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Benefits and Limitations of Analysis in the Design of Pressure Restraint Layers for Inflatable Space Habitats

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(presented by Andrew Lennon)

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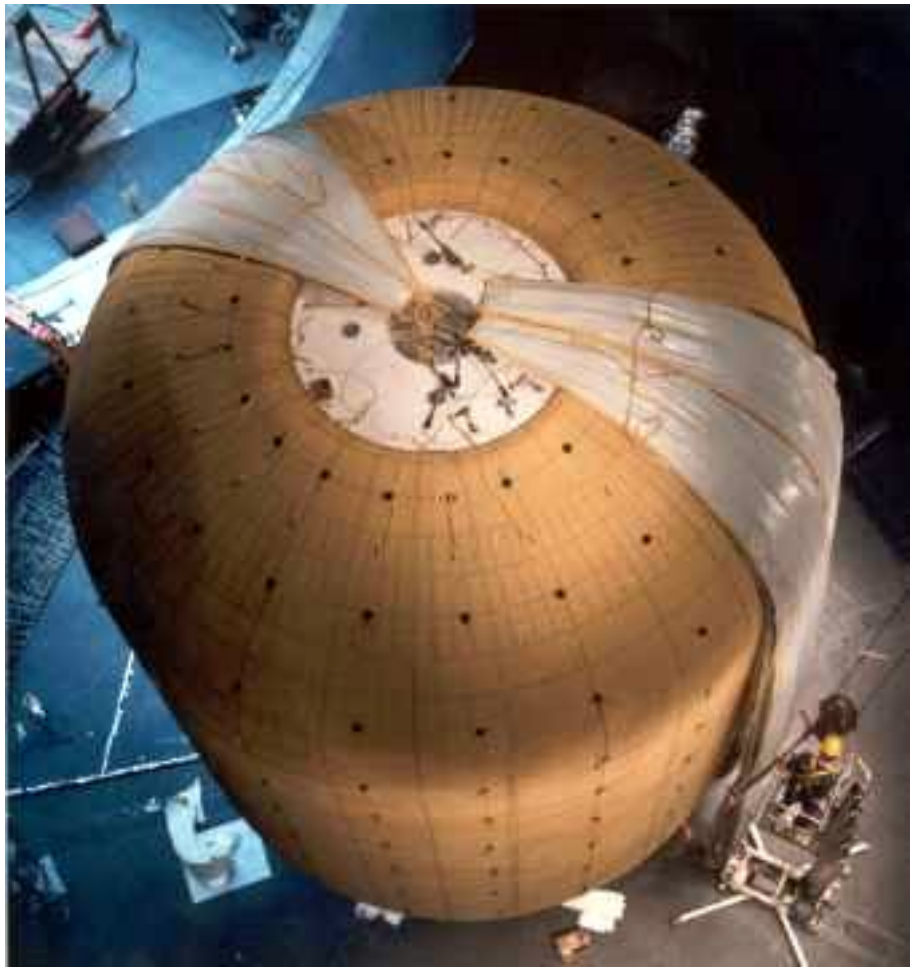
Contents

- Introduction
- Simple example
- TransHab and Genesis
- Effect of real (woven) materials
- And what we (can) do in practice …

Pressure Restraint Layer



TransHab (NASA photo)

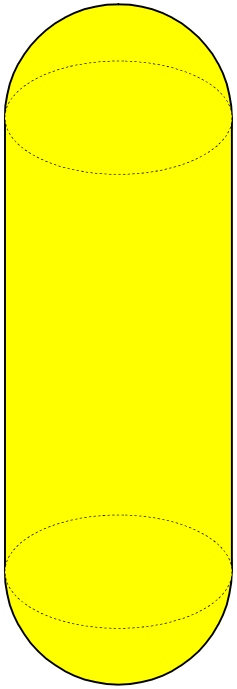
Overview for Design & Analysis

- Appropriate analysis
- Relatively simple load calculations because of complexity of material and load pathways
- Complex part is the geometric analysis
- Need to move to physical testing at an early stage

Simplified Analysis

- Start with a simple model
- Importance of understanding phenomena
- Useful things that we can learn from the simple model
- Issued raised by the model

Simple Model

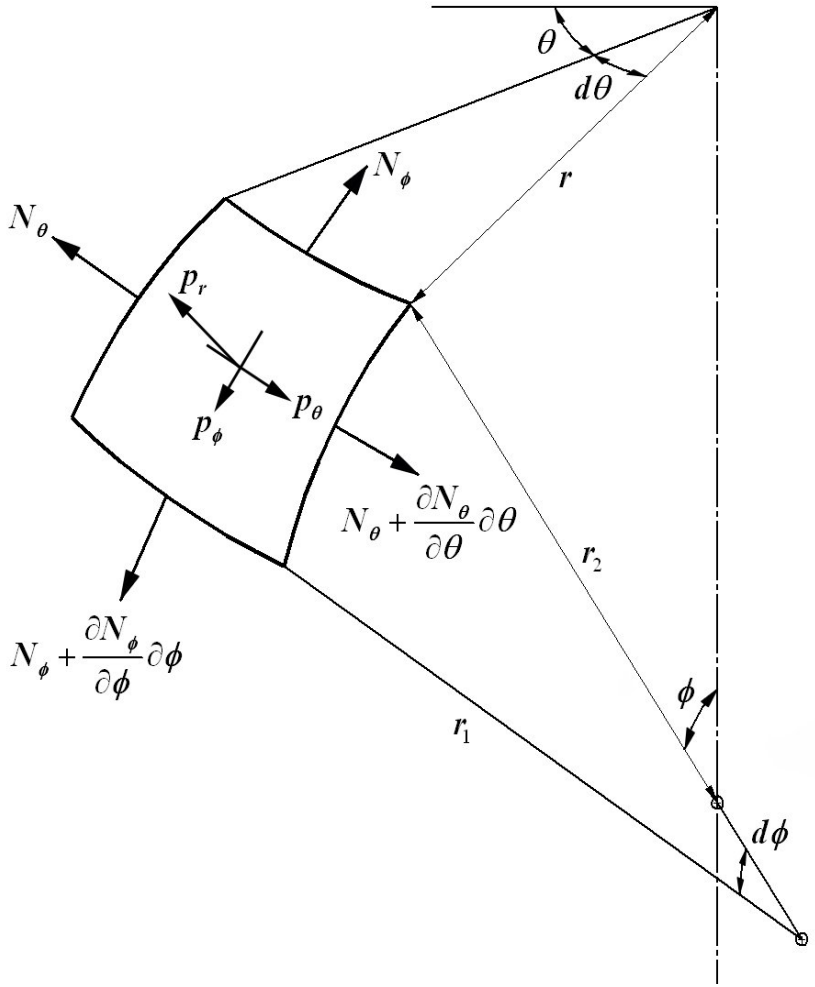


$$\sigma_{cyl,hoop} = \frac{pr}{t}$$

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

- Cylinder with hemi-spherical ends
- Simple structure, but it informs us about the importance of geometry in design

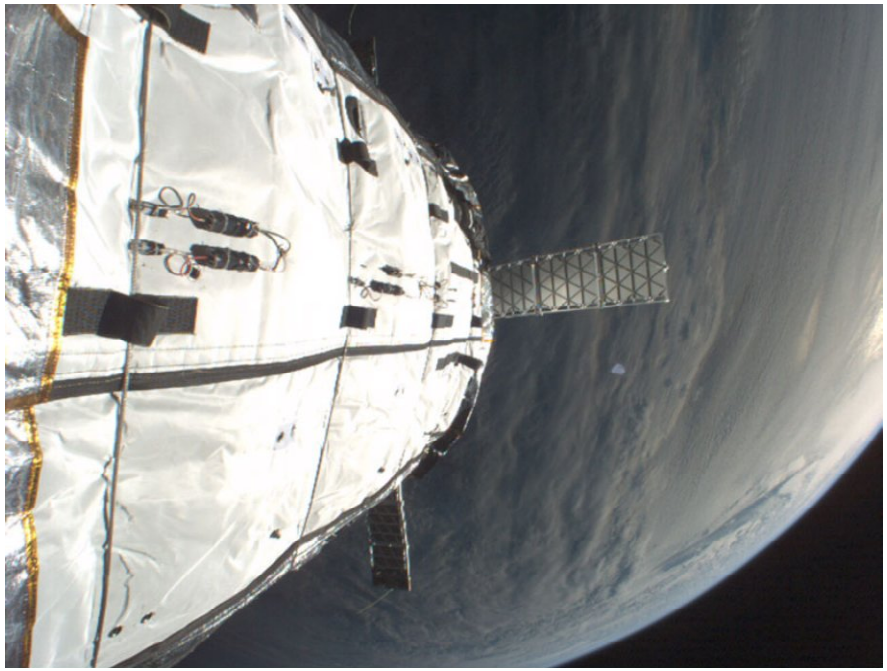
Generalised Surface



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

(see Flügge (1962) “Stresses in Shells” for detail)

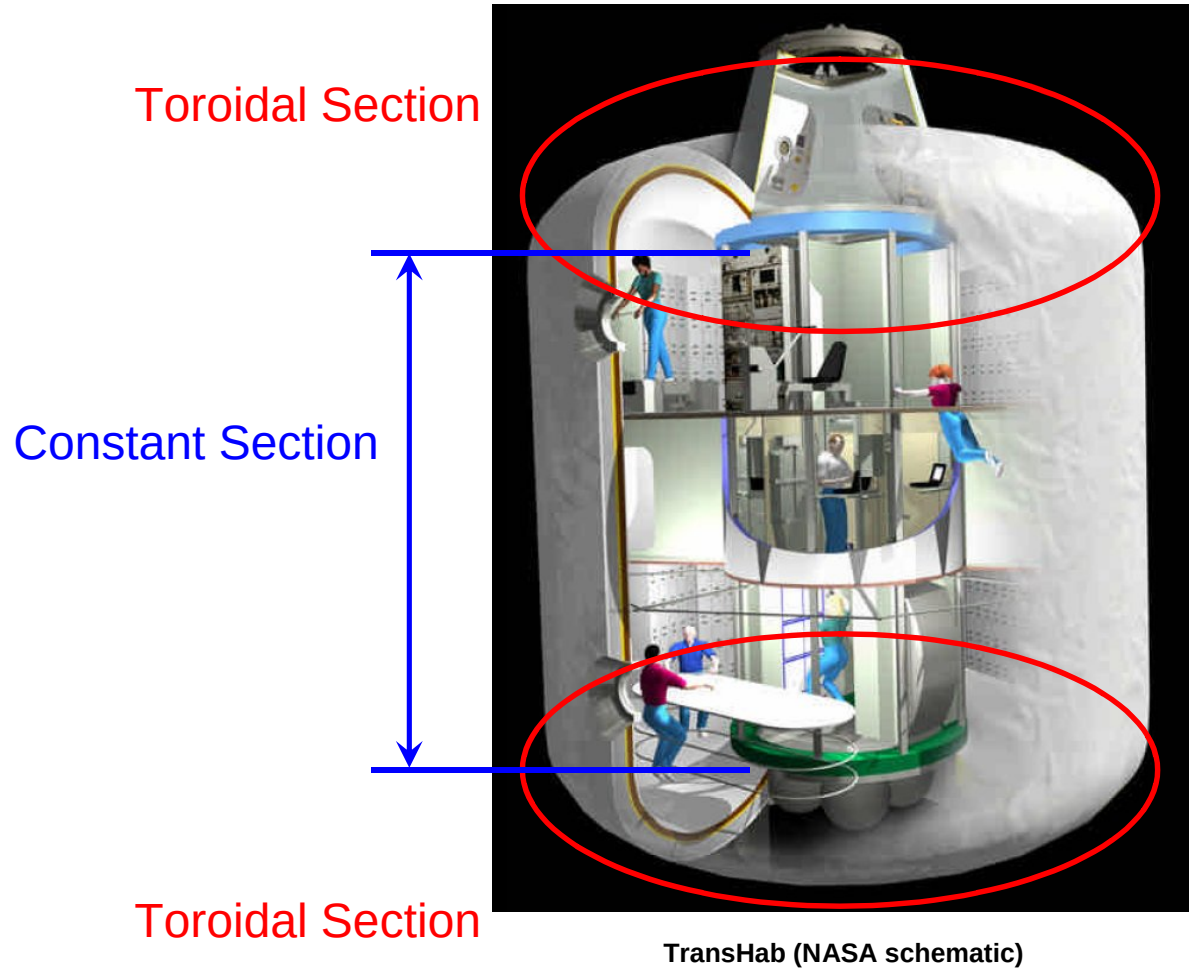
Genesis and TransHab



Genesis I (Bigelow Aerospace photo)

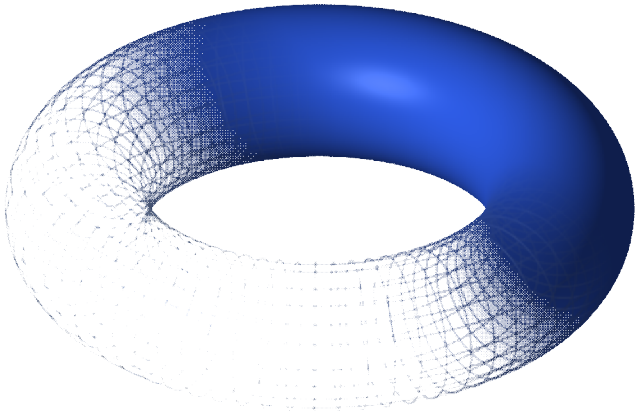
TransHab (NASA photo)

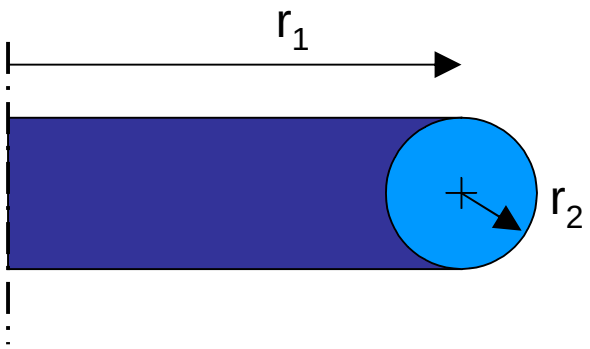
NASA TransHab Geometry



TransHab (NASA schematic)

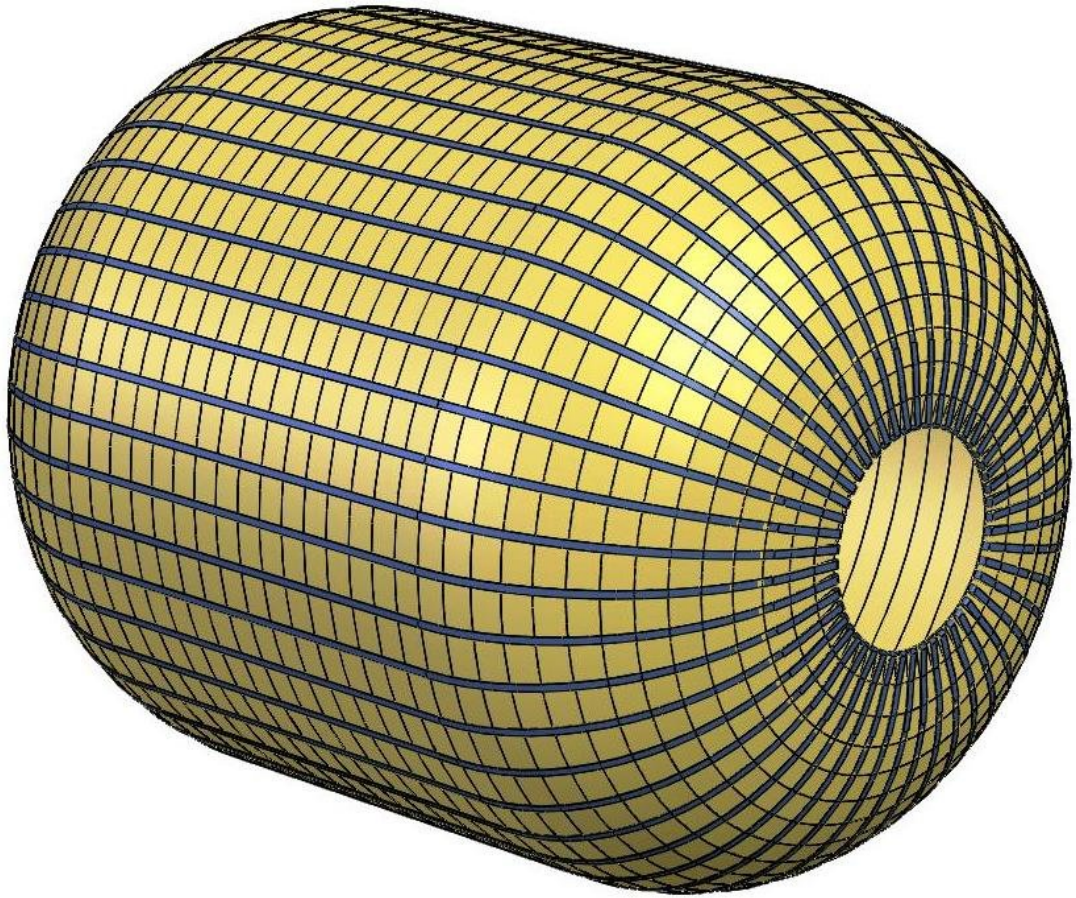
Stress in Inflated Torus





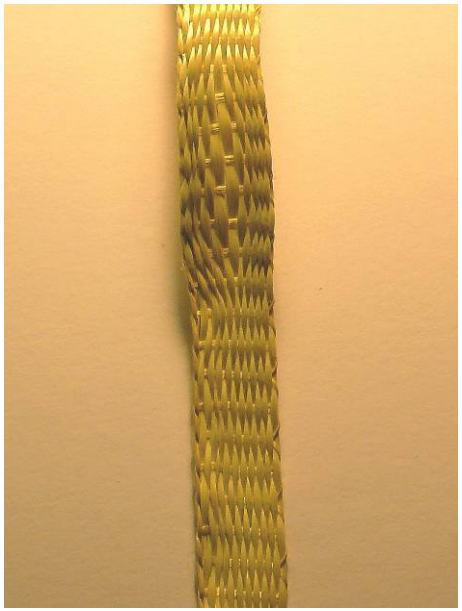
for r_1 large; $\sigma_{\max} \rightarrow \frac{pr_2}{t}$

Genesis Pressure Restraint



Woven Material

Broad Fabric



Webbing

Cordage

Variables for Analysis

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

How it works in practice …

- Careful attention to geometric analysis
- Simplified load calculations: feedback into geometric analysis
- Calculate preliminary strap forces using simple models
- Move from analysis to physical testing at level of strap construction

Future Work

- How do we improve analysis?
- Do better designs exist?
- Work is underway but commercially confidential (hope to present in future)

Conclusions

- Appropriate analysis is valuable to inform design
- Must remember limitations of analysis caused by variability and lack of precise data
- Need to move to physical processes at the level of strap construction

  (practical analysis limit … for now)

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