

Bioengineering Day Poster Addendum (with ABET questions)

1. Desired Needs

- a. Develop ultrasound compatible vascular flow phantoms that mimic complex tumor vasculature and microvascular perfusion networks.
- b. Validate advanced ultrasound imaging modalities such as ULM, CEUS, Doppler, and RF imaging.
- c. Improve visualization and tracking of single blood vessels and microbubble flow in tortuous vascular structures.

2. Constraints

- a. Safety/Regulatory Affairs
 - i. Safe handling of ultrasound systems, perfusion pumps, electrical/imaging equipment, and microbubble contrast agents.
 - ii. Preventing phantom material degradation during experimentation
 - iii. PVA-C freezing and thawing cycles made the process slower
- b. Risks
 - i. Phantom ruptures/leaks, channel obstruction, and air bubble formation
 - ii. Limited experience with ULM imaging and Verasonics reconstruction.
 - iii. PVA-C is a thick compared to agarose so ensuring that the PVA-C powder was dissolved was a concern to not affect the imaging.
- c. Global Impact
 - i. Advanced ultrasound technology is expensive
 - ii. Differences in imaging infrastructure and technical expertise
- d. Manufacturability
 - i. Replicating tortuous microvasculature with narrow vessels is difficult.
 - ii. Material selection required balancing acoustic realism, durability, manufacturability, and cost.
- e. Quality Control/Marketability
 - i. Repeatable channel geometry, stable perfusion, and consistent images

3. Engineering Standards

- a. Tissue-mimicking materials were selected to approximate biological acoustic properties
- b. Phantom architecture and perfusion systems were designed for high-frequency imaging

4. Ethical, Environmental, and Societal concerns

- a. Ethical: Reliable phantom validation reduces risk before clinical implementation
- b. Environmental: Phantom fabrication generates waste from hydrogels, tubing, and failed prototypes
- c. Societal: Improved ultrasound imaging may support earlier tumor detection & diagnostics

5. Active Teamwork and Leadership

- a. Collaboration and brainstorming was shared. Different opinions were welcomed and the combination of them ultimately led to the narrowing of our project scope
- b. Subprojects were delegated. At times, lack of structure & communication hurt progress
- c. Everyone contributed towards reaching our established goals and deadlines.
- d. After constructive feedback, one would help where help was needed.

6. Motivating Factors

- a. New knowledge:
 - a) acquire **new knowledge**

Learning about ultrasound imaging, ULM, tissue-mimicking materials, and phantom fabrication motivated us to explore new engineering concepts outside of the classroom. As well as Fusion 360 and CAD software skills.

b) be **self-initiating**

Many fabrication methods required independent troubleshooting, testing, and redesign because there was no single established workflow for our phantom design.

c) **persist** against challenges and setbacks.

Challenges such as phantom leakage, difficult material preparation, and failed channel fabrication required repeated redesigns and testing throughout the project. These failures were taken into account when looking at new materials and alternating solutions.

7. What are your most innovative and/or entrepreneurial ideas for this project

1. Developing customizable and low-cost vascular phantoms for ultrasound imaging validation.
2. Potential development of reusable educational or research phantoms for imaging laboratories and biomedical engineering training.