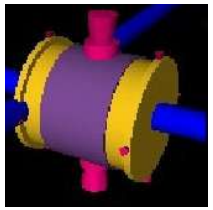
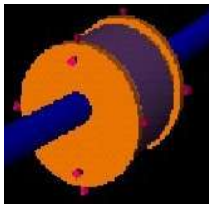
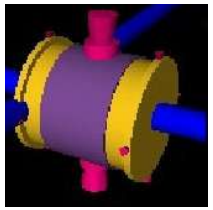
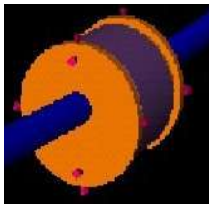
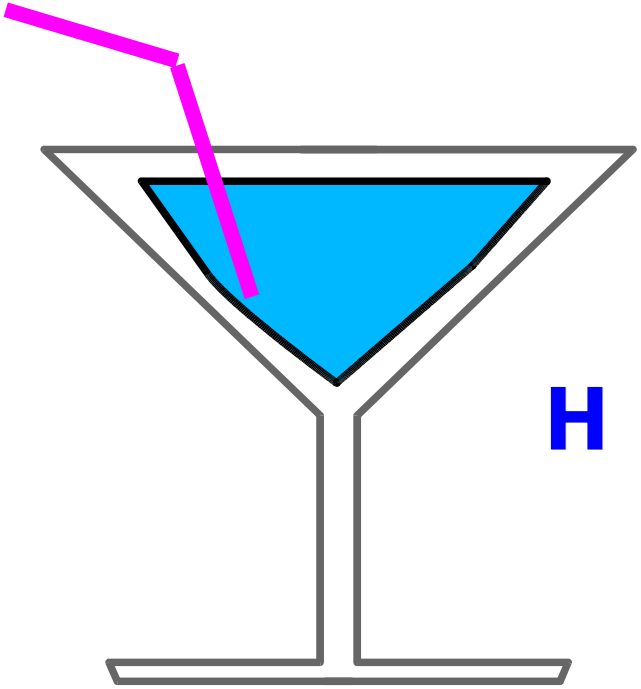


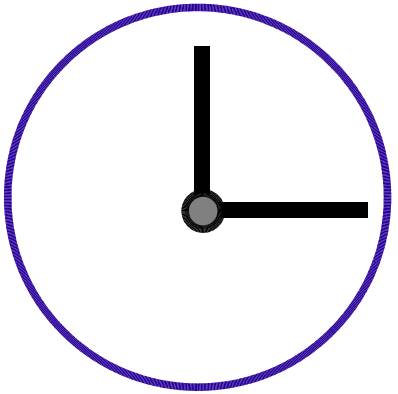




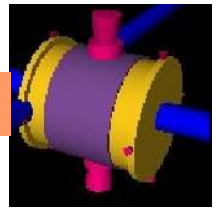


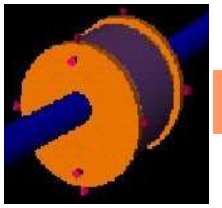


H – 15 min



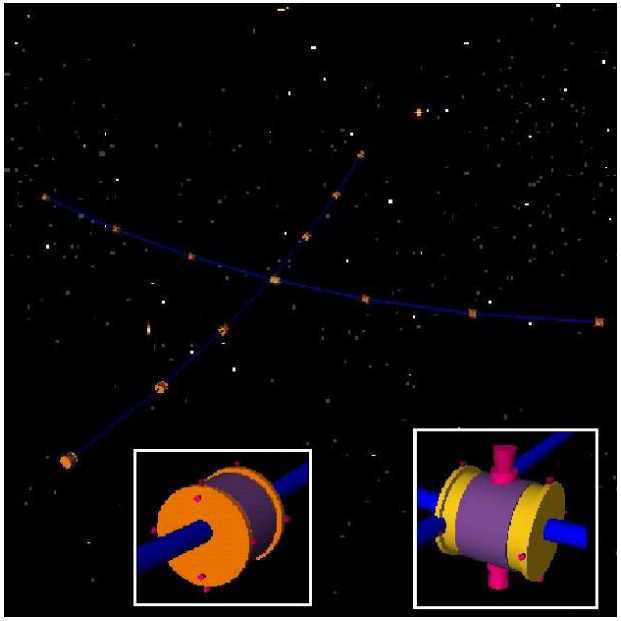
THIS PRESENTATION AIMS TO BE SHORT AND SWEET!



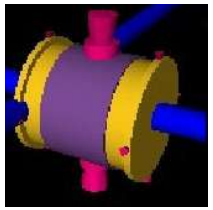


MICROCELLS for METASTRUCTURES

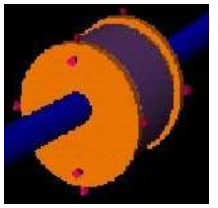
An long-term application of MNT to distributed space structures



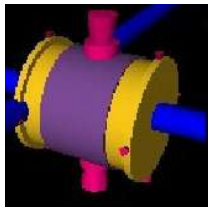
Arnaud Lecuyot (SSTL), S.E. Hobbs (Cranfield CoA), I. Honstvet (EADS Astrium)



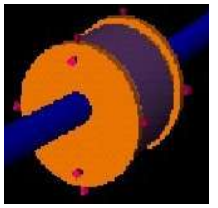
Warning & Acknowledgments



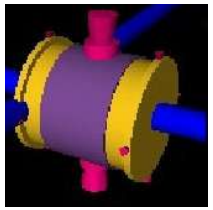
- *Acknowledgements*
  - *EADS Astrium*
  - *EPRSC*
- *Warning*
  - *Doctoral work*
  - *Long-term, exploratory*
  - *Interest in process as much as product*



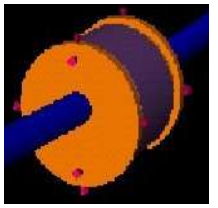
OUTLINE



- Introduction: Context & Concept rationale
- Study Logic: Research flow, Methods & Tools
- Analysis: Mission & System analysis
- Analysis: System and subsystem design
- Discussion: Metastructures in context
- Conclusion



Introduction: MNT System Eng.



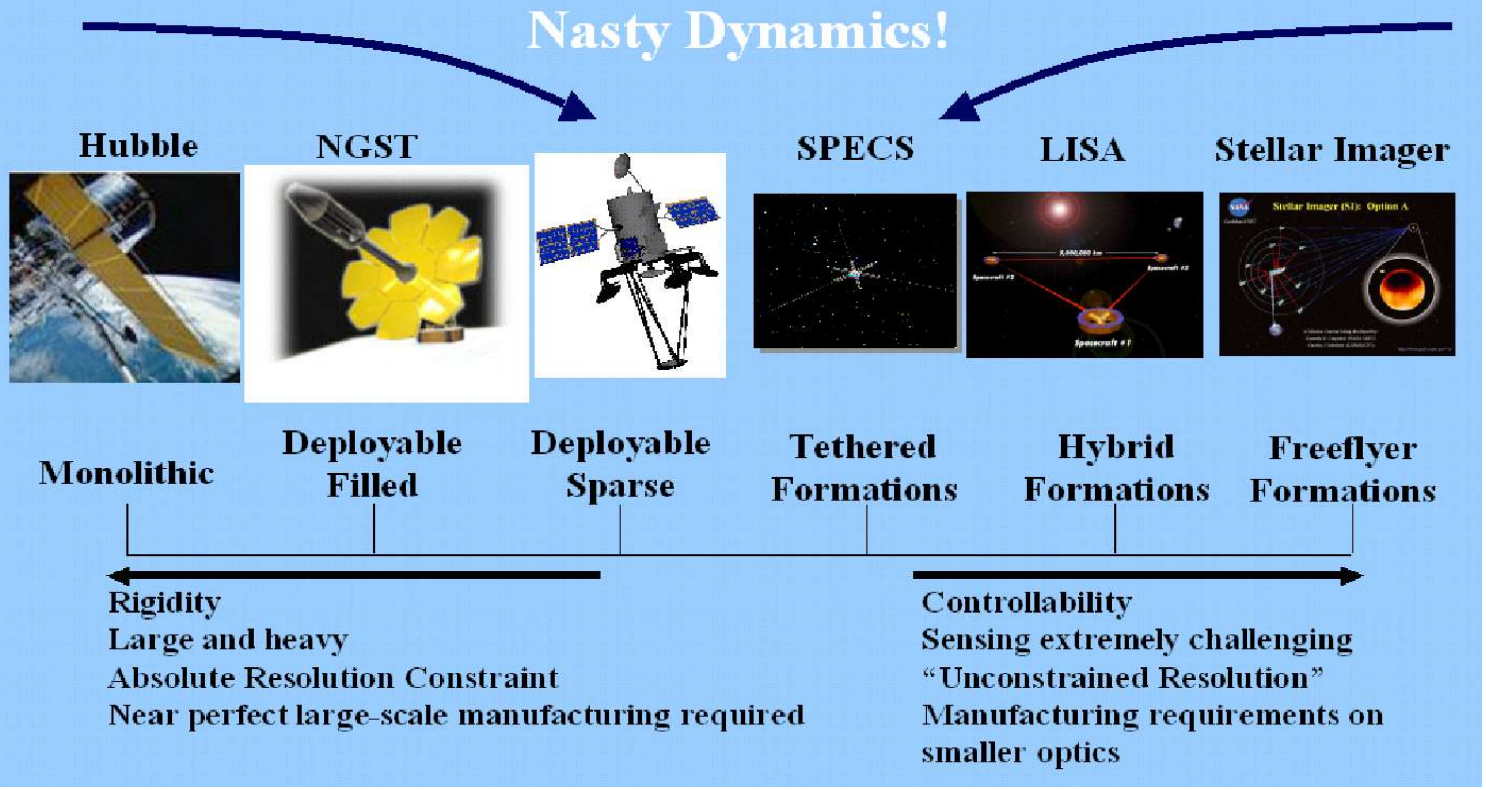
- Long-term (20 years) Systems Engineering to:
  - Fully realise the potential of MNT in space
  - Provide a long-term framework to space planners
  - Identify Technological points and requirements
- Systems Engineering Logic Applied
  - From Mission analysis to Requirement Flowdown
  - To include programmatics & “in context” analysis
  - Focus on distributed systems & structures

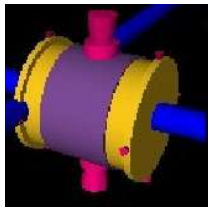
Introduction: Concept Rationale

Image source NASA GSFC

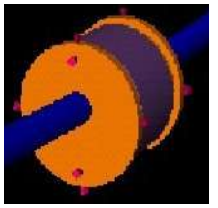
The Large Aperture Sensing Spectrum

What's best, connected or freeflying?



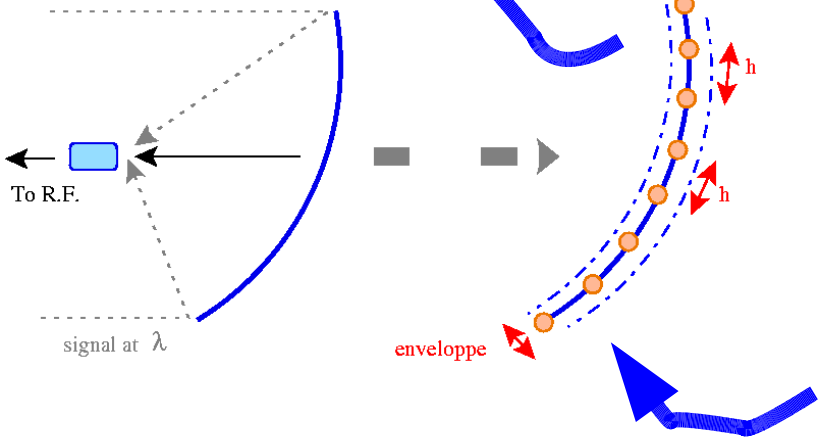


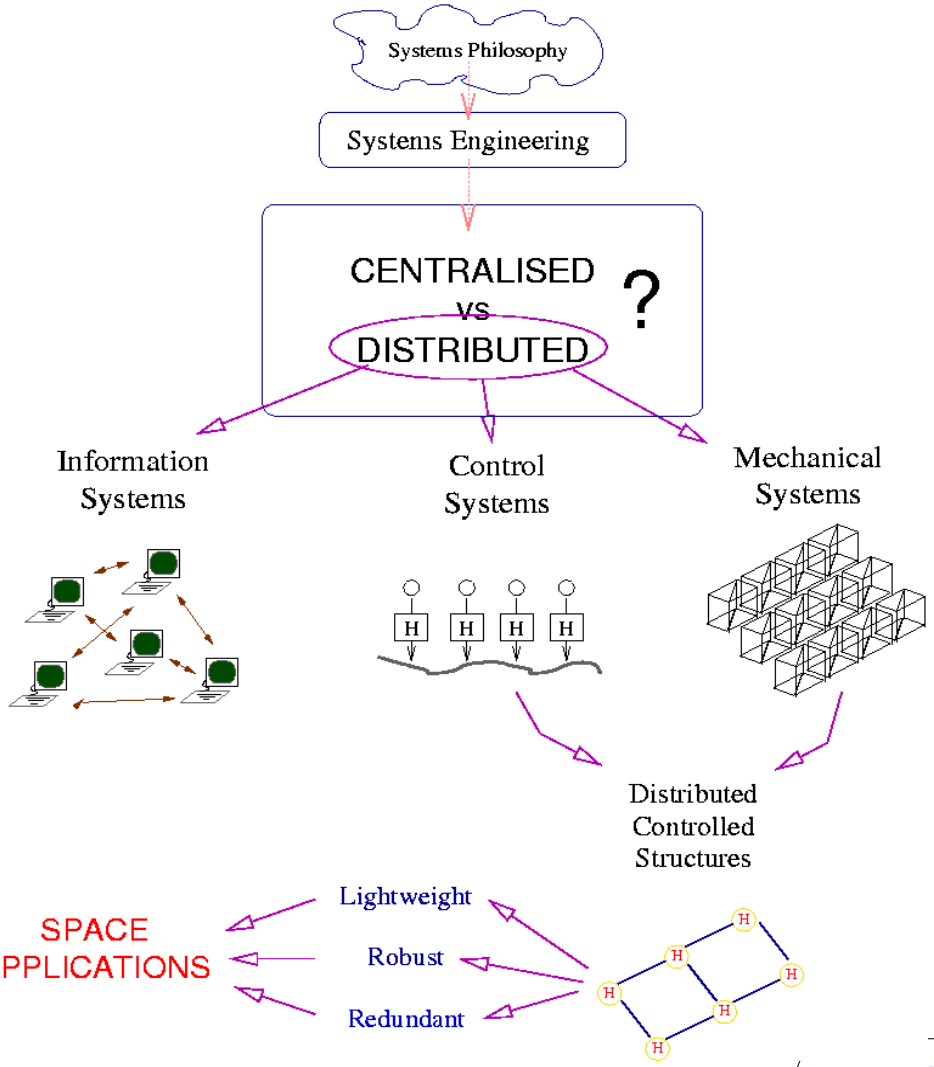
Introduction: MNT Attributes



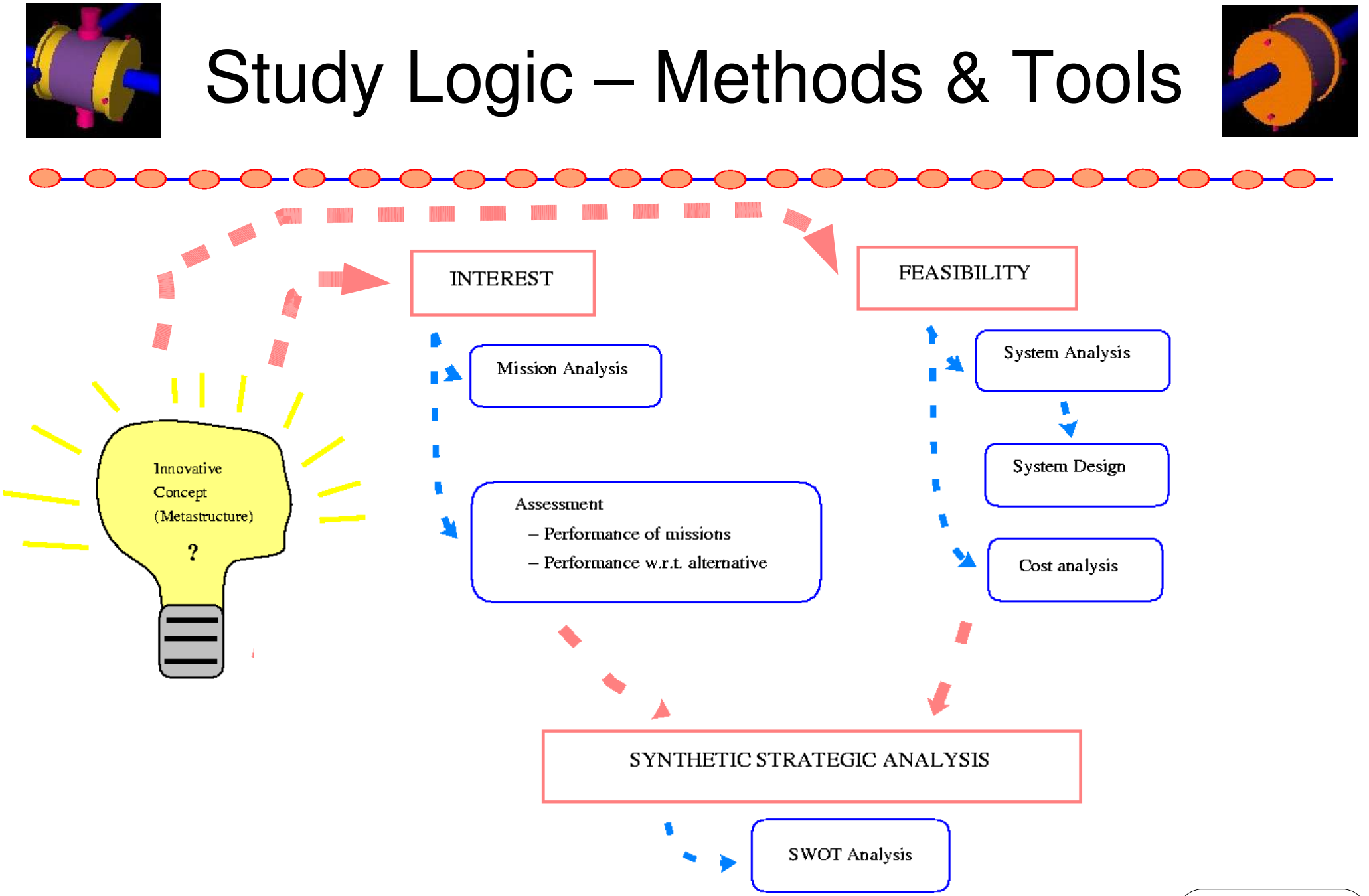
- System-level Distribution
- Subsystem-level Integration
- Multi-Domain Concurrence

Node Mass	Link Section	System Mass
0.5	8	600
1	10	1300
5	15	6500

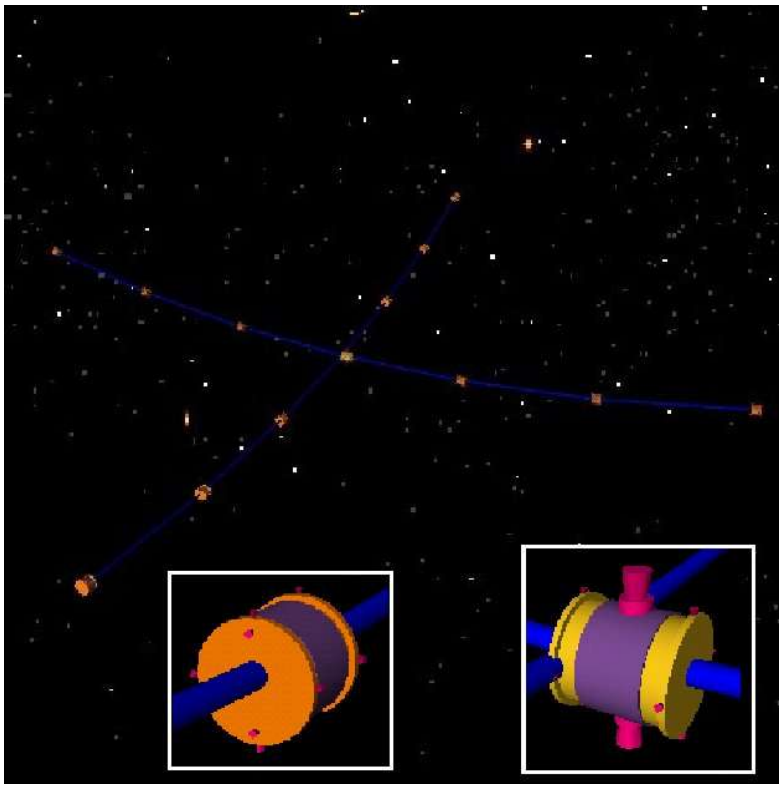


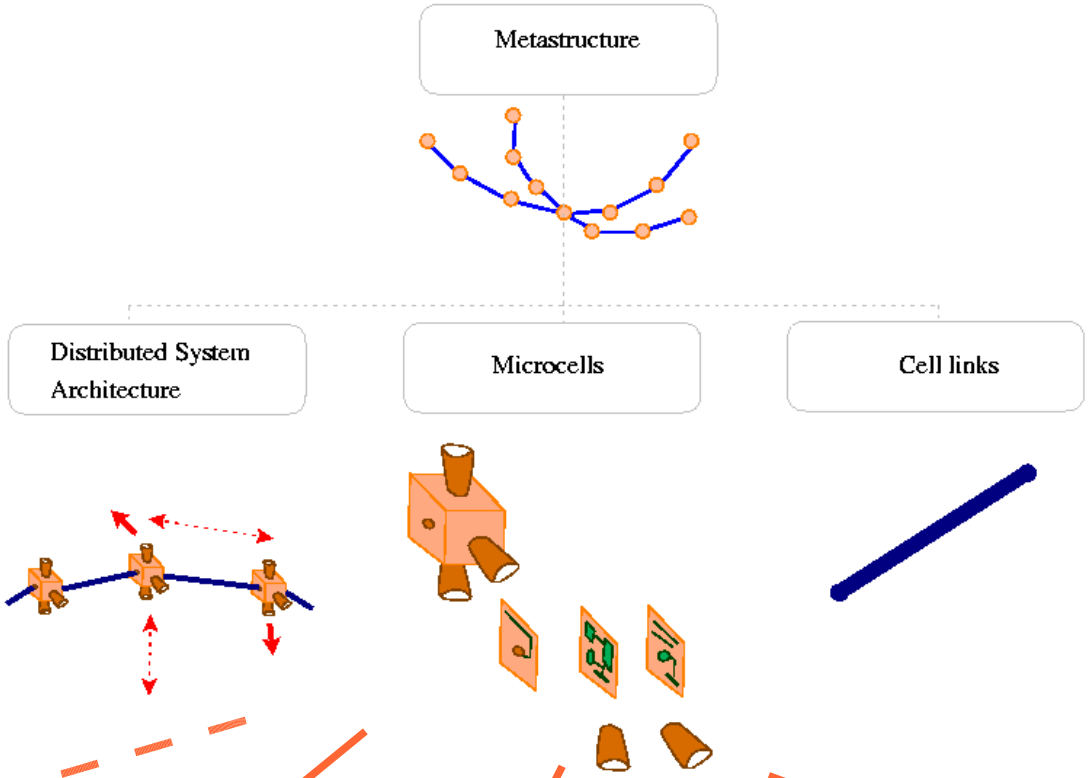


Study Logic – Methods & Tools



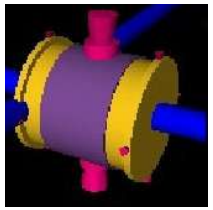
Mission & System Overview



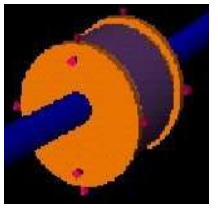


Reference Design (Test) Communications EO& Science Infrastructure

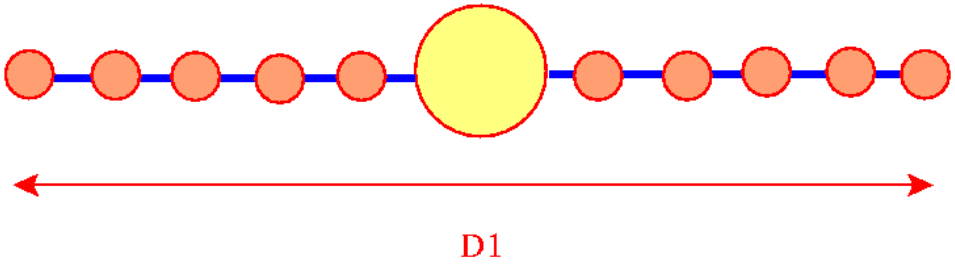
Interferometer (cm) Solar Concentrator

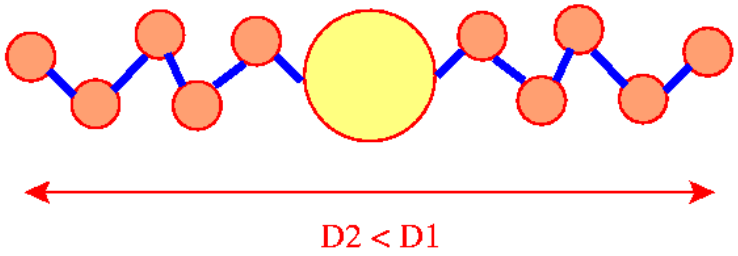


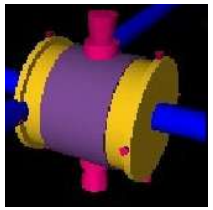
Mission – Cm Interferometer



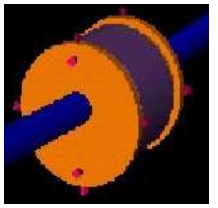
- For long λ RadioAstro
- In L1/L2 (& Earth)
- 32 x Mills-Cross array
- 5 cm accuracy
- 1 to 10 km Baseline D
- “Accordion” configuration



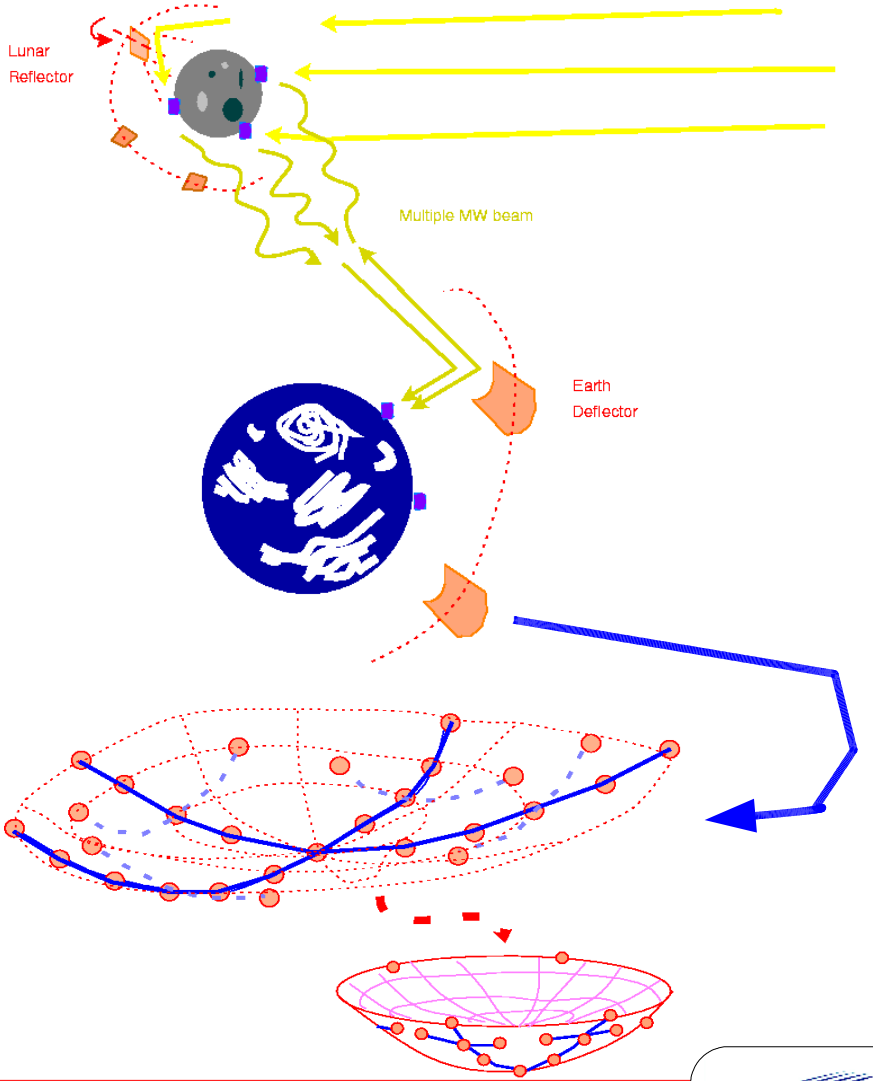


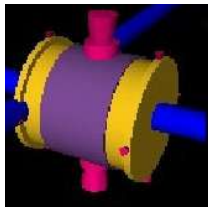


Mission – Solar Concentrator

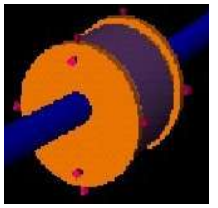


- For Earth/Moon Lunar Power System
- In ~6000 km Orbit
- 1 km x 1 km
- Parabolic Configuration
- 1 arcmin accuracy
- Lifetime 5 years

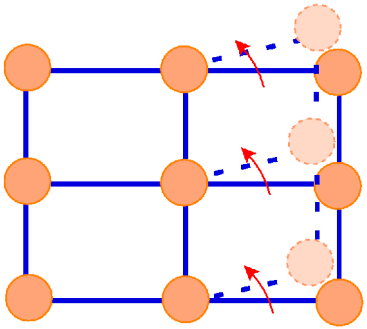




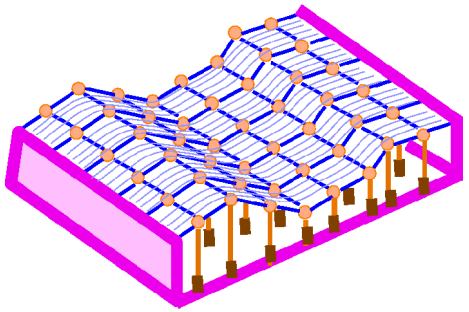
System Trade-offs



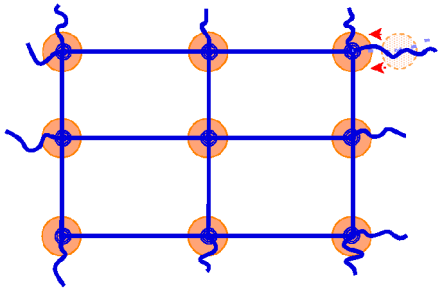
- Link Configuration



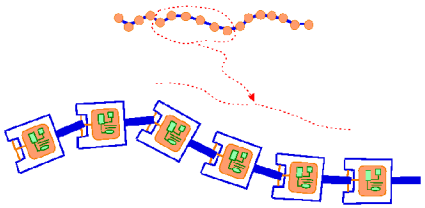
Rigid Net



“Tent”

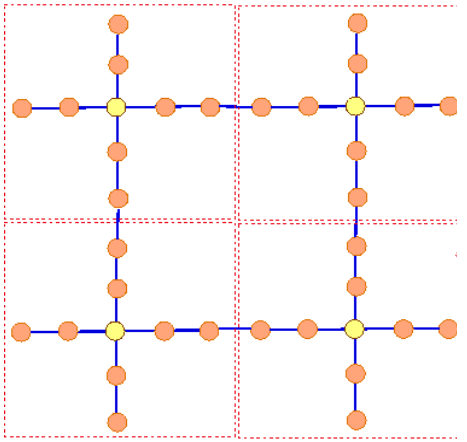


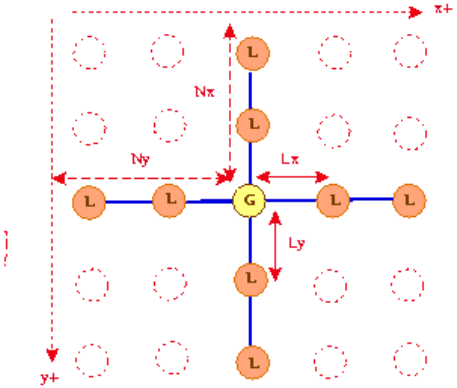
“Winch Net”

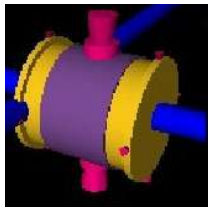


“Snake”

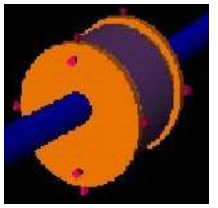
- Microcell patterns



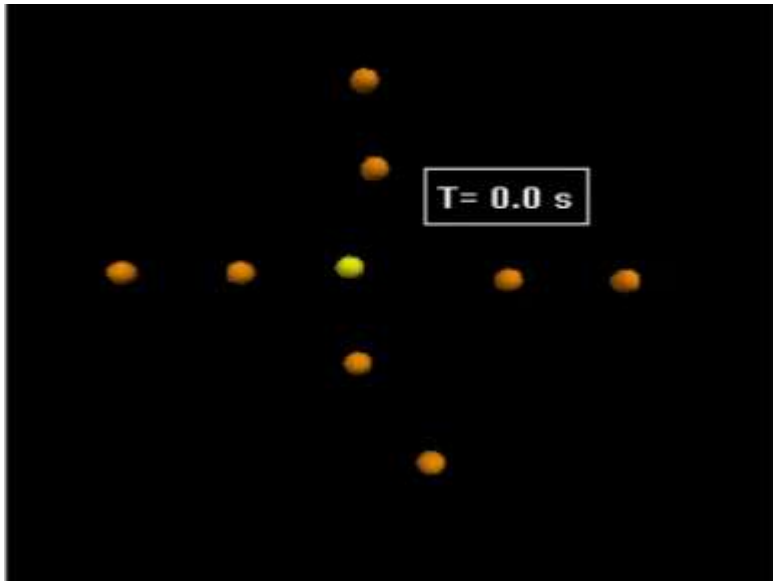




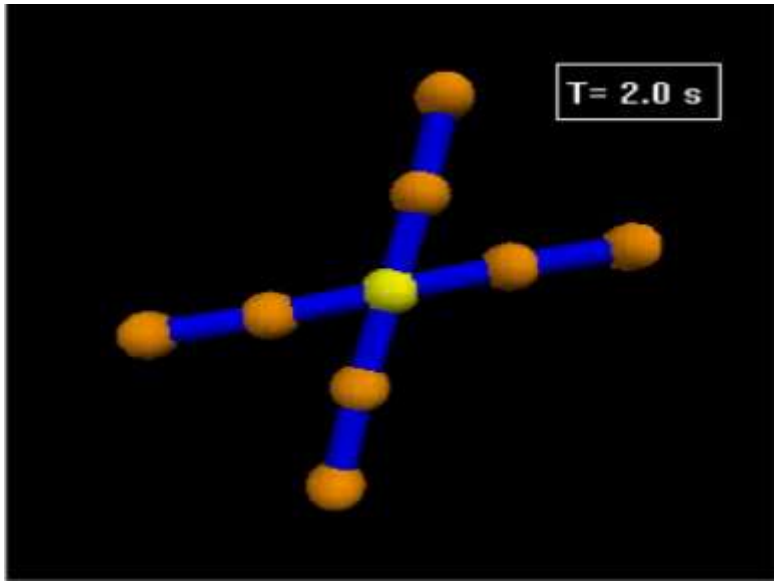
System Design - Simulations



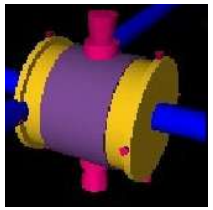
Reference metastructure



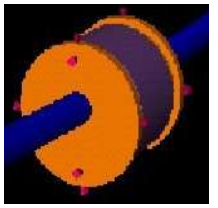
Unlinked structure (1000 km)



Basic controlled single pattern

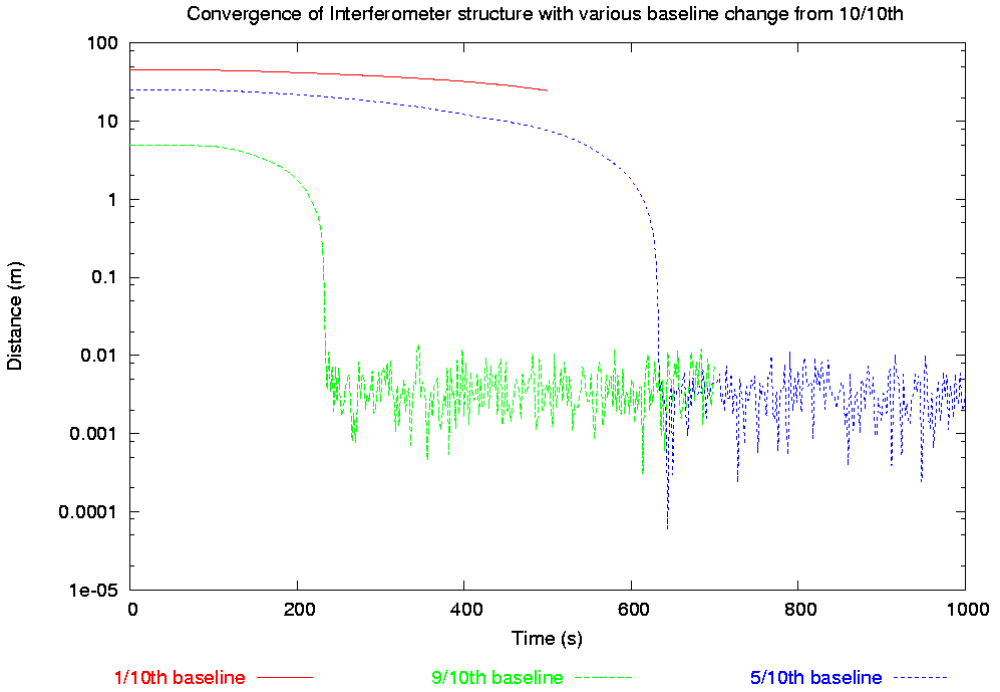


System Design - Simulations

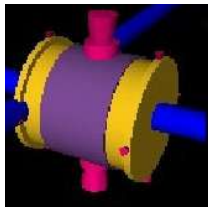


Interferometer

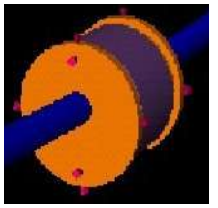
L1 Simulation



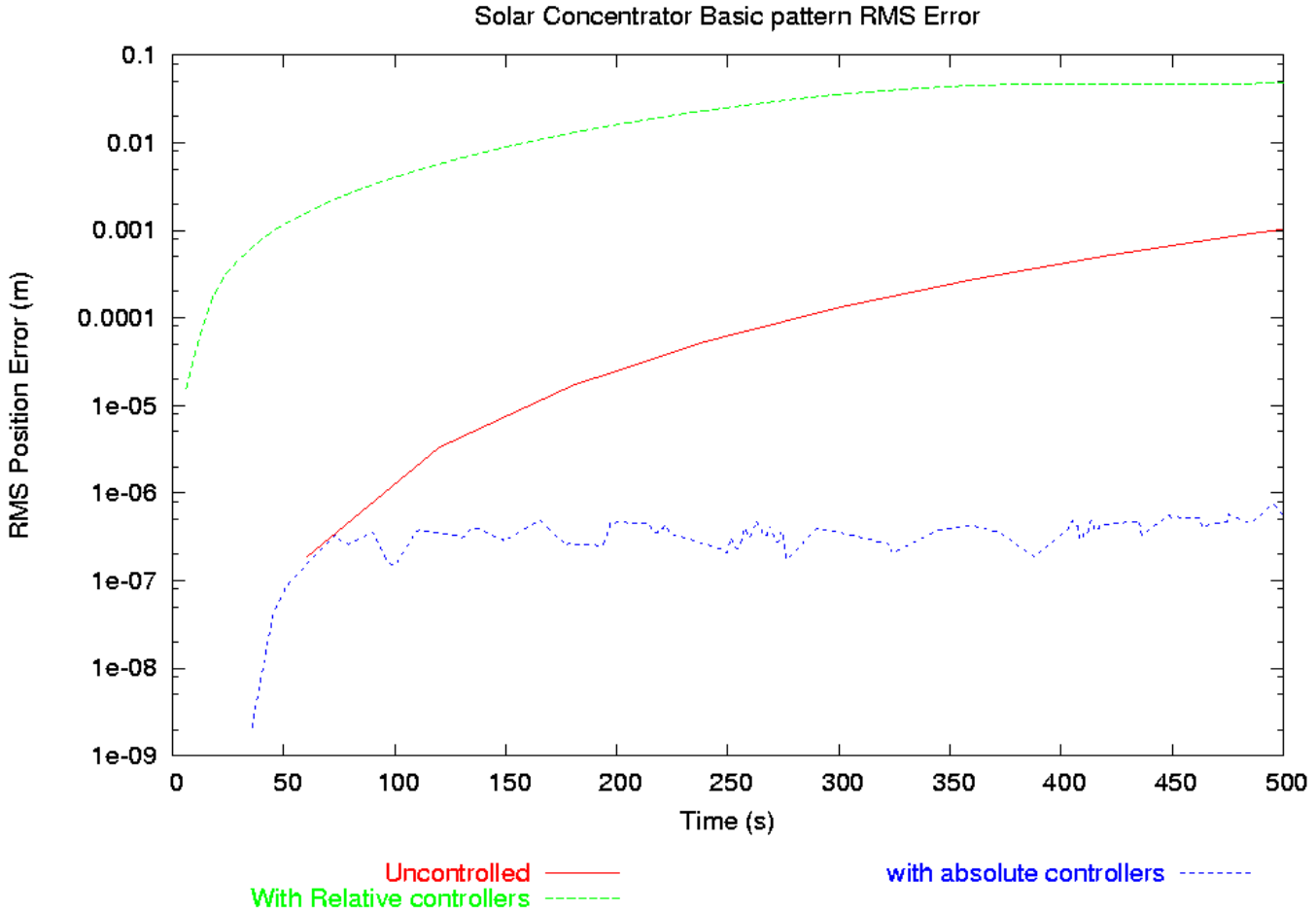
Baseline Changes

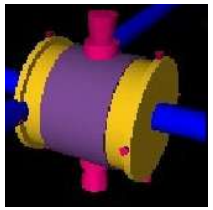


System Design - Simulations

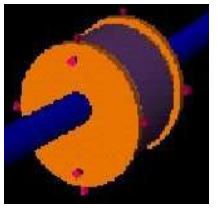


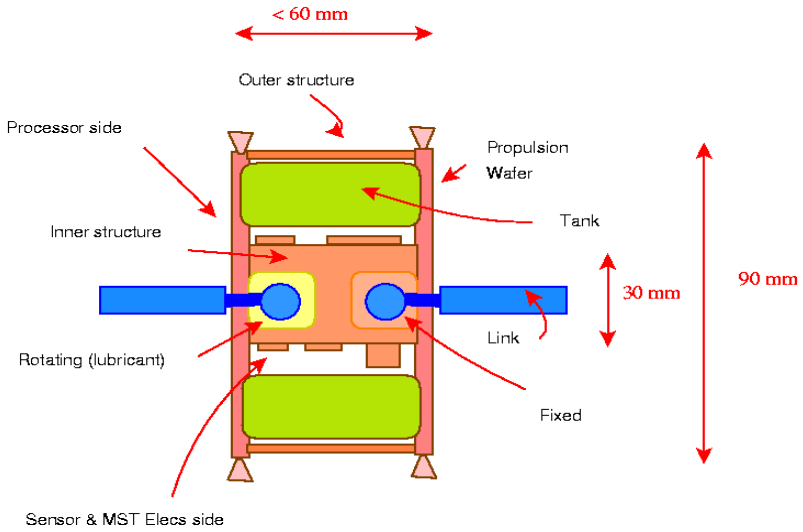
Solar Concentrator



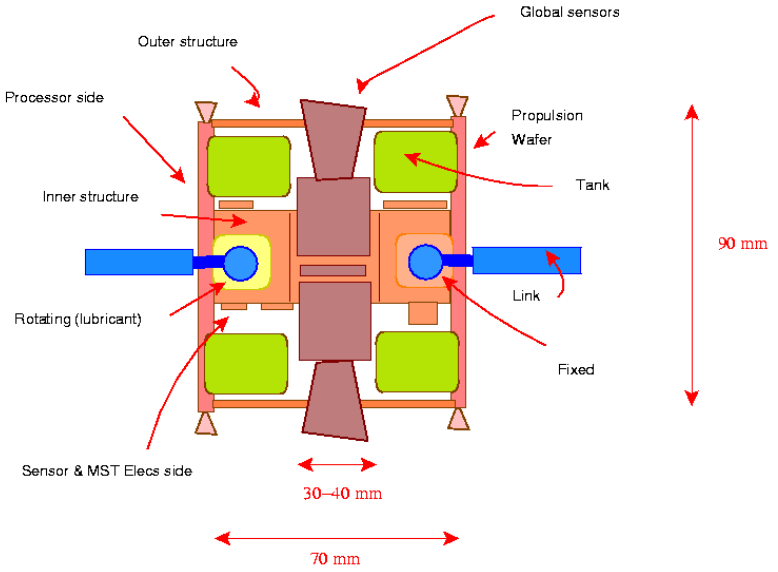


System Design – Cell layout

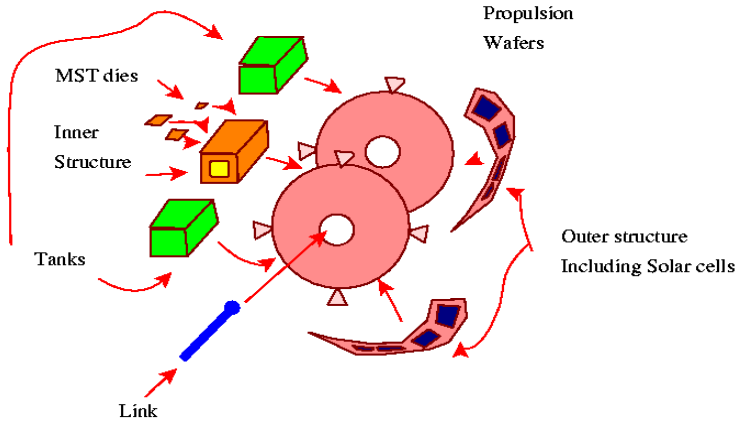


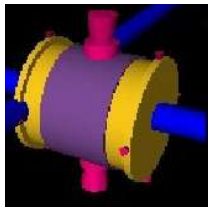


Local Cell

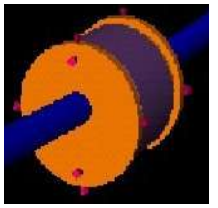


Global Cell

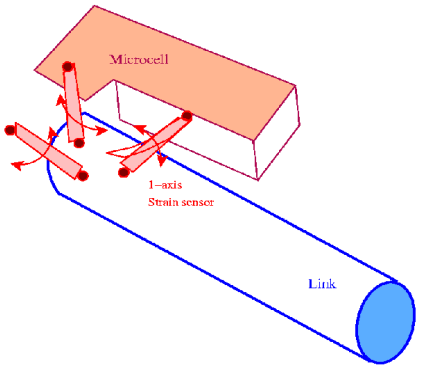




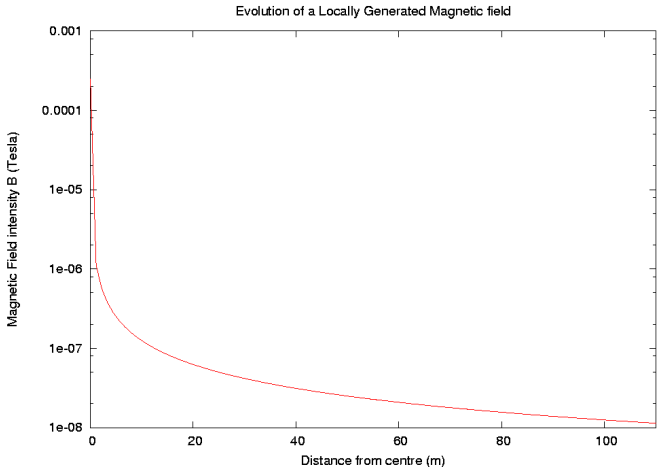
System Design – Cell systems



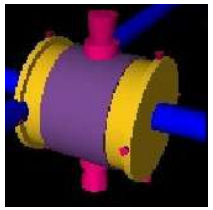
- Mass 340/380 g (L/G)
- Power 800/1100 mW
- Simple sensor Tech
- Micropropulsion (350 Ns)
- DH in Monolithic Wafers
- Similar to simpler “WaferSat”



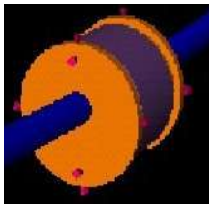
Link inclination strain sensing



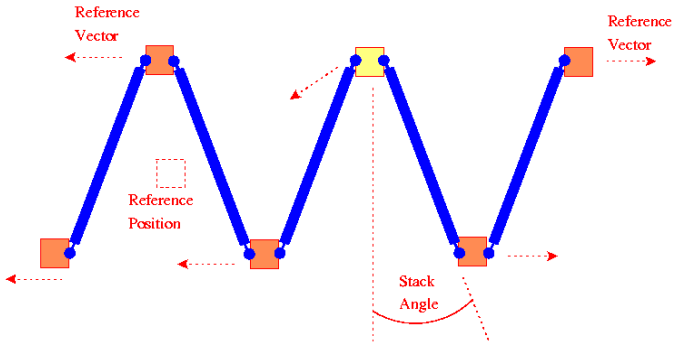
Position Local Magnetic sensing

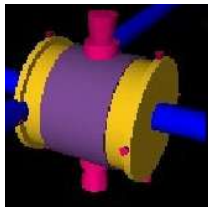


Discussion – Baseline & Issues

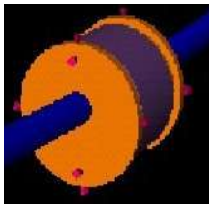


- Baseline & costing
  - Interferometer
    - L1 perf 0.02 m
    - 100 kg, 80 MEuro
    - Long links (>10 m)
  - Solar Concentrator
    - Earth perf 0.014 m
    - 2 tons, 170 MEuro
    - Short lifetime
  - NRE 340 MEuro
- Issues
  - Lifetime of cells
    - Better Controller
    - Lock-up links
  - Launch & Stowing
    - Problem TBD





Discussion - Alternatives



- Alternatives
  - Deployables
  - Inflatables/Active
  - Formation Flying

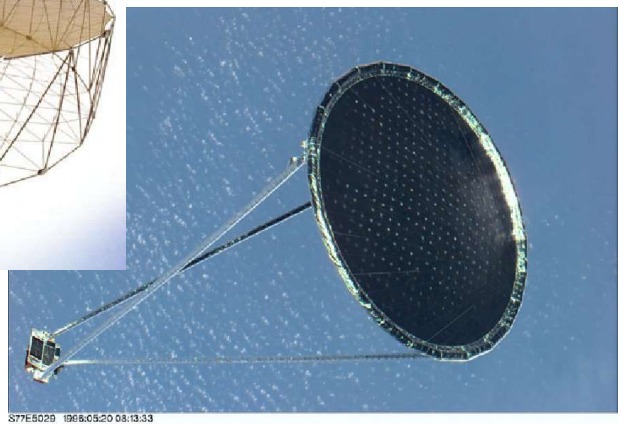
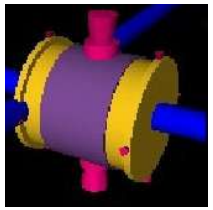
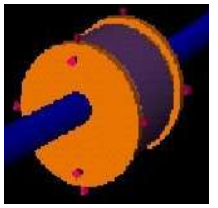


Image source AeroAstro/L'Garde

- SWOT Analysis
  - Strengths
    - Robust Arch, shape change
  - Weaknesses
    - Dynamics, Low Maturity
  - Opportunities
    - Applications, MNT use
  - Threats
    - FF perf, High NRE cost



Conclusions



- Concept on its own has potential interest
  - In special niche applications (with better control)
  - As ... eet the large structure needs
- Exercise is useful for astronautics MNT R&D
  - MNT maximum return dependant on:
    - Distributed Systems Theory & control, Smart Structures
    - Ultra-High Integration but not necessarily functionalities
  - Comparison to Alternatives is essential
  - Start with mission, applications, Requrt analysis