THE MIAMI RED BLADE

A GPS-aided
Autonomous Lawnmower

PRODUCTION PLAN

Miami University
School of Engineering and Applied Science
Miami University - Oxford, Ohio

Student Team Members	Advisors
Brett McNally---Team Leader Micah Stutzman Collin Koranda Chris Mantz Jeff Macasek Scott Miller Andrew Walker	Dr. Jade Morton---Chief Advisor Dr. Scott Campbell Mr. James Leonard

1. Introduction

The overall production, distribution, marketing, and sales of a GPS-aided autonomous lawnmower share many similarities to modern home-owned lawnmowers. Our target market, distribution chain, and much of the production process remain the same. The major differences lie in the production cost and marketing strategy. In this report, we will summarize our study of cost effective and feasible manufacturing approaches for autonomous lawn mower production, provide an analysis of the projected manufacturing cost of the various parts of an autonomous lawn mower, and present a sample marketing approach that promotes the autonomous lawn mower adaptation by the consumers.

2. Production Analysis

Modern lawnmowers are produced in a similar manner to the production of the autonomous mower. Many of the major components, such as engines, hydrostatic pumps, and electronic controls, are purchased from other industries. These parts are assembled at the mower factory along with the frame and cutting deck. An autonomous lawn mower will require additional components. For example, the Miami Red Blade incorporates: Global Positioning Systems (GPS) receivers, radio modems, a digital compass, Hall-effect sensors, microprocessors, servos, remote start and stop operations, and software that perform intelligent control. Most of these parts have established markets of their own and are available as off-the-shelf products.

Table 1 shows a description and retail price of each component used in the prototype Miami Red Blade. The costs of the prototype components will be drastically reduced in a production model.

Table 1 – Prototype Cost

Part	Cost	Quantity	Total
Garmin GPS Unit	$145	2	$290
Honeywell ECompass	$350	1	$350
Hall sensor/magnets	$20	2	$40
Dell Laptop	$3000	1	$3000
Radio Modem	$3000	1	$3000
Parker Hannifin Servos/Controllers	$600	2	$1200
Microcontroller, remote start and stop, interfacing converters, and other miscellaneous items	$300	1	$300
Snapper Lawn Mower`	$5000	1	$5000
Total			**$13,180**

Detailed marketing research and projected cost for each of the above components are presented in the following sections. Knowledge of traditional retail markup and discounting methods were used to determine production costs. The guidelines shown below are used throughout this analysis: For products manufactured by the manufacturer, projected cost is 20% of retail cost; for off-the-shelf products, projected cost is 50% of retail cost; for electronic goods, an additional 20% discount was added to account for performance depreciation. The quantity of components does not change from the prototype to the production model.

2.1 Base mower

The base lawn mower used in the construction of the Miami Red Blade is a 36-inch Walk-behind hydrostatic lawnmower with zero-degree turning (model #: SPLH141KW). The mower we would like to produce would be similar in size to a walk behind mower. It would have one blade and would be fairly lightweight. This would be not only familiar to our target market but also easy to navigate under manual control. There are very few mowers on the market with the combination of capabilities we desired so we used a variety of mower comparisons to project a realistic production price for the base mower. The information in tables 2-4 was gathered from www.snapper.com. Figure 1 shows a Snapper Walk-Behind mower (model name: 19" Lightweight). Table 2 compares the suggested retail price and production cost for a mulching walk-behind mower.

Figure 1 – Walk-Behind Mower

Table 2 – Walk-Behind Mower Retail and Production Cost Comparison

Mower	Retail Price	Production Cost
Walk-behind 19” Lightweight	$339.99 - $699.99	$103.99

Evidently, the production cost is much lower than the suggested retail price. We determined this figure based on typical production mark-up and consultation with our local Snapper dealer. The projected production cost of the base mower is about 20% of the average retail cost. We will use this scale to project the hydrostatic drive system and the zero-degree turning capability.

2.2 Hydrostatic Drive System

The Miami Red Blade base mower comes with a hydrostatic drive system which is highly desirable for the autonomous mower control. To determine the cost of a hydrostatic drive, we looked at the differences between two very similar riding lawnmowers: the basic riding lawnmower (figure 2), and a riding lawnmower with a hydrostatic drive (figure 3). We used the price difference between the two to compute the production cost of adding a hydrostatic drive. The results of this comparison are shown in table 3. Once again our understanding of retail mark-up was used to discount the cost for the production of this part.

Figure 2 – Basic Riding Mower

Figure 3 – Hydrostatic Riding Mower

Table 3 – Hydrostatic Drive Cost

Mower	Retail Price	Production Cost of Hydrostatic Drive For Riding Mower	Projected Hydrostatic Drive for Walk Behind Mowers
Basic riding (Hi – Vac)	$1,200	$180	$80
Hydro. Riding	$2,100		

The retail price differences between the basic mower with and without hydrostatic drive is $900. Based on this value, we project $180 production cost the addition of the hydrostatic drive for a riding mower. A walk-behind mower would require a much less robust drive system. We foresee this cost falling another one hundred dollars for our applications; this lead to our projected hydrostatic drive system cost of around $80.

2.3 Zero-degree Turning Capabilities

The zero-degree turning capability is desirable for precise mower maneuverability. It also allows the computer to control each drive wheel individually, which is necessary for autonomous guidance. The projected cost for the zero-degree turning capability is obtained through comparison of the previously mentioned hydrostatic drive riding lawnmower (figure 3) and a zero-degree turn, hydrostatic riding lawnmower (figure 4). This comparison will give us a solid idea of the cost of adding zero-degree turn capability.

Figure 4 – Zero-Degree Turn, Hydrostatic Riding Mower

Table 4 – Zero-Degree Turn Cost

Mower	Retail Price	Production Cost
Hydro. riding	$2,100	$200
Zero-degree hydro. Riding (Scrambler)	$3,100	

We feel that this production cost may be rather high as well. The difference between a regular hydrostatic drive and a zero-degree turn capability is the addition of one pump. Some of this price increase may result from a more complicated manual drive system or a different mower frame (see figures 3&4 for comparison). We feel this cost should come down considerably.

Taking all of this into consideration we have created an estimate of our desired mower production cost. The estimate is shown in table 5.

Table 5 – Estimated Mower Cost

Mower	Estimated Production Cost
Walk-behind, zero-degree turn, hydrostatic drive	$383.99

2.4 GPS Receivers

A key component of the Miami Red Blade navigation systems is a custom differential GPS system (DGPS). The DGPS system consists of two Garmin GPS 16 receivers, a set of radio modems, and custom processing software. The Garmin GPS 16 generates single frequency and carrier phase outputs which are used in precise relative position calculation. For off-the-shelf products, we will estimate their projected production cost based on the 50% bulk discount typically applied by the manufacturer. We will apply an additional discount of 20% to take into consideration the conventional falling price and technological advancement of the electronics goods market. The retail and projected cost for the GPS unit is shown in table 6.

Table 6: Retail and Projected Cost for Garmin GPS 16

Retail	$145.00
Projected production cost	$58.00
Total projected cost (two units)	$116.00

2.5 Servo Systems

Parker Hannifin donated the OEM 770X servo motors and controllers for our prototype lawnmower. Through experimentation we have found that these components are far more capable than the demands of our project. This added capability, however, does not come without added cost. We feel that using a high-resolution stepper motor could drastically reduce the price of this component. Our research shows that Nyden provides a motor and drive that fulfill our motion, resolution, torque, and voltage requirements. The production cost is slightly reduced from the retail price because we will be purchasing in bulk. The retail and projected cost of the servo systems are shown in table 8.

Table 8: Retail and Projected Cost for Nyden Stepper Motor and Controller

Retail	$201.53
Projected production cost	$80.61
Total projected cost (two units)	$161.22

2.6 Microprocessor

The current Miami Red Blade central control system is housed in a Dell lap top computer. This control system gathers information from the various sensors and determines mower position and heading. It then outputs the proper commands to keep the mower on its predetermined course. The functions of this computer can be easily replaced by a microprocessor such as the RCM 2200 RabbitCore processor. The retail and projected production cost for the microprocessors are shown in table 9.

Table 9: Retail and Production Cost for RabbitCore Microprocessor

Retail	$250.00
Projected production cost	$100

2.7 Radio modem

Miami Red Blade uses Freewave Technology's spread spectrum radio modem for communication between the two Garmin GPS 16 receivers. Its retail price is $3000 and has a coverage distance of two miles. A radio transceiver such as Lemos International's Promi SD-202, which has distance coverage around 100 meters could easily be used for the production mower. The retail and projected production costs for this radio transceiver are shown in table 7.

Table 7: Retail and Projected Cost for Lemos International Transceiver

Retail	$100.00
Projected production cost	$40.00
Total projected cost (two units)	$80.00

2.8 Electronic Compass

An electronic compass manufactured by Honeywell (HRM 3200) is used as a navigation aid on the Miami Red Blade. The GPS system is the most accurate sensor, but the compass provides accurate mower orientation information with a much higher update rates than the GPS receivers. The retail and production cost of the electronic compass is shown in table 10.

Table 10: Retail and Production cost for Honeywell Electronic Compass

Retail	$300.00
Projected production cost	$120

2.9 Miscellaneous Items

Miscellaneous items includes Hall-effect sensors used to monitor the wheel displacement on the mower, remote start and stop, wiring and cabling of the circuitry on board the mower, paint work, machining work, nuts and bolts, and gears. The production cost of miscellaneous items is estimated to be $50.00.

3. Summary

A final production cost is determined after adding all the costs of our mower components. We found that our Miami Red Blade was $11.21 shy of our target production price of $1000. We feel this minor excess could be eliminated with further research into production cost of the mower itself. For instance, addition of zero-degree turning capability is a rather high price to pay for the system. We are confident this cost would come down considerably in a production model. We are also comfortable, given the nature of the electronics industry, that future advancements will greatly reduce the cost of many components.

Table 5 – Production Cost Summary

Part	Manufacturer	Description	Projected Production Cost
Mower	Snapper	Walk-behind, zero-degree turn, hydrostatic drive	$383.99
GPS Receivers	Garmin	GPS16: Single frequency, carrier phase	$116.00
Stepper Motors/Drives	Nyden	Nema 34 PS499M-01A / IMS200 2- Phase, 486 oz-in continuous torque, 24V, high resolution	$161.22
Microprocessor	RabbitCore	RCM 2200	$100
RF Modem	Lemos International	SD-202 Radio transceiver: 100m range	$80
Electronic Compass	Honeywell	HRM 3200	$120
Miscellaneous Items	Hall sensors, wiring, cables, supplies, nuts, bolts, etc.		$50
Total			**$1011.21**

3. Marketing Analysis

A variety of techniques were used to determine proper marketing strategy for this new product. We began our search by looking into the target market, success, and methods of existing autonomous lawnmowers. We realized early on that the success of these mowers is not what the manufacturers expected so our strategy would need to be different. We also realized that our product had much more to offer than existing products and we could use this advantage to set us apart.

3.1 Target Market

We intend to appeal to the young and middle-aged homeowner. Due to the higher initial investment, a majority of our customers will be from the middle to upper economic class. We feel this lawnmower could be targeted to men and women alike. We foresee a particular niche with families on the go and parents with tight schedules.

3.2 Marketing Advantages

Unlike existing autonomous lawnmowers, our mower requires a very short setup program. Most current models work similar to a pool cleaner. They run random patterns and avoid objects as they work. This often results in areas of uncut grass and a drastically increased cutting time (days). Another important difference is that today's products require a wire to be run around the perimeter of the lawn – similar to an invisible fence for dogs. This limits the travel of the mower but also creates excess cost for the homeowner. It will also cause inconvenience when a home owner decides to change landscaping or home additions, etc. We hope to use the simplicity of our product as a marketing advantage. The owner does not need to be familiar with GPS or any of the other sensors to operate it. By following precise position information the mower will be able to complete a professional quality mowing job anytime, any where, with minimum human supervision.

Benefits Over Competitor products:

- Decreased cutting time
- Better results
- Simple to use
- Lower setup cost
- Dynamically adjust to property boundary adjustments

3.3 Tactics

We intend to promote this product at lawn and garden shows across the country. We will use a series of prime-time commercials to access our audience. We will concentrate our marketing on the promise of more free time and ease of operation. No longer will people need to slave under the hot sun during their time off, just to do it again in a week. Family life and the joys of good weather will be used to induce guilt and eventually create even more distaste for lawn care. We believe our strategy will change over time but this is how we feel we will begin. The following example shows how this product could be marketed on commercials, in pamphlets, or at lawn and garden shows.

3.4 A Marketing Example

THE MIAMI RED BLADE

The Future of Lawn Care

It's a sunny Sunday afternoon. The summer weather has finally come around and your family is eager to get to the beach. As you walk out the front door you realize your lawn is in dire need of attention. You have been so busy at work you have not had the energy to mow. You realize that if the yard doesn't get cut today it may last another week in disrepair. As heartbreaking as it is, you tell your family to go ahead and you decide to manage the yard.

Does this situation sound familiar? How much of your time is spent mowing a lawn on a beautiful afternoon?

Enter the Miami RED BLADE:
A GPS-aided autonomous lawnmower

Through a simple computer interface and one-time setup procedure, your life just became amazingly less complicated. The Miami RED BLADE will allow any homeowner the freedom to enjoy a beautiful afternoon - to get out and appreciate their time off. This new lawnmower uses the most advanced positioning technology (GPS) combined with a number of other sensors to create an intelligent, safe, reliable and efficient self-guided robot. The RED BLADE requires only five minutes of your time to start and after that, it's on its own. The autonomous lawnmower will literally navigate and mow your yard without any human interaction. It will stay within a predefined area and stop itself if it accidentally ventures too far. Below is a list of steps each new owner must run through to setup their RED BLADE. After this *Setup Procedure* is stored, normal use requires only the steps listed under *Regular Operation*.

Setup Procedure (one-time!):

- Turn the mower power ON

- Follow the on-screen directions to Mower Setup
- Manually control the mower to the limits of your yard
- Pause at each limit and select Define Waypoint #…
- Wait until the screen says Waypoint Defined before continuing to the next limit
- After the last waypoint is stored, select Yard Defined
- Check the on-screen map to ensure the yard is defined properly

Regular Operation:

- Turn the mower ON
- Manually control the mower to Waypoint #1
- Turn on the cutting blades
- Select Run Mower from the on-screen display

Recall the situation presented with your family going to the beach. As you walk out your front door you notice your lawn has not been cut. You pull your RED BLADE out of the garage while your family is loading the coolers and beach toys. You take the mower to its starting position and turn it on. With the cutting blades in operation you send the mower on its routine path around your yard. Five minutes later you are in the car and on the road. Your day just became ten times more enjoyable and it is all because of your new RED BLADE.

Still not impressed?

Would you change your mind if we told you that every year you spend 24.4* hours of your life guiding a lawnmower. An entire day each year! This may not move you, but when you think that most of your time spent with a lawnmower is on your weekend under a cloudless sky, that day looks much more valuable. Shall we begin to mention the time spent cleaning grass clippings out of your hair or sweat off your back? If mowing a lawn provided a health benefit, sweat and sore arms would be a welcome sacrifice, but for most people the process of mowing a lawn is dull, time consuming, non beneficial, and boring. Are we far off in our assumption that you share this sentiment?

Get out and purchase a new RED BLADE. Reclaim your free time, enjoy your family, and never again worry about an uncut lawn.

*We have calculated that each acre (4,047 m^2) of lawn will take 48.7 minutes to mow. This time, multiplied by an estimated mowing season of 30 weeks, provides the overall time of 24.4 hours per year. These numbers were developed using a mower speed of 10 km/h and a cutting width of .5 m.

4. Conclusion

This business plan recommends a viable and cost-effective manufacturing approach for the production of an autonomous lawn mower based on the Miami RED BLADE

prototype system. A detailed production analysis has been performed by the engineering design team and is presented in this plan. Our analysis shows that the projected production cost for autonomous lawnmower may be contained in the $1000 range. Some basic projection assumptions are: (1). The production cost for parts that are produced by the lawn mower manufacturers is 20% of the retail price, (2). The production cost for off-the-shelf goods manufactured by third party is 50% of the retail price, (3). Electronic good have a 20% price reduction over the next three years. These assumptions are based on consultations with local lawn mower dealers and other research conducted by the team.

We believe that the Miami RED BLADE's simplicity and functionality will make it appealing to our target market. The *marketing strategy* uses proven tactics and we firmly believe that, in the near future, a lawnmower similar to our prototype will be in the garage of every household across the nation.