Comprehensive In-Vitro Flow Model Testing Development

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Project Description

- The overall objective of this project is to develop a comprehensive flow model capable of medical device testing.
- The project is sponsored by Dr. Tim Becker, the Principal Investigator of the Bioengineering Devices Lab (BDL) at NAU.
- The main deliverables:
  - To create a pump system capable of cleaning the model interior from 3D support material.
  - Improve the In-Vitro benchtop model with additional parameters and system modifiers.

Background

- The Bioengineering Devices Lab at NAU is a lab that focuses on aneurysm treatment.
- Aneurysm: bulging or "ballooning" of an artery caused by weakened arterial walls.
- 50% are fatal, 66% of survivors suffer permanent neurological deficits, 15% die before reaching a hospital. [1]

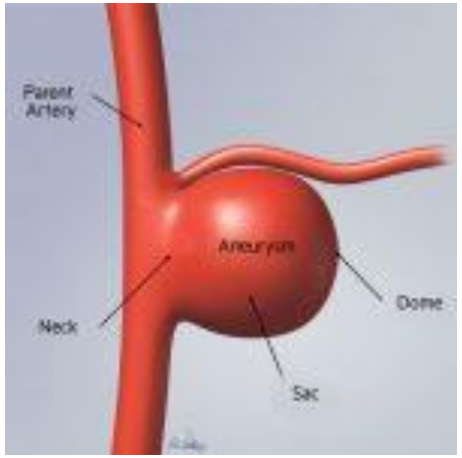
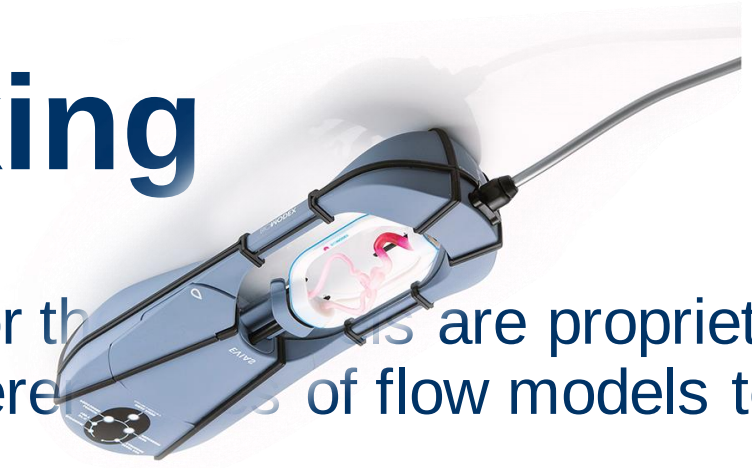


Figure 1: Aneurysm (bafound.org)

Figure 2: BDL Logo

Benchmarking



Most cleaning systems for th[illegible]s are proprietary, however, there are a variety of differe[illegible]s of flow models to simulate physiological conditions.

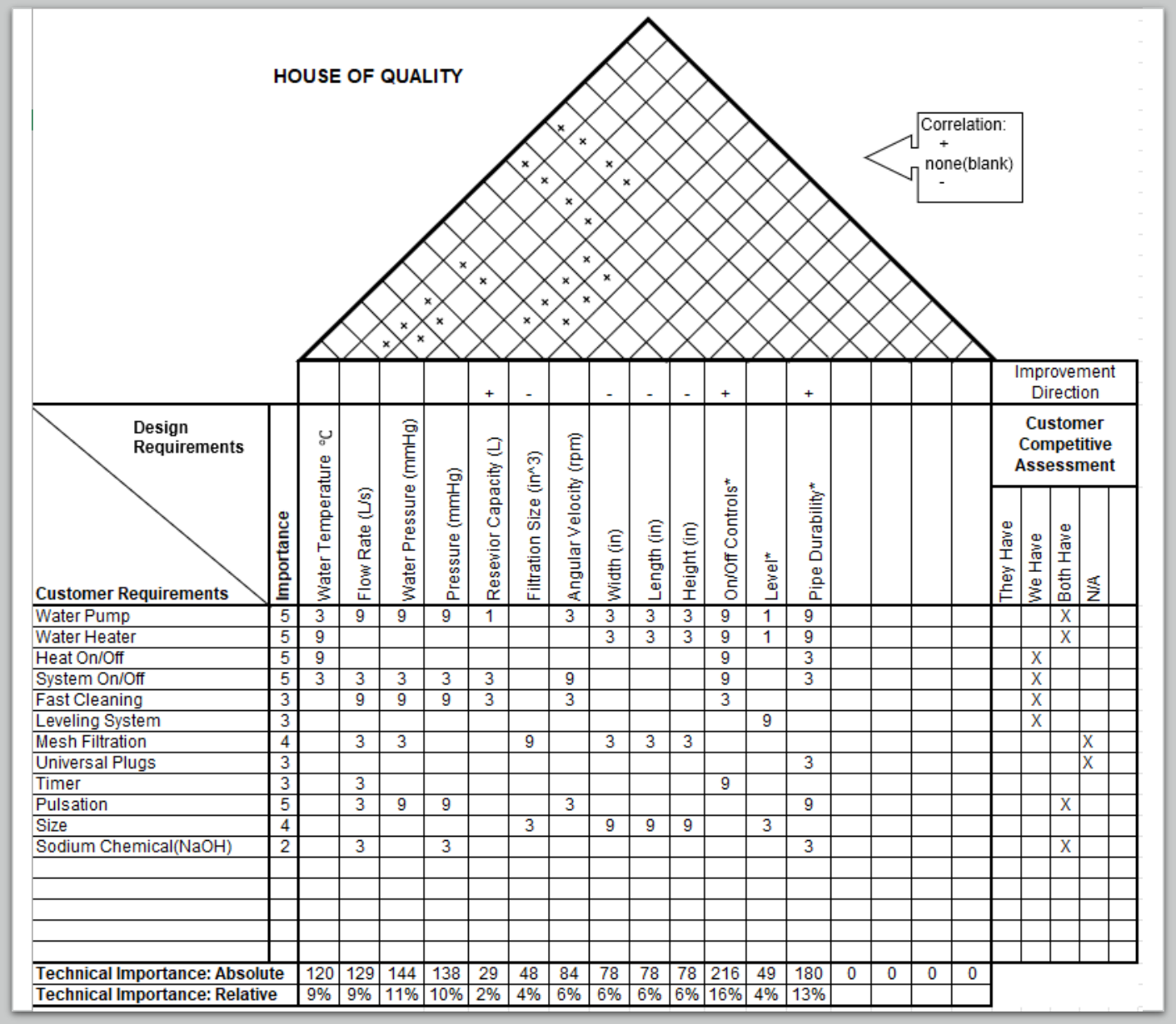
Figure 3. Mentice© Simulation Device

Figure 4. BioModex© 3d print Flow Device

Figure 5. United Biologics© Silicone model

Quality-Function Deployment [5]

- CR vs ER
- ER correlations
- Benchmarking
- Technical Importance Analysis
- Target Values



Design Requirements / Customer Requirements	Importance	Water Temperature °C	Flow Rate (L/s)	Water Pressure (mmHg)	Pressure (mmHg)	Resevior Capacity (L)	Filtration Size (in^3)	Angular Velocity (rpm)	Width (in)	Length (in)	Height (in)	On/Off Controls*	Level*	Pipe Durability*					Improvement Direction				
						+	-		-	-	-	+		+					Customer Competitive Assessment				
																			They Have	We Have	Both Have	N/A	
Water Pump	5	3	9	9	9	1		3	3	3	3	9	1	9							X		
Water Heater	5	9							3	3	3	9	1	9							X		
Heat On/Off	5	9										9		3						X			
System On/Off	5	3	3	3	3	3		9				9		3						X			
Fast Cleaning	3		9	9	9	3		3				3								X			
Leveling System	3												9							X			
Mesh Filtration	4		3	3			9		3	3	3											X	
Universal Plugs	3													3								X	
Timer	3		3									9											
Pulsation	5		3	9	9			3						9							X		
Size	4						3		9	9	9		3										
Sodium Chemical(NaOH)	2		3		3									3							X		
Technical Importance: Absolute		120	129	144	138	29	48	84	78	78	78	216	49	180	0	0	0	0					
Technical Importance: Relative		9%	9%	11%	10%	2%	4%	6%	6%	6%	6%	16%	4%	13%									

Figure 6: Cleaning System QFD

Mason

Literature Review

- **Brain Aneurysm Foundation**
  - Explains types of brain aneurysms and potential for long-term effects following treatment.
  - Team Leader (Steven) and Test Engineer (Milo) need the information to ensure accuracy during the refinement process.
- **In vitro vessel models**
  - Outlines material testing and properties of 3D printed material to replicate human blood vessels.
  - Financial manager (Mason) and Manufacturing Engineers (Muath and Milo) need proper understanding for parts and material purchasing and design for proper fitting and model safety.

Customer Requirements

- **To develop an effective system, we were given the following requirements:**

For the Cleaning System:

- **Pressure/Temperature Gauges**
- **Fluid Heating System**
- **Mesh Filter**
- **Water Reservoir**
- **Timer**
- **Pulsatile Pump**

For the Benchtop Model:

- **A fail-safe switch mechanism at critical pressure threshold.**
- **LabVIEW software to acquire pressure and flow data.**
- **Similar Physiological conditions to human vasculature (Temperature, Viscosity, Pressure, Flow Rate)**

Schedule

- As of this moment we are on schedule.
- A comprehensive overview can be found on the Gantt Chart.

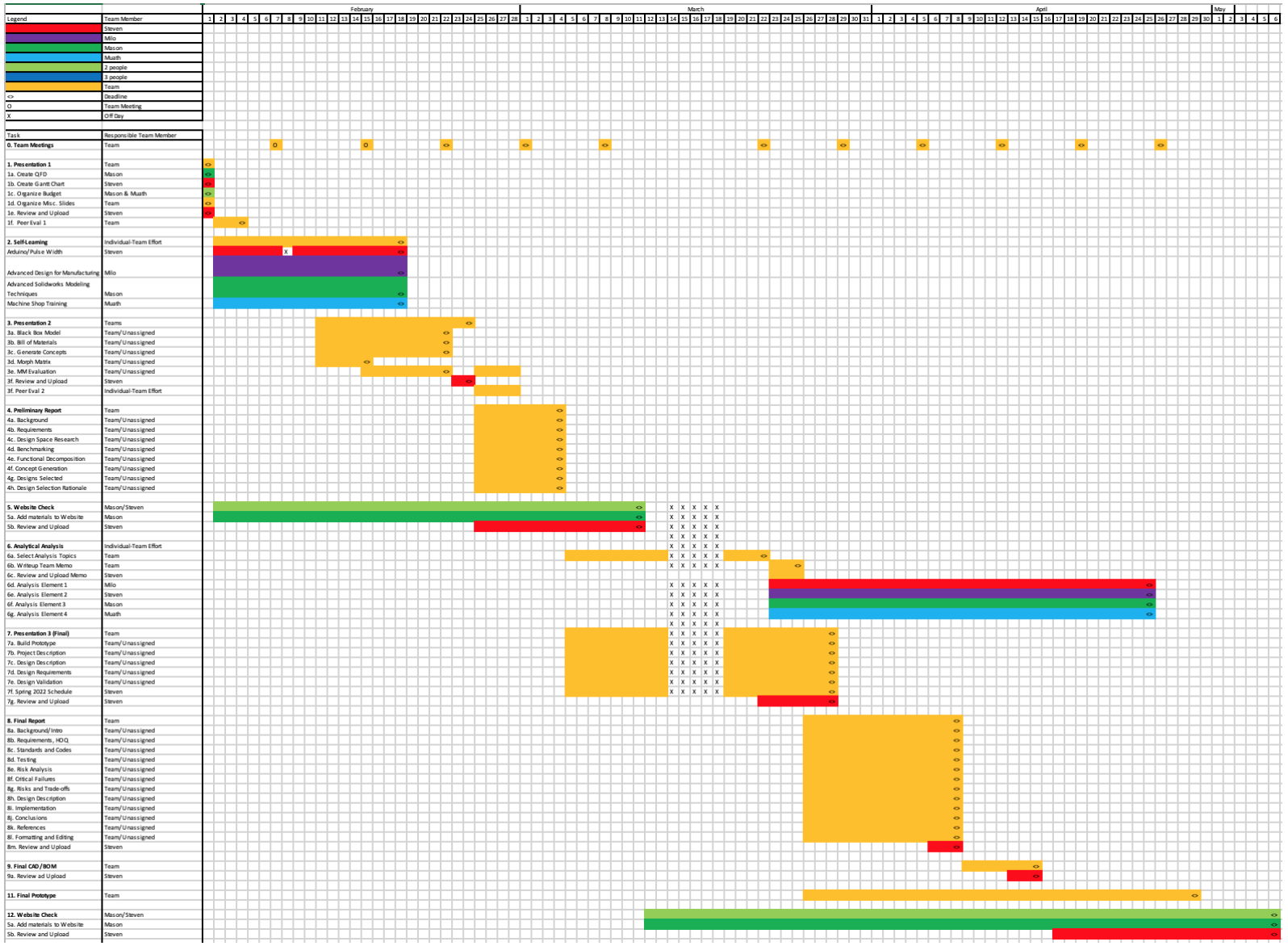


Figure 7. Team Gantt Chart

Budget

- **Total Budget: $1500**
- **Spent to date: $0**
- **Anticipated expenses:**
  - Material/frame for mounting equipment: < $400
  - Pulsating Pump: $70 - $200
  - Heating element/hot plate: Provided
  - Filament for universal connectors: $1.25/gram
  - Miscellaneous Gauges (Pressure/Temperature): Provided
  - Electronics: $100
  - Contingency Budget: $500

References

[1] Bafound.org. 2022. *Statistics and Facts – Brain Aneurysm Foundation*. [online] Available at: <https://www.bafound.org/about-brain-aneurysms/brain-aneurysm-basics/brain-aneurysm-statistics-and-facts/#:~:text=Ruptured%20brain%20aneurysms%20are%20fatal,die%20before%20reaching%20the%20hospital.> [Accessed 1 February 2022].

[2] M. AB, "Medical Simulators for Endovascular Therapies | Patient Simulators," *www.mentice.com*. https://www.mentice.com/simulators (accessed Feb. 01, 2022).

[3] "Biomodex," *Compass magazine*. https://compassmag.3ds.com/special-reports/the-personalized-health-revolution/biomodex/ (accessed Feb. 01, 2022).

[4] "3D Stabilizing Platforms | United Biologics." https://unitedbiologics.com/product/pap00v01_3d-pelvis_acrylic_platform/ (accessed Feb. 01, 2022).

[5] Cogswell, P.M., Rischall, M.A., Alexander, A.E. *et al.* Intracranial vasculature 3D printing: review of techniques and manufacturing processes to inform clinical practice. *3D Print Med* **6,** 18 (2020). https://doi.org/10.1186/s41205-020-00071-8

Questions/Feedback?