DIOACTIVE

A. R. M. H. A. I. R.

AUTOMATED RADIATION MONITORING HAZARDOUS INSPECTION ROBOT

MECH/MECA 440 B– Senior Project
Spring 2009

OCNL 124
Tuesday, May 12th, 2008

Design Team Members

Ross Huber

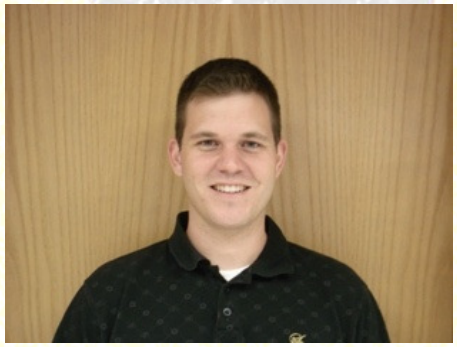
Mechanical Engineering

Joel Amato

Physics
Electrical
Mechanical
Mechatronic
Engineering

John Womack

Mechanical Engineering



James Stiling

Mechatronic Engineering

"If you can buy your way out of a problem, you don't have a problem."

- Nick Repanich

A.R.M. H.A.I.R.
Project Faculty Advisor
09/08 – 05/09

California State University, Chico
Adjunct Research Professor
09/00 - Present

CSU, Chico Research Foundation
Project Director – California Mechatronics Group
10/01 - Present

Industry Sponsor

Lawrence Livermore National Laboratory

… a premier applied science laboratory that is part of the National Nuclear Security Administration (NNSA) within the Department of Energy (DOE).

California Mechatronics CENTER

under the auspices of the
CSU, Chico Research Foundation

CSUC Research Foundation
Customer: Jason Coates

Goal Statement

- To develop, design and construct a system which can position diagnostic equipment in a hazardous environment.

- To reduce human exposure associated with nuclear inspections.

Project Objectives

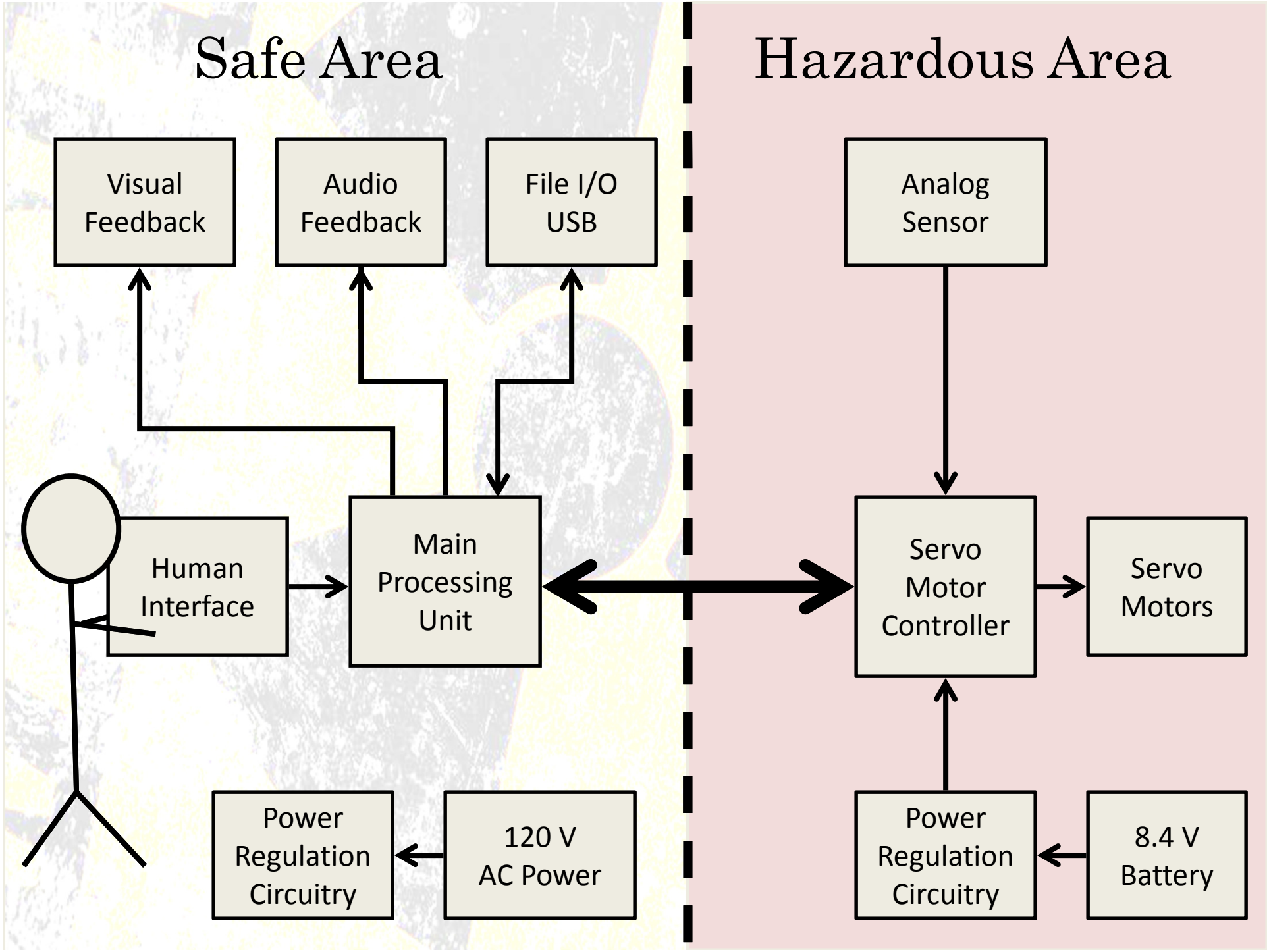
Objective	Target	Test Procedure
Work Envelope	$R \geq 36$ inches	Measure Total Distance from Base Origin to Center of Sensor Mount
System Resolution	$\Delta R \leq 1$ inch	Produce Standardized Grid, and Use System to Measure Spacing
Arm Extension Rate	$\frac{\Delta R}{\Delta T} \geq \frac{24 \text{ in}}{30 \text{ sec}}$	Measure Time of Travel for the System to Move from Point to Point
Retracted Length	$L \leq 20$ inch	Measure Horizontal Projection from the Base to the Origin

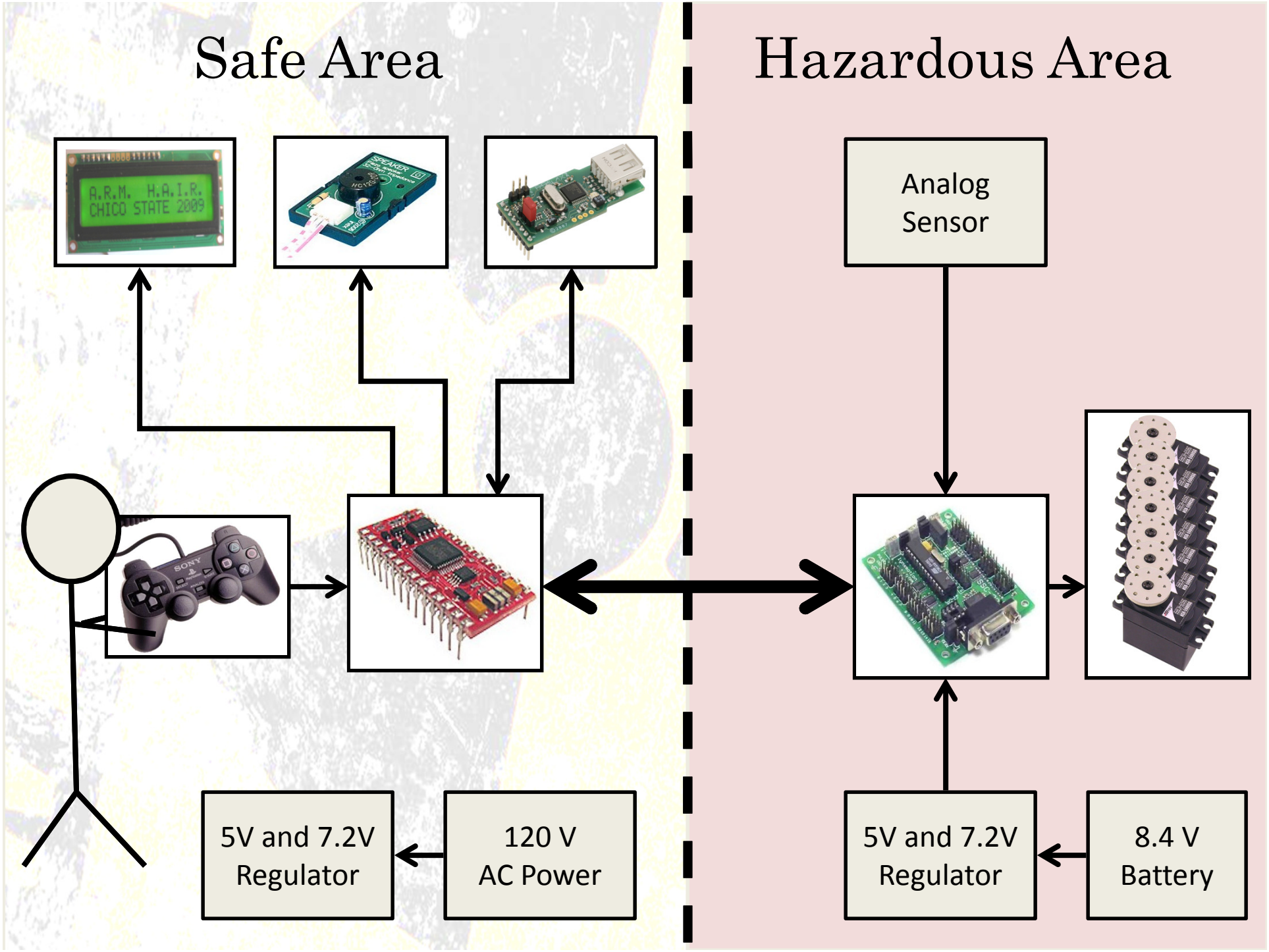
Mechanical Constraints

Attribute	Constraint
Sensor Attachment	Universal Mount
System Attachment	8 x 8 in. Square Maximum
Payload Capacity	4 Ounce Minimum
System Weight	8 Pounds Maximum
Life	0.5 miles of Sensor Travel

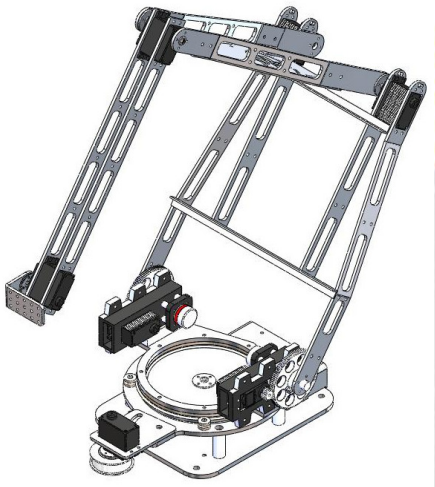
Mechatronic Constraints

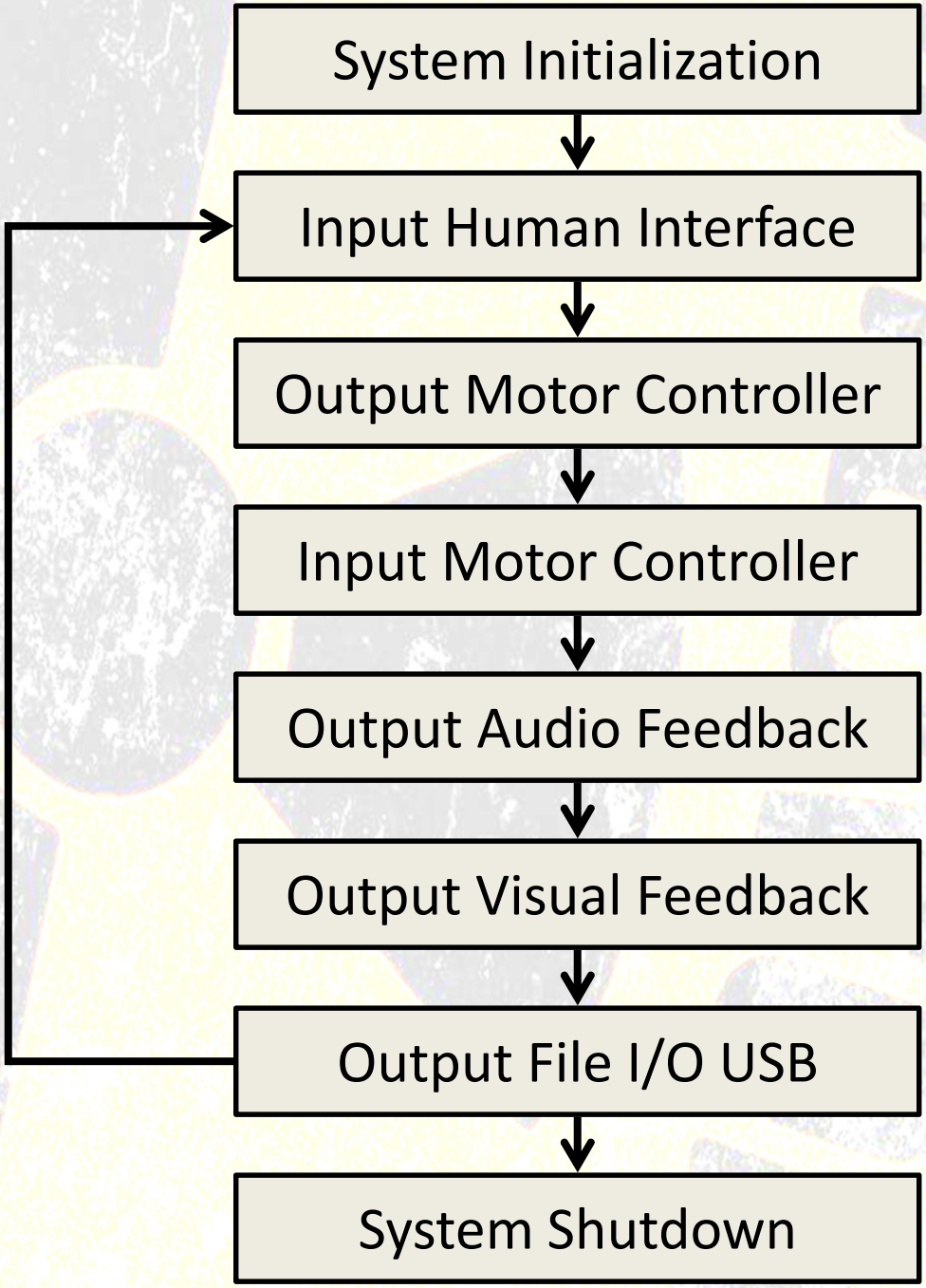
Attribute	Constraint
Supply Voltage	8.4 Volts Standard DC
Data Communication	4-Wire Serial Protocol
Sensor Output	0-5 Volt DC Test Signal
Required Feedback	Sensor and Telemetry Data
Operator Interface	Remote Control

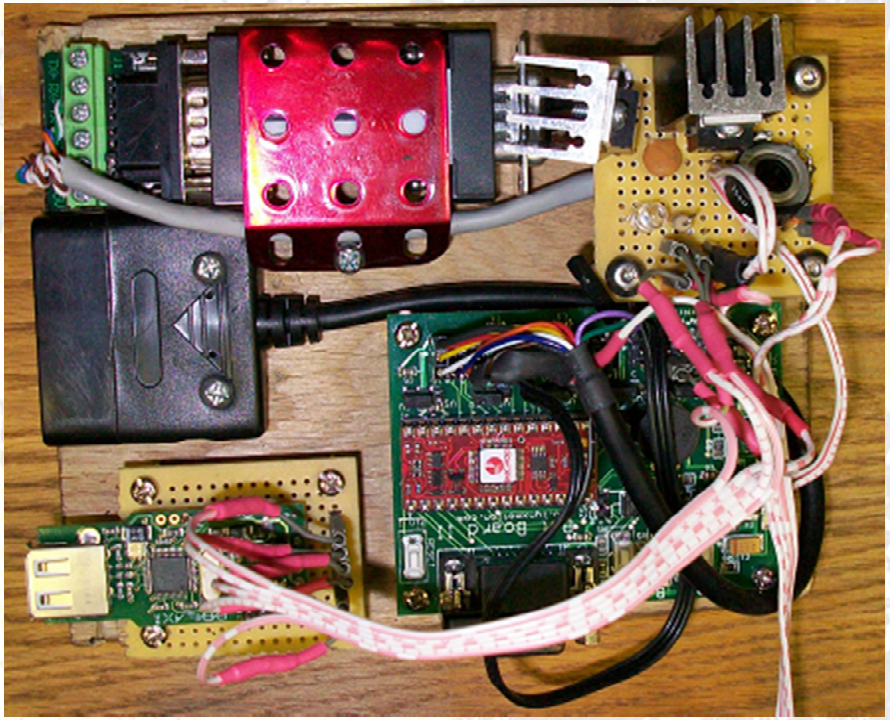

Safe Area
Hazardous Area
Visual Feedback
Audio Feedback
File I/O USB
Analog Sensor
Human Interface
Main Processing Unit
Servo Motor Controller
Servo Motors
Power Regulation Circuitry
120 V AC Power
Power Regulation Circuitry
8.4 V Battery


Safe Area
Hazardous Area
A.R.M. H.A.I.R.
CHICO STATE 2009
Analog
Sensor
5V and 7.2V
Regulator
120 V
AC Power
5V and 7.2V
Regulator
8.4 V
Battery

Software Block Diagram



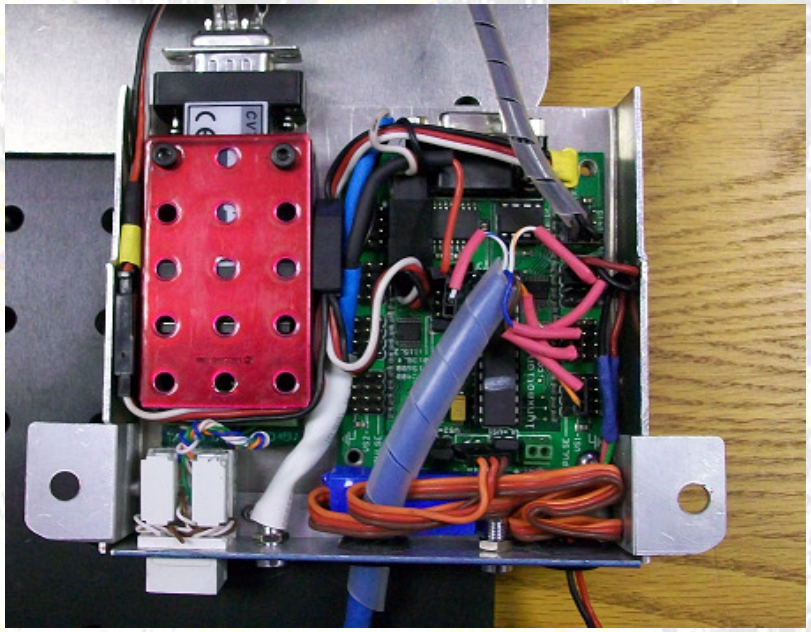


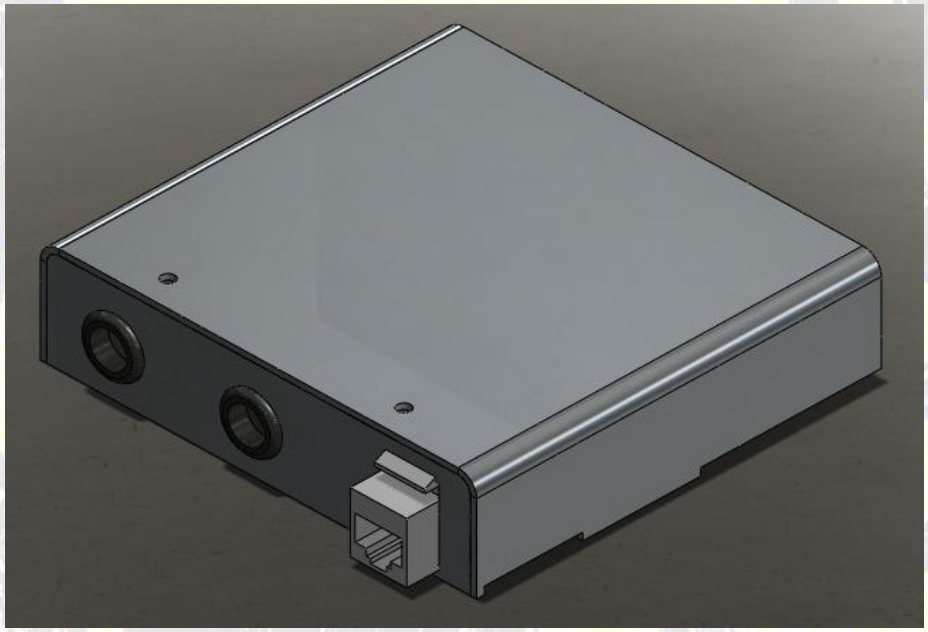


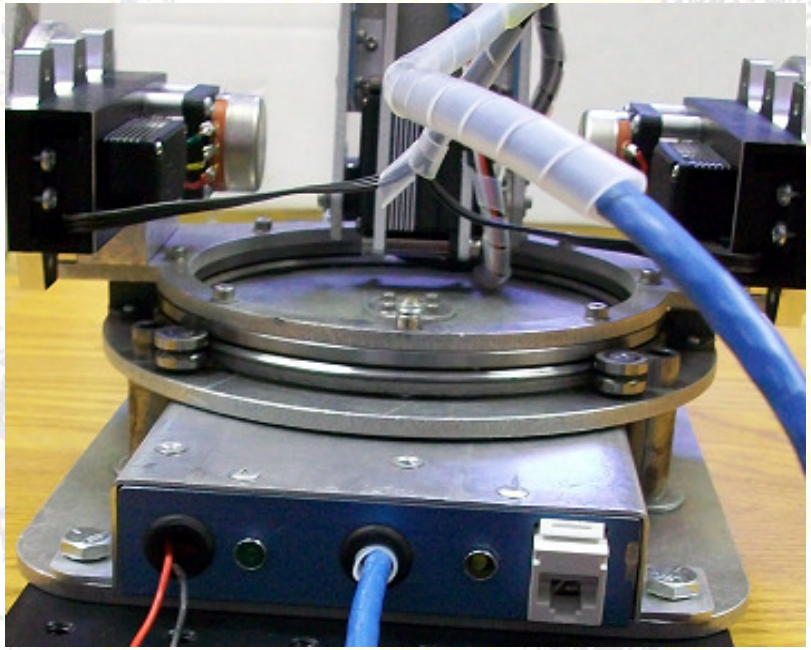
A.R.M.H.A.I.R

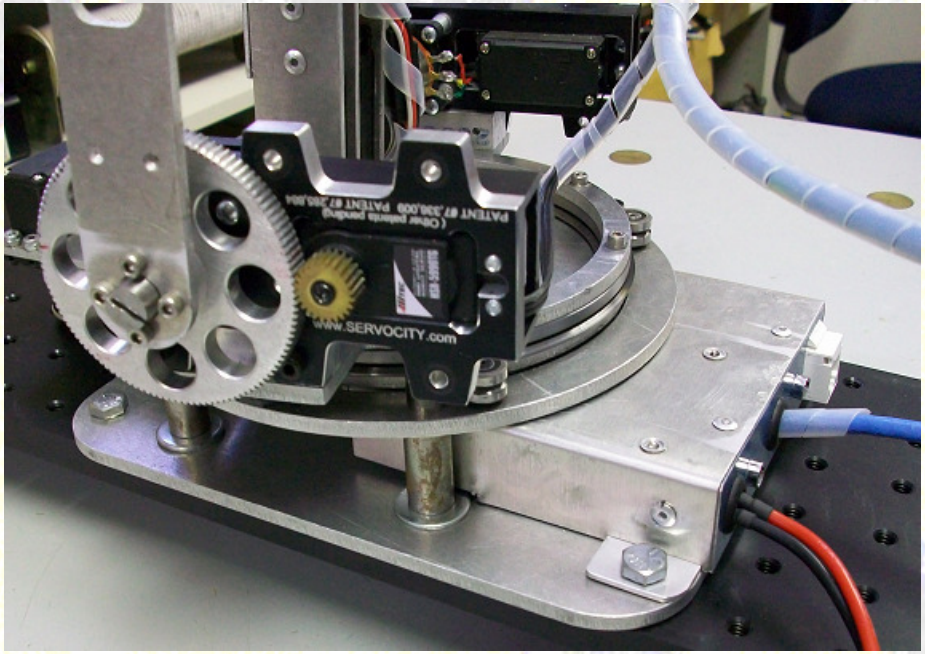
A.R.M.H.A.I.R

SYSTEM INITIALIZED
PRESS START





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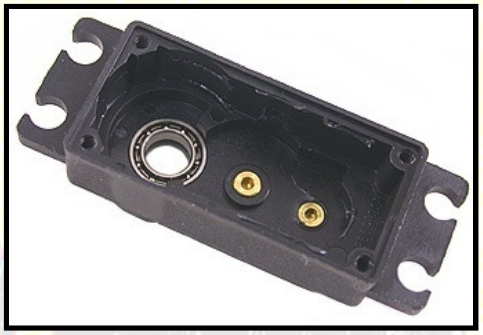
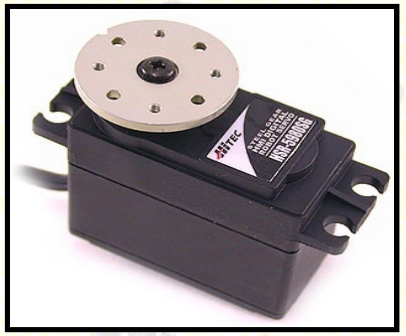
Hitec Servo Motors

HSR-5980SG

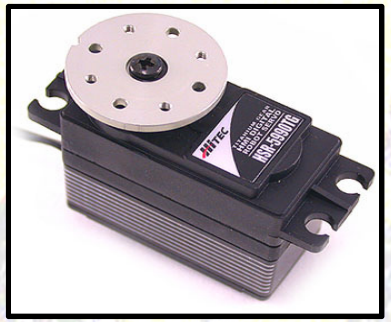
- 30 kg-cm Stall Torque
- Steel Gears





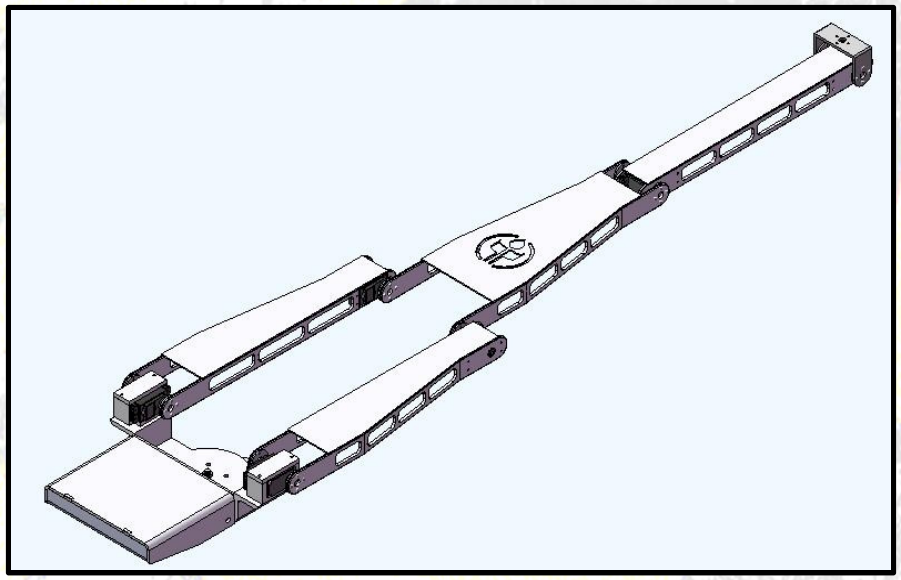
HSR-5990TG

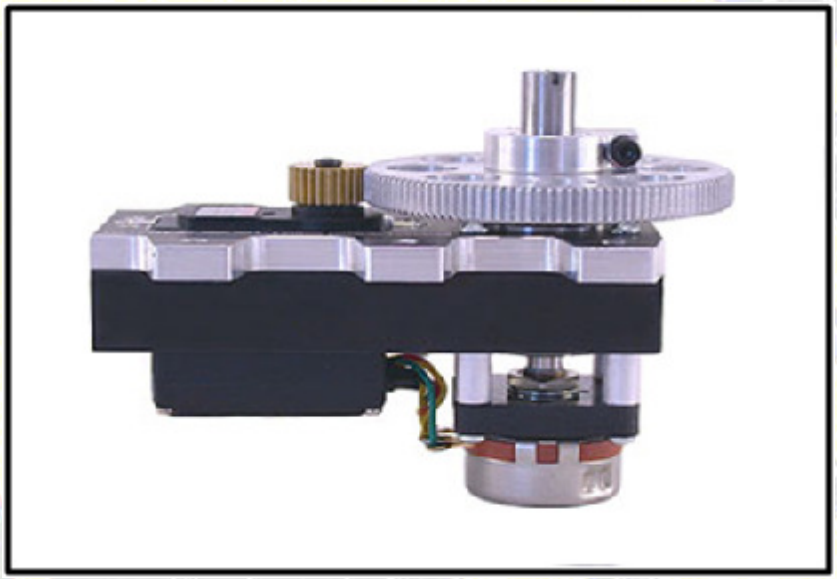
- 30 kg-cm Stall Torque
- Durable Titanium Gears
- Built in Heat Sink

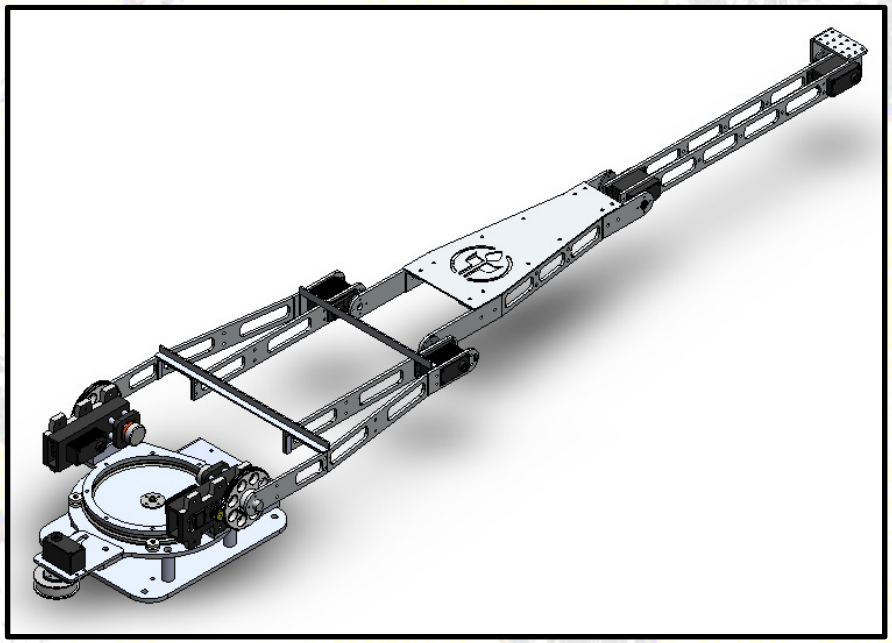


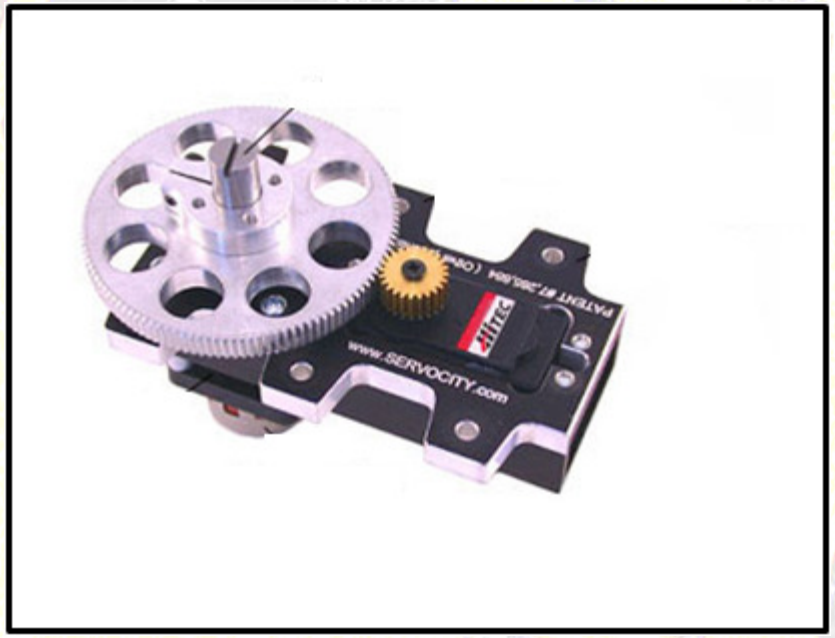
"No Such Thing as a Design Flaw, only a Design Opportunity."

-A.R.M.H.A.I.R








www.SERVOCITY.com

Project Objectives Testing

Objective	Target	A.R.M. H.A.I.R.
✓ Work Envelope	$R \geq 36$ in	$R \geq 37$ in
✓ System Resolution	$\Delta R \leq 1$ in	$\Delta R \leq 0.5$ in
✓ Arm Extension Rate	$\frac{\Delta R}{\Delta T} \geq \frac{24 \text{ in}}{30 \text{ sec}}$	$\frac{\Delta R}{\Delta T} \geq \frac{24 \text{ in}}{7 \text{ sec}}$
✓ Retracted Length	$L \leq 20$ in	$L \leq 18.3$ in

Mechanical Constraint Testing

Attribute	Constraint	A.R.M. H.A.I.R.
✓ Sensor Attachment	Universal Mount	Customer Approved
✓ System Attachment	8 in x 8 in Area Maximum	7.8 in x 6.5 in
✓ Payload Capacity	4 oz Minimum	6 oz
✓ System Weight	8 lbs Maximum	7 lbs
✓ Life	0.5 miles Travel	Designed to Last

Mechatronic Constraint Testing

Attribute	Constraint	A.R.M. H.A.I.R.
✓ Supply Voltage	8.4 Volts Standard DC	8.4 V Compatible
✓ Sensor Output	0-5 Volt DC Test Signal	8-Bit 5V DC A/D
✓ Communication	4-Wire Serial Protocol	RS-422 Protocol
✓ Required Feedback	Sensor /Telemetry Data	USB Storage Device
✓ Operator Interface	Remote Control	PS2 Dual Shock

Resources

- Funding
  - $5000 Provided by LLNL
- Manpower
  - One Team Consisting of Hardworking Individuals
  - One Industry Hardened Faculty Advisor
- Materials and Facilities
  - Access to Motion Control Equipment
  - Access to School Laboratories
  - $40 Rapid Prototyping

A.R.M. H.A.I.R. Budget

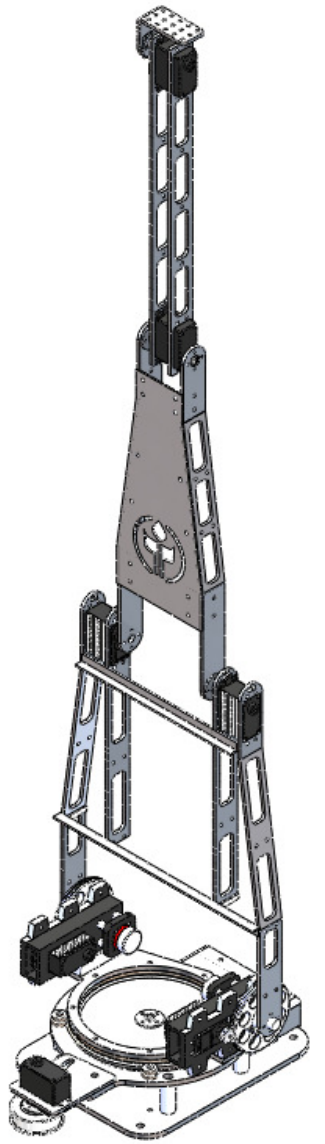
Mechanical System	Cost
Raw Materials	**$80.00**
Fasteners	**$103.58**
Manufacturing processing	**$145.77**
Total	**$329.35**

Electrical System	Cost
Servo Motors	**$1,119.73**
Main Processing Unit	**$74.90**
Servo Motor Controller	**$39.95**
Peripherals and Misc. Parts	**$292.56**
Power Regulation Circuitry	**$53.10**
Total	**$1,580.24**

Complete System	Cost
Mechanical System	**$329.35**
Electrical System	**$1,580.24**
Total	**$1,909.59**

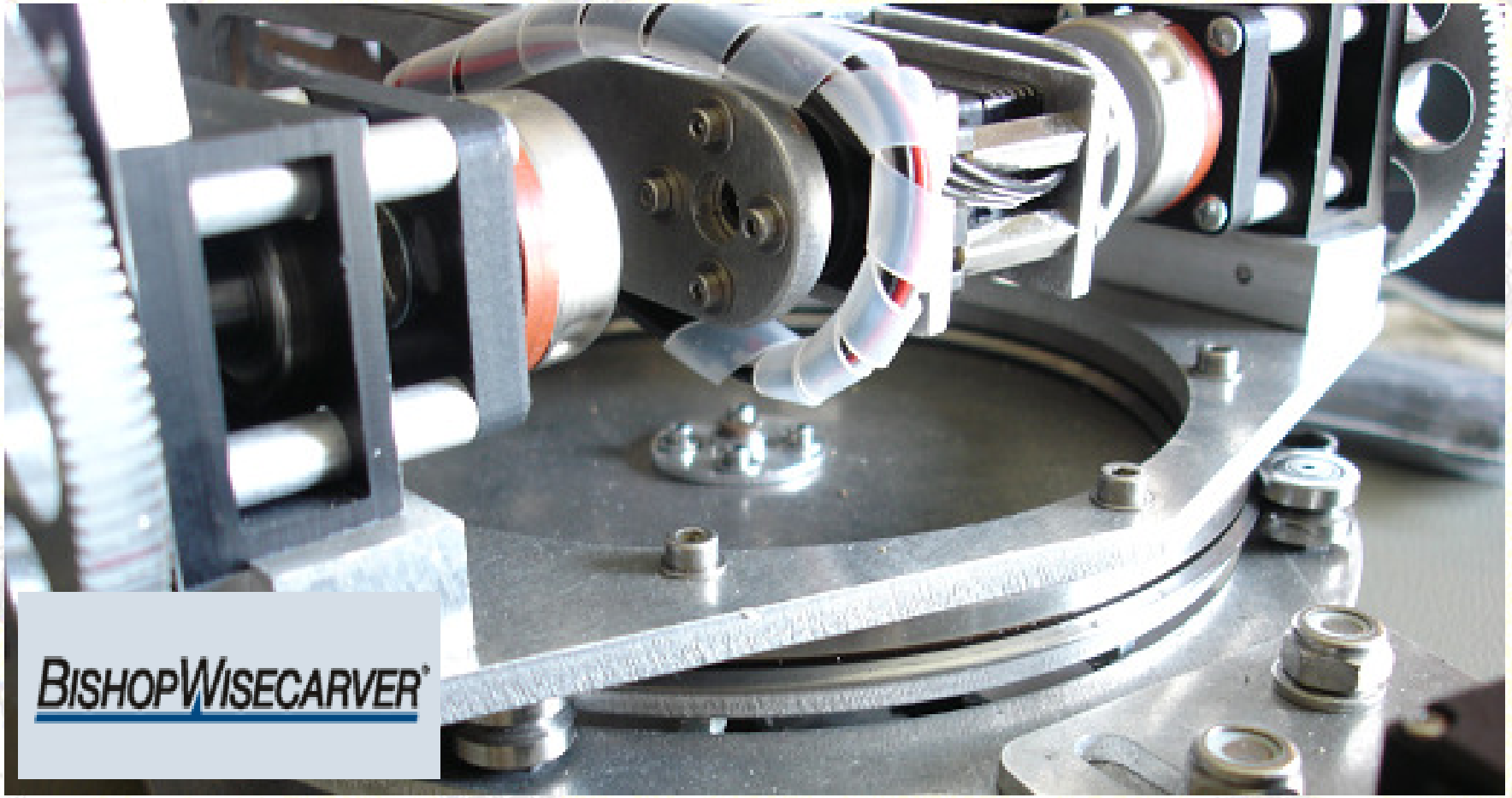
Labor	Cost
Entry Level Mechanical Engineer	**$27,286.60**
Entry Level Electrical Engineer	**$29,908.50**
Total	**$57,195.10**

Total Expenses	Cost
	$59,104.69



A Special Thank You

Bishop Wisecarver

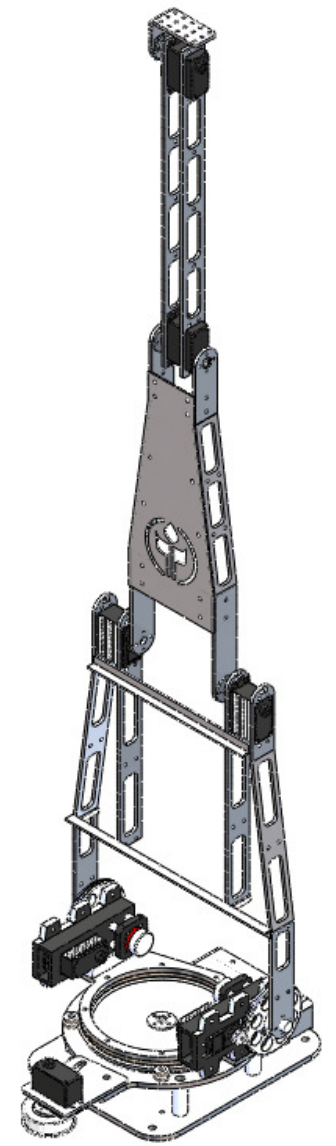


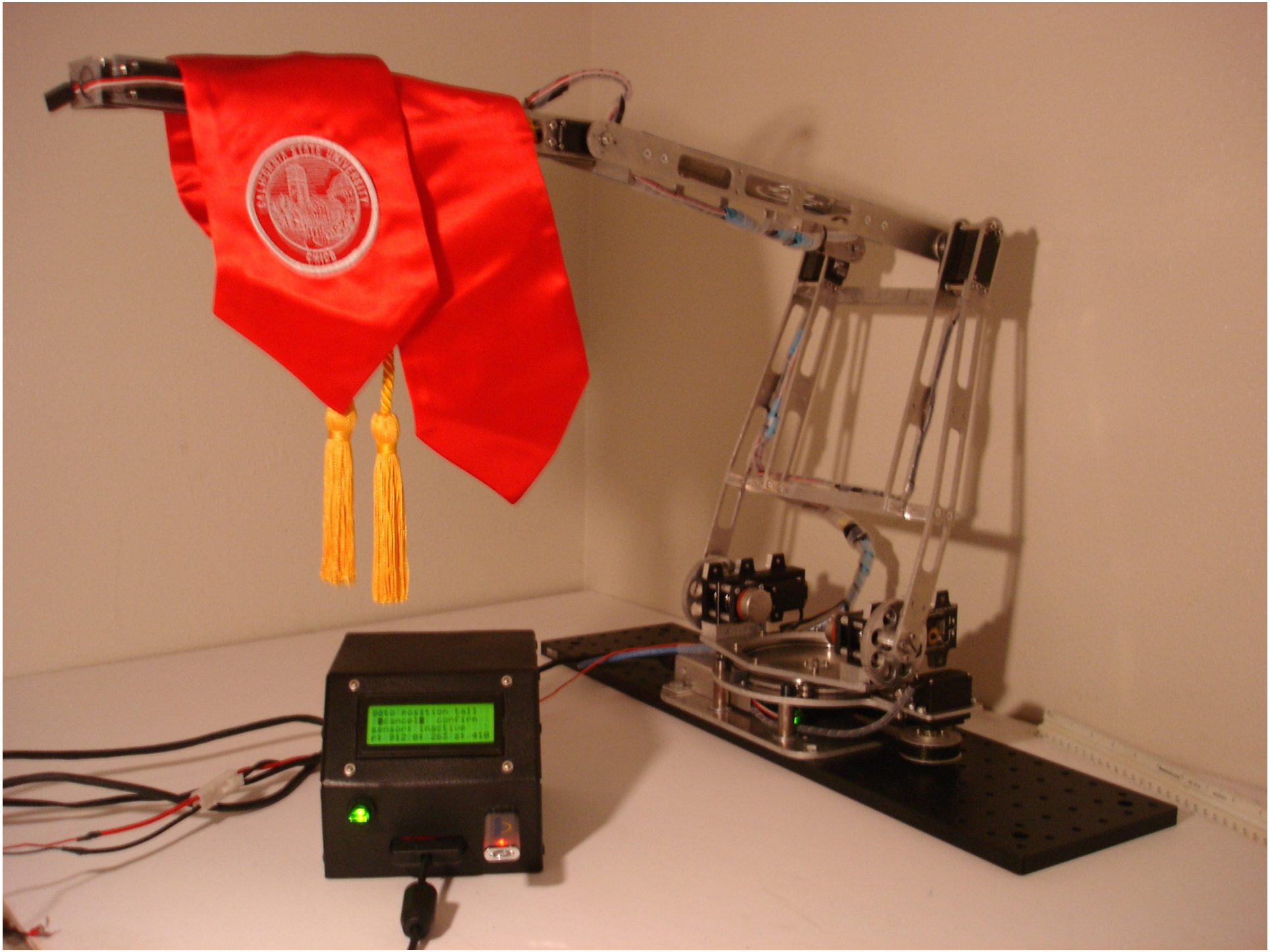
A Very Special Thank You

Steve Eckhart and the Tech Shop Boys..

Project Summary

- A.R.M. H.A.I.R
  - Automated Radiation Monitoring
  - Hazardous Area Inspection Robot
- Group Members
  - Joel Amato, Ross Huber
  - James Stiling, John Womack
- Faculty Advisor
  - Nick Repanich
- Industry Sponsor
  - Lawrence Livermore National Laboratory
- Project Customer
  - Jason Coates

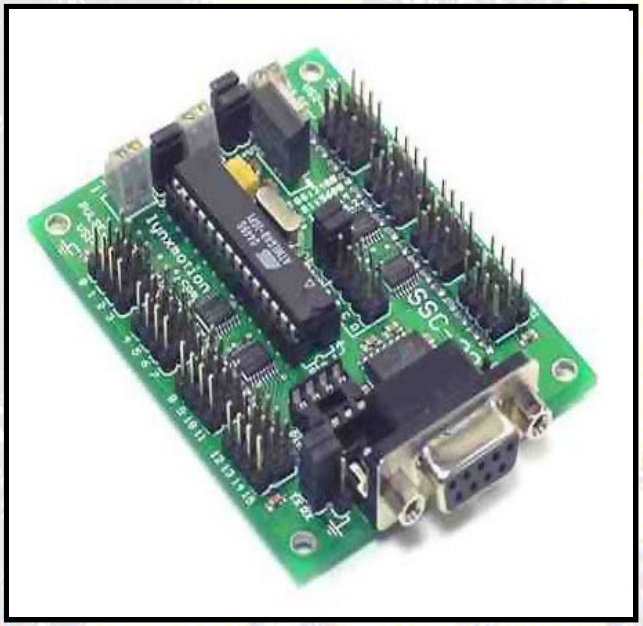




Servo Motor Controller

Lynxmotion SSC-32

- 32 Servo Motor Channels
- Advanced Control Commands
- 1 μS Timing Resolution
- 8-bit Analog Input Resolution



1

LCD SCREEN: PASS
THUMBDRIVE: INSERT

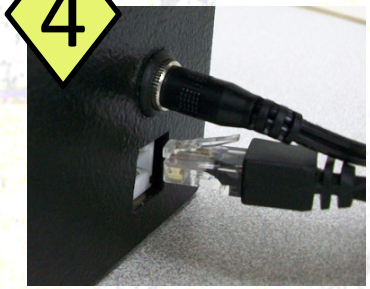
2

LCD SCREEN: PASS
THUMBDRIVE: PASS
SPEAKER: PASS
PS2 CONTROL: INSERT

3

ARMHAIR CONTROL UNIT
INITIALIZED
CONNECT THE ARM HAIR
SYSTEM TO CONTINUE

4



5

SYSTEM INITIALIZED
PRESS START

6

SYSTEM INITIALIZED
PRESS START