IPRO 344

Audio Quality & Energy Efficiency for Mobile Devices and Intercoms

Project Plan

Instructor: Dr. Thomas Wong

Teaching Assistant: Tao Shen

Sponsor: Shure Inc.

Team:

Alex Barnett
Kevin Gullikson
Mohammad Raza
Jeff Aigner
Yihan Su
Titilayo Craig
Steve Kuo
Jeff Chiles
Alex Walker

Illinois Institute of Technology

5 February 2009

1. Abstract

IPRO 344 began as an investigation into the applications of Class D amplifiers for low-power and high-quality audio devices. This semester's IPRO will focus on integrating the Class D amplifier into a drive-through order system. In addition to the Class D amplifier, this semester's team will be investigating high-fidelity microphones, microphone preamplifiers, and speaker mounting.

2. Ethics Statement

A. IPRO 344 will hold each one of its members to a high ethical standard, starting with showing up to team meetings, classes, and other obligations. Team members must comply with all local, state and national laws and regulations. IPRO 344 must also comply with the Illinois Institute of Technology's rules and policies. Members are expected to be constructive and professional when working with colleagues and avoid discrimination of any kind.
B. To avoid any confusion and problems IPRO 344 has established a few controls to prevent those potential situations.
    1. Team leaders will hold face to face meetings once every two weeks and will have meetings online once a week.
    2. Individual teams are expected to turn in progress repots once a week.
    3. All members must check the iGroups discussion board daily.
    4. Promptly respond to emails and threads on iGroups
    5. All team members will weigh in on major changes to the project.

3. Objectives

The IPRO 344 team has set forth the following objectives for the overall project and the 2009 spring semester as well as the expected results for the semester:

- Investigate microphones that most accurately capture customers' voices in outdoor environment.
- Improve the audio capabilities and quality of food service drive-thrus
- Incorporate class D amplification into two way communication systems
  - Investigate various microphone polar patterns, namely, Omni directional, cardioid, and super-cardioid.
  - Duplicate and improve the existing equipment.
  - Improve the ways in which the team conducts tests resulting in improved testing methods.
  - Obtain better qualitative and quantitative data from the prototypes.
  - Collaborate with IPRO 343 to better develop speech intelligibility using white noise and mixer technology.

4. Expected Results

IPRO 344 would like to meet and exceed its expected results for spring 2009:

- Achieve quality data that can be used by future IPRO 344 groups.
- Qualitative/quantitative test results on improved prototype and equipment.
- The development of more user friendly equipment
- The formation of quality standards resulting from good test results and data.
- Aim for the majority of construction to be completed by March 2009

5. Background

A. There is commercial interest and value in improving drive-thru systems in terms of the quality of communication, which supports the need for a prototype to explore a range of possible solutions.

B. Shure Inc. provided microphones to the project. IIT ECE department provided a laboratory to the IPRO 344 team for the development of the prototype.

C. The emphasis of drive-thru system operations has been on increasing speed-of-service, which has benefits for both the customer and the service provider. However, improvement in order accuracy is now regarded as at least as important as speed-of-service in delivering value for the customer and assuring efficient operations for the service provider.

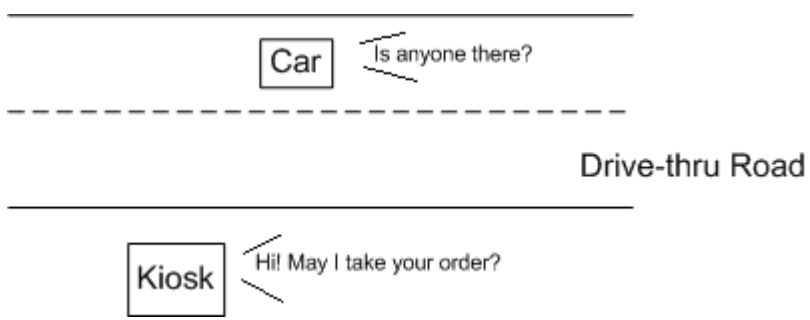
For examples:

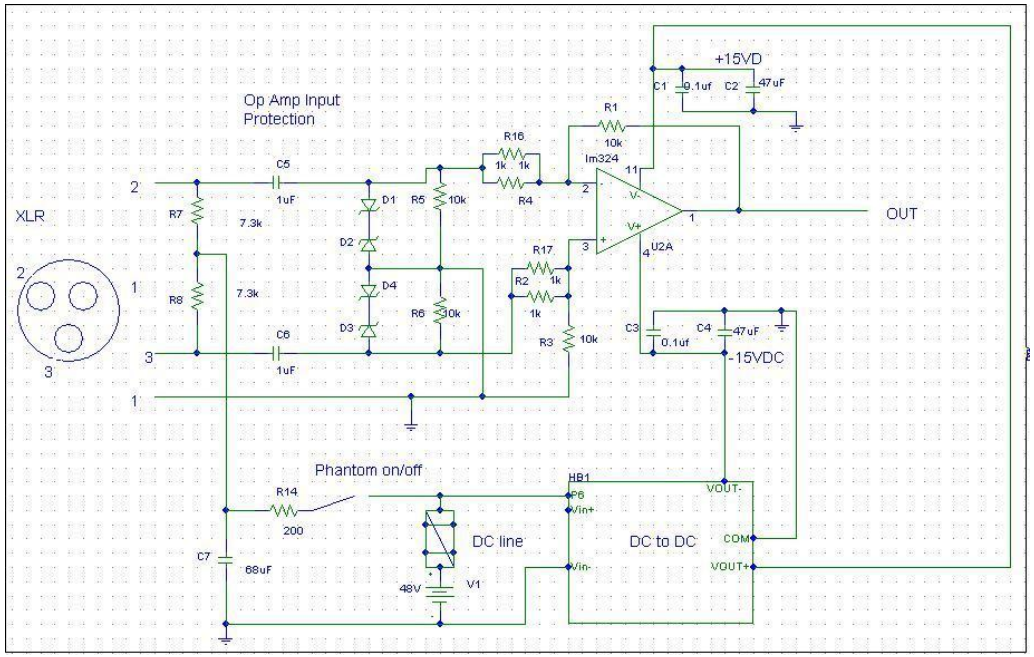
1. Environmental interference interrupts the communication between the customer and the clerk:
    a. Heavy rain/wind.
    b. Engine noises.

2. Customer's position relative to kiosk makes the communication difficult:
    a. Customer parks too far from the kiosk.
    b. Customer is not speaking into microphone.

To improve the accuracy and the sound quality of the drive-thru system, IPRO 344 team investigates proper outdoor/weather-proof speakers and pre-amplifier design for Shure's microphone.

Proposed pre-amplifier design for the Shure microphone:





Shure Microphone preamp design

The plan is to implement a professional balanced microphone preamp. This design utilizes three sections: a Phantom power supply with op amp protection, a difference amplifier, and an output attenuator. The phantom power circuit is isolated by DC-blocking capacitors c1 and c2. Next, zener diode limiters protect the op amp inputs from spikes at initial powering. The difference amplifier uses a single 5532-type op amp for 20dB of gain. The output trim will allow us to adjust for nominal input level to our class D amplifier. A stepped attenuator was chosen as opposed to a potentiometer for controlled repetition in later experiments. Overall, this design will provide a compatible low-noise preamplifier for our Shure MX-100 series microphones.

A. Previous IPRO 344 studied class-D amplifier, pre-amplifier, and post-amplification filter to propose an efficient and low-power/high quality audio system for mobile devices. For more details, please see the attached Abstract from previous IPRO 344.

*See the attachment for S08 IPRO 344 Abstract to better understand the overview of previous IPRO 344.

.

6. Budget

Shure Microphone Preamp

Part	Description	Price	Quantity	P*Q	Supplier
71-CMF551K0000BHEB	1/8W .1% 1k resistor	$0.36	8	$2.88	Mouser
71-RN60C-B-20K/R	1/8W .1% 20k resistor	$0.34	8	$2.72	Mouser
71-CMF5510K000BEEB	1/8W .1% 10k resistor	$0.52	12	$6.24	Mouser
660-MF1/4DCT52R1500F	1/4 1% 150 resistor	$0.05	12	$0.60	Mouser
594-5073NW200R0J	200 ohm 5%	$0.16	4	$0.64	Mouser
594-5073NW820R0J	820 ohm 5%	$0.16	4	$0.64	Mouser
660-MF1/4LCT52R222J	2.2k 5%	$0.05	4	$0.20	Mouser
71-CMF075K0000JNEK	5k 5%	$0.18	2	$0.36	Mouser
594-5073NW20K00J	20k 5%	$0.16	4	$0.64	Mouser
71-CCF02100KJKE36	100k 5%	$0.19	4	$0.76	Mouser
863-LM833NG	dual LM833 opamp	$0.91	6	$5.46	Mouser
523-AC3FDZ	xlr female connector	$3.96	2	$7.92	Mouser
502-BPJF02X	rca female connector	$1.70	2	$3.40	Mouser
270-6.81K-RC	6.81k .5% phantom resistor	$0.15	8	$1.20	Mouser
594-2222-021-90545	68uF 63v Polar Electrolytic Capacitor	$0.71	3	$2.13	Mouser
108-0038-EVX	spst switch toggle 5a	$2.83	4	$11.32	Mouser
647-UVP1E100MDD	10uf bipolar electrolytic	$0.19	4	$0.76	Mouser
647-UVP1C101MPD	100uf bipolar electrolytic	$0.27	4	$1.08	Mouser
313-1520F-10K	10k Audio Pot Solder lugs	$1.50	4	$6.00	Mouser
647-UVP1V220MED	22uf bipolar electrolytic	$0.26	4	$1.04	Mouser
546-1411RU	8inX6inX3.5in case Al	$15.89	2	$31.78	Mouser
575-343308	IC socket 8P dip	$1.03	6	$6.18	Mouser
647-UKT1V470MDD	35 V, 47 uF, Audio Electrolytic Cap	$0.15	4	$0.60	Mouser
81-RPER71H104K2P1A03	Monolithic Multilayer 0.1uF	$0.13	6	$0.78	Mouser
647-UVP1H010MDD	Bi-Polar Electrolytic Capcitors	$0.19	4	$0.76	Mouser
610-1N4627	0.25 W 5% Zener Diodes	$0.23	8	$1.84	Mouser
			Subtotal	**$97.93**	

			Shipping	**$7.77**	
			Total	**$105.70**	

Headset mic Preamp

Part	Description	Price	Quantity	P*Q	Supplier
512-NE5532N	5532 dip op amp	$0.51	4	$2.04	Mouser
291-10K-RC	10k 5% 1/4 w resistor	$0.10	4	$0.40	Mouser
291-1.5K-RC	1.5k 5% 1/4 w resistor	$0.10	4	$0.40	Mouser
291-27K-RC	27k 5% 1/4 w resistor	$0.10	12	$1.20	Mouser
291-33K-RC	33k 5% 1/4 w resistor	$0.10	4	$0.40	Mouser
291-100-RC	100 5% 1/4 w resistor	$0.10	4	$0.40	Mouser
313-1520F-10K	10k Audio Pot Solder lugs	$1.50	4	$6.00	Mouser
647-UST1H2R2MDD	2.2uf polar electrolytic	$0.18	8	$1.44	Mouser
625-1N5617	1amp 400v diode	$0.40	4	$1.60	Mouser
647-UPM1J470MPD	50uF Capacitor	$0.45	4	$1.80	Mouser
598-SK100M035ST	10uf electrolytic polar cap	$0.13	4	$0.52	Mouser
16PJ108-EX	3.5mm jack	$1.59	4	$6.36	Mouser
unknown	Chassis	$40	2	$80.00	
			Subtotal	**$102.56**	
			Shipping	**$7.77**	
			Total	**$110.33**	

CON-242	2-PIN Connector w/header .10"	$0.70	16	$11.20	All Electronics
CON-243	3-PIN Connector w/header .1"	$1.00	6	$6.00	All Electronics
			Subtotal	**$17.20**	
			Shipping	**$7.00**	
			Total	**$24.20**	

Connection / Mounting materials

Description	Price	Quantity	P*Q	Supplier
Heat Shrink				
Microphone cable adaptor	$4.99	1	$4.99	Radio Shack
Banana Plug	$3	2	$6.00	Radio Shack
Speaker cable	$10	1	$9.99	Radio Shack
Heat Shrink	*$4.99*	*1*	*$4.99*	*Radio Shack*
		Total	**$25.97**	

Miscellaneaous Items

Printed Circuit Board	Barebones Prototyping Boards	$70.00	3	$210.00	Advanced PCB
Class D Amplifier	Class D evaluation Kit	$49.99	1	$49.99	Texas Instruments
				$259.99	

Kiosk Materials

Part	Description	Price	Quantity	P*Q	Supplier
1.85E+11	5/8" Wood used for exterior walls, 4x8	$21.97	4	$87.88	Home Depot
Screws	Fasteners (screws)	$2.19	2	$4.38	Home Depot
Elmer's Carpenter's Glue	Wood Glue for all joints, 3.25 oz.	$1.97	1	$1.97	Home Depot
Alex Fast Dry White Caulk	Caulk for interior joints	$2.24	1	$2.24	Home Depot
Access Panels		$11.95	3	$35.85	Home Depot
Sand Paper	120 HP	$3.69	1	$3.69	Home Depot
4'x8' board for back panel		$20.00	1	$20.00	Home Depot
Hinges		$5.00	4	$20.00	Home Depot
Acoustic Foam		$35	1	$35.00	Foamorder.com
Black spraypaint		$5	1	$5	?
r-19 fiberglass insulation		$50	1	$50	Home Depot
Metallic tape		$15	12	$180	guitar center
			Total	**$446.01**	

Grand Total **$972.20**

7. Team Structure and Assignments

Name	Major, Year	Skills and Strength	Experience and Academic Interest	Team Responsible	Other Team involvements
Raza, Mohammad	BME/EE, 4th year	Fabrication, soldering, Matlab, Labview	Signal Processing, Neuroscience, Returning member of ipro 344	Tools and Media	Circuits and signal processing, research, documentation
Aigner, Jeff	CPE, 3rd Year	Electronics design and implementation, Web Design, Programming (HTML/CSS, Javascript, C, C++, Java, Perl, Python, Assembly, SQL), system administration on FreeBSD and GNU/Linux	Signal Processing, Distributed Systems, Digital Systems, 6 years industry experience programming (mostly PHP and SQL), research work for the WiNCOM laboratory, signal processing and microelectronics courses	Web	Circuits and signal processing, research, minutes
Gullikson, Kevin	Physics, 3rd year	Fabrication, C, C++, Python, GNU/Linux	Acoustics, Returning member of ipro 344	Kiosk Modification/Testing	Documentation, Research, Minutes
Su, Yihan	Applied Mathematics, 4th year	Some C++, Alice, and little Matlab	Probability, statistics, Alice, three months accounting assistant, 5 years hotel waiter	Economic	Purchasing and poster
Craig, Titilayo	CS/AM, 3rd year	Programming in java, matlab, a little bit of PHP and currently working with C	Numerical analysis, Software Engineering	Purchasing	Web, Poster

Kuo, Steve	ARCH, 4th year	Auto CAD, Adobe photoshop, Illustrator, 3d Max	Residential building design	Project Coordinator	Purchasing, Implementation-System Integration and Testing
Chiles, Jeff	EE/CPE 2nd year	Java, Python, C, AS 3.0, Assembly, microcontrollers, fabrication	Electromagnetics, Electronic Warfare, Optics, Digital Systems, IT Internship with VOA Associates, Inc.	Implementation – Circuits and Signal Processing	Research, Tools and Media
Barnett, Alex	EE/CPE, 3rd year	Audio Electronics design, audio equipment knowledge	Electronics, Signal Processing, Electromagnetics, Returning member of ipro 344	Research	Circuits and signal processing, research, System integration and testing
Walker, Alex	POLSC, 4th year	Practical application of organization and leadership, non-engineering viewpoint, wood/metal fabrication experience	Constitutional law	Documentation	Tools and Media

Sub-Team 1: Circuit and Signal Processing Team

Purpose: This team will work to improve the following aspects of the intercom system for IPRO 344: Audio Signal Fidelity, Speech Intelligibility, Reliability of electronic components in extreme conditions, Filtering of unwanted ambient sound, Filtering of erroneous signal noise, Clarity of dialog, Reduction of feedback, and Upgrades to the electronic system, directed at these criteria, will ultimately improve the overall usability and quality of the project.

Team Members:

- Mohammad Raza
- Jeff Aigner
- Alex Bartnett

Tasks:

*Prepare a second copy of the entire electronic system. This will allow testing to be done simultaneously with upgrades to the main circuit.
*Coordinate with the Kiosk Modification team to quickly mount the electronics in a more easily accessible position, so that the following upgrades may be performed without difficulty.
*Integrate a three-channel mixer component into the system, enabling testing for white-noise applications.
*Integrate a white-noise generator as an input to the mixer component.
*Implement a graphic equalizer that follows the mixer. This will allow frequency response testing to be conducted for improvements to speech intelligibility.
*Implement and integrate a gate-system to isolate one person's speech at a time (or a different etiquette), enabling better clarity of dialog and reducing feedback.
*Coordinate with the testing team to predict sources of distracting noise for the intercom, such as different types of car engines and high-speed winds. Isolate the characteristic audio components of these signals and develop filters to remove them from the output.
*Receive information from 343 and testing conducted in 344. Calibrate equalizer, speech gate, white noise, and filters to improve the results indicated by the test.
*Make the intercom system more easily operated by changing the control circuitry.

Sub-Team 2: Economic Team

Purpose**:** The objective of the Economic team is to assess the economic feasibility of implementing the project in an actual franchise.

Team Members:

- Yihan Su – Team Leader
- Jaroslaw Suwada

Tasks:

- Come up with a franchise scale cost estimate for the kiosk system.
- Working with the purchasing team to decide what price item we are going to use.
- To detail the advantage and disadvantage of different model of the same item by communicating with the research team.
- Calculate the cost of the product, and profit if put this product to the market.

Sub-Team 3: Documentation Team

Purpose: The objective of Documentation team is to create and maintain all documents related to IPRO 344 through official channels. The collected document help next IPRO team understand the purpose of IPRO 344 and identify the progress of it.

Team Members:

- Alex Walker
- Kevin Gullikson
- Raza, Mohammad

Tasks:

- Collect and maintain all documents.
- Support Poster team for offering information to make a poster.
- Support Presentation team for preparation of presentation.
- Production of project plan and final report
- Development of brochure and CD

Sub-Team 4: Kiosk Modification/Testing Team

Purpose: The purpose of the Kiosk Modification and Testing team is to make the kiosk easier to test by creating easier access to the electronics, as well as the speaker and microphone compartments. We also plan to line the inside of the speaker and microphone compartments with a metallic substance to more accurately represent the acoustical properties of the metal kiosks currently being used. Finally, we will perform acoustical tests on our system and obtain quantitative data on its performance.

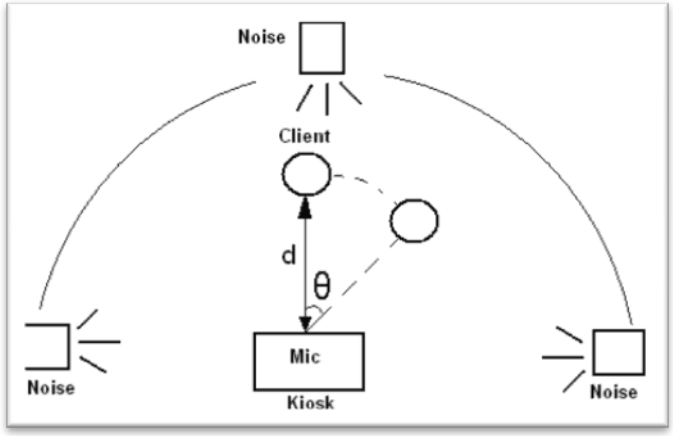
Tasks: The following are tasks for the Kiosk team to complete

1. Modify kiosk to provide easier access to the electronics, the microphone, and the speaker compartments. This will be done by creating a new back panel with hinges that will act as a door. The speaker and microphone compartments will both be accessed with an upper door, while all of the electronics will be accessed with a lower door. This two-door structure is to allow for the possibility of having the electronics accessible while keeping the acoustic chambers (the microphone and speaker compartments) of the kiosk sealed for testing.
2. Line the acoustic chambers with a metallic substance. This is to more accurately simulate the acoustic properties of the chambers in metal kiosks being used by fast food and banking drive-through systems. The chambers will be lined with a metallic tape available at many guitar parts stores. If that does not give the desired properties, the chambers will be lined with sheet metal.
3. Perform acoustical tests of the system. The test plan is detailed below

Test Plan:

We will determine the optimum position of the client relative to the kiosk by measuring the signal to noise ratio for various positions. The diagram to the right illustrates this concept. We will have ambient noise surrounding the client and the kiosk, and vary the angular position and distance of the client to determine which position produces the greatest signal-to-noise ratio. Bottom right is a simplified signal-to-noise ratio measurement table.

d / θ	1m	2m	3m
0	X dB	X dB	X dB
30	X dB	X dB	X dB
60	X dB	X dB	X dB
90	X dB	X dB	X dB



Timeline:

- February 6: Budgets due
- February 10: Purchase wood for new back, hinges, black spray-paint, metallic tape, and sound-absorbing foam.
- February 17: Cut wood for new back doors, paint black.
- February 24: Install new foam on inside of acoustic compartments, install new back with doors.
- March 2: begin acoustical testing. Install metal tape halfway through; this will be a variable we are testing.
- March 24: Finish acoustical testing
- April 3: Begin analysis of testing data

Expected Results: By the end of the semester, we should have two things. First, a kiosk that has easier access to all components than the current one, and which more accurately mimics the acoustic properties of kiosks currently being used in the fast food and banking industry. Second, quantitative data on the performance of the kiosk.

Sub Team 5: Project Coordination

Purpose: The main purpose of the Project Coordination team is to make sure each sub team follows the schedule of their tasks, and to make sure everyone finish their job on time. Project Coordination team needs to check with teams every week to let them know which task they should be on right now and how long it should take to finish it.

Team Members:

1. Steve Kuo
2. Tao Shen

Tasks:

1. Send out emails every week to remind the teams the timeline of their tasks.
2. Update the calendar on igroup website so it's easy to find out the project due dates.
3. Remind everyone the important due dates such as midterm and ipro day.

Sub-Team 6: Poster Board

Purpose: Produce a poster board for IPRO day that will provide necessary information as to what has been accomplished, what the goals of the team were, and provide conceptual information on the project itself.

Team Members:

- Jaroslaw Suwada (Team Leader)

- Titilayo Craig
- Yihan Su

Various Tasks:

- Work with presentation and documentation team to extract relevant material for displaying.
- Create a poster board for IPRO day.
- Provide clear concise information along with photographs.

Sub-Team 7: Purchasing Team

Purpose: The purchasing team is in charge of getting all equipment needed for the project. The purchasing team is responsible for sending the list of items needed to the IPRO office for purchase. In the event that the item needs to be purchased individually, the purchasing team is responsible for getting the needed item and submitting the receipts for all reimbursement to the IPRO office. Also, the purchasing team is in charge of the team's budget.

Task:

- Acquire list of all items needed from each team.
- Prepare team budget for the semester.
- Search necessary sites in which items can be purchased and the prices of each item.
- Send request to IPRO Office for purchase and follow up on details of purchase.
- Interact constantly with all other sub-teams to ensure all items needed through out the semester is purchased.

Timeline:

- **Feb 3**

Get all budget from each sub-team and compile them for the main team budget

- **Feb 5**

Team budget fully compiled and ready for submission.

Sub-Team 8: Research Team Responsibilities

Purpose: The research team provides information for other teams to utilize in the project implementation. The research team will utilize datasheets, web tutorials, journals, and published research to collect and convey data to the rest of the group, emphasizing the Circuit and Kiosk Testing teams.

Tasks:

- Acquire knowledge or studies of acoustic intelligibility to aid in developing kiosk standards.
- Acquire knowledge of common practice microphone and speaker mounting techniques for intercom systems.
- Acquire knowledge to supplement signal processing efforts by circuit team, i.e. the frequency response of diesel engines or male/female voice.

Timeline:
Primary research collection to supplement project:
1/22-2/13
Organization and posting of research with citations
1/29-2/19
Possible additional research to aid in findings:
4/3-4/17
Final Report Organization and citation:
4/10-4/24

Sub-Team 9: Web Team

Purpose: The purpose of the Web team is to create an informational website that is not only useful for the team, but also for public presentation and posterity. The website should present small to medium summaries of every aspect of the project, tentatively including ideas for the future. There will be various sources of information used in the development of the website, including but not limited to: archived websites of IPRO 344, off-site Internet resources, present research, and other internal documentation. Because of the dynamic nature of websites, the product of this team will gradually take form as more information and resources become available.

Tasks: The following are tentative tasks for the Web team to complete

1. Analyze the archived websites, making note of information that can still be used, as well as areas of improvement. This will give the team a solid base of information to work with and add on to throughout the project's lifespan.
2. Create a basic website skeleton with available information, including a rough-draft design and tentative sections and sub-sections. It should be noted that this work must be done carefully to allow ease of expansion.
3. Continue to maintain the site. This includes various tasks.
    a. Revise sections to make them more intuitive, aesthetically pleasing, and palatable in terms of language.
    b. Continue the design process. This includes updating, or even re-creating the visual design of the website. One of the goals of the Web team is to provide as aesthetically pleasing of a website as possible.
    c. Continue to add content. This includes networking with the various other teams to collect information useful for the website, searching the web for pertinent information, and any other method that comes to hand.
    d. Explore additions to the site. Videos are interactive media are examples of things that could possibly fit into the website.

Timeline:

- February 10: Have the old websites done being analyzed for useful information. If possible, get information that other teams have available
- February 17: Have a basic design up with available content. This does not need to be the final design, but a skeleton onto which a design can be imposed. Have all available content inserted into the site
- March 17: Have the "final" site done. This includes the final design, as well as all of the data available by that time. From here on, the website will be maintained by the methods described above. Assuming all is well, the bulk of the work of the web team will be finished at this point. Most of the work from this point forward will be adding new findings and media to the site.

Expected Results: By the end of the semester, the team should have produced a comprehensive, aesthetically pleasing website that will serve as an internal and external resource for informational material pertaining to IPRO 344.

Sub-Team 10: Tools and Media

Purpose: The purpose of the tools and media team is to collect specific utilities including software and hardware tools which help the IPRO in collecting and analyzing empirical data from the kiosk system. The data will be used to give the team a better understanding of the system's performance and a window into how future improvements to the system can be made.

Tasks: The following are the tasks the Tools & Media team set off to accomplish:

I: Collect tools to analyze the system hardware

1. Tools will include ones to measure total harmonic distortion and frequency response of the system's hardware.
2. Develop a methodology for hardware analysis for future drive thru systems.

II: Collect tools to be used for tests on the systems:

1. Audio analysis tools will be used to find the frequency response of common sources of noise in the drive thru facility ex: diesel engine.
2. Tools will be collected to record and analyze the data from experiments conducted by the experimental teams.

III: Create a matlab graphic user interface that can be used by future semesters for testing intercom systems.

1. This application will include Fourier based spectral analysis.
2. Time frequency analysis provided by wavelet transform and short-time fourier transform.
3. The ability to import audio files from outside sources.
   Analyze audio directly from the soundcard.

Timeline:

Collect and study hardware analysis tools used in previous semester.-1/22-2/1

Collect tools to analyze audio for testing.-:2/1-2/14

Develop a matlab application to analyze the system:

I: Research available audio analysis m-files.-2/15-2/28

II: Implement a time frequency algorithm for analyzing audio files. -3/1-3/14

III: Construct a graphic user interface implementing collected audio analysis tools in matlab. -3/15-4/1

Analyze collected empirical data and develop a methodology for testing intercom/drive thru-systems. -4/2-4/20

Sub-Team 11: Presentation Team

Purpose: The purpose of the presentation team is to deliver a power point presentation for the judges over the semester. The power point presentation will accurately and concisely summarize the activities and findings of IPRO344 over the semester.

Tasks:

- Work with the documentation team to develop and organize content for the power point presentation.
- Deliver a quality presentation after some rehearsal.

Timeline:

2/24 All team members will give a 5-minute presentation and vote on the team members.
3/1 Midterm Presentation Finished
4/15 Initial Version of the Final Presentation.

8. Designation of Roles

Agenda Maker- Steve Kuo

Time Keeper- Kevin Gullikson

Filing and Organizing Weekly Timesheets- Alex Barnett

Weekly Task Lists- Kevin Gullikson

iGroups Coordination- Titilayo Craig

Master Schedule Maker- Steve Kuo

IPRO344 Representative/Presenter- Alex Barnett