Smart Material Museum Exhibit
Fall Final Presentation

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Problem Statement

- The goal of this senior design project is to design, build, and test a museum exhibit
- Exhibit must utilize and demonstrate the behavior of a smart material and its applications
- Smart material chosen for this project is the piezoelectric type
- Exhibit must be interactive and entertaining for students
- Final product should be delivered to the museum ready for display

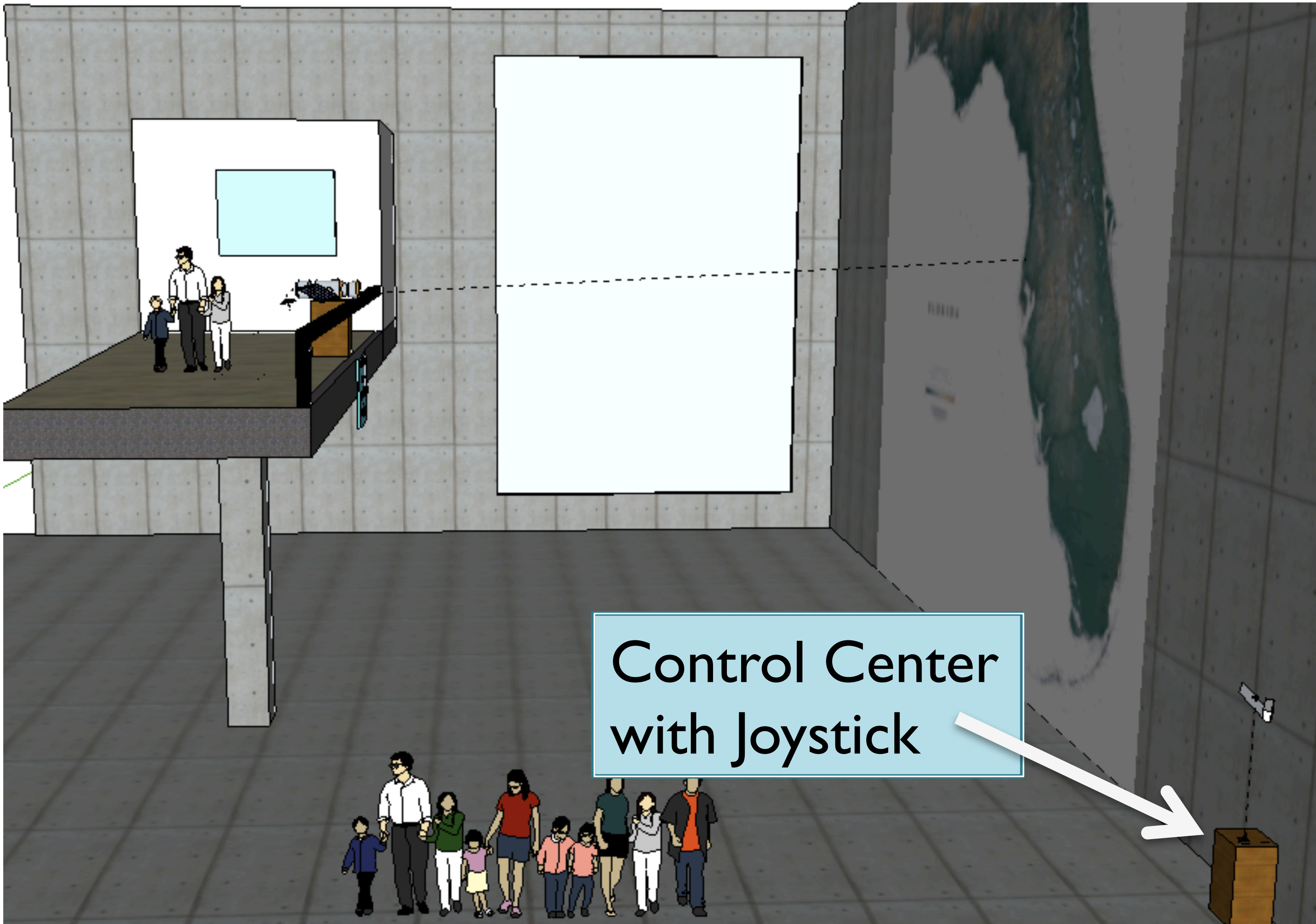
Constraints

- Safe for use for school aged children
- Must be space themed
- Sized appropriately to fit in the Challenger Learning Center
- Budget of $1500

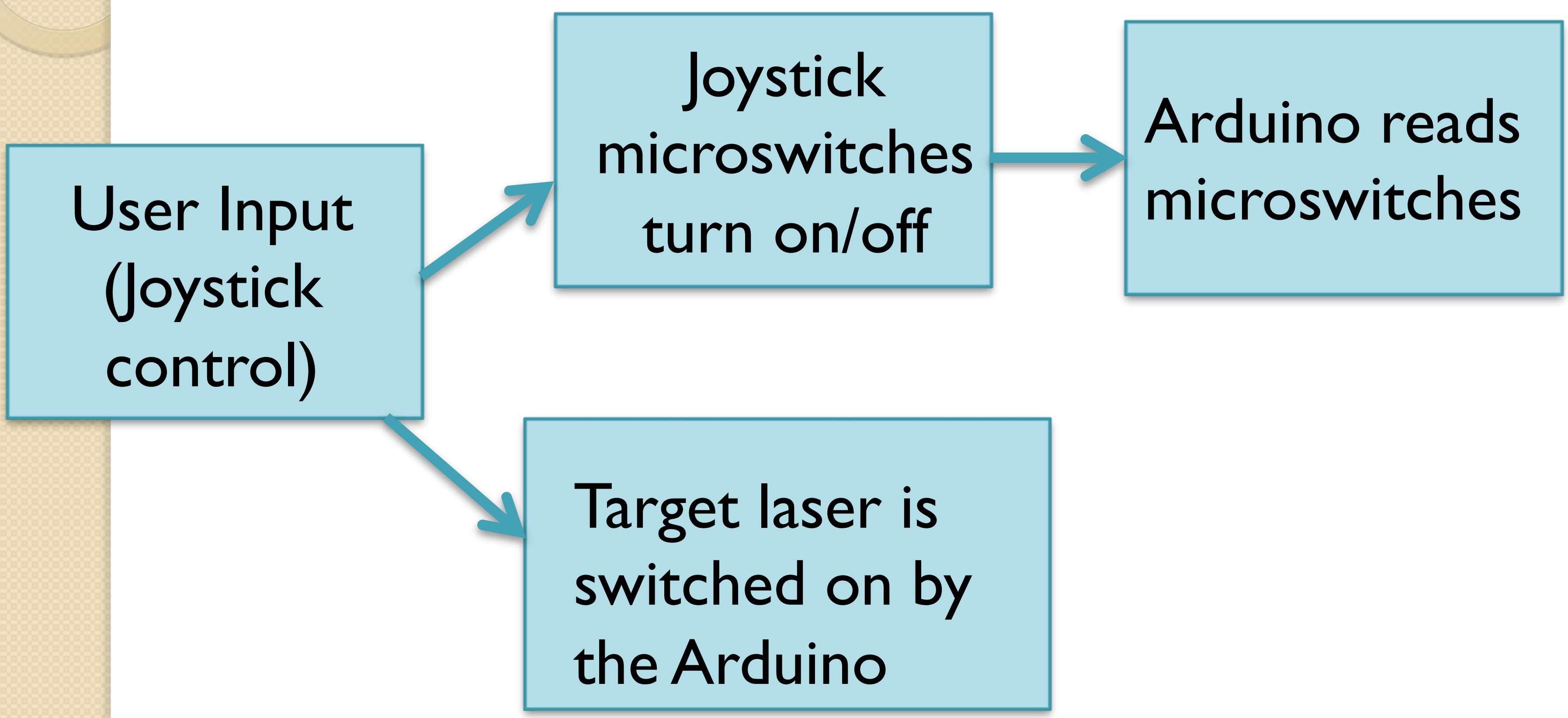
Design Inspiration

- Piezoelectric materials currently used in satellites today
- Applications include micropositioning and vibration damping of optics, signal sensors, and monitoring support structures
- We will utilize an MFC (macrofiber composite), invented by NASA in 1996

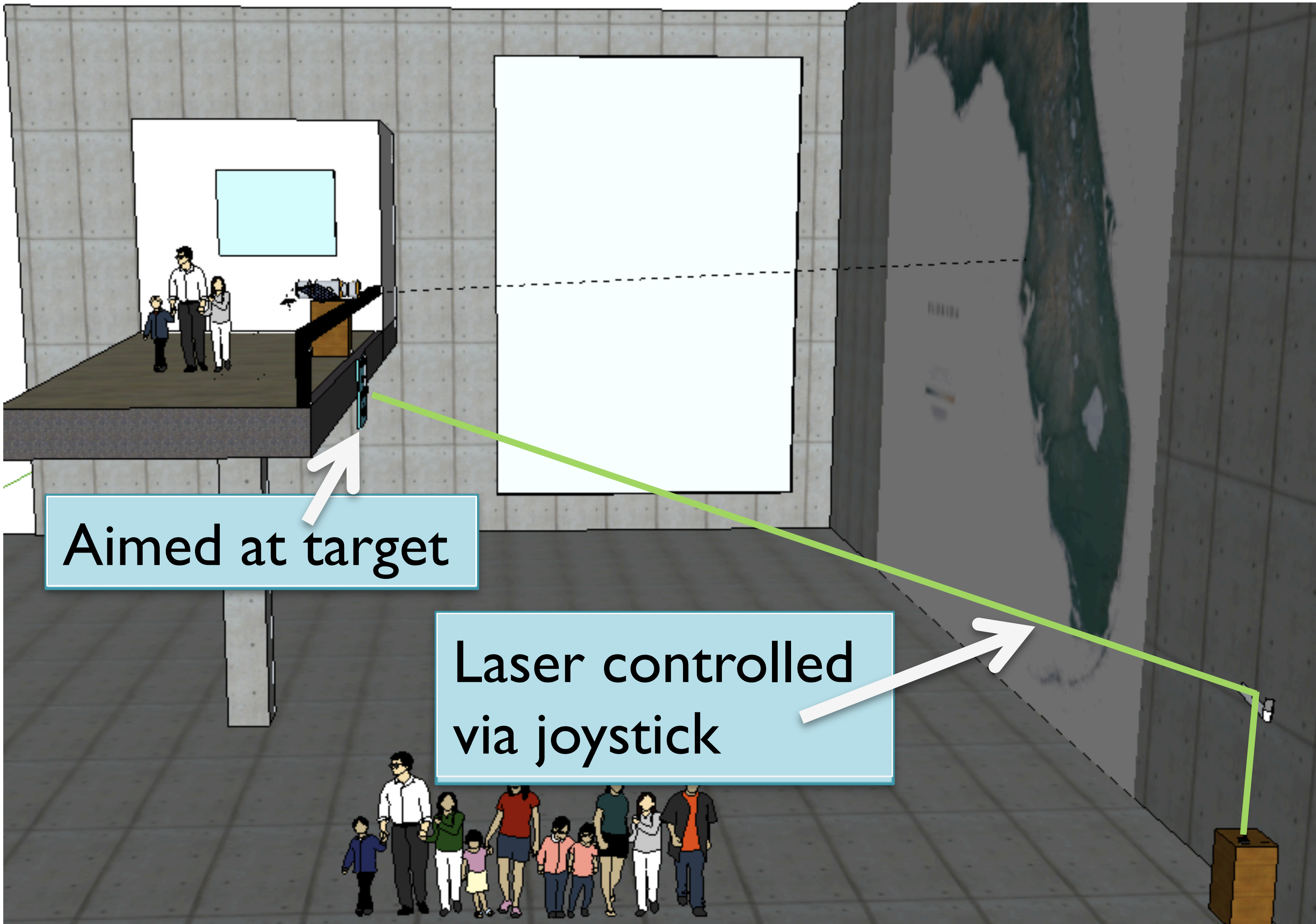
General View of Lobby



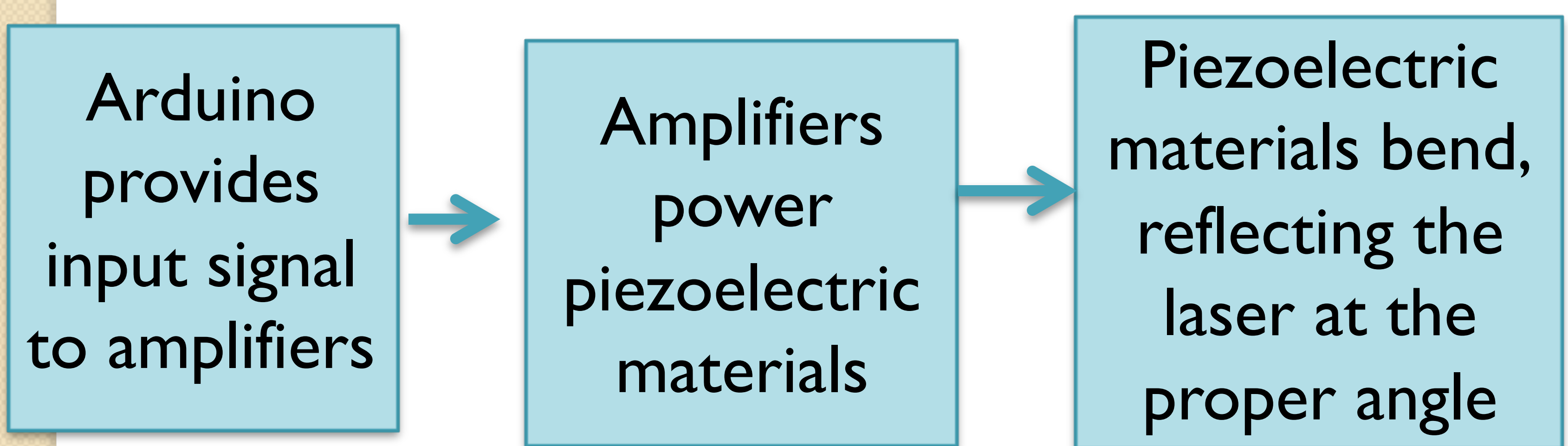
Step 1


User Input (Joystick control)
Joystick microswitches turn on/off
Arduino reads microswitches
Target laser is switched on by the Arduino

General View of Lobby

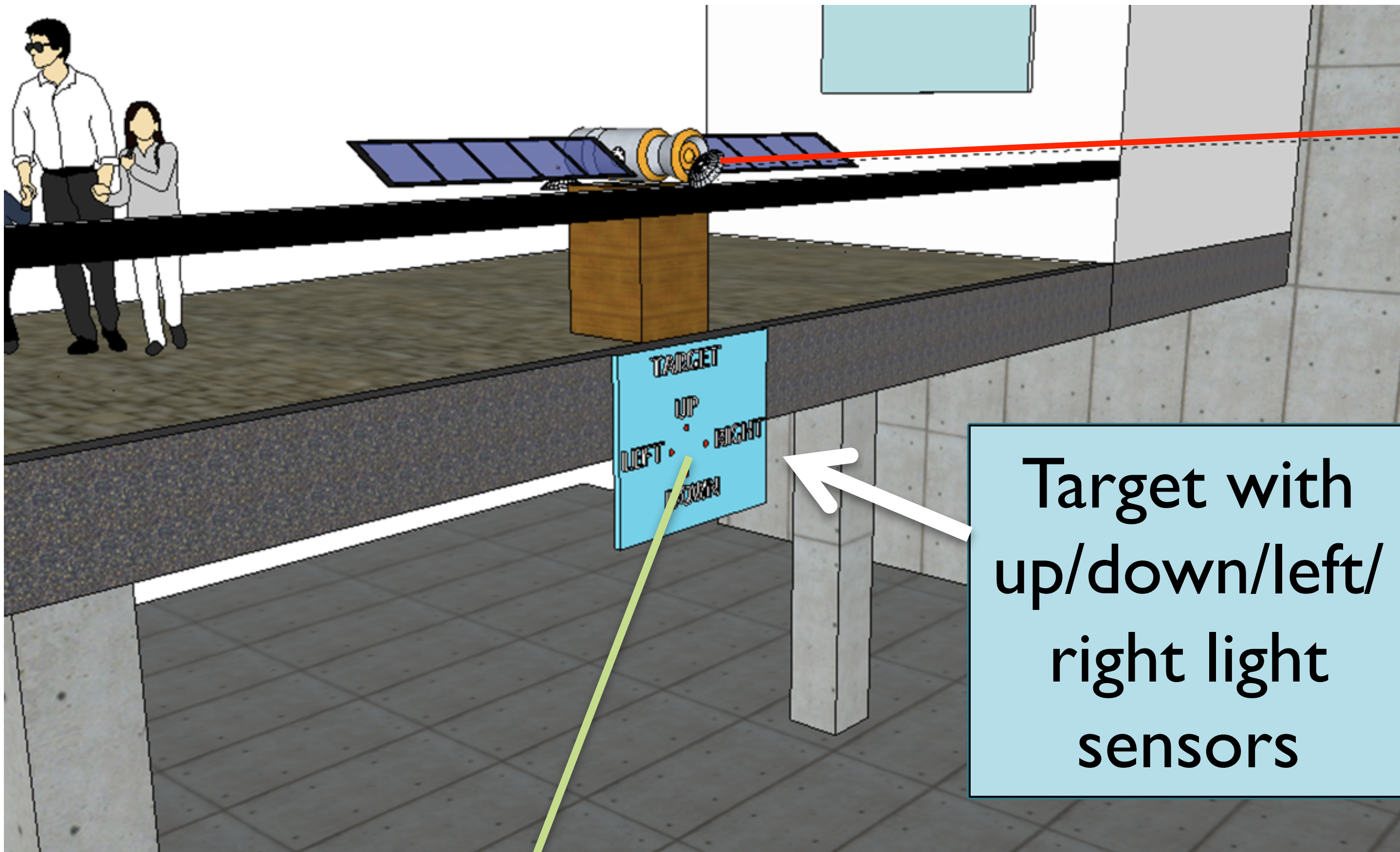


Step 2



Arduino provides input signal to amplifiers
Amplifiers power piezoelectric materials
Piezoelectric materials bend, reflecting the laser at the proper angle

Balcony View



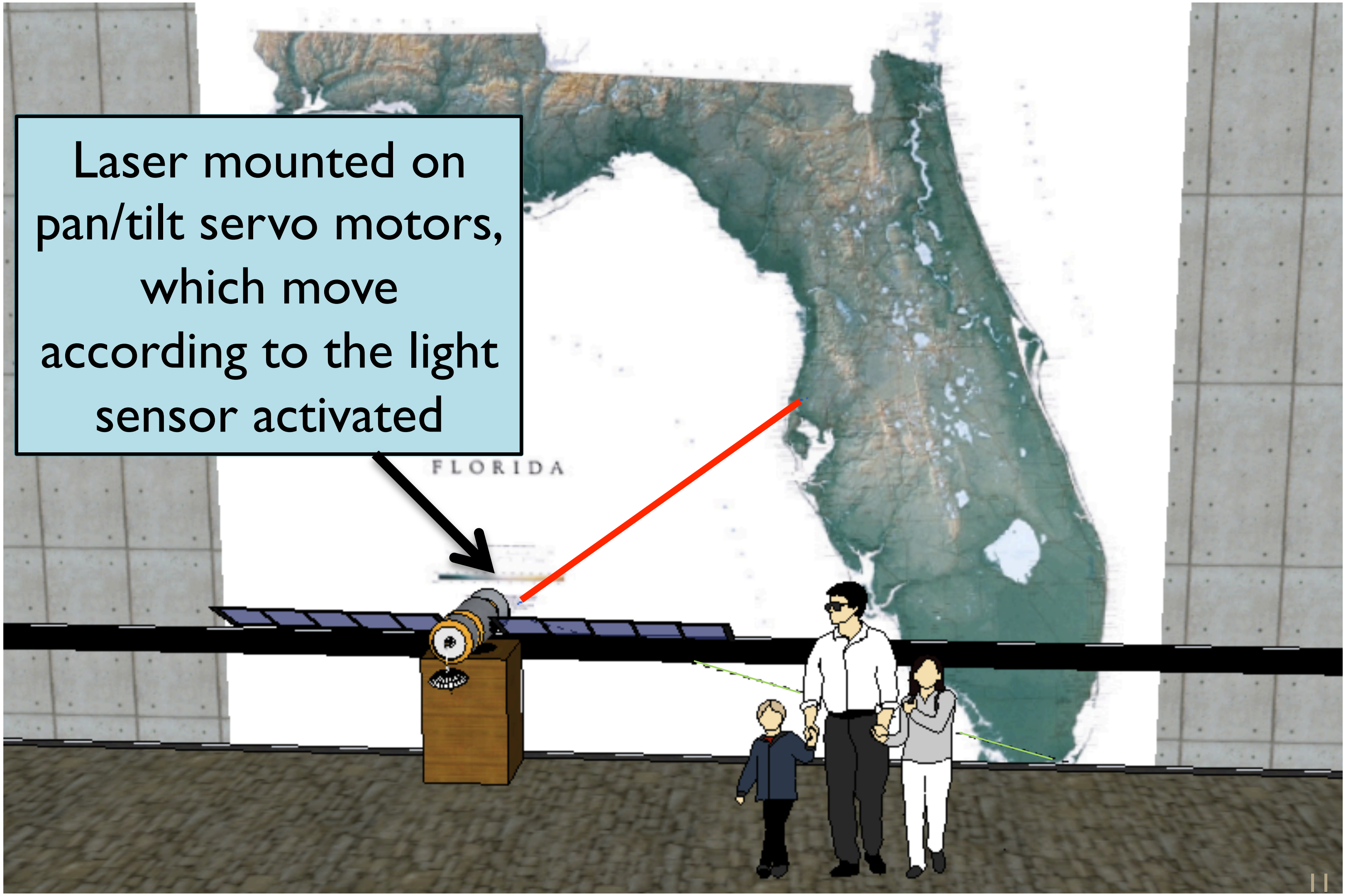
Step 3

Laser hits target light sensors

→

Light sensors signal fed to the second Arduino

Map View



Laser mounted on pan/tilt servo motors, which move according to the light sensor activated
FLORIDA

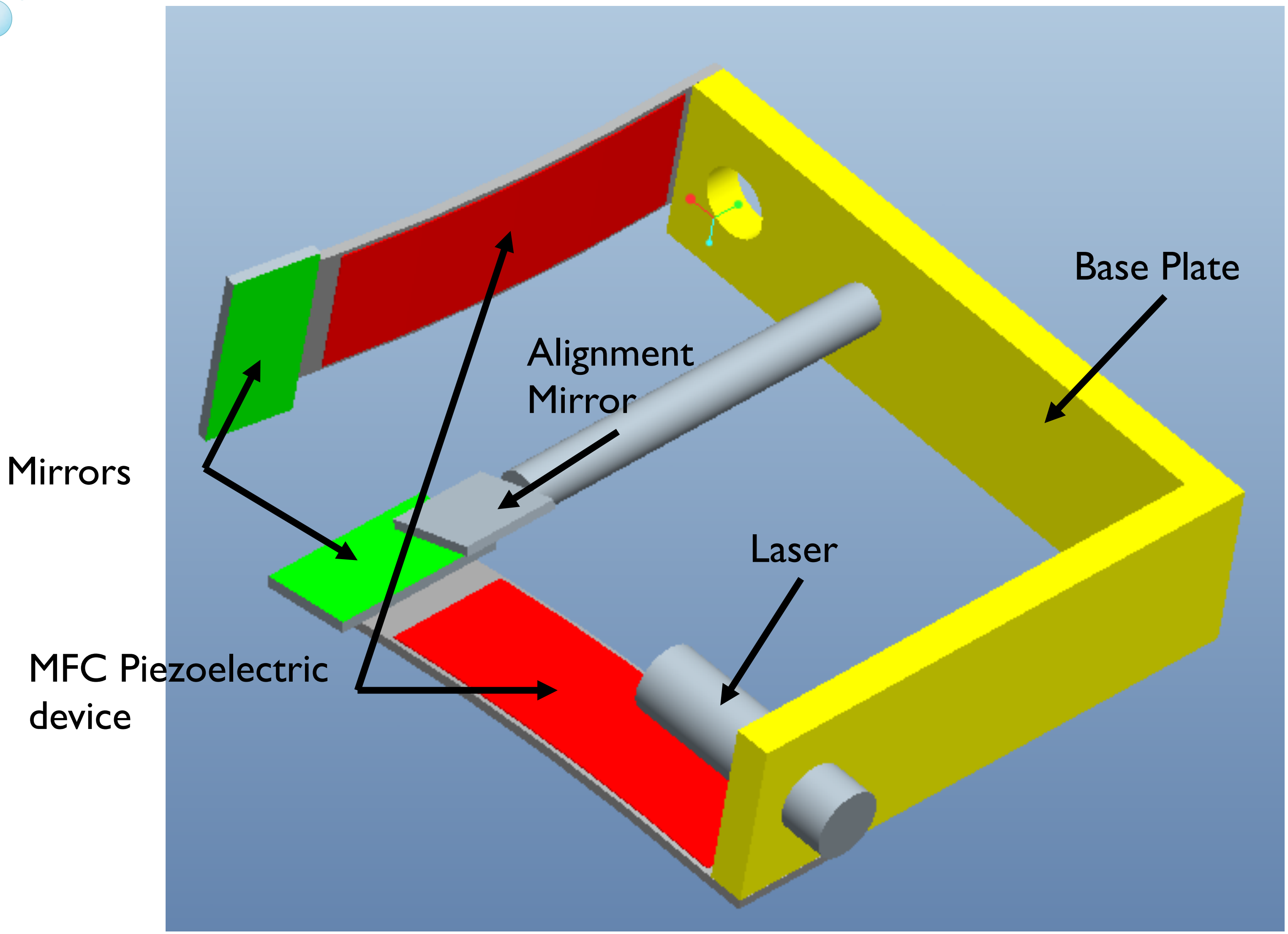
Step 4

Arduino powers the pan and tilt servos which move according to which light sensor is hit by the laser

→

Output laser is displayed on the map

Piezoelectric Laser Control Module

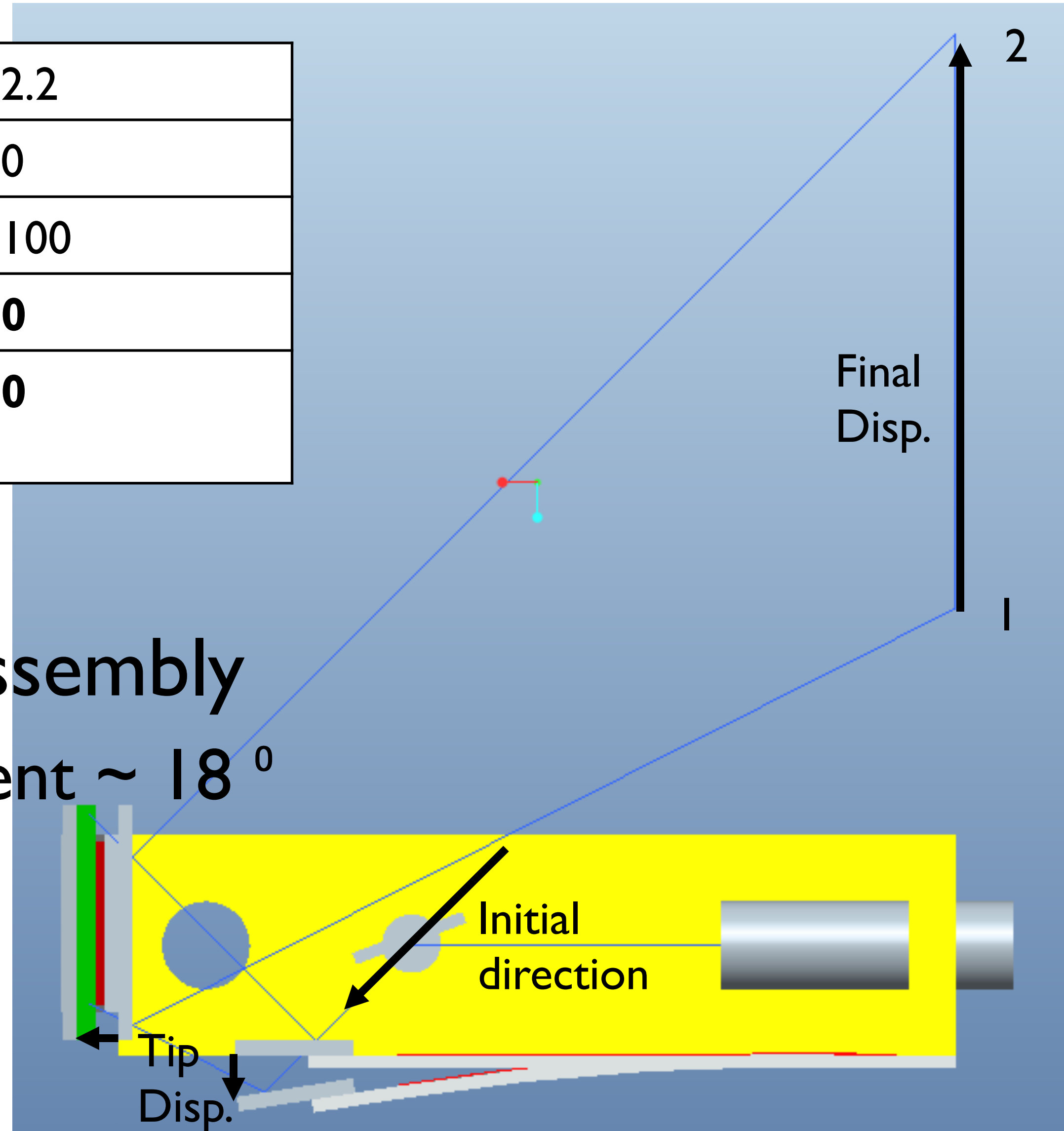


Calculations

Tmetal (mm)	2.2	2.2
Voltage(volts)	1500	0
Lin (mm)	100	100
difT (mm)	**1.9364**	**0**
Ang_disp (deg)	**9.07**	**0**

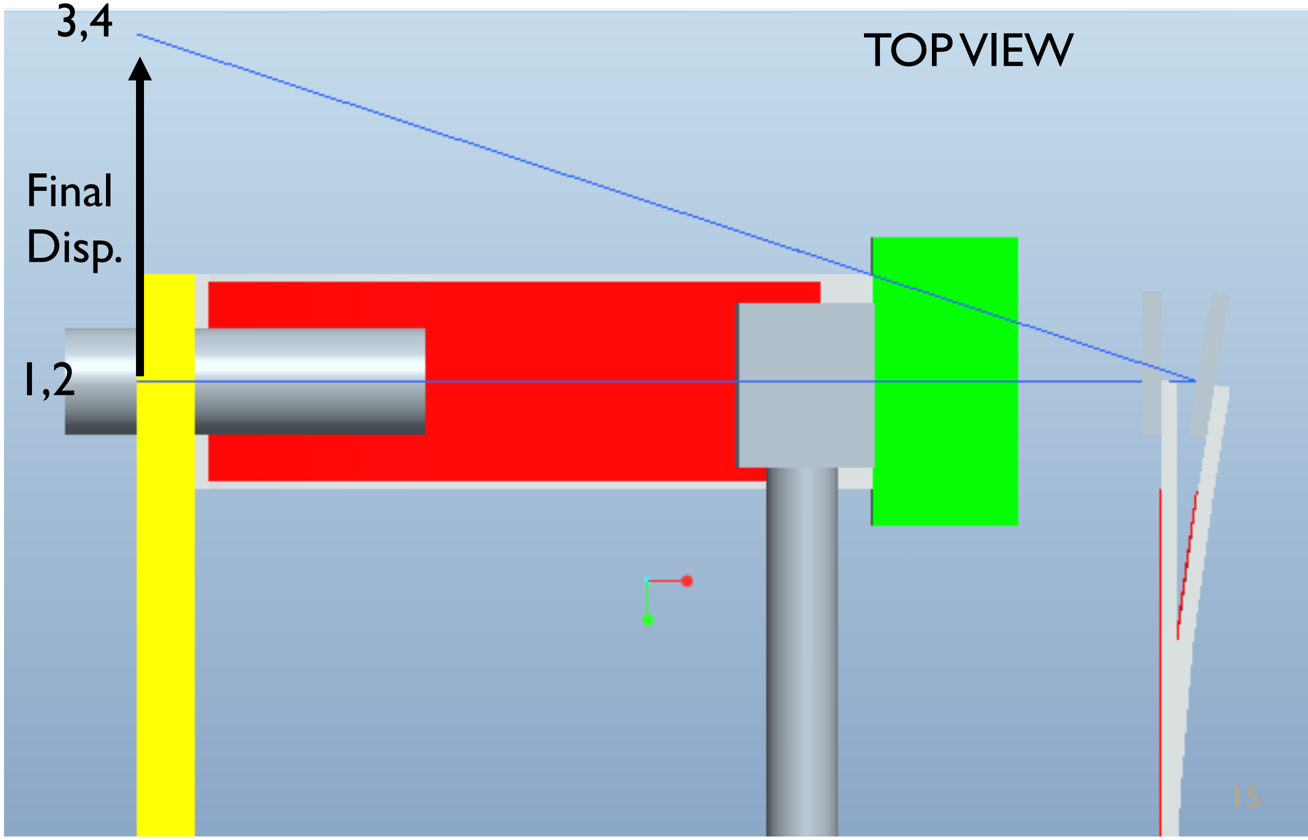
- Initial angle = 45 ^{0}
- 1st piezo/mirror assembly
  - Angular displacement ~ 18 ^{0}

FRONT VIEW



Calculations cont.

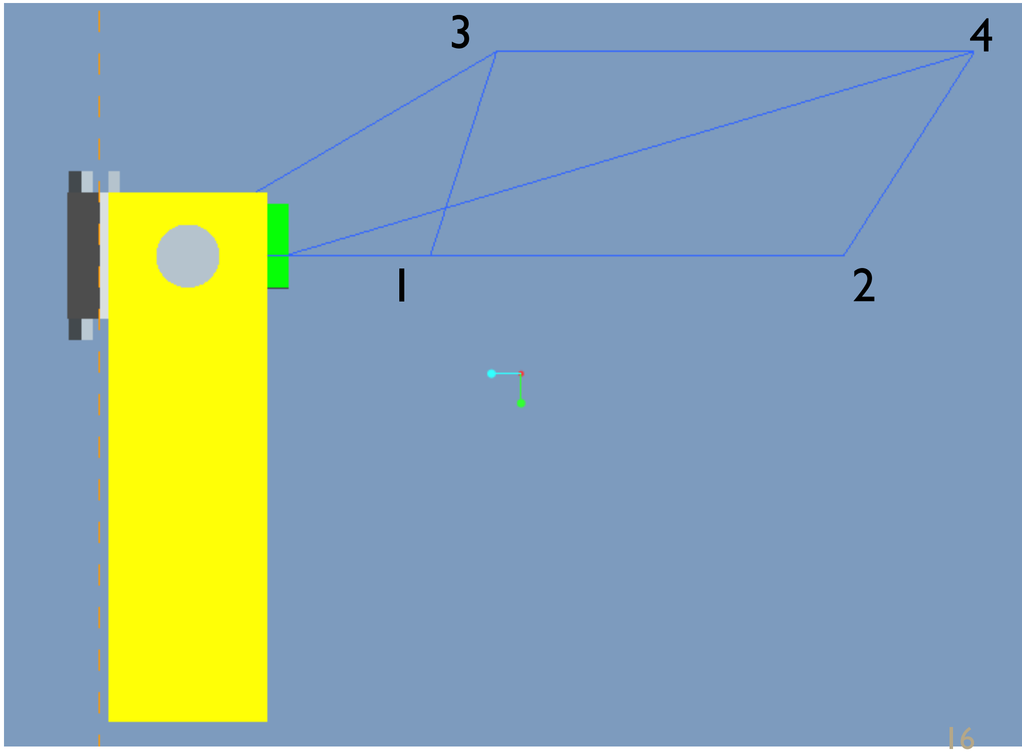
- 2nd piezo/mirror assembly
  - Angular displacement
    - ~ 12 ^{0}



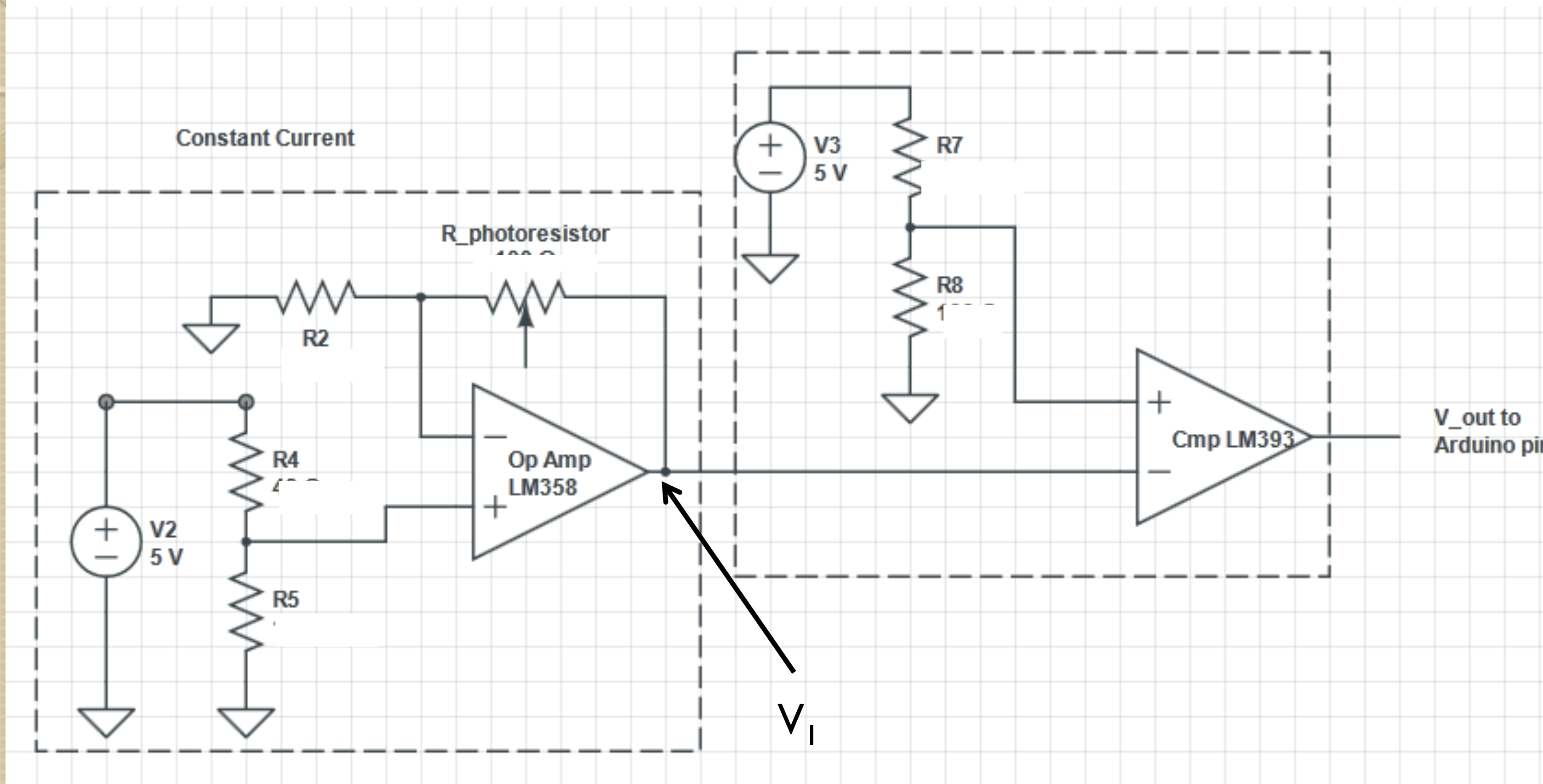
Projected area

- Expected
  - rectangular
- Actual
  - Trapezoidal
  - Caused by linear tip displacement

SIDE VIEW

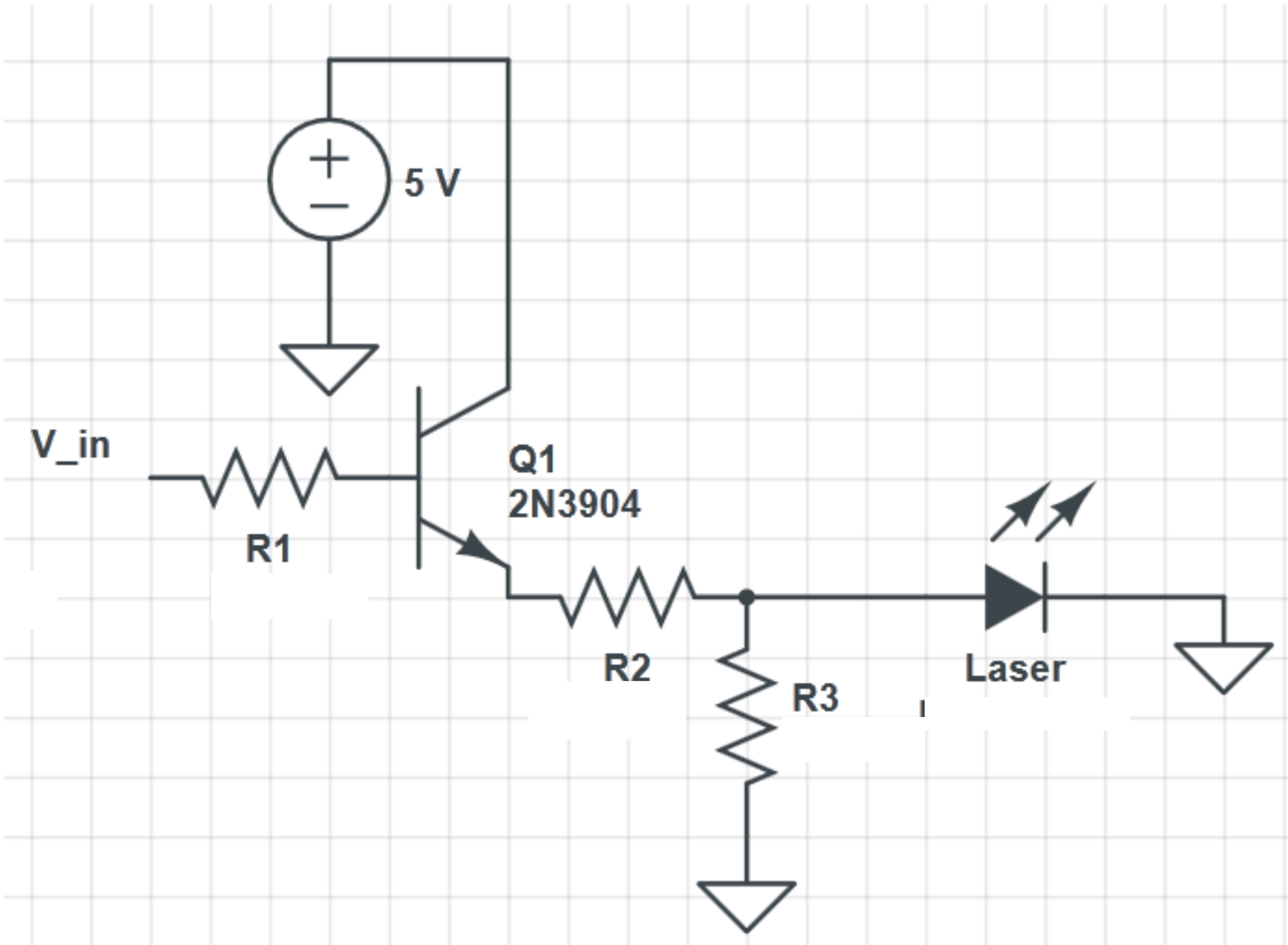


Laser Light sensor x4



Laser :: $R_{photoresistor}$ decrease :: V_1 decrease :: V_{out} = logic high

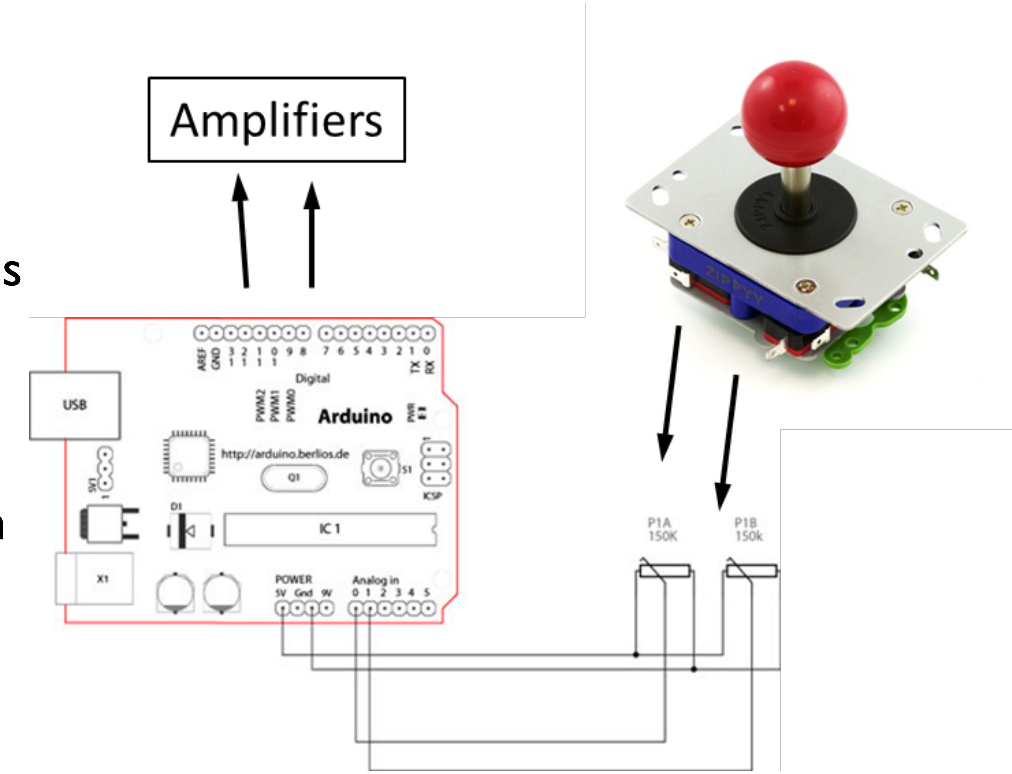
Laser Power Circuit x2



Materials

At User Interface:

- Joystick (Analog)
  - Final output of the laser is controlled via user input from joystick
- Arduino
- Two Amplifiers: **EMCO High Voltage**
  - Input: 0-5V
  - Output: 0-1500 V
- Two bending piezoelectric ceramics (MFC)
- Stationary Laser



Each amplifier and ceramic control one degree of freedom

Materials

At Satellite:

- Light Sensors
  - Photodiode, phototransistor, photo-resistors
- Arduino
  - Output controls pan and tilt servos
- Laser mounted on pan/ tilt kit
  - Laser projected onto map

Safety

- Laser
  - Keep out of people's line of sight
  - Raise height of piezoceramics
- Electrical wiring
  - Enclose it in locked case
- No environmental hazards

Concerns/Roadblocks

- Light sensors being visible
  - LED's around light sensors
  - Webcam

- School children understanding
  - Poster with proper instructions for operation
  - Information about smart materials

Conclusion/Future Plans

Purchase Materials

Testing

- Joystick control
- Pan/Tilt kit
- Laser projection on map

Assembly/ Installation

References

- "'NASA Invention of the Year' Controls Noise and Vibration." *NASA Spinoff*. NASA.gov, n.d. Web. 05 Dec. 2012. http://spinoff.nasa.gov/Spinoff2007/ip_9.html.
- "Performance High Voltage Power Supply Manufacturer." *EMCO High Voltage Power Supply Manufacturer*. N.p., n.d. Web. 25 Oct. 2012. <http://www.emcohighvoltage.com/>.
- "ArduinoBoardUno." *Arduino.cc*. N.p., n.d. Web. 05 Dec. 2012. <http://www.arduino.cc/en/Main/arduinoBoardUno>.
- "MFC." *Macrofiber Composite*. Smart Material, n.d. Web. 17 Nov. 2012. <http://www.smart-material.com/MFC-product-main.html>.
- "Piezo Actuators to Enable High-resolution Cosmic Dust Analysis." *SME Achievements*. European Space Agency, n.d. Web. 22 Oct. 2012. <http://www.esa.int/SPECIALS/SME_Achievements/SEMAADO7BTE_0.html>.
- "From the Satellite to the Ground." *Imagine the Universe*. NASA, n.d. Web. 22 Oct. 2012. <http://imagine.gsfc.nasa.gov/docs/sats_n_data/sat_to_grnd.html>.
- Turner, Janelle. "'NASA Invention of the Year' Controls Noise and Vibration." '*NASA Invention of the Year' Controls Noise and Vibration*. N.p., 1 May 2011. Web. 06 Dec. 2012.

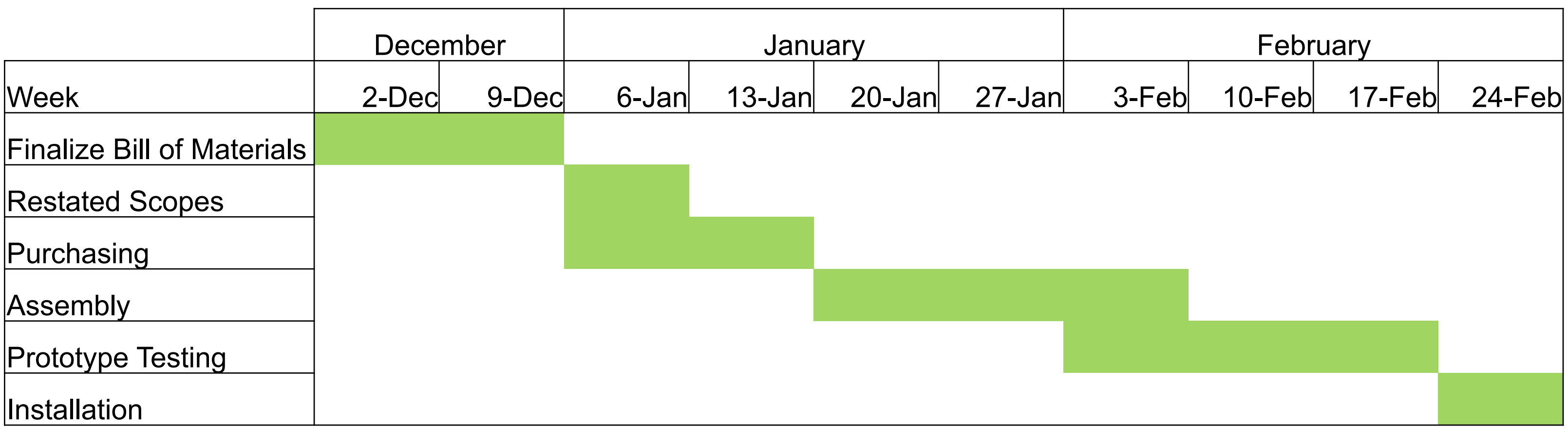
Bill of Materials

ITEM	DESCRIPTION	QUANTITY	COST
Piezoelectric Material	Smart Material Corp M8528 P1	2	Provided by FSU-FAMU COE
Laser	5 mW Green	2	$30.00
Laser/Piezo Stand and baseplate	Machined Aluminum	1	$50.00
Microcontroller	Arduino Uno	2	$59.90
Amplifier	EMCO-C30	2	Provided by FSU-FAMU COE
Light Sensors	Large photoresistors	4	$6.00
Mirror	Wall-mountable	1	$29.46
Joystick	4SJ200-0A-M4-S 2 Axis Joystick Potentiometer	1	$28.00
Exhibit Case	Acrylic	1	Provided by Sponsor
Exhibit Stand	Wood	1	$50.00
Pan/Tilt Kit	ROB-10335	1	$5.95
Small Servo Motor	ROB-09065	2	$17.90
Target	Craft Materials	1	$10.00
Mock Satellite	Craft Materials	1	$25

Total Cost: $312.21

Appendix

Gantt Chart

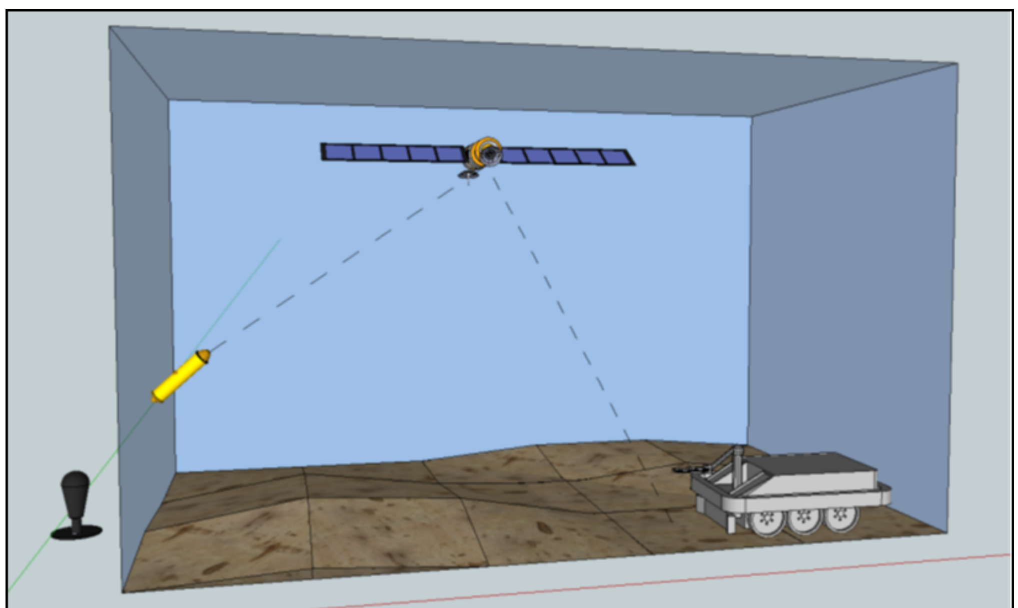


MFC: Macro-Fiber Composites

- Rectangular piezoceramic rods between layers of adhesive film containing tiny electrodes
- Transfer voltage to and from ribbon shaped robs
- Advantages:
  - Higher performance, flexibility, and durability

Concept 1: Laser Manipulated Robot

- Use direct/indirect laser control to manipulate the movement of a robot.
- Theme: Curiosity Mars Rover
- Operator guides the rover through a maze set up in the display

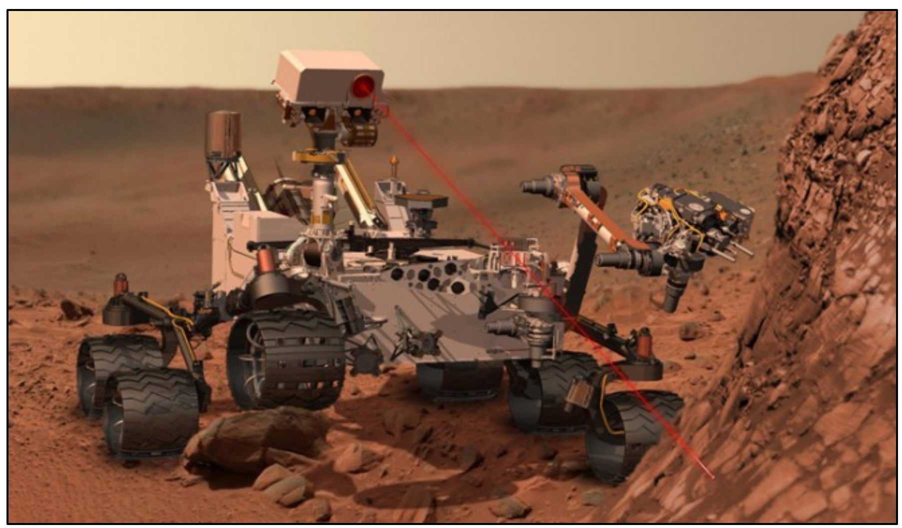


Concept 2: Laser Activated Satellite Control

- A mock satellite dish is positioned down range from the laser
- The movement (pan left/right, tilt up/down) of the dish is controlled by four different photodiodes
- Each respective photodiode induces specific movement in satellite when laser is pointed at it
- Satellite dish is positioned by the user so that the laser can be redirected by the reflective dish to a map

Concept 3: Mars Curiosity Rover Chem-Cam

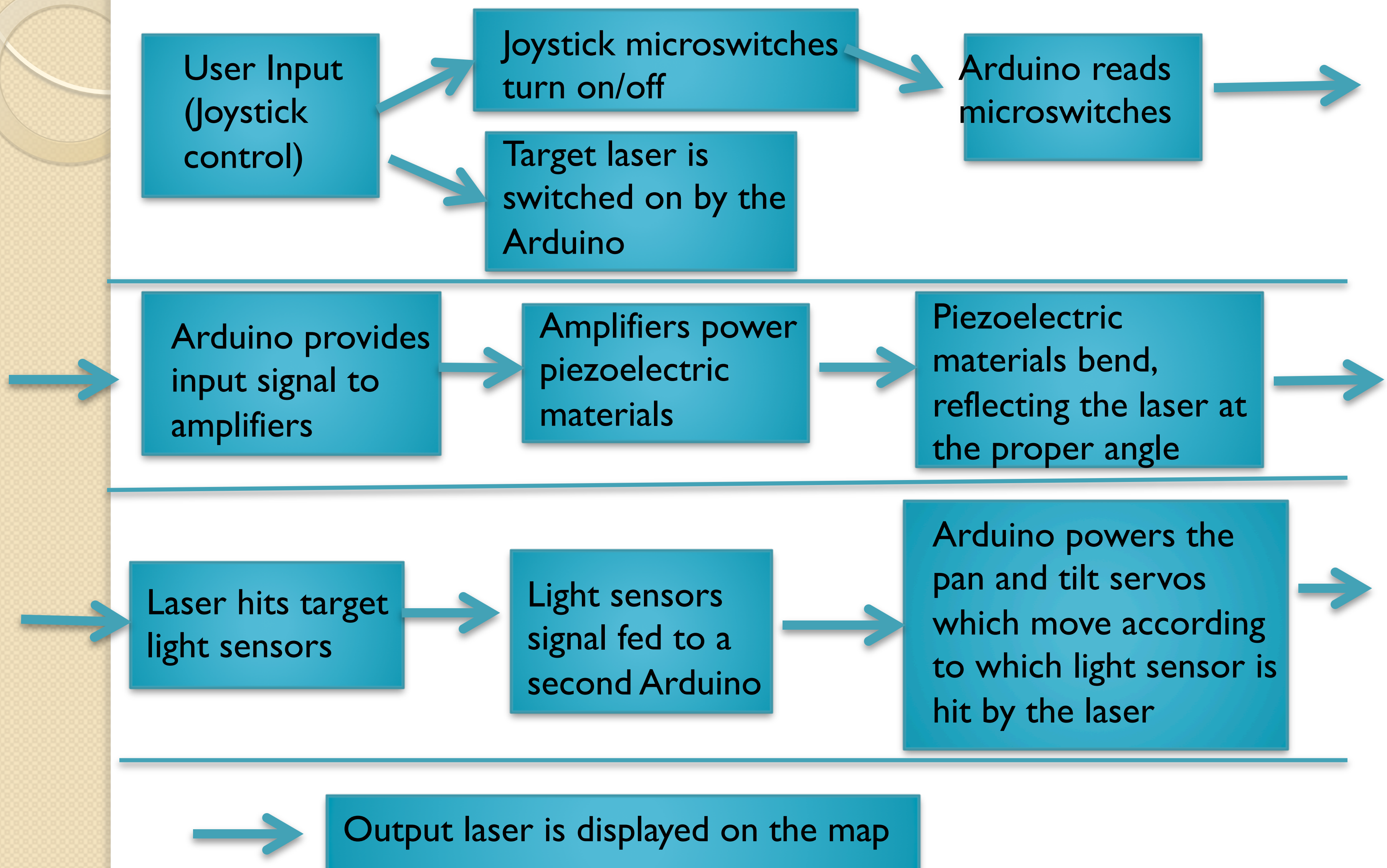
- Fixed laser turned on and aimed towards top of case
- It hits mirror and beam sent downward
- Laser beam then hits Curiosity's "ChemCam" which is composed of 2 piezoceramics covered in reflective material
- Beam then projected onto a Mars wall with photodoides (or Mars rocks)



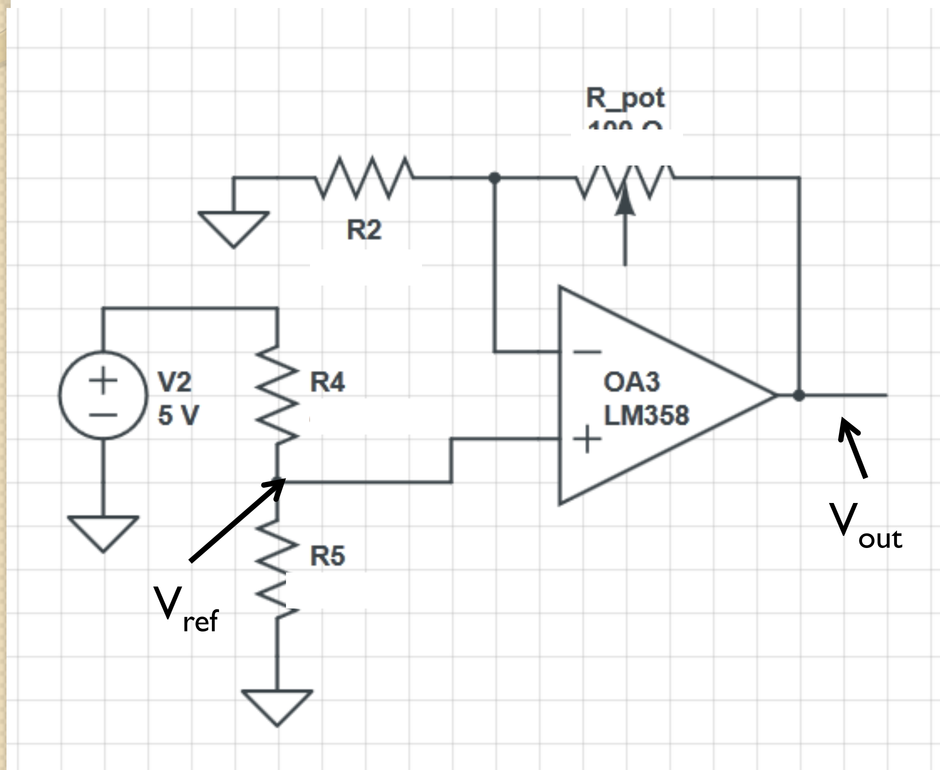
Decision Matrix

		Concept 1: Laser Manipulated Robot		Concept 2: Laser Activated Satellite Control		Concept 3: Mars Curiosity Rover Chem-Cam	
Specifications	Weight	Rating	Score	Rating	Score	Rating	Score
Estimated Cost	25%	3	0.75	4	1	2	0.5
Applicability to the Learning Center's educational program	40%	3	1.2	5	2	3	1.2
Educational Value	20%	3	0.6	3	0.6	4	0.8
Entertaining	15%	4	0.6	4	0.6	3	0.45
Total	100%		3.15		4.2		2.95

Flow Diagram



Joystick Sensor x2



$i_1 = V_{ref} / R_2$

$i_2 = 0$

$i_3 = i_1 = (V_{out} - V_{ref}) / R_{pot}$

$$\mathbf{V_{out} = V_{ref} (1 + R_{pot} / R_2)}$$
$$\mathbf{V_{ref} = 5 * (R_5 / (R_4 + R_5))}$$