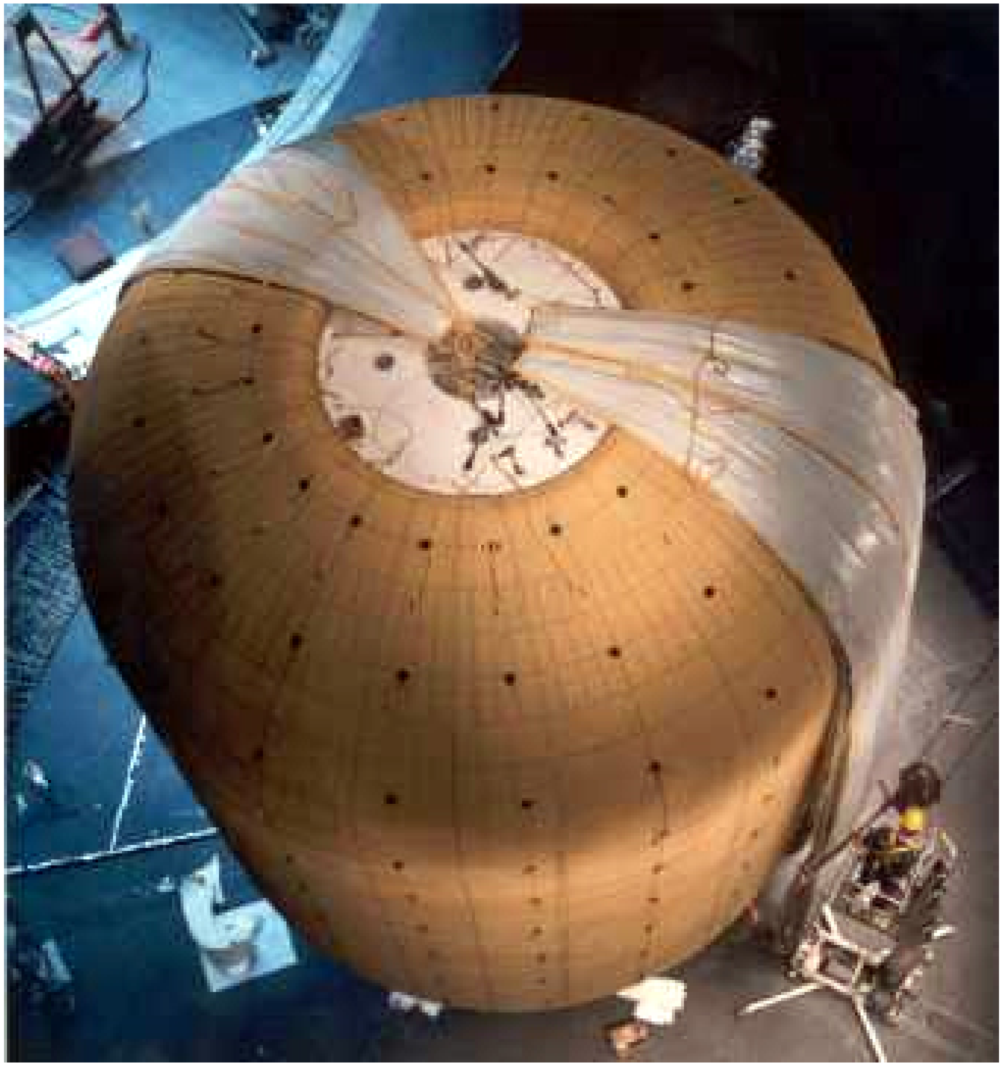
International Conference on Textile Composites and Inflatable Structures
STRUCTURAL MEMBRANES 2007
E. Oñate, and B. Kröplin, (Eds)

CIMNE, Barcelona, 2007

Geometric Analysis for Inflatable Space Habitats

Andrew Lennon[1] and Maxim de Jong[2]

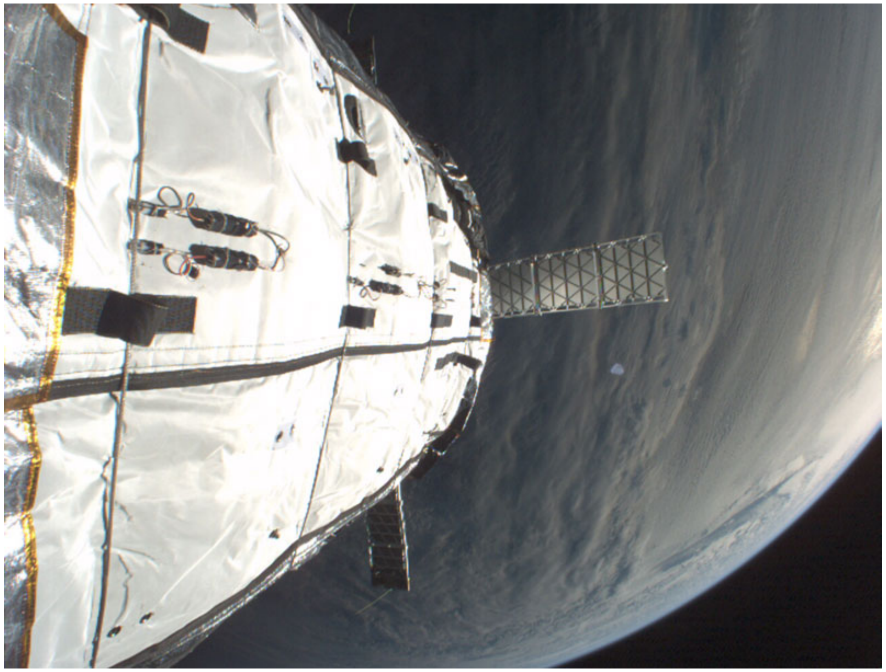
[1] ABL Engineering Ltd, Ireland (andrew.lennon@abl.ie www.abl.ie)
[2] Thin Red Line Aerospace Ltd, Canada (maxim@thin-red-line.com)



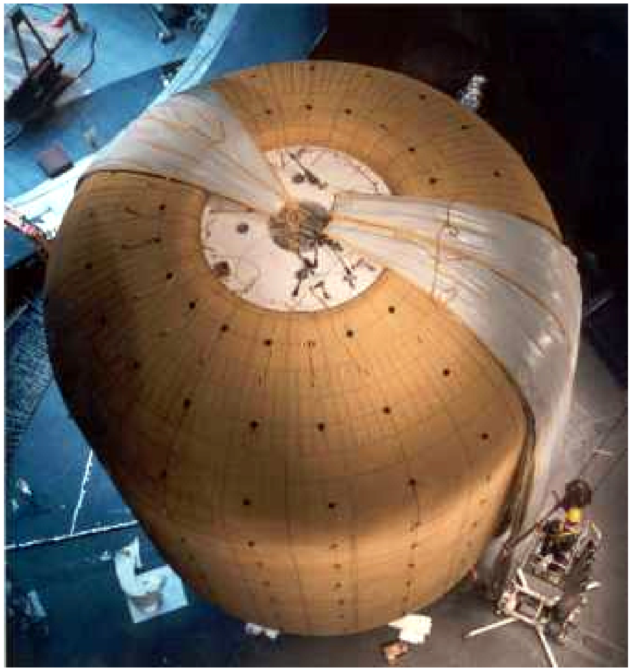
CONTENTS

- Introduction
- Simplified geometric analysis
- More complex analysis
- What happens in practice …

Genesis and Transhab



Genesis I (Bigelow Aerospace photo)



TransHab (NASA photo)

Overview for Design & Analysis

- Design and analysis uses relatively simple calculations
- Simple calculations necessary because of complexity of material and load pathways
- Need to move to physical testing at an early stage

Simple Models

- Start with a simple model
- Useful things that we can learn from the simple model
- The limitations of the simple model

Simple Models

- Very simple: cylinder with hemi-spherical ends

$$\sigma_{cyl,hoop} = \frac{pr}{t}$$

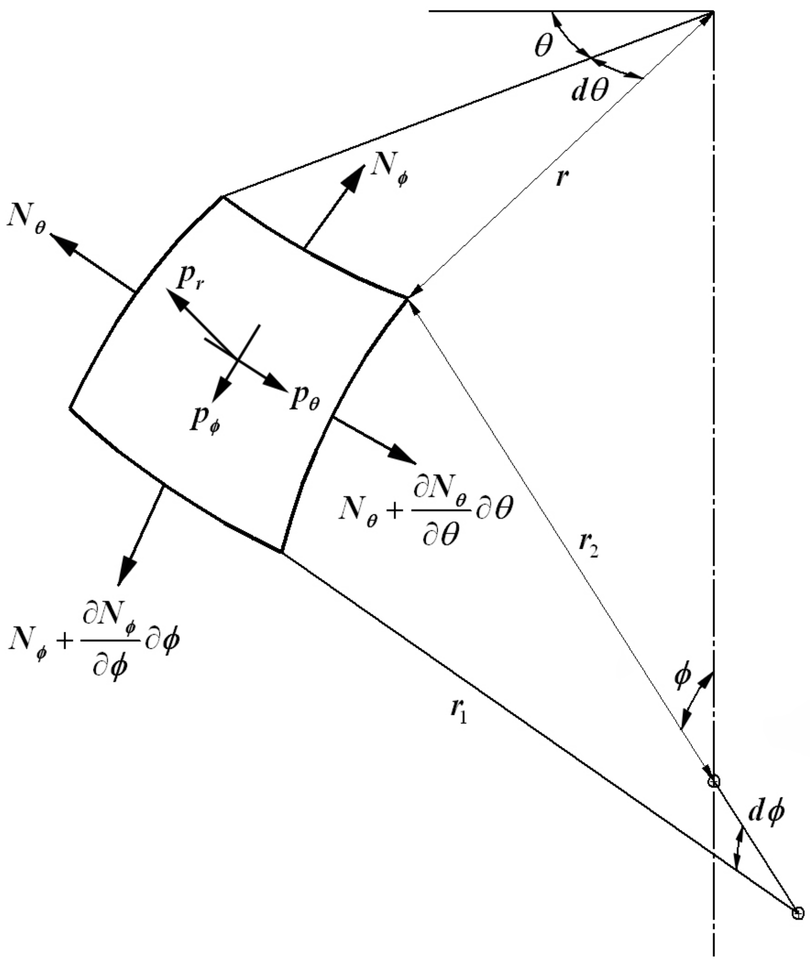
- Already we know something about structural efficiency

$$\sigma_{sphere} = \sigma_{cyl,long} = \frac{pr}{2t}$$

International Conference on Textile Composites and Inflatable Structures
STRUCTURAL MEMBRANES 2007
E. Oñate, and B. Kröplin, (Eds)

CIMNE, Barcelona, 2007

Generalised Surface



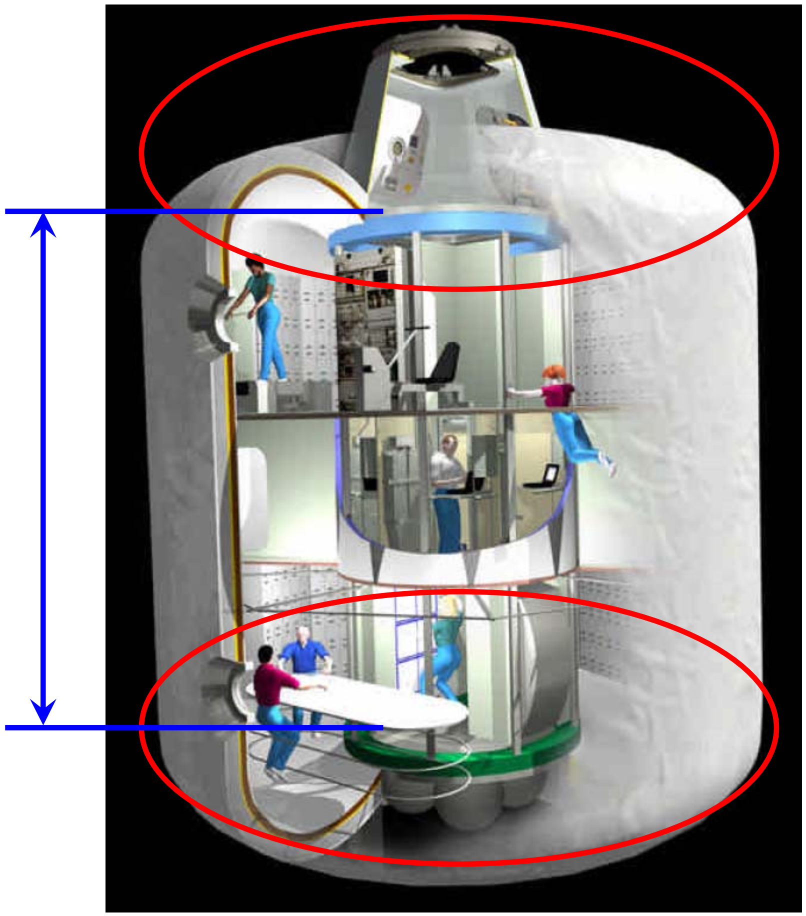
$$\frac{N_\phi}{r_1} + \frac{N_\theta}{r_2} = p$$

(see Flügge "Stresses in Shells" for detail)

International Conference on Textile Composites and Inflatable Structures
STRUCTURAL MEMBRANES 2007
E. Oñate, and B. Kröplin, (Eds)

CIMNE, Barcelona, 2007

NASA Transhab Geometry



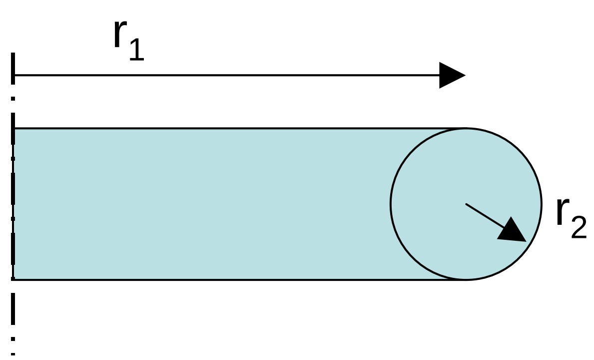
International Conference on Textile Composites and Inflatable Structures
STRUCTURAL MEMBRANES 2007
E. Oñate, and B. Kröplin, (Eds)

CIMNE, Barcelona, 2007

Geometric Design for Transhab

- NASA Transhab design
- Geometry is uses capped toruses for ends with a “constant section” between ends
- Torus has useful property that (for large r_1)

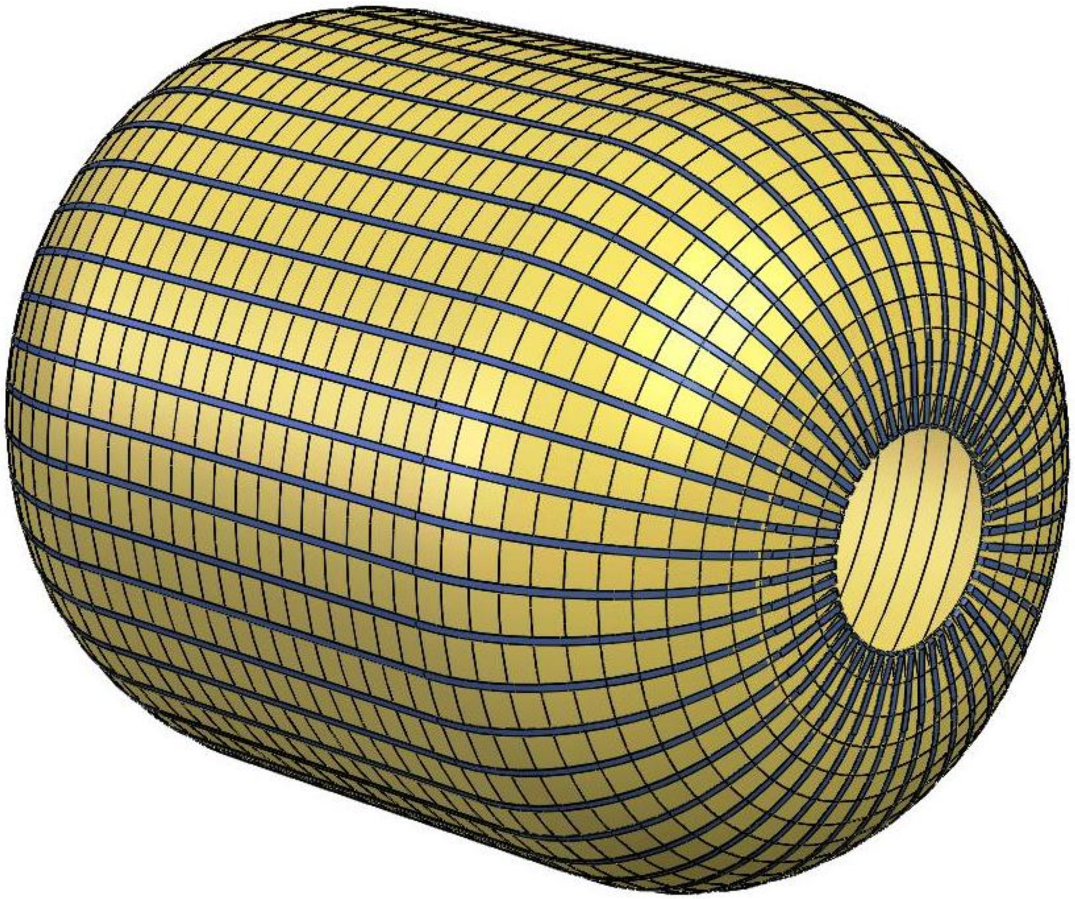
$$\sigma_{\max} \rightarrow \frac{pr_2}{t}$$



International Conference on Textile Composites and Inflatable Structures
STRUCTURAL MEMBRANES 2007
E. Oñate, and B. Kröplin, (Eds)

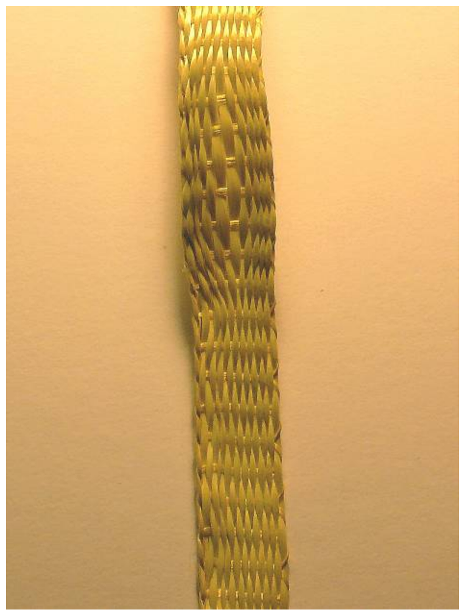
CIMNE, Barcelona, 2007

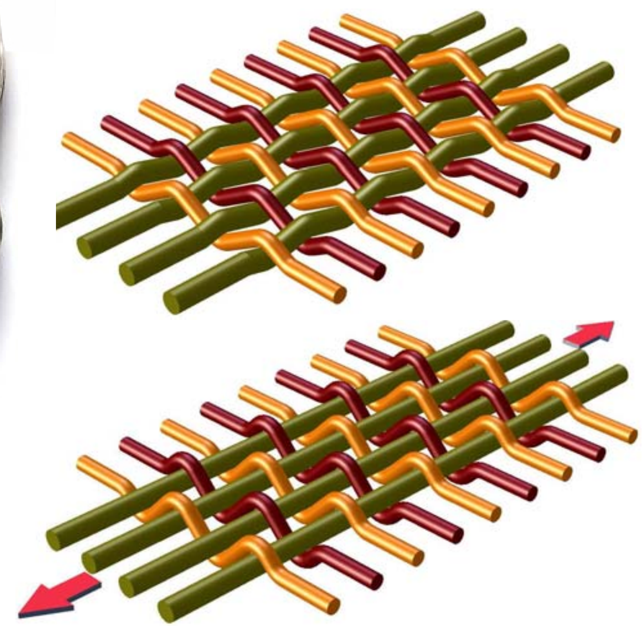
Genesis Pressure Restraint



International Conference on Textile Composites and Inflatable Structures
STRUCTURAL MEMBRANES 2007
E. Oñate, and B. Kröplin, (Eds)
CIMNE, Barcelona, 2007

Real Material





International Conference on Textile Composites and Inflatable Structures
STRUCTURAL MEMBRANES 2007
E. Oñate, and B. Kröplin, (Eds)
CIMNE, Barcelona, 2007

Some Variables

- Anisotrophy
- Non-linear elasticity
- Initial deformation/non-recoverable stretch (effect of load cycling)
- Material variability

A suggested path …

- Initial geometric design with simple shapes
- Work with geometry using generalised equations
- Calculate preliminary strap forces based on force from membrane model
- Move to physical testing at level of strap construction

Future Work

- How do we improve?
- Do better designs exist?
- Work is underway but commercially confidential for now

Conclusions

- Detailed analysis is difficult for practical inflatable space habitats
- Assumptions (implicit and explicit) limit applicability of complex models
- Need to move to physical testing at the level of strap construction
- Analytical models can be used to guide our design