

**IPRO 344**

**Improving Energy-Efficiency &  
Offering Quality Audio in  
Mobile Devices & Intercoms**



# Problem Statement

- ▣ Lack of **standardized test data and methodology** for evaluating the audio quality of a two-way communication system performing in a high noise level environment.
- ▣ We offer a solution to **measure performance** of fast food industry intercom systems and components to **decrease order capture error**.



# Previous Semesters' Progress

Fall 2007

Spring 2008

Fall 2008

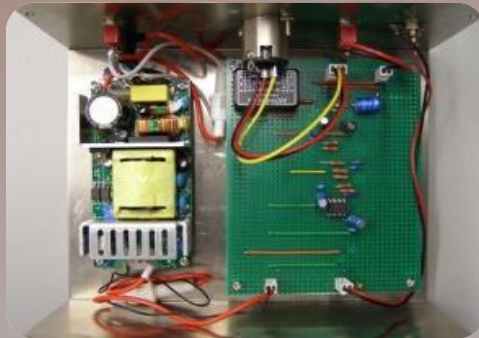
Spring 2009

Studied and improved technologies for low-power mobile audio, evaluated amplifier technology

Improved efficiency with Class D amplifier & developed two-way communication system

Designed pre-amplifier for headset & microphone

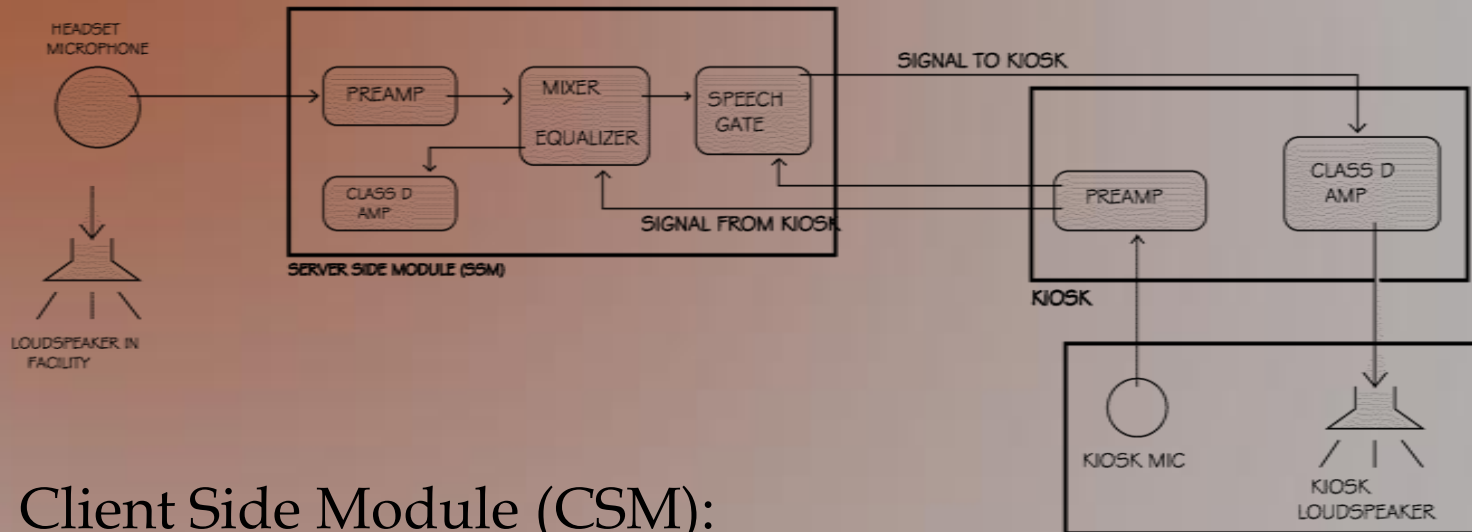
Rebuilt system, developed & implemented standardized test methodology





# iFidelity

## High Efficiency & Audio Quality Intercom System



- ❑ **Client Side Module (CSM):**  
Kiosk enclosure; contains Class D amplifier, mic, foam
- ❑ **Server Side Module (SSM):**  
Mixer, equalizer, headset and microphone pre-amplifier
- ❑ **Client Priority Gate (CPG):**  
Ensures proper etiquette in order capture process



# Objectives

- ❖ Reconstruct server side module
- ❖ Develop testing methodology
- ❖ Evaluate performance of our system
- ❖ Collect comparative real-world sample
- ❖ Conduct ambient noise tests



# Team Organization

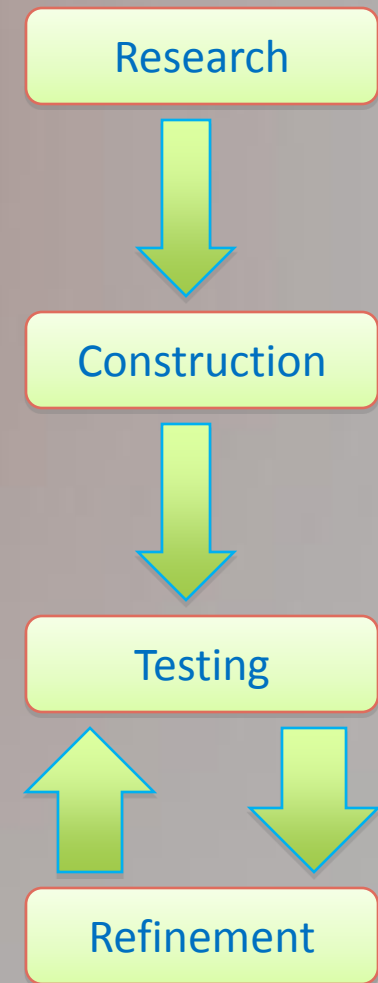






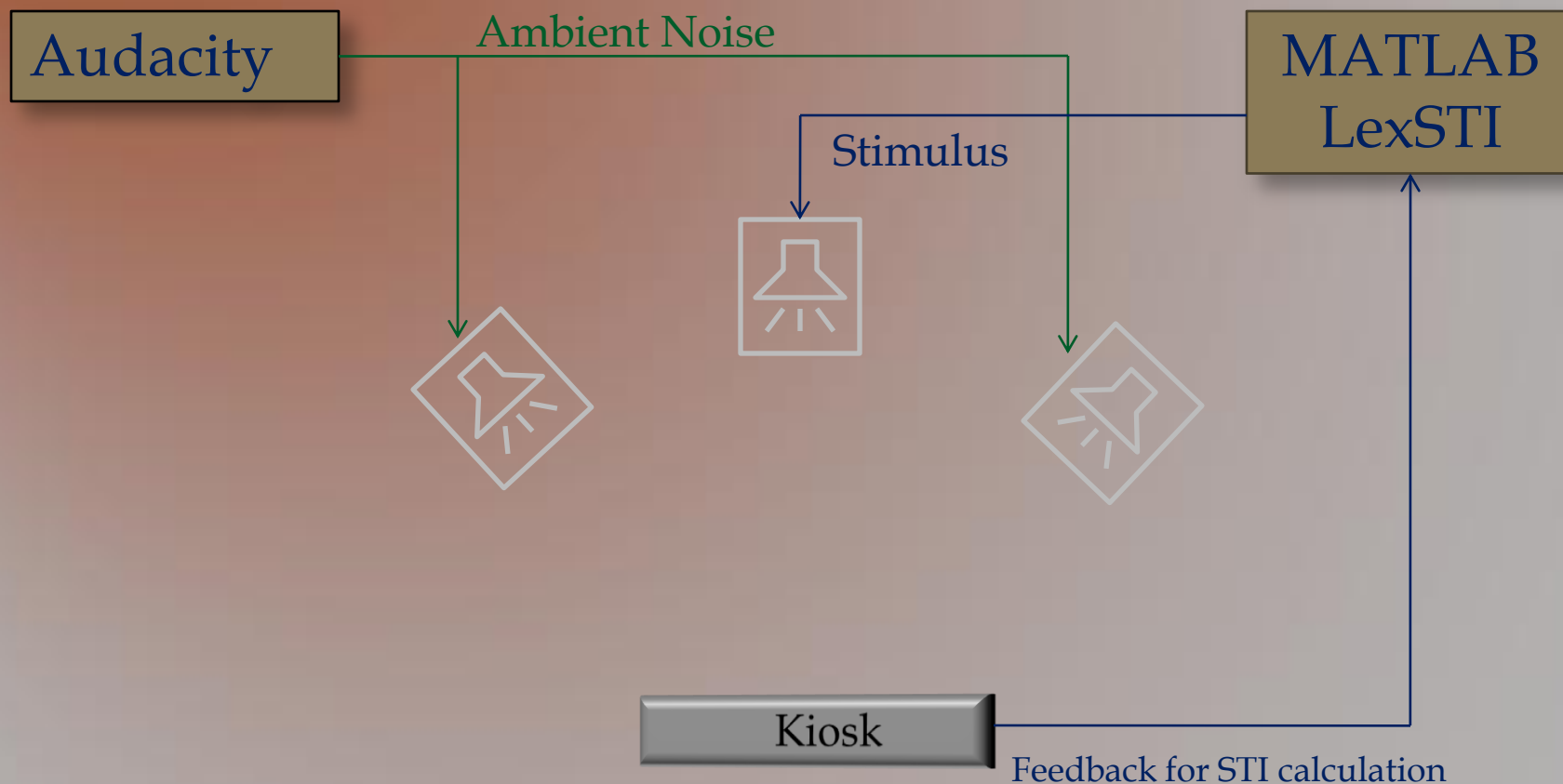
# Project Approach

- ❖ Phase I: Research & Construction
  - Two-way communication system
  - Ambient noise interference & STI
- ❖ Phase II: Testing
  - Establish standards and evaluate
- ❖ Phase III: Refinement
  - Use results for improvement of system





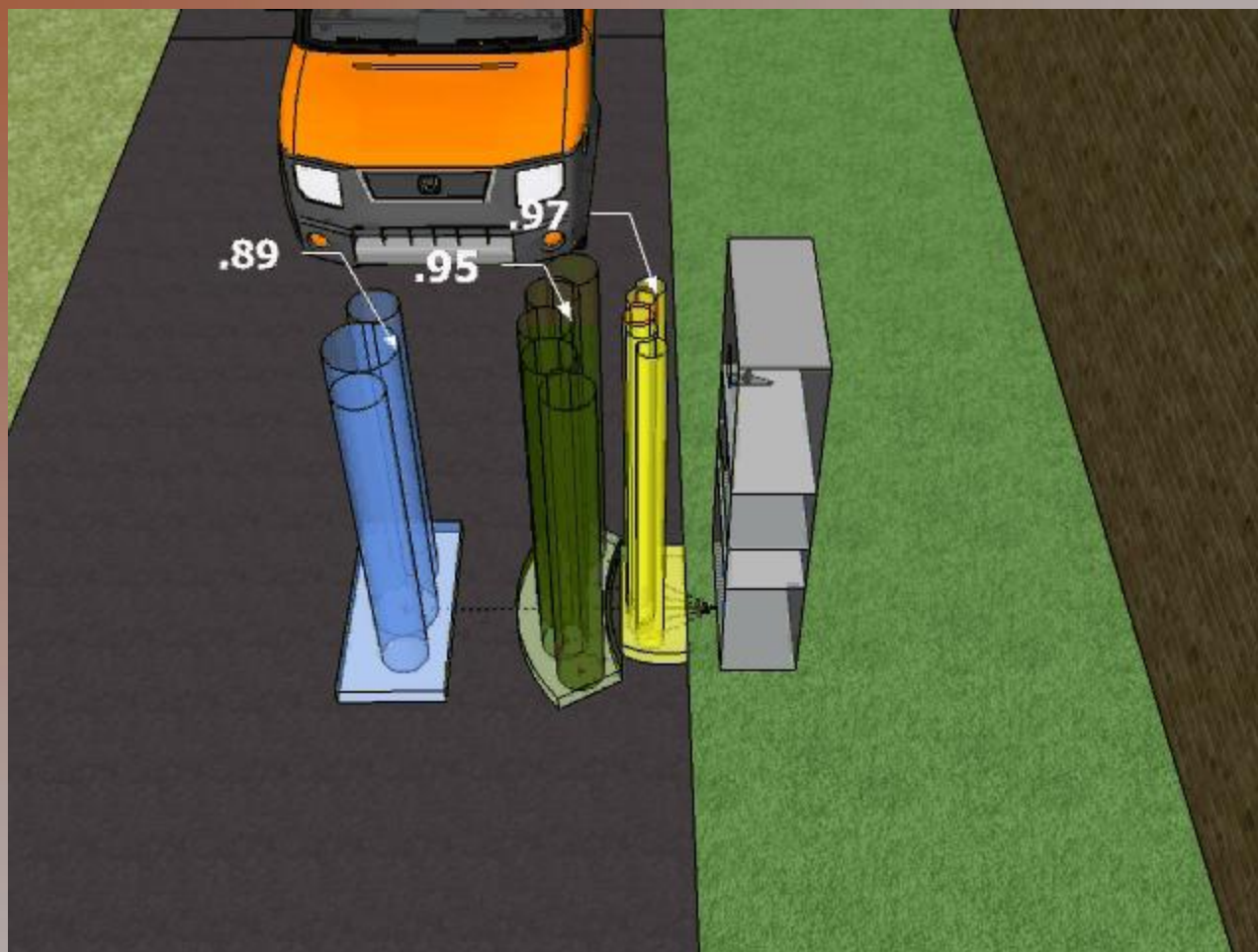
# Testing





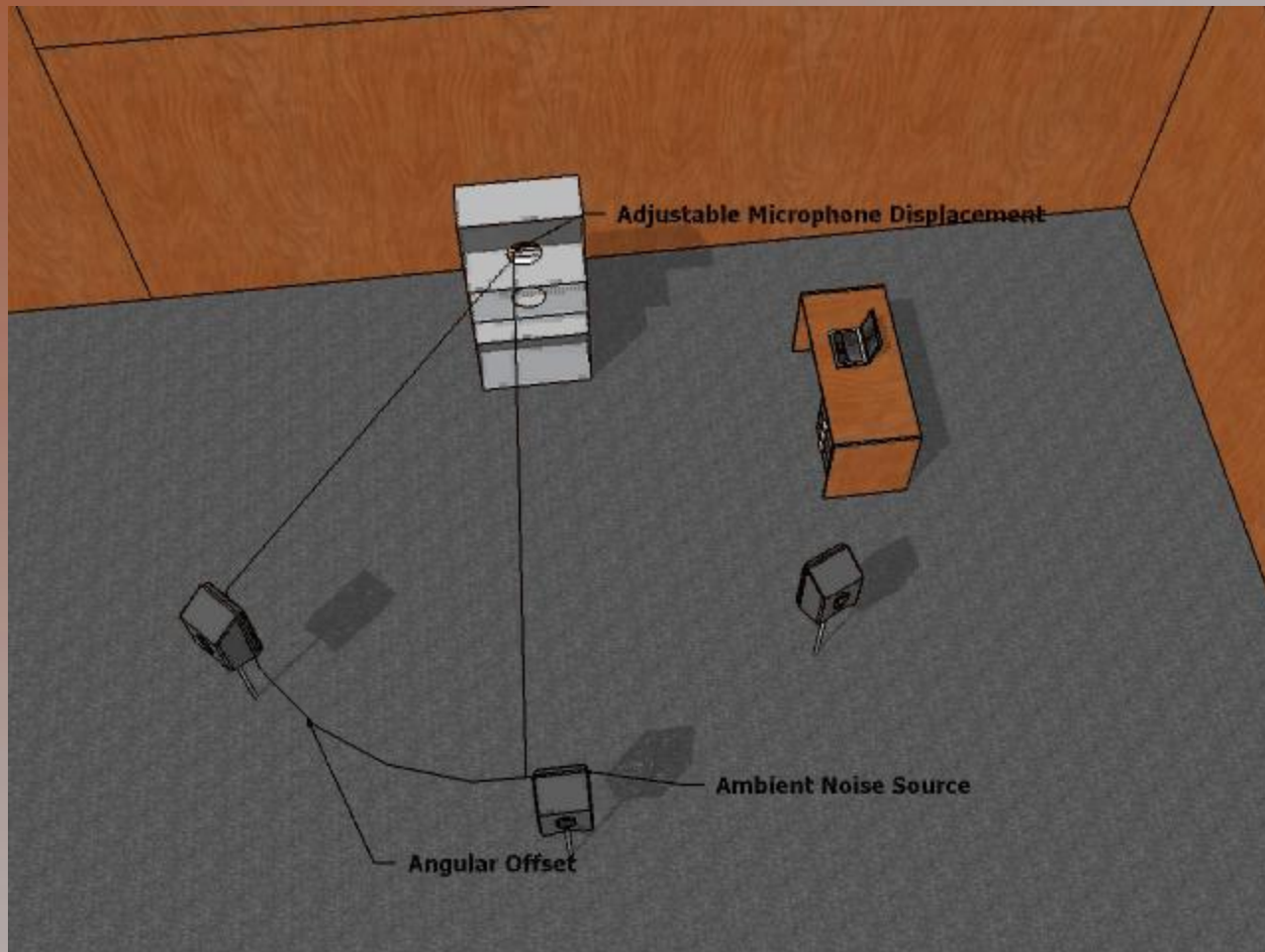


# Speech Transmission Index





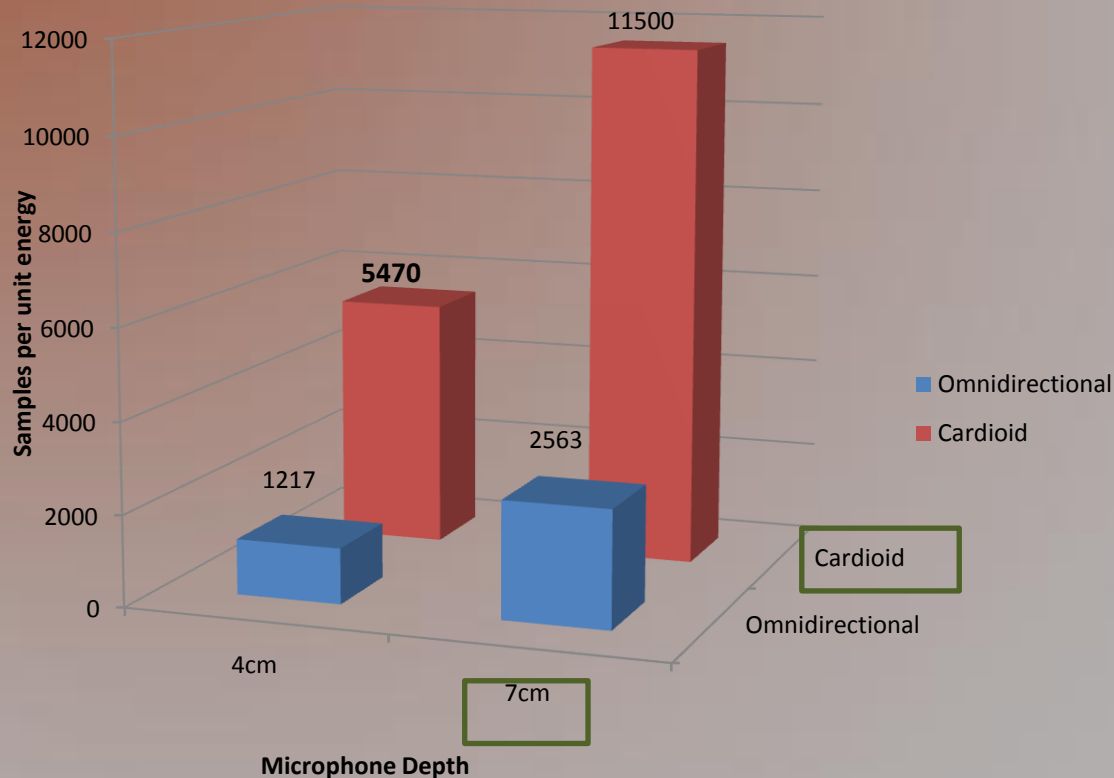
# Ambient Noise Acquisition & Analysis (ANAA)





# Analysis I

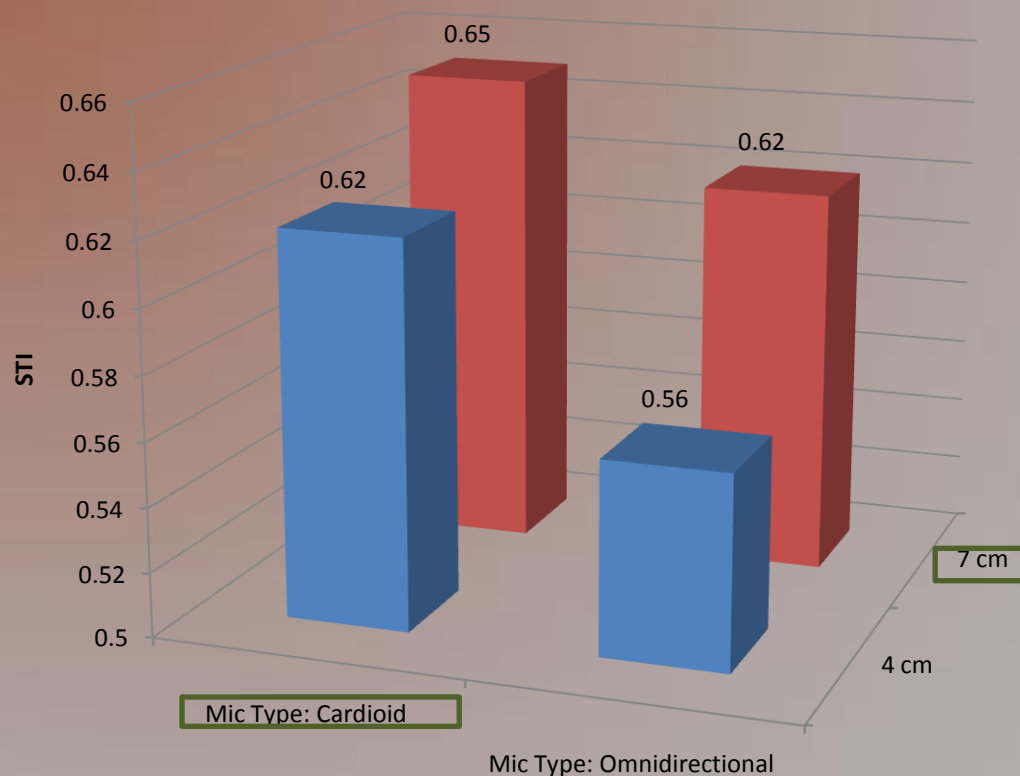
- ❖ Ambient Noise Rejection vs. Microphone Type and Depth





# Analysis II

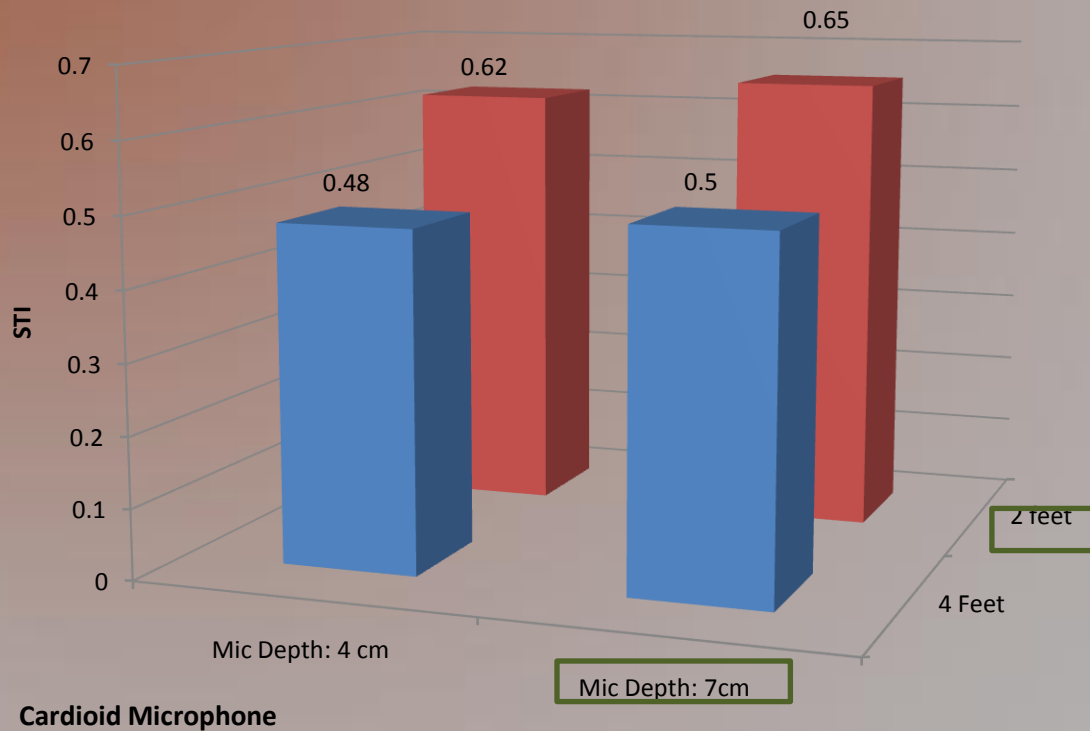
## Microphone Type and Depth vs. STI





# Analysis III

Relationship Between Distance from Stimulus Source and STI





# Qualitative Conclusion

- ▣ Optimal microphone depth: 7 cm
- ▣ Optimal distance from stimulus: 1 ft
- ▣ Microphone directionality pattern: cardioid
- ▣ Acoustic foam improves ambient noise rejection





# Franchise Testing

- ❖ Basis for comparison
- ❖ Industry standard drive-thru
- ❖ Order sample:



- ❖ iFidelity system sample:





# Server Side Module

- ❖ Adjust desired sound signals from different input & output channels
- ❖ Mixer, equalizer, pre-amplifiers, client priority gate
- ❖ Redesigned & rebuilt
  - Clean wiring
  - Audio equipment conventions





# Ethical Consideration

- ❖ Energy efficiency
  - Class D amplifiers are extremely efficient ( $\geq 90\%$ )
- ❖ ROHS compliance
  - Restriction of hazardous substances directive
  - Electrical equipment and components



# Economics

- ▣ QSR Magazine states, “The most important factor to increase business is order accuracy.”
- ▣ U.S. fast food industry : \$120B with 200K restaurants
- ▣ System facilitates the exchange of information
- ▣ Several viable configurations of components to evaluate, replace, enhance an existing system
- ▣ Low cost and energy efficiency provide a definite advantage over other systems



# Acknowledgments

- Dr. Ralph Muehleisen
- Shure, Inc.







Thank You!





# Q & A