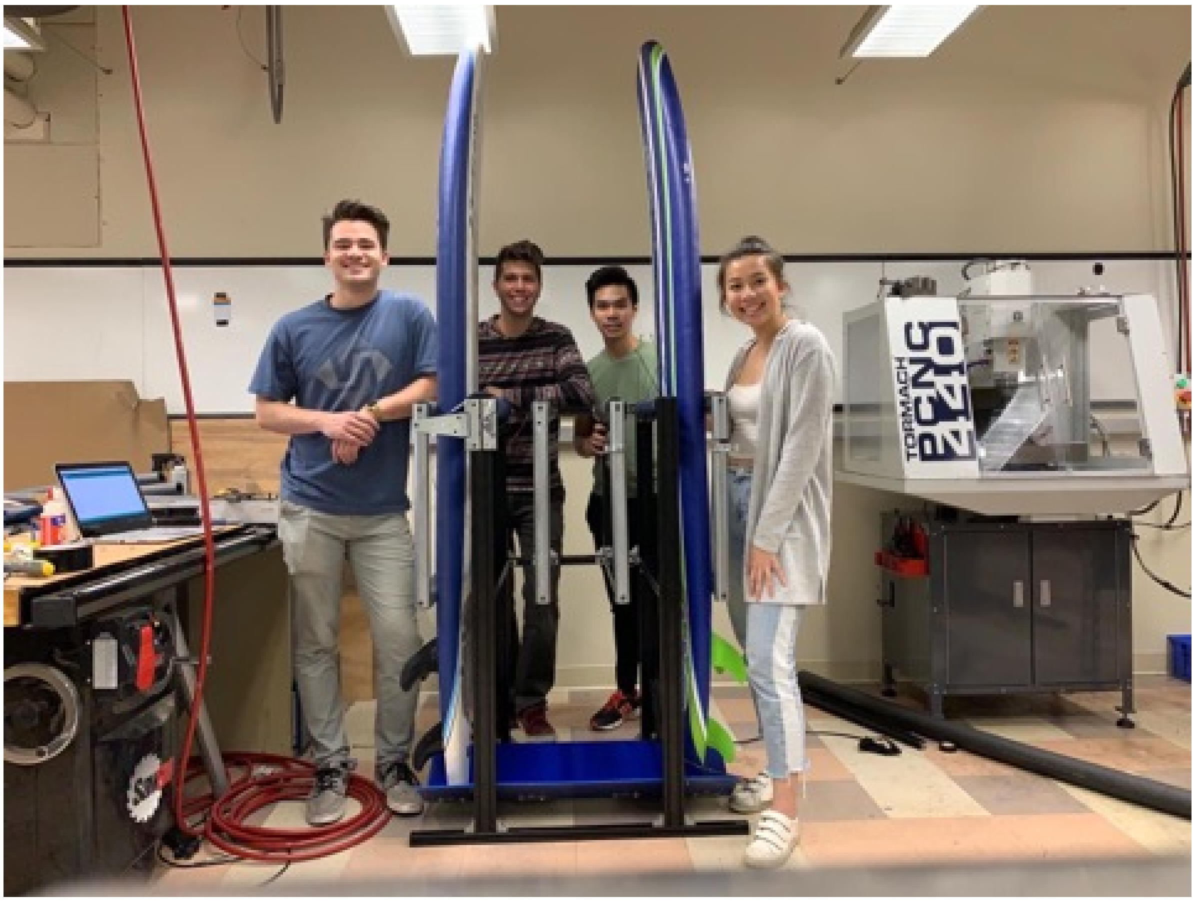
SurfUp

Providing a maintainable, environmentally-friendly, and safe standalone surfboard rental station



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MAE 156B: Fundamental Principles of Mechanical Design
Instructor: Dr. Jerry Tustaniwskyj
Presented 3/20/2019

SurfUp

Executive Summary

Performed by: Nic Maroun, Eric Edwards, Amber Chau, Jason Joshua

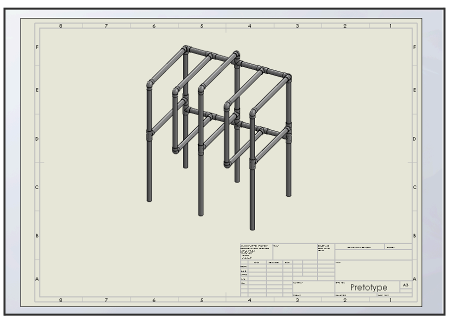
SurfUp is a startup that is sponsored by the Rady School of Management at the University of California, San Diego. With the rise in a surf community globally, there is a growing market for surf rentals. SurfUp allows amateur surfers to go to the beach, use the SurfUp app, choose a surfboard, and ride the waves! The three-step design process involved the initial development of a basic “pretotype”, a refined prototype, then finally a working product. During each step, the team conducted feedback tests both at the beach and in multiple startup conferences around San Diego. All user feedback was used to influence the design decisions and final user experience for the automated surfboard rental station.

With aesthetics, functionality, and user experience in mind, the SurfUp engineering team developed more and more effective designs. The SurfUp engineering team is dedicated to providing our sponsors with two different locking mechanism designs, and a rigid station that allows for continuous user testing. After minimal user testing it became evident that the surfboards should be oriented vertically for the most inviting aesthetics. The most involved design challenge was the production of an innovative locking mechanism. The team gained inspiration from prior products such as Bird Scooters and SPIN bikes, but none of the existing locking mechanisms translated directly to the automated station. After weeks of design iteration, the team developed two feasible locking mechanisms, both of which can be seen on the final product.

The first iteration of the prototype, which can be seen in Figure E1, was very simple. It was made entirely out of pvc pipe, and was incapable of implementing any locking mechanism. Its sole function was to put it on the beach with a SurfUp sign to see how passersby reacted. The SurfUp team used this first prototype to gauge interest and ask potential customers about possible design considerations.

The second iteration of the design, which can be seen in Figure E2 was the first to see the implementation of a locking mechanism. Although it was not connected to an app or any type of external functionality, user testing was accomplished along with the use of a dummy app. This app did not charge users, but allowed them to get the interactive experience and offer any constructive feedback.

The third and final prototype, which can be seen in Figure E3, is designed for full functionality. The RFID components are operable, and a user can experience the full functionality of the SurfUp concept. It was robustly made out of aluminum extrusion and is easy to modify for any future adjustments.



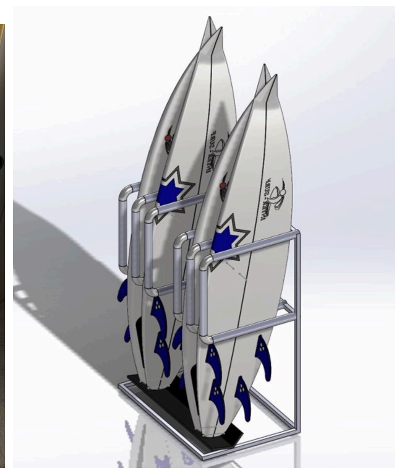


Figure E1 | Figure E2 | Figure E3

The locking mechanisms were the most involved design challenge in the project. The latch locking mechanism takes inspiration from a combination lock, and operates with actuation from a servo and torsional springs to lock the boards into place. Figure E4 shows the internals of this design. The linear slider locking mechanism utilizes a rack and pinion to lock an acrylic bar in place, and thus keeping the board in its place, as can be seen in Figure E5.

Figure E4

Figure E5

All of these lock and structural designs were combined to produce the most user-friendly, robust, functioning surfboard rental station possible.

ABSTRACT

SurfUp is a startup that is sponsored by the Rady School of Management at the University of California, San Diego. With the rise in a surf community globally, there is a growing market for surf rentals. SurfUp allows amateur surfers to go to the beach, use the SurfUp app, choose a surfboard, and ride the waves! The three-step design process involved the initial development of a basic “pretotype”, a refined prototype, then finally a working product. During each step, the team conducted feedback tests both at the beach and in multiple startup conferences around San Diego. All user feedback was used to influence the design decisions and final user experience for the automated surfboard rental station.

With aesthetics, functionality, and user experience in mind, the SurfUp engineering team developed more and more effective designs. The SurfUp engineering team is dedicated to providing our sponsors with two different locking mechanism designs, and a rigid station that allows for continuous user testing. After minimal user testing it became evident that the surfboards should be oriented vertically for the most inviting aesthetics. The most involved design challenge was the production of an innovative locking mechanism. The team gained inspiration from prior products such as Bird Scooters and SPIN bikes, but none of the existing locking mechanisms translated directly to the automated station. After weeks of design iteration, the team developed two feasible locking mechanisms, both of which can be seen on the final product and were the most involved steps of the design process.

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Chapter 1

Background

SurfUp, a startup company led by Christian Hissom, Jonathan Burris, Mishal al-Rawaf, Natalie Moazzez, aims to deploy an automated surfboard rental station on the beaches of San Diego. By doing so, the team aims to fill a niche market that has not yet been saturated, or even addressed yet. Only 2 million Americans surf, while 18 million claim that they want to try surfing, so there is clearly a market for user-friendly surfboard rentals. After seeing the increasing popularity of autonomous vehicle rentals such as Bird scooters and SPIN bikes, and the high demand from ameteur surf enthusiasts, SurfUp was born. SurfUp is just as passionate about the environment as they are about surfing, so the startup's ultimate mission is to introduce an entirely new community of environmentally-conscious surfers.

In the past, the best existing solution was to rent a board from a local surf shop, which takes an average of 20 minutes. SurfUp aims to decrease rental time to less than 3 minutes. Moreover, carrying a board from the surf shop to the beach is a hassle, so locating the stations on the beach will save San Diego's 37 million annual beach-goers even more time and effort. With the rapid rise of automated transportation apps, the need for customer-vendor interaction has begun to disappear. Despite their success, the market for these transportation apps is becoming saturated, which is why SurfUp aims to fill a market that has not even been addressed by other companies.

Figure 1: The Massive Surfboard Rental Market

Throughout the course of the project, the Rady sponsors handled the business side of the startup while the undergraduate engineering team addressed necessary design solutions. Despite this clear dichotomy in roles, there was a necessity for active communication between these two groups. This active communication was the only reason was able to succeed.

Statement of requirements and Deliverables:

1. **Theft Prevention**
    a. Building a locking mechanism with full support of boards, while keeping customer valuables safe by making a lock box.
    b. Automated locking mechanism integrated to the current web-app.
2. **Personal Safety**
    a. Using a safe and reliable material choice that allows for customers to navigate around the station without getting hurt or another words to prevent surfboards falling in any conditions.
3. **User-Interface**
    a. Creating a user-centric design that allows for customers to easily take out boards and put them back.
4. **Simplicity**
    a. Creating an aesthetic station that allows for DFM and attracting amateur tourist to surf.

Deliverables:

1. **Prototype:**
    a. **Station:** Hold 4 boards and support their weight.
    b. **Locking Mechanism:** Prevent surfboard theft, the team wants a fatigue resistant, impact resistant, and weather resistant station. The team decided to start with buildable models, and narrowed down based on these requirements. Additionally, the mechanism should be able to interact with the app, opening and closing according to the incoming signal. This locking mechanism includes the hinge mechanism to lock the boards
    c. **RFID Technology:** Using Bluetooth scanning technology, the team wants to implement HF RFID scanner/tags with the locking mechanism. This serves as part of the theft prevention as it detects whether the board is actually there before it locks.
2. **Bill of Materials:**
    a. The bill of materials outlines all the materials necessary to build an automated surfboard rental station.
3. **Drawing:**
    a. The shop drawings and schematics direct potential future groups on the exact dimensions and orientations of all the parts. Moreover, this allows for further research on the group on choosing the final materials

4. **Analysis and Test Data**
    a. The analysis and test data inform potential future groups on the capabilities of the construction and materials of the station, as well as feedback from users.
5. **Report**
    a. The report gives potential future groups all the information they need to recreate the SurfUp automated surfboard rental station, although patent infringement may prevent them from doing so.

Chapter 2

The Linear Locking Mechanism:

The linear locking mechanism utilizes a rack and pinion, gear, gear rack, motor, ball bearings, and acrylic housing. The idea is that the motor turns the gear on the gear rack to open the acrylic housing, allowing for the user to rotate the device at a 90 degree angle to get the surfboard. The locking mechanism is then pushed back into its initial position to close and the motor locks the gear rack in place. The locking mechanism is in figures 1, 2, and 3.

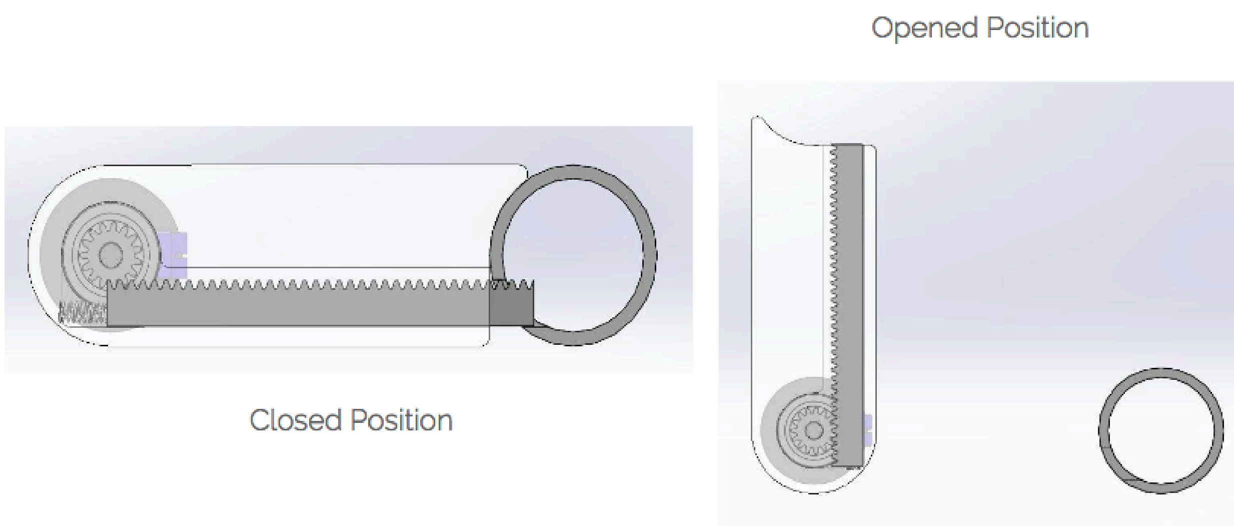

Figure 2: The closed and open positions of the linear locking mechanism

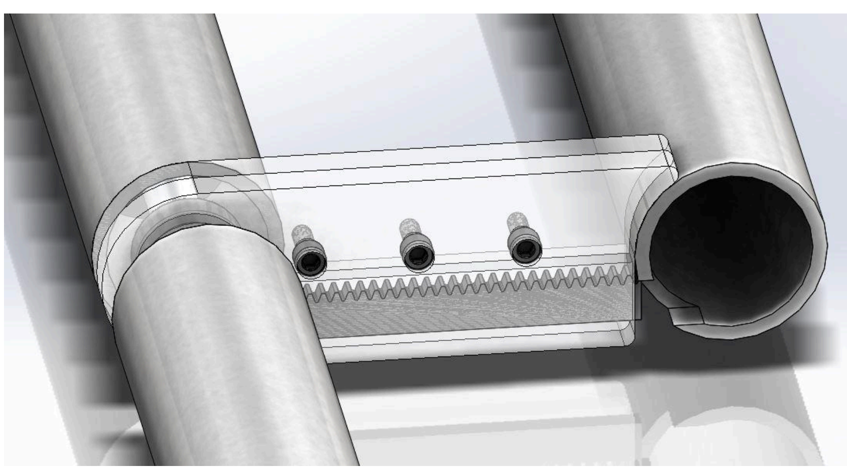

Figure 3: Isometric view of linear locking mechanism

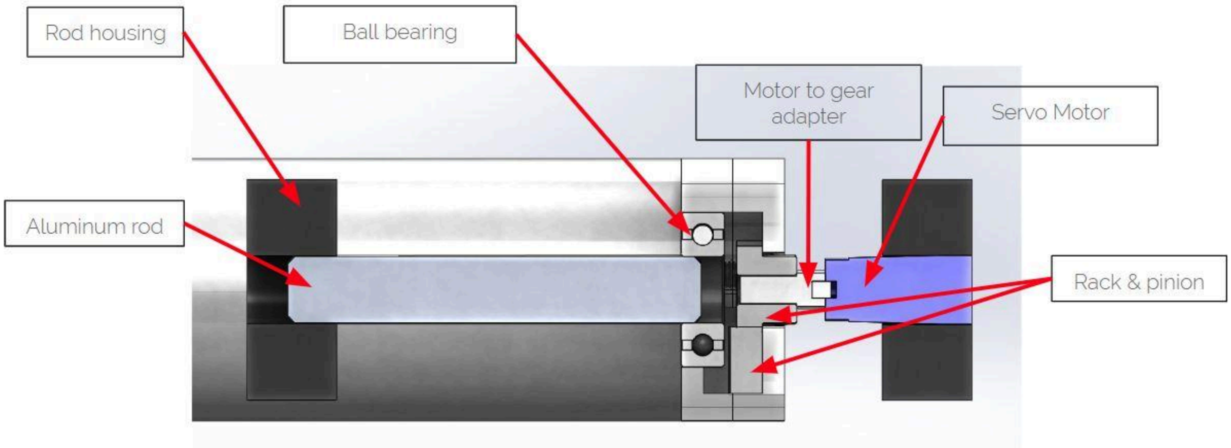

Figure 4: The cross-sectional view of each component of the linear locking mechanism

It is important to note that the ball-bearing is press-fit into the acrylic housing, which is connected to an aluminum rod and rod housing press fitted into the PVC piping. This acts as a hinge for the rotating housing. On the other side of the housing, there is the motor, motor adapter, and rack and pinion mechanism. The final note is that there is an extruded cut inside the PVC piping that allows for the rack to slide in and out but keeps it away from users and outsiders to ensure theft safety. This design includes two different types of rotational motion and one type of linear motion.

The Latch Mechanism:

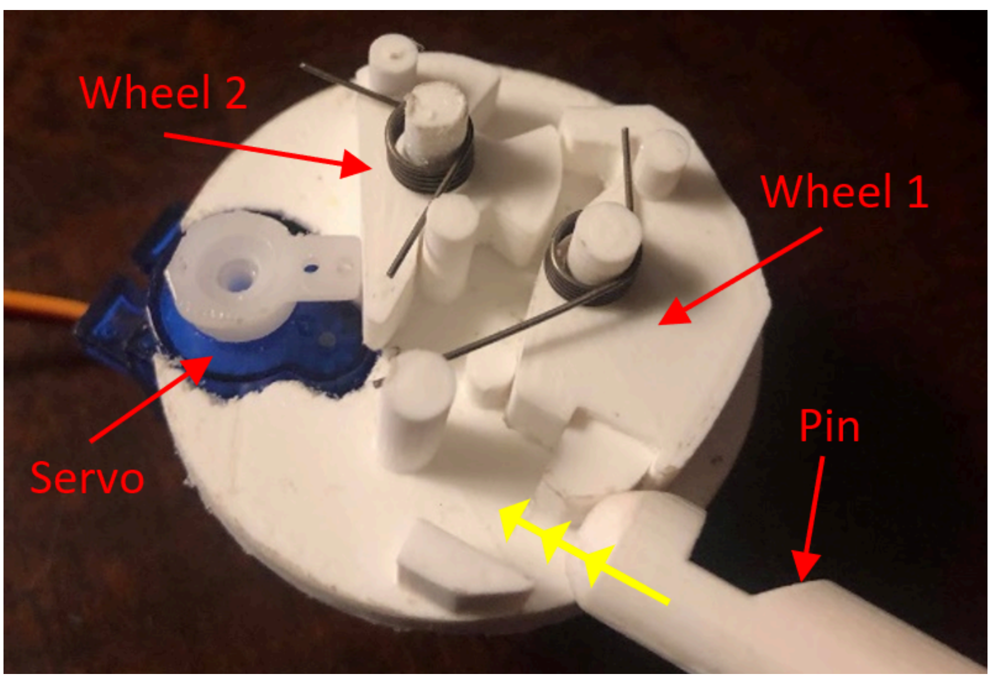

Figure 5: Latch Mechanism in locked position

The latch mechanism is inspired by the standard combination padlock. The lock was machined through wire EDM and conventional milling methods. The locking mechanism consists of a pin, a servo, and two wheels that are acted on by torsion springs. Both wheels are being spun clockwise by their respective torsion springs. The Servo actuates from a "locked" position shown in Figure 5 to an "unlocked" position in Figure 6.

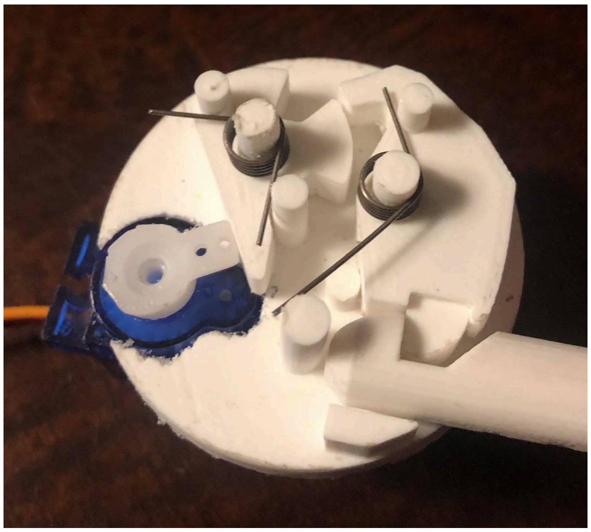

Figure 6: Mechanism in locked position

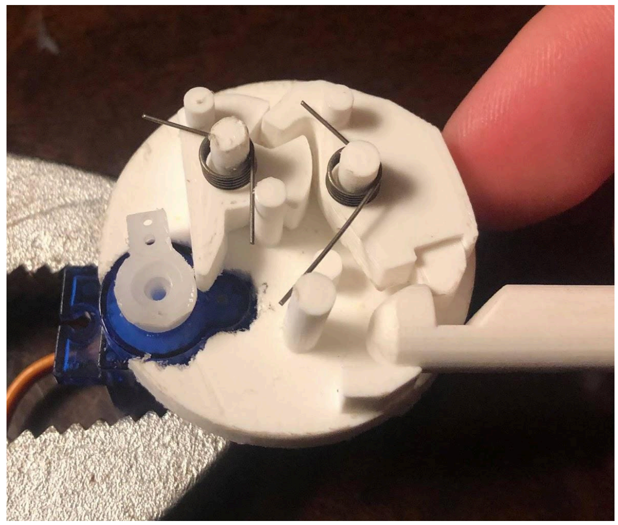

Figure 7: Pin being pulled out

When in the "unlocked" position, Wheel 1 is able to rotate into a slot in Wheel 2, allowing for the Pin to be pulled out of the mechanism. The Pin may be inserted back into the mechanism whether the servo is in "locked" or "unlocked" position because of a sliding peg in Wheel 1 that allows the Pin to pass into the mechanism.

The main concern for this locking mechanism involves the small internal components. These small springs and wheels may break and they may fall out of place. To counter the issues of strength, part dimensions and materials are optimized with strength in mind. The stainless steel rods that spin wheel's one and two had their diameter increased from 4mm to 4.5mm. This increased the rod cross sectional area by 26%. The entire final component is machined out of stainless steel. To keep components in their desired configurations, rods are press fit into their correct positions.

Chapter 3

The SurfUp engineering team divided the endeavor into four major components:

1. Hinge
2. Locking Mechanism
3. Station structure
4. RFID system

The locking mechanism is an essential component that both keeps SurfUp boards safe and shapes SurfUp user experience. The first functional requirement is for the lock to span the distance between two rods so that the surfboard is locked in the designed enclosure. Secondly, SurfUp design incorporates a mobile app and microcontroller. The locking mechanism should be actuated by a signal from the onboard microcontroller to be lock and unlock when users return and rent out boards, respectively. The third functional requirement is that SurfUp locking mechanism must be able to withstand all external forces, vibrations, and weather conditions. By designing the station for the beach, there will be 24/7 exposure to water, salt, and UV rays. The team used stainless steel for all moving and nonmoving components of the lock. Stainless steel provided us the rigidity, resistance to fatigue, and non-corrosive properties desired.

Figure 8: RFID scanner used

The RFID system was integrated to so SurfUp stations can recognize when it's surfboards are returned, rented, and done so correctly. The RFID system incorporates four RFID scanners in the station that match the positions of the RFID tag embedded in each surfboard. The onboard microprocessor (Arduino) relays the signal from the RFID scanner, and allow for the locking mechanisms to close. The SurfUp team hopes to fully integrate an RFID scanner in the station, that interacts with the locking mechanism. Figure 7 shows the RFID scanner purchased and tested.

Major Components:

1. **Latch**
    a. **Functional requirements**
        i. The latch must span the distance between two rods in order to secure the board in the station.
        ii. The pin that the latch inserts into the locking mechanism must be in the correct alignment to the locking mechanism. The pin may only be ±5mm from its intended position. Thus, the hinge that holds the latch, the surface the hinge is mounted on, and the latch itself must be rigid.
        iii. The latch must sustain repeated use, 10000+ usage cycles.
    b. **Design Consideration**
        i. Standard shed latch/hinge mechanisms were purchased from hardware stores, however these were not stainless steel or correctly dimensioned.
    c. **Final Design Choice**
        i. A stainless steel latch was machined to the right length and attached to a stainless steel hinge from Misumi. Stainless steel provided the resistance to forces and weather conditions necessary for precise and long-lasting functionality.
2. **Locking Mechanism**
    a. **Functional requirements**
        i. The locking mechanism holds a board in place, thereby locking the board into the station.
        ii. The locking mechanism is actuated by a signal from onboard microcontroller to lock and unlock when the user returns and rents a board, respectively.
        iii. The locking mechanism must be able to withstand external forces, vibrations, and weather conditions. By designing the station for the beach, there will be 24/7 exposure to water, salt, and UV rays.
        iv. Locking mechanism must sustain repeated use, 10000+ usage cycles
        v. The locking mechanism must fit inside a 42.7mm inner diameter pipe of The Walker.
    b. **Design Considerations**
        i. Stainless steel provided us the rigidity, resistance to fatigue, and non-corrosive properties desired.

3. **Station**
    a. **Functional Requirements**
        i. Station must be able to maintain its structural integrity through beach conditions of rain and saltwater.
        ii. Station must be able to prevent theft. Despite this, the value of a single surfboard is anticipated to be much lower than the cost of a rental station, so the integrity of the station must be prioritized over.
        iii. The structure must achieve rigidity along the front of the station that allows for precise alignment of the latch and locking mechanism.
    b. **Design Consideration**
        i. The boards look cooler and more appealing when they are visible and vertical, so SurfUp final iteration employs this strategy.
        ii. Ease of use is paramount, so the final design is likely to employ similar mechanisms to ones that are commonly seen, such as Bird scooters or SPIN bikes
    c. **Final Design Choice**
        i. Out of all the design choices that we considered, the most immediately appealing were clearly the vertical standing ones
        ii. Final design locks in fins and incorporate the locking mechanism that works the best during trials

When designing the structure of the station, there were some important considerations that the team had to make. First and most importantly, the station had to meet its Functional Requirements (FR's). The first FR that the team considered was robustness, and more specifically how it would hold up to the weather. The station had to be designed to withstand heavy rain and wind. On top of that, the station needed to be able to withstand human interference, with one caveat. The price of a board is significantly less than the manufacturing cost of a walker, so the station is designed to prioritize its own safety over the safety of the boards. Finally, the team had to design the station to accommodate a robust locking system.

After the FR's were met, the next order of business was to optimize the design. The first design consideration that was immediately determined was that the surfboards looked cooler and more appealing when they were standing up as opposed to laying on their sides, so all designs from that point forward incorporated vertical boards. On top of that, the importance of the user experience was immediately identified, so it was the team's mission to employ as many familiar mechanisms as possible, such as the locks for

SPIN Bikes, or the QR codes for Bird Scooters. After all these design choices were considered, we found it most beneficial to continue progress on The Walker, a station made of round and square steel tubing. Using these materials allowed us to incorporate the largest range of locking mechanisms and fulfill more design requirements than any other.

Chapter 4

Prototype Field Tests

Figure 9: The Walker Prototype

The prototype “Walker” was brought to La Jolla Shores beach multiple times. The SurfUp team noted how people approached and interacted with the prototype. When people left the prototype they were surveyed about the experience and asked questions involving the rental placement, pricing, and ease.

Unfortunately, the first two field tests were conducted in cloudy weather, but these field tests brought valuable conversations with prospective customers and even La Jolla County legislators. Through the SurfUp team meeting with the head of the SD county beaches, it has been resolved in existing contract that beachgoers and community alike prefer surf school and can therefore proceed to attempt to deploy the station on the beach site.

The team, in collaboration with the sponsors, have taken initiative to demo this prototype at the Ignite conference at UCSD with consumers in mind. Both team and conference goers alike have discussed ideas surrounding the prototype design already in place, and many have given feedback on the station.

Theoretical predictions

For the linear locking mechanism, it was necessary to determine the maximum load and torque applicable that allow for the locking mechanism to rotate about its hinge. The hinge in this case is the aluminum rod that holds the ball bearing. Major concerns include applying a load that hinder the servo motor's ability to function properly.

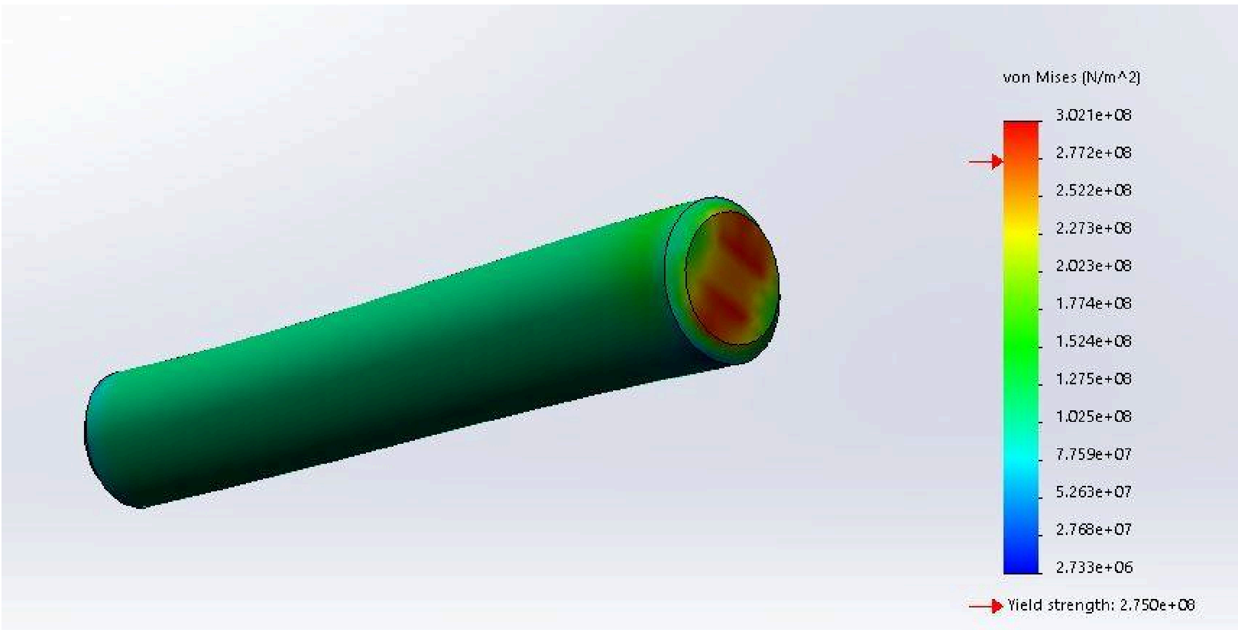

Figure 10: FEA simulation of aluminum rod that holds internal stress from moment applied

After performing a simulation, the results stated that at a distance of 4.25 inches away from the rod (which is the distance a human would apply 222.41 N of max load to the hinge), there is a yield strength on the aluminum rod of 2.750E+08 Pa (N/m^2). The rod performs with a factor of safety of approximately 2, which is desirable. The stresses on the face of the rod are neglected due to the simplification of the model analysis.

Chapter 5

Applicable Standards

The overall structure: The material the team choose may have to fit within a certain range of parameters according to where the team are intending to deploy our rental station. In addition, there is likely to be a standard that relates the mass of the metal structure to the height and width, a standard which the team needs to follow to assure that it does not fall over unexpectedly. One of the major concerns requires waterproofing standards, specifically in ASTM standards. This includes creating a station that "should maintain its integrity for the surface's – a building component or structure – life" ("ASTM waterproofing" par. 3) Some ways of testing this integrity can be through testing to determine hydrostatic movement. Another ASTM standard that can be applied is ASTM G52, which is the "Standard Practice for Exposing and Evaluating Metals and Alloys in Surface Seawater." This can be tested when the team decides to deploy the fully assembled prototype on the beaches during user testing.

RFID testing: One thing that the team have been able to glean from SurfUp standards research is that the RFID technology that the team are incorporating into SurfUp automated surfboard rental station needs to be tested according to a standard. There is an exact methodology to the testing process that the team must be sure to follow once the team purchase the applicable article. Both ISO 14443 and 15693 can be applied to this, in which smart cards are used for identity and proximity. More importantly, the transmission of radio frequency power and signal interface are both addressed in these standards.

Locking Mechanism: Although the team intend to perform stress tests ourselves, there are bound to be standards that dictate the exact testing process and resultant parameters. The team followed these thoroughly to make sure the integrity of the apparatus is not compromised. Using the IP 66 Enclosure standard, future iterations must ensure an enclosure that is rated as "dust tight" and protected against heavy seas or powerful jets of water. This can be done using polycarbonate or aluminum materials, as well as proper sealing methods for the mechanisms.

Microprocessor capabilities: The team intends to use an Arduino as a microcontroller for our prototype, for which it is easy to find the specifications for, but future iterations of the station allow for SIM card applicability. The standards found for Arduino can be located in the datasheet for the Arduino Uno, in which the physical characteristics and specifications are listed.

Government regulation on beach

One of the most important concerns about SurfUp's business model is that it requires the team to have an agreement with the government in order to put the station on the beach side. SurfUp has not reached up to the stage yet and it is still a work in progress when dealing with government beach regulation. However, the team has partnered up with the Scripps Institute of Oceanography to develop and implement Smartfins into surfboards to gather data to better improve the oceans condition. This way, SurfUp has a high chance of deploying the station on the beach with government approval.

Impact on Society

Global Impact: One of SurfUp's advantages is allowing for easier board access for non-locals. This can introduce a whole new surf etiquette for ocean-minded surfers that can be further impacted on other beaches. SurfUp stations allow surfers who do not speak English to be able to interact with the station. This can be future translated in the app settings as well.

Economic Impact: If SurfUp becomes successful, there will eventually come a time when the service becomes a threat to surfboard rental shops. It is likely that the surf shops will have to decide between going out of business and potentially acquiring SurfUp, both of which would still allow society to use the automated surfboard rental stations, leading to the following impacts on society.

Quality of life: For surfers recently joining the hobby, having automated surfboard rental stations on the beach will improve their lives by not requiring the hassle of transporting their board from their vehicle all the way to the beach. Surfboards, especially entry-level surfboards, are big and heavy, and the transportation of them alone is enough to make prospective surfers give up on the hobby. For prospective surfers who have never tried the hobby before, this will be the most simple way to do so. A beach-goer may not even realize that they want to surf that day, but seeing the SurfUp station at the beach may lead them to give it a try.

Public Welfare: Some people the team have talked to were worried about cluttering the beach up with artificial surfboard rental stations. That argument is valid, but the final design of the SurfUp station will be aesthetically pleasing and will be intended not to ruin the beach experience. There is concern that experienced surfers will not be happy with beginning surfers taking up space in the nicest locations. To combat this argument, the team will only be deploying SurfUp Automated Rental Stations in areas with waves that suit beginners, so they will not get in the way of the expert surfers on the best breaks. As there always are when someone attempts an extreme sport for the first time, there are obvious safety concerns. The best the team can do to mitigate risk is give users brief instructions on the app and have them sign a waiver.

Environmental Impact: SurfUp station and app will create an experience that will personally connect users with the ocean. The app will provide short instructional videos that teach the basics of surfing, surf etiquette, and ocean awareness. As the startup continues to grow the social media campaign of #oceanmindedsurfer, this will inspire SurfUp's customers and followers to care for the ocean. And as the public begins to recognize the hobby as an Olympic sport, the increasing number of new surfers will easily enjoy their first ride with SurfUp's surfboards. Fitted with SmartFins provided by key partnerships, SurfUp's boards will allow users to improve our ocean by simply surfing. These fins measure and provide valuable data about the temperature and acidity of the ocean to researchers around the world. For users that are moved to donate or volunteer, the station will serve as an innovative channel for organizations that are seeking to make an impact, such as Surfrider Foundation, NOAA, and The Ocean Cleanup. After surfing, users will be asked to rate their experience, and will learn about the donation and volunteer initiatives of SurfUprecommended ocean minded organizations. With a single click, users can donate directly or sign up to attend or volunteer at their events. Users can share the event and spread the word to inspire friends and family to support ocean wellness.

Design Recommendations for the Future:

The production of the first Walker station was meant to be a solitary endeavor, and not meant to be replicated, so there are obvious mass manufacturing options that SurfUp can employ to increase the rate of production of the final station. One method the team could employ is to use precise metal fixtures around which to build each station. This would ensure that all the dimensions are correct with ease.

While producing the final prototype, the team paid little attention to aesthetics until after the prototype was built. Consequently, the aesthetic elements added to the final walker look a little out of place. If aesthetic factors are considered during the manufacturing process, the mass-produced product will end up looking much better. In mass, the estimated cost is $400 per walker.

One concern for posterity is the station's weight. In an effort to reduce cost, there is a guarantee that posterity will try to use lighter material. It may seem that a lighter station may be less dangerous, but more than anything, the station needs to be robust. One Wavestorm surfboard falling from a standing height could seriously injure a small child. Posterity should not lower the weight past the point of being able to support the boards.

Acknowledgements:

The SurfUp undergraduate engineering team would like to thank the following people for their time, effort and lessons that made this project to be successful and a valuable investment in the student's college journey:

Course Instructor: Dr. Jerry Tustaniswskyj (jtustaniwskyj@ucsd.edu)

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Thank you for your time and effort. The team hopes that the team's paths will cross again in the near future.

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Hemmingway, Hardy. *The Enclosure Company - The Electrical Enclosure Specialists*, www.enclosurecompany.com/ip-ratings-explained.php.

"ISO/IEC 14443-3:2011." *ISO*, 27 May 2016, www.iso.org/standard/50942.html.

Appendices:

Individual Component Analyses

Amber Chau:

Component: Locking Mechanism

Category/Feature Area	Requirement	Priority
Theft Prevention	Locking mechanism that provides full support of boards while also keeping boards and customer valuables safe	A
Accessibility	Allow for user to open/close station without difficulty	A
RFID functionality	A type of connection to the surfboard/user's phone	B
Simplicity	Creating an aesthetic mechanism that allows for DFM	B

2.

Option 1: Deadbolt Mechanism

- used in many doors for security, but more complex than we need at the moment
- mechanism is very simple; linear movement through a solenoid
- can utilize that same concept in our automated mechanism

Option 2: RFID Activation

- sensors used to activate doors etc; can be used here from customer
- RFIDs attached to the surfboard, as well as activated by phone
- UHF RFID is the form needed here

Option 3: Cam Lock

- cam locks used for lockers; VERY simple design → easily produced and assembled
- best used in this prototype, as it is small scale and easily manageable
- link provided to padlock cam lock in bullet 4 (best fit for this project thus far):

3.

Mechanism:	Pros:	Cons:	Cost:
Deadbolt	- sturdy; very useful for theft prevention - fairly cheap & accessible	- too big of a scale for The Walker - not necessary for this prototype	$14.64
RFID Activation	- user-centric; allows for easy access - can also attach to board	- may be very difficult to implement in final prototype - expensive	$52 - 150
Cam Lock	- simple design; easily implemented in prototype - can incorporate with RFID technology	- not as sturdy as other locking mechanisms, but can be fixed with other actuators/sensors	$13.80

4.

Grainger – used to find the cam locking mechanisms
https://www.grainger.com/product/CCL-Padlockable-Keyless-Cam-Lock-15X358
McMaster-Carr – used to find CAD models of locks
Google Scholar – RFID technology → determining the UHF technology can be unlocked by phone (Key words: RFID unlock by phone scanning)
YouTube – keyless cam lock mechanism → (key words: how it works cam lock mechanism)

Eric Edwards

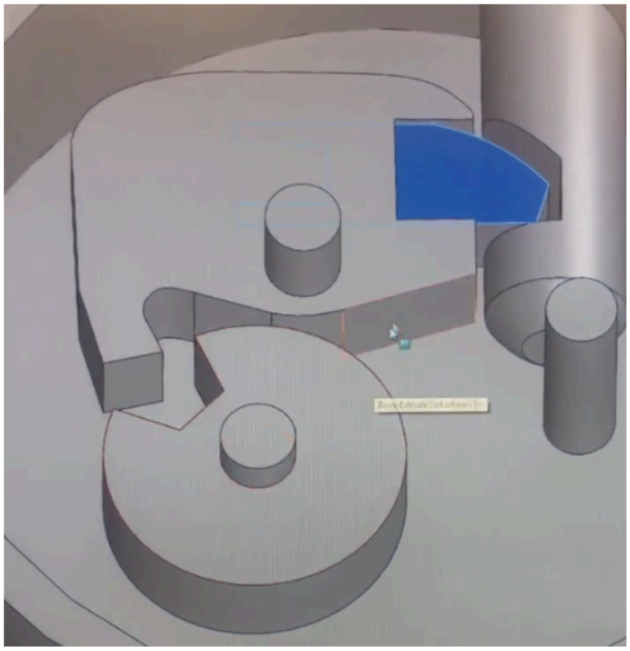
Locking Mechanism: A Component Analysis
The locking mechanism is the next, and perhaps most crucial aspect of our design to finalize. It must achieve several objectives and

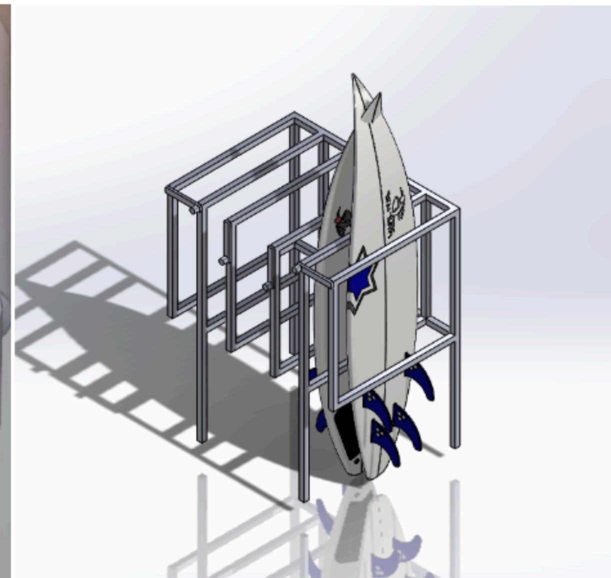
Fundamental Requirements: (in order of importance)

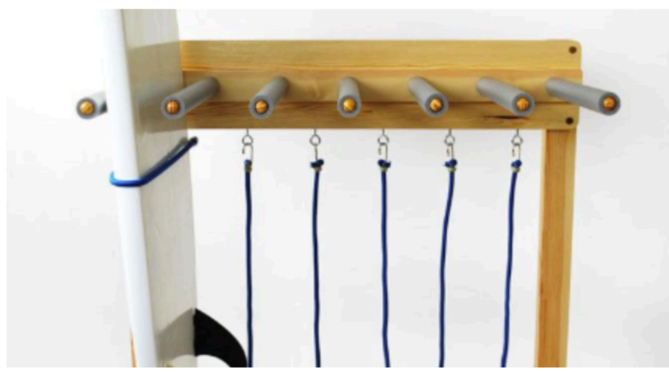
1. Locking mechanism provides a piece that spans between the two rods holding a board in place, thereby locking the board into The Walker.
2. Locking mechanism is actuated by a signal from onboard microcontroller to be openable and closeable when user rents out and docks a board, respectively.
3. Locking mechanism must be weather resistant, stable against all forces applied to its moving and nonmoving components
4. Locking mechanism must sustain repeated use, 10000+ usage cycles
5. Internal locking mechanism must fit inside a bar of The Walker

Options for lock mechanism inspiration:

1. **Combination padlock inspired**
   The combination padlock commonly used to lock lockers
   After much consideration, I decided on CADing up this lock mechanism because I liked how you can unlock the mechanism, even when the latch of the lock is under stress. I would simply need a servo to rotate the circular wheel in the Figure 5 to allow the other rotating component to slot its teeth into the circle. This allows the lock to release the vertical pin.







2. All weather strap

This idea would use a strap, perhaps wider than that pictured, to secure the board into the slot. The advantage of this would be that having a non-metal/rigid latch mechanism would decrease the chances of the mechanism snapping off, or rusting, etc. More importantly, this design would intrinsically provide inward force for the board into the slot, making the board not have freedom to move around. Since the board will not move around, the balance and center of gravity of the system will remain more stable.

3. **Siren alarm system**

Thinking outside the box, instead of a lock to keep the boards safe, a speaker in each board will deter someone from stealing a board during the day. It is a possible business model that each surfboard station could be brought inside every night and only be on the beach/resort during possible usage days/ hours. This siren system would function best at a moderately crowded beach.

Mechanism:	Pros:	Cons:	Cost:
padlock inspired mechanism	- very easy to replicate/test - strong -compact	-possibly can jam - moving electrical/metal components on beach	$50
all weather strap	- holds boards tight -cheap	-manual locking method -Could be cut	$35
Siren alarm system	- cheap -compact -simple	- might not prevent determined thieves -requires night removal	$13.80

4.
McMaster-Carr – used website to look at steel components and locks
Google Scholar – remote, waterproof speakers -
https://patents.google.com/patent/US9307307B2/en
YouTube – padlock internal mechanism CAD simulation

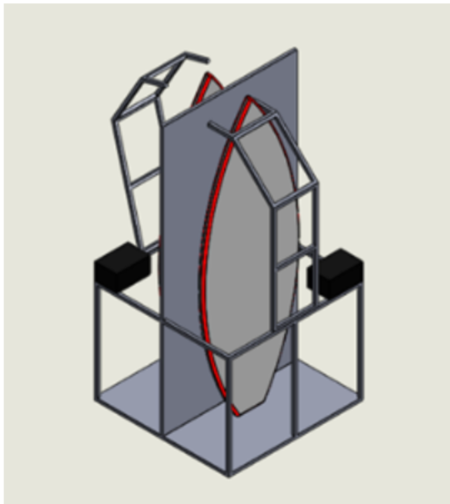
Nic Maroun

Component Preface: My team and I decided that the best component for me to analyze would be the overall structure itself. It may seem like this is too general of an item to pick for a component analysis, but I had the unique opportunity to go to the beach with our sponsor and gain user feedback. Although it may not technically be a "literature search" per se, but the amount of potential user feedback was enough that it will influence the design just as much, if not more than a traditional literature search.

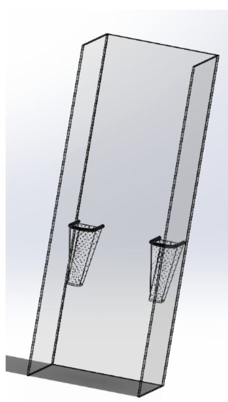
1. Functional Requirements
    a. Must be able to withstand weather conditions in the location at which it is placed
    b. Maximizing theft prevention
    c. The design of the structure cannot inhibit the user experience at all
    d. Must be able to accommodate the locking mechanism after a final locking design is determined

2. Component Options

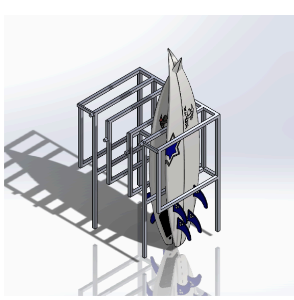
a. "The Claw"



b. "Enclosure"



c. "Metal Walker"



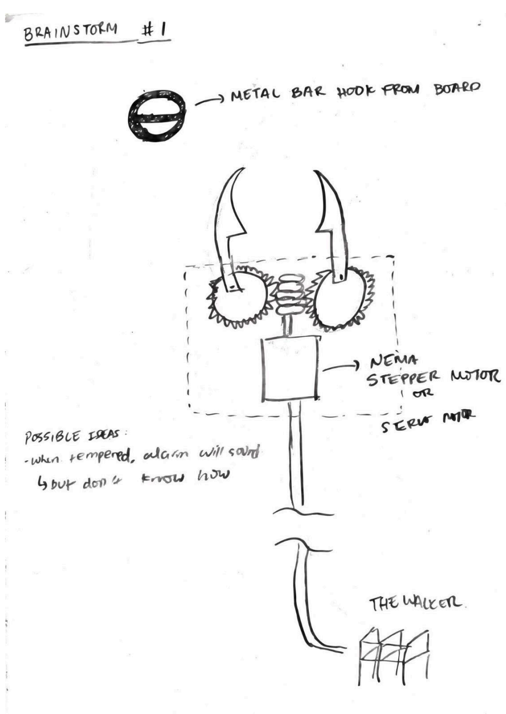
3.

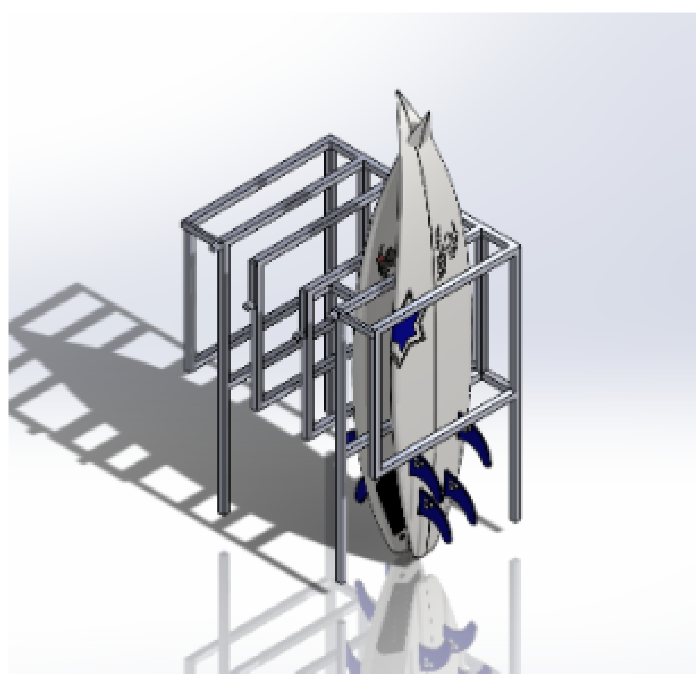
	Pros	Cons
The Claw	Easy Modularity Clear user design High board security Medium cost	Claw Arm may bend Heavy thanks to backing plate Ugly Hinges may not deal well with the weather User has to lift board over cage Medium Cost
Enclosure	Aesthetic design with a lot of customizability Seeing the boards is cool Easy to integrate a lockbox for essential items Cheapest option	Not much durability Easily vandalized Plastic is especially bad for the environment, so we may have trouble getting it on beaches
Metal Walker	Maximum security Holds 4 boards and is modular Able to adapt to different locking mechanisms	If fins don't hold, boards easily stolen Relatively ugly Expensive HEAVY

Jason Joshua

Component Description: This report is intended to analyze the locking mechanism to our design. The locking mechanism is an essential part to our design as this is needed to keep the boards safe.

1. **Fundamental Requirements (FR):**
    a. Has to withstand constant exposure of salt water as the machine is going to be exposed 24/7
    b. Must be tempered proof and when it is tempered, it should alert the surrounding
    c. Must be durable within 10000+ lock and unlock cycle.
2. **Components Options:**
    a. *Option 1:* Claw Mechanism
        i. As many surfboard has a metal bar that is used to connect the board to the surfer by using a leash, this can be utilized for securing the surfboard on the machine.
        ii. Mechanism is simple as it is using a worm gear
        iii. Price is reasonable
        iv. Going further step, this can be integrated with an alarm system that is going to ring when tempered.





b. *Option 2:* Deadbolt Lock Mechanism
   i. Locks these days are generally using the deadbolt mechanism
   ii. Simple Mechanism to be used in the prototype
   iii. Mechanism is modular, if our design doesn't work, this can still be used in other designs.
c. *Option 3:* Bike combination lock
   i. Simplest and least time design to be used in user interaction test
   ii. Best used if we are looking for a user interaction test whether if the machine actually attracts people or not
   iii. Price is very cheap. This option is used only if we are testing the concept of "surfboard rental station".

3. Pros and Cons Table:

	Mechanism	**Pros**	**Cons**	**Cost**
Option 1:	Claw Mechanism	-Very easy to prototype as we only need 3D Printers and worm gear from online shop -easy to integrate with the board and doesn't hurt the board	-Not very secure -Need to deal with electrical wires which is hard in a wet surroundings	~$23
Option 2:	Deadbolt lock	-strong -proven theft prevention	-hard to integrate with "the walker"	~$15
Option 3:	Bike combination	- easy to get and buy -easily combined with the machine if testing for proof of concept	-not a long time plan, temporary lock mechanism to allow design testing of "the walker"	~$10-20

4. **List of Reference Used:**
    a. McMaster Carr (to search for CAD models and estimated price of the worm gear)
    b. Amazon.com (Bike combination Lock)
    c. Misumi (Deadbolt Lock and 3D CAd Models)