Jonathan Schallert  
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**PROJECT PROPOSAL**

CoreXY Printer Build

“Rize”

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1. Summary

These first several pages will attempt to describe

Small, robust parts are some of the most commonly used parts on an FRC robot.

As of December 2016, FRC team 691 has no viable option for 3D printing parts.

1. Introduction

Since the dawn of time, mankind has strived to create clichéd derivatives of existing products, with the hope that they will somehow both retain functionality and improve upon an existing design.

That is what this project, also, intends to do.

It is best to begin by explaining how and why this project was founded. Currently, the robotics team’s manufacturing capabilities are somewhat limited. Producing parts is possible, but not within a reasonable timeframe. Small parts would have to be ordered from suppliers that could take multiple business days to ship. If team 691 were to look for a small, functional part, it would take days or weeks longer than other teams. It was established in the build season of 2015 that 3D printed parts could serve as both functional and exceptional parts—but the team now has no capability to produce any of these of high quality.

A simple solution would be to obtain a 3D printer. This was attempted in 2012, but ultimately ended in failure as the upkeep and operation of the printer faltered over the course of several years. The team’s current printer, a Cube 2 by 3D Systems, is a low-end X/Y Table style printer that is only capable of printing with proprietary, PLA cartridges. Their printer software is also extremely limited, with unintuitive controls and very limited capability to manipulate and calibrate the printer. This is obviously a problem for several reasons:

* PLA has extremely bad compression strength, tensile strength, and layer adhesion
* Inaccurate models of last-generation printers often fail and a jam could decommission the printer with little to no possibility of repair
* Constant use of this printer requires expensive and rare filament, and proprietary software that is outdated and has little functionality

Ultimately the only reasonable solution is to buy or make a reliable printer that has plug-and-play capability so little technical knowledge is required as a prerequisite for the printer’s use. This project will hopefully fill the team’s need for a permanent 3D printer of high quality while keeping both cost and maintenance low.

1. Needs/Problems

There are several key constraints that this project must address and work around. This printer must be:

**• Capable of lasting several years through an ever-changing team**

Being a team of high-school students, 691’s composition of members will change entirely every four years. The members with the most experience will leave, while new, inexperienced members will take their place and learn as they did. However, it is impossible for the team to retain all the knowledge that these members have gained over four years. The technical expertise of even mentors are limited. Thus, a printer must be capable of “plug-and-play” printing, or seamless transition from a CAD file to gcode to a finished product.

**• Producing parts with quality materials**

A severe limitation of the Cube is its lack of a decent hotend. Due to its flimsy and restrictive build, it is practically impossible to replace the hotend with anything capable of printing in exotic materials or useful materials besides ABS and PLA. Additionally, its proprietary filament introduces an additional limitation when printing parts. The disassembled RepRap printer had much greater capabilities—however, the hotend is currently missing. This new printer, to match the needs and capabilities of the ones before it, must have a hotend capable of printing in at the very least ABS and PLA. However, it is extremely preferable that unique materials like PETG and flexible filament are available to bridge the gap between tolerances and strength.

**• Maintain tight tolerances**

Previous parts printed for robots included holes for bolts, curves to fit inside sheet metal, and sharp edges to fit into corners. While it is possible to design around these issues and further machine printed parts, it is obviously not preferable. The printer should be capable of printing on par with previous printed parts—about 100 micron resolution. The primary factor in this tolerance is a robust construction. While decent stepper motors and higher quality controllers would help, this need is almost purely mechanical with the given budget, detailed below.

**• Sourced from replaceable parts from known suppliers**

This printer would be the team’s only usable printer, and will be designed to last several years. Throughout its usage, parts will inevitably break. Replacement parts should be easily obtainable and sourced from known, unambiguous suppliers. Included with the printer should be a documented bill of materials, with appropriate prices, sources, and shipping information.

**• Producing parts of a reasonably large volume while maintaining compactness**

A final constraint for the project is slightly subjective, but ultimately necessary. The robotics team has an extremely limited space for robots and components this year, and the inclusion of another tool, regardless of size, will fill a noticeable percentage of the build space. However, some parts require a large build space. As seen in the 2016 season, some parts will be approximately the size of a FlashForge Creator build volume, which should be the minimum capability of this printer. The ratio of build volume to overall volume will be taken into consideration.

1. Goals/Objectives

To address these needs, there are goals and objectives to address the needs/problems stated above. Also include key benefits of reaching goals/objectives.

**• Resilient, sturdy design with simple repairs**

This can be achieved primarily by using robust and easily repairable construction materials. The frame should be made from 80/20 20mm x 20mm extrusion, which can be sourced from nearly any supplier and is extremely sturdy and versatile for its cheap price. Proper use will result in little to no wobble and extremely tight tolerances.  
 The printer itself will be a CoreXY (or H-bot) style printer—its X and Y axes will be controlled dynamically about the frame with motors through the top of the printer, and the Z axis will be controlled by adjusting the height of the platform through threaded rods from the printer’s base. This is preferable to the other types of printers:

1. Cartesian (less robust)
2. Polar (difficult to calibrate)
3. Delta (less optimized build space, difficult to calibrate)
4. Scara (extremely expensive)

The extruder will be Bowden style. Instead of feeding directly to the hotend, the feeding mechanism will be located closer to the spool of filament. This separation will allow for much quicker maintenance of both the hotend and extruder, and will help isolate any potential problems with extrusion without any noticeable drop in quality from a direct extruder. A Bowden extruder would also place far less load on the extruder, and when paired with the CoreXY design, will allow for much quicker and more precise prints than traditional Cartesian printers with direct extrusion.

**• Capable of consistently extruding ABS, PLA, and PETG filaments**

The materials require only slight modifications to achieve. The capabilities of this printer are largely dependent on the hotend used. In this case, the hotend will be either the E3D V6 or the E3D volcano, both of which exceed the desired capabilities, with the capability to print in all the aforementioned materials as well as flexible and composite materials.

**• Potential to expand to a dual-extruder printer**

The something

1. Procedures/Scope of Work

With the constraint of one month to work on this project, there are obviously some serious concerns of time, manpower, and budget.

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Provide detailed information about proposed procedures, if available, and the scope of work. Include information on activities such as recruiting, training, testing, and actual work required.

1. Timetable

The project will be a product of several phases to better organize labor and meetings. Due to the existence of two important holidays, the work will be scheduled around these dates for more reasonable work hours. However, due to the short duration of this project, the first phase of research and design must be shortened considerably. The first phase has already begun, and will likely finish on schedule due to the necessity of shipping.

Phase Three and Four will overlap—as parts arrive and the build is completed, components will be properly calibrated and built in segments. The electronics board will be completed separately from the main frame and everything will be connected once the electronics and frame are operational separately. This work will be done by different teams, with Daniel leading the electronics aspect and Jonathan leading the mechanical aspect.

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| --- | --- | --- |
|  | **Description of Work** | **Start and End Dates** |
| **Phase One** | Research and Design Process | 12/19/2016 – 12/23/2016 |
| **Phase Two** | Purchasing and Proofing Design | 12/24/2016 – 12/30/2016 |
| **Phase Three** | Build | 12/31/2016 – 1/7/2015 |
| **Phase Four** | Calibration and Troubleshooting | 1/4/2016 – 1/15/2016 |

1. Budget

Below is the proposed budget for the program. I intend to limit costs by using existing materials and sourcing from a single supplier rather than buy individual items from separate suppliers. The entire build should be done after three orders from McMaster (hardware), Openbuilds (hardware) and E3D (electronics).

Some materials

|  |  |  |
| --- | --- | --- |
|  | **Description of Work** | **Costs (Approximate)** |
| **Moving Components** | Including print bed, axles, extruder, and hot end | $75-$100 |
| **Frame** | Including aluminum extrusion, mounting brackets, 3D printed parts, and raw materials for machining | $100 |
| **Electronics** | Including controller, power supply, wires, motors, limit switches, fan, and thermistors | $150-$250 |
|  | **Total** | **$ 350 - 450** |

1. Key Personnel

***"There must be a beginning of any great matter, but the continuing unto the end until it be thoroughly finished yields the true glory" - Sir Francis Drake, 1587***

As a month is an incredibly short amount of time, a single person cannot hope to involved in the project. In response to this, there will be a more complete team working on the design at one time to maximize efficiency. The personnel involved will be as followed:

|  |  |
| --- | --- |
| Client | Team 691 Robotics |
| Sponsor | Jonathan Schallert and Team 691 Robotics |
| Project manager | Jonathan Schallert |
| Team | Jonathan Schallert, Silas Sadia, Arjun Sridhar, Daniel Ring |

1. Evaluation

Discuss how progress will be evaluated throughout and at the end of the project.

– Formulate clear indicators for each objective and result

– Indicate how and when to conduct monitoring and evaluation activities to determine project’s progress and outcome

– State which methods will be used to monitor and evaluate the project

– Identify who will carry out the project evaluation.

1. Next Steps

Specify the actions required of the readers of this document.

• Specify reimbursement/purchasing process from Project 691

The first shipment of parts will

• Next Step 2

• Next Step 3

1. Future Work

The 3D printer is considered an open source concept. The authors encourage all members of the 691 community to contribute to the printer design process. Iteration of the design by various individuals and groups can help bring the 3D printer from an idea to a reality. The authors recognize the need for additional work, including but not limited to:

1. More expansion on the control mechanism for Hyperloop capsules,

including attitude thruster or control moment gyros.

2. Detailed station designs with loading and unloading of both passenger

and passenger plus vehicle versions of the Hyperloop capsules.

3. Trades comparing the costs and benefits of Hyperloop with more

conventional magnetic levitation systems.

4. Sub-scale testing based on a further optimized design to demonstrate

the physics of Hyperloop.

Feedback is welcomed on these or any useful aspects of the printer design.

E-mail feedback to [jschallert@hmc.edu](mailto:jschallert@hmc.edu) or [jpschallert@gmail.com](mailto:jpschallert@gmail.com).

Contact via phone at 661-714-1622.

1. Appendix

Provide supporting material for your proposal here. It may be:

* Research materials
* Statistics or estimates
* Detailed cost / benefit spreadsheets
* Other relevant information or correspondence.

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| [Name], Project Client  Date: \_\_\_\_\_\_\_\_\_\_\_\_\_ |  | [Name], Project Sponsor  Date: \_\_\_\_\_\_\_\_\_\_\_\_\_ |  | [Name], Project Manager  Date: \_\_\_\_\_\_\_\_\_\_\_\_\_ |