Rhyno Business Plan
April 2014

Ahmet Can Musabeyoğlu, acm@mit.edu
Birkan Uzun, birkanu@mit.edu
Wegene Tadele, wegene@mit.edu

EXECUTIVE SUMMARY

** What is the product ?*

Rhyno is a patentable human-computer interface tool that can be used to control gadgets running in bluetooth enabled devices wirelessly. It uses motion sensing electronic devices to identify different types of hand gestures and a bluetooth chip to transmit the commands remotely. It has applications ranging from smartphones, tablets, and computers to smart houses and assistive technologies.

**What is the market size ?*

Anyone with a smartphone or a tablet is potential customer for Rhyno, which results in a market size of around 2 billion people in the world including 150 million US citizens. By pricing Rhyno at $50, a sustainable revenue stream in the order of millions or billions of dollars can be accomplished even with a 1% market penetration in this market.

More than 15 million smart house owners around the world is another large market for Rhyno and it will be one of the first markets targeted by our product, since Rhyno's capabilities are very well suited for home automation applications. Furthermore, Rhyno will be used to assist elderly people or people with disabilities to maintain balance and alert emergency personnel if dangerous situations are detected.

**What are the startup costs ?*

Rhyno anticipates initially requiring $200,000 to complete the beta prototype of the product, provide for legal and infrastructure expenses related to startup and to cultivate potential customers. To finance this start-up we intend to seek initial capital from venture capitalists, kickstarter campaigns and corporate partners. Further investment of $1 million is needed for finalizing the product, further setting up company infrastructure, lining up lead vendor-channel relationships, landing significant corporate accounts, and accelerating global marketing efforts.

**What is the payoff ?*

As calculated in *Section 3*, with an average sales amount of 30,000 units per year, Rhyno will break-even within 3 years. In addition to our product sales, we expect royalty revenue from licensing our overall hardware design and hand gesture recognition machine learning algorithm. We have already established a connection with a start-up company that wants to use our code for the sensors and machine learning algorithms for gesture recognition.

1. THE COMPANY & THE PRODUCT

1.1 Overview

Rhyno Ring is a recent startup founded by a group of MIT undergraduate and graduate students in engineering and science. Our product is a smart bluetooth ring that can be used to control applications/gadgets running in bluetooth enabled devices wirelessly. Imagine you are working out and you want to increase the volume or change the song playing on your phone effortlessly, without grabbing the phone and interrupting your workout. If you were eating french fries and playing Angry Birds at the same time, you wouldn't want to touch your iPad with greasy fingers. Wouldn't it be cool if you could skip the slides in your presentation just by swiping your hand in the air or control a quadcopter or dim your light bulb just by making hand gestures in the air? These are all possible with our compact and affordable wearable device: Rhyno ring. In just one small ring, our product has the capability of providing the functionality of what would have previously required multiple devices.

We have worked to design a prototype system and business strategies, consulting with numerous professional contacts to assess the feasibility and functionality of our product. In late February 2015, we participated in the MakeMIT Hackathon, where the idea of Rhyno Ring was conceived. We were selected for the final round as one of the top 10 teams and received positive feedback from all of the expert judges at the expo. Some especially positive feedback we received was from the experienced hardware engineers at Apple and Facebook along with the CEO of a wearable wristband company called Pavlok, Maneesh Sethi, who encouraged us to push our idea further and we decided to apply for startup accelerators, including MIT GFSA, MIT 100K and MassChallenge. In March 2015 Rhyno developed and tested the first fully functional proof-of-concept prototype model.

1.2 Business Model

Our value proposition is to provide an affordable, compact and elegant smart ring that allows users to interact with their smart devices remotely and effortlessly. Our promotional proposition is to sell through smartphones and tablet retail stores, online order and specialty retailers, as well as to bundle with various bluetooth enabled hardware manufacturers. We intend to generate profit by selling modular products that can be purchased for various fingers in order to detect more complicated gestures.

Wearable technology has experienced a boom in the past decade, but none of the current products can provide the range of applications that Rhyno brings to the world. Some of the existing wearable devices, such as Fitbit or Jawbone are targeted towards only one specific application. For example, athletic training or gaming. These existing technologies are not only limited in ranges of applications they provide but they are also bulky, cumbersome, expensive and often annoying to use. Coupled with a smartphone app for various applications, Rhyno will revolutionize the way people interface with the smart technologies that exist around them.

1.3 The Product

Our system consists of a PCB board that contains the electronic components used to detect and process different types of hand gestures and a bluetooth chip to transmit the signal wirelessly, a phone app for users to enable them to connect their smart devices with Rhyno, a portable battery to charge the device, a ring to house the PCB and the battery, and API kit for developers amongst other features. Once activated, Rhyno connects automatically with your phone and can further be made to connect with the corresponding smart device that you want to control using your phone app. After the connection is made, you can send commands to that specific device/gadget by swiping your fingers in any of the four directions or by rotating it in 360 degrees.

Rhyno will be designed to be unobtrusive and require no specialized training to use. Aside from your existing personal computer, smartphone or tablet, no additional hardware will be required to communicate with Rhyno. To complement these devices, we intend to make several compelling API libraries available online so that our customers can download them to meet their needs.

We are in the process of working towards patenting our intellectual property. Our intellectual property is not in the components that make up Rhyno but in its overall electronic/mechanical design. We are also considering to patent our backend algorithm which detects wide range of hand gestures with high accuracy. We believe this will give us the possibility to outperform other similar wearable device providers in the market.

1.4 Product Value

The entire market of bluetooth enabled/connected devices compliment our technology .i.e. bluetooth headphones, smartphones and tablets. Some other examples include home automation systems, including Philips Hue smart lights and Nest smart thermostats. Because our system includes accelerometers, gyroscopes and magnetometers, which are the most essential sensors used in detecting orientation, acceleration and titling, our device can be independently used in assistive technologies particularly for older people to help them maintain balance. If there is a deviation from the individuals center of gravity Rhyno would alert them to adjust their position, or alert emergency personnel if they are unable to get back to their desired position. Another potential use for this product is in smart houses. A recent emergence of smart technologies related to housing appliances will benefit from Rhyno. For example, our ring will be used to monitor house temperature, control lighting, televisions, and sound systems all at once remotely. Gaming applications are numerous. Most games require motions such as translational motions in four directions and rotation such as shooting. For quadcopters and toy airplanes, the Rhyno ring could be used to accomplish yaw, pitch and roll motions. In conclusion if we can control all of these basic motions and communicate wirelessly through bluetooth we will be able to attract customers that use a wide variety of applications in internet connected devices. Thus, anyone with a smartphone or tablet is a potential customer for Rhyno which is a market size of around 2 billion people.

2. MARKET RESEARCH AND ANALYSIS

2.1 Market Definition

The market for the Rhyno ring is the set of people who own smartphones, tablets, personal computers or any other device with bluetooth connectivity. According to the "US Smartphone Use in 2015" report by Pew Research Center, 64% of US adults own a smartphone, which corresponds to more than 150 million people. Another report ("Worldwide Mobile Phone Users: H1 2014 Forecast and Comparative Estimated") by eMarketer estimates that number of smartphone users worldwide will surpass 2 billion by the end of 2015. A survey we conducted among 104 smartphone users yielded the results that 67 people would buy the Rhyno ring if its retail price is $49 or less, which corresponds to 64% of smartphone users. At an average retail price of $49 per unit, this results in a $4.7 billion domestic market with 96 million potential customers in the US. We predict that with a similar interest worldwide, potential global market for the Rhyno ring would exceed $10 billion.

2.2 Research Methodology

To estimate the number of potential customers, we needed the total number of people who own bluetooth connected devices. Because smartphones are the most ubiquitous product among the bluetooth connected devices, we chose smartphone owners as the baseline for our estimation. We reviewed market research data sources, including Pew Research Center and eMarketer, to obtain the total number of smartphone owners worldwide and in the US.

In order to learn the level of interest towards our product and to make a more realistic estimation of the domestic market size, we conducted surveys among 104 smartphone users in Greater Boston Metropolitan Area. 64% of the respondents said they would be willing to pay up to $49 for a smart ring with the capabilities of Rhyno, whereas 24% of the respondents said they would be willing to pay up to $99 and 12% of the respondents said they would be willing to pay up to $149. This means, making Rhyno available to the market at a retail price of $49 will make it a much more popular option compared to its competitors which offers similar capabilities with a retail price of $149. Furthermore, by multiplying different retail price options with the corresponding interest levels, it can be seen that a retail price of $49 will also maximize the total revenue.

By extrapolating the 64% positive response rate into the total number of smartphone users in the US, we came up with 96 million as the number of potential domestic customers, which corresponds to a market size of $4.7 billion. We believe that, this value for the domestic market size is realistic and it can be captured with a smart marketing strategy.

2.3 Marketing Strategy

Based on the preliminary research surveys we made to assess interest level in the market (*Section 2.2*), there is a demand for an inexpensive wearable technology that enables you to control all the smart electronic devices around you by simple hand gestures. Therefore, our marketing strategy is to position the Rhyno ring as the most affordable, scalable and comfortable wearable technology that exists in today's market.

We will initially market our product in two different niche areas. In order of importance for our marketing strategy, these markets will be: *Internet Of Things (IoT)* and *Assistive Technologies*.

Initially, capturing the market of IoT will be crucial for our company to reach a critical mass of customers. By providing developers with SDKs, we are planning to increase the range of our potential customers since they will be building software and hardware applications that could benefit many users.

Secondly, the market for assistive technologies is an important target. Working with disabled people who can use their hands, we are planning on developing applications that will make their interactions with household appliances easier.

Along with these two niche areas, our marketing strategy will also focus on other markets including V*irtual Reality*, *Smart Houses* and *Fitness Gadgets*.

2.4 Competitor Profile

An important potential competitor is Thalmic Labs' MYO, a wearable armband that uses muscle flexing in order to detect motions and control other devices. This product has most recently received $14.5 Million Series A Funding and widespread publicity. Not only is MYO bulky and frustrating to use because if its incapability to recognize simple gestures, but it is also expensive, retailing for $199. These issues make our much more affordable and user friendly Rhyno ring desirable.

Another potential competitor is the Logbar Ring, which received nearly $900,000 through Kickstarter and claims to detect many complex hand gestures. However its $149 retail price makes it an expensive alternative compared to Rhyno and it became a source of contention on the internet because it doesn't actually detect most hand gestures.

Finally, Nod Ring is another potential competitor which has received seed funding from important venture capital firms including Sequoia Capital, Menlo Ventures and Atlantic Bridge (they did not publicly release the amount of capital they received). Nod Ring seems to be the most capable competitor in terms of detecting hand gestures with high accuracy. However, similar to the Logbar Ring, Nod Ring has a retail price of $149 which makes it an expensive alternative compared to Rhyno.

2.5 Rhyno's Competitive Advantages

So, what makes Rhyno unique compared to its competitors? As indicated by the market research survey we conducted among 62 smartphone owners (*Section 2.2*), the demand for a wearable gesture recognition device plummets as the price exceeds $99. Therefore, we believe that making Rhyno more affordable without compromising its elegance is the key to succeed in a competitive market.

As opposed to Nod and Logbar, who use a classical circular ring as the starting point for their design, we came up with a unique design approach which gives Rhyno a substantial advantage in terms of production cost (consequently retail price), battery life, fitting flexibility and charging convenience. Since Nod and Logbar constrain themselves to a classical ring form factor, they use multiple micro PCB's that are connected to each other with another circular flexible PCB in order to fit inside a rigid constrained volume. As a result of this approach, the manufacturing process becomes fairly difficult and their production cost increases. However, the unique design of Rhyno, which is similar to a saddle that fits flexibly to the index finger (as shown on *Figure 4*), allows us to accomplish the same hardware features with a simple 2 layered PCB, thus reducing our manufacturing costs significantly. Furthermore, this design allows us to use a larger rechargeable battery (150 mAh), making Rhyno's battery life longer compared to its competitors.

Nod and Logbar rings require a separate charging dock to recharge their battery. On the other hand, Rhyno uses a micro USB port which enables it to be directly charged through any standard USB charger or personal computer. Eliminating the charging dock from the equation makes the recharge process more convenient for the customers of Rhyno. Furthermore, the cost of manufacturing is highly reduced due to this significant elimination.

Myo Armband uses muscle contraction for gesture recognition, as opposed to our Rhyno ring which uses accelerometer data for the same purpose. Such a difference between two different hardware approaches results in a bulky product size and a significantly increased production cost for Myo, which makes Rhyno a much more affordable and comfortable alternative.

As calculated in the *Table 2* of Appendices section, we estimate total manufacturing cost of the Rhyno ring to be approximately $12, which means our aimed retail price of $49 is a reasonable number, by using a cost multiplier (MSRP/Production Cost) of around 4 as a rule of thumb. We calculated the average battery life of Rhyno at the end of Appendices section and compared this value to the advertised battery lives of our competitors. Our overall competitive advantage is summarized in the comparison table shown below (Table 1).

	Retail Price	Size	Battery Life	Flexible Fit	Charging
Rhyno Ring	$49	Compact	9.4 hours	Yes	Micro USB
Myo Armband	$199	Bulky	6 hours	Yes	Micro USB
Nod Ring	$149	Compact	6 hour	No	Charging Dock
Logbar Ring	$149	Compact	3 hours	No	Charging Dock

Table 1: Competitor Comparison Table

2.6 Marketing Plan

For marketing Rhyno in our initial growth stage, we plan to use crowdsourcing websites, i.e. Kickstarter and IndieGOGO, which will give us enough capital to mass manufacture the first commercial version of our product and will help us to gain publicity among potential customers. By preparing a video showing the important use cases of Rhyno for the markets such as the Internet of Things and Assistive Technologies, we would like to draw attention from customers in these markets.

We realize that failing to satisfy the demand of our customers in our first crowdsourcing campaign will adversely affect our reputation as a start-up and we will take all the precautions to prevent such a failure. According to the report "The Dynamics of Crowd Funding: An Exploratory Study" (by Ethan Mollick, June 26, 2013), 75% of the crowdsourced campaigns delivers its product later than the scheduled time. To prevent such a possibility in our campaign, we will work with a Design for Manufacturing (DFM) firm, such as Dragon Innovations, which will assist us to transform our prototype into a commercial product, that can be mass manufactured effectively.

After receiving publicity and building a community of developers and potential customers through successful crowdsourcing campaigns, we will start retailing our product through our own website and various consumer electronics retailers, i.e. BestBuy, RadioShack.

3. FINANCIAL STATEMENTS

We have developed the following financial statements to project the financial performance of Rhyno Ring through the first three years of operation: Revenue Model, Expenses Model, Operating and Service expenses, and Hiring Plans and Wages.

Below are the summarized expenses, revenue and profits:

EXPENSES

	Year-1	Year-2	Year-3	Year-4
Staff				
CEO	$90,000	$120,000	$120,000	$120,000
VP OF Engineering	$90,000	$120,000	$120,000	$120,000
UI/UX	$60,000	$80,000	$80,000	$80,000
Product Manager	$66,000	$88,000	$88,000	$88,000
App Developer	$69,000	$92,000	$92,000	$92,000
Android Developer	$69,000	$92,000	$92,000	$92,000
Frontend Developer	$69,000	$92,000	$92,000	$92,000
Backend Developer	$69,000	$92,000	$92,000	$92,000
PR / Marketing	$30,000	$40,000	$40,000	$40,000
Mechanical Engineer	$69,000	$92,000	$92,000	$92,000
Electrical Engineer	$69,000	$92,000	$92,000	$92,000
Total Staff Expenses	**$750,000**	**$1,000,000**	**$1,000,000**	**$1,000,000**
Engineering				
Electronic Components and Assembly	($7,500)	$96,000	$192,000	$192,000
Research and Development	$12,000	$0	$0	$0
Manufacturing	$1,500	$96,000	$96,000	$96,000
Total Engineering Expenses	**$6,000**	**$192,000**	**$288,000**	**$288,000**
Services				
Design	$0	$5,000	$8,000	$8,000
Embedded Engineer (Firmware)	$12,000	$10,000	$20,000	$20,000
Customer service	$12,000	$30,000	$48,000	$48,000
Finance and accounting	$750	$3,000	$5,000	$5,000

Legal	$0	$12,000	$28,000	$28,000
Advertising and SEO/SEM	$8,000	$28,000	$40,000	$40,000
Total Services Expenses	**$32,750**	**$88,000**	**$149,000**	**$149,000**

Miscellaneous

Computers		$10,666	$16,000	$16,000
Software		$300	$400	$400
Servers/Hosting		$7,000	$12,000	$12,000
Office Space	$18,000	$27,200	$40,000	$40,000
Travel (non-manufacturing based)		$12,500	$20,000	$20,000
Misc		$7,000	$12,000	$12,000
Total Misc Expenses	**$18,000**	**$64,666**	**$100,400**	**$100,400**
	EXPENSES			
Total Expenses	**$806,750**	**$1,344,666**	**$1,537,400**	**$1,537,400**

REVENUE AND PROFIT

	Year-1	**Year-2**	**Year-3**	**Year-4**
Units Sold	**0**	**30,000**	**60,000**	**100,000**
Revenue Per Unit	$0	$49	$49	$49
% Sold wholesale **(wholesale = 60/40 split)**	0%	5%	5%	10%
Cost Per Unit	$19	$19	$19	$19
Total Revenue	**$0**	**$1,470,000**	**$2,940,000**	**$4,900,000**
Total Expenses	**$806,750**	**1,344,666**	**$1, 537,400**	**$1, 537,400**
Total Profit	**-$806,750**	**$125,334**	**$1,402,600**	**$3,362,600**

4. DESIGN AND DEVELOPMENT PLANS

4.1 Development Status and Tasks

Rhyno is currently under development. The base design has been completed and a fully functional proof-of-concept implementation has been completed. We are currently in the initial feedback stage which involves evaluating the initial prototype to test and improve the design. Rhyno consists of four main functional units: the actual ring, motion and gesture recognition software, wireless communication circuitry, and a user interface for visualizing the data received from the ring. Our work is currently focused on improving the accuracy of the motion and gesture recognition, miniaturizing the PCB and designing a comfortable ring.

4.2 Current design goals are:

- Evaluate current prototype and refine if needed.
- Improve the accuracy of the motion and gesture recognition algorithm with the help of machine learning.
- Design a more elegant and comfortable ring.
- Minimize the size of the PCB to 15mm x 10mm, i.e the size of a regular ring.
- Build the first version of the Rhyno API and an JavaScript SDK to make the ring data and gestures available to developers to build applications.
- Develop a Rhyno App Store where developers can submit their apps.

4.3 Hardware

The major modules of the hardware are the PCB design, the ring and the battery. A functionality description of these modules along with diagrams is given below.

4.3.1 PCB Design

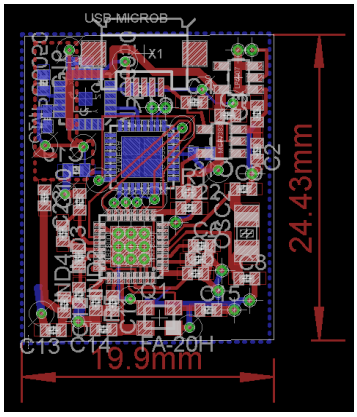


Figure 1: Current PCB Design

Our hardware has three important components: 9-axis motion sensor (this includes 3-axis accelerometer, 3-axis gyroscope and 3-axis magnetometer), a bluetooth chip and a microcontroller (MCU). The motion sensor uses a combination of acceleration, rotation and magnetic orientation to provide gesture information, the MCU processes the motion and sends a specific command through the bluetooth chip. Figure 1 shows the second revision of our PCB board (24mmX19mm) and has smaller form factor compared to our initial design. Moreover, we intend to further reduce the size of the PCB by half by replacing the computation circuitry with cloud computing system.

4.3.2 The Ring

The 3D caption of the of the first prototype of the ring is shown in Figure 2b of Section 5.2. As can be seen in the diagram, the ring has a rectangular groove to house the PCB, a side receptacle for a microUSB and a well-designed gap at the tip for installing an elastic band. The rectangular groove perfectly fits with the size of our PCB which has all the components we need to make this device work. The use of an elastic band at the bottom section of the ring makes our product extremely flexible. It can be worn by anyone regardless of their finger size. The size of the top part of the ring is 26mm x 20mm x 7mm.

4.3.3 The Battery

The current design of Rhyno is powered using a 150mAh thin, lightweight and rechargeable Lithium ion battery. It is a high energy density, high capacity, reliable and stable power source that is available in different custom sizes. Based on a conservative calculation we made a battery capacity of this much can provide a battery life of upto 10 hours if it is used continuously.

4.4 Motion and Gesture Detection Algorithm

For the first prototype of Rhyno ring, we used a deterministic finite state machine to accomplish the recognition of 8 different gestures (turn on, turn off, zoom in, zoom out, swipe up, swipe down, swipe left, swipe right). Our state machine continuously sampled the raw gyrometer data to determine which subcategory a gesture belongs to (Turn on/off vs. Zoom in/out vs. Swipe). Then we used the direction of gravity, which is obtained from raw accelerometer data, as a reference to decide the exact gesture in these subcategories. With this deterministic algorithm we were able to get recognition accuracies higher than 80% and recognition delays in the orders of 500 milliseconds.

Currently, there is no use of machine learning in the motion and gesture detection algorithm. However, it is known that machine learning algorithms such as neural networks and the HMM model technique are very effective for motion and gesture detection purposes. We are planning on adding our own custom machine learning algorithm to let our system detect short motions using the accelerometer and gyroscope data. This addition will also bring flexibility to the users so that they can define their

own gestures and use them as they please. As a backup plan, if our own machine learning algorithm does not perform well, we will consult Kiwi Wearable Tech which is a startup that provides a search engine for finding events in sensor data. Using their software, we can train our system so that it will be able to learn from individuals, and detect and compare gestures in real time.

4.5 The Rhyno API

When fully functional, the Rhyno system will track the finger with the ring. The ring will operate in an intimate proximity with high precision and tracking frame rate and report discrete positions, gestures and motion. We want to provide an API that presents all of this information to developers. Initially, we will provide an API in Javascript so that developers can build web applications using Rhyno. We believe that this is the simplest solution to have many people try out Rhyno and see if it works well in the real world. As we grow up and recruit more developers with particular skills, we are planning on providing an iOS and an Android API.

4.6 Interaction with Other Devices

We believe that Rhyno's interaction with other devices has to be really simple and intuitive for the user to outperform the competitor products.

4.6.1 Connection

Currently, the only way to connect to other devices is to connect Rhyno to a computer via bluetooth and use the computer as a hub to wirelessly connect to other devices such as mobile phones, wearables or bluetooth-enabled home appliances.

As a part of our short-term plans, we are planning to develop a mobile application, both for iOS and Android, that will pair with Rhyno via bluetooth and directly connect to any other compatible device. This way, the user will be able to use their mobile phone to pair with any appliance or device and start controlling them.

In addition to direct pairing, we are planning on working other companies producing hubs that can connect all of the different sensors around a house or an office to make the hubs compatible with Rhyno. Therefore, any device that is not compatible with Rhyno but the hub, we will be able to control with our software.

4.6.2 Usage

The mobile app we will build will offer a range of functionalities such as defining custom gestures. The users will be able to create a set of gestures for each device paired with Rhyno and train the system on a platform that will be provided on the mobile app.

The user will be able to configure a set of notification settings so that Rhyno can subtly vibrate when the user gets a notification on their mobile phone. This will help the user if they have incoming calls and they are away from their phones, or if they need to remind themselves of their tasks.

We are also working on providing finger position tracking and coordinate remapping so that the users can use their finger with the ring as a cursor on a computer to click on things or even type things if there is an on screen keyboard.

Finally, since we will be providing an API for developers to use Rhyno in their apps, we believe that they will come up with their own use cases that will be useful for people. Therefore, we will build our own App Store to make apps built by other developers available to all of our users.

4.7 Product Improvement

Once the initial implementation of Rhyno is completed and tested, we will begin enhancing the product. The initial work will be done on improving the battery life. Alternative charging solutions such as solar charging (charging from the light sources in the user's surroundings) or heat charging (charging from the user's body temperature) will be implemented and tested. A touch sensor will be added to the ring to make scrolling on any device easier. Furthermore, we want to do experiments by implementing NFC technology inside the ring to do file transfers between rings or NFC-enabled devices. If that turns out to be successful, we can easily implement a payment system using Rhyno's NFC feature. These are just simple examples of what can be done with Rhyno. It is a small but a very powerful device.

4.8 Proprietary Issues

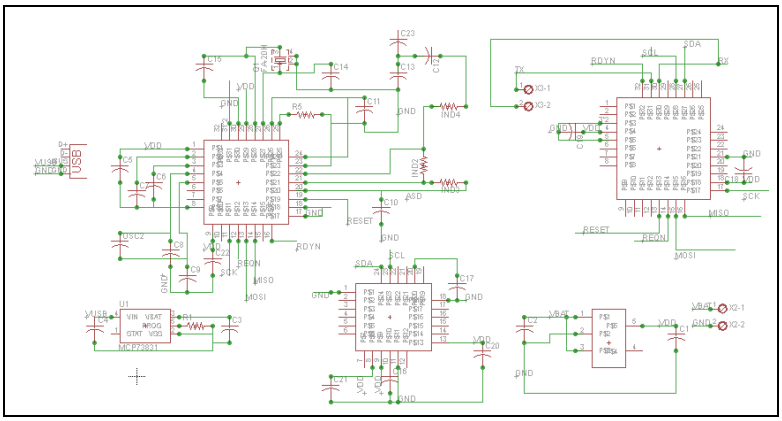
Rhyno will adhere to interface standards and can communicate with existing bluetooth enabled hardware devices without any compatibility issues. This is particularly important as Rhyno intends to be used in many various types of systems.

5. MANUFACTURING AND OPERATIONS PLAN

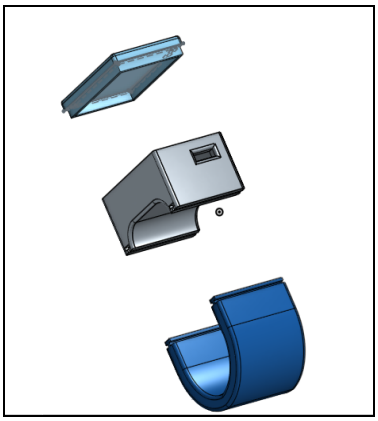
We have researched PCB manufacturers that can provide PCB fabrication services for affordable price. For instance, Shenzhen Amissiontech Co., Ltd, located in mainland China, provides electronic manufacturing services for various industries and specializes in manufacturing high volume printed

circuit boards and the assembly of electronics units. According to the current price estimation, Shenzhen Amissiontech can fabricate and assemble a single Rhyno PCB for about $1.25. Shenzhen Amissiontech is capable of providing upto 50000 pieces of PCBs a month. There are plenty of PCB component providers throughout the world. We intend to purchase our components from Digikey, Mouser Electronics and Alibaba. For further information, please refer to the summary of components given in table-1 in the appendix.

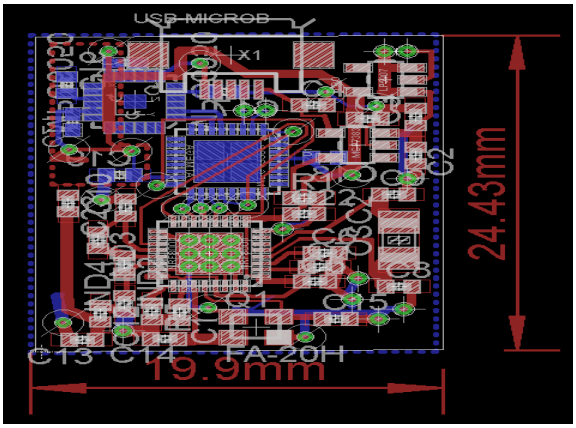
For the fabrication of the actual ring, we are consulting with manufacturing expertise to make final decisions. However, based on a recent research we made, Yiwu Dayao Accessory Co.Ltd seems to offer a great variety of ring manufacturing products with different fabrication materials for inexpensive prices. Manufacturing cost for the ring is approximately $1 per ring. The labor cost for complete assembly of the system will be about $2 per ring.



a. PCB Schematic



b. 3D Ring design



c. PCB Design (25mm X 20mm)

d. Rechargeable Polymer Battery (150mah)

Figure 2: Alpha Prototype Assembly Schematics

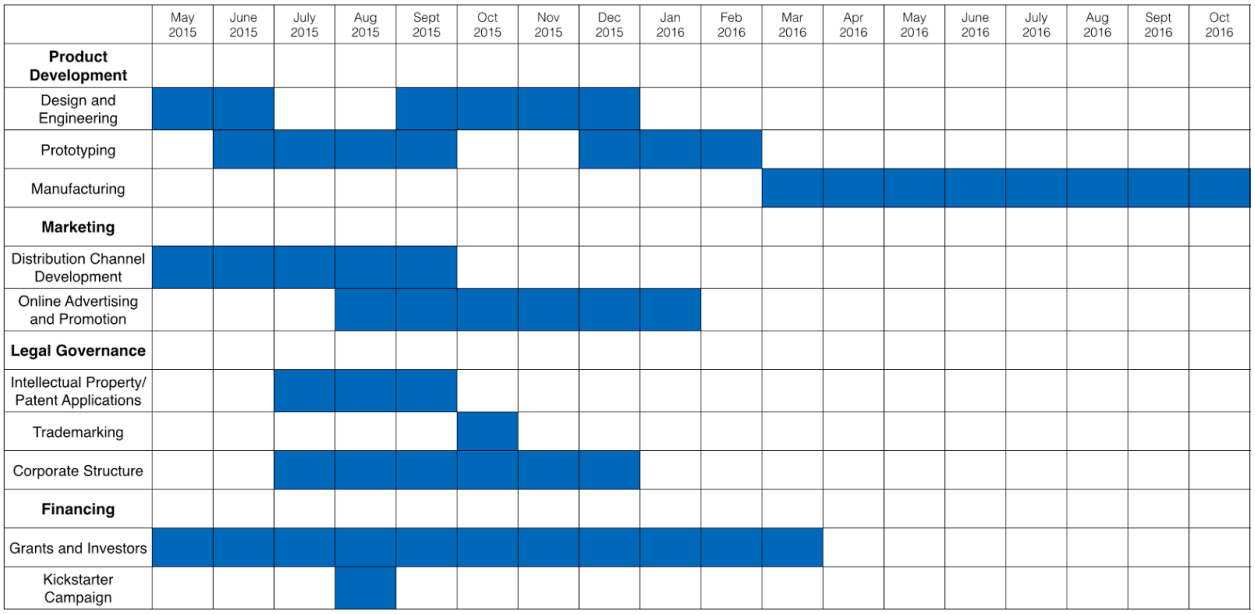


Figure 3: Milestones

6. MANAGEMENT TEAM

Rhyno Ring was founded in the Spring of 2015 by a group of MIT students during the MakeMIT hackathon. The three founders are Wegene Tadele, Ahmet Can Musabeyoğlu and Birkan Uzun. The diversity in technical expertise and experience in management and product development these founders possess will play a crucial role in determining the future direction of the start-up. We have worked collaboratively in the past four years and have proved our teamwork skills by conceiving and developing a proof-of-concept model for our product in a 24 hour period of time. Following that, in just one week, we developed the complete prototype model of the product. Our dedication, friendship and strong collaboration skills will greatly benefit this start-up as we move forward to developing a mass producible prototype.

Wegene Tadele is the Principal Hardware Development Engineer. Wegene obtained his B.Sc in EECS from MIT in June 2014 and he is currently working towards completing his MEng degree in EECS. He has experience in power electronics, RF and mixed signal circuit, mechanical and CAD design and product management. He will use these skills to come up with power efficient circuits, miniaturized PCB designs and elegant/comfortable mechanical designs for the Rhyno ring. He has previously interned at Teradyne, Schlumberger and Brunswick Corp.

Ahmet Can Musabeyoğlu will serve as the Principal Firmware and Sensor Development Engineer. Ahmet is a 4th year undergraduate student at MIT. He is double majoring in EECS and Physics. He has experience in analog and digital circuit designs, firmware and software development. He has interned at linear technology and has a lot of experience in system integration and product development. He recently developed efficient power converters for solar energy harvesting and tested them in remote rural indian villages. He will use his diversified sets of skills to develop the firmware

that detects the hand gestures of the user and connects Rhyno to other electronic devices via Bluetooth in order to transmit detected hand gestures.

Birkan Uzun is the Principal Software Architect. Birkan is a 4th year undergraduate student in Computer Science and Engineering at MIT. He has experience in software development, human-computer interaction and marketing. Birkan has previously interned at Amazon.com, Inc. and Akamai Technologies where he worked on several web development and systems engineering projects. Furthermore, Birkan's undergraduate research focuses on multi-modal interactions on virtual interfaces. Birkan will use his software engineering skills to improve Rhyno's motion and gesture recognition algorithm, build the Rhyno API and SDKs for future developers and develop applications for our users.

Appendices

Current Redesign of Rhyno

Figure 4: Current 3D Redesign of Rhyno (Work in Progress)

HackMIT Experience: Playing 2048 with Rhyno

We participated in the MakeMIT hackathon in February, and we were selected to be one of the top ten teams out of the fifty-five teams that participated in the event. During the hackathon, we built the first prototype of our product using a motion sensor which consisted of a six-axis accelerometer and a gyroscope. We used the Bluetooth LE technology to communicate with our laptops. We wrote a Node.js server that constantly listens to peripherals with a specific UUIDs (Rhyno in this case) to connect to it. Once a connection is achieved, the Node.js server starts waiting for notifications that the action characteristics of Rhyno advertises. For example, if the user does a gesture, the Node.js server will be notified.

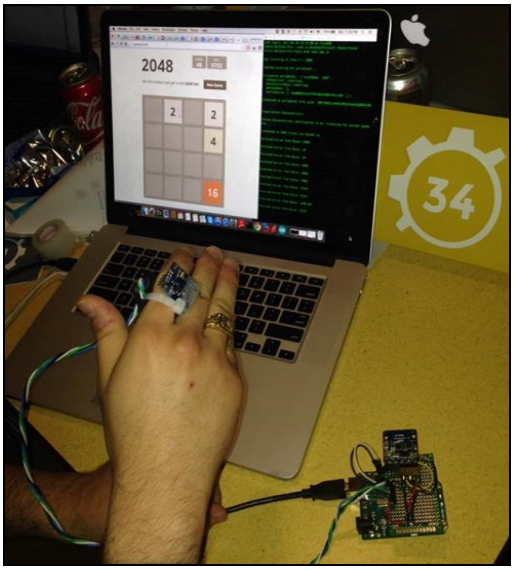


Figure 5: Playing 2048 with the first prototype of Rhyno

We were able to accomplish recognizing six different types of gestures during the competition: Swipe LEFT, RIGHT, UP, DOWN and Zoom IN, OUT. Furthermore, we incorporated hand motion commands to turn off the Bluetooth chip and bring it to an idle state to save power. To demonstrate this behavior we took the popular game, 2048, and played it with Rhyno. The connection with the 2048 Client and the Node.js server was handled by using Socket.io, which enables real-time bidirectional event based communication. Once the server receives an event from Rhyno, the action is reflected on the 2048 game board. The demonstration of the 2048 game is shown below in Figure 5.

Bill of Materials for the Alpha Prototype

Hardware Component		**Price per device($)**	**Size**
Accele/gyro	MPU6000	1.82	5mmx5mm
BLE 4.0	nRF8001	1.96	5mmx5mm
MCU	ATMEGA328P-MN	1.88	4mmx4mm
Li-ion Battery	P-1S5045BC	1.25	5mmx12mmx16mm
Li-ion Charge Man.	MCP73831/2	0.50	3mmx2mm
Female USB Connector	FCI 10118192-0001LF	0.25	7mmx5mmx2mm
LDO	LP5907	0.15	1mmx1mm
32.768 kHz Crystal Oscillator	LLC ABS07-32.768KHZ-T	0.24	3.2mmx1.5mm
16MHz	NDK NX3225GB-16M-STD-CRA-2	0.35	3.2mmx2.5mm
Total		**8.4**	

Table 2: PCB Electronic Components (Size and Price)

Summarized above (Table 2) is the bill of materials for all the electrical components that we used for the alpha prototype. The total cost is $8.4 without including the PCB, the mechanical house for the ring and SMD capacitors, resistors and inductors that cost less than 1 cent per piece. Including assembly/shipping costs, we predict the total cost to stay under $12.

Battery Life Calculation for Rhyno

MPU6050, nRF8001 and Atmega-328P are the components that causes most of Rhyno's power consumption. Our BLE chip nRF8001 uses an average current of 14 mA when it transmits information, while MPU6050 and Atmega-328P each consumes around 1 mA when they are actively running. This results in an average power consumption of 16 mA*Vdd. At this consumption levels, our 150 mAh battery yields a battery life of (150 mAh/16 mA) = **9.4 hours**.