Laser Pointer

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Overview

- Client Background
- Project Overview
- Need and Constraints
- Concept Generation
- Chosen Design
- Analysis
- Cost Breakdown
- Schedule
- Conclusion

Client Background

Client: Mr. Edwin Anderson

Support Systems Analyst for NAU Physics Department

Hosts astronomy talks to large groups using laser to point out stellar bodies

Need Statement

Mr. Anderson is unable to give star gazing talks to large groups of people because the laser isn’t powerful enough. More powerful lasers are too dangerous to be handheld.

Project Goal

The goal of this project is to design and construct a mechanism to safely focus the attention of an audience towards individual stars or constellations while observing the night sky.

Objectives

- Controllable laser pointer mechanism
- Laser pointer mounting elevation above ground greater than 6’ 5”
- Pointer resolution at ½°
- Collapsible to fit in cargo compartment of a small car - 48”
- Weight - One person mobility 100 lbs
- Rapid response time 24°/second

Operating Conditions

Locations:

- NAU Observatory grounds
- Buffalo Park
- Heritage Square
- Various schools

Weather Conditions:

- Typical Flagstaff year round night conditions
- Low temperatures, > -5 °F
- Medium-high wind speeds, Max = 30 mph

Constraints

- Must operate in safe manner i.e. no possibility of laser beam pointing into a person’s eyes
- Laser must toggle on and off upon user command
- Laser unit must be removable from device
- Must remain within allowable budget
- Must comply with all local, state, and federal regulations

Regulation

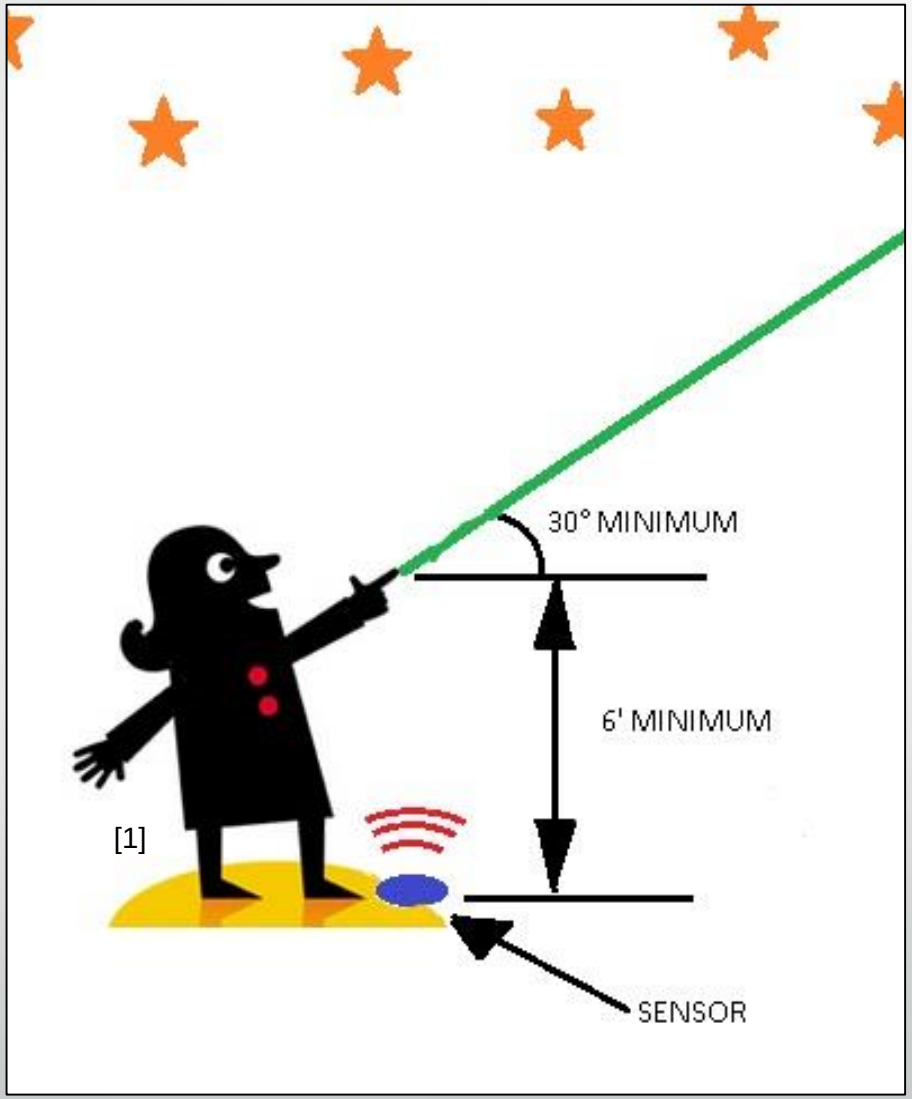
- AZRRA – AZ Radiation Regulatory Agency
  - Actively conduct inspections
  - Need administrative control of laser

- Legal compliance:
  - Controlled storage and use
  - Labeling
  - Training

Concept 1

Hand Held Unit

Hand Held Concept Diagram



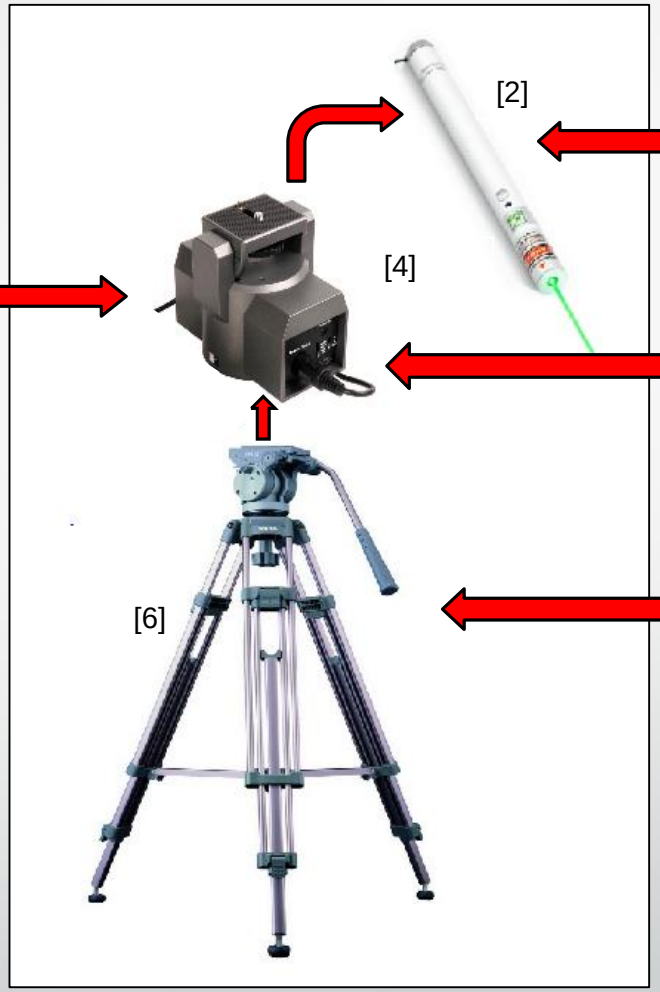
[1]

Concept 2

Tablet Control

[2]

Overall Design Concept



20 mW laser

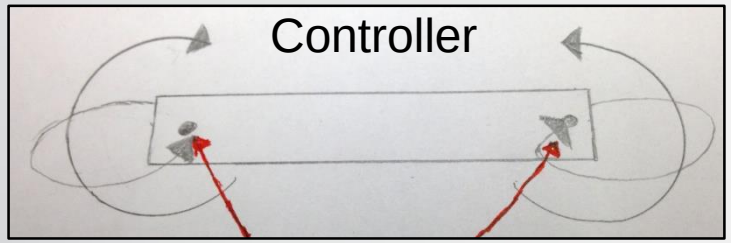
Two axis turret

6 Foot adjustable tripod

Concept 3

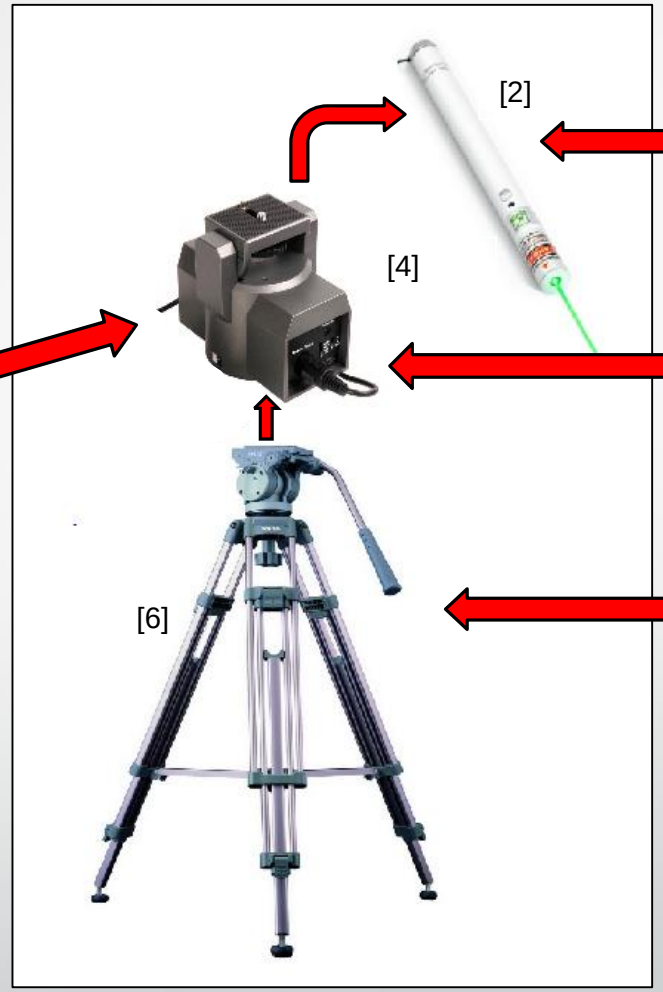
Smart Phone Control

6 Axis Controller



Accelerometers

Overall Design Concept



20 mW laser

Two axis turret

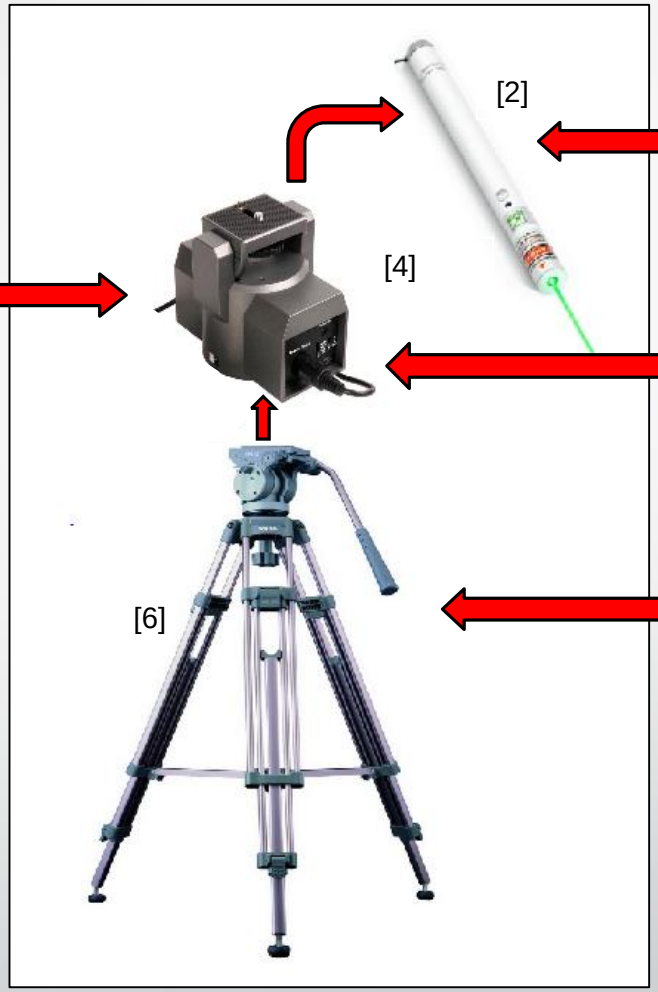
6 Foot adjustable tripod

Concept 4

Motion Sensor

[3]

Overall Design Concept



20 mW laser

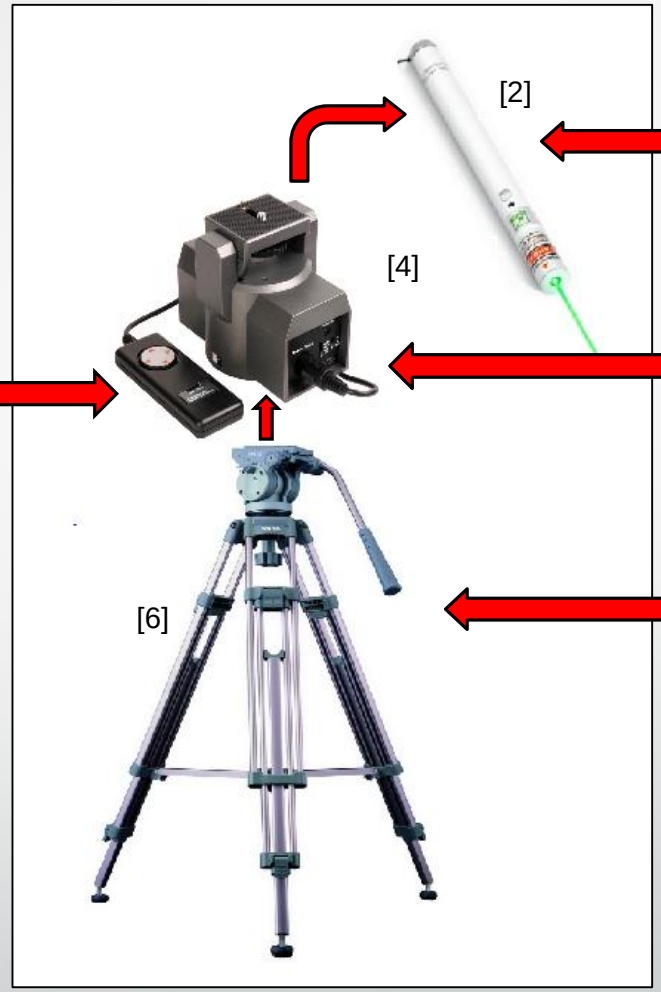
Two axis turret

6 Foot adjustable tripod

Concept 5

Joystick Control

Overall Design Concept



Joystick controller

20 mW laser

Two axis turret

6 Foot adjustable tripod

Concept Selection

Decision Matrix

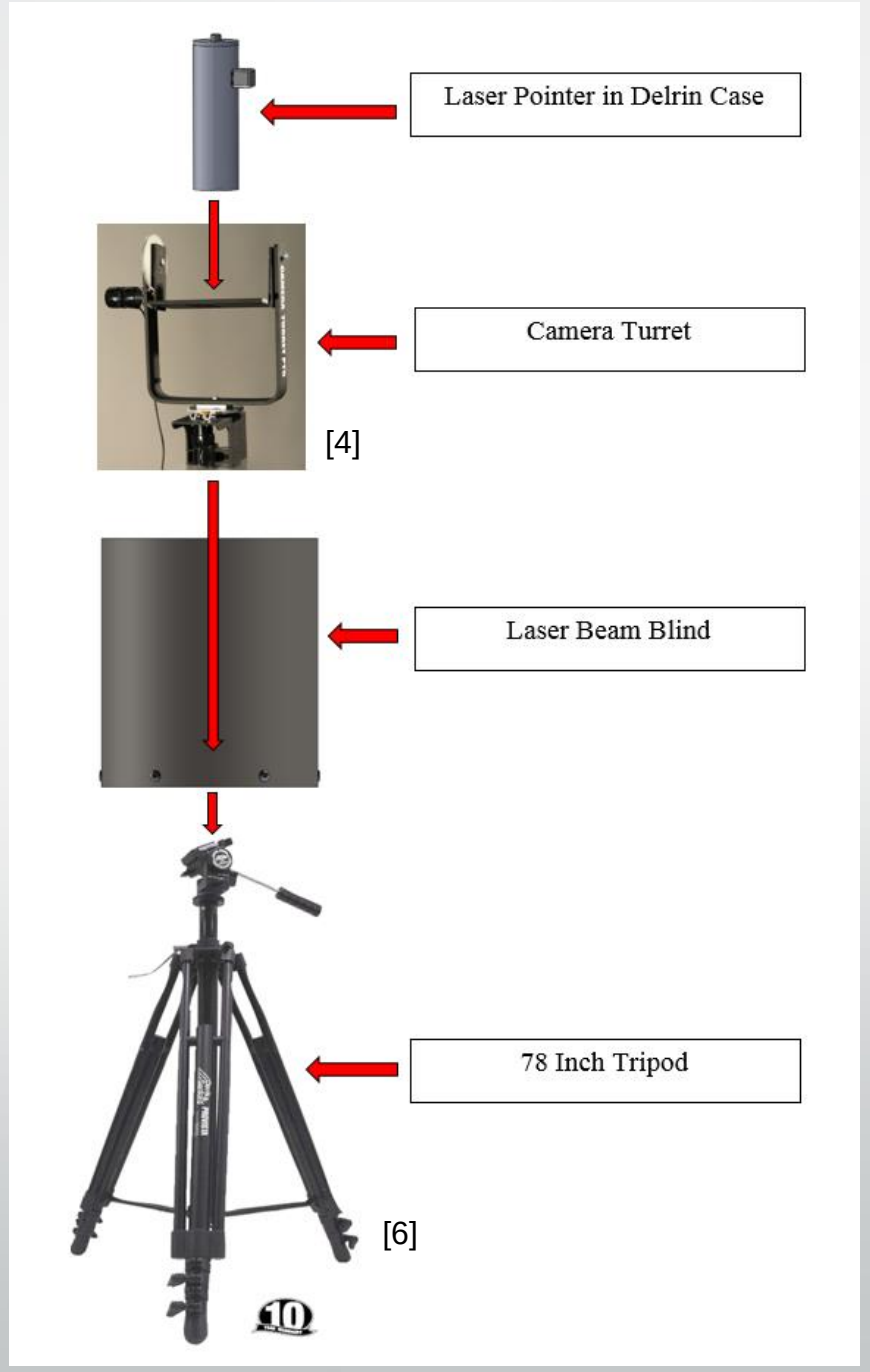
Weight	5	3	3	2	5	18	
Weight Percent	28%	17%	17%	11%	28%	100%	
System Design	User Control	Mechanical Design	Manuverability	Cost	Electrical Design	Score	Visual score
Hand Held	5	1	5	5	3	3.8	
Tablet Control	3	3	3	1	2	2.5	
Smart Phone Control	5	3	3	3	2	3.3	
Motion Sensor	4	3	3	3	1	2.7	
Joystick Control	2	3	3	5	5	3.5	

Scale: 1-5
1 = Least Desirable
5 = Most Desirable

Chosen Design

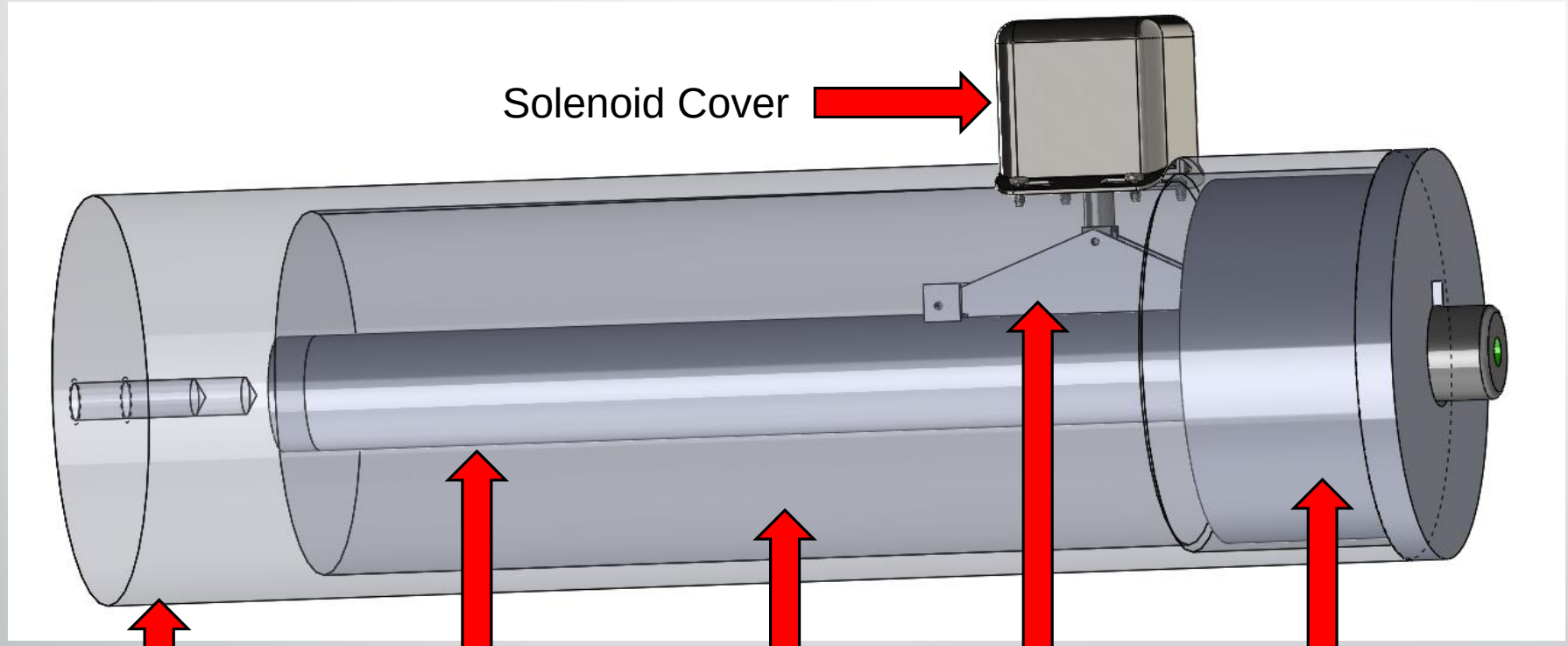
Joystick Camera Turret

- Laser Pointer in Delrin Case mounted to Camera Turret
- Camera Turret mounted inside Laser Beam Blind
- Laser Beam Blind and Camera Turret mounted to Tripod



Chosen Design

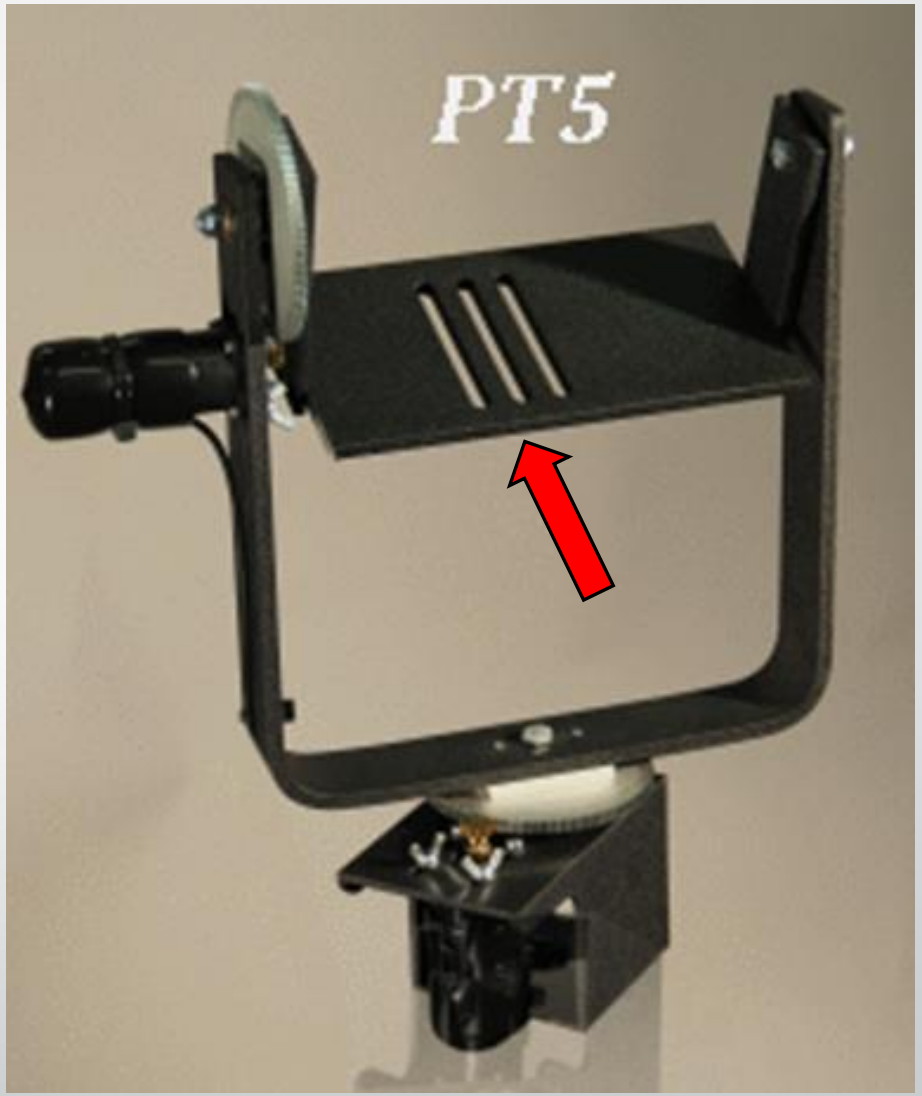
Insulated Tripod Mounted



Chosen Design

Camera Turret

- Delrin case mounts directly to turret
- Allows for 360° Pan and 360° Tilt
- Quick attach mounting to tripod
- Integrated switch mechanism built into joystick control



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Chosen Design

Laser Beam Blind

- Constrains laser beam below 30° above horizon
- Allows full motion of turret
- Mounts over quick attach bolt from turret

Chosen Design

78 Inch Tripod

- Quick attach mounting
- Functional at full height only
- Level adjustment in head

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Analysis

- Purchased components are not analyzed
  - Tripod
    - Item is going to be purchased
    - Maximum capable load – 12 lbs.
    - Turret weight including laser assembly ~ 6 lbs.
  - Turret
    - Item is going to be purchased
    - Maximum capable load – 5 lbs.
    - Estimate of laser assembly weight ~ 0.53 lbs.

- Thermal Analysis carried out on laser housing

Thermal Analysis

Motivation: Laser must remain within operating temperatures

Assumptions:

- Approximate coldest comfortable temperature for presentations: -5°F
- Laser pointer temperature isothermal
- No contact resistance from laser surface to polystyrene insulation
- Ambient wind in cross flow, 30 mph, used to find average value for heat transfer coefficient (h)

Thermal Analysis

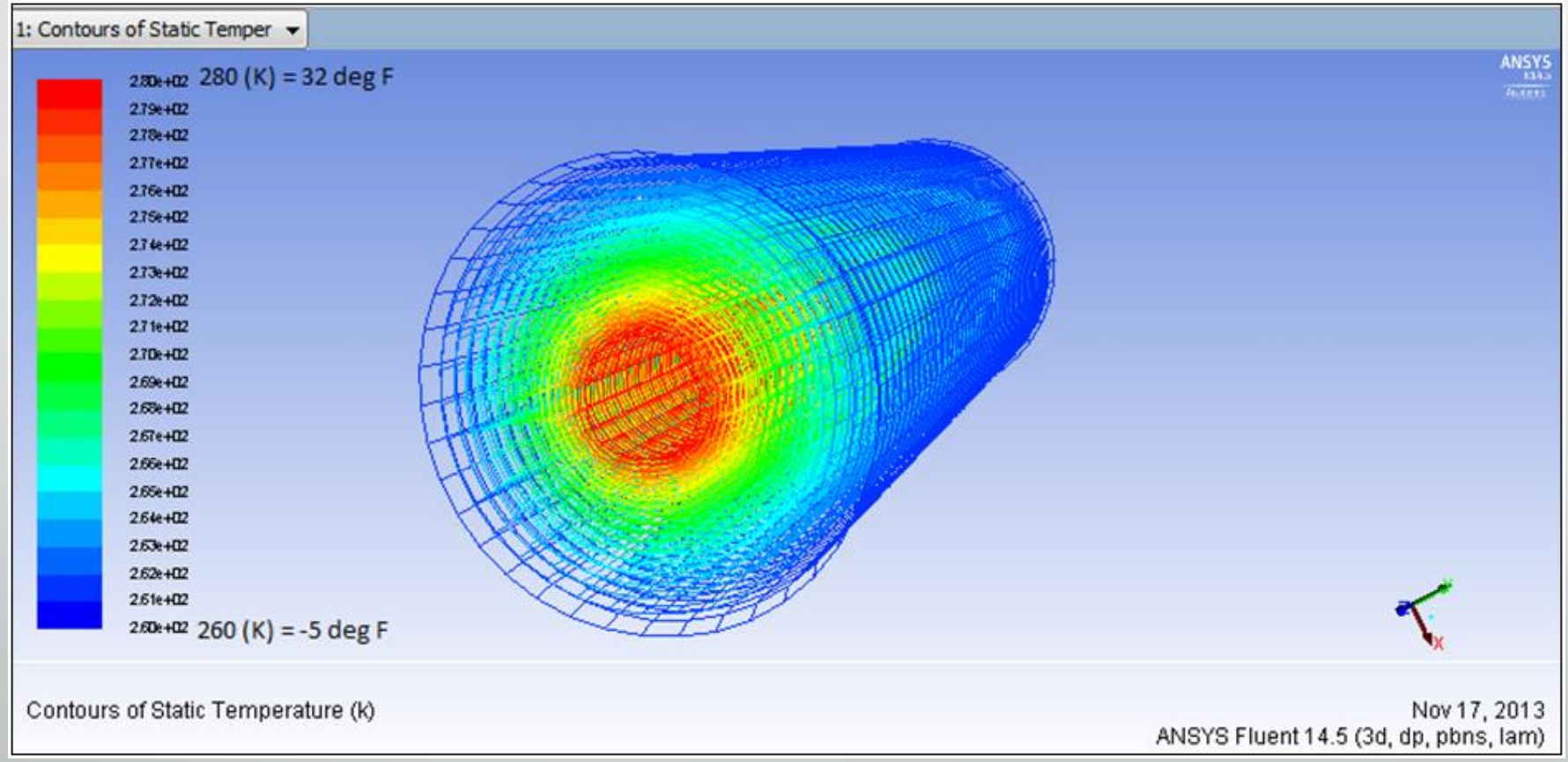
Derived equation for total heat loss in our system:

$$q = \frac{T_i - T_\infty}{\frac{1}{L\pi}\left[\frac{1}{hD_0} + \frac{ln\frac{r_2}{r_1}}{2k_{ins}} + \frac{ln\frac{r_3}{r_2}}{2k_{shell}}\right]}$$

$$q = 0.35\ W$$

Thermal Analysis

Ansys temperature distribution:



Transient Thermal Analysis

Temp initial: 70°F Ambient Temp: -5°F

Time for laser to reach 32°F: 24.64 minutes

$$\theta^* = C_1 exp(-\delta^2 F_o) cos(\delta_1 x^*)$$

$$F_o = \frac{\frac{k}{\rho C_p} t}{r_0}$$

$$\theta^* = \frac{(T_0 - T_\infty)}{(T_i - T_\infty)}$$

$C_1 = 1.1539$

$\delta_1 = 1.0873$

$k = Thermal\ conductivity\ of\ air\ \left[\frac{W}{mK}\right]$

$\rho = Density\ of\ air\ \left[\frac{kg}{m^3}\right]$

$C_p = Specific\ heat\ of\ air\ \left[\frac{kJ}{kgK}\right]$

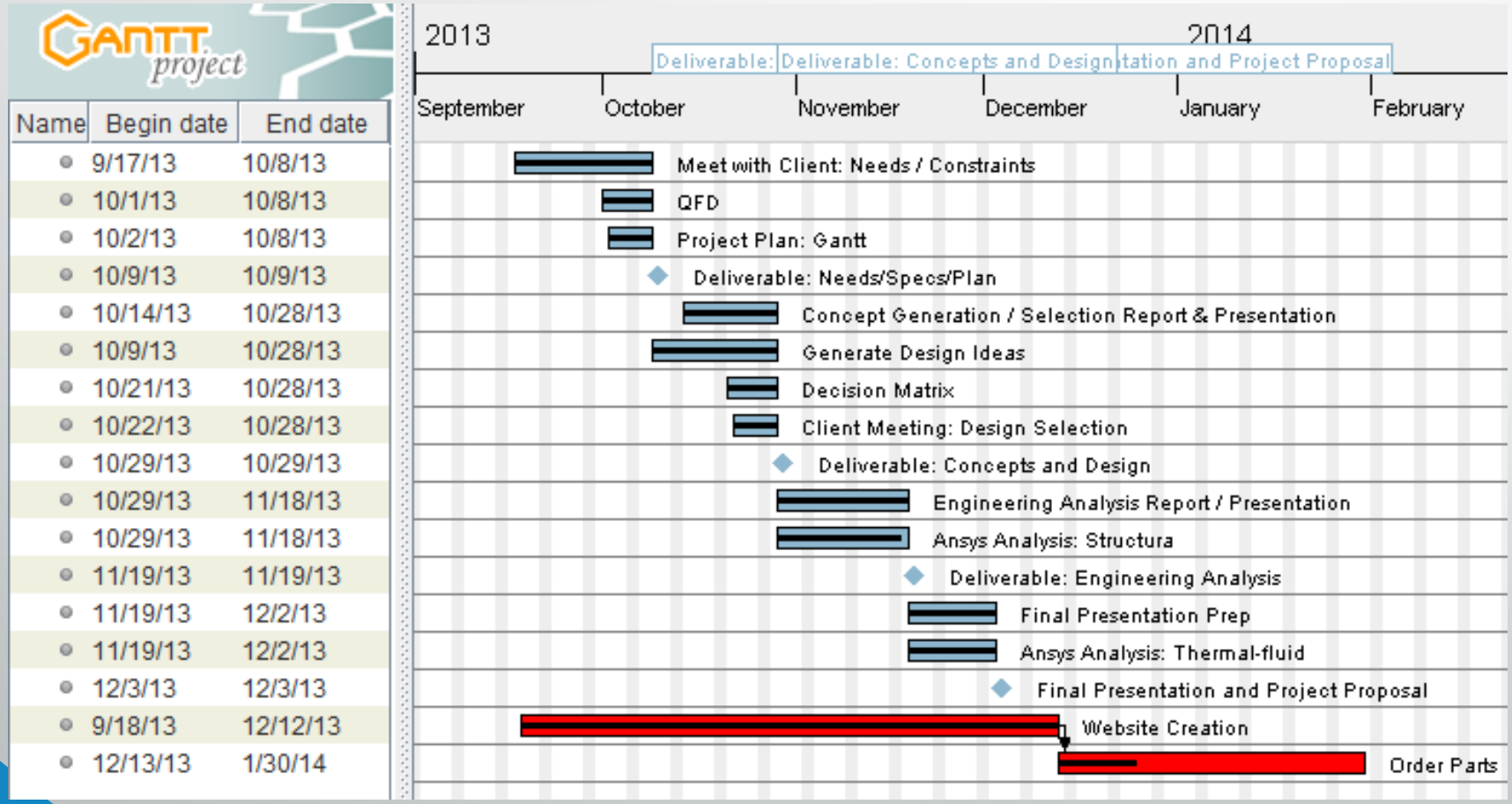
$r_0 = Radius\ of\ cylinder\ [m]$

Equipment to be Purchased

Component	Supplier	Part #	Cost [$]	Shipping [$]	Tax [$]	Total [$]
Davis and Sanford 78" Tripod	Amazon.com	N/A	189.95	21.95	0.00	211.90
RCA Cable	Amazon.com	N/A	12.15	7.25	0.00	19.40
.0589" Sheet Metal	Ace Hardware	N/A	30.99	0.00	2.62	33.61
PT5 Camera Turret	Camera Turret	PT5	839.00	22.00	0.00	861.00
Auxiliary Power Button	Camera Turret	N/A	0.00	0.00	0.00	0.00
Delrin Rod Stock 1'	McMaster Carr	8572K32	26.30	8.00	0.00	34.30
1/2" Electrical Conduit 5'	McMaster Carr	7126K11	1.55	8.00	0.00	9.55
Aluminum Stock 1 1/4" X 1' X 3/4"	McMaster Carr	8975K487	8.74	8.00	0.00	16.74
M1.4 X .3 - T5 Drive Screw	McMaster Carr	94209A111	9.38	3.25	0.00	12.63
Blind Rivet 3/16"	McMaster Carr	97525A485	10.34	3.55	0.00	13.89
Heater	Measurement Specialties	Custom	10.00	3.50	0.00	13.50
RCA Cable to Quick Connector	Radio Shack	N/A	7.50	4.50	0.00	12.00
Solenoid	Deltrol Controls	53648-81	40.00	12.00	3.38	55.38
Solenoid Cover	3-D Printer	N/A	0.00	0.00	0.00	0.00
Contingencies	Unknown	N/A	100.00	N/A	N/A	100.00
Grand Total [$]						**1393.90**

Project Plan

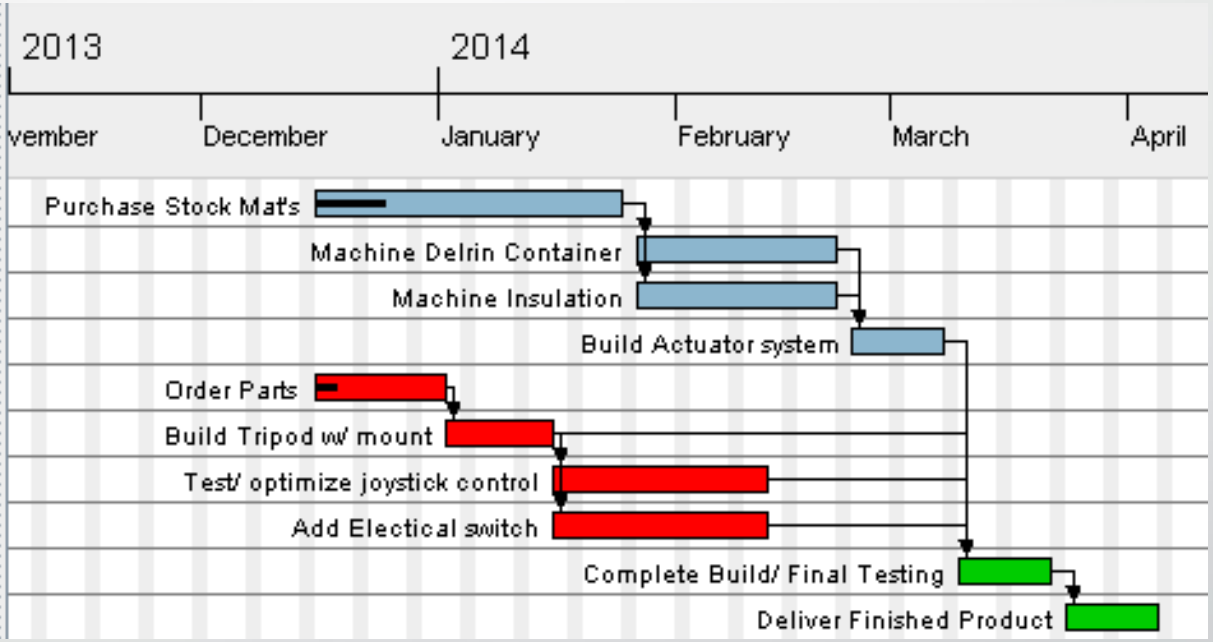
Final Fall 2013 Gantt Chart



Project Plan

Preliminary Spring 2013 Gantt Chart

Name	Begin date	End date
Purchase Stock Mat's	12/16/13	1/24/14
Machine Delrin Container	1/27/14	2/21/14
Machine Insulation	1/27/14	2/21/14
Build Actuator system	2/24/14	3/7/14
Order Parts	12/16/13	1/1/14
Build Tripod w/ mount	1/2/14	1/15/14
Test/ optimize joystick contr...	1/16/14	2/12/14
Add Electical switch	1/16/14	2/12/14
Complete Build/ Final Testi...	3/10/14	3/21/14
Deliver Finished Product	3/24/14	4/4/14



Conclusion

- Mr. Anderson needs a safe way to operate a 20 mW laser for guided talks about the night sky
- 5 concepts were generated and the remote joystick design was chosen
- Thermal analysis was conducted and results showed a small heating element is needed to maintain operating temperatures
- Final parts inventory total is $1393.90, well below the allotted $3000 budget
- All parts are ready to be ordered and project is on schedule to be completed by April 2014

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Questions?

Structural Analysis

Physical	
Dimensions (WxHxD)	10" x 14" x 4"
Weight	4.5 lbs.
Cable Length	12 Feet
Mounting	Upright or Inverted
Mounting Plate	3" x 3" with 3/8" hole
Controls	
2 Axis Thumbstick P/T	30/30 degrees
Ramp	none
Linear	none
Logarithmic	fixed
Speed Limit	0 to 100%

Electrical	
Power Supply	110-230 VAC to 12 DC 1000 MA
Connector	5.5 X 2.1 center Pos.
Capabilities	
Slowest Speed	1 rev in 10 minutes
Max Speed	4 RPM @ 12 V
Pan Revolution	360° +
Tilt Revolution	360° +
Capacity	5 ponds/2.3 kilos

Overall Specifications	
Max height	78" (1.98 m)
Min height	31" (0.7874 m)
Folded length	34" (0.8636 m)
Center post adjustment	15" (0.381 m)
Weight	9 lb (4.08 kg)
Max Tripod load	25 lb (11.34 kg)