GNG1103

Technical Report

Deliverable D: Conceptual Design

Submitted by

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Abstract

Group 7 brainstormed a variety of interesting and creative conceptual designs on how to greatly improve the STEM facilities according to their defined problem statement. The group settled on a design that utilizes dashboard as the UI centerpiece to a comprehensive system that oversees almost every part of the facility. The system will reserve machines for users, provide live technical data to staff for planning maintenance, keep hand tools and consumables stored safely away, and is still easily accessible by users. The system also notifies staff when their stock begins to run low. This system will allow the management to work efficiently and effectively, as this system has been designed to work in the STEM spaces it caters to their needs. With the use of this system CEED will be able to expand and grow without worrying about regularly scheduled stresses in life.

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List of Acronyms

Acronym	Definition
CEED	Center for Entrepreneurship and Engineering Design
CMMS	Computerized Maintenance Management System
OEE	Overall Equipment Effectiveness
STEM	Science, Technology, Engineering, and Mathematics
UI	User Interface
RFID	Radio Frequency Identification

1 Introduction

STEM workshops are almost always in use since a large population at the University of Ottawa are in Engineering. In order to maintain a safe and functioning environment, the CEED staff require a system to help keep track of the equipment and machine use. This system would help them schedule maintenance for the machines accordingly to ensure everything is kept up to date and is safe for use. It is also important for the machines to be in pristine condition and the equipment to be available in order to meet the requirements of the user. Every year, impressionable students attend workshops to expand their skill sets and grow. CEED hopes to help future leaders to be more, they cannot, however, help those around them if they themselves are struggling. The system will fulfil their needs without breaking most constraints. The product will be simple, cost effective and efficient, this makes it a tool rather than a hassle. The system will integrate into CEED management's busy lifestyle seamlessly. Furthermore, the team has tailored the system to STEM workshops specifically.

2 Need Identification and Product Specification Process

2.1 Interview Results:

Question	Customer/User Statement	Interpreted Need
What do you think the STEM spaces would benefit with?	Would like a simple method to keep track of Inventory	Simple and easy to use inventory
	It would be nice to have a map of sorts to show other users where everything is	Workshop layout map/Easy to understand organization
When are the spaces the busiest and who uses them?	Brunsfield: Average usage, mostly used by University students	Easily accessible to University students and staff
	Makerspace: Used by both community members and university students. Busiest on Sundays.	A simple system for Sundays and keeping track of Equipment use
What kinds of items go missing the most?	Both workshops: Small items like SD Cards (Makerspace), screwdrivers, tools, equipment. We end up running around looking for lost or missing items	Simple equipment owner/tracking method
What kinds of items/things do you have difficulty keeping track of?	Brunsfield: keeping track of machine usage	Simple way to know who's using what piece of equipment
What would you like in the workshops?	A better suggestion box would be beneficial	Efficient Customer Service feedback system
What concerns you the most with regards to safety?	In the Brunsfield center, keeping track of machine maintenance is key to preventing any big accidents Tracking 3D Printer Usage in Makerspace/Lab	Efficient system to track machine usage, as well as, if it is due for maintenance

Table 1: Needs Identification and interpretation

2.2 Needs Identification and Prioritization:

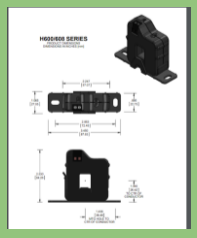
Table 2 provides the needs organized by importance. The higher the number assigned, the more important the need. It was determined that tracking the machine usage and maintenance of all machinery was of utmost importance for maintaining a safe environment within the STEM (specifically Brunsfield) workshops. The CEED management is currently unaware of precisely which machines are being used and for how long; that makes it difficult for them to schedule maintenance for various machines. Through maintaining the machines and their performance, CEED will be able to prevent most major injuries. Keeping an inventory of the equipment and materials within the space was found difficult to manage, and small tools regularly go missing from the space. The staff have difficulty locating lost equipment and ensuring that it is returned. Unfortunately, this comes at a great financial cost to the management, thus spending their budget efficiently is far more difficult. Ensuring that suggestions made by users of the space reach management is difficult since the current method involves the employees remembering the suggestion and personally telling the management. The Makerspace management would like a simple method to collect and process customer feedback, however, it is not a necessity at this time. During the rush hour periods, the various workshops would like to provide its customers with a pleasant and efficient experience.

Need	Rank
Tracking machine status/maintenance	3
Tracking Equipment usage	3
Tracking Inventory	2
tracking location of small equipment	2
Customer Service and feedback	1
Accessibility to Workshop users	1

Table 2: Need Prioritization

2.3 Benchmarking and Design Specifications:

As described in Table 3, there are multiple companies that manufacture machine monitoring systems. Companies such as Monnit valued live feedback, cost, data collection and a well-designed user interface. It has also been found when designing inventory tracking systems criteria, the criteria focused on are efficiency, accuracy, increasing profitability, and creating peace of mind. While network monitoring systems valued characteristics like a simple but well designed and effective system. It was found that the company focused on delivering great service by still being affordable. The software provides features that allow you to monitor servers, datasets and local networks. The aspect of the software that gives you detailed account of every application that runs on a network is exciting and seems to be of great use. Based on the research found, Team 7 has concluded that, CEED would benefit from a cost effective, efficient, automated system which accurately monitors machine data and usage while having a simple user interface is important, if not necessary.

Company	Product/ Model	Cost (Specify)	Attributes	Constraints
Veris Industries	H608 (Sensor) 	$157.78 (USD)	- Monitors machine status through monitoring loads on vent, recirculation pumps, etc - Dimensions: 87.63mm x 27.05mm x 64.26mm - small - Temp: -15 to 60 degrees Celsius - adjustable	- Pricy per unit - does not come accompanied with an optimized software
CMMS Data Group	MP2 	Unspecified Approx. +2000$USD	- Project equipment failures - Organize and track inventory - Manage equipment costs - Track equipment history - Schedule preventative maintenance tasks - Allocate resources	- very expensive
ShopVue by Casco Development	Machine Monitoring Software	$40,000 USD one-time cost plus a $299 USD setup fee	- Operator friendly; colour coded screens, touch-based, intuitive to use, configurable - Uses direct machine interface to capture machine data automatically at frequent intervals	- The system requires to have Windows/Android - Expensive one-time cost

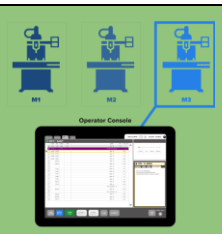
			- Translates raw data from machines to usable metrics like OEE	
XL Productivity Appliance by Vorne	Machine Monitoring Software 	$1990 per system and 90 days free trial.	- Automated data collection -Provides real-time machine monitoring -Tracks machine history -Provides downtime tracking - Provides performance metrics -Simple UI	-Does not provide cost tracking -Does not support MAC OS -No Quality control
Upkeep	Upkeep Solutions 	$500-$54,000/ year	- Preventative maintenance - Maintenance checklist that aids technicians with what requires maintenance - Shows current quantity of inv. and can set a minimum amount before an alert is sent -Automates the process of assigning a technician to a machine -Tracks depreciation rate of assets	-Can be expensive

Table 3: Benchmark Metrics

After compiling various benchmarked products, Team 7 has created a list of design criteria based on the needs listed in Table 2 and the design criteria, constraints, and functional/non-functional requirements defined in Table 4. The needs of greater importance were assigned a higher numerical value on a scale of 1 to 3. Based upon the research, a ranked list of the design criteria and specifications can be found in Table 5.

As observed in Table 5, the primary criteria were identified to be the system's ability to track and store data, providing live data, size, weight, and its ability to be used on various types of machines. These criteria were prioritized due to their direct relationship with the actual device and its functionality. On the other hand, criteria such as affordability and OS compatibility were placed lower on the list. It was determined that a product would be valued for its price to quality ratio. Fortunately, the CEED workshops primarily use Windows as their primary OS. The criteria in between were found to be necessary but not absolute.

Needs	Design Criteria	Functional Requirements	Non-Functional Requirements	Constraints
Track machine and equipment maintenance (Rank 3)	- Must track machine usage - must be Small in size (mm) - must be lightweight (g) - must withstand various temperature (Degrees Celsius)	- Predicts when a machine will need maintenance - Records when machines have had maintenance work - Provides downtime data - Calculates the overall equipment effectiveness - Must provide real-time data	- Easy access - Simple display - Reliable - Durable - Accessible - User-friendly	- Cost effective - Adaptable to various platforms and machines - Non-invasive
Machine and equipment usage and Data Analysis (Rank 3)	- Must track machine usage - Must collect data - Must be compatible with different OS - Must provide live data	- Provides downtime tracking - Must provide performance metrics based on data analysis - Must track cost	- Easy to use - Easy to program - Accessible - Durable	- Needs to track the accurate information of the user - Needs to browse through all the information to find the solicited machine/user - Needs to find the exact location of the machine - Needs to record the time when the machine was last used
Tracking Material stock, usage and location (Rank 2)	- Can track the amount of material - Must track the material location - Must track material usage	- track amount of material used at a workspace(material/day) - Tracks materials remaining - Predicts when stock will run out (days) - locates stocked materials	- Easy to understand -Simple code - Easy to modify - Reliable	- Needs to provide accurate date - Must be easy to read, understand and edit

Table 4: Needs and Design Criteria

Rank	Design Criteria	Specification (If applicable)
3	Consistent tracking of machine/equipment usage	Stores total runtime since last maintenance check; Run time: 12h
3	Must provide live data	Transmission Range: 5m to 10m
3	Must be small and lightweight	Size of hardware: 9cm x 5cm x 4cm to 12cm x 8cm x 7cm Weight of hardware: 200g to 300g
2.75	Easily modifiable for different machines	Adaptability range: Must be adaptable to most machines
2.5	Knows the designated location for material and small equipment	A location is set by the user and is remembered by the program
2.5	Must withstand physical blows	able to remain operational despite bumps as it will be in a shop floor
2	Must be affordable	Cost: $100 to $200 CAD too long
2	Must be capable of operating at varying temperatures	-15 to 60 degrees Celsius
1	Must be compatible with different OS	OS: Windows, Mac, Android, IOS

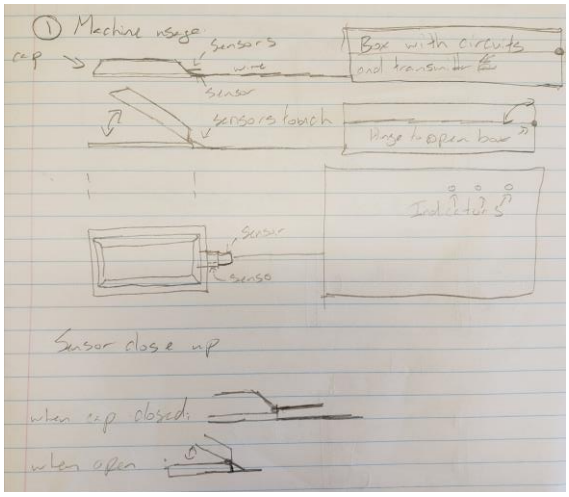
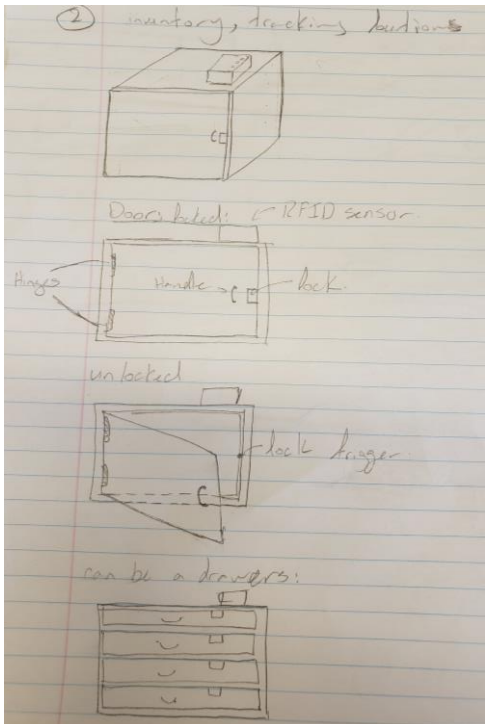
Table 5: Design Criteria and Specification Ranking

2.4 Problem Statement

CEED management needs an accessible and cost-effective visual interface. The system should easily inform users and staff at each workshop about the machine usage, availability, and provide technical data to aid in scheduling maintenance.

3 Conceptual Designs

3.1 Brainstorm Ideas

Sketch	Description
	This system works by placing a cap over the start button of any machine. When the cap is open the two-sensor plate touch sending a signal to the Arduino or circuit where a counter is kept tracking the number of times the machine has been used. The accompanied UI would keep track of the last maintenance date and other user data.
	To track the location of different equipment. The system works as a lock box (or drawer) where the only way to open the box is to tap on an RFID sensor this way, the management will be able to track who opened what last thus being able to contact the right people. The doors would be spring loaded or mechanized so that they closed even if someone leaves it open. On the UI, they would be able to track who used what, as well as, the usage of different equipment.

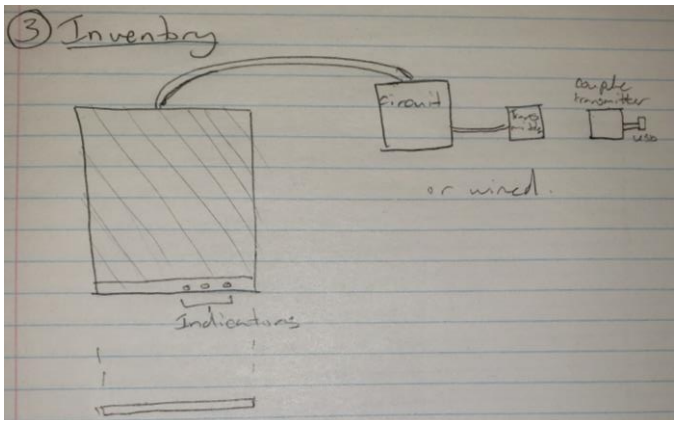
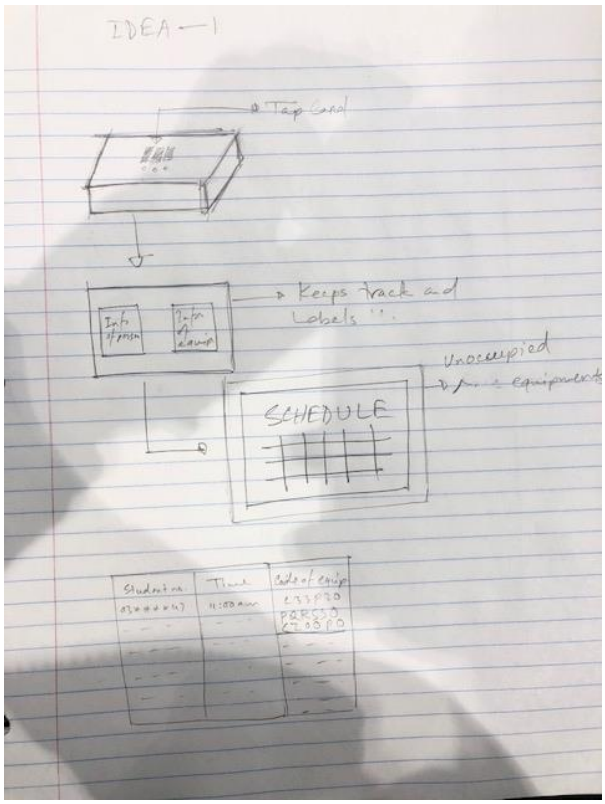
	To track inventory, this system works with a relatively precise scale. Since most items such as screws and 3-D print ink have a standard weight when its right out the box. By placing the mat at the bottom of any storage compartment. The system tracks the number of items in stock using the weight of a single item. Once the stock gets low, an alert would be sent to the accompanied UI. The UI would also show how much of what is remaining.

Table 6: Ayesha's Brainstorm Ideas

Sketch	Description
	Idea:1 For this idea, we are going to create a box or container with a sensor where the tool/equipment is kept and after tapping on the box the user's information will be recorded along with the code number of the equipment, they have taken for using and the exact time the box has been opened. This can also schedule a time when the equipment gets free to use after the user taps again when they are finished with the tool.

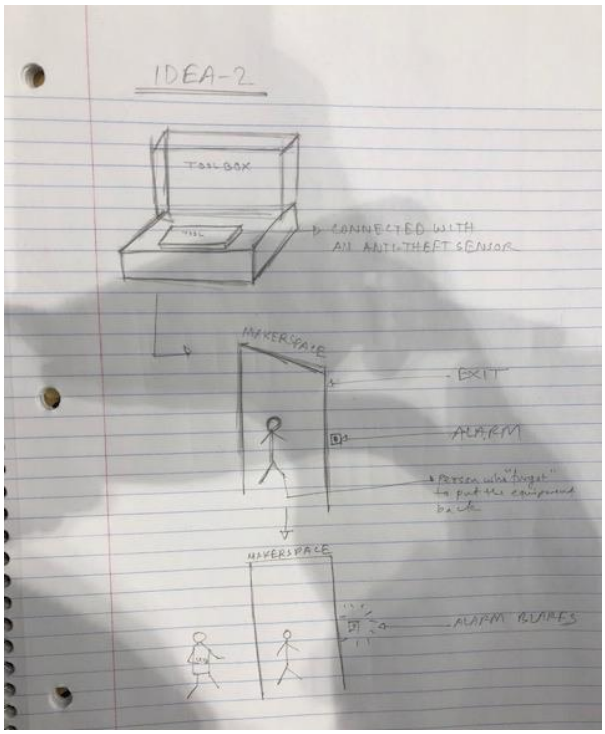
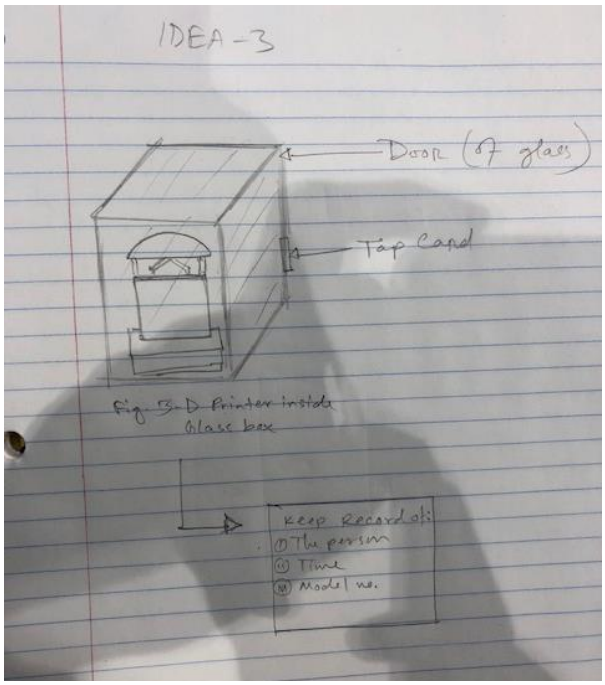
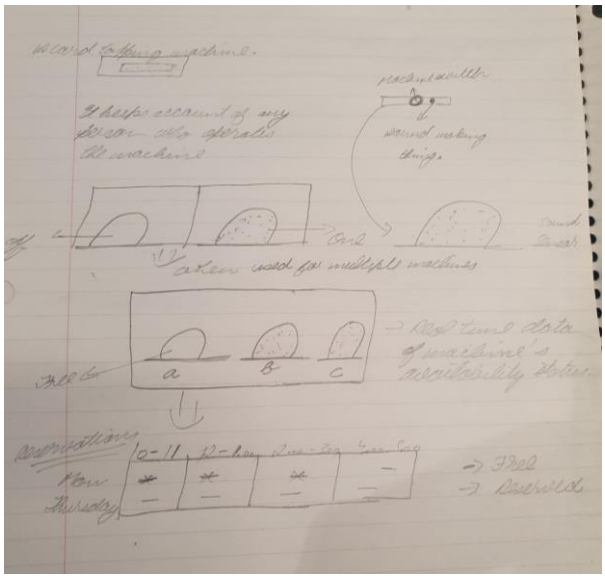
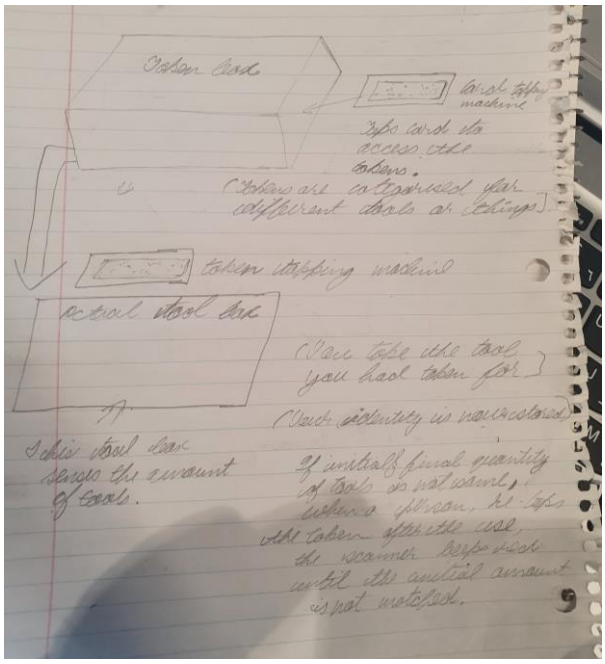
	Idea:2 The tool in the tool box will have an anti-theft sensor attached with it which is connected to another sensor in front of the room exit(s). There shall be alarms attached to the doors. If a user "forgets" to put the equipment they have been using to its designated box and tries to take it out with them, the alarms will start blaring, alerting the CEED members.
	Idea: 3 Makerspace has multiple 3D printers that are used almost every working day by the students and staff. It's hard to track who is using them, so if we put the printers inside glass boxes locked with same sensors as we used in Idea:1, it could track user information, what they are making, when they started making it, and how long it is going to take. Also, it's needless to say that there shall be a sensor to the glass itself so that if someone "accidentally" manages to break it, the alarm will go off.

Table 7: Shoaib's Brainstorm Ideas

Sketch	Description
	In this system, a sign in criteria is used to keep account of a person who is going to use the machine, so when a person turns on the machine, they also turn a sound-making rotating thing. A sound sensor of very small range is placed near the tool and it turns on when turning on criteria for the machine has been fulfilled. This sensor gives the information about machines' usage time and its availability status. The concept can be used to display the data for number of machines.
	This arrangement keeps track of small tools or equipment that can be categorized and placed in a toolbox with a type of sensing ability. For accessing the tools, a person will need to first tap the ID and then take the tokens (which have been categorized for specific tools and can be scanned). A person can then access the tool box, but they will need to tap the tokens they took earlier. Their ID is now stored. After finishing, they re-tap the token and if it differs from the tool number, the scanner beeps red and if that number is not matched again on that specific ID, authorities can track that.

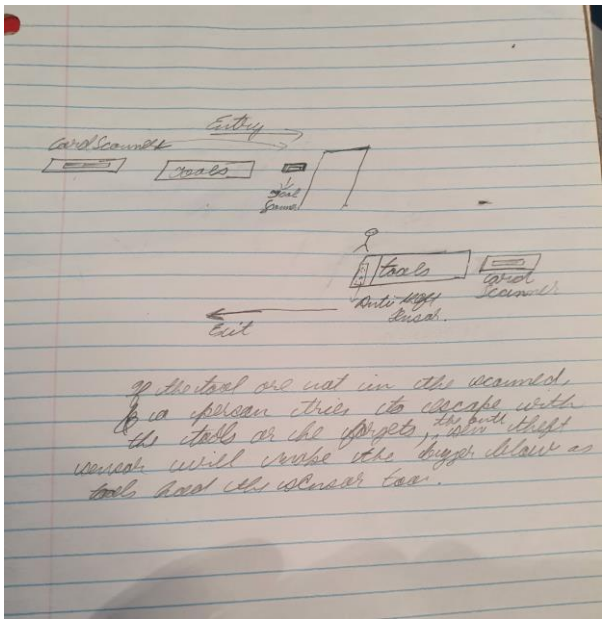
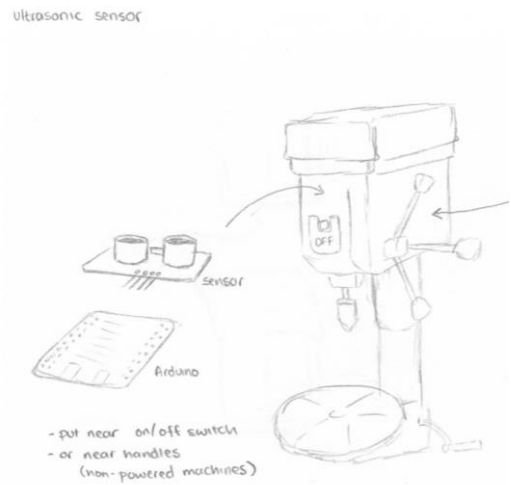
	In this system, a person taps the card and then takes the tools and then scans them. It keeps check of the name on which the tool is issued. After the person is finished, they tap the card to confirm his exit and then puts the tool in the box and it has a scanner inside the box. If a person just exits without scanning, his ID is still stored. It is to be solved that a box scans only when it is closed so that the person does not scan and leave. OR anti-theft sensors can be used on entry and exit doors and the buzzer blows when a person tries to escape with the tools.

Table 8: Gurinderpal's Brainstorm Ideas

Sketch	Description
	This consists of an ultrasonic sensor and an external drive to save all the information. It would be placed above the on/off switch or on a separate stand near the machine if it is powered. If it is a non-powered machine like the brake, then the sensor would be placed on a stand near the handle that performs the main function. The sensor will be set to have a certain range so that whenever someone is using the machine and is within the specified range, the sensor will mark that as the start of the machine use. When the range has been interfered with once more, that will be recorded as the end of the use. This data will then be sent to a program that records all the times the machine was used and the duration of each use. This allows machine maintenance to be scheduled according to the machine use.

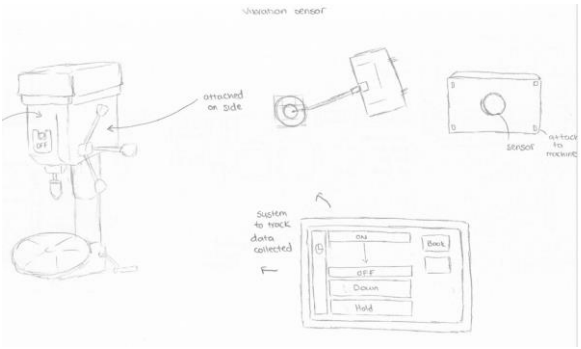
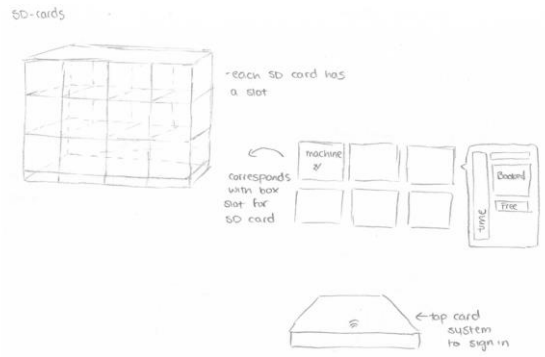
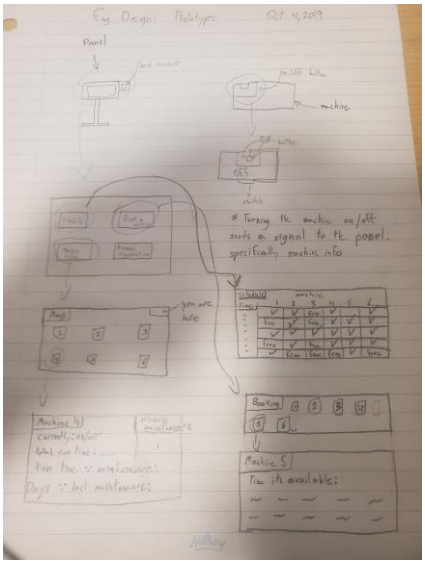
	This design uses a similar concept as the ultrasonic sensor which involves the vibration sensor. This would be placed inside a small box with an external drive/Arduino on the side of the machine. Whenever the machine is turned on, the sensor will sense the vibrations that indicate the machine is in use. When the vibrations are no longer received; the sensor records that as the end of the machine use. The data collected will be organized on an SD card or another external source
	This design is to help keep track of the SD card inventory and the usage of the 3D printer. This design consists of a container with programmed slots that open when signing out an SD card. Along with the SD card organization, there will be a tap card system to allow access to the interactive system. The 3D printers will be listed on the screen which would be displaying their availability. Once an open printer is selected, the corresponding SD card slot will unlock.

Table 9: Mariyam's Brainstorm Ideas

Sketch	Description
	This is a complete blueprint of a possible arrangement of the software on the dashboard. The initial screen is a menu that that leads to the machine schedule, information about each machine, as well as the ability to book/remove a reservation for a machine. The panel has an RFID scanner attached. Each machine will have sensors on its on/off button as well as Estop to check when it has been turned on or off, and update the machine information section.

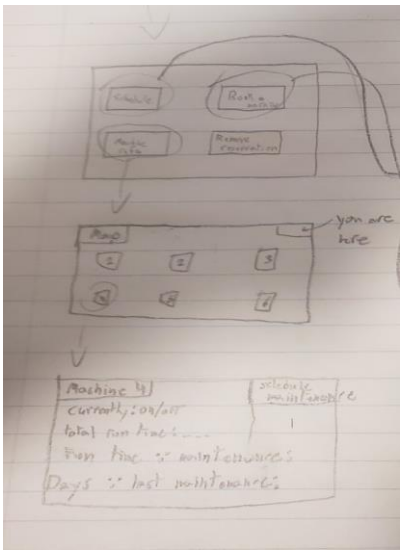
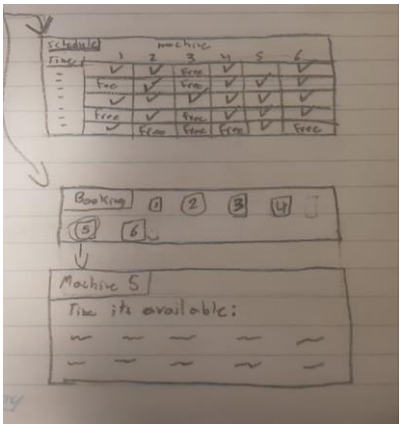
	Machine info: In order to access the machine info section, employees will need to scan their card on the RFID scanner, as a security measure. zThe machine info section will contain a series of information ranging from: its total run time, how long since its last maintenance check, whether the machine is currently on or off, as well as the ability to schedule maintenance for the machine at a certain time on a certain day.
	Schedule/reservations: In order to reserve a time to use a machine, you will scan your uOttawa card and pick a time. This will allow employees at CEED to see who used each machine at what time. A visual schedule will be used to show what times are available and who has booked which machine at what time. In order to remove your current reservation, you will need to scan your card again and remove any reservation you had.

Table 10: Adam's Brainstorm Ideas

3.2 Design Analysis

When comparing the concepts for machine maintenance and usage, it was found that with Ayesha's design, as found in Table 6, was liable since someone could open the cap but not actually use the machine. In order to correct this fault, the team researched different trigger switches. Adam suggested a pressure sensor or pad to go on top of the start button, but this will only work perfectly for push buttons; Brunsfield uses dials as well as switches to turn on their machines. While the pressure sensor will still work, people could hold the dial or switch, activate our sensor, but not actually turn on the machine. A sort of motion sensor is needed, one that can be attached to the switch, and will only activate if its been moved. Mariyam's sensor design consists of an ultrasonic sensor which would be placed directly above the on/off switch on the powered machines and near the handles for the non-powered ones. This sensor would activate anytime someone is within the pre-set range or perimeter around the sensor. When the range is interfered with, the sensor will record that as the start of usage and when it is interfered with once

more, that will be recorded as its end of use. This design idea is very similar to that of the vibration sensor as well, however, instead of having a sensor that tracks the movement of others, the vibration sensor would track the movement of the machine itself. Whenever the machine is turned on, the sensor will start recording the usage time and once the vibrations stop, so will the recording for that specific use. The downside of both designs in comparison with Ayesha's or Adam's design is that these sensors can easily be triggered by external movement/vibrations. This makes discerning between different machines and users difficult.

For equipment usage, Adam designed a schedule system that will keep track of who has or is going to use a certain machine and when. This system will give Brunsfield a more structured schedule. It will be useful for keeping track of machine & equipment usage but could cause some backlog if most of the machines are reserved by a few people since users will require a variety of different machines at Brunsfield for one job. A better idea is to have users sign into specific machines they believe they will need to use later and have an approximate schedule for what machines they are going to use and for how long. This modification will make it so that as soon as someone finishes working on a machine according to the schedule, the machine will then become reserved for the next person on schedule. Furthermore, the reserved time would have a set amount of specifically for cleaning up the user's workstation at the end of their session.

For Inventory management and keeping track of small equipment, Ayesha suggested a lockbox where a user would have to sign in through RFID in order to open and take a piece of equipment. The diagrams and description of the system can be found in Table 6. Whereas, Gurinderpal (Table 8) suggested a lockbox variation where the user would have to sign out an assigned token which would then unlock a drawer with a specific type of equipment. Both ideas would successfully track who used what and how much something would be used. However, where as Ayesha's design did not account for when things were returned, Gurinderpal's concept didn't account for if the tokens were lost. For Ayesha's design, the issue can be tackled by something like a signing out criteria. A person who took the equipment will have a record on their ID and it will only be removed once the item they took out is returned to its place. Additional security can be provided by incorporating her other concept of tracking inventory by weight. By tracking the change of weight in the drawer or lockbox, the system would be able to determine how many pieces of equipment have been removed, given that each box only has one type of equipment. For Gurinderpal's idea, a record of who signed out a token should available. So, if somehow a token is lost or intentionally not returned, the CEED staff would be able to locate who signed it out last. Shoaib's ideas generally focussed on security. Like the other concepts, he also thought of having the user sign out equipment and tools. He used a similar approach for the 3D printers; as described in Table 7, he suggested putting the printer itself in a glass box with an RFID sensor that can be used to track user information (name, student number, etc.). Additional motion or proximity sensors would track what has been made and the time it took for the print to complete. Any damage done to the glass would trigger an alarm, which would inform the management. This design fulfils its purpose but finding durable glass for the system is something the team will probably be unable to afford. Shoaib's other design consists of anti theft sensors near the doors of the workshop, so should anyone try to leave with the tools, a buzzer or alarm would ring, thus informing the staff. Although the design appears to be well versed, unfortunately since the needs were defined to be of a lower importance, it will not be the focus of the project.

3.3 Refining the System Designs

Based upon the concepts created by each group member, the team formulated three different systems consisting of the various subsystems. The Three fully functional systems that were selected all focus heavily on machine maintenance and equipment usage with an added functionality of tracking inventory. The importance is based upon the ranking found in Table 2.

3.3.1 System One

The first system (Figure 1) functions such that the user will be able to reserve their spot at a machine in the workspace. They would sign into the workshop using their uOttawa card when they enter and do the following: Users will enter how long they will be at Brunsfield, they will select which machines they are going to use and in what order, and for how long for each. The system will then reserve the specific machines for the user at the time they said they will use them. Once working at the machine, there is a pressure pad on the on/off switches that will signal when the machine is being turned on or off. The information is then sent to Dashboard to keep track of the machine usage in order to properly schedule maintenance for each machine. Once the user is finished working, they will sign out and the total time they spent will be logged into the system. For inventory management, expensive or valuable equipment will be kept separately from others, meaning users will need approval before they are able to use them. The more common tools will also be kept in boxes, but these boxes can be opened by users by tapping their card on a RFID scanner near the boxes and signing out that tool. The appropriate box will open and a pressure pad or scale on the bottom of the box will ensure that the number of items removed equals the number of items placed back. This subsystem functions by logging the weight of an individual item, then multiplies it by the number of items. If the item is consumable, i.e.: nails, bits, or goggles, or running low. An alert will be sent to a staff member saying that the item needs restocking.

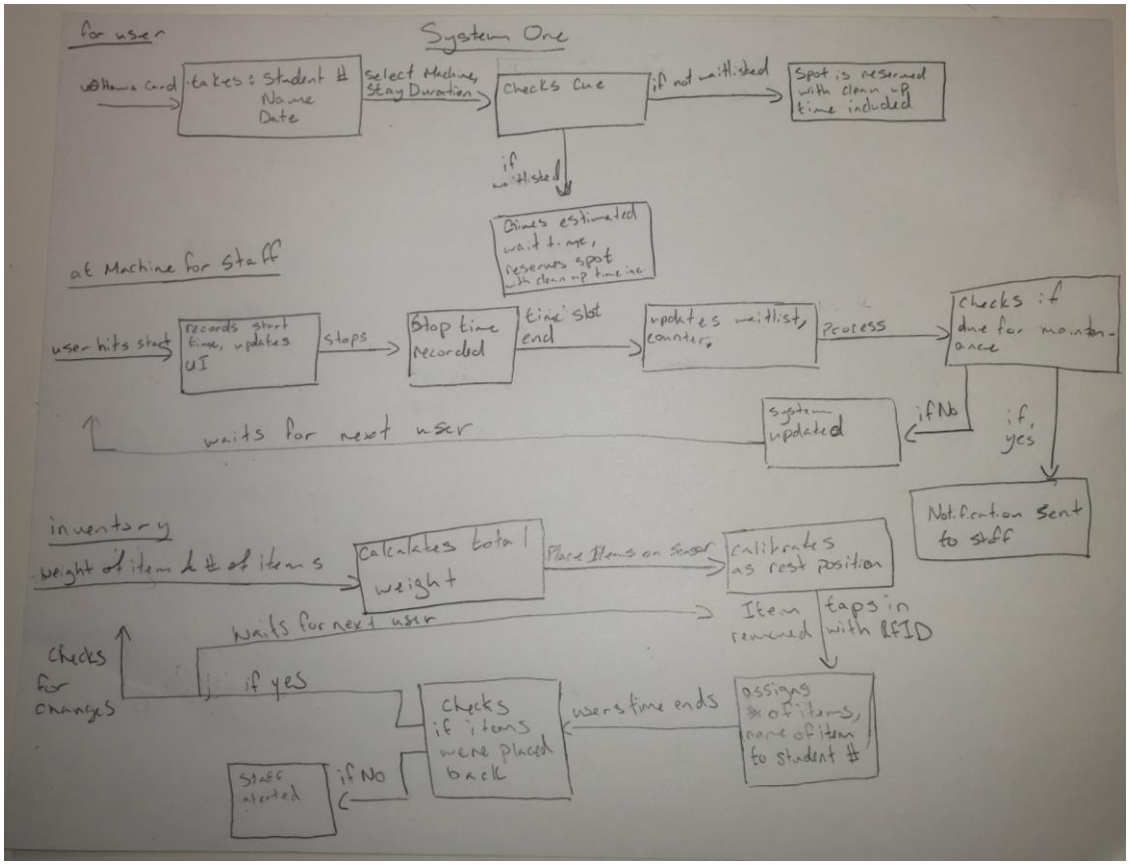


Figure 1: System One Block Diagram

3.3.2 System Two

The second system (Figure 2) is like that of system one, however, users must first reserve their space in the workshop ahead of time. They would first sign in on the UI and book a specific machine after entering the workshop using their student card. Each machine would be identified on the screen and the user would select what machine they would like to use for the time being. When they arrive to the machine the user would once again tap their student card on an RFID sensor. The user would use the machine how they normally would. There will be a vibration sensor placed on the side of the machine, so once it's turned on a signal is sent to the Arduino or processor indicating that the machine is now in use. The duration of the vibration would indicate how long it was used for. When the machine is turned on, the vibration sensor will record it as the start of use and once the vibrations are no longer received, the sensor will mark it as the end of the usage. In addition, there will be a scanning system located near all the tools to keep track of the inventory in the workshop. The scanners would be placed on all four sides of a drawer which is where

the tools would be kept. Each tool will also contain a barcode of some sort so that anytime a tool is borrowed, it will pass through the lasers that will then scan the barcode. This data will be recorded on the UI to keep track of the tools that are being used.

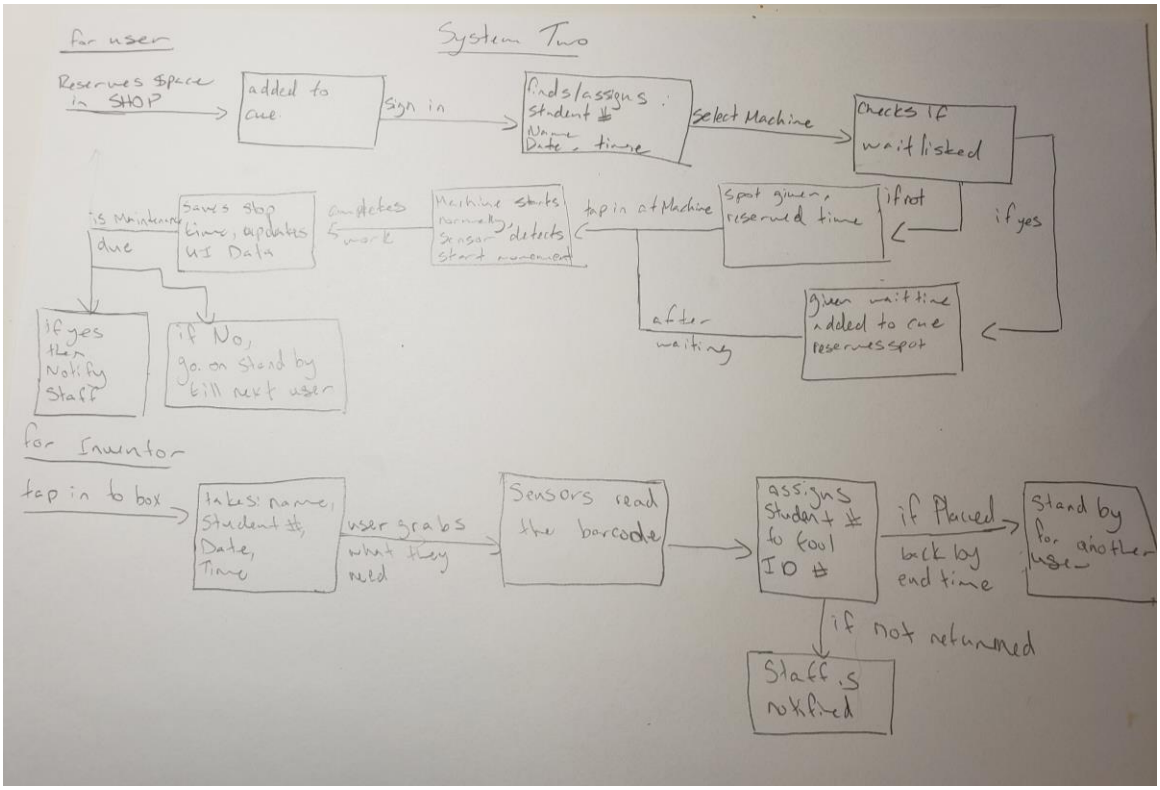


Figure 2: System Two Block diagram

3.3.3 System Three

For the third system (Figure 3), the user would sign in when they enter the workshop and sign out when they leave it. There will also be a system for reserving hand tools: Users would first sign out which tool they wish to use, the system has a record of how many of each hand tool is currently in use or in stock and will give the user access to the tool only if one is available. Once the user has finished using the tool, they would sign it back in. Upon entry the user will be able to see what machines are being used and which have been waitlisted. They will reserve a machine for themselves. For machine monitoring, there would be an upgraded version of the cap, or lid on top of the on/off switch. In this version, the cap would be motorized, and another RFID sensor would be placed by the machine. The cap would open once the user taps on the sensor and would automatically close after 60 seconds. This system accounts for a user's

lack of willingness to sign in at a podium or screen. The inventory would be tracked using a simple lockbox. The staff would be able to see who used what, as well as, what was used how many times. All information collected from sensors would be sent back to the dashboard to see.

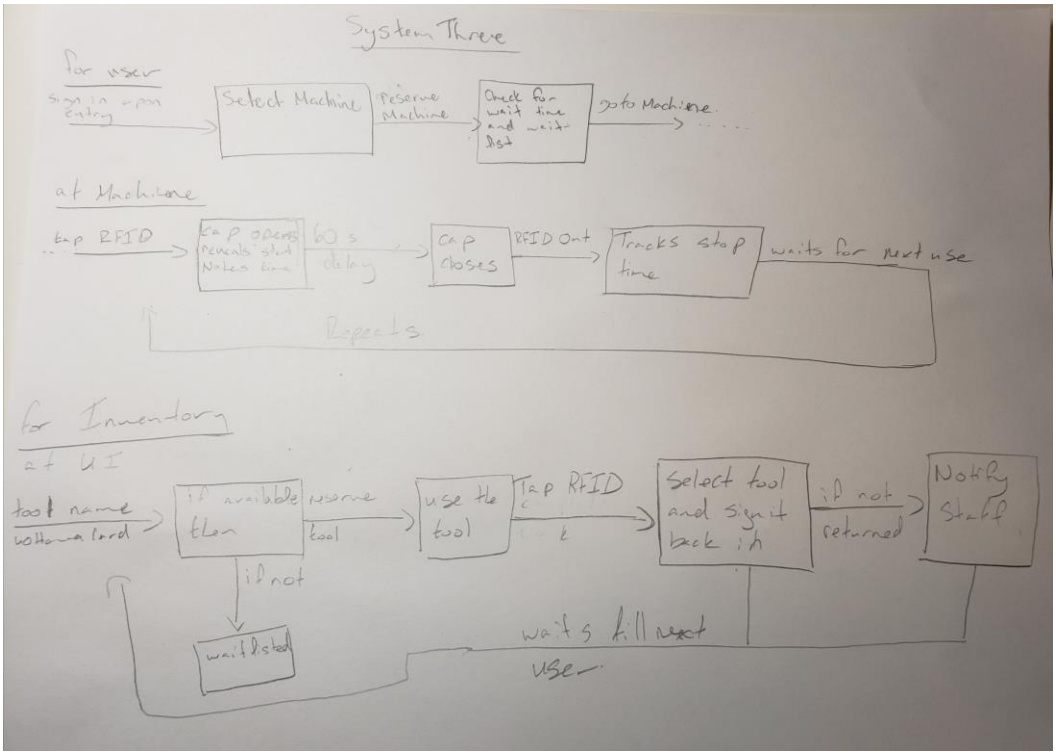


Figure 3: System Three Block Diagram

3.4 Project Selection

Upon comparing the systems to the design criteria (Tables 2, 4 and 5), Team 7 has decided to select System One. The first system is the best option for multiple reasons: its reservation system is compatible with the walk-in nature of Brunsfield. It also makes sure that the machine the user is working on won't be used by others until their reservation is completed, which eliminates a possible source of conflict in the space. The machine monitoring system will provide live and accurate measurements of machine run time, since the runtime sensor is directly connected to the machines on/off switch. This will be a great improvement, because the staff will then be able to accurately determine when the next maintenance check is and how long its been running since the last check.

The inventory management system will be effective since every item or tool taken and returned from the monitored boxes will be documented by the system on when it was taken, returned, and by whom. This will be beneficial for the staff, for example: If a staff member notices that one person keeps signing out drill bits and not returning them, they can seek that person and ask them where the bits went. The pressure pads/scale will make sure the correct number of items that were signed out are actually

taken and returned. If the user takes more than they signed out, a staff member will be alerted. A staff member will also be alerted if their current stock becomes too low. This is calculated using the weighted pads as well.

Furthermore, the design satisfies the problem statement as defined in section 2.4. The chosen solution will not only exceed the requirements for the problem statement, but the entire design is designed to be as simple and accessible as possible in order to reduce user frustration and allow for rapid implementation into the Brunsfield facility. The UI is made to be informative and will contain all the technical needed by the CEED staff. The information provided will have user information: a record of who signed into Brunsfield, and for how long, as well as what equipment they used, what hand tools they signed out, and if they returned them. Machine usage information will also be stored: When each machine last got a maintenance check, how long each machine has run for, since its last check, and a record of who used each machine and when. The inventory management component works to improve how Brunsfield manages their inventory and stock of small hand tools and consumables. This new system is almost completely automated and will reduce the amount of materials that go missing and ensure that CEED staff are informed when the supply of anything becomes too low. The system also fulfills the design specifications, as stated in Table 5. However, most importantly this system has been made to fit CEED's criteria and needs.

4 Conclusion

Team 7 has decided that STEM needs a system that is accessible, cost efficient and can easily inform users and staff at each workshop about the machine usage, availability, and provides technical data to aid in scheduling maintenance. The Team has come up with an effective solution to these problems and created a product that can keep users and CEED staff informed. The Product has the compatibility to work with minimum supervision, is very affordable when compared to the competition in similar markets and has the ability to track equipment and monitor the usage of specific machines in Brunsfield. Our competitors solutions cost much more than system one. The system is cater made towards Brunsfield in its entirety and is compatible with MTC, while the competition provides a more general solution for factory size workspaces. In conclusion, system one is simple yet complex enough to fulfill all of the client's needs. It fulfills the design criteria and specification and surpasses the defined problem statement.

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