Nature-Inspired Assembly: Biomimetic Approaches of the MIT Media Lab Space Exploration Initiative

Nature-Inspired Exploration for Aerospace (NIEA)
October 4-6, 2017
Ohio Aerospace Institute – Cleveland, OH
The Path to Biomimicry

Curiosity & Investigation Driven

Problem Driven

Image Credit: Biomimicry.org

Image Credit: ESA
Self-assembly in Nature

Image Credit: MD Simulation of Protein Folding, NIH & University of Illinois Urbana-Champaign
Self-assembly in Nature (human-mediated)

Self-assembly in Nature (coordinated systems)

*Image Credit: Courtesy of Matthew Lutz, Princeton University, and Chris Reid, University of Sydney*
Engineered, Self-assembly Analogs

*Image Credit: Tibbits Self-Assembly Lab & Architecture Practice, MIT*
Nature’s Geodesic Dome ("buckminsterfullerene")

$C_{60}$

Image Credit: Mstroek, CC

Image Credit: Montreal Biosphere
TESSERAE

(Tessellated Electromagnetic Space Structures for the Exploration of Reconfigurable, Adaptive Environments)
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Multiple TESSERAE form MOSAICs, or Mars-Orbiting Self-Assembling Interlocking Chambers
Path to Assembly Prototype

Magnet joint design
- Must fully constrain the bonding for proper geometry
- Minimally, define two unique joints

Modeling
- Fix the dihedral angle for proper geometric configuration
- Recessed holes for magnets, flush mating edges

Fabrication
- 3D printing & rapid prototyping approach
- 3mm Neodymium magnets
- Steps toward natively embedded sensor network
Native Sensor Embedding – rapid prototyping

Proof of Concept Circuit Design
- Completed in a matter of days
- Includes:
  - micro solar panels
  - Energy harvesting chip
  - Li-ion battery
  - BLE emitter
  - Gyro
  - Accelerometer
  - Magnetometer
  - Temperature sensor
  - Timing crystal

Sensor network should be built natively into the material
- Embedding PCBs into the tiles
- Flexible circuitry
- 3D traces & 3D circuits
Initial Mechanical & Dynamics Modeling Validations
Research & Deployment Goals

To advance the future of space architecture

To augment space architecture with natively embedded sensor networks

To support new waves of humans experiencing zero gravity

To support Mars & Deep Space mission concepts for NASA
Space Exploration Initiative | Mission

• *Democratize access to space exploration technology*

• *Build space technologies that revolutionize the future of exploration while also profoundly benefiting life on Earth.*

• *Unite engineers, scientists, artists and designers, to push forward on active prototyping of our sci-fi future at scale.*
Space Initiative Research

Space Telecommunications  
Robotics, Nets and Tethers  
Space BioEngineering  
Space Materials  
Self-Assembly  
Structures  
Exosuits  
Climate  
VR/AR
Space Initiative Research (nature-inspired)

Space Telecommunications
Robotics, Nets and Tethers
Space BioEngineering
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Space Exploration Initiative | Our Team & Advisors

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Thank you!

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- Space Exploration Initiative members
  - Dr. Joe Paradiso
  - Dr. Neri Oxman