TEAM CAVATAPPI PRESENTATION 3: FINAL PROPOSAL PRESENTATION

Project Clients: Dr. Michael Shafer, Diego Higueras-Ruiz

Team Members: Patricia Ann Lester, James Bennett, Ryn Shuster

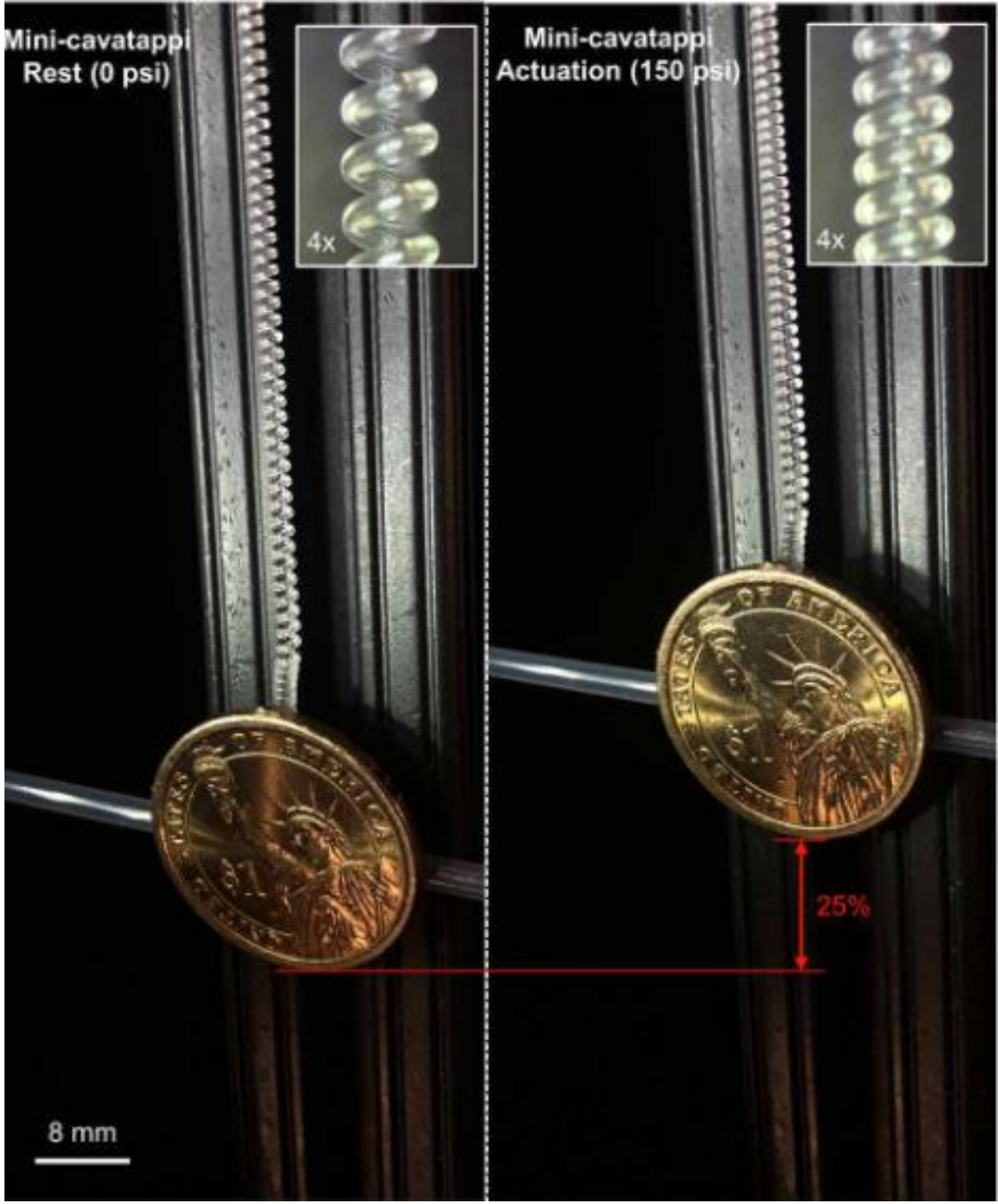

Figure 1: Sample Cavatappi Actuation Test

PROJECT DESCRIPTION

Review:

- Design Cavatappi artificial actuator manufacturing process
- Design laparoscopic surgical tool utilizing Cavatappi muscles
- Ensure scalability of Cavatappi muscles to work in parallel (muscle bundles)
- Possible Tests: needle/ coin on flat surfaces

Figure 2: Mini Cavatappi Prototypes (18 mm)

MANUFACTURING DESIGN DESCRIPTION

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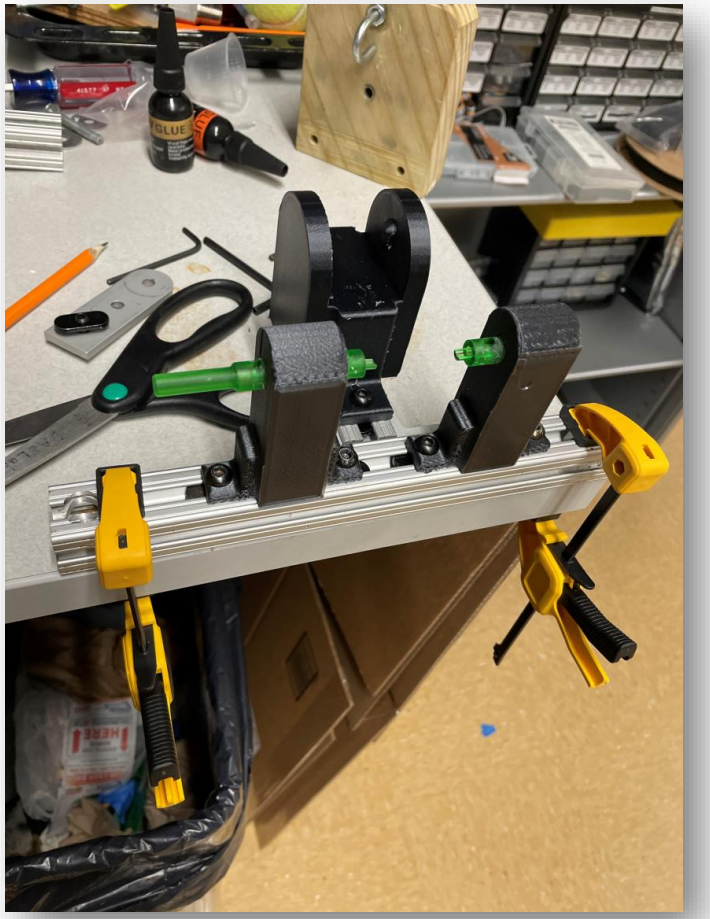

- **Major Improvements**
  - Overall footprint reduction
    - Approx. 60%
  - Combination of twisting hardware and clamps.
    - No need to release tension on non-annealed muscles to transfer to annealing process
  - Reduction of operator interaction with process.
  - New annealing process provides consistent overall heat.

DESIGN REQUIREMENTS

- Muscle Scalability / Parallel Bundles
  - D= 6.0 mm => 2.0 mm
- Consistent Manufacture Method
  - Current failure rate: 25% (was 60%)
  - Caused by old annealing method, tube flaws
- Reliability
  - Lower muscle leaks (better gluing, muscle geometry and manufacturing consistency)
  - low actuation pressure (P < 100 psi)

Figure 4: Parallel vs. Perpendicular Actuation

DESIGN VALIDATION

Cavatappi Hand		Development Team				Page No 1 of 1			
Manuafacting System						FMEA 1			
Coiling Mechanism									10/3/2021
Part # and Functions	Potential Failure Mode	Potential Effect(s) of Failure	Severity (S)	Potential Causes and Mechanisms of Failure	Occurance (O)	Current Design Controls Test	Detection (D)	RPN	Recommended Action
Clamps-to hold the polymer in place while cooking	Stress Corrosion	Shearing of the muscle, wasting material, inability to create reliable muscle.	8	Clamps could be digging into polymer	9	Identifying bulging in polymer	3	216	Design/manufactuing of new clamps as well as additional testing
Twisting/coiling Mechanism	Fatigue	Shearing of the muscle, wasting material, inability to create reliable muscle.	8	Over-twisting	9	Identifying bulging in polymer	3	216	Hand-coiling until system can be evaluated/redesigned
Polymer	Wear	Shearing of the muscle, wasting material, inability to create reliable muscle.	8	Size, material	9	None	10	720	Testing with various sizes and identifying materials with similar properties
								0	
								0	
								0	

DESIGN VALIDATION

- Note:
  - Parts 7, 8, and 9 are highest priority
  - RPN significantly reduced from previous design
  - Most design updates will be in the form of material modification
  - Most failure is wear related

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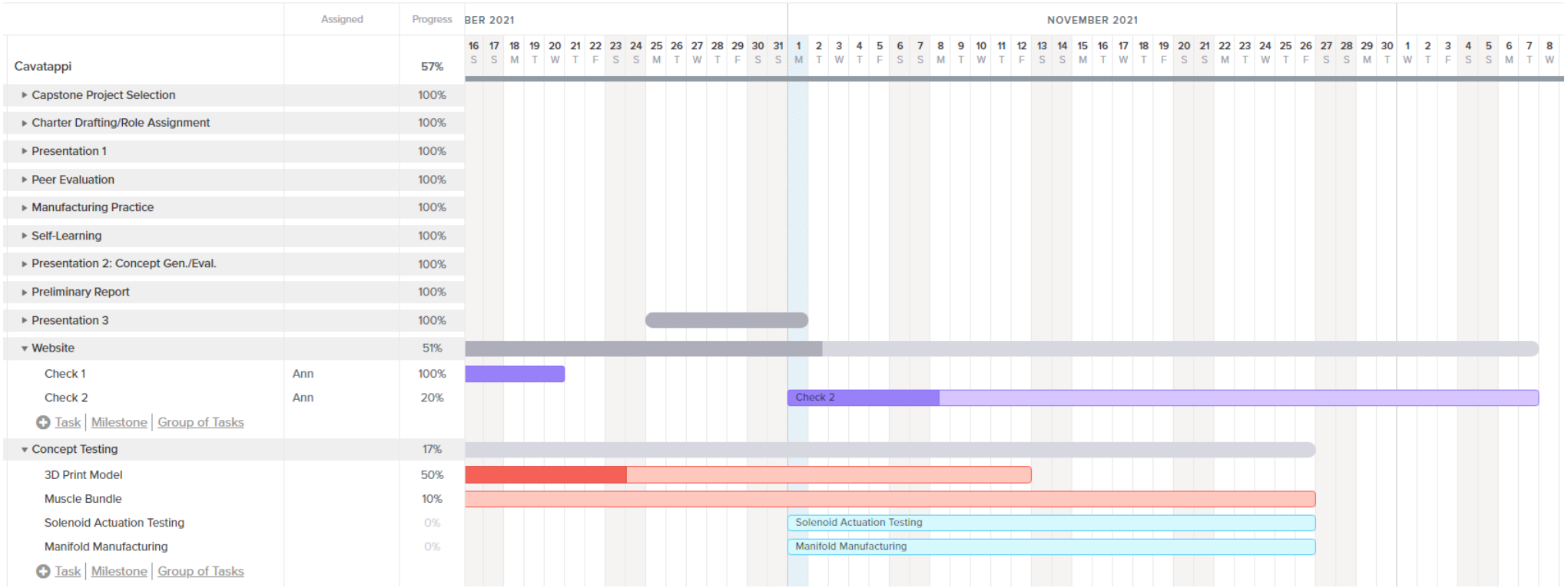
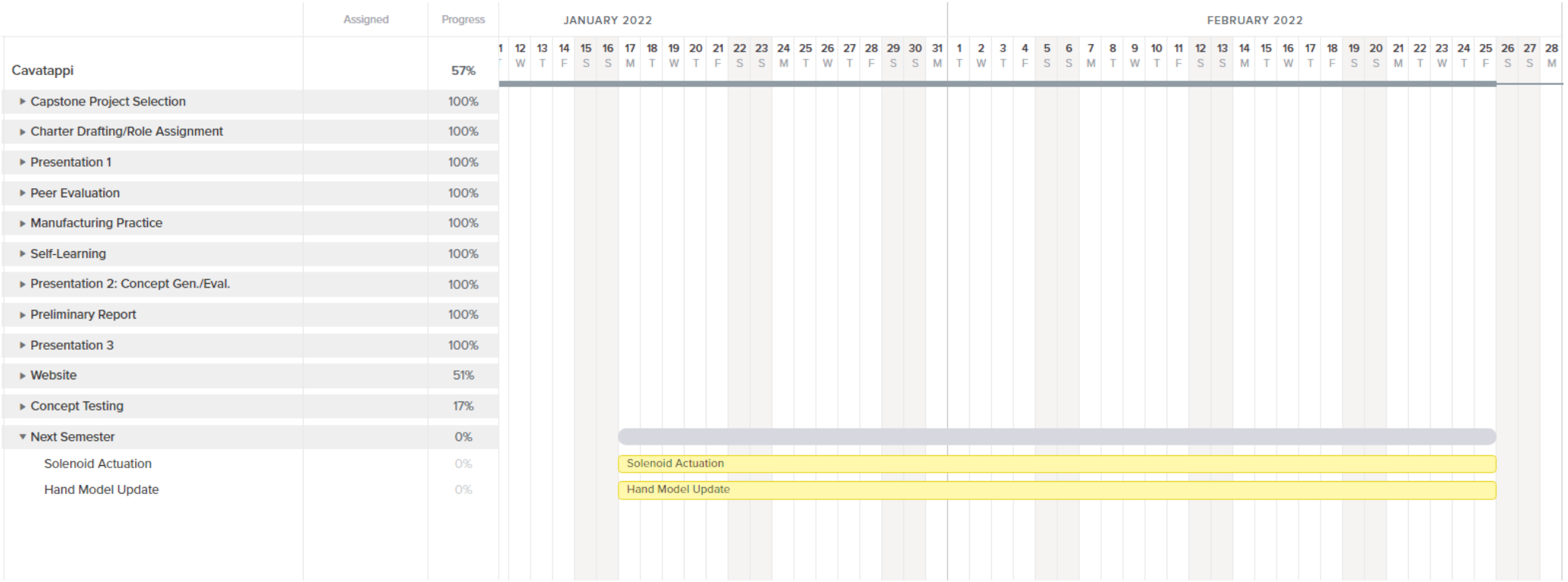
Manufacturing System							FMEA 1			
Coiling Mechanism							10/3/2021			
Part # and Functions	Potential Failure Mode	Potential Effect(s) of Failure	Severity (S)	Potential Causes and Mechanisms of Failure	Occurance (O)	Current Design Controls Test	Detection (D)	RPN	Recommended Action
1-T Slot Rail	Abrasive Wear	Noise, poor appearance	2	Overstressing, assembly errors	1	Physical Examination	1	2	Good RPN, no action needed
2-T Slot Rail	Abrasive Wear	Noise, poor appearance	2	Overstressing, assembly errors	1	Physical Examination	1	2	Good RPN, no action needed
3-T Slot Bracket	Abrasive Wear	Noise, poor appearance	2	Overstressing, assembly errors	1	Physical Examination	1	2	Good RPN, no action needed
4-Tower_Spool	Brittle Fracture	Erratic operation	4	Overstressing, assembly errors	3	Physical Examination	3	36	Look into properties of printing material. Possibly making modifications based on the fill, stiffness, strength, ect.
5-Spool	Brittle Fracture	Erratic operation	4	Overstressing, assembly errors	3	Physical Examination	3	36	Look into properties of printing material. Possibly making modifications based on the fill, stiffness, strength, ect.
6-Tower Mandrel	Brittle Fracture	Erratic operation	4	Overstressing, assembly errors	3	Physical Examination	3	36	Look into properties of printing material. Possibly making modifications based on the fill, stiffness, strength, ect.
7-Clamp	Fatigue/Abrasive Wear	Inconsistent manufacturing of muscles	6	Overstressing, assembly errors	4	Examination of Muscle	2	48	Look into properties of printing material. Potentionally redesign clamps
8-Clamp	Fatigue/Abrasive Wear	Inconsistent manufacturing of muscles	6	Overstressing, assemply errors	4	Examination of Muscle	2	48	Look into properties of printing material. Potentionally redesign clamps
9-Clamp Jaw	Stress Corrosion	Inconsistent manufacturing of muscles	6	Overstressing, assembly errors	4	Examination of Muscle	2	48	Look into properties of printing material. Potentionally redesign clamps/clamp jaw.
10-Set Screw	Wear	Difficulty with assembly	3	Overstressing	1	Only hand tightening	1	3	Good RPN, no action needed

SCHEDULE/ BUDGET-THIS SEMESTER



Team Cavatappi: Ann Lester

SCHEDULE/ BUDGET-NEXT SEMESTER



SCHEDULE/BUDGET

- Budget: 200.00
- Spent: 18.99
- Remaining: 181.01

Cavatappi Hand

Project Budget

Project Lead: Ryn Shuster
Start Date: 8/23/2021

Budget Summary

Budget	Actual	Under(Over)
$ 200	$ 19	$ 181

	Labor		Materials		Fixed Costs					
Tasks	Hrs	Rate	Units	$/Unit	Material	Travel	Other	Budget	Actual	Under(Over)
Cavatappi Manufacturing System								$ 150	$ 19	$ 131
3D Prints								45.00	-	45.00
Additional Muscle Material								35.00	-	35.00
Additional Hardware								45.00	-	45.00
Fasteners									-	-
Pins									-	-
Motors									-	-
Adhesive					18.99			25.00	18.99	6.01
									-	-
Emergency								$ 50	$ -	$ 50
Manufacturing System Failures								25.00	-	25.00
Additional 3D Prints								25.00	-	25.00
									-	-
									-	-
									-	-

Team Cavatappi: Ann Lester