Active Reflector Surface Shaping

Harris Sponsor:
Gustavo Toledo

Faculty Advisor:
Dr. William Oates

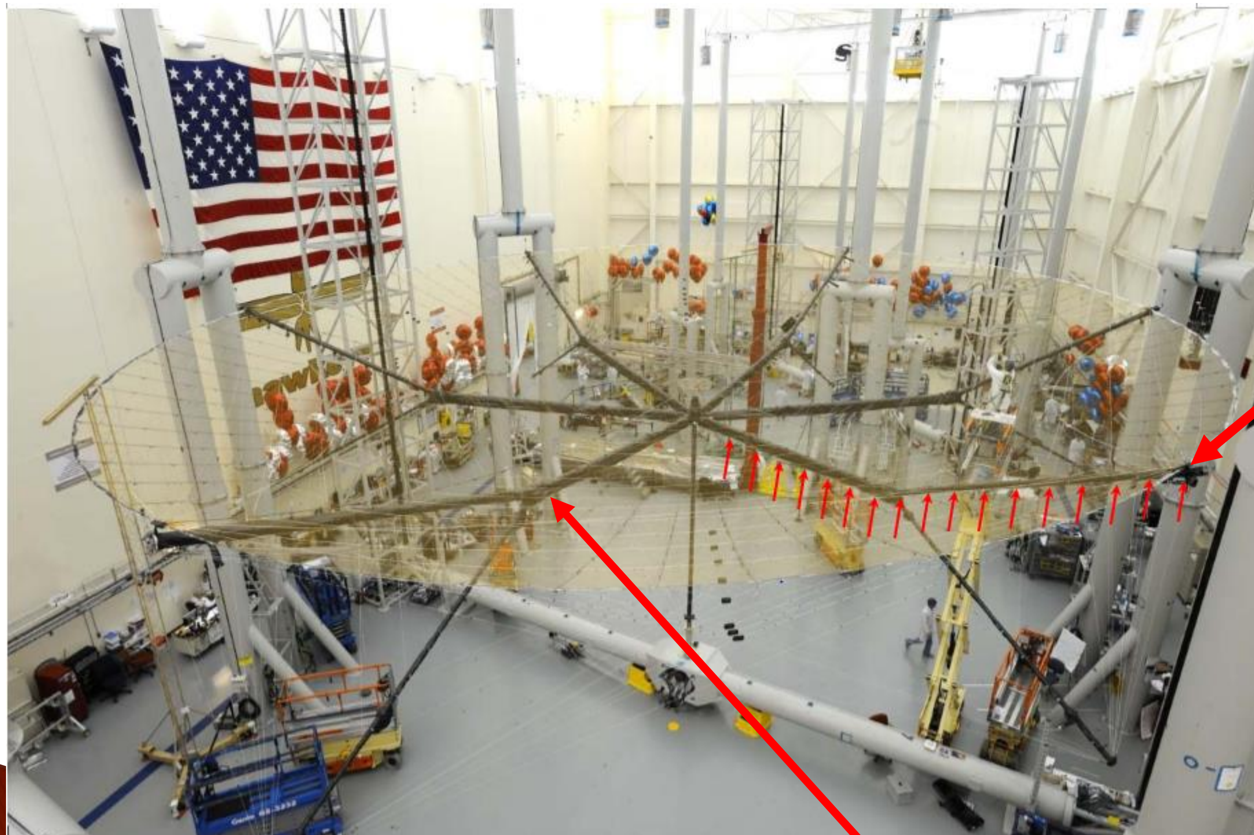
Team – 9
Cameron Duncan
Akeem Jordan
Raymond Mak

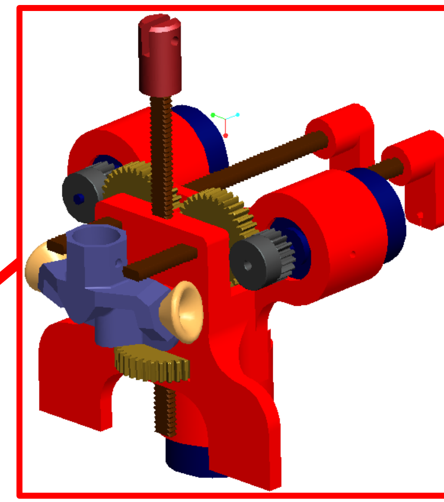
Overview

- Background
- Project Scope & Constraints
- Prototype
- Programming
- Function Diagram
- Testing & Results
- Bill of Materials
- Future Work

Background

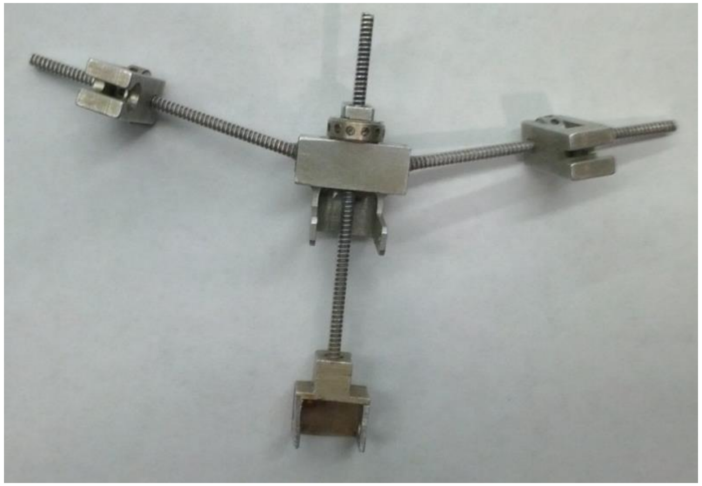
- Mesh reflectors
  - Pull cords and straw to adjust surface profile
  - 8 ribs, 17 per each rib, 136 adjusters, 408 adjustments



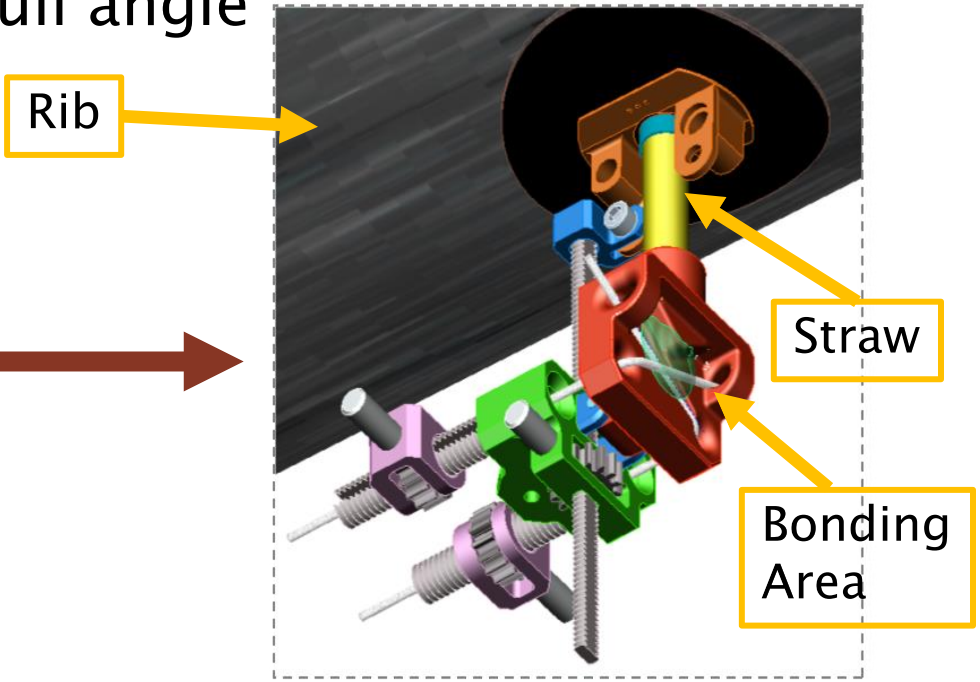


Previous Mechanisms

- Manual adjustment mechanisms
  - Time consuming
- Angled to parallel pull configuration
  - Interference with adjacent components when stowed
  - Independent of cord pull angle



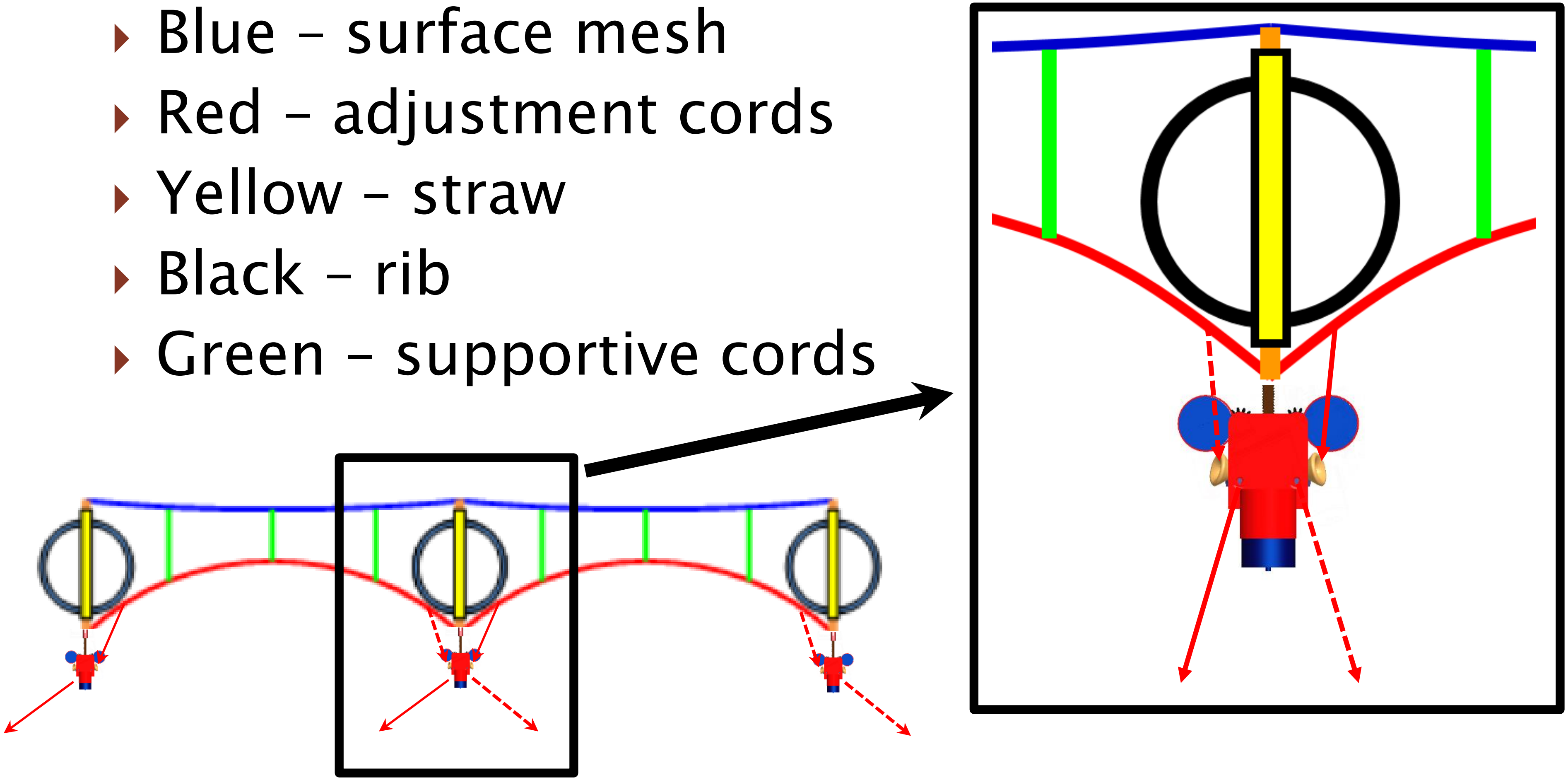
Manual Angle-Pull Design



Manual Parallel-Pull Design

Cord Configuration

- Blue – surface mesh
- Red – adjustment cords
- Yellow – straw
- Black – rib
- Green – supportive cords



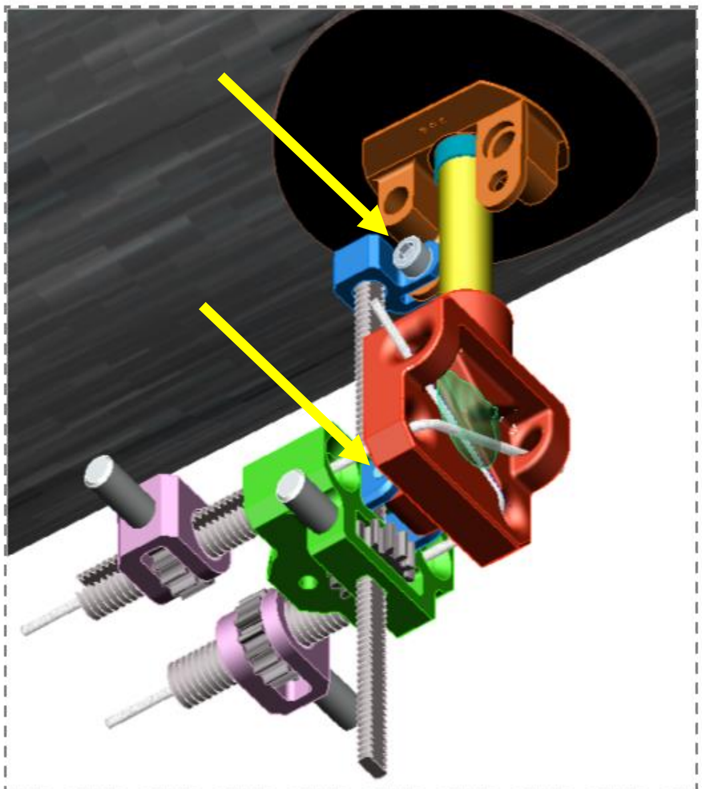
Project Scope

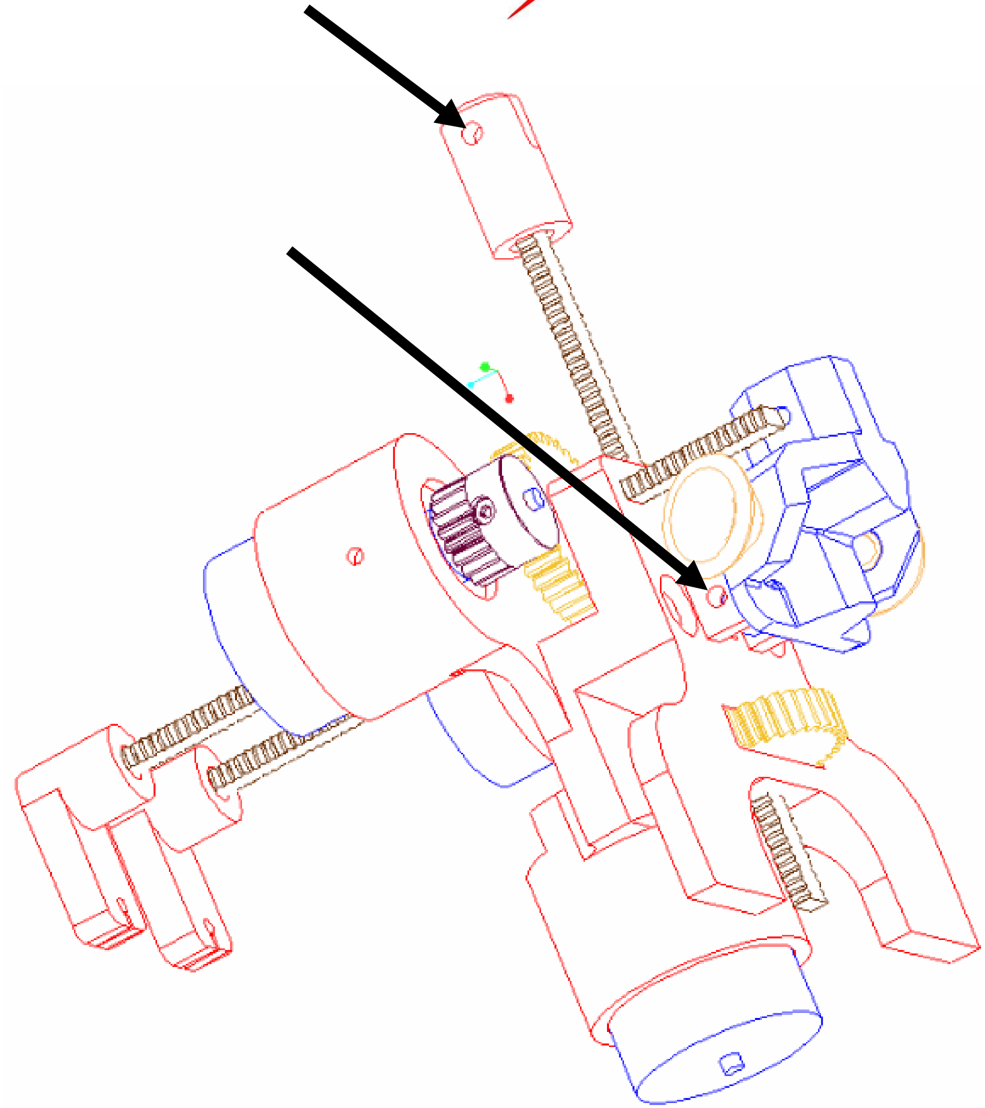
- Main Goal:
  - Build one automated high precision adjustment mechanism
  - Generate user friendly control logic
  - Tabletop visual demonstration
  - Ability to achieve accurate displacement
- Secondary Goal:
  - Integrated power supply

Constraints

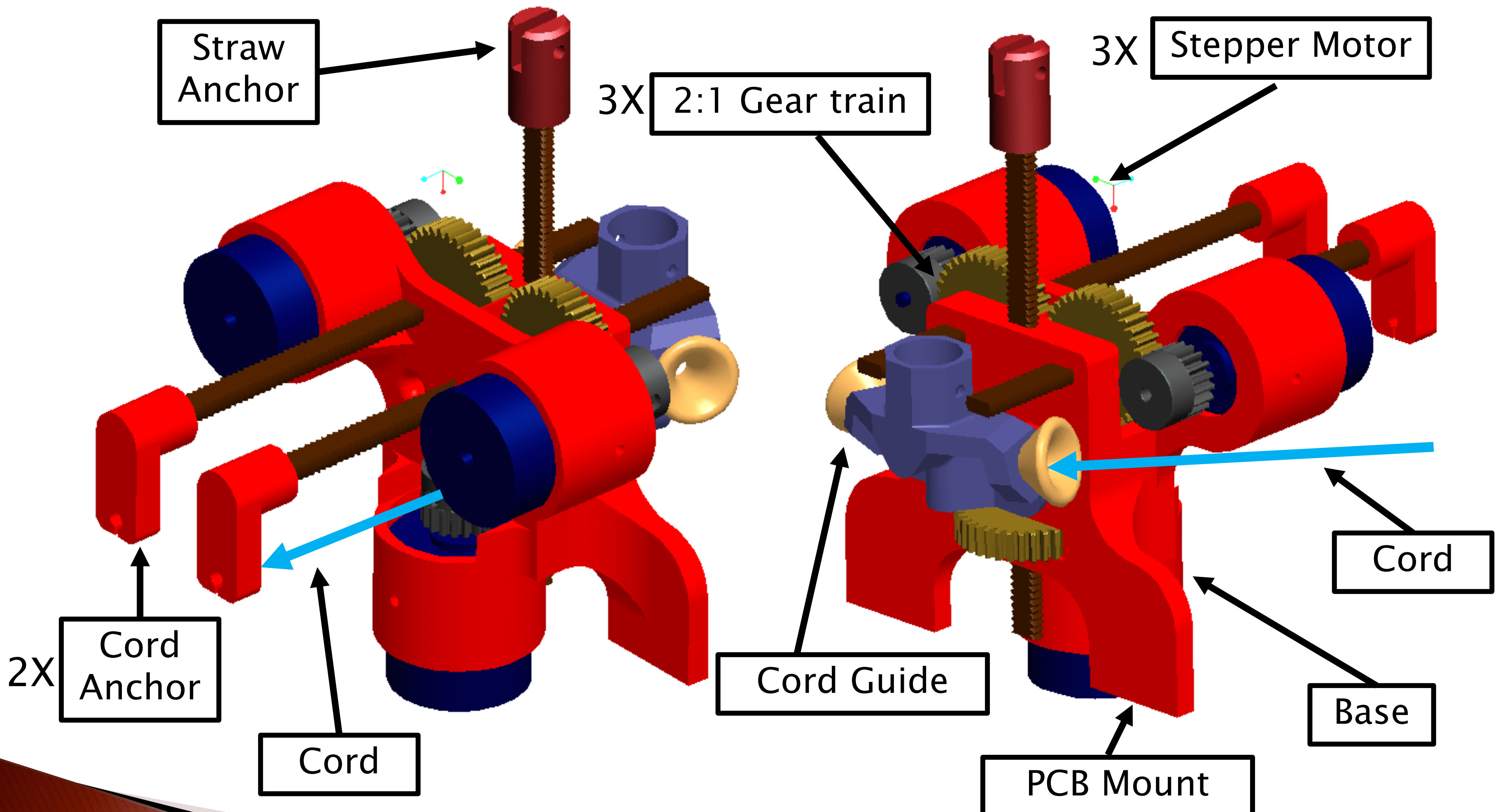
- Budget of total project: approximately $2,500
  - Each unit should cost less than $800
- Lightweight as possible, preferably under 80 grams
- Linear resolution 0.001”
- Total linear range of ±0.100”

Stationary Motor Design





Final Design

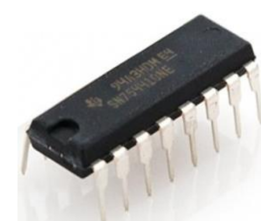


Mechanism Components

- 3x Micro stepper motors: Faulhaber AM1524
- Microcontroller: Arduino Nano
- 3x Motor driver chips: TI SN754410
- 3x 2:1 Gear Ratio

Stepper Motor

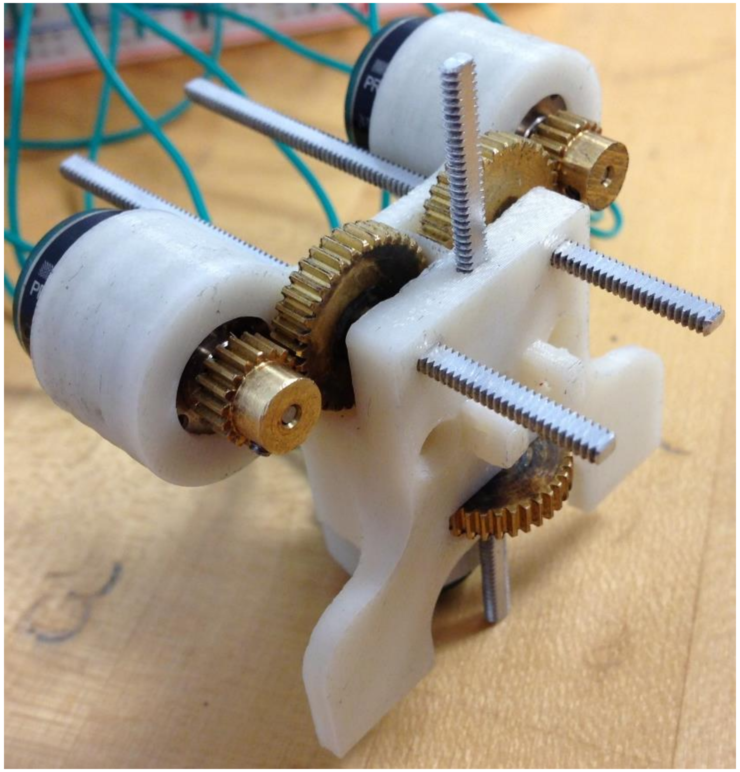
Microcontroller



Motor Driver

Prototype

- 3D printed base
  - Lightweight ABS plastic
  - Easier and faster to manufacture



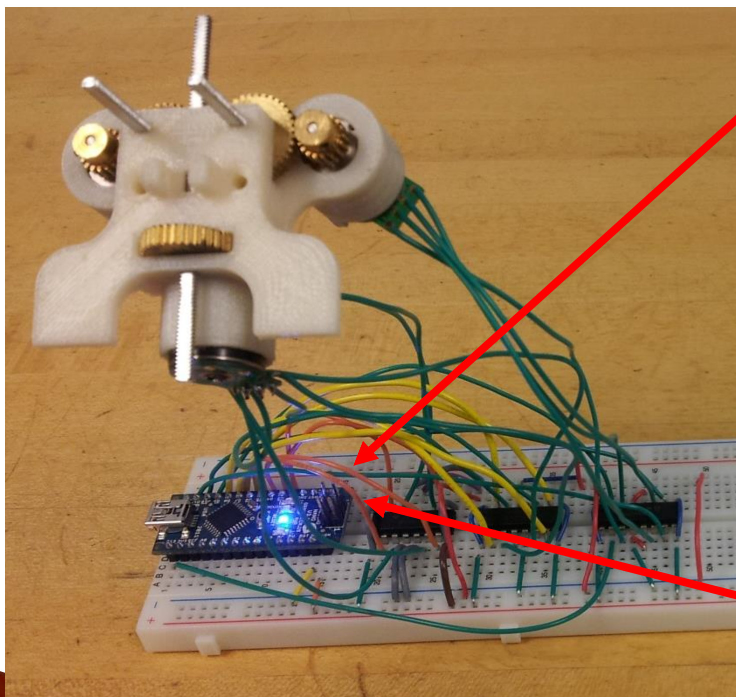
Assembled Adjustment Mechanism

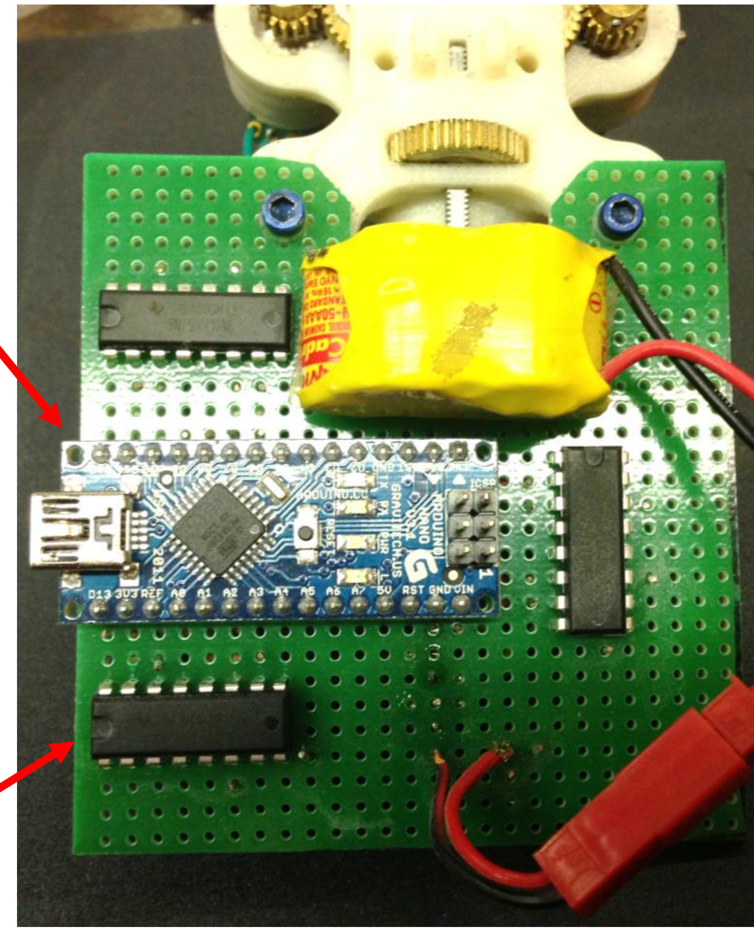
Weight Distribution

Component	Quantity	Weight/Unit	Total
Micro Stepper Motor	3	13.5g	40.5g
Battery Pack	1	19.5g	19.5g
Gear	3	4.2g	12.6g
Base	1	8.5g	8.5g
Arduino Nano	1	6g	6g
Pinion	3	1.7g	5.1g
Motor Driver	3	1g	3g
4-40 All Thread Rod	3	0.5g	1.5g
Cord Guide	1	1.4g	1.4g
Cord Anchors	2	0.4g	0.8g
Straw Anchor	1	0.2g	0.2g
Total			**99.1g**

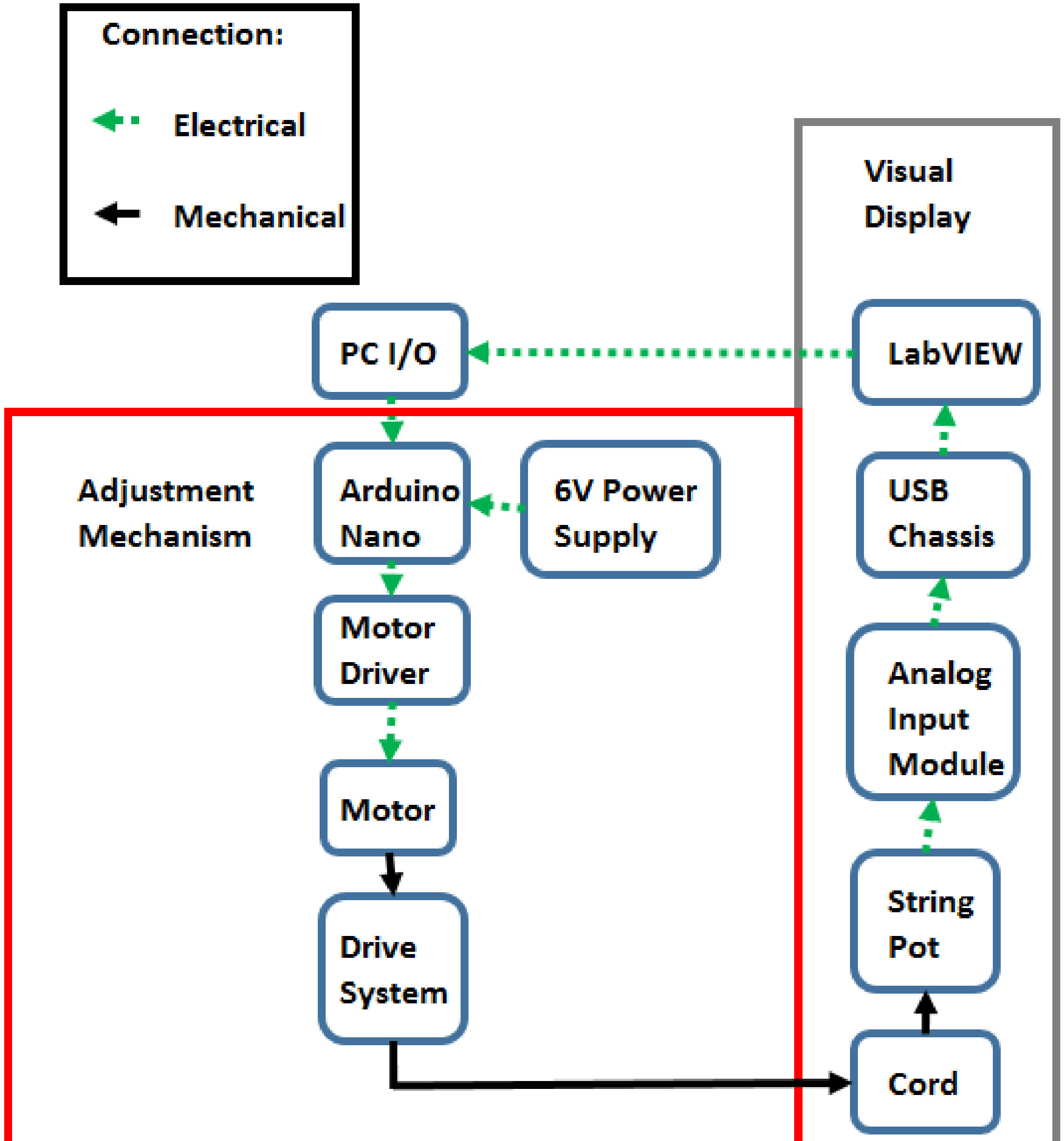
Programming

- Serial input
  - Accepts input from keyboard
- Switch between motors





Function Diagram



Data Acquisition Hardware

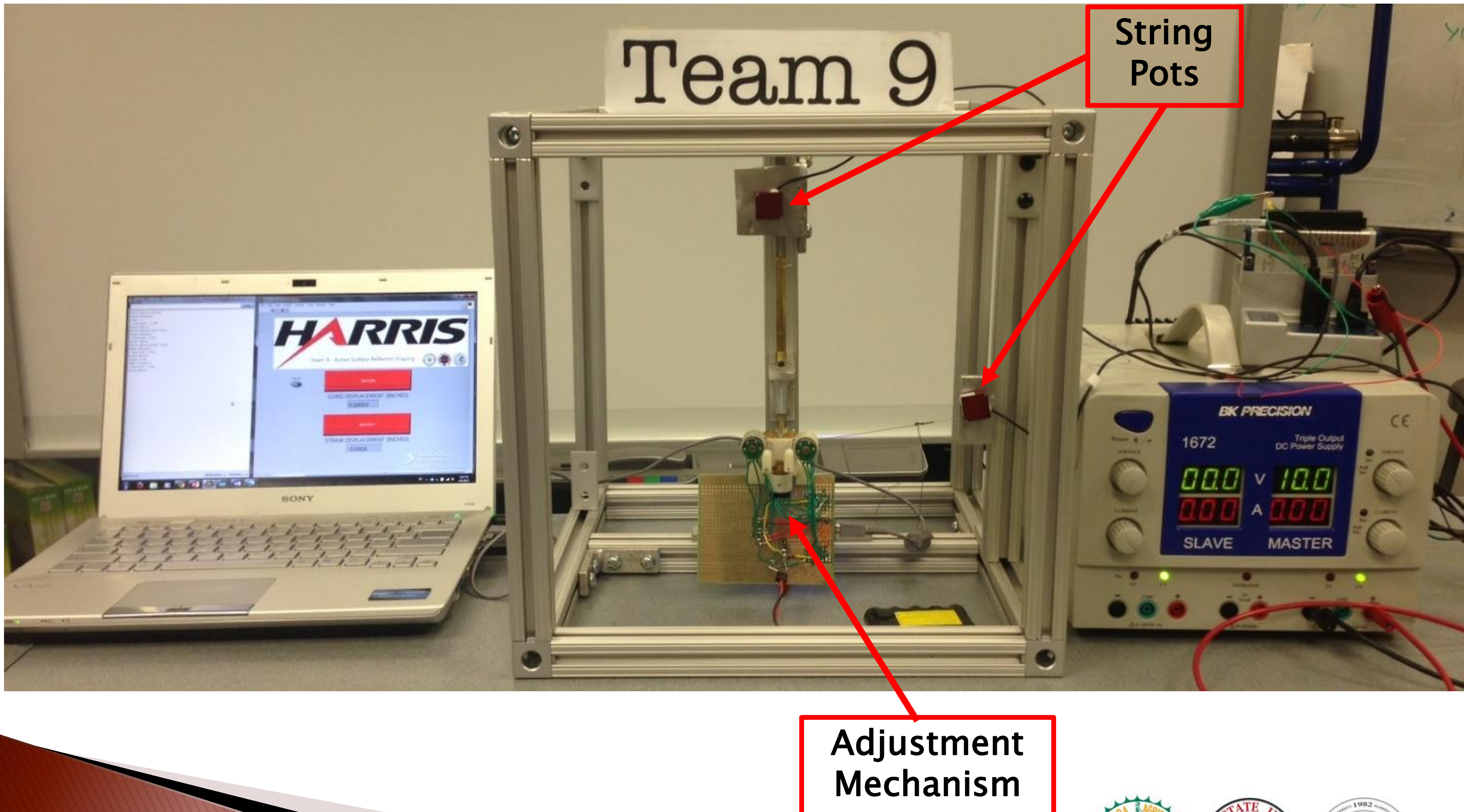
- 2x String potentiometers: Celesco M150
- 4-Slot USB Chassis: NI cDAQ-9174
- Analog Input Module: NI 9205
- 10VDC Power Supply

String Pot

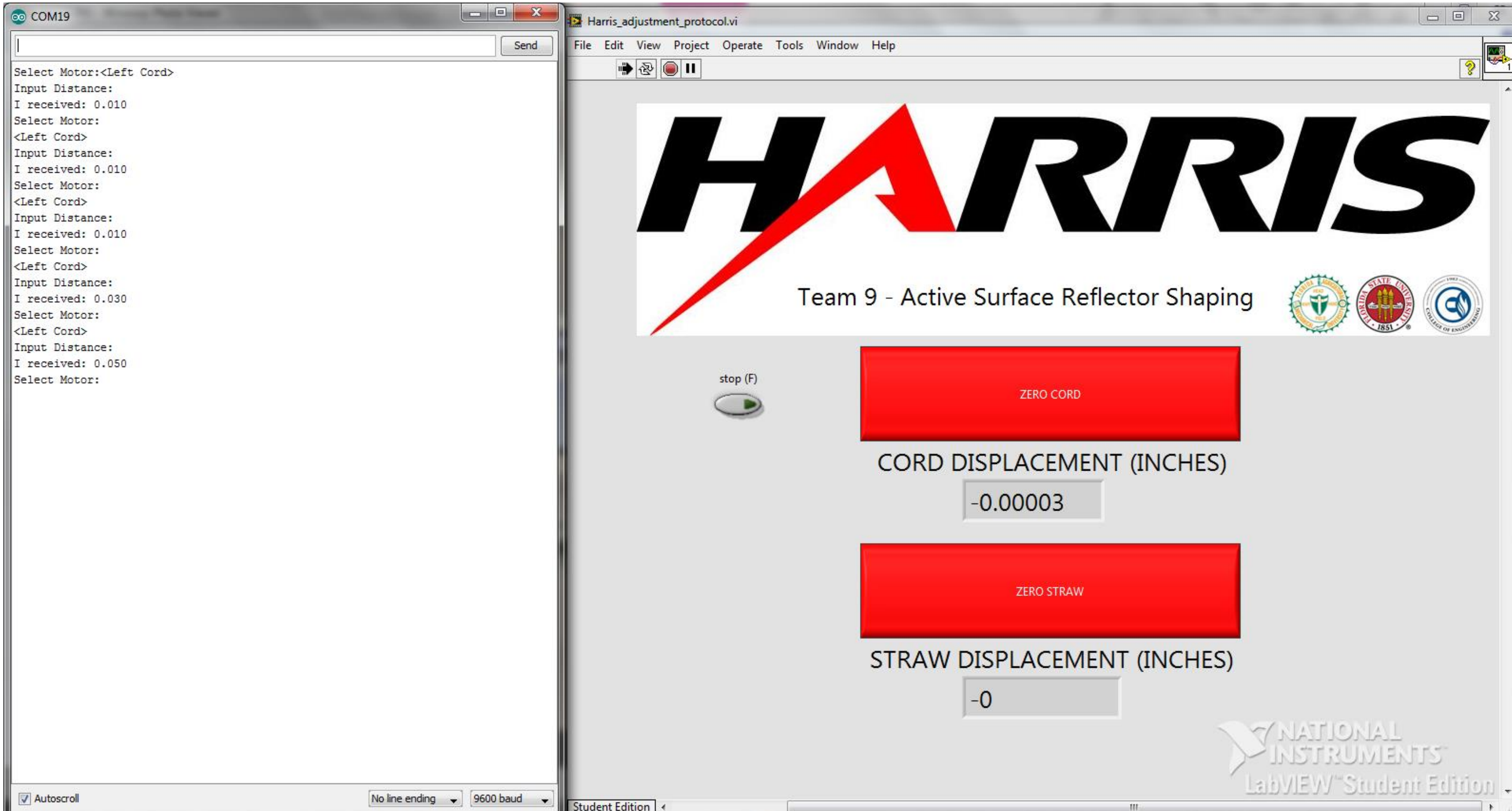
USB Chassis

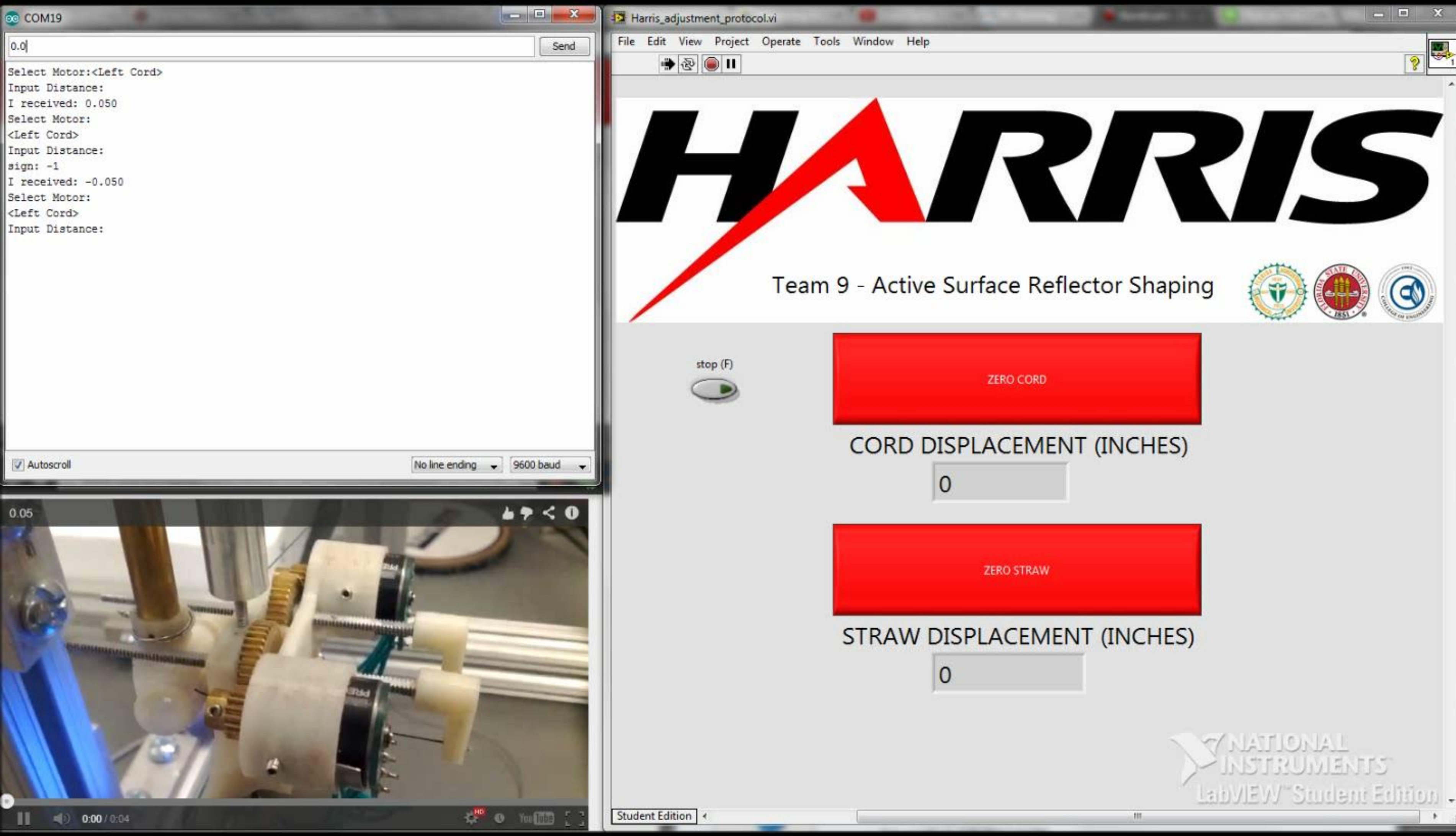
Analog Input Module

Testing Platform



Software Interface




COM19
0.0
Send
Select Motor:<Left Cord>
Input Distance:
I received: 0.050
Select Motor:
<Left Cord>
Input Distance:
sign: -1
I received: -0.050
Select Motor:
<Left Cord>
Input Distance:
Autoscroll
No line ending
9600 baud
0.05
0:00 / 0:04
Harris_adjustment_protocol.vi
File Edit View Project Operate Tools Window Help
HARRIS
Team 9 - Active Surface Reflector Shaping
stop (F)
ZERO CORD
CORD DISPLACEMENT (INCHES)
0
ZERO STRAW
STRAW DISPLACEMENT (INCHES)
0
NATIONAL INSTRUMENTS
LabVIEW Student Edition
Student Edition

Testing

- Resolution slightly outside of desired envelope at ±0.003"
- Adjustments inaccurate when changing directions within ±0.007"

Bill of Materials

Component	Purpose	Cost/Unit	Total Cost	Supplier
Adjustment Mechanism				
Arduino Nano	Microcontroller	$42.79	$42.79	Digikey
Faulhaber AM1524	Stepper Motor	$117.6	$352.80	Micromo
TI SN754410	Motor Driver	$2.35	$14.10	Sparkfun
Gear Stock	Drive System		$74.44	SDP/SI
3D Printer Services	Base Essentials	$3/cm^3	~$80.00 not included	FSU COE
Machine shop labor	Mill Threads Flat	$100/unit	$300.00 not included	Harris
		Total	**$500**	
Visual Display				
Celesco M150 String Pot	Measurement	$358.20	716.40	Celesco
80/20 Aluminum Frame	Visual Display		$209.87	McMaster
LabVIEW Student License	DAQ Software	$59.95	$59.95	Studica
		Total	**$927**	
Grand Total		**$1,486 of $2,500 Spent**		

*Note: not all items included in chart

Future Work

- Integrate wireless capabilities
- Build multiple mechanisms to change representative surface reflector shape
- Use higher quality gears to increase precision
- Custom printed circuit board for components
- Use higher step count motors
- Higher strength base material and higher precision 3D printer

Acknowledgements

- Harris Sponsor
  - Gustavo Toledo
- FAMU & FSU CoE
  - Dr. Kamal Amin
  - Dr. Oscar Chuy
  - Dr. Emmanuel Collins
  - Dr. William Oates
  - Dr. Chiang Shih

Questions/Comments

Torque Requirements

$$T_{raise} = \frac{Fd_m}{2}\left(\frac{l + \pi\mu d_m}{\pi d_m - \mu l}\right) = 4.23\mathrm{mN} * \mathrm{m}$$

d_m = mean diameter
μ = coefficient of friction
l = lead = #of Starts * Pitch
Pitch=1/threads per inch

$$\mathrm{T} = \mathrm{kFd} = 5.06\mathrm{mN} * \mathrm{m}$$

k = fitting factor

Linear Resolution

$$Required\ step\ angle\ from\ motor\ to\ obtain\ .001"\ resolution:$$

$$\frac{0.025"}{360deg} = \frac{0.001"}{x} \Rightarrow x = 14.4°$$

$$Actual\ step\ from\ Faulhaber\ AM1524\ motor:$$

$$\frac{0.025"}{360°} = \frac{x}{15°} \Rightarrow x = 0.00104"\ linear\ resolution$$

$$Using\ 2{:}1\ gear\ ratio:$$

$$\frac{0.025"}{360°} = \frac{x}{7.5°} \Rightarrow \mathrm{x} = 0.000521\text{" linear resolution}$$

Motor Selection

Faulhaber AM1524 motor

- Micro stepper motor
- Weight – 12 grams
- Rated torque is 6 mN*m
- $120 each after university discount
- Encoder not utilized due to weight constraints and radar scan monitoring