INTRODUCTION:

The primary objective of this Project Readiness Package (PRP) is to describe the proposed project by documenting requirements (customer needs and expectations, specifications, deliverables, anticipated budget, skills and resources needed, and people/ organizations affiliated with the project. This PRP will be utilized by faculty to evaluate project suitability in terms of challenge, depth, scope, skills, budget, and student / faculty resources needed. It will also serve as an important source of information for students during the planning phase to develop a project plan and schedule.

In this document, italicized text provides explanatory information regarding the desired content. If a particular item or aspect of a section is not applicable for a given project, enter N/A (not applicable). For questions, contact Mark Smith at 475-7102, mark.smith@rit.edu.

ADMINISTRATIVE INFORMATION:

- Project Name (tentative): Multi-Process 3D Printing
- Project Number, if known: P14551
- Preferred Start/End Semester in Senior Design:
  ☒ Fall/Spring ☐ Spring/Fall
- Faculty Champion: *(technical mentor: supports proposal development, anticipated technical mentor during project execution; may also be Sponsor)*

Name	Dept.	Email	Phone
Denis Cormier	ISE	drceie@rit.edu	475-2713

For assistance identifying a Champion: B. Debartolo (ME), G. Slack (EE), J. Kaemmerlen (ISE), R. Melton (CE)

- Other Support, if known: *(faculty or others willing to provide expertise in areas outside the domain of the Faculty Champion)*

Name	Dept.	Email	Phone

- Project "Guide" if known: *(project mentor: guides team through Senior Design process and grades students; may also be Faculty Champion)* John Kaemmerlen
- Primary Customer, if known (name, phone, email): Denis Cormier, 475-2713, drceie@rit.edu *(actual or representative user of project output; articulates needs/requirements)*
- Sponsor(s): (*provider(s) of financial support)*

Name/Organization	Contact Info.	Type & Amount of Support Committed
Denis Cormier/RIT	See above	$2,000

PROJECT OVERVIEW: *2-3 paragraphs that provide a general description of the project – background, motivation, customers, problem you're trying to solve, project objectives*.

The popularity of 3D printing has exploded in the last 2 years, and dozens of companies now sell inexpensive machines targeted towards hobbyists and aspiring inventors. The open source nature of these machines has spawned an impressive array of printing technologies, each of which has its own strengths and weaknesses. Material can be deposited via thermoplastic extrusion (i.e. hot melt glue guns), inkjet printing, laser melting, etc. Routers can be used to improve accuracy. Even electronic circuits can be directly printed. In order to take advantage of these technologies, one would normally have to purchase several machines, learn how to program and use each one, and maintain them. The aim of this project is to design, prototype, and demonstrate an open source platform that supports interchangeable "plug and play" tools.

DETAILED PROJECT DESCRIPTION:

The goal of this section is provide enough detail for faculty to assess whether the proposed project scope and required skills are appropriate for 5th year engineering students working over two quarters. The sequence of the steps listed below may depend on your project, and the process is usually iterative, so feel free to customize. Emphasis is on the "whats" (qualitative and quantitative), not the "hows" (solutions), except for the section on "potential concepts," which is necessary to assess the appropriateness of required skills and project scope. Not all of the information in this section may be shared with students. (Attach extra documentation as needed).

- Customer Needs and Objectives: *Comprehensive list of what the customer/user wants or needs to be able to do in the "voice of the customer," not in terms of how it might be done; desired attributes of the solution.*

  Objective: Develop and demonstrate an open-source 3D printer architecture that supports plug-and-play additive and subtractive tools.

  Needs: The system would need the following elements:
  - A frame that holds the system elements while providing the necessary level of user safety.
  - A motion control sub-system that moves the tools and/or the build platform.
  - An common tool interface where one tool can be unplugged, and another one plugged into its place without the need for the user to do wiring, plumbing, etc.
  - Sample additive and subtractive tools that allow the system operation to be demonstrated.
  - Control software that runs the hardware.
  - A graphical user interface.
  - Low overall system cost that is consistent with the hobbyist community needs.
  - Ease of use that is consistent with the hobbyist community needs.

- Functional Decomposition: *Functions and sub-functions (verb-noun pairs) that are associated with a system/solution that will satisfy customer needs and objectives. Focus on "what" has to be achieved and not on "how"it is to be achieved – decompose the system only as far as the (sub) functions are solution independent. This can be a simple function list or a diagram (functional diagram, FAST (why-how) diagram, function tree).*

- Potential Concepts*: Generate a short list of potential concepts (solutions) to realize the system and associated functions. This may involve benchmarking or reverse engineering of existing solutions. For each concept and its associated function(s), generate a list of key tasks or skills needed to design and realize the function(s), and identify which disciplines (ME, EE, CE, ISE, …) are likely to be involved in the design and realization of the function(s). See the "PRP_Checklist" document for a list of student skills by department.* ***Potential concepts, skills, and tasks should not be shared with students.***

  See for http://www.rapidprototypingmachine.com/ a $150K example.

- Specifications (or Engineering/Functional Requirements): *Translates "voice of the customer" into "voice of the engineer." Specifications describe what the system should (shall) do in language that has engineering formality. Specifications are quantitative and measureable because they must be testable/ verifiable, so they consist of a metric (dimension with units) and a value. We recommend utilizing the aforementioned functional decomposition to identify*

specifications at the function/ sub-function levels. Target values are adequate at this point – final values will likely be set after students develop concepts and make tradeoffs on the basis of chosen concepts. Consider the following types of specifications:geometry (dimensions, space), kinematics (type & direction of motion), forces, material, signals, safety, ergonomics (comfort, human interface issues), quality, production (waste, factory limitations), assembly, transport/packaging, operations (environmental/noise), maintenance, regulatory (UL, IEEE, FDA, FCC, RIT).

- Constraints: *External factors that, in some way, limit the selection of solution alternatives. They are usually imposed on the design and are not directly related to the functional objectives of the system but apply across the system (eg. cost and schedule constraints). Constraints are often included in the specifications list but they often violate the abstractness property by specifying "how".*

- Project Deliverables: *Expected output, what will be "delivered" – be as specific and thorough as possible.*

- Budget Estimate: *Major cost items anticipated.*
  I will commit a minimum of $2,000 plus access to plenty of hardware that the students can use if it meets the needs of the project (i.e. stepper motors, shafts, bearings, etc.).

- Intellectual Property (IP) considerations: *Describe any IP concerns or limitations associated with the project. Is there patent potential? Will confidentiality of any data or information be required?*
  None – this will be published as an open-source project.

- Other Information: *Describe potential benefits and liabilities, known project risks, etc.*

- Continuation Project Information, if appropriate: *Include prior project(s) information, and how prior project(s) relate to the proposed project.*

STUDENT STAFFING:

- Skills Checklist: *Complete the "PRP_Checklist" document and include with your submission.*

- Anticipated Staffing Levels by Discipline:

Discipline	How Many?	Anticipated Skills Needed (*concise descriptions*)
EE	1	Basic electronics and data communications skills for the plug-and-play tool interface, system power, etc.
ME	~2	(1) Basic machine design; (2) Motion control.
CE		
ISE	~2	Project management; Fabrication
Other		We've historically had a very hard time in MSD with the software side of things. This project does require software to slice CAD models, to run the motors, etc. Any students or other disciplines that can help out with this aspect that MSD students frequently complain about (i.e. they say that programming is beyond their skill set) would be very useful.

OTHER RESOURCES ANTICIPATED:

Describe resources needed to support successful development, implementation, and utilization of the project. This could include specific faculty expertise, laboratory space and equipment, outside services, customer facilities, etc. Indicate if resources are available, to your knowledge.

Category	Description	Resource Available?
Faculty		☐
		☐
		☐
Environment		☐
		☐
		☐
Equipment		☐
		☐
		☐
Materials		☐
		☐
		☐
Other		☐
		☐
		☐

Prepared by: Denis Cormier Date: 8/10/13