



TEAM: PATS

UNIVERSITY: Duke University

TEAM MEMBERS:

Ryan Blue, Electrical and Computer Engineering, May, 2026, Ryan.Blue@duke.edu
Ayush Gupta, Biomedical Engineering, May, 2026, Ayush.Gupta@duke.edu
Christopher Wyrzten, Biomedical Engineering, May, 2026, Christopher.Wyrzten@duke.edu
Nicholas Trigger, Biomedical Engineering, May, 2026, Nicholas.Trigger@duke.edu

Technology and Value Proposition

Abstract

Pulsatile arterial line insertions are conducted to give access to arterial blood, which is used to continuously measure the blood pressure of patients during medical procedures. A long-lasting and effective method to practice arterial line insertion does not exist on the market. Team PATS has created Pulse Mate, a system that enables medical personnel to learn and practice arterial line insertion. Pulse Mate costs \$190 to make, can withstand up to 50 uses per day, can be operated by a single person, feels and pulses like a human arm, and has multiple skin tones. We have continually been testing Pulse Mate with the Duke Hospital Simulation Center to receive feedback on effectiveness and realism. We aim for Pulse Mate to be accessible to medical students and professionals across the nation.

The Problem

Arterial line insertion involves puncturing the radial artery and then threading a catheter into the artery to continuously monitor the blood pressure of inpatients. A study of 357 incoming interns found that just over one-third (36.7%) reported having training in arterial line insertion, with an average of only one attempted insertion during medical school (Berg et al., 2014, 242). This lack of training can result in inaccurate insertions, with common complications being pain, swelling, and thrombosis (Scheer et al., 2002, 199-201). While the risk of major complications is only one percent, this still accounts for 19,617 people in the United States (Scheer et al., 2002, 199-201).



Fig. 1: *Previous Training Device Used in the Duke Hospital Simulation Lab*

Current Practice and Training

Arterial Line Placement Trainers (ALPT) are devices that allow medical professionals to practice arterial line insertion. Currently, medical students, nurses, and doctors lack an effective, reusable method to practice. Practicing involves finding a pulse close to the base of the thumb, inserting a catheter at a 45° angle then removing the needle. Some locations have purchased the expensive trainers on the market, which cost anywhere between \$700 to \$3,500. These solutions however, have limitations that negatively influence medical professionals using these devices:

1. Most trainers require a second user to simulate pulse through the radial artery through the actuation of a handheld squeeze bulb or other manual processes. This forces another person to be present to operate the pulse for the medical professional.
2. The skin of the trainers show the “location” of earlier successful punctures (e.g., note red marks on the arm in Fig. 1). This allows the physician to locate the artery by sight, removing the task of locating by feel.
3. The cost and maintenance of these devices is expensive.

The Pulse Mate

Working during the 22-23 academic year, Team PATS has created a functional medium-fidelity prototype of an ALPT (see Fig. 2.). Pulse Mate features an old manikin arm that was repurposed. The arm has a cutout above the wrist into which tubing lays embedded in an insertion medium; this tubing simulates the radial artery, while the insertion medium simulates the subdermal structure of the forearm. The silicon skin wrap is wrapped tightly around the arm, covering the artificial artery and insertion medium. The tubes connect to a housing containing control circuitry, the pump device, a simulation blood reservoir, and

vibration isolation systems. Simulation blood fills the tubing, which connects the pump device, the artificial artery in the forearm, and the reservoir together (see video demonstration at [A-3.6.I](#)). Pulse Mate has several features that allow for accurate and easy simulation.



Fig. 2: Medium Fidelity Prototype of ALPT

Pulse Mate Features

- Realistic simulation: Pulse Mate closely replicates the feel and appearance of a human arm, providing a realistic and immersive simulation environment for practicing arterial line insertions.
 - Catheter threading: Pulse Mate makes it possible to thread the guide wire present in catheters into the artificial artery. In addition, the catheter can draw blood into its canal, mimicking what occurs with actual patients. This allows the entire procedure to be practiced, not just the initial insertion.
 - Troubleshooting: Pulse Mate simulates the realistic process of troubleshooting the arterial insertion through maneuvers taught to medical professionals (similar to those found by Tegtmeier et al., 2006, e13).
- User-friendly interface: Pulse Mate is the only trainer for radial arterial insertions that has an intuitive touchscreen user interface. Existing models have one or two knobs, but lack the ability for updates and new features. Pulse Mate’s interface is easy to learn and runs smoothly.
- Electronic pulse simulation: Pulse Mate incorporates a cutting-edge electronic system that creates a realistic pulse, making the simulation experience even more authentic.
- Durable and replaceable parts: The replaceable skin wraps are durable and last over 300 punctures before replacement is necessary. The tubing underneath can also be replaced after rigorous wearing.
- Cost-effective: Pulse Mate can be sold for \$200 dollars less than the most popular trainers on the market. This allows a wide range of medical professionals and institutions access to quality training.

Pulse Mate Testing Data Summary

Our team has been working closely with Duke Hospital’s Simulation Center. We have received ongoing feedback from Dr. Carlos Falcon (Simulation Specialist at Duke University Medical School) during the design process. Additionally, we have conducted validation testing with seven attending physicians and residents at Duke Hospital. Table 1 shows positive feedback, with most participants rating the device as easy to use and providing a realistic pulse simulation.

Table 1

Survey Results from Current Physicians After Using Pulse Mate Device Prototype

Question Asked	^a Mean Score ± Standard Dev.
How realistic does the arm look?	5.87 ± 0.83
How realistic does puncturing the arm feel?	5.63 ± 1.60
How realistic does the pulse feel?	6.14 ± 0.38
How realistic is the feedback after the artery is punctured?	6.00 ± 0.93
How easy was the device to use?	6.38 ± 0.74

^aLikert scale of 1-7

Moreover, participants also provided specific suggestions ([A-1.1](#)). The feedback suggests that the device is a useful training tool; however, there is room for improvement in terms of realism and anatomical accuracy.

IP and Prior Art Search

The team has initiated the process of seeking a provisional patent. The application will be filed by Duke on our behalf, and subsequently, the team members will be granted the rights. The named inventors are the four team members listed. We have also conducted extensive research and found that there is no product in the market that matches the functionality of Pulse Mate. While most trainers available in the market are manual and rely on a hand pulse, electronic trainers are available but lack the advanced user interface and potential for software updates. Moreover, Pulse Mate has a unique skin and insertion system that is not found in any other trainer.

Market Potential

Pulse Mate provides value to those training to be medical professionals in schools and simulation labs. The market for medical training devices alone stands at \$1.9 billion (Grand View Research, 2021) and is expected to grow anywhere between \$3.19 and \$7.7 billion by 2027 (Sawyer et al. 2022). This is because simulation constitutes an indispensable method of learning and understanding theoretical knowledge, developing skills in the nursing and medical field (Koukourikos et al., 2021, 15-17).

User/Customer Interviews

Our potential customers include medical schools, nursing programs, teaching hospitals, simulation centers, and other healthcare institutions that provide training to healthcare professionals such as anesthesiologists, critical care physicians, nurses, and emergency medical technicians. Team PATS has talked to the Duke Simulation Lab Director and medical professionals who have expressed their interest in Pulse Mate, especially for their need for a low-cost alternative to current training devices. They have also confirmed there is a significant demand for our training device in the market.

Beachhead Market

Our target customers are 200+ medical schools (Wang, 2022) and 650+ simulation labs (The Society for Simulation in Healthcare, n.d.) across the nation. These institutions are seeking cost-effective, anatomically accurate, and reusable devices to enhance their students' and staff's skills in the field. Studies find that simulation using realistic simulators is a valuable method of learning, which has a positive impact on the clinical effectiveness of nursing students (McCaughy, 2010, 827-828). To find a serviceable available market, we limit ourselves to about 60% of those numbers due to geographical access and reach. We further define that market by 70% to include only schools or labs which focus on simulation as a form of training. This leaves us with an estimate of 350 medical facilities. We estimate that our initial serviceable obtainable market will be 50 regional medical schools or simulation labs. While this is a small initial market, there is a clear path to scale once we have established ourselves and gained more credibility. Once we have proven how Pulse Mate is effective in five universities in North Carolina, we will expand from that base..

Product Pricing

To ensure economic sustainability for our product, we plan to leverage our low production cost and durable materials to offer a competitive price point. Our team was able to source materials from online retailers and construct the training device for ~\$200. By sourcing raw materials in bulk, we believe we can bring down production below \$150. Since our low cost differentiates us from competitors, we aim to sell Pulse Mate at \$500, which is still

significantly cheaper than existing medical trainers that typically cost around \$700. This price point would result in a healthy profit margin while still being perceived as a high-value product. When talking to the Head of the Duke simulation lab, he said he would be interested in buying two to three for his lab. If we were to sell two or three units to 50 simulation labs, we could expect to receive \$31,000-\$46,500.

Competition

We hold a strong market position, thanks to our superior product (see Table 2). Pulse Mate outshines other models on the market with its diverse functionalities, such as the ability to change the pulse, preset cardiac conditions, and a wide range of skin tones, all at a significantly lower cost than inferior models. By initially undercutting the prices of established corporations, we can gain traction in the market and later optimize our price to maximize our profit margins.

Table 2
Market Comparison

Device	Cost	^a Pulse	^b User Interface	People Required	^c Durability
Pulse Mate	\$\$	advanced	yes	one	advanced
Life Form Trainer	\$\$\$	elementary	no	two	elementary
GTSimulators Trainer	\$\$\$\$\$	advanced	no	one	elementary

^aRefers to the capability of changing the pulse varying with different blood pressures and beats-per-minute

^bRefers to an advanced form of control – more sophisticated than knobs, buttons, or human-actuated pulse devices (eg., [A-1.2.IV](#))

^cRefers to the ability of the device to be replaced easily between uses, also based on manufacturer recommendation of when to replace certain components

Long-term Business Plan

Our long-term strategy is to drive sales and profits through a multi-faceted approach. Firstly, we aim to attract new customers by expanding our marketing efforts and building brand awareness. Additionally, we plan to explore new markets like the 2,000+ nursing schools across the US. Moreover, we plan to invest in the development of newer and more advanced models of Pulse Mate. This will not only allow us to replace older models and increase sales to repeat customers but also enable us to offer premium functions such as disease presets and annual software updates, which would generate additional revenue streams. Lastly, we have also considered implementing a subscription-based membership where members receive replacement parts, exclusive access to new product features, and other benefits. This would foster customer loyalty and further drive sales over the long term.

Our Team

Our project will be spearheaded by all four team members who will drive it to market. Ryan Blue will manage the team and lead communication efforts with new clients. Nicholas Trigger will oversee the finishing and updating of the software. Christopher Wyrzten will integrate all the hardware, testing, and functions. Ayush Gupta will focus on the design of the final product. Additionally, we have three external mentors to guide us: Dr. Ann Saterbak, who directs the Duke First-Year engineering experience; Dr. Carlos Falcon, our initial client; and Dr. Ankeet Udani, Head of the Duke University Hospital’s Simulation Lab and a practicing Anesthesiologist.

Workplan

The work plan for the next 2 years is noted in Table 3 below.

Table 3
Work Plan and Outcomes

High-Level Step	Description	Condition of Success	Timeline
Secure rights	Submit the provisional patent application through Duke University	Application submitted	5/23
Form a new company	Create a company and further define the roles of all members involved	Meet with Duke New Ventures group to start the process of forming a company	5/23-8/23
Customer Acquisition	Increase network and feedback from potential customers	Attend six competitions or conferences to make connections	5/23-12/23
Technical improvements	Refine method for attaching skin wrap, enhance pulse	Ask doctors to replace the wrap with no instruction and use a survey to gather data	6/23-8/23
Finish cardiac presets	Finalize cardiac preset feature to simulate conditions accurately.	Successful testing with 20 potential users	6/23-8/23
Large Scale Testing	Test with as many doctors, nurses, and residents as possible and get feedback	Data from 75+ potential users	9/23-10/23
Customer Acquisition	Broaden customer base	Reach out to at least 100 contacts with a one-page information sheet	1/24-3/24
Fundraise and apply for Utility Patent	Raise money to fund a patent (\$25,000).	Apply for patent	6/23-8/24
Design for manufacturing	Outsource manufacturing design	Production plans	12/24-4/25
Begin development on new features	Create new updates/features for Pulse Mate	Ultrasound compatible or disease presets	4/25

Resources

As outlined in the proposal; we have a strong network of contacts that will support us throughout the project, both within the university and the wider community. The most obvious limiting resource is the arm. We are currently using an old manikin arm from the Duke simulation lab. We have not been able to find more of the exact same arms. We anticipate that our arm will likely change when we design to manufacture. We have explored the creation of our own arm, and will continue to research the topic.

Another limiting factor is funding, but there are many opportunities through our university to obtain funding, such as the Duke Baquerizo innovation grant, Duke Design Health, Duke FastTrack Medical Device Translator, and many more. While these are small opportunities, funding would allow us to accelerate our plans.

Appendix

A-1.1: Specific Feedback from Survey

- 1.I: Thrill (vibration) feels more like a dialysis fistula. The artery should only feel pulsatile. Add color to blood. Great job! Could also be made shorter (hand/wrist/forearm)
- 1.II: The artery caliber is larger than a human artery. Smaller would be more realistic!
- 1.III: change rubber where punctures are, slippery and could be more anatomical
- 1.IV: bury the vessel loop; make ultrasound compatible
- 1.V: Return flow buried
- 1.VI: None, great simulation
- 1.VII: Because of the loop design, it felt like there were two pulses. I would hide one of the limbs to only feel one pulse. Also, I would shift the loop a few mm so it is not so lateral because a true pulse is a little bit more medial.
- 1.VIII: Tolerate multiple sticks a little better, palpation of pulse even more proximal.

A-1.2: List of Figures

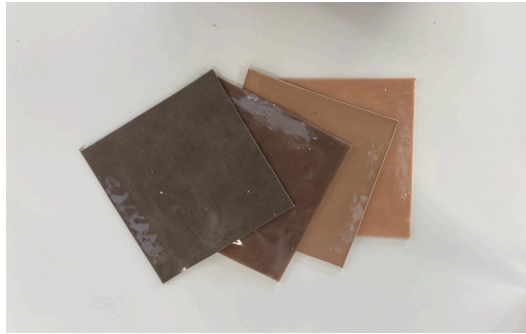
- 2.I: **Fig. 1:** *Previous Training Device Used in Duke University Medical Simulation Labs*



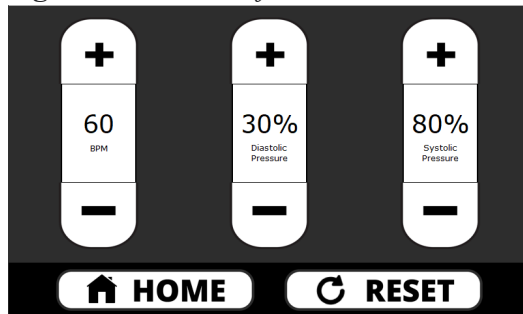
- 2.II: **Fig. 2:** *Medium Fidelity Prototype of ALPT*



2.III: **Fig. 3: Skin Wraps in Multiple Skin Tones**



2.IV: **Fig. 4: Screenshot of Touch Control Interface**



A-2.3: List of Tables

3.I: Table 1: <i>Survey Results from Current Physicians After using Pulse Mate Device Prototype</i>	3
3.II: Table 2: <i>Market Comparison</i>	4
3.III: Table 3: <i>Work Plan and Outcomes</i>	5-6

A-2.4: Technical Contributors

- 4.I: Ann Saterbak, PhD.
EGR 201 Professor, Duke University
- 4.II: Benjamin Cooke, PhD.
EGR 101 Professor, Duke University
- 4.III: Will Inigo
EGR 101 TA, Duke University
- 4.IV: Christopher Bingham
EGR 101 Technical Mentor, Duke University
- 4.V: Ankeet Udani, M.D.
Medicine Simulation Lab Director, Duke University

A-2.5: PATS Team Members and Contact Information

- 5.I: Ryan Blue
 - 5.I.i Ryan.Blue@Duke.edu
 - 5.I.ii www.linkedin.com/in/ryblue
- 5.II: Ayush Gupta
 - 5.II.i Ayush.Gupta@Duke.edu

5.III: Nicholas Trigger

5.III.i Nicholas.Trigger@Duke.edu

5.III.ii [LinkedIn - Nicholas Trigger](#)

5.III.iii NicholasTrigger.com

5.IV: Christopher Wyrzten

5.IV.i Christopher.Wyrzten@duke.edu

5.IV.ii <https://www.linkedin.com/in/christopher-wyrzten-a21603222/>

A-3.6: Video Demonstration

6.I: <https://youtu.be/cOleKeZGHyg>

References

- Berg, K., Riesenberg, L. A., Berg, D., Schaeffer, A., Davis, J., Justice, E. M., Tinkoff, G., & Jasper, E. (2014, May). The Development of a Validated Checklist for Radial Arterial Line Placement. *American journal of medical quality*, 29(3), 242-246. MEDLINE.
10.1177/1062860613492189
- Grand View Research. (2021, November 17). *Medical Simulation Market Size, Share & Trends Analysis Report By Product & Services (Medical Simulation Software, Web-based Simulators, Simulation Training Services), By Technology, By End Use, And Segment Forecasts, 2021 - 2028*. grandviewresearch.com.
<https://www.grandviewresearch.com/industry-analysis/medical-healthcare-simulation-market>
- Irwin, R. S., & Rippe, J. M. (Eds.). (2012). *Irwin and Rippe's Intensive Care Medicine* (7th ed.). Kluwer Academic.
<https://www.vlebooks.com/vleweb/product/openreader?id=none&isbn=9781975102227>
- Koukourikos, K., Tsaloglidou, A., Kourkouta, L., Papathanasiou, I. V., Iliadis, C., Fratzana, A., & Panagiotou, A. (2021, March 1). Simulation in Clinical Nursing Education. *Simulation in Clinical Nursing Education*, 29(1), 15-20. National Library of Medicine.
10.5455/aim.2021.29.15-20
- McCaughey, C. S. (2010, November). The role of simulation in nurse education (M. K. Traynor, Ed.). *Nurse Education Today*, 30(8), 827-832. ScienceDirect. 10.1016/j.nedt.2010.03.005
- Scheer, B., Perel, A., & Pfeiffer, U. J. (2002, June). Clinical review: complications and risk factors of peripheral arterial catheters used for haemodynamic monitoring in anaesthesia and intensive care medicine. *Critical Care*, 6(3), 199-204. 10.1186/cc1489

The Society for Simulation in Healthcare. (n.d.). *SIM Center Directory*. SIM Center Directory.

Retrieved April 20, 2023, from

<https://www.ssih.org/Home/SIM-Center-Directory/Area/US>

Swan, H. J. C. (1991, August). The pulmonary artery catheter. *Disease-a-Month*, 37(8), 478-508.

ScienceDirect. 10.1016/0011-5029(91)90010-9

Tegtmeyer, K., Brady, G., Lai, S., Hodo, R., & Braner, D. (2006, April 13). Placement of an

Arterial Line. *N Engl J Med*, 354(15), e13. The New England Journal of Medicine.

10.1056/NEJMvcm044149

Wang, L. (2022, November 30). *How Many Medical Schools Are in the United States? (2023 MD*

and DO Lists). Med School Insiders. Retrieved April 20, 2023, from

<https://medschoolinsiders.com/pre-med/how-many-medical-schools-in-the-united-states/>