MTRL 466 Meeting Minutes

Project Name:	Supports4SLA
Group:	Team TreeD
Current Meeting:	September 26, 2018
Minutes Prepared By:	Danish Abbas

Attendees:

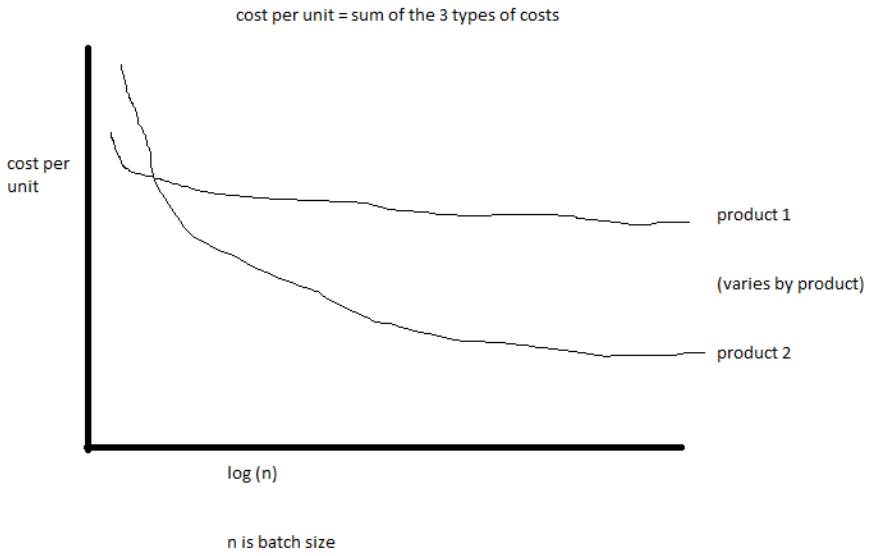
Danish Abbas	Yes
Eddie Lee	Yes
Jean Sautter	Yes
Yue Shi	Yes
Kamran Rafique	Yes
Luc Millary Burns	Yes

Agenda:

No.	Subject	Owner	Comments/Actions
1	Status Update - Proposal Report Status - Schedule Update	EL	- Completed Proposal - Next Week's Plans: Thursday (Sept 27)- Plan Economic aspect + Midterm Presentation Sunday (Sept 30)- Work on Economic aspect + presentation slides Next week (Oct 1 - Oct 7) - Complete Midterm presentation Following week (Oct 8 - Oct 12) - practice presentation - So far on schedule; we have the model, the equations
2	Cantilever Beam Calculations	JS	Cantilever Beam Calculations -Based on Maximum Deflection (1cm length -> 1mm deflection) - Won't see deflection for our proposed test model (0.3mm to 6mm) - Need to consider Young Modulus for semi-cured resin - Need to consider vacuum force -Based on Yield stress -As discussed, the reason we think the deflection is so small is because our E (Youngs modulus) does not take into account the fact that the resin is uncured.
3	Solidworks Model	JS	- Test sample 2: Icosagon (20 sided polygon) - Test sample 3: aims to keep print area of sample constant (keep vacuum force constant) - For samples <6mm the difference in length is added on to the interior of the base (keeping print area constant)
4	Money for resin	YS	- $300 per liter of clear resin from Formlabs, including tax and delivery fees. Or 125 dollars from Wanhao Premium UV Resin. - Properties of resin for NewPro3D available on wiki
5	Scope of Socio-Economic Discussion	EL	- Limited to SLA or support structures? Future vs current? Environmental concerns? Impact on lifestyle? Job Production? - include environmental effects (Socioeconomic effects) - try to include quantitative info and focus on one direction.

Minutes

- Upload the minutes, proposal to wiki and send it to Chad. He will provide us with feedback
- Objective is to minimize the amount of material that is being used. We're doing this by finding the critical length.
- We decided that by failure we mean a certain critical deflection
- Review the resin data uploaded on wiki, we don't want very differing data from different resins. Luc said that Just the vacuum force is different. There's an equation in it which outlines the basic phys
- ics of the resin.
- One of the things for analysis – economic and socioeconomic (not the same)/environmental
- Luc's question – we should again, narrow down on something and expand on something specific in detail. Luc's thing is too broad. We should be focusing on supports. What would be the economic value of reducing my supports by say 10%? Or 35%?
- Chad recommended that we should do an economic analysis/cost model on
  1. Overhead
  2. Material
  3. Tools



- Think about the support in terms of cost model – Support can come under material or batch size. Removal time/post processes that have to remove the surface blemishes – these are the conditions we should be considering. Cost does not matter in prototyping.
- What is the incremental cost of adding/removing supports in a mass-produced product?
- Do a sensitivity analysis for cost and environment. How can we think about environmental? We can throw away the waste after. But the question would be making it about the material cost of manufacturing the resin. Think about if it actually saves the environment but if the whole part fails then we cannot do anything. In FDM printing, we use PLA biodegradable polymers but the

resin is not. But look at the whole process, energy and carbon dioxide wise. Can we make a relationship between that? Is it linear or is it non-linear?

- Focus on one direction out of all of them. Do the one with which we can do a quantitative analysis. Not based on conjecture or opinion. His suggestion on economic is to look at Ashby's
- Lay out the methodology for how we're going to do the analysis for the midterm – don't show the calculations, save those for later. Dedicate half a slide to it. It is mostly arguing the logic of it rather than showing the quantitative side to it.
- Make the link back to the objective. Our hypothesis states there will be a positive correlation between saving supports and costs. However, we will need to adjust that hypothesis based on batch size.

Other Notes (and things to keep in mind when making our case)

- Don't say a number is small. Say it is small relative to something. Why is the deflection chosen to be that?
- Back to the calculations, isn't the vacuum force causing bending? Which one is more, its own weight or the vacuum force?
- Calculate force per unit length – get from your density (we're getting at W)
- E is constant which we can get that from the wiki after curing it doesn't change that much.
- Other thing about the bending, it is also going to depend on
  -I depends on thickness of layer.
  -I is not fixed
  -Stiffness goes $1/t^3$
  -Self-loading from the thin piece of paper will still cause it to deflect.
  -Separate the two from W. Try to look at the effects of the two things differently (self-loading and vacuum force)

About the calculations

- The calculations aren't necessarily wrong. Youngs modulus is good. H makes a big difference. These calculations would say that under self-loading the deflection is negligible.
- Increasing H (adding more layers) is only going to decrease thickness.
- How could we actually test it besides printing it? Make sure the equation is good, make sure the units are good. FEA testing would be hugely painful.
- This equation should work for anything right. Make a cantilever beam out of anything like aluminum and hang a weight on it and see if you get an approximately right deflection. This would give us more confidence in the equations.
- Weight of the vacuum (there's an equation in the report that doesn't work). Look at the graph again and get the force properly instead of just reading it from the graph
- 100 microns at 2.5 – this is about 4 times our layer thickness.
- There is a fundamental difference between the two loading cases. See how long the vacuum force actually acts on the part. Its only there for 1 second.

- What determines the critical deflection? Why would it not print properly? If the previous layer is not properly working. If the previous layers deflection has passed it yield strength, then it would get destroyed. One of our assumptions is its **elastic**. We should be checking the strength of the material and if it even deforms elastically. Another assumption we've made is that this is a beam.
- Another mode of failure – see if it plastically deforms.
- Think about the process step by step. Increase our confidence by testing our model.
- We can contact Sebastian for printing. David is a very limited resource, don't waste prints with him.
- Try to reflect the calculations above back to the 3D Solidworks model. We want to design our model based on our predicted mode of failure. We want to test our predictions using this model.
- **Questions to think about:** What happens if we put a support beam at the 2.5 mm point. What will happen in terms of deflection? Does everything (all the predictions and calculations) make sense? Look at the scenario when the self-loading is almost 0 and vacuum force is very large. That'll give us clues about the direction we're taking.
- Chad has tensile samples. Deliverables for next week – have that on schedule.

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Project Name:	Supports4SLA
Group:	Team TreeD
Current Meeting:	September 30, 2018
Minutes Prepared By:	Danish Abbas

Attendees:

Danish Abbas	Yes
Eddie Lee	Yes
Jean Sautter	No
Yue Shi	Yes
Kamran Rafique	Yes
Luc Millary Burns	No

Agenda:

No.	Subject	Owner	Comments/Actions
1	Status Update - Debrief after meeting with Chad Sinclair - Schedule Update	DA	
2	Midterm Report and presentation work break down	DA	

Minutes:

The midterm report will be delegated as follows:

	Suggested max length	Name	Tasks
Title Page			
Executive Summary	1 pg	Danish	Will be written after all the other sections are complete
Problem Definition	2 pg	Danish, Jean	• Rule of thumb not justified • Support material is waste • Challenges in scaling up 3d printing (finding a way to use 3D printing in mass production)

Technical Review	3 pg	Everyone	• Isotropy curing (constrained based on sure time) - Already done
			• How resin is made (for economic section) - Kamran
			• Calculations on Cantilever Beam - Yue and Eddie
			  • Find out Yield Strength of Resin (for elastic and plastic deformation)
			  • Find out Vacuum force

Project Objectives and Quantitative Goals	0.5 pg	Jean	Minimizing the amount of support material (Changes)

Design options and recommendations	5 pg	Everyone	• Part 1: Constraining Cross Section Area
			  • Improve equation after test print
			  • Use cube cross section area
			  • Self loading is the main failure mechanism
			• Part 2: Vary cross section area
			  • Find critical area when vacuum force becomes more main failure mechanism

Economic and Socio-Economic Assessment of Design	1 pg	Luc, Danish	• What is involved in printing process (material, tooling, overhead) - Produce graph • Savings from minimizing support - in terms of mass manufacturing • Benefits: Less post processing (to remove support, better surface) • • Environmental Impact • Recycling SLA supports 3D support structures -> Material Resin **Economic Cost Model** • Resin, Printer, electricity, tools, maintenance, workers, building (Check MTRL 280 model using batch size) • Find some indication as to pricing • If support structures are reduced, labour is reduced, material is reduced -> AM becomes more accessible **Socio-Economic Model:** Jobs - Reduced time needed if there are less support structures, so it would be less work for people **Environmental Model** • Less material wasted, means less environmental impact. • But by how much? Does the electrical input for printing cause most of the impact (as it operates)?
Updated project schedule	2 pg	Eddie	• Use previous schedule • Task list • Change varied angle to change in cross sectional area
Risk Assessment	1 pg	Kamran	• Limited literature on calculations behind rule-of-thumbs • Delays in communication with NewPro (Materialise Magic software) • Report may overly focus on theoretical models and not replicate real life scenarios
References and Appendices	No limit	Everyone	- Everyone should insert their own references in IEEE format

Suggested max ~ 15 pages

The following points will be presented in the midterm presentation:

Slide	Stuff to talk about on the slide
1	Intro to SLA printing - Benefits
	Challenges - Focus on printing time, costs - NewPro3D, Carbon also working on these - Companies like adidas want to use this technology for large scale operations (like shoes)
2	Our project
	Objective: minimize support material (time, costs)
	Focus on support material
3	Rules of thumb
4	Tackling overhang distance
	How? (very brief mention of using vacuum forces and self-loading of the beam)
5	What kind of savings can be achieved - Table that shoes critical length, volume used, costs incurred - Graph that shoes scaling up in industrial applications

- For overhang distance, we're trying to locate the critical length at which failure will occur. Failure is critical deflection which is defined as the point at which the next layer being printed is messed up.
- Look at feasible appearance (nothing to do with internal strength)
- The only two forces we will be considering are vacuum forces and the self-loading of the beam.
- What kind of savings can be done or shown? A table that shows the length (which is used to calculate volume which is used to calculate cost)
- This might look small now but if you scale this up, it adds up.