Remote Control Laser Pointer

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Concept Generation and Selection

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INTRODUCTION

This report will discuss the concept generation of five different designs. Discussion and selection of a final design choice will be based on evaluation of key design parameters that will be compared using a decision matrix. A detailed project plan will then display the groups plan to design and build a final prototype by May 2014.

PROJECT SUMMARY

Mr. Edwin Anderson, the Support Systems Analyst for the NAU Physics department has requested a device to aid him in safely directing the attention of groups of people toward individual stars and constellations. Mr. Anderson is requesting that a 20 mW laser is used to serve this purpose. The overall goal of this project is to design and build an apparatus capable of maintaining the safety of everyone while the laser is in operation. The design must be stable and comfortably operable in Flagstaff, Arizona weather conditions. The system must point out stellar objects within a reasonable time while retaining a resolution of 0.5°. The system must be able to fit into a small car and able to be transported around by a single adult.

CONCEPT GENERATION

Concept 1 Hand Held

This design will function in the same way a regular laser pointer is used. The handheld device will have 6-axis sensors built in to detect what angle the laser pointer is being pointed relative to the ground. If the laser pointer beam drops below a certain angle, the laser will automatically turn off. The threshold angle that turns the laser off will be selected by the user prior to use. This will prevent the laser from accidently shining into anyone's eyes. In addition to this safety feature, a sensor will be placed on the ground to detect the height of the laser pointer. In order to turn on the laser, the laser pointer will have to be a minimum of 6 feet high off the ground. This feature will prevent the possibility of shining into someone's eye if the laser pointer is dropped while the laser is on. The Hand Held design concept is displayed in Figure 1 below.

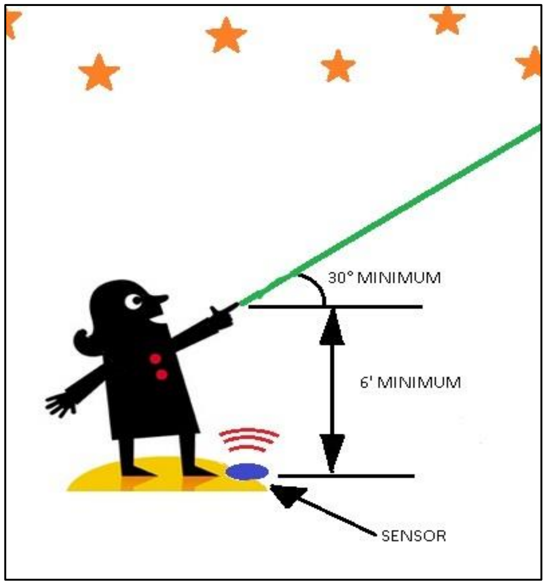


Figure 1 – Hand Held Design [1]

Concept 2-5 Overall Design

The next four concepts presented are composed of a similar overall design, the differences are focused on the control interface in which the user will operate the designed system. The overall design for concepts one through four include an extendable tripod base, a two axis rotational turret, and the laser itself inside of an insulated enclosure and a control system for the user to aim the laser. The overall system design for concept 2 through 5 is displayed in Figure 2 below.

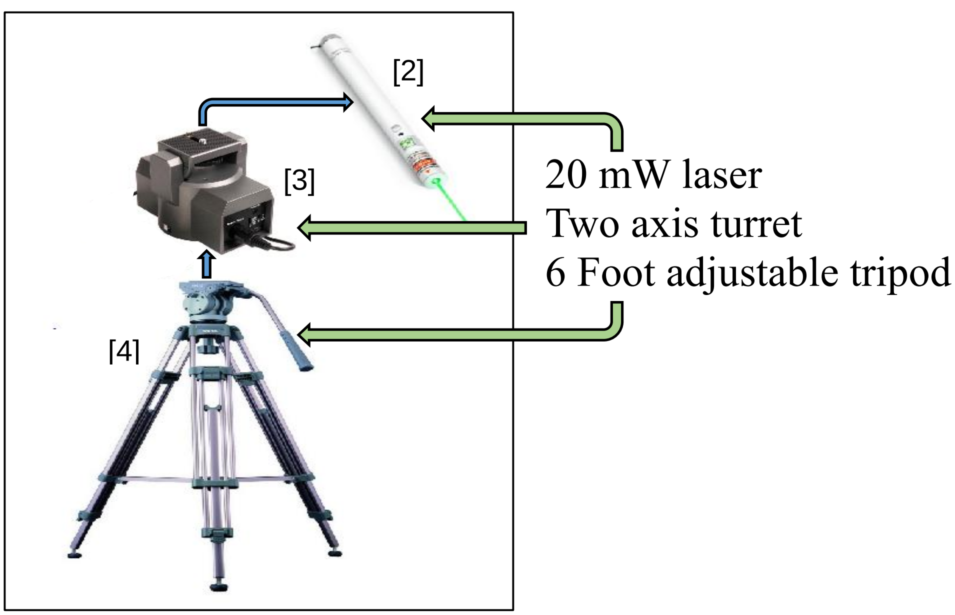


Figure 2 – Overall system for concepts 2-5 [2][3][4]

The tripod will to hold the laser at a minimum height of 6’5’’, the legs must be securely fastened to the ground with the use of spikes or something of equivalent strength and reliability. This feature is needed for high wind conditions or if someone were to walk into or trip over the legs the system would remain secure. The importance of this feature is twofold, first if the system were to fall over the laser could be shined into someone’s eyes, which is the main concern of the entire project. The second being avoiding damage to the equipment from fall impacts.

The two axis turret will be purchased, its control system modified. Many existing types are available. The turret will be used to physically aim the laser by moving in two spherical coordinate directions (i.e. theta and phi or a horizontal pan angle as well as a vertical elevation angle).

The laser’s enclosure will keep the laser within operating temperatures using insulation and will house the system responsible for toggling the laser on and off.

The purpose of the cylindrical blocks will be to block the laser from shining into a crowd at low angles. They will be mounted around the laser enclosure and interchangeable for differing minimum angles.

Concept 2 Tablet Control

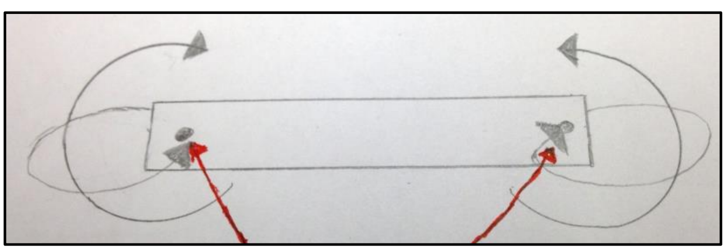
A tablet computer with a star mapping application, Figure 3, will be modified so that the user may enter specific coordinates, or simply touch a stellar body on the screen and the system will communicate with the turret moving the laser to the specified location. The software for this control scheme could also make available an option for a pre-planned number of locations to point out, allowing the user to simply click through the stellar bodies he wished to speak about, keeping the option to pick a location manually intermittently.

Figure 3 – Tablet Computer Star Map Application [5]

Concept 3 Six Axis Smartphone Control

This control scheme uses six axis motion detection available in most smartphones that incorporate accelerometers. The phone itself will used as a point and click like remote control. The user will have control over toggles for on/off and follow/not follow, so that the user need not hold the phone, or six axis controller as seen in Figure 4, at the object to be pointed out constantly. He will be able to turn the laser on, move it into position, and have the laser stay there while he relaxes his arm, and turns the laser off as desired.

One advantage of designing this sort of control system is that there is already a considerable foundation of software and knowledge for developing custom applications like this one.



Accelerometers

Figure 4 – 6 Axis Controller

Concept 4 Infrared Motion Sensing Control

Modern video game consoles, like Nintendo's Wii, have incorporated infrared motion sensing technology into their control schemes. This design concept aims to adapt and modify this existing technology to control our laser turret. For example a Wii remote, see Figure 5, would be used as a remote control and would be operated similarly to concept 3's six axis remote in the sense of point and click and toggling. However the system would function quite differently.

Two points in 3-D Cartesian coordinate space are needed to determine a line. The laser's location will serve as the origin and one point could be detected on the user's shoulder and another from his hand as he points to a stellar body. The distances from the turret to the two points would be determined and a line with angles relative the lasers current position can be calculated. The laser could then be moved into position by matching the angles acquired from the two points.

Figure 5 – Wii Remote and Sony Ball Controller [6][7]

Concept 5 Joystick Control

This control system will make use of a joystick like control, either wired or remote. The user will have the toggle options available as in concepts 3 and 4. The laser's horizontal position will be adjusted by twisting the joystick while the lateral or vertical position will be adjusted by tilting the joystick relative to its base.

An advantage of this system is that many turret systems are sold with a joystick as a working controller. Which would simplify the electrical and computational aspects of the project tremendously. However the interface could be seen as clunky or awkward from a user standpoint. Which is not desirable.

CONCEPT SELECTION

Table 1 is a design matrix consisting of the five potential design choices discussed above. The following paragraphs will describe how each category and weight pertains to each design alternative and why each score was chosen. This discussion will start with a description of what each design criteria entails, and how it can impact each design alternative. The weight, weight percent, score, and visual score will then be discussed, followed by the final design choice and rationale. Listed below are the individual criteria by which each design was assessed.

Table 1 – Decision Matrix

Weight	5	3	3	2	5	18	
Weight Percent	28%	17%	17%	11%	28%	100%	
System Design	User Control	Mechanical Design	Maneuverability	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 Control	4	3	3	3	1	2.7	
Joystick Control	2	3	3	5	5	3.5	

- ***User Control*** is the design criteria which describes the ease in which the operator can control the device against the backdrop of the night sky. A score of 1 would resemble a design that is difficult to place the laser where it is needed in the sky, as well as taking a long time to do so. A score of 5 would be a system that comfortably and quickly shines the laser to the desired location.
- ***Mechanical Design*** is the design criterion which describes any part in the system that is subjected to mechanical forces such as those due to acceleration, shear, and torque. A score of 1 would be a system that will be difficult to design and develop. A score of 5 would be a system that could be bought off the shelf and implemented with minimal effort.
- ***Maneuverability*** is the design criteria which describes the ability of the user to transport the device from one location to another without the need of assistance. This criterion also incorporates the ability of the design to be reduced in size for ease of transport in vehicles with small cargo compartments. A score of 1 would be a system that an adult would struggle to pick up and move around. A score of 5 would be a system that would be light and easy to carry.
- ***Cost*** is the design criterion which governs the feasibility of the potential design to remain at or below the project budget. A score of 1 would be a system that uses up all available

funds to complete the project. A score of 5 would be a system that would be well under budget.

- ***Electrical Design*** is the design criterion which describes any electrical component in each design alternative. This encompasses any electric motors, servos, switches, accelerometers, etc. which may be present in each design. This criterion also includes any software that would need to be developed. A score of 1 would be a system which uses many servos and controllers that would must be coded. A score of 5 would be a system that requires no additional servos or switches.

Weight

The top row in Table 1 shows the weight assigned to each design criterion. The scale ranges from 1 to 5, with 1 being the least important and 5 being the most important. The weights of each design criteria starting with User Control and ending with Electrical Design are explained in detail below for each design alternative.

User Control

Due to the danger associated with a 20mW laser, the user must be able to have full control at all times. For instance, if an airplane were to fly toward the laser beam, the user must be able to move the laser or shut the beam off in a short time period. All of the design alternatives meet this requirement; however, some of the alternatives exhibit more control than others. The scoring rationale for each alternative concerning user control is as follows:

- **Hand Held** – This design alternative was given a score of 5 for user control. This alternative will be controlled with physical contact from the user, thus the user will have complete control of the system at all times.
- **Tablet Control** – This alternative was given a score of 3 for user control because the user will have to enter in coordinates or touch a different location on the screen. This act will take a few moments thus the user does not have complete and immediate control of the system.
- **Smart Phone Control** – This design was given a score of 5 due to the user motioning the laser with a smart phone. The user will have immediate movement capability thus complete control of the system.

- **Motion Sensor Control** – This design was given a score of 4 due to the motion sensor software lag time. This lag time would hinder rapid response of the laser thus the user would not have immediate control of the system.
- **Joystick Control** – This design was given a score of 2 because the user would have to move the laser by means of a joystick controller rather than pointing at a destination. The user would have to become acclimated to operating a joystick to maneuver the laser to a position within the specified accuracy of 0.5°.

Mechanical Design

The mechanical design criterion for each design alternative is as follows:

- **Hand Held** – This design must incorporate the laser, an angle sensing device, and a proximity detector, in one case or housing. This housing must be designed, analyzed, and constructed for the device to function properly. Since design and manufacturing are time intensive, the Hand Held design alternative was given a score of 1.
- **Tablet Control** – This design will have few components to be modeled, or machined, and a small non-structural housing for heat retention, thus this alternative was given a score of 3.
- **Smart Phone Control** – This design will have few components to be modeled, or machined, and a small non-structural housing for heat retention, thus this alternative was given a score of 3.
- **Motion Sensor Control** – This design will have few components to be modeled, or machined, and a small non-structural housing for heat retention, thus this alternative was given a score of 3.
- **Joystick Control** – This design will have few components to be modeled, or machined, and a small non-structural housing for heat retention, thus this alternative was also given a score of 3.

Maneuverability

The maneuverability of the device is a critical design parameter because the user must transport the device without the aid of other personnel. Scores for of each design alternative are as follows:

- **Hand Held** – This design consists of a case or housing with all system components mounted inside. Since the system must be light weight for the user to be able to lift the device one handed, the Hand Held design was given a score of 5.
- **Tablet Control** – This design consists of a tripod mounted laser turret and a tablet. Since these items can be easily carried by one person yet heavier than the Hand Held design, the Tablet Control design was given a score of 3.
- **Smart Phone Control** – This design consists of a tripod mounted laser turret and a smart phone. Since these items can be easily carried by one person yet heavier than the Hand Held design, the Smart Phone design was given a score of 3.
- **Motion Sensor Control –** This design consists of a tripod mounted laser turret and a motion sensing device. Since these items can be easily carried by one person yet heavier than the Hand Held design, the Motion Sensor design was given a score of 3.
- **Joystick Control** – This design consists of a tripod mounted laser turret with a joystick attached via cable. Since these items can also be easily carried by one person yet heavier than the Hand Held design, the Joystick Control design was given a score of 3.

Cost

The cost of each design must remain below the project budget of $3000. The cost parameter was evaluated by researching rough component costs for each design. The scores for each design are as follows:

- **Hand Held –** This design has some unknown costs associated with it; however, the overall cost was determined to be less than $1500, thus a score of 5.
- **Tablet Control –** This design requires a tablet computer to operate an app to control the laser. Tablets can be very expensive, thus the overall cost was determined to be the full budget of $3000 with an assigned score of 1.
- **Smart Phone Control –** This design requires a smart phone to operate an app based off of the accelerometers in the phone, thus the overall cost was determined to be $2500 with a score of 3.
- **Motion Sensor Control –** This design requires several motion sensors and a sensor reading device. The overall cost was preliminarily estimated to be $2500, thus given a score of 3.

- **Joystick Control –** This design requires few parts yielding a total cost of $1500 warranting a score of 5 for this design.

Electrical Design

Each design must use electronics to accomplish the project. This section describes the score and the rationale behind the score assigned to each design.

- **Hand Held** – This design will use accelerometers and a small digital logic controller to operate the on/off switch on the laser. These electronic components will be simplistic to construct, but difficult to make accurate, thus a score of 3 was assigned to the design.
- **Tablet Control –** This design will be difficult to write and integrate an app to control the laser. This difficulty is reflected in a score of 2.
- **Smart Phone Control** – This design will also be difficult to write and integrate an app to control the laser. This difficulty is reflected in a score of 2.
- **Motion Sensor Control –** This design will incorporate motions sensors and a receiving device with a currently unknown difficulty level of integration. The best estimate of electronic difficulty yielded a score of 1.
- **Joystick Control** – This design will consist of an on/off switching device for the laser mounted to the joystick, thus the simplicity of this design yielded a score of 5.

Weight Percent

The weight percent row is the percentage which the weight represents out of a total of 18.

Score

A score was assigned to each design concept parameter for each design alternative. The score column is the total weighted score for each design. The highest score is the best design based off of the design parameters.

Visual Score

The visual score is a bar graph visual representation of the score column and is included for fast visual reference only.

Final Design Choice

The final design choice is based off of the values obtained in the decision matrix, Table 1. Based on the assigned values, the Hand Held design will be the best design choice to fulfill the project parameters. This design will be highly controllable, maneuverable, incur the least cost, and incorporate the fewest electronics.

PROJECT PLAN

A Gantt chart, as seen in Figure 6, is utilized to monitor the progression of the project, deliverables, and design goals. The Gantt chart has been updated with a critical path and new project goals. It now describes the timeline for ordering parts, building, and testing the device. The critical path involves ordering parts, programming and building software, building and testing device, and delivery of finished product, in order of precedence. Our team will utilize this project plan in order to ensure appropriate progress is completed with this project and the corresponding deliverables. Shown below is an image of the current Gantt chart.

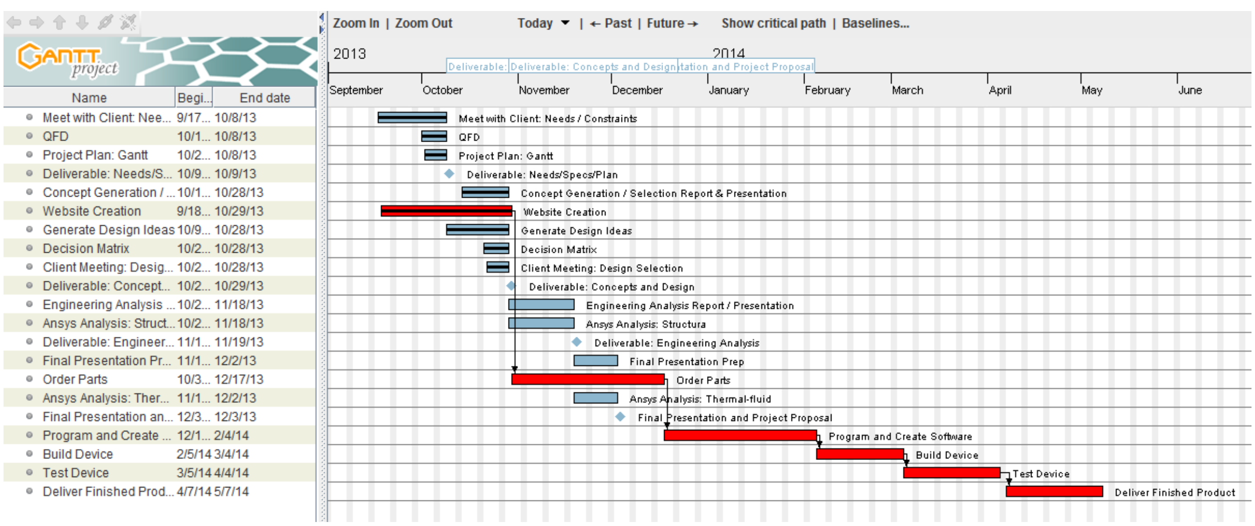


Figure 6 – Gantt Chart

CONCLUSION

To conclude, this report outlined the client's need, constraints, design concepts, concept selection, and the plan for the completion of this project. Mr. Anderson, our client, has asked us to design a device that will allow him to safely use a powerful laser when giving constellation presentations to large groups of people. Five different designs were conceptualized and one was chosen using a decision matrix. Concepts two though five all involve having a two-axis turret mounted on a tripod above and average person's height. The designs vary in the way the turret is controlled. The second design controls the turret using a tablet with an installed astronomy program that enables the user to touch a point of interest and the turret moves accordingly. The third design uses the accelerometer and or gyroscope to translate movements to the turret via a Bluetooth connection. The fourth design incorporates infrared motion detection, similar to Nintendo's Wii console system, to create a vector in space and translate and send appropriate movements to the turret controller. The fifth design uses a wired joystick to manually control the movement of the turret. Finally, the first design is one that differs entirely from the rest. This concept is a handheld device that works in conjunction to the laser. Two accelerometers and a sensor on the ground will be implemented to detect the height and angle of the laser. The device uses this information as an auto-shutoff feature in case the device is dropped or held at an angle that puts humans at risk. A decision matrix was used to aid in the design selection process. In the decision matrix, the quantified design criteria were user control, mechanical design, maneuverability, cost, and electrical design. Based on the quantities assigned to each category, as discussed previously in this report, concept one or the handheld design was selected. Following the design selection, the updated project plan was discussed. A Gantt chart is used to track the progress of this project as described above. We plan to have parts purchased by December and to begin building and testing by March.

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