Infrasound, in Context

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Consortium for Verification Technology, October 2014

New 2015-2019 Project: NNSA Consortium for Verification Technology (CVT)

Department of Energy FOA-0000892

Primary CVT Lead: Prof. Sara A. Pozzi
Department of Nuclear Engineering and Radiological Sciences
University of Michigan

- *The CVT's overarching theme is the advancement of the state-of-the-art in technologies and policies related to the verification of these treaties.*
- *The CVT consists of thirteen leading universities and eight national laboratories that will provide the R&D and human capital needed to address technology and policy issues in treaty-compliance monitoring.*

Thrust Area 4: Detection of Undeclared Activities and Inaccessible Facilities

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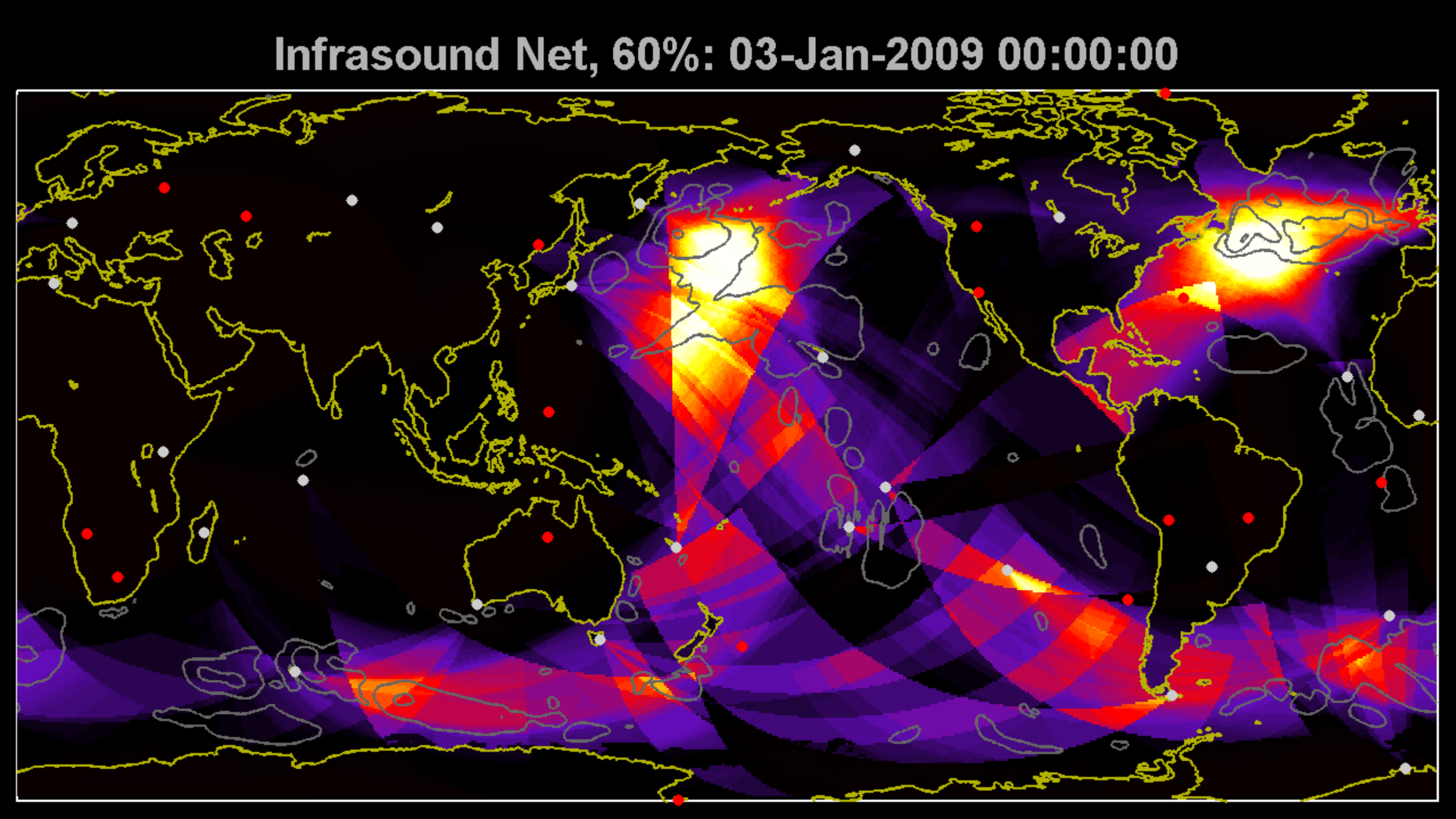
- ***Next-Generation Sensor Development***
- ***Ground Truth Event Re-Evaluation***
- ***Source Characterization***

Infrasound Technology Roadmap

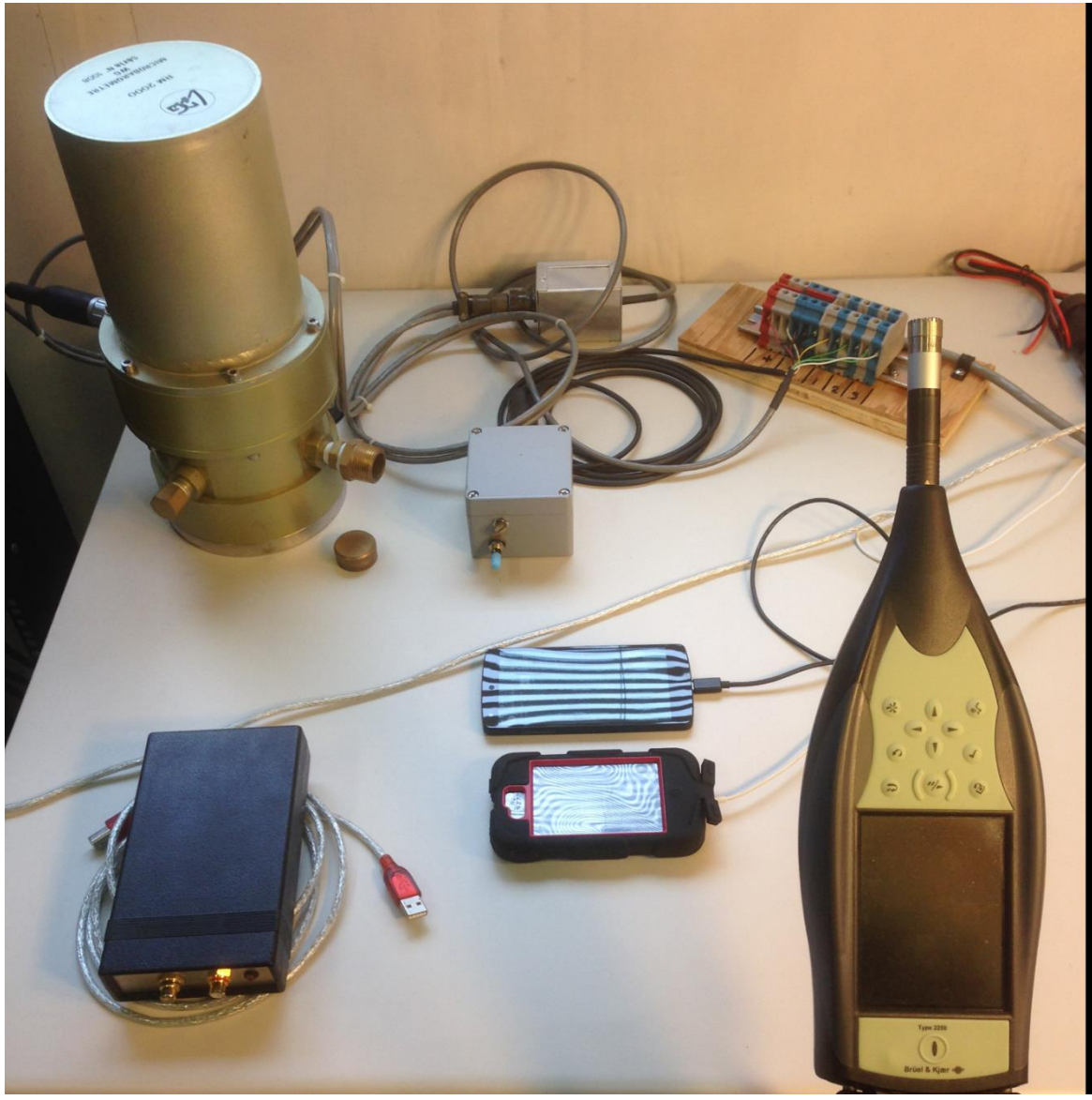
Disruptive Approaches

- ID Source Radiation Patterns (Pilger, et al., EGU14, ITW14)
- Machine Learning

- Both disruptive topics are hindered by sparsity
- More is better – High N initiatives in seismology for full waveform capture
- Legacy infrasound networks: 10^2 – 10^3 channels global
- How about 10^4 – 10^6 infrasound channels?


Infrasound Net, 60%: 03-Jan-2009 00:00:00

References: MB2000 and B&K 4193/UC0211 w/2250 Analyzer
Test: ITEM, Nexus5 BOSH barometer and iPhone5 MEMS microphone



Standardized Infrasound metrics
Frequency (ISO-03/ANSI/ASA)

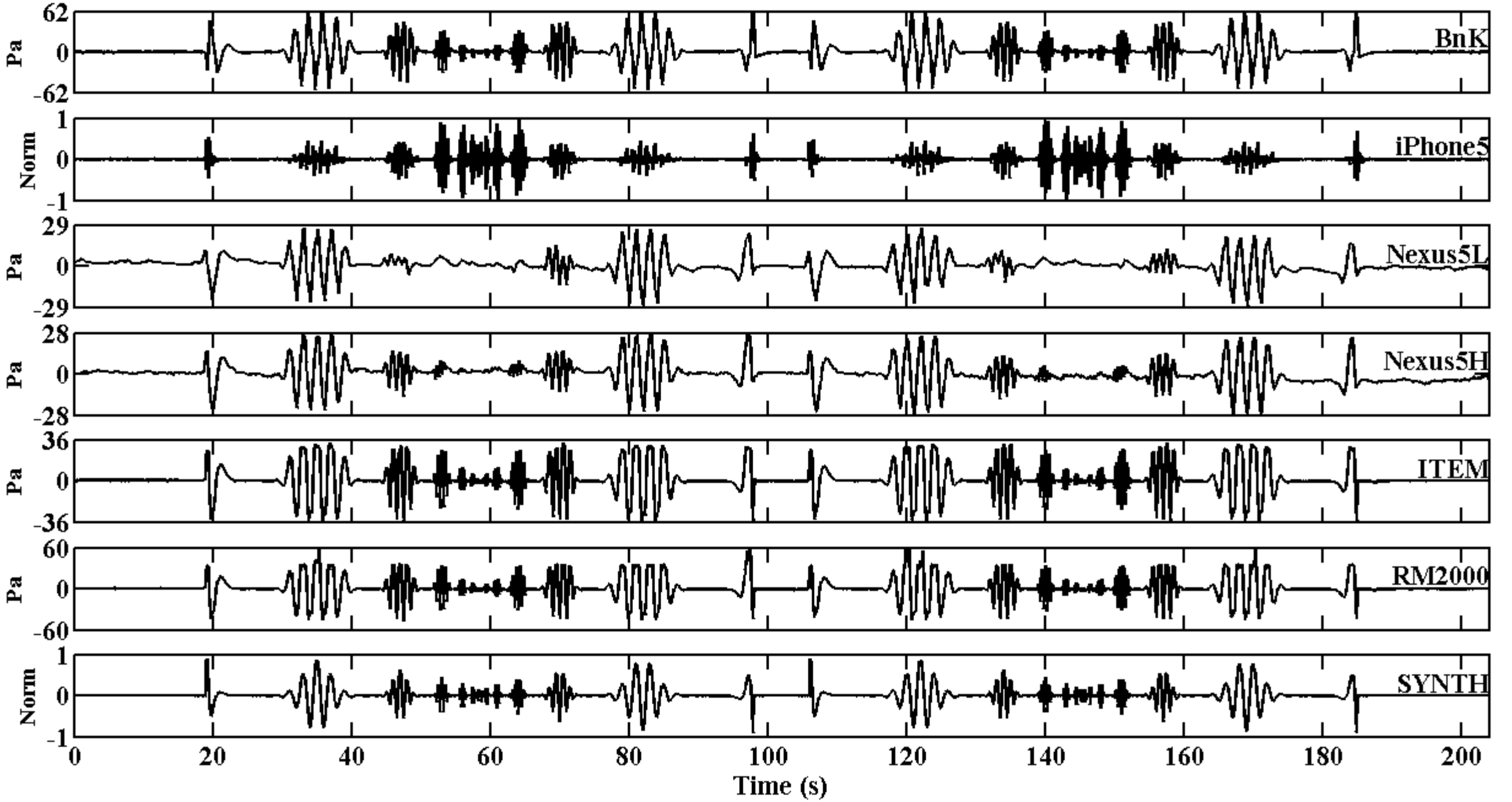
The center frequency of the 1/N octave band (N = 1, 3, 6, 12, 24) referenced to f_0 = 1 Hz in the infrasound range can be defined by the Renard Series (s_N = 10N/3 = 10/3, 10, 20, 40, 80)

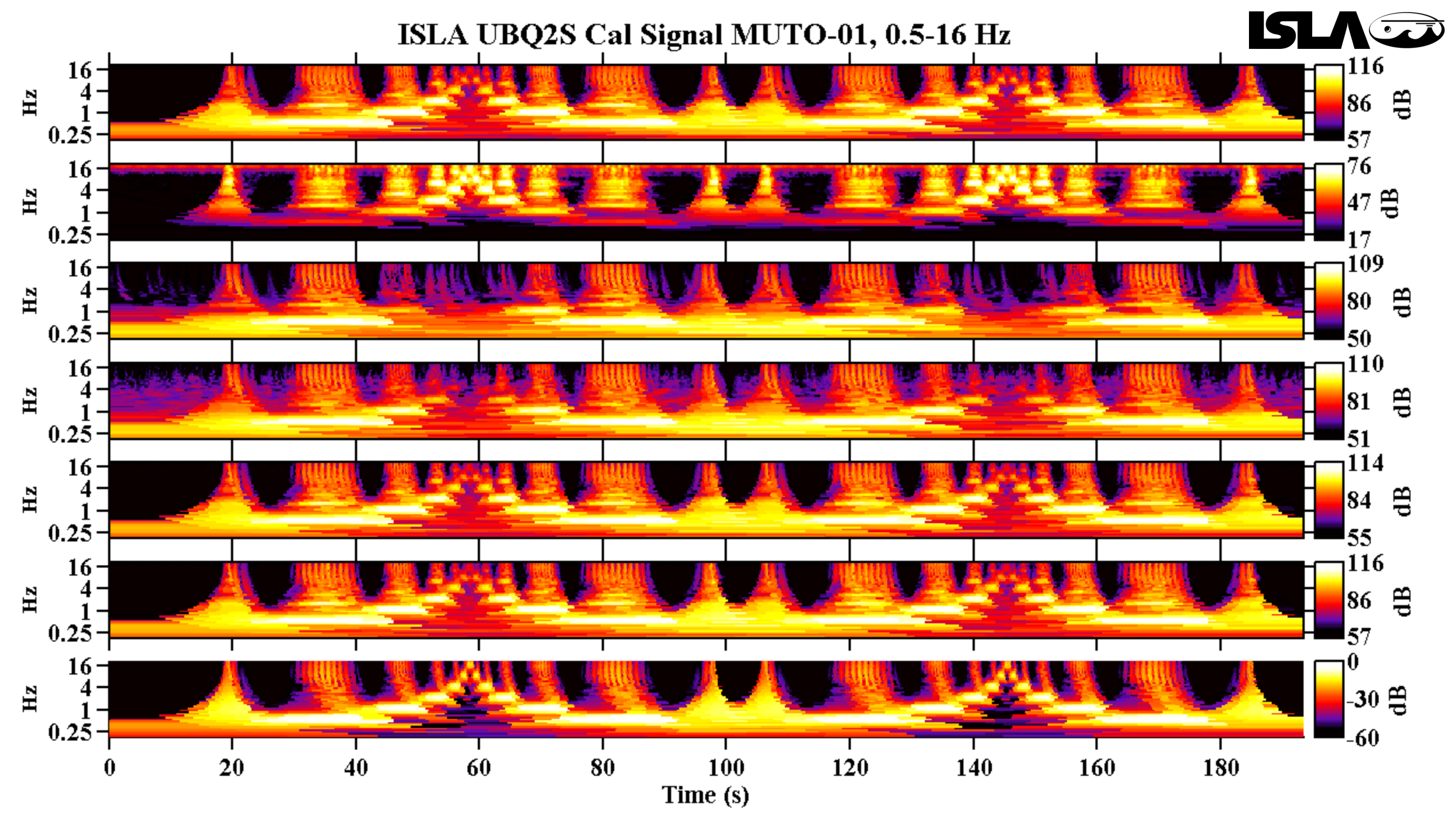
$$f_{cN} = f_0 10^{\frac{3}{10N} n_N} = f_0 10^{\frac{n_N}{s_N}}, \quad n_N \in Z \ .$$

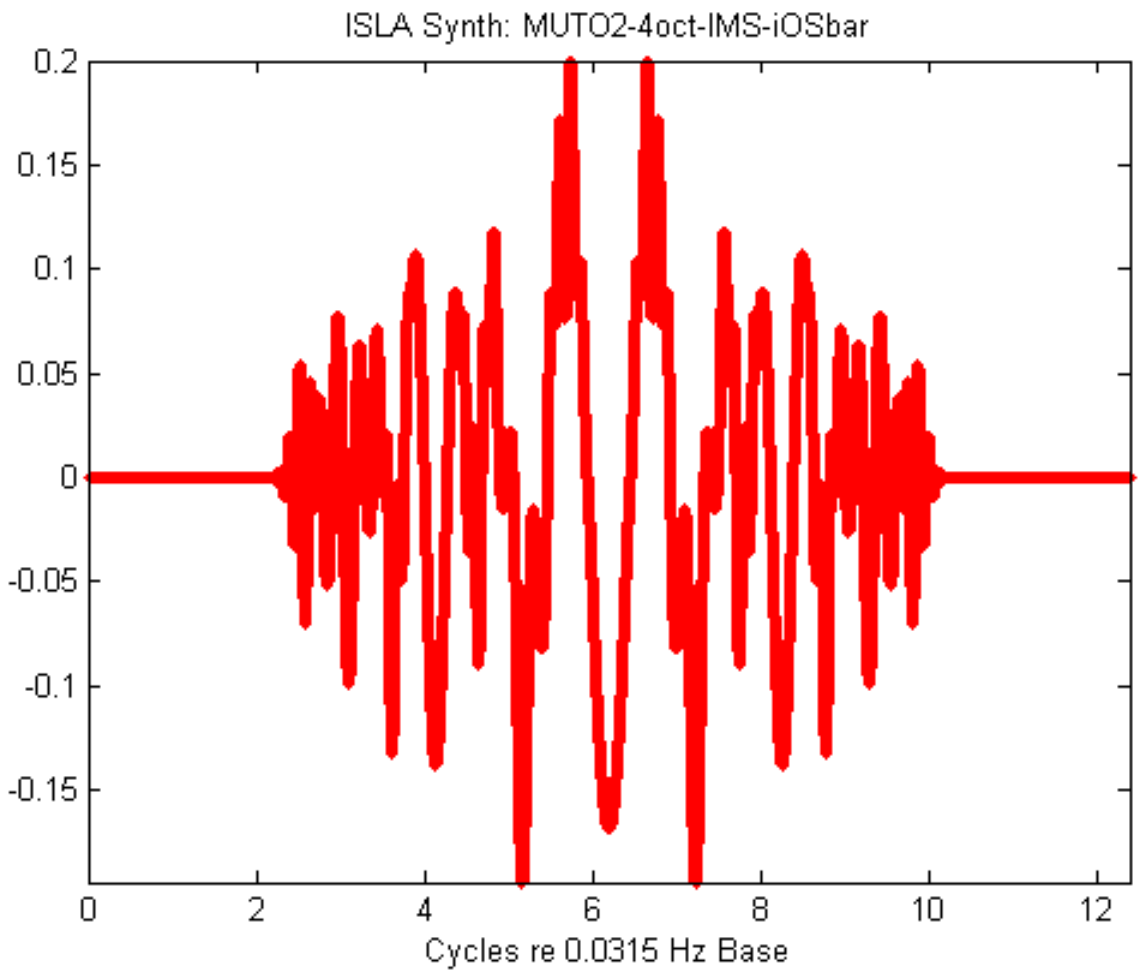
IMS OCTAVE BANDS

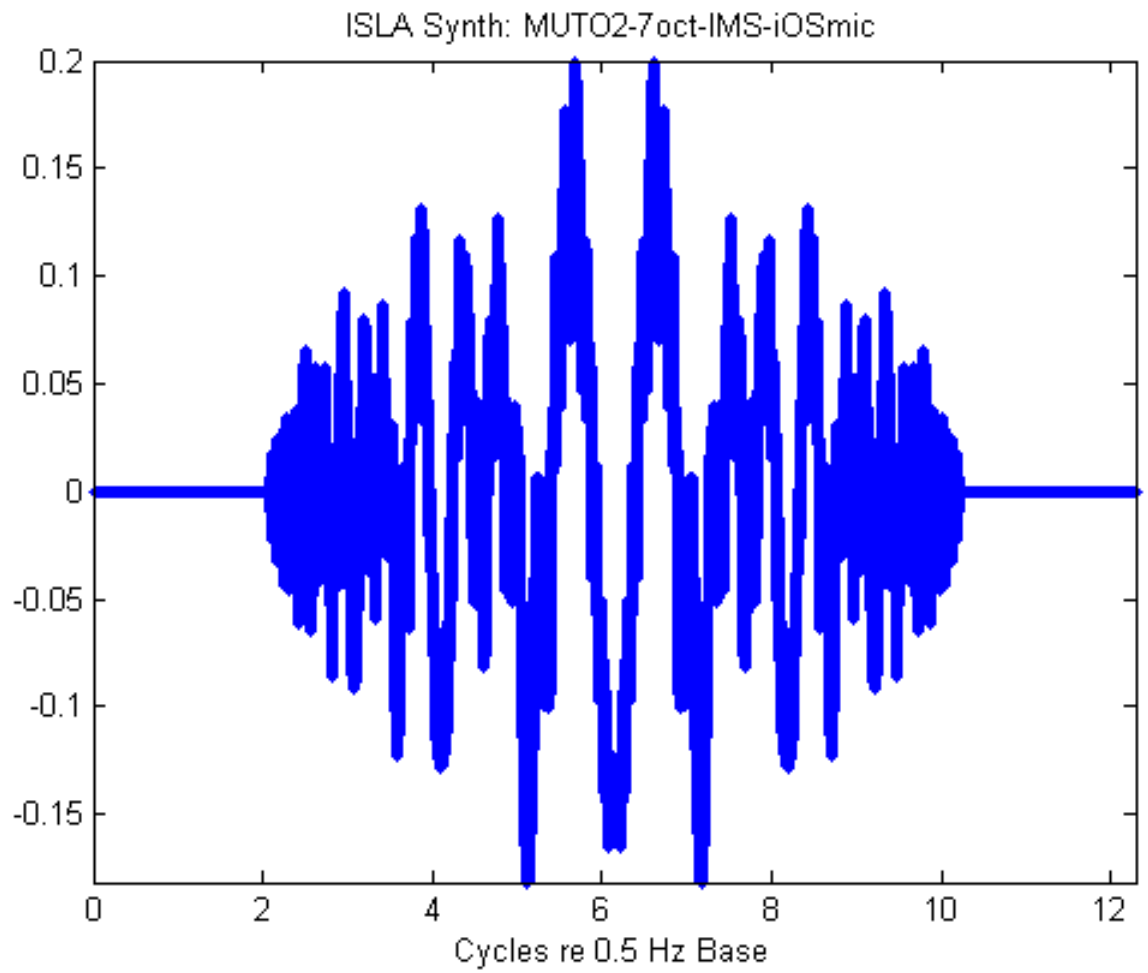
$10^{3n1/10}$ [n_1 = -6 … 2] ~ 2^n

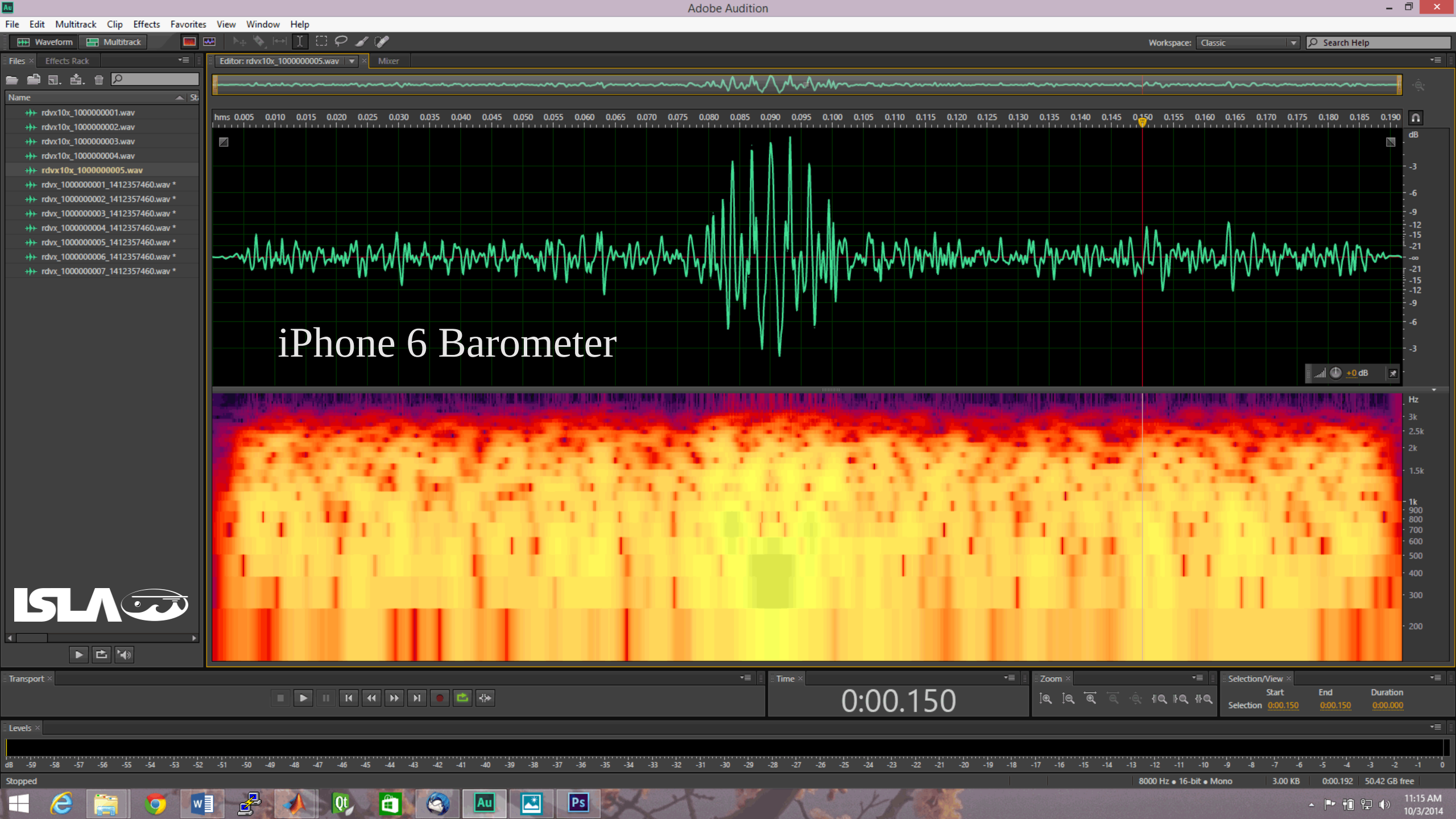
[0.016, 0.0315, 0.063, 0.125, 0.25, 0.5, 1, 2, 4]


ISLA UBQ2S Cal Signal MUTO-01, 0.5-16 Hz
Pa
62
0
-62
BnK
Norm
1
0
-1
iPhone5
Pa
29
0
-29
Nexus5L
Pa
28
0
-28
Nexus5H
Pa
36
0
-36
ITEM
Pa
60
0
-60
RM2000
Norm
1
0
-1
SYNTH
0
20
40
60
80
100
120
140
160
180
200
Time (s)


ISLA UBQ2S Cal Signal MUTO-01, 0.5-16 Hz
Hz
16
4
1
0.25
116
86
57
dB
76
47
17
109
80
50
110
81
51
114
84
55
0
-30
-60
0
20
40
60
80
100
120
140
160
180
Time (s)


ISLA Synth: MUTO2-4oct-IMS-iOSbar
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
0
2
4
6
8
10
12
Cycles re 0.0315 Hz Base


ISLA Synth: MUTO2-7oct-IMS-iOSmic
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
0
2
4
6
8
10
12
Cycles re 0.5 Hz Base


Adobe Audition
File Edit Multitrack Clip Effects Favorites View Window Help
Waveform Multitrack
Workspace: Classic
Search Help
Files Effects Rack
Editor: rdvx10x_1000000005.wav
Mixer
Name
rdvx10x_1000000001.wav
rdvx10x_1000000002.wav
rdvx10x_1000000003.wav
rdvx10x_1000000004.wav
rdvx10x_1000000005.wav
rdvx_1000000001_1412357460.wav *
rdvx_1000000002_1412357460.wav *
rdvx_1000000003_1412357460.wav *
rdvx_1000000004_1412357460.wav *
rdvx_1000000005_1412357460.wav *
rdvx_1000000006_1412357460.wav *
rdvx_1000000007_1412357460.wav *
hms 0.005 0.010 0.015 0.020 0.025 0.030 0.035 0.040 0.045 0.050 0.055 0.060 0.065 0.070 0.075 0.080 0.085 0.090 0.095 0.100 0.105 0.110 0.115 0.120 0.125 0.130 0.135 0.140 0.145 0.150 0.155 0.160 0.165 0.170 0.175 0.180 0.185 0.190
dB
-3 -6 -9 -12 -15 -21 -∞ -21 -15 -12 -9 -6 -3
iPhone 6 Barometer
+0 dB
Hz
3k 2.5k 2k 1.5k 1k 900 800 700 600 500 400 300 200
Transport
Time
0:00.150
Zoom
Selection/View
Start End Duration
Selection 0:00.150 0:00.150 0:00.000
Levels
dB -59 -58 -57 -56 -55 -54 -53 -52 -51 -50 -49 -48 -47 -46 -45 -44 -43 -42 -41 -40 -39 -38 -37 -36 -35 -34 -33 -32 -31 -30 -29 -28 -27 -26 -25 -24 -23 -22 -21 -20 -19 -18 -17 -16 -15 -14 -13 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0
Stopped
8000 Hz • 16-bit • Mono
3.00 KB
0:00.192
50.42 GB free
11:15 AM
10/3/2014

Context

Within the framework of ubiquitous system design, context may be defined as “any information that can be used to characterize the situation of entities (i.e. whether a person, place or object) that are considered relevant to the interaction between a user and an application, including the user and the application themselves. ***There are four essential categories, or characteristics, of context information: identity, location, status (or activity) and time”*** (Denzil, 2013).

Who, where, what, when … and why.

Context-based Wireless Sensor Networks

Different domain, different vocabulary

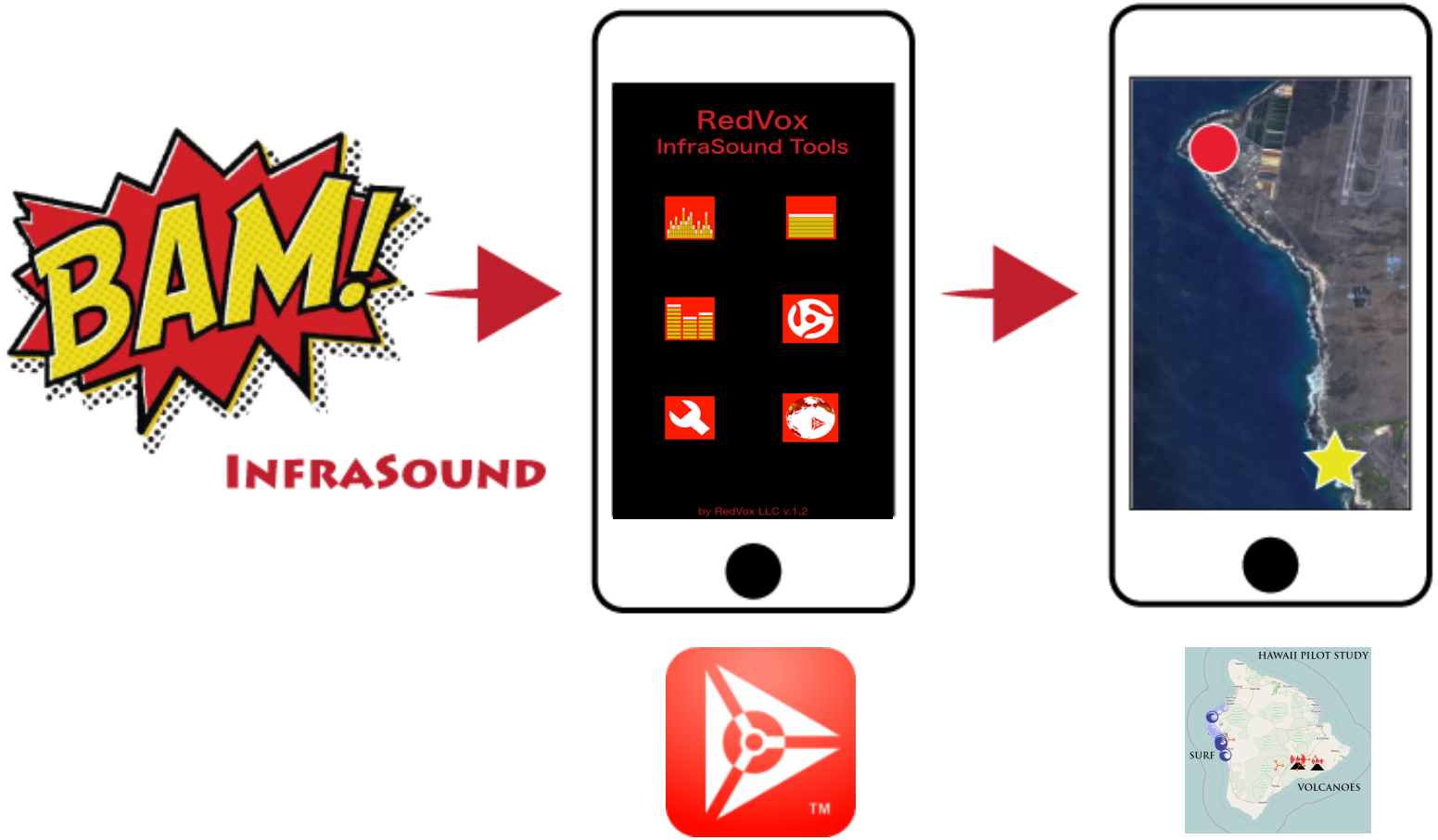
- Middleware is the key interface between App and the Operating System
- Software engineering and programming skill set
- LAMP (Linux, Apache, MySQL, Perl/PHP/Python) stack may be inadequate
- Standard data schemas where sensor sample rate is stable and position is static are inadequate

IoT, Big Data framework

- Identity is sensitive
- Statistics rule. Bayesian framework generally assumed.
- Parallel computing and machine learning
- Clear, robust standards and metrics are needed!

Basic Concept

1. Capture infrasound with App using on-board microphone and barometers
2. Send, process and plot in server



Pilot study: capability demonstration