IPRO 344

Improving Energy Efficiency and Offering Quality Audio in Mobile Devices and Intercom Systems

Objectives

- **Overall Goals**
  - Create an industry standard for testing and implementing drive thru systems
- **Immediate Goals**
  - Obtain quantitative data on the quality of sound capture for two-way communication systems
  - Create a refined prototype Drive-Thru kiosk
  - Analyze common sources of noise in the Drive-Thru environment

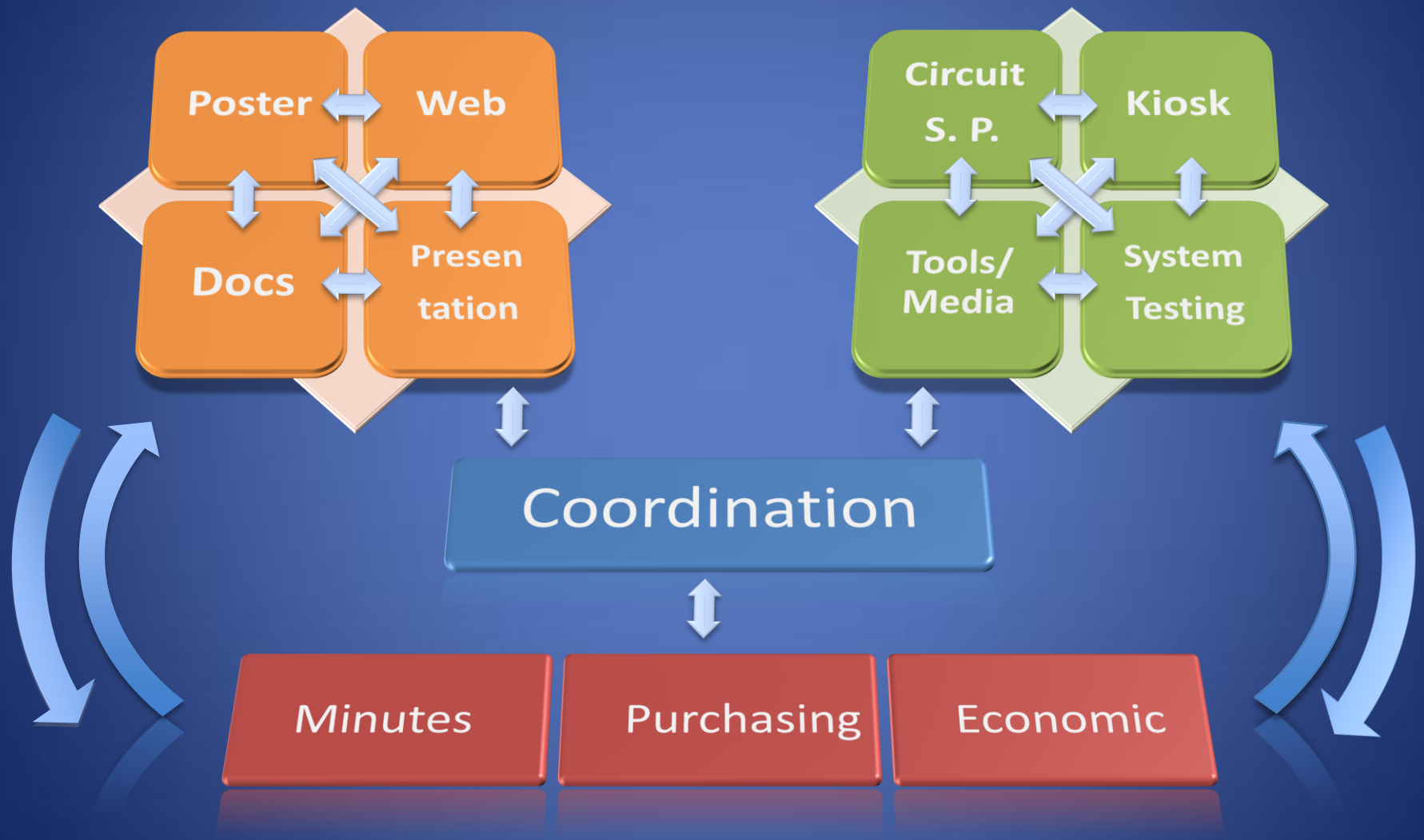
Background

- Businesses seek new and innovative ways to remain competitive
- Over 50% of inaccuracy in drive-thru occurs during order capture
- Results from poor acoustic performance

Past Semesters' Progress

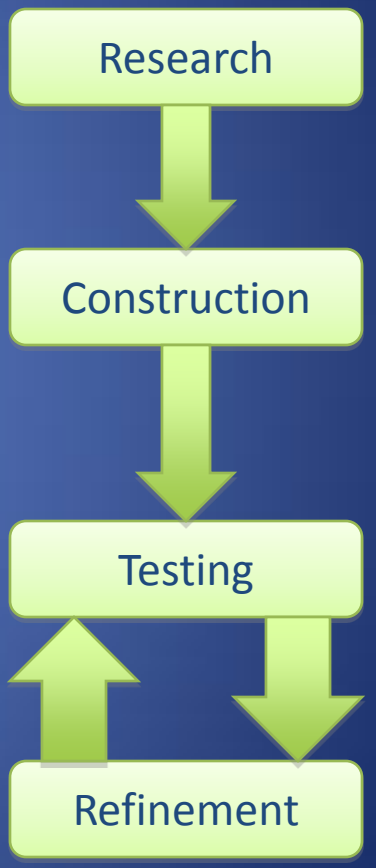
- Identified Class-D Amplifiers as energy efficient and high quality in audio application
- Designed preamplifiers for headset and kiosk microphones
- Developed a full two-way communication system

Team Structure



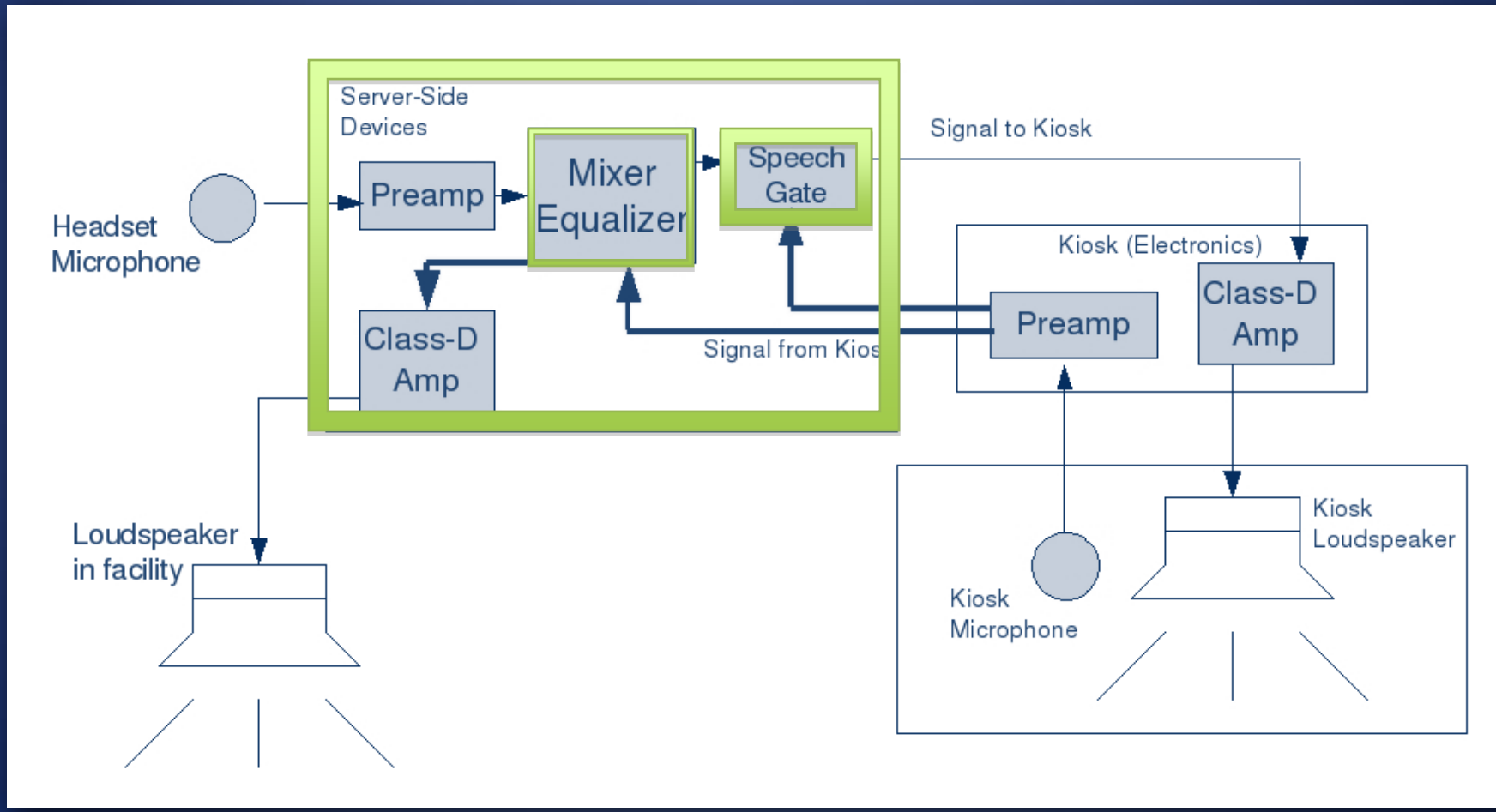
Project Approach

- Phase I: Research & Construction
  - Design and construct the kiosk
  - Design and Implement a two-way communication system
- Phase II: Testing
  - Determine the intelligibility of the system under several conditions
- Phase III: Refinement
  - Use Phase II results for improvement of the system



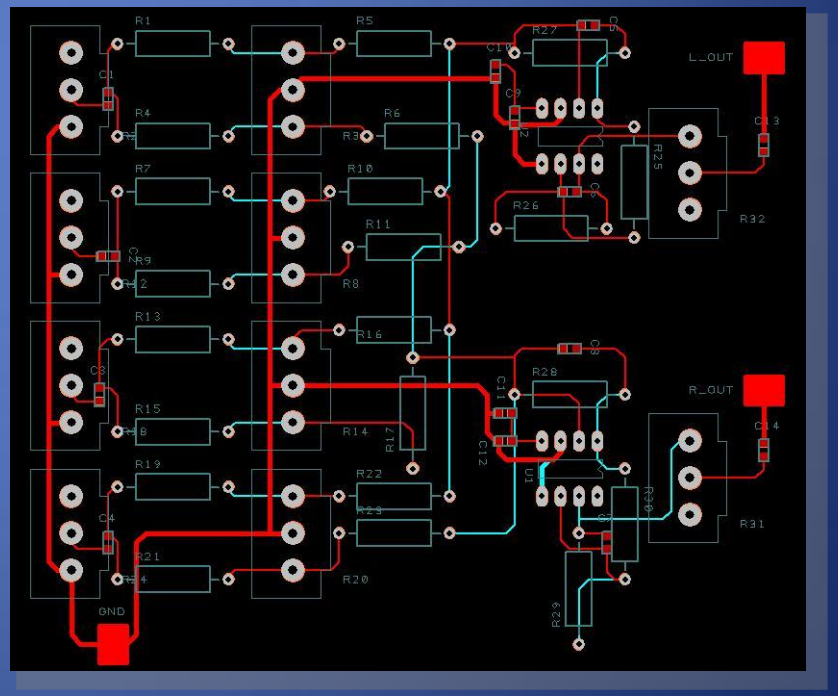
Achievements

System Diagram



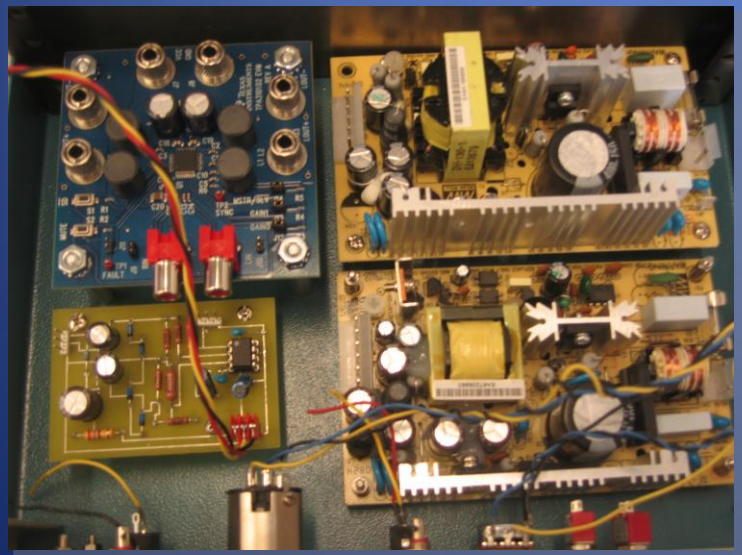
New Components

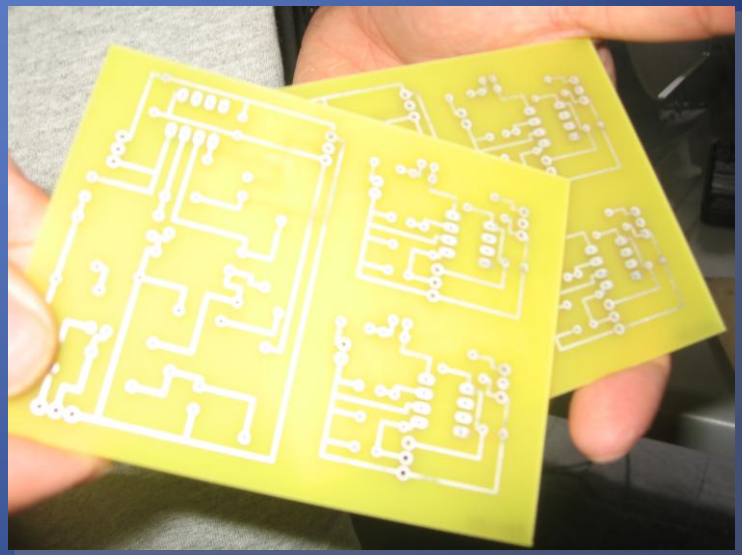
- 4 Channel Mixer
- Equalizer
- Client Priority Gate



Improvements on Inherited Components

- Condensed Chassis
- Moved Components to Server Station
- Printed Circuit Boards for All Circuits

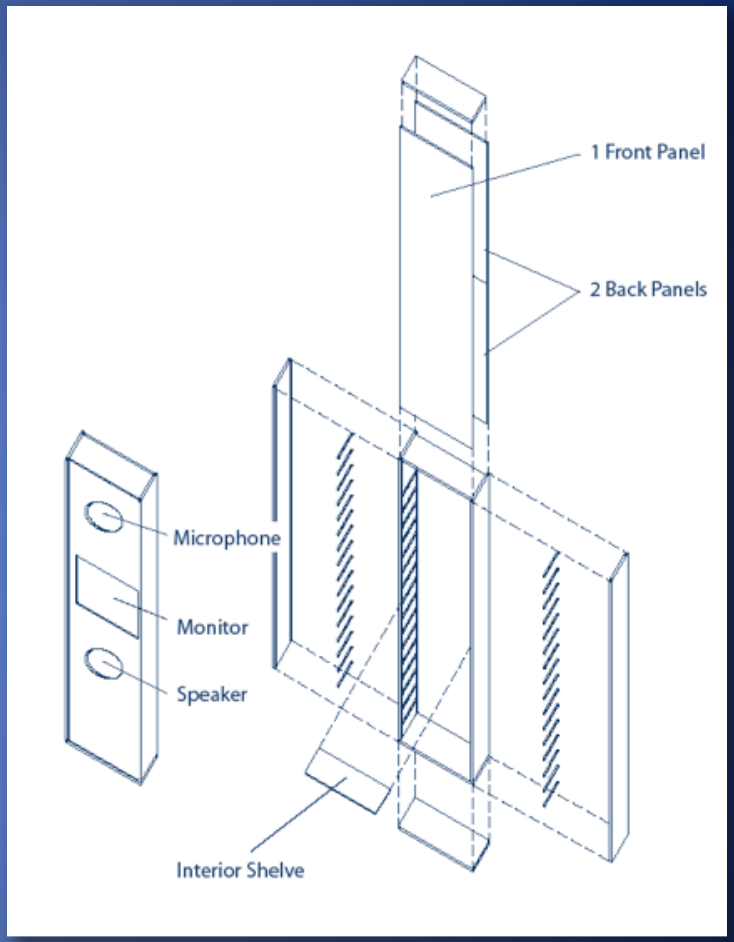




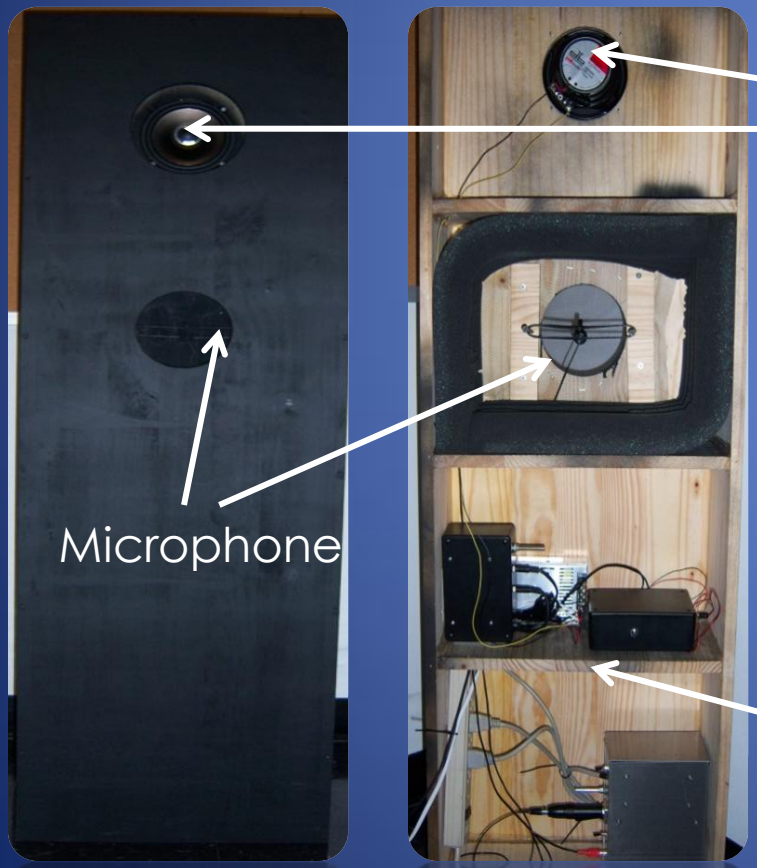
New Kiosk

- Offers easier access to components
- Modular design allows for additional components and dynamic testing

New Kiosk



Old Kiosk



Class D amp,
preamp,
power supplies

Testing Process

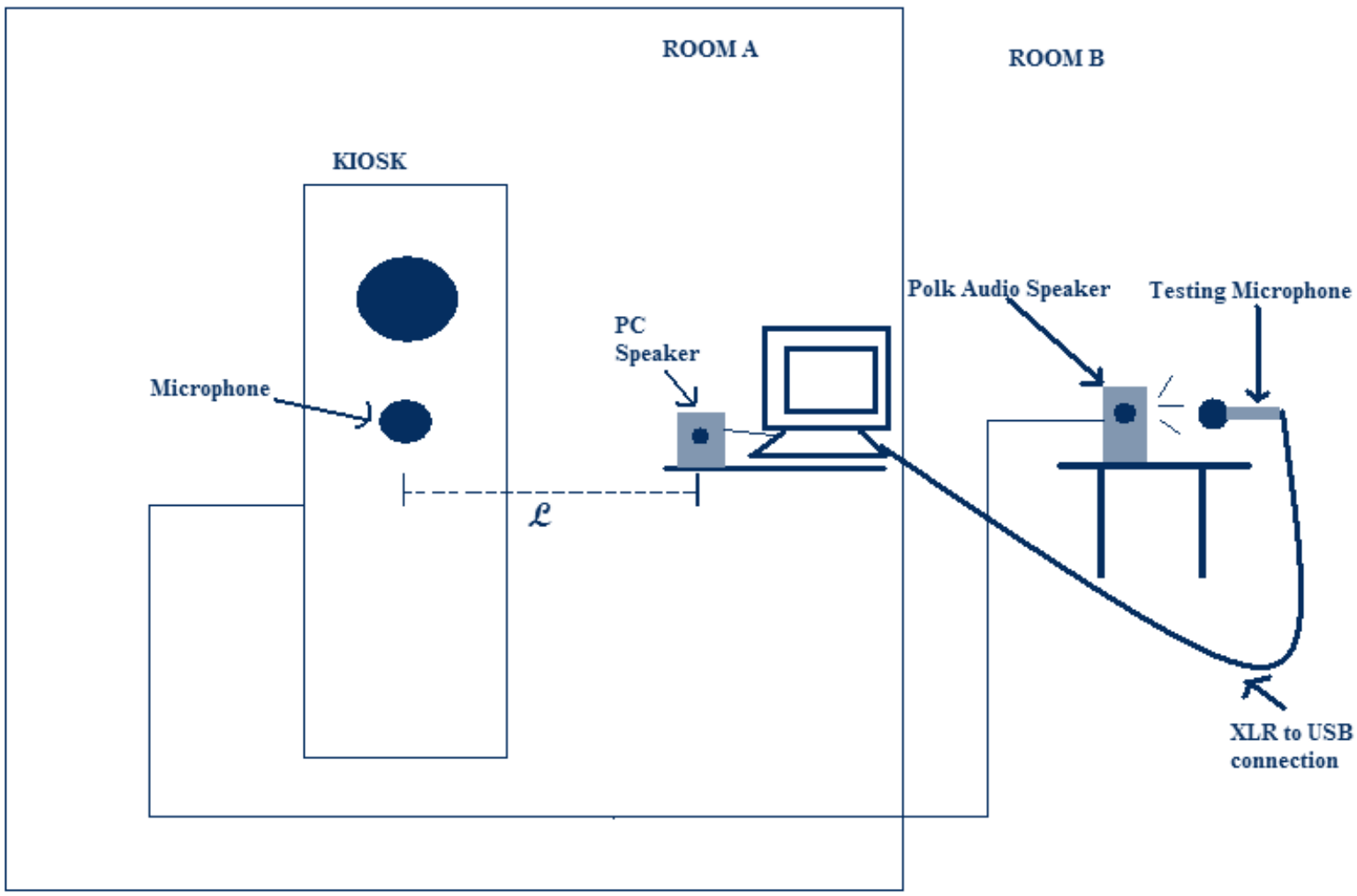
Speech Transmission Index (STI)

- International standard for measurement of speech intelligibility
- Frequency-weighted sum of signal transmission
- Envelope modulation of signals to simulate speech nuances
- Free software available to directly measure STI

Software

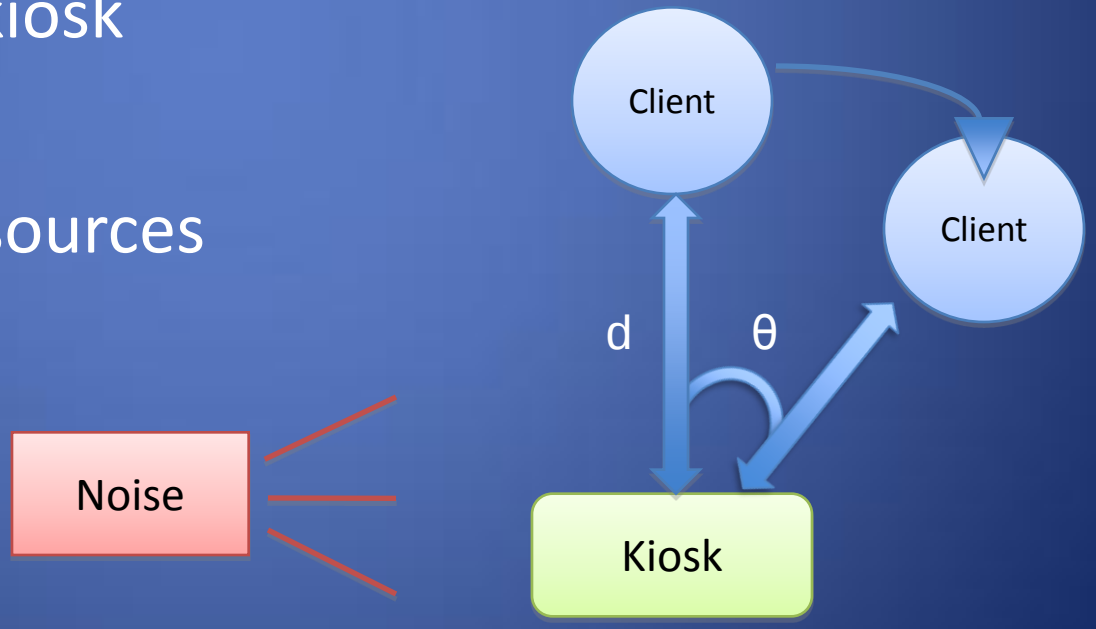
- LexSTI
  - Measures the STI of audio signals
- TruRTA
  - Take SPL measurements for reference
- Audacity
  - Calibrate recording levels for testing
- MATLAB
  - Created software to fix corrupted output files recorded by LexSTI

Testing Diagram

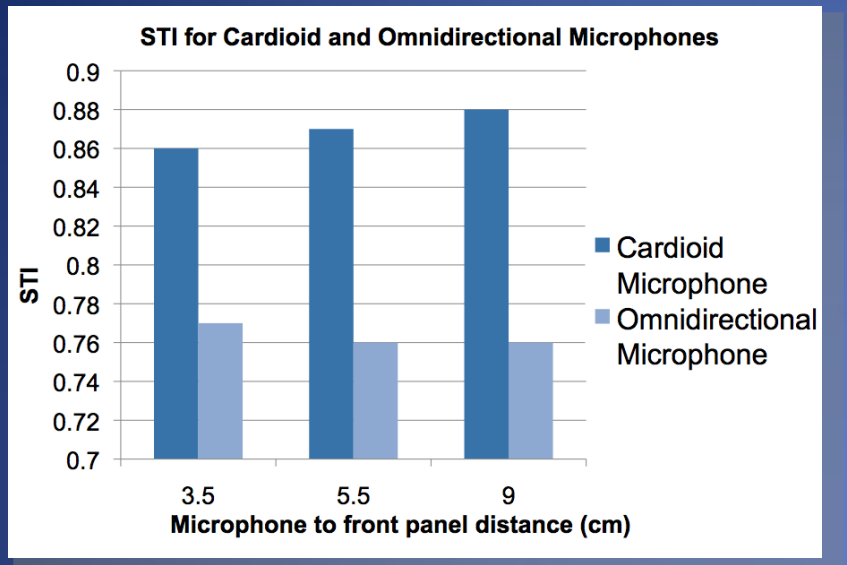


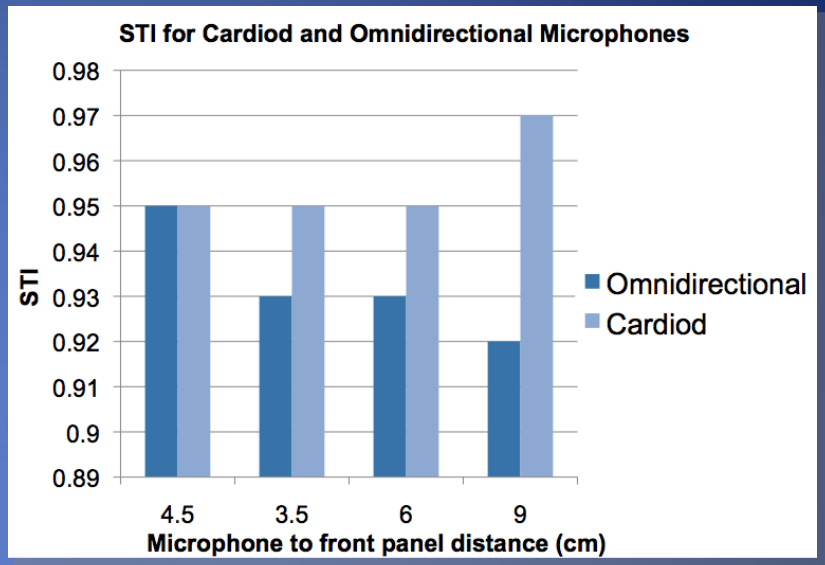
Testing Variables

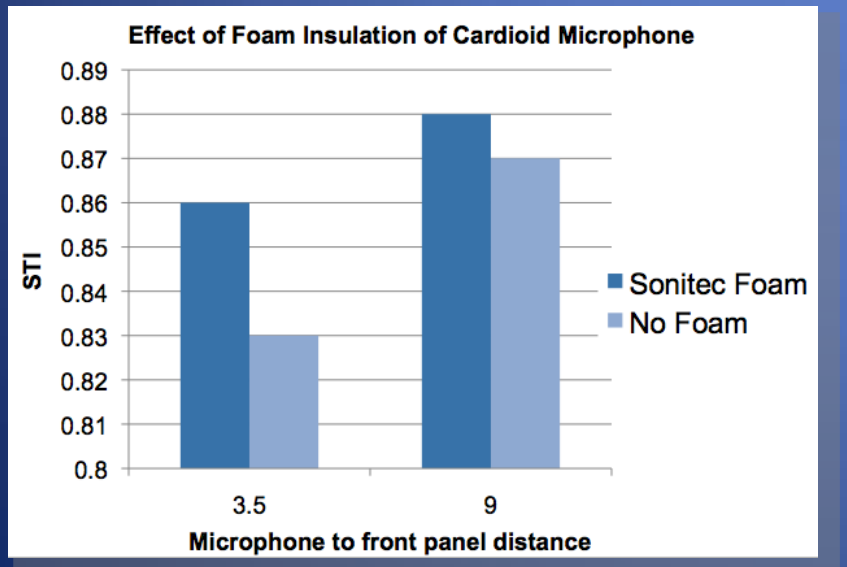
- Microphone types
  - Cardioid (unidirectional)
  - Omnidirectional
- Distance from kiosk
- Kiosk insulation
- External noise sources

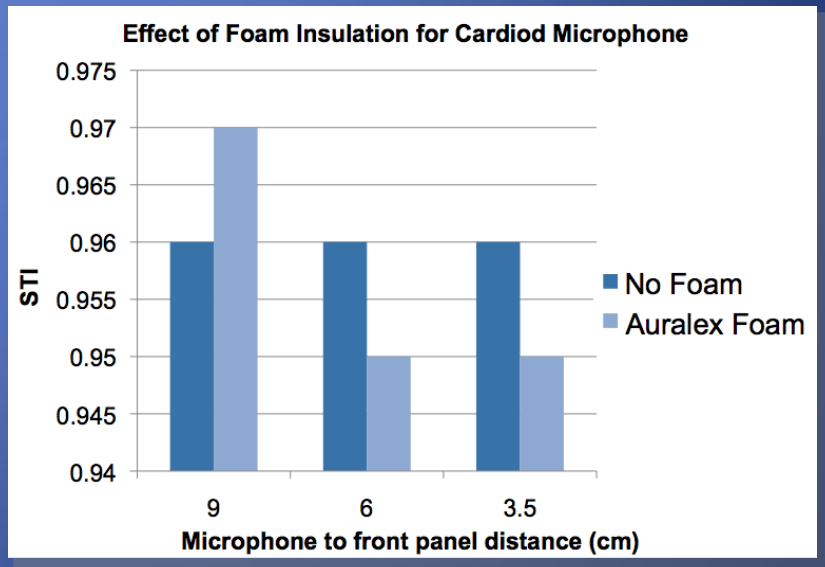


Testing Results







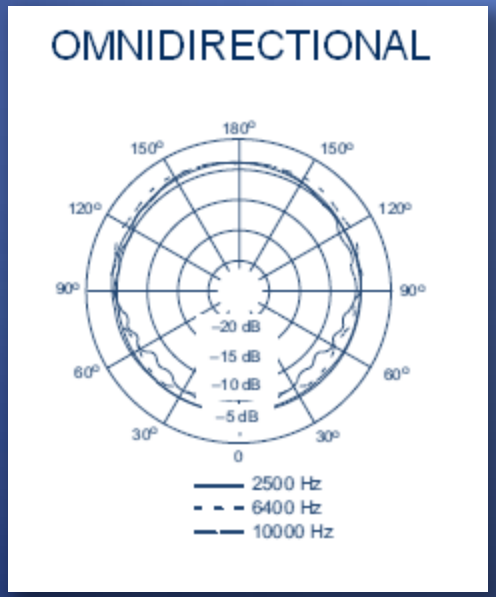


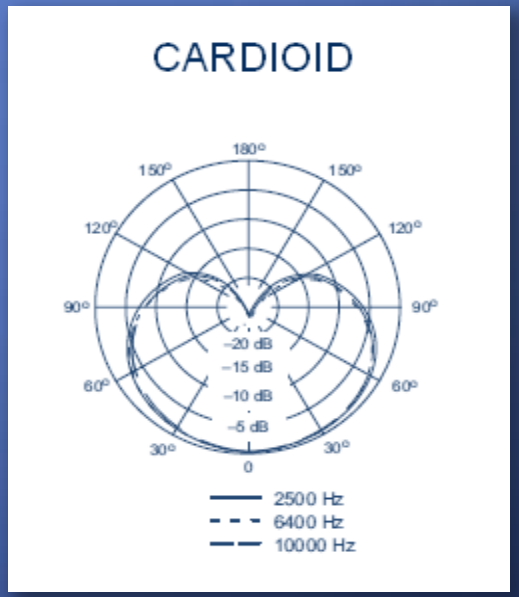
New Kiosk

Old Kiosk

Conclusions

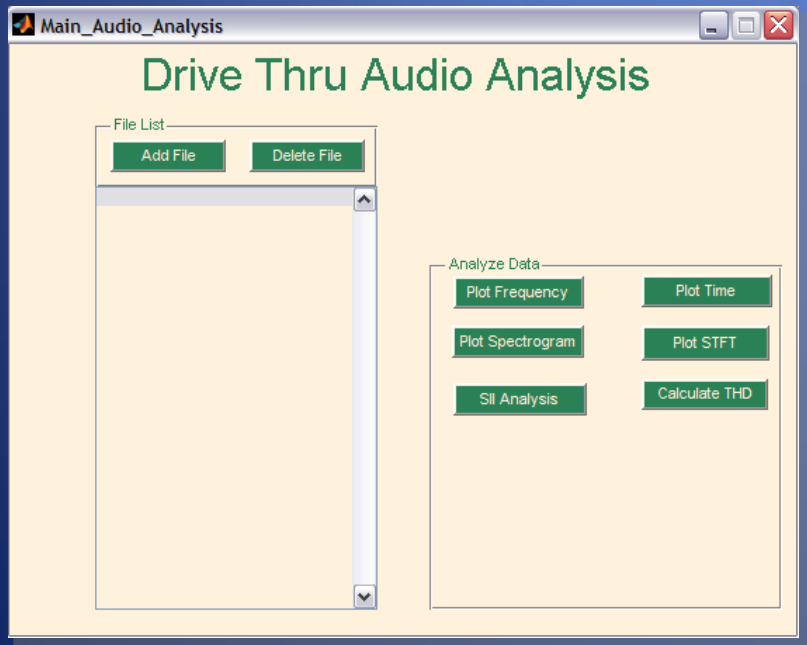
- Cardioid Microphones have a higher STI than Omnidirectional Microphones
- Foam insulation raises the STI
- Increased microphone depth raises the STI

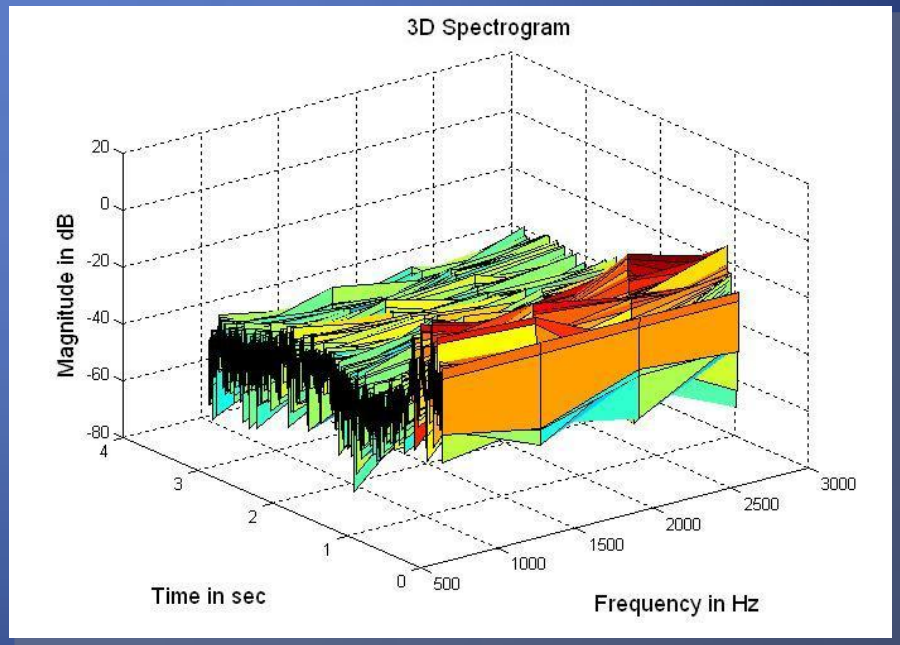




Future Work

- More Testing
  - A testing procedure has been developed
  - The system and kiosk are built dynamically to allow for modular testing
- Filters
  - Remove common noise sources





Economics

- Total cost for this semester: $1190.73
  - A large portion of the cost is reduced when produced on a larger scale
- Cost looks promising, however more market research is required for a solid cost analysis

Ethical Considerations

- Current global energy production and usage is considered
  - Class D amplifiers are near perfectly efficient

- ROHS compliance where available
  - The ROHS Directive stands for “the restriction of the use of certain hazardous substances in electrical and electronic equipment
  - Law in the EU, ethical option for our IPRO

Obstacles

- No access to a consistent, quiet testing space
  - Solved by focusing on STI differences for variable differences
- Mangled output from LexSTI
  - Solved by creating a MATLAB program to fix the output files prior to STI analysis
- No data on existing kiosks
  - Solved by investigating ways to systematically improve the STI of our system

Acknowledgments

- Dr. Ralph Muehleisen
- Shure, Inc.

Q & A