

Title: 3D Printed Respiratory Motion Phantom PgR 2

Date: 9/23/2026

Client: Dr. Andrew Shepard

Advisor: Prof. Mehmet Orman

Team:

Student 1: Matthew Niemuth - Team Leader

Student 2: Royal Swick - Communicator

Student 3: Drew Kruse - BSAC

Student 4: Natalie Waibel - BWIG

Student 5: Avi Ganti - Co-BPAG

Student 6: Jahan Ingraham - Co-BPAG

Problem statement: Design and Fabricate a 3D-printed respiratory motion phantom insert that simulates two lung lesions with realistic density and anatomy for evaluation of real-time tumor tracking during radiotherapy.

Brief status update: This week, the team came up with a few preliminary designs to discuss with the client at the second client meeting. Once we get feedback about our designs, we can start creating our design matrix and criteria to go with it before the preliminary presentation next week.

Difficulties / **advice requests**: What would you like to know more about? Any particular questions you want us to ask to the client after this meeting? What questions set us up for the best success in the design process?

Current design: Awaiting Feedback from Client once we meet on Friday

Materials and expenses:

Item	Description	Manufac-turer	Mft Pt#	Vendo r	Vendo r Cat#	Date	#	Cost Each	Total	Link
Category 1										
									\$0.00	
									\$0.00	
Category 2										
									\$0.00	
									\$0.00	
								TOTAL:	\$0.00	

Goals

Major team goals for the next week

1. Consider feedback from Dr. Shepard on preliminary designs and create a design matrix and criteria to weigh each design by. Choose one based on determined criteria to move forward with and clarify with the client.
2. Get the preliminary presentation completed before next Friday, and begin working on the Preliminary Report due the following week.
3. Create 3D models of selected designs in SolidWorks if time on top of other goals.

Next week's individual goals

- Royal Swick
 - Meet with Dr. Shepherd on Friday and get dimensions on the phantom and a better idea of how the phantom integrates with the QUASAR system. Find specific materials to be used for the phantom and the tumors and look at places to order the materials. Begin working on the preliminary presentation.
- Matthew Niemuth
 - Continue to conduct more research on respiratory phantoms, radiotherapy techniques, and materials. Complete the preliminary presentation and meet with the team to practice presenting. Also begin thinking about the preliminary report.
- Drew Kruse
 - The client meeting is Friday, so we will take detailed notes on what we learn from him and being in the clinic. We will ask many questions as we need to in our meeting at the hospital to get the most out of our first time seeing the device in person. We will also work on our report and presentation.
- Natalie Waibel
 - Meet with Dr. Shepherd to get dimensions of the phantom and a better understanding of the QUASAR system's role in medicine. Research materials to use in our design.
- Jahan Ingraham
 - Get a better understanding of what specific characteristics of our designs the client wants on Friday and create options to present.
- Avi Ganti
 - Meet with Dr. Shepard to ask specific questions to further my understanding of the QUASAR system. Sketch preliminary designs to figure out dimensions and costs of potential materials. Attend the BPAG meeting in order to further understand my role as we get closer to the prototyping stage.

Timeline:

Task	Sep			Oct					Nov				Dec	
	12	19	26	3	8	17	24	31	7	14	21	28	5	10
Project R&D														
Research	X	X												
Design														
Prototyping														
Testings														
Deliverables														
Progress Reports	X	X												
PDS		X												
Design Matrix														
Prelim Presentation														
Prelim Report														
Final Poster														
Final Report														
Meetings														
Client		X												
Advisor	X													
Website														
Update														

Filled boxes = projected timeline

X = task was worked on or completed

Detailed accomplishments

Previous week's goals and accomplishments

- Royal Swick:
 - Previous Goals: Attend the client meeting to get the dimensions of the phantom and understand how it integrates with the QUASAR system. Begin sketching designs.
 - Accomplishments: The meeting was delayed until Friday so I was not able to get specific dimensions, however, I sketched a couple designs that I will be able to refine once seeing the set up in person. I also researched where we can get materials and I found that UW-Madison shops have PLA and PLA-CF which, if their infill density is altered, can replicate the tissue in a human lung and tumors on a CT scan.
- Matthew Niemuth
 - Previous Goals: Continue to conduct more research on respiratory phantoms, radiotherapy techniques, and materials. Meet with Dr. Shepard on Wednesday to learn more about and ask questions regarding the phantom's integration with the QUASAR system and other radiotherapy technology involved in Lung Cancer treatment.

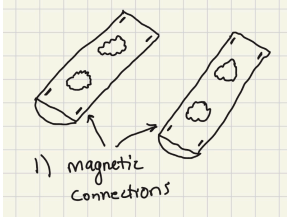
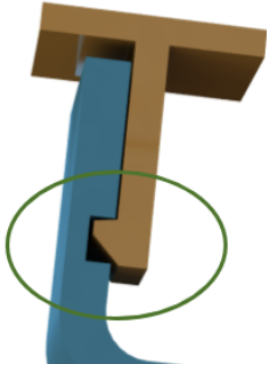
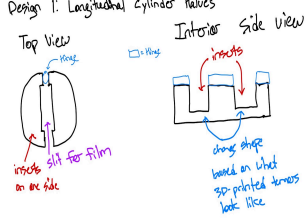
- Accomplishments: I completed additional research regarding materials and how different materials based on their densities show up differently on CT scans. This means our material selection has to be precise based on densities of healthy lung tissue and tumor tissue so the scans can tell the difference. I also updated LabArchives with team and advisor meeting notes as well as added the PDS to project files. The last thing I did was draw out preliminary designs, create the design matrix, and come up with the design matrix criteria and explain what they are and why they are weighted in that way.
- Drew Kruse
 - Previous Goals: Keep learning about the project and informing each other, so we can all have a comprehensive idea of the whole system as well as the small part of the system we will be working on exclusively. After completing extensive research on competing designs and standards, I think I will be able to help brainstorm compliant designs for our presentation.
 - Accomplishments: Did some research on materials and the 3D slicer technology, I also drew up some design ideas to compare with our teammates. We all met and talked about designs and what we should do to prepare for our client meeting.
- Jahan Ingraham
 - Previous Goals: Continue research on the lung phantom specifically how to realistically print tumor density and begin stitching and creating preliminary design ideas.
 - Accomplishments: Sketched up rough preliminary designs to compare with teammates and think about the main designs we will present next week.
- Natalie Waibel
 - Previous Goals: Look at Quasar machine and get measurements and start designing.
 - Accomplishments: Sketched out the phantom design and researched more on specific components of the phantom since we didn't get to meet.
- Avi Ganti
 - Previous Goals: Meet with Dr Shepard and begin to sketch out designs.
 - Accomplishments: Researched a lot about the reliability of the phantoms and the specific types of tumors they can analyze. Found legislation regarding safety measures and requirements we will need to follow both in the product we make as well as when we use the system.

Activities

Name	Date	Activity	Time (h)	Week Total (h)	Sem. Total (h)
Matthew Niemuth	9/16/26	Spent time researching, briefly sketching out preliminary designs, creating the design matrix, coming up with and describing design matrix criteria, and updating lab archives.	6	6	10
Royal Swick	9/16/26	- Conducted research about materials and where we can get them from - Completed progress report - Sketched some design ideas and	3	3	10

		helped complete the design matrix			
Drew Kruse	9/17/2026	- Conducted research about competing designs and standards - Learned more about the purpose of the machine and project. - Finished PDS and progress report	3	3	9
Natalie Waibel	9/17/26	- Conducted research to sketch out a design - Sketched out a design - Jotted down some questions to ask the client	4	4	6
Avi Ganti	9/17/26	- Completed progress report - Contributed to design matrix - Researched different density materials to differentiate tumors - Figured out questions to ask client in rescheduled meeting	3	3	9
Jahan Ingraham	9/16/16	Continued research on replicating tumor density for the phantom, worked on progress report, and began preliminary design sketches.	2	2	8

Design Matrix:

Design		Magnet Design with PLA and PLA-CF		Snap-Fit Joint Design		Hinge Design with different infill densities	
Design Image							
Criteria	Weight	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Compatibility	30	4/5	24	4/5	24	4/5	24
Differentiability	20	4/5	16	3/5	12	4/5	16
Repeatability/Durability	20	5/5	20	3/5	12	3/5	12
Ease of Use	15	4/5	12	3/5	9	2/5	6
Ease of Fabrication	10	4/5	8	3/5	6	3/5	6
Cost	5	2/5	2	5/5	5	3/5	3
Total	100	82		68		67	

Criteria:

Criteria:

Compatibility: Compatibility is how well the phantom fits with the QUASAR system in respect to size, motion, and how easily it attaches to the system. This is by far the most important criteria to consider in the design because if the phantom is not compatible with the system, then the system can not be used to validate the radiotherapy treatment before patient use. This validation is necessary to limit surrounding healthy tissue exposure to radiation. Additionally, this criteria includes the phantom's ability to store 2 or more tumor inserts.

Differentiability: Differentiability is how easy it is to tell the material of the phantom apart from the tumor inserts on the CT scans. This weight is high because if the CT scan can not differentiate between the tumors and the phantom, the motion

tracking performed by the QUASAR system may not be able to accurately track the tumors, and therefore not be able to accurately validate the planned radiotherapy treatment for the patient to limit unnecessary exposure to radiation.

Repeatability/Durability: Repeatability is how reliably the phantom maintains its structural integrity and fits over time with continuous use. The phantom has to handle constant motion and repeated assembly without snapping, wearing down, or getting loose. This is essential for keeping the phantom reliable for long-term use, ensuring that every validation test yields consistent, dependable results every time it's run on the QUASAR system.

Ease of Use: Ease of use is how easy and efficient this device is to use in practice for the physicians. There should be too many moving parts to overcomplicate protocols for the doctors. It is important in the clinic because efficiency is key to some cases, and if a device is easy to use, that is one less thing to worry about in what can be a high stress environment.

Ease of Fabrication: Ease of fabrication is how feasible it is to manufacture the phantom. This weight is somewhat important, but not a main factor in determining the design to move forward with. Whether the design is difficult or easy to fabricate, it will be made. Nonetheless, if one design is significantly easier to fabricate, it will score higher in this category versus if there is only a slight increase in difficulty.

Cost: Cost is how expensive creating the phantom will be. This is not weighted to be as important because the manufacturing method will be 3D printing which is not very expensive at only around \$10-15 per prototype so all designs will cost a similar amount to create. An additional cost to consider is what will be used to attach the two halves of the phantom.

Safety: Safety involves the risk posed to the user during the validation of the treatment plan. Since the phantom will be attached to the system and have minimal interaction with the user, there is low risk and therefore safety has a low weight. Another factor contributing to this low weight is the fact the patient will not come in contact with or use the phantom at all.