# Costs:

## Crowdsourcing Campaign: DMO

The idea of crowdsourcing Project PAM was brought up during the spring; however, it was decided to be too much of a commitment for the team members at that time. As the semester continued and the estimated cost of building the prototype became apparent crowdsourcing was again looked at. The decision was made at the beginning of the fall to move forward with a crowdsourcing campaign.

The first step of this process was to pick a crowdsourcing platform. Originally Kickstarter was chosen; however, after during the process of trying to create the campaign it was determined Kickstarter did not meet the needs of the project. Because of this Indiegogo was chosen as the crowdsourcing platform for Project PAM.

One of GitHub’s features called GitHub Pages, which hosts simple static HTML websites for free and provides Creative Commons licensed templates to use, was used to develop a website for Project PAM [1]. GitHub supports both project pages (website for repo) and organization pages. For Project PAM an organization page along with two project pages (Hardware and Software Repos) were created using the Architect theme as a starting point. The print outs of the website are included at Appendix.

### Indiegogo

The first part of the Indiegogo campaign was to take the information from the website and modify to follow the Indiegogo Playbook, a guide to running a successful crowdsourcing campaign [2]. Indiegogo recommends creating a short video to introduce the project and be a commercial for the product [2]. The decision was made to use an online tool called Prezi, a kind of PowerPoint tool for presenting ideas on a virtual canvas [3]. With the help of a student in the Mass Communications program voice over was recorded for the Prezi.

The second step for the Indiegogo campaign was to set the funding goal for the campaign. Unlike other crowdsourcing platforms Indiegogo has an option to allow the campaign to keep all funds raised instead of requiring the campaign to reach the goal to receive the funds. Indiegogo calls this option flexible funding and charges a higher rate if the goal is not reached. Because of this and the ability to receive funds that were donated through PayPal immediately it was decided to use Indiegogo flexible funding option [4]. The main portion of the project that was hoped to be funded through the crowdsourcing campaign was the two 1080p projectors, which at the time coasted a total of $1,400. Because of Indiegogo’s and credit card companies’ percentage they take of the raised funds and it was decided to set the goal at $2,500. This goal would have made possible for the purchase of the two projectors along with the purchase of additional resin and additional prototyping costs.

The final step was to decide on the perks for funders to claim. It was decided for Project PAM to have 4 perks at differing price points. The perks that were used for Project PAM are described in Table 1 along with the number of funders who claimed them.

Table 1. Indiegogo Perks

|  |  |  |  |
| --- | --- | --- | --- |
| Perk | Price | Description | Number Claimed |
| Thank You | $5 | For contributing $5.00 or more you will receive a personalized thank you email from the team and you will be immortalized as a funder on our website. | 0 |
| Key Chains | $25 | For a contribution of $25.00 or more you will receive one Open Source Hardware Association logo key chain AND one Open Source Initiative logo key chain. Our intent is to 3D print these key chains with the Project PAM prototype. (Additional cost of $10 for international shipping.) | 7 |
| Bound Documentation of Design | $250 | For a contribution of $250.00 or more you will receive all documentation associated with the design professionally bound and well presented. Also includes $25 perk. (Additional cost of $50 for international shipping.) | 1 |
| Full Kit and Documentation | $1500 | For a contribution of $1,500.00 or more you will receive a full unassembled build kit for the printer. (The kit does not include projectors.) Also includes $25 perk and $250 perk. (Additional cost of $300 for international shipping.) | 0 |

The campaign was launched on September 30, 2014 and was originally planned to be 14 days and end on October 14, 2014. However, after a week and a half the decision was made to use Indiegogo’s one time campaign extension to extend it to a full 30 days and to end on October 28, 2014. The performance of the campaign is shown in Figure 1. The majority of the funds raised was raised in the final day of the campaign, it went from $300 to over $700 during that day.

Overall $741 was raised, in 11 contributions, of the $2,500 goal or the project was 29.64 % funded. This does not include funds raised outside of Indiegogo. If the funds raised outside of the Indiegogo are included the total was around $960, which was enough to purchase a single refurbished 1080p projector and additional items needed for prototyping. Additionally the Indiegogo page had 1,253 visits and 146 referrals.

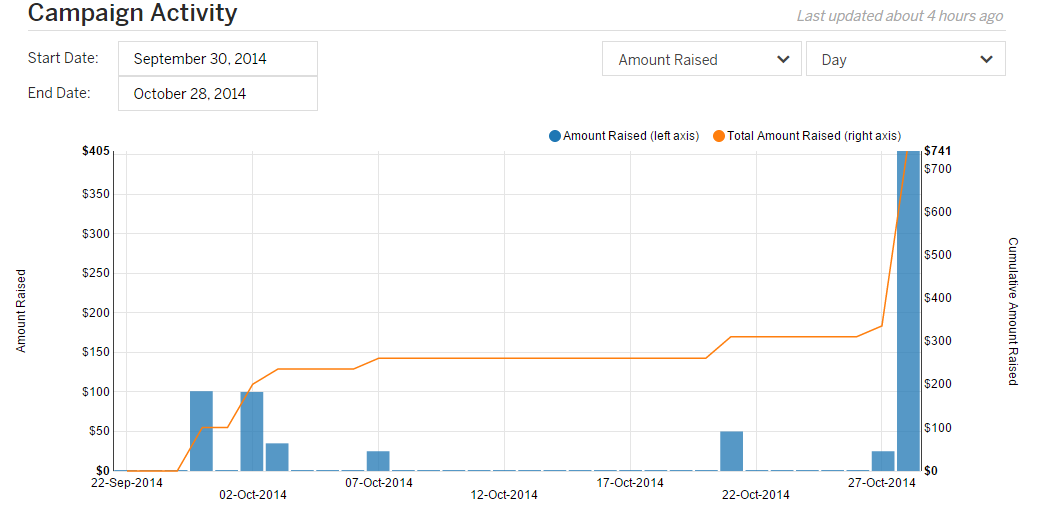


Figure 1. Crowdsourcing campaign activity

### Social Media

In addition to the GitHub organization for Project PAM, a Gmail account for email, and the GitHub Pages, social media accounts/pages were created to supplement the crowdsourcing campaign. These accounts/pages included Twitter (@ProjectPAM), Facebook, Google+, and YouTube. Twitter had 59 tweets and 17 followers, Facebook had 40 likes, and the YouTube videos had 1062 views. Additionally, Google Analytics were set up for the GitHub Page and the reports of traffic for September to December are included at Appendix.

### Media Coverage

The Project PAM crowdsourcing campaign was featured in 4 major news outlets. Those include 3DPrint.com, 3DPrintingIndustry.com, WSIU, and Make Magazine. Full page print outs are included at Appendix.

Table 2. Articles Project PAM was featured in

|  |  |
| --- | --- |
| Media Outlet | Article Titles |
| 3DPrint.com | Project PAM – College Students Look to Create an Entirely Open Source DLP 3D Printer [5] |
| 3DPrintingIndustry.com | Help The Open Sourced DLP 3D Printer called Project Pam on Indiegogo? [6] |
| WSIU | SIU Engineering Students Use Crowdfunding for 3D Printer [7] |
| Make Magazine | Cool Crowdfunding: October 26, 2014 [8] |

## Prototype Costs: DMO

The costs of Project PAM are split into two tables: one for the cost of the subsystems and the total cost of the printer including the projector. A complete bill of materials is included at Appendix.

Table 3. Cost of subsystems

|  |  |
| --- | --- |
| Subsystem | Price |
| Motion control | $113.61 |
| Chassis | $315.99 |
| Hardware software interface | $25.97 |
| Motors/motor control | $82.83 |
| MakerJuice G+ resin | $45.00 |
| Total | $602.17 |

Table 4. Total Cost

|  |  |
| --- | --- |
| Subsystem | Price |
| Printer | $602.17 |
| Projector | $690.00 |
| Total | $1292.17 |

# Schedules:

## Proposed and Reworked Schedule: DMO

With the addition of an additional team member at the start of the second semester, the schedule was able to be reworked to free up team members. The proposed and reworked (additions in orange) are at Appendix.

## As Worked Schedule: DMO

Project PAM experienced procurement problems that set the schedule back 3 weeks. The set back was not a total waste because it allowed for the construction of a linear motion test rig to be used for testing as soon as the parts arrived.

The other big change to the schedule was the addition of the crowdsourcing campaign. This set software back a whole month because the team member doing software was put in charge of developing the campaign.

The as worked schedule can be found at Appendix.

# Subsystem Descriptions

## Printer Control Software: DMO

### Process of Design

Project PAM’s printer control software set out to solve the issue of with the recent rise of DLP 3D printing in the hobbyist market there is a need for a more consolidated form of printer control software that is also open source. Originally it was proposed to modify the B9 Creator printer control software and make it more flexible and make the user interface better, as explained in Figure 2.

Figure 2. Proposal for Project PAM printer control software

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | B9 Creator | MiiCraft | Creation Workshop | Project PAM |
| Language | C++ [9] | Python [10] | C# [11] | C++ |
| Cross-platform | ✓ [12] | ✗ [13] | ✓ [14] | ✓ |
| Slicing Software | Custom [9] | Skeinforge [10] | Slic3r [11] | Slic3r |
| G-Code Support | ✗ [9] | ✓ [10] | ✓ [11] | ✓ |
| CAD File Input | STL [12] | STL [13] | STL, OBJ, 3DS [14] | STL, OBJ, 3DS, STEP, AMF |
| Ablity to Add Supports | ✓ [12] | ✗ [13] | ✓ [14] | ✓ |
| Image Output | SLC [9] | SVG [15] | SVG [16] | SVG |

Figure 2 also shows the comparison of the B9 Creator and Project PAM to additional DLP 3D printer control software on the market. During the time since the B9 Creator software was evaluated there had been multiple updates; however, the updated source code was not being posted to their GitHub. These updates consisted of very important bug fixes and support for more hardware. Eventually the developers of the B9 Creator software were contacted, after multiple attempts through various mediums, and they had decided to not release any additional source code. Their reasoning for this was that they weren’t getting any help from the community and doing all the work themselves. This was an unfortunate set back but one that was not a show stopper.

Once it was determined that there would be no newer versions of the B9 Creator printer control software to fork from the newest version was forked and development began. The first step was to change various code formatting problems, for example mixed file formatting, and wrong licensing information in file headers. The B9 Creator software came with a built in updater, which was removed. An attempt at porting the B9Creator software to Qt 5 from Qt 4 was made; however, because of the differences in the OpenGL portions of Qt between the versions were so great that effort was abandoned.

The first big modification that was attempted was to remove the custom slicing software and replace it with Slic3r. It was at this point that it was discovered the custom slicer was so heavily embedded into the software that by removing it would cause more headaches then it would fix, i.e. it was easier to start from scratch then to try to remove the slicer.

Once it was determined that the B9Creator software should not be used as a starting point an in depth evaluation of Slic3r was done. Slic3r supports STL (Sterelithography), AMF (Additive Manufacturing File Format), and OBJ files [16]. Because a goal of the Project PAM printer control software was to add STEP file support and Slic3r only supports mesh based models there would have been no way to modify Slic3r to support STEP files. The only option would have been to convert STEP files into one of the supported file formats when the model was loaded. However, that defeats the whole reason to support STEP files.

The reason STEP needed to be supported was to ensure flexibility, because STEP files are a CAD file interchange format, and to allow for the better printing of curves [17]. The problem of mesh based models is illustrated in Figure 3.

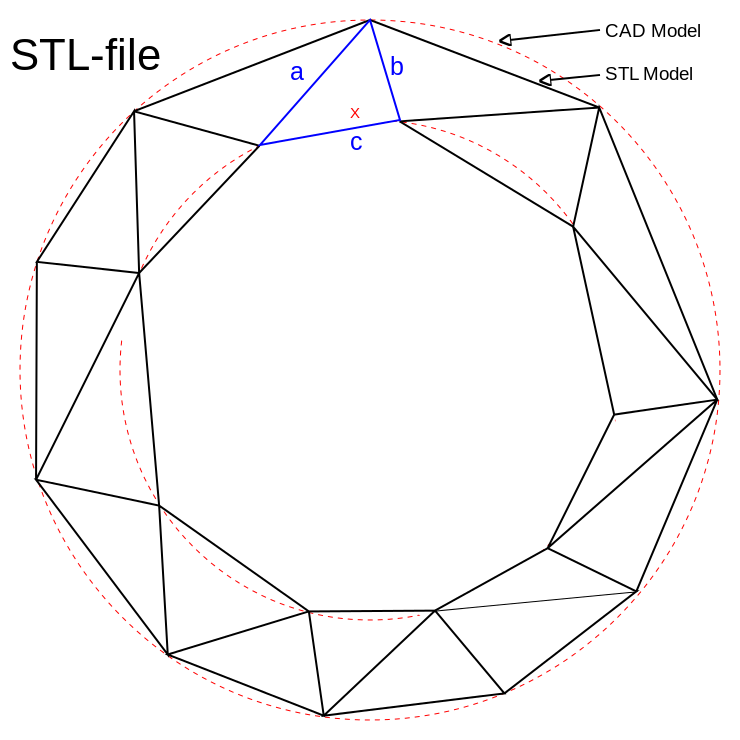


Figure 3. Problem with STL files [18]

Additive Manufacturing File Format (AMF) was released, a superset of STL, by the International Organization of Standards (ISO) and American Society for Testing and Materials (ASTM) as ISO/ASTM 52915:2013 [19]. AMF supports curved triangles that are then recursively subdivided into smaller triangles at import, this allows for “smoother models” and smaller file sizes [19] [20]. Even though AMF is an improvement of STL it still does has the problem of turning curves into triangles and introducing error into the print.

The larger problem with developing an open source 3D printing control software platform is the lack of open source CAM software, which is why the idea of DLP 3D printing control software has grown to become a complete open source CAM platform with a DLP 3D printing plugin. This new software is being called LibreCAM. The main reason this is possible is because there is an open source library called Open CASCADE, which is a C++ platform for 3D CAD/CAM and can be easily integrated into the Qt platform [21].

FreeCAD was evaluated to determine if it was a suitable candidate for fork to create LibreCAM. FreeCAD is written in C++ and uses Open CASCADE [22]. However, FreeCAD uses an outdated 3D visualization library (this feature is now built into Qt), also, FreeCAD was a completely custom user interface [22] [23].

It was decided to start from scratch and define a new platform and user interface. The challenge with was to pick an interface that was strait forward and easily conveyed the steps the user needed to make something. However, this would have been a lot of rework and would have mediocre results.

### development Process

KDevelop and the KDevPlatform are a C++/Qt/KDE based IDE and IDE development platform, respectably [24] . Currently these platforms are based on Qt 4 and KDE 4; however, in August of 2014 the process of porting the platforms to Qt 5 and KDE Frameworks 5 had begun [25]. The most recent release from September of 2014 was still based on Qt 4 and KDE 4 [26]. The port to Qt 5 and KDE Frameworks 5 is still in pre-alpha stage, a screenshot of the pre-alpha stage is shown in Figure 4. The developers of KDevelop say that KDevelop 5 will “become the first true cross-platform release of [they’re] IDE” [26]. KDevelop 5 is on track to release early 2015 [26].

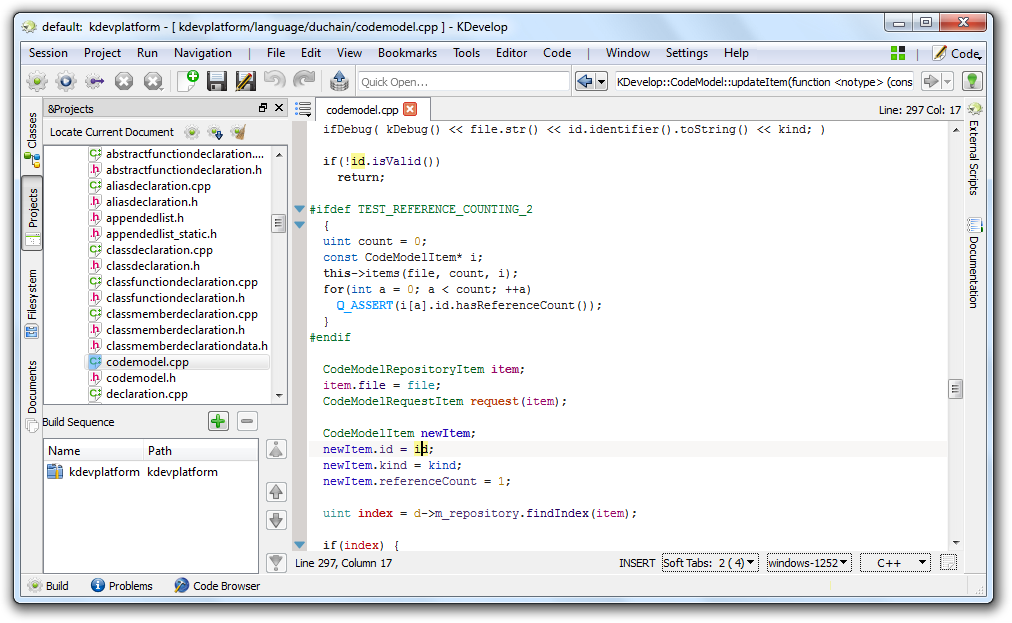


Figure 4. KDevelop 5 pre-alpha on Windows [27]

A great example of a tool built with the KDevPlatform is KTechLab, an IDE for microcontrollers and electronics [28]. A screenshot of KTechLab is shown in Figure 5.

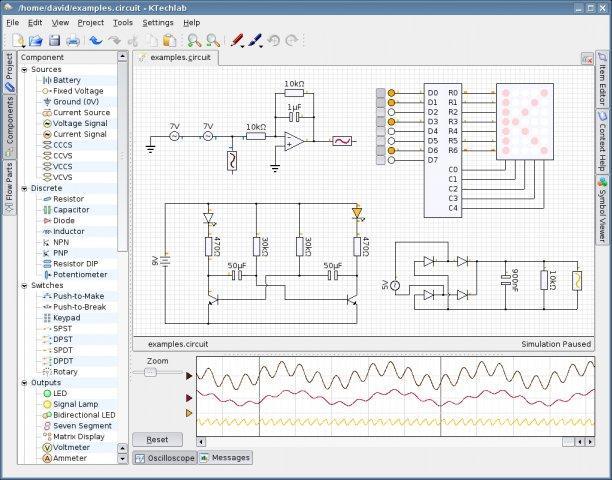


Figure 5. Screenshot of KTechLab

The problem with the current release of KDevelop using Qt 4 instead of Qt 5 is a show stopper. There were massive changes to Qt’s OpenGL module between Ot 4 and Qt 5. Because LibreCAM requires Qt’s OpenGL support. The QtOpenGL module was deprecated in Qt 5 and completely rewritten to support full OpenGL instead of only OpenGL ES (Embedded Systems) as in Qt 4. If the current version of KDevPlatform was used to create LibreCAM the entire 3D visualization portion would have to be redone early next year when KDevPlatform 5 is released.

### development SCHEDULE

The first major planned releases of LibreCAM are outlined below.

Ver. 0.1.0: Initial user interface and ability to load in CAD models.

Ver. 1.0.0: Completed user interface, full support for plugins, and support for projects.

The first major planned release of the DLP 3D printer control plugin for LibreCAM, called LibrePAM, are outlined below.

Ver. 0.1.0: Basic slicing to SVG and G-Code and G-Code transmission to firmware.

Ver. 1.0.0: Resin profiles, projector control, projects, and automatic support generation.

Ver. 2.0.0: Parallel slicing and continuous printing.

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|  |  |
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