NASA Institute for Advanced Concepts

Large Telescope Using a Holographically-Corrected Membrane Mirror

(LTHM)

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L'Garde, Inc.

Tustin, California

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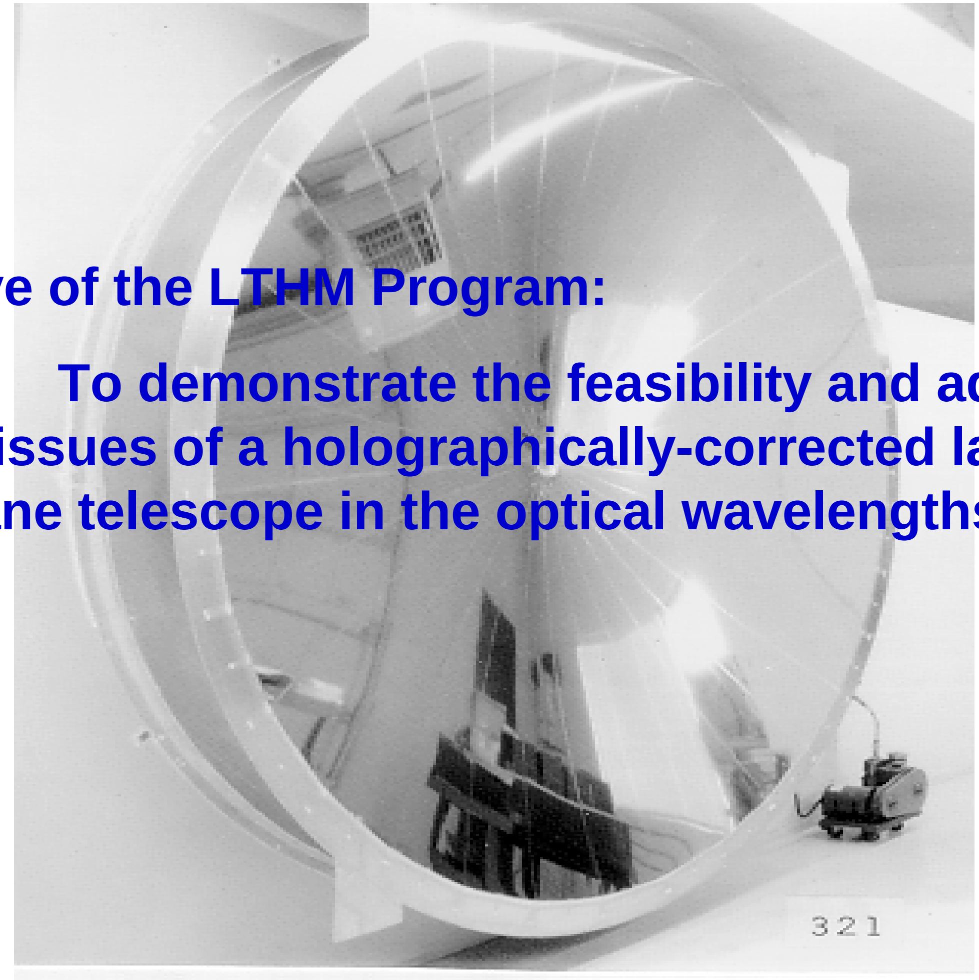
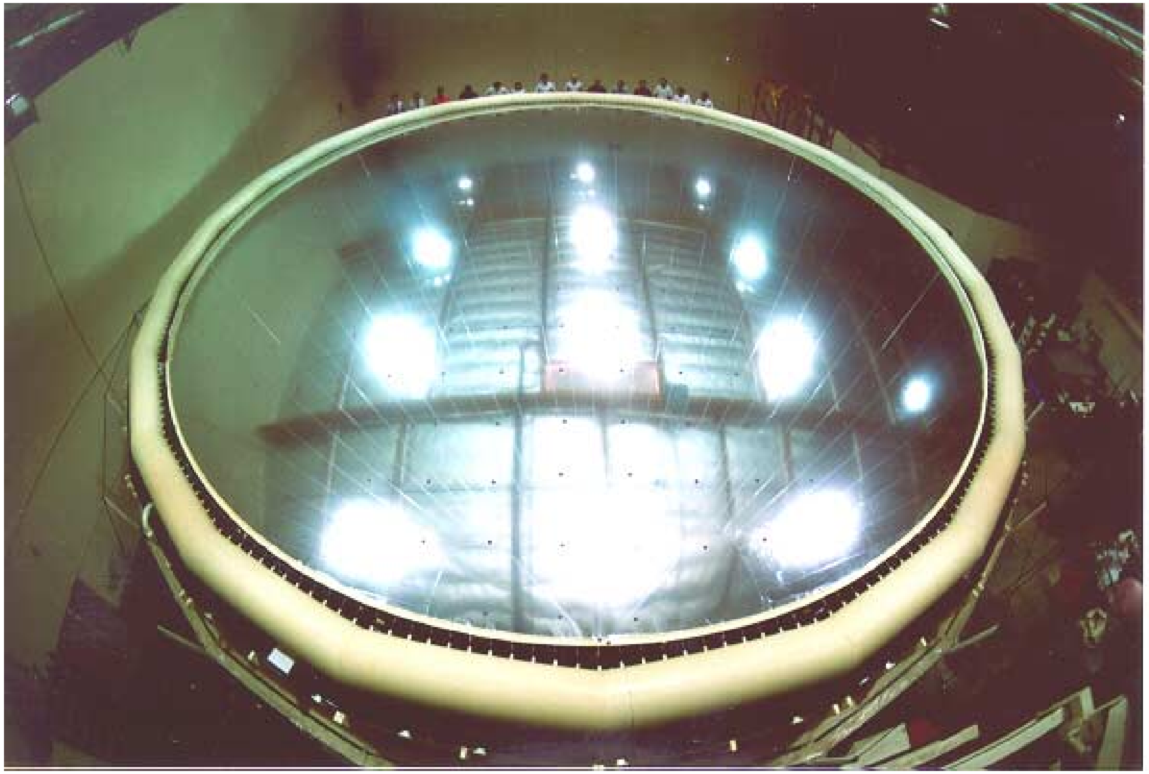
Large Telescope Using Holographically-Corrected Membrane Mirror



Objective of the LTHM Program:

To demonstrate the feasibility and address the system issues of a holographically-corrected large aperture membrane telescope in the optical wavelengths.

Inflatable Antenna Experiment



Membrane Mirrors

3 m diameter HAIR reflector (on-axis)

1/5th sector of the IAE reflector (off-axis)

Large Telescope Using Holographically-Corrected Membrane Mirror
State of the Art Surface Precision

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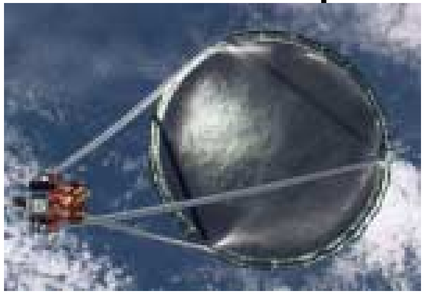
Inflatable Antenna Experiment (IAE)



D=50 ft (offset), F/D=1
As-built rms: 1.5 mm
RMS: center 11 meters

IRD Inflatable Reflector

D=23 ft, F/D=1/2
As-built rms: 1.2 mm RMS

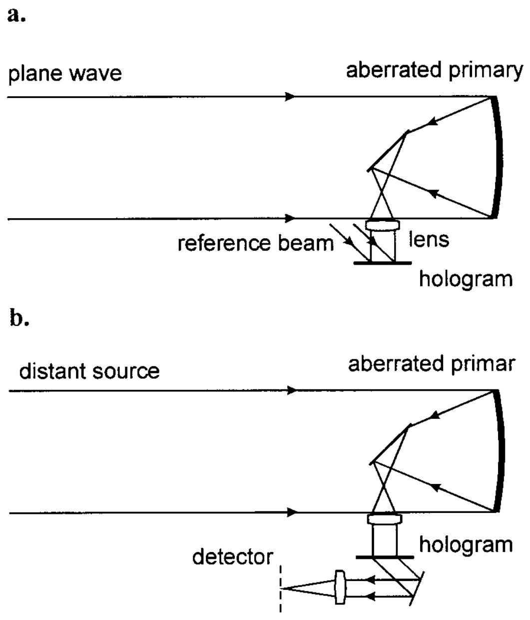
9.8 ft IAE Sector

D=9.8 ft, F/D=1
As-built rms: 0.6 mm RMS

LIS Inflatable Reflector

D=9.8 ft, F/D=1/2
As-built rms: 0.86 mm RMS

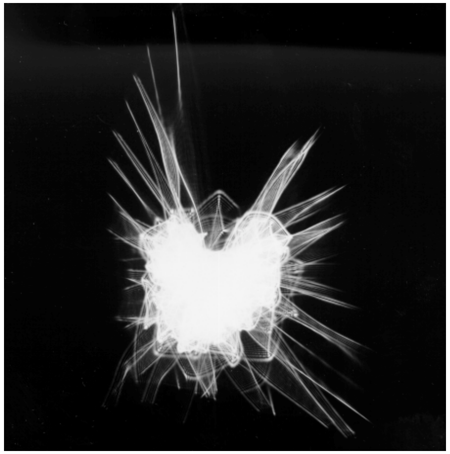
Holographic Correction



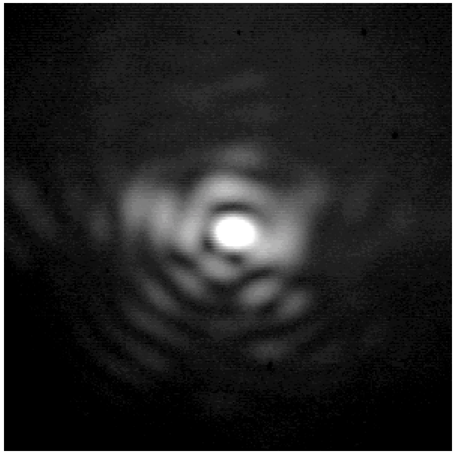
(a) Recording: collimated light illuminates the aberrated primary to form the object beam. The hologram is written with a reference beam incident at an angle.

(b) Reconstruction: starlight (distant object) produces a reconstructed beam, which is focused to produce an unaberrated image.

Holographic Correction



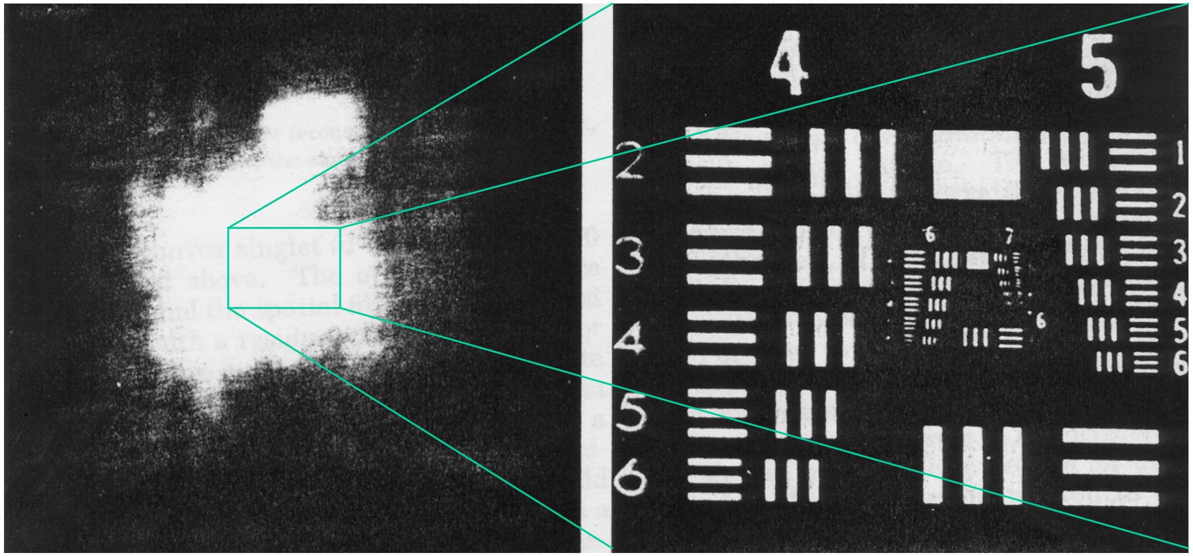
(a)



(b)

Focal spot images: (*a*) Before correction (actual size). (*b*) After correction (magnified 450X).

Holographic Correction



(a) ***(b)***

1951 USAF resolution chart before and after holographic correction.

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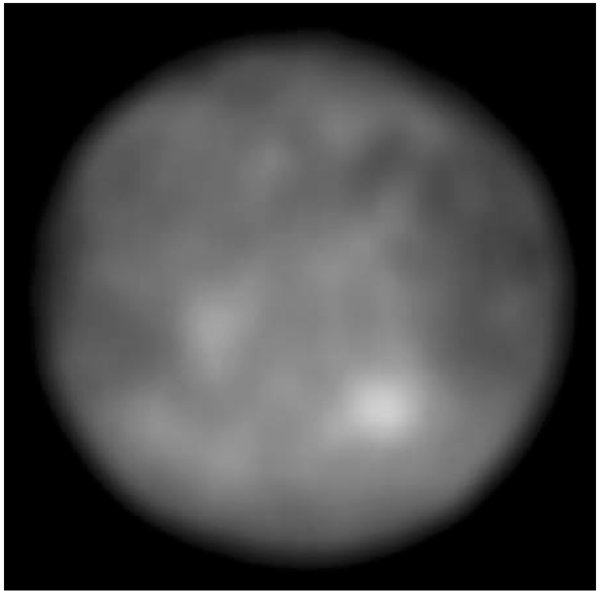
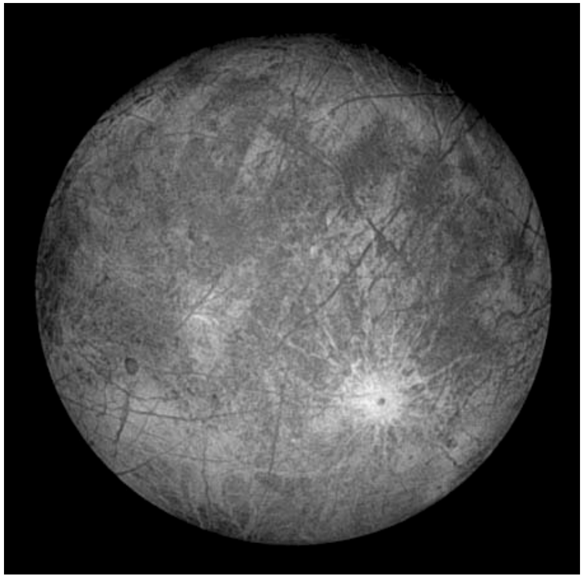
Simulation using a 100m diameter Holographically-Corrected Telescope



Europa as viewed by the Hubble Space Telescope



Europa as viewed by a 100 m Holographically-Corrected Telescope

Test Facilities

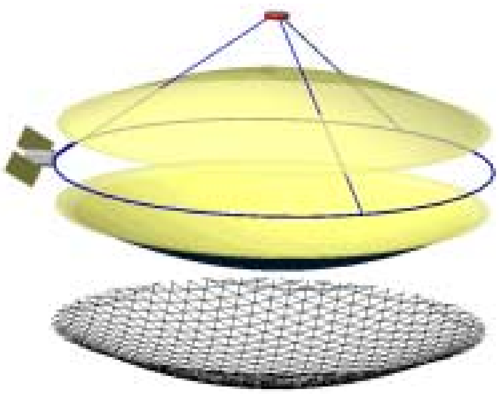
L'Garde, Inc., Tustin, California

- **Analysis, design, & fabrication of membrane mirror**
- **Membrane materials testing**
- **Surface profile measurement of membrane mirror**

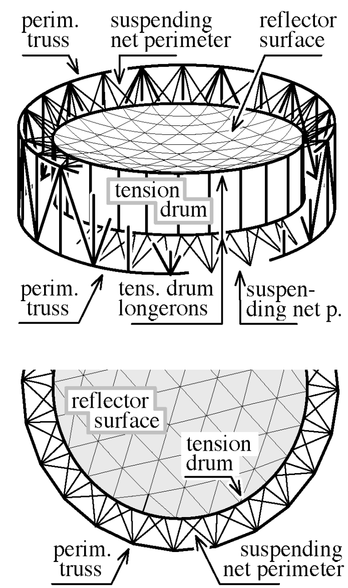
USAF Academy, Colorado Springs

- **Holographic tests and correction of membrane mirror**

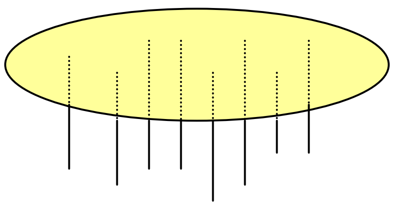
Membrane Mirror Configurations



Inflatable Net-Membrane



Non-inflated Net-Membrane Configuration



Non-inflated Net-less Configuration

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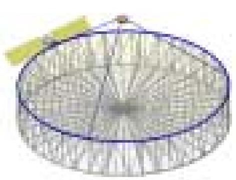
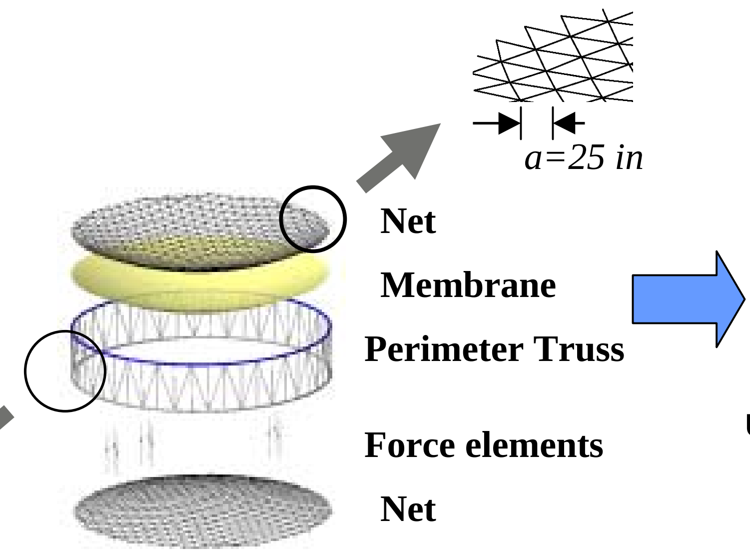
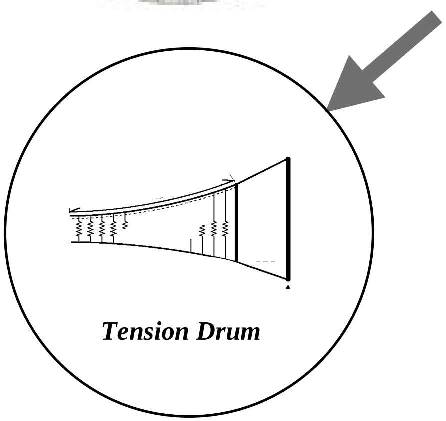
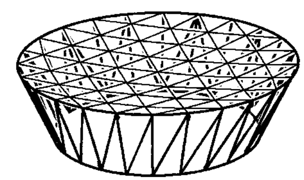
Membrane Mirror Configurations

Non-inflated Net-Membrane



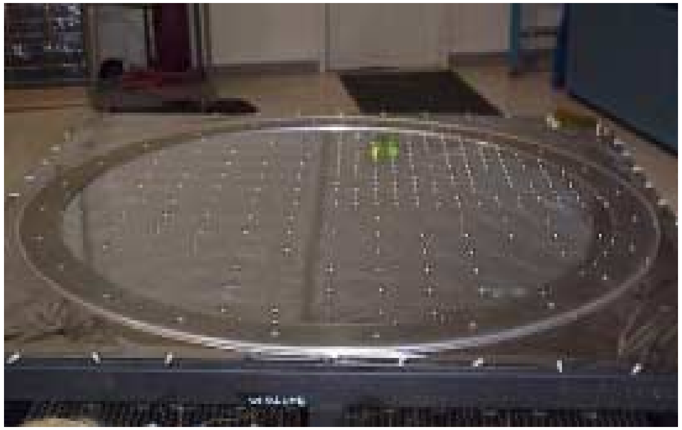






Use conical configuration to further reduce weight

The *Net-Less* Membrane Mirror



Membrane Mirror Configurations

Purely Inflatable

- Smoothest surface
- Highest surface accuracy
- Canopy obscures signal
- Needs makeup gas
- Simplest to manufacture
- Packageable into the smallest volume

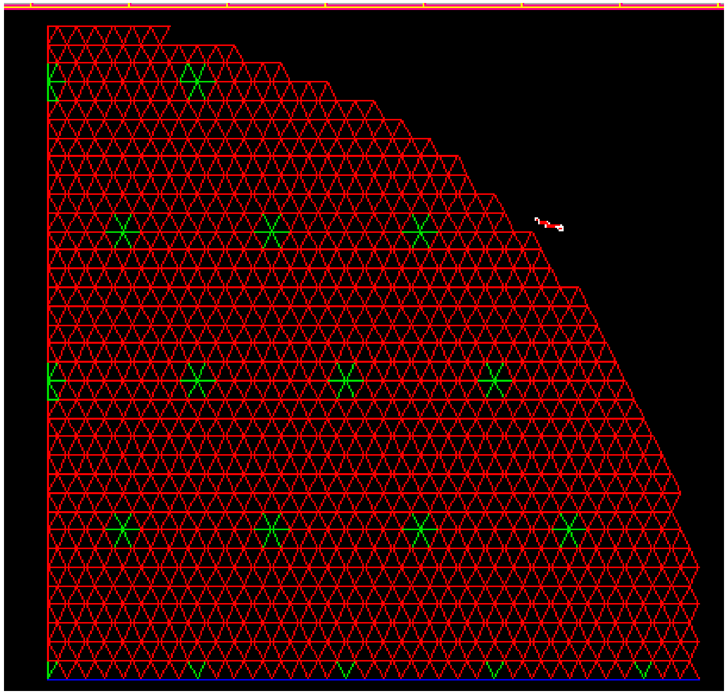
Net-Membrane

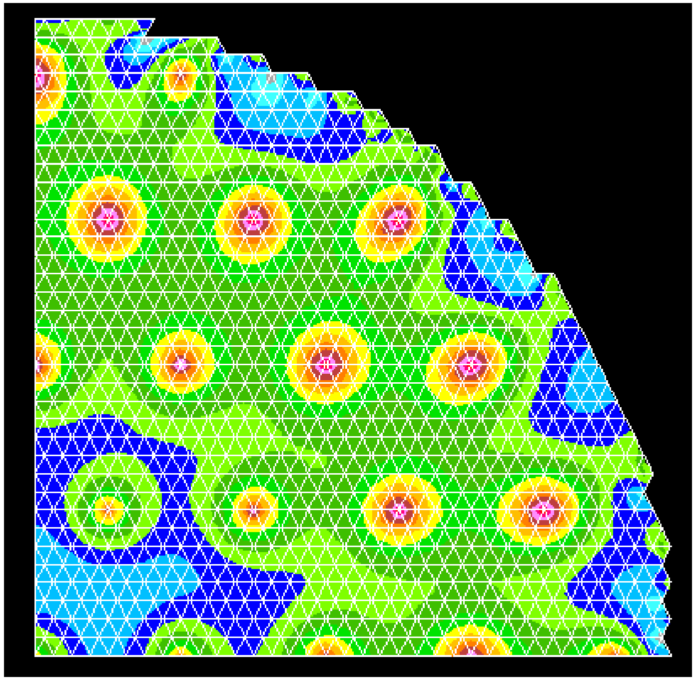
- Nearly flat triangular facets
- Moderate surface accuracy
- No canopy needed
- No makeup gas needed
- More labor intensive
- Packageable into a small volume.

Net-Less Membrane

- Cusps at tab locations
- Moderate surface accuracy
- No canopy needed
- No makeup gas needed
- Simpler than net-membrane
- Packaging volume is smaller than that of Net-membrane but larger than that of purely inflatable

Finite Element Simulation of Net-Less Membrane Mirror





Predicted Surface Accuracy: ε = 0.25 mm RMS

Phase I Tasks

- **Conceptual design of a compact, space-based membrane telescope that incorporates a real-time holographic correction.**
- **Build on the work for the NRO where we will prove the holographic correction of a 1 m diameter membrane telescope.**
- **Analytically characterize the net-membrane and net-less membrane concepts – sensitivity analyses.**
- **Investigate the production of holograms in real-time and at several wavelengths *in-situ*; e.g. use of photopolymers.**
- **Compare performance relative to each other: *inflatable* v.s. *net-membrane* v.s. *net-less membrane* configuration.**
- **Identify and address the system issues.**
- **Chart a roadmap to an orbiting 10 m diameter imaging telescope using holographically-corrected membrane mirrors.**

System Issues

- Real-Time Holographic Correction
- Bandwidth
- Wideband holographic correction
- Holographic materials
    - photopolymers
    - FBAG
    - OASLM
- Laser beacon source – "fixed" versus trailing
- Single hologram recorded at multiple wavelengths
- CTE and creep of membrane material – PBO has extremely low CTE.
- Space environment resistance

Phase II Plans

- **Build a 1m diameter membrane telescope with holographic correction *in-situ*.**
- **Carry out a full static and dynamic analysis of the concept selected for a 10 m diameter.**
- **Continue to investigate *Real-Time* holographic materials – suitability of photopolymers as a holographic medium in a space environment.**
- **Investigate the possibility of using a distant laser source in space – "trailing" or fixed at the *ISS* for example.**
- **Feasibility of a simple, secondary adaptive optics system.**
- **Modularizing and shielding of the telescope for optimum performance.**