Observed Realtime Latencies Using KMI Etna2 data loggers with Bighorn

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Traditional Strong Motion Response Spectra Determinations

- Event detection and recording at remote dataloggers
- After complete recording, event files are telemetered back to data processing center
- Strong motion response spectra are then computed over the entire event recording
- Latency for producing final results are in the 10s of seconds to minutes range mainly depending on the latencies in assimilating event files in the dataloggers

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New Strong Motion Response Spectra Determination

- We present the results of computing strong motion response spectra based upon the **`Bighorn`** software processing system.
- **`Bighorn`** does not depend on event detection by the dataloggers
- Rather it processes real-time accelerogram data streams and produces real-time strong motion response spectra to produce damage estimates as soon as possible
- Although the results show here are for single stations, all of the software has been fully threaded on a per station basis so that similar results can be obtained over multiple stations on computer hosts with multiple independent hyper-threads.

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Strong Motion Response Spectra Equations of Motion

- Strong Motion Response Spectra defined as a set of maximum amplitude values from a comb of damped harmonic oscillators

  The basic SMR EOMs can be expressed as a Laplace transfer function,

$$\mathrm{H}(S) = \frac{\omega^2 + 2\xi\omega S}{\omega^2 + 2\xi\omega S + S^2}$$

  Where ω = oscillator natural frequency in radians per second
  and ξ = oscillator damping ratio

- This transfer function can be designed using normal digital filtering methodologies. The resulting recursion relation requires 5 multiplies per sample per oscillator as opposed to the 10 multiplies per sample per oscillator required in the traditional numerical integration based approach.

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filter_designer

File Filter

Stage1: Strong motion response frequency = 1.0 damping = 0.05

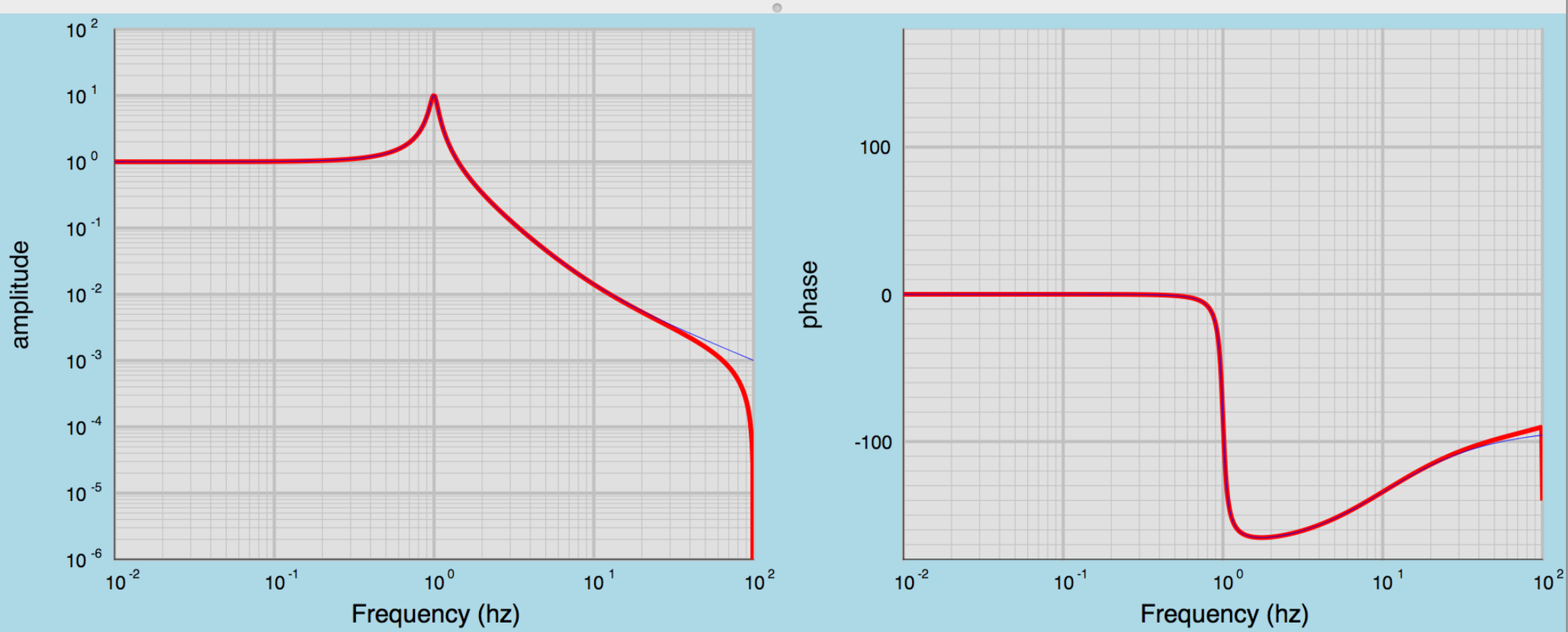
Stage2: None

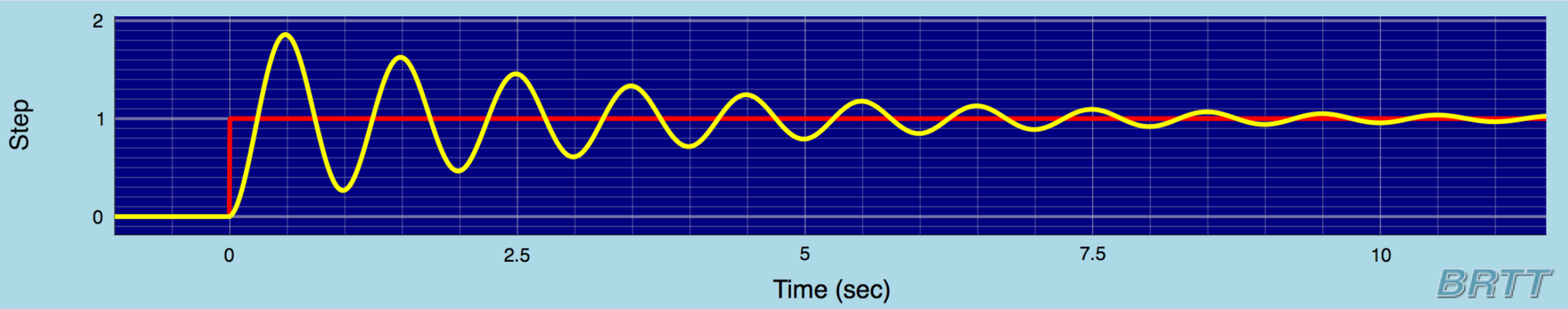
Stage3: None

normalization frequency =

SPF DSNF 1.000000e+00h 5.000000e-02d 1.000000e+00h 5.000000e-02d

compute samprate = 200 response type = Step





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filter_designer

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Stage1: Strong motion response frequency = 1.0 damping = 0.05

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Stage3: None

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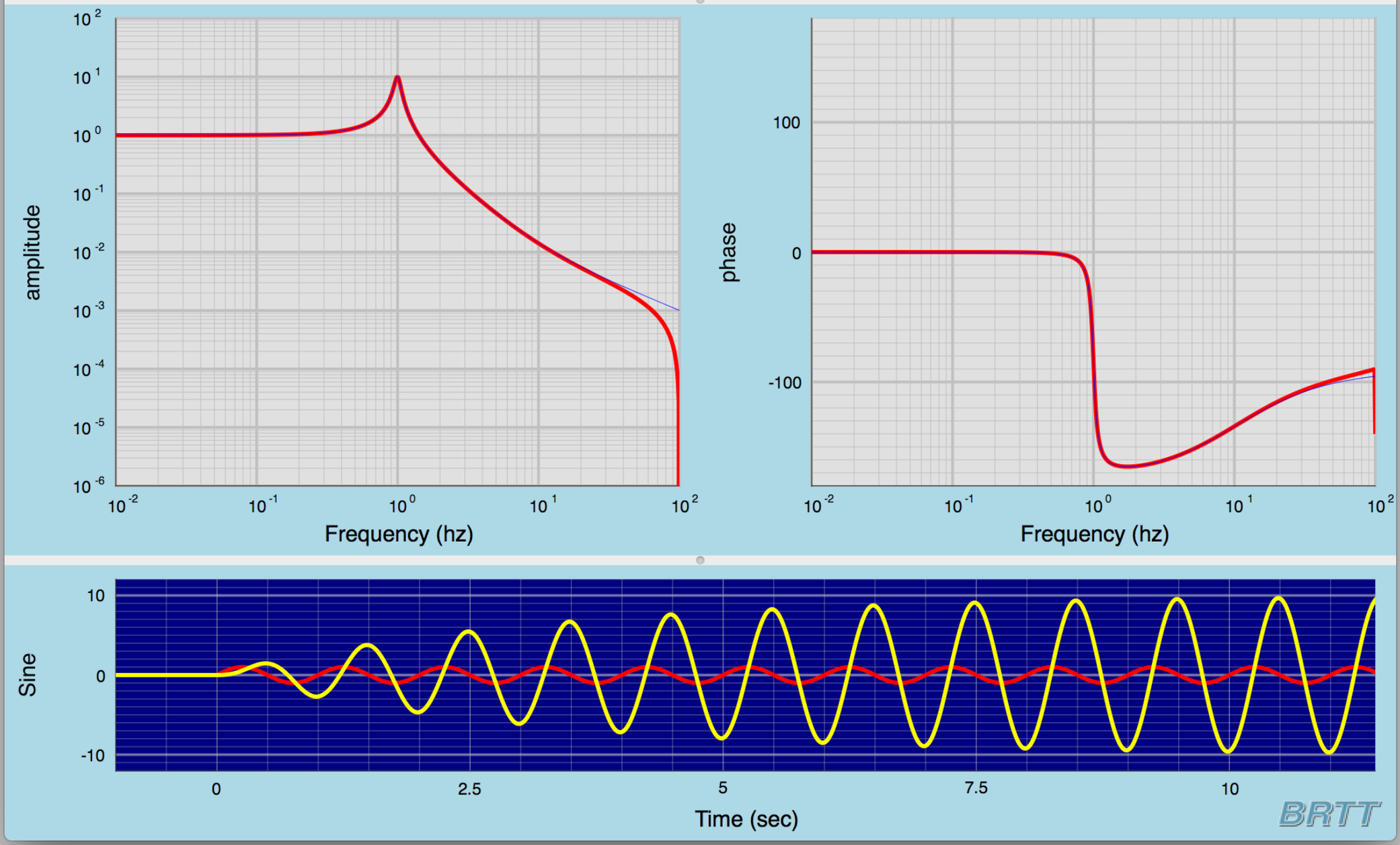
SPF DSNF 1.000000e+00h 5.000000e-02d 1.000000e+00h 5.000000e-02d

compute samprate = 200 response type = Sine frequency = 1.0



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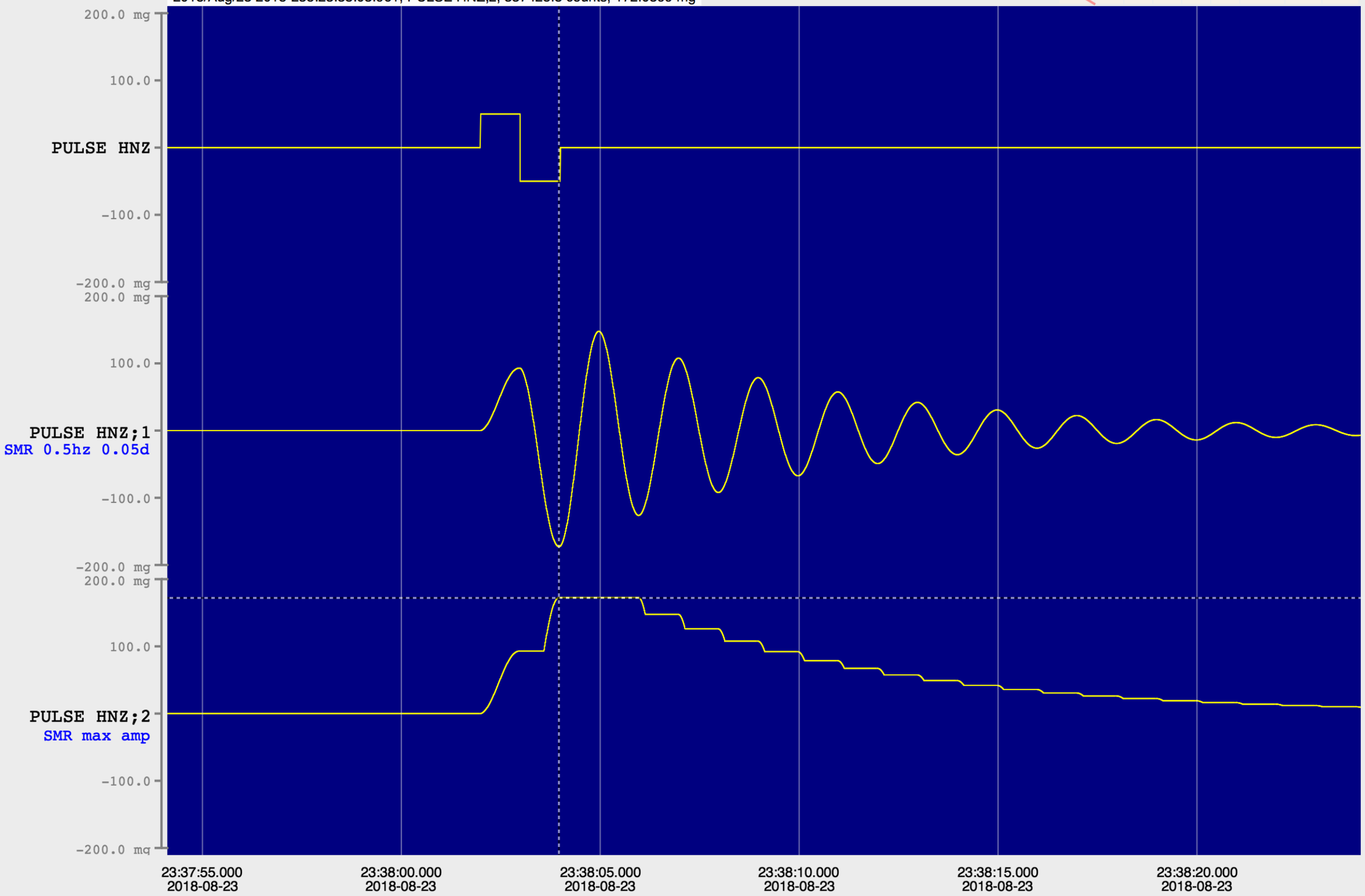
traceview

2018/Aug/23 2018-235:23:38:03.961, PULSE HNZ;2, 337425.8 counts, 172.0399 mg

Sas Fe Ne Ce Pe Le Swad Swd Swa



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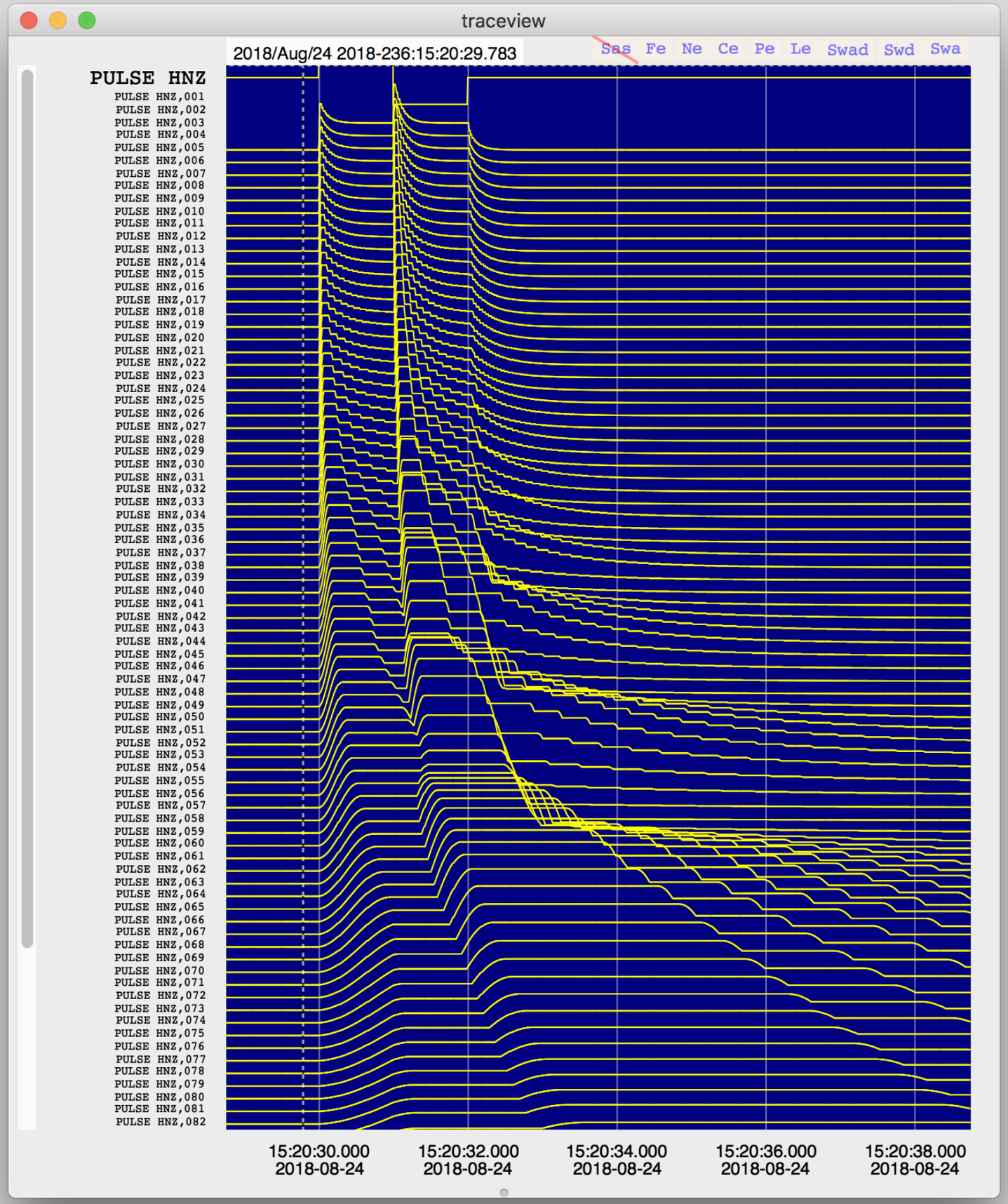

- Maximum Amplitude Signals
- 96 different oscillators
- Computed in real time
- Time synchronized with incoming accelerograms

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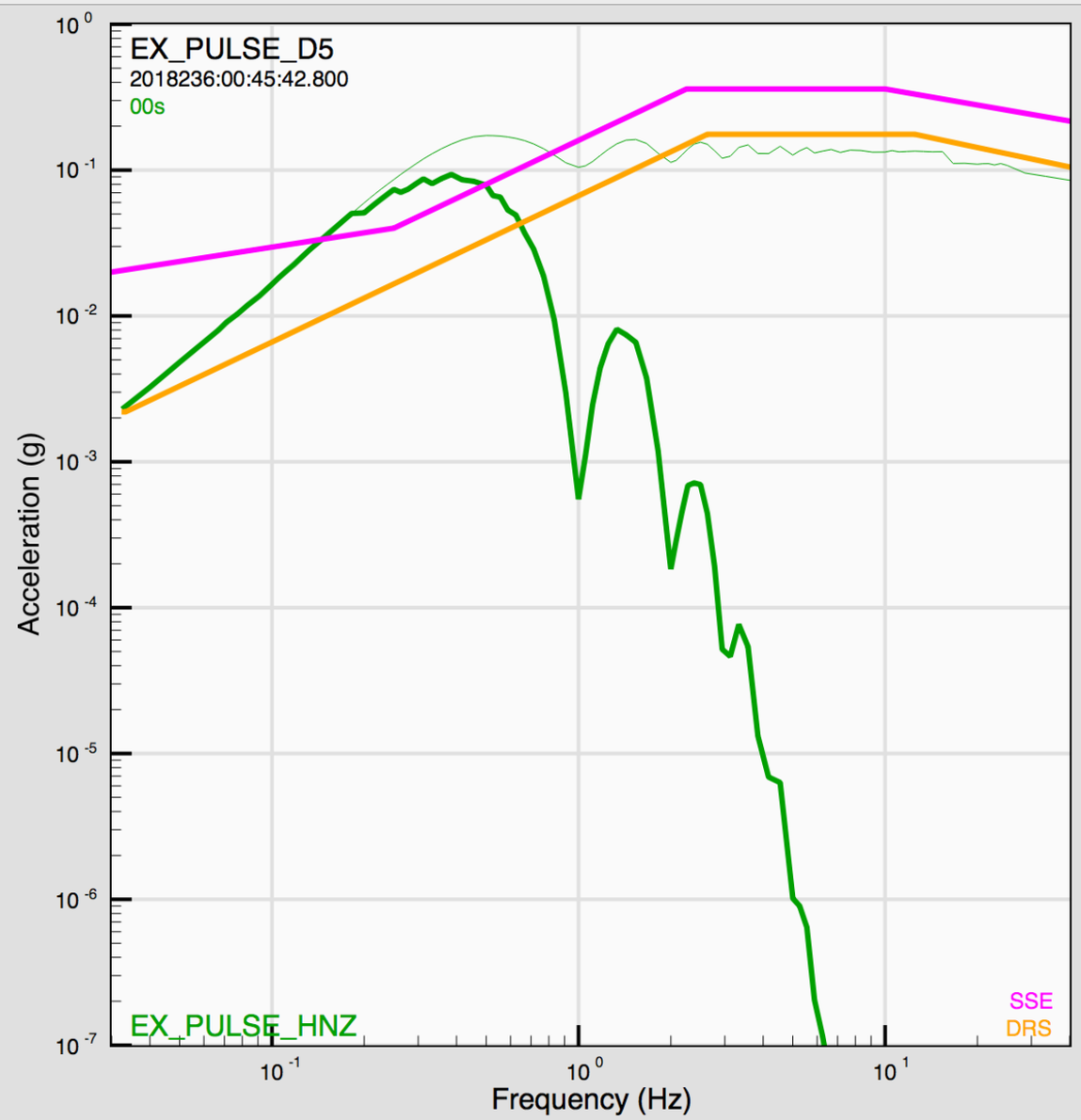
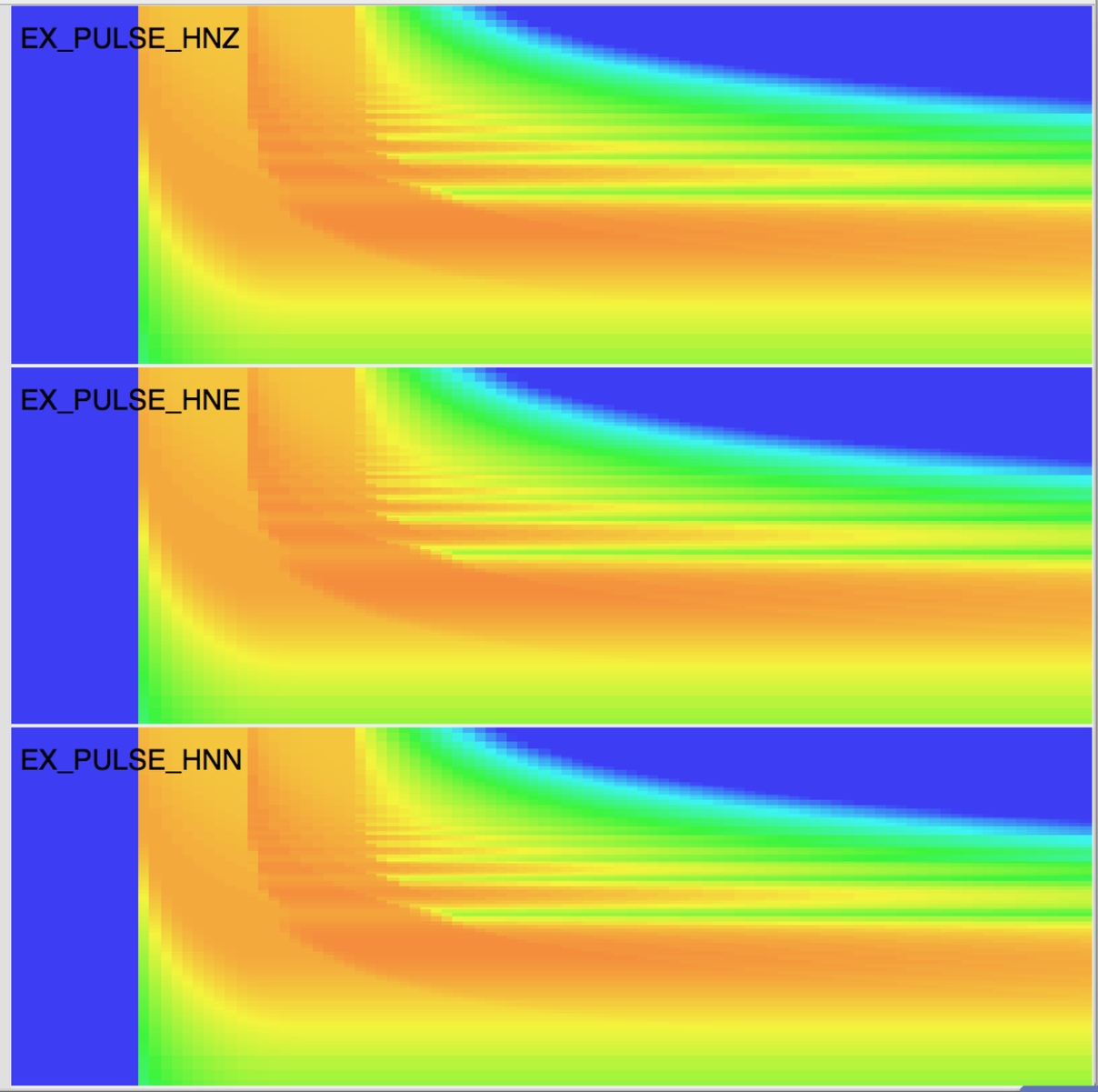
50 mg two sided boxcar
2 second width

10 Seconds

display_spec

File





Last SMRS window

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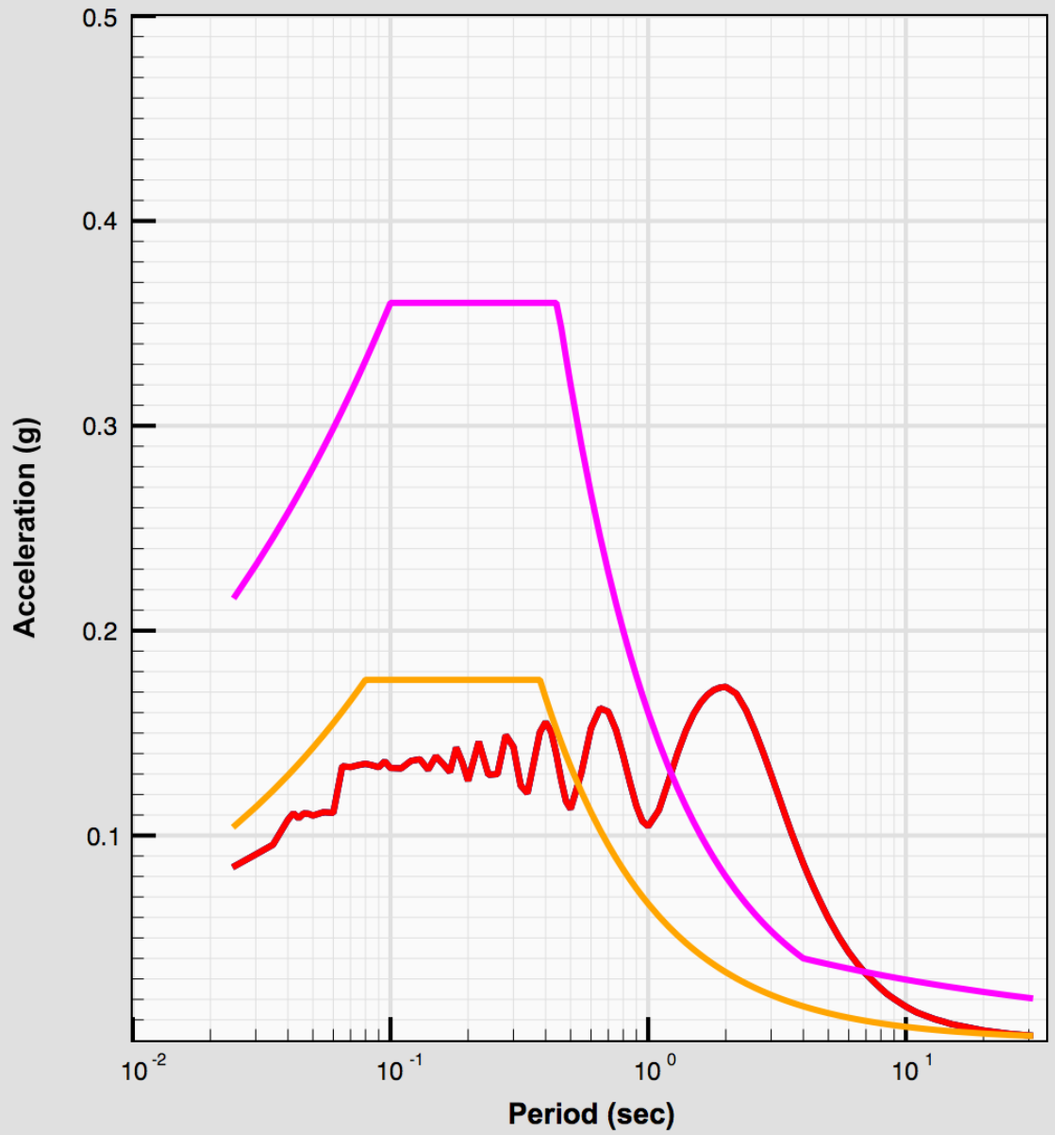
display_smrspalarm:EX_PULSE_D5/1535125578.300000



Response Spectrum ALARM

Staproc: **EX_PULSE_D5**
Time: **2018236:15:46:18.300**
Facility: **PULSE**
Station: **EX_PULSE**
State: **final**
Duration: **66.4**
Channels: **HNZ** **HNE** **HNN**
Peak Acceleration: **0.050 g** **0.050 g** **0.050 g**
Peak Velocity: **48.665 cm/s** **48.665 cm/s** **48.665 cm/s**

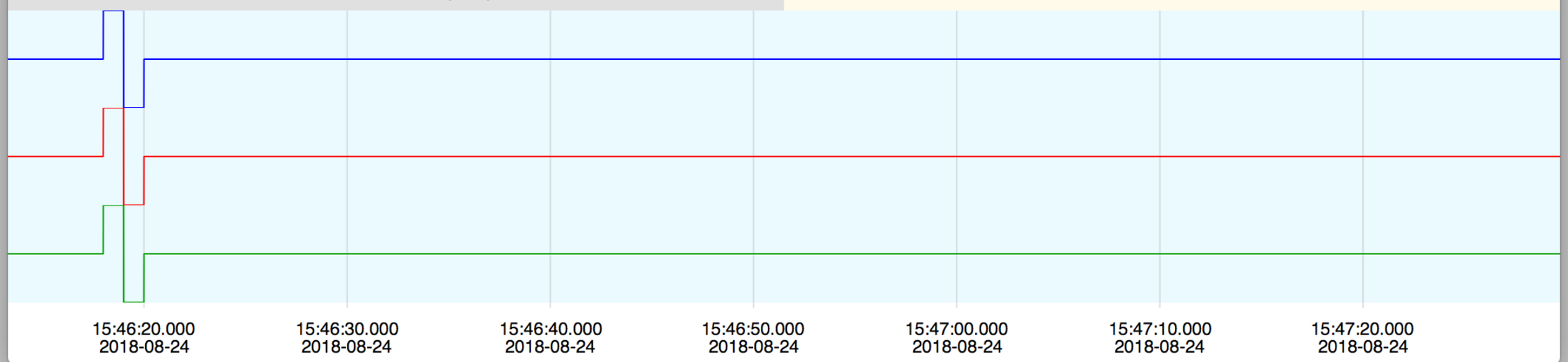
Exceedances:

limit **STRUC1_DRS** type **DRS**

chan	nfreqs	fmax	pmax	percent
HNZ	53	0.36	2.80	490.55
HNE	53	0.36	2.80	490.55
HNN	53	0.36	2.80	490.55

limit **STRUC1_SSE** type **SSE**

chan	nfreqs	fmax	pmax	percent
HNZ	26	0.36	2.80	145.36
HNE	26	0.36	2.80	145.36
HNN	26	0.36	2.80	145.36



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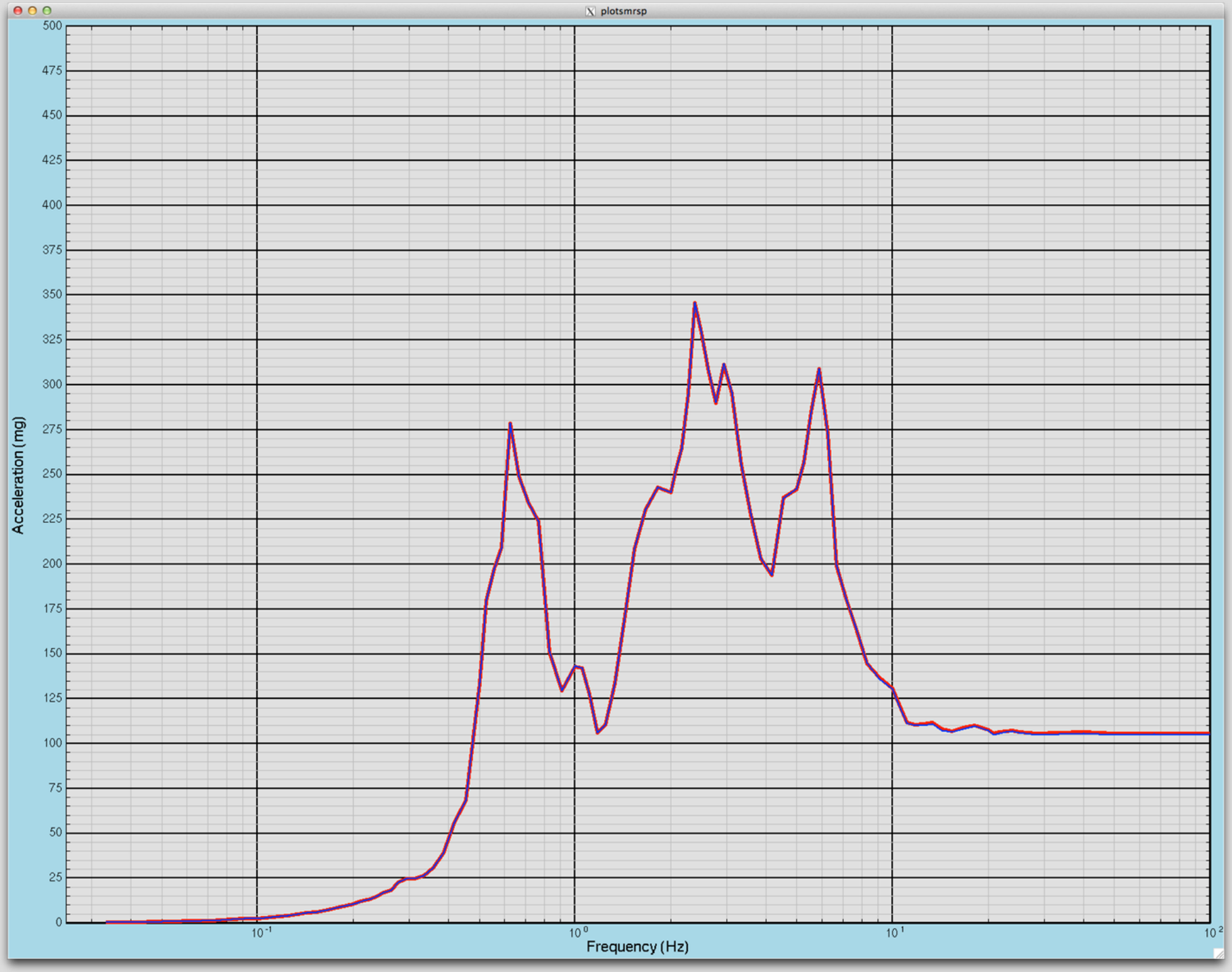
Loma Prieta Response Spectrum



Kinemetrics Condor System Response Spectra

Bighorn Response Spectra

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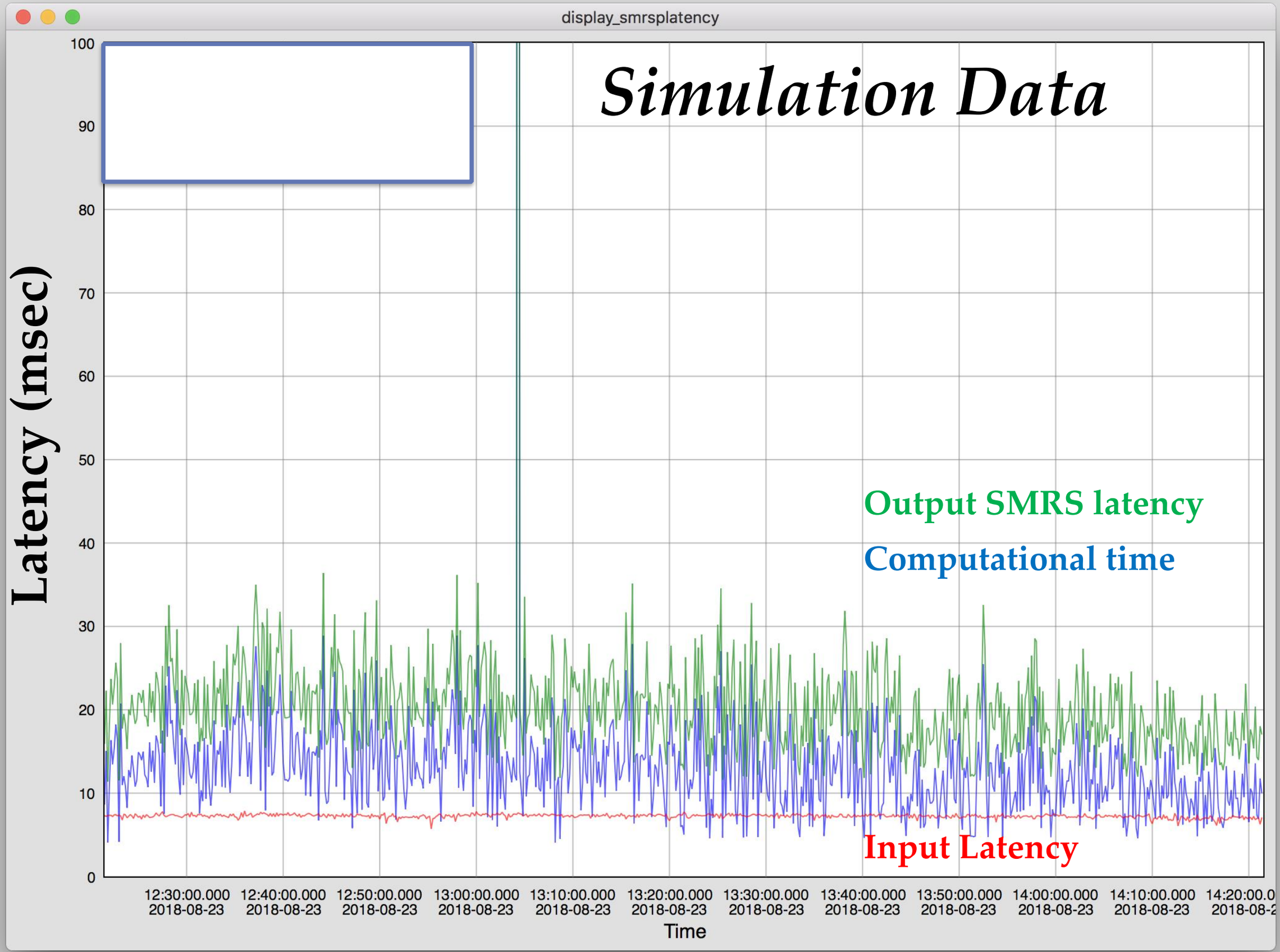
Latencies

- We present the results of computing time latencies strong motion response spectra produced by **`Bighorn`**
- All processing was done on a single 3-component station over the 96 oscillators shown previously
- Latencies were computed by subtracting the data time stamps from the system time. All of these results were generated on an Apple laptop computer with the system time synchronized using NTP.
- Simulation results using the same test signal as used previously will be shown
- Real data from a remote datalogger will be shown


display_smrsplatency
Simulation Data
Latency (msec)
100
90
80
70
60
50
40
30
20
10
0
Output SMRS latency
Computational time
Input Latency
12:30:00.000 2018-08-23
12:40:00.000 2018-08-23
12:50:00.000 2018-08-23
13:00:00.000 2018-08-23
13:10:00.000 2018-08-23
13:20:00.000 2018-08-23
13:30:00.000 2018-08-23
13:40:00.000 2018-08-23
13:50:00.000 2018-08-23
14:00:00.000 2018-08-23
14:10:00.000 2018-08-23
Time

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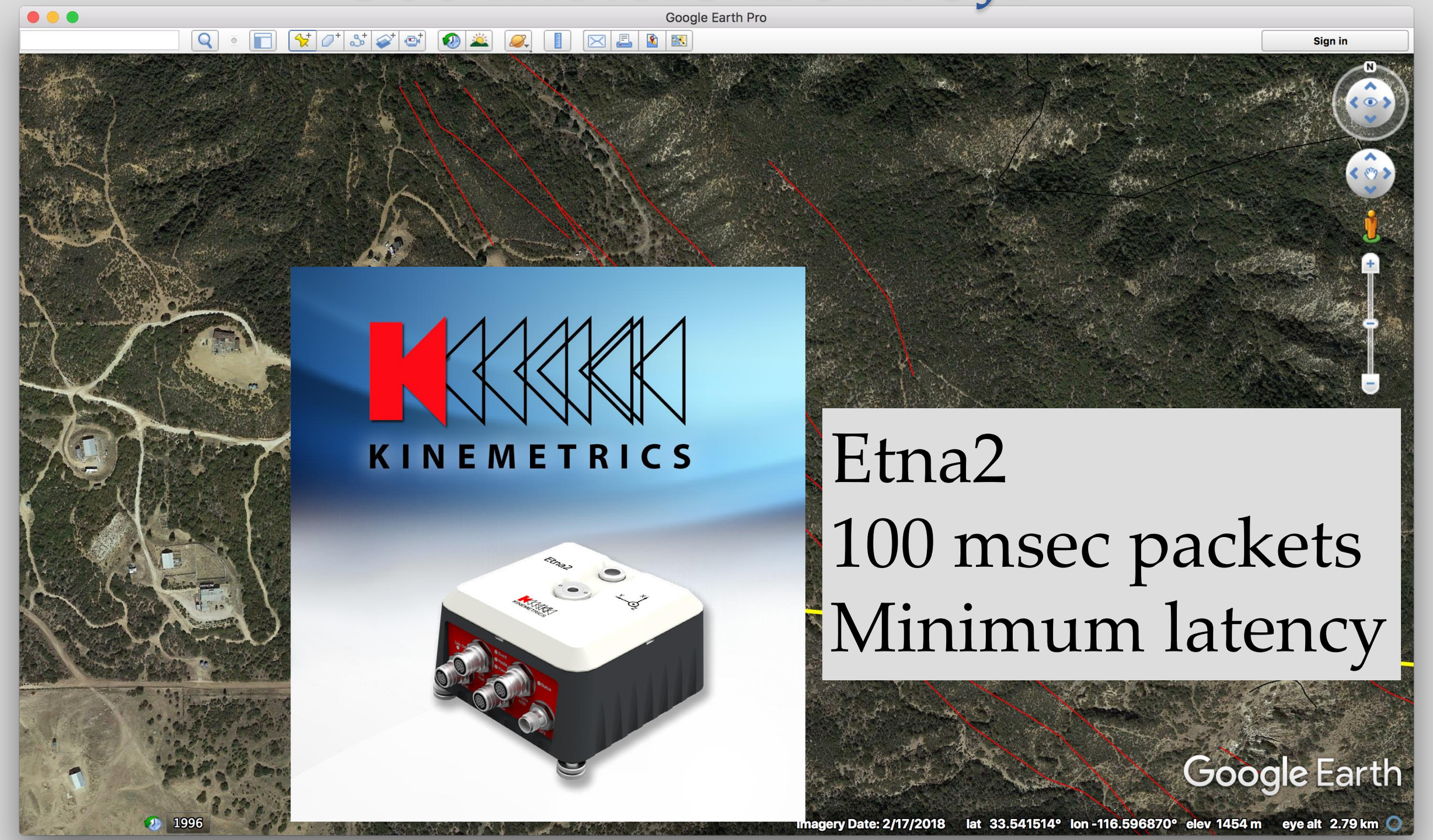
2 hours

Sagebrush Flats – Etna 2
300 meters from SJF



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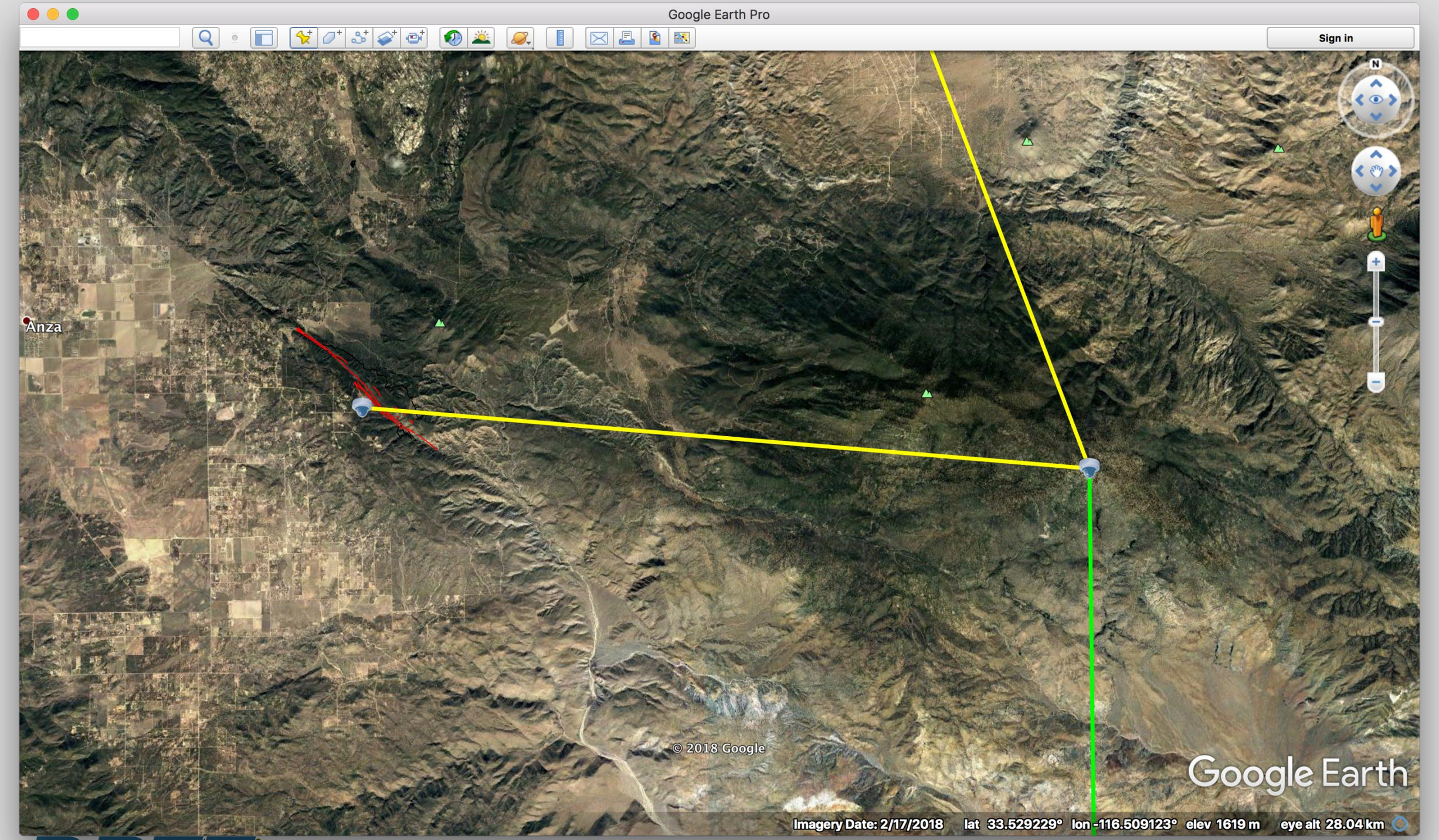
Sagebrush Flats to Toro Peak
15.5 km link



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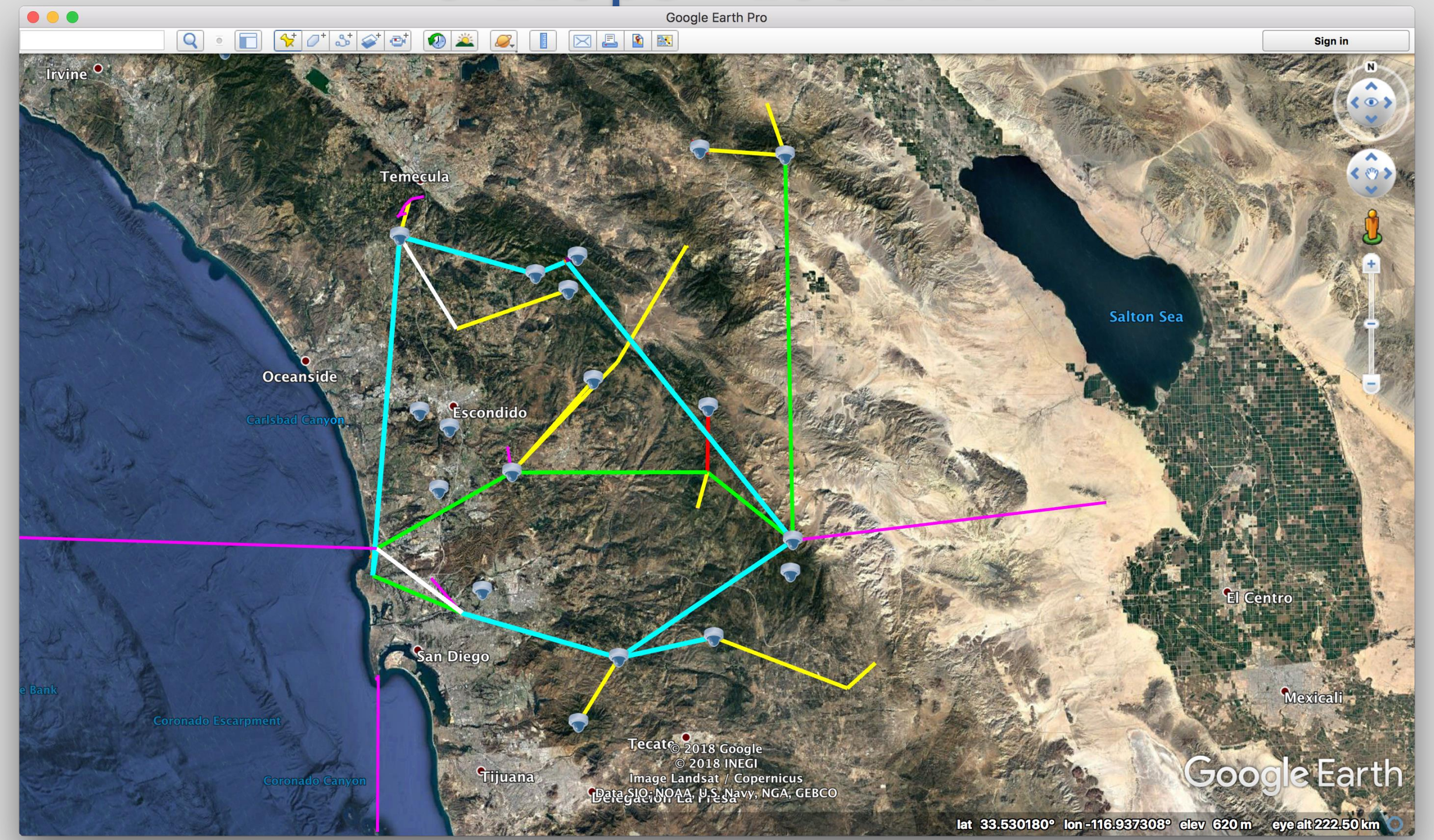
Sagebrush Flats – UCSD
5 Hops 100 km



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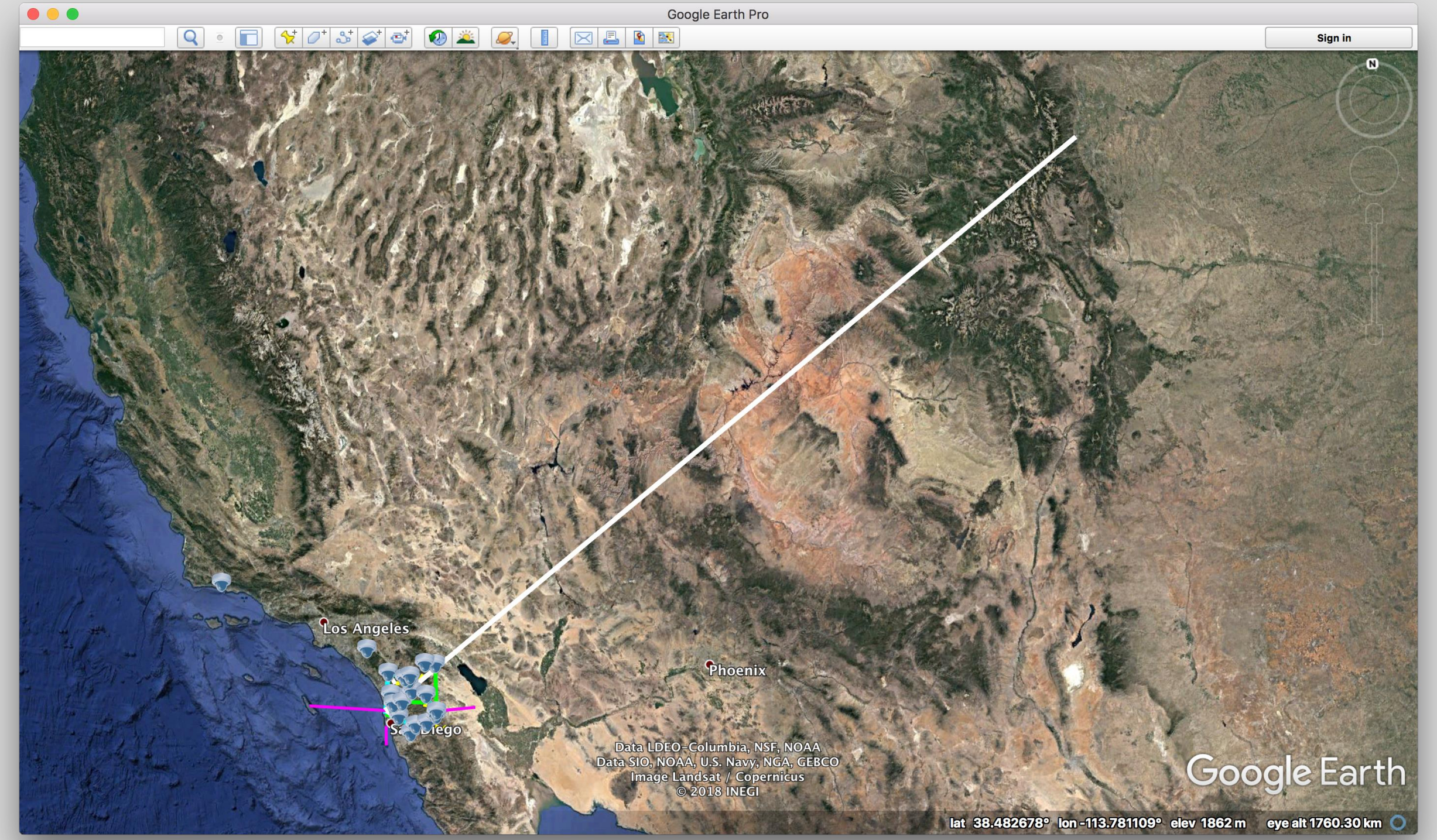
Sagebrush Flats – Boulder
Public Domain Internet 1300 km



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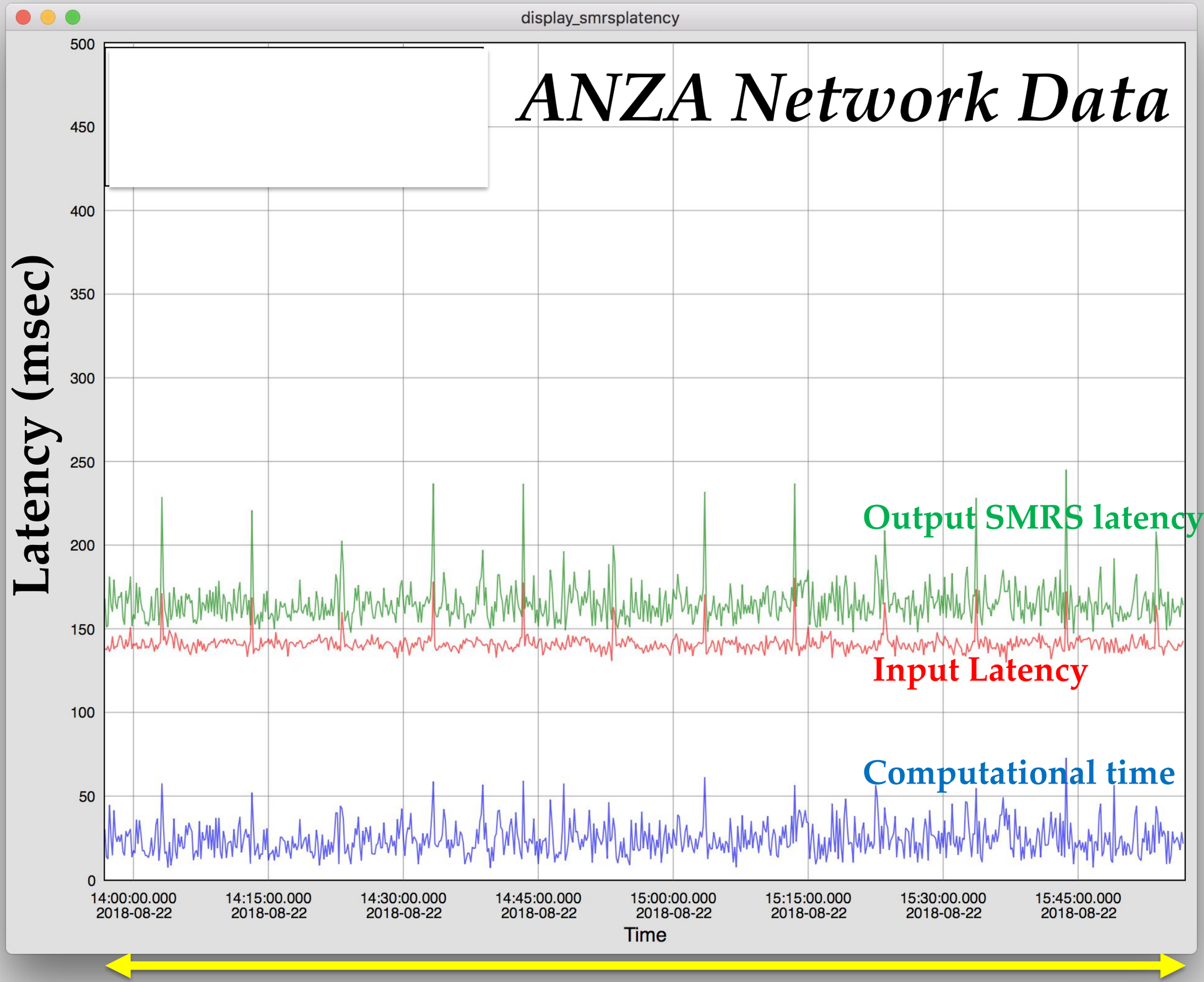
display_smrsplatency
ANZA Network Data
Latency (msec)
500
450
400
350
300
250
200
150
100
50
0
Output SMRS latency
Input Latency
Computational time
14:00:00.000
2018-08-22
14:15:00.000
2018-08-22
14:30:00.000
2018-08-22
14:45:00.000
2018-08-22
15:00:00.000
2018-08-22
15:15:00.000
2018-08-22
15:30:00.000
2018-08-22
15:45:00.000
2018-08-22
Time

BRTT

2 hours

Conclusions

- **Bighorn** produces real-time strong motion response spectra efficiently with processing latencies of approximately 25 msec.
- With proper data sources, these results can be compared in real time against exceedance levels to produce potential structure damage alarms within fractions of one second
- **Bighorn** with a properly configured Etna2 is capable of producing produces real-time strong motion response spectra from field sites with latencies less than ***170 msec***.
- **Bighorn** greatly reduces damage alarm latencies relative to traditional strong motion response processing systems

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