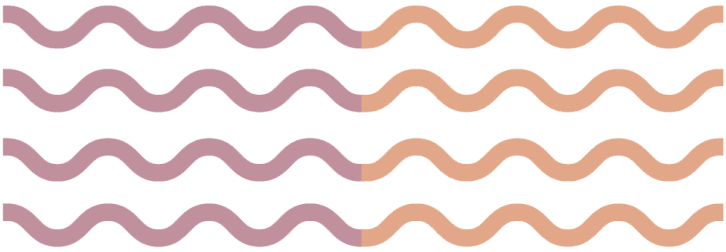

VERRO TOUCH

Sharpen Your Senses. Feel the Truth.

Anyka Chan, Yiwei (Estee) Chen, Brian Grimaldi,

Meng Lei, Zhiyao Tang

1 Executive Summary

At VerroTouch, we aim to enhance the precision and feedback during surgical procedures using robotic systems such as da Vinci. This allows surgeons to upgrade existing technology using inexpensive hardware-software integrated products compared to purchasing a new system that is substantially more expensive and does not have the features we aim to deliver. We have found that in previous studies using this technology, 90 percent of surgeons found VerroTouch to significantly improve their surgical skills with a telerobotic system.

Currently, the surgical robotics industry is still young and as a result, we are the first providers of an integrable accessory in surgical robotic systems that provides precise vibrational sensations, which are currently absent in all robotic systems currently sold. Surgeons will be able to experience a robotic surgery that feels similar to that of a real surgery, a feature that surgeons such as Dr. Thodiyil, Dr. Sloane Guy, and Dr. Shukla have stated would enhance the nature of the surgery. With VerroTouch, we are able to successfully close the learning gap that comes with training on surgical robotic systems for new surgeons, as well as implement touch sensations that many surgeons desire during surgeries.

With over 5,000 da Vinci models in circulation and over 3000 hospitals that own a da Vinci model, we believe we are able to capture a significant portion of this market with our value proposition for VerroTouch. The valuation of the US market for haptic technology is expected to increase from $161M to $402M in 2022 and surgical robotics is expected to increase from $4.8B to $5.4B by the end of 2021. Any peripherals sold separately or included in these surgical robotic systems, most importantly haptic technologies, will certainly grow proportionally with these two market segment's growth trends.

Through market research, we have determined that the end-users in the hospital segment have the highest desire for haptic feedback, and thus the highest motivation to purchase VerroTouch. VerroTouch differentiates itself to these users by being the first on the market that is self-contained, low-latency, and realistic haptic feedback device for surgical robotics. It can be easily mounted onto the da Vinci robot, and similar robotic systems lacking haptic feedback, without any concerns about software compatibility. These differentiating factors are designed to appeal to our target users, who are also influencers in hospitals' purchasing processes.

We have spoken to surgeons across the United States and validated the need for haptic feedback during robotic surgery. The learning curve for surgeons to adapt to relying fully on visual feedback has been expressed to be a difficult one to adjust to. Surgeons such as Dr. Aseem R. Shukla, Dr. Sloane Guy, and many more have expressed that haptic feedback should be in the future of surgical robotics and believe that it will improve the safety and comfort of surgeons with access to these kinds of technologies.

The first batch sales will go to hospitals within the University of Pennsylvania network. These sales, however, do not generate revenue as they are devices we will "give" to the hospital through a joint research program. This will help us to boost our branding image and validity, at a cost of zero revenue. The hospital we are considering consists of the Presbyterian Medical Center, Children Hospital of Philadelphia, and Hospital of University of Pennsylvania. Receiving endorsement from surgeons with expertise in robot-assisted surgeries is significant for us as it represents acknowledgement from academia leaders in the field.

In years 3-6 however, we will be opening up to the American market and expanding into APAC (Asia-Pacific) markets in years 5 and 6. In those six years, we will have captured about 20% of the surgical robotics market with the percentage continuing to increase as our product becomes more accepted in the medical and surgical robotics communities.

At the beginning of our business, each of us in the founders team will invest a founders' investment for 10,000 dollars, in total $50,000, as we believe in and are committed to our product and business model. This will be used to fuel the first production of our prototypes and the employee compensation while we actively search for the first round of financing. In the first year, we will go for the first round of investment at $2,500,000 with preferred equity. This investment will facilitate the activity of the joint research programs and related salaries of R&D personnels. We would hit the milestone of prototyping and FDA clearance with this investment. In exchange, we will give 10% stock to the Seed Round investor. The estimated final return is 12.8x the original investment. The second round of financing is aimed to achieve in the second year with $5,700,000 preferred equity. In this year we will start our marketing activities and build the production capacity. Our R&D department will be expanded to publish papers for the joint research and finalize the first generation of the product that is to be launched in year 3. We will draw the $5.7 million in tranches,with $3.55 million by year 2 and $2.15 million by year 3. We will give 10% stock to the Series B investor. The estimated final return is 5.6x the investment in Year 2. In year 4, the major milestone we will be hitting is the first bulk order. We will continuously work on R&D for the second generation, also working on marketing activities to get ourselves ready for opening the APAC market in year 5. In this year we will go for the third round of financing of $2,600,000 preferred equity. In exchange, we will give 2% stock to the Series C investor. Similar to Series B, we will draw this amount in tranches, with 1.6M in year 4 and 1M in year 5. For Series C investors, the final return is $6.4 million. The estimated final return is 2.5x the investment in Year 4.

We plan to go public with an IPO by year 7 with steady launched market share and customer loyalty. An IPO would be an important path for us to build the customer credibility and will increase our publicity. We have found with more publicity, we are able to achieve more market share in a geographically area. On top of that, an IPO will provide us more cash to fuel our sequential activities: more R&D that allow VerroTouch to be versatile on different surgical robotic systems with enhanced haptic technique, and better establish collaborations with surgical robotic companies that would integrate our product with theirs.

VerroTouch was founded by five students at the University of Pennsylvania, Estee Chen, Brian Grimaldi, Anyka Chan, Zhiyao Tang, and Meng Lei. Coming from various academic and professional backgrounds and experiences, we are confident that together we can execute our outlined business plan. Additionally, we will be hiring experts in the industry to guide us through some of the aspects of the business we have less personal experience with such as financial and surgical robotics knowledge.

VerroTouch will provide surgeons with a better experience of touch sensation during surgeries. This solves the problem of current robotic surgery relying solely on visual cues, and will enhance the learning process for surgeons, while providing a better clinical outcome. With a growing total addressable market and the endorsement from our end-users, we believe that VerroTouch will be welcome in the market and be profitable. The financial forecast indicates a positive net revenue starting from year 5. By the time we exit, we are able to provide 12.8x return on investment for series A investors, 5.6x for series B, and 2.5x for series C.

2 Company Overview

We are VerroTouch and our mission is: to elevate the experience of surgeons by enhancing the precision and feel of surgical robotics, to even the playing field of the surgical robotics industry by upgrading all technologies to the modern era of haptic feedback and to achieve excellence through innovation, collaboration, and diligence.

We plan to achieve this through our product, VerroTouch. VerroTouch is the first external accessory to surgical robotic systems that provides realistic, low-latency haptic feedback in an integrative, self-contained product. We enable the surgeons to feel the long-desired sense of touch within robotic surgery. As shown in feedback from surgeons who used our product, 90 percent of surgeons found it to significantly improve their surgical skills with a telerobotic system. (Penn Center for Innovation, 2016) Additionally, the surgical robotics industry has suffered from difficulties in training new surgeons to use their systems. Haptic feedback has been cited to help surgeons learn and adapt to new robotic technologies. (Gewirtz, 2021)

We are a team of enthusiastic Penn students who are driven and excited to grow and learn as we execute our business plan. Estee Chen, our Executive Officer, is a candidate for Bachelor's and Master's in Computer Science. She has previously worked as a startup investment analyst at Sequoia China Seed Fund and as the founder of a social enterprise. Anyka Chan is our Marketing Officer and is a candidate for a Bachelor's of Science in Engineering in Computer Science. She brings experience serving in marketing roles within Penn organizations and serving on the board of a non-profit. Brian Grimaldi, our Technology Officer, is a candidate for Master's in Mechanical Engineering, concentrating in robotics and mechatronic systems. Meng Lei, our Operations Officer, is a candidate for Master's in Chemical and Biomolecular Engineering, concentrating in pharmaceutics development, which works closely with the FDA regulation process. Zhiyao Tang, our Financial Officer, is a candidate for Bachelor's in Computer Engineering and a Master's in Electrical Engineering. He had prior experience working with technology startups which were involved in the financial aspect. Our diverse backgrounds allow us to bring various experiences in leadership, marketing, and operations, and as engineering students have deep knowledge of technologies and their potentials. To fill gaps in our financial, legal, and industry knowledge, we plan to hire experts in the field of surgical robotics.

VerroTouch's name is a combination of two key traits of the product, Verro meaning truth, and Touch because VerroTouch recreates the true feeling of surgery. We hope surgeons can feel exactly what they will feel as if they are doing surgeries with their hands. Our company has not been formed, but we plan to do so soon. It is going to be based in Philadelphia as that is our founding team's unifying city, but we plan to expand nationwide and overseas to Asia in order to market and sell easily to various regions. We will be filing as an LLC, because it offers stability and limits personal liability in the case of failure, as well as financial and tax rate benefits.

VerroTouch's goal is to equip all surgical robotics with haptic feedback and become an industry-standard in haptic feedback. We are striving to expand our market to all hospitals and surgical robot companies in the world. In addition to expanding the market for our current product, VerroTouch will be expanding our R&D to develop additional technologies within our company mission and objectives. This will help VerroTouch achieve a sustainable business with healthy cash flow and return on equity, at which point we plan to go public. In the meanwhile, we will also explore opportunities for mergers and acquisitions by large companies within the surgical robotics industry to cover our bases.

3 Product Description

3.1 Complete Product Description and Value Proposition

VerroTouch is an accurate haptic feedback system that can be easily integrated into various aspects of the robotics field and is especially applicable to the surgical robotics industry. Vibration sensors are attached to the patient-side robot control consoles to evaluate the tool contacts that occur during surgery.[1] These signals are collected, conditioned, and processed to be delivered to the voice coil actuators mounted near the surgeon's hands to generate vibrotactile, haptic feedback of the instrument vibrations, allowing the surgeon to feel the contacts. (Kuchenbecker, 2016). VerroTouch would be unobtrusive to the existing force feedback the system currently has when the controller moves outside of the boundary the robot is able to operate in. [2]

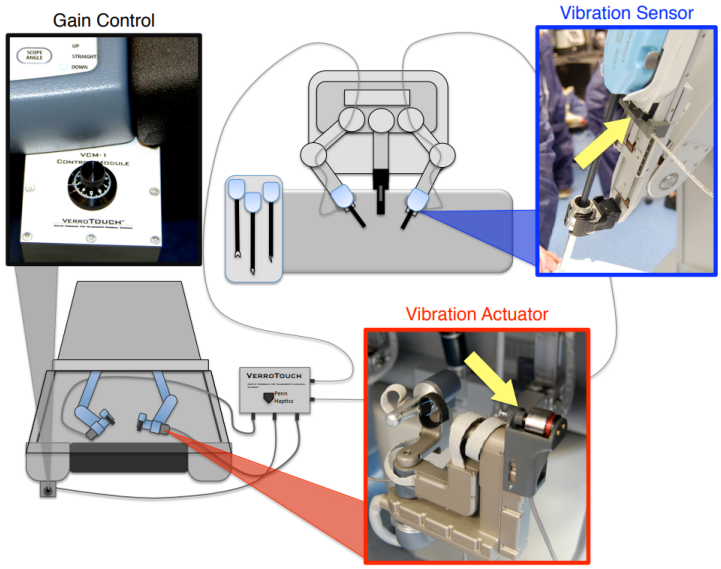

Figure 1: Illustration of the Product (Kuchenbecker, 2012)

VerroTouch is designed for solving the problem that many currently implemented surgical robot systems do not offer haptic feedback. (Shukla, 2021) As shown in feedback from surgeons who used our product, 90 percent of surgeons found it to significantly improve their surgical skills with a telerobotic system. [3](Penn Center for Innovation, 2016) Our product will send haptic vibration feedback that matches what is being sensed by the robot. Additionally, the surgical robotics industry has suffered from difficulties in training new surgeons to use their systems. Haptic feedback has been cited to help surgeons learn and adapt to new robotic technologies. (Gewirtz, 2021) Compared to the classic tradition of relying on visuals and prior knowledge, VerroTouch can assist in the improvement of training and simulations with surgical robot systems..

Those hospitals who have the capability of robotic surgery already and would like to improve the surgeon's experience of doing minimally invasive surgeries, or those who would love to give a

better training experience to their surgeons, will be likely to purchase our product. (Shukla, 2021)

Our core value proposition is that VerroTouch provides accurate, instant haptic feedback that is highly desired within the surgical robotics community and easily integrable with all existing surgical robotic systems and controls. (Shukla, 2021) Surgeons working with surgical robotics have often cited the lack of haptic feedback to be a detractor from their accuracy and training with the systems. (Nolin, 2021) VerroTouch provides this realistic, low latency feedback. Additionally, since many of these hospitals working with these surgeons already have paid the large upfront cost of obtaining and installing these haptic-less surgical robots, they are seeking a solution that is easily integrable with their existing systems to reduce the switching cost of gaining haptic feedback. (Gewirtz, 2021)

Currently, the surgical robotics industry is still relatively young and continuing to develop. We are the first providers of an integrable haptic feedback accessory in surgical robotic systems. With Intuitive not currently including haptics in their devices, simulation consoles beginning to implement them, and new entrants such as Hugo Medtronics including haptic feedback in their systems, we have found a large market that spans from hospitals owning existing systems and simulation/hardware companies desiring the addition of haptic feedback actuators in their hardware (Nolin, 2021). Additionally, companies such as Johnson & Johnson are preparing to take on the incumbent giant that is Intuitive Surgical, giving VerroTouch many avenues and companies we can explore for partnership and acquisition opportunities. (Healthcare, 2021) Entering the market soon and being the first to bring a new aspect to this industry would allow us to corner a brand-new market segment that has yet to be fulfilled.

Our revenue model is broken down into three main parts. First, we should sell directly to hospitals. The potential customers of this segment are doctors or operation rooms that own surgical robots that currently lack haptic feedback. Secondly, we would be licensing to both surgical robot companies or simulation companies. For a price point, the expected price of our product is in the range between $40,000 and $50,000[4]. We defer further discussion on this to the revenue model and pricing strategy section.

3.2 Proprietary Right

VerroTouch is currently a file patent with proprietary rights in the stack where we connect sensors to haptic actuators.[5] The system features ultra-low latency haptic feedback, which is a result of yearlong research, and is currently state-of-art technology. The patent covers the system and methods for providing low-latency vibration feedback in robotic systems. The entry barrier to this niche field for future companies is also high. First, the technology comes from years of research which is hard to replicate or surpass. This is also because, as the first to explore this market, we are aiming beyond the functional value of the product. Rather, we aim to offer the potential customer a well-rounded experience, and therefore create a platform for the surgical community that allows the intrusion of exterior companies. Currently, the patent is assigned to the Trustee of the University of Pennsylvania since it is based on research done by Penn faculty. The entirety of our team comes from Penn students, which allows us to acquire licenses to the Patent by going through Penn's Center for Innovation. (Kuchenbecker, 2016)

3.3 Stage of Development

VerroTouch is not currently ready for the market and is presently in development. As of right now, VerroTouch is a patented technology and has been in the prototyping stage as a bench prototype. As a bench prototype, VerroTouch is currently used in a controlled environment on inanimate objects and not human patients. To fully produce and market VerroTouch as a complete product, we first must test VerroTouch in a stochastic environment to determine the robustness, efficiency and efficacy of our product. One we have determined if our product can function in real world surgeries, we must then find a manufacturer to mass produce the VerroTouch chip and haptic feedback actuators for attachment to existing surgical robotic systems. This manufacturer must also fit the desired specifications of producing our product with the highest quality for the lowest possible cost to increase profit and value simultaneously. (Kuchenbecker, 2016)

4 Industry and Market Analysis

4.1 Industry Analysis

Our product falls at the intersection of 2 industries: 1. NAICS 334510: Electromedical and Electrotherapeutic Apparatus Manufacturing(SIC 3845), 2. NAICS 339112: Surgical and Medical Instrument Manufacturing (SIC 3841).

Our product is a hardware that is an accessory specifically designed for surgical robots, its sensors attaching to the rigid robotic arm and providing vibrational feedback on the side of the surgeon's hand. Compared with the general haptic sensor manufacturing, we are differentiating from the unique design for surgical robots, which is a market that would be costly for them to enter because they need to re-engineer the hardware. Compared with simulation companies that may come up with the same solution on hardware with us -- the haptic feedback, we are having a more focused force on sales, and will be entering the market more swiftly than they do since we already have a prototype stage product. Those are our competitive advantages and unique value for our customer segment, which expand the existing boundary of the surgical instrument industry, meanwhile avoiding direct competition with haptic sensor-feedback hardware and simulation program providers.

[6]The risk incurred from customers is relatively small. Despite the concentrated surgical robot market with 3 firms sharing 69% of the total market and thus huge bargaining power (BCCResearch, 2021), our product only takes up a very small portion of their price tag of $2M (Crew, 2020) and their profit margin is as high as 68.69% (Macrotrends, 2021). They are also incentivized to improve product quality by including critical add-ons, such as our own. The threat from new entrants is moderate. Although our hardware solution is protected by a patent that lasts 15 years (Kuchenbecker, 2016), big indirect competitors such as Boston Dynamics may enter with a different technology that solves the same issue, and it might be resource-draining for us to compete. The threat from the incumbents is moderate. For our haptic feedback system, we have found very few incumbent firms that provide similar products, with none of them being large companies. Some of them have grown large and have secured partnerships with our other incumbents like Intuitive. Our main suppliers are digital component manufacturers and assemblers. It is a red ocean market with homogeneous products, and the cost can be further reduced due to the low electronic appliances cost overseas (Made-in-China, 2021). The threat of substitute products is low. We are highly specialized in surgical robots and our customers value the quality of our product, as 95% of our pilot test surveyees prefer additional vibrational feedback (Penn Center for Innovation, 2016).

There are two main barriers to entry we need to contend with. The first is the considerably long time required to validate our customer needs and the regulatory process. The second barrier is the existing relationships our competitors, like Simbionix and MIMIC, have with giants in the surgical robot industry , like Intuitive (Simbionix, 2021) (MIMIC, 2018). To prove we are a better alternative, we have to strongly differentiate ourselves or specialize in a niche function. We are collaborating with hospitals for a research program at the beginning of our business to do the customer need validation and handle the regulation problems, selling to hospitals directly to gain revenue in the first few years before we launch partnership with industry incumbents to win a better deal.

Firms in the electromedical appliances industry are typically licensors or orchestrators [7] because they are software providers and thus require minimal manufacturing or assembly. They typically perform in-house R&D like software development and outsource manufacturing. Integrators are uncommon because the industry faces a very concentrated customer market, making vertical integration hard. Strategic alliances seem like the best practice in the industry to secure long-term revenue and growth. We have seen Simbionix and Mimic partnering with Intuitive in providing surgical simulation training (Simbionix, 2021) (MIMIC, 2018).

Within surgical robotics as a whole, a typical revenue model would follow a three-category approach: surgical system, accessories and instruments, and service, where the accessories/instruments and service are recurring revenue sources. The largest percentage of revenue is attributed to accessories and instruments as these need to be replaced often for each surgery. This is the fastest-growing category within the surgical companies' revenue model. (Intuitive Surgical, 2021) The systems themselves are also either purchased in full or leased on a long-term basis for terms ranging from 24 to 84 months. (ISRG, 2021)

Surgical robotics industry influences mainly involve the frequency and necessity of minimally invasive procedures. Optional surgeries are not performed often when the country is in financial crisis as was demonstrated in 2008-2010 during the recession, decreasing industry growth. (BCCResearch, 2021) The downturn in the economy due to the COVID-19 epidemic has similarly contributed to a drop in the growth and profits of the surgical robotics industry due to a lowered amount of elective procedures for financial reasons as well as the general lack of hospital space. The industry is still actively growing, meaning that current incumbents such as Intuitive don't necessarily have a firm grasp over market monopoly. As technology continues to develop, there has been an increase in active competitors within the surgical robotics market. (Trefis Team, 2020).

The surgical robotics industry does face regulatory scrutiny especially from the United States Food and Drug Administration (FDA). We will be filing 510(k) clearance for being Class II medical device, since we are exposing low to moderate risk to the patient. This took approximately 90 days. Healthcare reform has added a 2.3% excise tax on medical devices, causing a small decrease in profit. Additionally, the Patient Protection and Affordable Care Act (PPACA) has allocated a large amount of funding to scrutinize the effectiveness, cost efficiency, risk, and benefits of all incoming medical technologies. Thorough evidence must be presented that these products truly do cut costs for patients and improve quality of life. (Crompton, 2020)

4.2 Competitor Analysis

There are two categories of VerroTouch's competitors, first comes from the haptic feedback system designers who may be trying to enter the surgical robot market, the other is the simulation companies who have launched connections with hospitals, who may come up with similar products that we have.

Competitors (Haptic Technology Companies):

Tactical Haptics: Tactical haptics is the "developer of a motion controlling device designed to deliver a realistic sense of touch in virtual reality." (Tactical Haptics PitchBook, 2021) They are a relatively young and small company, with a seed round of 2.22M and a total of 4 employees. As of May 29th, they launched their Reactive Grip™ controller, a development kit primarily targeting the virtual reality gaming market (Takahashi, 2019). Using two independent motors, they use sheer force feedback in order to replicate the feelings of resistance, inertia, weight, elasticity and recoil. While their target audience is for the video game market, they state that this feedback can be used in any augmented reality scenario, including our target market of laparoscopic or telerobotic surgery (Takahashi, 2019). With VerroTouch already having a patent secured on haptic feedback hardware to be attached to the da Vinci system, and the main target market of Tactical Haptics being that of the video game industry, we are not concerned with Tactical Haptics being a direct competitor. On the dimension of specification[8] we are having different product lines, and different target customer segments.

Haption: Haption is a France-based company that was incubated in 2001. Their primary focus is on haptic devices with professional quality. As a hardware company, their haptic omni-directional controller spans a spectrum of application fields. (Haption S.A. PitchBook, 2021) Their Virtuose Desktop product line focuses on providing high-force feedback for users using such controllers. They maintain an impressive ecosystem of technology partners, integrators, and resellers across the globe. (Haption, 2021) One of their application domains is the medical device domain. They claim that the product they provide is an enabler surgery simulation for surgical robots with haptic feedback provided. (Haption, 2021) They also claim the usage in remote robotic surgery, also known as telerobotics, and co-manipulation, a new term defining a system where robots and operators work together. In co-manipulation, the focus is on providing help to force the operator to stay within a defined zone or guide him to access the desired area. (Haption, 2021) Since they are targeting a much larger market, spanning from research, medical, transportation, to robotics, They are less incentive to focus on robotics surgery enhancement, since this field requires plenty of regulatory barriers. (Haption, 2021) Their solution is focused on pure hardware with an entire robotic arm. (Haption, 2021) Their interest in the general and broad market put them as an indirect competitor to VerroTouch while we are having a narrow market focus and concentrated customer group.

Competitors (Surgical Robot Industry):

MIMIC Technologies: MIMIC Technologies is the "developer of robotic surgery simulation systems intended to advance the field of robotic surgery." (MIMIC Technologies PitchBook, 2021) Founded in 2001, MIMIC is an established company in the surgical simulation market, having developed a variety of basic simulation programs and developed a suite of products for those who wish to license them for their surgical robotic system. MIMIC had a 33.76 M post valuation and was purchased by Surgical Science Sweden for SEK 280 M (MIMIC Technologies PitchBook, 2021). With Surgical Science also owning LapSim, EndoSim, and SimPraxis, they

have a large hold over the surgical simulation market. MIMIC Technologies also partnered with Intuitive Surgical through their Simulator for da Vinci robots (MIMIC, 2018), while making it easier for them to come up with a haptic solution by themselves. With this collaboration already having been established, it is imperative that we do not have MIMIC technologies as a competitor, but rather a strategic partner. VerroTouch plans to collaborate with them to provide an application programming interface(API), after we steadily establish our hardware market. So that these programs can seamlessly integrate our accurate haptic feedback into their simulation software. That avoids the direct competition with MIMIC technologies, as long as Intuitive Surgical that they are in collaboration with.

3D SYSTEMS – Simbionix: 3D SYSTEMS is in general a company that deals with the field of 3D digital design and fabrication solutions. However, under the corporation, there is a subsidiary called Simbionix, which focuses on haptic simulation in surgical robotics. This puts the company in competition with VerroTouch, especially in the simulation field. Being a subsidiary of the 3D SYSTEM corporation. Simbionix focuses primarily on providing hardware and software for high-fidelity simulation, training, and education service to medical professionals and healthcare providers. They are aimed at providing complete solutions in forms of simulation training programs to perform optimization on the surgical procedural outcome. (Simbionix PitchBook, 2021) As of 2021, they have released a haptic training product named LAP Mentor. This family of products features in haptic, “True-to-life”, simulations to laparoscopic medical procedures. (Simbionix, 2021) Testimonials from the company website indicate that surgeons are generally satisfied with the provided training program, as it helps them to discuss best practices and complication management. (Simbionix Testimonials, 2021) Beyond targeting traditional hands-on surgeries, they also target at providing simulation programs to robotic clinical procedures. Their RobotiX Mentor program provides a comprehensive curriculum with “true-to-life” tissue behavior. This product includes simulation features for the Da Vinci Surgery System. (Simbionix, 2021) However, their product direction does not suggest that they are interested in making haptic systems for robotic-assisted surgeries like VerroTouch. The haptic simulation they feature is only for laparoscopic operations that require hands-on operations. While they have custom surgery simulation for Da Vinci System, they don’t feature anything related to actual physical robots. Their focus is primarily on simulation solely (Simbionix PitchBook, 2021). This makes them not in direct competition with us.

4.3 Market Analysis

Our market is a smaller set of markets under the general haptic technology market. In particular, focus on providing haptic technology for modern surgical robots. The market for general haptic technology globally is large and is expected to grow even more in 2022. When looking at the projected US market, we are expecting an increase in the market from $161M to $402M in 2022. Research suggests that this is because the patenting and regulatory regime in the US offers the surest way towards monetization of haptic technology in the healthcare field. This trend is reported to continue in the future years. (BCCResearch, 2017) Since our technology goes alongside surgical robots, our market grows with them. Studies on surgical robotics markets reported that the market is expected to increase from $4.8B in 2020 to $5.4B by the end of 2021. Further, the expected annual compounded growth rate from 2020 to 2025 is 13.6%. (BCCResearch, 2020) Peripherals sold with or separately from the robotic systems, such as our product VerroTouch, will certainly ride on this market growth.

Market Trends and Voids

One trend that is seen is the "robotic surgery market is expected to benefit from the growing incidence of disorders..." (Mordor Intelligence, 2021). With robotic surgery becoming more mainstream, with more hospitals accepting the technology as it becomes safer and even more effective than the normal surgery it is augmenting, peripherals sold with or separately from the robotic systems will also grow in popularity, such as our product VerroTouch. Another trend is the increasing number of mergers and acquisitions in the surgical robotics industry. According to Fortune Business Insights, this assists "in the increasing number of robotic surgical procedures, the rapid growth of the market, and introduction of new technologies and applications" (Fortune Business Insights, 2021). This is very important for us since while our product will increase the value of existing systems, it will not reach a wide enough audience until the market rapidly grows (Van der Meijden et al., 2009).

Precision is very much desired by surgeons in these robotic systems. According to Mordor Intelligence, "growing demand for non-invasive surgeries with more precision and flexibility are the factors driving the market". With robotic systems not currently supplying surgeons with the precision they desire, and the number of robotic surgeries increasing, we wish to fill this void by providing existing owners and robotics companies with a technology that will imbue precision into these systems. Another void in the market is a service that has a low cost of installation (Mordor Intelligence, 2021). We will be a part of these innovations, providing our easy-to-install product that will be integrated seamlessly into existing surgical robotics and simulation software.

Market Needs That VerroTouch Fills

Surgeons working on surgical robotics, especially those who are new to training with these robots often have complaints about the lack of haptic feedback within laparoscopic robotic surgery. (Tirmizi et al., 2016) Natural haptic cues that previously could be taken into account such as tissue tension and resistance are no longer felt by the surgeons, forcing them to rely on visuals and muscle memory to perform the surgeries. (Brown et al., 2016) VerroTouch seeks to solve this issue by introducing haptic feedback to surgical robotics systems.

Market Segmentation Delineation

Haptic feedback is a very vast market that can be applicable to many other aspects of technology. It is often used in video games, remote controllers, wearable tech, and more. Delineating segments from the haptic feedback side mainly boil down to what the end user's market is. (Xu, 2021) From a surgical robotics market perspective, we can delineate based on the component role it is filling, the type of surgery it assists in, and the region it fills, what we will be focusing on at the beginning of our business will be orthopedics surgery, depend on the fact that our haptic mode is the vibrational mode. For components, the categories are specifically: a system, an instrument/accessory, or service, and what we fill in are the accessory(the hardware itself) and service component. (Allied Market Research, 2021)

4.4 Customer Analysis

The Early Adopters[9]

For our hardware, among the total addressable market, hospitals that own the da Vinci robot are likely to be early adopters because our product is directly compatible and easily installable onto the da Vinci robot (Penn Center for Innovation, 2016). This will involve cutting-edge

thought-leaders like University of Pennsylvania affiliated hospitals, since they are prone to accept new technology. The early majority will likely be hospitals in the East, especially hospitals in the Greater Philadelphia and New York region for the convenience of sales and after sale service.

The Motivation

For our early adopters of hospitals that own surgical robots, what motivates them is the need of surgeons. Surgeons are the biggest influencer related to hospital procurement and have increased power over the years(Chiaravalloti, 2018)(Think with Google, 2013). More than 80% of surgeons and procurement officers say they work in collaborative partnerships to purchase medical equipment, weighing clinical and economic value together(Biesen et.al., 2019). The surgeons like innovation but only to the extent that it improves patient care(Chiaravalloti, 2018), thus their motivation for purchasing comes from the enhancement inpatient care outcome. Our product with accurate haptic feedback would be helpful in this aspect(Van der Meijden et al., 2009) since it provides them more authenticity while doing operations with surgical robots.

The Purchasing Decision-Makers

In hospitals, the buyer's decision-making process is different from other industries. Hospitals use a value analysis committee to evaluate the product, which consists of physicians, nurses, purchasing agents, liability specialists, supply chain management, and administrators, together with evaluating all new product purchases (River Cities Capital, 2016), in this case, we need to deal with different personalities in the sales process. They also deal in fiscal year budgets, which means if a product is being evaluated currently, it has to be able to fit into the next year's budget. (Macey, 2015) They utilize the group purchasing organization (GPO)[10], which helps to facilitate and negotiate contracts on their behalf. (Macey, 2015) Depending on this situation and the possible delay in purchasing, influences like the internal structure of GPO, possible new entrants, economic factors come into play. For a surgical robot company like Intuitive, our salesperson needs to get to their purchasing or strategic sourcing management department to promote our products.

The Distribution Channel

For the current stage, customers will buy our hardware product through direct orders. The product will be delivered through shipping. Additionally, an installation assistance appointment can be scheduled with VerroTouch if needed. Customers will purchase the subscription through a website or through direct orders, and the product can either be installed directly or installed with the help of IT assistants.

In our expansionary stage when we would have established ourselves as a brand, we will also offer sales through online channels so hospitals can directly order and get their hardware.

5 Marketing, Sales and Distribution Plan

5.1 Target Market Strategy

VerroTouch will be targeting hospitals utilizing surgical robotic technologies that don't already have an implementation of vibrational haptic feedback, with our initial market being opinion leading hospitals using surgical robots for orthopedic, neurological, and other surgery that deal with working on hard bodily material, such as Penn Medicine. The most important defining characteristics of our potential customers are that they are lacking existing haptic solutions, they believe that haptic feedback is an improvement in the quality of surgeries performed, and that they are not looking to fully replace or re-invent their existing surgical robot.

While our initial segment is a very specific target, it is still profitable and makes up a large percentage of the surgical robotics community. Intuitive Surgical is the known dominant incumbent of surgical robotics and their flagship product, the Da Vinci System, does not have haptic feedback. There are over 5,000 Da Vinci Models currently in circulation in the United States[11]. In 2020, Intuitive Surgical was the global leader in the market for medical robotics and computer-assisted surgery with a share of 52%, followed by Medtronic with a market share of 10%. (BCCResearch, 2021)

Medtronic's devices have a focus on orthopedic and neurological surgeries, and thus we will be targeting their devices initially to gain market validation for VerroTouch. Medtronic has repeatedly received feedback from the orthopedic surgeons using their surgical robots that the surgeons are looking for more haptic feedback, specifically vibrational as they are working with hard bone material and vibrations translate that feeling the most accurately. (Avasthi, 2021) Dr. Sloane Guy, the Director of Robotic Cardiac Surgery at Thomas Jefferson Hospital, also mentioned that vibrational feedback would be most beneficial to working on these harder bodily materials, further validating this initial target segment. (Sloane Guy, 2021) VerroTouch will be able to capture the majority of the market for hospitals with robots that don't have existing haptic feedback, and would benefit from its addition.

Haptic feedback solutions in surgical robots currently only exist in customized, pre-integrated solutions such as those at Kawasaki Robotics. (Nolin, 2021) VerroTouch's unique offering of integrable haptic feedback helps in the creation of a new market segment that we can then take over and expand rapidly.[12] VerroTouch can be installed onto any tele-operated machine and requires no adjustments for integration and is easily installed onto any surgical robot post-manufacturing (Gewirtz, 2021). VerroTouch enables haptic feedback as an upgrade to existing equipment, increasing accessibility to haptic feedback, easing the transition from traditional to robotic surgeries, and is something that has been expressed to be valued by surgeons, such as Dr. Aseem R. Shukla, Director of minimally invasive surgery at the Children's Hospital of Pennsylvania. (Shukla, 2021)

VerroTouch succeeds in our integrability where our competitors fail. VerroTouch is highly accurate without needing to be installed into the robots during manufacturing. It can be added at any stage. Other competitors such as Medtronic Hugo that do offer haptic feedback offer it pre-integrated into their product, but this means hospitals with other robots such as the Da Vinci system would have high switching costs to gain haptic feedback. (Nolin, 2021) VerroTouch enables haptic feedback without a whole system replacement, providing a way to alleviate the

switching costs to gain good haptic feedback, which gives VerroTouch a distinct competitive edge.

VerroTouch's positioning with our target customer can be summarized with the following statement:

> *VerroTouch is the first external accessory to surgical robotic systems that provides realistic, low-latency haptic feedback in an integrative, self-contained product. We enable the surgeons to feel the long-desired sense of touch within robotic surgery.*

The segment of the large hospital market we chose as our early adopters are opinion leading hospitals that currently have surgical robots used for orthopedic and neurological surgeries without vibrational haptic feedback.[13] This is because, after initial market research, we found the end-users in this segment have the highest desire for vibrational haptic feedback, which is lacking in current orthopedic robots, thus the highest motivation to purchase VerroTouch. (Avasthi, 2021) VerroTouch differentiates itself by being the first on the market that is self-contained, low-latency, and realistic. (Kuchenbecker, 2016) It can be easily mounted onto any surgical robot without any concerns about software compatibility. It is self-contained because no additional hardware or software is required to use VerroTouch. All the differentiating factors are designed to appeal to our target users, surgeons, who are the main influencers in hospitals' purchasing processes.

Our main group of target customers, namely hospitals owning surgical robots such as Intuitive's Da Vinci or Medtronic's Hugo, are influenced by the Value Analysis Committee, research fellows, and c-suite. Among them, the Value Analysis Committee (VAC) is the biggest influencer. In the VAC, surgeons have the highest say in decision-making, so it is important that we market our products to the surgeons using surgical robots and win their support. Furthermore, hospital research fellows can also request the purchase of medical devices with their research budget, so they are another group of influencers. The C-suite ultimately holds the veto power to the purchasing decisions, so it is important to manage relationships with them. (Shukla, 2021) (Nolin, 2021)

We have collected significant evidence showing that our main target market, the hospitals and surgeons with surgical robots without haptic feedback, want our product. (Shukla, 2021) (Avasthi, 2021) Firstly, surgeons in hospitals with surgical robots without haptic feedback have expressed enthusiasm towards our technology and satisfaction with the haptic feedback VerroTouch provides. One of our surgeon interviewees, Dr. Aseem R. Shukla, has worked with previous iterations of VerroTouch and has remained very enthusiastic about its potential and usage in the industry. (Shukla, 2021) Additionally, 90% of surgeons who were surveyed thought having haptic feedback improves their surgical procedure, so we are confident that VerroTouch will be well-received by surgeons. (Penn Center for Innovation, 2016)

To transition between the early adopters and the early majority of the hospital segment, we will rely on word of mouth.[14] Hospitals are influenced mainly by word of mouth and the opinions of leaders within the community. VerroTouch will validate our effectiveness with these research leading hospitals, as these are the hospitals that not only influence the others in the medical community, but also are the hospitals that control their own funding for research, and thus can be more flexible with testing new technologies in the industry such as VerroTouch. Once the early adopters feel satisfied with the product, they will promote it to other hospitals because hospitals

have a strong network especially for sourcing and purchasing, as evident in many of the follower hospitals sharing one Group Purchasing Organization. (Macey, 2015)

We plan to enter a research partnership with these hospitals to receive market validation for VerroTouch and utilize these industry leaders' opinions to gain ground at hospitals across the country. This consists of us providing VerroTouch without cost to research hospitals such as Penn Medicine to use in their surgeries. We aim to develop a strong relationship with these influential hospitals and iterate upon our product based on their feedback so that we have strong supporters going into the general hospital market.

After achieving success within the United States market, we aim to expand our customer base worldwide, specifically in the Asia Pacific region (APAC). Market research that we have conducted indicates that the APAC region has a growing market for surgical robots. In Japan, for example, there were 183 da Vinci Systems installed by 2015, and there are about 400 surgical robots in Japan in 2020, and that number is expected to grow as more hospitals are adapting this new technology. (Nishimura, 2015) (Nature, 2021) Expanding into countries such as China, Japan, and Korea, VerroTouch can continue to expand our customer base and ensure continued influence over our market segment.

5.2 Revenue Model and Pricing Strategy

The revenue model of VerroTouch is split between two parts. The first part is direct sale to hospitals. This consists of selling self-contained products to hospitals where they can enhance their existing surgical robotics model with haptic feedback, without going back to the manufacturer or buying new products. Hospitals have already established strong relationships with different distribution channels. Local industry leaders have already demonstrated interest in such collaboration. (Shukla, 2021).

The pricing strategy echoes our goal of providing affordable haptic solutions to surgical robot solutions. Thus, the expected initial price of our product is $40,000 as we iterate on our product and make it more effective. This has been remarked to be reasonable by surgeons such as Dr. Paul Thodiyil of Mount Sinai Hospital. (Thodiyil, 2021) Through initial price point validation, we have received positive feedback at different price points, ranging from $10,000 to $80,000. (Shukla, 2021) (Spier, 2021) This information is also reflected when contacting the VP of Direct Sales at MIMIC, who expressed that our price range is also a reasonable price for hospitals which already owned surgical robotics systems. (Nolin, 2021) VerroTouch plans to start out priced at a lower point, and raise our prices as we release future generations of the product based upon user feedback of our existing models.

None of the existing industry leaders focus on providing haptic upgrades to existing robots.[15] In fact, they can be split into two categories based on their revenue models. The first kind are large companies, like Intuitive, who have a very concentrated market and process strong R&D ability. Note that these companies are also manufacturers of surgical robots. These companies collect most revenue through direct sale to customers. (BCCResearch, 2021) While they do upgrade existing generations of robots and could potentially have haptic features in the future, they still sell older models to developing countries like China, India, etc, which continues to open new markets for us. (Nolin, 2021) (Intuitive, 2021) Another set are smaller companies, who do most through strategic alliances, with inhouse R&D and outsourced manufacturing. These companies collect most of the revenue from licensing technology to bigger companies and collect commission out of alliances. (BCCResearch, 2021)

As observed above, there is limited comparison with other companies within the surgical robotics industry. VerroTouch is the first to market surgical robot accessory that is able to provide vibrational haptic feedback through a standalone solution. Currently, there is no solution that is able to enable haptic feedback for existing surgical robots with the same performance as affordable as ours. (Nolin, 2021) (Shukla, 2021) When an operating room wants to upgrade for haptic enabled surgical robots, they would either have to upgrade to newer versions, potentially different brands, of surgical robots, or they would have to purchase simulation devices with haptic feature enabled. Neither of the solutions resolve the situation like we do. (Shukla, 2021)

Purchasing a new robot is about $2 million, with negligible improvement on the surgical outcome, but only newer technology. (Crew, 2020) In fact, current market leader Intuitive's da Vinci System is not haptic enabled, and there is no solid information on whether the next generation will be haptic enabled. (Shukla, 2021) Alternative solutions like Hugo from Medtronics, or SenHance all have a price tag of about $1.5 million to $2 million. (Perez and Schwaitzberg, 2019)

The alternative of pursuing simulation devices with haptic features does not solve the ultimate problem. Doctors are still required to perform surgeries with only visual feedback, which is reported to be very different from the training in medical school. (Shukla, 2021) Such a solution is also expensive in nature. Research study suggests that even the cheapest solution out of dV-Trainer (dVT; Mimic Technologies, Inc., Seattle, Washington, USA), da Vinci Skills Simulator (dVSS; Intuitive Surgical Inc., Sunnyvale, California, USA), and RobotiX Mentor (RM; 3D Systems, Rock Hill, South Carolina, USA), is about $8,000, and does not change the actual operation procedure. (Hertz et al., 2018)

5.3 Distribution Plan

For our target market segment, namely large hospitals having surgical robots without providing vibrational haptic feedback, we will use a direct distribution channel. Our sales and R&D teams will be negotiating with the hospital's robotics research department to set up a system to utilize and evaluate VerroTouch at these hospitals. As we move beyond our initial adopters, our sales team will work with other hospitals' procurement departments to negotiate prices and contracts (Shukla, 2021). Additionally, we will use our early adopters' strong hospital network and influence to reach other hospitals more efficiently.

VerroTouch's manufactured, sterilized device will be shipped directly to our customers as it is not very large and can be delivered through traditional shipping methods without issue. Additionally, VerroTouch will also provide installation assistants to hospitals to help them install VerroTouch as necessary. VerroTouch is relatively simple to install, but requires a bit of knowledge about the product. Further R&D will be conducted to potentially eliminate the need for in-person installation assistance at all.

Overall, VerroTouch's distribution is very self contained and straightforward, given that most of the elements are handled in-house.

5.4 Advertising and Promotion Plan

Our key selling point is "Elevate your robotic surgery with accurate haptic feedback using VerroTouch." This message appeals to our potential customers by emphasizing that we are able to solve their pain point of lacking haptic feedback when using surgical robot devices. For our

customers to know the message we convey, we will be actively participating in media interviews related to healthcare to boost brand awareness.

We will be mainly utilizing word of mouth through the existing hospital networks to reach our customers. By establishing research relationships with large, influential hospitals, we can demonstrate VerroTouch's effectiveness and gain their approval and validation within the surgical robotics community. In our prototype testing, we would also want to utilize the power of UPenn's network (Nolin, 2021). By letting surgeons in Penn hospital and Children's Hospital of Philadelphia participate in the prototype testing, we will be able to spread awareness and appreciation of our product among the Penn Hospital's network through word of mouth.

After the research and prototyping stage is complete, we will additionally reach out to Group Purchasing Organizations -- which are an important nexus in the healthcare industry to connect healthcare providers and vendors to smaller hospitals that still utilize surgical robots. Their large network will help us bring our product to the market of hospitals that exist under GPOs (Healthcare, 2021). With the leverage of having backing from hospitals such as Penn Medicine, we will be able to effectively promote our product within these communities.

As we saturate the United States market, we will start to expand our customer spectrum to the Asia Pacific (APAC) market. We will leverage our success in the United States market in order to promote our product in the new region. Using connections between international hospitals, we will be able to gain contacts within major APAC markets. From this point, we will execute the same advertisement strategy of gaining the support of large hospitals before expanding into smaller hospitals by utilizing large hospitals' support.

5.5 Sales Plan

Our sales plan will incorporate a three-step process: initiating relationships with hospitals, transitioning into a larger market, and hiring large scale sales teams. This will allow us to sell our product efficiently and effectively as we start out, gradually growing our sales team as we go through our transition phase, and eventually, once we are established, hire more traditional salespeople (Leslie/Holloway 2014). In all three stages, we plan on selling VerroTouch directly to our customers.[16]

In our initialization stage, we will first be sold to local hospitals to build rapport with the medical community and will be selling our product by ourselves. With large, influential research hospitals being our early adopters, we can have our bench prototype reach an experimental market, being that of the local Penn Hospital community. By selling our product at a lower price to them, we can prove the effectiveness of our product as we go forward in our targeted sales. Next, we plan on selling our product by ourselves to these hospitals as we will be able to effectively market VerroTouch to our target consumer since we know our product's application very well. Since we are keeping our sales force between the five of us, we would require minimal training as we are already knowledgeable about our product and its benefits, positioning ourselves as effective salespeople as we start out. Finally, we would be individually packing our product, as it will reduce cost. Also, since hospitals do not have the technical knowledge of our product, we would be the ones to deliver and install the device onto their existing systems.

As we transition into the next market phase beyond our early adopters, we will have established a small market for our product being that of the hospital community. We plan on starting to sell our product to other hospitals beyond research hospitals by using our early adopter's good

opinions and network to reach further audiences. With our market established locally, we will begin hiring and training a small internal sales force to lead sales in other states, regions, and countries. As we begin to hire this sales team, we would want to recruit someone who is passionate about our product, being able to effectively convey its usefulness to a potential customer but also be receptive to the criticisms and needs that the product doesn't address. (Pipedrive, 2021) These traits are required in all salespeople that we recruit. In terms of training, we would need them to understand our product well enough to sell to robotics committee members and surgeon champions, convincing them that our product is a necessary requirement and is worthy of a portion of their budget (Nolan, 2021). Finally, we would hire installation and service technicians to install the product rather than have our core members or sales personnel perform the installation.

In our final stage, we will be established enough in the hospital community and surgical robotics industry to begin hiring traditional salespeople, providing expectations for their designated regions and training them on VerroTouch's sales plan, price book, and other needed marketing materials. (Leslie/Holloway 2014) These salespeople will be experts in the field within each region that we are marketing to with experience in the languages and customs of the area, especially as we move to international markets in the Asia-Pacific region. We will need to ensure that we are able to overcome any language barriers and have personal connections within the region. The sales force chosen at this point will be critical in our success in expanding to this region.

6 Operations

6.1 Scope of Operations

With our device already in its prototyping stage, we do not need to go through initial design and prototyping phases for VerroTouch. In terms of manufacturing, most components of our product can be bought off the shelf with the exception of the housing and custom made plastic molds as seen in our schematic flow chart for our business model in *figure 2* . With those parts ready, we will do the assembly process-in house, and package it to deliver to the customers, and help them with the installation. As we scale up, there will be a considerable amount of cost related to delivery and packaging and we will be considering a warehousing and distribution service from transport companies such as FedEx, to ensure a fast delivery speed for areas that we want to cover. However, with the option of partnering with surgical robot companies and simulation companies, we can also sell through their distribution centers so that we could save the cost of warehousing service. In the future, we will need a few experienced technicians to assemble the product. We aim for continuous R&D improvements so that we will need haptic experts to join our team. This R&D expenditure will also go into developing a second generation for our product in the fifth and sixth year of our operation. This second generation model will include updates made from the feedback we received from surgeons along with more precise feedback for soft tissue surgeries, a factor that generation one of VerroTouch does not take into account, widening our market[17]. We will also need more salesforce to travel around the world to explore the market in the west, in Europe, or Asia. The customer service is a crucial part too since we will be performing installations and after-sales service with our people so we will need more trained personnel for that.

For the first generation VerroTouch model, we will start with purchasing these components that are the same from VerroTouch's prototype, which is an accelerometer from Analog Device, a voice coil actuator from H2W Industries, and the main receiver takes the acceleration signals from the sensor clips and drives the corresponding voice coil actuators to replicate these vibrations for the surgeon to feel (Kuchenbecker, 2010). Those are the components we need to purchase from vendors and we will seek higher quality and lower cost alternatives if needed in the future. The only thing that is not off-the-shelf is the plastic mounting parts for the accelerometer and actuator, we intended to perform it in-house since it's not costly and not place-restricted.

There are multiple aspects of our competitive strategy with their order of importance being[18]:

Cost leadership: Our low-cost manufacturing model ensures we have cost leadership in the market. The components needed to make the VerroTouch system are very commoditized and easily accessible on the market. This gives us a lot of options to choose from. The in-house variable cost of assembling VerroTouch is also low, requiring only the work of a few technicians. (Kuchenbecker, 2016) Hence, we can provide this product at a price lower than any other future competitors

Specialization: We will start with a relatively narrow product line. We will specialize in building a self-contained haptic feedback system that is universally integrable to most surgical robots on the market. However, in the future, we will invest in R&D to develop more product lines.

Ancillary service: We will have a dedicated sales team, installation assistance, post-sale checkups and services, and constant feedback collection, as some of our key processes. The reason is we want to have a "dedicated personal assistance" relationship with our customers; secondly, selling to hospitals rely heavily on managing surgeons relationships; thirdly, having quality ancillary service allows us to differentiate ourselves from new entrants and earn loyalty, building a higher entry barrier.

Product quality: We will stay competitive by ensuring that our products are of the highest quality. The quality of our products is characterized by safety, reliability, precision, and low latency.

Distribution Channel: We are selling and delivering through our own distribution channel and in-house sales team. The reasons are: first, with the small community of robotic surgeons, one on one sales and communication is the strategy that would encourage hospitals to go with our product over others; secondly, since it is unlikely that the hospitals will bulk order our product, it is preferable to craft each set of our product to ensure high product quality; thirdly, the short distribution channel reduces unnecessary waste of time and resources; finally, it is easier for us to build deeper relationships and closely observe their needs to iterate our product.

Brand identification: we want to expand the sales to as many hospitals in the US and in the world as possible to establish VerroTouch as a premium brand in haptic feedback hardware. Firstly, brand identification creates a moat that deters competitors. Secondly, establishing our brand helps promote us through words of mouth and urges potential customers to look at us and consider our products, which helps achieve marketing objectives with little cost.

VerroTouch's focus on competitive strategy also echoes with our plan in building defensive positions against various stakeholders in the market. First, VerroTouch focuses on a relatively narrow product line. Our focus on providing self-contained solutions to enhance surgical robots helps us to provide differentiated and unique products that are different from what the industry has provided.[19] The high level of differentiation also helps us to stand out from potential substitutes. None of the current haptic solutions to surgical robots is as low-cost and easy to install as ours, while most of the solutions don't really resolve the issue. These solutions are mainly haptic enabled simulation programs. (Nolin, 2021) (Shukla, 2021)

We also set barriers to new entrants who come later to this market. VerroTouch has identified the unique problem of providing doctors long desired haptic feedback with a low-cost solution. Our strategy aims at long term, continued investment in R&D, that further helps to provide technological advantage that is hard to achieve by new entrants.

Our cost leadership strategy also helps us to build defensive positions from the customers and suppliers' bargaining power. First, as mentioned above, the components that are needed to produce VerroTouch are very flexible and are generally very accessible in the electronics market. This allows a very low switching cost from one component supplier to another. Therefore, it decreases the bargaining power manufacturers or suppliers would usually have. If any of the suppliers have decided to raise the price, we can easily switch from one to another, with minimum effects on our product delivery timeline. This defensive position is further fortified by applying our in-house manufacturing strategy. This relieves us from strong and dependent relationships with one to few particular manufacturers. Rather, it makes us really flexible and responsive to raw material price change, which helps to sustain the product cost at a low level.

Our focus on product quality also serves as an important resolution to decreasing the bargaining power of the consumer. In fact, there are a couple of aspects in our operation strategy that are associated with making ourselves more valuable to our customers. Beyond the fact that our product is self-contained and offers a unique solution with a low price, our product also looks at a wide spectrum of users. Our marketing plan looks at both hospitals who are our direct customers and at simulation and surgical robot companies who sell various accessories to their customers. One of our revenue streams as mentioned before, is licensing to these companies and collecting commission out of their sale. This means that none of our clients would take a majority of our sales.

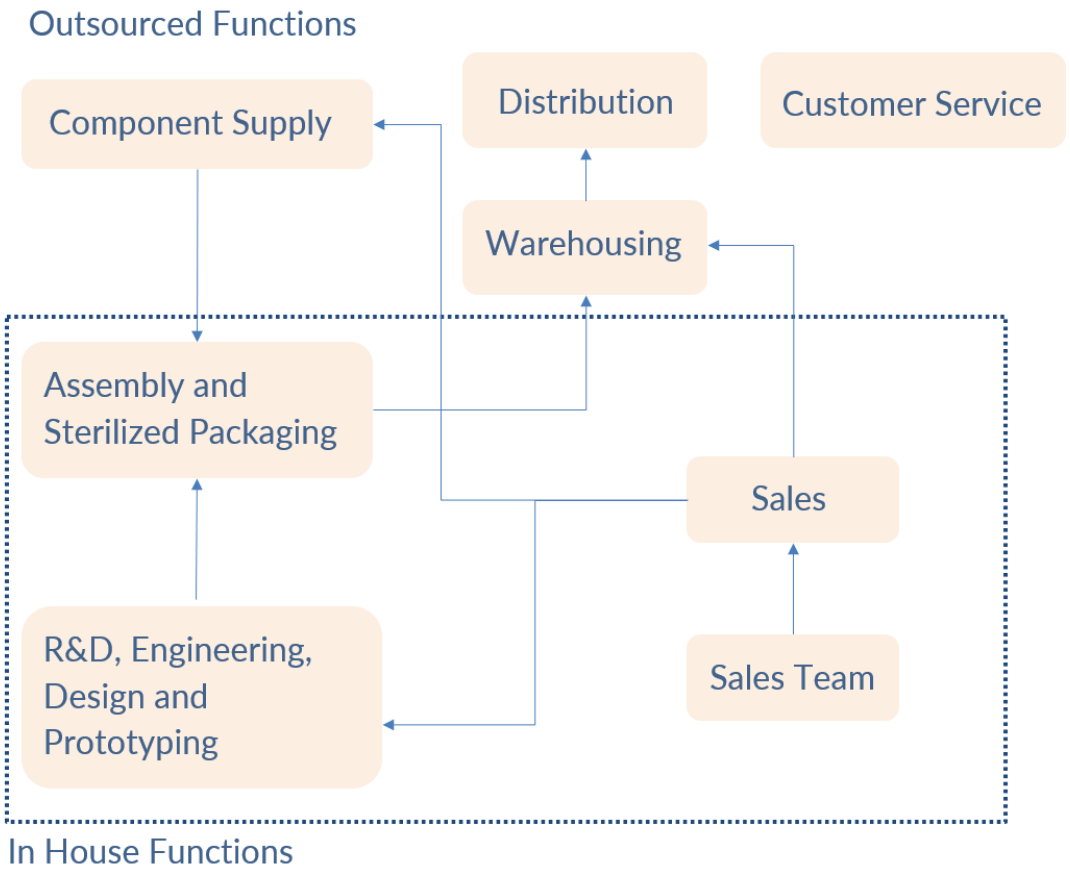

Figure 2: Schematic Flow Chart for our Business Model

6.2 Scaling Operations

As our company's operations begin to grow, we aim to add three activities that will assist in the growth of VerroTouch.[20] First, we will establish more partnerships with established surgical robotic companies. We will licence our technology to these companies so that companies such as Intuitive and Surgical Science could fully integrate our technology while maintaining the safety in their machinery (Hurst 2021). Second, we will fund more R&D in our company, creating a suite of surgical robotic accessories that would compliment our brand, so we can successfully establish a long tail business model. Finally, we aim to build up our consumer base and loyalty through more marketing endeavors and facilitating the growth of our VerroTouch Community.

Additionally, we must modify our decision making and on-boarding processes at VerroTouch. We must train service technicians to successfully install VerroTouch onto existing or new systems, minimizing the time it takes to effectively and safely teach the installation process to our employees. The quality of our new hire process must be immaculate since our product must not malfunction due to improper installation and calibration. With regards to decision making, we want to minimize the number of decision makers for a given department[21]. While we are currently able to effectively make decisions as a group, as we scale VerroTouch formal reviews should be conducted by only one of the five chief officers depending on the subject matter.

As stated earlier, the functional positions that we will develop in VerroTouch will be a more segmented departmental approach. Each chief officer will eventually take on more responsibilities and more employees. Our horizontal and vertical expansion will effectively organize roles at VerroTouch. However, with this expansion comes the risk of losing the entrepreneurial culture we currently have[22]. Our main concern would be maintaining the same communication and partnership that we currently have as a startup. By maintaining communication, individual departmental goals within the company would not outweigh each other, leading to a collaborative, entrepreneurial environment that would permeate through all employees at VerroTouch[23]. We want to hire those who are willing to make significant contributions to the company and not sacrifice their individual ideas, something that could lead to hive mind mentality and eventually failure in the company.

7 Development Plan: Activities and Milestones

We plan to track and monitor our progress by setting milestones that signify important transitions or phases of our company.[24] We roughly separated our journey into two main sections – business initiation and business expansion.

The initiation part includes milestones 1 through 5, where we perform concept testing, prototyping, and market testing. At the point we hit milestone 1 in 3 months, we intend to finish concept and product testing. We are validating surgeons' needs with surveys and initiating research programs with hospital surgeons. Some more detailed tasks would involve securing a license, initiating joint research opportunities between surgeons, and a large amount of personal selling, surveying, and interviewing with subject matter experts which helps us to provide a better idea of the product. It must be noted that we plan to perform concept testing in a wide range of surgeries that involve surgical robots to confirm that there is a wide need for our product. However, we would select some areas as the starting point for our joint research program, as the current survey shows the strongest need amongst surgeons in this field. Once we hit milestone 1 we would start looking for R&D talents, bring in one or two technical experts to the company, which prepares us for continued R&D and future product improvements.

The second milestone is the point we finish our prototype, this builds on the result of our extensive survey with subject matter experts. The key events here are product modification, financing projection, and starting to reach out to suppliers. The projected time for this is about 3 months. By the end of prototyping, we would start to file 510(k) to achieve FDA clearance using the first generation model, as we will be unable to use a prototype to achieve FDA clearance[25]. The projected time for that is 150 days, which will go concurrent with the next milestone.

The next milestone is when we would finish the first financing round. The key events here are preparing for investment, seeking venture capital investment. In the end, we want one investment round to close. We expect this to take 3 - 4 months. It must be noted that at this point 510(k) should settle from the FDA, allowing us to legally sell our devices. We will start our alpha testing, as soon as FDA clearance settles.

The 4th milestone will hit when we settle with our supply chain. We will have a standardized way of sourcing from component suppliers, assembling the product, and fixing it with our packaging and delivery plan. At this point, we would finish standardization of product manufacture end-to-end and have office sites scouted and fixed. Essentially, the company should be ready to run from an operational standpoint. This is projected to take 3 months to settle.

The 5th milestone concludes the business initiation phase, in this phase we want to be actively involved in personal selling, reaching out to hospitals, and marketing our product. Our initial joint research with hospitals would most likely have papers published by then, which helps to increase the validity of the product and assist with marketing. We would have built a small batch of products and have them sent to interested hospitals to collect feedback on pricing, performance and purchase intents. This helps us realize what level of market share is realistically achievable by us. We will also know our product's position among other competitors in the market. This is expected to take 10 months. By the time we hit the milestone, we will be finishing our market testing and making the final tune to the product. We would also collect results from alpha testing, and finish beta testing, before the milestone hits. Our product should be final for the first large batch, as we hit a milestone.

The next 5 phases are about business scaling. First, we hit the milestone of a production startup. Therefore, we would perform inventory accumulation before the shipment of the product began, so we can stick to the delivery commitment we made without compromising the product quality. We project this to take about 6 months. This is also the time we get prepared for the next few phases of the business expansion. At this phase, we actively start acquiring talents who fit the company's values and are willing to contribute. By the end, we are expecting to complete personnel hiring, and have adequate inventory for the first batch of customers.

The next two milestones involve getting the first large batch order settled and seeing how the existing incumbents respond. We intend to achieve these two milestones concurrently. Before we start selling, we should be planning for potential actions incumbents would take. This would take about 1.5 years. The last two milestones would hit, as we are receiving feedback from customers, when we revise the product characteristics. Further, it is also the time we expand our market landscape, we would be starting to do marketing research again for surgeries beyond our initial focus, iterate on product design, and make necessary adjustments to the marketing plan, product feature, and price. This would take around 2 years as we scale up the business.

To make our business model work, we will need a strategic alliance with the surgical robot, reaching agreements with them on licensing our product and integrating into their manufacturing process. We will also need employees and haptic experts added for our hospital-target product lines, in-house assembly and installation, and customer service.

Securing the license of VerroTouch from Penn and finally obtaining the ownership is the critical path of our timeline. The ownership transfer is also important for us since we cannot license our product to our potential partners if we don't own this patent and that will significantly impact our scale up process (UpCounsel, 2020). The FDA clearance process is also critical for us. We identify our product as a low to moderate risk medical device belonging to Class I or II which needs to file 510(k) (Center, 2020), a premarket notification. We need claims of substantial equivalency for marketed medical devices to do that. Currently we found Senhance surgical robot system, which is new on the market, and is equipped with haptic feedback (FDA, 2017). The projected time for FDA clearance is 150 days. However, if we fail to prove substantial equivalency or the FDA does not consent to it, we will have to detour to the de novo path after receiving FDA's response to our 510(k) submission. From the initial submission of 510(k) to the approval of de novo takes approximately 480 days (Dures, 2014), which would significantly delay our market date compared with 510(k) clearance.

The risk for us is the competitive landscape with large incumbents. For example, if we sell directly to hospitals bypassing the Intuitive, the hospitals and us need to take the responsibility for machine safety maintenance, because this has the high risk of void intuitive warranty policy (Hurst, 2021), which is very pricey and needs to be paid every year. This will decrease the buying intention of hospital groups.

The alliance will help us tackle a lot of problems such as brand advertising, the distribution channels, and ancillary services. Alpha/Beta testing at an early stage would help us build some data to prove the effectiveness of our product in a clinical setting. Our activities including the sales and advertising strategy would help us establish a solid message of specific customer segmentation, which will defend the force coming from the substitutes and buyers. Conducting continuous R&D would help us deal with the new entrants in the market.

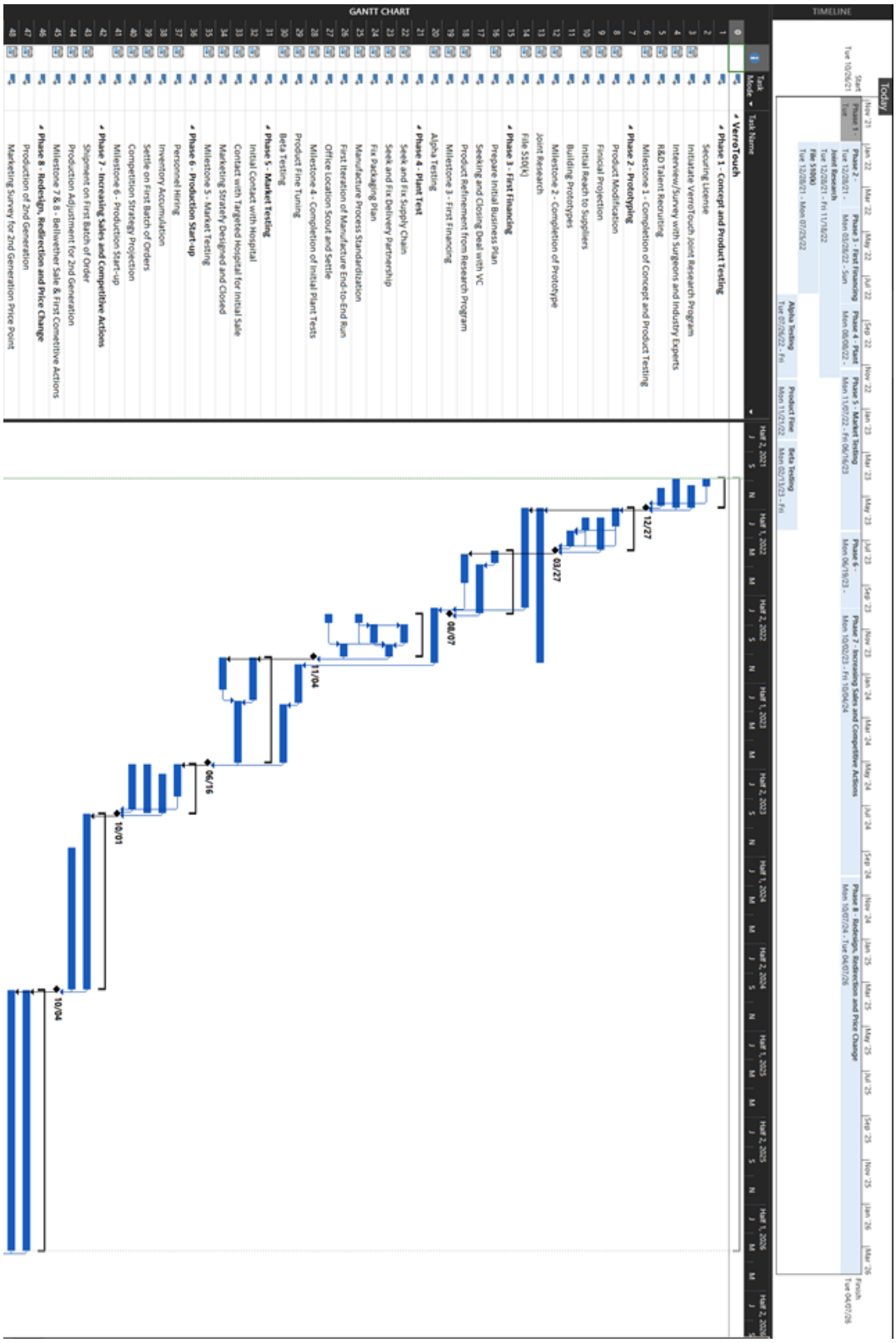

Figure 3: Schematic Flow Chart for our Business Model

8 Management

8.1 Company Organization

VerroTouch follows a mainly horizontal organizational structure, as observed in Figure 4 below. The board of directors along with the CEO will guide the main direction of the company. The board of advisors plays a secondary advisory role to the company at that same level. VerroTouch will benefit greatly from a separate auxiliary Board of Advisors as there are many aspects of the surgical robotics industry that we will need to permeate such as hospitals, manufacturers, sales, and more. Advisors will serve to bring ties and necessary knowledge about these aspects of the industry to VerroTouch without requiring the expenses or time commitment that being a member of the Board of Directors would require.

Beyond the CEO, the organization follows a more horizontal structure with the Marketing, Financial, Operations, and Technology officers each heading their own distinct departments, then reporting decisions back to the CEO.

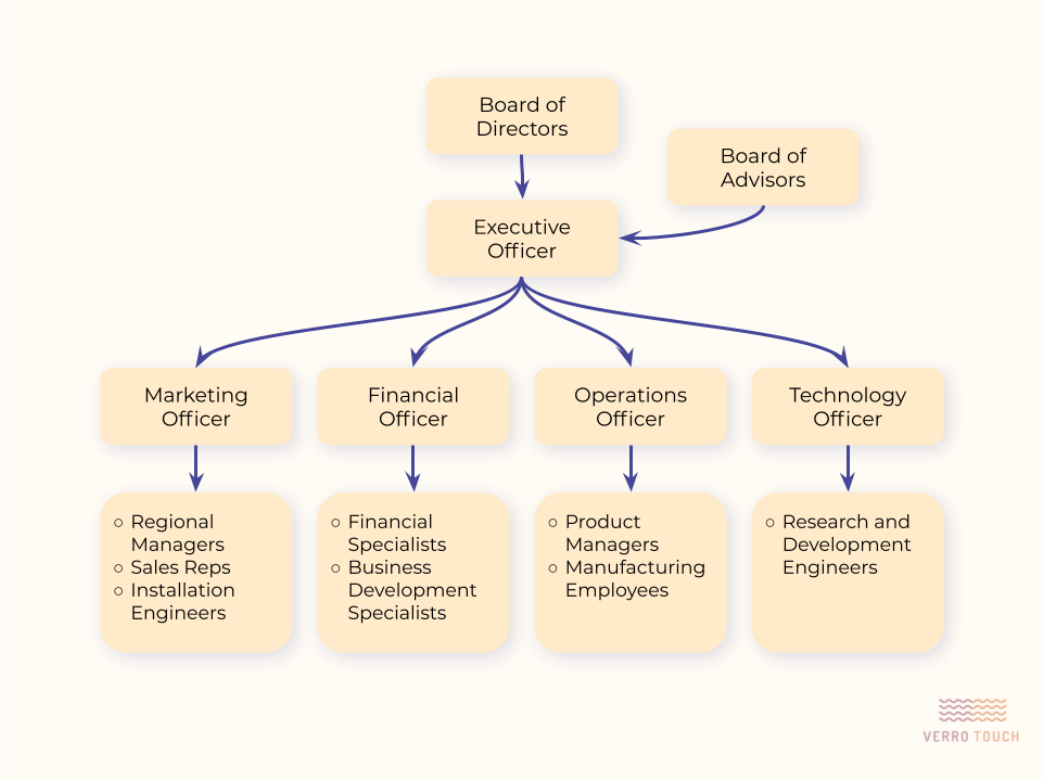

Figure 4: VerroTouch Company Organization Structure

The ownership of VerroTouch will start out distributed between the founders, with the board of directors also taking a small percentage of ownership as well. We plan to have a five-person board of directors, including the CEO, who will each receive 1% of the ownership of the company. The VerroTouch founders will each receive 19% of shares to start out, with the CEO receiving both the founder shares and the board of directors share, resulting in 20%. As VerroTouch takes on additional investors, the ownership of the owners will be diluted to accommodate for the shares given to the investors.

8.2 Management Team

Our five core leaders are Estee Chen, the Chief Executive Officer, Brian Brimaldi, the Technology Officer, Meng Lei, the Operating Officer, Anyka Chan, the Marketing Officer, Zhiyao Tang, the Financial Officer.

The primary responsibilities of Estee Chen, the Chief Executive Officer, are strategic planning of the company's developmental roadmap, outreaching to and building relationships with partners and allies, and managing the internal structure and external relationships. Estee's unique skill is strategic thinking and startup management & analysis from her previous VC internship and startup experience. Her annual compensation level is $120,000.

The primary responsibilities of Brian Grimaldi, the Technology Officer, are overseeing the research and development of existing and new product lines, managing the R&D engineer team, and managing the technical knowledge and its sharing within the company. Brian's unique skill is his technological expertise from his engineering and robotics background. His annual compensation level is $100,000.

The primary responsibilities of Meng Lei, the Operating Officer, are overseeing the production of VerroTouch's products from procurement to delivery, detailed planning, and execution of VerroTouch's developmental plan, and managing the product and field application engineer team. Meng's unique skill is her experience and academic background in pharmaceutical development and legal processes. Her annual compensation level is $100,000.

The primary responsibilities of Anyka Chan, the Marketing Officer, are overseeing the sales marketing and post-sales team, and managing media, public, and customer relations. Her unique skill is her experience in marketing from previous marketing roles in Penn organizations. Her annual compensation level is $100,000.

The primary responsibilities of Zhiyao Tang, the Financial Officer, are managing VerroTouch's finance and budgeting, making plans for VerroTouch's funding, and managing VerroTouch's business development team. His unique skill is his prior experience working with technology startups which involved the financial aspects. Her annual compensation level is $100,000.

Additional employees we will hire are a Product Manager, a Lead Field Application Engineer (FAE), a Lead R&D Engineer, a Sales Manager, a Marketing Manager, a Financial Specialist, and a Business Development Specialist. We plan to hire them after we secure our first round of financing. The salaries for the product manager and the two Lead Engineers are $85,000, and the salaries for all the other managers and specialists are $65,000.

8.3 Advisors and Board of Directors

Our board of directors will consist of five members, Estee Chen, the CEO of VerroTouch, Katherine J. Kuchenbecker, Director at the Max Planck Institute in Haptic Technologies, Steve Davis, Medical Products Executive that has close knowledge of the VerroTouch Technology, Bryan Nolin, Director of Healthcare Sales at Aeroclean and Ex-VP of Mimic Technologies, and Thomas Sloane Guy, Professor of Surgery at Thomas Jefferson University. We will also have an advisory board consisting of two members, Michael Hurst, a research engineer at Facebook Reality Labs and Ex-Design Engineer at Intuitive Surgical, and Jamie Gewirtz, an R&D manager at Portescap and researcher who developed VerroTouch at the University of Pennsylvania in its early stages. Based on previous standards, we will compensate each member on the Board of Directors $60,000 annually and compensate each member on the Advisory Board $20,000 annually. (Fontinelle 2021)(AdvisoryCloud 2015). Shown in table 1 below are the credentials and connections that each member of our board has.

With our board of directors and advisory board having backgrounds that span robotic and haptic engineering, sales, marketing, practical surgical robotic expertise, and entrepreneurial endeavors in the medical industry, we would be able to confer with these members on what the best decision would be as we grow our company, establish outside connections with their contacts listed above, and bring our product to an ever-expanding market.

Table 1: VerroTouch's Planned Board of Directors and Advisory Boards

Board of Directors	**Current Position**	**Past Positions**	**Expertise**	**Connections**
Estee Chen	CEO of VerroTouch	Business Analyst, Program Manager Intern, Software Engineer Intern	Computer Science, Engineering Entrepreneurship	McKinsey, Sequoia Capital China, Microsoft, NVIDIA
Katherine J. Kuchenbecker	Director at Max Planck Institute: Haptic Technologies	Adjunct/Associate Professor at the University of Pennsylvania	Haptic Interfaces/Technologies, Mechanical Engineering	Intuitive, University of Pennsylvania
Steve Davis	Medical Products Executive	Co-Founder and CEO of VerroTouch Medical	Entrepreneurship, Surgical and Interventional Devices	Connections within the Medical Industry as a whole
Bryan Nolin	Director of Healthcare Sales at Aeroclean	Vice President Direct Sales at Mimic Technologies; Clinical Sales Manager at Intuitive Surgical	Sales, growing disruptive technologies within challenging markets	Intuitive,Mimic
Thomas Sloane Guy	Professor of Surgery at Thomas Jefferson University	Director of Robotic Cardiac Surgery	Medicine, Robotics, Business	Medical Community in Philadelphia, Atlanta and Ithaca, NY

Advisory Board	**Current Position**	**Past Positions**	**Expertise**	**Connections**
Jamie Gewirtz	R&D Manager at Portescap	Design Engineer at Micro Interventional Devices, developed VerroTouch in early stages	Robotics, Medical Robotics	Portescap (Leading manufacturer of miniature motors
Michael Hurst	Research Engineer at Facebook Reality Labs	Mechanical Design Engineer at Intuitive Surgical	Robotics, autonomous vehicles, product design	Intuitive, Facebook, Intel

9 Financial Plan

9.1 Sales Forecast

Table 2: Revenue Forecast of VerroTouch in next 7 Years

Revenue Projections	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**
Unit Sold	0	0	49	95	179	407	800
Price per Unit	$0	$0	$4,000	$4,000	$5,000	$5,000	$5,000
Net Revenue	$0	$0	$1,960,000	$3,800,000	$8,950,000	$20,325,000	$40,000,000

Based on our interviews with surgeons from different backgrounds, who would be the end user of our product, their attitude towards our technology can be categorized in two ways. One believes the haptic feature would be helpful in both speeding up training progress and improving clinical outcomes (Shukla, 2021). The other emphasizes that for an experienced surgeon with trained "visual haptics", our product would be a "nice-to-have feature" while uncertain about its clinical value, but confirms that our product will be helpful with the training progress for new surgeons (Sloane Guy, 2021) (Davis, 2021).

We can predict an innovation coefficient and imitation coefficient based on the information we gathered from the surgeons. Our diffusion model can be compared with other innovative medical devices at their time, since we are facing a similar regulatory process and attitude from the end-users (Sillup, 1992). We observe a trend of low innovation coefficient (p) and high imitation coefficient (q) generally within the medical device industry of durable medical equipments, supporting by the value of Ultrasound imaging ($p = 0.001$, $q = 0.51$), Mammography ($p = 0.000$, $q = 0.738$), and CT scanners ($p = 0.034$, $q = 0.254$) (Ganjeizadeh, 2017)(Sillup, 1992). We are using a weighted coefficient with p value of 0.017 and a q value of 0.439 of the above to reflect the low initial acceptance and high imitation rate. These values are based on the values presented for Ultrasound imaging and CT scanners.[26]

With these values, we project that within a 6 year time frame we will cover 10% of the hospitals that have intuitive systems installed world wide. We present our argument in the following sales projection. The calculation is based on the fact that there are 3581 base installment in the US by quarter 2 of 2020, and 800 base installment in Asia by quarter 2 of 2020. (Surgical, 2020) We project conservatively assuming that there will not be any increase in the base installment year to come. (Surgical, 2021) In reality, we should see sales larger than projected, as the market continues to boom. (BCCResearch, 2021) (BCCResearch, 2017)

The first batch of initial sales plans to go to hospitals within the university of Pennsylvania network. These sales, however, do not generate revenue as they are devices we used to "give" to the hospital in the joint research program. This helps to boost our branding image and validity, at cost of revenue. The hospital we are considering consists of the presbyterian medical center, children hospital of Philadelphia, and Thomas Jefferson University of Hospital. (Intuitive, 2021)

Our projection is based on the number of hospitals with a da Vinci System, as it is typical for a hospital to have only one da Vinci system, given it is a million-dollar investment with recurring cost on accessories. (Crew, 2020) This helps to test projections from publicly available data.

For the real first batch of sales goes to hospitals in the 100 miles region of Philadelphia. Out of the 116 hospitals in the region, we expect to see 30% of them adopting our product at introduction, based on our initial marketing survey.(Shukla, 2021) (Spier, 2021) This corroborates with our projection of 49 units sold in year 3. (Intuitive, 2021) This is also consistent with our business operation timeline, which indicates bellwether sales by year 3.

The sales are based on geographical closeness, as we are selling delicate artifacts with high value to the customer. It is paramount for us to provide support to the customers onsite, which constrains us on close geographic regions, for the first 4 years of the company. Selling at close geographical cost also saves us from high transportation costs.

In year 4, we expect to expand our sales, from 100 miles radius to 500 miles radius. This includes another 302 hospitals with the da Vinci System. (Intuitive, 2021) Again, we assume 30% of hospitals would adopt the technology upfront, which gives us 112 hospitals to sell new products.(Shukla, 2021) (Spier, 2021) This again corroborates with our model which projects 95 units sold by year 4.

At this point, we will be collecting information and feedback from hospitals that we have sold products to. As indicated in our timeline, we will be initiating the development for the second generation of the device, which aims at addressing other types of surgical robots beyond the da Vinci system.

Research indicates that the Asia-Pacific (APAC region) has a growing market for surgical robots. In Japan, for example, there were 183 da Vinci Systems installed by 2015, and there are about 400 surgical robots in Japan in 2020, and that number is expected to grow as more hospitals are adapting this new technology. (Nishimura, 2015) (Nature, 2021) Similar situation happens in China. In 2011, the central government published its 15-year plan, indicating that robots should be used to support society in a wide range of roles. Since then, there has been a rising demand for surgical robots. In fact, 59 new da Vinci Systems will be installed in China in 2019 alone, rising from 8 in 2018. (Zhou, 2020) (O'Meara, 2020) We also acknowledge the fact that Intuitive, for example, sells older models to the APAC region, which confirms the lack of haptic feedback feature creating a bigger need for our product. (Shukla, 2021)

All of the above indicate a huge market existing in the APAC region. By opening to APAC areas especially in large countries like, Korea, Japan, India, and China, we project a strong increase in sales. Therefore, by year 5, we would like to expand our salesforce to the entirety of the US and also APAC market.

Further, we would also have finished a two-year development on the second generation 2 of the product, which is designed to fit more types of surgical robots beyond the da Vinci System. At this point we would be raising our price from $40,000 to $50,000. This is an increase that is deemed to be reasonable based on our interview and survey with industry experts. (Shukla, 2021) (Nolin, 2021) (Spier, 2021)

Based on the number of hospitals currently having the da Vinci system, we project 179 new pieces being sold across the US and APAC market. A number of key events by year 6 would help

to further increase the sales. First, we would have been engaging in a joint research program with hospitals for 6 years with a number of publications on our technology, this helps to build a strong image of our product.

Since we have established brand image in the APAC and North America region, we predict a strong sales of 407 units. This is consistent with the Bass Diffusion Model that is used to predict the sales achievable, given that there are more than 3581 da Vinci Systems in the United State by Q2 2020 (Surgical, 2021) (Surgical, 2020), and there exists a growing trend of adopting surgical robots throughout the APAC region as presented above. (O'Meara, 2020) (Nature, 2021)

As the company scales up, we also plan on including recurring revenue streams. In particular, we are looking at subscribed customer service, and disposable components.

9.2 Financial Forecast

[27]Following our exponential growth in our sales, VerroTouch plans to appropriately scale as a company to match our expected sales. VerroTouch plans to start out with research partnerships with local hospitals to verify our usability and make any final adjustments before fully going into market. Thus, our first sales will occur in Year Three with expansion into the Asia-Pacific territories occurring in Year Five with our second generation model. This will ensure our continued growth in our potential market (Nature, 2021) and thus total product output.

Beyond matching sales proportions, VerroTouch has also been careful in taking other effects into consideration. We account for inflation in our forecasts through annual salary increases for all employees that cover both inflation and performance bonus (Miller, 2021). We plan to release new models with price bumps that will cover the cost of inflation as well as the increase in value. This is due to the fact that the community that we are servicing is a relatively small and prudent community, adjusting pricing annually by small amounts is not consistent with our co-creating customer relationship and value delivery business model. Within our first six years of operations, we plan to release our second generation in year five, which will come with a large price bump to cover new facilities, equipment, and personnel. Additionally, VerroTouch plans to match similar companies within our industry (NAICS 339112, Surgical and Medical Instrument Manufacturing) in order to verify that we follow industry expectations.[28]

Below, in table 3, we have outlined VerroTouch's plans for personnel expansion. In most categories, you can observe growth through years 2 through 6 in order to meet our growing customer base. However, we don't quite match the same exponential velocity as our sales because as employees work within the company for longer, their customer capacity will also increase.

Table 3: VerroTouch Staffing Schedule

General & Administration	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
Executive Officer	1	1	1	1	1	1
Financial Officer	1	1	1	1	1	1
Technology Officer	1	1	1	1	1	1
Marketing Officer	1	1	1	1	1	1
Operating Officer	1	1	1	1	1	1
Accounting	1	1	1	1	1	1
Secretarial	1	1	2	2	2	3
Human Resources Manager	0	0	0	0	1	1

Sales & Marketing	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
Sales Manager	0	0	1	1	2	2
Marketing Manager	0	1	1	1	1	1
Public Relations Manager	0	0	1	1	2	2
Sales Reps	0	0	2	4	7	10
Customer Service	0	0	2	2	4	5
Marketing Associate	0	0	1	1	1	1

Research & Development	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
R & D Manager	1	1	1	1	2	2
Engineers	3	4	4	5	6	7
Technicians	1	2	2	2	3	3

Cost of Goods Sold	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
Manufacturing Manager	0	1	1	1	2	3
Manufacturing Analyst	0	1	1	1	2	3
Quality Control Manager	0	1	1	1	2	3
Quality Control Technician	0	1	1	1	2	3
Procurement Manager	0	1	1	1	2	3
Procurement Analyst	0	1	1	1	2	3
Operations Manager	0	1	1	1	2	3
Operations Analyst	0	1	1	1	2	3

We recruit R&D personnels up front in year 1 to prepare for the joint research program that we would develop subsequently. We lean on the staffing as our product is highly focused and localized, which would only need a small number of engineering experts to improve the product based on our feedback from doctors who participated in the program. Excessive staffing at this stage would add inefficiency.

Our first personnel increase happens in Year 3 when we stop focusing on our research partnership and go into the general market. It is observable that most growth in staffing numbers happens in year 5. This is due to VerroTouch's plan to release our second generation model and expand into the Asia Pacific region. It makes logical sense that our personnel numbers scale to match our new demand as well. These are especially observable in the Sales & Marketing as well as the Research & Development headcounts. As mentioned previously, these personnel are a growing cost not only because of the increase in headcount, but also due to planned annual raises of 4-5%, depending on how critical the role is to the company.

In general, VerroTouch does not need to produce a large quantity of products, especially in the first few years of business, thus our equipment expenditures don't need to be very high.[29] Our initial manufacturing equipment expenditure will occur in year 2, to prepare for our product release to the general market in year 3. VerroTouch plans to expand our research and development programs in year 3 in order to start designing and testing our second generation model. Therefore, we have a second large manufacturing equipment expenditure occurring in year 4, to produce our new product model.

In year 5, VerroTouch's expansion to the APAC market will mark a significant increase in facilities and personnel costs. Expanding into overseas markets rapidly and efficiently will be time and resource consuming. All expenses face a large increase in this time frame. However, we plan to be able to fund all of these expenses through previous financing rounds and our built up revenue from years 3 and 4.

Other small expenditure decisions to make note of include our office equipment timeline. VerroTouch plans on having our first few employees work from personal laptops for the first year, and expanding to having office equipment and company bought computers in year 2.

9.3 Funding Requirements

[30]At the beginning of our business, each of us in the founders team will invest a founders' investment for 10,000 dollars, in total 50,000, to fuel the first production of our prototypes and the compensation for ourselves while we actively search for the first round of financing. This early input will also get us some monetary inputs rather than just sweat equity, which would be hard to evaluate when new capital comes in.

[31]In the first year, we will go for the first round of investment at $2,500,000 with preferred equity. This investment will facilitate the activity of the joint research programs and related salaries of R&D personnels. We would hit the milestone of prototyping and FDA clearance with this investment.

The second round of financing is aimed to achieve in the second year with $5,700,000 preferred equity. In this year we will start our marketing activities and build the production capacity. This includes hiring manufacturing personnels, renting the manufacturing plant and purchasing new machines. At the same time, our R&D department will be expanded to publish papers for the joint research and finalize the first generation of the product that is to be launched in year 3. However, we do not plan to draw all $5.7 million all at one time. Instead, we would draw $3.55 million by year 2, and $2.15 million by year 3.

While to $3.55 million is meant to cover the aforementioned cost in year 2, the $2.15 million in year 3 helps us to achieve a bellwether sales, which is selling to the hospitals within the 100 miles radius region of Greater Philadelphia Region. A lot of expenditures will be for the sales team building, marketing activities. At the same time we will start developing the second generation of VerroTouch, so there's a large addition to the R&D cost on lab renting and new equipment purchasing.

This allows us to secure a larger investment easier than closing a $5.7 million investment directly, as it allows VC to monitor our performance and make investment decisions, while we are able to keep positive cashflow year to year.

In the fourth year, the major milestone we will be hitting is the first bulk order. We will continuously work on R&D for the second generation, also working on marketing activities to get ready for opening the APAC market in year 5. In this year we will go for the third round of financing of $2,600,000 preferred equity and that will give us enough cumulative capital to operate the activity from year 4 to our final exit. This small investment is due to revenue from year 3's bellwether sale and we will be riding the projecting exponential growth as of year 4.

We plan to draw $1.6 million in year 4 to cover the hiring expenses that we have to pay prior to opening the APAC market, and then, we draw the remaining $1 million to cover for the continued expenses of expanding our market reach.

[32]From our cash flow, we can see that we were able to realize a positive net earning and an increase in cash in year 6, which means we will be majorly using the venture capital from year 1 to year 5.

10 Offering

10.1 Investment Requirements

In total, we are seeking three rounds of investments in years 1, 2, and 4. In the first year, we will source the Series A investment for $2.5 million with preferred equity. This investment will facilitate the activity of the joint research programs and related salaries of R&D personnel. We would hit the milestone of prototyping and FDA clearance with this investment.

In the second year, we are raising $5.7 million from series B, drawing $3.55 million in year 2 and $2.15 million in year 3. In year 2, we are hitting the milestones of production capacity build-up and the completion of the market test. The money will be mainly spent on building the production capacity. This includes hiring manufacturing personnel, renting the manufacturing plant, and purchasing new machines. At the same time, the R&D capacity will be expanded to finalize the first generation of the product that is to be launched in year 3. In year 3 we are taking $2 million and this investment will be majorly used on marketing activities to hit the milestone of bellwether sales while starting the product redesign with R&D activities on that.

In year 4 we will raise the series C for $2.6 million, withdrawing $1.6 million to manufacture the first bulk order and design the second-generation product. This year we are investing heavily in marketing and research, getting ourselves ready for opening to the APAC market. In year 5 we are drawing the last $1 million to fuel the milestone of the first retaliatory action, which is opening to APAC. This will be costly but since we are still working from a US base, the personnel will be added while there won't be a lot spent on renting new plants or offices. Our R&D capacity will be completed this year, getting ready for the next generation design.

10.2 Exit Opportunities

We intend to go public with an IPO at year 7. IPO would be an important path for us to build customer credibility and will increase our publicity. With more publicity, we are able to achieve more market shares. On top of that, IPO will be providing us more cash to fund our future strategic plans, namely more R&D that allows VerroTouch to be compatible with different types of surgical robot models, with enhanced haptic technique, and partner with surgical robot or simulation companies to establish some joint products that equipped with our product. Although the IPO process will be very costly and time-consuming (Cook, 2021), we decided to go for this IPO investment for further growth of the company and to push for a higher valuation, and we will be able to devote ourselves to this process since in year 7 we will have a stable established profit and a build-up capacity for sales, manufacturing, and R&D.

10.3 Valuation of Business

We estimate the value of our company at exit using the P/R ratio method. We plan to go public in Year 7, and from our financial workbook, we project the revenue at Year 7 to be about $40 million. This is because in Year 6 our revenue will be 20 million, assuming our sales and revenue double in Year 7, given that we are rapidly penetrating the US and Asia market. We also estimate

a P/R ratio of about 8. Hence, the value of VerroTouch upon exit is about $40 million * 8 = $320 million.

While estimating the P/R value of VerroTouch, the medical supplies & equipment industry average information is also taken into account. According to CSIMarket, the industry average P/R ratio from 2020 to 2021 is about 8. (CSIMarket, 2021)

We also take into account comparable young high-tech companies as references, such as ShockWave, Minerva, and NeuroPace. However, since there are hardly any companies with similar business models or target market segments, their P/R ratios will just be lightly referenced and the industry average P/R ratio will be the major estimation ballpark.

Minerva Surgical is a 10-year-old medical device-making company that just went IPO last month. It focuses on developing, manufacturing, and commercializing minimally invasive solutions to meet the uterine healthcare needs of women. It's traded at about $9 and the P/R ratio is about 5.3. (Simply Wall St, 2021)

NeuroPace is a company that just commercialized an implantable medical device that treats epilepsy. Despite it being 21 years old, it experienced rapid growth recently and went IPO in 2021, trading at $14 currently. Its P/R ratio is about 8. (Simply Wall St, 2021)

ShockWave Medical is a 7-year-old company that engages in developing and commercializing intravascular lithotripsy technology to treat calcified plaque. (ShockWave Medical, 2021) It went public in March 2019 and is currently trading at around 200 dollars. This company is chosen because it is a relatively new company that has grown rapidly, going public just 5 years after it was founded. The P/R ratio, as stated on Yahoo Finance, was about 40 when it went public. (YCharts, 2021)

10.4 Offer

[33]We plan to raise funds in exchange for our equity. We will need $2.5 million for our Series A funding in Year 1. In exchange, we will give 10% stock to the Seed Round investor. For Series A investors, the final return is 10% * $320 million = 32 million. The final return is 12.8x the original investment. The final return is 12.8 times the initial investment after 6 years.

We will need $5.7 million for Series B in Year 2. In exchange, we will give 10% stock to the Series B investor. For Series B funding, we hope the $5.7 million payment can be separately withdrawn in the following 2 years, that is $3.55 million in Year 2, $2.15 million in Year 3, so we do not hold extra cash in Year 2 - 3 when our development does not require that much cash yet. For Series B investors, the final return is 10% * $320 million = $32 million. The final return is 5.6 times the initial investment in 5 years.

[34]We will need $2.6 million for Series C in Year 4. In exchange, we will give 2% stock to the Series C investor. For Series C funding, the $2.6 million payment can be withdrawn in tranches in the following 2 years, that is $1.6 million in Year 4, $1 million in Year 5 with the same reason stated above. For Series C investors, the final return is 2% * $320 million = $6.4 million. The final return is 2.5 times the initial investment in 2 years.

11 Conclusion

VerroTouch is a unique product that provides a solution to the long existing problem of lacking haptics within the surgical robotics industry. We are integrable with varying surgical systems and highly accurate in our translation of robotic movement to haptic sensation. Afterall, there is a reason we are called VerroTouch, we enable our users to feel the truth.

VerroTouch has thoroughly researched our target market and we have a clear and fruitful path ahead of us and our customers. We have eager partners within the Penn and Philadelphia hospital communities who will work with us in our early years to validate our market potential and product satisfaction. Utilizing the good opinions and strong networks of these hospitals, VerroTouch will be able to expand its customer base throughout the United States market and eventually globally as well.

We have spoken to surgeons across the United States and validated the need for haptic feedback during robotic surgery. The learning curve for surgeons to adapt to relying fully on visual feedback has been expressed to be a difficult one to adjust to. Surgeons such as Dr. Aseem R. Shukla, Dr. Sloane Guy, and many more have expressed that haptic feedback should be in the future of surgical robotics and believe that it will improve the safety and comfort of surgeons with access to these technologies.

Most existing robotic haptics are extremely lacking as most companies stick to forced borders and visual cues rather than truly attempting any real sensation replication. Those that are more realistic are pre-integrated with new surgical systems. This is why VerroTouch's realism and integrability are key values. We provide high quality upgrades for low switching costs.

Starting out by concentrating our efforts on large, research hospitals and orthopedic surgeries,[35] VerroTouch will gain strong backing and market validation in our first few years of operations. Over this time period, we will continue developing our product to be exactly what surgeons are looking for. These hospitals are market leaders and the medical industry is very reliant on their opinions to influence purchasing decisions on a national scale, and we may leverage this to our benefit. Surgical robotics as an industry is still rapidly expanding within the United States and other regions such as the Asia Pacific market. These international regions are working with older versions of surgical robots without haptics enabled, so our product will be appealing to them.

We have plans to have an IPO in year 7, after establishing strong national and global markets, providing an exit opportunity for our investors or a chance to convert their shares into stocks. We offer a high annual return on investment to all investors at a rate above 40%, and even higher for our early investors. VerroTouch was founded by five students at the University of Pennsylvania, Estee Chen, Brian Grimaldi, Anyka Chan, Zhiyao Tang, and Meng Lei. Coming from various academic and professional backgrounds and experiences, we are confident that together we can execute our outlined business plan.

VerroTouch will better the experience of surgeons performing robotic surgeries across the globe by providing the realistic comfort of vibrational haptic feedback. By being able to provide this important upgrade to many existing robotic systems, VerroTouch will also level the playing field of surgical robotics, allowing hospitals that cannot afford expensive replacements of machinery to still receive upgrades in haptic technology. VerroTouch aims to elevate and equalize the haptic feedback standards across the globe to improve and forward the surgical robotics industry.

Reference List

AdvisoryCloud. (2015, March 4) *How much should you pay an advisor for your company?* . Retrieved October 26, 2021, from https://www.advisorycloud.com/board-of-directors-articles/how-much-should-you-pay an-advisor-for-your-company/.

Allied Market Research. (2021). *Surgical robotics market size & growth: By 2017-2024*. Retrieved October 6, 2021. https://www.alliedmarketresearch.com/surgical-robotics-market

Avasthi, T. (2021, November 12) Product Manager, Medtronic. Video interview with A. Chan, M. Lei. Discussed Medtronic and surgeons' decisions and opinions on haptic feedback and her previous experience working at a biotech startup.

BCCResearch. (2017, June). *Haptic Technology: Application and Global Markets*. https://academic-bccresearch-com.proxy.library.upenn.edu/market-research/instrumentati on-and-sensors/haptic-technology-applications-markets-report.html

BCCResearch. (2021, June). *Medical Robotics and Computer-assisted Surgery: The Global Market.* https://academic-bccresearch-com.proxy.library.upenn.edu/market-research/healthcare/m edical-robotics-mrcas-market.html

Biesen, T., Weisbrod, J., Brookshire, M., & Coffman, J. (2019, April 25). *Front Line of Healthcare Report 2017: Why involving doctors can help improve US Healthcare*. Retrieved October 06, 2021, from https://www.bain.com/insights/front-line-of-healthcare-report-2017/

Brown J. D., Ibrahim M., Chase E. D. Z., Pacchierotti C. & Kuchenbecker K. J., (2016) *Data-driven comparison of four cutaneous displays for pinching palpation in robotic surgery.* 2016 IEEE Haptics Symposium (HAPTICS). pp. 147-154 https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7463169

Center for Devices and Radiological Health. (2020, July 2). *Classify your medical device.* U.S. Food and Drug Administration. Retrieved October 27, 2021, from https://www.fda.gov/medical-devices/overview device-regulation/classify-your-medical-device.

Chiaravalloti, D. (2018, January 05). *Surgeons and purchasing decisions: Their power is increasing.* Retrieved October 06, 2021, from https://www.boardvitals.com/blog/surgeons-purchasing-decisions-power/

Cook, B. (2021, October 4). *Advantages and disadvantages of going public with an IPO.* Tipalti. Retrieved November 17, 2021, from https://tipalti.com/advantages-and-disadvantages-of-going-public/.

Crew, B. (2020, April 22). *Worth the cost? A closer look at the Da Vinci Robot's impact on Prostate cancer surgery. Nature News.* Retrieved October 13, 2021, from https://www.nature.com/articles/d41586-020-01037-w#:~:text=But%20the%20robot's%2 0US%242,%2Dbased%20tech%20giant%2C%20Intuitive.

Crompton, T. (2020) *Industry Report: Robotic Surgery Equipment Manufacturing.* IBISWorld. Retrieved September 12, 2021, from https://www.ibisworld.com/united-states/market-research-reports/robotic-surgery-equipment-manufacturing-industry/

CSIMarket. (2021). *Medical Equipment & Supplies Industry Price To Sales Ratio Valuation Information and Trends by quarter - CSIMarket.* Retrieved 15 November 2021, from https://csimarket.com/Industry/industry_valuation_ttm.php?ps&ind=804

Davis, S. (2021, October 13th). Ex-CEO, VerroTouch Inc. Video interview with E. Chen, B. Grimaldi, M. Lei, and A. Chan. Discussed previous startup experience of VerroTouch, potential business and revenue models, reasons for failure, FDA filing process, and the possibility to extend VerroTouch to other robotic systems.

Drues, M. (2014, February 5). *Secrets Of The De Novo Pathway, Part 1: Why Aren't More Device Makers Using It?* Retrieved October 27, 2021, from https://www.meddeviceonline.com/doc/secrets-of-the-de-novo-pathway-part-why-aren-tmore-device-makers-using-it-0001.

Eun, D. (2021, Nov 2nd) Director, Minimally Invasive Robotic Urologic Oncology and Reconstructive Surgery, Temple University Hospital. Video interview with B. Grimaldi, M. Lei, A.Chan and Z. Tang. Discussed purchase intention of VerroTouch, surgical robot training procedure.

FDA. (2017, October 3). *K212004* - accessdata.fda.gov. Retrieved October 27, 2021, from https://www.accessdata.fda.gov/cdrh_docs/pdf21/K212004.pdf.

Fontinelle, A. (2021, September 13). *How much board of directors members get paid and what they do.* Investopedia. Retrieved October 26, 2021, from https://www.investopedia.com/articles/wealth management/040416/retired-execs-what-do-corporate-boards-pay.asp#:~:text=The%20median%20compensation%20for%20members%20of%20private%20company,1%20It%20goes%20a%20lot%20higher%20from%20there.

Fortune Business Insights.(2021, Feb) *Robotic Surgical Procedures Market Size, Share & Growth [2020-2027]*. Retrieved October 5, 2021, from https://www.fortunebusinessinsights.com/industry-reports/robotic-surgical-procedures-market-100124

Ganjeizadeh, F., Lei, H., Goraya, P., & Olivar, E. (2017, September 18). *Applying looks-like analysis and bass diffusion model techniques to forecast a neurostimulator device with no historical data.* Procedia Manufacturing. Retrieved November 3, 2021, from https://www.sciencedirect.com/science/article/pii/S2351978917305425.

Gewirtz, J. (2021, October 11). Co-owner, VerroTouch Patent, University of Pennsylvania. Video interview with E. Chen, M. Lei, A. Chan, B. Grimaldi and Z. Tang. Discussed original concept for the company and product design, how they collaborated with Intuitive, what their marketing strategies were and what customers they targeted, what SMEs he talked to, and his original revenue model.

Haption S. A. PitchBook. (n.d.) Retrieved September 28, 2021, from https://my-pitchbook-com.proxy.library.upenn.edu/profile/106842-16/company/profile#insights

Healthcare, G. D. (n.d.). *Johnson & Johnson's new robotic surgical system to rival Intuitive Surgical's da vinci.* Medical device Network. Retrieved October 13, 2021, from https://www.medicaldevice-network.com/features/ottava-robotic-johnson/.

Hertz, A. M., George, E. I., Vaccaro, C. M., & Brand, T. C. (2018). *Head-to-head comparison of three virtual-reality robotic surgery simulators*. JSLS : Journal of the Society of Laparoendoscopic Surgeons, 22(1). https://doi.org/10.4293/jsls.2017.00081

Hurst, M. (2021, October 19th) Ex-employee, Intuitive Surgical. Video interview with E. Chen, B. Grimaldi, M. Lei, Z. Tang, and A. Chan. Discussed Intuitive's interest and attitude towards third-party add-ons, Intuitive's distribution channel, surgical robot market growth, and Da Vinci's warranty policy.

Intuitive (n.d.) *Intuitive Provider Locator. Find a provider near you.* (n.d.). Retrieved November 3, 2021, from https://www.davincisurgery.com/provider-locator?gclid=Cj0KCQjww4OMBhCUARIsAILndv4TGRhhmXM5wumpiS6U35aY0dHx-kdSTW2R27RssRw-HcU-U-9PeccaAunfEALw_wcB.

Intuitive Homepage. (n.d.). Retrieved October 13, 2021, from https://www.intuitive.com/en-us.

Intuitive Surgical. (n.d.) *Intuitive announces fourth quarter earning.* Retrieved September 28, 2021, from http://isrg.intuitive.com/news-releases/news-release-details/intuitive-announces-fourth-quarter-earnings-0.

ISRG, Intuitive Surgical US Securities and Exchange Commission (n.d.). Retrieved September 28, 2021, from https://isrg.intuitive.com/static-files/efac2adc-bd4c-4cf9-8a9d-0948b5134d0a.

Kuchenbecker, Katherine J. (2012). *VerroTouch: Haptic Instrument Vibration Feedback for Robotic Minimally Invasive Surgery,* http://haptics.seas.upenn.edu/index.php/Research/VerroTouch

Kuchenbecker, Katherine J. (2016, May 10). *Systems and methods for providing vibration feedback in robotic systems.* (U.S. Patent No. 9,333,039) U.S. Patent and Trademark Office. https://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=9333039.PN.&OS=PN/9333039&RS=PN/9333039

Kuchenbecker, Katherine J.; Gewirtz, Jamie; McMahan, William; Standish, Dorsey; Mendoza, Pierre J.; and Lee, David I., "VerroTouch: High-Frequency Acceleration Feedback for Telerobotic Surgery" (2010). Departmental Papers (MEAM). 292. https://repository.upenn.edu/meam_papers/292

Leslie, M., & Holloway, C. A. (2014, August 1). *The Sales Learning Curve*. Harvard Business Review. Retrieved October 13, 2021, from https://hbr.org/2006/07/the-sales-learning-curve

Macey, A. (2015, May 12). *How do buyers in health services differ from other industries?* Retrieved October 06, 2021, from https://www.smartbugmedia.com/blog/how-do-buyers-in-health-services-differ-from-other-industries

Macrotrends. (2021). Intuitive Surgical Profit Margin 2006-2021: ISRG. Macrotrends. Retrieved September 28, 2021, from https://www.macrotrends.net/stocks/charts/ISRG/intuitive-surgical/profit-margins

Made-in-china. (2021). *Pressure sensor prices:* search result. https://www.made-in-china.com/productdirectory.do?word=pressure%2BSensor&file=&searchType=0&subaction=hunt&style=b&mode=and&code=0&comProvince=nolimit&order=0&isOpenCorrection=1&org=top

Miller, S. (2021, October 13). 2022 salary increases look to trail inflation. SHRM. Retrieved November 10, 2021, from https://www.shrm.org/resourcesandtools/hr-topics/compensation/pages/2022-salary-increases-look-to-trail-inflation.aspx.

Mimic Simulation. (2018, November 14)., Inside DV-trainer®partnership. Retrieved September 28, 2021, from https://mimicsimulation.com/inside-dv-trainerpartnership/.

MIMIC Technologies PitchBook. (n.d.) MIMIC Technologies Profile. Retrieved September 28, 2021, from https://my-pitchbook-com.proxy.library.upenn.edu/profile/142688-71/company/profile#general-info.

Mordor Intelligence.(2021) *Surgical Robots Market: 2021 - 26: Industry share, size, growth.* Retrieved October 5, 2021, from https://www.mordorintelligence.com/industry-reports/surgical-robots-market

Nature Research. (n.d.). *A new era of robotic-assisted surgery.* Nature news. Retrieved November 3, 2021, from https://www.nature.com/articles/d42473-021-00164-w.

Nishimura, K. (2015). *Current status of robotic surgery in Japan. Korean Journal of Urology,* 56(3), 170. https://doi.org/10.4111/kju.2015.56.3.170

Nolin, B. (2021, October 8). Ex-Vice President of Sales, Intuitive and MIMIC. Video interview with E. Chen, B. Grimaldi and A. Chan. Discussed Mimic's work in surgical robotics, strategies to sell to a manufacturer like intuitive and Medtronic, collaboration and value creation between VerroTouch and simulation companies.

O'Meara, S. (2020, June 24). *Medical Robotics in China: The Rise of Technology in three charts.* Nature News. Retrieved November 3, 2021, from https://www.nature.com/articles/d41586-020-01795-7.

Penn Center for Innovation. (2016) *VerroTouch: Tactile augmentation for robot-assisted minimally invasive surgery*. https://upenn.technologypublisher.com/technology/39291

Perez, R. E., & Schwaitzberg, S. D. (2019). Robotic surgery: Finding value in 2019 and Beyond. Annals of Laparoscopic and Endoscopic Surgery, 4, 51–51. https://doi.org/10.21037/ales.2019.05.0

Pipedrive Inc / Pipedrive. (n.d.). *Hiring salespeople: Sales Team Recruitment Strategy.* Pipedrive. Retrieved October 13, 2021, from https://www.pipedrive.com/en/blog/hiring-sales-people

Pitchbook (n.d.). Conmed Financial Profile. PitchBook. Retrieved from https://my-pitchbook-com.proxy.library.upenn.edu/profile/41031-91/company/financials/CASH_FLOW

Pitchbook (n.d.). Globus Medical Financial Profile. PitchBook. Retrieved from https://my-pitchbook-com.proxy.library.upenn.edu/profile/10577-26/company/financials/CASH_FLOW

PitchBook. (n.d.). *The Venture Capital Lifecycle.* PitchBook. Retrieved October 27, 2021, from https://pitchbook.com/news/articles/the-venture-capital-lifecycle.

River Cities Capital (2016, August 24). *Navigating the value analysis committee.* Retrieved October 06, 2021, from https://rccf.com/navigating-the-value-analysis-committee/

ShockWave Medical. (2021). *Home Page.* Retrieved 15 November 2021, from https://shockwavemedical.com/

Shukla, A. (2021, October 11). Director of Minimally Invasive Surgery, Division of Urology, Children's Hospital of Philadelphia. Video interview with E. Chen, M. Lei and Z. Tang. Discussed the decision-making process and key stakeholders of hospital equipment purchasing, training and simulation process before actual surgeries. simulation programs, and the acceptable pricing of VerroTouch.

Sillup G. P. (1992). *Forecasting the adoption of new medical technology using the Bass model.* Journal of health care marketing, 12(4), 42–51.

Simbionix PitchBook. (n.d.). Retrieved September 28, 2021, from https://my-pitchbook-com.proxy.library.upenn.edu/profile/42952-96/company/profile#general-info

Simbionix Testimonials, LAP Mentor Testimonials. (n.d.). Retrieved September 28, 2021, from https://simbionix.com/simulators/lap-mentor/testimonials/

Simbionix, LAP Mentor Product Page. (n.d.). Retrieved September 28, 2021, from https://simbionix.com/simulators/lap-mentor/lap-team-training/

Simply Wall St. (2021) *Minerva Surgical (NasdaqGM:UTRS) - Share price, News & Analysis - Simply Wall St.*. Retrieved 15 November 2021, from https://simplywall.st/stocks/us/healthcare/nasdaq-utrs/minerva-surgical

Simply Wall St. (2021) *NeuroPace (NasdaqGM:NPCE) - Share price, News & Analysis - Simply Wall St.* Retrieved 15 November 2021, from https://simplywall.st/stocks/us/healthcare/nasdaq-npce/neuropace

Sloane Guy, T. (2021, November 1). Director of Robotic Cardiac Surgery, Thomas Jefferson Hospital. Video interview with A. Chan, M. Lei, and Z. Tang. Discussed the effectiveness of VerroTouch on various tissues and the importance of haptic feedback in the industry.

Spier, L. (2021, October 26th) Surgeon, Chief of Thoracic Surgery, NYU-Long Island. Phone interview with B. Grimaldi, A, Chan, M. Lei. Discussed specifics of service warranty for Intuitive da Vinci robotics, price point for VerroTouch, levels of danger in specific surgeries, and visual haptics.

Surgical, INC, I. (2020). *Q2 2020 Intuitive Investor Presentation. Intuitive | ISRG for Investors.* Retrieved November 3, 2021, from https://isrg.gcs-web.com/static-files/8b2cf45a-fd9d-4358-ad04-115fc9747b5e.

Surgical, INC, I. (2021). *Q3 2021 Financial Data Table. Intuitive | ISRG for Investors.* Retrieved November 3, 2021, from https://isrg.gcs-web.com/static-files/8b2cf45a-fd9d-4358-ad04-115fc9747b5e.

Tactical Haptics PitchBook. (n.d.).*Tactical Haptics Profile.* Retrieved September 28, 2021, from https://my-pitchbook-com.proxy.library.upenn.edu/profile/113298-76/company/profile#general-info.

Takahashi, D. (2019, May 16). *Tactical Haptics will launch Dev Kit preorders for 'haptic controllers' on May 29*. VentureBeat. Retrieved September 28, 2021, from https://venturebeat.com/2019/05/16/tactical-haptics-will-launch-dev-kit-preorders-for-haptic-controllers-on-may-29/.

Think with Google .(2013, May). *How hospital administrators make purchase decisions.* Retrieved October 6, 2021, from https://think.storage.googleapis.com/docs/how-hospital-administrators-make-purchase-decisions_research-studies.pdf

Thodiyil, P. (2021, November 15) Surgeon, Robotic Bariatric Surgery, Mount Sinai Hospital. Video interview with E. Chen, B. Grimaldi. Discussed thoughts on haptic feedback and its necessity to surgical robotics.

Tirmizi A., Pacchierotti C., Hussain I., Alberico G. & Prattichizzo D., (2016) *A perceptually-motivated deadband compression approach for cutaneous haptic feedback.* 2016 IEEE Haptics Symposium (HAPTICS) pp. 223-228 https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7463181

Trefis. (2020, April 14). *50% drop in revenue growth for intuitive surgical this year?* Forbes. Retrieved September 28, 2021, from https://www.forbes.com/sites/greatspeculations/2020/04/14/50-drop-in-revenue-growth-for-intuitive-surgical-this-year/?sh=be0d36338f56.

UpCounsel. (2020, June 30). *Patent licensing: Everything you need to know.* UpCounsel. Retrieved October 27, 2021, from https://www.upcounsel.com/patent-licensing.

Van der Meijden, O. A., & Schijven, M. P. (2009). *The value of haptic feedback in conventional and robot-assisted minimal invasive surgery and virtual reality training: A current review. Surgical Endoscopy*, 23(6), 1180-1190. doi:10.1007/s00464-008-0298-x

Xu, T. (2021, March 30). *Haptic technology has more applications than you think. Built In.* Retrieved October 6, 2021. https://builtin.com/artificial-intelligence/haptic-technology.

YCharts. (2021). *ShockWave Medical PS Ratio*. Retrieved 15 November 2021, from https://ycharts.com/companies/SWAV/ps_ratiohttps://ycharts.com/companies/SWAV/ps_ratio

Zhou , W. (2020, November 6). *Da Vinci Surgery Robot debuts at CIIE*. Chinadaily.com.cn. Retrieved November 3, 2021, from https://www.chinadaily.com.cn/a/202011/06/WS5fa4e9bba31024ad0ba838f5.html.

Appendix A - Financial Report

VerroTouch

Income Statement

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Industry
NET REVENUES	0	0	1,960,000	3,800,000	8,950,000	20,325,000	
COST OF GOODS SOLD	3,000	623,107	1,211,107	1,904,972	4,192,485	9,098,190	
% of Revenues	#DIV/0!	#DIV/0!	61.8%	50.1%	46.8%	44.8%	45.0%
GROSS PROFIT	(3,000)	(623,107)	748,893	1,895,028	4,757,515	11,226,810	
% of Revenues	#DIV/0!	#DIV/0!	38.2%	49.9%	53.2%	55.2%	55.0%
OPERATING EXPENSES							
Sales & Marketing	0	84,000	638,961	843,746	1,543,814	2,339,067	
Research & Development	621,250	903,413	942,958	1,147,066	1,678,167	1,955,638	
General and Administration	774,500	803,480	883,373	931,781	1,028,646	1,152,288	
Depreciation of Operating Assets	50,000	75,714	92,857	127,143	204,286	211,429	
Total Operating Expenses	1,445,750	1,866,607	2,558,149	3,049,736	4,454,912	5,658,421	
% of Revenues	#DIV/0!	#DIV/0!	131%	80%	50%	28%	30.0%
EARNINGS FROM OPERATIONS	(1,448,750)	(2,489,714)	(1,809,256)	(1,154,708)	302,603	5,568,389	
EXTRAORDINARY INCOME (EXPENSE)	(145,000)	(100,000)	(50,000)	(100,000)	0	0	
EARNINGS BEFORE INTEREST & TAXES	(1,593,750)	(2,589,714)	(1,859,256)	(1,254,708)	302,603	5,568,389	
INTEREST INCOME (EXPENSE)	0	0	0	0	0	100,000	
NET EARNINGS BEFORE TAXES	(1,593,750)	(2,589,714)	(1,859,256)	(1,254,708)	302,603	5,668,389	
TAXES	0	0	0	0	0	0	
NET EARNINGS (LOSS)	(1,593,750)	(2,589,714)	(1,859,256)	(1,254,708)	302,603	5,668,389	
% of Revenues	#DIV/0!	#DIV/0!	-94.9%	-33.0%	3.4%	27.9%	22.5%

VerroTouch

Balance Sheet

	Begin	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
ASSETS							
CURRENT ASSETS							
Cash	50,000	656,250	655,108	823,622	662,368	621,136	4,519,415
Accounts Receivable		0	0	294,000	570,000	1,342,500	3,048,750
Inventories		0	0	323,366	508,628	1,119,393	2,429,217
Other Current Assets		0	0	39,200	76,000	179,000	406,500
Total Current Assets	50,000	656,250	655,108	1,480,188	1,816,995	3,262,030	10,403,881
NET FIXED ASSETS		300,000	1,261,429	1,145,714	1,458,571	2,237,143	2,768,571
TOTAL ASSETS	50,000	956,250	1,916,536	2,625,902	3,275,567	5,499,172	13,172,453
LIABILITIES & SHAREHOLDERS' EQUITY							
CURRENT LIABILITIES							
Short Term Debt		0	0	0	0	0	0
Accounts Payable & Accrued Expenses		0	0	242,221	380,994	838,497	1,819,638
Other Current Liab		0	0	176,400	342,000	805,500	1,829,250
Current Portion of Long Term Debt		0	0	0	0	0	0
Total Current Liabilities	0	0	0	418,621	722,994	1,643,997	3,648,888
LONG TERM DEBT (less current portion)		0	0	0	0	0	0
STOCKHOLDERS' EQUITY							
CommonStock	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Preferred Stock		2,500,000	6,050,000	8,200,000	9,800,000	10,800,000	10,800,000
Retained Earnings		(1,593,750)	(4,183,464)	(6,042,720)	(7,297,428)	(6,994,825)	(1,326,435)
Total Equity	50,000	956,250	1,916,536	2,207,280	2,552,572	3,855,175	9,523,565
TOTAL LIABILITIES & EQUITY	50,000	956,250	1,916,536	2,625,902	3,275,567	5,499,172	13,172,453

VerroTouch

Cash Flow Statememt

	Begin	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
OPERATING ACTIVITIES							
Net Earnings		(1,593,750)	(2,589,714)	(1,859,256)	(1,254,708)	302,603	5,668,389
Depreciation		50,000	218,571	235,714	327,143	511,429	518,571
Working Capital Changes							
(Increase)/Decrease Accounts Receivable		0	0	(294,000)	(276,000)	(772,500)	(1,706,250)
(Increase)/Decrease Inventories		0	0	(323,366)	(185,262)	(610,766)	(1,309,823)
(Increase)/Decrease Other Current Assets		0	0	(39,200)	(36,800)	(103,000)	(227,500)
Increase/(Decrease) Accts Pay & Accrd Expenses		0	0	242,221	138,773	457,503	981,141
Increase/(Decrease) Other Current Liab		0	0	176,400	165,600	463,500	1,023,750
Net Cash Provided by Operating Activities		(1,543,750)	(2,371,143)	(1,861,486)	(1,121,254)	248,768	4,948,278
INVESTING ACTIVITIES							
Plant & Equipment		(350,000)	(1,180,000)	(120,000)	(640,000)	(1,290,000)	(1,050,000)
Other							
Net Cash Used in Investing Activities		(350,000)	(1,180,000)	(120,000)	(640,000)	(1,290,000)	(1,050,000)
FINANCING ACTIVITIES	50,000	(1,893,750)	(3,551,143)	(1,981,486)	(1,761,254)	(1,041,232)	3,898,278
Increase/(Decrease) Short Term Debt							
Increase/(Decrease) Current Long Term Debt							
Increase/(Decrease) Non-Current Long Term Debt							
Increase/(Decrease) Common Stock							
Increase/(Decrease) Preferred Stock		2,500,000	3,550,000	2,150,000	1,600,000	1,000,000	
Dividends Declared		0	0	0	0	0	0
Net Cash Provided / (Used) by Financing		2,500,000	3,550,000	2,150,000	1,600,000	1,000,000	0
INCREASE/(DECREASE) IN CASH		606,250	(1,143)	168,514	(161,254)	(41,232)	3,898,278
CASH AT BEGINNING OF YEAR		50,000	656,250	655,108	823,622	662,368	621,136
CASH AT END OF YEAR	50,000	656,250	655,108	823,622	662,368	621,136	4,519,415

VerroTouch

Summary

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Industry
Summary Financials ($)							
Revenue	0	0	1,960,000	3,800,000	8,950,000	20,325,000	
Gross Profit	(3,000)	(623,107)	748,893	1,895,028	4,757,515	11,226,810	
EBIT	(1,593,750)	(2,589,714)	(1,859,256)	(1,254,708)	302,603	5,568,389	
Net Earnings	(1,593,750)	(2,589,714)	(1,859,256)	(1,254,708)	302,603	5,668,389	
Net Cash from Operating Activities	(1,543,750)	(2,371,143)	(1,861,486)	(1,121,254)	248,768	4,948,278	
Capital Expenditures	350,000	1,180,000	120,000	640,000	1,290,000	1,050,000	
Dividends							
Cash	656,250	655,108	823,622	662,368	621,136	4,519,415	
Total Equity	956,250	1,916,536	2,207,280	2,552,572	3,855,175	9,523,565	
Total Debt	0	0	0	0	0	0	
Growth							
Revenue Growth Rate - CAGR:		#DIV/0!	#DIV/0!	94%	136%	127%	
Net Earnings Growth Rate - CAGR:		62%	-28%	-33%	-124%	1773%	
Ratios							
Solvency							
Current Ratio	#DIV/0!	#DIV/0!	3.5	2.5	2.0	2.9	**2.1**
Quick Ratio	#DIV/0!	#DIV/0!	2.8	1.8	1.3	2.2	**1.4**
Debt to Capital (LT Debt + Equity)	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Efficiency							
Collection Period (Days) (DPC)	#DIV/0!	#DIV/0!	55	55	55	55	**55**
Payables Period (Days) (DPO)	0	0	73	73	73	73	**73**
Inventory Turnover (Days) (DOI)	0	0	97	97	97	97	**97**
Asset Turnover Ratio	0.0	0.0	0.7	1.2	1.6	1.5	**1.7**
Fixed Asset Turnover Ratio	0.0	0.0	1.7	2.6	4.0	7.3	**6.7**
Cash Conversion Cycle			79	79	79	79	**79**
Profitability							
Gross Profit %	#DIV/0!	#DIV/0!	38.2%	49.9%	53.2%	55.2%	**55.0%**
Operating Expenses %	#DIV/0!	#DIV/0!	130.5%	80.3%	49.8%	27.8%	**30.0%**
Net Earnings (After Tax) %	#DIV/0!	#DIV/0!	-94.9%	-33.0%	3.4%	27.9%	**22.5%**
Return on Net Fixed Assets	-531.3%	-205.3%	-162.3%	-86.0%	13.5%	204.7%	**150.0%**
Return on Assets	-166.7%	-135.1%	-70.8%	-38.3%	5.5%	43.0%	**38.8%**
Return on Equity	-166.7%	-135.1%	-84.2%	-49.2%	7.8%	59.5%	**59.2%**
Return on Capital (LT Debt + Equity)	-166.7%	-135.1%	-84.2%	-49.2%	7.8%	59.5%	**59.2%**

Appendix B - Founder and Principle Résumés

ANYKA CHAN

(650) 686-9737 ANYKA.CHAN@GMAIL.COM
GITHUB: @ANYKAC LINKEDIN: @ANYKAC

Education

UNIVERSITY OF PENNSYLVANIA
B.S.E in Computer Science
Minoring in Electrical Engineering, Mathematics, and Engineering Entrepreneurship
Expected 2022

Relevant Courses:
CIS 121 - Data Structures and Algorithms
CIS 240 - Intro to Computer Systems
CIS 350 - Software Development/Engineering
CIS 371 - Computer Organization and Design
CIS 380 - Computer Operation Systems
IPD 515 - Product Design

Programming Skills

Java, Go, Android Development, Python, GitHub, C, Node.js, JavaScript, MongoDB, Agile Development, HTML/CSS, Software Design Patterns, OCaml

Recent Projects

SURVEYNET 2020
- Developed a webapp and mobile app for posting surveys with features to filter by demographics and earn points upon survey completion
- Languages: Webapp in Node.js and Express; Android mobile app in Java; Database built with MongoDB

INTERACTION LOGGING OVERLAY 2019
- Designed and built a developer tool to display user interactions on the YouTube mobile app
- Languages and tools: Android app development in Java and XML; Observers; Handlers

QUILTIFY (quiltify.appspot.com) 2018
- Built a website for image uploads and collaboration
- Languages: Backend in Python; Frontend in HTML/CSS; Database built with Google Cloud

BRICKBREAKER 2018
- Programmed a computer game that breaks blocks on impact with user-aimed balls
- Languages and tools: Programmed in Java; Graphics with JSwing; File I/O; Collections; Inheritance

PENNTILES 2018
- Built a webapp for students to organize academic links
- Developed at PennApps, a US nationwide invitational hackathon for university students
- Languages: Backend in Python; Frontend in HTML/CSS; Database built with Google Cloud

Work Experience

TWITTER Summer 2021
Software Engineering Intern
- Created a new service for the distribution of manifests for TSS, twitter's service for secure distribution, on the platform security team
- Implemented external caching for the manifests as well to improve efficiency and reliability
- Language: Scala

FACEBOOK Winter 2021
Software Engineering Intern
- Developed the Download Your Information tool for Facebook Ad Accounts on the Data Productions Infrastructure team
- Implemented fetching and translating of personal data from the Facebook database to the end user
- Languages: Hack PHP

GOOGLE CLOUD Summer 2020
Software Engineering Intern
- Built a networking resource generator for the Cloud Network team
- Automated procedures for generating end-to-end feedback configs, resource links, and helper functions
- Currently used by Google engineers to generate new network resources in the Cloud stack
- Languages: Go, Java

FIFE-PENN CS ACADEMY 2019 - present
Student Program Manager, Instructor
- Develop coding curricula for SCRATCH and Python
- Manage training and onboarding of instructors
- Lead programming classes at local elementary and middle schools

YOUTUBE Summer 2019
Software Engineering Intern
- Designed and built the interaction logging overlay for the Client Logging team on YouTube's Android mobile application
- Currently used by engineers at YouTube for backend troubleshooting in developer (DEV) environment
- Languages and Tools: Android mobile development in Java and XML in Android Studio; Observers; Handlers

Achievements

CHAIRMAN'S AWARD & DIVISION CHAMPIONS, FIRST ROBOTICS 2018
GOLD AWARD, GIRL SCOUTS 2017
RUNNER UP, XXHACKS 2017

Organizations

COMPUTER ENGINEERS OF THE NEXT GENERATION since 2016
Board Member, Co-Founder, Volunteer
- Founded a 503(c) non-profit that offers free programming classes for underrepresented minorities in local elementary schools

DISNEY A CAPPELLA since 2018
Treasurer, Webmaster
SOCIETY OF WOMEN ENGINEERS since 2018
GIRL SCOUTS @ PENN since 2019

Brian Grimaldi

Philadelphia, PA 19104 • 908.548.4297▪ bvgrimaldi@gmail.com

Mechanical Engineering

Exhibiting Openness to Learning for Optimum Development

- Aspiring mechanical engineer with an in-depth understanding of Physics and Economics, programming, efficient lab environment coupled with notable computer software knowledge and technical writing skills. Eager to gain further experience to enhance and process engineering expertise for professional development
- Self-starter, fast-learner, and proactive team player able to collaborate and build relationships with colleagues

EDUCATION

Master of Science in Mechanical Engineering and Applied Mechanics
University of Pennsylvania, Philadelphia, PA, Aug 2020 – May 2022

Bachelor of Arts in Physics and Economics (Joint Major) Minor in Applied Mathematics
Franklin & Marshall College, Lancaster, PA, Aug 2016 – May 2020
Cum Laude – May 2020

RESEARCH EXPERIENCE

Independent Researcher for Professor Etienne Gagnon
Franklin and Marshall College, Lancaster, PA **Sep 2019 – May 2020**
Scrutinized the saturation in the generation of terahertz waves from photoconductive antennas

- Applied strong attention to detail in performing optical alignment with standard and elliptical mirrors in laser setup
- Gained vital strategy in troubleshooting technical electronic and optic apparatus, most notably on experimental terahertz generation apparatus while following safety standards and adhering to proper practices
- Critically evaluated collected data via intensive configuration and modification of existing code in Python and MATLAB
- Graduated with departmental honors in Physics after the documentation, presentation, and defense of the thesis

PROFESSIONAL EXPERIENCE

MECHANICAL ENGINEER INTERN, WSP U.S.A, New York, NY **Jun 2019 – Aug 2019**
Built fundamental skills as a member of the engineering design team for large commercial projects in New York City

- Attained competence in basic engineering design, production, and construction administration services
- Utilized AutoCAD and Revit software strategies in drafting and aligning markups regarding construction documents
- Cultivated innovative design and maximized specific materials in conducting load calculations and design for ductwork or plumbing as well as accounting for building codes dedicated to producing competitive results
- Obtained fundamental principles of HVAC and Plumbing system design coupled with practical operations management

LEADERSHIP EXPERIENCE

TREASURER, Physics and Astronomy Club **Aug 2018 – May 2020**

- Employ transparency while utilizing management experience in handling budget proposal with associated appropriations, and management for specific club activities; keep records of budget statistics and flex results professionally

MUSIC DIRECTOR/MEMBER, The Poor Richards (A Capella Group) **Sep 2017 –May 2020**

- Conduct and spearhead rehearsals as a Music Director; creating arrangements and training each member of respective voice parts while guiding individual vocal techniques utilizing knowledge in past classical voice experience

Yiwei (Estee) Chen
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LinkedIn: https://www.linkedin.com/in/esteecyw/ **|GitHub:** https://github.com/esteechenyiwei

EDUCATION

University of Pennsylvania *School of Engineering* (Expected) 2022
Master of Science in Engineering in Computer and Information Science ***(GPA: 4.00/4.00)***
Bachelor of Applied Science in Computer and Information Science ***(GPA: 3.91/4.00)***

- Minor in Mathematics, Data Science and Entrepreneurship
- **Honors and Awards:** Dean's List 2018 - 2019, ACT Score 35/36
- **Relevant Coursework:** Corporate Finance and Accounting, Management Science with Excel, Macroeconomics, Microeconomics, Venture Capital Management and Valuation, Big Data Analytics with R and Python, Machine Learning, Product Design, Engineering Entrepreneurship

WORK EXPERIENCES

Program Manager Intern **at Microsoft** *Redmond, Washington* May 2021 – Present

- Lead and plan the rejuvenation initiative of a first-party application with 120 million MAD for Windows 11
- Identify key user pain points through app data telemetry and user review analysis with Excel and define product goals that reflect the vision of Windows 11 to empower creators of all types
- Collaborate across the Windows division to advance the project, including management, developers, and designers
- Develop and pitch to executives innovative and goal-oriented features to boost customer satisfaction and retention

Seed Fund Analyst Intern **at Sequoia Capital China** *Shanghai, China* Aug 2020 – Feb 2021

- Independently sourced about 100 high-tech startups in more than 15 industries through active research and networking with professionals and experts
- Conducted in-depth market research about 10+ tracks like SaaS, semiconductor, LiDAR, cloud services, POCT, database
- Evaluated 40+ companies from an investor's perspective; analyzed key success indicators like cashflow, business models, distribution channels, strategies, and team dynamics to support investment hypotheses and decisions

UX Software Engineer Intern at **NVIDIA** *Santa Clara, California* May 2020 – July 2020

- With a team, built data analytics and visualization platform for the new GPU Research Group
- Designed data query, storage, and transportation system to streamline NVIDIA's hardware design flows

Operations and Data Analytics Intern **at Ant Financial, Alibaba** *(Headquarter) Hangzhou, China* Jul 2019 – Aug 2019

- Conducted quantitative market research on China's digital payment service providers using Excel and various online databases; analyzed and recommended feature solutions that were implemented to impact millions of users
- Proposed Alipay's strategic partnership plans to stakeholders like investors, local government, and corporates

LEADERSHIP

Operations Chair (Project Manager) **at Penn Wharton China Summit** Mar 2019 – Jun 2020

- Director of a team of 20, led the planning of a summit that hosted 1500 audience and invited key business founders like Xiaomi CEO as speakers; reported by mainstream media such as Forbes, ABC News, and NY Times
- Overall PM in charge of whole-year timeline, budget, supplies, program, volunteers, speakers, press, and ticketing

Executive Vice President of Marketing **at Penn Student Agencies** Jan 2019 – Jun 2020

- Led marketing initiatives, directed budget, executed about 10 marketing campaigns, boosted followers count by 20%
- Provided marketing consultation and solutions to 9 business agencies directors under the Executive Suite
- Designed numerous marketing deliverables, including websites, recruitment info booklets, and office wall decals

Founder, Chief Executive Officer **of** ***AlphaBridge*** **Education and Technology Co.** Jun 2018 – Feb 2019

- Led a team of 20 employees; using an Agile model, designed products, and implemented go-to-market strategies like bundled services, price differentiation and social media campaigns
- Partnered with five big educational businesses simultaneously, earned $20k revenue in 6 months

AWARDS

Global 2nd Runner-Up Team among 400 Teams **in LIKE A BOSS Global Business Case Competition** Oct 2019

- Developed and pitched a smart business solution for a unicorn startup; carried out user research in the key market segment, projected cash flow model, predicted market reactions and risks

Global Top 15 among 3000 teams **in World Bank Ideas4Action Sustainable Business Competition** May 2018

- Proposed a SaaS solution to over-packaging in the Chinese shipping industry, developed a machine learning model to analyze package sizes and recommend optimal packaging methods

ADDITIONAL INFORMATION

Skills | Office Suite, Python, R, Data Analytics**,** Project Management, Statistical Modeling, Machine Learning, Web Crawling
Other Activities | Member of Wharton Undergraduate Consulting Club, Vice President of Finance at Wharton Undergraduate Finance Club, student researcher at Wharton Behavioral Lab, web designer for PRECISE Lab, teaching assistant for Cognitive Science, performer at the Penn Arabic Choir and Opera Scene

Sunyimeng (Meng) Lei

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Philadelphia, PA, 19104, USA
Tel: 1(734)-353-2596 Email: lsym@seas.upenn.edu

Education

UNIVERSITY OF PENNSYLVANIA (PHILADELPHIA, PA, US) Sept 2020- Dec 2021 (anticipated)
Master of Science in Engineering : Chemical and Biomolecular Engineering
Coursework: Transport phenomena, Advanced Thermodynamics, Chemical Kinetics and Reactor design, Tissue Engineering, Biomechanics, Stem cell and Soft Matter, Engineering Entrepreneurship.

UNIVERSITY OF MICHIGAN (ANN ARBOR, MI, US) Sept 2018- May 2020
Bachelor of Science in Pharmaceutical Science (Honors, James B. Angell Scholar)
Coursework: Human Physiology, Pharmacokinetics, Medicinal Chemistry and Cancer Therapy, (Bio)pharmaceutics, Biostatistics(R), Intro to C++, Economics, Public health& Health policy.

CHINA PHARMACEUTICAL UNIVERSITY (NANJING, JIANGSU, CHINA)
Sept 2016- June 2018(in school), June 2020(graduation)
Bachelor of Science in Medicinal Chemistry
Coursework: Organic Chemistry, Analytical Chemistry, Physical Chemistry, Biochemistry, Business Law, Linear Algebra, Statistics, Physics, Calculus.

Academic Experiences

Research Experience in Tissue Engineering June 2021 - Now
Task: Application and Industry Connection of Eye-on-Chip Project
Work as a group in the lab, connecting with Roche and GSK to develop our eye-on-chip product, apply it in a dry eye disease model and drug testing project.

Undergraduate Honors Research Thesis May 2019- Apr 2020
Task: High Throughput Screening for GSTO1 in Cancer Therapeutics
Conducted thermal shift assay and in-gel fluorescence assay to determine if a compound bind to certain protein. Analysis and interpret data for further SAR(structure-activity relationship) studies. A poster session and a thesis is completed for this project.

Research Experience in Medicinal Chemistry Mar 2018- July 2018, June 2019- July 2019
Task: Design, Synthesis and Anti-tumor Activity of Novel BRD4 Protein Inhibitors
Synthesized and purifying compounds, identify compound with HPLC-MS machine. Testing drug toxicity through colorimetric assays assessing cell metabolic activity.

Other Experiences

- **Teaching Assistant at Neoscholar Aug 2021 - Now**

Communicate with externally hired professor and the institution, draft and correct homework for students and give lectures that is supplemental to the professor's lectures at the TA session.

- **Cranbrook Tower Event Feb 2019**

Translated between the English-speaking pharmacy students and the Mandarin-speaking senior citizens as a community social work practice.

- **SINCE Guitar Association (Student Organization in China Pharmaceutical University) May 2017**

Help arranged an on-campus music festival, invited and negotiated with guest bands, performed as vocal in own band.

Qualifications

Language
- Mandarin (Native)
- English (IELTS: 7.0 / TOEFL: 102)
- Japanese (Competent)
- German(Advanced beginner)

Others
- Proficient in R, Visual Basic
- Advanced beginner in C++ and python

Zhiyao Tang

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EDUCATION

The University of Pennsylvania
Bachelor of Science in Engineering: Computer Engineering
Minor: Engineering Entrepreneurship | Rachleff Scholar, GPA 3.85/4.00
September 2018 - May 2022 | Philadelphia, PA, USA

PUBLICATION

Hoffman, M., **Tang, Z**, Orgill, J., Nelson, J., Glanzman, D., Nelson, B., & DeHon, A. "XBERT: Xilinx Logical-Level Bitstream Embedded RAM Transfusion" *2021 IEEE 29rd Annual International Symposium on Field-Programmable Custom Computing Machines. IEEE, 2021*

EXPERIENCE

NVIDIA | Incoming Architecture Intern
Expected; May 2021 – Aug 2021 | Remote in Philadelphia, PA

- Incoming intern expected to work on Nvidia's new VLIW accelerator for computer vision application

SENSETIME | Research Intern (Education Robotics)
Jul 2019 - Sep 2019 | Shanghai, China

- Involved in development of **advanced computer vision** on educational robots
- Led the development of interfacing **customized PCB** and hardware stack with LEGO Sensor Pack, enabling **open-source communication** with the sensor

DJI INNOVATION | Summer Intern
Jun 2018 - Aug 2018 | Shenzhen, China

- Performed AutoCAD design, assembly, and static force analysis on function specific robots in SolidWorks
- Programmed under C environment embedded system based on STM32
- Practiced multi-task controlling, CAN, advanced PID control theory, and built filter for gyro sensor's raw data

PROJECTS

RACHLEFF SCHOLAR | University of Pennsylvania | Verilog, Python, C/C++, Xilinx FPGA, Symbiflow-prjxray, SDSoC
Aug 2019 - Present | Philadelphia, PA

FPGA memory accessing/writing optimization using configuration bitstream

- Innovated generalizable strategies for deciphering the mapping from logical memory in **RTL/HLS design** to **physical BlockRAM bits** in **partial bitstream**
- Created unique toolchain to perform mapping with a one-line command using **Xilinx design checkpoint file**
- Forked **Xilfpga** from Xilinx to enable **reading and writing of BlockRAM** in unit of logical memory designs through PCAP using the designed toolchain
- Designed API, BERT, enabling **zero-routing, zero-overhead access to FPGA on-silicon-fabric memory** through embedded code in on-chip ARM core
- Working on open sourcing tool chain under submitted publication *XBERT: Xilinx Logical-Level Bitstream Embedded RAM Transfusion*

ELECTRICAL/AUTONOMOUS ENGINEER | Penn Electric Racing - University of Pennsylvania | Verilog, Python, C/C++, Altium, LTSpice, ROS
Aug 2018 - Present | Philadelphia, PA

Formula SAE electric vehicle team, third place winner for 2019 Formula SAE Lincoln

- Actively engaged in the design, assembly, and testing of the winning car REV 5, team's first functional 4-wheel-drive race car, **with customized in-wheel motor controller**
- Developed **PCM (Powertrain Control Module)** and **AMS (300V Accumulator Management System)** with **customized PCB** that runs on award-winning car
- Leading the development of team's **perception stack**, as team work towards autonomous racing

CONV2D ACCELERATOR | Student Project, University of Pennsylvania | Verilog, Python, C/C++, Vitis, OpenCL, PyTorch, PYNQ
Oct 2019 - Present | Philadelphia, PA

VGG16 Hardware Accelerator on AWS F1 FPGA Instance

- Customized FPGA computing unit for matrix multiplication by implementing **GEMM** through **systolic arrays** with **HLS design flow.**
- Interfaced PyTorch with **OpenCL** host code using **C++ extension** in PyTorch
- Implemented **out-of-order scheduling** for 3 on-silicon computer unit

SKILLS

Programming
Over 7000 lines:
Java • C • C++ • Python • LaTeX
Over 1500 lines:
OCaml • Verilog/VHDL • Rust
Proficient:
PyTorch • TensorFlow • Git
CAD & Design Tools
SolidWorks • Autodesk Inventor
AutoCAD • Altium
FPGA
Vivado HLS • Vivado • Xilinx SDK • Vitis • OpenCL • Symbiflow PrjXray
Simulation
Mathematica • MATLAB • Simulink
Embed Dev
STM32 • AVR • MQTT
Unix
GNU Make • GNU Bash • CMake
Circuit Simulation
LTSpice • NgSpice

COURSEWORK

Graduate
Machine Perception
(traditional CV & NN approach)

Hardware/Software Co-Design for Machine Learning
(ML Algorithm acceleration on FPGA)

Design & Implementation of OS

Computer Organization and Design
(VHDL)

Embedded Software for Life-Critical Cyber Physical System/IoT Applications

Embedded Systems/Microcontroller Laboratory

Networks and Protocols

Privacy & Anonymity

Undergraduate
Circuit-Level Modeling Design, and Optimization for Digital Systems
(VLSI Design)

Algorithms and Data Structures

Electrical Circuits and Systems

Engineering Probability

ACTIVITIES & LEADERSHIP

Penn Electric Racing
(Electrical/Autonomous Engineer)

Rachleff Scholar Society
(President)

Penn Chinese Theater
(President)

Appendix C- Expert Testimony

"I tested it, it was very good, it worked very well."

– Dr. Aseem R. Shukla, Director of Minimally Invasive Surgery, Children's Hospital of Philadelphia

"I think VerroTouch will be more than a nice-to-have."

– Dr. Paul Thodiyil, Robotic Bariatric Surgeon, Mount Sinai Hospital

"I believe that with haptic feedback, I would be able to work faster."

– Dr. Thomas Sloane Guy, Director of Robotic Cardiac Surgery, Thomas Jefferson Hospital

"They (surgeons) accelerate so much better when they have the sense of feel."

– Steve Davis, Co-founder and the CEO of VerroTouch Medical

"I think haptic feedback is important and I would undoubtedly recommend having haptic feedback to surgical robots."

– Dr. Laurence Spier, Chief of Thoracic Surgery, NYU-long Island Hospital