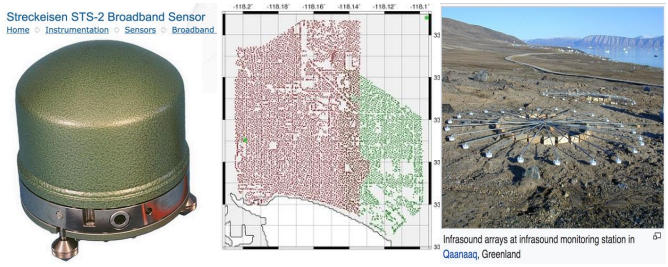
EAS 4801 - Planetary Sound
Lec #10: Recording devices (Cont)

Dr. Zhigang Peng
01/27/2020
Spring 2020



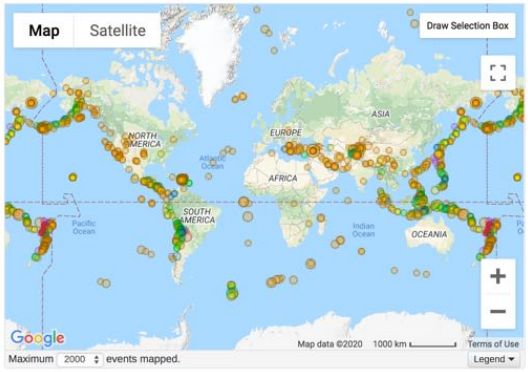
Exam this wed. 12:20-1:10 pm

- 30 multiple choices (30 points)
- 3 simple answer/definitions (30 points)
- 2 simple calculations (20 points)
- 2 graphics (20 points)

https://www.iris.edu/hq/internship/news/applications_summer_2020

How to access scientific data

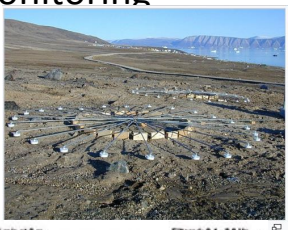
http://ds.iris.edu/mda/ **http://ds.iris.edu/wilber3/find_event**

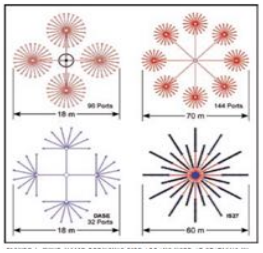


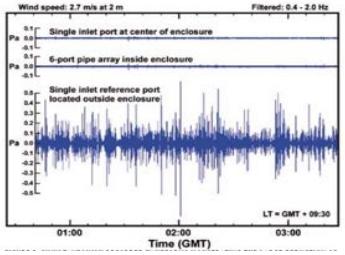
Infrasound Monitoring

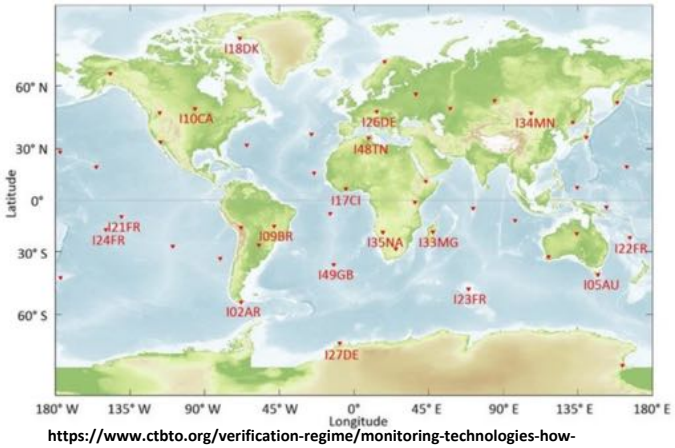
The Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) Preparatory Commission uses infrasound as one of its monitoring technologies, along with seismic, hydroacoustic, and atmospheric radionuclide monitoring. The loudest infrasound recorded to date by the monitoring system was generated by the 2013 Chelyabinsk meteor.

https://en.wikipedia.org/wiki/Infrasound



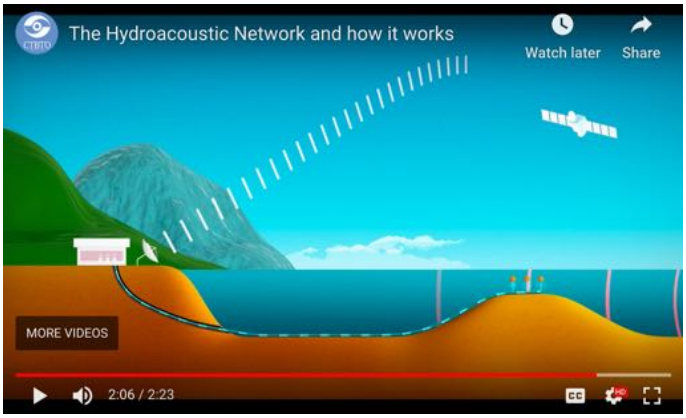




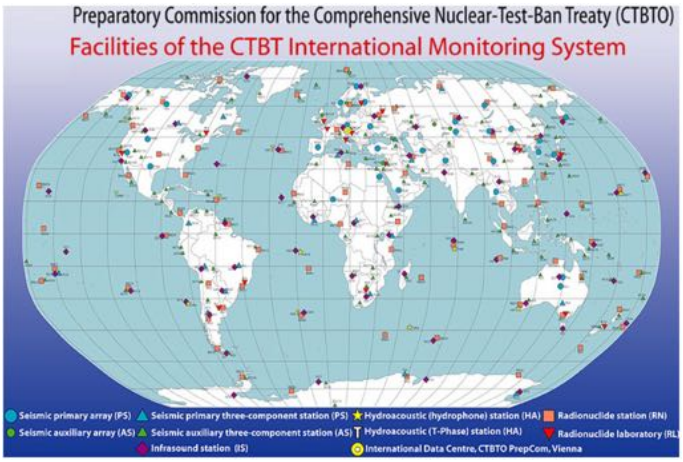


https://www.ctbto.org/verification-regime/monitoring-technologies-how-they-work/infrasound-monitoring/

https://www.ctbto.org/fileadmin/content/reference/outreach/ctbto_spectrum_10/p18_19_Recent_developments_in_IS_monitoring_technology.pdf

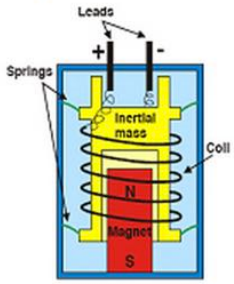


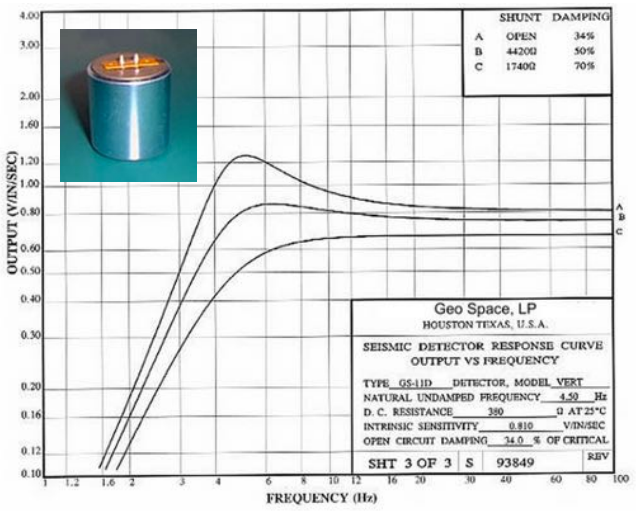
https://www.ctbto.org/verification-regime/monitoring-technologies-how-they-work/hydroacoustic-monitoring/

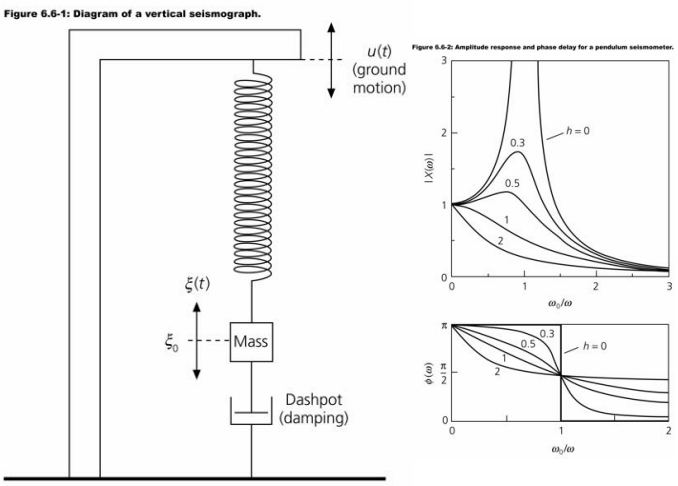


Geophone: a device that converts ground motion into voltage

Geophones

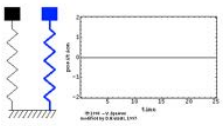






damped harmonic oscillator composed of a spring and dashpot

Newton's Law: $\mathbf{F} = m\mathbf{a}$



Case for no damping:

$$m\frac{d^2u(t)}{dt^2} + k\,u(t) = 0$$ where k is the spring constant.

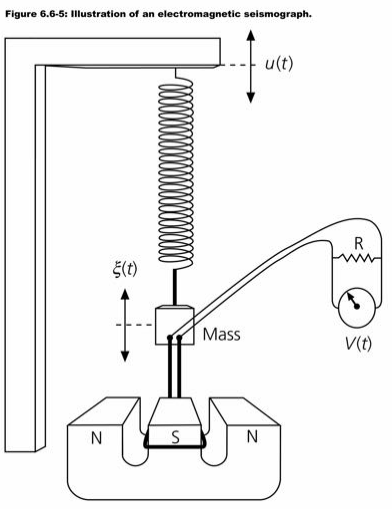
Solution is perpetual harmonic oscillation:

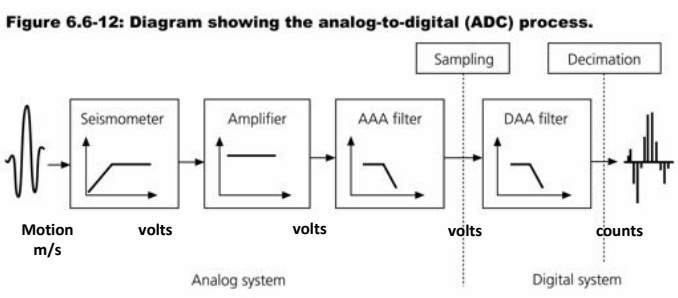
$$u(t) = Ae^{i\omega_0 t} + Be^{-i\omega_0 t} \quad \text{or} \quad u(t) = A_0\cos(\omega_0 t)$$

(A and B are constants)

The mass moves back and forth with a natural frequency $\omega_0 = (k/m)^{1/2}$

Once the motion is started, the oscillation continues forever.

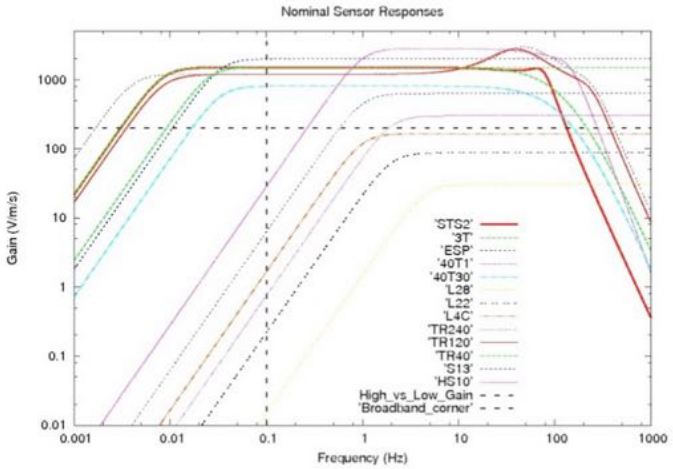




AAA: Analog Anti-Aliasing Filter
DAA: Digital Anti-Aliasing Filter

Broadband Seismometers

Typical seismic deployment



https://www.passcal.nmt.edu/content/instrumentation/sensors/sensor-comparison-chart

Traditional Land Deployment

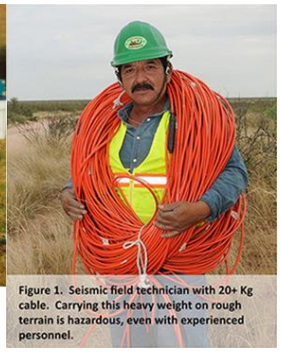


Figure 1. Seismic field technician with 20+ Kg cable. Carrying this heavy weight on rough terrain is hazardous, even with experienced personnel.

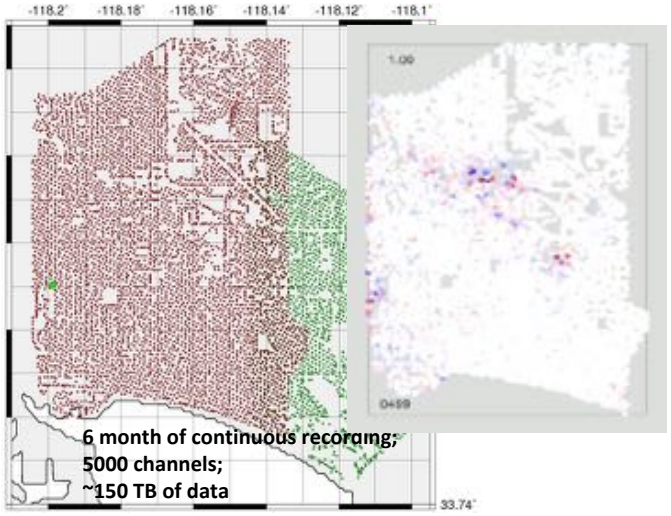
New types of sensor/recording system

Typical Node specifications

Seismic Data Channels: 3
ADC Resolution: 24 bits
Sample Interval
0.5, 1, 2, 4 milliseconds
Preamplifier Gain
0 dB to 36 dB in 6 dB steps
Anti-Alias Filter
206.5 Hz @ 2ms (82.6% of Nyquist), Selectable - Linear Phase or Minimum Phase
DC Blocking Filter
1 Hz to 60 Hz, 1 Hz increments, 6 dB/Octave, or OUT
Operating Temperature Range
-40˚C to +60˚C
Operating Life
33 days (continuous @ 25˚C @ 2ms

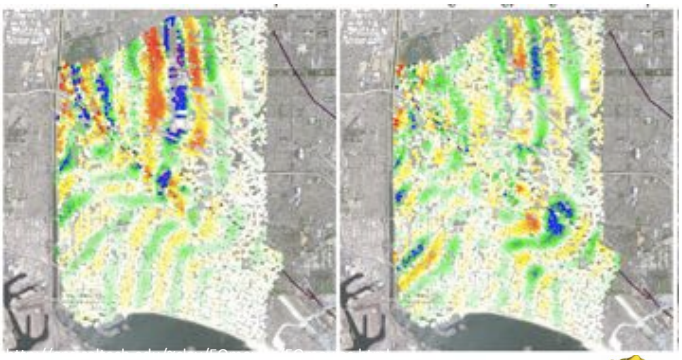
Total Harmonic Distortion
0.0002% @ 12 dB Gain, -3 dB Full Scale
Equivalent Input Noise
0.75 µVrms @ 0 dB
0.2 µVrms @ 12 dB
0.1 µVrms @ 24 dB
0.1 µVrms @ 36 dB
Full Scale Input Signal
2500 mV peak @ 0 dB
625 mV peak @ 12 dB
156 mV peak @ 24 dB
39 mV peak @ 36 dB
Gain Accuracy: 0.50%
Dynamic Range
127 dB @ 0 dB Preamplifier Gain
Common Mode Rejection Ratio
>110 dB
DC Offset <10% of Input Noise with DC Blocking Filter IN
Timing Accuracy
±10 µseconds GPS Disciplined

Sensor Impedance
Sensor Step Response
Sensor DC Resistance
Sensor
3 Geophones, Orthogonal Configuration
10 Hz - 70% damped, 2 V/√s (78.7 V/m/s)
5 Hz - 70% damped, 1.95 V/√s (76.7 V/m/s)
Battery
Type: Rechargeable Li-Ion
Charging Temperature Range
+5˚C to +40˚C
Recharge Time: <4 hours
Physical
Weight: 6.2 lb (2.8 kg), including spike
Dimensions: 4.6 in (11.7 cm) diameter by 6.4 in (16.3 cm) high



6 month of continuous recording;
5000 channels;
~150 TB of data

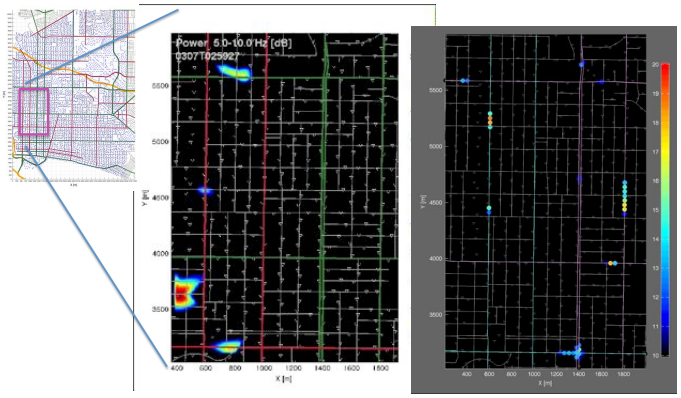
http://www.gps.caltech.edu/~clay/LB3D/Survey.html



Cable free, fast deployment system

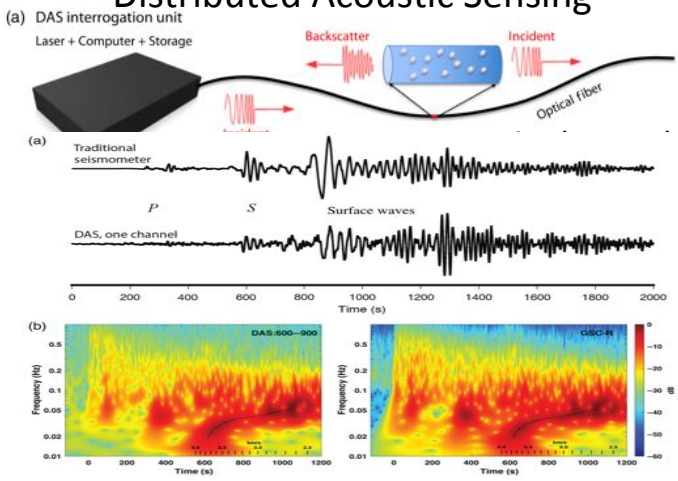
Noise Tracking of Cars/Trains/Airplanes

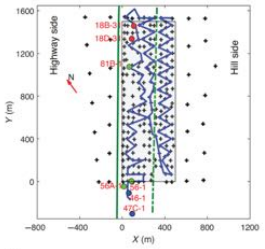
5200 element Long Beach array (Dan Hollis)

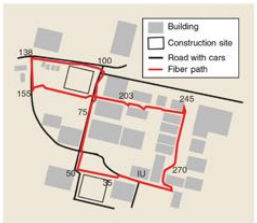


Riahi, Gerstoft, The seismic traffic footprint: Tracking trains, aircraft, and cars seismically, GRL 2015

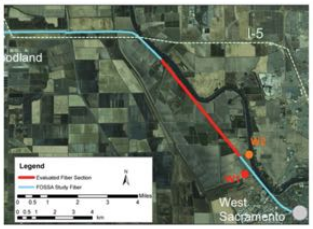
Distributed Acoustic Sensing







(e)



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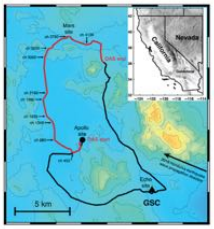

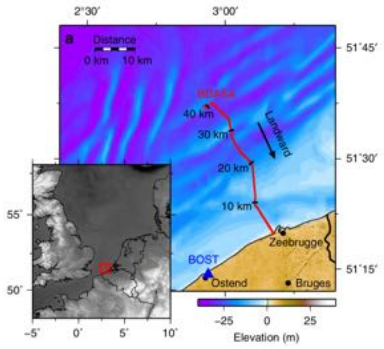

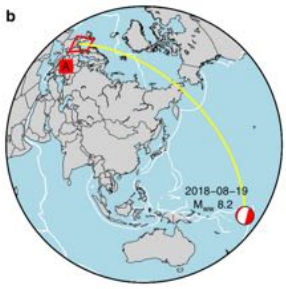

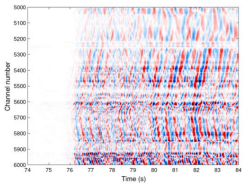

Williams et al. (Nature Comm., 2019)

Dark fiber refers to unused fiber-optic cable. Often times companies lay more lines than what's needed in order to curb costs of having to do it again and again.