Background

The FeedRite Feeding Tube is the next generation in naso-duodenal/naso-jejunal (ND/NJ) feeding. Currently, ND/NJ feeding tubes are placed with one of two main methods. The first method, fluoroscopy, accurately places tubes in the duodenum and jejunum. However, it is a notoriously slow process and often requires repeated fluoroscopic procedures, exposing the patient to unnecessary amounts of radiation. The second method relies on RF communication between the tube and a receiver placed on the xiphoid process. This method is relatively safe, but often results in improper tube placement.

Instead of using external indicators like those previously mentioned, the FeedRite Feeding Tube utilizes the body's natural physiology to determine tube location in the gastrointestinal tract. By relying on known pH and pressure differences between the stomach, duodenum, and jejunum, FeedRite plans to accurately, safely, and efficiently place ND/NJ tubes.

Achievements since last report

Our team has focused on the business end of our project during this week. We prepared a description and illustration of our device and its anticipated impact. We also met with our advisor so that he could approve our sensors and our testing chamber. This week we also visited CELA to see the equipment available. While our chamber will demonstrate the sensors' ability to detect pH and pressure changes, we hope to use the equipment at CELA to test our devices physical structure and its compatibility with the size and shape of the typical foregut. We will be using an upper GI SimMan at CELA once we have purchased our tubing material.

Upon meeting with Dr. Abumrad last week, we have determined that the best strategy moving forward is to exert most of our attention on finding a suitable pH probe for a micro-scale prototype. Dr. Abumrad believes pH to be the physiological indicator with the highest resolution between the stomach and duodenum. Even in diseased states where pH might be higher around 3-5, the duodenum offers a pH around 7 consistently, making pH a widely applicable metric to investigate. As such, we have begun an in-depth search to find appropriate micro-pH sensors.

Here is a summary of potential sensors:

Sensor	pH range	response time	Resolution	Temp Range	Tip Diameter	Max diameter
Presens	2-10	<10s	0.1 pH units	-10-60C	10-600um	11mm
Amani Leak-Free	0-14	3s	-----	0-100C	650um	75mm
Micro Combination pH electrode	1-12	-----	-------	---------	1mm	-----

Microset HF series	0-14	------	----	0-100C	150x25.9mm	
Presens	5.5-8.5	30s	0.01pH units	5-50C	150um	900um

In addition to these commercial micro pH sensors, there are a good number of new sensors being developed in academia. Due to the very high cost of some of the commercial sensors and required hardware, we will be exploring the possibility of renting or purchasing one of these experimental sensors instead. During the next week, we will be contacting various labs to get specifics on sensor parameters, if there are any available to use, and the costs associated with renting or purchasing these systems. We are in the final stages of securing quotes from all of the commercial sensor companies. After we have received all necessary information on sensor parameters and pricing, we will be able to identify the sensor that best fits our needs and begin constructing our final device.

We have made progress in the physical appearance of our testing chamber. To show the desired change in pressure, the chamber will need a height of approximately one meter. The chamber will be clear in color and will be filled with colored but relatively transparent liquids so that the audience will have a visual cue of when to expect changes in pH. Potential materials for the chamber include clear PVC pipe (http://www.homedepot.com/) , clear acrylic tubing (http://www.eplastics.com/plexiglass-cast-acrylic-tubing), and standard food storage containers. We will be finalizing the design of the testing chamber and purchasing the materials in preparation to begin building in the next two weeks.

The estimated pH and density values for each buffer we plan to use are listed below. Alcohol represents the esophagus, vinegar represents the stomach, and dish soap represents the small intestine. We will use a thin layer of vegetable oil to separate vinegar from mixing with alcohol. One concern is that we may see a reaction between vinegar and dish soap. We will experiment on various buffers to find the most compatible combination in the following week.

	Density (g/cm^3)	pH
Swan Isopropyl Alcohol, 99%	0.785	7
Vegetable Oil (a thin layer for separation)	0.92	NO
Heinz Distilled White Vinegar	1.01	2.4
Dawn Ultra Concentrated Antibacterial Hand Soap Dishwashing Liquid	1.06	9

Problems that have arisen

While the contents of the testing chamber are easy to find, the actual tube is more difficult. We would like to use a cylinder with one closed end and another capped end. The benefit to a capped end is we will be able to remove the cap for the demonstration without having to refill the tube each time. This will save time and money in the future. However, standard storage containers will not have the approximately one meter height we desire. One meter is needed to show an appreciable change in pressure. However, if we choose to move forward with only a pH probe, we may be able to use a considerably smaller testing chamber.

When building the pH sensor circuit and connecting the probe last week, the pH readings were highly variable and incorrect. The company suggested integrating a pH shield into our circuit to acquire more reliable readings. We have recently received this shield and are working on completing this circuit.

Future Steps

With the arrival of our pH shield, we anticipate having a functional circuit and code before our next presentation. We will also be choosing and purchasing the materials for the testing chamber including the cylindrical container and inner solutions.

Assessment of Schedule, Budget, and Objectives

After meeting with our advisor, we have re-oriented our plan to focus on the pH probe. Our needs assessment necessitates two methods of tracking the placement of the tube, and we chose to measure pH and pressure as our indicators. However, pH will be the main indication of placement, so we are focusing our efforts on building our pH probe and sensor. Once we have a functional prototype testing pH, we may be able to incorporate pressure measurements into the design. We have recently purchased a waterproof pressure sensor that we hope be able to use in our testing chamber.

Our choice of materials for the testing chamber will allow a low cost but effective demonstration of our device. By using this chamber and the resources at CELA to test our device, we will save money we would have needed to allocate to testing. This will potentially allow us more flexibility in our budget should we move onto using microsensors in our final design. As of now, the available microsensors are out of budget for the scope of this project. However, we will research these sensors and how to incorporate them into our design in the event that our sponsor decides to use the design in patients in the future.

Gantt Chart

ID	Task Name	Start	Finish	Duration
1	Configure pH Sensor	3/2/2016	3/14/2016	9d
2	Configure Pressure Sensor	3/14/2016	3/21/2016	6d
3	Waterproof pressure circuitboard	3/15/2016	3/21/2016	4d 4h
4	Build pH and Pressure testing chamber	3/14/2016	3/18/2016	5d
5	Test tubing on SimMan	3/21/2016	3/22/2016	2d
6	Investigate micro-pH sensors	3/23/2016	4/15/2016	18d
7	Develop future plan to integrate micro sensors into system	3/28/2016	4/25/2016	21d
8	Prepare Design Day Presentation	4/11/2016	5/2/2016	16d