



Finite Element Modeling of Army Airbeam Structures

May 4, 2005

JOCOTAS – Port Hueneme, CA

U.S. Army RDECOM - Natick Soldier Center Collective
Protection Directorate, Fabric Structures Team

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Agenda

- Brief Overview of Airbeams
- Engineering Process
- Modeling Approaches
- Fabric Airbeam Models
- Modeling Technical Barrier
- Cavity Filled Membrane Models
- Airbeam and Fabric Membrane Models
- Application of Modeling
- Center of Excellence
- Current Small Business Innovative Research Projects



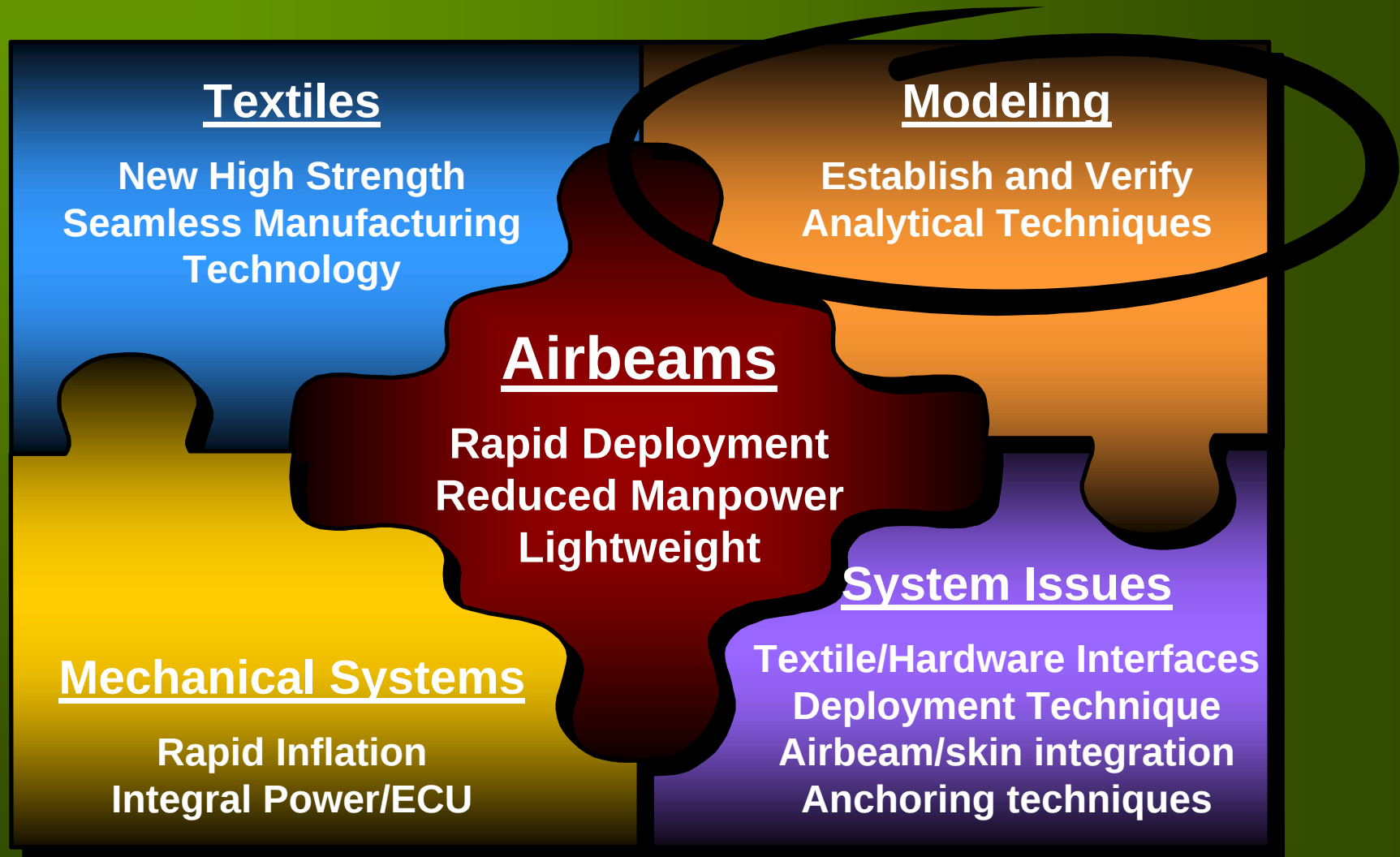
Brief Overview of Airbeams

- Load Bearing Pressurized Fabric Structures
- Pressurization pre-tensions the fibers, creating a structure that is rigid under design loads, but deflects without damage when overloaded
- Outstanding strength-to-weight ratio





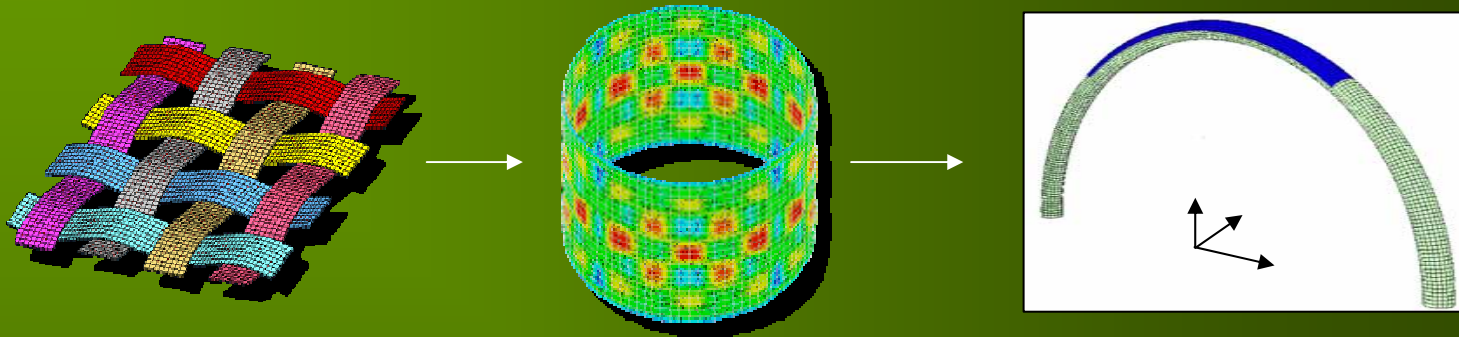
Engineering Process



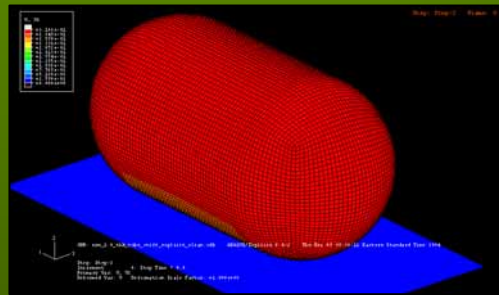


Modeling Approaches

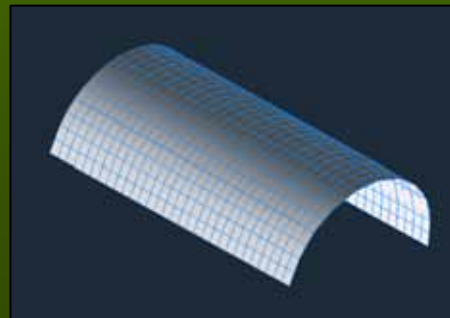
Airbeam
Fabric



Cavity Filled
Membrane

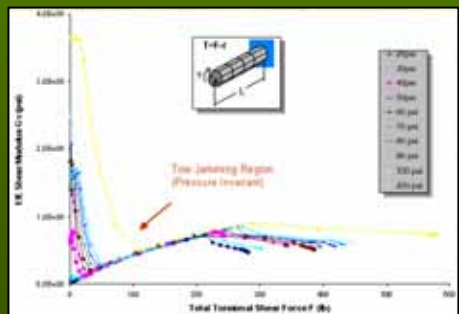
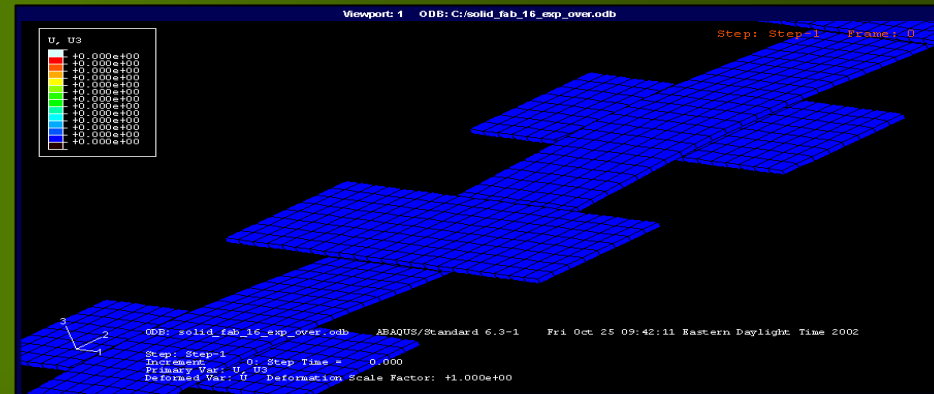


Airbeam & Fabric
Membrane

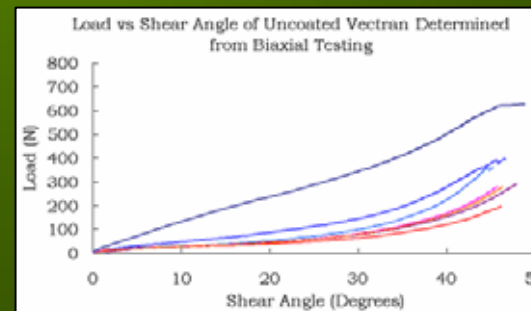




Fabric Airbeam Models



Finite Element Results
for Shear



Experimental Results
for Shear



Modeling Technical Barrier

Barrier:

Test method to evaluate structural properties of fabrics subjected to combined multi-axial tension and shear loads for design purposes

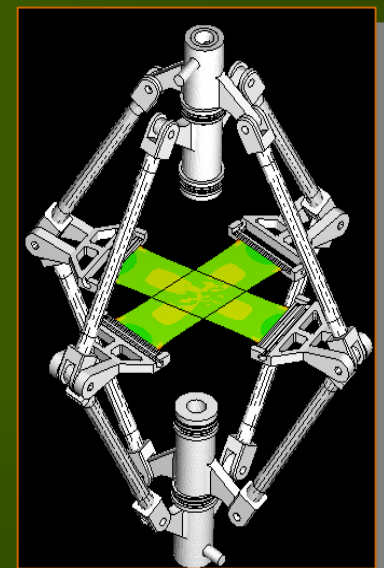
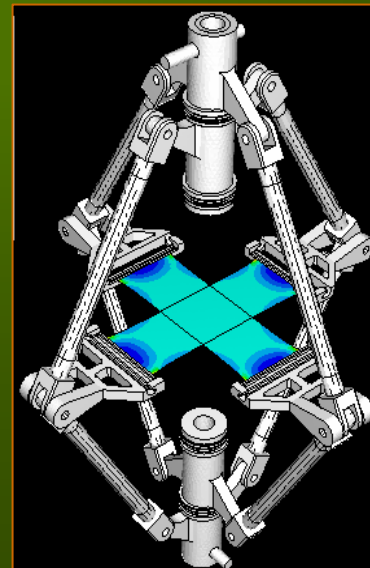
Problem:

Fabric elastic modulus & shear stiffness are dependent on:

- ✓ Fiber Directions
- ✓ Fabric Construction
- ✓ Tow Density Ratios (TDR)
- ✓ Coatings
- ✓ Inflation Pressure
- ✓ Structural Loads

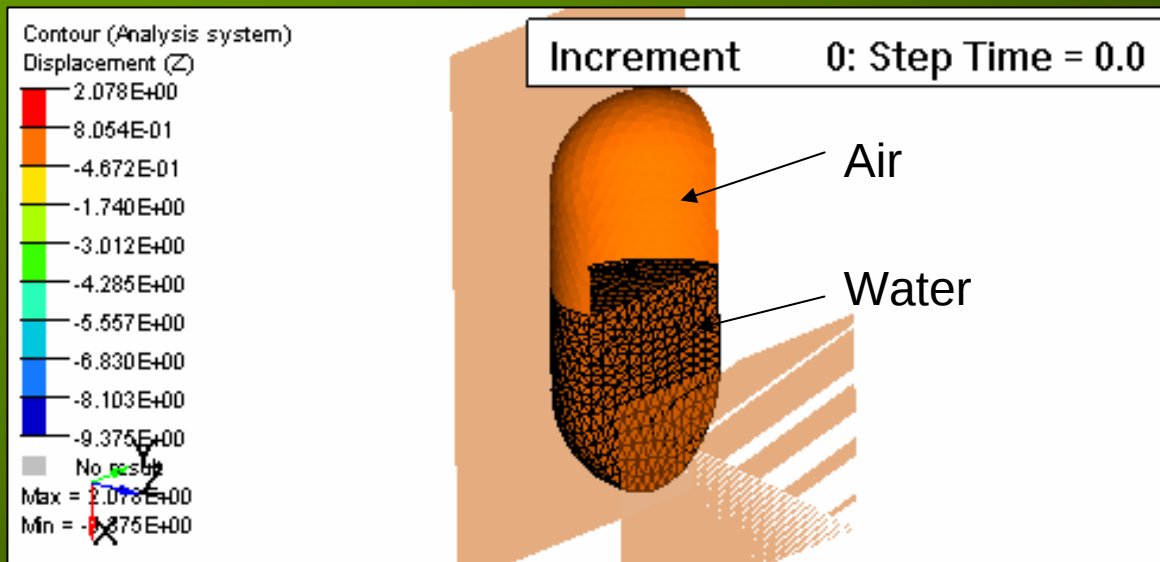
Solution:

A new test apparatus that can determine the pressure dependent elastic modulus and pressure dependent shear modulus.





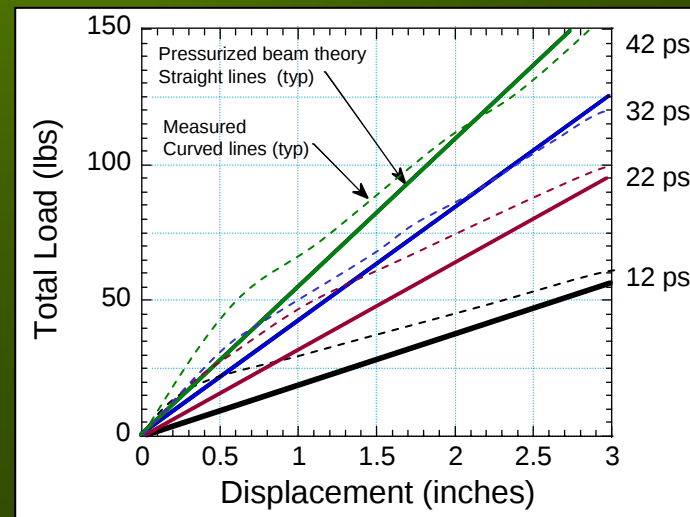
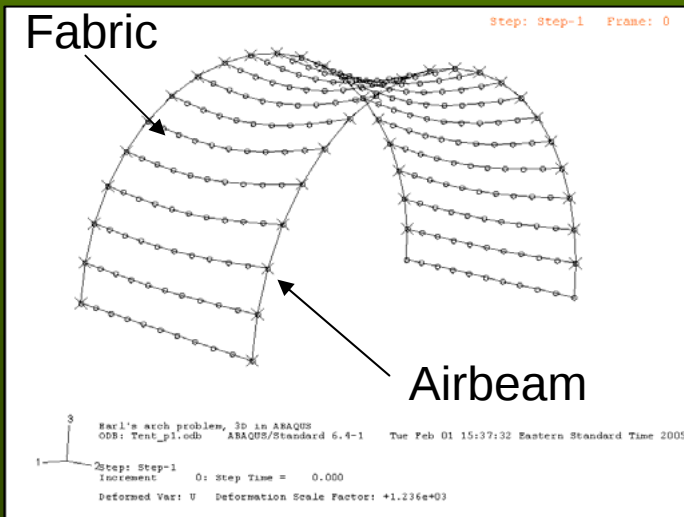
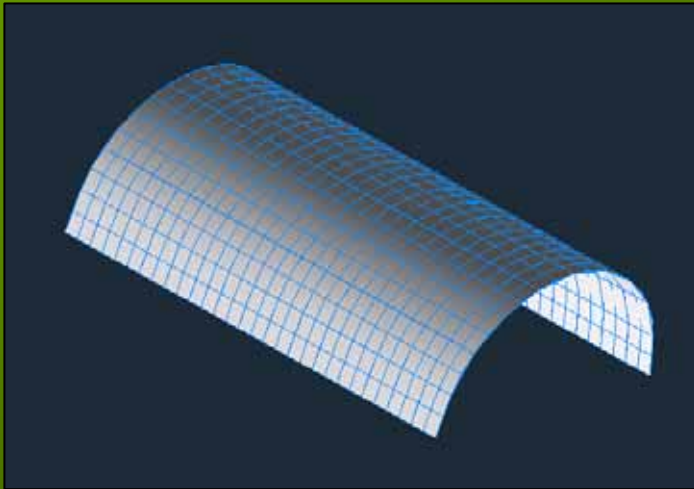
Cavity Filled Membrane Models



- Model results based on changes in cavity volume and inflation pressure
- Has begun to be explored and is in process of validation



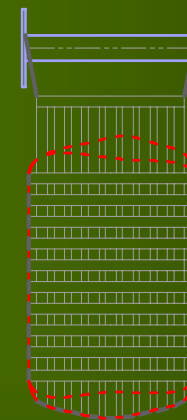
Airbeam and Fabric Membrane Models



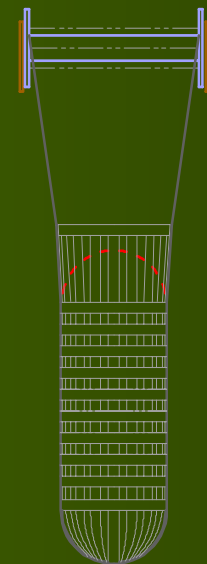


Application of Modeling

Deployable Airbeam Fender System for the Joint High Speed Connector



Deflated



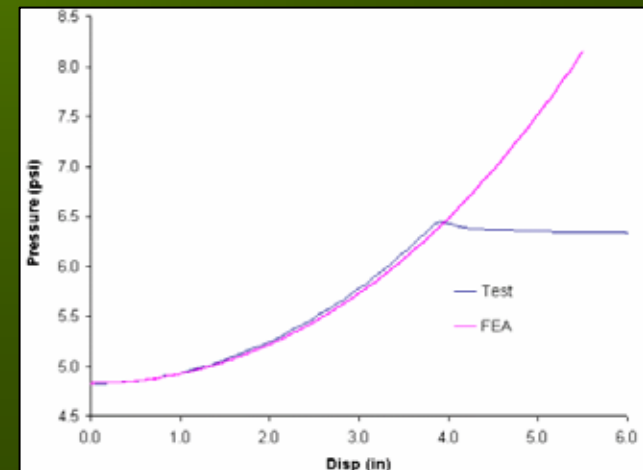
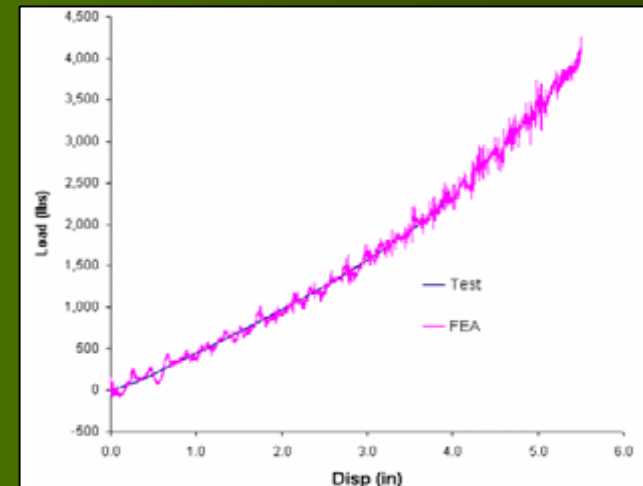
Inflated



Verification of Model



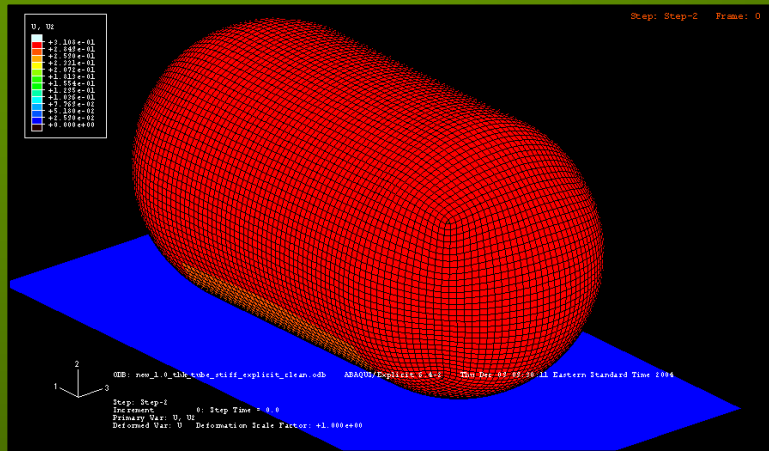
Side View ~ 50% Compression



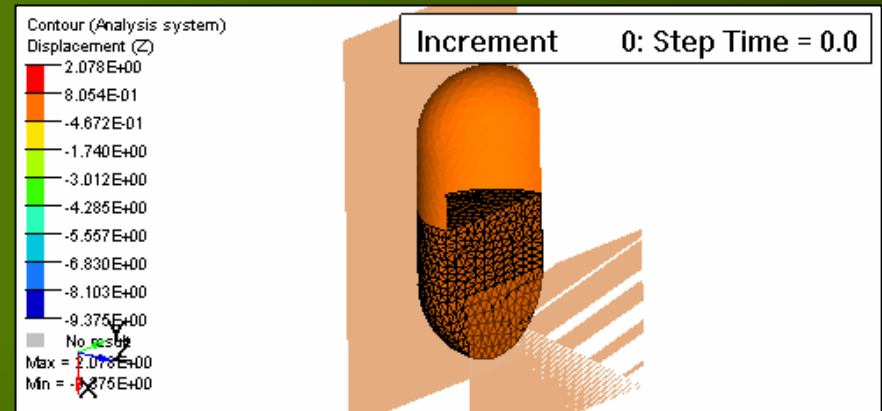


Model Variations

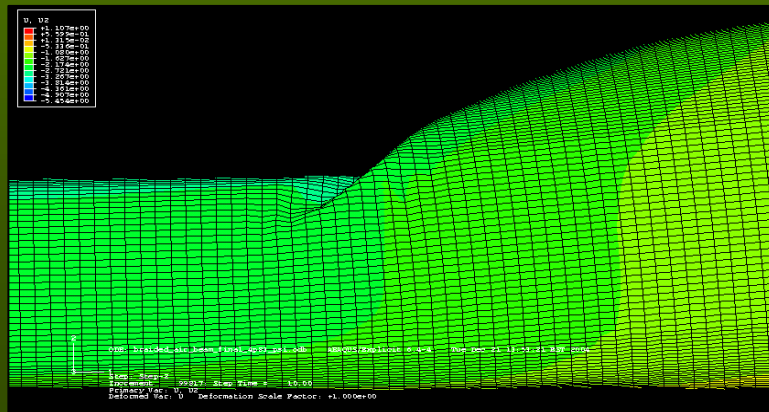
Scaled Prototype Model



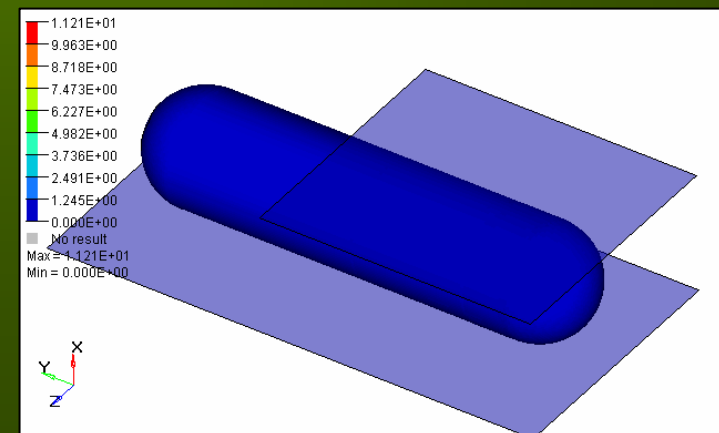
Partial Air and Water Model



Side View of Pinch Point



Partial Compression





Center of Excellence Inflationary Composite Structures

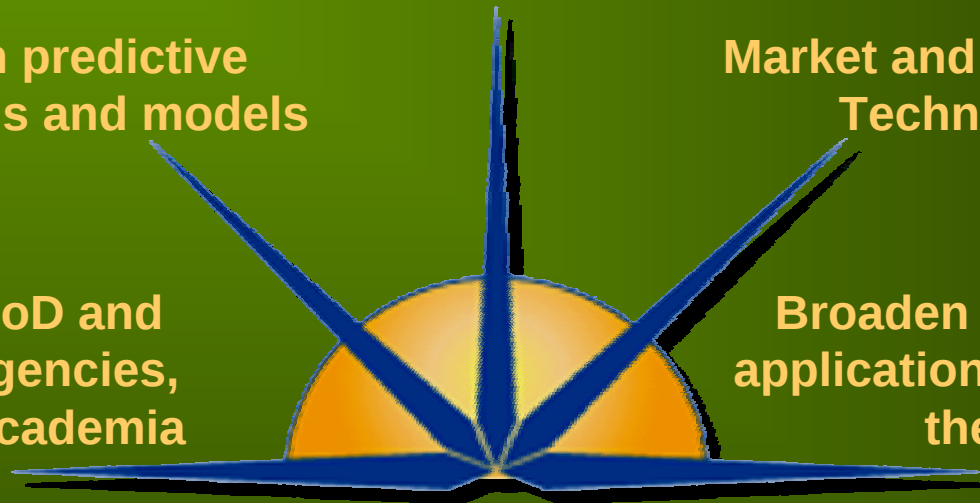
**Increase durability, reliability
and affordability**

**Establish predictive
design tools and models**

**Market and Document
Technology**

**Partner with DoD and
government agencies,
industry, and academia**

**Broaden inflationary structure
applications and commercialize
the technology**



Vision

**Deliver new inflationary technology into
the hands of warfighters and commercial users.**

(Established in 2001 at the Natick Soldier Center in Natick, MA)

04 May 2005



Small Business Innovative Research Project

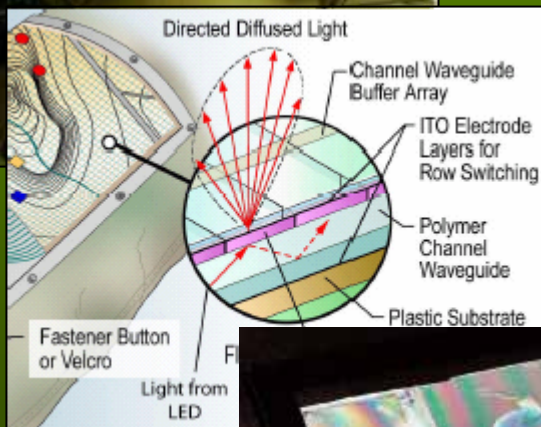
- Flexible Display
 - Physical Optics Corporation
- Solid State Lighting
 - Space Hardware Optimization Technology
 - Physical Optics Corporation
- Photovoltaic Power Shade
 - Iowa Thin Film Technologies
- Insulation
 - Aspen Aerogels
 - L'Garde, Inc.





Flexible Display

POC *Physical Optics Corporation*



Capabilities:

- Ultra thin (<1 mm), flexible (6-10 cm bending radius), high-resolution (100 mm pixel size, total up to 640 x 480 pixels)
- Lightweight (<0.5 g per 1 cm² of display area, <100 g for electronics)
- Full-color, real-time (30-60 Hz refresh), high-optical-contrast (>100:1) display
- Scalability in the display area (from 1 cm² to 1 m² active area)
- Visual images, such as maps and drawings, will be displayed on shelter fabric



Solid State Lighting

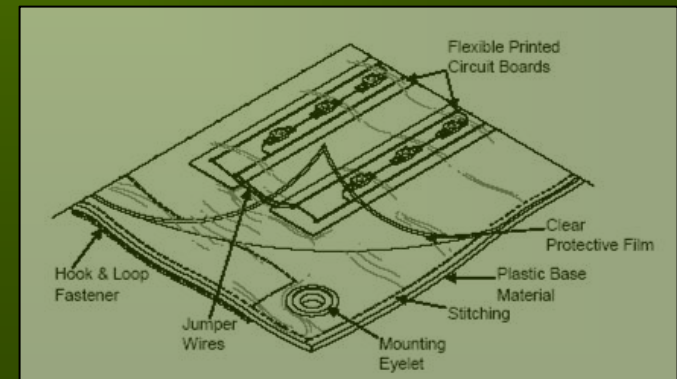
Capabilities

- Evenly illuminates floor level (one fixture for 1 m²) 3 m² in near future
- Permanently attached to shelter (deployed together)
- Operates from outside power or from battery 100,000 hr. lifetime
- Runs 6 hr. on 5 AA batteries with power shutoff
- 10 times longer life than fluorescent light
- Compact, lightweight (100 g fixture)
- All light is directed to the floor (no dispersed light)
- Solar spectrum
- Low cost in mass production (\$5/fixture)



SOSIL Luminaire

POC *Physical Optics Corporation*





Photovoltaic Power Shade

"Power Shade"

Application:

- Solar shade w/ integral PV power
- Provides 1 Kw of PV power, reduces solar load 80% – 90%
- Design to fit over: MGPTS small, 16' TEMPER
- Modular expandability



Dimensions: 22' x 20' x 10'9" - 14'6"

Power: ~1 Kw

Operating Voltage: 12V

BOS required

PV combiner boxes

Master disconnect switch

Charge controllers

12V Deep cycle batteries

Inverter for 120 VAC use





Insulation



- Aspen Aerogels

- 85% Packing Cube Reduction
- R-value > 6 °F·ft²·hr/Btu
- Flame Resistance
- 99% Open Porosity
- Noise and IR Suppression
- Phase II partner with Johnson Outdoors



MIL-C-44154B

Aspen Insulation

- L'Garde

- Phase III
- R-value > 6 °F·ft²·hr/Btu
- Weight < 20 oz/yd²
- Demonstrated 65% reduction in heating/cooling power requirements
- Automated fabrication
- Adjustable to fit multiple shelter geometries





Thank You