Idaho Robotic Lunar Exploration Program (RLEP)

Sponsors:

- NASA Ames Research Center
- NASA Idaho Space Grant Consortium
- University of Idaho College of Engineering

Graduate Fellow:

Aaron Goodin

Outline

- RLEP Introduction and Description
- RLEP for the undergraduate program
  - Non-Prehensile Manipulator → L07
  - Undergraduate Experiences
- RLEP for the Graduate program
  - Summer Internship at Ames Research Center 2007
  - Graduate Mentor and Project Design → M08
  - Moses Lake NASA Field Test
  - Instrument Recommendation for IRG
- My Own Thesis work : Bio-Tensegrity Applications
  - Tensegrity Description
  - Tensegrity Background
  - RLEP Applications
  - NASA Applications

Idaho RLEP Background

- Idaho RLEP began in 2006
- Robotic Projects would be designed and fabricated at accredited Universities in Idaho
- Projects are prioritized by the Intelligent Robotics Group at NASA Ames Research Center.
- All designs will be returned the following summer for testing at Ames.

Idaho RLEP Description

- RLEP fellows consist of graduate students from related fields including: Mechanical, Electrical, Computer, & Aerospace Engineering.
- RLEP fellows are required to attend two summer internships at Ames Research Center.
- RLEP fellows are required to pursue a thesis driven master's degree with research relating to RLEP.
- RLEP fellows should specify projects for the following year and also act as graduate mentors.

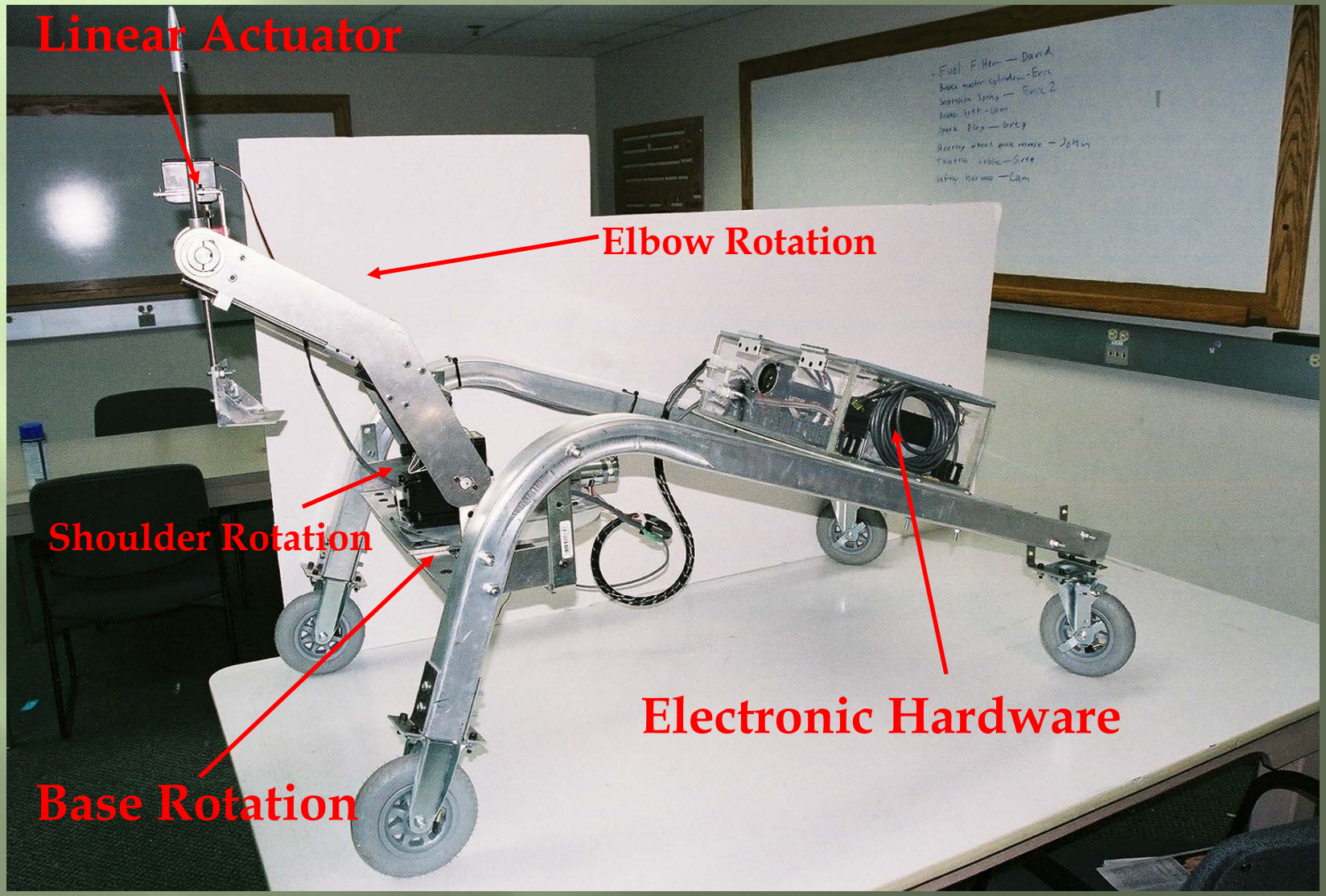
RLEP for Undergraduates

- Joined the RLEP team as a ME undergrad in the Capstone Design Program at the University of Idaho.
- Tasked with a project to create a non-prehensile robotic manipulator to accomplish multiple tasks outlined by the Intelligent Robotics Group at NASA ARC
- Initial goal was to adapt to IRG's K10 rover

Non-Prehensile Tasks

- **Soil Sample Collection**
- Trenching
- **Dislodging K-10 Rover**
- Cable Laying
- **Rock Chipping**
- **Soil Compaction**
- Path Clearing
- Soil Relocating
- **Rock Flipping**
- Rock Pushing
- Soil Sifting
- Tilling
- Stake Planting

1st Year Deliverable: L07



Opportunities for Undergraduate Students

- Able to work on multi-disciplinary projects (ME, EE, CompE, CS)
- Integrating multiple designs into one final package that has to work
- Robotics = Motors
  - In-depth motor research
  - Motor Control
  - Micro processing & Programming
- Applying CAD for a real purpose
- Spending time in the machine shop learning important manufacturing principles
- Working with a team!!! not always easy

RLEP for Graduate Students

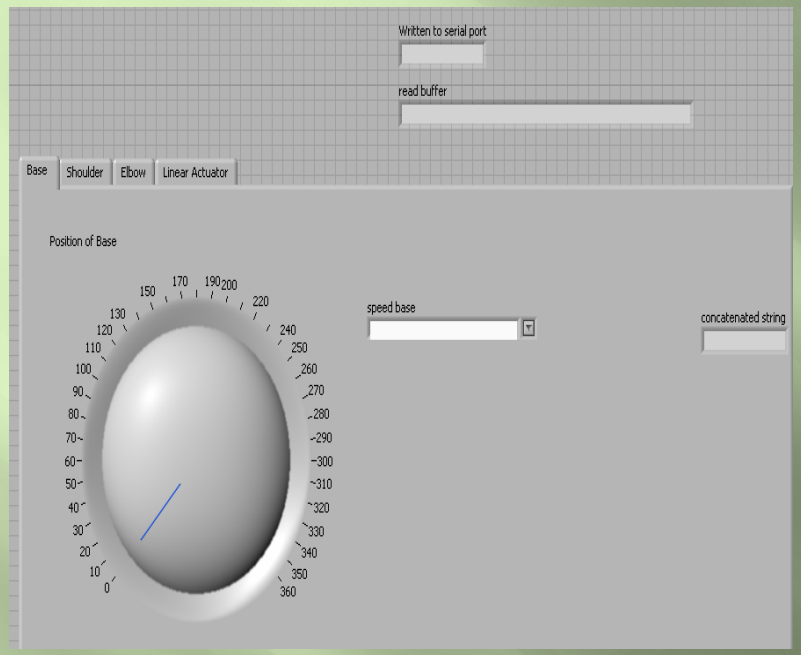
- Applied for ISGC fellowship and became the next RLEP fellow.
- Traveled to NASA ARC for the first summer internship.
- Mentored in the design and fabrication of the second RLEP robotic platform.

Summer Internship

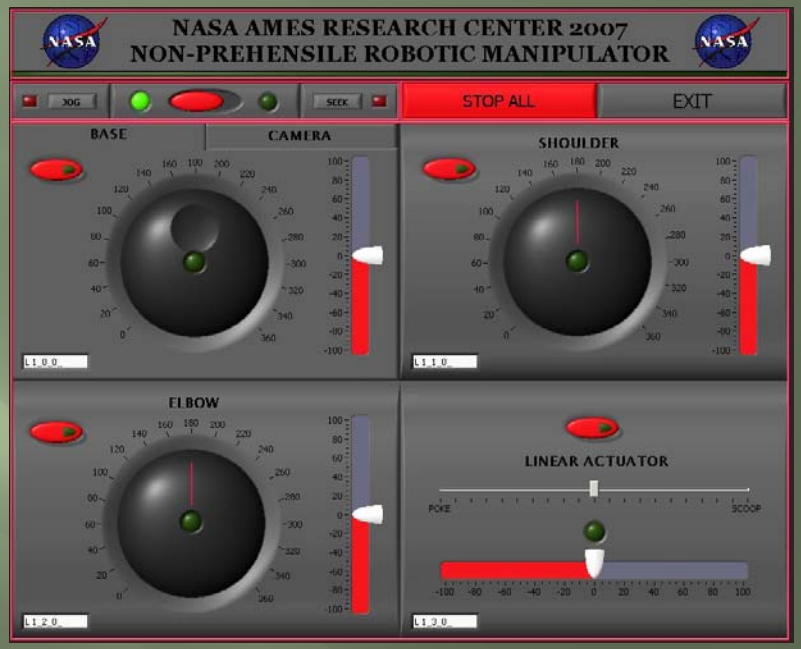
- Gained project management experience by co-managing a team of Robotics Academy Students to improve L07
- Mentored students to help them in the design process
- Worked to specify the next RLEP project

New Interface

Old Interface



New and Improved Interface

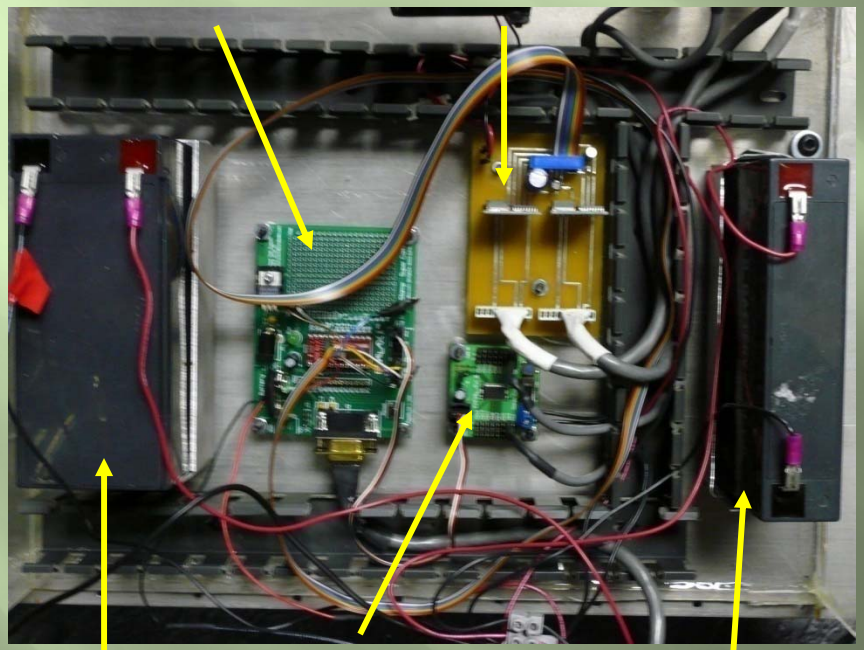


Improvement Areas:

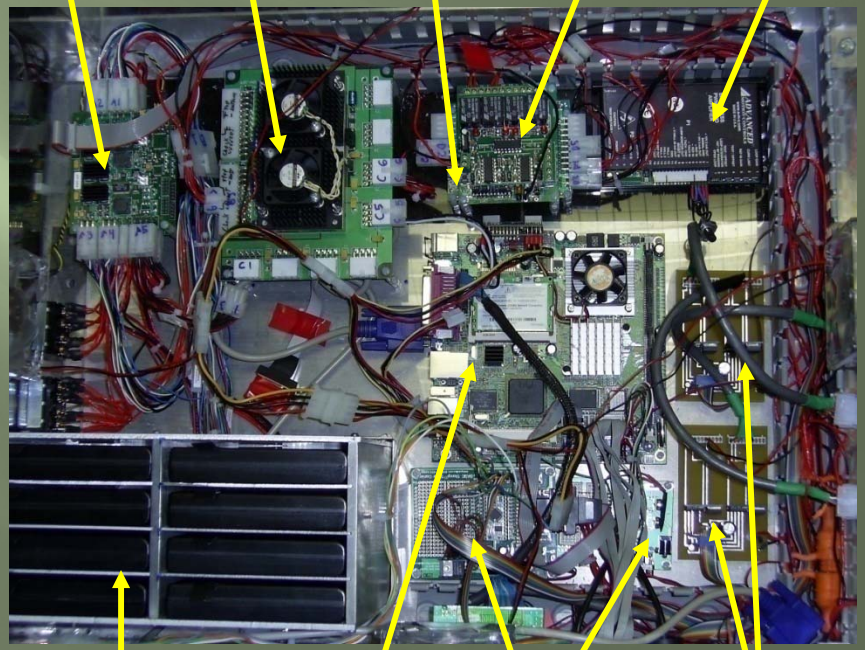
- **Easier navigation between joint control**
- **More control options**
- **Incorporate real time video**
- **Programmed Stop command**

Avionics Box Improvements

Old Avionics

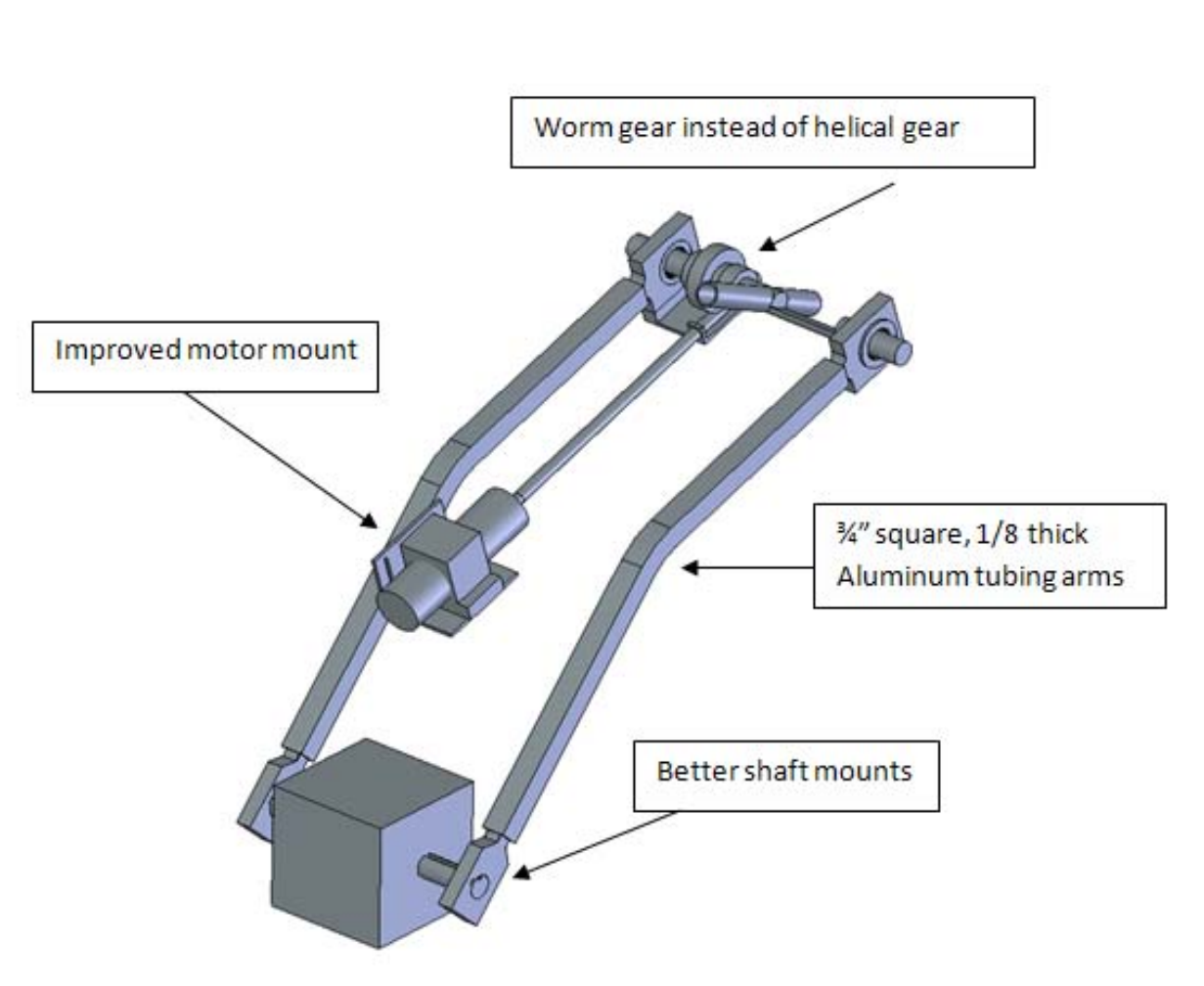


New Avionics



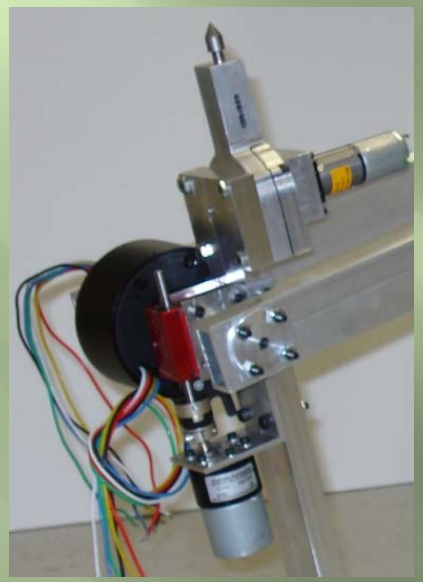
Wiring done by Jennifer Allen

All Around Improved Robot

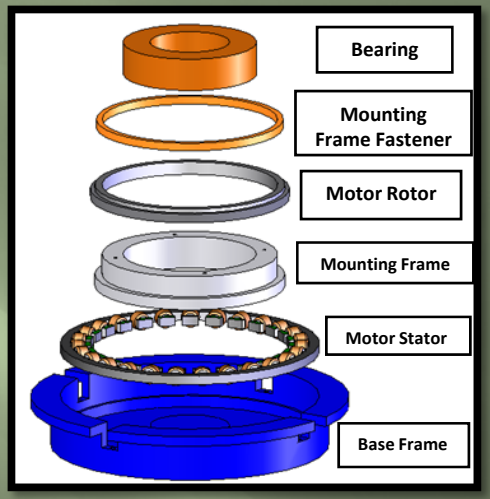


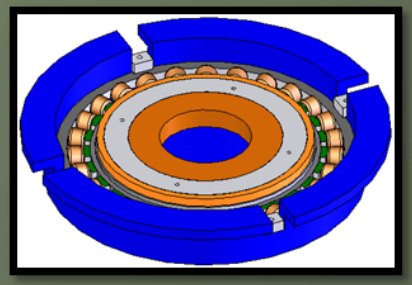
CNC Machining and Electrical Advancement

Cam/Follower poker design used for percussive pecking

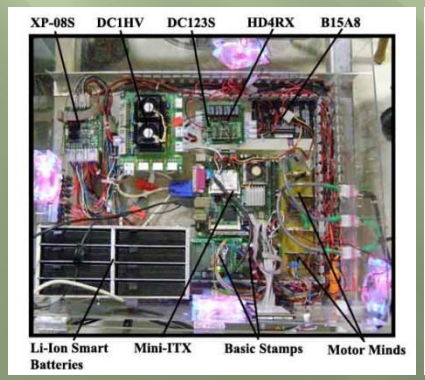


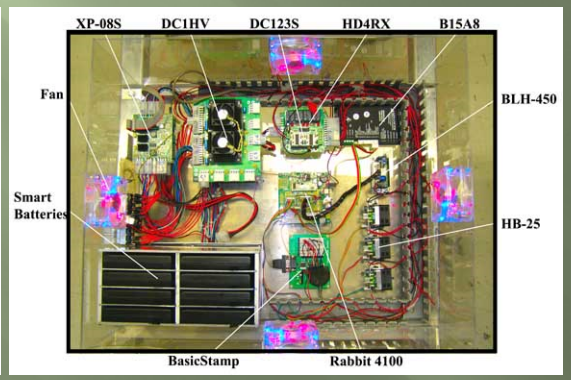
Base Design for 3-phase direct drive motor

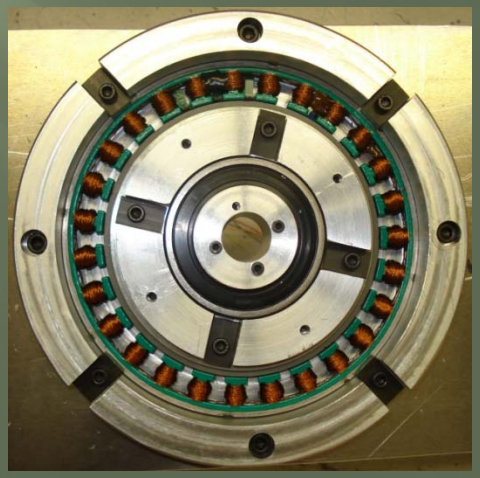




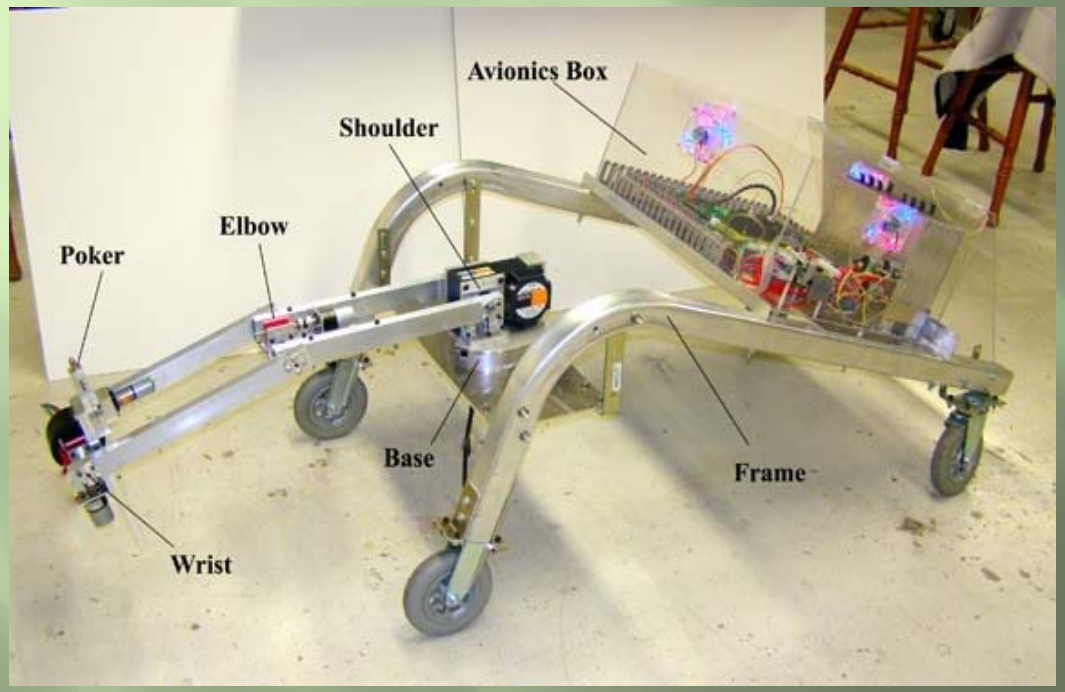
Greatly Improved Avionics Box







2nd Year Deliverable: M08



Opportunities for Graduate Students

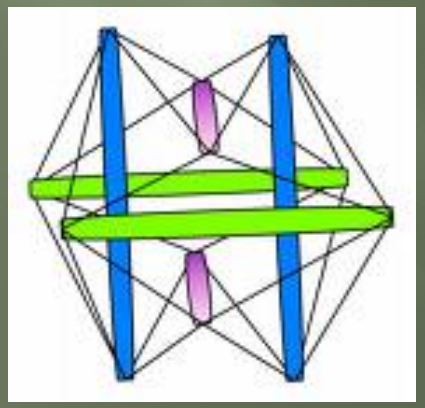
- Project management experience
  - Learning to delegate
  - Learning to manage: i.e. problematic team members
- Advanced machining capabilities
- Presentations, Publishing's, Networking, and more
  - Leveraging
  - Experiences
- Great research opportunities
  - NASA related research → Lunar Science Institute
  - RLEP related research → Robots going to The Moon
  - My Thesis work → NASA + RLEP = MSME
    - Bio-Tensegrity

Tensegrity: What is it???

•a continuous TENSION network structured by discontinuous COMPRESSION members.

•Tension members must be pre-stressed and will never go into compression.

•No Bending or Shear stresses!!!



The History of Tensegrity

R. BUCKMINSTER FULLER

- Architect and Inventor
- Coined the term Tensegrity by joining the terms: “Tension” & “Structural Integrity”

Fuller Dome:
Geodesic Dome

KENNETH SNELSON

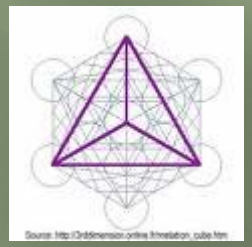
- Artist
- Known as the “Father of Tensegrity”

Snelson’s Tower:
Needle Tower

Regular Polyhedrons & Tensegrity Examples

- Five shapes are said to enable the construction of tensegrity structures

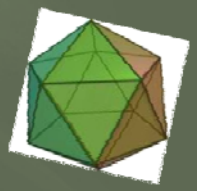
- All of these shapes are based off of the equilateral triangle



Tetrahedron

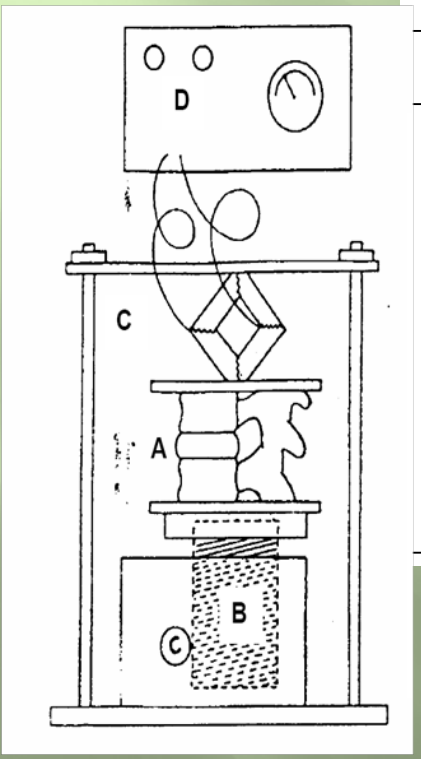
Octahedron

Dodecahedron



Icosahedron

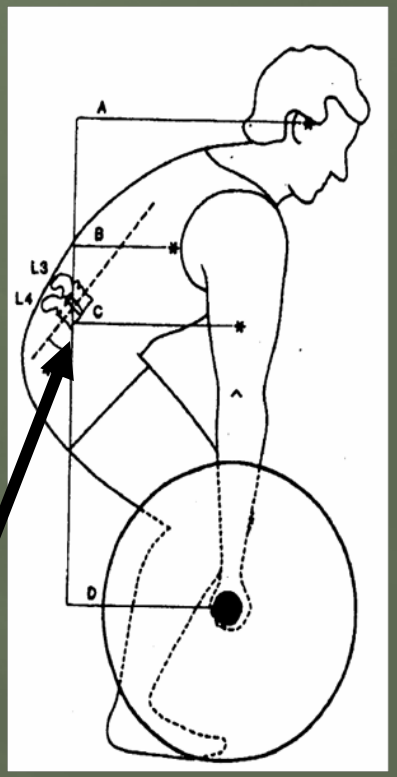
Math Model for the Human Body



Calculation of Vertebral Strengths

Vertebrae	Percentage of Body Weight Carried	Mass in kg Carried by 72.7 kg Man	Breaking Strength (N)	Breaking Stress in g's+	Percentage of L4 Breaking Strength
T1	9	6.5	1,605	25.0	16.6
T2	12	8.7	2,140	25.0	22.1
T3	15	10.9	2,675	25.0	27.7
T4	18	13.1	3,211	25.0	33.2
T5	21*	15.2	3,746	25.0	38.7
T6	25*	18.1	4,459	25.0	46.1
T7	29*	21.0	5,173	25.0	53.5
T8	33*	23.9	5,864*	24.9	60.7
T9	37*	26.9	6,657*	25.2	68.9
T10	40*	29.1	7,277*	25.5	75.3
T11	44*	32.0	7,580*	24.2	78.4
T12	47*	34.2	7,835*	23.4	81.0
L1	50*	36.4	7,982*	22.4	82.6
L2	53*	38.5	8,584*	22.7	88.8
L3	56*	40.7	9,636*	24.1	99.6
L4	58*	42.2	9,667*	23.4	**100.0**
L5	60*	43.6	10,550*	24.6	109.1

Max: 9,600 N



Calculated: 36,000N

The Human Body & Biotensegrity

Fascia –

•The soft connective tissue in the body comprised of tendons, ligaments, and cartilage

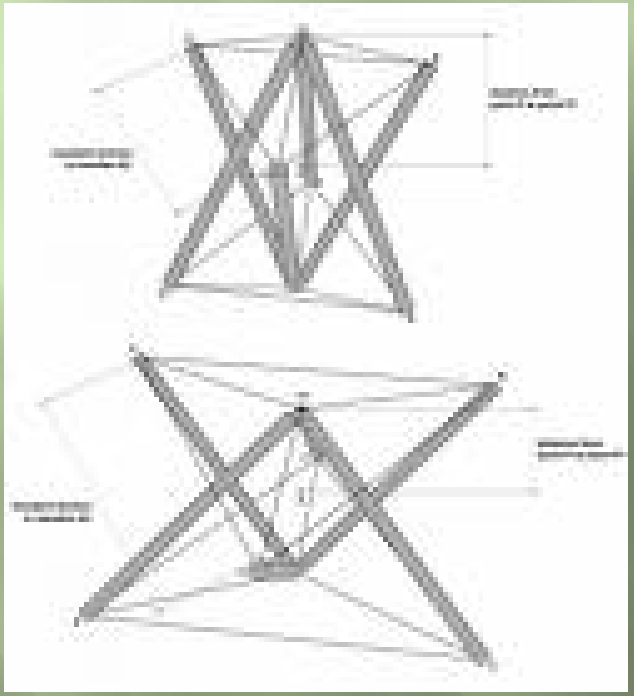
•Uninterrupted, three-dimensional web of tissue that extends from head to toe.

Tom Flemmons –

•Began designing and building bio-tensegrity structures in the 1970's

Robotic Applications

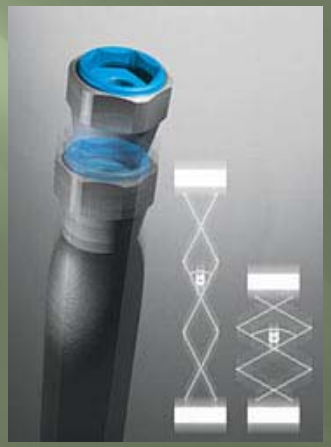
- ANDREW O. PAYNE FROM LIFT ARCHITECTS

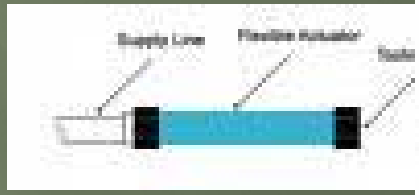


VIDEO

FLUIDIC ACTUATORS

Airics Arm





My Thesis Ideas

DEPLOYABLE TENSEGRITIES

- Tensegrity Structures excel at taking unknown force vectors and distributing the stress efficiently
- Could be used to package instruments being deployed that will take loads from any direction of unknown magnitude.

STRESS ANALYSIS FOR SIMPLE TENSEGRITY STRUCTURES.

- Use rods with given area, length, and material properties
- Apply loads with a known direction and magnitude
- Using strain gauges to measure stress at multiple points on rods

Questions???