

# COBS Project

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# A continuously inhabited orbiting platform: ISS International Space Station



- Altitude extends from 460 to 350 km
- ✓ External Temperature (-/+ 140°C)
    - ✓ Meteoroids & Debris
    - ✓ Microgravity condition
      - ✓ Radiation
    - ✓ External vacuum

- ✓ 1 orbit every 90 minutes
- ✓ orbital velocity: about 8 km/s
- ✓ Inclination: 51,6° over the equator



# ISS International Space Station



November 20<sup>th</sup>, 2003:  
5<sup>th</sup> year in orbit  
36 launches  
187 tons, 425 m<sup>3</sup>  
(420 tons, 1200 m<sup>3</sup>)  
5 agencies, 16 Countries

More than 100 visitors  
from 9 different Countries  
Manned continuously from 1300  
days

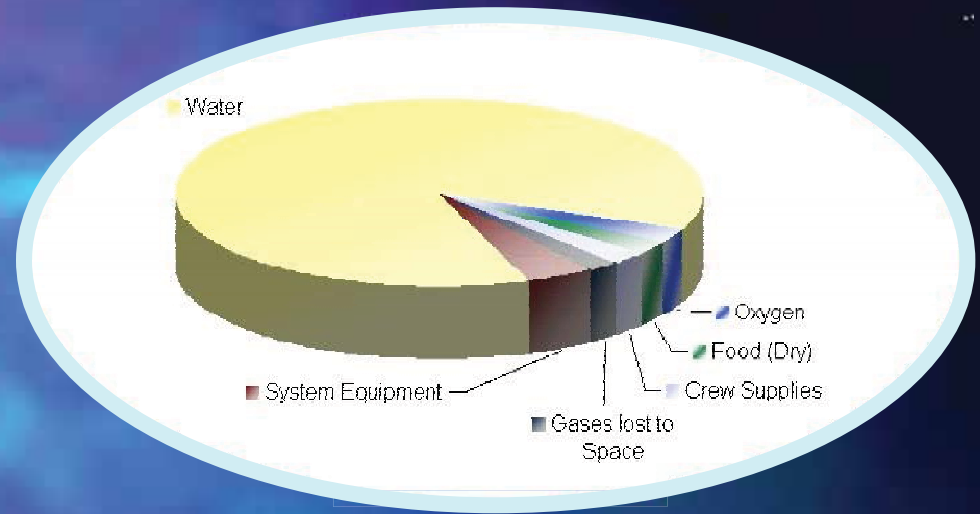


**Expedition 9:** Commander G. Padalka,  
Flight Eng M. Finche

# Supplies



Space Shuttle at launch



## ISS Supplies

Cost: ~30.000\$/Kg

2,5 / 3 tons each 3 months

- ✓ Soyuz (oct 2003)
- ✓ Progress 13 (jan 2004)
- ✓ Progress 14 (may 2004)

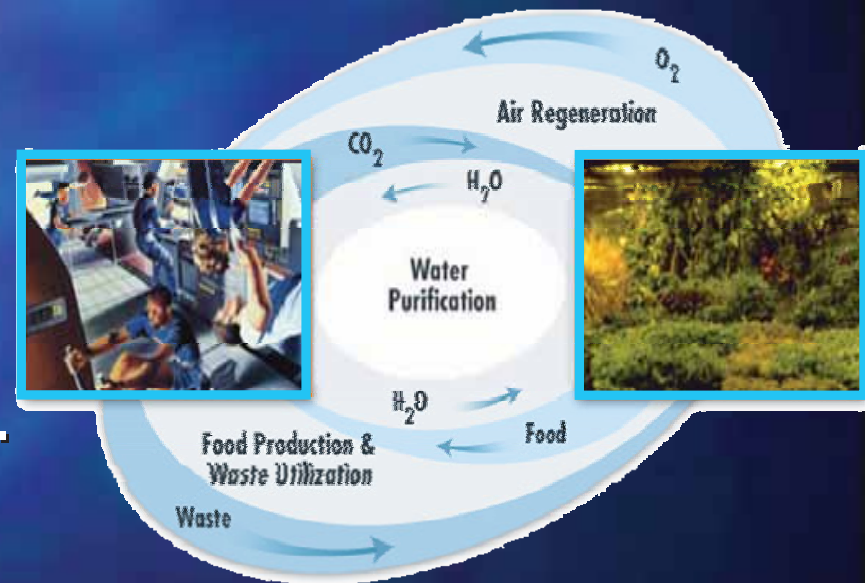


Soyuz capsule

# Bio-regenerative Life Support System

Main target is to ensure that the three fundamental cycles of life make up a closed loop:

- ✓ Plants provide crew with food when deliveries from Earth aren't possible.
- ✓ Plants make for breathable air (consuming  $\text{CO}_2$  and releasing  $\text{O}_2$ ).
- ✓ Plants make for drinkable water.



# Bio-regenerative Life Support System

A number of standard facilities are provided by NASA, ESA or Russian Federal Space Agency to support this area of research:



(March 2003) Zvezda Service Module  
Russian BIO-5 Rasteniya-2/Lada-2 (Plants-2) plant growth  
experiment

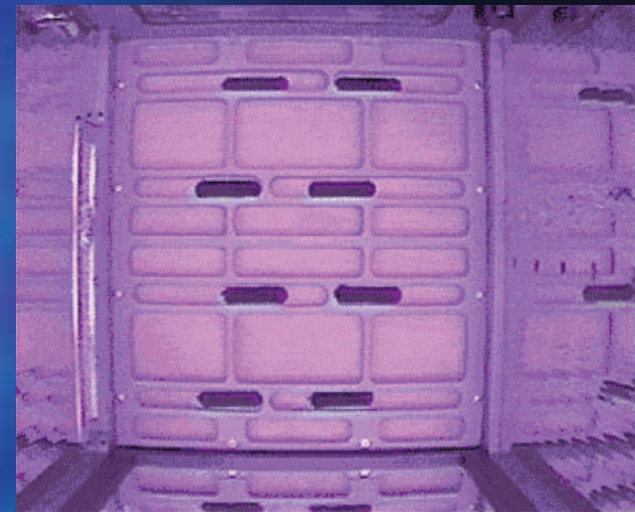
# Bio-regenerative Life Support System

2443 cm<sup>2</sup> x (45+5)cm  
microgravity

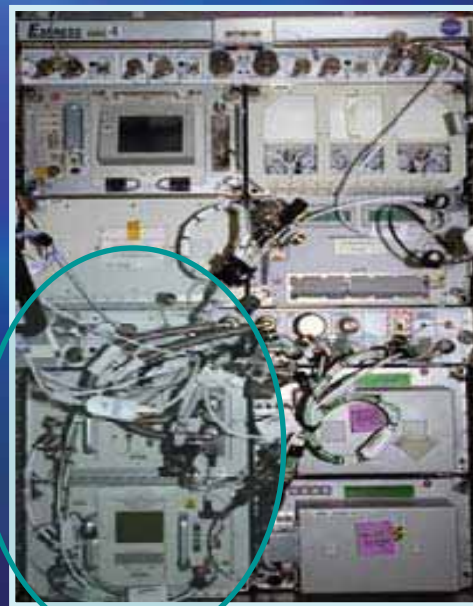


Commercial Plant Biotechnology  
Facility  
(NASA-US Lab Module)

486 cm<sup>2</sup> x (5+35) cm  
microgravity



Soybean ISS 11 June/2July 2002

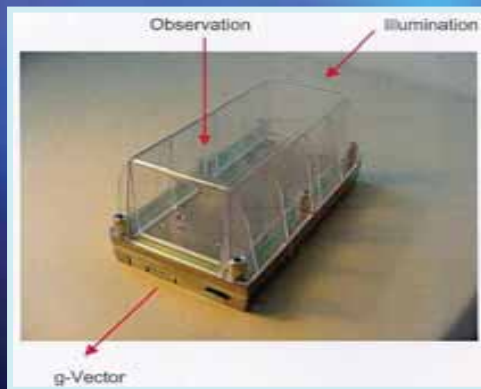


ADVANCED  
ASTROCULTURE  
(NASA-US Lab  
Module)

# Bio-regenerative Life Support System



2 rotor x 4 EC  
160x60x60mm



2 centrifuges x 4 EC  
60x60x100mm  
or 2 AEC 175x147x125

EUROPEAN MODULAR  
CULTIVATION SYSTEM  
(ESA- DESTINY lab)



BIOLAB FACILITY  
(ESA- COLUMBUS lab)

# ESM: Equivalent System Mass

A method to compare two systems that are equivalent but of a completely different type



2559,96 + 8,0 t kg ESM

969,9 + 10,9 t kg ESM

bio-regenerative system

chemical-physical system

# Inflatable technology for Space



**Promising technology** for systems with:

- ✓ high performances
- ✓ light weight
- ✓ significant operational dimensions



Wide range of **applications**:

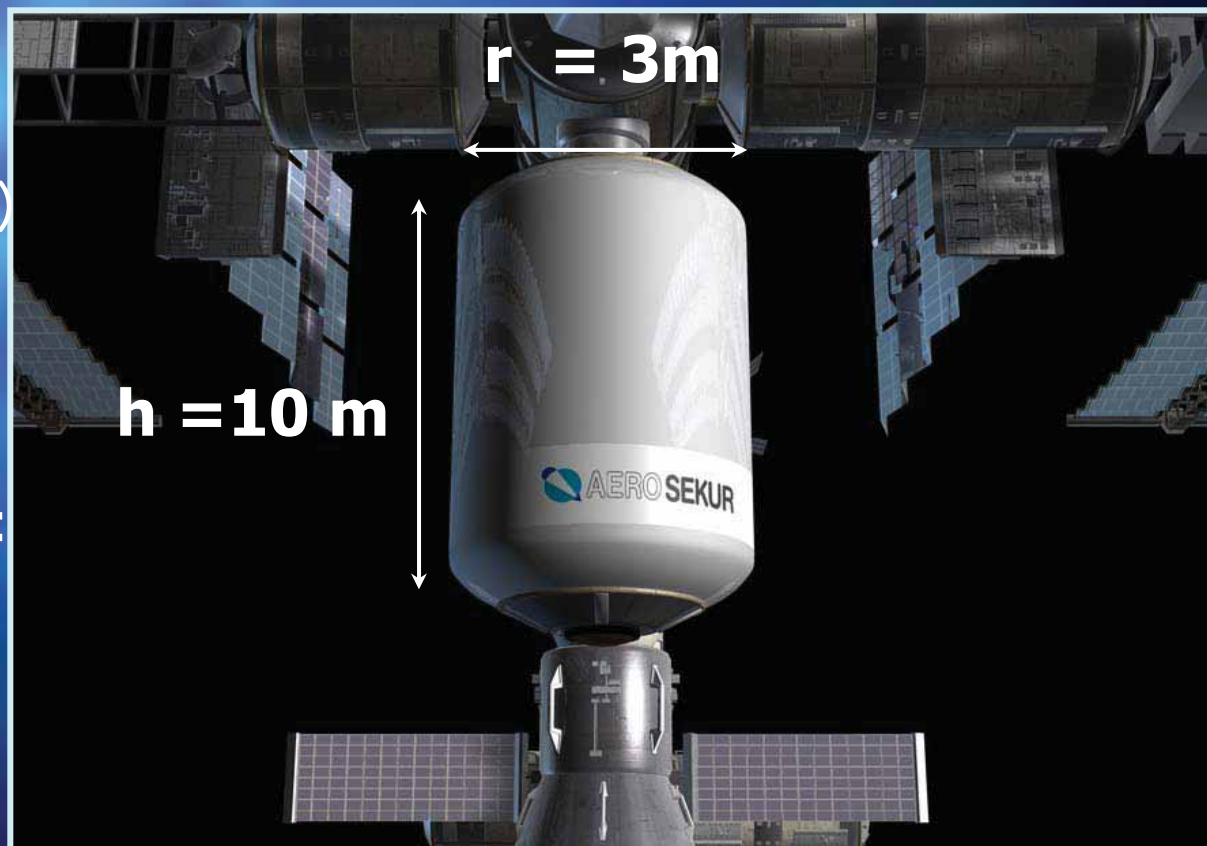
- ✓ Habitation Modules
- ✓ Re-Entry Systems
- ✓ Lightweight Antennas
- ✓ Solar Arrays



# COBS: Cosmic Orbital Bioregenerative System

Inflatable module for ISS, to provide breathable air, drinkable water and food

- ✓ Dimensioned for 3 people (about 110 m<sup>2</sup>)
- ✓ Provides condition for plants growth
- ✓ Simulated parameters:
  - Gravity
  - Photoperiod
  - Temperature
  - Humidity





# COBS Concept

## Structural Layer

### Features

- ✓ Structural Resistance
- ✓ Easily foldable
- ✓ Easily configurable

### Candidate materials:

- ✓ Kevlar
- ✓ Zylon

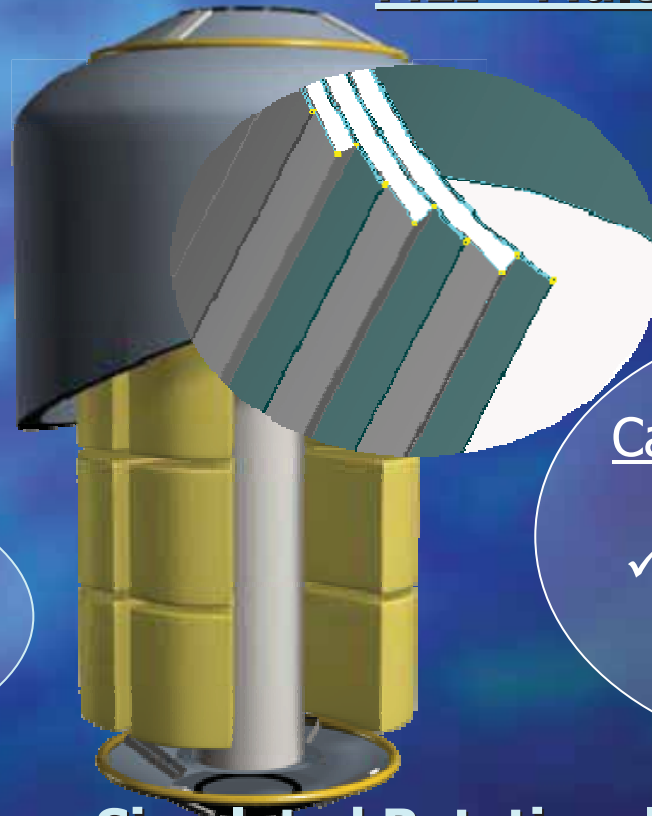
## MLI - Multi-Layer Insulation

### Features

- ✓ Debris protection
- ✓ Thermal insulation

### Candidate materials:

- ✓ Mylar
- ✓ Nextel 312 o 440
- ✓ Sonex



## Simulated Rotational Gravity

- Gravimorphic limit 0,18 g = 2,65 rpm



# COBS: Internal Architecture

## Service Area

- ✓ Maintenance and monitoring activities
- ✓ Modules replacement

## GreenHouse Modules

- ✓ Plants cultivation
- ✓ Interface (flange) with beam
- ✓ Flexible /Rigid Interface
- ✓ Artificial lighting
- ✓ Irrigation rack



## ISS Rigid Cover/Hatch

- ✓ Connection with ISS
- ✓ Flexible/Rigid interface
- ✓ Sealing

## Central Telescopic Beam

- ✓ Telescopic deployment
- ✓ Cables and connectors
- ✓ Interface flange with modules

## Aft cover

- ✓ Shape keeping during deployment
- ✓ Structural resistance

# COBS: Structural Analysis

## LS-DYNA FEM Simulation (25000 membrane elements)

### Hypotheses:

Silicon coated Kevlar

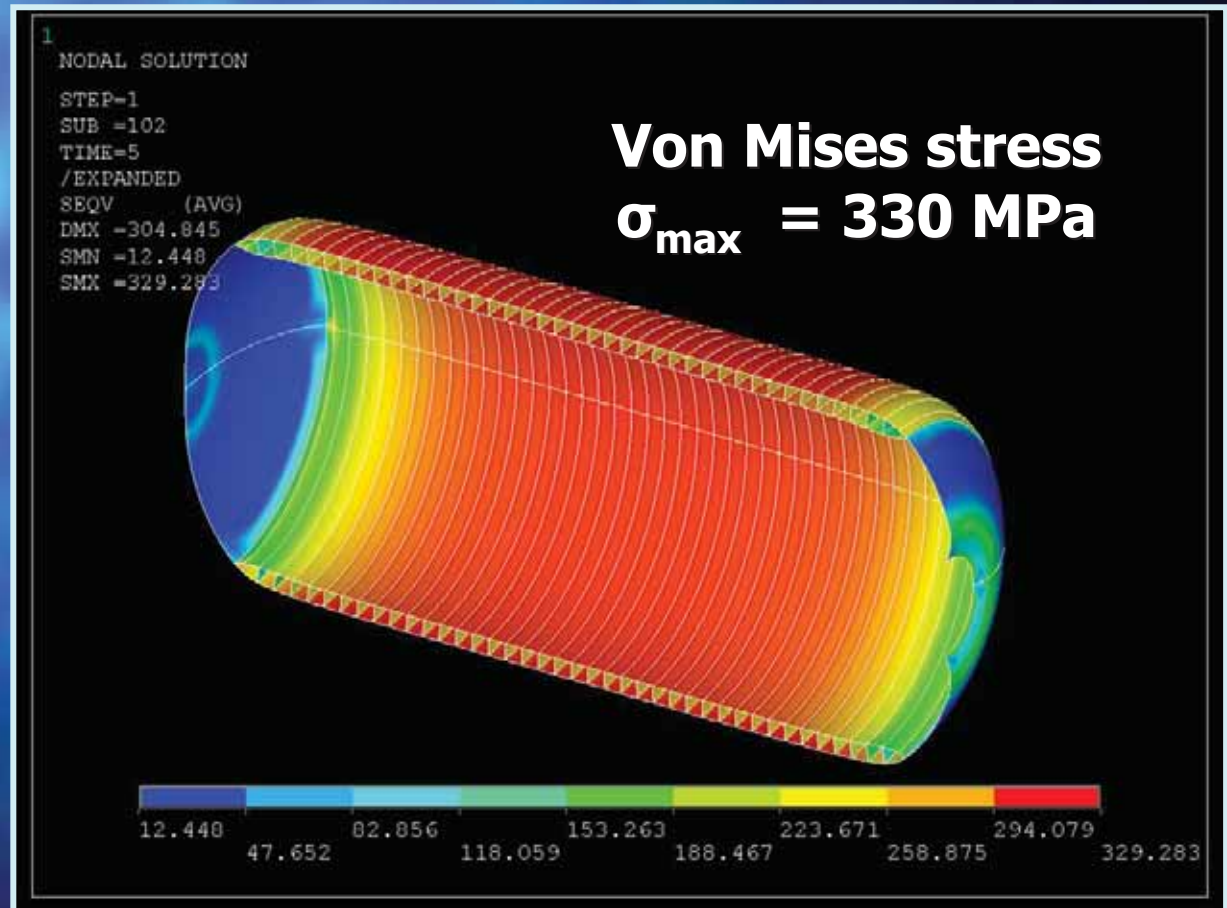
Thickness: 0,26 mm

Weight: 120 g/m<sup>2</sup>

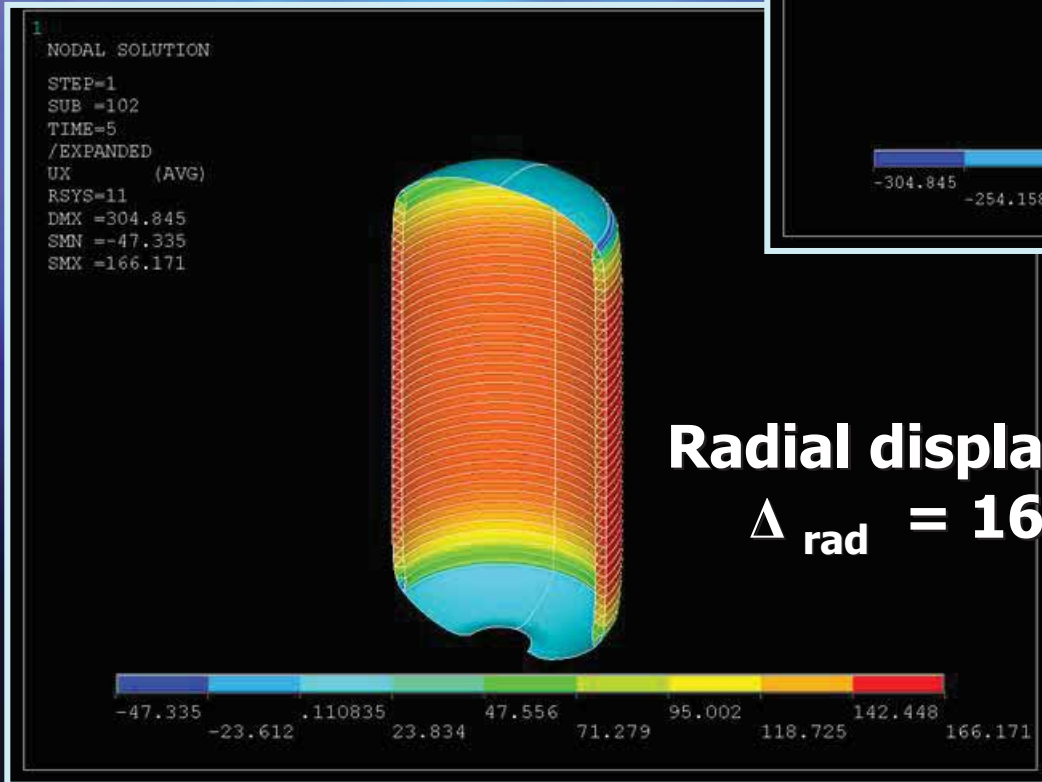
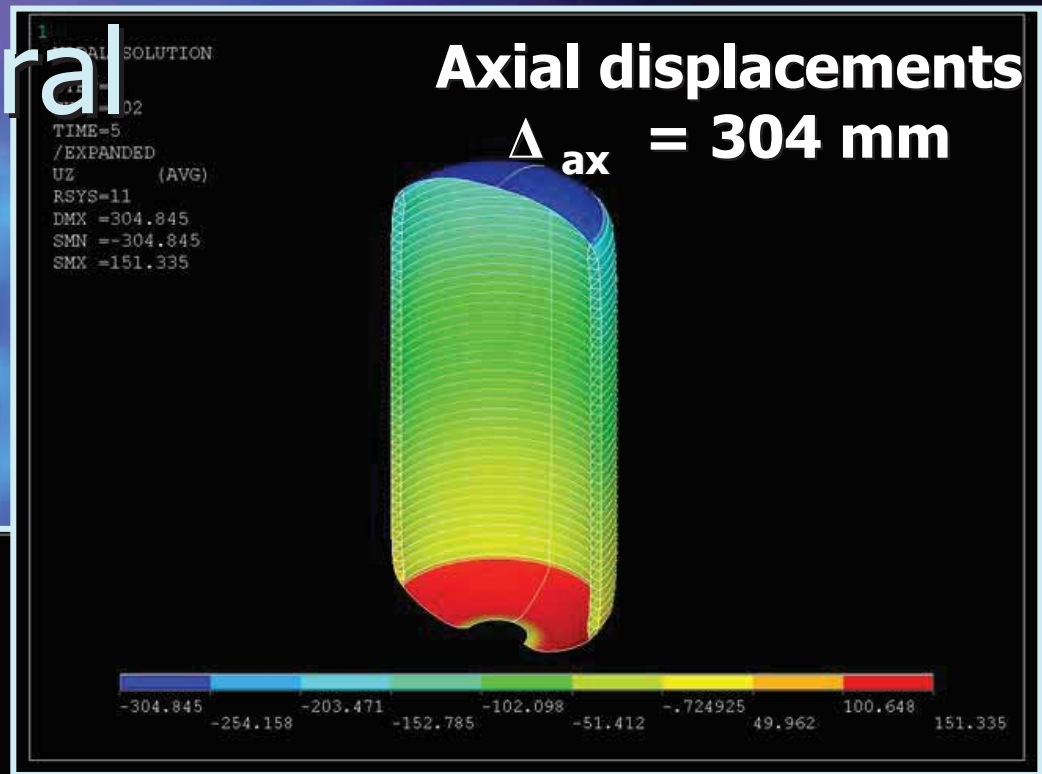
Allowable  $\sigma$  = 400 MPa

Internal Pressure: 1,1 bar

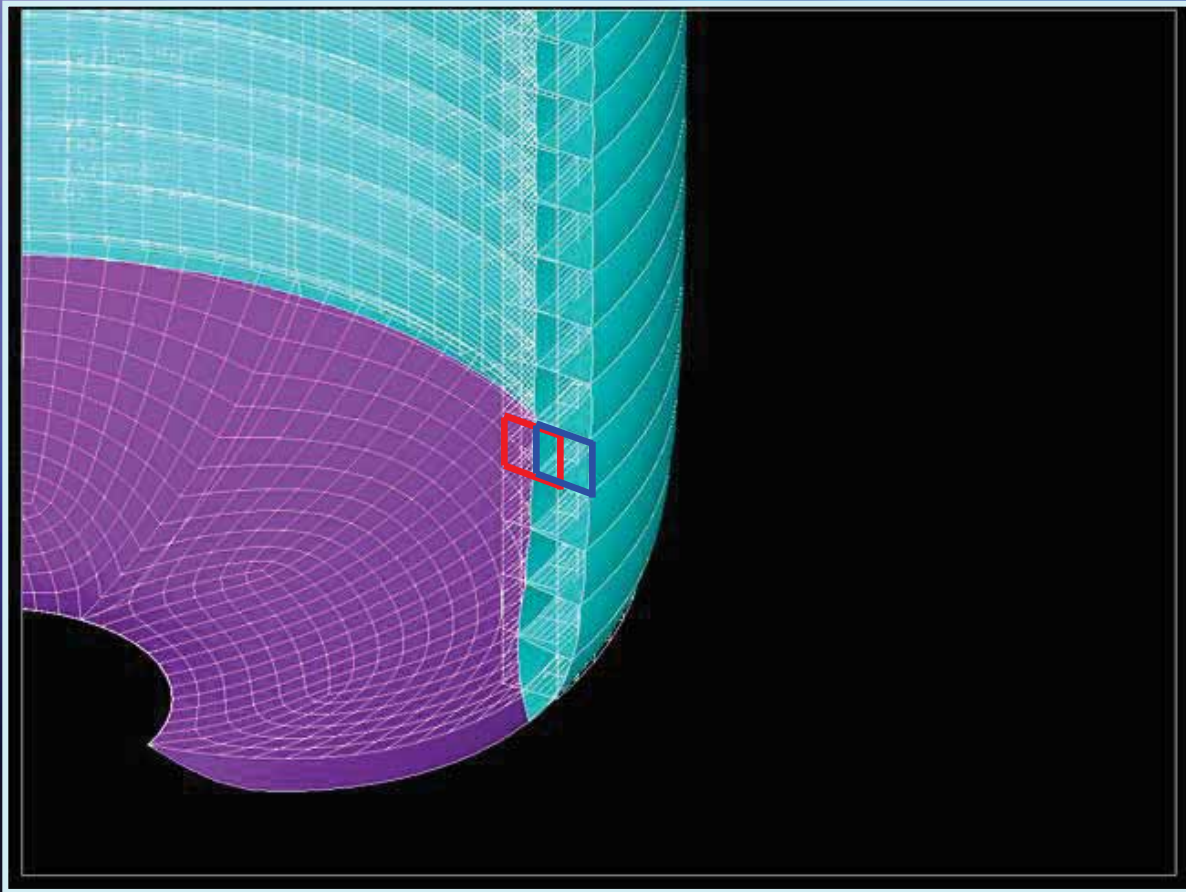
Inflated volume: 30 m<sup>3</sup>



# COBS: Structural Analysis



# COBS: Structural Analysis



Deformed vs. Undeformed shape

## Results:

Limited displacement

Stresses within  
allowable values

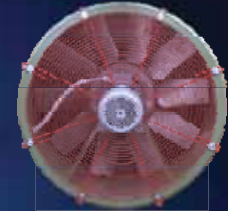
Promising concept

Demonstrator  
and testing activity to be  
performed to validate  
the concept



# COBS Module

## Air Conditioning



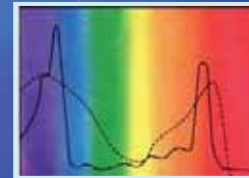
Air speed  
0,08/0,2 m/s

## LED + Lamp Lighting

**Red:** (670 nm) 550  $\mu\text{mol}/\text{m}^2\text{s}$

**Blue:** (470 nm) 70  $\mu\text{mol}/\text{m}^2$

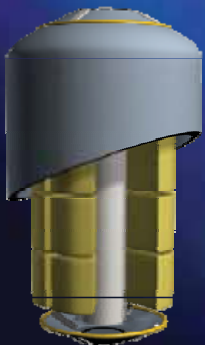
**Lamp:** Wide spectrum



## COBS Cycle

CO<sub>2</sub>, H<sub>2</sub>O,  
Nutrients,  
Energy

O<sub>2</sub>, Food,  
Purified H<sub>2</sub>O



## Cultivation environment

- ✓ Simulated Gravity
- ✓ Optimal Temperature (18°/25°)
- ✓ Humidity (75 %)
- ✓ Light Intensity (150 W/m<sup>2</sup>)
- ✓ Photoperiod (12h/16h)
- ✓ Conditioned Ventilation

**Cultivation Inflatable Rack**

# COBS: Species selection

Species selection will be done trading-off various parameters

Parameters	Cultivars						
	Spinach	Lettuce	Cauliflower	String Bean	Potato	Bean	Tomato
Cycle Duration	50-80	50-90	90-110	50-70	80-100	60-80	60-90
Photoperiod	16	>14	16	14	12	14	12
Temperature	8-20	8-20	8-20	12-23	13-25	15-23	10-25
Light intensity	350	350	350	350	350	350	350
UR (%)	65-70	60-80	65-70	70-80	65-70	70-80	55-60
pH	6-7	5.5-6.5	5.5-6.5	6-7	5.5-7	6-7	6.5-7.2
CE	1000	<1000	1000	1000	1500	1000	<2000
N:P:K	1:0.5:2	1:0.4:2.3	1:1:2	1:0.3:0.8	1:0.4:1.1	1:0.3:2.6	1:0.4:1.7

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