Horned Lark Management for the Protection of Lettuce Sprouts

Final Project Report

Sponsor: Tanimura & Antle Inc.

Team: Birds Be Gone

6/6/14

Taylor Wetzel
tbwetzel@calpoly.edu

Eduardo Morales
emoral03@calpoly.edu

Kyle Suguitan
suguitan@calpoly.edu

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Abstract

The following document is the Final Project Report. Following the Critical Design Report, the top idea taken from there was modified once again to suit the needs of the sponsor. Details regarding the changes are outlined throughout Chapter 3.

The provided background section explains why there is a need for a new device at T&A that will suit the customer's needs better than current methods and existing products. The top ideas picked for the Conceptual Design Review are then presented to reiterate the problems that were depicted in them and why they were not selected as part of the final design. The final design selected is presented with the new modifications made after the Critical Design Report and includes all the material acquisition, building time, costs and final production.

The testing plan will help provide new or updated information on the performance of the prototype and how to reiterate the design to achieve better results. New engineering requirements/specifications were also updated or added in order to correlate with the new design. An updated management plan also lays out the timeline for the rest of the project as well. The last section of this report contains information on how well the device works, how its design may be improved, and recommendations on actual use of the device at Tanimura & Antle farm. The Appendices contain the detailed information about the final design, its components and related costs, the timeline for goals, and any extra analysis that needed to be done for the actual construction of the final design.

Chapter 1: Introduction

Background and Needs

The need to keep birds off of agricultural land is not uncommon. A 2013 USDA study, limited to two crops in seven states, found that US fruit growers lose tens of millions of dollars each year solely from indirect bird management costs and direct costs due to crop loss. Many methods have been employed by various groups of people for different ranges of use and application. Both audio and visual deterrents are used, to varying degree of effectiveness. Your company, Tanimura & Antle, faces a similar bird management issue with continuous costs to buy and replace shotguns, which you have found as their most effective solution, and also continuous costs of ammunition.

The horned lark is the primary culprit of crop damage for Tanimura & Antle (T&A). *Wildlife Leaflet 308*, titled "Protecting Crops from Damage by horned larks in California" and written by the Fish and Wildlife Service in 1948 details crop damage, severity, and some historic control methods for mitigating crop damage by horned larks. Many of the control methods are not practical for use today, but much of the information on bird behavior is applicable to this project. Their food source consists mainly of seeds picked up from the ground. At Tanimura & Antle, lettuce crop that has recently sprouted is a favorite food source for horned larks because the birds can simply walk down the line and eat the small, sprouting lettuce.

Formal Problem Definition

Our goal is to create a lightweight, mobile device that can mimic the effectiveness of a shotgun to ward off the horned lark at the Tanimura & Antle, 5300 acre, Fresno County farm in Five Points, CA. This goal is to the effect of protecting lettuce during germination and maturation, especially during the fall and early winter season, with safe, non-firearm use. The use of the device will ideally replace the current shotgun use by workers at T&A while attempting to lower the labor cost as well. The power source of the device has been chosen as a DC battery. Compressed air and propane have also been considered but have been deemed unsuitable options.

Objective/Specification Development

After a meeting with pest control expert Dr. David Headrick and crop expert Dr. Lauren Garner (both Cal Poly professors), a few more important considerations were discussed. 1) Collecting species-specific assays is crucial in determining the response of the species. Finding species-generic data should not be considered helpful. 2) Birds, as discussed before, are highly intelligent and therefore respond better to a scarer's methods if this method is followed by an actual threat, like a shotgun for example. Since the scope of this project prioritizes eliminating shotguns (or any "real" threat, as it poses safety

concerns) such a threat may only be *simulated*. 3) Any given scaring method's effectiveness drastically increases when employed *before* the pest species begins roosting in the targeted area for protection. In other words, establishing an uncomfortable presence before the birds even begin to attack the lettuce would greatly reduce the birds' presence throughout the entire window of time in which the lettuce is vulnerable. 4) Birds are highly sensitive creatures and should respond to *high quality* audio deterring methods (i.e. the lark's natural predator) even if the sources of these sounds are up to a half mile away. It is important to note that the importance of authentic, high quality audio.

Management Plan

The following management plan will be employed in order to organize available resources on this project. The plan consists mostly of deadlines to keep the project on track.

The Conceptual Design Report was previously released which detailed various possible solutions/ideas for the Horned Lark problem. These ideas were presented with all of the pros and cons from each member of the team, along with the top ideas selected during the final decision. A Conceptual Design Review was held to present all of these ideas with T&A and to receive input from the sponsor on which solution would work best. However, after this review was done, the team experienced various problems with the top ideas that were selected. Due to this, the team came up with a new solution that took was a compromise between the previous top two ideas (this solution formed the basis of this report). The problems that were found previously were well thought out and presented to the sponsor in order to get approval for the new design. After receiving approval, detailed analysis for the construction of the device was presented and approved of in the Critical Design Report.

This Final Project Report provides all the details on the costs and production of the system. Breakdown on the component selection, testing procedures, and achievable goals for the device are documented. The Senior Project Exposition will be held to showcase the final prototype of the device to the Engineering faculty and staff at Cal Poly as well as the sponsor. After the Exposition, a Final Design Report will be approved by the team advisor. Upon approval, the report and the prototype will be delivered to the sponsor, at which point the project will be considered done.

Certain individuals will be responsible for different aspects of the project. Individuals are listed below with their primary responsibilities:

- Eddie Morales - prototype fabrication and documenting project progress
- Kyle Suguitan - budget coordinator and manufacturing considerations
- Taylor Wetzel - communication with sponsor, testing plans and information gathering

Table 2 lists milestones that will require your participation. Items listed as documents will be sent to you via email in PDF format and will need to be reviewed and approved by you. Items listed as meetings will require your physical participation at a location and time to be announced.

Table 1. Timetable of Relevant Milestones

Milestone Number	Milestone Description	Type	Due Date
1.	Project Proposal (Requirements)	Document	10/24/13
2.	Conceptual Design Report	Document	12/5/13
3.	Conceptual Design Review	Meeting	12/9/13-1/12/13*
4.	Design Report	Document	2/10/14
5.	Critical Design Review	Meeting	TBD*
6.	Prototype Testing	Meeting	3/1/14-5/10/14*
7.	Design Project Exposition	Meeting	5/31/14 2:00-5:00PM
8.	Final Report	Document	6/6/14

* Exact date and time to be determined

Chapter 2: Background

Existing Products

In order to deter birds from crops, various types of scaring devices and management solutions are commonly employed. Whether the scarer depends on audio, visual, or other methods, the primary consideration for the effectiveness of a scarer is its dynamic ability. Birds are intelligent creatures and quickly recognize sources that are found to pose no real threat and also quickly adapt to deterrents that behave predictably. At the Honolulu International Airport, for example, professional bird scarers, driving white trucks, make rounds around the runways to protect disembarking airplanes from bird strikes. The mynahs, a certain species of starling, are capable of distinguishing the Wildlife Service's white trucks from the typically yellow airport vehicles. If a white truck approaches, the mynahs, knowing the trucks cannot cross the runway, react by safely hopping to the other side. If the vehicle is yellow, the birds usually show no signs of fear. Moreover, birds quickly grow accustomed to characteristically non-dynamic scarers. Propane cannons, for example, that periodically emit loud bursts, lose effectiveness if their bursts' time interval, loudness, and pitch do not change. Birds may become momentarily startled, but may simply relocate nearby knowing the cannon pose no real threat.

The most effective bird deterrent methods employ, in some manner, sound as a scare method. Various audio bird scarers can be found on the market covering anywhere from 900 ft^2 to 6 acres. Many audio scarers rely on either ultrasonic noise, predator calls, or distress signals of prey to frighten nearby birds. (Depending on the species of bird, distress signals may actually initially draw them in as they seek to aid a fellow bird in trouble. Typically the birds, confused at the sight of no predator, will then disperse.) Most audio scarers require an outlet for power, although some use photovoltaic panels for solar power.

An experiment conducted in Samsun, Turkey in 2007 compared the effectiveness of various predator calls and time intervals for scaring crows (found to be the least sensitive species among pigeons, sparrows, starlings, and blackbirds) from a 50x50 meter college campus enclosure. The study found the call of the *Buteo Lagopus*, in North America referred to as the Rough-legged Hawk, to scare the greatest percentage of crows from the area. The study also confirmed that scaring intervals of 60 seconds and 360 seconds yielded the highest success.

Visual deterrents are the lesser effective of the two methods. Although birds, generally speaking, rely on vision the most of any sense, visual methods tend to be less dynamic and less uncomfortable for the birds. They also require that the bird notice them, which results in a smaller area of coverage compared to audio scarers. Common visual scaring methods include: reflective tape, scarecrows, kites/balloons, dead birds, predator bird decoys, and even lasers. Any one of these methods by itself offers no complete solution, especially for a plot of land larger than a couple acres. Visual methods, therefore,

should be employed as supplementary deterrents, perhaps as a larger bird management campaign.

Figure 1. A typical helikite scarer. The reflectivity visually irritates birds. The kite also creates a discomforting aerial presence that may be perceived as a predator. (Source: Bird Busters.)

Figure 2. A simple falcon decoy used to present a visual threat to prey. Such a decoy could easily supplement a more complete management solution. This particular decoy is motion-activated and inexpensive. (Source: Northern Tool & Equipment.)

Natural predators are also used as deterrents that either eliminate or reduce the pest species or intimidate the pest species from roosting near the area of interest. Your company, for example, hired a falconer with several falcons that would patrol the 5,300 acre farm to deter or reduce the horned lark's presence. The solution was not considered effective: the trained falcons were used sparingly for fear of harm from wild falcons, the lark's presence did not abate, and relative to the solution's effectiveness, it was very expensive. With more aggressive use, the use of natural predators may be a well-suited solution for such a large farm, but, again, it is a very expensive method that may not work out well depending on the falconer.

Current State of the Art

Although various scarers employ ultrasonic audio, there are questions regarding their effectiveness. Positive reviews exist for ultrasonic scarers, but the hearing range of a bird measures similarly to that of humans. A 2004 study by USDA Wildlife Services determined that the hearing range of birds, although depending on the particular species, is most sensitive between 1 and 4 kHz. Moreover, the study found that no species of birds demonstrates ultrasonic (> 20 kHz) hearing.

Figure 3. The BroadBand PRO, a typical audio bird scarer which covers up to 6 acres, a range on the higher end for commercial audio deterrents. Speakers emit both sonic and ultrasonic sounds to confuse and intimidate birds. This particular bird scarer includes supplementary visual scarers. All together it costs upwards of $900. (Source: Bird-X.)

Figure 4. The Bird Gard, a lower quality bird scarer which can play predator signals and the distress call of several prey species. The Bird Gard requires a 110V outlet for power. (Source: Bird Busters.)

Besides audio scarers that rely on electronic amplifiers to produce noise, propane cannons, like that used at the Five Points T&A farm, have also been used to deter birds. The

cannons, as suggested by the name, are powered by propane and fire at intervals. Various propane cannons designed for bird scaring can be found on the market.

Figure 5. Zon Gun, a propane cannon used to scare birds and other wildlife. With all accessories, this product costs over $700. (Source: Bird Busters.)

Similar to the propane cannon, shotguns and other guns are also used as deterrent solutions. Your company, for example, has found patrols wielding shotguns to be the most effective bird management solution. However, the use of guns not only requires human operation (which itself is taxing and costly), but also requires hefty repair, upkeep, and ammunition expenditures. In this case, $40,000 is spent annually on shotgun ammunition alone. The use of shotguns, besides financial drawbacks, also constitutes a continual safety hazard.

Chapter 3: Design Development

Discussion of Conceptual Designs

As discussed in the Project Proposal, heavy research was done in order to understand the problem at hand, including: visiting Tanimura & Antle, finding information pertaining to general bird biology and reactions to common scaring methods, papers written about problems/solutions with the lark in agriculture, and consulting the aforementioned crop and pest control experts. The conclusion that was reached affirmed that audio deterrents should be most effective in warding off the horned lark. Using an olfactory or taste deterrent does not lend itself to a mechanical solution and also relies on extensive testing and data to support its feasibility. Moreover, a solution that employs physical touch poses obvious scope issues (i.e., how to physically span such a large area?) and safety issues for the birds (i.e. how to balance deterring birds with not harming them?) An audio deterrent, shotguns, is currently in use and further research reinforced the notion that audio deterrents are not only the most prevalent, but the most practical.

The conclusion to rely on audio deterrents was reinforced by the brainstorming process, which was performed to produce several ideas. Below are listed the most popular ones that were chosen, along with the final design concepts that will be further developed until the critical design phase.

#1: Birds on Track/Zipline

This idea implemented bird-scaring decoys like fake birds on some form of zipline that would stretch out across the quarter-section of lettuce. The zipline would be held up with posts that would have a station to enable the decoy to pivot and turn. Other posts along the perimeter would have speakers that would play a predator call mixed with lark distress signals. Ideally, the larks would believe a predator was flying in the area, making calls as it swooped down for a kill.

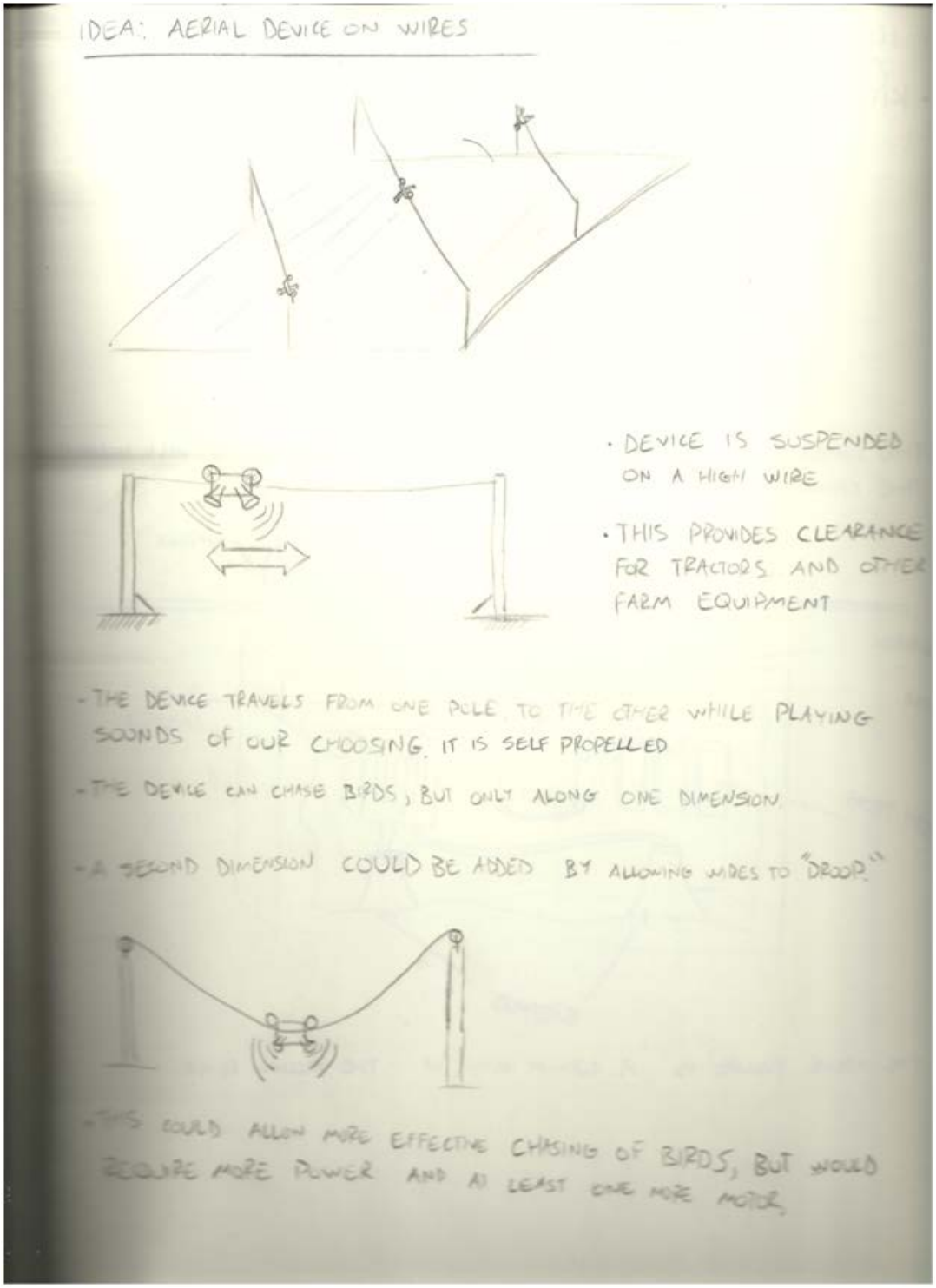


Figure 6a. Kyle's version of an overhanging system with a noise device. The noise maker would run along wires/cables that would stretch across the length of the quarter-section. Batteries would be the power source in this particular design.

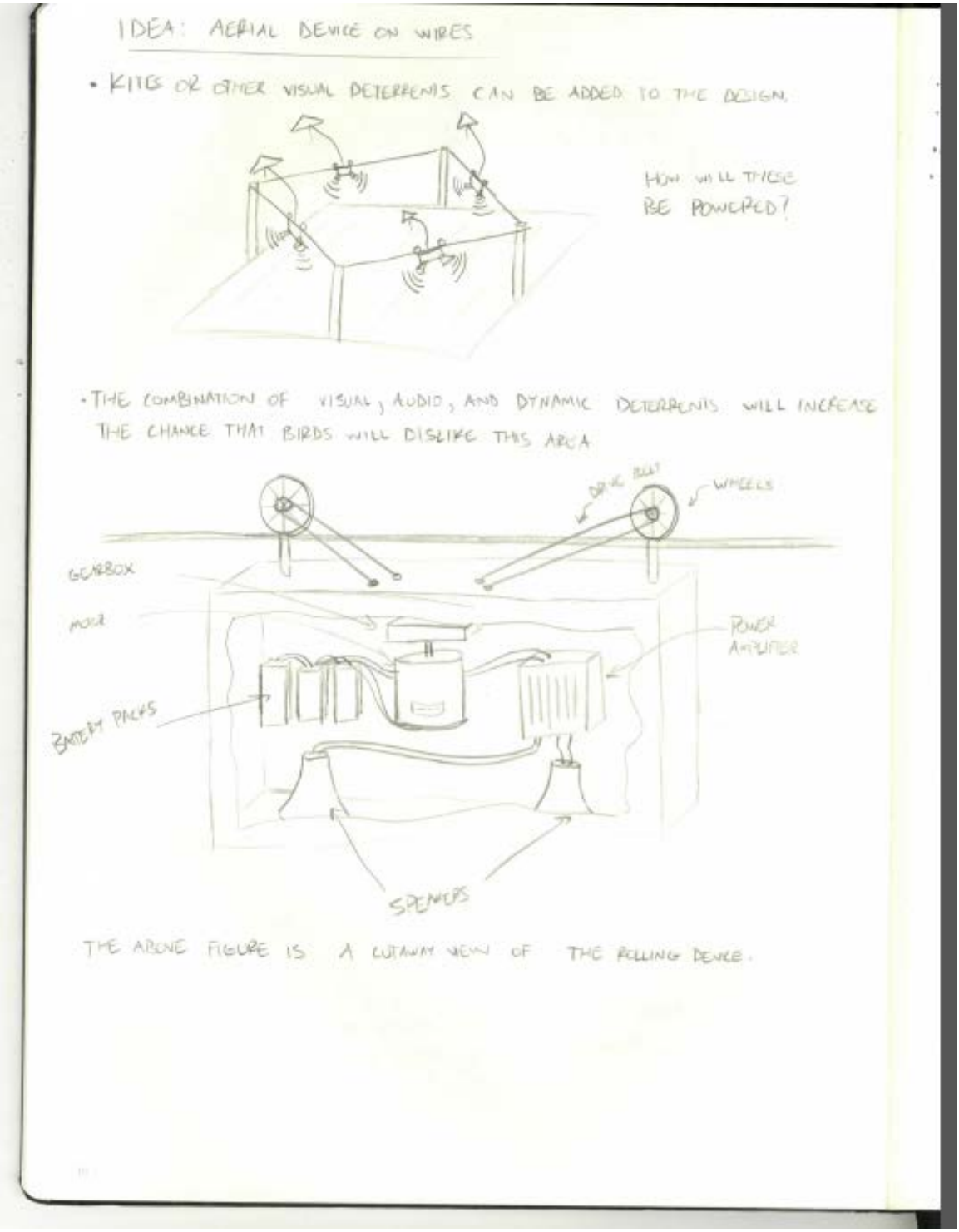


Figure 7. Kyle's version of an overhanging system with a noise device. The noise maker would run along wires/cables that would stretch across the length of the quarter-section. Batteries would be the power source in this particular design.

Problems: This idea was deemed unfeasible because of the huge area that the cables would have to span (each quarter-section being 0.5x0.5 miles). Each line would have to be extremely taught in order to avoid excessive drooping or slack, as well as withstand winds up to 30+ mph. The posts would have to be at least 15 feet in height (assuming the cables don't droop) and easy to move to allow tractors and other machines to come through the quarter-section. The weight and cost of so much material are also impracticalities. Overall, the required span of the cables would be far too expensive and impractical to implement.

#2: Rover

An idea also generated during brainstorming included building a remote-controlled or autonomous rover to drive around the field to ward off the birds. The rover would have a top that would allow exchangeable mounts, such as speakers or air guns, to scare the larks. The design would be weatherproof and reliable as to avoid excessive demands for repair or upkeep. As was mentioned previously, the rover could be programmed to run on its own in a predefined path, which would greatly contribute to the design's ease of use. The rover could either be battery-powered or could run on fuel, which would contribute to its overall noise level.

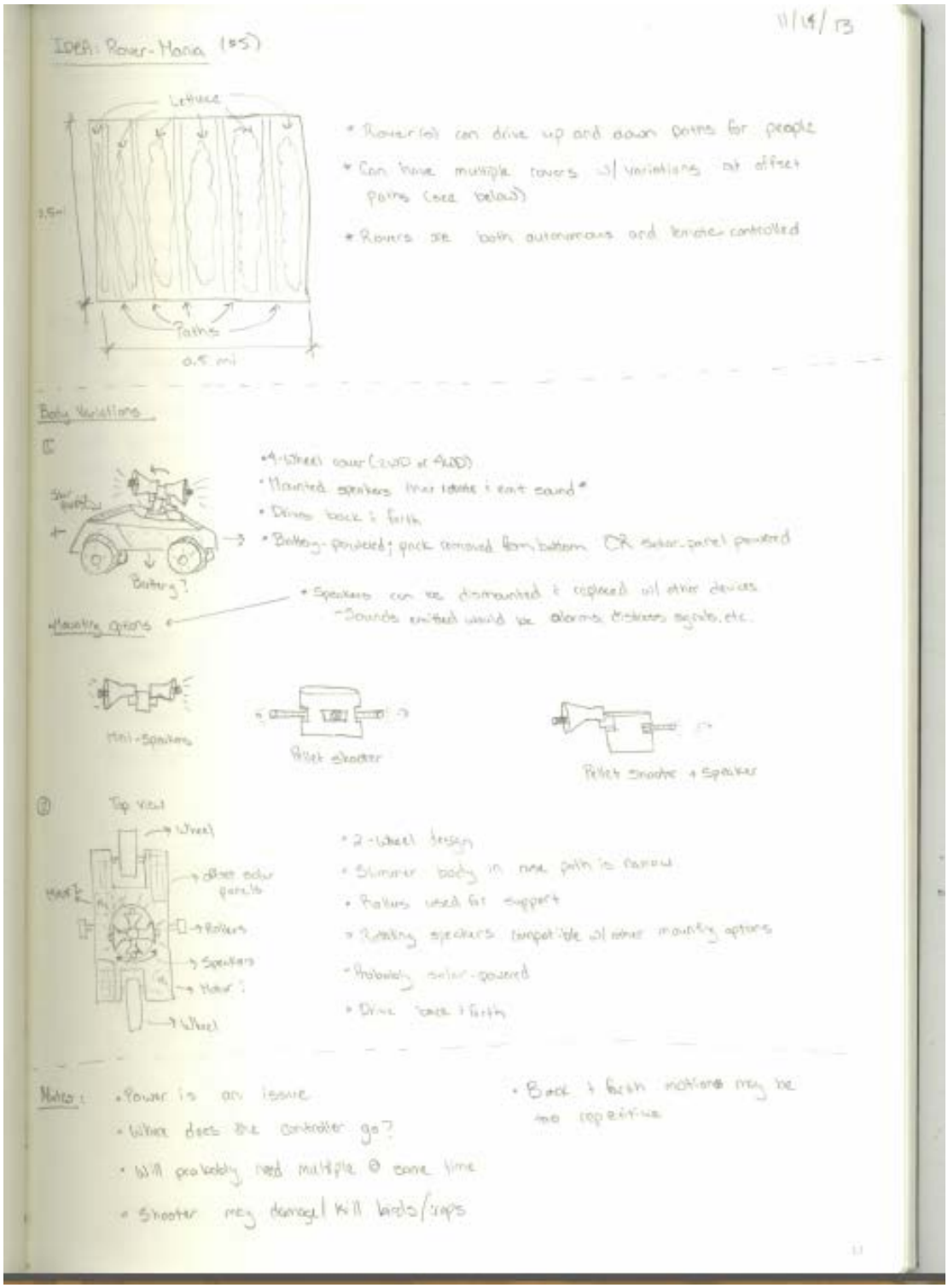


Figure 8. Eduardo's Rover idea. This design would have an exchangeable top that could be used for speakers, gun pellets, or a combination of both. Potential power sources include solar, batteries, or gasoline, if the design were to run off a simple internal combustion engine. The rover would be controlled via remote control or would run autonomously.

Problems: The primary concern for this idea is its complexity and general upkeep and repair. If something were to go wrong with the rover's electronics or programming, repairs may not be easy to make. There are no nearby electronic stores, and any given malfunction may pose too big a challenge to address without adequate technical expertise, so the device would simply be scrapped. Another concern is that the larks may get used to a device that is not sufficiently dynamic. Although the design is generally dynamic, mimicking the dynamic effect of a human user is tough. It may scare them in the beginning, but repeated use would likely habituate the birds to the rover and its effectiveness would quickly decline.

#3: Sound Mines

This idea was based off the fact that the horned larks are warded with loud sounds. Small, "mine" speakers would be laid out across the quarter-section in a strategic path to achieve a specific sound effect. These speakers would be programmed to mimic the sound of a predator "flying" through; this would be achieved by having speakers synchronized to turn on as another turns off, carrying the sound throughout the quarter-section.

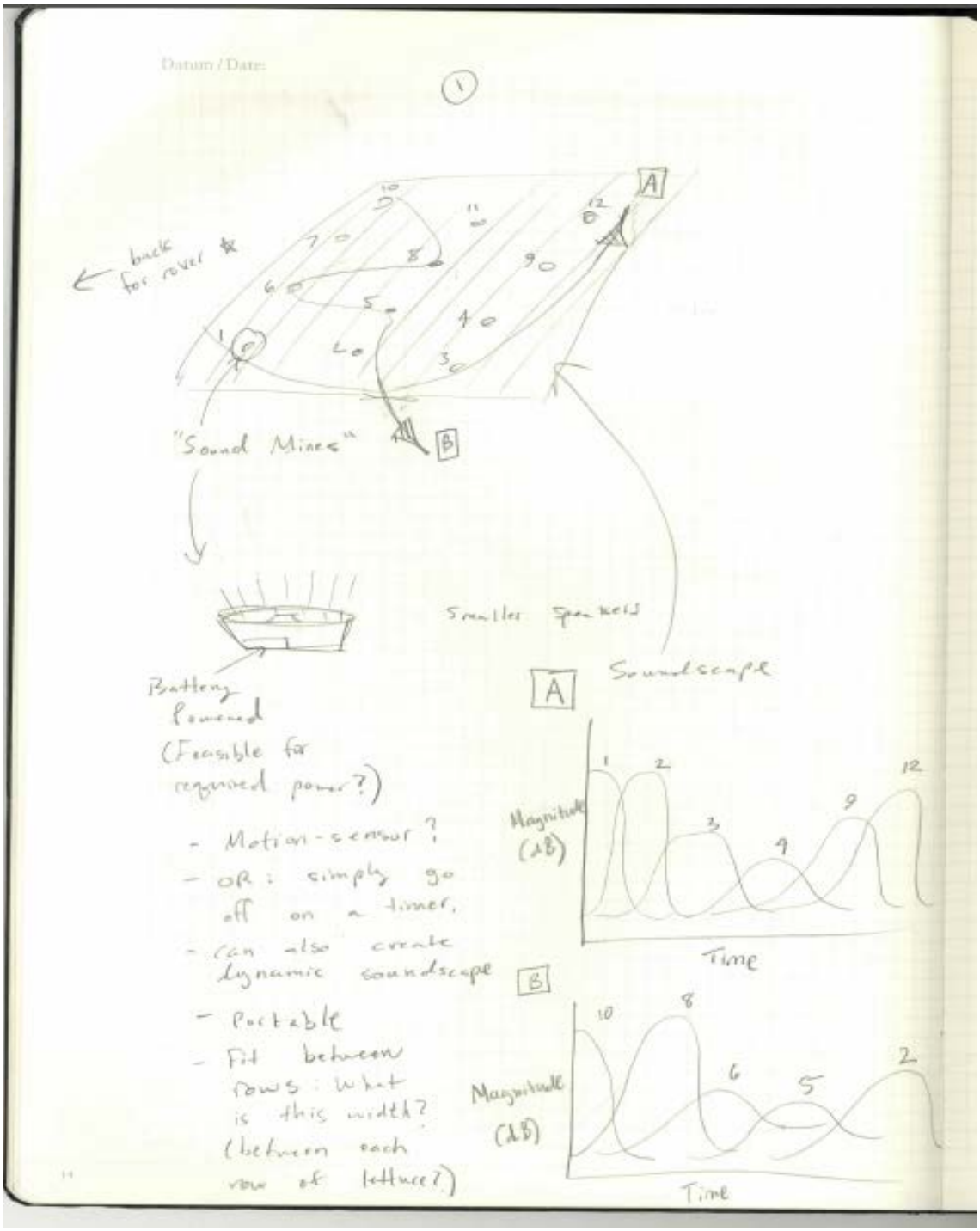


Figure 9. Taylor's Sound Mine design. The various units would be synchronized together so that the sound they emit would create a traveling effect, a sort of dynamic soundscape, throughout the quarter-section. Potential problems with the dynamic effect of the devices and powering all the units greatly hindered the predicted effectiveness of this idea.

Problems: The biggest problem with this idea is how to power all the "mines" at once. Many of these speakers would need to cover the quarter-section, so solar power, the most practical, would be initially be very expensive. There is concern about the illusive dynamic impact without data. Constant relocation of the devices would be required for the tractors and other farm equipment passing through the field and to also keep the larks from getting used to the mines. Similar to the rover idea, complexity is also a concern. If anything were to go wrong with the devices' programming, they would likely be scrapped as there would not be sufficient on-hand technical expertise for repair. The design also poses concerns over its complexity not just in terms of repair, but also in terms of its actual design: how exactly would they be synchronized? How would reliability be ensured?

#4 Electronic Shotgun

One of the highest scoring ideas was a portable, preferably handheld device that would mimic the effectiveness of the shotguns currently used. The original idea consisted of an electronic version of a shotgun that would replace the shotguns currently in use. The device would consist of a woofer and/or tweeter (for low frequency shotgun tones and possibly high frequency bird calls) mounted on a handheld device with a directional cone, and an amplifier and battery housed separately in a backpack. Although this design would not reduce the amount of workers, the dynamic aspect of a human-controlled device is highly reliable and known to be effective. Ammunition costs would effectively be eliminated as well. Originally, the device was to be electronically powered (by rechargeable batteries); however, certain concerns have since arisen about electric power and are discussed in the following pages.

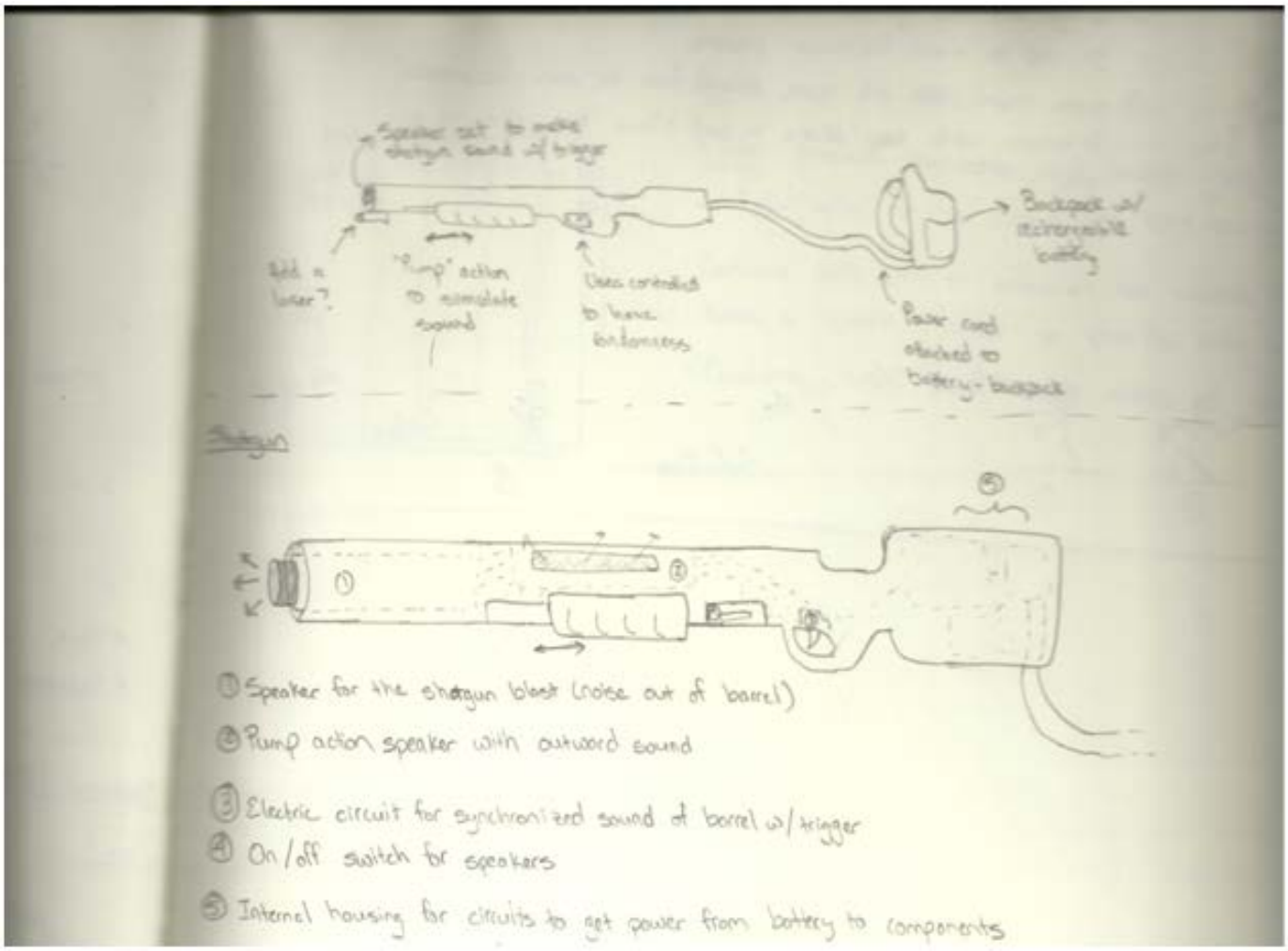


Figure 10. Eduardo's Electronic Shotgun design. A backpack with batteries would be used to power the electronics of the gun. Preliminary design features are written, such as the pump action sound. Other potential power sources include solar power, propane, and compressed air. Please see below for more details.

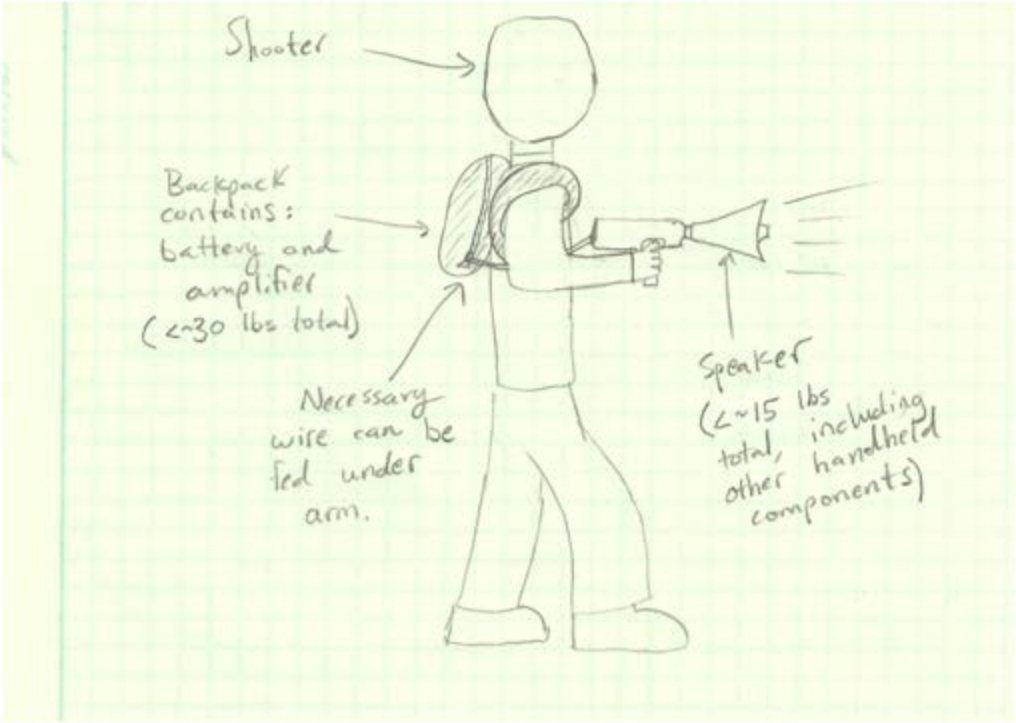


Figure 11. The battery, amplifier, and other necessary components could be kept within a backpack to help reduce some of the weight carried in the hands. The speaker would likely be fitted to a handheld device. Also storing the speaker components inside the backpack poses difficulties with the sound's directionality and also may result in excessive weight borne by the back.

Problems: Although the gun is the top concept, there are some problems that have been encountered in terms of powering the device, safe usage, weight and feasibility. The issues vary depending on the power source, so the different problems associated with each source have been listed.

- Electronic Power: The biggest concern is finding a way to implement a simple design for a speaker, amplifier, and battery into a handheld device that is both lightweight (< ~40 lbs. total between handheld and backpack components) and that can produce a high enough sound level (directly outward from the cone) to scare off the larks. Testing will need to be done to determine a necessary dB level and extensive research into these components will also need to be done for this variation. However, user safety is not a huge concern with this device. All electronic components would be properly encased and grounded. Various sounds can also be played through electronic use, such as distress and alarm calls, so this power option offers a wider option of recordings.
- Propane Power: Propane-powered cannons already exist, although not in handheld form. There are many homemade devices that shoot potatoes or other similar projectiles, and commercial propane guns or cannons are on the market as well. Weight is not a concern here since propane has relatively high energy density and can power several hundred explosions with only a couple pounds of fuel. The most

important concern is user safety: propane is flammable and safely controlling the explosions is a feat for which failure in really not an option. Because of safety concerns, propane power should be avoided.

- Compressed Air: Weight is the biggest concern in this variation. Propane tanks are sold in many shapes and sizes, but the power that can be achieved from propane is greater than compressed air. A large tank of compressed air or large, heavy compressor would be needed for this option, which would not be practical. Lugging around excessive equipment would be extremely inconvenient.

#5 Tower of Power

Another high-scoring idea, referred to as the Tower of Power, includes a PA/speaker system mounted on posts placed at the edges of the quarter-sections. This idea could either be combined with the electronic shotgun idea, as the posts would offer convenient charging stations for the shotguns, or even be employed by itself. The system would play various recordings, such as shotgun echoes or predator calls, to help in a follow-up to the gun blast. Power would be drawn from a solar panel that would be used to charge and recharge the onboard batteries. The entire tower would need to be transportable via forklift, so a flush bottom would be required. Because machinery is available to transport such a device, its weight can be as high as 600 lbs.

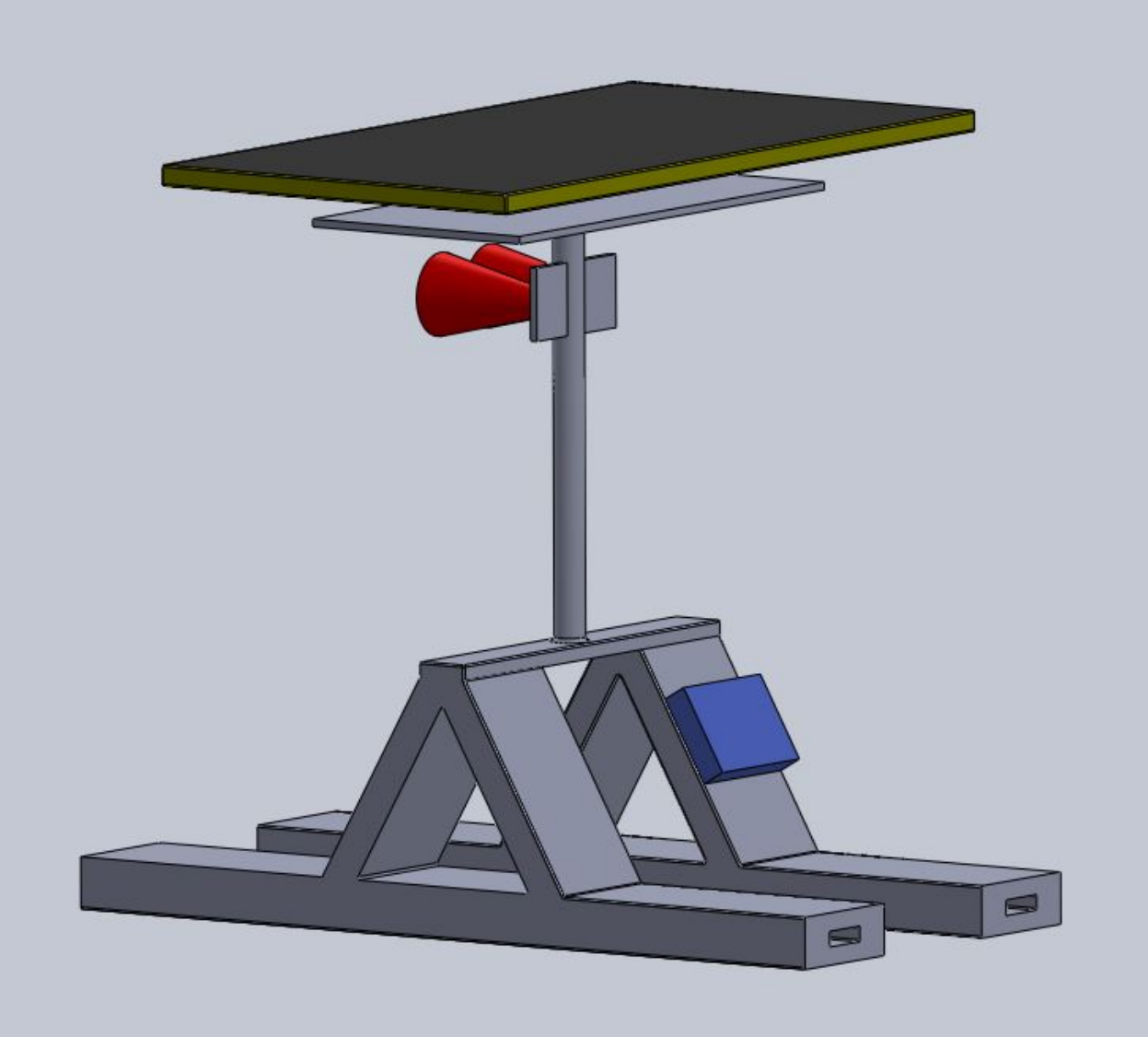


Figure 12. Preliminary design of the "Tower of Power". The frame and post are shown in grey, the amplifier and battery compartment is shown in blue, the speakers are shown in red, and the solar panel is shown with a black top and yellow edges. Rough dimensions are shown in the detail drawing in Appendix B.

Problems: Getting the needed electric power to the speakers using solar power may pose an issue. Will sufficient power be available? Also, the horned larks may also quickly grow accustomed to the post since it would be stationary. To account for this, the recordings could be randomized. The tower(s) must be able to be moved via forklift, so designing them to be easy to move will keep the birds from getting used to them as well. Lastly, the post is similar to designs already on the market which similarly play audio recordings over a system of speakers. The challenge, therefore, is creating a unique design. Designing a high range, high quality system with sounds specifically addressed to the horned lark may resolve the preceding concern. No commercial audio scarers are designed specifically for the lark and many are for residential farms.

Further investigation is required to decide between the handheld sound device and Tower of Power and to also determine whether a combination of the two would pose too large a scope for the project.

Concept Selection

#6 Mobile Lark Scare

After much thought and deliberation regarding the two highest scoring designs (Electronic Shotgun and Tower of Power), there were still too many issues to make either one of the designs completely effective. It would be impossible to stay within the weight requirement for the handheld shotgun idea. The space needed to mount all of the components needed for the desired sound would also make the device extremely difficult to comfortably used by the user. In regards to the Tower of Power, the inability to be easily transported (a forklift would be required) along with the electrical power needed were the biggest issues in making the design feasible.

In order to come up with an effective design, another concept was created that took the best of the two designs above and put them together. These benefits were the portability required from the handheld device and the high sound quality the Tower of Power could give. The device would be a human trailer with a single wheel that the user can manually carry and easily move across the lettuce fields. All the electrical components would be mounted onto the trailer and be able to fold down into a smaller size when not in use. Full details about the build of the design may be seen in Chapter 4 of this report

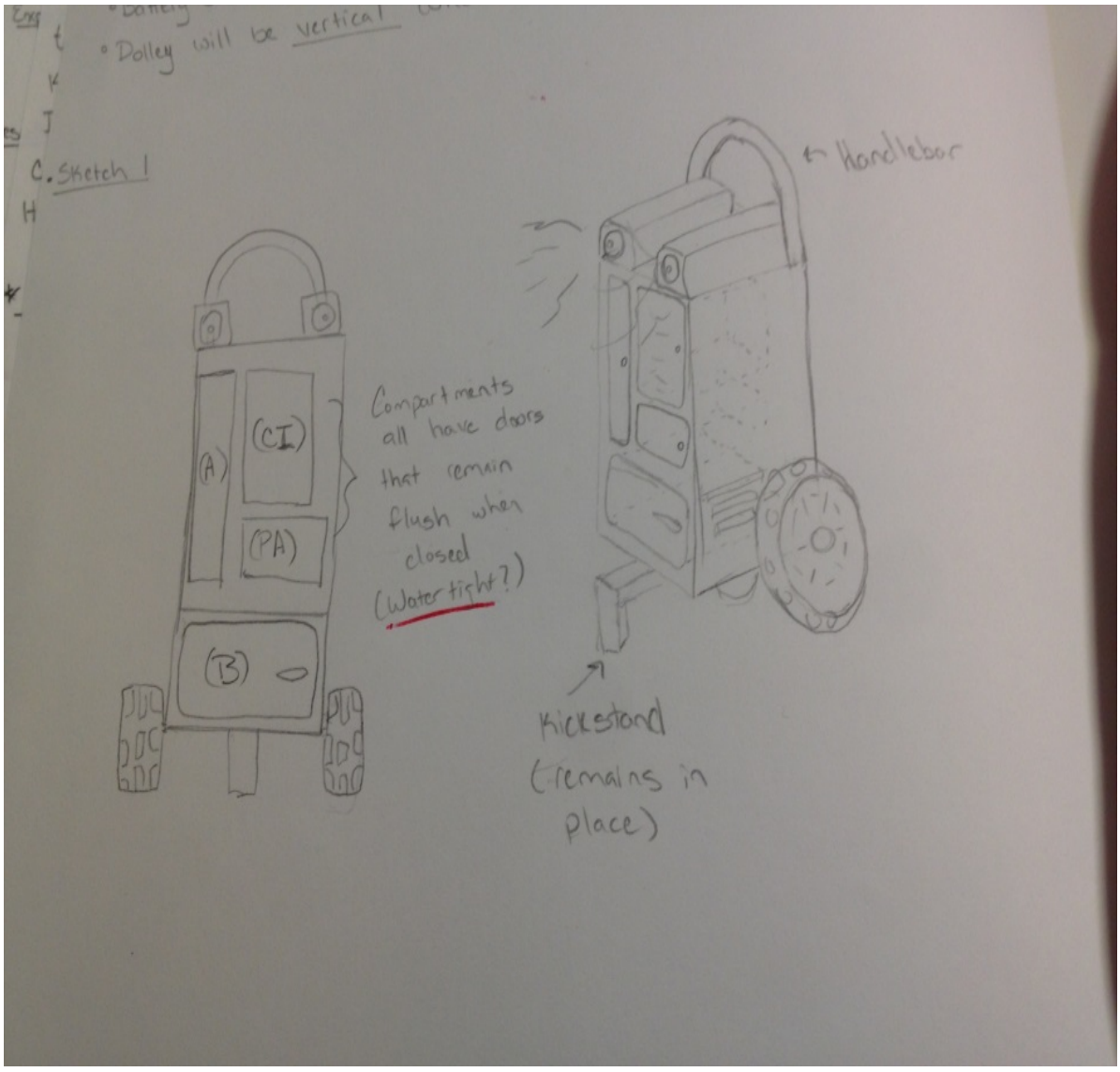


Figure 13: Eduardo's preliminary sketch for the human trailer. Various design concepts in regards to how the components would mount are further discussed in Chapter 4.

Mobile Lark Scare (Initial Design)

The new design that was made after regarding the issues of the Electronic Shotgun and the Tower of Power had the ease of transportation along with high quality power/sound in mind. This design has a single-wheeled, portable device that can be moved manually across and through the quarter-sections, carries all of the electrical components within its housing, and can operate up to a max. of 2 hours continuously on its own. A mechanical aspect will allow the device to be moved behind the user like a human trailer and be placed horizontally on the ground when in use. An armature design will let the user move posts that hold the speakers from a folded position to its vertical upright spot when needed. Height adjustments can be done by the user as needed, and the device will play falcon and lark calls at random time intervals with varying frequencies and loudness. This device will be moved around during the day at times deemed by the user and be used in conjunction with one shotgun user during the testing phase of the project.

Figure 14. Overall assembly of the entire device (intial)

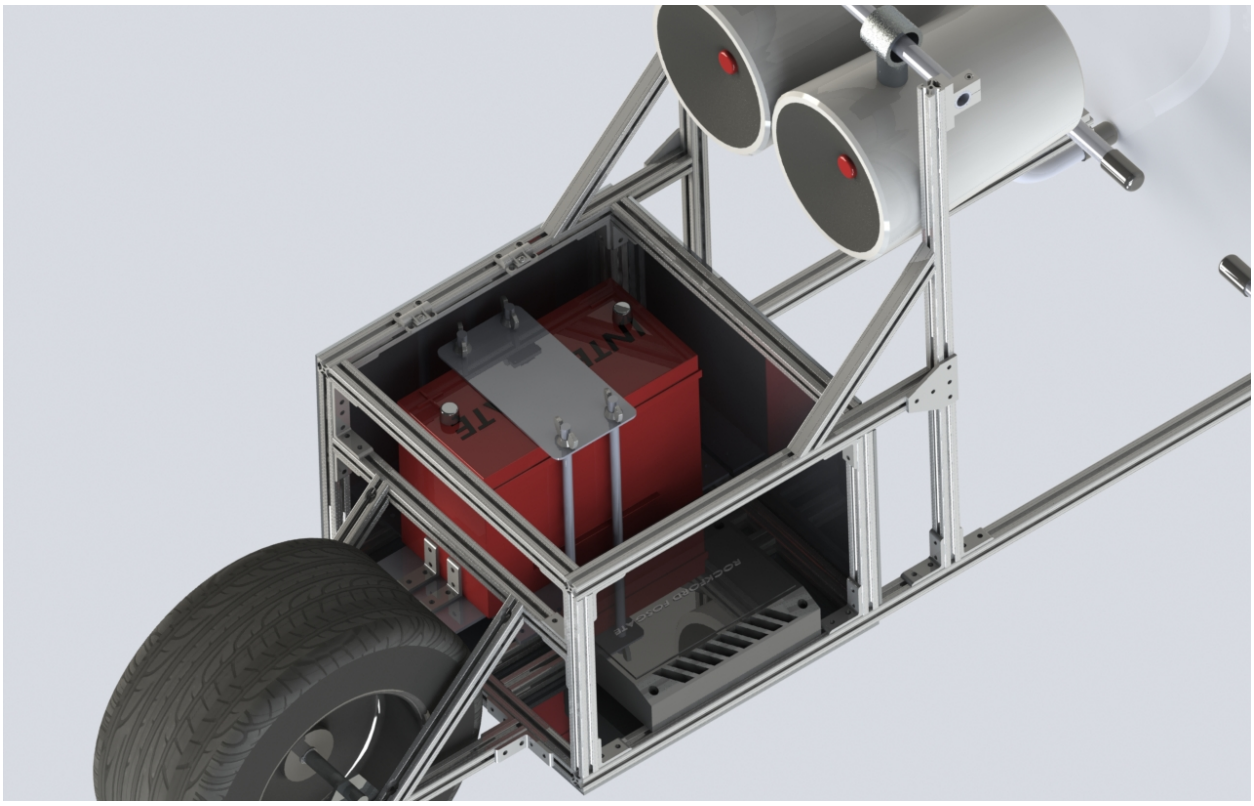


Figure 15. Inside view of the electrical housing (initial). NOTE: Wires and fasteners are not shown for simplicity.

Problems: Although the implementation of the wheel was good for the mobility of the device, potential problems that a user may face when moving the device across the field include getting stuck between furrows, sinking in muddy earth, and heavy weight for the user. Modifications were made in the final production of the device to better suit the needs of the sponsor. Please see Chapter 4 for a full description of these modifications and the final product of the device.

Proof of Concept Analysis and Testing

One of the things that needed to be done was actual sound testing of the predator calls and other bird-scaring audio to see what reactions we could expect with louder and better sound devices. A megaphone with USB compatibility was used to play calls of lark alarm/stress, along with peregrine and prairie falcon calls (the lark's natural predator).

One of the very first things we found was that the megaphone worked some of the time very well and then very poorly at other times. Falcon calls scared the larks away successfully during several runs at distances of about 50-70 yards away, but at other times had no reactions whatsoever at distances of 40-50 yards away. This was probably due to the saturation of the sounds from the megaphone as well as the varying quality of the calls.

However, it was noted that the larks all flew off upon hearing any of the falcon calls. Better quality sound devices and falcon calls will have a much higher rate of success in scaring the larks off each time. One of the devices used at T&A, a sort of firecracker whistler, also had a high rate of success in scaring the birds off. The frequency response from that device hit about 2 kHz-3 kHz, showing that higher frequency sounds were also effective. These findings definitely showed that high-quality components would be needed in order to have a good chance of scaring off the larks.

A final finding worth noting was that a huge flock of crows were found in one of the neighboring quarter sections. A falcon call was played in order to see what reactions could be achieved. All the crows (except for 2) *immediately* flew off scared from the sound. They were several hundred feet away. It reinforced how effective the falcons are in deterring other birds from coming into their hunting areas and how we could effectively use their calls.

Chapter 4: Description of the Final Design

Overall Description/Layout

After presenting the final design to the sponsor, several suggestions were made that would help improve the final product of the project. Although the implementation of the wheel was good for the mobility of the device, the sponsor preferred to have the entire device be able to sit in the bed of a pickup truck or in a trailer in order to be moved around. This was done in order to avoid any potential problems that a user may face when moving the device across the field (problems include getting stuck between furrows, sinking in muddy earth, and heavy weight for the user). The modifications would still allow the device to be picked up, but would require two users as opposed to only one. Since the device would be mounted onto a trailer or pickup, it was okay to make it slightly heavier (the users will only have to pick up the device to place/remove it from the trailer or pickup with ease). A final and small addition to the design includes the placement of air vents at the front and back of the device to allow air flow for cooling of the electrical components.

Figure 16. Final version of the Mobile Lark Scarer

Figure 17. Different view of the Mobile Lark Scarer. The back of the MLS is also shown. The red handle of the ON/OFF switch can be seen as well as the cover for the male end of the charger receptacle.

Detailed Design Description

The design of the entire system is simple. An iPod (or suitable MP3 player) is programmed with the calls and alarms of the horned lark, falcons, dog growls/barks, and loud, high frequency noises such as fireworks (these recordings can be changed however the user sees best). The attached IPod is set to a "Shuffle" setting to randomly play the selected files set by the user.

The media player is connected to a line driver (pre-amplifier) that boosts the signal with a user-adjustable gain control knob. This will also set the varying volume from the speakers. The signal from the pre-amplifier runs into a dual channel amplifier that is connected to two speakers (Note: the amplifier has been tested and set beforehand to configurations ideal for the IPod and the current speakers). All the components are placed within the devices' housing (except the speakers) which is sealed to be as water-proof as possible. All of the power for the device comes from a deep-cycle rechargeable battery. The entire device can be charged overnight with a car-charger that will plug into the back of the device and trickle charge to ensure long battery life.

The housing of the frame for the device consists of aluminum T-slot with a side-door panel for access the volume-control knob and the IPod. Two speakers will be held in place via tubing attached to the outer frame of the electrical housing that will run across the face

of the housing area around 3.5’ off the ground. The system can be mounted onto the bed of a pickup truck or small trailer and be driven around while the sounds play. The idea behind the device is to test out the ability to scare off the horned larks and, if need be, be used in conjunction with one of the shotgun users currently employed at T&A.

Success of the device will be measured by the ability to move the larks across the fields as the calls are played. The birds may not necessarily be warded off completely, but as long as the birds are moved within some reasonable distance, the device can be used either on its own or with one of the shotgun users.

The figure below depicts the wiring schematic for the design. Note that a switch was added to allow the user to easily turn the device off and on. A fuse was also added to ensure the currents stay at a safe level below 50 amps.

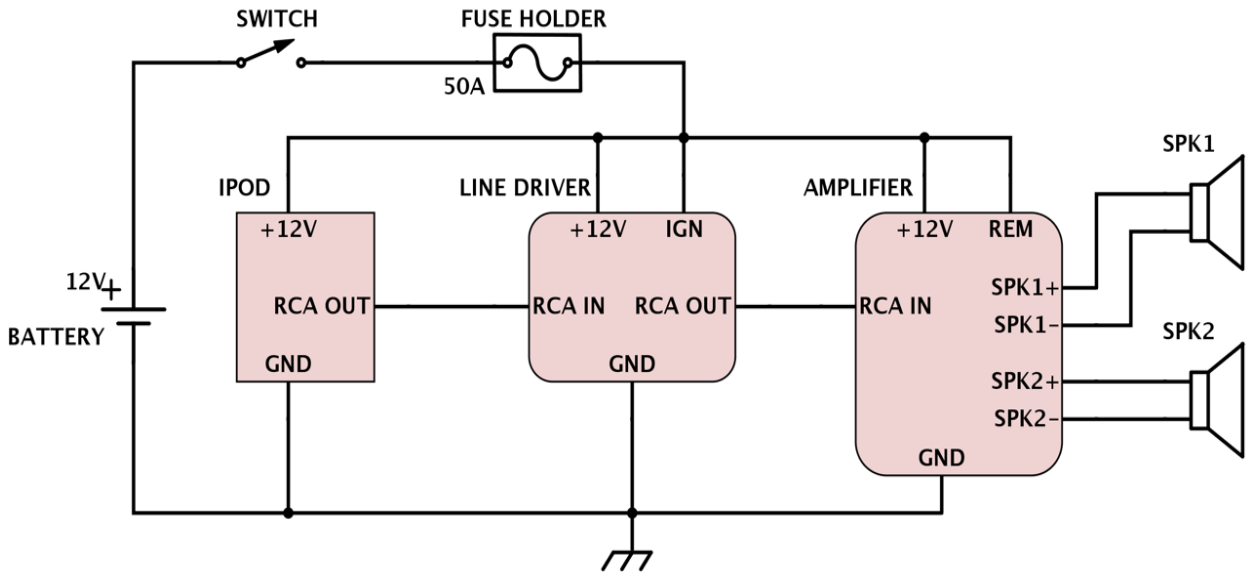


Figure 18. The wiring schematic for our design.

Analysis Results

In order to know what exact components needed to be used, various calculations needed to be done in order to know what to look for when buying all the components.

Preliminary Calculations

In order to get the sound level required, speakers able to emit a total of 200 Watts were going to be needed. This enabled the search for the requirements of the other electrical components. In order to have good safety factors, it was decided that 60% of the devices’ outputs would be needed in order to not burn out the components.

- At 200 W, an amplifier that can produce this (at 60%) would need a minimum rating of 333.33 W at max. power.
- To run this amplifier, the battery would need to be rated at a minimum of 555.56 W (at 60% output).
- With this battery power, and using a 12V battery, the current draw would be 46.3 A.
- At a time of 2 hours max. in use, the battery would need to have a capacity of 92.6 Amp-hrs. This in turn would require either 8 or 6 gauge wire.

With these numbers, the electrical components could be selected.

Cost Analysis

The overall budget of the entire project was $7000. This allows for various powerful components to be bought and ensure the high quality sound emission from the speakers as well as the high strength and durability of the materials for the frame and its respective bracings. Although the individual components may be costly, the overall sum of the project is well below the budget. Below you will find the estimated percentage of the budget used as well as the final percentage of the budget used. Please see Appendix B for an overall Cost Analysis Table, along with drawings with their respective Bill of Materials.

- Total budget for Birds Be Gone: $7000
- Total sum of all components (initial estimate): $2723.21
- Percentage used (initial estimate):

$$\frac{\$2723.21}{\$7000} * 100\% = \mathbf{38.90}\%$$

- Total sum of all components (final): 2696.29
- Percentage used (final):

$$\frac{\$2696.29}{\$7000} * 100\% = \mathbf{38.51}\%$$

Material, Geometry, Component Selection

The following sections explain the reasoning behind the selection of each device for the project based on the calculations used in the "Analysis Results" section.

Electrical Component Selection

The first thing searched to power everything was a strong battery. It was determined that a deep-cycle marine battery would be sufficient for the job. Although the device may not operate at 2 hrs. continuously, the safety factor would allow wiggle room for slight error. An AGM battery was also chosen so that there would be no problems from spillage as the device is moved from place to place. With all this information, the **DieHard Platinum Marine Battery, Group Size 31M**, was selected (any other battery at this equivalence would also work). A battery charger will also be used in order to have the battery charged overnight and when it is not in use during the day.

Figure 19. The battery selected was a DieHard Platinum Marine Batt Battery.

The next big item needed would be the amplifier. Since amplifiers are rated at power ratings usually ending in 0s, a 400 W amplifier was sufficient for this application. The amplifier was chosen to only have 2 channels in order to be able to have more power at each channel during its output. It would have to be strong enough to be able to be bridged in different configurations for testing purposes, as well as have a large frequency response. Based off this, the **Rockford Fosgate Punch 400-Watt Stereo Amplifier** was selected for its various bridging options and excellent specifications.

Figure 20. The amplifier selected was a Rockford Fosgate Punch 400-Watt Stereo Amplifier.

The speakers of the entire device would also have to be of very high quality and able to play the strong boosted signal from the amplifier. With its outdoor use, the speakers would have to be weather resistant (since these are the components facing the environment). It was determined that marine speakers would be used since they are built for strong water and UV resistance, and have the required specifications (the speakers would need to output 100 W continuously). The **Rockford Fosgate M282 WAKE 8" Tower Speaker** (x2) was selected for this application.

Figure 21. The speakers selected were Rockford Fosgate M282 WAKE 8" Tower Speakers.

Other smaller items needed would be an adapter for converting the signal from an iPod in MP3 format to a signal that the amplifier can read, as well as all the necessary wiring, battery terminals, etc. (Please see the table in the "Cost Analysis" section for all materials).

Mechanical/Frame Component Selection

In order to be able to hold all of the above components, a strong yet lightweight frame would be needed. **Aluminum T-slot framing** would provide the most durable housing. Adapters at the handle sections of the frame would allow tubing to be used for the handlebar sections of the device. The speaker mounting for the device will be made from tubing attached to the outer frame of the electrical housing. Two bars will be held in place coming off the housing, then have another tube run across them. This tube is what the speakers will attach to (the speakers will be held in place below the support). Electrical wire will be running through the tubes and into the electrical housing. The speakers will be able to be rotated around as needed to have the sound emission placed at any desired location when in use.

Picture

A swinging side door to the electrical housing will provide access to all of the electronics. It was designed so that the iPod and the volume-control knob can be pulled outward. The interior of the housing will have holding areas for all of the components. The entire device will be supported with 4 stationary legs made from the aluminum t-slot framing. The legs are rigidly held in place with two (2) L-brackets at each leg that attach to the housing of the device. The legs will help the device stand firmly in the uneven terrain that is present at the Tanimura & Antle farm. All ends of the t-slot framing have end caps that will prevent users from potentially hurting themselves on an edge of the frame.

Special Safety Considerations

As with all engineering projects, safety is the number one concern. The major potential problem that the device may bring about is the danger of loud sound affecting the user(s) hearing. With the device creating high frequency bird calls, it is possible that there may be some hearing damage if precautions are not followed. In order to help mitigate this, the speakers chosen are powerful, but very directional. That is, someone standing next to the device will hear something lower than someone standing right in front of it. With this directional emission, a user can walk around the device in order to safely turn it off.

With all the electrical components, another concern is regarding shortages, electrical shocks, and water damage to the circuitry of everything. In order to make sure all electrical components are properly grounded and as safe as possible, professors and electricians from Cal Poly have checked all heavy electrical designs. In regards to water damage, proper measures to make the entire device as water proof as possible were taken in the form of caulk seals at openings of the device, such as the door, frame and vents. Most of the components themselves are also able to resist moisture and cold temperatures while working continuously. The battery is meant for deep discharge and able to work in harsh temperatures. The speakers are the marine type and built to withstand moisture, UV rays and corrosion. The main component that will need protection will be the amplifier. Despite the many precautions taken against moisture, it would still not be recommended to operate the device in moderate rain.

Maintenance and Repair Considerations

The Mobile Lark Scare is built to be as simple as possible while maintaining its high quality and durability. There are a few things the user should be aware of in case there is a problem during the use of the device. If the power should ever run out or become low during use, the entire device can be charged with the provided charger. If need be, the top panel can also be taken off for complete access to all of the components. The charger is able to charge the battery at various rates in order to get different charge times. Built-in resistors will allow slow trickle charging as the battery comes close to full charge. The battery should be kept at the charging station when not in use.

Other maintenance concerns regard moisture. The device should not be operated in moderate rain. Although we took many precautions against moisture, and although the speakers are waterproof, it would be better for the life of the design if it were not exposed to rain.

Chapter 5: Product Realization

Manufacturing

One of the biggest things that has been mentioned regarding the construction of the MLS is the material used for the housing of the entire project. In order to have a lightweight and strong, durable material that can resist various types of weather conditions without oxidation issues, aluminum was the best option chosen by the team. Another thing that the team needed for the project was to have an easy way to assemble/disassemble and access the interior components of the housing. T-slot aluminum extrusion was the answer for this problem. The material is easy to work with and can be cut to any lengths needed for the MLS. Its versatility to mount various components allowed the MLS to be strong and sturdy. The extrusion is used for the base of the housing, its respective supports and legs, and the stands on which the speakers are held in place. Stanchions run across two extrusion lengths and hold up metal tubing. This tubing is the base for the speaker clamps to mount on to and houses the wiring from the speakers to the housing (see Figure 18 on the follow page for a better visual).

All the necessary electrical equipment that was needed was directly mounted onto the housing of the extrusion. To protect it all, aluminum panels were custom cut and bolted to the sides of the housing and caulked along the edges in order to prevent moisture from entering and damaging the electrical devices (the images at the end of Chapter 4 show the MLS with all of its panels in place). Electrical wire was then run from the battery to a power switch. The switch runs into a 50-amp fuse for surge protection purposes. After the fuse, wire runs and provides power to the line driver, iPod player and amplifier. Finally, everything loops back to the negative terminal of the battery (see the Figure below for a visual of all the wiring). Wiring for the charger of the MLS is run in parallel to the circuitry for the amplifier and speakers and connected directly onto the terminals of the battery.

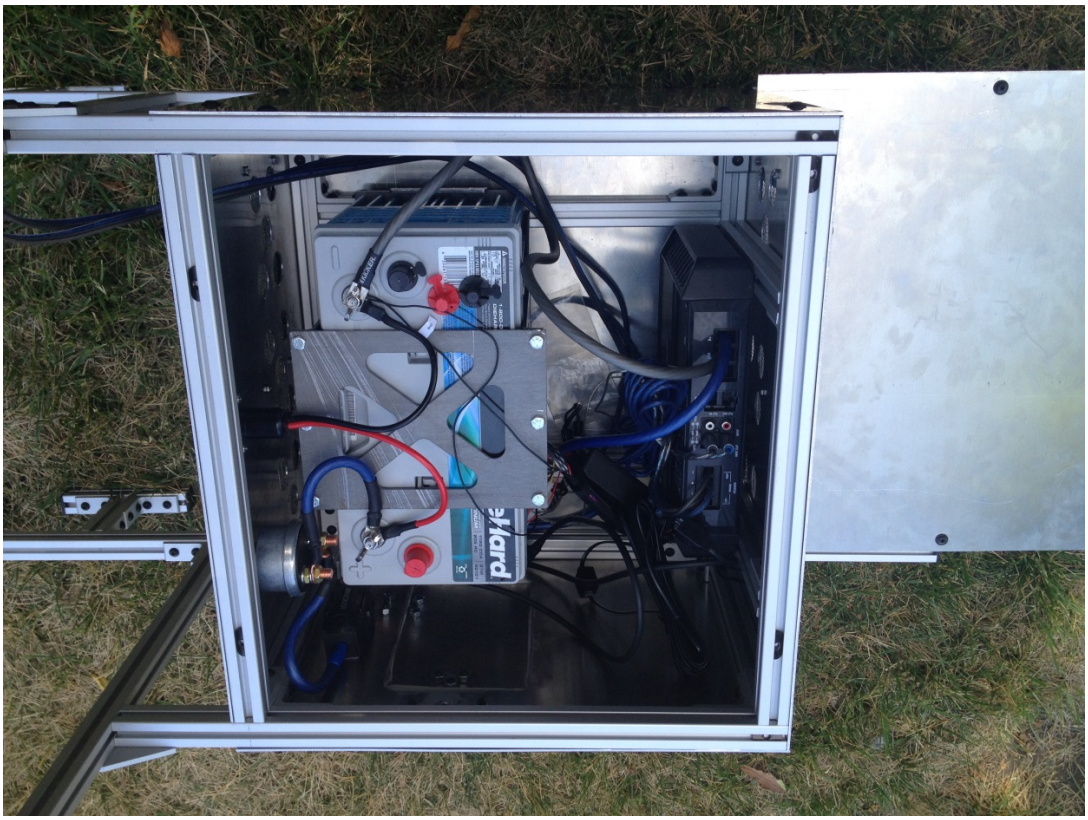


Figure 22. Internal wiring. NOTE: This is not the final wiring for the delivered version of the MLS.

The amplifier also has four (4) wire speakers running from it directly into the 2 speakers for the entire system (2 wires per speaker). This wiring runs out of the housing and into the tube that holds the speakers in place. Note that in the final version of the electrical wiring, all loose cables and wires were placed within looming to prevent any tangling of wires and to keep everything organized and easy to follow. The looming also serves as an added layer of protection against moisture for the wiring.

Figure 23. View of the MLS with speaker wire running from the amplifier shown.

Differences

The final version of the MLS turned out to be very different from the original concepts drawn up. However, once the final design was chosen, the differences between the initial drawing of it and the final prototype are small. The following section will address the components that were changed or removed and provide the explanations for them.

Air Vents, Charger and Switch

A concern that the team had was internal heat building up within the electrical components. To minimize any potential damage the components may face with heat buildup, air vents were placed at the front and back of the MLS to allow air to flow in and out freely. The vents have downward facing slits that prevent water from entering, and both vents were caulked around all edges to prevent water running into the housing. Another safety concern that was addressed was having a charging receptacle attached to the MLS directly. The original idea was to have the battery be removed or have alligator clips from a charger attach directly to the battery (while it was still within the device) in order to charge it. However, there was a big risk of having someone receive an electrical shock (given that the entire device is made from aluminum). To eliminate this risk, a male receptacle (with water proof cover) was connected to the battery and attached to the back panel. Its respective female end was attached to the cables of a battery charger specifically for the AGM battery. This way, all the user has to do is plug the receptacles together and charge the battery overnight. Finally, a big power switch was attached to give the user easy access to turn the device on or off. With a big red handle, the power switch is easy to see and use, giving the operators safe and easy access (see Figure 17).

Door Access and Internal Component Placement

One of the problems that an operator would have faced with the original rendition of the MLS was having access to the components. The only way to have done this would have been to remove the top panel every time. This proved to be a cumbersome task, since bolting the panel back on is not as easy as it may seem. To remove this issue, a small door was placed to the left of the MLS. Originally, the door was to be at the front, but with the need for air flow and vents, the door was simply moved to another panel (see Figure 16). The panel gives the operator easy access to the volume-control knob and the iPod player. The door is held in place with a spring-loaded sliding lock and has weather stripping all around to minimize water entering through it. The operator can reach in and lower or raise the volume at their discretion, and select which file or playlist to play from the iPod. This adds the human dynamic ability that can make the MLS more effective during attacks from the horned lark.

A final change to the design of the MLS was the placement of the components. If the original format was kept, the two operators would have experienced a significant

difference in the weight distribution of the device since the battery was completely placed on one side. To address the issue, the electrical components were all rotated to run across the housing of the MLS in order to even out the weight distribution. This gives the operators more stability when lifting the MLS and places its center of gravity in a lower and more centered area.

Manufacturing Changes

There are a couple of big changes that can be done if the device is to be rebuilt or produced in greater quantity. One of these changes would be the way the housing is assembled. Instead of using aluminum T-slot extrusion, the housing can be welded together using aluminum piping or sheet metal. Someone with good welding skills would have to do the task, but it may be more cost effective, so it is worth investigating if the device is to be made again. The welding would also be applied to any of the components that were attached to the extrusion, such as the stanchions and L-brackets. Another big change would the entire selection of the electrical components. Upon completion of the MLS, lettuce production at T&A is not at risk of attacks from horned larks, so effective testing of the device on the target species was not possible. Testing the effects of the MLS on the larks can determine what kind of changes may be done on the component selection. For example, if it is found that the larks respond better to high frequency sounds, the entire device may be downsized. Speakers with high-frequency tweeters may then be selected along with an amplifier to suit the needs of this application. Ultimately, the device may be small enough to be handheld. Another example may be that speakers of higher quality are needed in order to carry the sounds emitted from the MLS further. The changes on the MLS will be determined by the needs discovered after extensive testing of it during horned lark attacks. Please see Chapter 6 for more details regarding testing.

Chapter 6: Design Verification (Testing)

Full testing of the device could not be conducted prior to writing this report simply because the testing requires availability of a specific species of bird that was not accessible for testing during spring quarter. The horned larks are only present at Tanimura & Antle's Five Points farm when lettuce is sprouting. During spring quarter, the lettuce at the Five Points farm was too mature to be vulnerable to the larks, and therefore, larks were not present. Although every effort was made to fully convert the customer requirements into design specifications, the unpredictable and adaptive nature of the birds leaves some uncertainty in simply testing the device against the design specifications. In the end, we cannot know how well the device performs against birds until the device is actually tested against birds. Nevertheless, the scaring device was tested against the design specifications to measure the device's effectiveness. An overview of the testing results as compared to the design specifications is shown below in Table 2 Reminder: the compliance column indicates the method that will be used to verify that the requirement is met: T (Testing), A (Analysis), S (Similarity to Existing Designs), and I (Inspection).

Table 2. Overview of Final Design Testing Results

Spec. #	Parameter Description	Requirement or Target (units)	Tolerance	Actual Tested Value	Compliance
1.	Number of Operators	1-2 person per quarter section	Max	2 people to transport, 1 person to run, Autonomous once running	T
2.	Operating Temperature	15-100 °F	Given Range	Pass	A,T,S
3.	Wind Resistance	30 mph	±10	Pass	A,T
4.	Weight	250 lbs	Max	~150 lbs	A,T,S
5.	Total Area Covered	150 Acres	Min	1-3 acres (needs to be verified with testing)	A,T
6.	Cost	$7,000	±$2,000	$2700	I

7.	Immediate Range	70% of Maximum Shotgun Range (~100 yard)	Min	100 yards (needs to be verified with testing	A,T
8.	Decibel Level	150 dB at 1 meter	Max	105 dB at 1 meter	A,T,S
9.	Onboard Power	Y	Y	Y	A,T,I
10.	Self-Operation Time	2 hrs	Min	6-8 hrs	A,T,I

Explanation of Testing

1. Number of Operators
    - The design requires two people to fully function and be transported. Given the weight and size of the device, two people are required to move the device or load it into a truck bed. For operation, only one person is required to turn the device on or off and to select which audio will be played. Once the device is running, it can run autonomously for up to 8 hours.
2. Operating Temperature
    - The device has been tested in temperatures in excess of 80 degrees. An in-depth heat transfer calculation was not conducted as it was deemed unnecessary by the team. The fact that the sounds are dispersed between large lengths of silence (10 seconds to 3 minutes) results in discontinuous power consumption by the amplifier. This gives the amplifier and battery more than adequate time to cool, especially given the amplifier's large heat sink and the cooling vents added to the side panels of the housing.
3. Wind Resistance
    - The device handled sub –twenty mph winds with ease during device testing. After further analysis, it was calculated that the device could withstand winds of nearly 60 mph. Stability should therefore not be a concern.
4. Weight
    - The device weighs about 150 lbs. At this weight, the device satisfies the 250 lb requirement.
5. Total Area Covered
    - This specification was deemed untestable without field testing against birds. Since the device uses sound to scare the birds, this parameter is likely related to both parameter 7 and parameter 6. Although the parameter was deemed

untestable without access to the target species, the team realizes that the specification was not close to being realized. An estimate of 1-3 acres covered has been made by the team, given the sound testing done to verify the dB level specification.

6. Cost
    - Please see Appendix B, Table 4 for a breakdown of the cost of materials.
7. Immediate Range
    - The immediate range of the device was also deemed untestable without access to horned larks, since we cannot know how exactly the birds will react. The range of the device is directly related to the decibel level, which was tested with results shown in the following section.
8. Decibel Level
    - The decibel level testing was conducted using an Extech sound pressure level meter rented from the Mechanical Engineering Department. The meter has a range of 35-130 dB with an accuracy of ±1.5 dB. Results from testing are shown in the figure below.

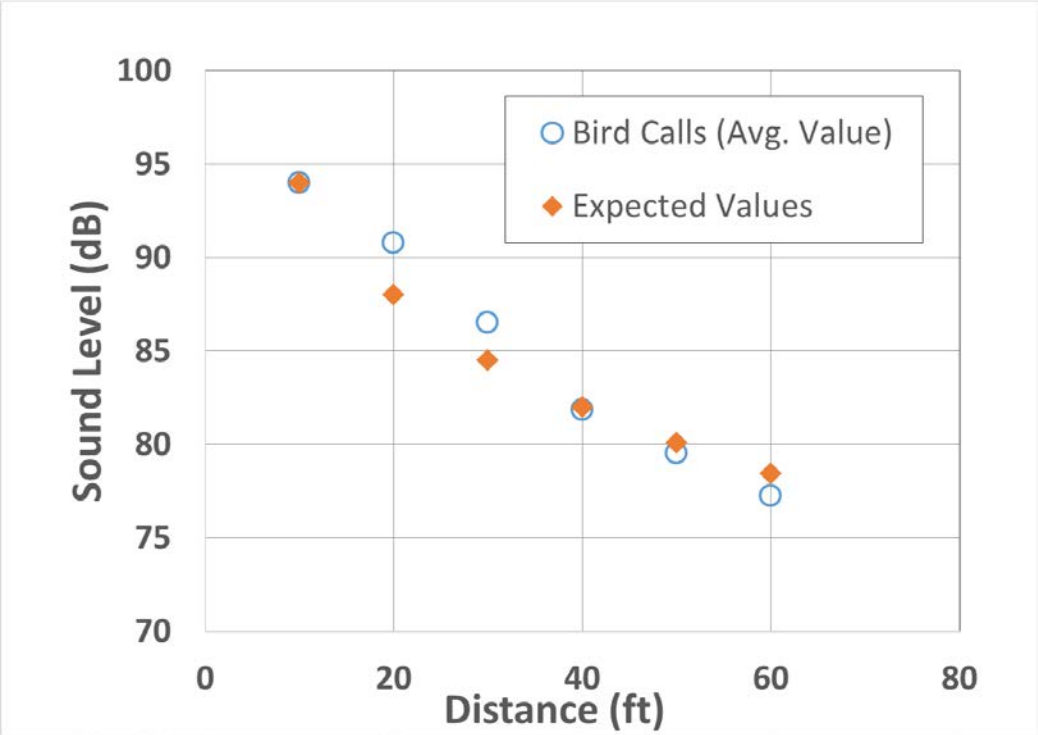


Figure 24. Sound Level vs. Distance graph. It is easy to see that the decibel drop off rate is close to the expected values

- The sound pressure level meter readings are compared to a purely theoretical sound pressure level drop-off curve in ideal conditions. The test was not conducted in ideal conditions, with approximately 10 mph winds and surrounding structures instead of an empty field. Given the sound

pressure levels from our testing, the deterrence sounds played by the device should be audible to birds out to about 100 yards.

9. Onboard Power
    - The device is powered by a DieHard Platinum PM-1 deep cycle marine battery with 100 amp-hours of capacity. The battery provides power for the entire system, including the amplifier, line driver, iPod, and speakers. The battery must be charged overnight, using the provided charger that has been included with delivery to the sponsor.
10. Self-Operation Time
    - After a full charge, the battery was tested to perform for approximately 6-8 hours, depending on frequencies played and the duty cycle of the amplifier. Lower frequencies will reduce battery life more quickly wince the speaker will drive the 8" subwoofer to create the sound. Higher frequencies use only the tweeter, which drives a smaller speaker over shorter oscillations with better efficiency. Playing sounds with larger spaces of silence will also increase battery life.

Test Descriptions

Once the device has been built, various forms of testing will have to be undertaken during attacks from the horned lark. The following items will be the goals of the testing methods used for the project:

Goals during T&A testing

1. Test mobility of the device along the terrain and with workers.
2. Test the range of sound frequencies from MP3 player (with bird calls) and record effects on birds.
3. Test the durability of the device in the varying weather at T&A and how long the device is able to play.
4. Verify that the charging station for the device will work and that repeated use is feasible.

Chapter 7: Conclusions and Recommendations

Ultimately, the MLS is a very loud and dynamic device with the strong potential to work well in conjunction with shotgun users. Although the original goal of the team was to do its best to eliminate the use of shotguns entirely, it is extremely difficult to replicate the exact effects of bullets and human dynamics through electronics. The team agreed that the device has potential to work all by itself, but in the long run it may not be too effective. The life and potential of the device can be greatly improved if it is used alongside the shotgun operators. The goal with it is to mitigate the use of the shotgun and potentially reduce labor and ammunition costs. Extensive testing on its effectiveness must be conducted throughout a long period of time (6 months-1 year) in order to see its effect on the horned larks for more than one season. A look at cost records after a year of use of the device will help the sponsor see if the MLS helped reduce cost and labor along with the extent of this reduction.

Although the device has been built to be water-proof, it is not recommended to use in a heavy downpour. The component with the highest risk of damage from moisture is the amplifier. However, the entire device can handle light rain, foggy, hot, and windy conditions. Air vents allow cooling of all the internal components. It is recommended that the user(s) set the volume on the control knob to a low setting and then select and play the file(s) they wish, bringing the volume up afterwards. This will help prevent anyone from getting startled or blasted with sound. The entire device should also be OFF when charging. Although the device will run and operate while charging, having it off will help minimize the amount of heat that can build up within the housing compartment. When the device needs charging, the given plug and receptacle should be used. The battery itself can be accessed by removing the top panel, but charging it with direct connection to the terminals is not recommended. Since the entire device is made from aluminum, there is a risk of shorting out the electrical components or getting an electrical shock.

References

Appendix A: QFD and Decision Matrices

Customer Requirements (Step #2)	Lower # of workers	2				6				3													
	Must be weather-proof	4	9	9																		6	
	Easy to Use	3							3												6	6	6
	Must be safe	5										9									1	3	3
	Needs to cover quarter-section	5			9			6													1	1	1
	Portable	2							9												6	6	9
	Preferably autonomous	1				1				9													
	Eliminate shotgun use	5						3															
	Within budget	4									9												
	Self-powered device	4					9														1	9	9
																					1	3	1
	Units																						
	Targets																						
	Benchmark #1																						
	Benchmark #2																						
	Importance Scoring		36	36	45	13	36	45	27	15	36	45	0	0	0	0	0	0	0	0	0		
	Importance Rating (%)		80	80	100	29	80	100	60	33	80	100	0	0	0	0	0	0	0	0	0		
● = 9	Strong Correlation																						
○ = 3	Medium Correlation																						
Δ = 1	Small Correlation																						
Blank	No Correlation																						

Figure 25: QFD Table to determine engineering importance of engineering specifications.

		Concept										
		1	2	3	4	5	6	7	8	9	10	11
Criteria	A	-	+	DATUM	+	S	S	-	+	+	+	S
	B	-	+		-	S	+	+	+	+	-	S
	C	-	S		-	S	S	-	+	-	+	S
	D	S	S		S	S	-	S	-	S	S	S
	E	+	S		+	S	S	S	S	S	+	S
	F	+	+		+	S	+	-	+	+	+	S
	G	+	S		S	-	+	S	+	+	-	-
	H	S	-		-	S	S	S	-	S	S	S
	I	S	-		S	S	S	+	S	-	S	-
	J	-	S		S	-	+	+	-	S	-	S
	K	+	-		-	+	S	+	S	-	-	S
	Σ+	4	3		3	1	4	4	5	4	4	0
	Σ-	4	3		4	2	1	3	3	3	4	2
	ΣS	3	5		4	8	6	4	3	4	3	9

Criteria	
A	Safety
B	Lower Cost
C	Reliability
D	Little to no Labor
E	Temp Resistance
F	Wind Resistance
G	Lower Weight
H	Total Area Coverage
I	Immediate Range
J	Noise Level
K	Dynamic

Concept	
1	The Hive
2	Pop-Up Dog
3	Device on Wire
4	Sound Laser Barrier
5	Birds on Track
6	Electronic Shotgun
7	Propane Cannon Ball
8	Rover
9	Motion Speaker Wire
10	Veggie Casing
11	Zipline Bird

Figure 26: Pugh Chart used to rank team member initial ideas.

Appendix B: Vendor Information and Data Sheets

Table 3. TSlots Bill of Materials.

Bill of Materials from Tslots				
1"x1" Aluminum T-Slot Framing Extrusion	***Part Number 650000***	***Length (in)***	***Quantity***	***Total Length (in)***
		46	2	180
		32	2	
		24	1	
		22	2	
		18	4	
		16	2	
		12	6	
		6	4	
		4	4	

Hardware	***Part Number***	***Description***	***Quantity***
4 Hole Inside Corner Bracket	653052 & 651171	1/4-20 x 1/2" BHSCS & Economy T-Nut	43
5 Hole Tee Joining Plate	651129	5/16-18 x 11/16" FBHSCS & Economy T-Nut	2
90° Deadbolt Latch	655103	Deadbolt Latch With Side Latch	1
Universal Door Hinge	655768	10 S & 15 S Universal Die Cast Hinge w/ Oblong Holes	1
Door Hinge Bolts	651023 & 651163	1/4-20 x 5/8" BHSCS & Economy T-Nut	2
Stanchions - Single Horizontal Base	659047	15 S 2" Single Horizontal Base	2
Stanchions Fasteners: 2" Base	651487	Recommened Fasteners for Stanchion	4

Fasteners	***Part Number***	***Description***	***Quantity***
Single	651163	Black Zinc 10 S Economy T-Nut	104
Single	651019	Extra fasteners	104

Table 4. List of Project Transactions

Date	Payee	Description	Debit	Credit	Balance
4/7/2014	Student Project Account	Check from Jad		$1,500.00	$1,500.00
4/8/2014	Sears	Battery	$283.07		$1,216.93
4/10/2014	Amazon	Amplifier	$266.97		$949.96
4/16/2014	Metals Depot	Aluminum Panels for Housing	$177.69		$772.27
4/16/2014	Student Project Account	Check from Jad		$1,200.00	$1,972.27
4/25/2014	MobileWorks	Speakers	$1,253.54		$718.73
5/7/2014	Batteries Plus	Battery Charger	$70.74		$647.99
5/7/2014	Lombards Stereo	Ipod Connector Cable	$54.11		$593.88
5/8/2014	Artec Industries	Battery Mount	$103.55		$490.33
5/10/2014	McMaster-Carr	Extrusion End Caps	$14.40		$475.93
5/17/2014	iBoats	Connector Receptacle & Plug	$28.92		$447.01
5/17/2014	Performance Plus Connection	Battery Shut Off Switch	$31.95		$415.06
5/17/2014	Best Buy	Amp/Speaker Wiring Kit	$161.99		$253.07
5/17/2014	Miners Ace Hardware	Vents	$4.30		$248.77
5/23/2014	Miners Ace Hardware	Fasteners/Electrical Connectors	$30.51		$218.26
5/24/2014	Home Depot	Weatherstripping	$2.13		$216.13
5/24/2014	Lombards Stereo	Fuse	$5.41		$210.72
5/24/2014	Miners Ace Hardware	Fasteners/Caulk/Battery Sealer	$27.55		$183.17
5/26/2014	Miners Ace Hardware	Electrical Connectors	$15.48		$167.69
5/26/2014	Miners Ace Hardware	Heat Shrink Tubing	$3.88		$163.81
5/28/2014	Lombards Stereo	Line Driver	$64.95		$98.86
5/28/2014	Miners Ace Hardware	Flex Tubing, Zip Ties, Velcro	$18.32		$80.54
1/7/2014	Amazon	Megaphone (preliminary testing)	$42.38		$38.16
5/19/2014	McMaster-Carr	Aluminum Tube for Speaker Mount	$34.45		$3.71

Table 5. Battery Selection Table. The chosen component is highlighted in yellow.

Senior Project Battery Selection Chart (12 V)						
Battery Description	**Capacity (amp-hrs)**	**Price ($)**	**Height (in)**	**Width (in)**	**Depth (in)**	**Link**
Deep Cycle Lead Acid (wet cell): 71805K94, rechargeable	115	$195.26	9.4	13	6.8	http://www.mcmaster.com/#12-volt-batteries/=qi9ej9
Dual Purpose Deep Cycle/Starting Lead Acid (wet cell): 71805K83	100	123.21	9.4	12	6.8	http://www.mcmaster.com/#12-volt-batteries/=qi9is2
Dual Purpose Deep Cycle/Starting Sealed Lead Acid AGM (dry cell): 71805K15	105	278.70	9.4	12.9	6.8	http://www.mcmaster.com/#12-volt-batteries/=qi9k3t
CAT Battery: 175-4360 Premium High Output, Wet, Deep Cycle /Starting	100 (@ 20 hrs)	???-Need to call dealer	9.29	12.9	6.74	https://commerce.cat.com/en/catcorp/175-4360
CAT Battery: 175-4370 Premium High Output, Wet, Starting/Deep Cycle	100 (@ 20 hrs)	???-Need to call dealer	9.29	12.9	6.74	https://commerce.cat.com/en/catcorp/batteries/premium-high-output/175-4370
UPG Group 27 12V AGM Sealed Lead Acid Rechargeable Deep Cycle Battery	100	189.95	9.13	12.05	6.61	http://www.ebay.com/itm/UPG-Group-27-12V-100Ah-Sealed-Lead-Acid-Rechargeable-Deep-Cycle-Battery-/190776710112
New UB121100 D5751 12V 110/100AH Battery Wheelchair Mobility Deep Cycle Solar	100/110	209.98	9.3	12.9	6.8	http://www.ebay.com/itm/New-UB121100-D5751-12V-110AH-100AH-Battery-Wheelchair-Mobility-Deep-Cycle-Solar-/171129854281
PowerStar® Group 27 Sealed Lead Acid Rechargeable Deep Cycle Battery	100	198.1	8.2	12	6.6	http://www.ebay.com/itm/PowerStar-Group-27-12V-100Ah-Sealed-Lead-Acid-Rechargeable-Deep-

						Cycle-Battery-/161178796097
DieHard Marine Deep Cycle/RV Battery- Group Size 27M (Price With Exchange)	105 (@20 hrs)	109.99	9.5	12.75	6.875	http://www.sears.com/shc/s/p_10153_12605_02827524000P?mv=rr#reviewsWrap
DieHard Platinum Marine Battery Group Size 31M*	100 (@20 hrs)	231.99	9.5	13	6.8	http://www.sears.com/diehard-platinum-marine-battery-group-size-31m-price/p-02850131000P?prdNo=1&blockNo=1&blockType=G1

Table 6. Amplifier Selection Table. The chosen component is highlighted in yellow.

Senior Project Amplifier Selection (400 W)				
Amp Description	Number of Channels	Impedance (Ohms)	Price ($)	Link
New BOSS Epic CE404 Car Audio Amplifier Power AB Amp MOSFET	4	50 W x 4 Channel @ 4 Ohms 100 W x 4 Channel @ 2 Ohms	39.37	http://www.ebay.com/itm/New-BOSS-Epic-CE404-400-Watt-4-Channel-Car-Audio-Amplifier-Power-AB-Amp-MOSFET-/390741168772
New SSL Soundstorm F4.400 400 Watt 4-Channel Car Audio Power Amplifier Amp	4	100 W x 4 Channel @ 2 Ohms (Max Power) 50 W x 4 Channel @ 4 Ohms (RMS Power)	39.95	http://www.ebay.com/itm/New-SSL-Soundstorm-F4-400-400-Watt-4-Channel-Car-Audio-Power-Amplifier-Amp-/231109698810
Boss AR2000M Monoblock Mosfet Amplifier	???-Did not state	Max Power, 2 Ohms: 2000W x 1 RMS Power, 4 Ohms: 1000W x 1	75.00	http://www.walmart.com/ip/Boss-AR2000M-Monoblock-Mosfet-Amplifier/17323988
GM-3500T 2-Channel Bridgeable	2	60 Watts RMS x 2 Channels (4	100.00	http://www.pioneerelectronics.com/PUSA/Car/Amplifiers/GM+Series/GM-3500T

Amplifier wtih 400 Watts Max.		ohms ≤ 1% THD+N)		
Dual 400W XPE2700 2-Channel Amplifier	2	50W x 2 RMS power	49.24	http://www.walmart.com/ip/Dual-400W-XPE2700-2-Channel-Amplifier/15819244
Rockford Fosgate Punch 400-Watt Stereo Amplifier*	2	100W x 2 @ 4-Ohms 200W x 2 @ 2-Ohms 400W x 1 @ 4-Ohms bridged mono	229.95	http://www.amazon.com/Rockford-Fosgate-400-Watt-Stereo-Amplifier/dp/B0013KZ0HO

*Items have their own page(s) containing pertinent information due to their specific and important need/use within the device. Please refer to the next few pages for their complete details.

Battery Information Section

DieHard Platinum Marine Battery Group Size 31M

Dimensions:	
Height (in.):	9.5
Item Weight (lbs.):	75
Length (in.):	13
Width (in.):	6.8
Battery Type:	
Group Size:	31M
Power Configuration:	
Number of Cells:	6
Power Ratings:	
Amp Hours at 20 Hour Rate:	100
Capacity Amp Hours at 10 Hour Rating:	92
Cold Cranking Amps (CCA at 0 deg.F):	1150
Reserve Capacity (RC):	205 min.
Design & Construction:	
Battery Design:	Absorbed Glass Mat
Container Material:	Polycarbonate/polyester
Maintenance:	Maintenance Free
Overall Type:	Deep-cycle
Temperate Zone:	North or South
Positive Terminal Side:	Right
Terminal Post Location:	Top
Warranties & Coverage:	
Free Replacement Warranty Term:	36 months

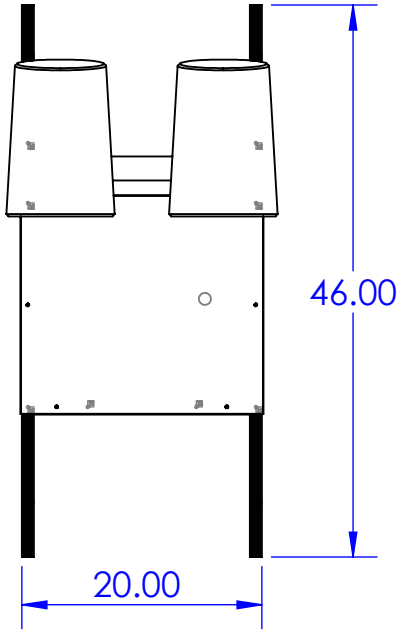
Amplifier Information Section

Rockford Fosgate P400-2 Punch 400-Watt Stereo Amplifier Specifications

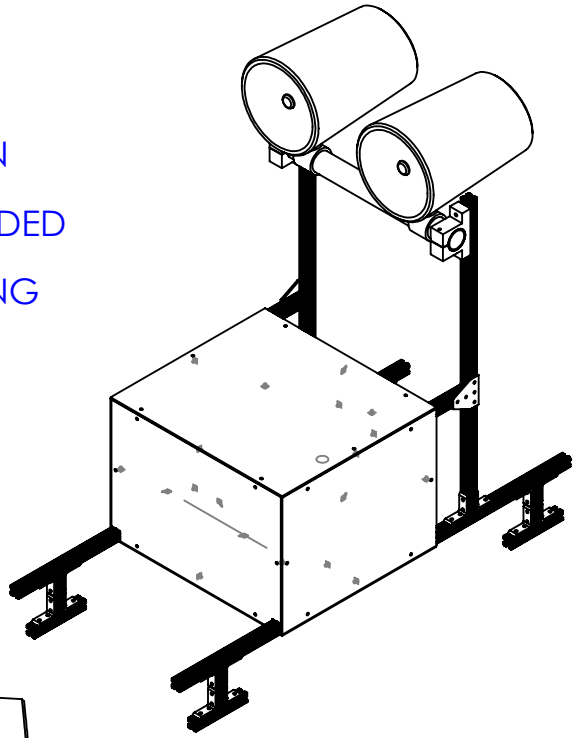
Number of Channels:	2
Rated Power:	100 Watts RMS x 2 @ 4-Ohms 200 Watts RMS x 2 @ 2-Ohms 400 Watts RMS x 1 @ 4-Ohms Bridged/Mono
Total Power:	400 Watts
Dynamic Power:	140 Watts x 2 @ 4-Ohms 0 degrees Res 234 Watts x 2 @ 2-Ohms 0 degrees Res
Bridgeable:	Yes
Efficiency (average):	70% @ 4-Ohm 65% @ 2-Ohm
Crossover Controls:	High-Pass (HP): 50Hz-500Hz 12dB/octave Butterworth Low-Pass (LP): 50-500Hz 12dB/octave Butterworth
Tone Controls:	Punch EQ2 Bass: 0dB to +18dB @ 45Hz and/or Punch EQ2 Treble: 0dB to +12dB @ 12kHz Function depends upon LP/AP/HP switch position
Signal Input:	Low level: 1 RCA pair
Signal Output:	Low level: 1 RCA pair
Power Input Connector:	Block

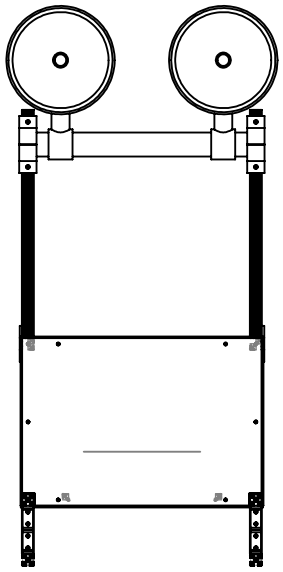
Power Wire Gauge:	4 AWG
Speaker Output Connector:	Screw terminal barrier strip
Speaker Wire Gauge:	8 AWG to 18 AWG
Heat Sink Type:	Cast aluminum
Cooling:	Convection
Remote Controls:	Optional PEQ Remote Punch EQ (overrides built-in Punch EQ2)
Visual Indicators:	Power Thermal Protect
Circuit Topology Class:	Class A/B
Frequency Response:	20Hz to 20kHz +/- 1dB
Shipping Weight:	7.25 Lbs. (3.28 Kg.)
Dimensions (HxWxL):	2.25 x 7.625 x 10.25 (in) 5.71 x 19.37 x 26.03 (cm)

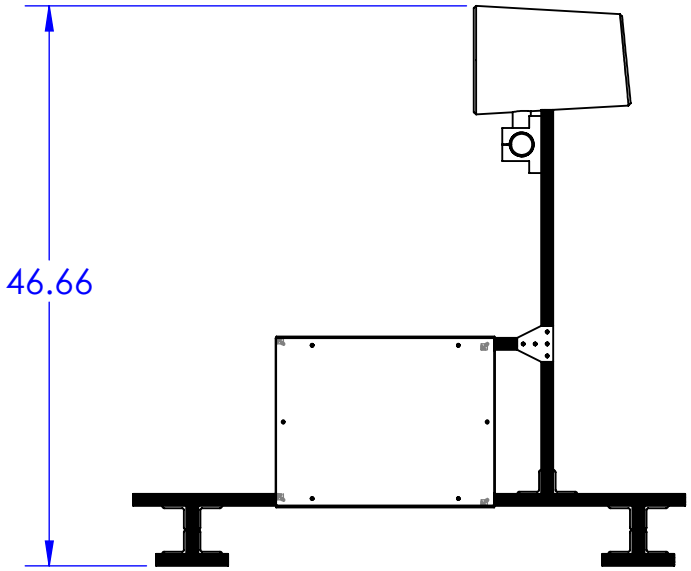
Appendix C: Drawings and Renderings



Note:
1. ALL DIMENSIONS ARE IN INCHES
2. THIS DRAWING IS INTENDED FOR USE AS OVERALL ASSEMBLY DIMENSIONING

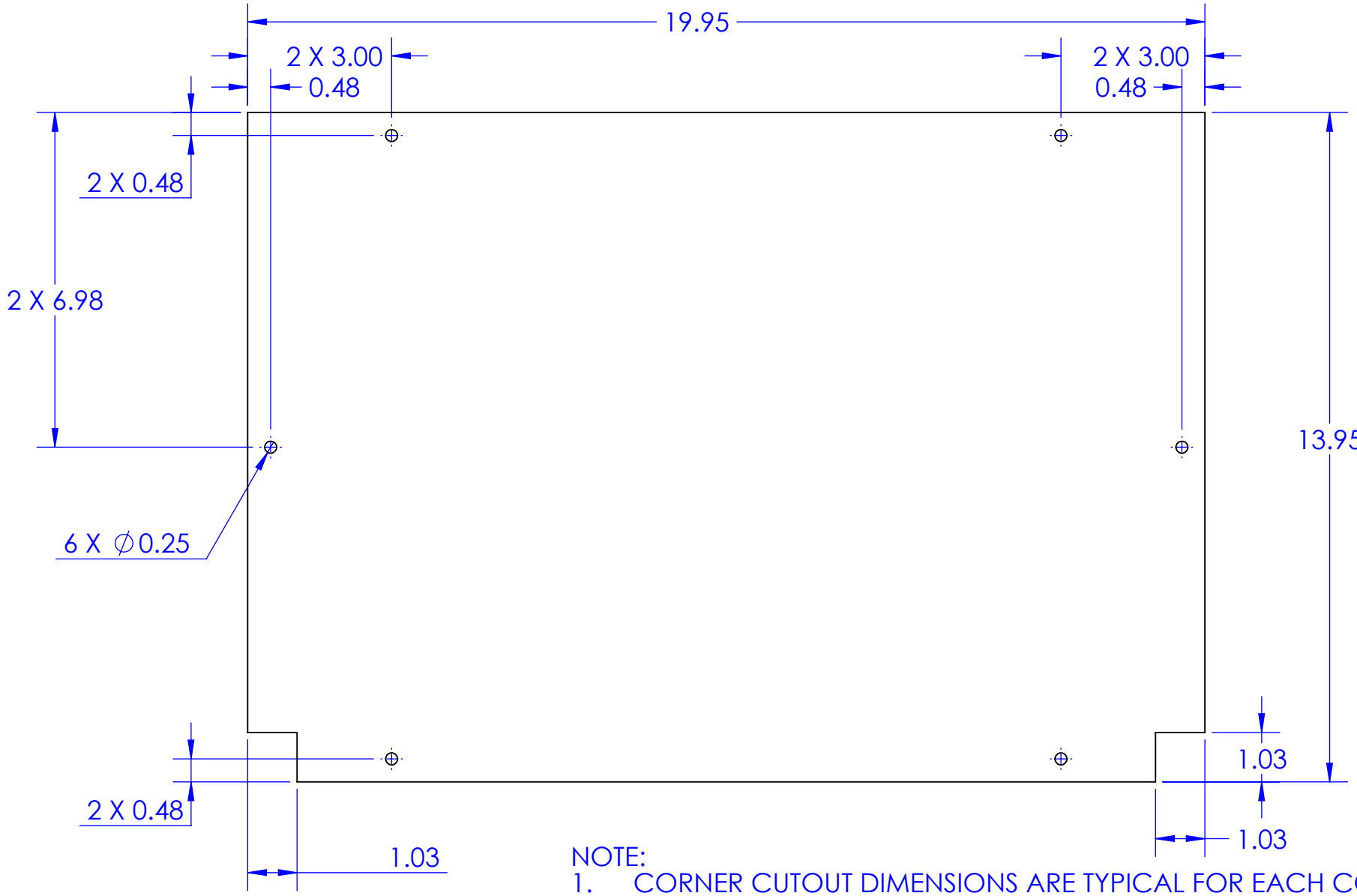






BIRDS BE GONE

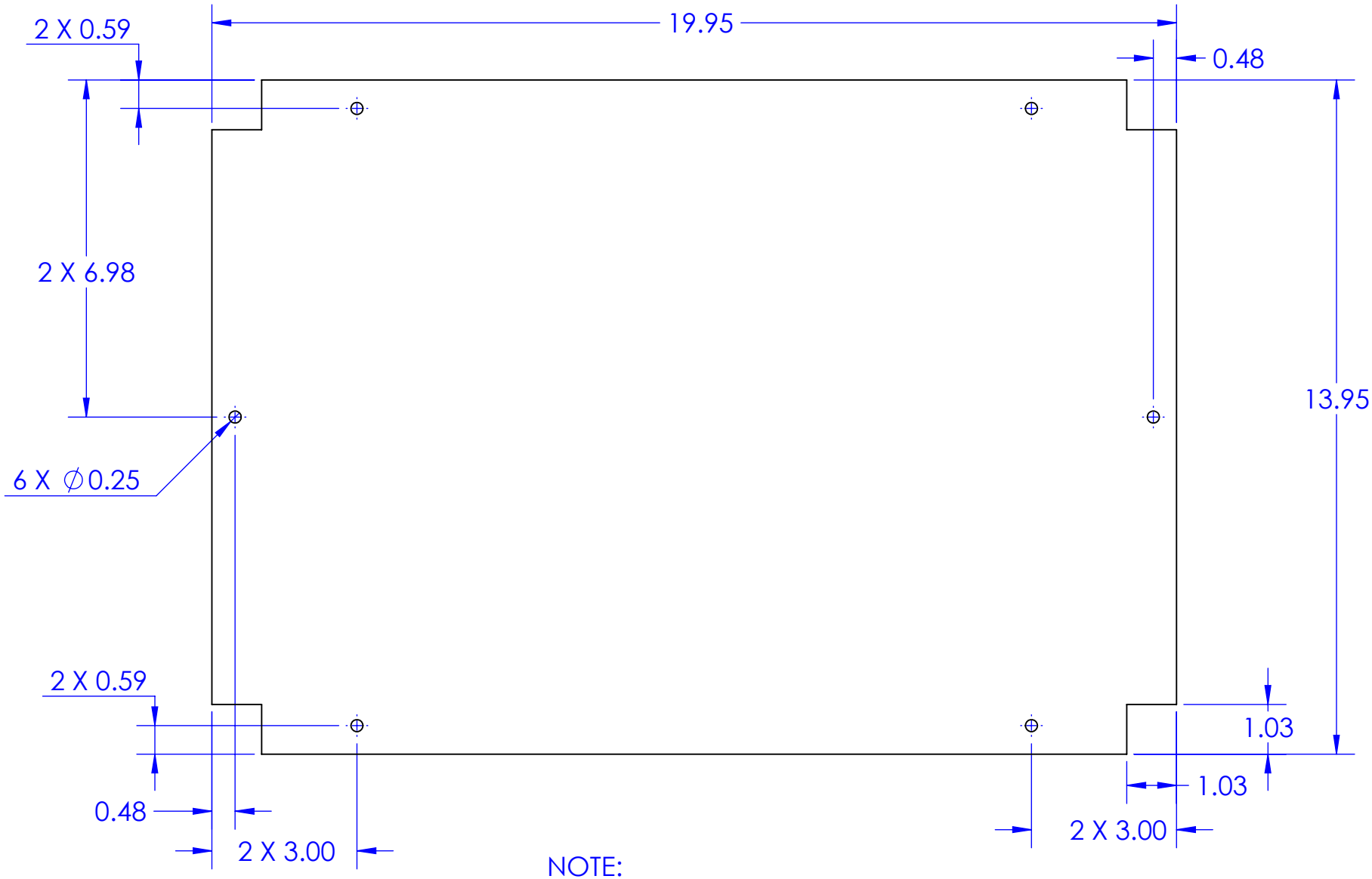
Cal Poly Mechanical Engineering ME430 - Spring 2014	Lab Section: 05 Dwg. #: BBG-310	Senior Project Nxt Asb:	Title: OVERALL ASSEMBLY Date: 4/26/13	Scale: 1:16	Drwn. By: KYLE SUGUITAN Chkd. By: EDUARDO MORALES



NOTE:
1. CORNER CUTOUT DIMENSIONS ARE TYPICAL FOR EACH CORNER
2. PANEL THICKNESS IS 0.090" (STK)
3. MATERIAL IS ALUMINUM
4. ALL DIMENSIONS ARE IN INCHES
5. TOLERANCE IS ±0.01 INCHES

BIRDS BE GONE

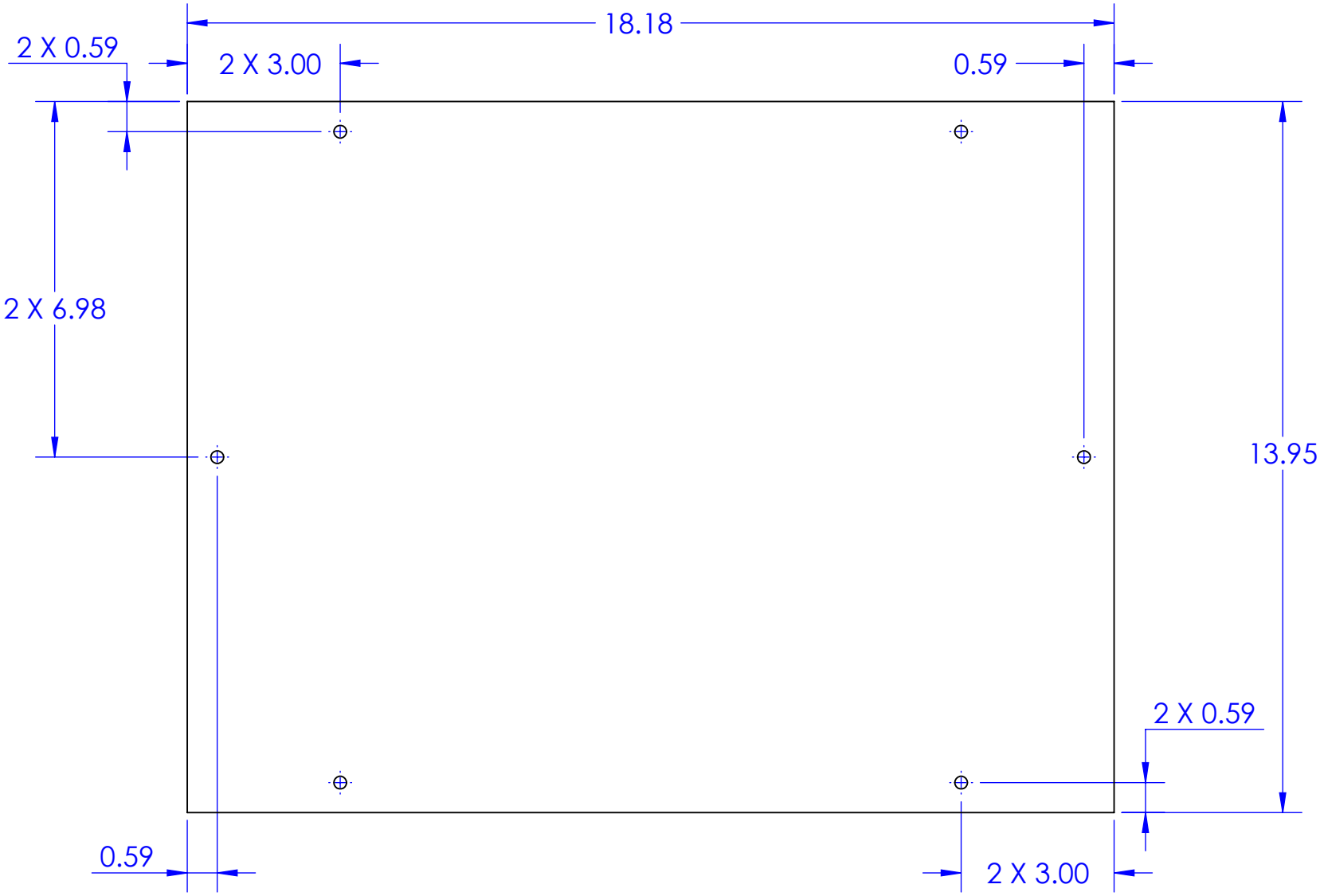
Cal Poly Mechanical Engineering ME430 - Spring 2014	Lab Section: 05 Dwg. #: BBG-300	Senior Project Nxt Asb: BBG-310	Title: FRONT PANEL Date: 4/26/13	Scale: 1:3	Drwn. By: KYLE SUGUITAN Chkd. By: EDUARDO MORALES



NOTE:
1. CORNER CUTOUT DIMENSIONS ARE TYPICAL FOR EACH CORNER
2. PANEL THICKNESS IS 0.090" (STK)
3. MATERIAL IS ALUMINUM
4. ALL DIMENSIONS ARE IN INCHES
5. TOLERANCE IS ±0.01 INCHES

BIRDS BE GONE

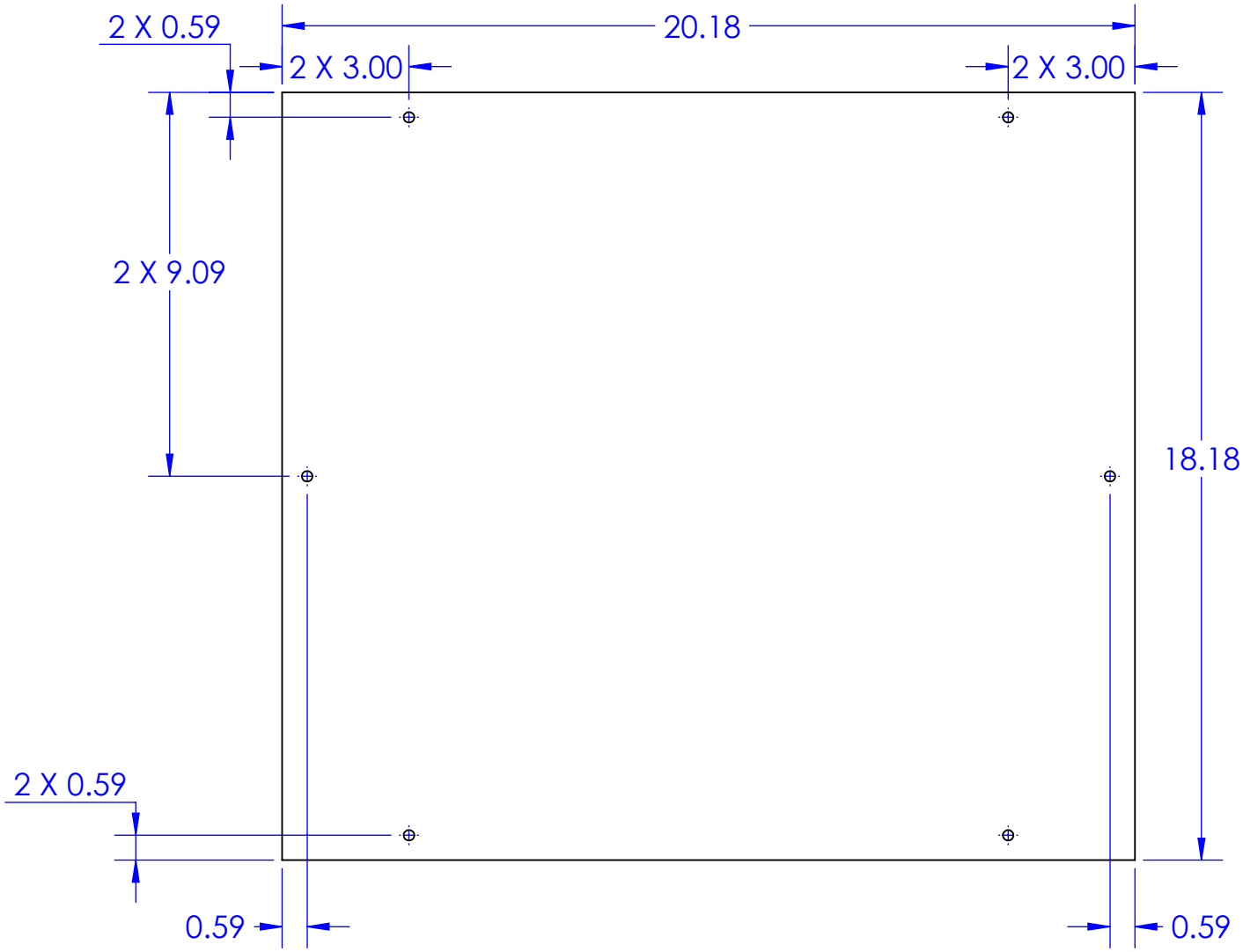
Cal Poly Mechanical Engineering ME430 - Spring 2014	Lab Section: 05 Dwg. #: BBG-301	Senior Project Nxt Asb: BBG-310	Title: REAR PANEL Date: 4/26/13	Scale: 1:3	Drwn. By: KYLE SUGUITAN Chkd. By: EDUARDO MORALES



NOTE:
1. PANEL THICKNESS IS .090" (STK)
2. MATERIAL IS ALUMINUM
3. ALL DIMENSIONS ARE IN INCHES
4. TOLERANCE IS ±0.01 INCHES

BIRDS BE GONE

Cal Poly Mechanical Engineering ME430 - Spring 2014	Lab Section: 05 Dwg. #: BBG-303	Senior Project Nxt Asb: BBG-310	Title: SIDE PANEL Date: 4/26/13	Scale: 1:3	Drwn. By: KYLE SUGUITAN Chkd. By: EDUARDO MORALES

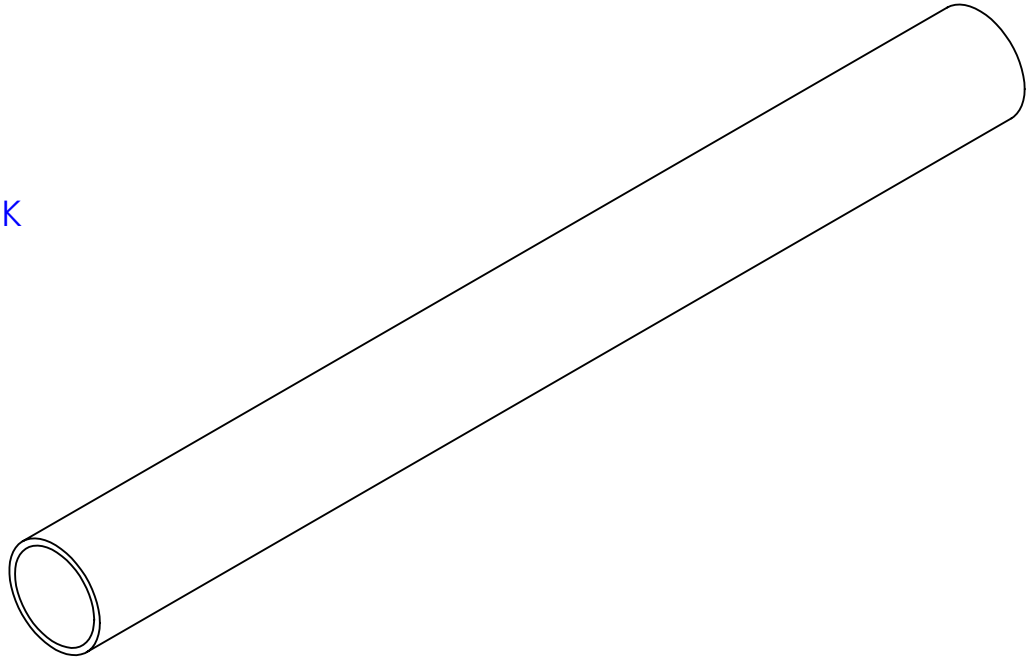


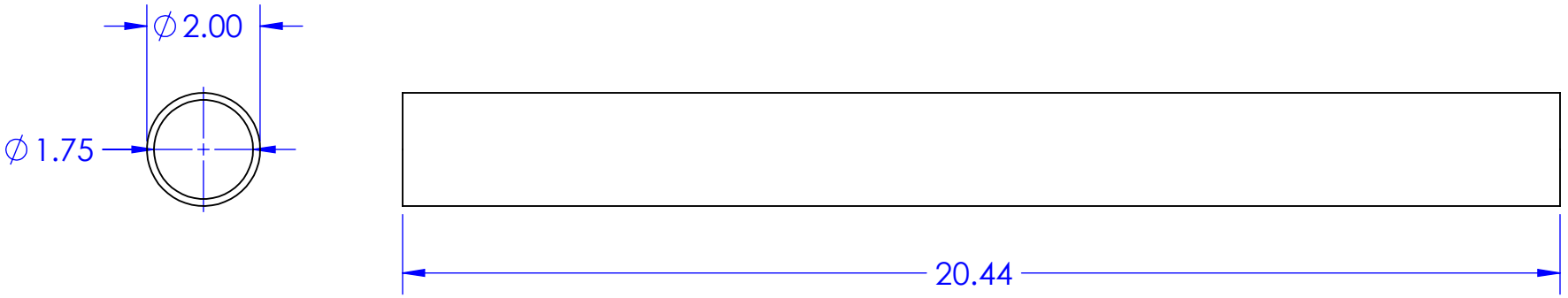
NOTE:
1. PANEL THICKNESS IS .090" (STK)
2. MATERIAL IS ALUMINUM
3. ALL DIMENSIONS ARE IN INCHES
4. TOLERANCE IS ±0.01 INCHES

BIRDS BE GONE

Cal Poly Mechanical Engineering ME430 - Spring 2014	Lab Section: 05 Dwg. #: BBG-302	Senior Project Nxt Asb: BBG-310	Title: TOP/BOTTOM PANEL Date: 4/26/13	Scale: 1:4	Drwn. By: KYLE SUGUITAN Chkd. By: EDUARDO MORALES

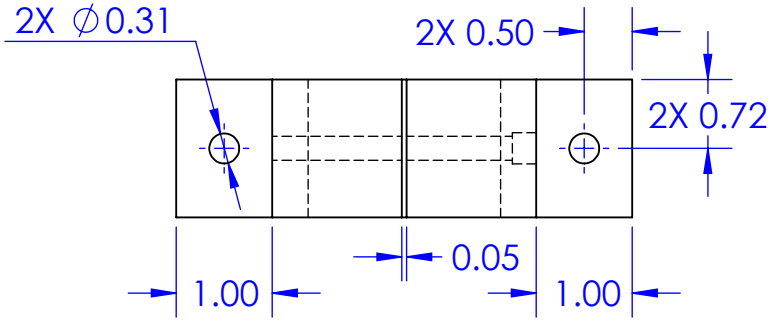
NOTE:
1. ALL DIMENSIONS ARE IN INCHES
2. OD AND WALL THICKNESS ARE STOCK
3. MATERIAL IS ALUMINUM

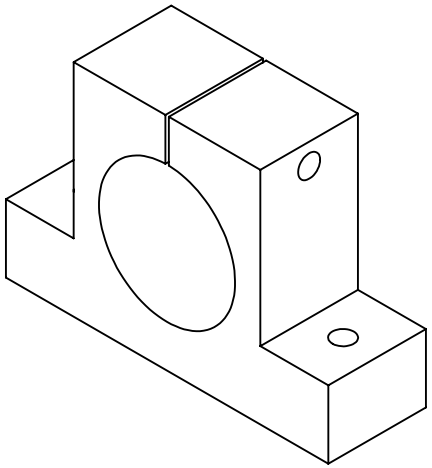


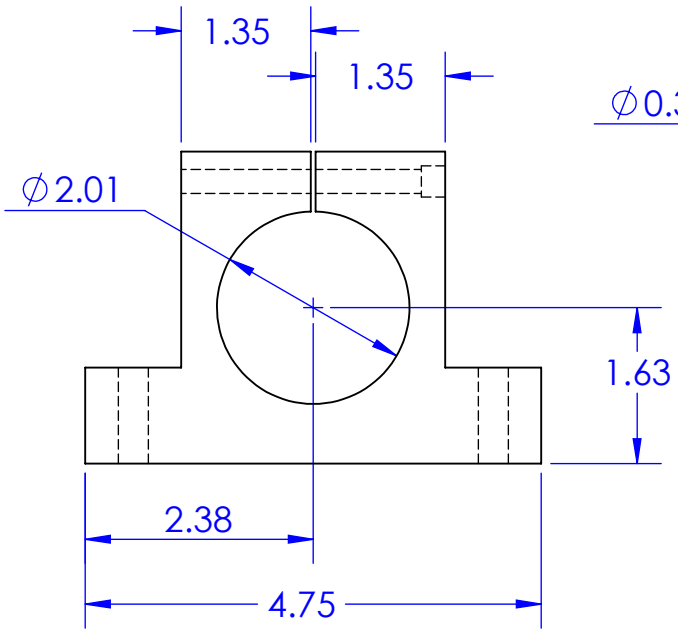


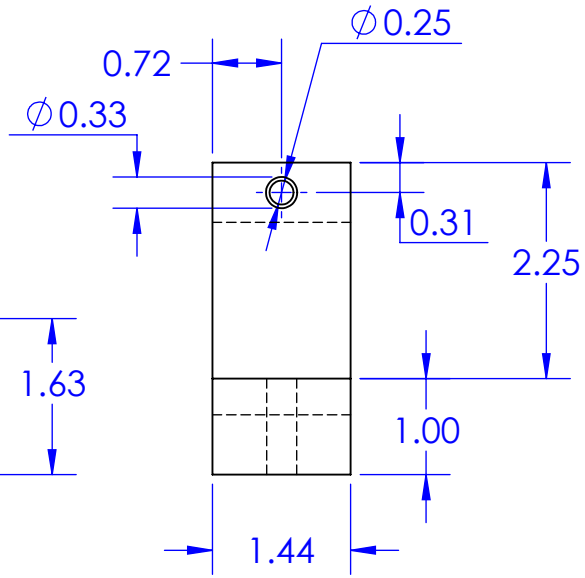
BIRDS BE GONE

Cal Poly Mechanical Engineering ME430 - Spring 2014	Lab Section: 05 Dwg. #: BBG-305	Senior Project Nxt Asb: BBG-310	Title: SPEAKER MOUNT PIPE Date: 6/5/2014	Scale: 1:3	Drwn. By: KYLE SUGUITAN Chkd. By: TAYLOR WETZEL





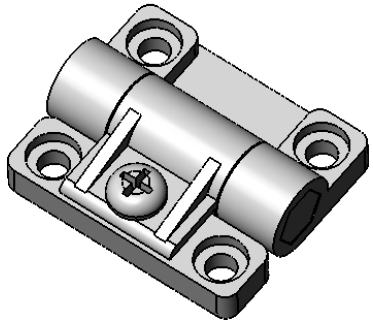


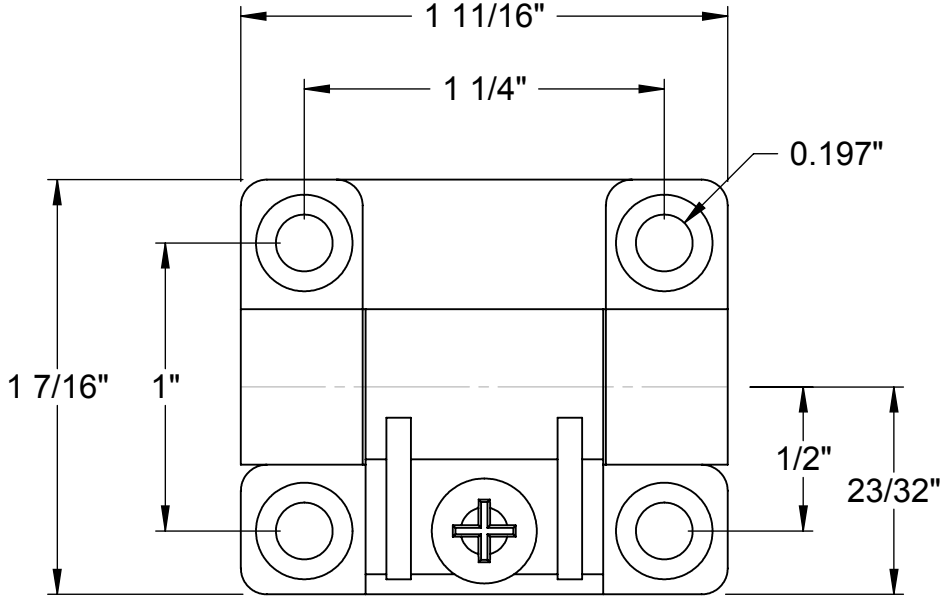


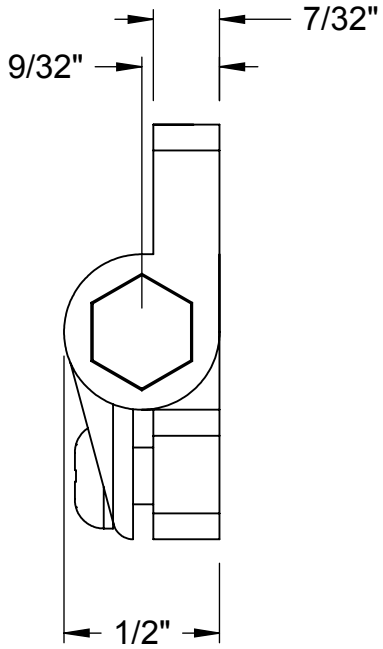
NOTE:
1. ALL DIMENSIONS ARE IN INCHES
2. MATERIAL IS ALUMINUM
3. THIS IS A PURCHASED PART; ALL DIMENSIONS ARE AS DELIVERED FROM SUPPLIER

BIRDS BE GONE

Cal Poly Mechanical Engineering ME430 - Spring 2014	Lab Section: 05	Senior Project	Title: 2 INCH PIPE STANCHION		Drwn. By: KYLE SUGUITAN
	Dwg. #: BBG-304	Nxt Asb: BBG-310	Date: 6/5/2014	Scale: 1:2	Chkd. By: TAYLOR WETZEL





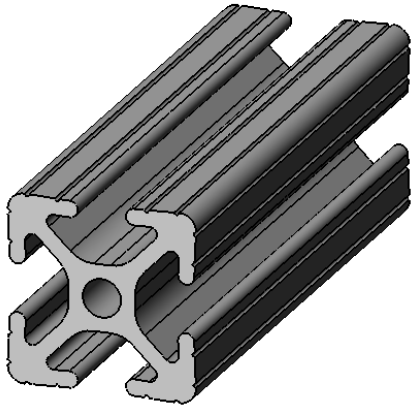


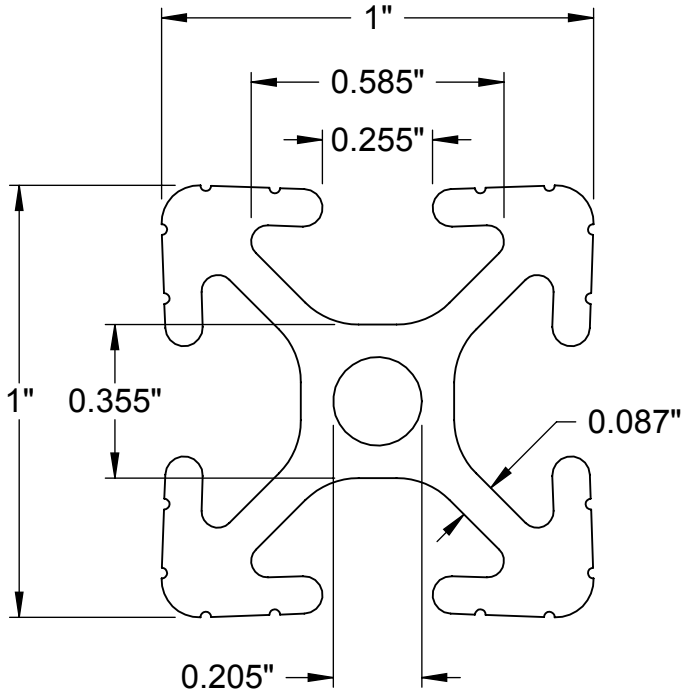
McMASTER-CARR® CAD

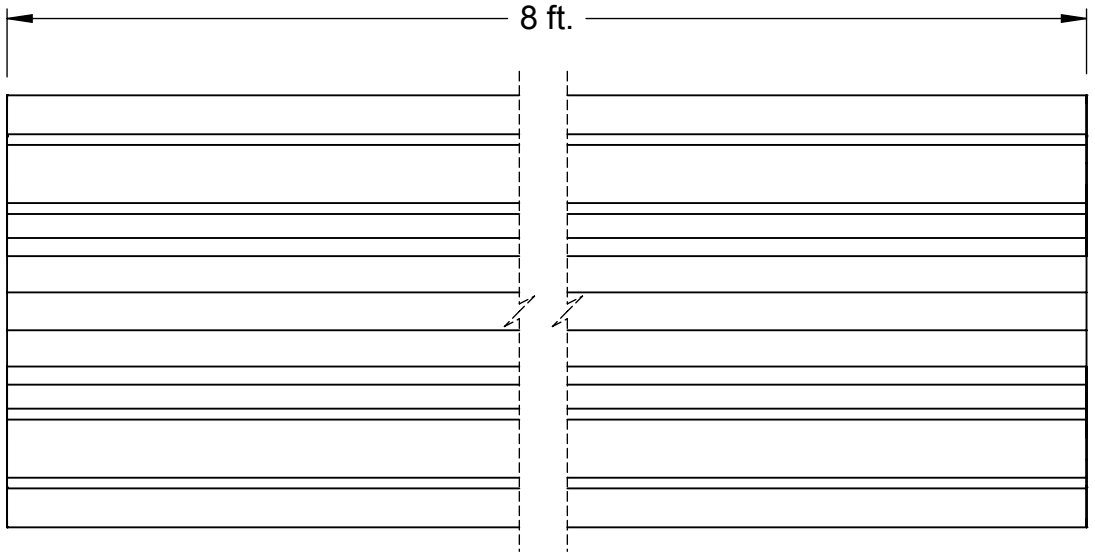
http://www.mcmaster.com

PART NUMBER **47065T162**

Black Plastic
Panel Hinge





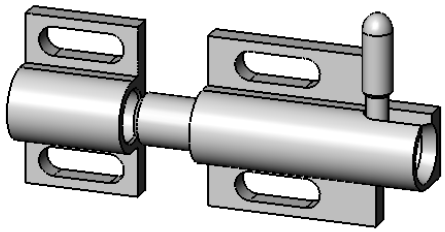


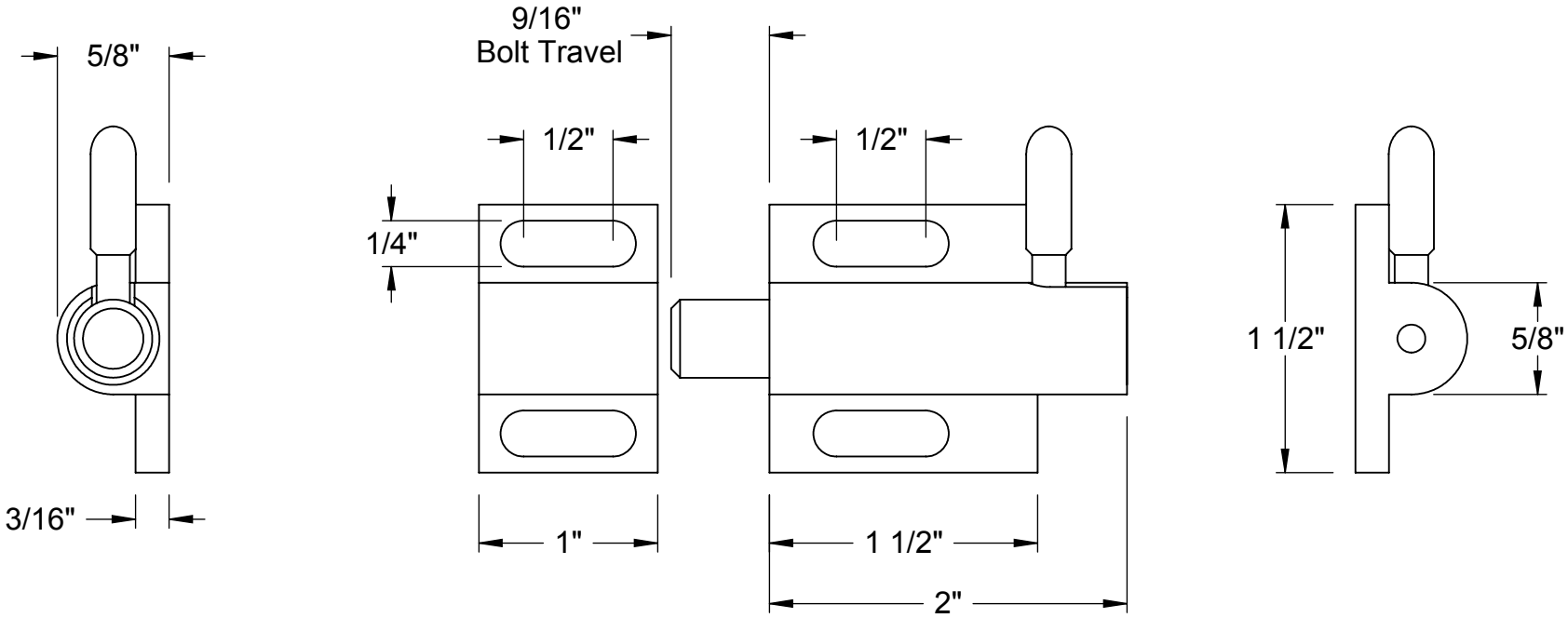
McMASTER-CARR® CAD

http://www.mcmaster.com

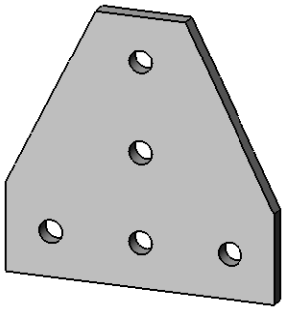
PART NUMBER **47065T123**

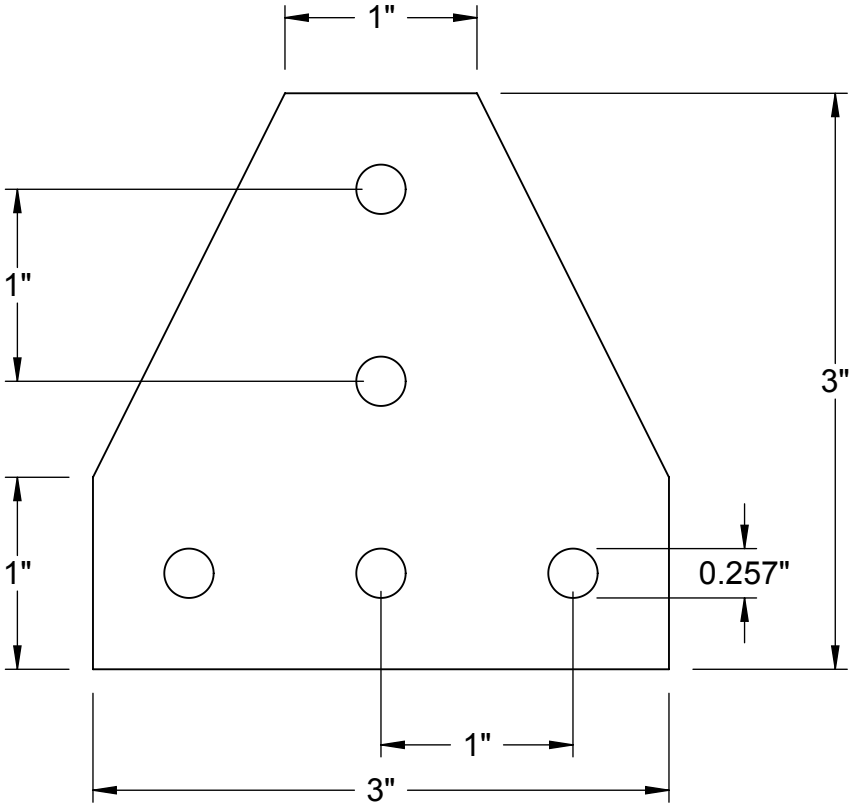
Aluminum Four-Slot
Single Extrusion

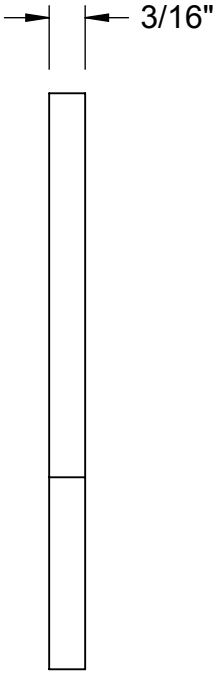




McMASTER-CARR® CAD	PART NUMBER 47065T57
http://www.mcmaster.com © 2010 McMaster-Carr Supply Company Information in this drawing is provided for reference only.	Aluminum Slide-Bolt Extrusion Latch





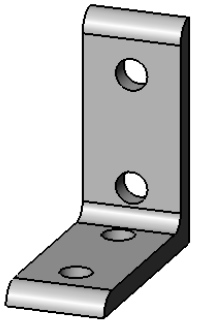


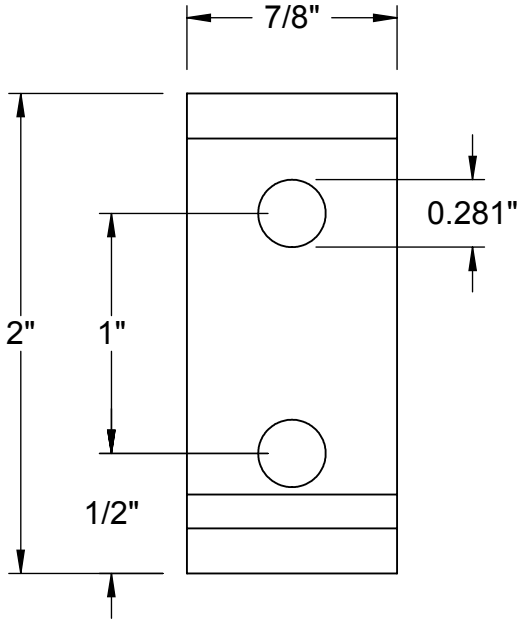
McMASTER-CARR® CAD

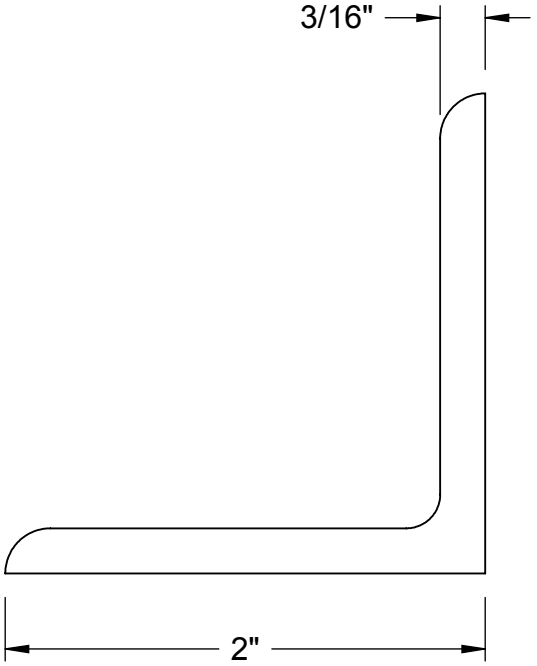
http://www.mcmaster.com

PART NUMBER **47065T182**

Auminum Single Tee Plate







McMASTER-CARR® CAD

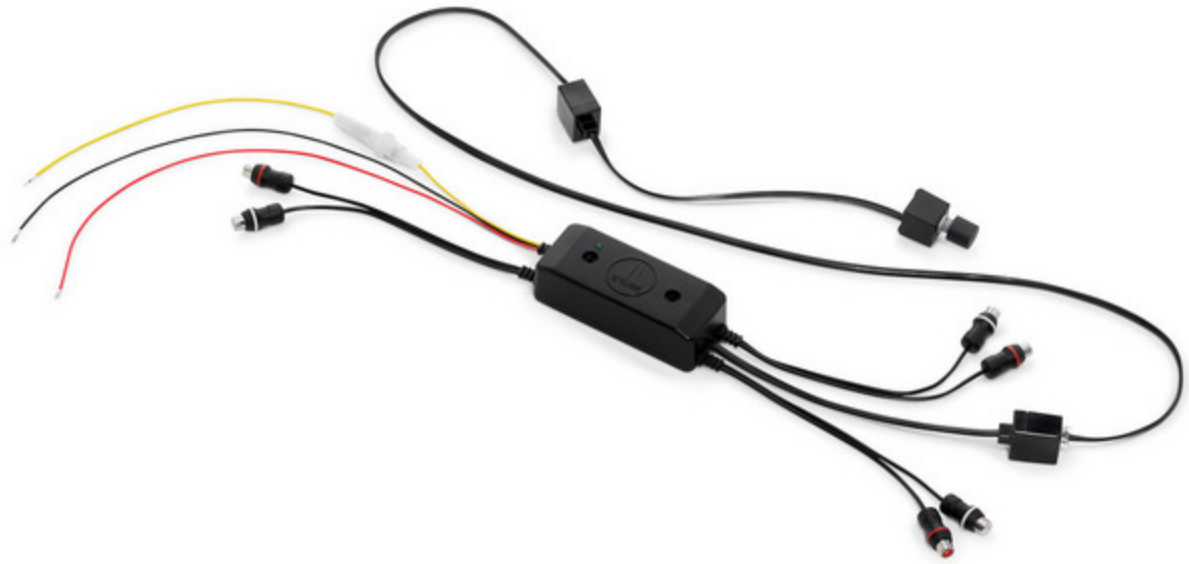
http://www.mcmaster.com

PART NUMBER **47065T175**

Aluminum

Single Extended 90° Bracket

JL Audio CL-RLC: Remote Level Control / Line Driver



Specifications

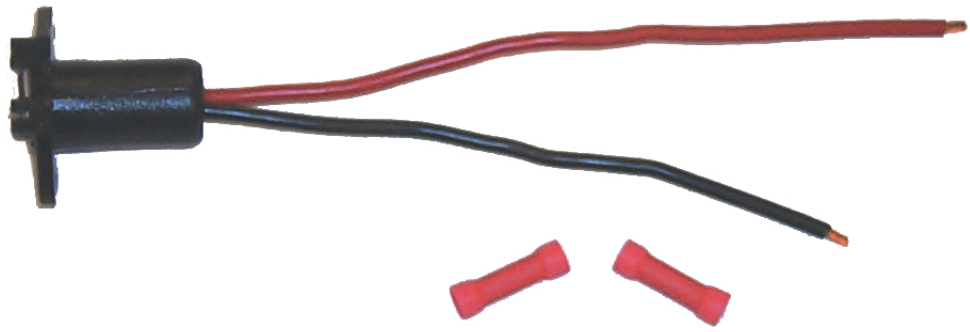
Channel Separation	>80 dB
Output Impedance	475 Ω
Gain Range	7.5 V RMS
Max. Unclipped Output	7.5 V RMS
Frequency Response	10 Hz - 30 kHz (+0/-1 dB)

THD+N @ Rated Output	Less than 0.05% @ 7.5 V RMS
S/N Ratio	>117 dB @ 7.5 V RMS
Maximum Input Level	4 V RMS
Operating Current Draw	90 mA

Trolling Motor Connector Female Plug 8 gauge 2-Wire - Sierra

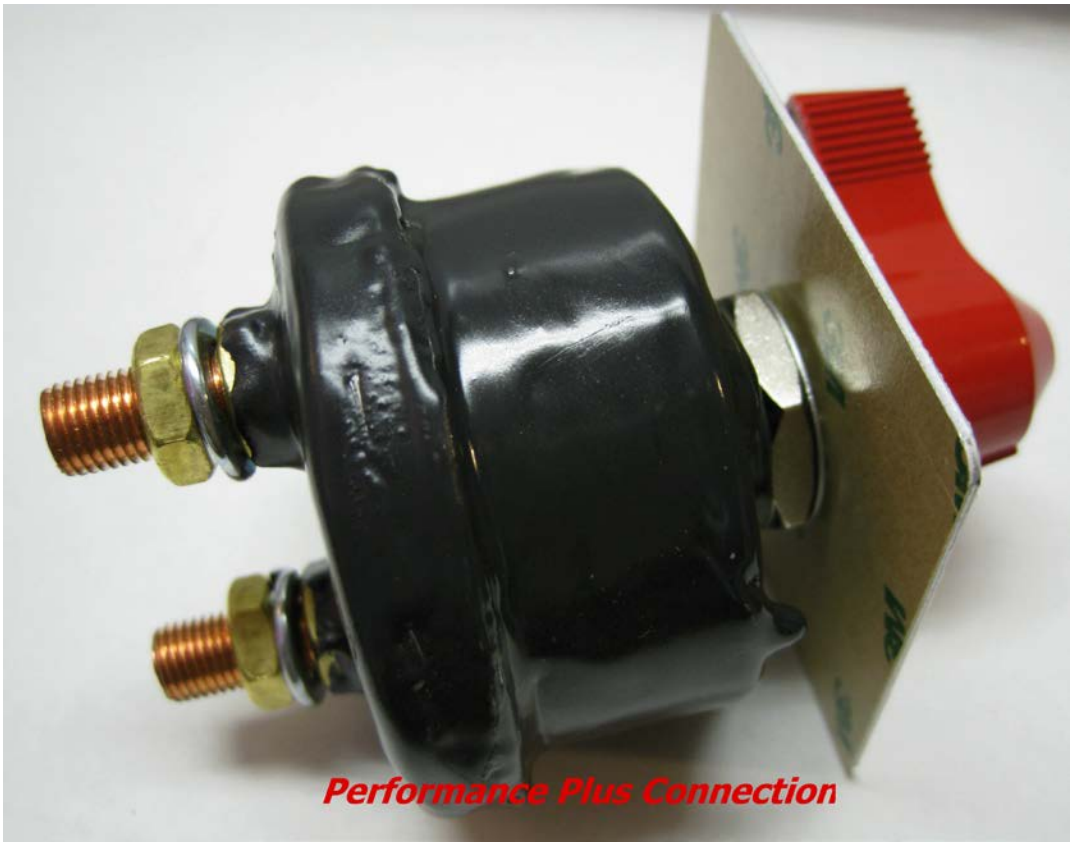
- 12 Volt
- Available in 8 gauge wire.
- Features molded black plastic, moisture proof construction.
- Receptacle has all-weather spring loaded door.
- Wiring is 6-inches long with butt connectors.

Trolling Motor Connector Male Receptacle 8 gauge 2-Wire - Sierra



- 12 Volt
- Available in 8 gauge wire.
- Features molded black plastic, moisture proof construction.
- Receptacle has all-weather spring loaded door.
- Wiring is 6-inches long with butt connectors.

PRYW-4103-3 - Weatherproof Battery Switch Safety Disconnect ShutOff 2 Pole



NEW WEATHERPROOF BATTERY KILL SAFETY SHUT OFF DISCONNECT SWITCH 2 POLE

New Weatherproof Battery 2-pole shut down cut off switch This switch is designed to provide a complete power shut down in case of an emergency. 2-post with solid brass terminals with 3/8" SAE threads and brass nuts included. Need a ¾" diameter round hole in your bulkhead or rear panel for mounting. 2 position (Off or On) and position panel is included.

This switch is brand new and has many uses

- · RACING
- · CIRCLE TRACK
- · DRAG RACE
- · STREET ROD
- · OFF ROAD
- · RV's
- · HI-PERFORMANCE
- · CARS
- · TRUCKS· MARINE AND MORE

Designed for all electrical systems and 16 Volt batteries. Rated at 450 amps momentary service (6/12/16/24/36V) 250 amps continual

Battery Disconnect Switch Manually disconnect your battery with a turn of a switch. Prevents battery drain. Required in NASCAR, SCCA, NHRA A bright red handle to make it easier to find in an emergency. 450 amp continuous rating, 6-36 volt Panel included Cutoff Switches Are A Required Safety Feature In Many Racing Organizations & Race Tracks

SC-1200A

2/8/12A 12V Automatic SpeedCharge Charger

Detailed Description:

12 Amp Fast Charge – charger monitors battery condition and adjusts charge rate downward to prevent battery damage; for car, light truck, marine, RV, farm equipment, AGM, gel cell and deep-cycle batteries

• 8 Amp Medium Charge – self-adjusting charge rate for everyday charging needs and keeping your battery in peak condition

• 2 Amp Slow Charge – for charging and maintaining small batteries; charges motorcycle, ATV, snowmobile and lawn tractor batteries

• 50 Amp Clamps – for top and side-mounted battery posts

• Electronic Push Button Controls – easy-to-feel switches for selection of Display Mode, Charge Rate or Battery Type. Choose from regular automotive (low maintenance or and maintenance-free), deep-cycle, AGM or gel cell batteries

• Retractable Handle – for easy portability and storage

Uses:

Spec Sheet:

Accessory	N/A
Charger Type	Fully Automatic Microprocessor Controlled
Energy Star	-
Input Current Cont	0.8A 2.2A 3.2A
Input Voltage	120VAC
Output Current Cont	2A 8A 12A
Output Voltage	12VDC
Period Type	Year
Rating Agency	CUL UL
RoHS	✓
Sell Country	United States of America
Unit Depth	9.76
Unit Height	7.63
Unit Weight	3.06
Unit Width	3.46
Warranty Period	5

Manuals:

Manaul #: 00-99-000909 for : SC-1200A

Find all manual versions for this Model #

IS7603

iSimple® SwitchPlay™

AUDIO/VIDEO
CABLE WITH CHARGING


Connector for iPod, iPhone or iPad


Audio/Video Processor


RCA audio/video output

MAKE THE CONNECTION ▶

to your
iPod
to your
iPhone
to your
iPad

Stinger® TECHNOLOGY INSIDE

iSimple®
A Division of AAMP of America™
13190 56th Court Clearwater, FL 33760
Ph. 866-788-4237
support@isimplesolutions.com

www.isimplesolutions.com

Made for iPod iPhone iPad

Rev.041912

1. Introduction

Thank you for purchasing the iSimple® SwitchPlay™. This product is designed to provide endless hours of listening and viewing pleasure from your factory or aftermarket entertainment system. To ensure optimal performance of the SwitchPlay™ we recommend that you read this entire manual before beginning the installation of this product. The SwitchPlay™ provides connectivity between your iPod, iPhone or iPad and any audio or audio/video source that accepts RCA connections. The audio from the attached device will be passed through the cable into the radio's auxiliary Audio or A/V input. Note: many factory radios require an auxiliary input device to accept an RCA connection. For video output, an iPod, iPhone or iPad with video capability is required.

The SwitchPlay™ will also charge your iPod, iPhone or iPad while connected.

Visit **http://www.iSimpleSolutions.com** to see auxiliary input solutions for your radio.

2. Precautions

PREVENTING DAMAGE TO YOUR VEHICLE OR MEDIA PLAYER

Installation of this product requires you to make wiring connections. To eliminate the risk of an electrical short, we recommend disconnecting the vehicle's battery prior to installation. If you do not feel comfortable making these connections, we suggest you seek professional installation. We recommend that the iPod, iPhone or iPad be disconnected from the cable when the vehicle is not in use.

3. Installation

1. Using a voltmeter identify a 12V+ wire and a ground wire

2. Connect the red wire on the SwitchPlay™ to the 12V+ constant power wire (or you can connect the SwitchPlay™ red wire to a switched accessory wire to provide battery charging only when the vehicle is running).

3. Connect the black wire on the SwitchPlay™ to ground. Depending on the vehicle this may be a wire or the chassis.

4. Plug the male RCA connector ends of the SwitchPlay™ into the receivers auxiliary audio or A/V input.

5. Choose a convenient mounting location for your iPod, iPhone or iPad. This is typically a glove box, center console or mounting cradle.

6. Run the docking cable and RCA connectors to the desired mounting location. Use caution to not cut, pinch to crimp the cable during this step.

7. Securely install the cable in a location free from heat, humidity, moving parts, or sharp metal edges. We recommend securing the SwitchPlay™ to a suitable location using double sided tape, Velcro™ or zip-ties.

Accessing your auxiliary audio source
Please refer to the owners manual that came with your radio or vehicle for directions on how to access your radio's auxiliary input source.

On some models of iPod, iPhone or iPad you will need to enter the settings menu, and select video, select TV out, and set this option to "ASK". When a video is selected to play, the iPod, iPhone or iPad, will ask "do you want to enable TV out?" select "ON", to view video on an external screen using this product.

Some newer models of iPod, iPhone or iPad do not have this option in the video settings menu. Instead, after connecting your iPod to our product, and selecting a video to play, the device will ask you automatically "Display on TV?"

Choose "YES" to watch the video on an external monitor.

4. Operation

1. Plug your iPod, iPhone, or iPad into the connector. Charging should automatically begin if charging is supported by your device.
2. Choose the media on your phone that you would like to play.
3. If you would like to change video playback from your device to an external screen, simply press the button once on the connector. Press play on your device and your video will now display on the other screen.
4. To change the video display back to your device, repeat step 3.

5. Troubleshooting

Symptom	Cause	Remedy
iPod, iPhone or iPad is not charging	Fuse is blown	Check the fuse in the SwitchPlay™. If the fuse is blown, replace with a fuse of the same amperage. If fuse blows again, please call tech support.
iPod, iPhone or iPad is not charging and fuse isn't blown	Weak wiring connection	Check the Power (RED) and Ground (BLACK) wires to ensure that they are correctly connected to 12V+ and Ground.
No video	iPod, iPhone or iPad is not set for video out	In settings menu select Video Output ON.
No video	Wrong mode	Press button on 30-pin connector. Press play on iPod, iPhone, or iPad
No audio	RCA is not connected	Verify connection of RCA's to Receiver.

6. Warranty
One Year Limited Warranty

The quality controls used in the manufacture of this product will ensure your satisfaction. This warranty applies only to the original purchaser of this product from an authorized iSimple® dealer. This warranty covers any supplied or manufactured parts of this product that, upon inspection by iSimple® authorized personnel, is found to have failed in normal use due to defects in material or workmanship. This warranty does not apply to installation expenses. Attempting to service or modify this unit, operating this unit under conditions other than the recommended voltage will render this WARRANTY VOID.

Unless otherwise prescribed by law, iSimple® shall not be liable for any personal injury, property damage and or any incidental or consequential damages of any kind (including water damage) resulting from malfunctions, defects, misuse, improper installation or alteration of this product. All parts of this iSimple® product are guaranteed for a period of 1 year as follows: Within the first 12 months from date of purchase, subject to the conditions above, iSimple® will repair or replace the product at our discretion, if it is defective in material or workmanship providing it is returned to an Authorized iSimple™ dealer, with PROOF OF PURCHASE from an authorized iSimple® dealer.

Warning:

This equipment may be reset by unintentional electrostatic discharge during operation. Exposure to direct sunlight or extreme heat may cause damage or malfunction.

FCC Class B Radio Frequency Interference Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

1. Re-orientate or relocate the receiving antenna.
2. Increase the separation between the equipment and receiver.
3. Connect the equipment into an outlet on a circuit different from that of which the receiver is connected.
4. Consult the dealer or an experienced radio / television technical for help.

Notice : The changes or modifications not expressly approved by the party responsible for compliance could void the user authority to operate the equipment.

A division of AAMP of America™
13190 56th Court Clearwater, Florida 33760
Ph. 866-788-4237
support@iSimpleSolutions.com

www.isimplesolutions.com

LIMITED WARRANTY STATEMENT

Rockford Corporation offers a limited warranty on Rockford Fosgate products on the following terms:

Length of Warranty

Speakers – 1 Year. Any Factory Refurbished Product – 90 days (receipt required)

What is Covered

This warranty applies only to Rockford Fosgate products sold to consumers by Authorized Rockford Fosgate Dealers in the United States of America or its possessions. Product purchased by consumers from an Authorized Rockford Fosgate Dealer in another country are covered only by that country's Distributor and not by Rockford Corporation.

Who is Covered

This warranty covers only the original purchaser of Rockford product purchased from an Authorized Rockford Fosgate Dealer in the United States. In order to receive service, the purchaser must provide Rockford with a copy of the receipt stating the customer name, dealer name, product purchased and date of purchase. Products found to be defective during the warranty period will be repaired or replaced (with a product deemed to be equivalent) at Rockford's discretion.

What is Not Covered

1. Damage caused by accident, abuse, improper operations, water, theft, shipping
2. Any cost or expense related to the removal or reinstallation of product
3. Service performed by anyone other than Rockford or an Authorized Rockford Fosgate Service Center
4. Any product which has had the serial number defaced, altered, or removed
5. Subsequent damage to other components
6. Any product purchased outside the U.S.
7. Any product not purchased from an Authorized Rockford Fosgate Dealer

Limit on Implied Warranties

Any implied warranties including warranties of fitness for use and merchantability are limited in duration to the period of the express warranty set forth above. Some states do not allow limitations on the length of an implied warranty, so this limitation may not apply. No person is authorized to assume for Rockford Fosgate any other liability in connection with the sale of the product.

How to Obtain Service

Contact the Authorized Rockford Fosgate Dealer you purchased this product from. If you need further assistance, call 1-800-669-9899 for Rockford Customer Service. You must obtain an **RA# (Return Authorization number)** to return any product to Rockford Fosgate. You are responsible for shipment of product to Rockford.

EU Warranty

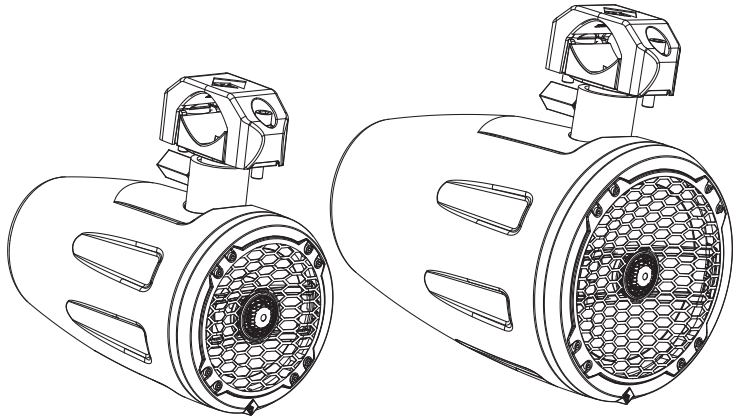
This product meets the current EU warranty requirements, see your Authorized dealer for details.

Check our website for additional information and updates on these products.

www.RockfordFosgate.com

1230-57454-03 Printed in China

Rockford Fosgate®



M2

MARINE GRADE

M2 – WAKEBOARD TOWER SPEAKERS

6.5"	8"
M262-WAKE	M282-WAKE
M262B-WAKE	M282B-WAKE

Installation & Operation

Serial Number:_____ Date of Purchase: _____

Safety

CAUTION: Before installation, disconnect the battery negative (-) terminal to prevent damage to the unit, fire and/or possible injury.

PRACTICE SAFE SOUND™

Continuous exposure to sound pressure levels over 100dB may cause permanent hearing loss. High powered auto sound systems may produce sound pressure levels well over 130dB. Use common sense and practice safe sound.

Carton Contents

- (1) Set Marine Grade M2 Wakeboard Tower Speakers
- (1) Set of adjustable swivel clamps
- (1) Allen head wrench
- (1) Molex speaker harness
- (1) Set of rubber inserts for 1 1/2" - 1 3/4" applications
- (1) Set of rubber inserts for 1 7/8" - 2 3/4" applications

Installation Considerations

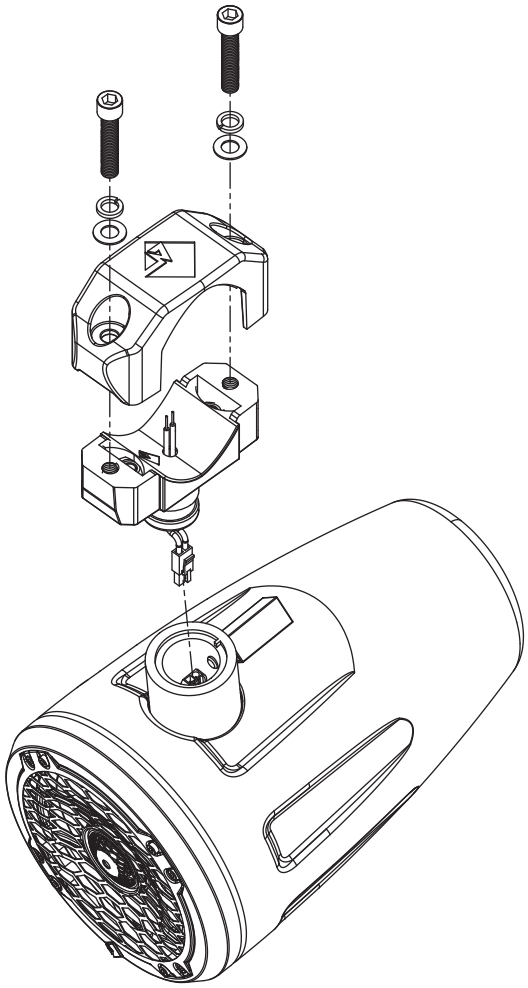
Before beginning any installation, follow these simple rules:

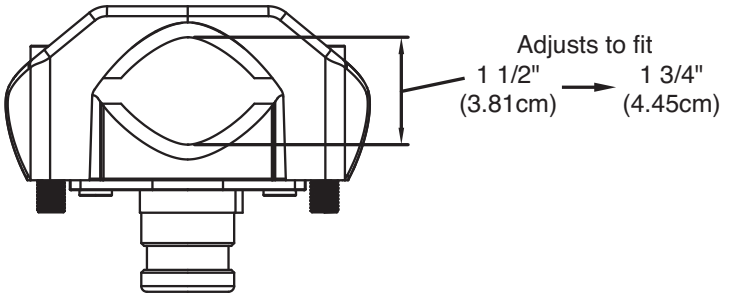
1. Be sure to carefully read and understand the instructions before attempting to install these speakers.
2. For safety, disconnect the negative lead from the battery prior to beginning the installation.
3. For easier assembly, we suggest you run all wires prior to mounting your speakers in place.
4. Use high quality connectors for a reliable installation and to minimize signal or power loss.
5. **Think before you drill!** Be careful not to cut or drill into gas tanks, fuel lines, brake or hydraulic lines, vacuum lines or electrical wiring when working on any vehicle. If installation in a boat, take care not to cut or drill through the main hull.
6. Never run wires in the open area of the boat. Running the wires inside the wakeboard tower and hull area provides the best protection.
7. Avoid running wires over or through sharp edges. Use rubber or plastic grommets to protect any wires routed through metal.

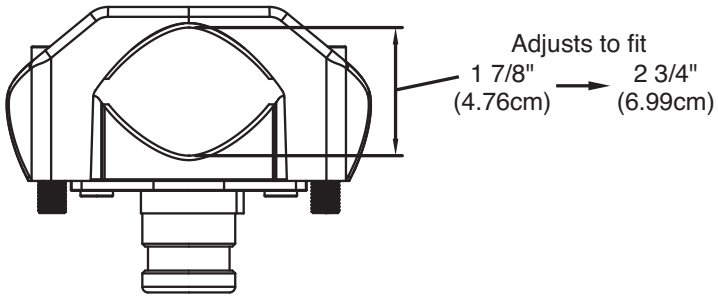
Mounting

1. Determine where the speakers will be mounted. Be sure that the mounting location has sufficient clearance in all directions for the speaker to swivel; conduct a full rotation to ensure there is no obstruction.
2. Mark the locations on the underside of the clamping surface for the speaker harness to be feed through. Drill the holes with a 3/8" bit.
3. Feed the speaker wires through the hole and connect to the speaker harness. Be sure to observe proper polarity when connecting the wires. The speaker harness's negative wire is indicated with a "black-stripe".
4. Feed the speaker harness through the center of the base of the clamp. Fit the clamp to the mounting area and tighten the bolts evenly with the supplied allen wrench.

NOTE: Use the proper rubber insert for the corresponding clamping diameter.



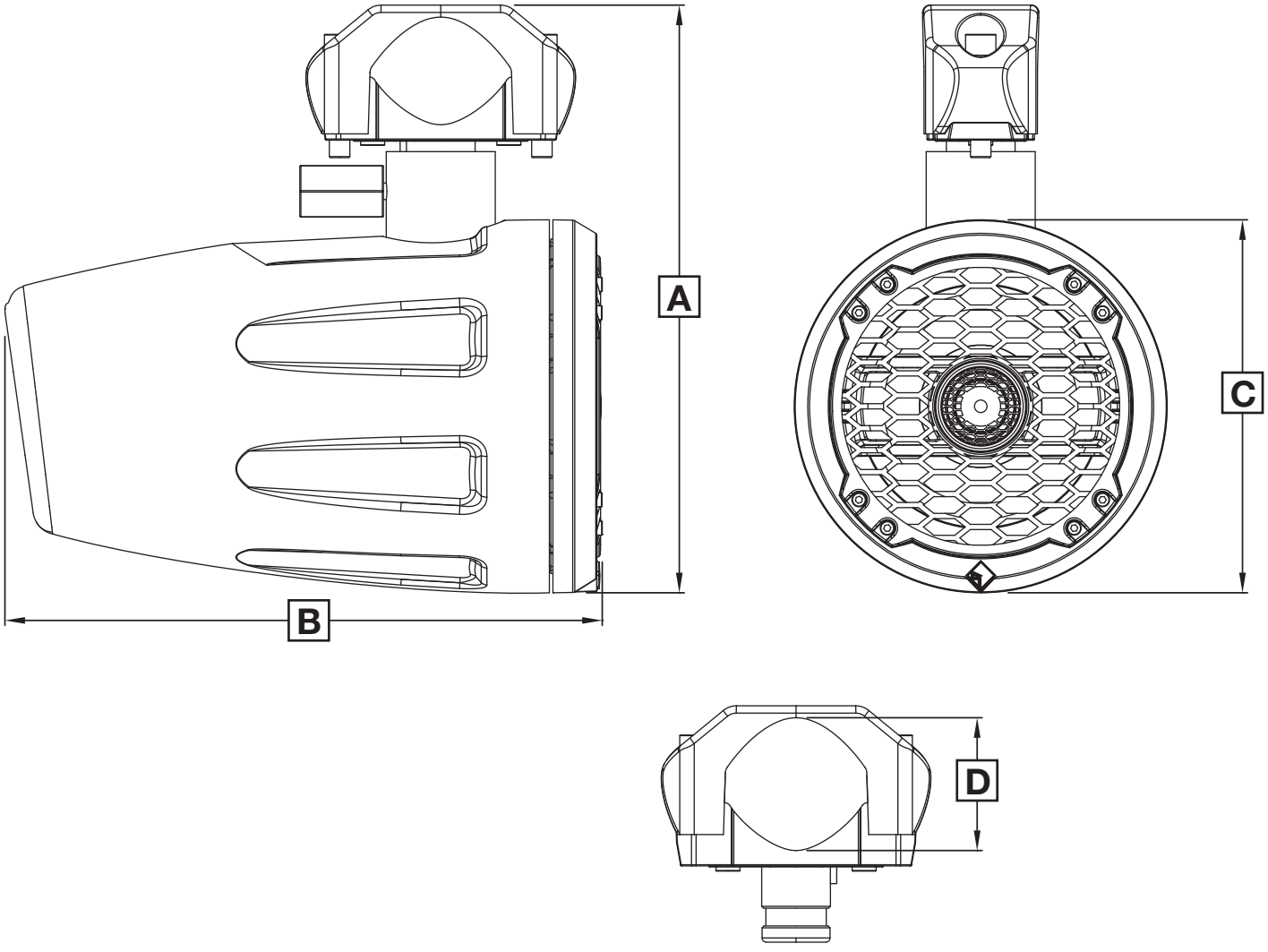




PHYSICAL DIMENSIONS

MARINE GRADE M2	6.5" M262-WAKE/M262B-WAKE	8" M282-WAKE/M282B-WAKE
A - Overall height-inch (cm)	10.96 (27.83)	13.14 (33.37)
B - Overall length-inch (cm)	11.26 (28.59)	13.10 (33.25)
C - Overall diameter-inch (cm)	7.03 (11.85)	9.05 (23.00)
D - Clamp Range-inch (cm)	1.5 to 2.75 (3.81 to 6.99)	1.5 to 2.75 (3.81 to 6.99)
Mass (Weight) - lbs. (kg)	6.20 (2.80)	8.80 (4.00)
Power handling-watts (RMS) (Peak)	75 150	100 200

Specifications subject to change without notice



Français

MISE EN GARDE: Avant d'entamer l'installation, déconnectez la broche négative (-) de la batterie pour éviter tout risque de blessures, d'incendie ou de dommages à l'appareil.

PRATIQUEZ UNE ÉCOUTE SANS RISQUES

Une exposition continue à des niveaux de pression acoustique supérieurs à 100 dB peut causer une perte d'acuité auditive permanente. Les systèmes audio de forte puissance pour auto peuvent produire des niveaux de pression acoustique bien au-delà de 130 dB. Faites preuve de bon sens et pratiquez une écoute sans risques

Considérations d'installation

Avant de commencer toute installation, suivre ces simples règles:

1. S'assurer de lire attentivement et de comprendre les instructions avant d'essayer d'installer ces enceintes.
2. Par mesure de sécurité, déconnecter le fil négatif de la batterie avant de commencer l'installation.
3. Pour faciliter l'assemblage, il est recommandé d'acheminer tous les fils avant de monter les enceintes en place.
4. Utiliser des connecteurs de haute qualité pour une installation fiable et pour minimiser la perte de signal ou de puissance.
5. Réfléchir avant de percer! Faire attention de ne pas couper ou percer dans les réservoirs d'essence, les conduites de carburant, les conduites de frein ou hydrauliques, les lignes de vide ou le câblage électrique lors de tout travail sur un véhicule. Pour une installation dans un bateau, faire attention de ne pas couper ou percer à travers la coque principale.
6. Ne jamais acheminer de fils dans la zone ouverte d'un bateau. Acheminer les fils à l'intérieur de la tour de remorquage et de la coque offre la meilleure protection possible.
7. Éviter d'acheminer les fils sur ou à travers des chants coupants. Utiliser des passe-câbles en caoutchouc ou en plastique pour protéger tout fil acheminé à travers le métal.

Montage

1. Déterminer l'endroit de montage des enceintes. S'assurer que l'emplacement de montage a suffisamment de dégagement dans tous les sens pour que l'enceinte puisse pivoter; exécuter une rotation complète pour s'assurer qu'il n'y pas d'obstruction.
2. Marquer les emplacements sur le dessous de surface de serrage pour alimenter le faisceau de l'enceinte. Percer les trous avec un trépan 3/8".
3. Alimenter les fils d'enceinte à travers le trou et connecter au faisceau d'enceinte. S'assurer d'observer la polarité appropriée lors de la connexion des fils. Le harnais de haut-parleur le fil négatif est indiqué avec une «noir-piste».
4. Alimenter le faisceau d'enceinte à travers le centre de la base de la pince. Mettre la pince sur la surface de montage et serrer les boulons uniformément à l'aide de la clé Allen fournie.

REMARQUE: Utiliser l'insert en caoutchouc approprié pour le diamètre de pince correspondant.

Español

PRECAUCIÓN: Antes de la instalación, desconecte el terminal negativo de la batería (-) para prevenir daño a la unidad, incendio y/o posibles lesiones.

PRACTIQUE EL SONIDO SEGURO

El contacto continuo con niveles de presión de sonido superiores a 100 dB puede causar la pérdida permanente de la audición. Los sistemas de sonido para automóviles de alta potencia pueden producir niveles de presión de sonido superiores a los 130 dB. Use su sentido común y practique el sonido seguro.

Consideraciones para la instalación

Antes de comenzar cualquier instalación, siga estas simples normas:

1. Asegúrese de leer cuidadosamente y de entender las instrucciones antes de tratar de instalar estos altavoces.
2. Por seguridad, desconecte el conductor negativo de la batería antes de comenzar la instalación.
3. Para facilitar el montaje, sugerimos que tienda todos los cables antes de montar sus altavoces en su sitio.
4. Utilice conectores de alta calidad para tener una instalación confiable y para reducir al mínimo las pérdidas de señal o de potencia.
5. ¡Piense siempre antes de perforar! Tenga cuidado de no cortar ni perforar tanques de combustible, tuberías de combustible, de frenos o hidráulicas, tuberías de vacío o cableado eléctrico al trabajar en cualquier vehículo. Si la instalación se hace en una embarcación, tenga cuidado de no cortar ni perforar a través del casco principal.
6. Nunca tienda los cables en el área abierta de una embarcación. Tender los cables adentro de la torre para esquí y el área del casco proporciona la mejor protección.
7. Evite tender cables arriba o a través de bordes filosos. Use arandelas de caucho o plástico para proteger los cables tendidos a través de metal.

Montaje

1. Determine adónde se montarán los altavoces. Asegúrese de que la localidad de montaje tenga suficiente espacio libre en todas las direcciones para que el altavoz bascule, hágalo dar toda una vuelta para asegurarse de que no haya obstrucciones.
2. Marque la localidad del lado de abajo se la superficie de fijación para hacer pasar el arnés del altavoz. Perfore los agujeros usando una broca de 3/8 pulg.
3. Tienda los cables del altavoz a través del agujero y conecte al arnés del altavoz. Asegúrese de usar la polaridad correcta al conectar los cables. El harness del altavoz el alambre negativo se indica con una "negro-raya".
4. Alimente el arnés del altavoz a través del centro de la base de la abrazadera. Calce la abrazadera al área de montaje y apriete los pernos de manera uniforme con la llave Allen proporcionada.

NOTA: Use el inserto de caucho correcto para el diámetro de fijación con abrazadera correspondiente.

Deutsch

VORSICHT: Entfernen Sie vor dem Einbau den negative Batteriepol, um Schäden am Gerät, Feuer bzw. mögliche Verletzungen zu vermeiden.

PRAKTIZIEREN SIE SICHEREN SOUND

Fortgesetzte Geräuschdruckpegel von über 100 dB können beim Menschen zu permanentem Hörverlust führen. Leistungsstarke Autosoundsysteme können Geräuschdruckpegel erzeugen, die weit über 130 dB liegen. Bitte wenden Sie gesunden Menschenverstand an und praktizieren Sie sicheren Sound.

Einbauüberlegungen

Befolgen Sie vor dem Einbau diese einfachen Regeln:

1. Lesen Sie die Anleitung sorgfältig, bevor Sie versuchen diese Lautsprecher einzubauen.
2. Entfernen Sie vor dem Einbau aus Sicherheitsgründen das negative Kabel von der Batterie.
3. Um die Montage zu erleichtern, empfehlen wir alle Kabel vor der Befestigung Ihrer Lautsprecher zu verlegen.
4. Verwenden Sie nur Qualitätsstecker, um einen zuverlässigen Einbau zu gewährleisten und Signal- und Stromverlust zu minimieren.
5. Denken Sie nach, bevor Sie bohren! Achten Sie darauf, nicht in den Benzintank, die Benzin-, Brems- oder hydraulischen Leitungen, Vakuumleitungen oder Elektrokabel zu schneiden oder zu bohren, wenn Sie am Fahrzeug arbeiten. Achten Sie beim Einbau in einem Boot darauf, nicht durch den Bootsrumpf zu schneiden oder zu bohren.
6. Verlegen Sie Kabel niemals in einem offenen Bereich des Boots. Die Kabel im Inneren des Wakeboard-Tower oder Bootsrumpfs zu verlegen, bietet den besten Schutz.
7. Vermeiden Sie es, Kabel über scharfe Kanten zu verlegen. Verwenden Sie Gummi- oder Plastikringe, um Kabel zu schützen, die durch Metall verlegt werden.

Befestigung

1. Entscheiden, wo die Lautsprecher befestigt werden sollen. Durch eine volle Rotation des Lautsprechers gewährleisten, dass die Befestigungsstelle in alle Richtungen ausreichenden Spielraum zum Schwenken bietet;
2. Die Stellen an der Unterseite der Klammerungsoberfläche markieren, an denen der Kabelbaum durchgeführt werden soll. Die Löcher mit einer 3/8-Zoll (3,2 mm) Bohrerspitze bohren.
3. Die Lautsprecherdrähte durch das Loch führen und an den Lautsprecher-Kabelbaum anschließen. Beim Anschließen der Kabel die ordnungsgemäße Polarität beachten. Des Sprechergeschirrs negativer Draht wird mit einem „Schwarzstreifen" angezeigt.
4. Den Lautsprecher-Kabelbaum durch die Mitte am Fuß der Klammer führen. Die Klammer an die Befestigungsstelle anpassen und die Bolzen mit dem beiliegenden Inbusschlüssel gleichmäßig anziehen.

HINWEIS: Den dem jeweiligen Klammerdurchmesser entsprechenden Gummieinsatz verwenden.

Italiano

ATTENZIONE: Prima dell'installazione, scollegate il terminale negativo (-) della batteria per evitare danni all'unità, pericoli d'incendio e/o potenziali lesioni personali.

OSSERVATE LE REGOLE DEL SUONO SENZA PERICOLI

La costante esposizione a livelli di pressione acustica al di sopra dei 100dB possono causare la perdita permanente dell'udito. I sistemi audio ad alta potenza possono produrre livelli di pressione acustica ben superiori ai 130dB. Si consiglia il buon senso e l'osservanza delle regole del suono senza pericoli

Considerazioni sull'installazione

Prima di iniziare un'installazione qualsiasi osservare le semplici indicazioni seguenti:

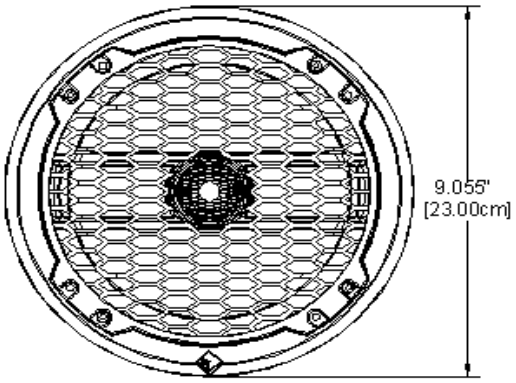
1. Accertarsi di leggere e comprendere tutte le istruzioni prima di tentare d'installare questi diffusori.
2. Per ragioni di sicurezza, scollegare il conduttore negativo della batteria prima d'iniziare l'installazione.
3. Per facilitare il montaggio, consigliamo di predisporre tutti i fili in loco prima di fissare i diffusori in posizione.
4. Per ottenere un'istallazione affidabile, con perdita minima di segnale o potenza, usare connettori d'alta qualità.
5. Pensarci prima di fare fori col trapano! Quando si lavora su un veicolo, fare sempre attenzione a non intaccare o praticare fori nel serbatoio e nei tubi della carburante, nei tubi idraulici o in quelli dei freni, nei tubi sottovuoto e nelle linee dell'impianto elettrico. Quando si installa su una imbarcazione, prestare attenzione a non tagliare o perforare lo scafo principale.
6. In una imbarcazione, non stendere mai i fili in un'area aperta. Stendendo i fili all'interno della torre per wakeboard e dell'area dello scafo si ottiene la protezione migliore.
7. Evitare di far passare i fili su o attraverso bordi taglienti. Usare guarnizioni di gomma o di plastica per proteggere i fili che attraversano pareti metalliche.

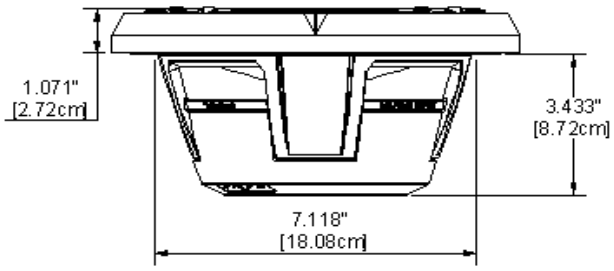
Installazione

1. Stabilire in quale posizione montare i diffusori. Accertarsi che il posto scelto abbia spazio sufficiente in tutte le direzioni per consentire al diffusore di ruotare liberamente; ruotare il diffusore di un giro completo per accertarsi che non ci sono ostacoli.
2. Marcare sul lato inferiore della superficie di fissaggio le posizioni per fare passare il cablaggio del diffusore. Praticare i fori con una punta da trapano di 3/8 di pollice (3,2 mm)
3. Passare i fili del diffusore nel foro e collegarli al cablaggio del diffusore. Quando si esegue la connessione, accertarsi di osservare la polarità corretta. Il cablaggio dell'altoparlante il cavo negativo è indicato con "una nero-banda,,.
4. Infilare il cablaggio del diffusore attraverso il centro della base del morsetto. Adattare il morsetto all'area di montaggio e serrare i bulloni in modo uniforme servendosi della chiave per viti Allen.

NOTA: Usare l'inserto di gomma adatto al diametro corrispondente del morsetto.

Model: M282/M282B
Type: Marine 8" 2-way Speaker
Power Rating: 100 Watts
Impedance: 4 ohms





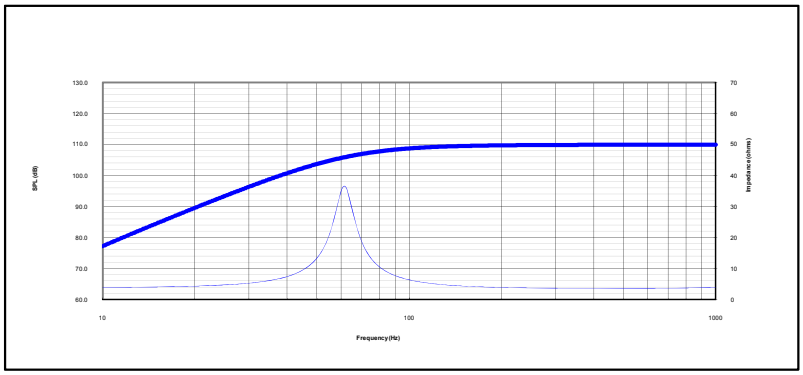
Features

- True Marine Grade Compliance.
- UV stable Centrex™ 814 injection molded plastic parts.
- Corrosion resistant gold plated polarized input terminals.
- Injection molded mineral filled polypropylene cone body with UV inhibitors.
- UV & Salt-Fog resistant TPE (Thermo-Plastic Elastomer) surround.
- 1" (25mm) bridge mounted component grade coated aluminum alloy tweeter.
- 18 AWG Corrosion resistant removable Stainless Steel grill cover insert.
- Fully insulated flex lead wire stitched under spider.
- Spare terminal set for optional additional tweeters
- Moisture, tear and fatigue resistant aramid fiber spider.
- Linear, high excursion matched motor magnetics and suspension design.
- Integrated 6/12 dB per octave sealed crossover.
- Removable trim ring/grill options

Recommended Applications

Enclosure	Volume (Vb)		Tuning(Fb)	System	-3dB (F_3)	Port Dia.		Port Length	
	Liters	cu.ft.	Hz	(Qtc)	Hz	in.	mm	in.	mm
Inf. Baffle:	56.6	2.00	69.2	0.67	69.7	-	-	-	-
Sealed:	10.6	0.38	61.4	1.16	62.0	-	-	-	-

SPL (Near Field) & Impedance



SPL (Far Field)

Technical Specifications

Voice Coil Diameter:	1.27	32.334	inches | mm
Voice Coil Height:	0.79	20.0	inches | mm
Voice Coil Layers:		2	layers
Magnetic Gap Height:	0.24	6.0	inches | mm
Linear Excursion, pk-pk (Xmax):	0.55	14.0	inches | mm
Maximum Excursion, pk-pk:	0.94	24.0	inches | mm
Magnet Weight:	21.2	0.60	oz. | kg
Woofer Displacement:	1.5	0.053	liters | cubic ft.
Net Weight:	4.62	2.1	lbs. | kg
Power Rating:	100	200	RMS | Peak

Thiele-Small Specifications

Fs (Hz):	50
Re (Ohms):	3.50
Le (mH):	0.3
Qts:	0.53
Qes:	0.57
Qms:	8.00
Cms (mm/N):	0.45
Vas (L):	30.0
Mms (g):	22.7
Mmd (g):	20.7
Rms (kg/s):	0.9
Airload (g):	2.0
No (%):	0.64
SPL (dB - 1W/1M):	90.0
BL (T*M):	6.6
*$Xmax_{10}$ (mm):	8.0
Sd (cm2):	232
EBP:	87
Krm (mOhms):	0.7
Erm:	0.82
Kxm (mH):	4.1
Exm:	0.73
Rem (Ohms):	1.86

* All parameters are derived using a laser velocity measurement method and verified with actual measured Mmd and Re. All dual voice coil models are wired in series. $Xmax_{10}$ represents actual effective excursion at <10% THD.

Above specifications and dimensions comply with the CEA-2031 standard.

Specifications subject to change without notice.

Odyssey PC 2150 Battery Mount

Features / Options include:

- One piece design, carefully engineered for lighter weight and added strength. Battery fits snug, eliminating movement that causes premature wear and shorter life.
- No welds to to fatigue and crack over time, common with other designs.
- CNC Cut from 10GA. (.130) Cold Roll steel plate
- Finish options: Bare, *Powder Coated (Black) (*extra charge)
- 6 - 1/4" bolts w/ nylock nuts included for securing battery
- Mounting: 6 - 1/4" countersunk holes in bottom or direct weld
- **Lifetime No-Hassle replacement!

Outside dimensions of mount: D 8.25" x W 13.25" x H 9" (Height does not include terminal posts on battery).

Appendix D: Gantt Chart

Final Gantt Chart

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		**ME 428**	**55 days**	**Mon 9/30/13**	**Fri 12/13/13**	
2		Form Design Team	0 days	Mon 9/30/13	Mon 9/30/13	
3		Define Problem	6 days	Mon 9/30/13	Mon 10/7/13	2
4		Introduction to Sponsor	0 days	Mon 9/30/13	Mon 9/30/13	2
5		Background Research	15 days	Wed 10/2/13	Tue 10/22/13	3SS+2 days
6		Consult with Sponsor	2 days	Sat 10/12/13	Sun 10/13/13	4
7		Project Proposal	0 days	Wed 10/23/13	Wed 10/23/13	3,5,6
8		Formulate Possible Solutions	11 days	Wed 10/23/13	Wed 11/6/13	7
9		Concept Modeling/Testing	11 days	Fri 10/25/13	Fri 11/8/13	8SS+2 days
10		Pugh Matrix	1 day	Mon 11/18/13	Mon 11/18/13	8
11		Check Patents	1 day	Mon 11/11/13	Mon 11/11/13	8
12		Evaluate Possible Solutions	22 days	Thu 11/7/13	Fri 12/6/13	8,11FF,10FF
13		Gantt Chart	5 days	Mon 12/2/13	Fri 12/6/13	10
14		Concept Design Report	8 days	Tue 12/3/13	Thu 12/12/13	7,12SS,10,13FF
15		Conceptual Design Review	0 days	Fri 12/13/13	Fri 12/13/13	14
16		Winter Break	17 days	Sat 12/14/13	Sun 1/5/14	
17		**ME 429**	**55 days**	**Mon 1/6/14**	**Fri 3/21/14**	**1**
18		Pick a Top Concept	0 days	Tue 1/7/14	Tue 1/7/14	15
19		Detail Design with Calculations/Analysis	12 days	Wed 1/8/14	Thu 1/23/14	18
20		Bill of Materials	6 days	Thu 1/16/14	Thu 1/23/14	19FF
21		Test Plan Development	6 days	Wed 1/8/14	Wed 1/15/14	18,19SS
22		Critical Design Report	5 days	Thu 1/30/14	Wed 2/5/14	19,20FF
23		Critical Design Review	0 days	Thu 2/6/14	Thu 2/6/14	22
24		Manufacturing and Test Review	3 days	Thu 1/16/14	Mon 1/20/14	18,21
25		Order Parts	16 days	Fri 2/7/14	Fri 2/28/14	24,19,21,22
26		Beginning Manufacturing	31 days	Fri 2/7/14	Fri 3/21/14	24,25SS
27		Project Update Memo (to Sponsor)	0 days	Tue 3/11/14	Tue 3/11/14	24,25SS
28		Spring Break	7 days	Sat 3/22/14	Mon 3/31/14	
29		**ME 430**	**54 days**	**Tue 4/1/14**	**Fri 6/13/14**	**17**

Final Gantt Chart

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
30		Continue Manufacturing	13 days	Tue 4/1/14	Thu 4/17/14	26
31		Testing of Design	11 days	Fri 4/18/14	Fri 5/2/14	21,30
32		Project Hardware/Assembly Demo	0 days	Mon 4/28/14	Mon 4/28/14	30
33		Iterate Design	15 days	Sat 5/3/14	Thu 5/22/14	30,31
34		Prep for Expo	6 days	Fri 5/23/14	Fri 5/30/14	33
35		Senior Project Expo	0 days	Sat 5/31/14	Sat 5/31/14	30,31,34
36		Final Project Report	11 days	Mon 5/19/14	Mon 6/2/14	33SS,35FF,32

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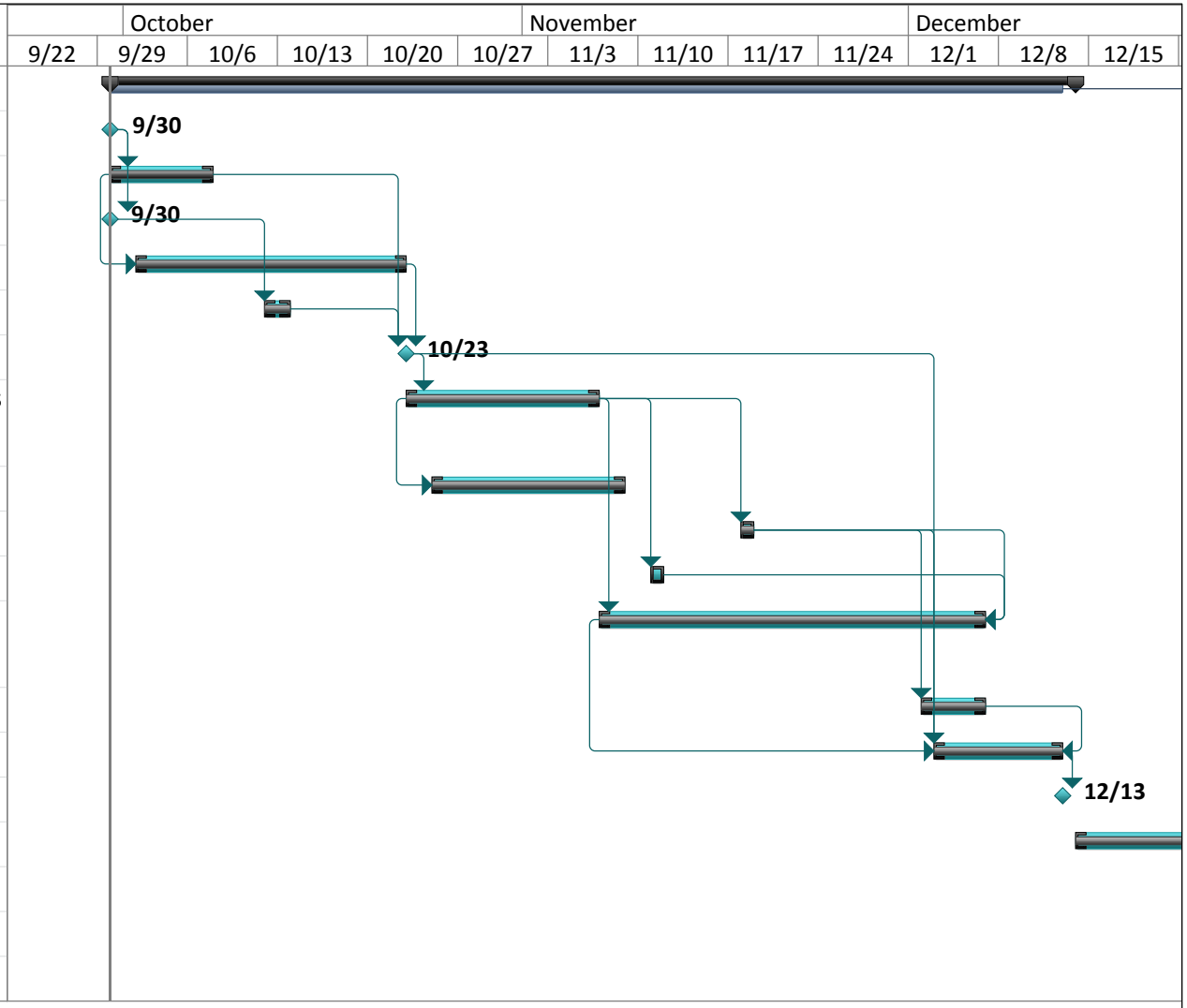
6		Consult with Sponsor
7		Project Proposal
8		Formulate Possible Solutions
9		Concept Modeling/Testing
10		Pugh Matrix
11		Check Patents
12		Evaluate Possible Solutions
13		Gantt Chart
14		Concept Design Report
15		Conceptual Design Review
16		Winter Break
17		**ME 429**
28		Spring Break
29		**ME 430**



Project: Final Gantt Chart.mpp
Date: Wed 6/4/14

Task		External Milestone		Manual Summary Rollup	
Split		Inactive Task		Manual Summary	
Milestone		Inactive Milestone		Start-only	
Summary		Inactive Summary		Finish-only	
Project Summary		Manual Task		Deadline	
External Tasks		Duration-only		Progress	

ID	Task Mode	Task Name
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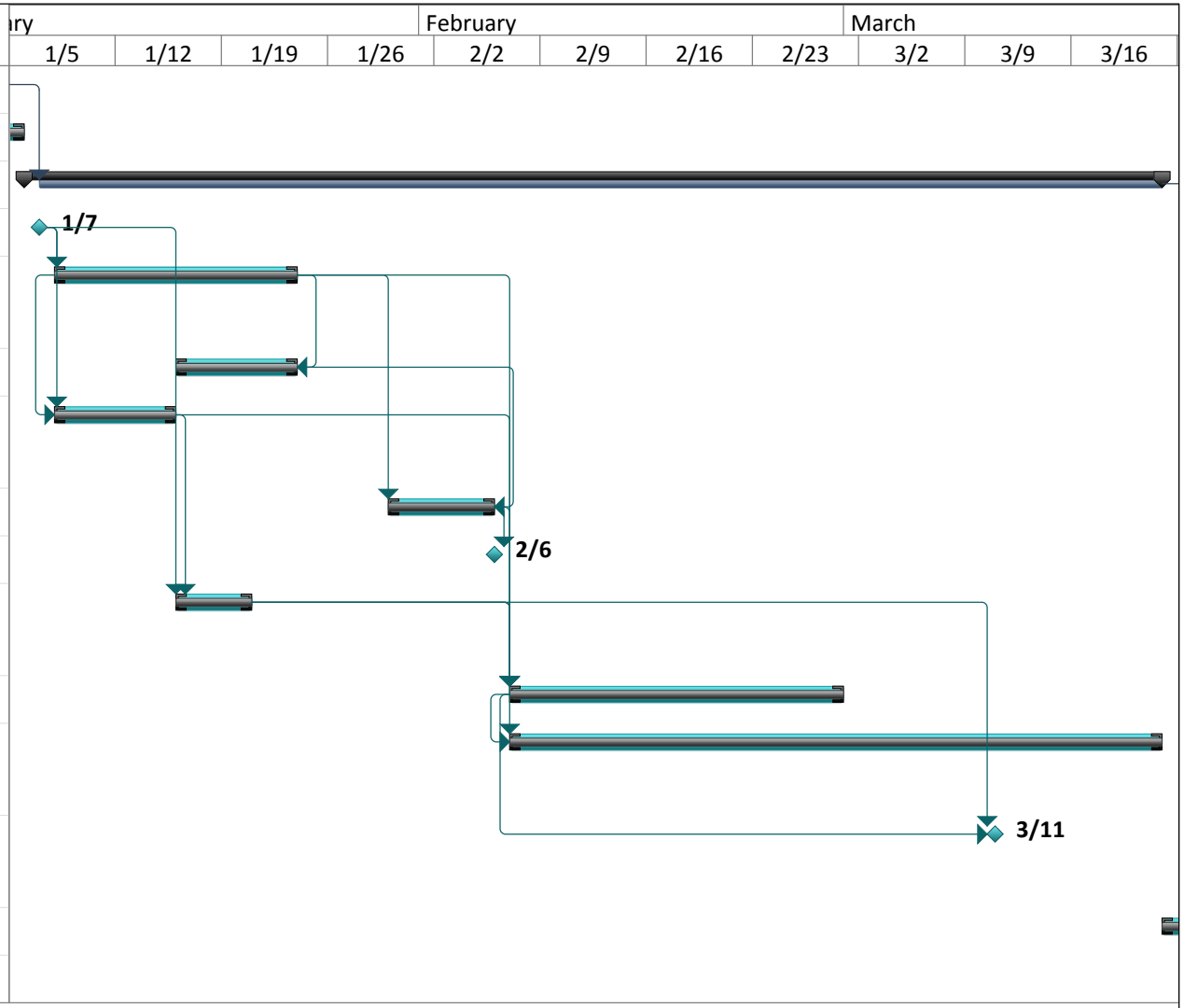
21		Test Plan Development
22		Critical Design Report
23		Critical Design Review
24		Manufacturing and Test Review
25		Order Parts
26		Beginning Manufacturing
27		Project Update Memo (to Sponsor)
28		Spring Break
29		**ME 430**



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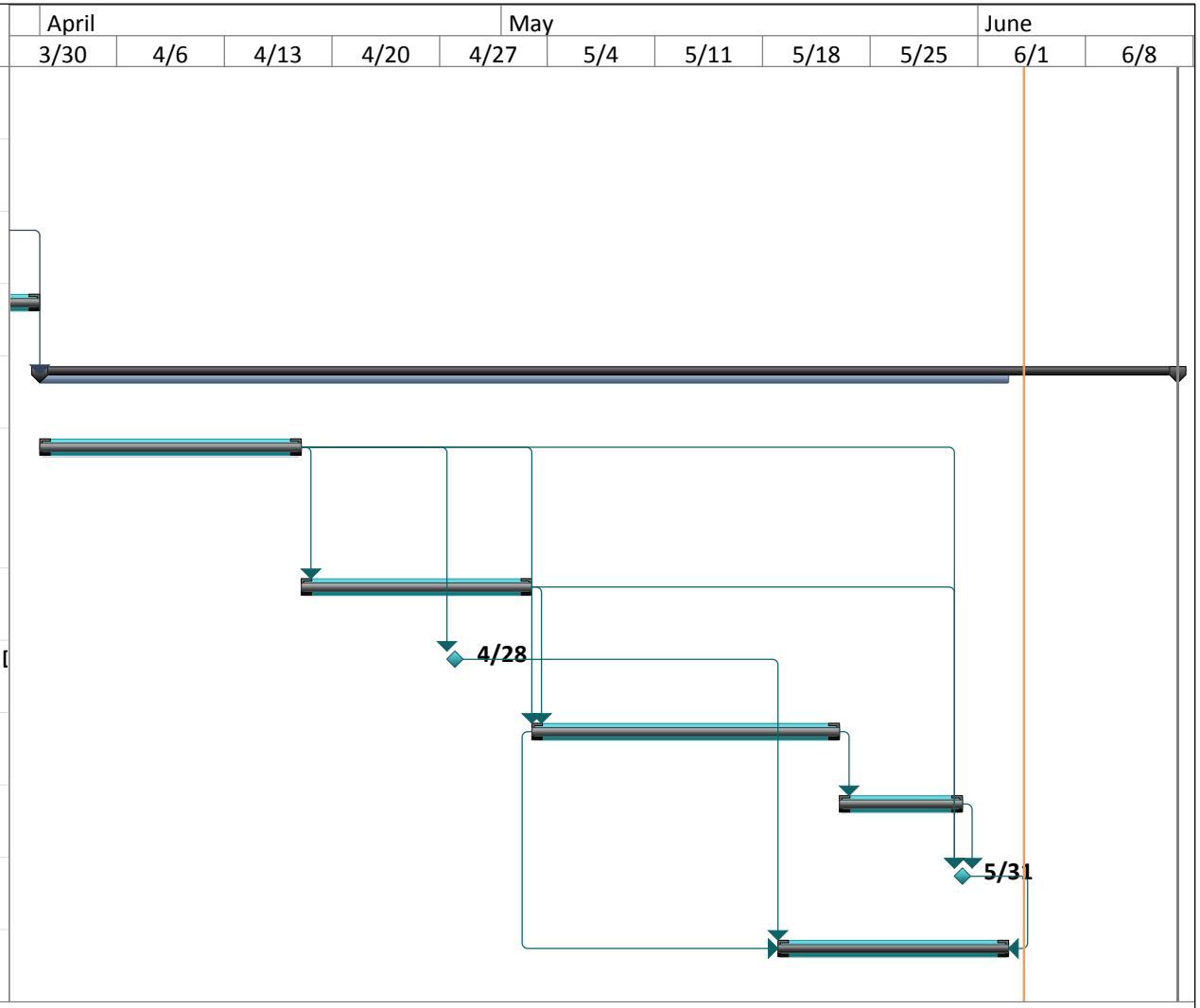
33		Iterate Design
34		Prep for Expo
35		Senior Project Expo
36		Final Project Report



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