Systems Level Design Review

Project: 11552
DLP Prototyping System

Team Members:
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Faculty Guide:
Dr. Denis Cormier

Meeting Agenda

- **Meeting Purpose**:
- Project Overview
- Confirm Engineering Specs & Customer Needs
- Concept Review
- Review proposed design – confirm feasibility and desired functionality
- Generate further ideas

- **Materials Reviewed:**
- Project Description
- Customer Needs
- Engineering Specifications
- House of Quality
- Benchmarking / Research
- Functional Decomposition –
- Concept Generation – Morphological Chart
- Concept Selection – Pugh Chart
- Concept Overview
- Risk Assessment
- Project Plan
- Future Steps

Project Description

<u>Project Overview</u>

The aim of this project is to design and fabricate a projected image photopolymer curing R&D platform. The system will use a Texas Instruments digital light projector (DLP) development system to project black and white ultraviolet (UV) light images onto a film of UV curable photopolymer in order to selectively cure/harden the polymer. Students will therefore design and construct a liquid resin spreading system, an optics system capable of transmitting and focusing a suitably powered UV light source, and the software needed to slice a 3D CAD model into the individual black and white images to be cured.

<u>Major Deliverables</u>

- Liquid Resin Spreading Sub-System
- UV Image Projection Sub-System
- Control System/ Model Slicing Software
- Enclosure for Sub-Systems

Customer Needs

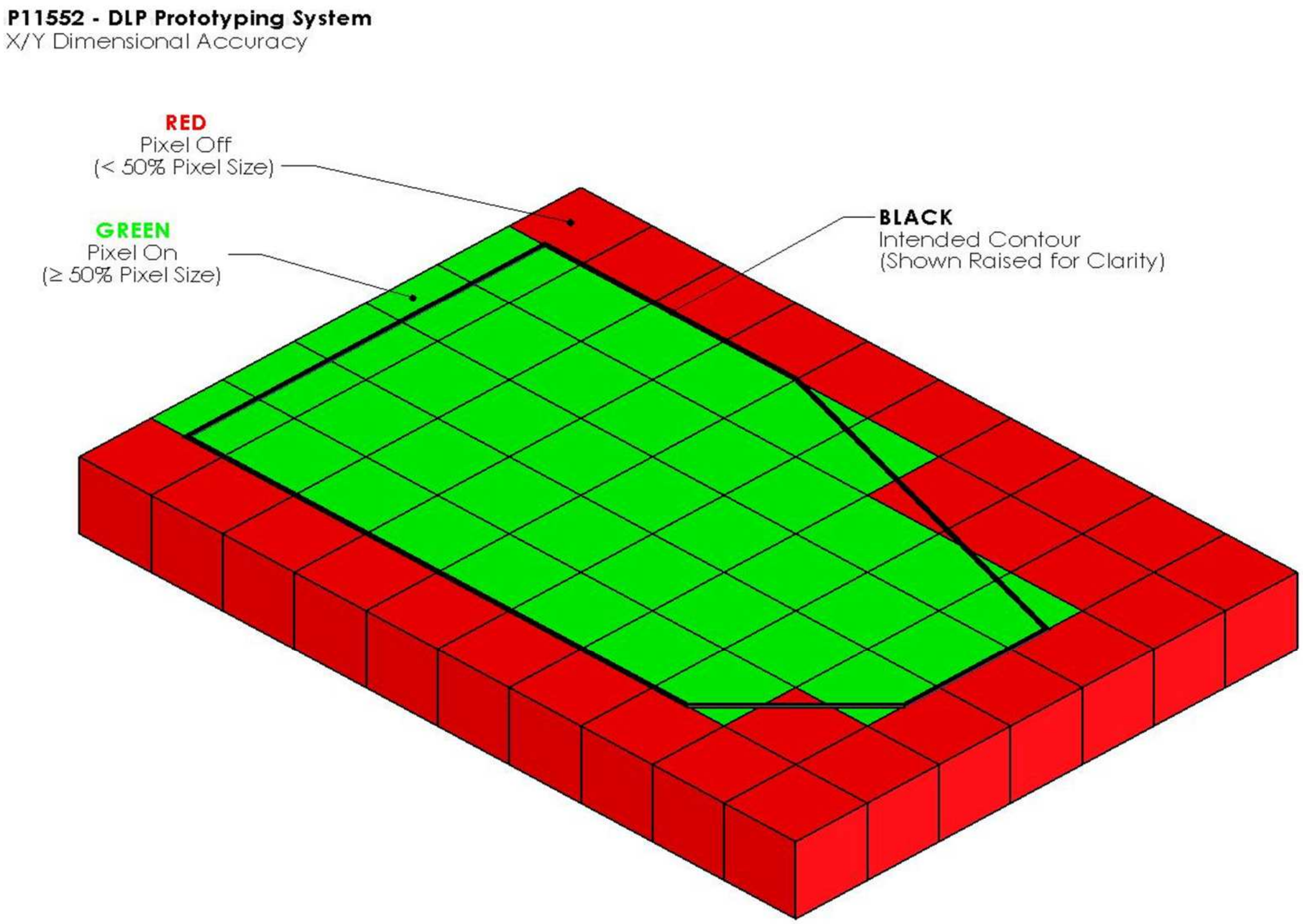
Customer: Dr. Denis Cormier

Customer Need #	Importance	Description	Title
CN1	9	Device utilizes a DLP Projector	Utilized DLP Projector
CN2	9	Utilize a 3D software model for replication by prototype	3D Model Slicing Software
CN3	9	Fully automated after the command to print is sent	Fully Automated
CN4	9	Use a photosensitive polymer resin as a medium	Utilized Photopolymer
CN5	1	Ability to use multiple types of curing resins	Device Functionality
CN6	9	Thorough documentation of design	Prepare for Future MSD
CN7	9	The system is safe to operate	Device Safety Features
CN8	3	Device adheres to budgetary constraints	Device Cost
CN9	9	Acceptable quality of final prototype part	Quality Prototype
CN10	3	Device has simple user interface	Operator Satisfaction
CN11	3	Reasonable fabrication time	Prototype Creation Time
CN12	9	Reasonably sized finished prototype	Prototype Size
CN13	1	Reasonably sized DLP system	Device Size

Engineering Specifications (1 of 3)

ES #	Engineering Spec	Source	Importance	Description	Measure of Performance	Units	Marginal Value	Ideal Value	Validation Method
ES1	Layer Cure Time	CN11	3	Constrain the cure time of each layer	Time the cure time of a standard layer and cross section	sec	≤ 60	≤ 10	Experimentation
ES2	Prototype Size	CN12	3	Set an expected range of possible prototype outputs	Calibrated measurement devices (calipers, micrometers)	inches (cm)	≥5.5x4x4 (13.97x10.16x10.16)	≥9x6.75x8 (22.86x17.15x20.32)	Inspection
ES3	Layer to Layer Registration	CN9	9	Consistency of layer position relative to adjacent layers	Degree of interlayer registration (contact profilometer)	inches (cm)	≤ .008 (.02032)	≤ .003 (.00762)	Inspection
ES4	X-Y Dimensional Accuracy	CN9	3	Accuracy due to projector image - pixel size	Calibrated measurement devices (calipers, micrometers)	inches (cm)	≤ ± .010 (.0254)	± .005 (.0127)	Inspection
ES5	X-Y Resolution	CN9	3	Pixel dimensions	Pixel dimensions	inches (cm)	TBD	TBD	Inspection
ES6	Cumulative Z-Dimensional Accuracy	CN9	3	Accuracy due to cumulative layer accuracy	Variability in layer thickness - calibrated measurement devices (calipers, micrometers)	inches/in (cm/cm)	≤ .010 (.010)	≤ .005 (.005)	Inspection
ES7	Layer Thickness	CN9	3	Accuracy of each cured layer in the Z direction	Variability in layer thickness - calibrated measurement devices (calipers, micrometers)	inches (cm)	≤ .005 (.0127)	≤ .004 (.01016)	Inspection

Pixel Accuracy Diagram



Engineering Specifications (2 of 3)

ES #	Engineering Spec	Source	Importance	Description	Measure of Performance	Units	Marginal Value	Ideal Value	Validation Method
ES8	Level of Automation	CN2, CN3	9	Required manual steps by operator	Number of steps	[---]	TBD	TBD	Experimentation
ES9	Utilized Photopolymer	CN1, CN4	9	Use photo-sensitive polymers as medium	Inspect to see if light of any wavelength is being used to cure the model	[binary]	No	Yes	Inspection
ES10	Design Documentation	CN6	9	Allow future MSD teams to easily understand design of DLP system	Inspect to see if there is documented and physical evidence of forethought to future MSD teams	[binary]	No	Yes	Inspection
ES11	Emergency Stop	CN7	9	System automatically shuts down when emergency stop is pressed	Safety inspection	[binary]	No	Yes	Inspection
ES12	Safety Interlock	CN7	3	System automatically shuts down when opened	Safety inspection	[binary]	No	Yes	Inspection
ES13	Light Leakage	CN7	1	Design minimizes the amount of light that escapes the DLP System (varying wavelengths)	Lux meter, UV radiometer	Lumens	TBD	TBD	Inspection
ES14	Pinch Points	CN7	3	Design minimizes opportunities for injury due to pinch points	Safety inspection	[---]	3	0	Inspection

Engineering Specifications (3 of 3)

ES #	Engineering Spec	Source	Importance	Description	Measure of Performance	Units	Marginal Value	Ideal Value	Validation Method
ES15	Device Cost	CN8	3	Constrain purchases and design to coincide with given budget	Inspect documentation of purchases	$	≤2000	≤1000	Inspection
ES16	Multiple Resins	CN5	1	Device should allow for resins with varying viscosities	Inspect documentation that proves adaptability	cP	≥500	≥10000	Inspection
ES17	DLP System Envelope	CN13	3	Constrain overall size of system	Bounding box dimensions	feet (m)	≤6x4x4 (1.829x1.219x1.219)	≤4x2x2 (1.219x.6096x.6096)	Inspection
ES18	Prototype Hardness	CN9	3	Check final product to ensure complete curing of polymer	Shore D Hardness Test	[---]	≥70	≥75	Inspection
ES19	Modular Design	CN1, CN5, CN6	1	Projector light source must be easily replaceable, Resin is easy to interchange	Inspect ease of light source change	[binary]	No	Yes	Inspection
ES20	Operator Satisfaction	CN10	3	Device must be simple and logical to use	Review survey results from operator use	Likert Scale	≥3	5	Survery

House of Quality

(1 of 2)

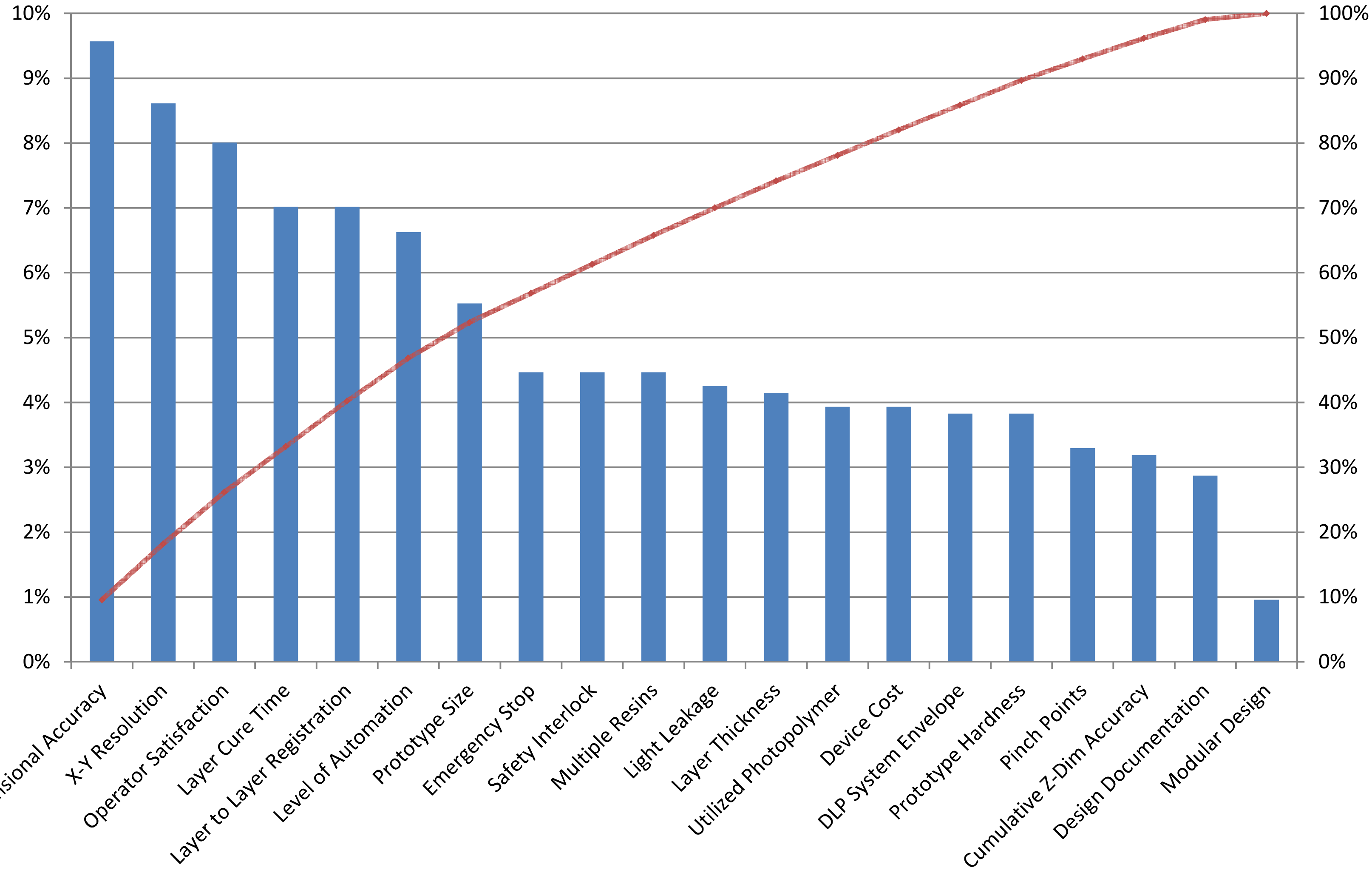
	Layer Cure Time	Prototype Size	Layer to Layer Registration	X-Y Dimensional Accuracy	X-Y Resolution	Cumulative Z-Dim Accuracy	Layer Thickness	Level of Automation	Utilized Photopolymer	Design Documentation	Emergency Stop	Safety Interlock	Light Leakage	Pinch Points	Device Cost	Multiple Resins	DLP System Envelope	Prototype Hardness	Modular Design	Operator Satisfaction
Layer Cure Time																				
Prototype Size	-																			
Layer to Layer																				
X-Y Dimensional	-	-	+																	
X-Y Resolution	-	-		+																
Cumulative Z-		-																		
Layer Thickness	-					+														
Level of Automation																				
Utilized Photopolymer																				
Design Documentation								-												
Emergency Stop								-												
Safety Interlock								-												
Light Leakage									-											
Pinch Points																				
Device Cost		-						-			-	-	-	-						
Multiple Resins									+						-					
DLP System Envelope		-						-												
Prototype Hardness	-																			
Modular Design															-					
Operator Satisfaction								+			+	+	+	+						

Engineering Specifications

House of Quality
(2 of 2)

Customer Needs	Customer Weights	Layer Cure Time	Prototype Size	Layer to Layer Registration	X-Y Dimensional Accuracy	X-Y Resolution	Cumulative Z-Dim Accuracy	Layer Thickness	Level of Automation	Utilized Photopolymer	Design Documentation	Emergency Stop	Safety Interlock	Light Leakage	Pinch Points	Device Cost	Multiple Resins	DLP System Envelope	Prototype Hardness	Modular Design	Operator Satisfaction
Utilized DLP Projector	9			3	3	9				3				3			1			1	
3D Model Slicing Software	9			9	9			3	3												
Fully Automated	9			1					9			3	3			3		1			9
Utilized Photopolymer	9									9							9				
Device Functionality	1								3	3							9			9	1
Prepare for Future MSD	9								3		9						3				
Device Safety Features	9								1			9	9	9	9	3					9
Device Cost	3		1						3			3	3	3	1	9		3			
Quality Prototype	9	9	3	9	9	9	9	9								3			9		
Operator Satisfaction	3	3	3						9			3	3	1	3					3	9
Prototype Creation Time	3	9	9					3	1										9		3
Prototype Size	9	9	9		9	9	1											9			3
Device Size	1		9						1							3		9			
		sec	inches (cm)	inches (cm)	inches (cm)	inches (cm)	inches/in (cm/cm)	inches (cm)	[---]	[binary]	[binary]	[binary]	[binary]	Lumens	[---]	$	cP	feet (m)	[---]	[binary]	Likert Scale
Raw Score		198	156	198	270	243	90	117	187	111	81	126	126	120	93	111	126	108	108	27	226
Relative Weight		7%	6%	7%	10%	9%	3%	4%	7%	4%	3%	4%	4%	4%	3%	4%	4%	4%	4%	1%	8%

Engineering Specification Weights



Benchmarking and Research

System Level

Z-Corp

- Commercially available DLP system. Machine uses a resin bath to apply new layers of resin - not conducive to multi-material capabilities.

V-Flash

- Commercially available DLP system. Machine uses a self contained cartridge to load and apply resin - feasible technology for multi-material capabilities.

Benchmarking and Research

Sub-System Level

Software

The software requirements include importing a 3D CAD model of .stl file format, slicing the 3D model, and exporting the 2D layer images.

- Solidworks
- ProENGINEER
- 3D Slicer (opensource)

Microcontroller

The basic function of the microcontroller will be motor control. The requirements will depend on the type of motors (stepper, servo, etc.) and the number of motors.

- Freescale
- Texas Instruments
- Arduino
- Hobby CNC

Benchmarking and Research

Sub-System Level

Resin Application

A key part of our design is the resin application. It has to be able to accommodate multiple resins and be open to further development in the area of models with multiple materials.

- Doctor Blade
- Resin Bath
- Film Rollers as used in Laminated Object Manufacturing (LOM)

UV Light Application

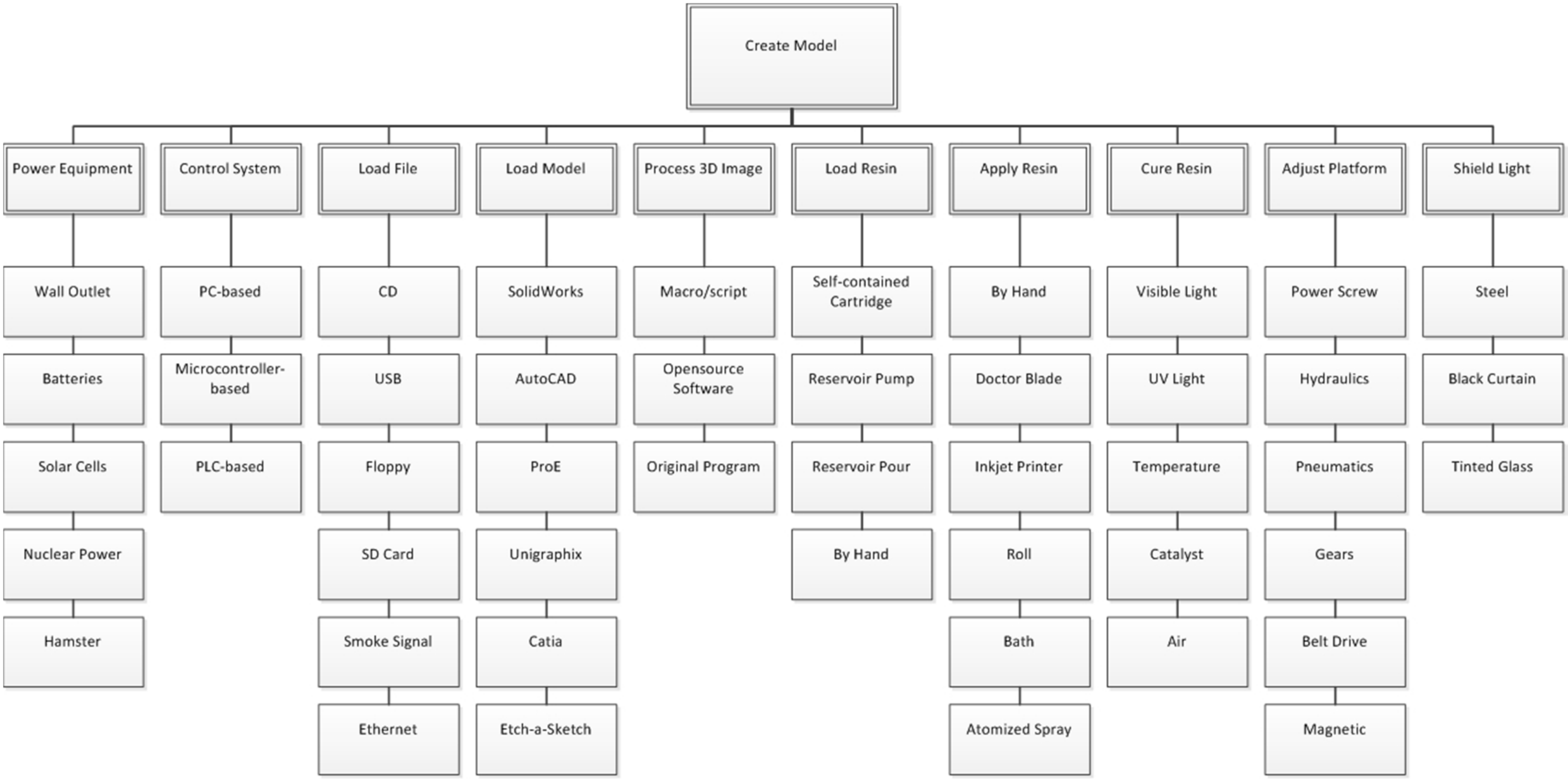
Calculations and testing are required to determine aspects such as cure time and cure depth. Both influence the layer to layer curing and accuracy of the prototype part being cured. Light intensity emitted by the LEDs can be controlled by the DLP software. Proper balancing of light intensity, cure time, and cure depth will contribute largely to an accurate cured layer and part.

Benchmarking and Research

Motion Control

- Open Loop
  - Movement instructions are converted to electrical pulses by the controller and sent to the servo amplifier to energize the servo motors.
    - The cumulative number of electrical pulses determines the distance
    - The pulse frequency determines the velocity
  - Drawback of the open-loop system is that there is no feedback system to check whether the program position and velocity has been achieved.
  - Open-loop system is generally used in point-to-point systems where the accuracy requirements are not critical.
- Closed Loop
  - The closed-loop system has a feedback subsystem to monitor the actual output and correct any discrepancy from the programmed input.
  - Closed-loop systems accurate because they are capable of monitoring operating conditions through feedback.
  - Closed-looped systems require more control devices and circuitry and are more costly to implement.

Functional Decomposition



Concept Generation
Multidisciplinary Senior Design I
DLP Prototyping System
Team 11552

Concept Generation (1 of 2)

	Power Equipment	Wall Outlet	Solar Cell	Battery	Nuclear	Hamster	
	Load File	CD	USB	SD	Floppy	Smoke Signal	
Concept1	**Load Model**	SolidWorks	Pro/E	Unigraphics	Catia	Etch-a-Sketch	
Create Model	**Process 3D Image**	Macro Script	Open Source	Original Program			
	Load Resin	Cartridge	Pump	Pour	Hand		
	Apply Resin	Hand	Blade	Inkjet / Spray	Roll	Bath	Atomized Spray
	Cure Resin	Visible Light	UV Light	Heat	Catalyst	Air	
	Adjust Platform	Power Screw	Hydraulics	Gears	Magnetic	Pneumatics	Belt Drive
	Shield Light	Steel	Tinted Glass	Black Curtain			
	Power Equipment	Wall Outlet	Solar Cell	Battery	Nuclear	Hamster	
	Load File	CD	USB	SD	Floppy	Smoke Signal	
Concept 2	**Load Model**	SolidWorks	Pro/E	Unigraphics	Catia	Etch-a-Sketch	
Create Model	**Process 3D Image**	Macro Script	Open Source	Original Program			
	Load Resin	Cartridge	Pump	Pour	Hand		
	Apply Resin	Hand	Blade	Inkjet / Spray	Roll	Bath	Atomized Spray
	Cure Resin	Visible Light	UV Light	Heat	Catalyst	Air	
	Adjust Platform	Power Screw	Hydraulics	Gears	Magnetic	Pneumatics	Belt Drive
	Shield Light	Steel	Tinted Glass	Black Curtain			
	Power Equipment	Wall Outlet	Solar Cell	Battery	Nuclear	Hamster	
	Load File	CD	USB	SD	Floppy	Smoke Signal	
Concept 3	**Load Model**	SolidWorks	Pro/E	Unigraphics	Catia	Etch-a-Sketch	
Create Model	**Process 3D Image**	Macro Script	Open Source	Original Program			
	Load Resin	Cartridge	Pump	Pour	Hand		
	Apply Resin	Hand	Blade	Inkjet / Spray	Roll	Bath	Atomized Spray
	Cure Resin	Visible Light	UV Light	Heat	Catalyst	Air	
	Adjust Platform	Power Screw	Hydraulics	Gears	Magnetic	Pneumatics	Belt Drive
	Shield Light	Steel	Tinted Glass	Black Curtain			

Concept Generation (2 of 2)

	Power Equipment	Wall Outlet	Solar Cell	Battery	Nuclear	Hamster	
	Load File	CD	USB	SD	Floppy	Smoke Signal	
Concept 4	**Load Model**	SolidWorks	Pro/E	Unigraphics	Catia	Etch-a-Sketch	
Create Model	**Process 3D Image**	Macro Script	Open Source	Original Program			
	Load Resin	Cartridge	Pump	Pour	Hand		
	Apply Resin	Hand	Blade	Inkjet / Spray	Roll	Bath	Atomized Spray
	Cure Resin	Visible Light	UV Light	Heat	Catalyst	Air	
	Adjust Platform	Power Screw	Hydraulics	Gears	Magnetic	Pneumatics	Belt Drive
	Shield Light	Steel	Tinted Glass	Black Curtain			
	Power Equipment	Wall Outlet	Solar Cell	Battery	Nuclear	Hamster	
	Load File	CD	USB	SD	Floppy	Smoke Signal	
Concept 5	**Load Model**	SolidWorks	Pro/E	Unigraphics	Catia	Etch-a-Sketch	
Create Model	**Process 3D Image**	Macro Script	Open Source	Original Program			
	Load Resin	Cartridge	Pump	Pour	Hand		
	Apply Resin	Hand	Blade	Inkjet / Spray	Roll	Bath	Atomized Spray
	Cure Resin	Visible Light	UV Light	Heat	Catalyst	Air	
	Adjust Platform	Power Screw	Hydraulics	Gears	Magnetic	Pneumatics	Belt Drive
	Shield Light	Steel	Tinted Glass	Black Curtain			
	Power Equipment	Wall Outlet	Solar Cell	Battery	Nuclear	Hamster	
	Load File	CD	USB	SD	Floppy	Smoke Signal	
Concept 6	**Load Model**	SolidWorks	Pro/E	Unigraphics	Catia	Etch-a-Sketch	
Create Model	**Process 3D Image**	Macro Script	Open Source	Original Program			
	Load Resin	Cartridge	Pump	Pour	Hand		
	Apply Resin	Hand	Blade	Inkjet / Spray	Roll	Bath	Atomized Spray
	Cure Resin	Visible Light	UV Light	Heat	Catalyst	Air	
	Adjust Platform	Power Screw	Hydraulics	Gears	Magnetic	Pneumatics	Belt Drive
	Shield Light	Steel	Tinted Glass	Black Curtain			

Concept Selection – System Perspective

Pugh Chart - Revised

P11552

Customer Need #	Customer Requirements	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6
CN1	Device utilizes a DLP Projector	**S**		'-	'-	S	S
CN2	Utilize a 3D software model for replication by prototype	**S**		'-	S	S	S
CN3	Fully automated after the command to print is sent	**S**		'-	S	S	S
CN4	Use a photosensitive polymer resin as a medium	**S**		S	'-	S	'+
CN5	Ability to use multiple types of curing resins	**'+**		S	'-	S	'+
CN6	Thorough documentation of design	**'+**		'-	'-	'+	'+
CN7	The system is safe to operate	**'+**		'-	'-	'-	'+
CN8	Device adheres to budgetary constraints	**'-**		'+	S	'-	'-
CN9	Acceptable quality of final prototype part	**S**		'-	'-	S	S
CN10	Device has simple user interface	**'-**		'-	S	S	S
CN11	Reasonable fabrication time	**S**		'-	'-	S	S
CN12	Reasonably sized finished prototype	**S**		'-	S	S	S
CN13	Reasonably sized DLP system	**'+**		'-	'-	'-	S
	Sum "+"	0	0	0	0	0	0
	Sum "-"	0	0	0	0	0	0
	Sum "S"	7	0	2	5	9	8
Key:			DATUM				
"+"	Better than DATUM Concept						
"-"	Worse than DATUM Concept						
"S"	Same as DATUM Concept						

Concept Selection – Application Method

Concept Selection - Application Method

Iteration #1

Criteria	Roll	Blade	Inkjet	Bath	Dip/Blade	Atomized Spray
Reliable/repeatable results	-	S	+	S	+	+
Accurate resin thickness	-	-	+	S	+	+
Feasiblity of design	S	+	+	S	+	-
Adapt to multiple material	+	S	+	S	+	+
Required Control	+	+	-	S	S	-
				DATUM		

Iteration #2

Criteria	Roll	Blade	Inkjet	Bath	Dip/Blade	Atomized Spray
Reliable/repeatable results	-	-	S	S	S	S
Accurate resin thickness	-	-	S	S	S	S
Feasiblity of design	S	S	-	S	S	-
Adapt to multiple material	-	S	S	-	S	S
Required Control	+	+	-	-	S	-
					DATUM	

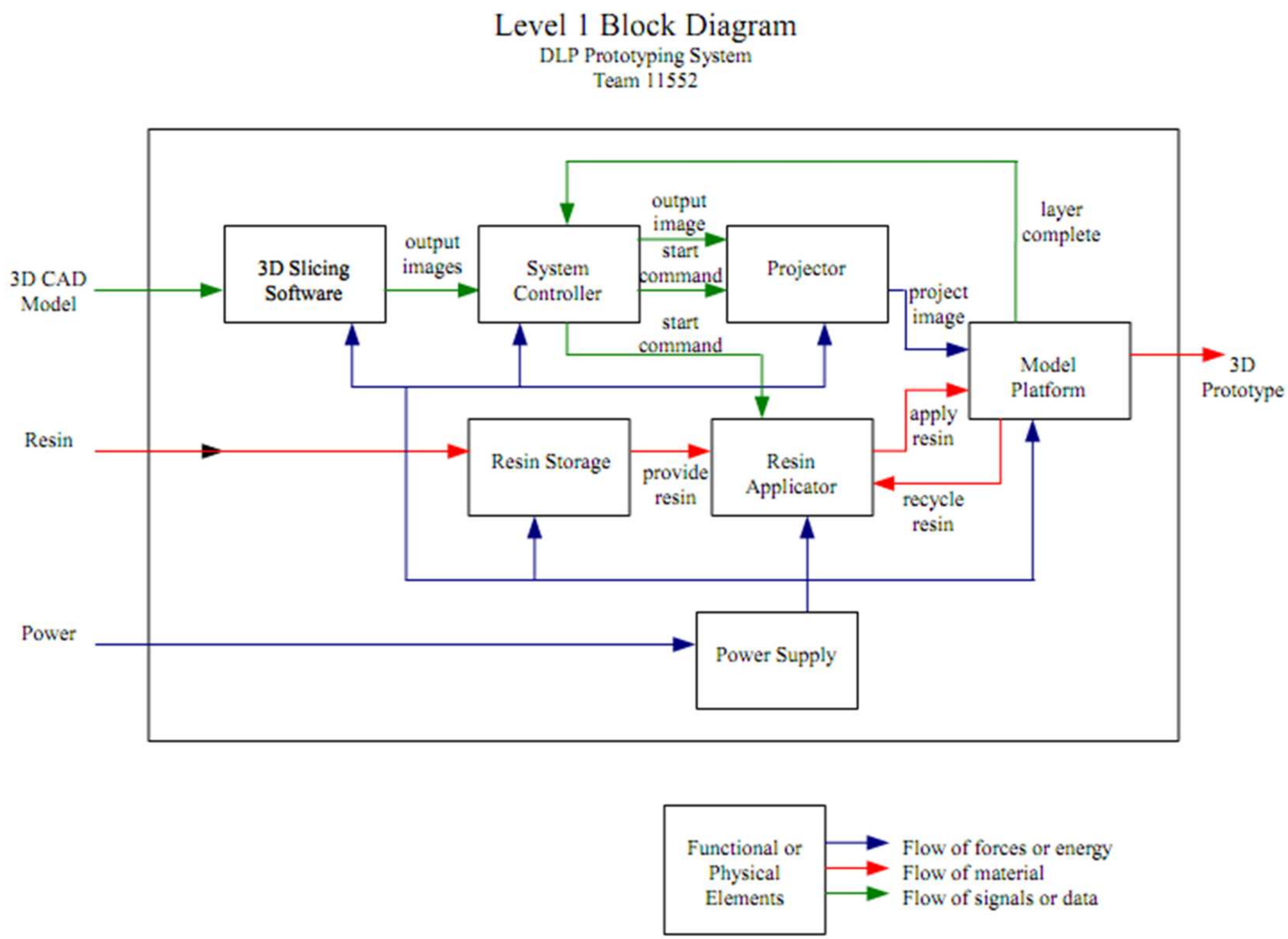
Concept Selection Summary

Concept	Power Equipment	Control System	Load File	Load Model	Process 3D Image	Load Resin	Apply Resin	Cure Resin	Adjust Platform	Shield Light
1	Wall Outlet	Microcontroller	SD	SolidWorks	Macro Script	Cartridge	Doctor Blade	UV, Visible	Power Screw	Steel
2	Wall Outlet	PC	USB	SolidWorks	Macro Script	Cartridge	Doctor Blade	Visible	Gears	Tinted Glass
6	Wall Outlet	PC/ Microcontroller	SD,USB, ethernet	SolidWorks	Macro Script	Cartridge	Roll	UV, Visible	Power Screw	Steel, Tinted Glass

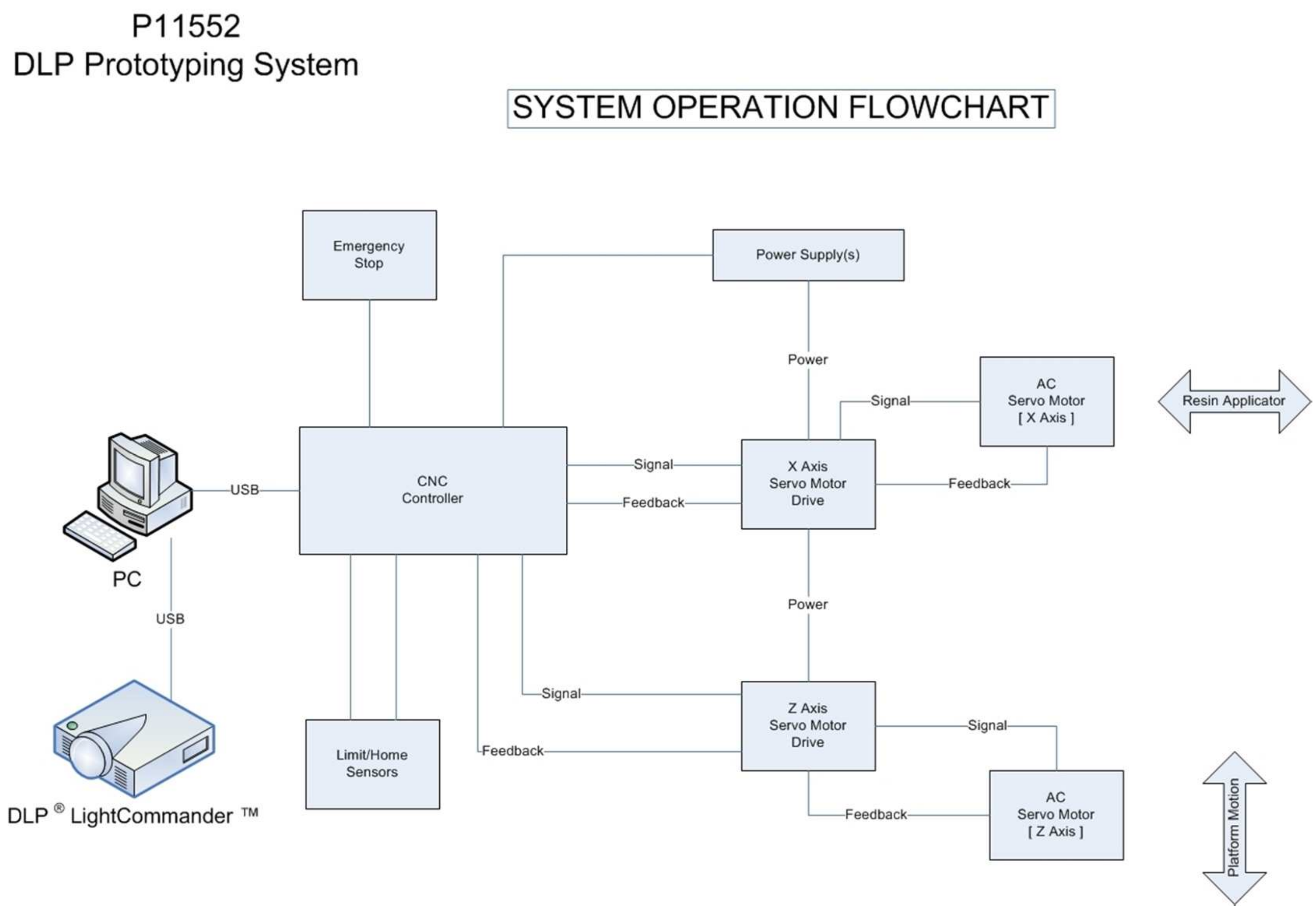
Areas of Concern

- Resin Application Technique
- Platform/Resin Spreader Translation

Concept Overview



Concept Overview



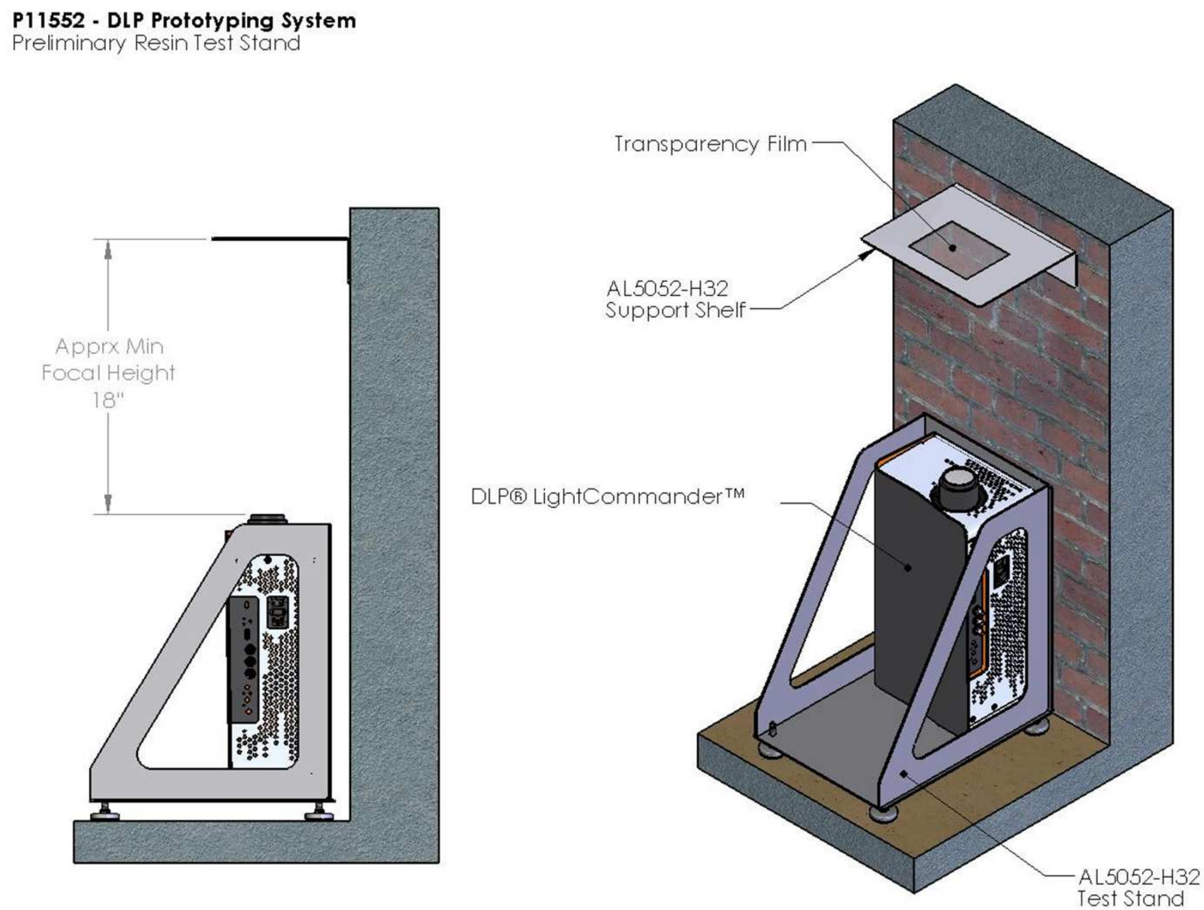
Risk Management (1 of 2)

	Risk Assessment P11552 - DLP System							
ID	**Risk Item**	**Effect**	**Cause**	**Likelihood**	**Severity**	**Importance**	**Action to Minimize Risk**	**Owner**
R1	Team deliverables schedule unclear	Schedule delay	Poor Planning	1	3	3	Creation of Team AIDs (Actions,Issues,Decisions) Log	ISE
R2	DLP unit fails to provide sufficient light power	Uncured resin, inaccurate part	Damaged Optics	1	3	3	Read DLP instruction/operation manual before use	ME
			Damaged Light Source	1	3	3	Read DLP instruction/operation manual before use	ME
			Flawed Calculations/Assumptions	2	1	2	Verify resin curing calculations with guide	ME
R3	Desired design not within budget	Costly Design	Overdesigned	1	1	1	Verify proposed design and additional cost with guide	ISE
R4	Parts for final assembly arrive late	Schedule delay	Long lead components not identified	2	2	4	Identify long lead components and order in advance	TEAM
			Unreliable vendor/source	2	2	4	Work with vendor to ensure delivery schedule is met	TEAM
R5	Motors fail to stop at desired position	Hardware failure	Poor control algorithm	2	3	6	Simulate control laws prior to issuing commands to hardware	ME/CE
			Failed sensors	1	3	3	Choose robust sensors	ME
R6	Component timing is out of sync	Hardware failure/incorrect model	Timing control is incorrect	2	2	4	Simulate control laws prior to issuing commands to hardware	ME/CE
			Component failure	2	2	4	Create stops in the control architecture if one component shows sign of failure.	CE
R7	DLP chip burns out	Projector becomes inoperational	Over work DLP chip	1	3	3	Ensure projector is well ventilated. Auto-stop when projector reaches dangerous heat level.	ME
			Command more light intensity that can be handled by the chip	1	3	3	Research light intensity capacity of DLP chip	ME
R8	Resin supply runs out before prototype is complete	Prototype cannot be completed	Not enough resin was allotted for part	2	2	4	Perform a volume calculation of prototype and account for excess resin in process. Include a factor of safety	ME
R9	Resin clogs during application	Prototype cannot be completed	Resin partly cures at storage opening causing a blockage of flow	2	2	4	Protect application process from light	ME
R10	Bubbles form in resin just before curing	Prototype has porous features	Air is introduced in the application process	1	2	2	Keep flow undisturbed and steady when applying resin.	ME

Risk Management (2 of 2)

ID	Risk Item	Effect	Cause	Likelihood	Severity	Importance	Action to Minimize Risk	Owner
R11	Prototype never adheres to build platform	Prototype cannot be completed	Features on the build platform don't allow for construction	1	2	2	Inherent a high surface area structure from benchmarking to accommodate additive building.	ISE
R12	Image is out of focus	Prototype is inaccurate	Focal distance is incorrect on projector lens	3	1	3	Test focus prior to running device.	ISE
R13	Light leaks into device from outside	Cure time and accuracy are compromised	Improper enclosure	3	1	3	Use materials that are impervious to light and make sure all interfaces of the enclosure are light tight	ISE
R14	Resin sits unevenly with respect to cure platform	Prototype will not be cured properly	Device is out of level	2	1	2	Install leveling legs on device	ME
R15	Dark spots on projected image occur when they are not desired	Prototype is inaccurate	Dirty projector lens	2	1	2	Inspect lens prior to use and use a photo grade cloth for cleaning the lens to protect film on lens	ME
			Improperly programmed image	2	1	2	Test images with projector before cure process	CE
R16	Software crash	Prototype is unfinished	Underlying problems with the native computer.	3	3	9	Make sure computer meets system requirements of software, is clean of viruses, and running smoothly	CE
R17	Component communication failure	Prototype is unfinished, possible hardware failure	Physical break of signal lines	1	3	3	Inspect all signal lines	CE
			Failed Microprocessor	1	3	3	Start design with a new microprocessor	CE
			Loss of power	1	3	3	Ensure power is securely connected	CE
R18	Cure platform not clean	Prototype will be inaccurate	Residual resin present after previous cure cycle	2	1	2	Use a wiper style blade to clean off cure platform after each cure cycle.	ME
R19	Customer needs change	Design change to accommodate	Change of scope	1	3	3	Keep steady communication with customer	ISE
R20	Cured layer adheres to resin cure platform	Prototype is unfinished, Possible hardware damage	Interface between cure platform and resin layer is conducive to adhesion	2	3	6	Thorough testing of cure platform surface with various resins, auto-stop if model platform z-directional movement required momvement	ME

Resin Curing Platform



Detailed Design Testing

- Image Projection Sub-System
  - Curing Time
  - Light Intensity
  - Resolution Calculation
- Liquid Resin Spreading Sub-System
  - Motor Selection
  - Spreading Technique Accuracies
  - Build Surface Testing

$$[illegible] = [illegible] \cdot [illegible]$$

$$[illegible] = 1024 \; [illegible] \; 768$$

$$5\frac{1}{3} \; [illegible] \; 4 \; [illegible] = [illegible]$$

$$[illegible] = \frac{4 \; [illegible]}{768 \; [illegible]} = 0.00521 \; [illegible]$$

$$[illegible] = \frac{5.333 \; [illegible]}{1024 \; [illegible]} = 0.00521 \; [illegible]$$

$$[illegible] = (0.00521 \; [illegible])^2 = 0.00002714 \; [illegible]^2$$

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$$\frac{[illegible]}{[illegible]} = \frac{[illegible]}{[illegible]^2} \Big/ \frac{[illegible]}{[illegible]^2} = [illegible]$$

V-Flash Demonstration

Questions?