Smart Material Museum Exhibit
Interim Design Review

Senior Design Group 13

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What Are Smart Materials?

- Materials with a property that can be controlled by an outside source such as stress, temperature, or electric and magnetic charge
- Piezoelectric materials: can produce a voltage if bent or altered and conversely the material will bend and produce a mechanical stress when a voltage is applied to it

Energy Transfer

Mechanical  Electrical

Real Life Applications

- Piezoceramics are currently used in adjustable antennas for satellite communications
- Antenna with piezoceramic components is able to bend slightly when provided with voltage
- Piezoceramics can change the reflector shape and this allows for an improvement of signal quality while the satellite is in orbit

Problem Statement

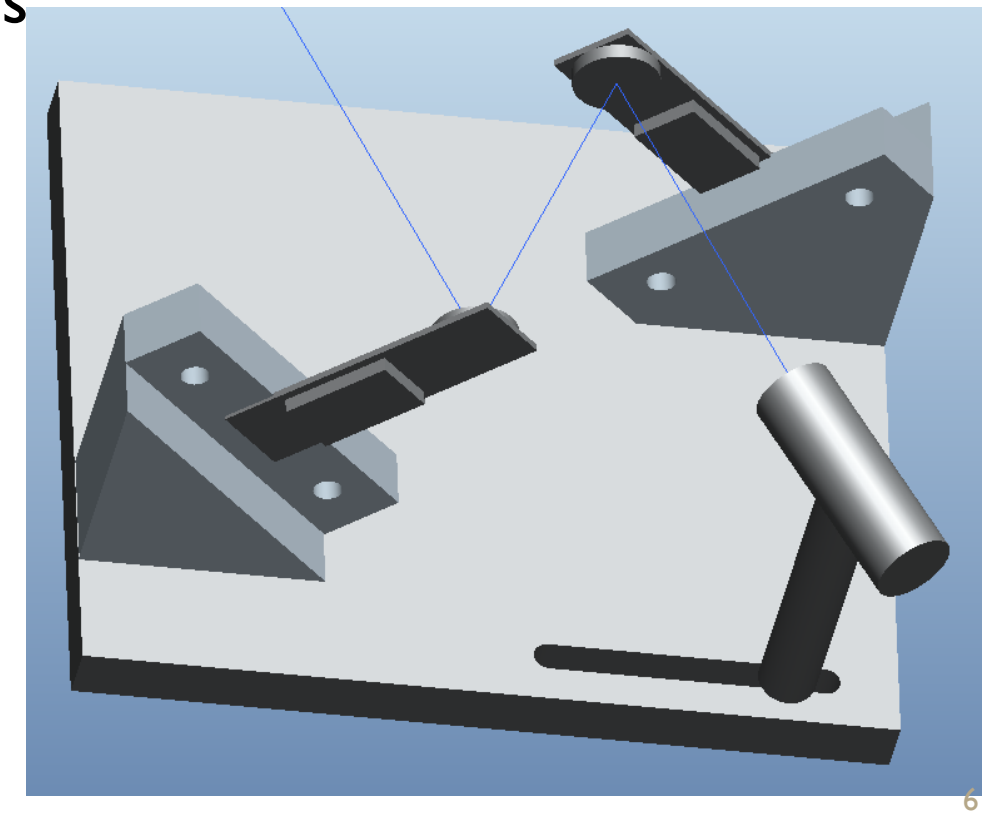
- The goal of this senior design project is to design, build, and test a museum exhibit
- Exhibit must utilize and demonstrate the behavior of a smart material and its applications
- Smart material chosen for this project is the piezoelectric type
- Exhibit must be interactive and entertaining for students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

Laser and Motion

- Class 3A Laser (laser pointer)
  - May need addition heat sink
- Indirect motion
  - Piezos move mirrors
  - Laser stationary



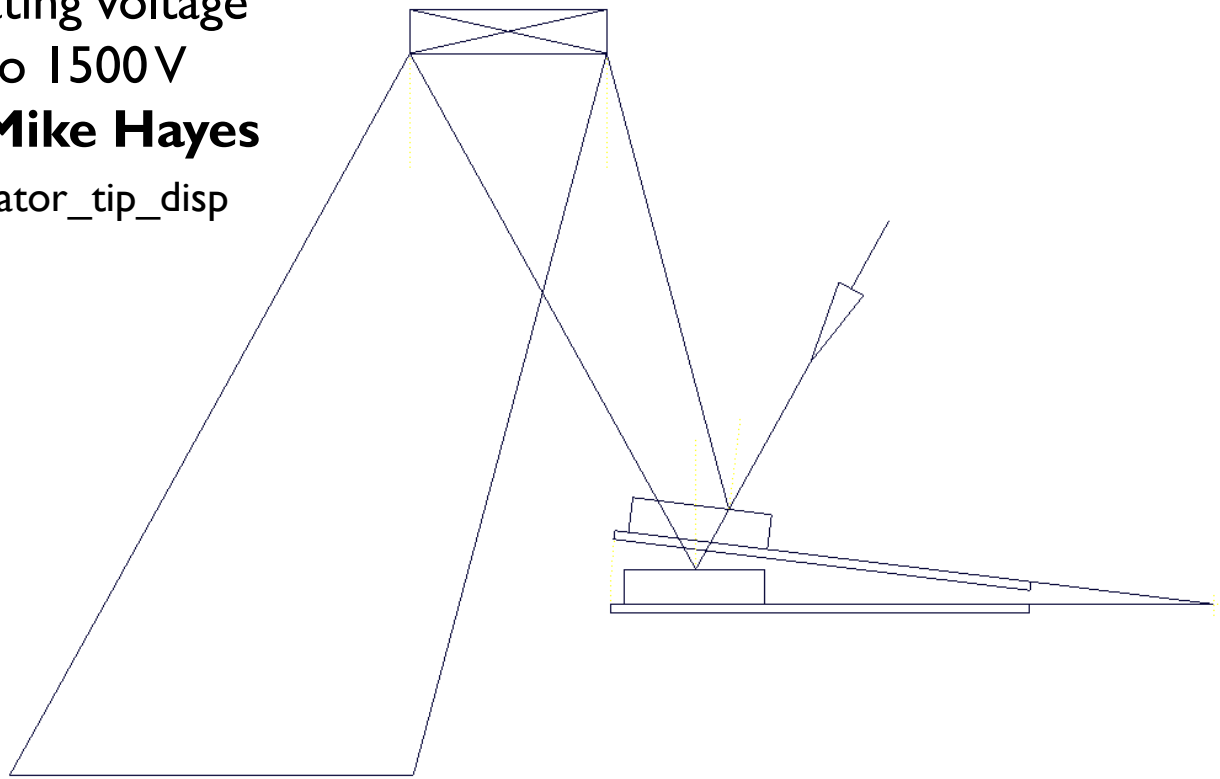
MFC Movement and Calculations

- **Smart Material Corp.**
  - **Macro Fiber Composite (MFC)**
    - MFC P1 type (d33 effect)
      - Elongator
    - Max operating voltage
      - -500 to 1500 V

Code provided by: Mike Hayes

>> laminar_actuator_tip_disp

Tmetal	2.2 mm
Voltage	1500 volts
Lin	2.15 inches
difT	**1.9364 mm**

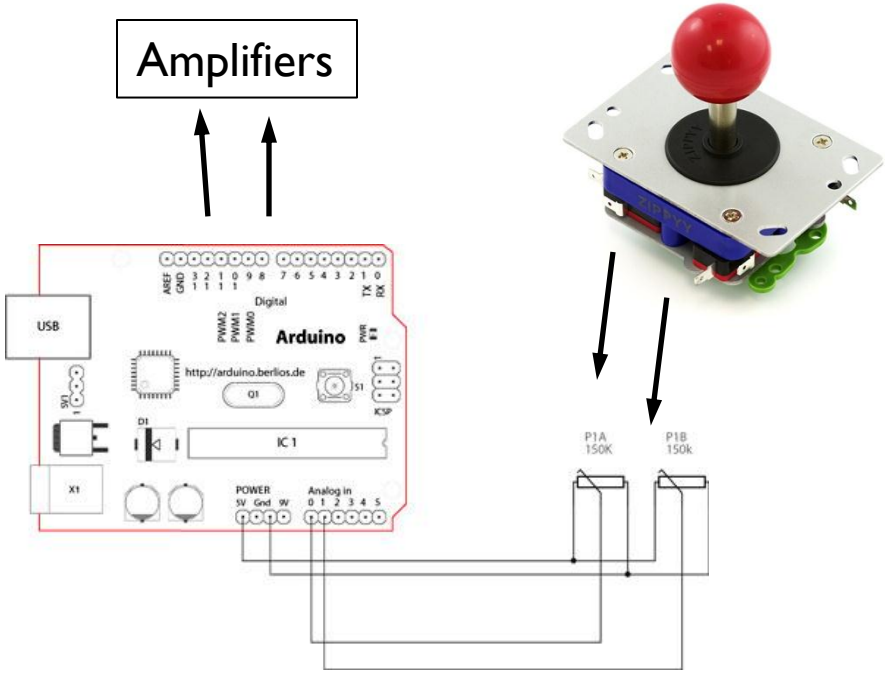


Amplifiers

- **EMCO High Voltage**
  - C series- 1 watt amplifiers
    - Needs a 1 watt 11.5-16 VDC power adapter
    - Input 0-5 V
    - Output 0-1500 V

Misc. Parts

- Light sensors
  - Photodiode, phototransistor, photo-resistors
- User interface
  - Joystick (Analog)
  - Arduino
  - Amplifiers



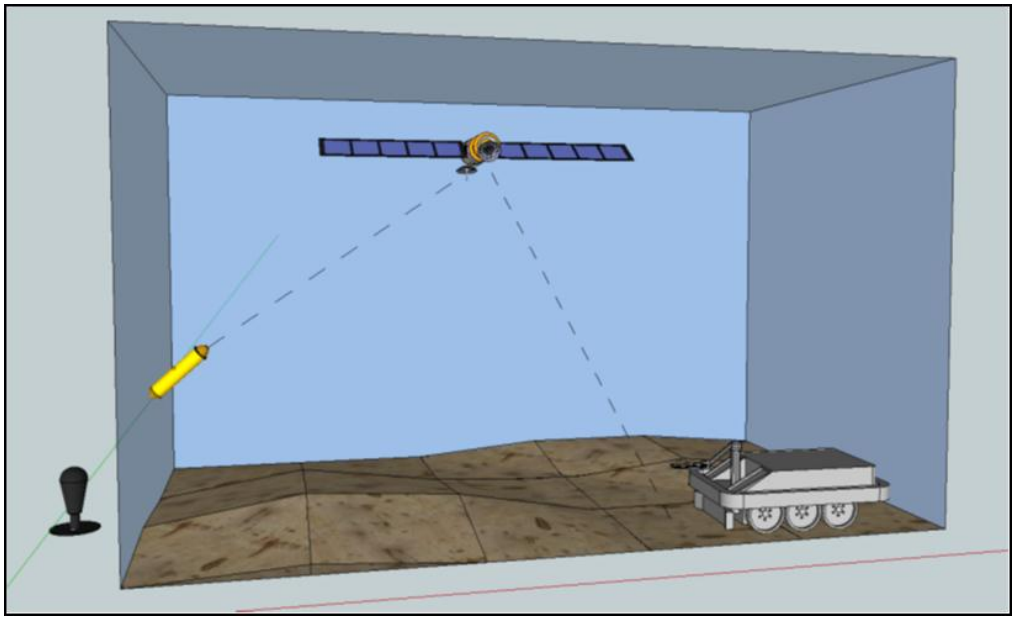
All design concepts utilize….

- Two bending piezoelectric ceramics
- Two amplifiers
- Joystick
- Laser

- Final output of the laser is controlled via user input from joystick
- Each amplifier and ceramic control one degree of freedom
- Each design concept also requires additional supplies unique to the design.

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

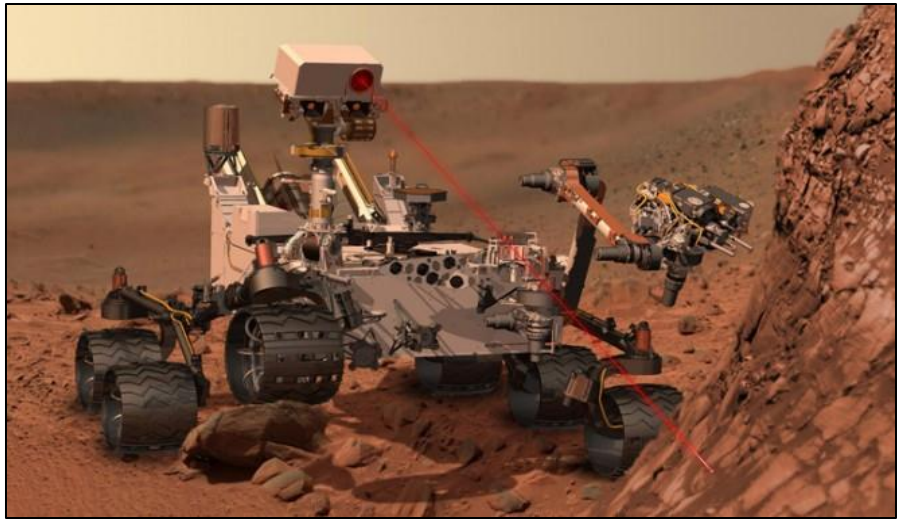


Concept 2: Laser Activated Satellite Control

- 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

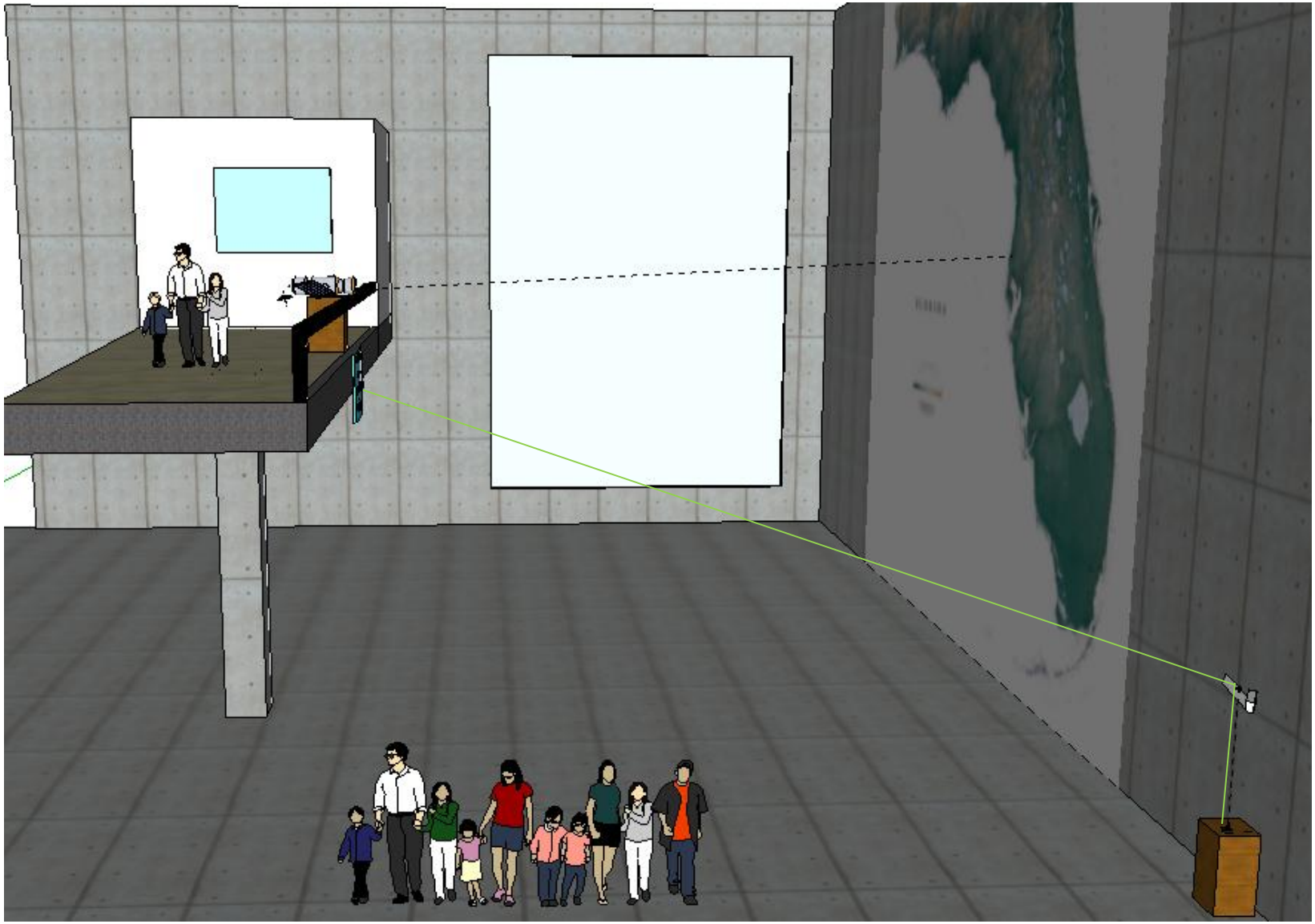
- Fixed laser turned on and aimed towards top of case
- It hits mirror and beam sent downward
- Laser beam then hits Curiosity's "ChemCam" which is composed of 2 piezoceramics covered in reflective material
- Beam then projected onto a Mars wall with photodoides (or Mars rocks)



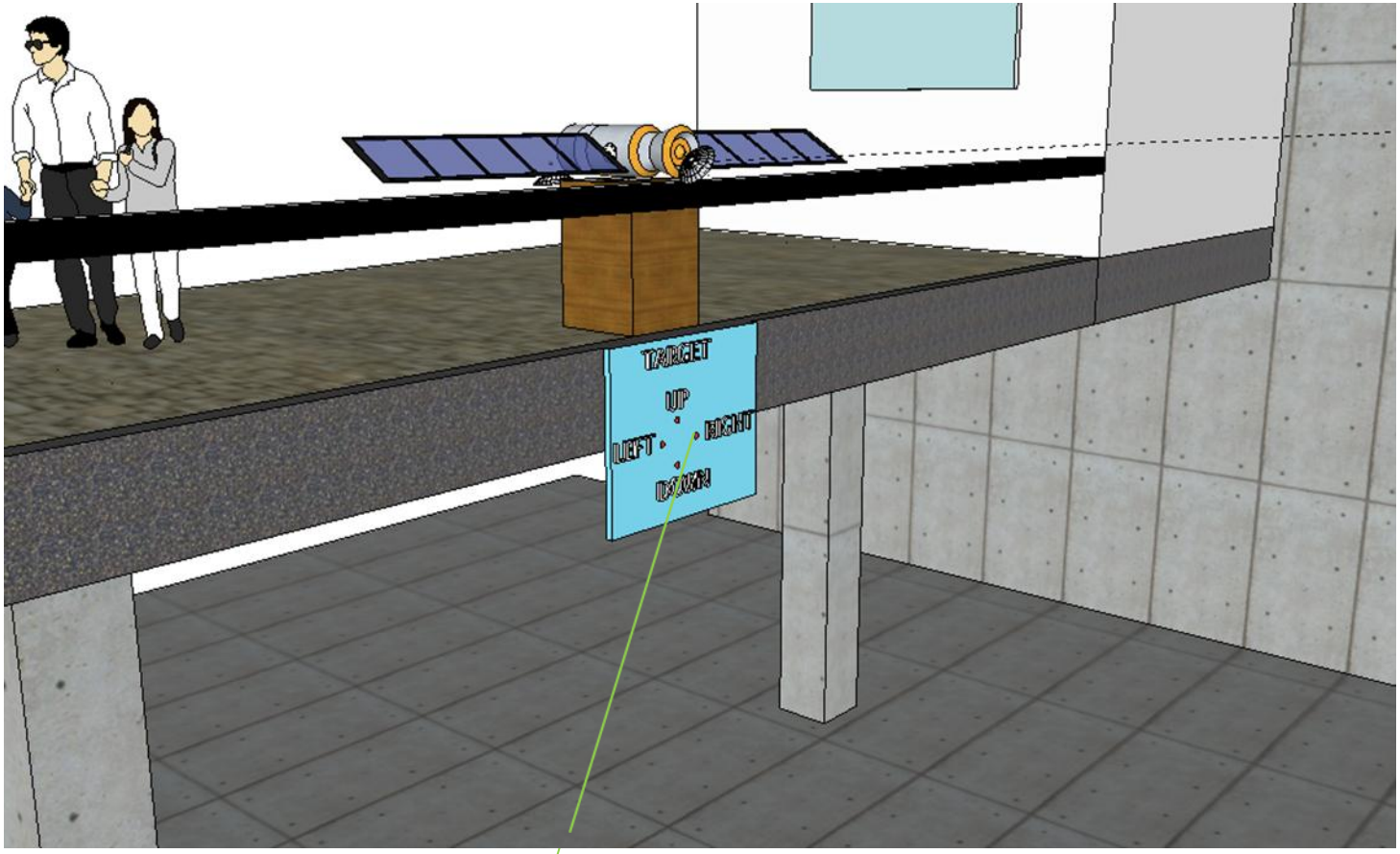
Decision Matrix

		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

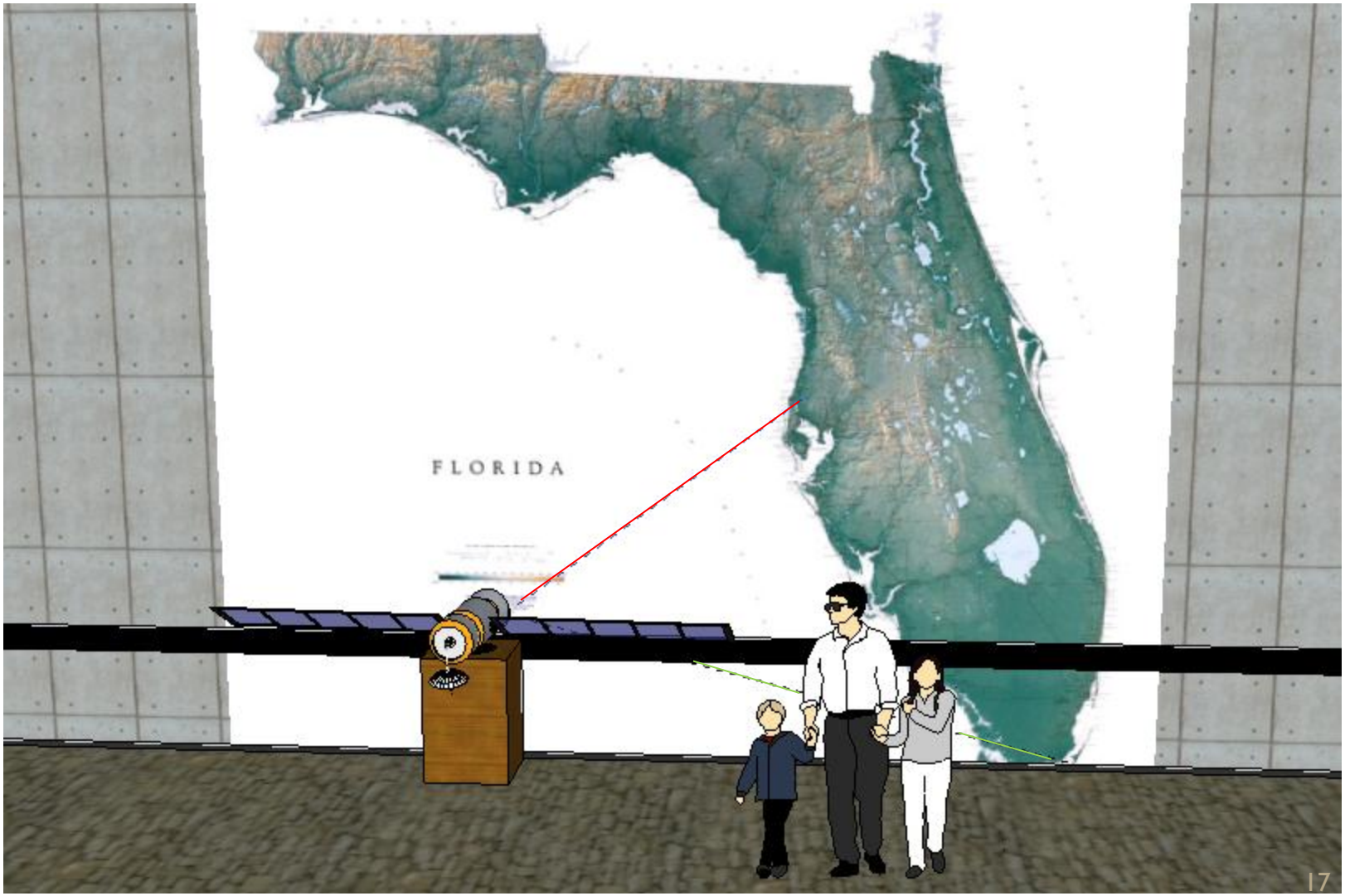
General View of Lobby



Balcony View

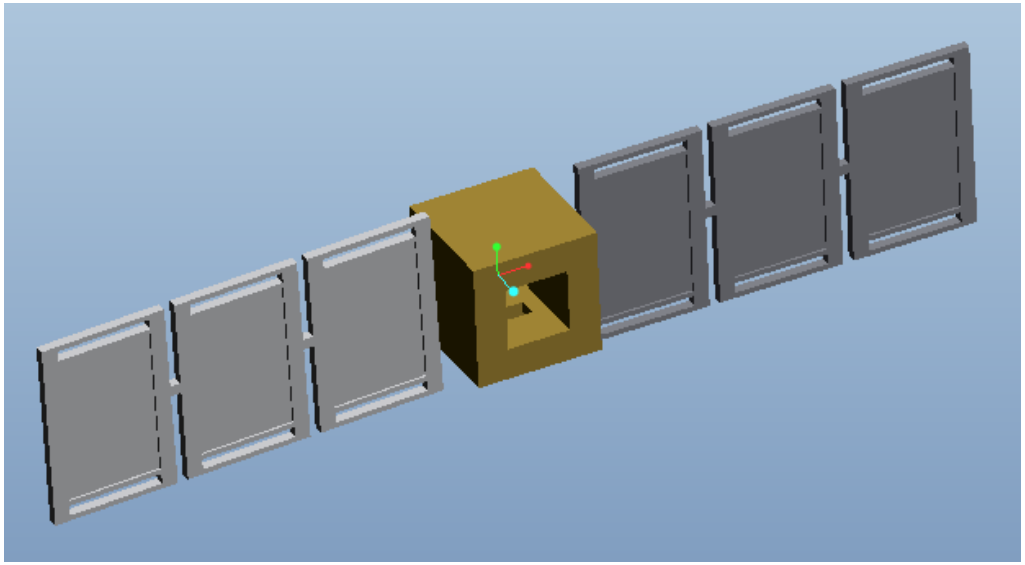


Map View



Satellite

- Majority of the satellite structure is for aesthetics
- Mounted on/near railing
- The outside will be stationary
- Cheap materials
- Laser mounted on pan/tilt kit mounted in hollow opening

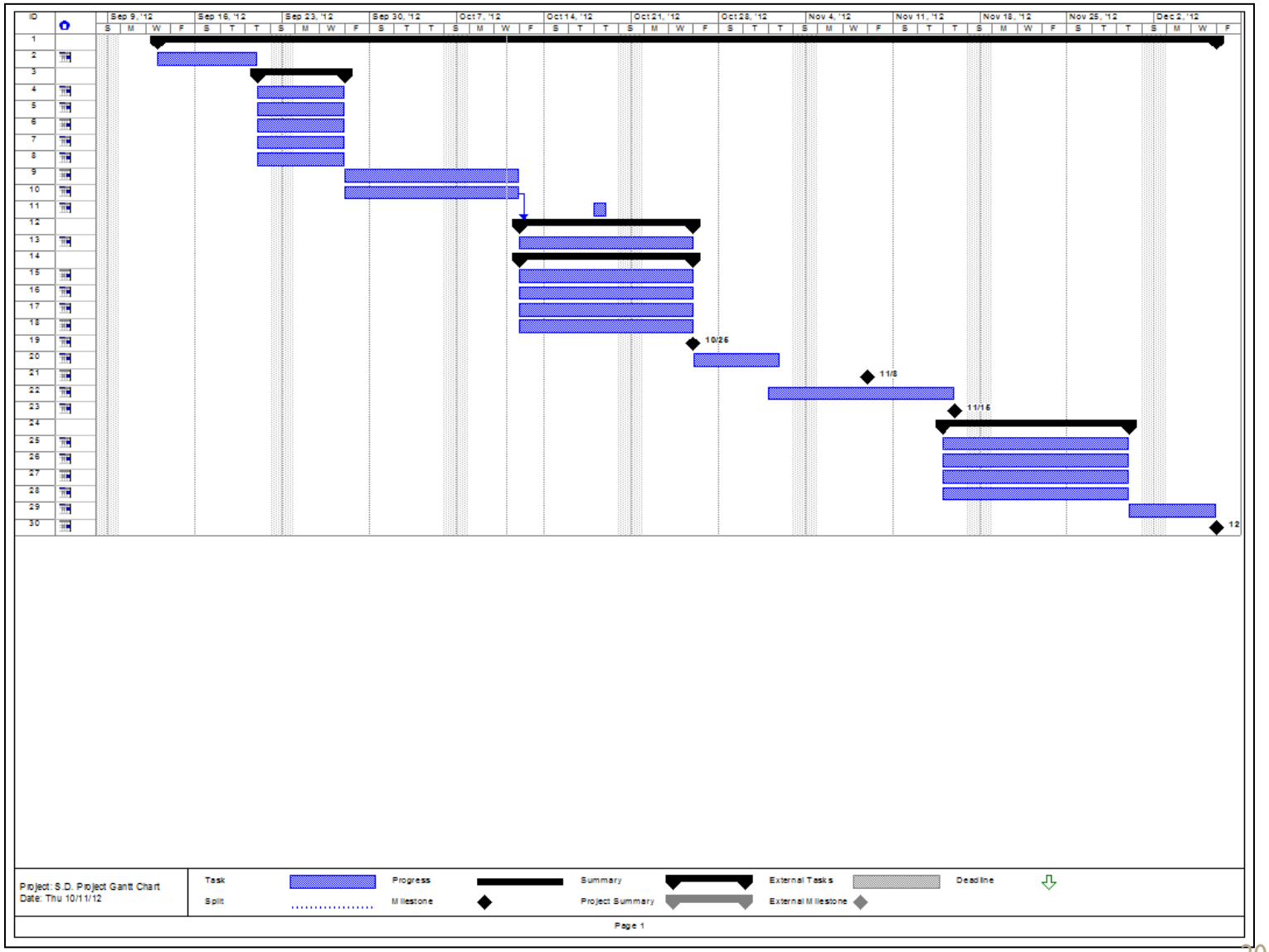


Schedule

S.D. Project Gantt Chart

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Fall 2012**	**61 days**	**Thu 9/13/12**	**Thu 12/6/12**	
2	Milestone #1 Code of Conduct	6 days	Thu 9/13/12	Thu 9/20/12	
3	**Milestone #2 Needs Analysis**	**5 days**	**Fri 9/21/12**	**Thu 9/27/12**	
4	Project Scope	5 days	Fri 9/21/12	Thu 9/27/12	
5	Problem Statement	5 days	Fri 9/21/12	Thu 9/27/12	
6	Justification/Background	5 days	Fri 9/21/12	Thu 9/27/12	
7	Objectives (Measurable Criteria)	5 days	Fri 9/21/12	Thu 9/27/12	
8	Constraints	5 days	Fri 9/21/12	Thu 9/27/12	
9	Milestone #3 Project Plan/ Product Spec	10 days	Fri 9/28/12	Thu 10/11/12	
10	Gantt Chart	10 days	Fri 9/28/12	Thu 10/11/12	
11	Discussion of Teams Eval. And Selection of	1 day	Thu 10/18/12	Thu 10/18/12	
12	**Milestone #4 Concept Generation/Selecti**	**10 days**	**Fri 10/12/12**	**Thu 10/25/12**	**10**
13	Functional Analysis	10 days	Fri 10/12/12	Thu 10/25/12	
14	**Individual Tasks and Assignments**	**10 days**	**Fri 10/12/12**	**Thu 10/25/12**	
15	Design Concepts Development	10 days	Fri 10/12/12	Thu 10/25/12	
16	Concept Evaluation and Selection	10 days	Fri 10/12/12	Thu 10/25/12	
17	Product Specifications for hardwan	10 days	Fri 10/12/12	Thu 10/25/12	
18	Performance and Functional Spec	10 days	Fri 10/12/12	Thu 10/25/12	
19	Midterm Presentation I	0 days	Thu 10/25/12	Thu 10/25/12	
20	Team Evaluation Report	5 days	Fri 10/26/12	Thu 11/1/12	
21	Presentation to MEAC	0 days	Thu 11/8/12	Thu 11/8/12	
22	Interim Design Review	11 days	Thu 11/1/12	Thu 11/15/12	
23	Midterm Prsentation II	0 days	Thu 11/15/12	Thu 11/15/12	
24	**Interim Design Deliverables**	**11 days**	**Thu 11/15/12**	**Thu 11/29/12**	
25	Bill of Material	11 days	Thu 11/15/12	Thu 11/29/12	
26	Work Orders	11 days	Thu 11/15/12	Thu 11/29/12	
27	Parts	11 days	Thu 11/15/12	Thu 11/29/12	
28	Machining	11 days	Thu 11/15/12	Thu 11/29/12	
29	Milestone #5 Deliverable Package Report	5 days	Fri 11/30/12	Thu 12/6/12	
30	Final Design Presentation	0 days	Thu 12/6/12	Thu 12/6/12	

Schedule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Sep 9, '12
Sep 16, '12
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Oct 7, '12
Oct 14, '12
Oct 21, '12
Oct 28, '12
Nov 4, '12
Nov 11, '12
Nov 18, '12
Nov 25, '12
Dec 2, '12
10/26
11/8
11/16
12
Project: S.D. Project Gantt Chart
Date: Thu 10/11/12
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline
Page 1

Potential Roadblocks/Concerns

- Photodiodes being visible
  - -binocular
  - -webcam
- Safety
  - - laser
  - - electrical wiring
- Kids understanding “smart material”

Conclusion

- Part selection and purchasing is currently underway
- Another meeting with Challenger Learning Center before the end of the semester to update our progress
- After obtaining components, building and testing will commence

References

- "Boe-Bot Robot Information." *Boe-Bot Robot Information*. N.p., n.d. Web. 20 Oct. 2012. <http://www.parallax.com/go/boebot>.
- "NASA - National Aeronautics and Space Administration." *NASA*. N.p., n.d. Web. 17 Oct. 2012. <http://www.nasa.gov/mission_pages/msl/index.html>.
- "Phototransistors Information." *On GlobalSpec*. N.p., 1999. Web. 20 Oct. 2012. <http://www.globalspec.com/learnmore/optoelectronics_fiber_optics/optoelectronics/phototransistors>.
- "Scribbler Robot Information." *Scribbler Robot Information*. N.p., 2012. Web. 24 Oct. 2012. <http://www.parallax.com/tabid/455/Default.aspx>.
- "Performance High Voltage Power Supply Manufacturer." *EMCO High Voltage Power Supply Manufacturer*. N.p., n.d. Web. 25 Oct. 2012. <http://www.emcohighvoltage.com/>.
- "MFC." *Macrofiber Composite*. Smart Material, n.d. Web. 22 Oct. 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>.