Noise Mitigation in an Organic Rankine Cycle (ORC) Turbine Bypass Line

Team 14

Members:
Chad Adams
Austin Houser
William Mauch
Luis Figueroa

Faculty Advisor
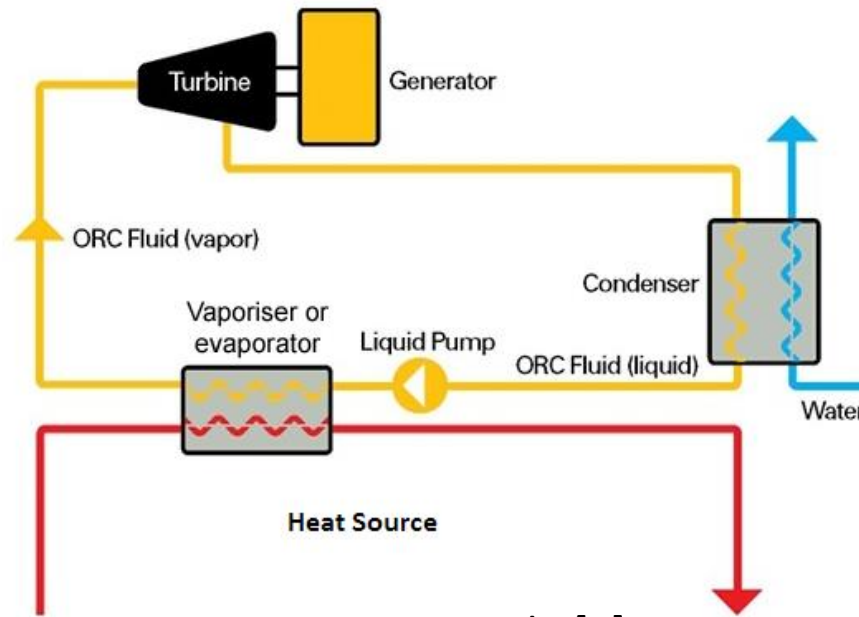Dr. Louis Cattafesta

Sponsor Representative
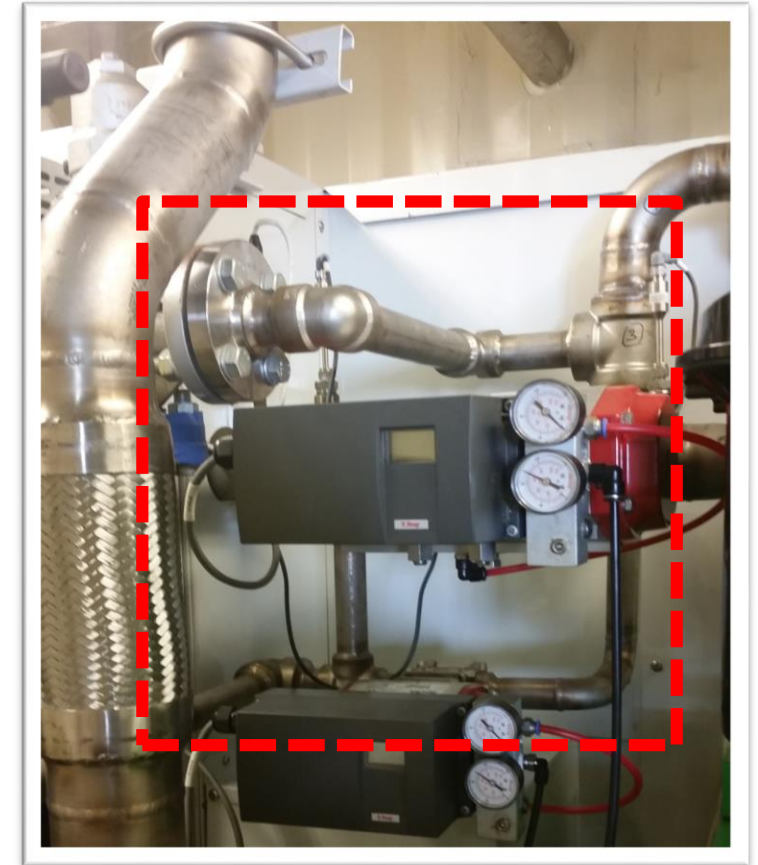Cory Nelson

Instructors
Dr. Chiang Shih

Organic Rankine Cycle (ORC) Overview

- Thermodynamic Cycle used to convert heat energy into work.
- Utilized by Verdicorp to turn waste heat from industrial processes into reusable electricity.

ORC Operation Cycle [1]

ORC Bypass Line

Project Definition

Problem Statement

- When operating in bypass, the ORC system generates an unacceptably loud amount of noise. A solution needs to be found to mitigate the bypass line noise while not impeding the performance of the system nor requiring significant modifications of existing components.

Project Scope and Goals

- Solution must be cost effective.
- Must not impede performance of the system.
- Reduce bypass line noise levels toward turbine steady-state noise levels.
- Can be manufactured in Verdicorp machine shop.

Scope - Project Objectives

Find Source of Bypass Noise produced by ORC System

- Properly measure steady-state and transient noise of the ORC System.
  - Specifically frequency domain and decibel level.
- Compare noise level analysis of both scenarios.
  - Determine which frequencies are more intrusive than others.

Create a Working Prototype for the ORC System

- The type of noise mitigation method will depend on the desired frequencies to dampen.
  - Material choice and prototype location will be aimed to specifically address said frequencies.

Scope - Project Goals

Lower Noise levels of ORC System when Operating in Bypass Mode

- **Initial goal:** Test prototype - document new noise levels of the system when operating in bypass mode.

    o Address prototype issues: Does prototype fit correctly and seal well?

- **Final goal:** Lower bypass mode noise levels close to those seen during steady-state operation.
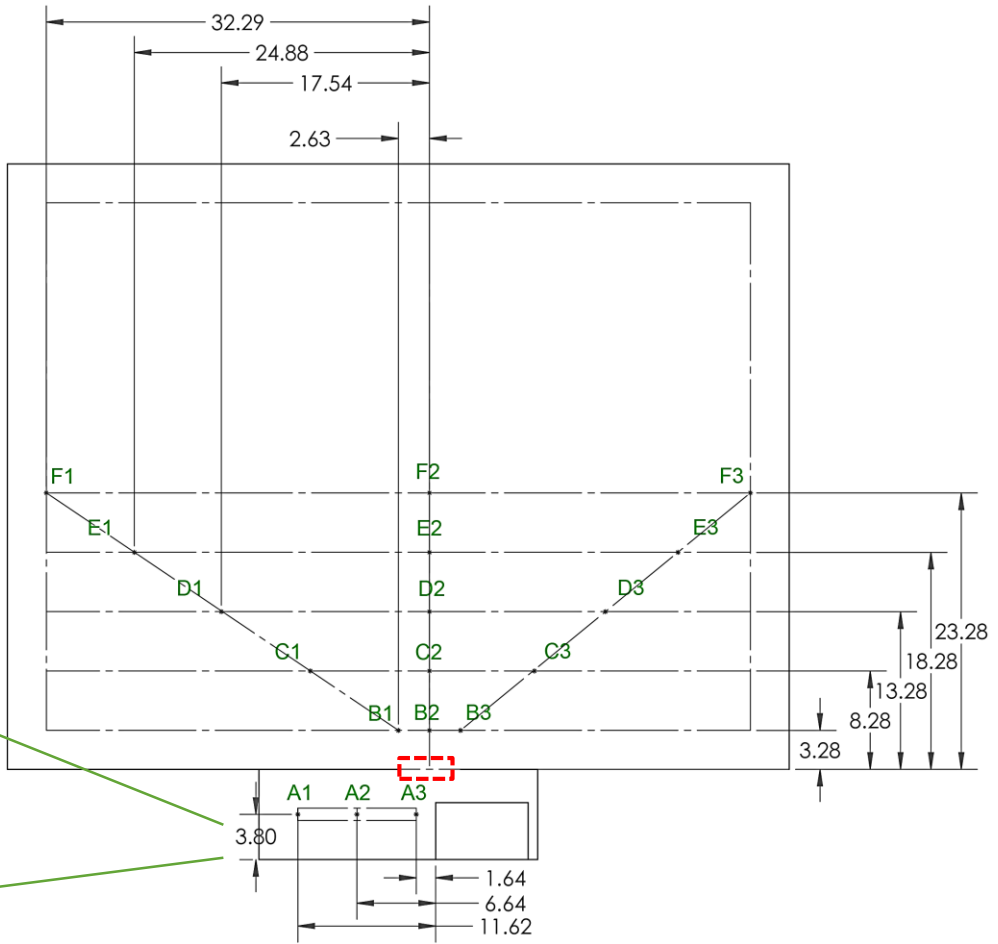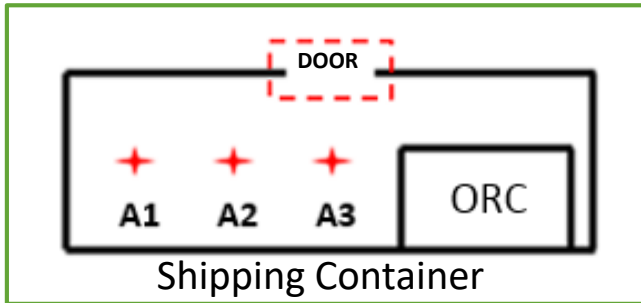
Approach

Original:

- Measurements taken 1 m from walls, 1.2 m from ground at 5 m intervals.
- Catalog background noise.
- Generate contour plot based on dB recordings.

Updates:

- Further analysis is necessary to ensure results gathered are authentic.
- Plan to measure sound levels at a further distance (D, E, and F ranges).
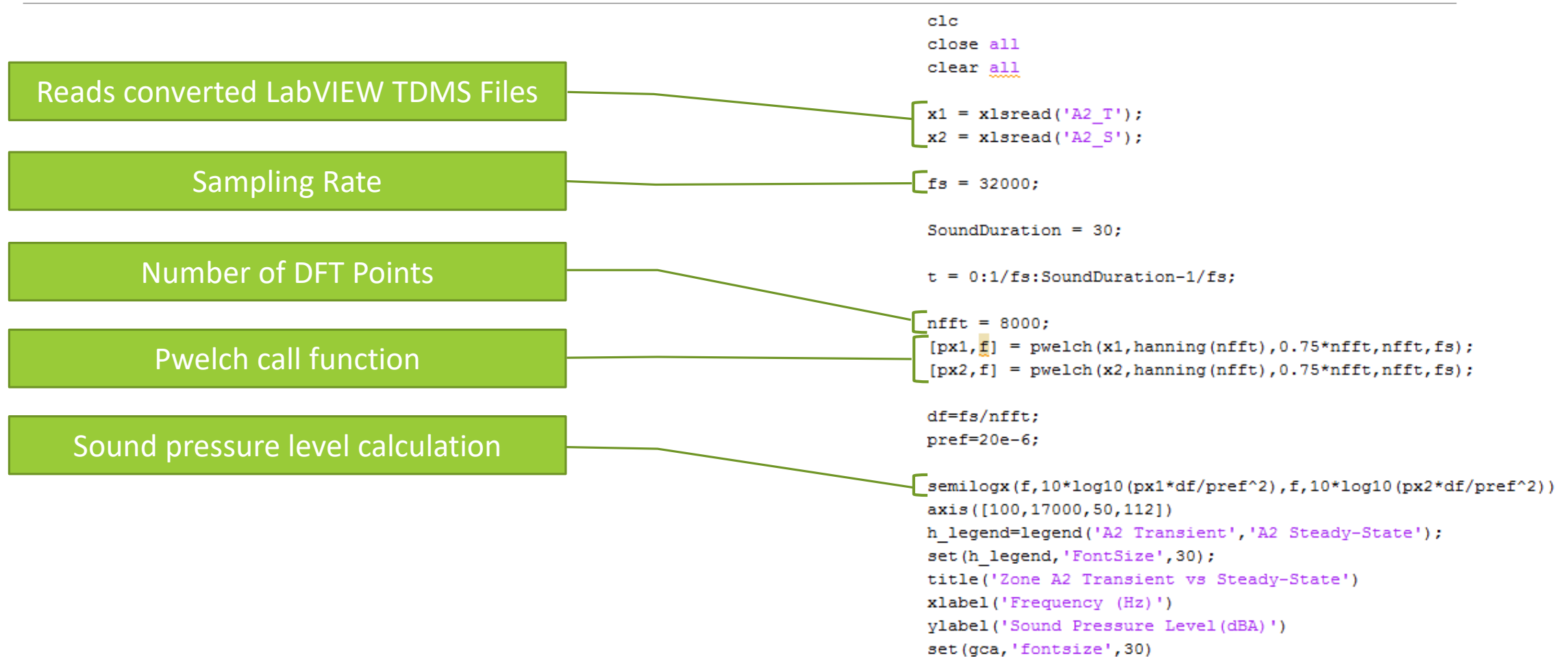- Measure and compare the ORC noise level with orifice sealed

Shipping Container

Approach
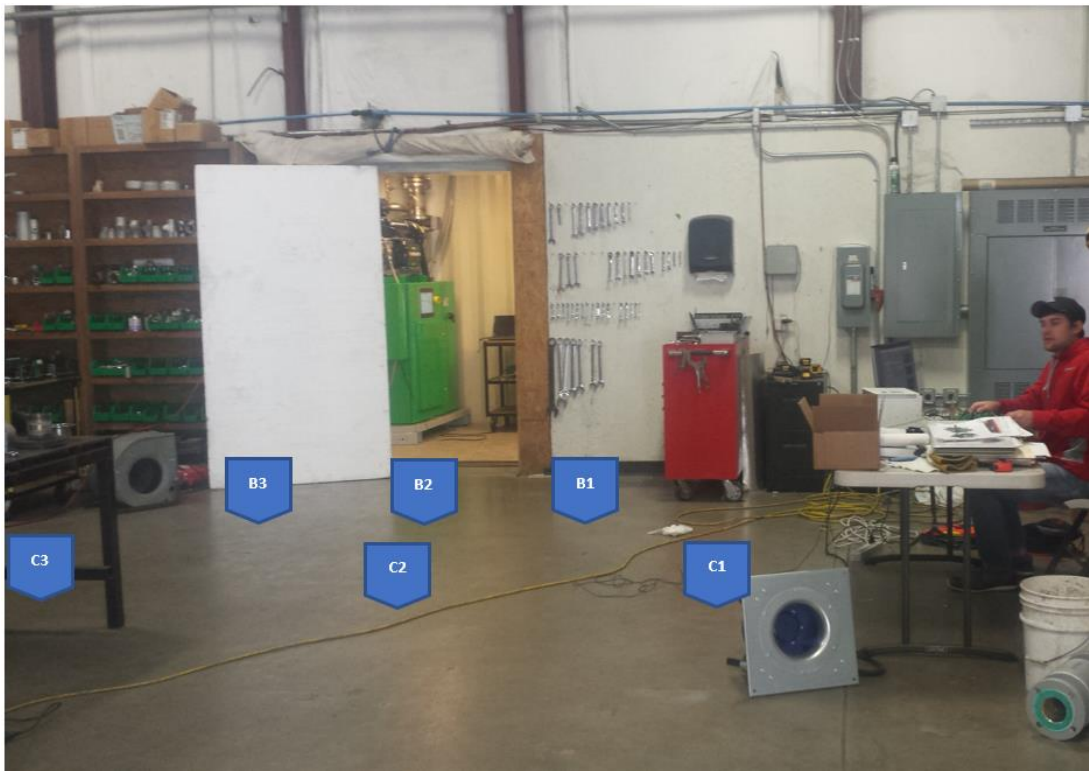
Note: Test point position not too scale

Project Progress
Matlab Code

Reads converted LabVIEW TDMS Files

Sampling Rate

Number of DFT Points

Pwelch call function

Sound pressure level calculation

```
clc
close all
clear all

x1 = xlsread('A2_T');
x2 = xlsread('A2_S');

fs = 32000;

SoundDuration = 30;

t = 0:1/fs:SoundDuration-1/fs;

nfft = 8000;
[px1,f] = pwelch(x1,hanning(nfft),0.75*nfft,nfft,fs);
[px2,f] = pwelch(x2,hanning(nfft),0.75*nfft,nfft,fs);

df=fs/nfft;
pref=20e-6;

semilogx(f,10*log10(px1*df/pref^2),f,10*log10(px2*df/pref^2))
axis([100,17000,50,112])
h_legend=legend('A2 Transient','A2 Steady-State');
set(h_legend,'FontSize',30);
title('Zone A2 Transient vs Steady-State')
xlabel('Frequency (Hz)')
ylabel('Sound Pressure Level(dBA)')
set(gca,'fontsize',30)
```

Project Progress
Position 2 Analysis
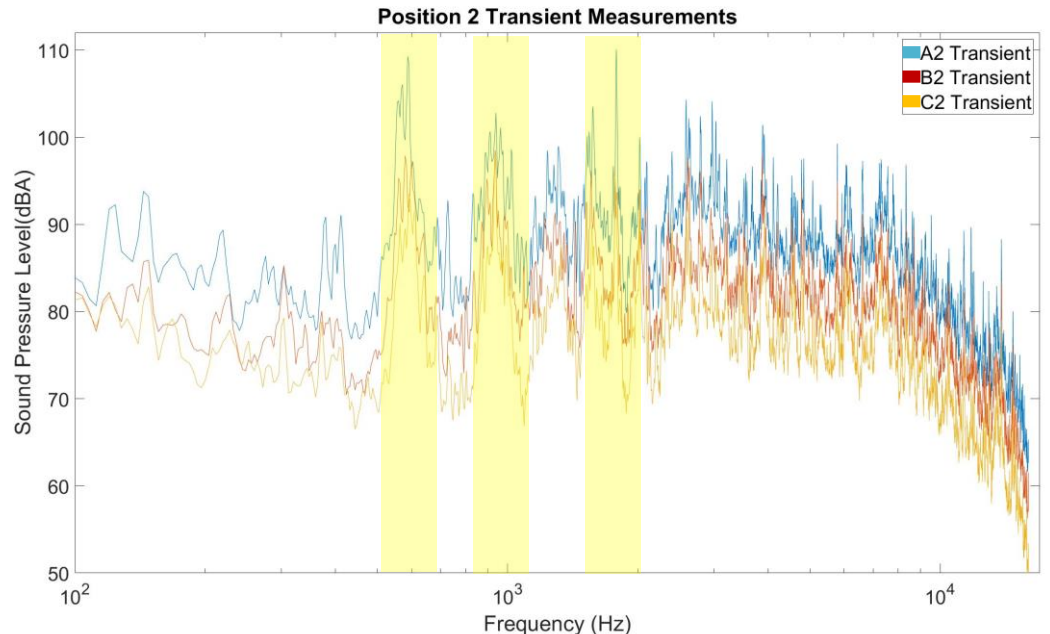
Transient	Average SPL (dB)
A2	83
B2	78
C2	72
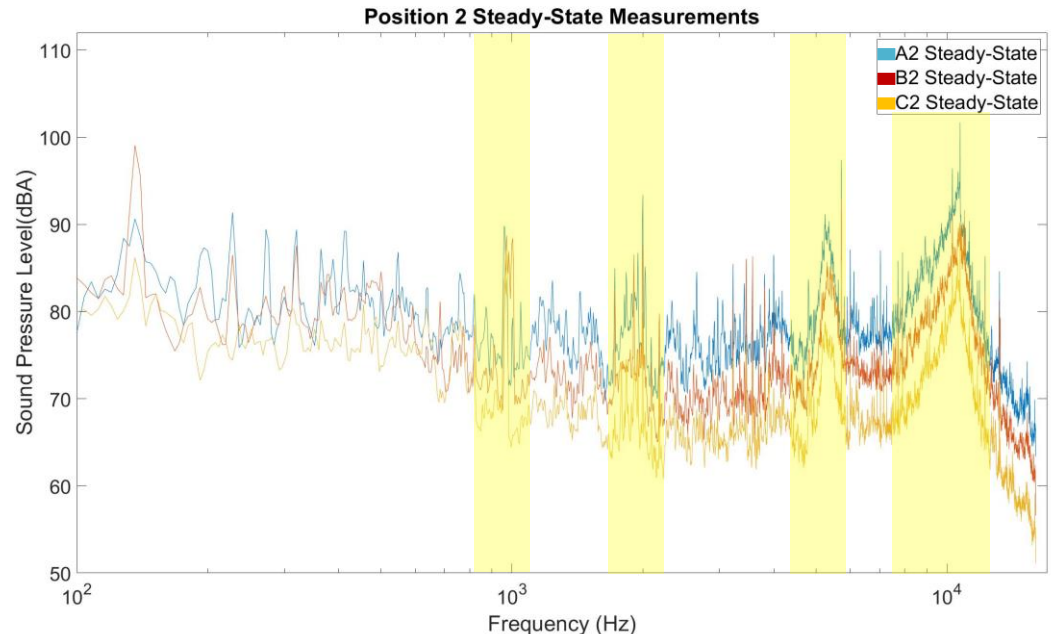
Steady-State	Average SPL (dB)
A2	78
B2	74
C2	68

Project Progress
Data Comparison

Zone A2 Transient vs Steady-State
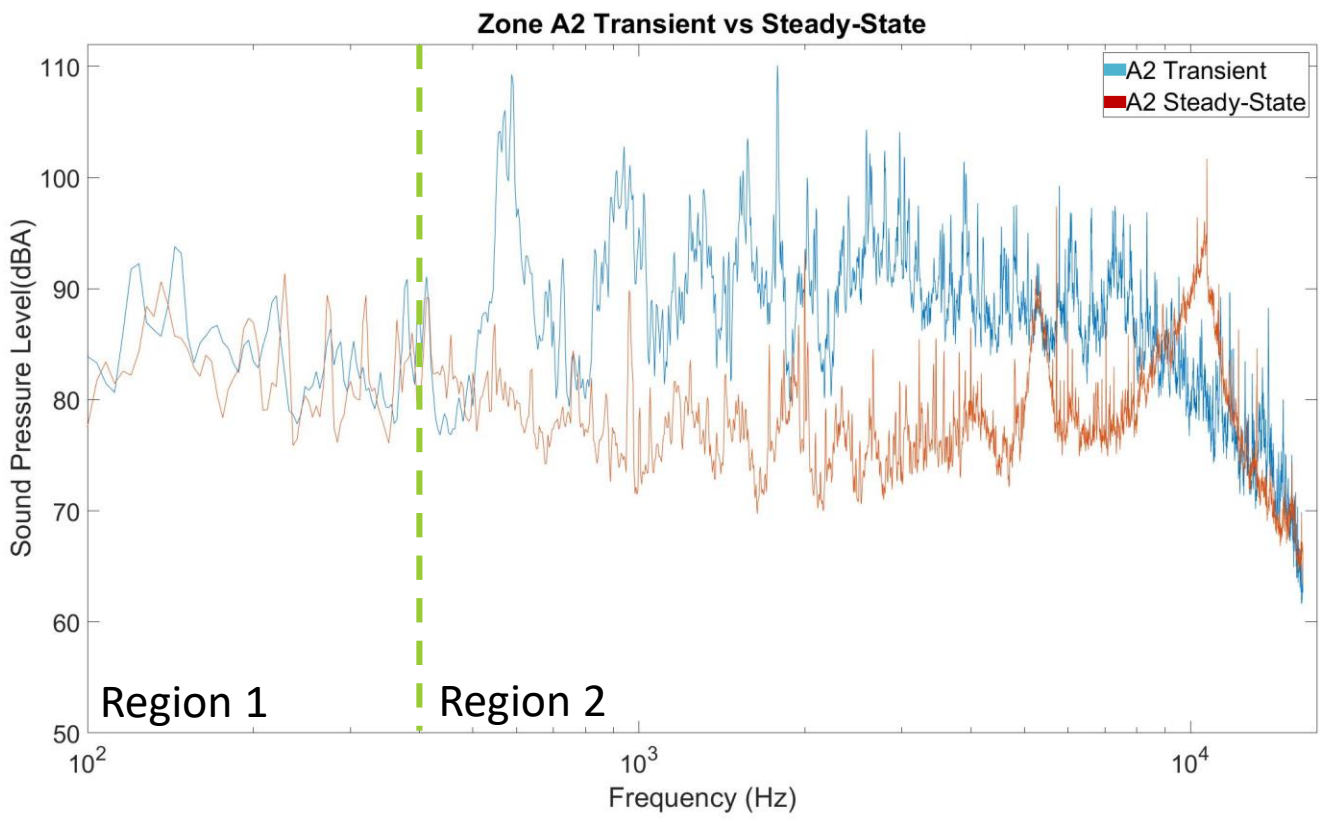
Region 1 & 2	Average (dB)	Max (dB)
Steady-State	78	102
Transient	83	110

Steady-State	Sound Pressure Level (dB)
Average	81
Maximum	102 at 10.7 kHz
Transient	**Sound Pressure Level**
Average	88
Maximum	110 at 1784 Hz

Challenges

- Environment and location of the system
  - Organic Rankine Cycle is located inside a steel shipping container

$$RT_{60} = \frac{0.161 \frac{m}{s} * V}{S_a} = 2.2s$$

Direct sound
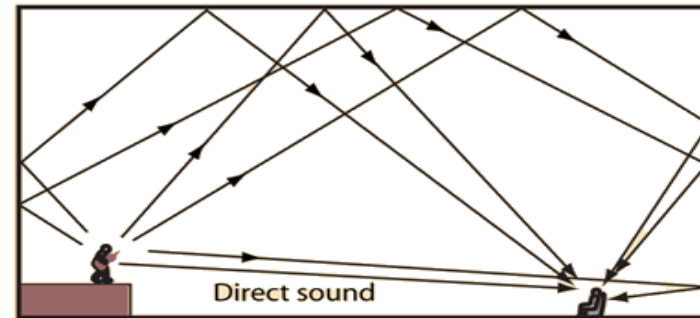
- Characterizing the noise source
  - Dampening individual components of bypass line with varying acoustic traits
- ORC Availability Conflicts

Timeline

Task Name	Duration	Start	Finish	Dec 18	Jan 1	Jan 15	Jan 29	Feb 12	Feb 26	Mar 12	Mar 26	Apr 9
Team 14 Spring 2017	**71 days**	**Mon 1/9/17**	**Mon 4/17/17**									
Conclude Data Analysis	14 days	Mon 1/9/17	Thu 1/26/17									
Concept Development	14 days	Mon 1/16/17	Thu 2/2/17									
Measurement Confirmation	28 days	Thu 2/2/17	Mon 3/13/17									
Procurement of Materials	28 days	Thu 2/2/17	Mon 3/13/17									
Prototype Manufacturing	14 days	Mon 3/13/17	Thu 3/30/17									
Prototype Measurements	7 days	Thu 3/30/17	Fri 4/7/17									
Prototype Comparison	7 days	Fri 4/7/17	Mon 4/17/17									

Summary

Data Results

- Frequency domain sound level analysis
- Steady-State measurement of 78 dB
- Difference of 7 dB between transient and desired levels

Future Work

- Data based concept development
- Measurement confirmation
- Prototype manufacturing
- Prototype testing

Resources

1. "Energy, Exergy and Performance Analysis of Small-Scale Organic Rankine Cycle Systems for Electrical Power Generation Applicable in Rural Areas of Developing Countries," *MDPI*. [Online]. Available: http://www.mdpi.com/1996-1073/8/2/684/htm. [Accessed: 04-Oct-2016].

2. "High performance tri-generation," *Verdicorp Environmental Technologies*. [Online]. Available: http://www.verdicorp.com/trigeneration brochure 20120428.pdf. [Accessed: 25-Sep-2016].

3. "City of Tallahassee Code of Ordinance ," *Municode Library*. [Online]. Available: https://www.municode.com/library/fl/tallahassee/codes/code_of_ordinances?nodeid=ptiicogeor_ch12ofmipr. [Accessed: 08-Oct-2016].

Questions?