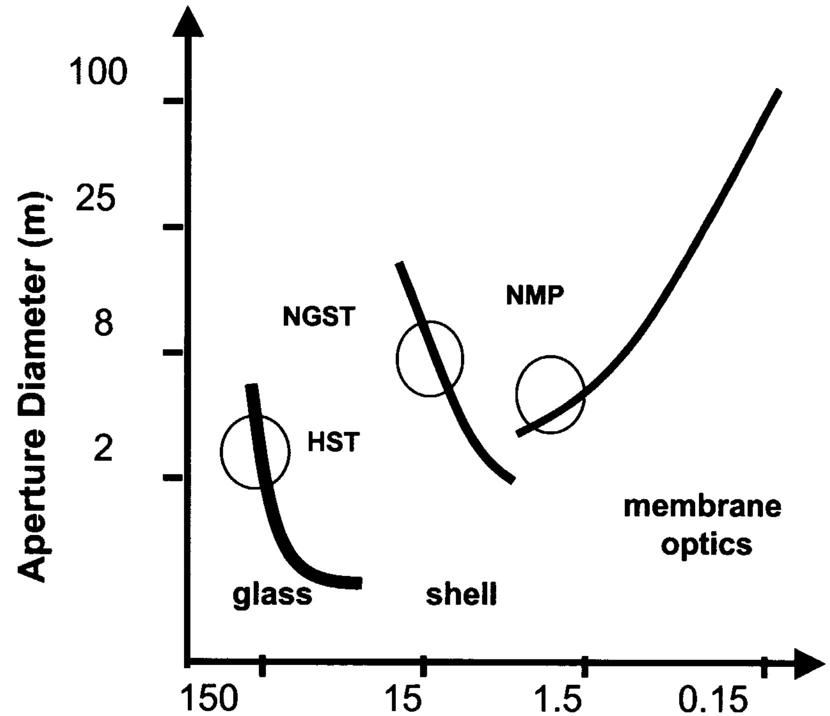
Scalability

DART optical system areal mass density decreases with the increased size of the telescope (up to a limit determined by practical resonant frequencies)

• smaller telescope mass is dominated by the structure

• for larger telescopes the relative ratio of structure mass to the reflector mass is smaller

• critical to achieving apertures on the order of 10-40m



Existing prototype has an areal mass density of 7 kg/m^2

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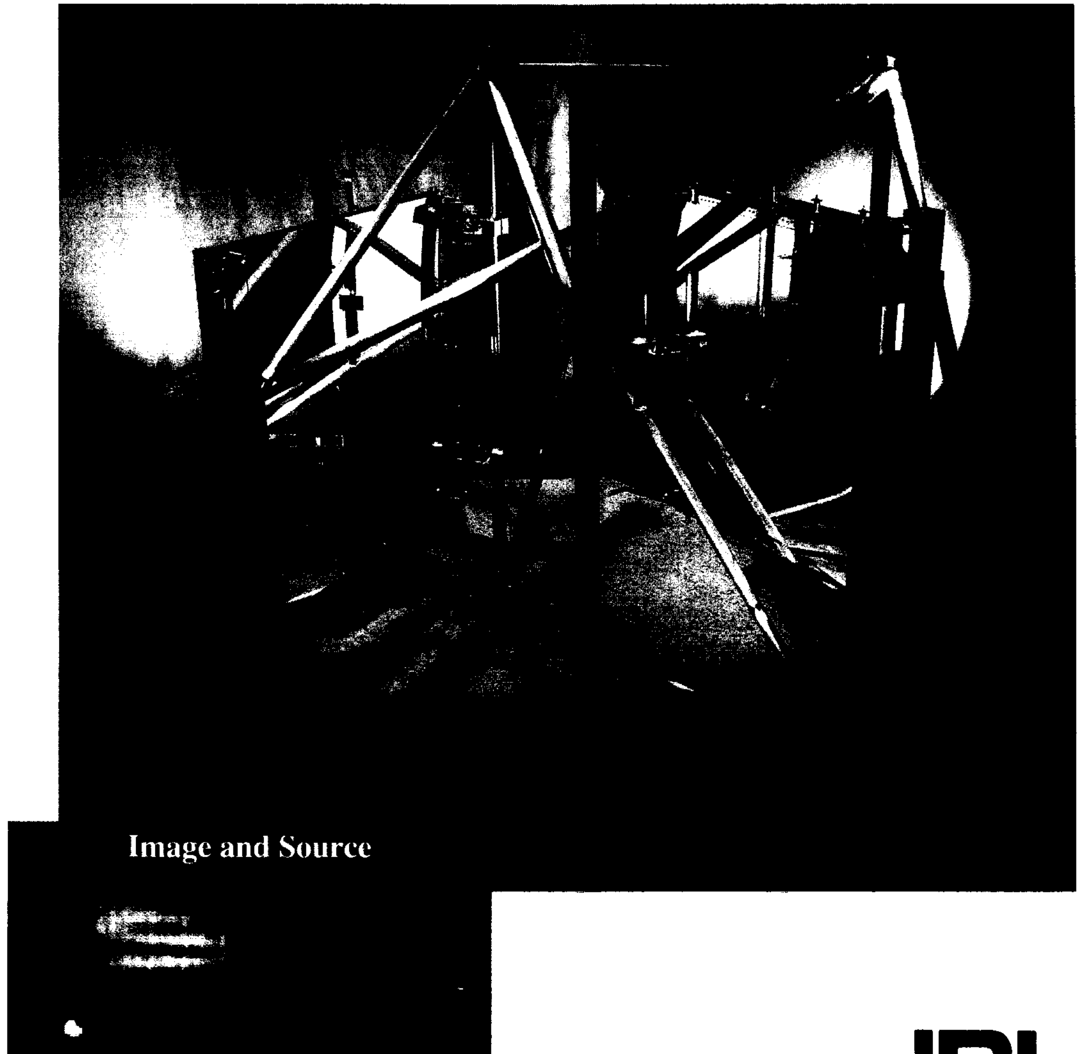
DART 1.2 m Prototype

- 1.2 m aperture prototype built by LMSSC/JPL team
- NMP ST6 Phase A development advanced DART technology (commenced by the Cross Technology Development Program) past TRL 3
- achieved 40 μm diffraction limited performance over 40 cm aperture (testing limited by size of collimator)



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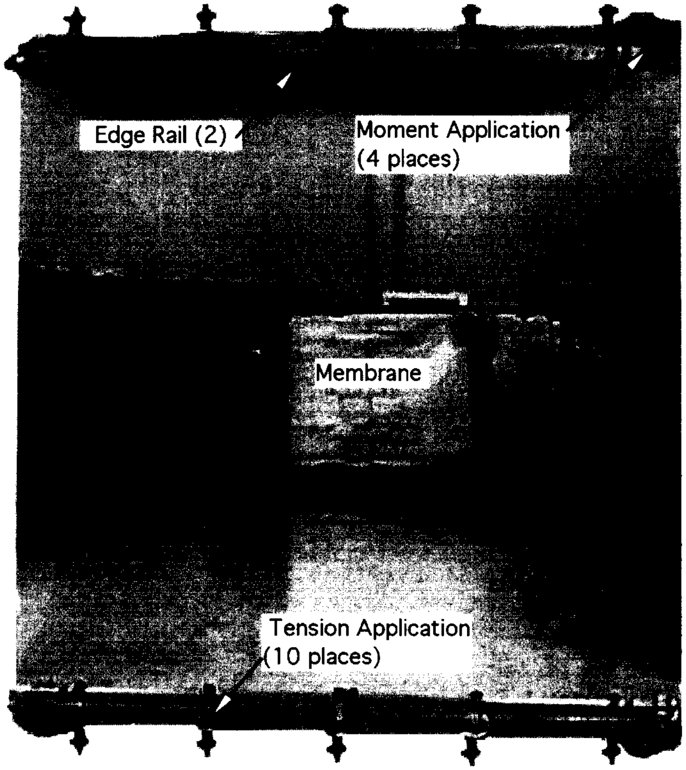
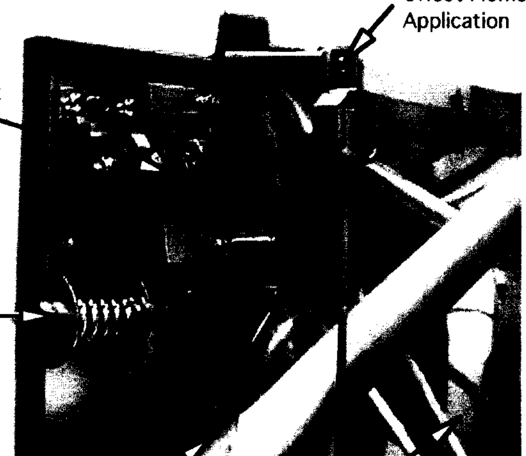
Testbed Design Details





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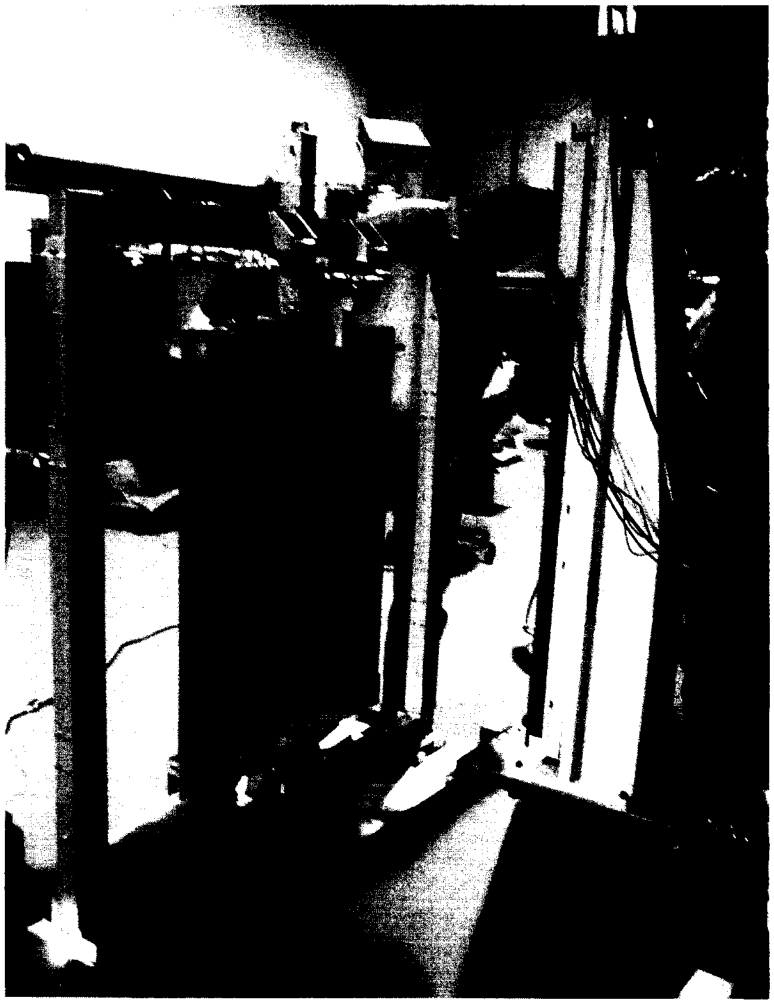
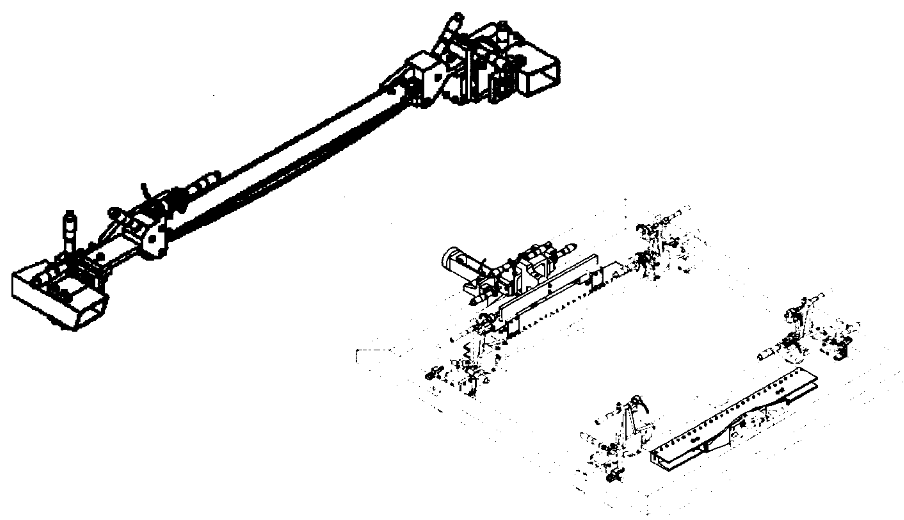
50 cm Precision Testbed



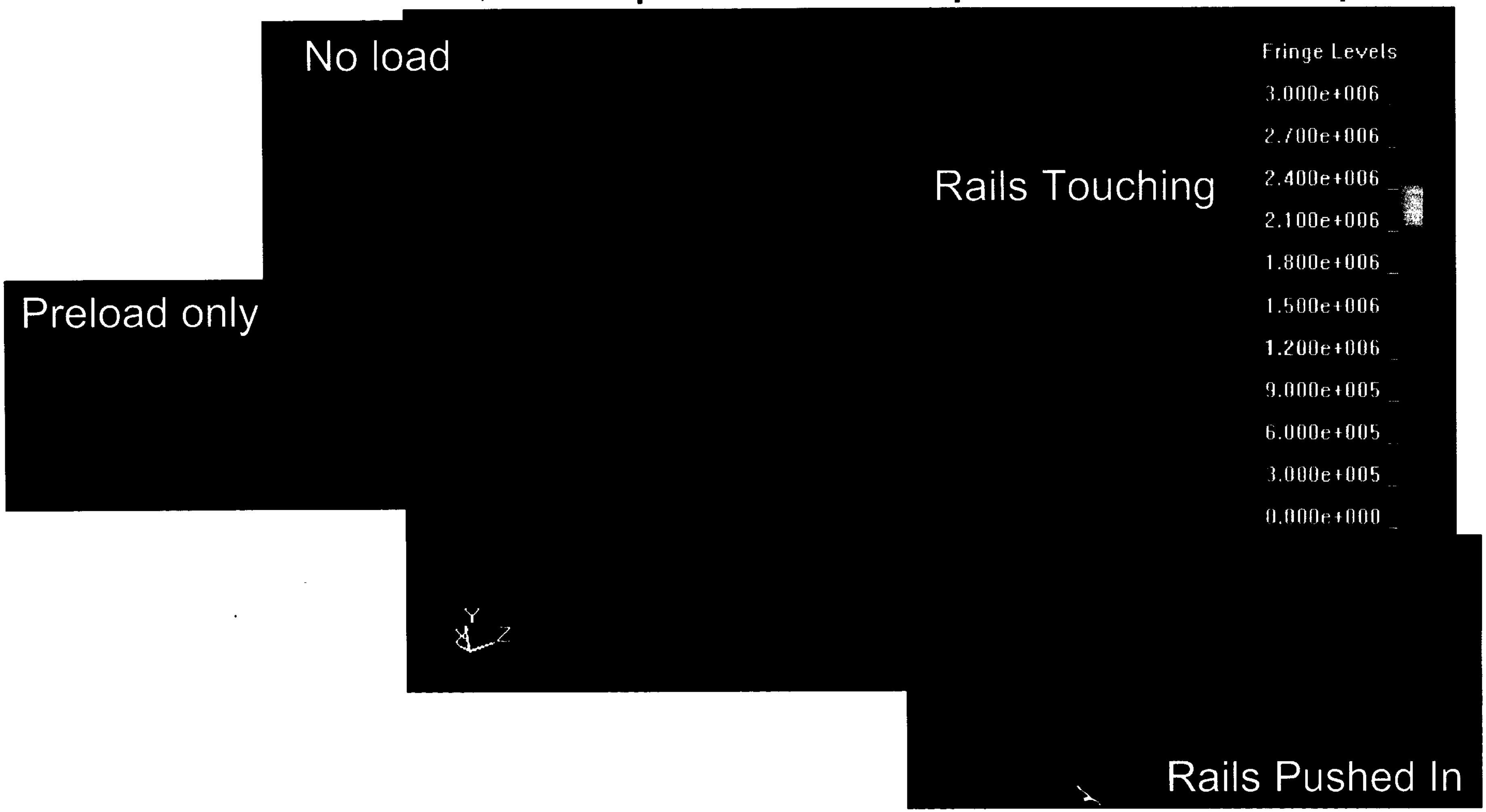
Recent Progress:

- 1.2 m prototype demonstrated imaging at 10 μm
- Initial Membrane Model Completed
  - Gravity Studies
  - Alignment Sensitivity Studies
- Frame Completed
- Alignment Mechanisms Completed
- Rail Shape Modeled
- Precision Rail Design Completed
- 2-axis Profilometer Completed



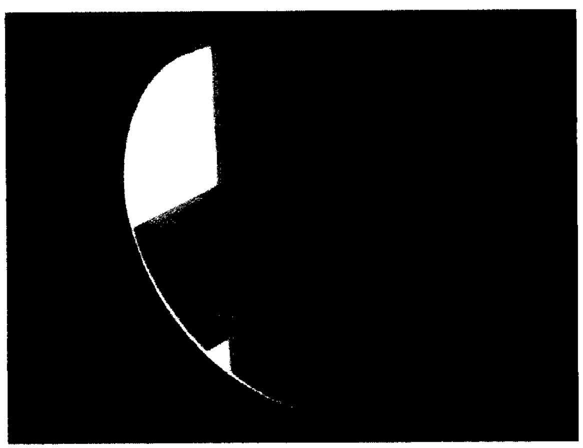
Membrane Modeling

Non-linear finite element analysis used to predict effects of clamp misalignments, tension (Poisson effect), gravity, introduction of rails, and optimization of precision rail shape



Membrane Candidates

- Material Properties
  - Uniform thickness
  - Manufacturing scalability
  - Surface finish
  - Handling
- Material candidates
  - Electroform Cu, Ni foils
  - Aluminized polymer films
  - Nanolaminate



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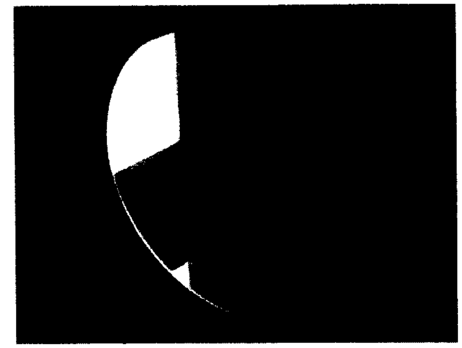
Nanolaminate Membranes



- Manufacturing
  - Sputtering of alternating multilayers
  - Sputter onto precision negative
  - Same negative can be used 10-15 times
  - Surface finish of 1.2 to 2.0 nm
- Material Properties
  - Number of material combinations to choose from; example is Cu/Zr
  - High strength (5x over Cu) and hardness (40x) improves handling
- Deployable
  - Originally investigated for deployable mirrors
  - Curved mirrors resist rolling necessitating substantial structure
  - DART would use flats

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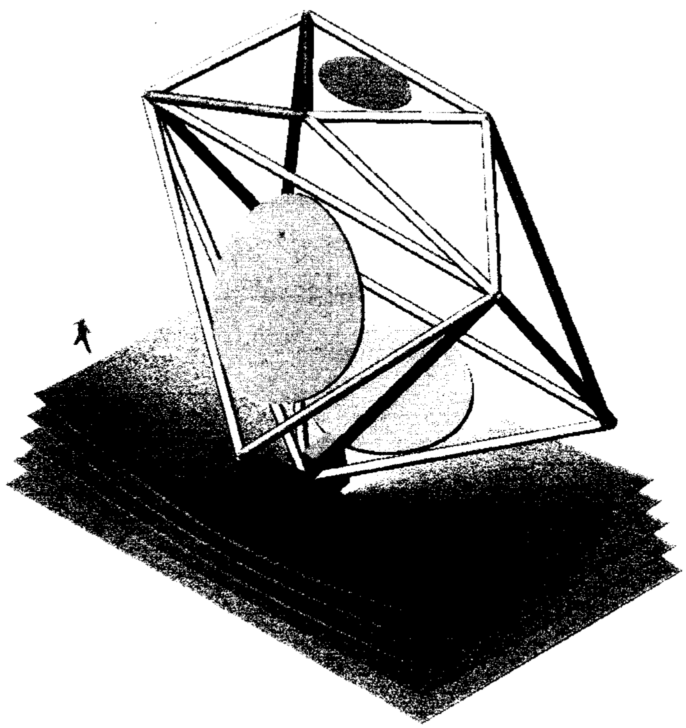
Single Aperture Far-Infrared Observatory (SAFIR)



- DART is being carried as a potential architecture for SAFIR (10m, 4K telescope)

Ongoing efforts:

- Primary effort is 50cm precision test-bed and model validation of achievable figure
- Thermal analysis and cryogenic experiment definition for single DART reflector
- Study of 10m structure, packaging and deployment, and thermal control concept

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Conclusions

DART architecture enables

- large, deployable ultra-lightweight telescopes
- shorter lead times
- reduced mass
- reduced cost

Applications include

- Origins: SAFIR, Life Finder and Planet Imager
- SEU: ARISE 60X, Orbiting Wide-angle Light-collectors (OWL)
- Commercial antennas
- DOD surveillance
- Optical Communications
- High data rate antennas for Mars and other planetary missions. Can increase data rate from Jupiter and its moons from kilobits to 3 Mb/s

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