Esophageal Simulator

- Joel Schmocker ~ Leader
- Luke Juckett ~ Communicator
- Ian Linsmeier ~ BSAC
- Tyler Klann ~ BWIG
- Bonnie Reinke ~ Client Eso-Technologies
- Stephen Gorski ~ Client Eso-Technologies
- John Webster ~ Advisor
- Dept of Biomedical Engineering

Outline

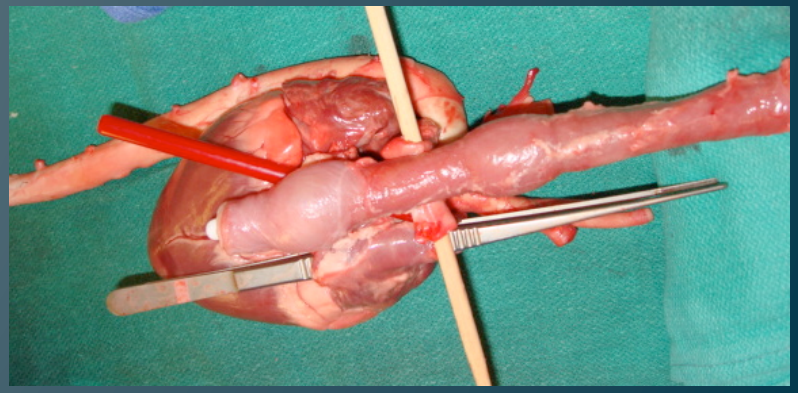
- Problem Statement
- Current Testing Methods
- Background information
- Design Specifications
- Work Completed/Components
- Design Alternatives
- Future Work

Problem Statement

Eso-technologies cardiac monitor, is designed to replace the Pulmonary Artery Catheter. The probe is placed in the esophagus to measure the pressure waveforms of the heart and lungs through the wall of the esophagus. Our goal is to design an esophageal simulator to test the Eso-technologies esophageal probe. It should minimizes patient interaction while allowing quicker testing and refinement of the esophageal probe. Our device needs to be able to mimic the pressure waveforms of the heart and lungs.

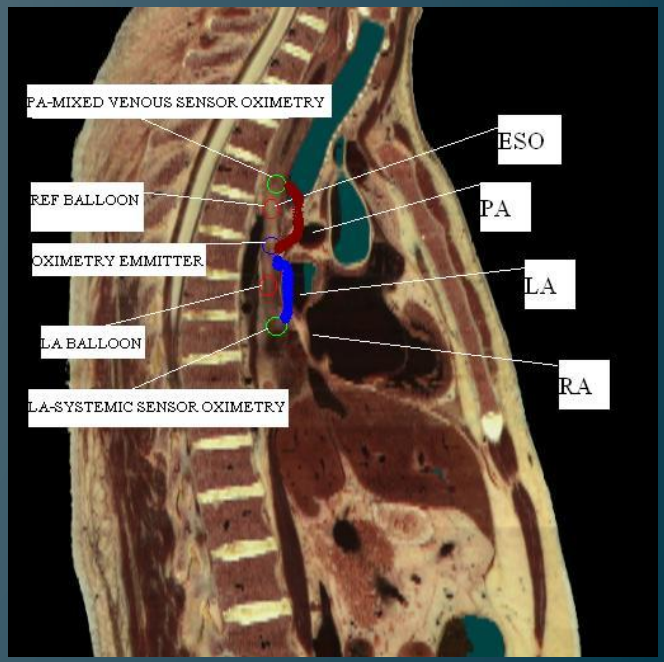
Current Testing Methods

- Eso-technologies' esophageal probe still in refinement phase
  - Testing is done in clinical trials
  - FDA has limited the probe to 40 clinical trials
- Limiting patient interaction
  - More tests per probe
  - More opportunities for improvement
  - Avoids potential clinical mishaps



Background

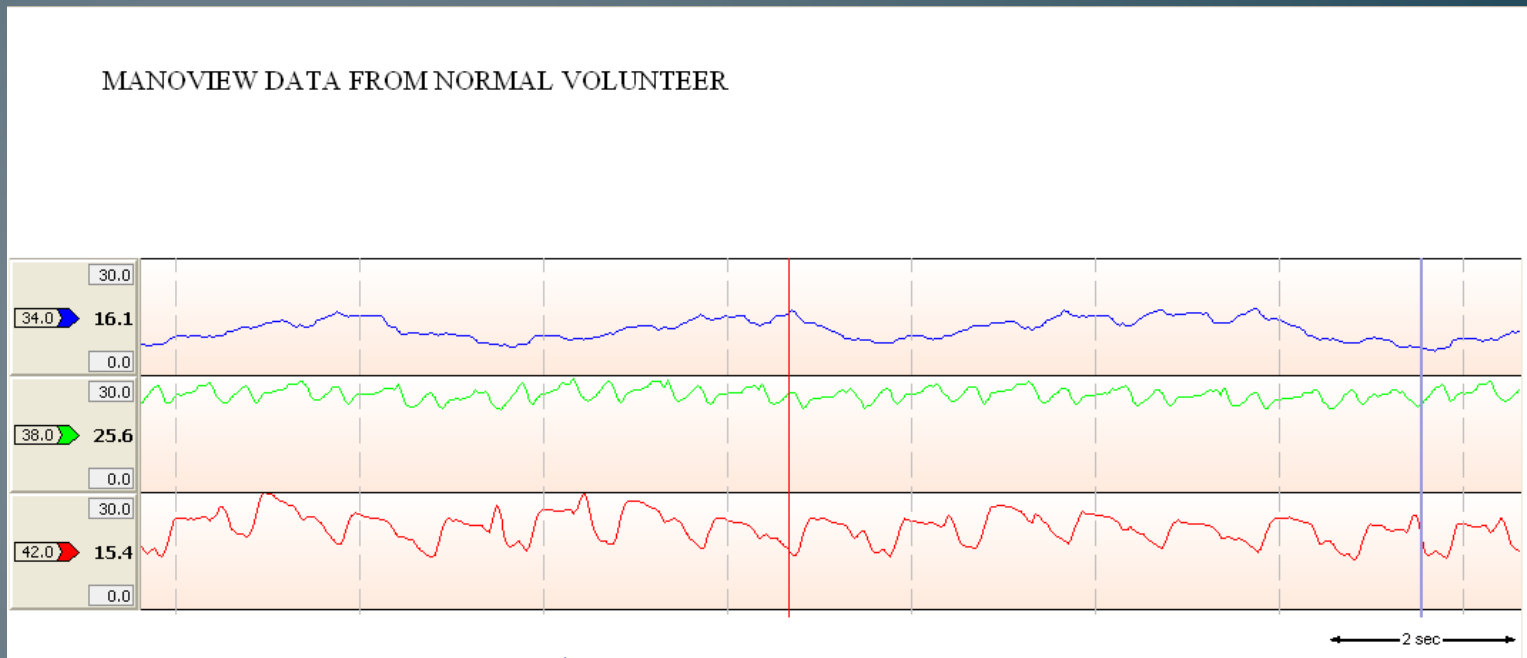
- Pulmonary Artery Catheter
  - Causes 40,000 problems per year
  - Invasive
- Anatomy of Esophagus
  - Resides in chest cavity
  - In contact with left atrium wall

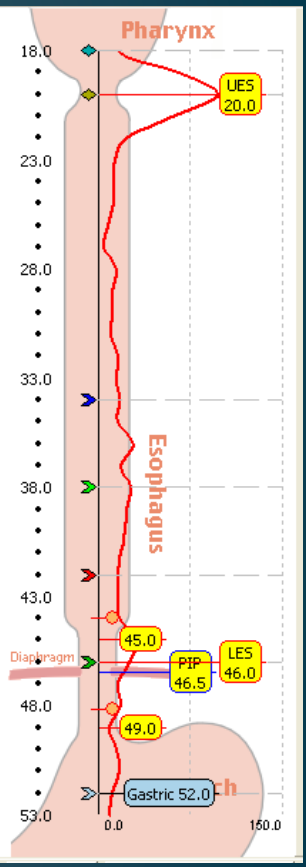


Product Design Specifications

- Incorporate new Eso-Technologies esophageal probe design
- Respiratory Pressure
  - Range: 0 to 2.93 KPa (3 to 8 cycles per minute)
- Esophageal Pressure
  - Static: 0 to 6.67 KPa mmHg
- Cardiac Pressure
  - .800 to 2.93 KPa (60 to 120 per minute)
- Balloons
  - Reference Balloon ~ records respiratory pressure waveform
  - Recording Balloon ~ records respiratory and cardiac pressure waveforms
  - Recording Balloon – Reference Balloon = Cardiac Waveform

MANOVIEW DATA FROM NORMAL VOLUNTEER





BLUE TRACING: 34cm on MANOVIEW ~ 29 cm on ESO scale

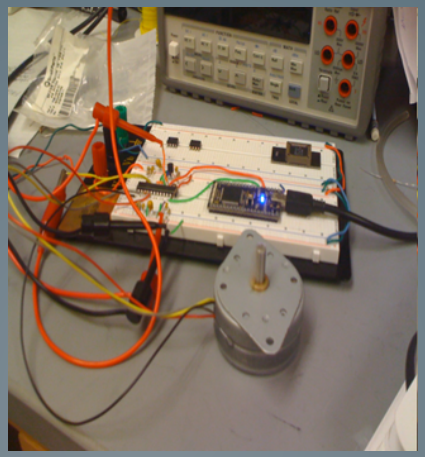
GREEN TRACING: 38 cm on MANOVIEW ~ 33 cm on ESO scale

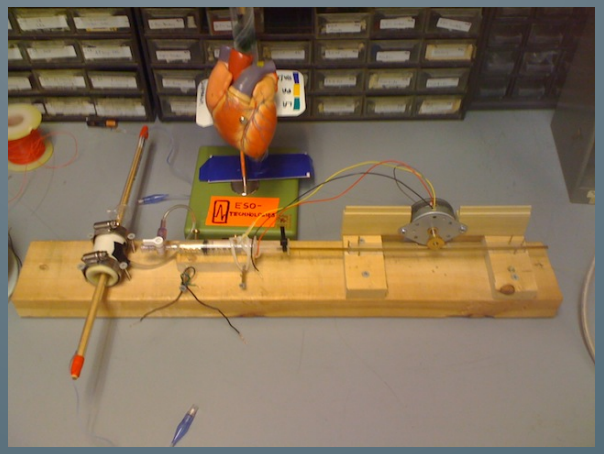
RED TRACING: 42 cm on MANOVIEW ~ 37 cm on ESO scale

THE ESO TECHNOLOGIES HYPOTHESIS IS AS FOLLOWS:

GREEN (LAP) - BLUE (REFERENCE) = LEFT ATRIAL PRESSURE

Work Completed





- Microcontroller
  - mbed NXP LPC1768
  - Sends phase signals to driver
  - C++ Code
- Stepper Motor Driver
  - L6219
  - Drives stepper motor
- Motor
  - 55M048D
  - Drives syringe to create pressure changes

Components

- Stepper motor
  - Programmed to drive syringe and create pressure waveforms
- Syringe
  - Pumps air into “esophagus” simulator
- Pressure sensor to measure output and provide a feedback loop
- Rack and Pinion
  - Converts rotational motion of motor to linear motion of syringe
- Flexible membrane that transmits pressure to the sensor
  - Pen-rose drain

Gear Reduction System

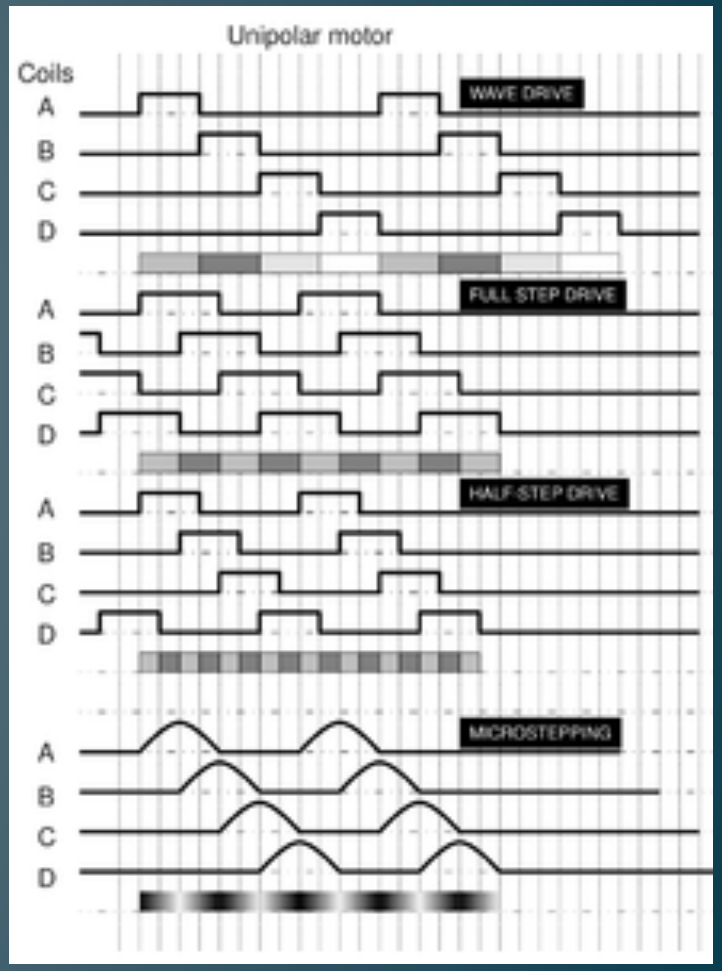
- Faster motor speeds with slower output rotation
  - Leads to higher resolution and better control
- Implementation
  - Pre-manufactured gear reduction system
  - External rack and pinion system

http://www.partshp.com/Gear1.jpg

Micro-step Mode

- Increase number of steps per rotation
  - Better control
  - Changes in program rather than physical components

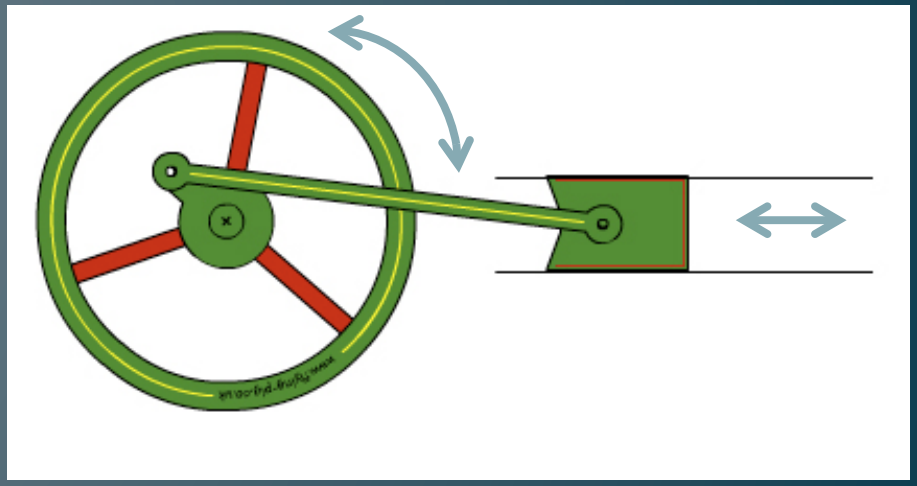
http://www.lirtex.com/images/electronics/StepperMotorController/StepperMotor.jpg



http://en.wikipedia.org/wiki/Stepper_motor#Microstepping

Piston-like System

- Simple transition from rotational motion to linear motion
  - Easier motor control
- Implementation
  - Simple attachment
  - Poor resolution



http://www.makingthingsmove.org/blog/wp-content/uploads/2008/10/piston.jpg

Design Matrix

	Resolution (40)	Design Incorporation (25)	Cost (10)	Programming (25)	Total (100)
Micro-step Mode	**33**	**23**	**10**	**13**	**79**
Gear Reduction System	**32**	**15**	**7**	**17**	**71**
Piston-like System	**27**	**20**	**4**	**15**	**66**

Future Work

- Pressure Sensor
  - Calibration and implementation
- Programming
  - Micro-step mode
  - Pressure Output Graph
- Replication
- Balloon Relationship
  - Recording Balloon – Reference Balloon = LA Cardiac Pressure Waveform
- Testing
  - Compare Eso-Technologies probe measurements vs. pressure sensor measurements

Acknowledgements

- Eso-Technologies
  - Bonnie Reinke and Stephen Gorski
- Dr. Chris Reikersdorfer
- John Webster
- Dennis Bahr
- Amit Nimunkar
- Peter Klomberg