

# Can a Machine Be Trained to Reliably Report the Operational Status of Building Equipment Systems through Simply Listening? And If It Can, So What?

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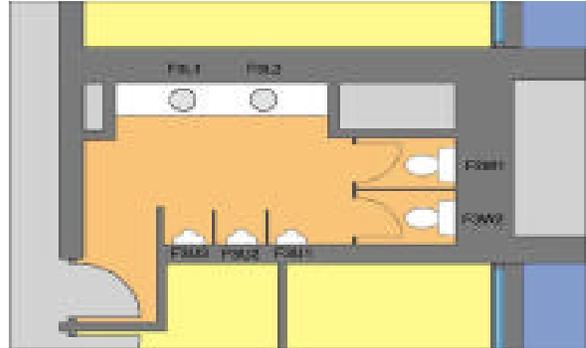
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## Airs Experimental Setup



*Typical Bathroom Plan*

## Purpose of the Research

The purpose of this research is to determine the system-wide reliability of the Acoustic Information and Retrieval System (AIRS); and if the reliability is good, describe the potential importance of this new data-acquisition system to architectural research.

## Methods and Procedures

- Digitally record representative acoustic events.
- Prepare a training score for AIRS based on the digital recordings. For the purposes of this research, the term *score* means something akin to a musical score: a digital recording of a series of acoustic events.
- Train AIRS.
- Prepare a test score of randomized acoustic events.
- Input the test recording to the AIRS acoustic pattern recognition engine.
- After approximately 1000 replications, calculate the recognition rate.



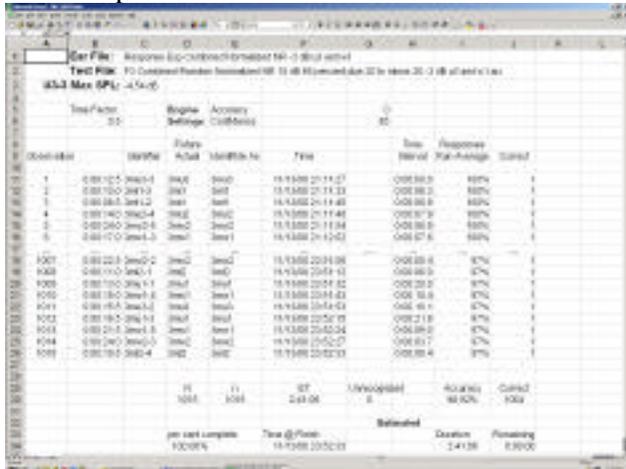
*Test Bench*



*Score on Cool Edit 2000*

## Main Results

The experiment resulted in 1004 correctly recognized events and 11 incorrectly recognized events. This is a system-wide reliability near 99 percent under laboratory conditions. Field results can be expected to be somewhat less than this.



Time Factor	Fixture	Response	Accuracy	Date
1	1001	1001	99%	10/10/01
1	1002	1002	99%	10/10/01
1	1003	1003	99%	10/10/01
1	1004	1004	99%	10/10/01
1	1005	1005	99%	10/10/01
1	1006	1006	99%	10/10/01
1	1007	1007	99%	10/10/01
1	1008	1008	99%	10/10/01
1	1009	1009	99%	10/10/01
1	1010	1010	99%	10/10/01
1	1011	1011	99%	10/10/01
1	1012	1012	99%	10/10/01
1	1013	1013	99%	10/10/01
1	1014	1014	99%	10/10/01
1	1015	1015	99%	10/10/01

*Partial Experimental Data Log Spreadsheet*

## Status of the Effort

### Implications for Architectural Research

In this experiment we chose to use the sound generated by plumbing fixtures as they were operated to exemplify an observable acoustic event. Even the ability to successfully observe these seemingly mundane phenomena has important implications to architectural research.

A review of the literature reveals that there is little or no empirical research on the actual use of bathrooms in the US. This is understandable given our socio-cultural bias toward extreme privacy when it comes to bathrooms. Can you imagine trying to get human-subject-committee approval for placing a video camera in a public bathroom or even standing around with a clipboard to make observational notes? I sincerely doubt it. So, this bias mitigates against actually observing how bathrooms are used; and without the ability to make observations, there can be no empirical research. The key to acoustic observations of actual fixture operation is that it

maintains personal anonymity while providing meaningful data on actual fixture use.

These data can be used to answer many architectural research questions. Here are four examples for a start:

- What is the proper fixture-to-occupant ratio for different occupancy types?
- What is the proper fixture-to-occupant ratio for different occupancy types based on sex?
- Are certain fixtures of the same type used at a higher frequency in a given bathroom layout than others? If they are, what are the design implications of these asymmetric patterns of use?
- What is the average time per use for different fixtures considering the sex of the user?

## Future Work

We have begun live data collection on a seven-fixture men's room in a campus building. We expect to expand our coverage to three more men's rooms and then four additional women's rooms. Once the instrumentation is working reliably, we will begin data collection aimed at answering some of the research questions posed earlier in this paper.