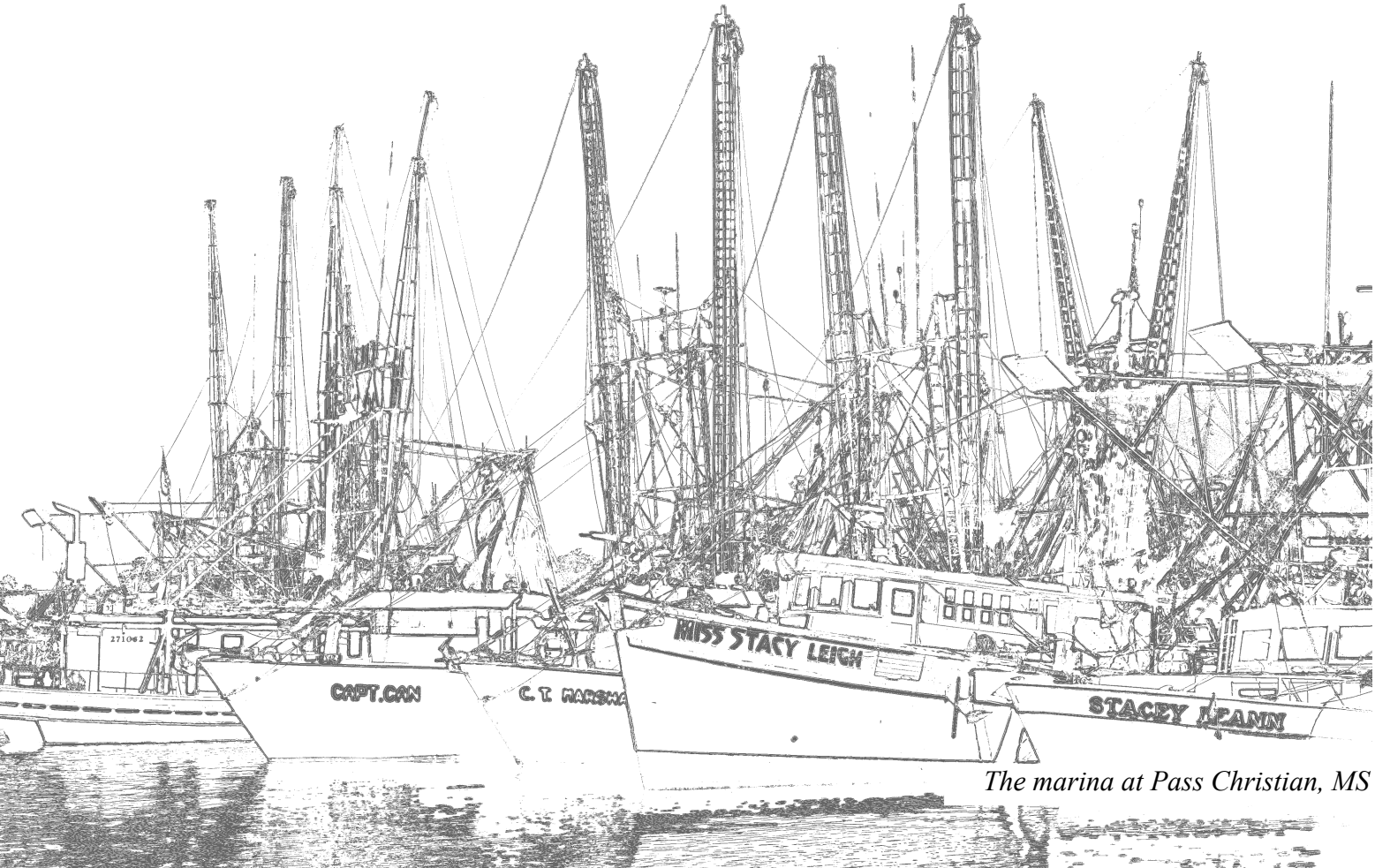
Detecting Toilet Flushes in a Restroom

Test Report: TR005

Revision: A
Date: June 22, 2017

Abstract: We all do it. Sitting on the throne, contemplating the world's mysteries. How many flushes occur throughout a given day at a public restroom? Well, wonder no more. Our crack field engineers used the X2-2 logger to monitor the flush cycles at a busy restroom located at Walt Disney World. Yes, we went there. The overall results show a clear indication of activity in the restroom.



The marina at Pass Christian, MS

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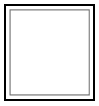
1 Introduction

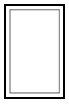
1.1 Document Conventions

This test report describes in detail the background information, procedure, and analysis method used to conduct an experiment using a GCDC data logger. This experiment is an example application using an accelerometer that is both educational and fun.

Each section also presents relevant tips and warnings to help the user repeat the experiment or make improvements.



This icon indicates a helpful tip that may enhance the results or add a new perspective to the objective.



This icon indicates a warning, restriction, or limitation that the user should be aware of regarding the experiment or logger operation.

1.2 Repeating this Experiment

Obviously, a GCDC data logger is required to repeat the test procedure. The exact product type is described in section 4. However, the raw data and analysis methods are provided such that a user may recreate the same results without repeating the test process. Stepping through the analysis process with the data files will help the user understand the steps and see the expected results. The raw data files, spreadsheets, and R scripts are available for download at www.gcdataconcepts.com.

A spreadsheet is used for simple analysis, so the user should be familiar with manipulating data and creating plots in a spreadsheet. We recommend Microsoft Excel or OpenOffice Calc.

"R" is used for more complex data analysis. R is a simple command line programming environment that can manipulate large data sets using common math commands as well as complex function libraries. The software is compact, free, and available at www.r-project.org for Windows, Mac, and Linux. The R scripts provided herein are designed to run on Windows and may not be fully compatible with Mac and Linux systems. Specifically, file path references will not translate properly to the Mac and Linux systems. These differences will be noted in the script comments.

1.3 Disclaimers

This test report is presented "as-is" and for informational purposes only. No claims, representations or warranties, whether expressed or implied, are made to the safety and performance of the procedures described herein. Furthermore, we do not make any guarantee that your son or daughter will get an "A" on their science project, which is probably due tomorrow morning...but that's not our problem, and you should have started earlier anyway.

2 Background Information

We all do it. Sitting on the throne, contemplating the world's mysteries. How many flushes occur throughout a given day at a public restroom? Well, wonder no more. Our crack field engineers used the X2-2 logger to monitor the flush cycles at a busy restroom located at Walt Disney World. Yes, we went there.

3 Objective

This experiment uses the X2-2 accelerometer logger to monitor the flush activity of a public restroom toilet.

4 Experiment Setup

4.1 Materials and Equipment

Table 1: Materials and Equipment List

Description	Quantity	Comments
X2-2 Accelerometer Data Logger	1	Purchase online from GCDC.
3M Command Adhesive Strips (med)	1	Available at most retail stores in the hardware department. Medium size strip works well.
Money	Excessive	Walt Disney World park tickets are expensive!

4.2 Equipment Setup

4.2.1 Test Setup

The excellent sensitivity of the X2-2 accelerometer affords the detection of very low amplitude vibrations. In this case, the X2-2 was used to capture the vibration of water flushing through a toilet.

A restroom with high traffic in a crowded location was selected at Walt Disney World in Florida. The selection helped justify the 600 mile drive, condo rental, park tickets, and fun-filled research expedition. We chose the first restroom upon entering the Magic Kingdom theme park. This particular men's restroom was configured with three side-by-side stalls. The logger was attached to the toilet in the middle stall using a 3M Command strip. The logger was placed underneath the toilet near the water inlet such that the logger was concealed.

The X2-2 logger was configured according to Figure 1. The sample rate was set to 128 so the analysis would provide vibration spectrum between 0-64Hz.

4.2.2 Logger Configuration

```
;X2-2 configuration
;set sample rate
;available rates 4, 8, 16, 32, 64, 128, 256, 512
samplerate = 128
;record constantly
deadband = 0
deadbandtimeout = 0
;set file size to 15 minutes of data
samplesperfile = 115200
;set status indicator brightness
statusindicators = Normal
stoponvusb
;rebootOnDisconnect
microres
gain = low
;see user manual for other config options
```

Figure 1: Logger Configuration

5 Procedure

5.1 Test Procedure

The following steps outline the procedures taken to collect data on the vibration of water flushing through a toilet:

1. Started the X2-2 data logger after attaching it to the public toilet.
2. Allowed the logger to collect data for 6 hours before retrieving it.

5.2 Analysis Procedure

The data was processed into the frequency domain using a Fast Fourier Transform (FFT), and the spectral response summed in a specific band. Initial findings indicated that the water inlet vibrated in the 10-50 Hz range. Isolating the 35-45 Hz range removed some of the influence of neighboring toilets. An R script similar to the analysis used in our the train vibration experiment (TR004) processed all the data files. The results were exported into Excel for plotting purposes.

6 Results

The analysis determined the occurrence of at least one flush at the test toilet as well as other toilets in the same restroom. The results illustrate the overall loading conditions at this restroom throughout the evening from 4pm to 10pm. The period of inactivity from 8:15-9:30 coincides with the evening parade and fireworks at the Magic Kingdom park. The event at approximately 9:15pm was the most likely case for a flush at the test toilet.

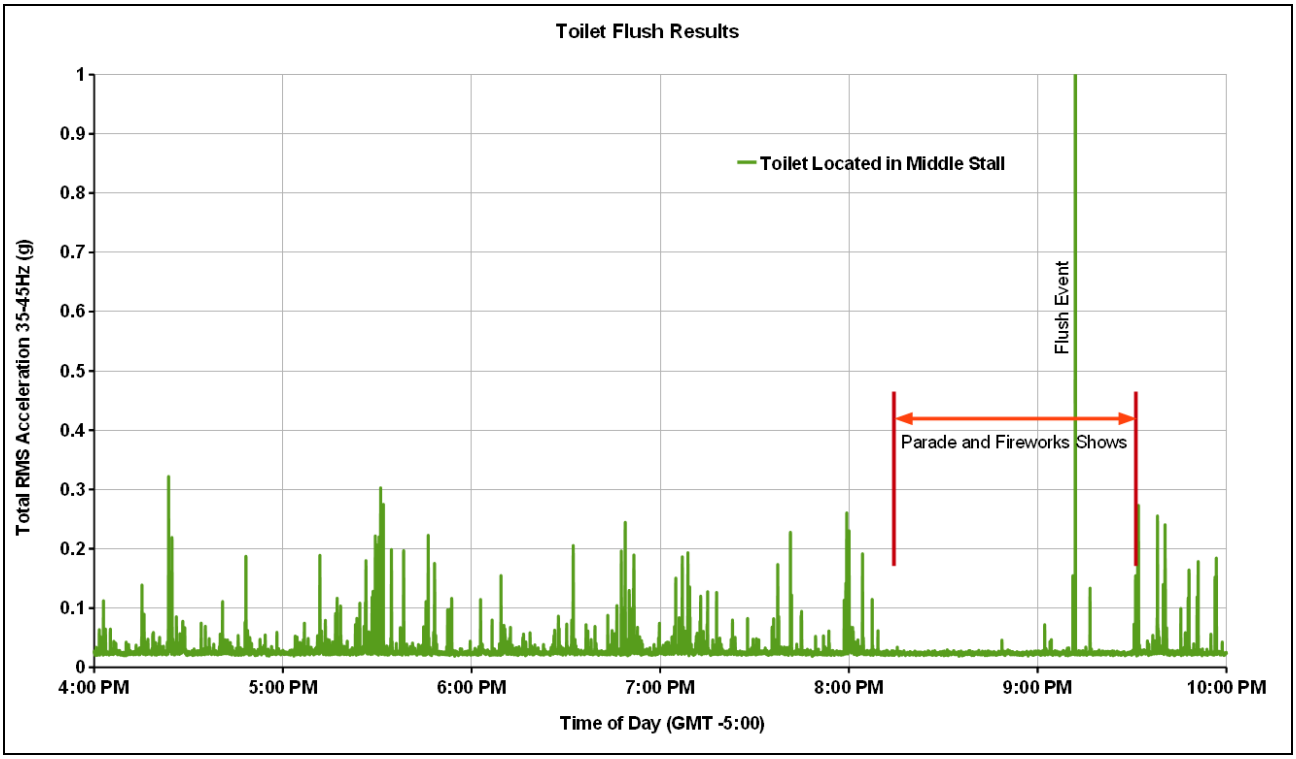


Figure 2: Toilet Flush Events

7 Discussion

The overall results show a clear indication of activity in the restroom, which could be valuable information for cleaning and maintenance scheduling. Unfortunately, a baseline flush from the test toilet was not characterized first. The response from other nearby toilets was not expected, and this interfered with determining the flush occurrence of the particular test toilet. If this test is repeated, all of the toilets should be flushed individually several times to characterize the typical vibration responses.

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