## Introduction

Following various meetings with the client and sponsor, a needs identification list was created. We then consolidated a list of criteria from our needs as well as met with several staff members of the Makerspace to refine our understanding of their needs. From that, we came up with various design criteria to formulate a solid foundation for evaluating ideas as well serving as a reference for future prototypes. We created a list of functional and non-functional requirements to make sure that the product meets the needs of the user. Furthermore, a comparison table of similar products was created to identify any performance gaps, find areas of improvement, and set expectations of the product. Finally, technical specifications were developed to ensure that the product remains within a set of restrictions.

## Initial Constraints

1. Size of parts we are able to make (cm•cm•cm)
2. Amount of space around the 3D printers we are able to work in (cm•cm•cm)
3. Cost ($)
4. Hardware: computing ability of an Arduino/Raspberry Pi, power distribution in devices (currently unknown)
5. Software: languages of microprocessor, printer, and Ross Video DashBoard
6. Time: prototyping deadlines, attention span of users

## Requirements

### Functional Requirements

* Real-time tracking of the usage of 3D printers
* Display availability of various brands and types of 3D printers
* Display remotely
* Distinguish between printers that are unused and printers under maintenance

### Non-Functional Requirements

* UI aesthetics
* Easy to use for all makerspace users
* Scalable to a varying number of printers
* Product life
* Resistant to dust and ambient temperature

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|  | Identified Need | Rank | Design Criteria | Criteria |
| 1 | Maintainable | 5 | - Physical Product  - UI | -Tough and durable to survive wear and tear for 10 years.  -UI should be adaptable and easily modified  -Protects contact surface from dust and damage. |
| 2 | Modular | 4 | - Physical Product  - UI | - Must be able to easily scale it up or down as the Makerspace changes.  - UI must be able to adapt to changing numbers of printers. |
| 3 | Unobtrusive | 4 | - Physical Product | - Must not physically interfere with the 3D printer printing bed, nozzle, or card reader.  - Must not interfere with basic functions such as re-levelling table, replacing filament, or moving the printer from place to place. |
| 4 | User friendly | 5 | - UI  - Physical Product | - Must be easily accessible to everyone using the MakerSpace. |
| 5 | Attractive | 4 | - Physical Product  - UI | - Physical design must be aesthetically pleasing.  -UI must showcase an interesting feature of Ross Video.  -UI must be clean (uncluttered). |
| 6 | Easy to use | 5 | - UI  - Physical Product | - Must be immediately obvious how to set-up and use.  - Must take a reasonable amount of time to get information to a user. |
| 7 | Bilingual | 3 | - UI | - Must be available in English and French to comply with the university’s policies. |
| 8 | Automated | 5 | - Physical Product | - Must update information on 3D printer use with no physical input from staff. |
| 9 | Space surveillance | 4 | - UI | - Must provide an accurate assessment of 3D printer availability. |
| 10 | Inventory management | 3 | - UI | - Must allow users working in the Makerspace to know which printers are available. |
| 11 | Lets users know about their time limits | 3 | - UI | - Must include information about how long projects will last and how long there is left in the work day. |
| 12 | Lets users know about their physical surroundings | 2 | - UI | - Must have information on where each printer is in the space. |
| 13 | Safe environment to human health | 5 | - Safety | - Must not deteriorate human health or the state of the MakerSpace. |
| 14 | General comfortable experience of product and space | 4 | - Safety | - Must be safe to handle and provide no danger to people or equipment while in operation. |
| 15 | Encourage user engagement with space | 4 | - Perception | - Must be fun to use. |
| 16 | Encourage positive Interaction between makers | 2 | - Perception | - Must promote a sense of collaboration and team-building (as opposed to competitiveness and resentment of users using the Makerspace). |
| 17 | Affordable | 5 | - Cost | - Must fit within $100 budget. |

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| Criteria Category | Community Forum Webcam Solution | AstroBox Raspberry Pi Kit | Cura Monitoring |
| Picture of Product |  |  |  |
| Physical Product | This is a simple design that simply monitors the 3D printing process by recording it as a timelapse to be able to troubleshoot problems occurring during the process.  It is a very simple design, requiring simple equipment such as a PC, a timelapse software and a recording camera. While it does not intervene during the printing process to fix issues occurring on the fly, it gives the operator the opportunity to look back at the printing to determine where things went wrong if the process did not go as planned. Would not be durable against movement. Would require intervention from Makerspace staff. | This is essentially a Raspberry Pi that has a custom case, custom connections, and pre-made proprietary software that plugs into the USB-B port of a printer and allows up to 4 printers to be connected at once. | This is a built-in feature of newer Ultimaker printers and similar 3D printers, from version 3 onwards. It requires an internet connection on the part of owners.  Unfortunately we do not have built-in connection with the majority of printers in the Makerspace, so this pre-existing software lacks the ability to interface with our equipment. |
| UI | Scaling this product would require importing video feed for up to 30 devices, and it would likely not allow our users to easily obtain information. Could provide information on colour and time remaining if the camera is pointing at the LCD screen of the printer. Would likely require more power than could be given by a Raspberry Pi or an Arduino. | This product allows for remote file upload, printing progress, temperature monitoring, material information, print job queuing, workflow management, and print monitoring if a camera is connected as well.  UI is easy to use and easy to understand.  UI works remotely and updates immediately. Will also work on a phone app. | This product displays relevant info like printer usage, camera feed, print material information, temperature information, remaining time on current build, and also allows you to switch between printers on the network to view their progress as well. It does not give summaries, so users would need to navigate through a menu to determine their relevant info. |
| Safety | This device does not occupy a lot of space and can be easily stored since it requires minimal equipment. Deterioration of human health and of the space it is installed in is also not an issue. | This device does not occupy a lot of space and takes most of the decision-making away, limiting human error. | This product takes up no space because it is built into the printers themselves. Safety and health is not an issue. |
| Perception | Would be fun to watch video feeds. | Product is compact and UI is beautiful. | Product is sleek and UI is beautiful. |
| Cost | $25-50 USD | $100 USD (for a DIY kit) | $5,600CAD (least expensive printer with this capability) |

#### Technical Specifications:

* **Dimensions:** Individual devices must be able to fit in and around a 3D printer - 20cm by 10 cm by 10 cm
* **Cost:** $100 CAD
* **Production Time:** Must have a fully-working prototype in 2 months
* **Scale:** Prototype must completely incorporate at least 2 different printers
* **User Time:** Must not take user longer than 1 minute to receive desired information
* **Lifetime:** Must last between 3-8 years

## Discussion

It has been challenging to create technical specifications relating to our product as we do not have a lot of experience creating criteria for software, and unlike examples we have seen in class and examples of past projects, this is a very software-heavy project. As a result, most of our criteria are “yes/no” criteria and our technical specifications are somewhat sparse. We also acknowledge that as some of our needs are not ranked as highly as other needs, these criteria will weigh less once we begin to apply them to our design ideas.

## Conclusion

We now how a decent starting point for designing our product. We have much to learn about software product development and we have many possible ways we could proceed with our problem statement - this is no more clear than when looking at our benchmarking references, where we see systems that vary from hardware to software, and professional products to community-driven passion projects. The combination of our criteria listed here and the document we created for our problem statement will serve as a good roadmap for the rest of the product development process. We believe that our biggest challenge moving forward will be learning how to incorporate scalability into our design, and we will need to do a lot of reading on circuit theory and DashBoard to ensure that we fulfill this criteria.