Rapid Adaptable Zoom for Automatic Rifle

RAZAR

Sandia National Laboratories

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In collaboration with

Joint Service Small Arms Program (ARDEC)

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CONOP
Mixed Range Environments

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“At the touch of a button”

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M4 Automatic Rifle Current Solutions

All are manually actuated.

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SU-237 (Trijicon)

Elcan SpecterDr

Leupold CQT

SU-237:
- requires a “hold-off” due to over/under
- binary (1X or 4X)

Leupold:
- limited to 3X
- narrower FFOV (20°) at 1X
- long

Elcan:
- binary (1X **OR** 4X)
- heavy (1.3 lbs)

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M4 **RAZAR**

Concept

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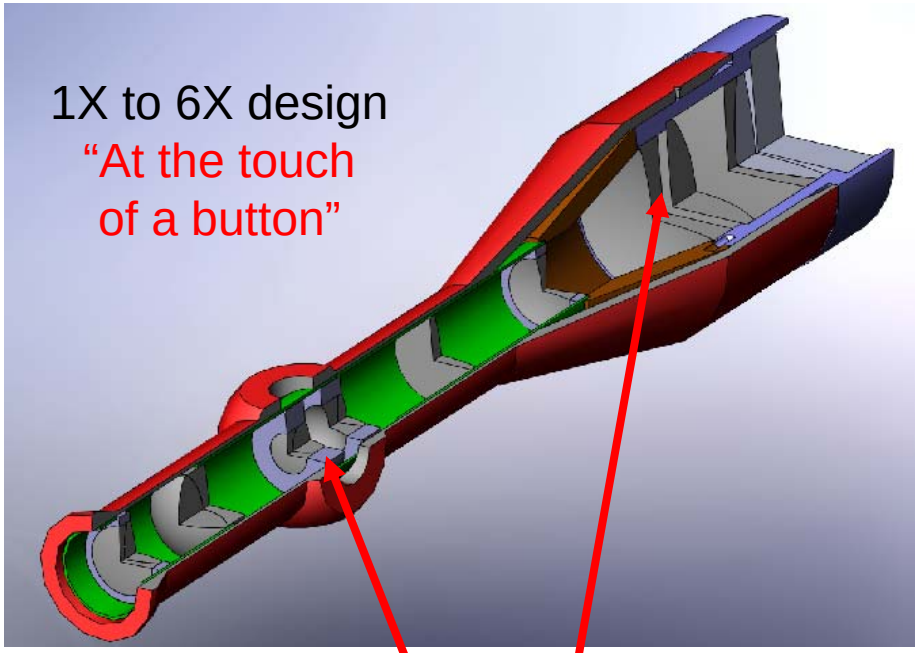
- **Multiple** zoom positions (quasi-continuous, or multiple discrete states)
- Large zoom range
  (6X for M4 - could be 8X)
- **Push-button** actuation
  (maintain sight picture)
- Coaxial optical path
  (not over/under)
- Small package (~ ACOG)



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Adaptive Zoom Overview

Sandia Patent #6,977,777

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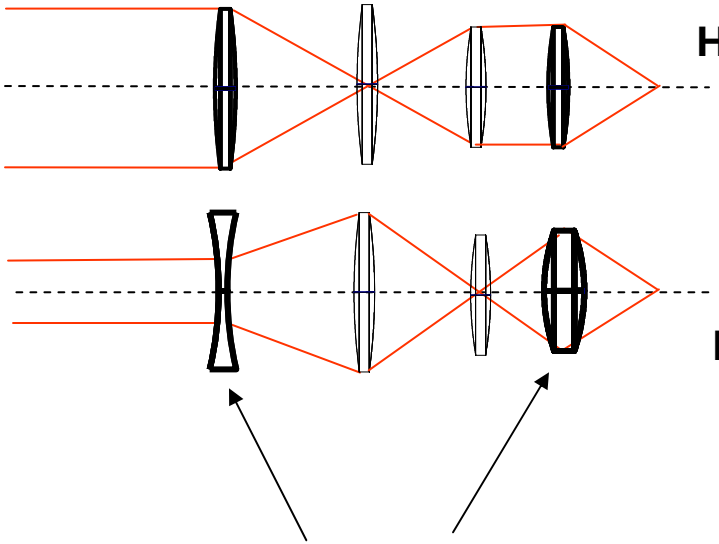
Adaptive Zoom



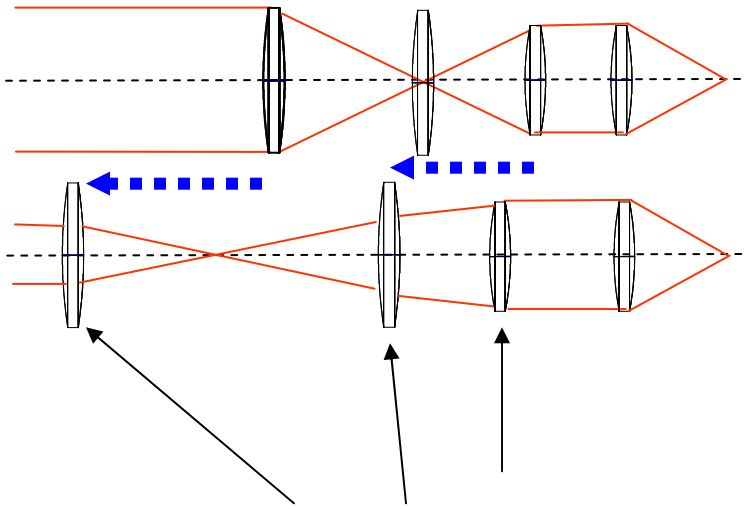
Active Lenses Change Focal Length

HIGH MAG

VS.

LOW MAG

Conventional Zoom



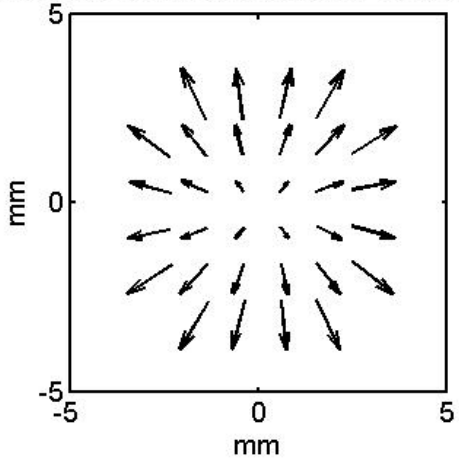
Static Lenses Move Along Optical Axis (e.g. 35mm camera)

RAZAR Program Goals

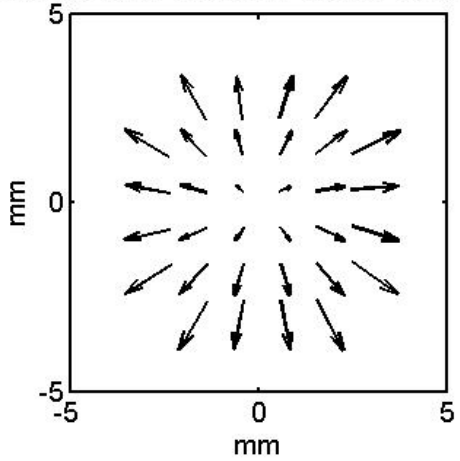
- **Magnification:**1-6X (larger zoom is possible but increases overall length/weight)
- **Overall Length:** 200 mm
- **Weight:** 680 grams (1.5lb)
- **Full Field of View:** 24 deg (1X) , 4 deg (6X)
- **Objective Diameter:** 32 mm
- **Power:** 2 AA Lithium Batteries
- **Reliability (MTBF):** 480 operational hours, 20 actuations/hr.

Polymer Lens: Fabrication

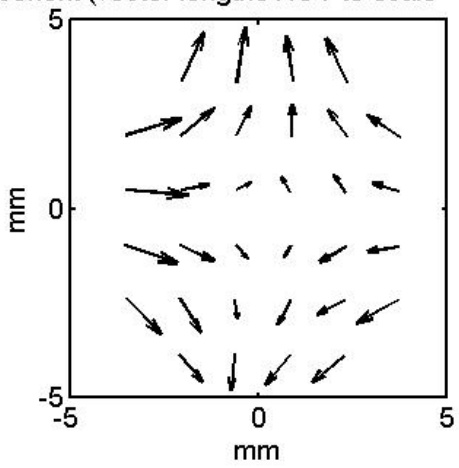
Total Displacement Vectors (vector lengths to scale)



Radial Component r=r+.5062*r (vector lengths to scale)



Non-Radial Component (vector lengths NOT to scale - enlarged for visibility)



Stretch vectors for membrane show some astigmatism representing 8.2% of the magnitude of the radial component

FE Modeling

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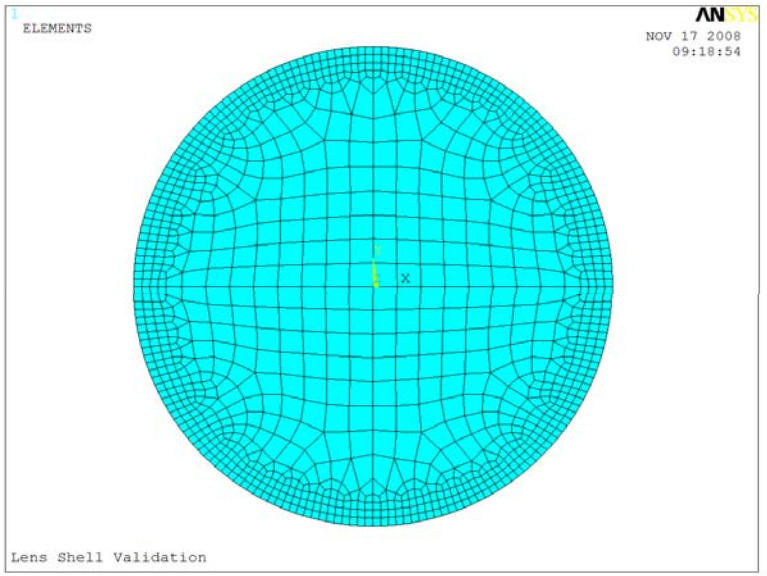
Un-prestrained

- Thin and Thick shell models (FEA)
- **Low Order**: Peak deflection as a function of membrane thickness.
- **Higher Order**: Departure from Best-Fitting Sphere (BFS) as a function of pressure.



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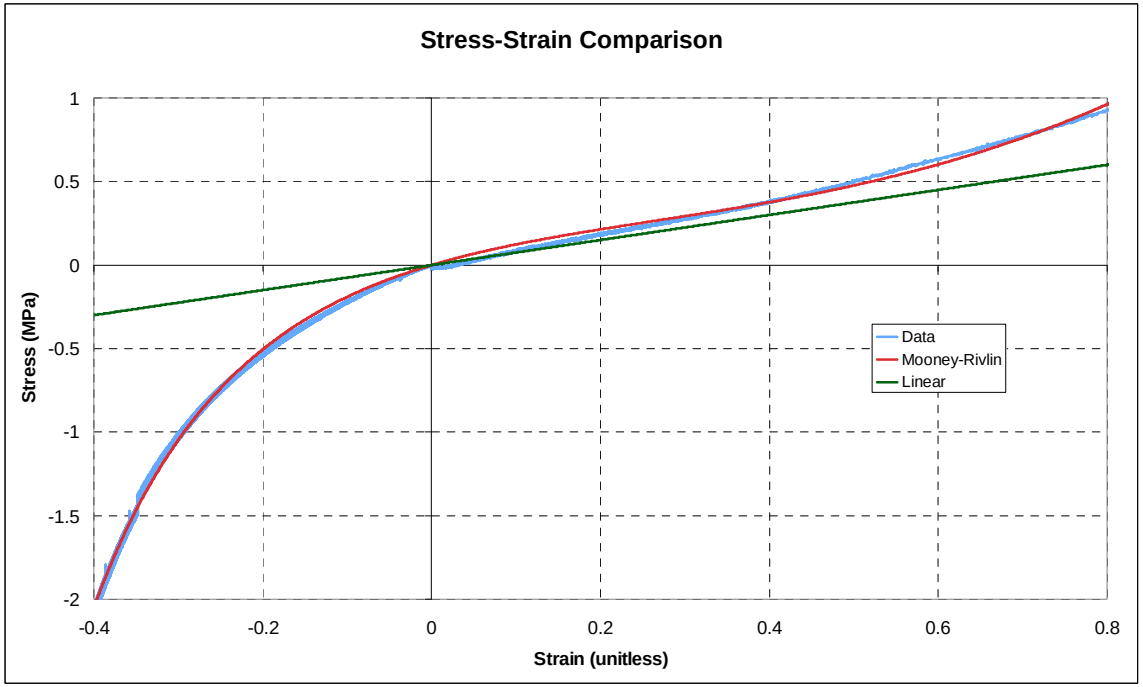
Measurement: Uniaxial Properties

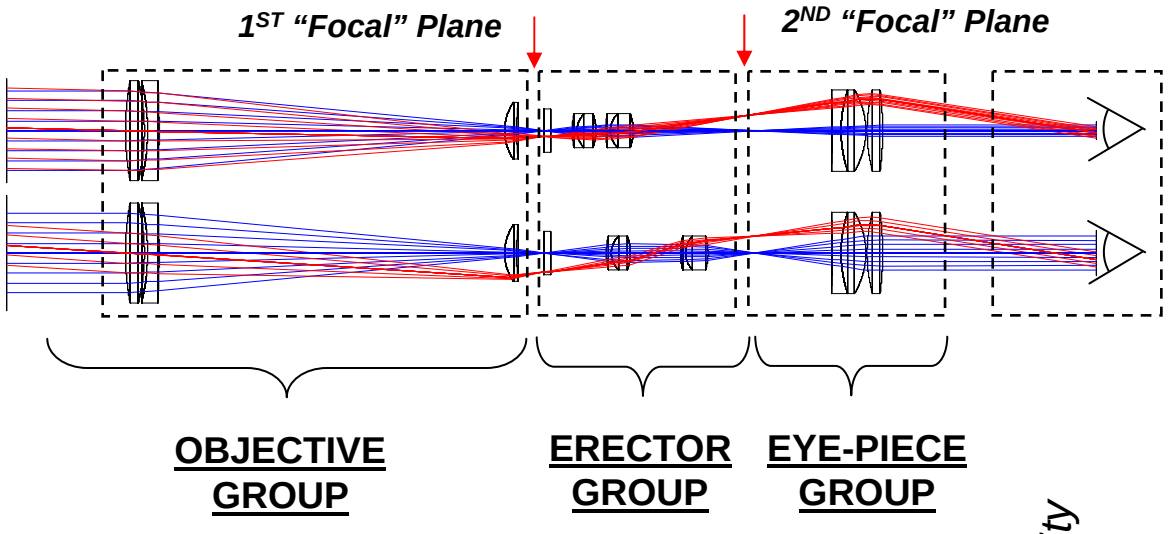


$$T = 2\left(\lambda - \frac{1}{\lambda^2}\right)\left[C_{10} + \frac{C_{01}}{\lambda} + 2C_{20}\left(I_1 - 3\right) + C_{11}\left[\left(I_2 - 3\right) + \frac{\left(I_1 - 3\right)}{\lambda}\right] + 3C_{30}\left(I_1 - 3\right)^2\right]$$

C_{10} = 0.2 MPa, C_{01} = 0.15 MPa, C_{30} = 0.05 MPa, and C_{11} = 0

Comparison of stress-strain data, Mooney-Rivlin model fit, and linear Young's Modulus.

Review - System



Order of Priority

Adaptive Zoom Module =
- **Erector**
- **Erector + Eyepiece**
- **Erector + Eyepiece + Objective**

SWaP Objectives
- Length: 200 mm (O)
- Diameter: 50 mm (O)
- Weight: 680 grams (O)
- Power: 3K Actuations (O), 1K Actuations (T) – Source = 2 x AA Batteries

First Demonstration

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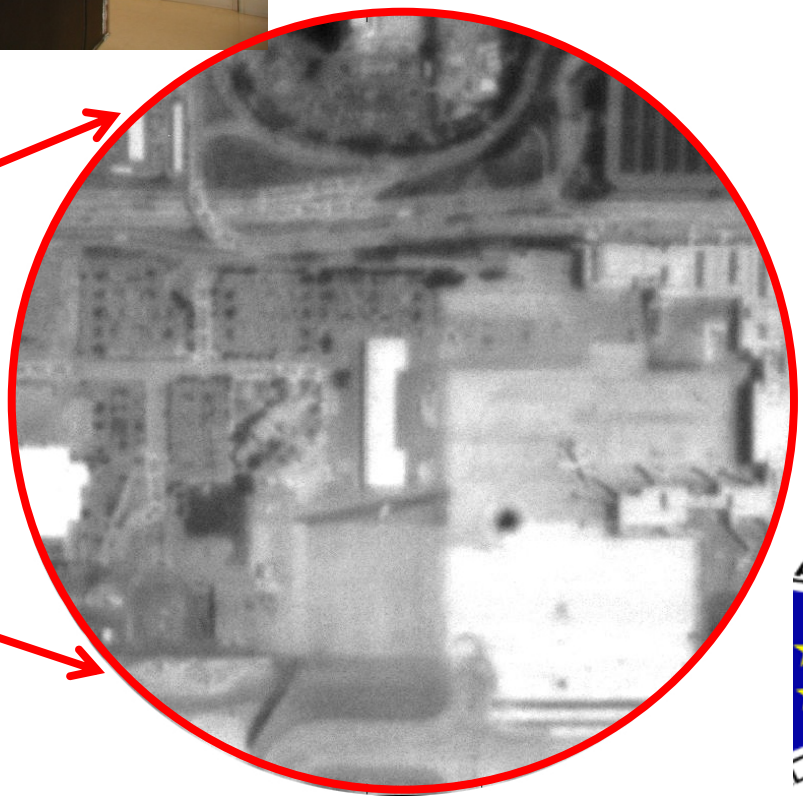
*No Longitudinal Motion

8X zoom using two APLs – 23 inches long

1X

8X



Second Demonstration

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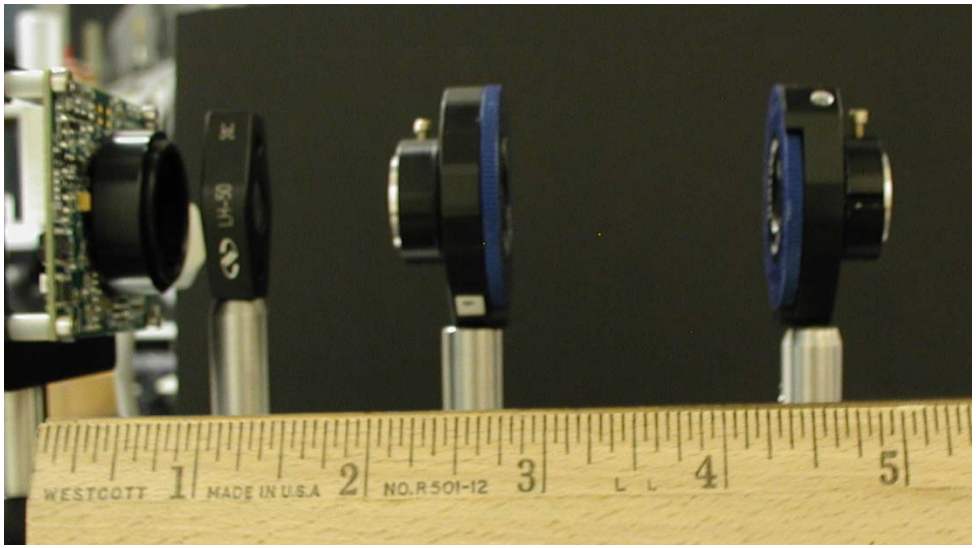
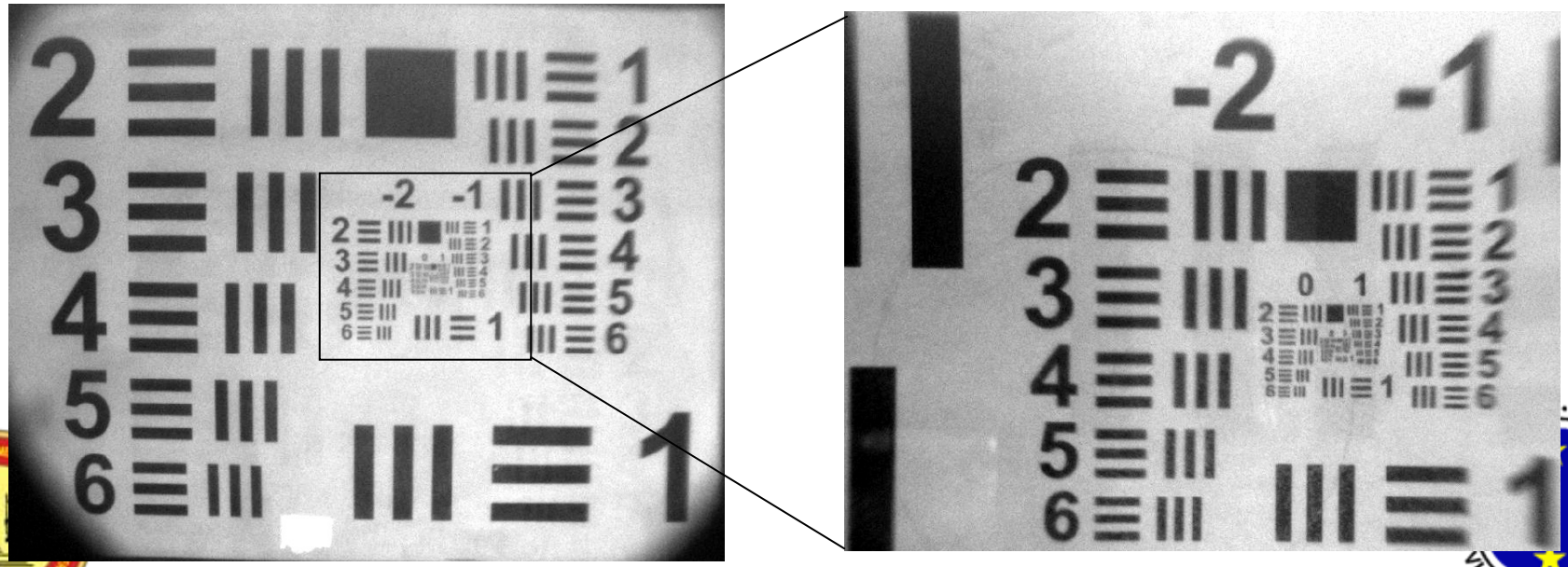
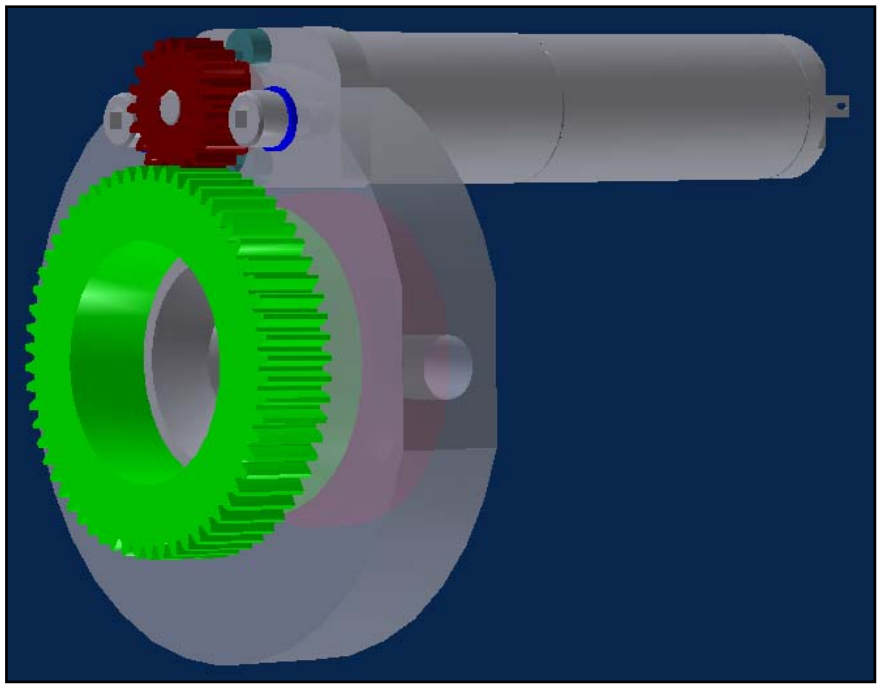
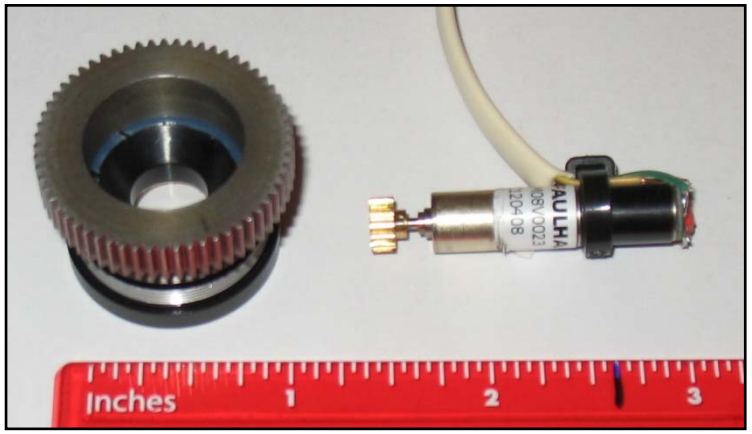
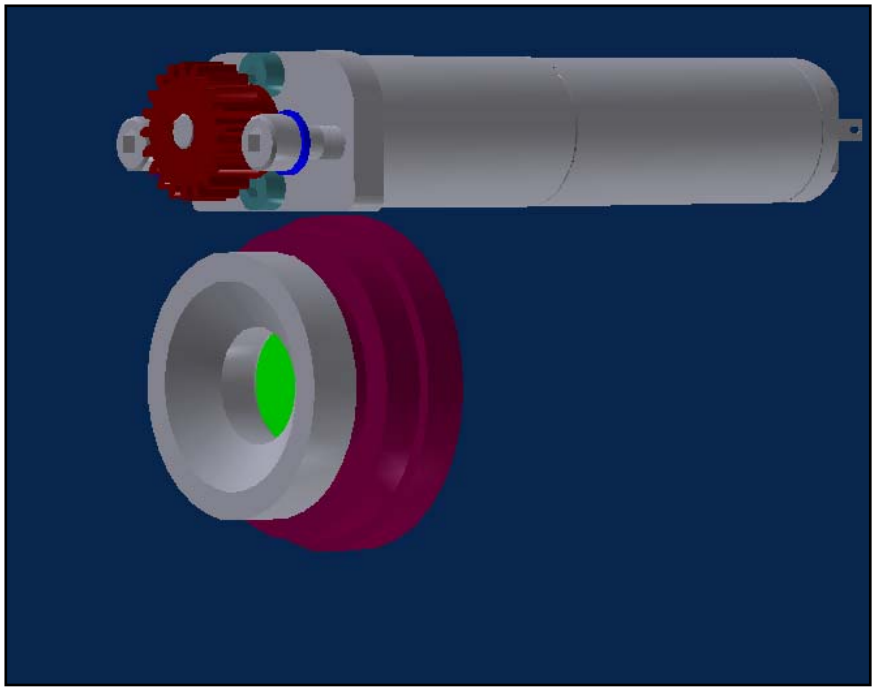




Actuation: Current

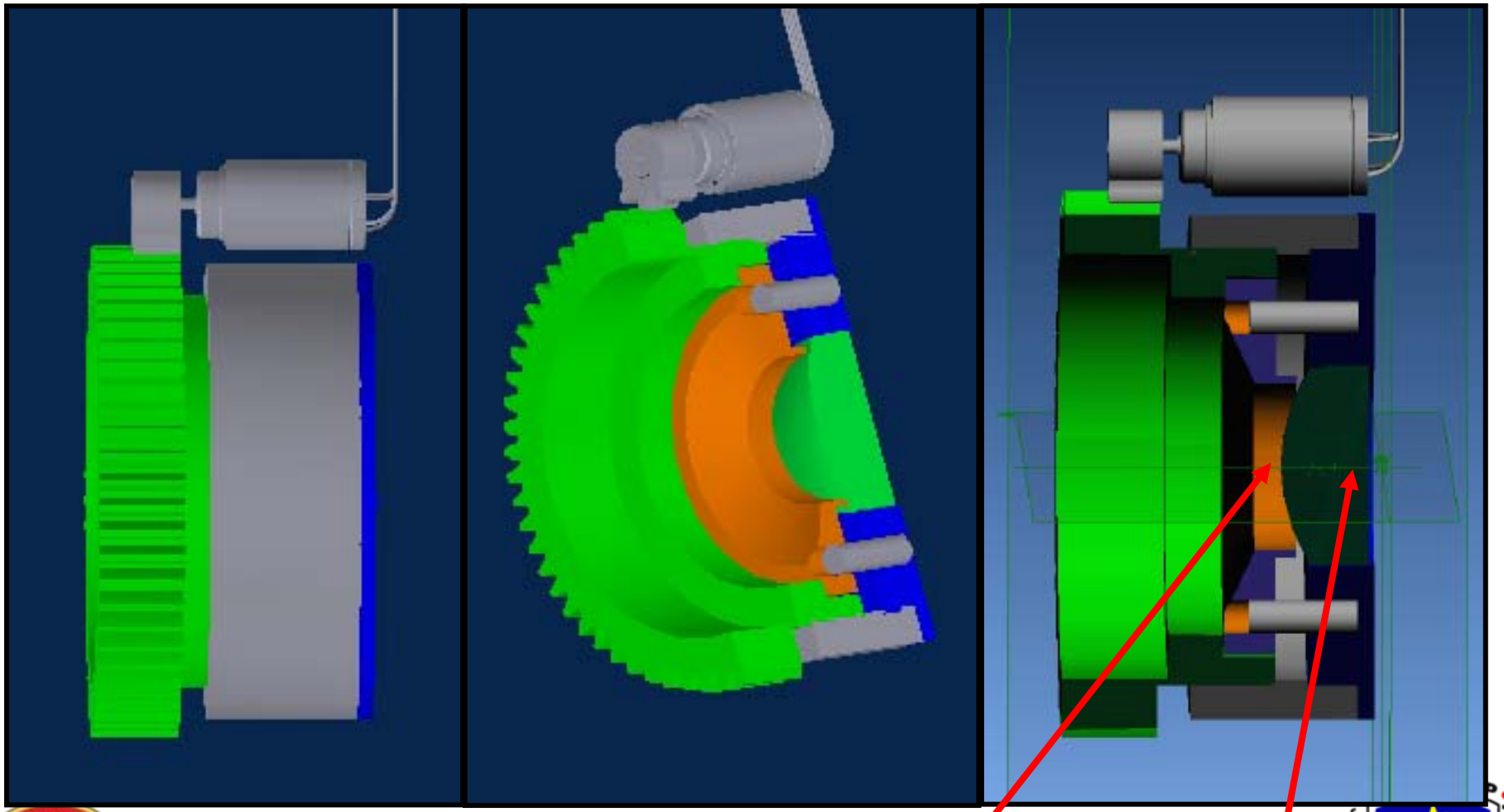






- 3RD Iterarion of unaltered APL (1W → 3 W → 6W instantaneous power).
- Combination of friction and increased membrane pre-strain (necessary for image quality).

Actuation



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