April 1, 2023

Dr. Michael Hegedus
Simon Fraser University
School of Engineering Science
Burnaby, British Columbia
V5A 1S6

Re: ENSC 405W Final Proposal for Croma Tech's S-ROM

Dear Dr. Hegedus,

The attached document outlines our proposal for S-ROM, a wearable device with a data presentation application used for comprehensively evaluating a shoulder's range of motion (RoM).

The aim of our proposal is to convey the need, feasibility, and market potential of S-ROM. The document includes a description of the scope of our project, analysis of our target market, an introduction to the Croma Tech company and team, as well as prototype costs and a timeline demonstrating major milestones in the product development process.

Our team – Ansley Ang, David Bechert, Diego Flores, Luka Cuk, Ritesh Nandakumar, and I – are senior Simon Fraser University engineering students. With our diverse backgrounds in physics, electronics, systems, and computer engineering, we are confident in our ability to complete this project.

Thank you for taking the time to review our final proposal. For inquiries, please contact our Chief Communications Officer, Ansley Ang, by phone (778-987-4926) or by email (ansleya@sfu.ca).

Sincerely,

Elias Bircher
Chief Executive Officer
Croma Tech

Enclosed: Croma Tech Final Proposal document for S-ROM

Project Proposal: S-ROM

April 1st, 2023

Elias Bircher	Chief Executive Officer
David Bechert	Chief Technology Officer
Ansley Ang	Chief Communications Officer
Luka Cuk	Chief Operations Officer
Diego Flores	Chief Financial Officer
Ritesh Nandakumar	Chief Product Officer

Executive Summary

Shoulder injuries are prevalent among most individuals seeking physiotherapy. Whether it is recovering from a shoulder surgery or healing from a minor shoulder strain, people desire a return to their daily life as soon as possible [1]. Physiotherapy is the most prevalent method for overseeing this recovery due to its foundation in prevention and rehabilitation of physical injuries. During appointments, physiotherapists (PTs) rely heavily on qualitative analysis for range of motion (RoM) measurements to then assess and treat shoulder injuries.

Despite its popularity, using the universal long-arm goniometer to perform shoulder RoM assessments can lead to varying measurements across multiple physiotherapy appointments or practitioners. The goniometer is operated by placing one arm of the device in parallel with the patient's body or arm, which is highly susceptible to user error and minor differences in placement across multiple measurements.

Croma Tech strives to remove the ambiguity of shoulder RoM measurements through the development of S-ROM. S-ROM consists of a wearable sleeve, housing the angle measurement hardware, and an application for viewing and analyzing assessment results. Not only does S-ROM provide displacement angle information, but it stores that information for future use, and also provides graphs of the patient's movement through their entire range of motion to help PTs to identify painful angle ranges. Our product was designed with ease of use and cost effectiveness as key decision drivers. Two inertial measurement units are used cohesively to measure rotation angles and determine if the exercises are performed correctly. Then, the data is streamed to the user's PC and displayed in real time.

Evaluating the market value for S-ROM in North America, the size of the physiotherapy equipment market is valued at 19.9 billion USD globally, with North America owning 38.3% of the share [2]. Further investigation has shown that there is a large growth of PTs available in both Canada and the United States with demand for treatment due to the inevitability of shoulder injuries. Our most prominent competitors, the Halo Digital Goniometer and the traditional goniometer are also capable of providing RoM measurements; however, S-ROM offers additional RoM assessment data including long term data storage, overcompensation and incorrect form detection. The current cost estimate of our engineering prototype is $91.87, which can be reasonably covered by the Wighton Fund, Engineering Science Student Endowment Fund, and/or our own finances.

The team at Croma Tech is comprised of six exceptional Simon Fraser University engineering students with proven time-management abilities and extensive experience with hardware design and firmware development. We are tremendously excited to bring S-ROM to the market and revolutionize RoM assessments.

Table of Contents

List of Figures

List of Tables

Glossary

Term	Definition
FW	Firmware
Goniometer	An instrument that measures the range of motion at a joint using relative angles
GUI	Graphical User Interface – the display of our software application
HW	Hardware, in relation to the electronic components of the design
IMU	Inertial Measurement Unit
Overcompensation	Tightening and straining of non-injured muscles caused by changes in normal joint mechanics
Passive Device	A medical device that does not use force or power to measure metrics of the human body
PC	Personal Computer
PoC	Proof of Concept
PT	Physiotherapist
RoM	Range of Motion
S-ROM	Shoulder - Range of Motion (Our Product Name)
SW	Software

1) Introduction

Shoulder injuries are commonly encountered by many physiotherapists (PT). Overuse, tendon tears, and shoulder surgery recovery are just some of the injuries that the average person can experience in their lifetime [1]. Typically, PTs will evaluate the injured patient's current range of motion (RoM) and assign at-home exercises to facilitate shoulder recovery. However, discussions with licensed PTs have revealed fundamental issues with this process. Goniometers, the main instrument used for measuring a patient's maximum range, are insufficient in obtaining repeatable and precise measurements [3]. Additionally, the bulk of the patient's recovery occurs outside of the office. Since physiotherapy appointments only occur once a week on average, a lot of important details may be lost between appointments [4]. PTs only see snapshots of the patient's recovery and do not have access to whether the patient's recovery is linear, exponential, or decreasing daily. This can be discouraging for patients who may not see a direct correlation between their exercises and their recovery.

Croma Tech aims to address these issues with our new product, S-ROM. S-ROM is a wearable device which transmits RoM measurement data in real-time to a desktop application to be used in comprehensively evaluating shoulder RoM. In addition to making the measurements themselves, PTs can review results from individual at-home measurements or assess trends over multiple exercises and adjust recovery plans based on the efficacy of different exercises. S-ROM will give both patients and PTs a holistic view of the shoulder recovery and identify where improvements or detriments occurred throughout a week. Figure 1 visualizes our prototype design of the S-ROM's wearable device and GUI.

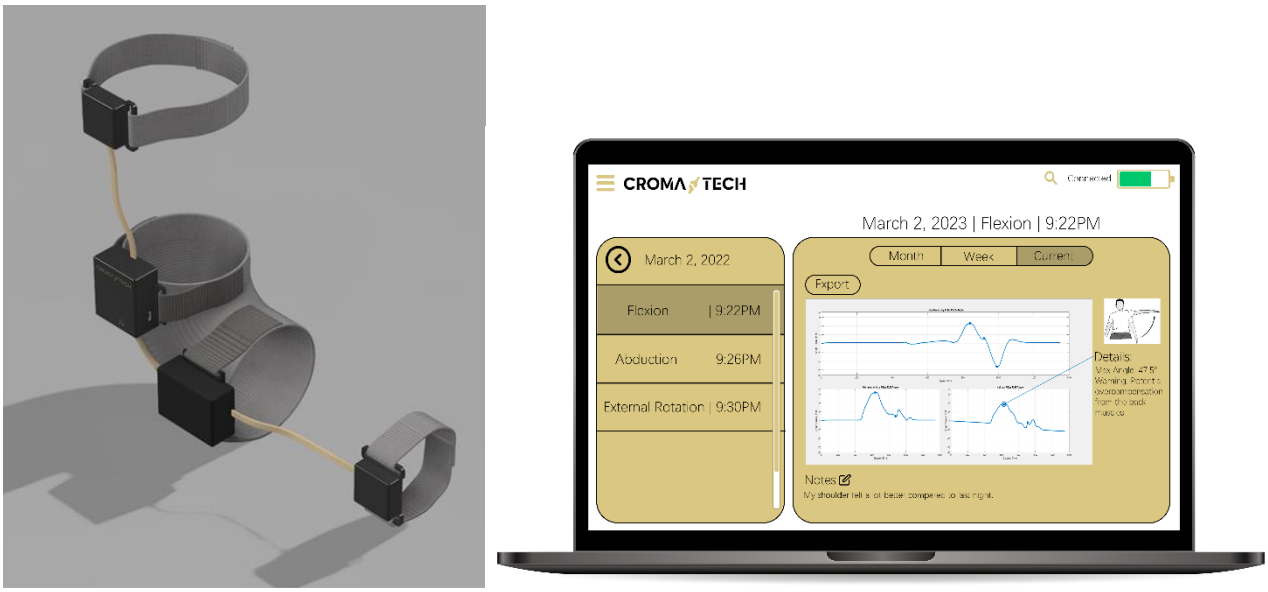

Figure 1: S-ROM Device and GUI

This proposal document will outline S-ROM's value in the physiotherapy market and its impact on shoulder injury recovery. Croma Tech has performed the necessary analysis and research to bring our idea from conception to production in the following sections of the proposal:

(1) **Risks/Benefits:** Outlines the impact of our product on society and considerations for the business itself.
(2) **Market Outline:** Describes the commercial target market and potential competitors.
(3) **Company Details:** Introduces our brand and our team capabilities.
(4) **Project Planning:** Outlines our project timeline from the past four months and the future.
(5) **Cost Considerations:** Details the projected cost of our engineering protype.

1.1) Scope

The goal of S-ROM is to be a complete system that can objectively measure the shoulder's RoM and present the data for analysis. PTs need to be able to decipher the data and patients should be able to use the product independently despite their shoulder injury. S-ROM will support measurement functionality for three of the most common shoulder RoM assessment exercises used by PTs: flexion, abduction, and external rotation, all of which are shown in Figure 2 [5]. The features supported for the three exercises are listed below:

- Capture the complete motion of the shoulder for the exercises listed in Figure 2.
- Detect overcompensation due to over exertion of surrounding (supporting) muscles.
- Detect incorrect performance of the exercise.
- Instruct the patient on how to carry out the exercise.
- Provide adjustable device straps to fit patients with different arm sizes.
- Store measurements and display data over a day, week, or month.
- Export patient data to a .csv file for compatibility with other software.
- Support Bluetooth and USB connectivity to a desktop.

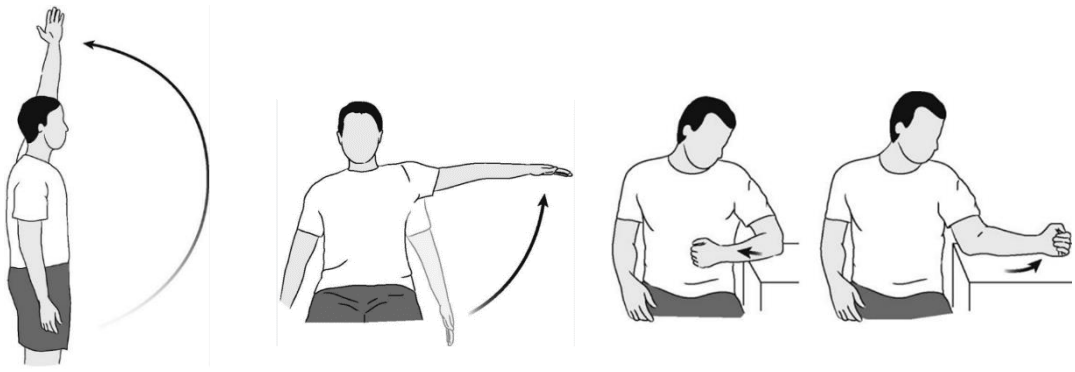

Figure 2: Flexion (left), Abduction (middle), and External Rotation (right) Exercises [6]

These features will be implemented through our system which will use two 9-axis inertial measurement units (IMU) to calculate the shoulder rotations. For a typical use case, the patient

will power on the device, connect the device to their computer through Bluetooth or USB, and then follow a series of prompts to collect measurements for the aforementioned exercises. This patient data will be available on a physiotherapy version of the GUI, where practicing PTs can examine the patient's performance. An overview of this arrangement can be visualized in Figure 3.

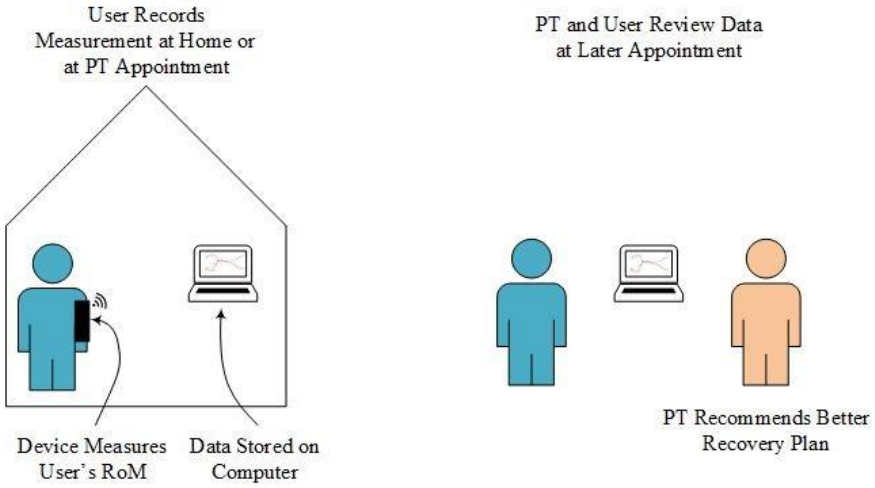

Figure 3: S-ROM Use Case Diagram

2) Risks

As a Class 1 medical device, defined by the passive measurement nature of the device, the foreseeable risks associated with our product are minimal. By adhering to the safety requirements outlined by the government of Canada's Medical Device Regulations, our device will have no safety risks to the user when used as intended [7].

2.1) Society

Risks to society involve the potential adverse effects of our product on consumer lives directly or indirectly. For S-ROM, the risks are minimal is it as passive measurement device. However, there are risks related to the battery pack, sanitization of the device between users, and putting the device on which will be critical to mitigate when considering the device will be used by patients with injured arms that may not be able to respond to hazards effectively.

2.1.1) Battery Hazards

The portability of S-ROM requires inclusion of a battery to power the device. As a result, potential risks arise from the necessity of the battery. The S-ROM device uses a lithium polymer (Li-Po) battery which can catch on fire or explode if it is overcharged, punctured, or exposed to high temperatures [8] [9]. These risks are mitigated by our carefully crafted hardware and

mechanical design. The product will include a proper charging and protection circuitry to prevent electrodes from being shorted, and a robust housing to prevent the battery from being punctured accidentally.

2.1.2) Sanitization

PTs lending a single S-ROM device to multiple users will require a high level of sanitization between users to avoid transferring viruses or diseases. The current design follows a modular structure in which electronic components are shielded, allowing consumers to sanitize the device without performance degradation. A detailed sanitization protocol will be provided in the accompanying user manual.

2.1.3) Complications From Equipping the Device

S-ROM is designed with thorough consideration for the at-home use case. Patients should be able to equip the device without further harm to their shoulder based on results from our usability testing. However, due to the diversity of human arm shapes and sizes, there may be special cases where the user struggles to put the device onto their injured arm that was not covered in our testing. These cases would be accounted for in future design iterations.

2.2) Business

Business risks outline the potential risks our product will face economically. In our case, this largely pertains to the efficacy of our device for different demographics and challenges caused by the current global chip shortage. We are confident that our proactive actions will allow us to supply S-ROM to consumers and avoid financial difficulties.

2.2.1) Range of Users

The current S-ROM design relies on the user orienting the device with the sensor modules on the outer edge of their arm. Should the user equip the device severely out-of-place, the angle measurements may be incorrect. Certain users with arm shapes dissimilar to ones used during testing may be susceptible to incorrect readings. This could limit our overall user range and discourage some PTs from purchasing the device. However, we anticipate these cases to be extremely rare and, if they occur, we will emphasize finding solutions in future design iterations.

2.2.2) Global Chip Shortage

The global chip shortage, which stems from the COVID-19 pandemic in 2020, has heightened the demand for electronic components and increased component prices [10]. The trickle-down effect of the increased demand may make it difficult for us to source certain parts for the S-ROM device both presently and in the future if additional features are added. The current hardware design accounted for this shortage, and we are well equipped to bring S-ROM to the market with the current feature set.

3) Benefits

The main benefits of S-ROM stem from its low cost and advanced functionality not available from traditional goniometers or our competitors. Identifying these benefits is crucial to advertising and convincing consumers to adopt our device.

3.1) Cost Effectiveness

The engineering prototype is expected to have a final cost of less than $100. Accounting for lower component costs when scaled up for production allows us to market the device at a very reasonable price. This will ease the burden on PTs who wish to buy multiple devices to lend out to patients and use them in clinic.

3.2) Improved RoM Measurement Accuracy

Current shoulder injury assessments are limited by the qualitative judgement of the PT and the repeatability of goniometer measurements. Using the S-ROM device allows PTs to obtain precise measurements that are not susceptible to human measurement error. Furthermore, one specific use case mentioned by our PT is for trigger-point dry needling. This practice involves the PT using acupuncture needles to engage certain muscles in the shoulder to determine their effect on the patient's RoM. In some cases, the RoM increase may only be five degrees or less which is difficult for the human eye to discern and difficult for a traditional goniometer to measure. S-ROM will allow PTs to quantitatively determine this increase and thus provide better insight into which muscles are restricting the patient's RoM.

3.3) Larger Muscle Recovery Dataset

Our product is carefully designed to allow patients to use the device at home. This equips PTs with a larger data set showing daily RoM recovery progress. The additional measurements can eliminate another issue brought up by our conversations with PTs, where they observed sudden drops in their patient's RoM across their weekly meetings; the patient was not always aware of what caused these occurrences. With S-ROM's additional progress tracking, they can review where the decrease first occurred and the severity of the issue (sharp or gradual decrease).

3.4) Additional Capabilities

The products of our primary competitors are limited to angle displacement measurements only. Adding data analysis to assess overcompensation and incorrect exercise form is where Croma Tech elevates above the competition, since it opens the opportunity for patients to perform the exercises at home. Typically, overcompensation and incorrect form can skew RoM measurements and they are difficult to identify with pure angle measurements alone. This feature informs PTs and patients of external factors that could have affected the RoM and allows them to take steps to mitigate the issue. Additionally, S-ROM includes an export feature that allows physiotherapists to integrate our software with their existing practice management software.

4) Market Outline

Croma Tech's S-ROM is designed to be marketed towards PTs in North America, who would then use and lend our product to patients with shoulder injuries. Our device can be considered a part of the physiotherapy equipment market which is valued at 19.9 billion USD globally according to a report from 2022 by Grand View Research [2]. This market is expected to grow by 6.95% annually for the next seven years, with North America holding majority of this share at 38.3%. A full breakdown of the market share by region is shown in Figure 4. With these factors in mind, we are highly optimistic about the growth potential of our company in the next few years.

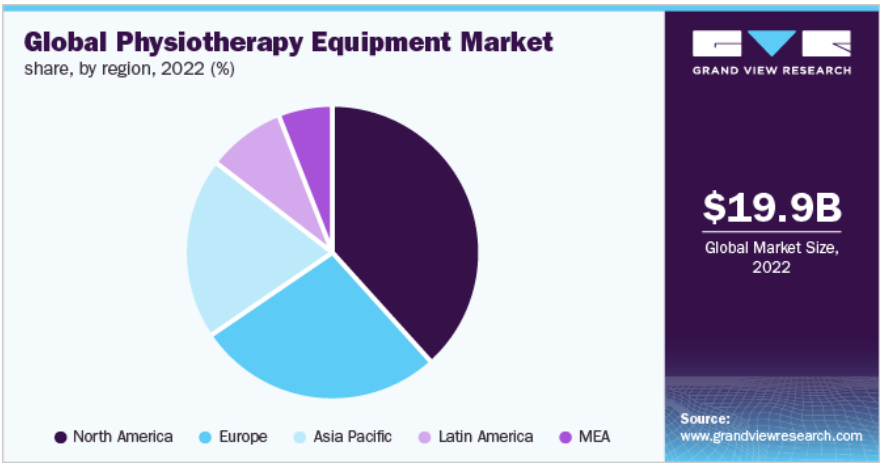

Figure 4: Global Physiotherapy Equipment Market Size and Share Distribution [2]

Furthermore, we have identified additional statistics specific to S-ROM that demonstrate the product's potential success and profitability. According to a Statistics Canada health survey in 2011, 13.2% of the population had their most serious injury relating to the shoulder, elbow, or arm in the past year for age groups above 12 years old [11]. Additionally, shoulder arthroscopy, a type of shoulder treatment through surgery, is the second most common arthroscopy treatment [12]. These statistics highlight that shoulder injuries are prevalent in society, and with recovery times ranging from weeks to months, it is clear that identifying the best treatment quickly and accurately will help accelerate the recovery process.

The number of PTs in North America also emphasizes the promising market size. According to the Canadian Institute for Health Information (CIHI), there are approximately 27,000 licenced PTs in Canada as of 2021. In the USA, there are around 312,000 PTs according to the American Physical Therapy Association (APTA) in 2020 [13] [14]. The market size in North America is thus approximately 339,000 with each consumer (PTs) potentially purchasing multiple products. Additional insight on the market is sourced from interviews with Tony Marci and Renzo Carbonel, two practicing PTs in Canada who have both identified the value of our business model and vowed to personally purchase our product.

Croma Tech will market S-ROM to PTs instead of shoulder injury patients to maximize the potential of the device. Not only are PTs likely to encounter many patients with shoulder injuries in their workplace, but they are also the most qualified to interpret the measurement data. Additionally, marketing S-ROM to consumers needing to use the device more than once avoids consumer hesitation about purchasing a single use product.

4.1) Competition

The most popular option used by PTs for RoM measurements is the goniometer [5]. This tool is known for its simplicity and ability to take measurements for a wide variety of areas (the shoulder, elbow, knee, etc.). However, a common criticism of the goniometer is its lack of reliability and repeatability in measurements; studies have shown that the measurements taken are often imprecise and inconsistent across many trials [3].

Multiple companies have attempted to tackle this issue. We have identified our main competitor in the market to be Halo Medical Devices and their product, the Halo Digital Goniometer [15]. Their product shares similar features with S-ROM as a replacement for the traditional goniometer. PTs can use the Halo Digital Goniometer to measure a patient's angular displacement for joints including the shoulder, knee, and elbow, with an accuracy within one degree. Furthermore, the device can store up to four angles at a time to take measurements in quick succession and is small enough to be operated with one hand.

Figure 5: Traditional Goniometer (left) and Halo Digital Goniometer (right) [5] [15]

However, unlike the Halo Digital Goniometer, S-ROM is a complete assessment system that allows PTs to track and analyze a patients recovery progress. Also, pure angle measurement devices fail to consider overcompensation or incorrect performance of the exercise. S-ROM strives to be an improvement over the goniometer by providing higher accuracy and more consistent measurements, additional overcompensation and incorrect form detection metrics, and a software application that allows PTs to confidently observe trends in patient performance over time. Patients should be able to use our device and app at home, providing them recovery insight outside of the physiotherapy office.

5) Company Details

Croma Tech is a physiotherapy solutions company founded in January 2023 by six friends who met in their first year at Simon Fraser University. Our first product, S-ROM, is an accumulation of our passion for bettering human health and skills obtained over the past five years of our engineering undergraduate degrees. The engineering prototype for S-ROM is expected to be completed by August 2023 as the very first commercially available shoulder RoM assessment device on the market.

5.1) The Team

Elias Bircher
Chief Executive Officer

Elias is an Engineering Physics student in his final year. Outside of the classroom, he is the president of the SFU Rocketry Club, where he has demonstated his leadership skills overseeing a group of over 70 engineering students. This has taught him the basics in electronics, software, mechanics and analysis.

David Bechert
Chief Technology Officer

David is a Computer Engineering student with experience in ASIC development and verification. He has worked with universal verification methodology at both Intel and Andes Technology. At Andes, he had the opportunity to work with a RISC-V memory management unit. At Intel, he worked on full chip level ASIC simulations including C/C++ FW driver code and SystemVerilog tests. David has a passion for ASIC design and verification. For the S-ROM team he has been working on FW development and design including communication with the GUI.

Ansley Ang
Chief Communications Officer

Ansley is an Electronics Engineering student in his final year. After joining the SFU Robot Soccer Club, he has discovered a passion for both the hardware and software components of electronic systems**.** With co-op experiences at both Intel Corporation and DarkVision Technologies in electrical engineering positions, he is excited to bring his knowledge in schematic and board design to make S-ROM a reality.

Luka Cuk
Chief Operations Officer

Luka is a Systems Engineering student with experience in firmware development and UI design. His most recent electrical engineering co-op at Kardium, which was primarily focused on FPGA design and UART firmware development, combined with his UI experience, help bridge the S-ROM GUI and firmware developent. Luka is developing the S-ROM application with feedback from PT Tony Macri.

Diego Flores
Chief Financial Officer

Diego is an Electronics Engineering student with experience in hardware, and firmware development. His most recent co-op position at Conetec focused on project prototyping and hardware design using Altium. Diego also has an interest in mechanical design and 3D printing naturally assigning him the leadership position of the S-ROM mechanical design team.

Ritesh Nandakumar
Chief Product Officer

Ritesh is a Systems Engineering student with his most recent co-op at Delta Controls. This allowed him to learn the ins and outs of product development and hardware design. He is excited to contribute to the hardware design and development of the S-ROM device and bring this revolutionary product to market.

6) Project Planning

To ensure well defined tasks with known deadlines are made readily available to team members, Croma Tech uses the Jira Issue and Project Tracking Software. The software allows us to track progress through assigned tasks, milestones, meeting minutes, and other documentation.

Our original GANTT chart suggested that much of the product development could be done in parallel. However, we learned throughout the term that different aspects of the design relied heavily on the design of other parts. For example, the mechanical design heavily depended on the result of the IMU testing to determine the optimal placement along the length of the arm, how many sensors were required, and where to place them on the circumference of the arm.

Some of the GUI/SW development was blocked by the FW development as we distinguished data processed by FW and by SW.

The GANTT charts showing our predicted and expected milestones for the PoC prototype development are shown in Figure 6 below.

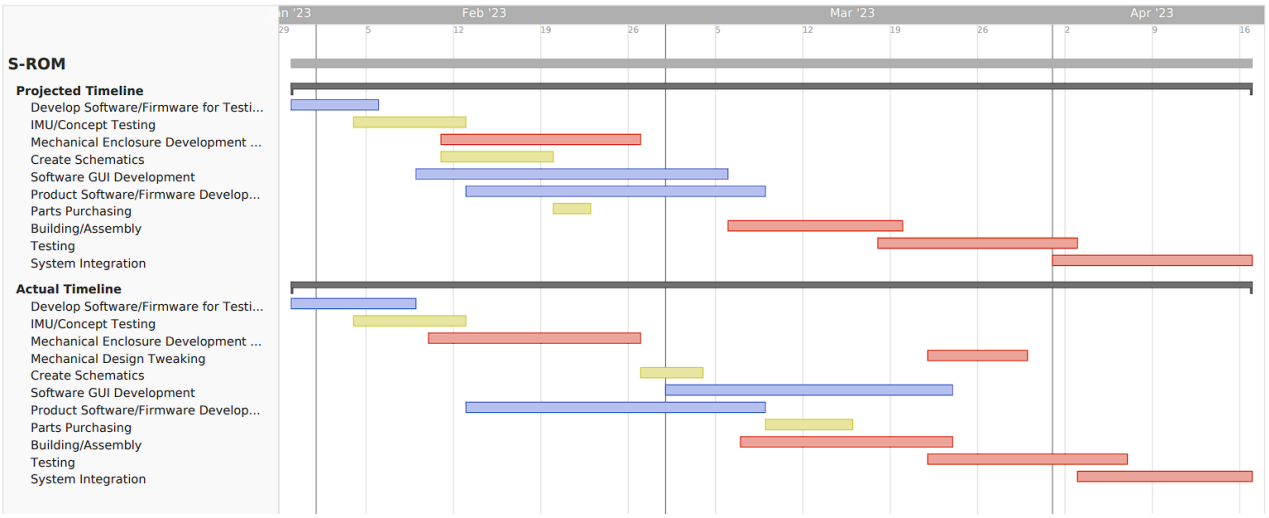

Figure 6: Predicted and Expected Gantt Charts

As we can see from the milestones, our initial testing and system integration/final testing match the expected timeline well. Aligning the final milestones with the predicted ones exhibits the exceptional time management and problem-solving abilities of our team as we were able to mitigate issues found during testing and adjust milestones and priorities accordingly. The main discrepancies occur in the timeframe from the middle of February to the middle of March specifically related to GUI development and mechanical design. GUI development was delayed to create better testbeds for the IMU and initial mechanical testing. Once the primary hardware design was developed with appropriate software, testing revealed issues with the mechanical design. This ultimately required tweaking late in the development cycle as shown in Figure 6. Overall, issues revealed by subsystem were handled swiftly by the team to adhere to our aggressive timeline.

7) Financials

To ensure PTs can purchase multiple devices to lend to their patients, Croma Tech is dedicated to keeping product costs low while maintaining a level of accuracy and functionality that separates S-ROM from competitors.

7.1) Project Costs

The expected cost breakdown for S-ROM's engineering prototype is outlined in Table 1. Traditional goniometers used for shoulder RoM measurements range in price from roughly $15

to $30 [16]. Our engineering prototype costs are expectedly inflated due the high unit costs of purchasing low volume items such as the 9-axis IMUs and elbow sleeve. Once the product is ready for initial release and production is scaled up, development costs will be dramatically decreased allowing us to price the device at an attractive figure to consumers.

Table 1: Cost Breakdown for the Engineering Prototype

	Component	Quantity	Ext. Price
Hardware	Microcontroller	1	$6.09
	9-axis IMU	2	$30.94
	Battery Charging/Management	1	$1.67
	LiPo Battery	1	$14.00
	Voltage Regulator	2	$1.47
	Bluetooth Module	1	$10.42
	Misc. Components	-	$7.00
Mechanical	Velcro Straps	3	$6.99
	Elbow Sleeve	1	$10.99
	3D Printer Filament	1	$2.30
Total			91.87

Much of the cost breakdown for the engineering prototype is guided by proactive research done by the team. This includes monitoring product stock for various electronic components and keeping account of performance margins that allow future functionality to be added without requiring a full redesign. The relatively low cost of the project is indicative of the firmware and software effort in the design.

7.2) Funding

As our engineering prototype is expected to be relatively inexpensive, finding appropriate funding for the project is less of a challenge. We plan to apply for funding from the following two sources with the hopes that the entire cost of the prototype can be covered:

- **Wighton Engineering Development Fund.** Croma Tech will submit a proposal for funding from the Wighton Fund with an emphasis on the benefits of our product in injury recovery and assessment.
- **Engineering Science Student Endowment Fund.** An application for funding from the ESSS would be submitted if Croma Tech is not approved by the Wighton Fund. This is a secondary option as the preference of the team is not to defer ownership of components to outside sources.

If the two funding options above are not approved, Croma Tech will approach the consulted PTs to gauge their interest in helping to fund the project in exchange for being the first users. Finally, any remaining costs of the project development will be distributed evenly among the six members.

8) Conclusion

Traditional universal goniometers, the most commonly used instrument for measuring joint RoM, fall short when it comes to accuracy and repeatability in measurements according to various research and personal accounts from consulted PTs. Croma Tech is excited to tackle this issue by introducing S-ROM into the market. Using S-ROM, PTs will have access to more accurate RoM measurement data including angle displacement, overcompensation detection, and exercise form detection. With this information, they will be able to assess trends in shoulder exercise RoM measurements across multiple sessions and subsequently provide more tailored recovery plans and accelerate patient recovery. We have thoroughly evaluated the business risks and safety concerns for the user and are highly confident in our ability to minimize these issues. The substantial physiotherapy equipment market, supply of physiotherapists, and demand for shoulder injury treatment justify the high growth potential of S-ROM. Our team has outlined the current timeline of our project with most major milestones being met accordingly. Analysis of the engineering prototype costs exhibit the cost effectiveness of the design and can realistically be financed by available funds. Croma Tech is encouraged by the combination of market potential, low costs, and technological innovation of S-ROM and we are thrilled to bring it to market.

References

[1] Health Encylopedia, "Common Injuries of the Shoulder," University of Rochester Medical Centre, New York.

[2] Grand View Research, "Physiotherapy Equipment Market Size, Share & Trends Analysis Report By Application (Neurology, Musculoskeletal, Pediatrics), By Type, By Demographics, By End Use, By Region, And Segment Forecasts, 2023 - 2030," Grand View Research, San Francisco, 2022.

[3] J. R. W. Z. L. S. G. A. M. Kimberley Hayes, "Reliability of five methods for assessing shoulder range of motion," *Australian Journal of Physiotherapy,* vol. 47, no. 4, pp. 289-294, 2001.

[4] L. Newlands, "How Often Are Physio Appointments," Strive Physiotherapy & Performance, [Online]. Available: https://strivept.ca/how-often-are-physio-appointments. [Accessed 11 February 2023].

[5] "Goniometer," Physiopedia, 12 November 2021. [Online]. Available: https://www.physio-pedia.com/Goniometer. [Accessed 12 February 2023].

[6] M. T. E. George S. Athwal, "Shoulder Surgery Exercise Guide," OrthoInfo, August 2022. [Online]. Available: https://orthoinfo.aaos.org/en/recovery/shoulder-surgery-exercise-guide/. [Accessed 04 February 2023].

[7] "Medical Devices Regulations," Consolidated federal laws of Canada, [Online]. Available: https://laws-lois.justice.gc.ca/eng/regulations/sor-98-282/FullText.html. [Accessed 1 February 2023].

[8] OSHA, "Preventing Fire and/or Explosion Injury from Small and Wearable Lithium Battery Powered Devices," 20 June 2019. [Online]. Available: https://www.osha.gov/sites/default/files/publications/shib011819.pdf. [Accessed 28 March 2023].

[9] C. Mikolajczak, M. Kahn, K. White and R. T. Long, "Lithium-Ion Batteries Hazard," NFPA, Massachusetts, 2011.

[10] H. Lynne McKeefry, "Global Chip Shortages Cast a Long Shadow With No End in Sight," DigiKey, 23 November 2021. [Online]. Available: https://www.digikey.com/en/blog/global-chip-shortages-cast-a-long-shadow. [Accessed 25 February 2023].

[11] Statistics Canada, "Injuries in Canada: Insights from the Canadian Community Health Survey," 28 June 2011. [Online]. Available: https://www150.statcan.gc.ca/n1/pub/82-624-x/2011001/article/11506-eng.htm#a4. [Accessed 20 March 2023].

[12] Cleveland Clinic, "Shoulder Arthroscopy," 26 August 2021. [Online]. Available: https://my.clevelandclinic.org/health/treatments/21785-shoulder-arthroscopy. [Accessed 20 March 2023].

[13] Canadian Institute for Health Information, "Physiotherapists," 17 November 2022. [Online]. Available: https://www.cihi.ca/en/physiotherapists. [Accessed 20 March 2023].

[14] America Physical Therapy Association, "APTA Physical Therapy Workforce Analysis," America Physical Therapy Association, Alexandria, 2020.

[15] Halo Medical Devices, "Halo Digital Goniometer," [Online]. Available: https://halomedicaldevices.com/. [Accessed 20 March 2023].

[16] Precision Goniometer, "Precision Goniometer," Precision Goniometer, [Online]. Available: https://www.precisiongoniometer.com/shop. [Accessed 1 February 2023].

[17] O. INC, "Goniometers, ISOM Plastic," ORTHOCANDA INC, 2023. [Online]. Available: https://www.orthocanada.com/en/goniometers-isom-plastic. [Accessed 15 February 2023].

[18] "Goniometer (360° Degree Head)," Relaxus Professional, 2023. [Online]. Available: https://relaxusonline.com/products/buy-goniometer?variant=20294002835567. [Accessed 15 February 2023].