MOIRE
Membrane Optic Image Real-Time Exploitation

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SeeMe Industry Day
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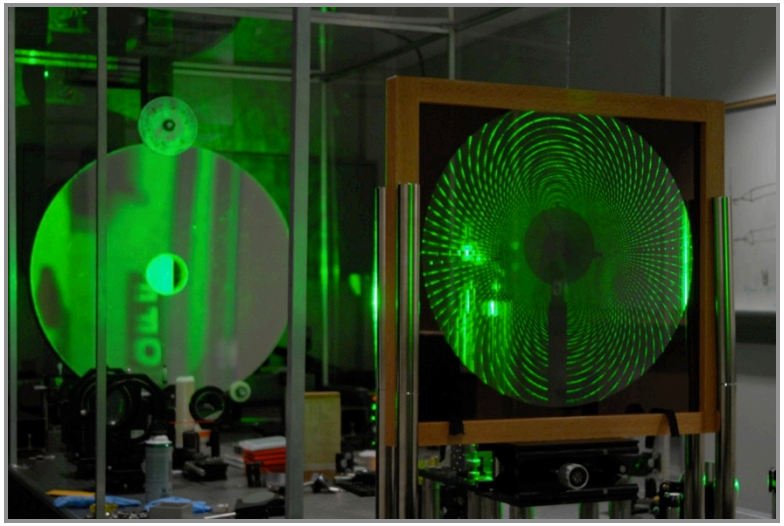
Membrane Optical Imager for Real-Time Exploitation (MOIRE)

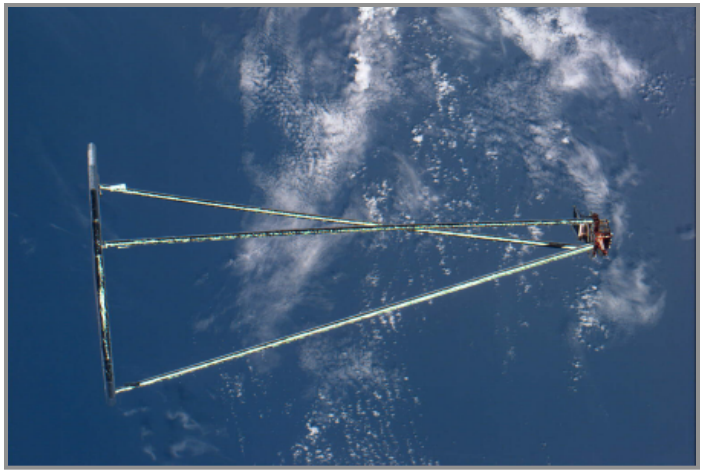


Program Objectives

- Persistent, tactical, real-time video from geosynchronous orbit
  - 24/7 coverage of denied territory
  - No similar capability exists today
  - Provide real-time troop movements, targeting & BDA
  - Provide TEL tracking, missile launch detection and tracking

Performance Metrics

- Membrane optics system with a Fresnel zone pattern to focus an image for 15x resolution improvement over same mass to orbit for a reflective telescope
- 500x reduction in primary optic weight for same resolution
- 10x savings in production costs compared to glass optics for same resolution



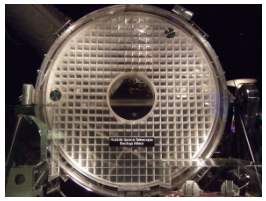
Military Utility

- **Real-time 1 frame/sec video to warfighters**
- One satellite can image 1/3 of earth's surface, without changing orbit, at 1 meter ground sample distance resolution

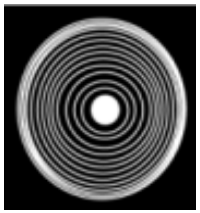
MOIRE will provide persistent, tactical video coverage to the warfighter

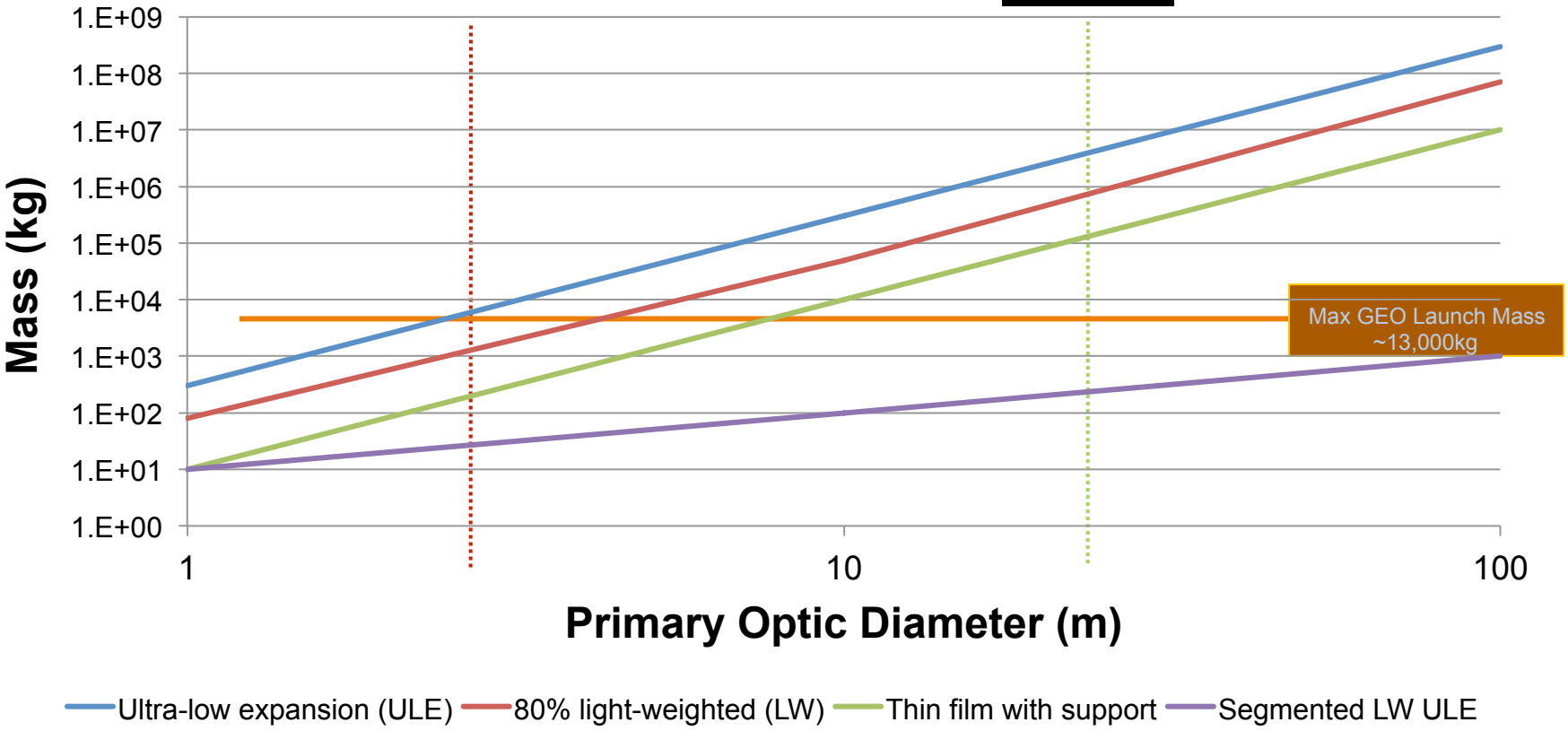
Diffractive Optics Enable Cost Effective Tactical GEO Imager

Hubble – 2.4m, 80% LW-ULE



20 m Optic

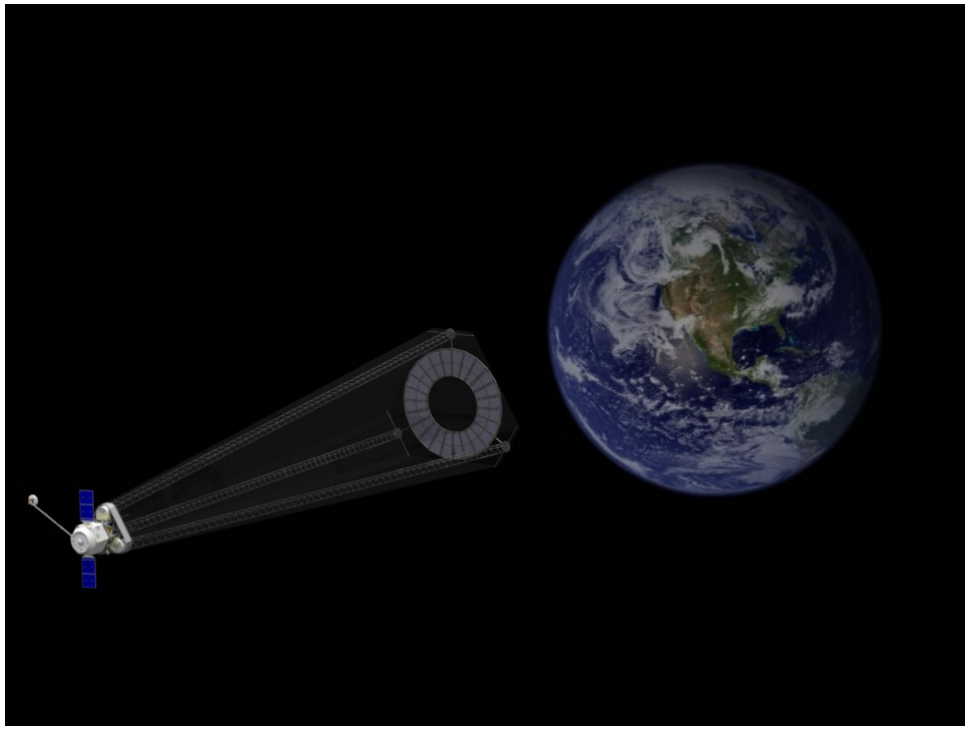




MOIRE Objective System

Design Reference Mission Performance Goals

- Persistence – 24/7
- Missile launch detection & tracking
- VNIIRS – 3.5+
- Ground Sample Distance -- ~ 1m
- Visible/IR Video @ > 1 Hz
- Field of View > 100 sq km
- Field of Regard – 15,000km^2 w/o re-pointing
- < $500M/copy (after R&D)



Diffractive Telescope Challenges

Telescope Design For Utility

- **Efficiency**, Now = 0.35% , Current Theoretical =16%
  - Drives Integration Time For Video & SNR/Image Quality
  - Exploration Path Is Pattern Optimization, Fractals
- **Spectral Response**, Now 50-70 nm, Full Visible And SWIR Desired
  - Drives Image Utility
  - Exploration Paths: Diffractive Secondary Recombination, Switchable LCPD, Gradient Index, And Multiple Foci Pickoffs
- **Moving target blurring**, 0.1 s integration Limits to Walking, > Highway Speed Desired
  - Solution Paths: Image Processing, Detector Sensitivity & DOE optimization

Membrane Material

- Thickness Uniformity Control, Coatings/layers, stowage impacts (need 20λ)

Membrane Fabrication

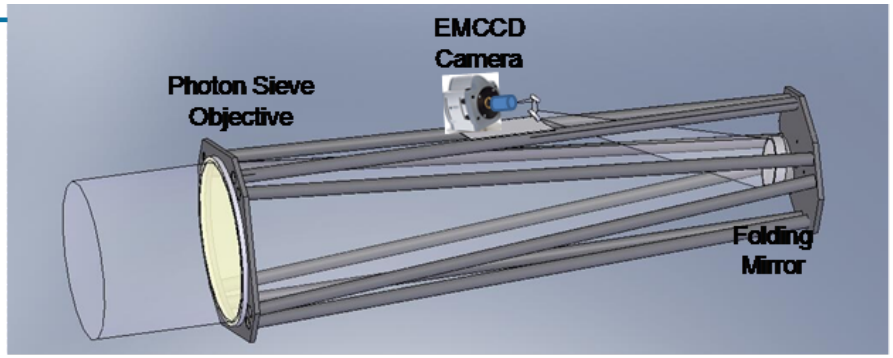
- At Full Scale: Seams Techniques, Pattern Accuracy, Minimum Hole Sizes

Space Systems

- Long Focal Lengths Resulting In Long Structures – Mechanism And Deployments, Optical Design Folding, Opto-mechanical Telescope Stability
- Attitude Knowledge & Control For Jitter & Geolocation – Leverage Persistence for Accumulated Knowledge, Existing Control Points – Near Real Time Post Processing

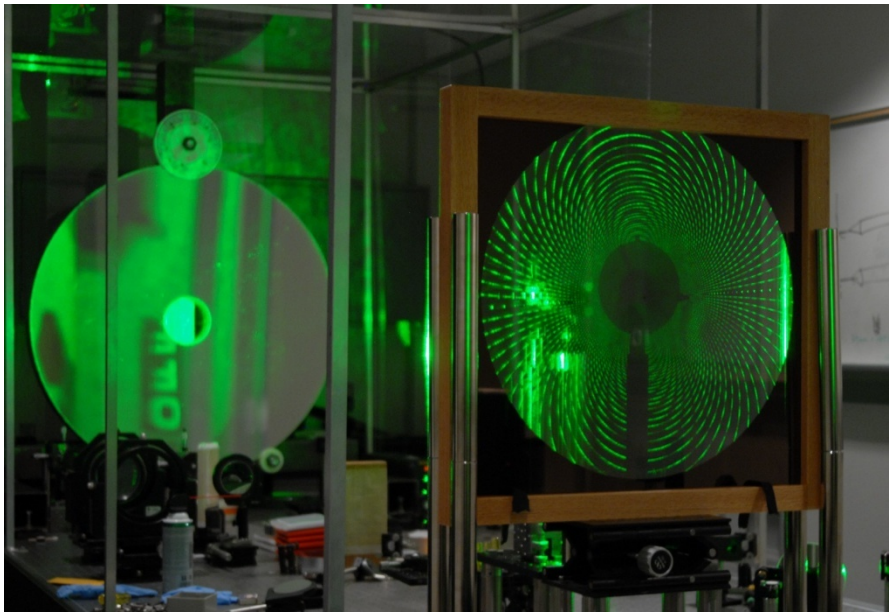
2009 Study Lab Results

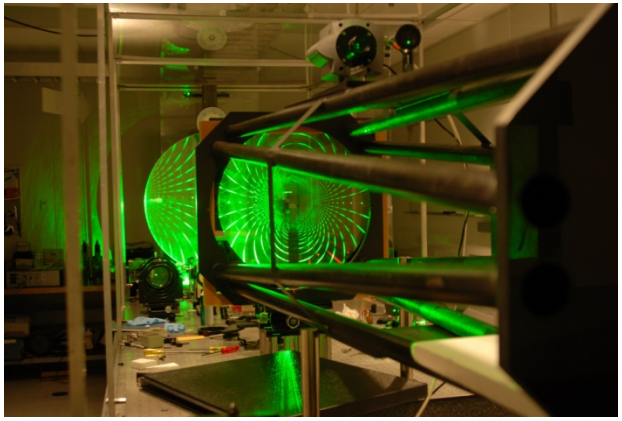
- Proof of Concept 60 cm Optic
- Membrane Printing Demonstrated
- Established Vendor Capability to Mill Photon Sieve Patterns
  - Milling eliminates thickness tolerance challenge



Design Parameters of 2009 MOIRE Photon Sieve Telescope:

Wavelength	532 nm
Aperture of Photon Sieve	0.56 m
Focal length of Photon Sieve	3.0 m
f-number of Photon Sieve	f/5.4
Diffraction-limited resolution	1.16 μrad
Barlow lens pair	4.6x
Effective focal length of telescope	14 m
Effective f-number of telescope	f/25





Summary

MOIRE will provide tactical video coverage and missile launch and detection

Membrane, diffractive optics enable relatively low cost solution for GEO based imager

Future system enhancements can provide greater spectral content and improved resolution

MOIRE Phase 1 ground demonstrations will focus on payload risk reduction, large scale fabrication, image quality metrics, structural deployment, and image processing

MOIRE Phase 1 will culminate with a space system CoDR and payload PDR

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