

Project PAM

A Reference Design for

Photoresin Additive Manufacturing for

The Open Source Community

Saluki Engineering Company

Reference Number: S14-75-3DPR

Date

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# Transmittal Letter: CWB

2014-11-18

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Mr. Blair,

On behalf of the Saluki Engineering Company, I would like to thank you for including us in the bid for a project to design a digital light processing printer. Attached is a design report for a DLP photoresin printer, Project PAM. Along with this report, we have included the computer host software code and build instructions of the prototype.

Talk about Prototype here

Project PAM proposes a reference Photoresin Additive Manufacturing (PAM) system which maximizes accessibility to the hobbyist. It is intended to be flexible by allowing for configurations of hardware available or easily obtainable to the end user. This is achieved through extensive use of currently available or easily fabricated hardware and open-source software. The reference design will be open-source hardware and software to the lowest practical level. Thorough documentation will provide the necessary means for the end user to go from an empty table to a functioning printer.

Please feel free to contact me at (815) 214 9661 or by email, burdickjp@siu.edu, if you have questions about this project.

Sincerely,

Jeffrey P Burdick

Project Manager

Project PAM: Team75-3DPR

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# Acknowledgements: CWB

To begin we would like to express our thanks to Dr. Spyros Tragoudas and Dr. Rasit Koc along with the Electrical and Computer Department and the Mechanical Department for the support and financial contributions. The project would not have been possible without their financial backings.

We would also like to take the time to thank the backers of the crowed funding campaign. Very person’s contribution was very much accommodating to the needs of our group. We would like to thank them for not only their financial report but their words of encouragement and belief in our project.

From the beginning of the project Dr. Lizette Chevalier has given priceless words of encouragement and advice that has been very critical to the success of the project.

At this time we would like to thank Lakendria Kenner of WSIU, Scott J. Grunewald of 3D Printing Industry, Eddie Krassenstein of 3D Print, and Austin Miller of Dailey Egyptian for the kind words in their articles. Their articles have help spread the work of Project PAM out to the global community.

We would like to take this opportunity to thank Dr. James Mathias for him allowing us to have use to his laboratory space giving Project PAM a place to call home.

We also would like to express a deep sense of gratitude to the team’s Faculty Technical Advisors; Dr. James Mabry and Joe Lennox, for their constant support, valuable guidance, and professional advice throughout the various stages of the design project.

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# Table of Contents: CWB

[Transmittal Letter: CWB 2](#_Toc404195208)

[Acknowledgements: CWB 3](#_Toc404195209)

[Table of Contents: CWB 4](#_Toc404195210)

[Table of Figures: CWB 4](#_Toc404195211)

[Table of Tables: CWB 4](#_Toc404195212)

[Table of Drawings: CWB 4](#_Toc404195213)

[1 Executive Summary:CWB 6](#_Toc404195214)

[2 Project Description: 6](#_Toc404195215)

[2.1 Introduction: CWB 6](#_Toc404195216)

[2.2 overall Printer Diagram: 6](#_Toc404195217)

[3 Costs: 6](#_Toc404195218)

[4 Schedules: 7](#_Toc404195219)

[5 Subsystem Descriptions: 7](#_Toc404195220)

[5.1 Mechanical Motion-JPB 7](#_Toc404195221)

[5.2 Chassis-JPB 7](#_Toc404195222)

[5.2.1 Process of Design 7](#_Toc404195223)

[5.2.2 Process of Assembling 7](#_Toc404195224)

[5.2.3 IMPLEMENTATION SCHEDULE 7](#_Toc404195225)

[5.2.4 Equipment Needed 7](#_Toc404195226)

[5.2.5 Health and Safety Issues 7](#_Toc404195227)

[5.2.6 Conclusions and Recommendations 7](#_Toc404195228)

[5.3 Printer Control Software- DMO 7](#_Toc404195229)

[5.4 Hardware-Software Interface- NAL 7](#_Toc404195230)

[5.5 Resin Management-CWB 7](#_Toc404195231)

[5.6 Optics-CWB 7](#_Toc404195232)

[5.7 Vat-NBT 7](#_Toc404195233)

[5.8 Coupler-NBT 7](#_Toc404195234)

[6 References: CWB 8](#_Toc404195235)

# Table of Figures: CWB

[Figure 1: Overall Printer Block Diagram (WW) 11](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v2.docx#_Toc385446916)

[Figure 2: SEC Semester Schedule, As planned and as worked (ALL) 13](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v2.docx#_Toc385446917)

[Figure 3: Implementation Schedule (PZ) 14](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v2.docx#_Toc385446918)

[Figure 4: Original design of the frame (PZ) 15](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v2.docx#_Toc385446919)

[Figure 5: Original design of the X/Y carriage and platforms (PZ) 16](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v2.docx#_Toc385446920)

[Figure 6: Second design of the frame (PZ) 16](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v2.docx#_Toc385446921)

[Figure 7: Third design of the frame (PZ) 17](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v2.docx#_Toc385446922)

[Figure 8: Bottom base of frame (PZ) 18](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v2.docx#_Toc385446923)

# Table of Tables: CWB

[Table 1: Prototype Costs 11](#_Toc385423812)

[Table 2: Implementation Costs 11](#_Toc385423813)

[Table 3: Detail of parts in frame subsystem (HL) 21](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423814)

[Table 4: Prototype cost of frame subsystem 25](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423815)

[Table 5: Implementation cost of (PZ)frame subsystem 25](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423816)

[Table 6: Prototype cost of X/Y translation subsystem (JC) 31](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423817)

[Table 7: Implementation cost of X/Y translation subsystem (JC) 31](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423818)

[Table 8: Production cost of roller mechanism subsystem (JC) 34](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423819)

# Table of Drawings: CWB

[Drawing 1: Makerslide cross section (JC) 90](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423866)

[Drawing 2: Roller plate - Motor (JC) 91](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423867)

[Drawing 3: Pwdr. Project's X/Y Translation assembly drawing (JC) 92](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423868)

[Drawing 4: Rolling Plate - Bearing (JC) 93](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423869)

[Drawing 5: Makerslide belt clip (JC) 94](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423870)

[Drawing 6: Makerslide motor mounting plate (JC) 95](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423871)

[Drawing 7: Makerslide eccentric nut (JC) 96](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423872)

[Drawing 8: Rolling Mechanism Flange (JC) 97](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423873)

[Drawing 9: Base Panel (PZ) 98](file:///E:\Documents\Homework\SIUC\Senior%20Design%203D%20Printer\Design%20report\Design%20Report%20v1.docx#_Toc385423874)

# Executive Summary:CWB

Project PAM proposes a reference Photoresin Additive Manufacturing (PAM) system which maximizes accessibility to the hobbyist. It is intended to be flexible by allowing for configurations of hardware available or easily obtainable to the end user. This is achieved through extensive use of currently available or easily fabricated hardware and open-source software. The reference design uses open-source hardware and software to the lowest practical level. Thorough documentation provides the necessary means for the end user to go from an empty table to a functioning printer.

The major subsystems of Project PAM include: Mechanical Motion, Chassis, Printer Control Software, Hardware-Software Interface, Resin Management, Optics, Vat, and Coupler. Our teams is still striving to achieve the optimist solution to achieve the highest level of quality.

Several of the design activities and decisions show how Project PAM is more desirable than the competition. One example of this is Project PAM’s build size. The maximum build size is almost double that of any other DLP printer. This is achieved by supporting the use of two 1080p projectors. As consumer resins increase with quality this feature will allow the PAM system to grow. Though the maximum build size would use up to nine liters, Project PAM’s flexible design allows the use of multiple vats and build tables. This will lead to minimal resin waste, saving the user money.

This printer is expected to have the capability of producing high quality prints. The initial goals of Project PAM included: keep the cost of the project under $700 excluding the price of the projectors, support the use of two projectors, have a maximum build size of 20X20X19 cm, layer thickness as thin as 100 µm, and have a printing resolution error within 100 µm.

Talk about Prototype here.

This report consists of: a project description that will introduce the report and project, a cost analysis allowing the open-source community to see the end cost, expected build time schedule, detailed subsystems descriptions along with recommendations, and an appendix.

# Project Description:

## Introduction: CWS

Today when one uses the term "3D printing" they referring to the manufacturing process that allows three dimensional drawing on the computer to be built before their eyes with just a click of a button. 3D printing is unique from other machining processes because it implements what's known as additive manufacturing rather than the more common techniques of drilling or cutting to remove material. 3D Printers are able to accomplish this by slicing the virtual models into several two dimensional layers and then printing those layer one by one to build up the object. This is advantageous because it is much less wasteful than traditional techniques. A 3D printer is also capable of building nearly any object which allows manufacturers to change products without having to buy any new equipment.

The first 3D printer was built in 1984 by Chuck Hall [1] but the process has not been widely available until the early 2010's. Printers are most commonly used for cheap and rapid prototyping but the process has shown potential in a number of fields, including architecture, automotive design, and even the biomedical field to print human tissue and organs. Because of this potential the industry is estimated to be worth more than $2.2 billion today [2].

There are several techniques used to accomplish this layer-by-layer building operation, the most common of the additive manufacturing processes today is extrusion deposition. With this extrusion deposition each 2D layer is built by extruding a bead of material which will harden almost instantly upon leaving the extruder nozzle. The nozzle head moves across a surface depositing the material in the shape of the given layer and then moves on to build the next layer of the object. As each layer is added the print object gains volume. This method is simple and inexpensive but is less accurate than other techniques and also error prone since any defect can lead to a jam or clog in the extruder.

However, another method that is slowly gaining popularity is using light and photocurable resins to build these layers. The resin is exposed to some form of UV light which hardens the resin. This hardened section of resin is one layer of the object. The print area then moves down and the process is repeated to build the next layer. This is known as photopolymerization and the most common form of photopolymerization is using a DLP projector to project images onto the resin. DLP printing has several advantages over the previously mentioned extrusion deposition method, the first of which is speed. Instead of moving an extrusion nozzle slowly across a surface to build the individual layers, DLP printers project an image of the entire layer and cure it all at once. Another advantage is that since there is no physical contact between the projector and the building material there is not possibility for jamming. However, DLP printing’s greatest strength lies in its ability to produce extremely precise and detailed print objects since its resolution is only limited by the resolution of the projector used.

## overall Printer Diagram:



Figure 1. Flow Diagram for Project PAM printer control software

# Costs:

# Schedules:

# Subsystem Descriptions:

## Mechanical Motion-JPB

## Chassis-JPB

### Process of Design

### Process of Assembling

### IMPLEMENTATION SCHEDULE

### Equipment Needed

### Health and Safety Issues

### Recommendations

## Printer Control Software- DMO

## Hardware-Software Interface- NAL

## Resin Management-CWB

### Process of Design

## Optics-CWB

## Vat-NBT

## Coupler-NBT

# References: CWB

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| [2] | "3D Printing Scales Up," *The Economist,* 7 September 2013. |

# Appendix