Project Design Specification Report

Bed Controller

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Problem Statement:

To develop and design an animal bed system that will be able to translate in the x, y, and z directions, as well as angular motion. This bed system must be capable to work in micro CT, micro PET, and micro RT systems. Must design a platform for mice that can move in the treatment area. The bed must have at least five degrees of freedom: movement in all three axial directions and rotation about the x and y-axis. The bed system should also be made with oxygen and isoflourine ducts to keep the subject unconscious. If possible design should incorporate a heat pad and other vital readings during the treatment like: heart rate, blood pressure, temperature, etc. In addition, shielding of the animal bed system may be required to attenuate the treatment X-rays. Our positioning system must be made with a low-density material and made so that it does interfere with the imaging systems. The specimen bed should be designed so that the specimen is positioned in the same way each time for imaging or therapy.

Client Requirements:

- Should have 5 DOF, all 6 if possible: rotation about the x-axis, y-axis, and movement in the x, y and z direction
- Should have movement with 0.1mm precision up to 1 cm in xy and up to 75 cm in z
- Should have rotational movement up to 5 degree with 0.1 degree precision on both sides

Design Requirements:

1. Physical and Operational Characteristics

a. *Performance Requirements:* A mouse or similar sized animal will be lowered onto the device from above and then will be moved into the machine, along the z-axis, by our positioning system. Our positioning system must be very precise to place our animal in the same position as the last test.

b. Safety: The client's device will include an x-ray system, so we may have to come up with a shielding method.

c. *Accuracy and Reliability:* Our animal positioning system must have precision in the x, y, and z-direction of 100 microns up to 75 cm in the z-direction, and 1 cm in the x and y-directions.

d. Shelf Life: Will be incorporated into the client's imaging system so it will need to work many times.

e. *Operating Environment:* The holding device will undergo both CT and PET scans, but the motor system will remain outside. Our device will be housed inside the client's device.

f. Ergonomics: Qualified technicians should be using the machine with animals similar in size to a large rat or a small, skinny bunny.

g. *Size:* The hole in which our bed will be inserted has a diameter of 12 cm, so our bed will be a maximum of10 cm wide to incorporate a cm of movement along the x-axis but will be more likely 5 cm wide.

h. *Materials:* We need to use a low-density but sturdy material, such as carbon fiber, for the bed as to not interfere with x-rays and stay rigid even at 75 cm.

2. Production Characteristics

a. *Quantity:* Only one device will be needed

b. *Target Product Cost:* Our client has not given us a limit. However, he would like us to keep it as cheap as possible so groups looking to build his device will not be discouraged.

3. Miscellaneous

a. *Standards and Specifications*: The device is an animal positioning system which holds specimen (mostly rats for this project) in an imaging and radiotherapy system for CT micro, PET and micro RT scanning. This positioning system has five degrees of freedom in x, y, z direction and angular motion about the x and y-axis in the imaging and radiotherapy system. General specifications on the functional aspect of this device include:

-Positioning specimen in a particular way all the time on the animal bed.

-Enabling the bed to freely move in and out from the imaging and radiotherapy system in specified distance (75 cm).

-Enabling the bed to translate and rotate in x, y and z direction inside the imaging and radiotherapy system with specified distance (1 cm), angle (5 degrees) and precision (0.1 mm and 0.1 degree)

-Facilitating the system with oxygen duct, isofluorine duct and probes for carrying out certain supplemental tasks during scanning.

b. *Customer:* The customer mentioned that this animal positioning system is preferred to be in rectangular shape, which would fit better for a rat specimen's physical shape. In addition, the customer pointed out that among the six degrees of freedom for translation and rotation, the function of rotation motion on z- axis would be the least significant and can be neglected if it causes tremendous works or delays on the whole project, as the imaging and radiotherapy system itself can rotate in this way to compensate it. Besides these two points and answering questions, no further ideas and specifications about the project were provided yet. Variations and creativity are allowed and encouraged, which lower down the possibility of existing prejudices.

c. *Patient-related concerns:* The patient for our design will be a mouse or other small animal. The most important element of our design for the patient will be the oxygen and isoflourine ducts, which will allow the patient to breathe and keep it unconscious. In addition, the patient will need to be fully supported during the scanning and treatment procedures by the stage.

d. *Competition:* The goal of the project is to make this technology accessible by making this small animal imaging and therapy system design open source and freely available. To do this it should be less expensive than existing systems (both
the entire product and our bed controller design). Examples of existing systems, which include small animal positioning systems, include:

-Siemens Inveon PET and CT scanner: commercially available product, our group will be able to see week of 9/18

-GE Triumph: commercially available PET/SPECT/CT imaging product

-SARRP (Small Animal Radiation Research Platform): Developed at Johns Hopkins and commercialized by Xstrahl, it has a robotic animal positioning system with 4 degrees of freedom (X, Y, Z, and Θ)

-X-Rad 225Cx by Precision X-Ray Inc.: has 3D computer controlled stage, makes automated stage corrections