Design Proposal Report

The Vassar Company

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Introduction

Prime Designs worked with Vassar Equipment to create a new arena groomer. This product can become a part of the Vassar family of farm equipment. Prime Designs used the information in this report to help with the designing, building and marketing of this project.

Problem Statement

Prime Designs provided a uniquely innovative design of an arena smoother that is functional, marketable, scalable, shippable, and cost competitive for a pre-existing distributor network while abiding by Vassar's commitment to quality, reliability and dependability.

Statement of Work

This section includes the Statement of Work for the arena groomer project. This report was developed early in the design stages, so changes have been made accordingly. The project scope, location, performance and acceptance criteria are included in the following sections.

Scope of Work:

The initial design of the arena groomer required the Prime Designs team to meet and discuss different ideas and generate design concepts. After the best design concept was chosen, the team began 3-D modeling using Pro-E. This aspect of the project was expected to take the longest amount of time. To determine which tine to use on the groomer, horsepower requirement calculations were required on several tines to determine the most efficient one. The tine that requires the least amount of horsepower to pull through the soil at a specified depth was considered the most efficient.

During the second semester, engineering drawings were created for each part before the building process began. Each part was then manufactured or ordered, depending on feasibility, then assembled. After the device was built, it was tested to compare with competitors' products. A brochure, magazine advertisement, and Web site addition were also created to help Vassar Equipment market their product.

Location of Work:

The majority of the 2-D and 3-D design work was done in the College of Engineering, Architecture and Technology computer labs using Pro-E. A facility for testing the performance of the arena drag was the Animal Science Arena in Stillwater, Okla. The large pieces were manufactured for the groomer at the Vassar Equipment facility, while the smaller pieces were machined at the Biosystems and Agricultural Engineering Lab. The overall construction of the arena groomer took place in the BAE Lab.

Period of Performance:

The 3-D modeling of the initial concept took two to three weeks to complete since it was a detailed design. This included time for corrections, as necessary. The horsepower calculations only required a week to complete the research, write the Excel sheet and to perform the calculations.

During the spring 2009 semester, engineering drawings required multiple weeks to create since all the necessary dimensions were known. The construction of the arena groomer required a minimum of eight weeks to manufacture each part, order necessary parts and assemble the pieces for the final prototype. For final testing of the groomer, Prime Designs needed

approximately one week to acquire the results, as several pieces of equipment were tested for a good comparison.

Acceptance Criteria:

If added to the current Vassar product line, the product Prime Designs produced for Vassar Equipment will be sold to dealers and suppliers, not directly to individuals. From the team's research, it was determined customer satisfaction as an important goal for dealers. Prime Designs produced an arena groomer to be durable and functional, minimizing two of the main reasons customers return these products to their dealer.

Because this is a new product, it was anticipated dealers will want an incentive to market it to their customers. During the final production stages of marketing materials, Prime Designs discussed dealer-incentive possibilities with Vassar. To advertise the new product to customers, brochures, co-op magazine ads, and a Web site addition were created.

Special Requirements:

For this project Prime Designs needed hardware and metal parts like bolts and nuts to fasten the machine components together. Tines, steel bars for the chassis and frame work were also needed. Some of these were ordered ready-made and, some were fabricated using steel bars. Other components needed included the rake that was cut on a flame table, a 3-point hitch assembly, and wheels to roll the groomer behind the tractor.

The design software (Pro-E), available in Agricultural Hall's engineering computer labs, was used for electronic design generation. Microsoft Project and Excel were used for planning, scheduling, engineering calculations and budget calculation. Computer files from a previous

project with the Vassar Equipment Co. were used to design and create the brochure, magazine advertisement, and Web site.

For a work force, trained milling and lathe machine operators were needed as well as skilled operators of simple and powered machine tools. Some Prime Designs team members were already trained to operate these machines in the course of their engineering studies. Trained or certified welders and the advice and direction of both professors and application engineers was also necessary.

Work Breakdown Schedule

To create an effective schedule for the project, a work breakdown schedule was developed. This list of tasks was set up in a hierarchal, chronological order to aid in the development of a Gantt chart schedule. This can be found in Appendix A: Work Breakdown Schedule.

Competitive Analysis

This technical report was prepared by Prime Designs as an aid for the development of an arena groomer for a local farm products company, Vassar Equipment. The material presented is a complete industry, customer, competitor and technical analysis. This allowed the Prime Designs team to develop a good design for production by the end of the fall 2008 semester.

Industry Analysis:

Arena drag companies like Riata Rake began making drags in 2000 and have already doubled their production twice in recent years. In the United States, horses are used for leisure

activities, sport and working purposes. The American Horse Council Web site reported in 2005 the world horse population was 58,372,106.

According to The American Horse Council Web site, in November 2008, "the horse industry has a direct economic effect on the U.S. of $39 billion annually." In addition, "the industry has a $102 billion impact on the U.S. economy when the multiplier effect of spending by industry suppliers and employees is taken into account. Including off-site spending of spectators would result in an even higher figure."

Equine activities take place in arenas of all kinds. From rodeos and horse shows to private practice arenas, needs of the arena dirt are dictated by the event for which it is used.

Arena drags are marketed several ways, including trade show exhibits and magazine advertisements. Vassar Equipment currently exhibits their products at 12 trade shows around the country and publishes advertisements in 10 magazines. Trade shows are commonly held in conjunction with large horse shows such as state, national and world-level championship events. An example of an Oklahoma horse show would be the 2008 Grand National and World Championship Morgan Horse Show, which had 61,267 spectators and brought in $14.3 million, according to http://www.okstatefairpark.com/.

Customers / Buyers:

The following research was done through an online search of consumer reports and reviews. Prime Designs used this information, including the customer "likes", and the information found in Appendix B to perfect a design and focus in on our target customers' needs.

When reading the reviews of the competitor's equipment, noted several qualities expected from each individual as well as some the customer enjoyed but did not expect. In general, individuals need the surface to be level with soft, aerated soil of varying depths. Some qualities of different devices customers enjoyed include hydraulic lifting mechanism, ball hitch and side drag. Prime Design used these implementations as well as others to create a new drag that is an improvement over the competition.

Vassar and Its Resources:

The client company, Vassar, is a 70-year-old farm equipment manufacturer based in Perkins, Okla. Vassar prides itself in producing "labor saving farm equipment" and is run by owner/general manager Jack Vassar and national sales manager/engineer Larry Kimmel. Vassar currently produces a variety of small implements and front-end attachments, including everything from box blades and tandem discs to tree shears and grapples.

The operation is housed in a new 200,000-square-foot facility. The manufacturing shop consists of welding stations, a machine shop, a couple of press brakes, powder-coating equipment and a plasma table. All products are made from steel with a few components outsourced, such as discs, tines and hydraulic cylinders.

Vassar uses a loyal distributor network to sell its products. This means price will vary among dealers. For a complete list of products and pricing information, please see Appendix C: Vassar.

Competitors and Their Resources:

Information gathered on competitors is included in Appendix D: Competitor Information. The information included is what Prime Designs deemed most important to the product and the completion of a useable design for Vassar. Many competitors are located all throughout the United States. Potential competitors include Riata Rake, What a Drag Company, ABI Equine, Parma, home-made drags and many others.

Figure 1: Riata Rake

http://www.riataranch.com/arena%20drag.html

Figure 2: What a Drag

http://www.whatadragco.com/products.htm

Figure 3: ABI Equine, manufacturer of the Kiser family of arena drags

http://www.abiequine.com/products/arena_drags/kiser_dragmaster.php

Figure 4: Parma

http://www.arenagroomer.net/

Most of these companies have numerous models of arena drags to meet different customers' needs and price ranges. One of the goals of Prime Designs was to create a single, scalable model with interchangeable parts so the customer can customize their drag to meet their individual

expectations. The table below shows the different options that each of these competitors offer for their drags and what Prime Designs proposed for the prototype.

Figure 5: Competitive Analysis

Name	hitch type	type of tine	Secondary harrow	type of finisher	water sprayer	side drag
Riata Rake	3 point/ball hitch	Straight		rake		x
What a Drag	3 point	C-shank	x	bared roller		
ABI Equine	3 point/ball hitch	C-shank	x	rake	x	
Parma	3 point	S-tine	x	bared roller		
Prime Designs Concept	ball hitch	S-tine	x	rake/roller	x	x

Technical Analysis:

This section contains all relevant published information that aided in the design of the product, such as standards and patents. Testing and modeling information that was completed during the development of the product is also provided.

Standards:

Industry standards are a good source of information for concept development. They help generate ideas that incorporate exchangeability among components. The American Society of Agricultural and Biological Engineers publish industry standards for agricultural applications.

Prime Designs found numerous standards that pertain to the current design, including terminology for tillage equipment, standards for hydraulic cylinders and 3-point hitch requirements. The terminology for tillage equipment helped Prime Designs name different parts of the drag relevant to what is already on the market. This would allow the customers to better understand each part of the drag because the terms already are familiar to them. The standards for hydraulic cylinders helped Prime Designs develop a working hydraulic lifting mechanism for

the arena drag. Since Prime Designs chose to use a 3-point hitch design for the pulling and lifting mechanism, several different standards were necessary to follow. A complete list of relevant standards can be found in Appendix E: Standards.

Patents:

Patents provided information used during design and concept development. Patents include a basic summary of the device, a full description, how it is suppose to be used, and what the device is claimed to achieve. Patents are beneficial when trying to come up with a new idea because it is possible to see what others have already done. Using past ideas as inspiration allowed new thoughts and ideas to be generated. Several patents were found referring to harrows, tines, and general arena smoothers. Most of the tines the patents show are used as rippers or cultivators for deeper applications then what are necessary for an arena drag but were interesting to review for new ideas. The general arena smoothers have several innovative features that were able to inspire creative ideas. One of these included the main tines being attached to a rotating cylinder which is powered by the tractor's output drive. These patents were used to analyze the process used by patent holders when they developed their products. All patents relevant to this project can be found in Appendix F: Patents.

Physical Testing and Data:

Testing and data analysis were needed on the tines. The connecting 3-point hitch needed to be designed to meet industry standards. The tines (or shanks) required calculations to determine the pulling force needed for the shanks to rip the ground effectively. This depended upon the depth of the shank, the spacing, number of rows and the type of shank used.

For the calculations for the tines, a Microsoft Excel sheet was created to allow the client to compare the results of changes in multiple time variables. The variables included drag force from the soil, drag force of the shanks, draw bar horsepower of the tractor, speed of the tractor, depth of shanks, number of shanks and spacing for shanks. The results of the calculations included the horsepower required for different shanks under different applications, the spacing required for the shanks, the number of shanks that can be pulled and which shank is more efficient to drag. The results from the calculations were used to determine the shank Prime Designs used for the prototype design. The calculations were confirmed during testing once the prototype was built.

The testing for the trailer tongue depended upon the choice of the tractor 3-point hitch; the results from the testing had to match with the standards and requirements.

Performing the data analysis and tests allowed Prime Designs to determine horsepower requirements and helped Prime Designs match up the various sizes of the new implement with horsepower ratings. It also assisted Prime Designs in deciding on the best possible final design.

Simulation and Modeling:

Prime Designs modeled the entire final design as well as preliminary ideas to help visualize concepts. Pro-E was used to model components and generate computer assemblies. This was done during concept generation to assist in confirming or disproving ideas. In addition, FEA analysis and other simulation programs were run as needed on critical components of the design as necessary.

Environmental and Global Impacts

Prime Designs took into consideration the environmental and global impacts an arena groomer might have. Beginning with the production stage, it is important to understand where the materials will come from and how they are manufactured.

Factors that could affect the environment would be chemical runoff from manufacturing plants, maintenance materials like oil and grease, and disposal of no-longer-useful groomers.

One global impact of an area groomer involved the acquisition of materials. Steel, hitches and tines may be purchased in or outside the United States. With the production of the groomer incorporating this option, there is also the opportunity for a global market, where it is economically feasible. Vassar Equipment obtains most of their materials for constructing farm implements from other countries where it is cheaper to purchase, but they construct the device in the United States. The arena drag Prime Designs created for Vassar will be produced in the same manner their current products are; therefore, there will be no greater impact on the surrounding environment than what is already being done.

All mechanical equipment requires some maintenance at some point during its life cycle. The arena drag design Prime Designs proposed to Vassar Equipment is no different. The wheels used will need to be periodically greased to stay in working order and certain parts of the drag may be subject to wear or failing over time due to rust and general use. The only parts that eventually would need to be replaced would be the S-tines and the shovel tips. The S-tines themselves would rarely, if ever, have to be replaced except under extreme cases. The shovel tips are reversible, so once one edge is worn down it can be rotated to a brand new edge, increasing the lifetime of the overall part.

The greatest environmental impact of the Prime Designs arena drag, would occur at the end of its life cycle. When the part is no longer being used it will more than likely be sold as scrap to a junk yard or deteriorate in a field. Prime Designs suggested a recycle program to Vassar where their products can be brought back to dealers. This suggestion could greatly reduce the waste produced not only from the Prime Designs product but also the rest of Vassar Equipment's products.

Design Criteria

Vassar Equipment required the following components to be incorporated into the final arena groomer design:

1. Manufacturable
2. Scalable
3. Shippable
4. Functional
5. Something new/unique
6. Cost Competitive

Vassar requested a family of arena drags, preferably three different sizes, ranging from four feet wide to eight feet wide. The four-foot drag should be four-wheeler compatible, and a 40-to-60 hp tractor should be able to pull the eight-foot drag. This provided a challenge because the designs needed to be similar.

Because Vassar ships directly to dealers and not individual customers, they also requested the product be easy to ship to their distributors. Distributors want to have several drags in stock so it would be best for several drags to be shipped together on one truck to the

distributor rather than having to ship them individually. To meet this expectation, there is a requirement for the device to be easily assembled for packing and shipping purposes.

Concept Development

Prime Designs decided to divide the project into four major components:

1. Hitch
2. Primary Tillage
3. Secondary Tillage
4. Finisher

This allowed for the design of each component to meet requirements and industry standards while also meeting customers' needs.

Concepts were developed for each of the categories. Prime Designs adapted these concepts to meet the design criteria, as discussed in the following sections.

Potential Solutions

The first component is the hitch. A hitch is necessary to attach the pulling implement (tractor or other powered equipment) to the groomer so it can be pulled through the arena. Within this category exist two options: drawbar pull and 3-point hitch.

The drawbar pull requires wheels for the groomer to move along the ground. This provides the option to control plow depth. Prime Designs considered the possibility of using a similar design to Vassar's current large disk, shown in Figure 6 below. A hydraulic cylinder was also considered to be used on the disk, or larger groomers, to easily control plow depth. This

requires hydraulic input on whatever machine is pulling it (tractor or other powered equipment); however, the groomer can be transportable without a tractor.

This design will scale down easily, allowing for the production of smaller groomers. The smaller the implement size, the less need for hydraulics to raise and lower the groomer; with a smaller design, less weight needs to be adjusted. A smaller option can be used to adjust the depth with less effort.

A vehicle other than a tractor can be used with a drawbar pull hitch, making this a versatile option.

Figure 6: Vassar Dual Disk

Lifting hydraulic actuator

Actuator attached to rotating axel

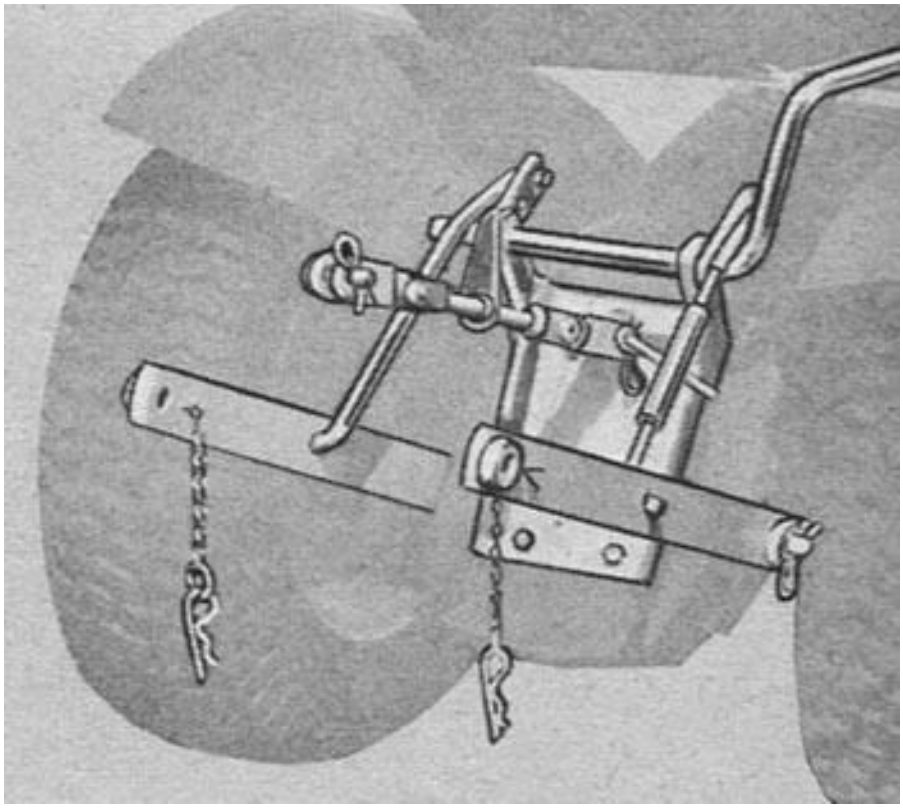
Adjustable spring on rotating hitch

Rotating hitch for lifting

A 3-point hitch will allow the tractor to control the depth without the use of hydraulics on the drag itself. Using the tractors 3-point control system allows for faster adjustments from the

operators seat. However, this design cannot be scaled down to produce smaller groomers. 3-point hitches have different categories, so the selection of the proper category is essential to the success of the product. This design will be less expensive to build, but it will require a tractor with a 3-point hitch to be moved. An example of a tractor's 3-point hitch is shown in Figure 7.

Figure 7: 3-point Hitch



The second major category is the primary tillage component. This is used for the initial break-up of the ground. The tools used in this section of the groomer needs to be small enough to be pulled easily behind a tractor, but big enough to till the ground properly. Prime Designs considered two main options for a primary tillage tool: C-shank tine and Danish S-tine.

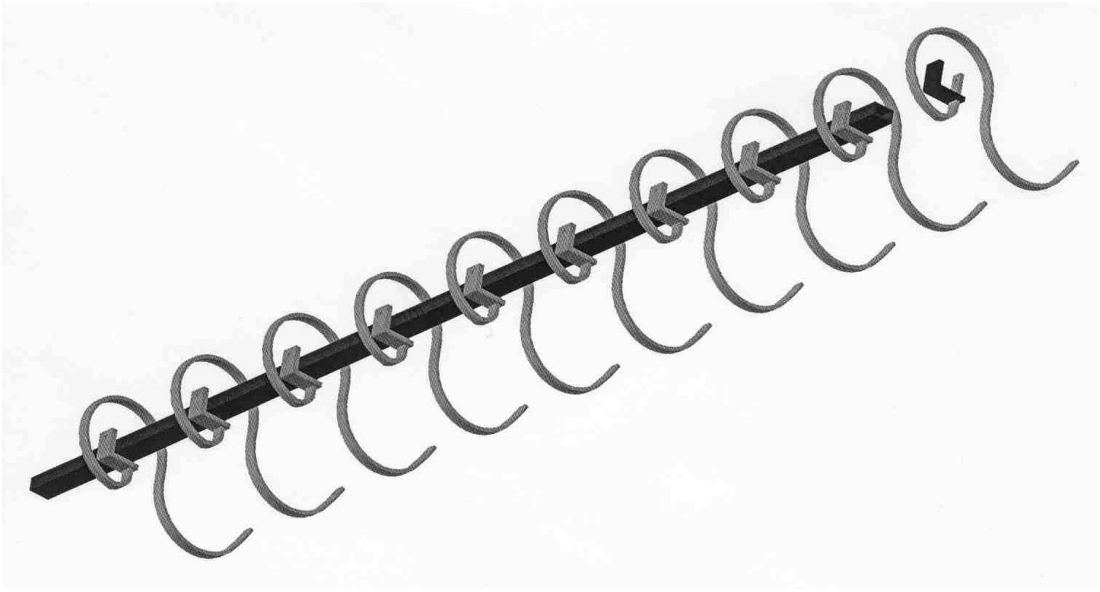
The C-shank tool, as shown in Figure 8, is used as a rigid tillage tool, which was originally meant for an 8-inch depth.

Figure 8: C-Shank

Picture from: http://www.yerikindia.com/1-Agricultural-Implements/1-C-Tine.html

The Danish S-tine, as shown in Figure 9, is an S-shaped tillage tool that follows the path of least resistance in the soil. The spring-like action of the coil at the top allows for the sweep attached on the end to move around and break up the soil easily. S-tines are easier to pull than C-shanks, as is proven through design calculations.

Figure 9: S-Tine



For secondary tillage, a set of harrow spikes is used for breaking up the clumps left over from the primary tillage. These spikes will be attached after the initial tines. This allows for two options: loose spikes or a rigid bar with the harrow spikes attached.

The loose spikes break up clods better than rigid spikes by allowing the harrow to follow the path of least resistance. However, the loose spikes tangle easily, which can make them difficult to transport. They need to be locked in place for safe transport. Rigid spikes are a better option when moving the implement, but do not allow maximum flexibility when drug through the soil.

For the finisher, two options are available to the customer. An arena comb or a roller that both create a nice, fine finish on the top of the soil, as shown in Figures 10 and 11. The finishers are interchangeable, so a customer can purchase both and switch them out easily to fit their specific needs. Vassar has chosen the comb option for prototype production.

Figure 10: Comb Harrow

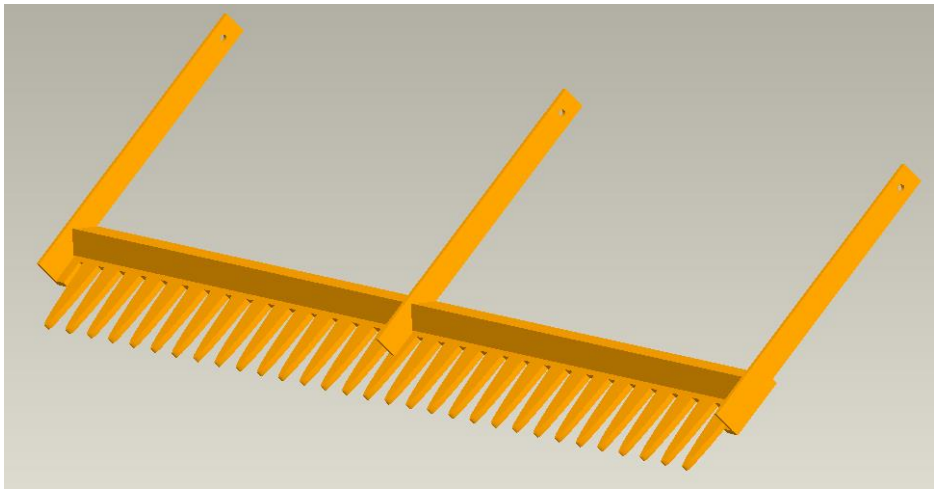
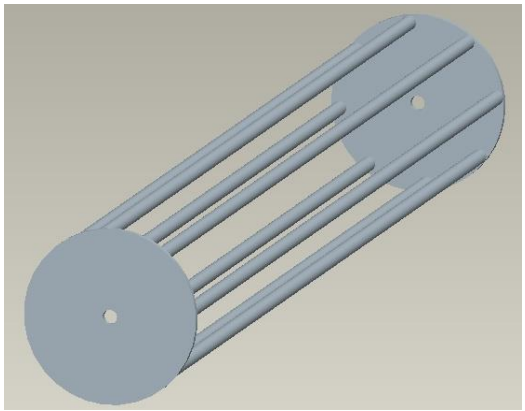


Figure 11: Roller Harrow



Potential Issues

A common problem occurs when tilling with tines or shanks. If the shanks are spaced too far apart or the wrong shovels are used, large rows are left in the soil. It is important to level the deepest level of the soil when tilling. Simply running a harrow over the soil does not fix this problem. It only levels the top of the soil. One way to ensure thorough and complete tillage is to have the correct spacing and shovels for the application.

When dragging an arena with walls, soil collects around the edges. The most common solution is to use a shovel and manually walk around the arena walls pushing the soil back into the arena. Prime Design's way of addressing this issue was to place a shovel on either side of the implement. This allows the operator to drag the entire area and scrape the sides with minimal effort, eliminating the use of manual labor. The shovel is a sheet of metal protruding from the drag, on either side. The shovels are attached with a spring mechanism so there will be "give" to any encountered resistance, such as a solid object; however, Vassar has decided to not use a shovel on the side of the drag.

Dust control in indoor arenas is also an area of concern. One way to control this is to apply water to the top soil. A problem arises when having to use a hose to water an entire arena. Some areas are well watered, while others are dry. An equal application is necessary to ensure a level, good footing for equestrian and rodeo events. A water sprayer on the tillage implement is beneficial. It allows for water to be evenly spread around the arena while tilling, making it easy to apply all in one step. Therefore, a water sprayer option would be possible to attach to the drag; however, Vassar has decided to not use a sprayer on the prototype.

Solution Analysis

A few issues are in need of analysis. These can be resolved by engineering calculations and stress analysis models. This analysis is necessary to determine the best component combinations while meeting all specifications and requirements.

Engineering Calculations

Engineering calculations are useful in determining what tillage tools are feasible. Some tools require more horsepower than is available. Also, in order to match horsepower from a tractor to the right size implement, calculations have been completed on all major drag components. All equations were derived from a variety of ASABE standards, which were used in the calculations to ensure validity.

Tillage Tools

To create good footing for horses and their riders, a two-to-six-inch plow depth is ideal. Tillage tools are used to plow to the desired depth. Prime Designs considered two major types of tillage tools for this application: S-tine and C-shank. A C-shank is a chisel plowing tool with a standard tilling depth of eight inches. As shown in Figure 13, the C-shank requires too much power/depth to meet the requirements and standards Vassar Equipment has provided for this groomer. Chisel plows can be used to till an eight-inch depth. If the implement needs to go eight inches deep, chisel shanks must be used. S-tines cannot hold up to deeper than six inches, as illustrated in Figure 12.

Figure 12: S-Tine vs. C-Shank

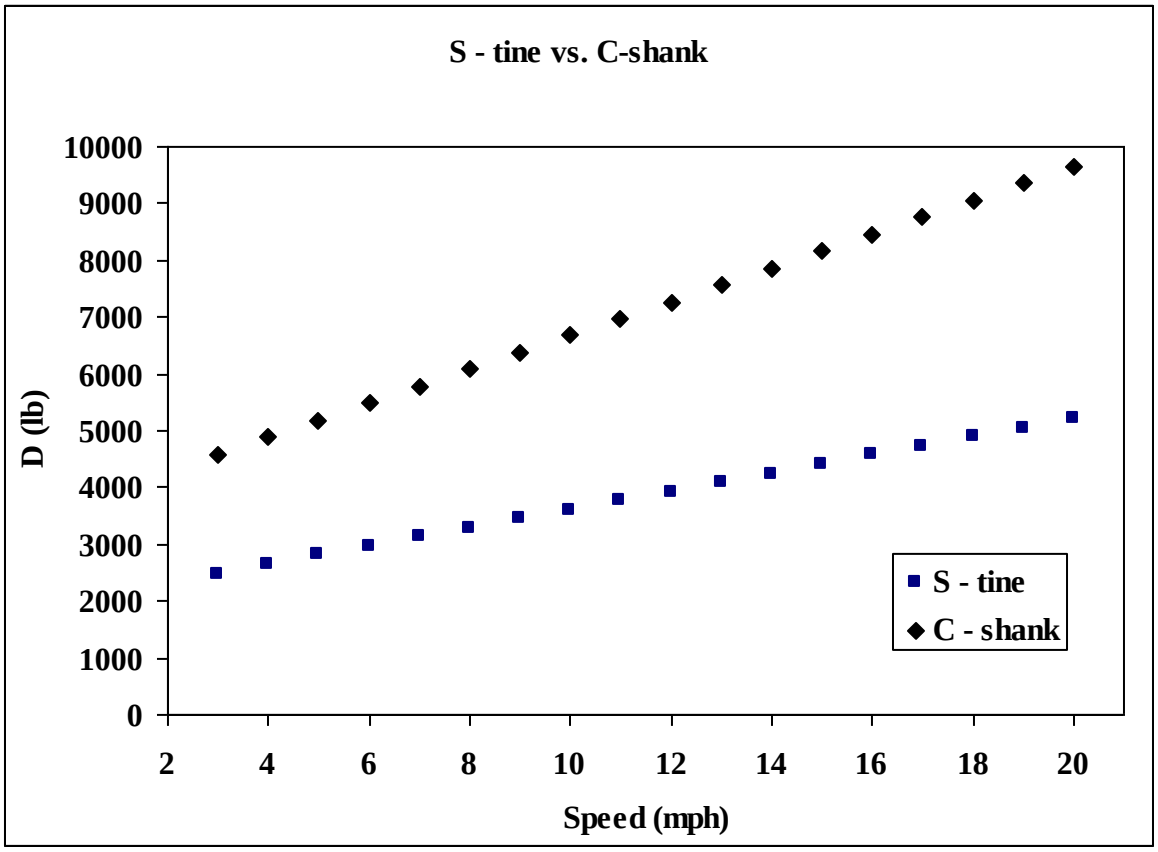


Figure 13: Acceptable Depths of Tines

Acceptable depths for Tillage Tools:	
Implement	Depth
Primary Tillage Cultivator	2 - 6 in
S-tine	2 - 6 in
C-shank	6 - 8 in

HP Requirements

ASAE Standard D497.3: Agricultural Machinery Management, found in Appendix E, was used to approximate the horsepower required to pull an arena drag. This standard provides different categories to determine the draw bar force needed to pull the implement. Many categories could be applied, such as Row Crop Cultivator – S-tine and C-shank, Chisel Plow – 5

cm straight point and 7.5 cm shovel, Field Cultivator – primary tillage and secondary tillage and Spike Tooth Harrow. The values given in Figure 15: (draft parameters and an expected range in drafts estimated by the model parameters for tillage and seeding implements of ASAE Standard D497.3) can be put into the draft pull equation with the following assumptions:

- Speed of five mph
- All values are per one foot of width
- Sandy loam soil – medium soil texture
- Two WD and Tilled Ground
- Total D = tillage + harrow
- Six inch spacing for tillage tools
- Two tools or rows per foot of width

Prime Designs assumed a speed of five miles per hour because it is a reasonable approximation for the velocity of a pulling tractor and the implement in the soil. All values are per one foot of width to make it easier to understand the values and decide the specific widths needed. A two-wheel-drive tractor on tilled ground was assumed for the worst case scenario. This combination gave the least amount of traction, to produce the biggest pull force. Prime Designs added the tillage component to the harrow component to give a reasonable approximation for the implement. Six inches between tillage tools is a standard spacing and is what Prime Designs chose for the final dimensions. Prime Designs assumed two tools per foot of width, because they are six inches apart.

With all these assumptions, the following values were found. Figure 14 shows the depth vs. horsepower required for a four-to-eight inch depth (all values in the table are per one foot of width of the implement). As shown in the figure below, eight inches requires too much horsepower for tractors in the 60 hp range. This makes a depth of eight inches obsolete.

Figure 14: Tine Depth vs. HP

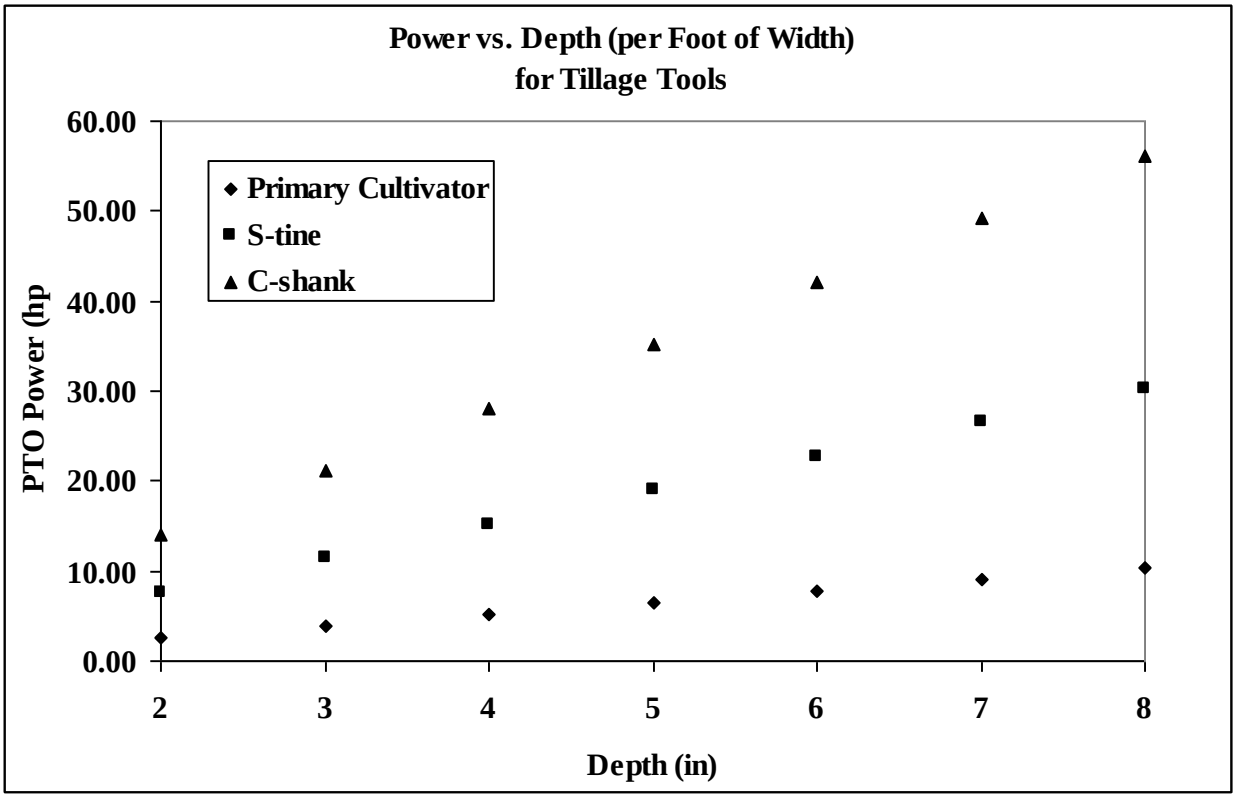


Figure 15 shows the values for different depths, with all the assumptions discussed above. Of all the pulling implement categories, secondary tillage gives the most reasonable number.

Figure 15: Tine comparison

Implement	Depth (in)	Total Drawbar(lb)	Drawbar (hp)	PTO (hp)
Primary Tillage	2	130.90	1.75	2.60
	3	196.35	2.62	3.91
	4	261.80	3.49	5.21
	5	327.25	4.36	6.51
	6	392.70	5.24	7.81
	7	458.15	6.11	9.12
	8	523.60	6.98	10.42
Secondary Tillage	2	95.2	1.27	1.89
	3	142.8	1.90	2.84
	4	190.4	2.54	3.79
	5	238	3.17	4.74
	6	285.6	3.81	5.68
	7	333.2	4.44	6.63
	8	380.8	5.08	7.58
S-tine	2	380.80	5.08	7.58
	3	571.20	7.62	11.37
	4	761.60	10.15	15.16
	5	952.00	12.69	18.95
	6	1142.40	15.23	22.73
	7	1332.80	17.77	26.52
	8	1523.20	20.31	30.31
C-shank	2	705.50	9.41	14.04
	3	1058.25	14.11	21.06
	4	1411.00	18.81	28.08
	5	1763.75	23.52	35.10
	6	2116.50	28.22	42.12
	7	2469.25	32.92	49.14
	8	2822.00	37.63	56.16

Original Design Recommendations

Based on previous calculations and assumptions, Prime Designs recommended a drawbar pull hitch drag with a maximum depth of six inches, using S-tines. This would allow for the least required horsepower for each implement. The spacing for the S-tines was determined during the Spring 2009 semester. Secondary tillage is the best approximation for horsepower

requirements, as shown in the horsepower/width match up of Figure 16. These values include secondary tillage horsepower requirements with and without the harrow. This is a good approximation for the horsepower required to pull the arena drag.

Prime Design's implement has two rows of harrow tines behind the S-tines with an attachment option of a comb or roller in the back. In addition, shovels are attached, as explained earlier, extending six inches on either side of the drag. Since the standard gate size is eight feet, the maximum width used will be seven feet wide (because of the foot of shovels). Prime Designs proposed this design recommendation at the mid-project presentation at the end of the Fall 2008 semester.

Figure 16: HP Requirements

Maximum Horsepower Requirements		
Width	Hp (w/o harrow)	Hp (with harrow)
4	22.73	25.92
5	28.42	31.60
6	34.10	37.29
7	39.79	42.97

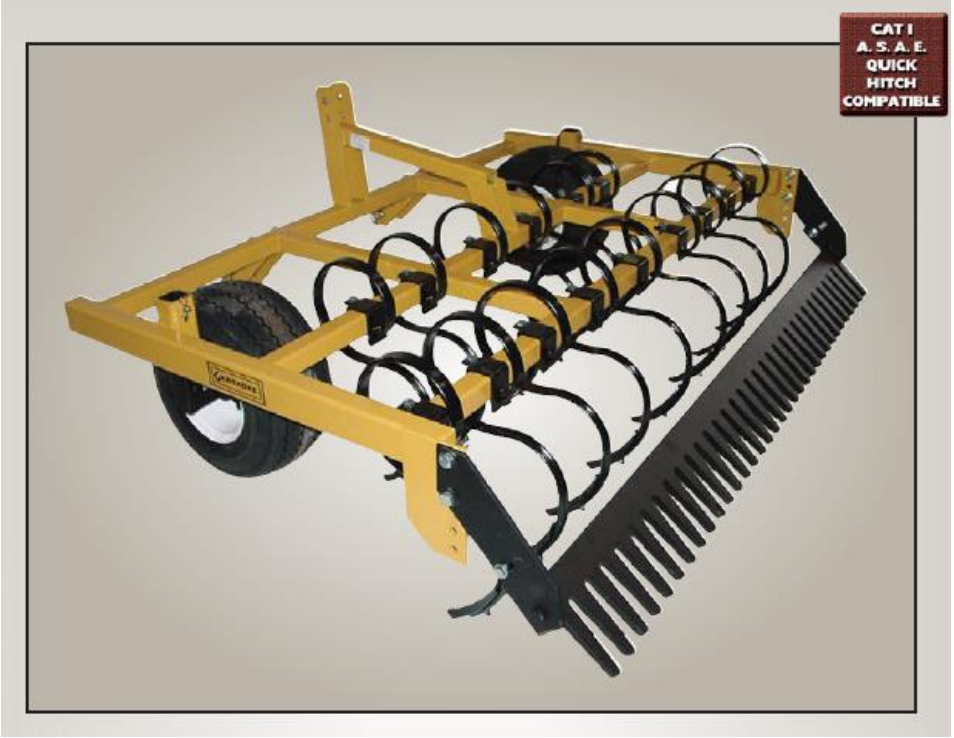
Design Feedback

At the beginning of the Spring semester, Vassar informed Prime Designs of exactly what they wanted for a product and how they wanted to enter the market of arena drags. Vassar gave the team information and design specifications of an existing arena drag made by Gearmore. They also reiterated the importance of the following criteria:

- Simple
- Economical
- Strong Appearance
- Easy to Manufacture

One of the team's goals was to minimize the amount of steel used, while keeping a sturdy frame to conform to Vassar's rugged equipment reputation. Based on these criteria, Prime Designs redesigned the Gearmore drag to Vassar's specifications.

Figure 177: Example Drag: Gearmore



Final design:

During the course of the design project in the fall 2008, Prime Designs designed an arena drag that was as long as it was wide (8ft by 8ft). Along the width were two rows of S-tines in the front, a pair of wheels and an axle mounted in the middle with a hydraulic system to raise and lower it. This was followed by two rows of harrows. For the finisher, there was an option of rollers, comb or rake. Prime Designs also had optional water tank for spraying water on the soil while grooming it with the equipment.

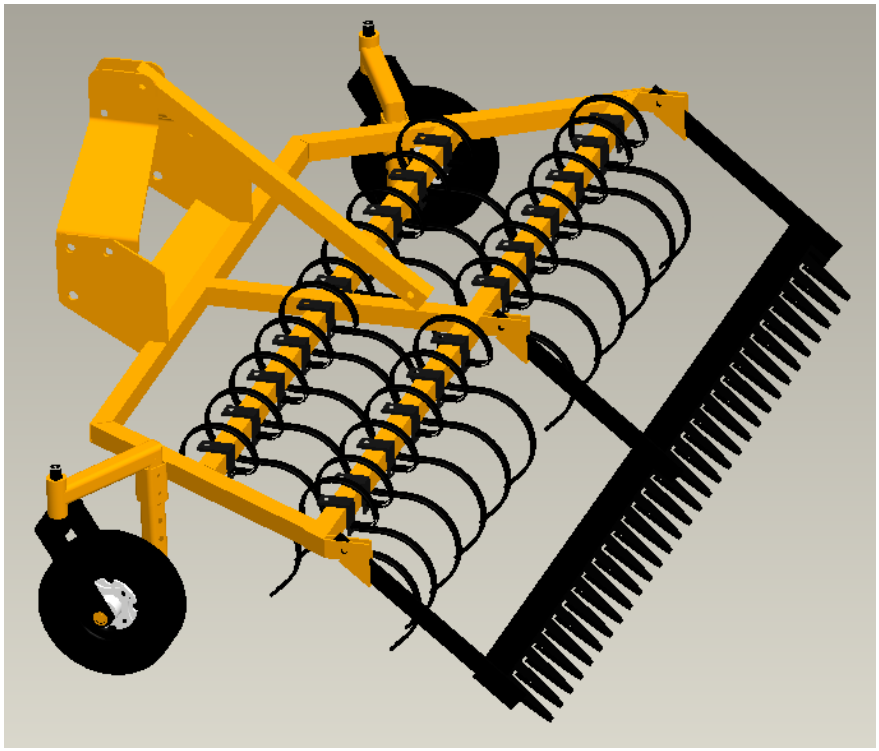


Figure 18: Final design

After our presentation, Prime Designs received feedback from Vassar. Based on what the team gathered from Vassar, it was determined that the final design needed to be changed to comply with the similarities of the Gearmore drag. Their decision was based on the marketing experience and success of their distributors. They requested a design that featured two rows of S-tines only, wheels inside the rectangular frame right before the first row of tines as well as a 3-point hitch for a category one tractor mounted on the frame. This design was almost identical to one of their competitors. Prime Designs discussed this issue with Vassar and agreed to modify the design to give it a unique look and function. It was also important to Prime Designs to avoid duplication of another product.

The frame of the design was trapezoidal in shape instead of rectangular, with enough space to let the wheel be mounted outside the frame work and not inside. Because of the trapezoidal shape, the soil behind the wheels will still be tilled, leaving no tire marks in the soil. The final design of the frame also uses a smaller amount of steel than most drags. After testing

the S-tines on the frame, Prime Designs discovered there was a problem of not being able to replace the S tines in the future because they cannot fit into the 3-inch tubing from which our frames were made. Therefore, 2-inch tubing was used for the 6-foot design. Figure 17 shows the final design of the 8-foot arena drag.

The final design promises simplicity in manufacturing and uniqueness in shape. Because of the unique trapezoidal shape of the frame, less steel tubing will be required to build the frame when compared to competitors of the same class. The final design uses wheels mounted on frames that rotate about the vertical axis like shopping carts; this gives an advantage in the ease of turning.

The use of S-tines instead of other kinds of cultivators, like harrows, provides not only a better look but also a technical advantage. S-tines having an elastic tendency when they come in contact with a barrier in the soil. This will ensure there is less chance of failure of the cultivator.

The performance of this arena drag is expected to match or even beat that of its competitors because of the combination of S-tines, rake, and rotating wheels. With the choice of an 8 foot and 6 foot width drag, consumers have the luxury of choosing which size best suits the needs of their arenas.

Building of Prototype

After the Vassar Company confirmed the final design met all of their requirements, Prime Design began construction of the 8-foot model with the help of the BAE Lab. This full-scale model of the final design was used as the prototype that was tested and compared to other drags. During the construction of the design, several issues had to be solved that required some design changes that were not expected.

Several issues arose during the construction of the drag that was solved before they became large issues. The first problem arose after the original 3-inch frame was constructed. The S-tines chosen to be used did not have enough spacing to slide them onto the frame correctly. Figure 19 shows the original three inch square tubing frame that was built.

Figure 19: Original Frame

Prime Designs decided to recreate the frame from 2-inch square tubing so the S-tines could slide on and off. From a customer's perspective, the S-tines needed to be easily replaceable if one had been worn or broken. Other options included cutting notches into the three inch frame, cutting out a small piece from each of the main frame tubes, or constructing a new 3-inch frame but installing the S-tines in the process instead of afterward. Figure 20 shows the new 2-inch frame with the 3-point hitch installed.

Figure 20: New Frame with Original 3 Point

Another issue that arose involved the rake that would be on the back of the device. With how the rake was originally designed and the material chosen to construct it, it was able to bend under its own weight. This was corrected by adding an additional third rake arm so that it would be mounted to the frame at three points instead of just two. In addition to the third arm, 2-inch angle steel was welded to the back side between each of the arms along the length of the rake to help stiffen it.

Figure 21: Rake

The next issue that came up involved how to attach the rake to the frame. This problem was never truly solved during the initial design phase in computer modeling and now had to be faced. The concern was how to attach the rake to the frame and let it be able to rotate to a specified angle. The solution Prime Designs came up with involved creating a bracket that had the angle cut into it with a small piece of plate welded to the bottom to keep the arm of the rake from rotating past that point. The sides of the bracket were designed to be easy for Vassar to manufacture when the product was put into full production.

Figure 22: Rake Bracket – End and Center

The final problem faced by Prime Designs during the construction of the prototype was discovered when discussing the height adjustable wheels. Originally, the wheels would be on a telescoping shaft that was welded to the frame and the wheels would not be able to rotate on a vertical axis. Wayne Kiner, the BAE Lab manager, to use caster wheels instead, which would allowint the wheels to rotate along the vertical axis. This would allow the wheels to spin while the tractor is turning, instead of being drug through the dirt. To install these types of wheels, the telescoping bracket had to be completely redesigned to accept them and still be able to adjust the height of the device. Figure 23 is of the telescoping bracket that was constructed to solve this issue. Eventually, the device was finished being built and testing began.

Figure 23: Caster Wheel Bracket

After the prototype was completed it was tested to see if any changes to the overall design needed to be made before delivering it to Vassar Equipment. After testing the drag it was found the 3-point hitch was too low to the ground and prevented the tractor from being able to lower the device to the depth desired. Another issue arisen while testing involved the bracket used for the caster wheels. The bracket arm was found to be longer than the frame thus making it prone to breaking if the drag would be struck by something with enough force. Because the bracket arm was not a needed change until final production, Prime Designs decided to leave the changes as a recommendation to Vassar Equipment.

To prepare for a second testing session the 3-point hitch had to be moved to allow for the wanted depth. A new mounting bracket was designed to raise the 3-point hitch off the frame to a height that would allow the tractor to lower the arena drag to the depth desired. After this was finished the drag was tested for the second and final time. The results from the second testing were satisfactory and the design of the drag was completed.

The final part of building the drag was having it powder coated to Vassar Equipment's standards. To do this the drag was taken apart so the individual parts could be powder coated. Each piece was then delivered to Vassar Equipment so they could powder coat it using their own facilities as well as put on the necessary safety and hazard stickers. Once the drag was delivered back to Prime Designs, it was reassembled and prepared for final presentations and delivery to Vassar Equipment.

Testing Results

Testing was performed to confirm that the designed product will work, as it is expected to, in the field under normal use. Testing was done at Oklahoma State University's Animal

Science Arena. The constructed prototype was tested alongside competitors being used at OSU's Animal Science Arena.

Figure 24: Testing

Corrections

During the testing of the arena drag a couple of flaws were observed. First, the 3-point hitch bracket was too low resulting in a maximum depth of 2-inches. In order to correct this, the 3-point bracket was redesigned to move the hitch up 10 inches. This allows the tractor to lower the drag further to a deeper penetration into the soil. The previous and corrected designs are shown in Figures 25 and 26 respectively.

Figure 25: Original 3 Point

Figure 26: New 3 Point

The second problem observed during testing was in the last row of S-tines, the last two S-tines on both sides where too close to each other and as such, the two of them were cultivating as one tine hence leading to a ridge-like look in the soil. While the spacing in the two rows of S-tines is about two-to-three inches, the spacing between two tines in the same row is about twice that, these last two tines are about two-to-three inches close in one row, so they dig up dirt more than others. In order to correct this, Prime Designs team members simply re-spaced them by removing two S-tines from the last row and had the same spacing across the frame. Figures 27 and 28 show the original and new spacing of the S-tines.

Figure 27: Original S-Tine Design

Figure 28: Corrected S-Tines

Final testing

After the corrections were made and the drag was tested, an improved performance was observed as the drag could be lowered deeper to the soil than before, and the S-tines were re-spaced. This led to more depth of cultivation and the disappearance of the ridge-like look on the dragged soil. Figure 29 shows the drag in the modified state and the achieved result on the dirt.

Figure 29: Final Testing

Proposed media / communications plan

When talking with Vassar Equipment, Prime Designs decided to create a brochure, advertisement and Web page for the arena drag Prime Designs has created for them. Vassar is currently redesigning its Web site; thus Prime Designs cannot create a page for the arena drag until Vassar has completed the update of the Web site.

The brochure Prime Designs created for Vassar will be a tri-fold, full-color brochure. Prime Designs evaluated the cost of printers for the printing of this brochure to get the best printer for Vassar's needs. Once Prime Designs collected the information, they included it in an Excel spreadsheet accompanying this document. To maintain product unity and company recognition, the brochure is similar in design to the current brochure template Vassar is using for

its other products. Since this product is different from any other product Vassar manufactures, Vassar and Prime Designs have decided it would be best to create a new brochure for this product.

The advertisements Prime Designs created also will be similar to other designs Vassar has used in the past. Prime Designs made a cooperative ad, which will include splitting the total cost with a distributor to help with the costs of advertising as a single company. Prime Designs created an advertisement for Vassar without the distributor information so Vassar can decide which type of advertisement they would like to use in the future. Prime Designs suggested advertising in several major equine publications, such as *The Quarter Horse Journal, Paint Horse Journal, Palomino Magazine, Western Horseman, Equus* and *Horse Illustrated*. Prime Designs obtained the information on advertising rates for these equine publications. In addition, they researched the costs and benefits of advertising in non-equine publications. These advertisements and brochures can be seen in Appendix G: Media Materials

The last element Vassar requested was an adaptation to their Web site. Since Vassar is redesigning their Web site, Prime Designs would like to hold production of the Web page until the update is complete to ensure consistency between the team's design and that which Vassar is creating. The Vassar product line is currently in a description table like list, thus Prime Designs suggests a modification to the list, by adding individual product pages. If this modification is not made, the new product can be added to the current list on the Web site.

Proposed business plan / financial analysis

INPUT PRODUCTS, INITIAL VOLUME, MARGIN PER UNIT AND ANTICIPATED SALES GROWTH RATE		
Product Name	**Arena Drag**	
Units	lbs	
Initial Volume	50	
Sales growth	10%	
Price/unit	$	2,872.63

VARIABLE COST OF PRODUCTION PER UNIT

Product	Cost	VC/unit
Arena Drag	Materials	$1,921.75
	Building	$ 160.00
	Marketing	$ 16.35
	Shipping	$ 200.00
	Total	$2,298.10

Projected Cost Per Unit

Materials Cost Of Production per Unit for 8 ft. Drag

Material	Unit Price	Qty	Cost
High Clearance S-tines	$ 30.00	22	$ 660.00
S-tine shovels	$ 3.00	22	$ 66.00
4'x8' Steel Plate	$ 500.00	0.2	$ 100.00
3'' Square Tubing 20'	$ 4.45	35	$ 155.75
Wheel and Tire Unit	$ 270.00	2	$ 540.00
Misc. Small Parts	$ 400.00	1	$ 400.00
		Total	$ 1,921.75

Building Cost of Production per Unit

Material	Unit Price	Qty	Cost
Labor	$ 20.00	5	$ 100.00
Welding Wire	$ 100.00	0.2	$ 20.00
Welding Gas	$ 100.00	0.2	$ 20.00
Misc. Cost	$ 20.00	1	$ 20.00
		Total	$ 160.00

Materials Cost Of Production per Unit of 6 ft. Drag

Material	Unit Price	Qty	Cost
High Clearance S-tines	$ 30.00	18	$ 540.00
S-tine shovels	$ 3.00	18	$ 54.00
4'x8' Steel Plate	$ 500.00	0.2	$ 100.00
3'' Square Tubing 20'	$ 4.45	28	$ 124.60
Wheel and Tire Unit	$ 270.00	2	$ 540.00
Misc. Small Parts	$ 400.00	1	$ 400.00
		Total	$ 1,758.60

Marketing Cost of Production per Unit

Material	Unit Price	Qty	Cost
Magazine Ads	$ 5.00	1	$ 5.00
Trade Show Cost	$ 10.00	1	$ 10.00
Brochures	$ 1.35	1	$ 1.35
		Total	$ 16.35

Shipping Cost Of Production Per Unit

Material	Cost
Shipping	$ 200.00
Total	$ 200.00

Gross Sales Projection

Gross Sales

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Arena Drag	$0	$ 178,626.50	$ 196,489.15	$ 216,138.07	$ 237,751.87	$ 261,527.06
Total	**$0**	**$ 178,626.50**	**$ 196,489.15**	**$ 216,138.07**	**$ 237,751.87**	**$ 261,527.06**
Expenses						
Variable	$0	$116,088	$127,696	$140,466	$154,512	$169,964
Fixed	$0	$0	$0	$0	$0	$0
Other	$0	$0	$0	$0	$0	$0
Total Expenses	**$0**	**$116,088**	**$127,696**	**$140,466**	**$154,512**	**$169,964**
Before Tax Profit	$0	$62,539	$68,793	$75,672	$83,239	$91,563
Tax	$ -	$ 18,762	$ 20,638	$ 22,702	$ 24,972	$ 27,469
After Tax Profit	**$ -**	**$ 43,777**	**$ 48,155**	**$ 52,971**	**$ 58,268**	**$ 64,094**

Estimate of Cash Flows

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
After Tax Profits	$ -	$ 43,777	$ 48,155	$ 52,971	$ 58,268	$ 64,094
Depreciation	$ -	$ -	$ -	$ -	$ -	$ -
Principle	$ -	$ -	$ -	$ -	$ -	$ -
Cash Flow	**$ -**	**$ 43,777**	**$ 48,155**	**$ 52,971**	**$ 58,268**	**$ 64,094**

(does not consider increases or decreases in working capital loan)

Market Projection

	Year 1	Year 2	Year 3	Year 4	Year 5
Arena Drag					
Total Volume	50	55	61	67	73
Price/Unit	$ 3,572.53	$ 3,572.53	$ 3,572.53	$ 3,572.53	$ 3,572.53
Gross Sales	$ 178,627	$ 196,489	$ 216,138	$ 237,752	$ 261,527

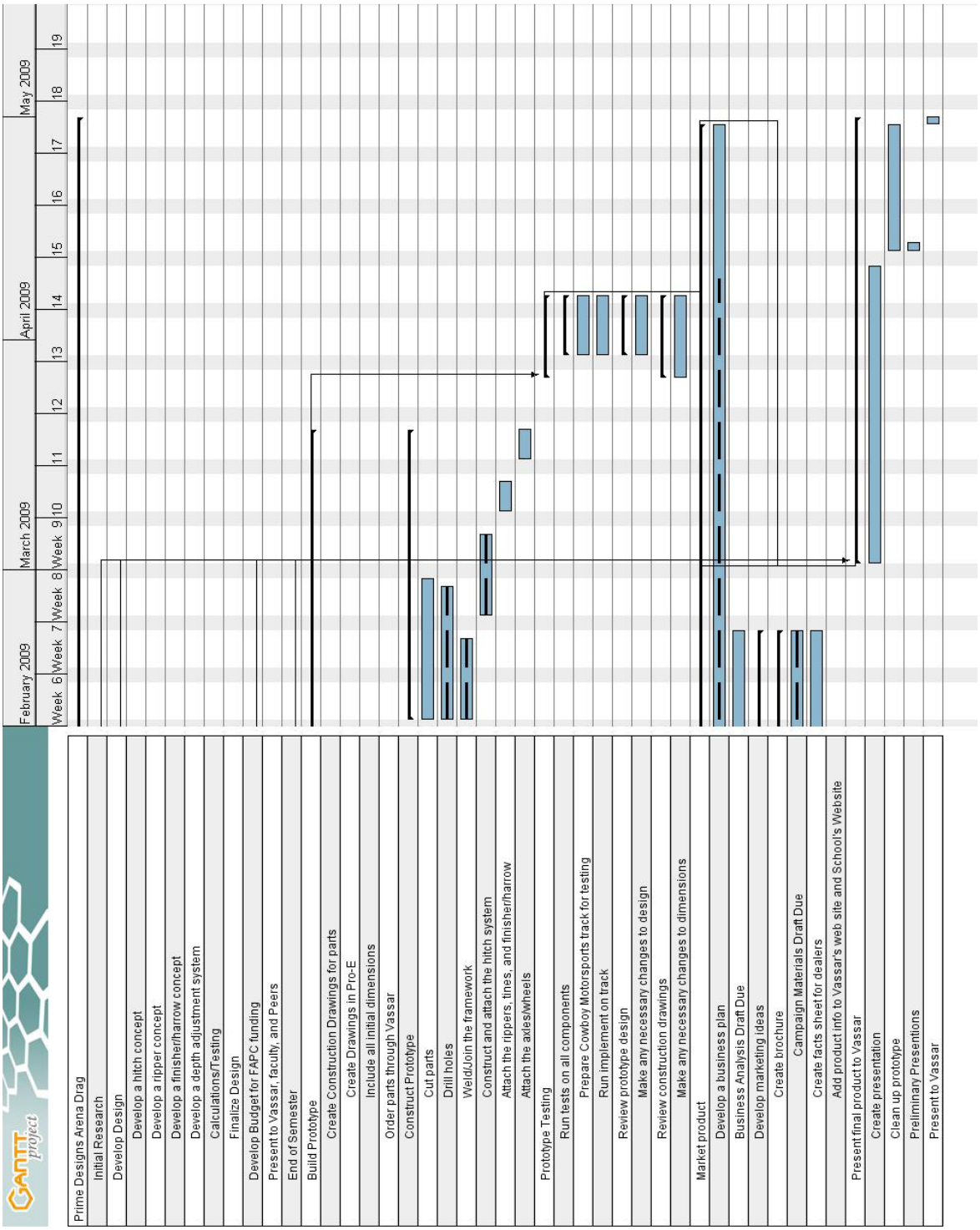
Return on Investment

Year	0	1	2	3	4	5
Gross Margin		$178,627	$196,489	$216,138	$237,752	$261,527
Discount Factor	1	0.892857143	0.797193878	0.711780248	0.635518078	0.567426856
PV of Income	$0	$159,488	$156,640	$153,843	$151,096	$148,397
Total Expense	$0	$116,088	$116,088	$127,696	$140,466	$154,512
Less Depreciation and Term Interest		$0	$0	$0	$0	$0
Cash Expenses	$0	$116,088	$116,088	$127,696	$140,466	$154,512
Discount Factor	1	0.892857143	0.797193878	0.711780248	0.635518078	0.567426856
PV of Expenses	$0	$103,650	$92,544	$90,892	$89,269	$87,675
Benefits less Costs	$0	$62,539	$80,402	$88,442	$97,286	$107,015
PV Benefits Less PV Costs	$0	$55,838	$64,096	$62,951	$61,827	$60,723

Total PV of Income	$1,472,636
Total PV of Expenses	$879,469
Net Present Value	$593,167
Internal Rate of Return	0
PV Benefit/PV Cost Ratio	1.67

Project Schedule

Figure 30: Gantt Chart



Cost Analysis

Vassar was straight-forward with their requirements for what this product should be. Vassar stated to build an arena drag for them it had to be easy to ship and competitive in the market. With this design, Prime Designs has accomplished both. With the overall budget, Prime Designs shows Vassar can compete with the more expensive drags at a medium price range. Prime Designs split the budget in four pieces: materials, building, marketing, and shipping costs. Listed below is the proposed budget for the materials needed for building the prototype.

Figure 31: Proposed Budget

Materials Cost Of Production Per Unit

Item	Unit Price	Qty	Cost
High Clearance S-tines	$20	30	$600
S-tine shovels	$10	30	$300
4'x8' steel plate	$500	1	$500
2" steel square tubing 20'	$100	3	$300
Hub/Spindle End Unit	$50	2	$100
14" Wheel/Tire	$50	2	$100
1" steel rod 20'	$64	1	$64
Misc Small Parts	$400	1	$400
		Total	$2,364

Recommendations:

Prime Designs has designed a family of arena drags ranging from a four-foot model up to an eight-foot wide model. Vassar Equipment wanted a family of drags so their customers have a choice of drag based on their budget and arena size. All engineering drawings and parts lists for the eight-foot and six-foot drags can be found in Appendix G: Design Drawings. A print out of a three-dimensional model for the four-foot drag is also provided.

From the results of the final testing session, Prime Designs is recommending a few changes to the overall design of the eight and six-foot models to Vassar Equipment before the arena drag is put into production. The first issue that needs to be addressed is the length of the arms for the caster wheels. The way they are designed now they exceed the eight-foot dimension requirement. This could become an issue if the drag is used close to a fence because the wheel could get caught on a fence post causing the bracket to fail. If Vassar could shorten the arm of the bracket, this issue would be resolved. Another issue found during testing involved the spacing of the S-tines. During testing it was determined that spacing of the two outermost S-tines on the second row of the drag was two small and led to some issues. To fix this issue, Prime Designs found if the outermost S-tines were removed the drag would perform as desired. The six-foot model would have the same issues as the eight-foot model and would need these recommendations as well.

Prime Designs did not create design drawings for the four-foot model of the arena drag for Vassar Equipment. After completing the competitor research it was discovered that very few companies create a drag that small. A four-foot drag would only be used with ATV's and there for would require a lifting and lower device on the drag itself such as an electronic actuator, a hydraulic actuator or a manual crank. Adding these devices to the drag would raise the price to be close to the six-foot wide drag. Prime Designs saw no benefit in Vassar Equipment producing a four-foot drag based on the market research and price. If Vassar Equipment chooses to produce a four-foot drag, Prime Designs created a sample 3-dimensional model of a recommended design that is in Appendix G: Design Drawings.

Conclusion

Prime Designs has created a new product for Vassar Equipment to add to its family of farm equipment. This new arena drag was built to be competitive with the market, scalable,

shippable and functional. Prime Designs used the information gathered in this report from the market research, patent search, industry standards, and team member ideas to develop a design that met all of these goals.

Appendix A: Work Breakdown Schedule

Design, Build and Market an Arena Groomer for client company – Vassar Equipment

- **Initial Research**
    - Researched Vassar
        - Determined who they are
        - Determined what they do
        - Determined what their resources are
            - Determined Vassar's supplier(s)
            - Obtained catalog from the supplier(s)
    - Researched Industry
        - Determined industry size
        - Determined market size
    - Researched Competitors
        - Researched Competitor Resources
        - Researched Competitor Products
            - Determined their products
            - Identified what is unique to their product
                - Determined what is good about the competitors' products
                - Determined what is bad about the competitors' products
            - Determined competitors prices
    - Researched Dealers
    - Researched Customers
        - Identified customers' need
        - Learned what they like about existing drags
        - Learned what they don't like about existing drags
    - Researched Technical Sources
        - Researched Standards

        - Researched ASABE standards
            - Found Standard for General Tillage Terminology
            - Found Standard for Machinery Management
            - Found Standard for Hydraulics
            - Found Standard for 3-point Hitches
    - Researched Patents
- **Developed Rough Budget for NPDC funding**
    - Reviewed Initial Research
    - Created Budget
    - Submitted to NPDC for review
- **Developed Design**
    - Developed a hitch concept
        - Reviewed Initial Research
            - Looked at previous patents
            - Looked at previous standards
            - Looked at competitor products
        - Drew final concepts in Pro-E
    - Developed a ripper concept
        - Researched different types of rippers
        - Reviewed Initial Research
            - Looked at previous patents
            - Looked at previous standards
            - Looked at competitor products
        - Looked at calculations to decide on ripper type
        - Drew final concepts in Pro-E
    - Developed a finisher / harrow concept
        - Researched different types of finishers / harrows
        - Reviewed Initial Research

        - Looked at previous patents
        - Looked at previous standards
        - Looked at competitor products
    - Looked at calculations to decide on finisher/harrow type
    - Drew final concepts in Pro-E
- Developed a depth adjustment system
    - Researched different types of depth adjustment systems
    - Reviewed Initial Research
        - Looked at previous patents
        - Looked at previous standards
        - Looked at competitor products
    - Drew up final concepts in Pro-E
- Calculations/Testing
    - Calculated groomer force requirements for each ripper type
    - Calculated pull force available from rated horse power for common four-wheelers to 60 hp tractors
    - Calculated finisher/harrow groomer force requirements for each type
    - Miscellaneous calculations (on all other necessary components)
- Finalized Design
    - Decided on final hitch concept
    - Decided on final ripper concept
    - Decided on final finisher/harrow concept
    - Decided on final depth adjustment system
    - Created a full assembly of all parts
    - Created a presentation of all work completed
    - Presented to Vassar, Faculty and Peers

---------- **Spring Semester** ----------

- **Built Prototype**
    - Created Construction Drawings for each part
        - Created drawings in Pro-E
        - Included all initial dimensions
    - Decided where to build machine
    - Ordered parts through Vassar
    - Constructed Prototype
        - Cut steel bars, rods, angles, etc. to desired sizes for framework and other parts
        - Drilled holes in steel for various parts
        - Joined/Welded the framework together
        - Attached (fastened or welded) the rippers/tines, the groomer/finisher
        - Attached the axles/wheels
        - Constructed and attached the hitch system
- **Prototype Testing**
    - Ran tests on all components
        - Prepared Animal Science Arena for testing
        - Hooked implement to tractor
        - Ran implement on arena
    - Reviewed Prototype Design
        - Made any necessary changes to design
    - Reviewed Construction Drawings
        - Made any necessary changes to dimensions
    - Repeat
- **Marketed Product**
    - Developed a Business Plan
    - Developed Marketing Ideas
        - Created brochure for product

        - Created fact sheet for dealers with breakdown of sizes and prices of product
        - Added product information to Vassar Web site

- **Presented Final Design with Prototype and Marketing Materials to Vassar Equipment**
    - Created a Presentation
    - Cleaned up Prototype
    - Presented to Vassar, Faculty, and Peers

Appendix B: Customer reviews of competitors products

"The Riata Rake is an unbelievable piece of equipment! Over the past 35 years I have managed and trained hundreds of horses to National titles. One of the keys to my success is that I am a nut about great footing. Certainly the right material is important; however without a quality implement to work the footing, any arena can become almost worthless in days."

"[The Riata Rake] conditions, levels, and compacts my footing perfectly and easily… it is so versatile it is the only implement I used to lay down and condition the material in my present arena from the inception."

-Horseman Profile, Ray LaCroix, Riata Rake Customer Since 2003

"The ring is constructed of a two inch sand footing over a 10" layer of compacted stone dust. The drag does an excellent job of leveling the footing and getting rid of the "racetrack" depression around the rail. The dragging pattern on the Web site is the best way to condition the ring. After dragging, the footing is level, fluffy and uniform. It also is easy to hook up to my tractor. I use a 2" ball hitch attached to the tractor's drawbar. It is a great product."

-Mike Kanzer Landenberg, PA

"We have both an indoor and outdoor roping arenas… Both arenas have a 6" sand top coat with a pit run base. In the case of the indoor arena, the sand was put down during the framing of the arena and thus became very compacted and hard during the rest of the construction. This resulted in a hardpan of sand that we tried to disc first but had no luck as we didn't want to turn up the base coat into the sand (note: you don't want to do this else your top coat will get corrupted and will not rake as well).

"In talking with the Riata folks… they said to use the rake with the rippers and go for it…

they said just make multiple passes, increasing the depth with each pass and we should be fine. They also said if we broke it, they would take it back, no questions asked. I was worried as the ground was as nearly as hard as concrete and I was convinced we were going to be sending a broken rake back. But to my surprise, the rake worked perfectly!"

"I bought the 10' rake and the ripper, hydraulic and side drag options. This rake weighs in at 1000lbs, but the extra weight is great for digging in."

"The smoothing plate on the rear of the rake does a great job of finishing the top coat. The tines are designed that if you have any holes to fill they will sweep sand into the depressions with the end result being a soft level landing (in my case crashing) area."

"You can manually adjust the rake, but the hydraulics is nice for making adjustments while in the cab."

"The rippers are a must if you need to start from where I started from or if you have seasonality in your arena and the top coat gets compacted (i.e. my outdoor arena will get compacted over the winter)."

"The side rail/drag works great for "sweeping" back in the excess sand that will build around the edges of the raked area. If you don't have this option, you will be using a shovel around the border of your arena and that can take a lot of time."

-B. Valentine (Seattle, WA)

The above quotes were found on this Web link:

http://www.riataranch.com/?gclid=CPT7t4G0uZYCFQq4sgodLgxYKw

"We start lots of young horses so it's vital that the footing in our round pen and arena be safe, level and properly conditioned as these youngsters learn how to move at all gaits carrying a rider. Recently we moved our operation to a new location. The arena at that location had not been dragged in four months so it was hard, uneven and pock marked. After half an hour with the Arena Rascal the footing looked like new, perfectly level and conditioned to the proper depth. I even use the Arena Rascal to smooth out our gravel driveway and to rake our boarding pastures. The Arena Rascal is easy to use, adjustable for many different jobs and well designed. It is one tough piece of equipment! I couldn't be happier with the Arena Rascal and with the quality of service I have experienced with the team of professionals at ABI Equine."

-Ed Dabney

Gentle Horsemanship

Dacula, GA

“I also purchased the aerating spikes so I could over-seed my pasture and yard. I was very pleased how well the spikes prepped the ground for seeding. Once again the Arena Rascal has proven to me that it's a very useful tool to own if you have acreage and you don't own a large tractor. Thanks to ABI Equine I can keep my acreage in great shape."

-Jason W.

Magnolia, TX

The above quotes were found on this Web link: http://www.abiequine.com/reviews/index.php

Appendix C: Vassar

Appendix D: Competitor Information

Appendix E: Standards

Appendix F: Patents

Appendix G: Media Materials

Appendix H: Design Drawings

Appendix I: Safety and Owner's Manual

Arena Drag Design Proposal

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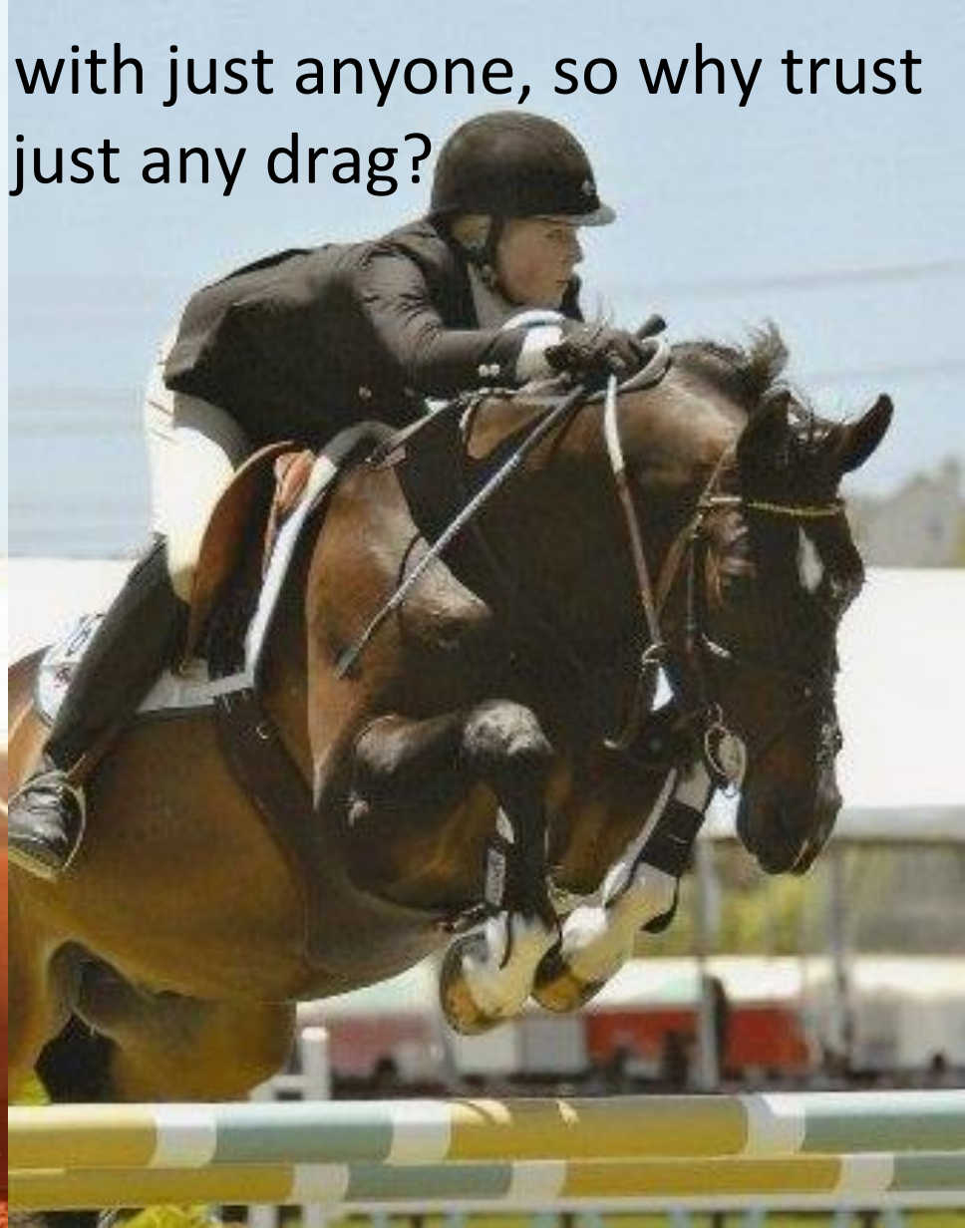
You wouldn’t trust your horse with just anyone, so why trust your dirt with just any drag?



Prime designs

The Problem

- Vassar Equipment
  - Design
  - Build
  - Market
  - Family of Arena Drags
    - 4 ft to 8 ft
    - Adjustable Depth
    - 40 to 60 hp max
    - ATV min

- Innovative
- Functional
- Marketable
- Scalable
- Shippable
- Cost Competitive

Prime Designs

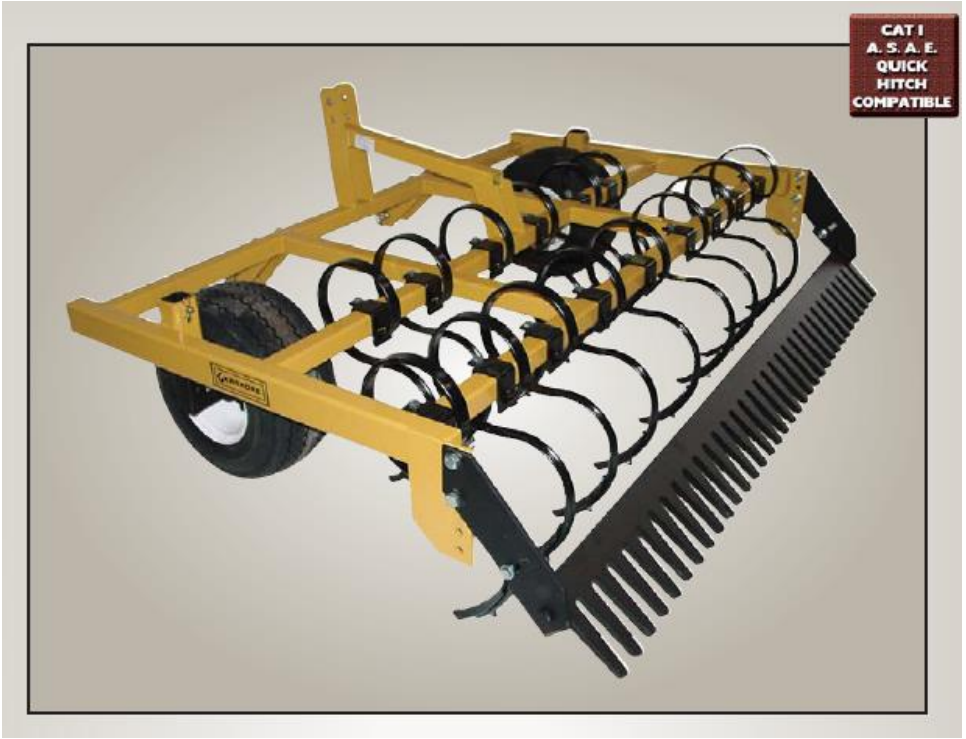
Fall Semester

- Research
  - Vassar
  - Customer
  - Industry
  - Competitors
  - Standards/Patents
- Developed Budget
- Preliminary Marketing Ideas
- Developed Design Ideas
  - Hitch
  - Tillage
  - Finisher
- Horsepower Calculations
- Design Recommendation

Prime Designs

Spring Semester

- Finalized Design
  - Example Drag
  - Market, Size, Tools
- Design Drawings
- Built Prototype
- Tested Prototype
- Finished Budget
- Finished Marketing Materials



Competitors & Customers

- Riata Rake, Arena Rascal & ABI Equine (Kiser)
  - Services recommended and used by: AQHA, APHA, NRHA, NCHA, NRCHA and many more
- Distributors
  - Farm equipment dealers, specialty businesses
- Customers
  - Recreational
  - Competitive (show, rodeo/roping)

Prime Designs

Competitors

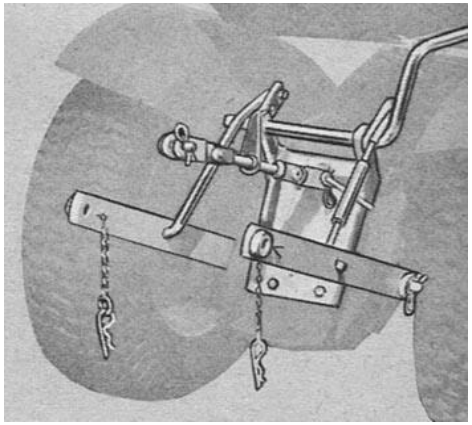
- Kiser
  - Arena Drags Begin At $1,495.00 & Range Up to $29,995.00
  - Water Wagons Begin At $3,650.00 & Range Up to $11,945.00

Nuts and Bolts

- Drag Components
  - Hitch
  - Tillage Tools
  - Finisher
  - Adjustable Depth

3-Point Hitch Vs. Draw Bar

- 3-Point
  - Category 1
  - Requires Tractor
- Draw Bar
  - Universal
  - Requires Tires



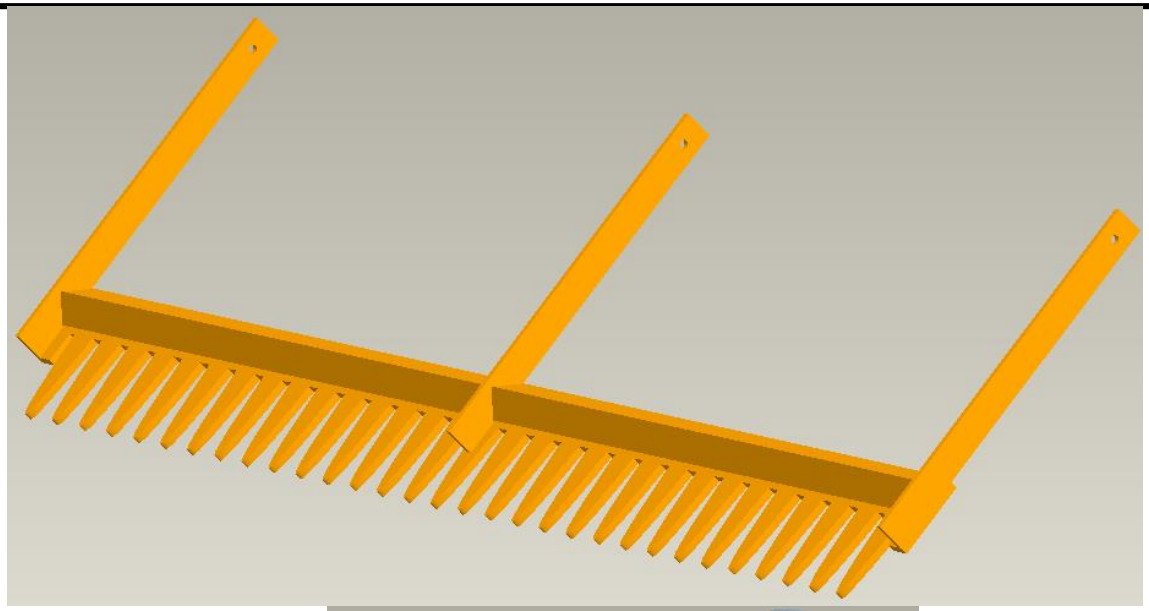
Prime Designs

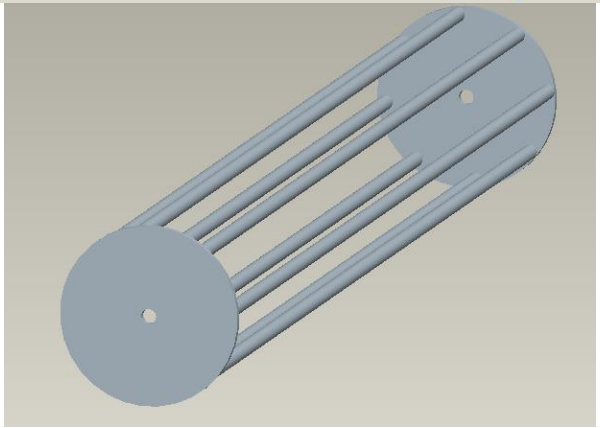
S-Tines Vs. C-Shanks

- S-Tines
  - Least Resistance
- C-Shank
  - Rigid
- Calculations
  - 8 ft
  - 5 mph
  - 2 tools / ft of width

Tillage Tool	Hp Required
S-Tines	30.31
C-Shank	56.16

Rake Vs. Roller





Prime designs

Proposed Ideas

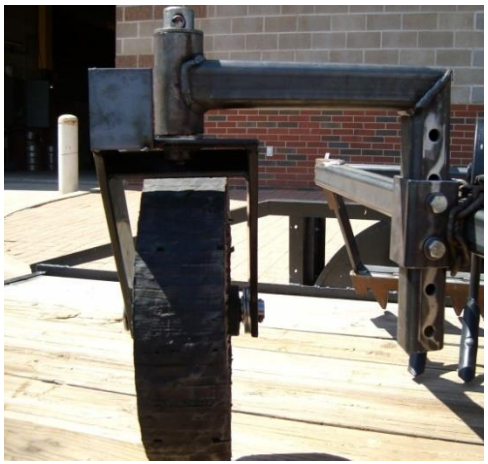
- Draw Bar Pull
- 2 Types of Tillage Tools
- Side Shovels
- Water Tank

www.farmstar.com
www.cropcareerequipment.com

Prime Designs

Final Design

- 3 point – Cat. 1
- 20 S-tines
  - 2 Rows
- 8 ft Rake
- Caster Gage Wheels



Prime Designs

Final Design

Prime Designs

Marketing Plan

- Brochure
  - Informative
  - Clean, Modern Design
  - Tri-fold
- Web page
  - “Package” of Materials for Addition to Current Site

Marketing Plan

- Advertisement
  - Two Options, Several Variations
  - Cooperative Advertisement
  - ½ Page, and ¼ Page
  - Full Color, Black and White, Spot Color

Business Plan

- Price per unit
  - 8 ft. $2,800
- Projected Sales
  - 50 units sold in the 1st year
  - $40,000 profit in the 1st year
  - 10% sales growth est. for the following years

Prime Designs

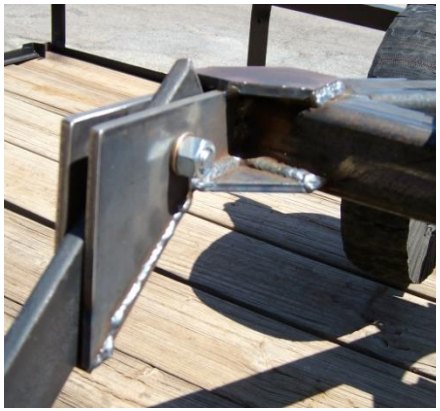
Building Prototype

- Ordering of Parts
  - Vassar / NPDC
  - Square Tubing
  - S-Tines and brackets
  - Caster Wheel

Prime Designs

Building Prototype

- Fabrication of Parts
  - Vassar
    - 3 point hitch
    - Rake
  - BAE Lab
    - Frame
    - Wheel Brackets
    - Rake Brackets



Prime Designs

Testing Prototype

- Test 1 (Animal Science Arena)
  - Pulled in an arena to observe performance
  - Problem with depth of penetration (3 point hitch)

Prime Designs

Prototype Modification

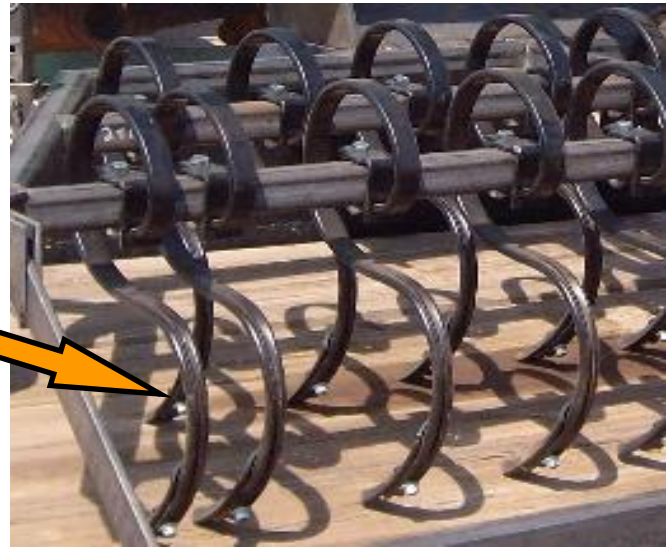
- Modification:
  - Redesign of 3 point hitch (raised by 10 inches)

Prime Designs

Testing Prototype

- Test 2 (Animal Science Arena)
  - Closeness of two tines in the second row
  - Two tines cultivating as one
  - Creates a Ridge

Too Close Together



Prime Designs

Final Testing

- Final Testing:
  - Proper depth achieved
  - Ridge disappeared

Prime Designs

Recommendations

- 20 S-tines instead of 22
- Use Larger 3 Point Bracket
- Floatation Tires with Caster Wheels
  - Design New Caster Wheel Bracket
- Grind/Round off all corners
- Always paint it Orange and Black

Video

Prime designs

Special Thanks

- Vassar Equipment
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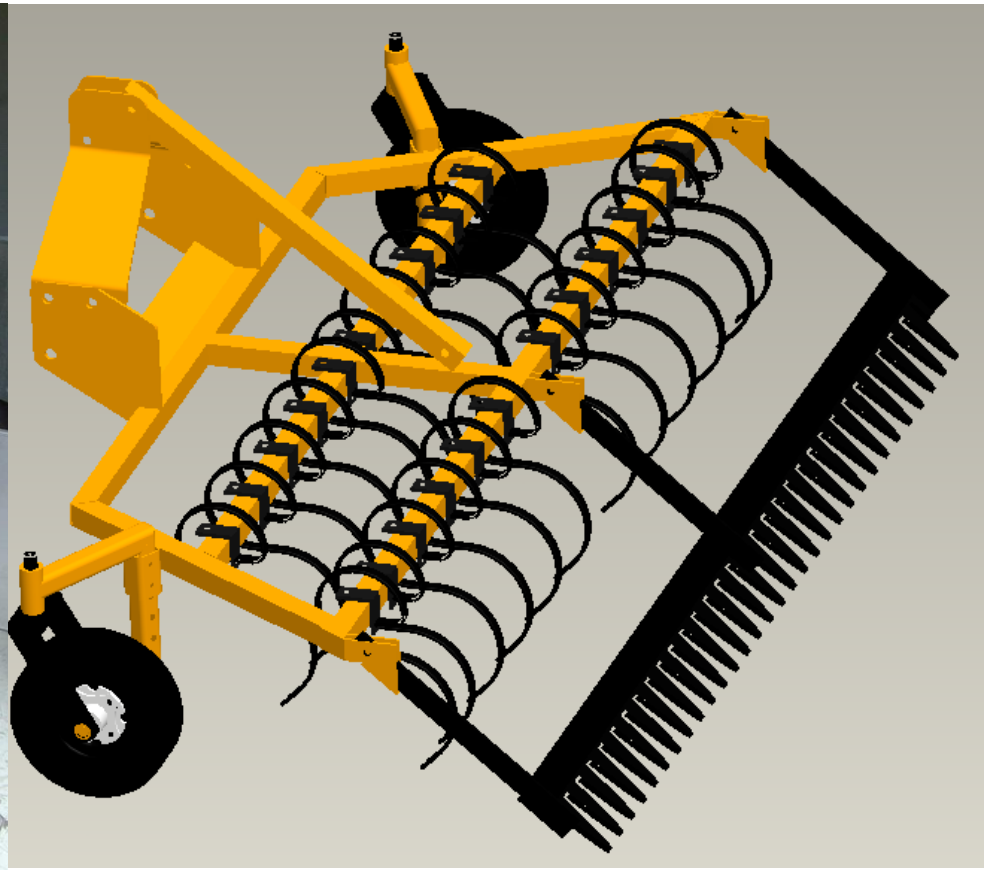
- Josh Bible, OSU Equestrian Herd Manager
- Joe Genet, Manufacturing Extension Agent
- Our Innovation Professors

dPrime Designs

Conclusion



Prime Designs