Department of Computer Science and Engineering  
The University of Texas at Arlington

Ink3d

3D Printer Fabrication System

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# General Organization

## Project Manager

Daniel Lain is the project manager and team lead for the 3D Printer Fabrication System. Dan was selected for this role due to his many years of project management and leadership experience in manufacturing and materials. The project manager will be responsible for creating and maintaining the project plan, assigning team tasks, and monitoring progress toward completion. The project manager will also be responsible for leading team meetings and document review activities.

## Project Oversight

Project oversight will be achieved through internal and external team controls. Internally the project manager will track and ensure the team adheres to the published project plan. Task status will be reported via email or during the regularly scheduled team meetings. The team will review all deliverables for accuracy and completeness. Externally Dr. O’Dell will manage the project through the regularly scheduled gate reviews and status reports. The sponsor Dr. Shiakolas will oversee the overall project goals and scope through regular meetings with the team. Additionally the team will meet with the ME team semi regularly to ensure the projects are aligned for success.

## Roles and Responsibilities

|  |  |  |
| --- | --- | --- |
| **Role** | **Assigned To** | **Responsibility** |
| **Development Manager** | **Dr. O’Dell** | **Mentoring**  **Documentation Approval**  **Schedule Approval**  **Expense Approval** |
| **Project Sponsor** | **Dr. Shiakolas** | **Requirements Approval**  **Guidance**  **Customer Representative** |
| **Project Manger** | **Daniel Lain** | **Maintain Project Plan**  **Assign Tasks to Team**  **Turn in Deliverables** |
| **Hardware Lead** | **Shawn Simonson** | **Plan Hardware Interfaces**  **Research Hardware**  **Hardware Development** |
| **Software Engineering Lead** | **Jesse Bowles** | **System Architecture**  **Modular Planning**  **Scalability Planning**  **Develop UMLs** |
| **Lead Programmer** | **Tim Edmonson** | **Algorithm Development**  **Open Source Selection**  **Algorithm Research** |

**Table 1.1**

## Project Constraints

The 3D Printer Fabrication System will have to cope with a number of constraints during the course of the project. Specific constraints below:

* Team’s limited prior analytical geometry experience
* Budget of $800
* Hardware is controlled by ME team
* Schedule limited to eight months

## Project Assumptions

* Project will utilize an open source system for the analytical slicing
* ME team will produce a functional printer
* Team will meet at least twice a week
* Team will work as required to fulfill the project needs

## Preliminary Schedule and Cost Estimates

|  |  |
| --- | --- |
| **Preliminary Schedule** | |
| Project Milestone | Due Date |
| SRS Draft Document | 10/9/13 |
| Project Plan First Draft | 10/16/13 |
| Project Charter First Draft | 10/16/13 |
| Requirements Gate Review | 10/30/13 |
| Architecture Design Specification Draft | 12/2/13 |
| Baseline Project Charter | 12/4/13 |
| Baseline Microsoft Project Plan | 12/4/13 |
| Final Gate Review ADS | 12/11/13 |
| Baseline Architecture Design | January 2014 |

Table 1.2

|  |  |  |  |
| --- | --- | --- | --- |
| **Preliminary Costs** | | | |
| Component | Quantity | Cost/Unit | Total Cost |
| SainSmart Mega2560 Controller | 1 | 43.17 | 43.17 |
| SainSmart RAMPS 1.4 Shield | 1 | 25.9 | 25.9 |
| SainSmart A4988 Driver | 7 | 10.97 | 76.79 |
| Raspberry Pi Model B R2.0 | 1 | 39.95 | 39.95 |
| 8GB SD Flash Card | 1 | 9.88 | 9.88 |
| Male/Male USB 2.0 Cable | 1 | 9.95 | 9.95 |
| 50ft. 20GA Solid Copper Interconnect | 1 | 15.95 | 15.95 |
| SainSmart 1602 LCD Shield | 1 | 24.95 | 24.95 |
| Passive Electronics Budget | 1 | 25 | 25 |
| Total |  |  | 271.54 |

Table 1.3

# Scope Statement

*A brief statement of the* ***general scope*** *of the project.*

# Cost Management Plan

*Exactly* ***what do you plan to do to stay within the budget****? How will you control costs in terms of person-hours and dollars? ($800 and roughly 2000 person-hours)*

# Earned Value Management

## Introduction

Earned Value Management will be used to monitor the progress and status of the 3D Printer Fabrication System project. Earned Value Management provides and objective measure of the actual progress versus the planned progress at any given time during the course of the project. This measure is achieved by assigning each planned project task a value (in person-hours), then tracking the actual value spent (actual person-hours spent) for each of those tasks. This data is used to derive various metrics that can be analyzed to track project progress and status in order refine the project plan accordingly.

## Core Components

Each planned project task has the following values associated with it. These components are all recorded in units of person-hours.

**Budgeted Cost of Work Scheduled (BCWS) – Planned Value**

* How much work is planned to be accomplished at a given point in time.

This value is assigned for each task during the planning phase as an estimation of the work needed in order to complete that task.

**Actual Cost of Work Performed (ACWP) – Actual Cost**

* How much work is actually spent at a given point in time.

As work is completed on a given task, the actual cost (ACWP) for that task is updated accordingly.

**Budgeted Cost of Work Performed (BCWP) – Earned Value**

* The value earned for a given task.

For this project, this value is recorded for each task as zero until that task is complete. Once the task is completed, if the actual cost value (ACWP) is greater than the planned value (BCWS) then this value is recorded as the planned value (BCWS). If the actual cost (ACWP) is lower than the planned value then this value is recorded as the actual cost (ACWP).

## Performance Tracking

The values collected for the core components above can be used to calculate indices that provide a measure for both cost and schedule performance at any given time during the project.

### Cost Performance Index

The cost performance index (CPI) is used to measure the efficiency of the work being performed. The CPI also gives an idea of how accurate the estimated time cost of the project is.

This value can be determined by dividing the earned value (BCWP) by the actual cost (ACWP).

[insert equation]

Equation 4-1: Cost Performance Index

CPI > 1.0 🡪 Exceptional performance

CPI < 1.0 🡪 Poor performance

### Schedule Performance Index

The schedule performance index (SPI) is used to measure if project deadlines are being met.

This value can be determined by dividing the earned value (BCWP) by the planned value (BCWS).

Equation 4-2: Schedule Performance Index

SPI > 1.0 🡪 Exceptional performance

SPI < 1.0 🡪 Poor performance

## Reporting Earned Value

In order for earned value management to be a valuable tool, earned values must be current and accurate. To ensure that these values are current, each team member reports their progress on their assigned tasks at the beginning of every team meeting. This information is recorded in the team’s Microsoft Project plan, which then calculates earned value, CPI, and SPI. In addition to maintaining internal records of earned value, each team member submits an individual status report containing earned value records each week.

# Scope Management Plan

This section describes the scope management framework for this project. Any communication that pertains to the project’s scope will adhere to the procedures described in this section.

## Scope Management Approach

Scope management will be the responsibility of the team lead. Team members may propose scope changes by presenting the change to the team lead. If the team lead determines the proposed change has merit, he will present it to the team. If the entire team approves of the scope change, the team lead will propose the change to the sponsor. Only when the sponsor approves the proposed change will the change be accepted. The sponsor may also propose scope change. This scope change proposal must be made to the team lead, who will then present the proposed change to the team. All team members must approve the change in order for it to be accepted. Upon acceptance of scope changes, all documents involving scope must be updated appropriately.

## Scope Definition

The scope of this project was defined through documents derived from the collection and analysis of system requirements. Initially, the team held meetings with the sponsor to understand his vision and expectations for the 3D Printer Fabrication System. Once the sponsor’s expectations were understood, customer requirements were created and presented to the sponsor. Once the customer requirements were approved, additional requirements were created based on research into current technology in the 3D printing domain. Based on the requirements collected, a System Requirements Specification and Work Breakdown Structure were formed. Together, these two documents define the scope of the 3D Printer Fabrication System.

## Scope Statement

This project includes the design, implementation, and testing of a software system that analyzes digital descriptions of multi-material 3D objects and sends machine instructions to a 3D printer capable of extruding multiple materials in a single print. The deliverables of this project include the Systems Requirements Specification, Project Charter, Architectural Design Specification, Detailed Design Document, and the prototype of the system. This project will be accepted when all acceptance criteria items defined in the System Requirements Specification have been verified by the sponsor. This project does not include the design or development of the physical 3D printing machine, nor does it include ongoing maintenance of the product. Additionally, work on this project will not exceed past the month of May 2014.

## Scope Verification

Throughout this project, the team lead will verify all project deliverables against the original scope as defined in the System Requirements Specification and the Work Breakdown Schedule. Any concerns that arise during the verification will be discussed with the project’s sponsor and team members. If a deliverable is not found to be within the defined scope, modifications will be made and then the deliverable will be subject to the verification process once again. Only when deliverables have successfully been through this verification process will they be considered acceptable.

## Scope Control

The project team will work together to ensure the control of scope of the project. Team meetings are held twice a week, in which each team member will report on their activities and their progress toward assigned deliverables. During these status reports, team members will hold each other accountable for staying within the defined scope of their respective tasks and deliverables. The Work Breakdown Structure will serve as a definition for the scope of the work that is to be performed.

# Work Breakdown Structure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Task Number | Task Name | Planed Start | Planned Finish | BCWS |
| 1 | Senior Design 1 | Wed 9/11/13 | Wed 12/11/13 | 227 |
| 1.1 | Documents | Wed 9/11/13 | Wed 12/11/13 | 227 |
| 1.1.1 | System Requirements Specification | Wed 9/11/13 | Fri 11/8/13 | 88 |
| 1.1.1.1 | Version 1.0 | Wed 9/11/13 | Wed 10/9/13 | 57 |
| 1.1.1.2 | Version 2.0 | Wed 10/9/13 | Fri 11/8/13 | 31 |
| 1.1.2 | Team Charter | Thu 10/3/13 | Wed 12/4/13 | 74 |
| 1.1.2.1 | Version 1.0 | Thu 10/3/13 | Wed 10/16/13 | 44 |
| 1.1.2.2 | Version 2.0 | Thu 10/17/13 | Wed 12/4/13 | 30 |
| 1.1.3 | Architecture Design Specification | Fri 11/1/13 | Wed 12/11/13 | 65 |
| 1.1.3.1 | Version 1.0 | Fri 11/1/13 | Mon 12/2/13 | 35 |
| 1.1.3.2 | Version 2.0 | Tue 12/3/13 | Wed 12/11/13 | 30 |
|  |  |  |  |  |
| 2 | Senior Design 2 | Wed 1/15/14 | Fri 5/23/14 | 261 |
| 2.1 | Documents | Wed 1/15/14 | Fri 5/23/14 | 111 |
| 2.1.1 | Detailed Design Documnetation | Wed 1/15/14 | Tue 2/18/14 | 71 |
| 2.1.1.1 | Version 1.0 | Wed 1/15/14 | Wed 2/12/14 | 36 |
| 2.1.1.2 | Version 2.0 | Wed 2/12/14 | Tue 2/18/14 | 35 |
| 2.1.2 | Test Plan |  |  | 40 |
| 2.2 | Prototype Implementation | Tue 2/18/14 | Thu 5/15/14 | 150 |
| 2.2.1 | Version 1.0 | Tue 2/18/14 | Tue 3/18/14 | 50 |
| 2.2.2 | Version 2.0 | Tue 3/18/14 | Fri 4/18/14 | 50 |
| 2.2.3 | Final Product | Fri 4/18/14 | Thu 5/15/14 | 50 |
|  |  |  |  |  |
| 3 | Presentations | Fri 9/13/13 | Wed 12/11/13 | 28 |
| 3.1 | SRS Gate Review | Wed 10/9/13 | Fri 11/8/13 | 7 |
| 3.2 | Charter and Plan Review | Wed 10/16/13 | Wed 12/4/13 | 7 |
| 3.3 | Architecture Design Review | Mon 12/2/13 | Wed 12/11/13 | 7 |
| 3.4 | Team Status Report SD 1 | Fri 9/13/13 | Fri 12/6/13 | 7 |
|  |  |  |  |  |
| 4 | Team Meetings | Tue 9/10/13 | Tue 12/3/13 | 52 |
| 4.1 | Team Meeting SD1 | Tue 9/10/13 | Tue 12/3/13 | 52 |
|  |  |  |  |  |
| 5 | MS Project | Sun 9/29/13 | Fri 1/10/14 | 40 |
| 5.1 | SD 1 | Sun 9/29/13 | Wed 12/4/13 | 20 |
| 5.2 | SD 2 | Fri 1/10/14 | Fri 1/10/14 | 20 |

# Quality Management Plan

## Introduction

## Team Ink3D believes that quality is important in our products and documentation. We have derived a couple of ways for us to verify that our product meets the stated requirements. Below are the actions the team will take to ensure good quality.

## Documentation

Good documentation will be one the key strategies to ensure good quality in our product. Each team member is keeping up with his own personal engineering notebook. The notebook can cover any subject that the writer feels is important for his part of the assignment and to the success of the project as a whole. We also have deliverables for Dr. O’ Dell

## Software

Modular and scalable software is especially important to our particular project.. We will use version control. Currently we are using Github. The interface

## Hardware

Hardware cannot be guaranteed because it is being developed by the ME team. Sorry for this inconvenience.

## Testing

Test incrementally as new requirements are added. Each time a new requirement is added, all requirements should be tested individually again before testing by use cases.

## Reviews

Another way to ensure good quality in our product is by

# Communications Plan

*How will you* ***ensure good communication*** *with each other – and with everyone else! How will you keep everyone on the same page throughout the life of the project? What about reports, impromptu meetings, scheduled team meetings, email, etc.?*

## Introduction

For the 3D Printer Fabrication System project, the team will require appropriate communication within the organization as well as communication with the team’s sponsor, the professor of this course, and the Mechanical Engineering Team.

## Internal Team Communication

We have established

### Team Meetings

We have schedule two regular meetings a week every Tuesday and Thursday at 7:00 p.m. There is no defined time limit for how long the meetings should last, but before each meeting, team lead Daniel Lain is responsible for finalizing the meeting agenda beforehand. The team follows the criteria listed for the team meeting. Once everything on the agenda list has been discussed, the team finishes with a session of open discussion and then decides on the next meeting’s agenda. Team meetings are primarily for reporting individual progress, addressing concerns to the team, ensuring our individual work is collaborated, and deciding on the next step of the project.

### GitHub

GitHub is our primary source control for the system. The file architecture of the team’s GitHub account is structured to neatly accommodate several types of documentation, research, and deliverables. GitHub’s comment feature allows individual members to briefly update the team on the individual’s progress.

### E-mail

The team’s quickest method of communication will be by e-mail. The consensus of the team is that not every member is comfortable with receiving and sending text messages as a reliable source of communication. However, the individual members have proven so far to be very responsive to emails. Almost every e-mail has been responded to within the day, usually within hours. E-mail is used for primarily for questions, concerns, and clarification. Important information or helpful notes that were not discussed during the meeting (ie. We forgot to talk about it) can be brought up via the E-mail.

## External Communication

Asfasdf

### Dr. Shiakolas

We have two primary forms of communication with our sponsor, Dr. Shiakolas. First form of communication is by e-mail. We use e-mail as a means to ask smaller questions such as clarification on a requirement. The other form of communication is scheduled meetings. Meetings with Dr. Shiakolas are not regular, so before a meeting can be scheduled, we must first e-mail Dr. Shiakolas and discuss an appropriate meeting time. Our normal meeting time is on Wednesday at 1:00p.m. During meetings with Dr. Shiakolas, we discuss the scope of the project, clarification of requirements, and possible changes to the project.

### Dr. O’ Dell

### Mechanical Engineering Team

As per Dr. Shiakolas’s request, we have not yet met with the Mechanical Engineering Team. However, meeting with the ME Team will eventually be necessary, so a form of communication must be established between the two teams. Very likely, we will be using the same channels of communication between the ME Team and Ink3D as Ink3D uses internally. Initial contact will be made by e-mail or by both teams meeting with Dr. Shiakolas.

# Change Management Plan

## Purpose of Integrated Change Management Plan

*Describe the purpose of the Integrated Change Management Plan using the following guidelines. Do not merely describe the content of the plan, but explain why Integrated Change Management is necessary for the project.*

*Projects are dynamic efforts and as such,* ***change is inevitable****. One of the greatest challenges to a project’s success is controlling the impact of change or managing changes to the benefit of the project objectives. By accepting the fact that change will occur and planning for the management of change, the probability of project success is increased and enhanced.* ***Discuss here where you might expect change to arise, what might cause it, etc.***

*The purpose of the Integrated Change Control Plan is to* ***define all processes, practices, tools, review bodies, and authority necessary to monitor and control project performance, identified change and the potential impact of change on project objectives****.*

## Roles and Responsibilities

*Describe how the following project participants, at a minimum, perform in the planning and execution of project change management.*

*Project Sponsor*

*Project Manager*

*Project Team*

*Other Stakeholders*

## Review and Approval Process

*Describe the process to identify change in the project scope, cost, and budget. Describe the change approval authorities and review boards that will process change control documents. An example may be a change control board made up of leaders in various project disciplines such as project management, cost, scheduling, configuration management, technical design, and test. Sponsors, system owners, and users should also be considered. A process flow chart is appropriate for this section.*

## Change Identification, Documentation, Implementation and Reporting

*Define and describe the* ***change control form*** *and the documentation required to track a change request. Describe any automated tools used to manage and track changes and identify the process for entering and reporting changes. Describe the process for* ***updating any affected documents, the WBS (schedules) and budget/cost documents with approved changes****. If the baseline for these documents changes, describe the means for capturing the baseline change in the OMB Exhibit 300 process.*

# Risk Management Plan

## Purpose of Risk Management Plan

*Describe the purpose of the Risk Management Plan using the following guidelines. Do not merely describe the content of the plan, but why Risk Management is necessary for your project.*

*Risk is an indicator of uncertainty about the future. The greater the investment in a project, the more one has to lose should any problems delay or derail the project. Risks on any project must be identified and analyzed so that project teams can prepare for their potential occurrence and lessen or eliminate their chance of occurring.*

*The Risk Management Plan provides a systematic method of identifying and analyzing the effects of uncertainties in the project and to plan for minimizing or containing the consequences of any undesired event that may influence the success of the project.*

## Roles and Responsibilities

*Describe how the following project participants, at a minimum, perform in the planning and execution of project communications*

* *Project Sponsor*
* *Project Manager*
* *Project Team*
* *Project Stakeholders*
* *Risk Manager*

## Risk Identification

*During risk identification, the perception of a potential problem is documented in sufficient detail to enable effective assessment of the risk to support subsequent management decisions. Once the risk has been identified and reviewed, the risk is recorded into the risk database.*

*The project team systematically reviews the project deliverables and activities for possible risk information. Typically, risk information is derived from:*

*Analysis of high-level deliverables*

*Analysis of the work Breakdown Structure (WBS) and Network diagram*

*Analysis of change requests*

*Project team input (experience, lessons learned etc.)*

*Stakeholder input (assumptions, organizational requirements etc.)*

## Risk Triggers

*Risk triggers are events or performance characteristics that warn of the occurrence of risk events. An example of a risk trigger would be a supplier missing deliverable dates, delaying related activities, and adding cost to project.*

## Risk Analysis

*The goal of risk analysis is to ensure that the risks are examined in a structured and systematic manner. The risk owner may work with the risk coordinator to formulate the initial risk assessment. Two methods of risk analysis are employed in this process – qualitative and quantitative analysis.*

*A qualitative risk assessment qualifies the expected impact, probability, and timeframe of a risk. The results of the risk analysis are recorded on a risk identification form. The results are used to determine Risk Management priorities.*

*A quantitative risk analysis is also accomplished where the impact of a risk is ranked against other risk events or in the case or performance, the risk is assessed as a percentage of reduction in performance.*

## Risk Severity

*The results of qualitative analysis and quantitative analysis are captured on an impact/probability chart, called the Risk Severity Grid. The grid is used to determine the priority that is assigned each risk and the need to develop containment strategies.*

## Risk Response Planning

*Risk response planning involves identifying the strategy for minimizing the effects of the risk to a level where the risk can be controlled and managed to ensure the project objectives are achieved. Risk reduction strategies include research, watch, mitigate, accept, or transfer.*

## Risk Documentation and Reporting

Create a central repository for risk information and mitigation strategies. This is typically an automated system where risk information is available to appropriate project team members and risk owners. Typical tools include the risk register (the complete risk database) and a monthly risk status report that is part of the OMB Exhibit 300 process.

## Risk Control

*Define the risk control process that addresses risks on a periodic basis. Describe how risks are regularly reassessed and the risk database is updated. Describe how the risk triggers are regularly assessed and validated. Insure, on a periodic basis that new risks are being identified, assessed and captured in the database.*

# Procurement Management Plan

## Purpose of the Procurement Management Plan

*Describe the purpose of the Procurement Management Plan using the following guidelines. Do not merely describe the content of the plan, but explain why Procurement Management is necessary for the*

*The organization is unable to create or supply all the products and services necessary to complete the project and therefore needs to use external sources that have the expertise in certain areas to assist in completing all required project deliverables. Procurement planning gives the project team knowledge and confidence to obtain quality products and services from qualified vendors in a timely manner.*

## Roles and Responsibilities

*Describe how the following project participants, at a minimum, perform in the planning and execution of project procurement*

*Project Sponsor*

*Project Manager*

*Project Team*

*Project Stakeholders*

*Contract Office Technical Representative (COTR)*

## Required Project Procurements and Timing

*Discuss the necessity for planned procurements, including the results of alternative analyses and make or buy analyses. Discuss the best times to initiate the procurement processes to meet the detailed project schedule.*

## Description of Items/ Services to be acquired

*Briefly describe the overall scope of the project. What are the specific items/services/major contract deliverables that will be acquired?*

# Project Closeout Report

## The following are suggested sections for the Project Closeout Report:

## Purpose of Closeout Report

*Describe the purpose of the Closeout Report using the following guidelines:*

*The closeout report insures that personnel, contract, administrative, and financial issues are resolved, that documents are archived, and lessons learned are captured.*

## Administrative Closure

### Were the objectives of the project met?

*Review the project objectives and indicate if the objectives were met. If there were deviations from the baseline objectives and the final product, describe those here.*

### Archiving Project Artifacts

*Describe how project documents will be collected and archived for future reference. Documentation to consider:*

*Financial records*

*Cost and schedule performance reports and records*

*Quality data*

*Correspondence*

*Meeting Notes*

*Status Reports*

*Issue and Action Log*

*Risk Log*

*Contract Files*

*Change Requests*

*Technical documents*

*Acceptance records*

### Lessons Learned

*Conduct a lessons learned session to discuss and capture the performance (e.g., what worked well, what did not work well) from start to finish on the project. Capturing and incorporating lessons learned on future projects are among the most important ways in which an organization gathers information to institutionalize repeatable processes and avoid repeated mistakes.*

### Plans for Post Implementation Review (PIR)

*Describe the plan to conduct the Post Implementation Review (PIR).*

### Final Customer Acceptance

*Describe the achievement of final customer acceptance. Describe the final meeting with customer, who attended and what disciplines were represented (finance, contracts, quality, etc.) Discuss the documents signed. If open issues remain, discuss the plan for their resolution.*

### Financial Records

*Discuss the review of invoices, purchase orders, and final cost reporting. Describe where the final cost records are archived.*

### Final Project Performance Report

*Summarize the project’s scope management, schedule performance, cost performance, quality achievements, and a review of the risk containment performance. Discuss the reasons for cost or schedule variances.*