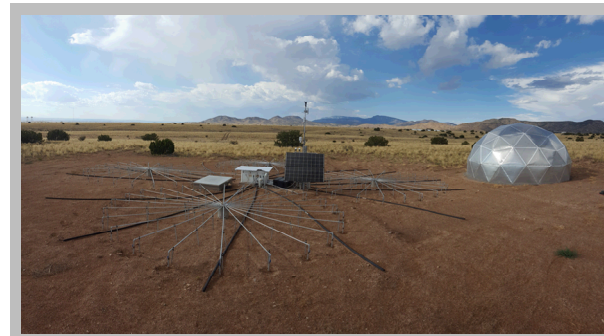
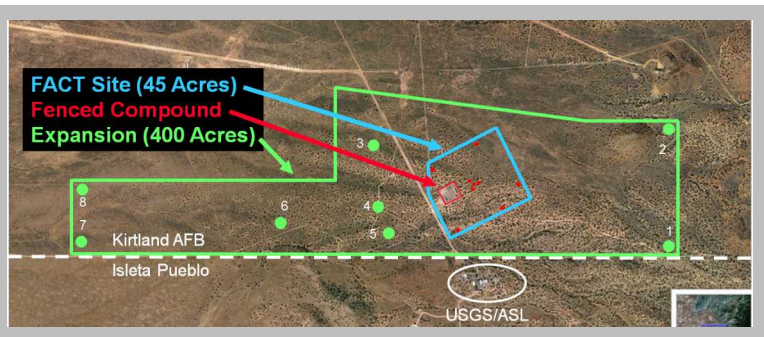


*Exceptional service in the national interest*



# Infrasound Evaluation at Sandia FACT Site

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November 7-11, 2016

Approved for public release; distribution is unlimited

# Overview

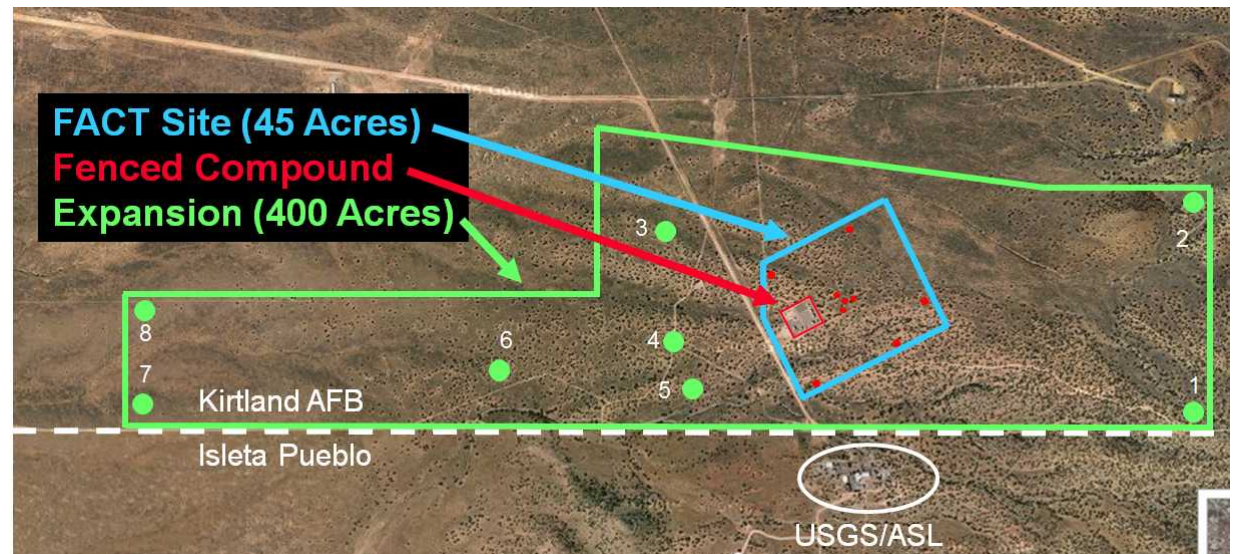
- Facility for Acceptance, Calibration, and Testing (FACT)  
Overview
- Infrasound Evaluation Chamber
- Field sites to prototype infrasound arrays

# FACT Overview

- Sandia National Laboratories, Kirtland AFB (KAFB), Albuquerque, NM.
- Founded in the early 1980's to support R&D of regional seismic arrays.
- In 1990's, transitioned to evaluation as systems became increasingly commercialized.

## Testing:

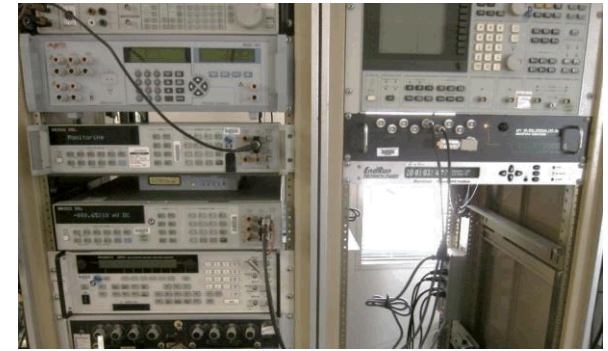
- Digitizers
- Seismometers
- Infrasound
- Complete Systems



Focus will be on infrasound for this talk

# FACT Overview

- Capabilities include:
  - Seismometer boreholes
  - Underground vault for seismometer & infrasound testing
  - Infrasound isolation chambers
  - Temperature chambers
  - Signal generators / calibrators for digitizer testing
  - On-site Primary Standards Laboratory for equipment traceability



# FACT Overview

- Evaluate infrasound sensors to support US and International use:

- Chaparral 4.11 (1997)
- Chaparral 5 (2000)
- MB2000 (2000)
- MB2005 (2009)
- Chaparral 50A (2010)
- MB3a (2014)
- Hyperion 5113 (2014/15)



- Sandia FACT Site is the Defense Threat Reduction Agency / Nuclear Arms Control Technology's "US International Monitoring System Waveform Test Bed"
- Under direct contract with the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) to perform evaluations.

# Infrasound Sensor Testing

- Testing Fundamentals:

- Control environmental conditions:

Desired State	How it is addressed
Stable temperature	We test in an underground bunker with typically < 1 degree C variation over the course of a week
Minimal vibration	FACT site is far from sources of anthropogenic noise
Isolate ambient pressure	Sealed isolation chamber

- Introduce known signals with a pressure driver.
    - Compare sensor outputs against a known reference sensor.

- Sensor performance is evaluated against requirements:

- Self-noise
  - Sensitivity
  - Dynamic Range
  - Response
  - Passband

# Current Infrasound Chamber

- Half-dome isolation chamber
- ½" thick steel
- Approximate 1 meter across
- 300 L volume
- Variable amplitude & frequency piston-phone can drive signals over 0.01 – 10 Hz up to 5 Pascal.
- Capable of testing 6 sensors simultaneously
- Limited background attenuation, especially below 1 Hz



# New Infrasound Chamber

- Chamber designed and built for SNL by National Center for Physical Acoustics (University of Mississippi)
- 1" thick steel
- 1 meter x 2 meters
- 1400L Volume
- Pressure driver on either end



## Benefits:

- Improved isolation of background
- Long thermal-constant
- Larger volume to test more sensors simultaneously

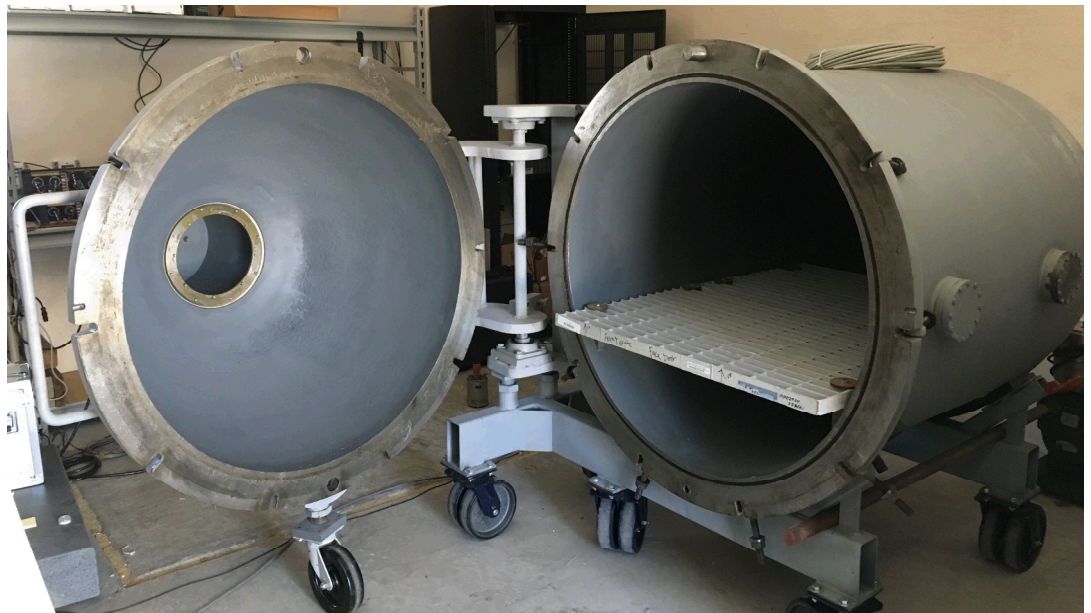
# Chamber Enhanced Capabilities

SNL has begun assembly to pressurize and evacuate the chamber.

From a nominal 81 kPa (1.8 km):

- +30 kPa (sea level)
- -70 kPa (15 km elevation)

This will allow testing to simulate conditions at different elevations



Expected completion for pressurization is later this year

# New Pressure Driver

Larger, more power driver needed to generate pressure signals.

- 10" speaker used in car-audio competitions.
- 1 kW amplifier to drive the speaker, 0 Hz – kHz bandwidth.
- ~ 100 Pa output per driver
- Displacement transducer to measure the actual speaker motion
- Plan is for 2 drivers:
  - Twice the peak output
  - or
  - 2 simultaneous frequencies

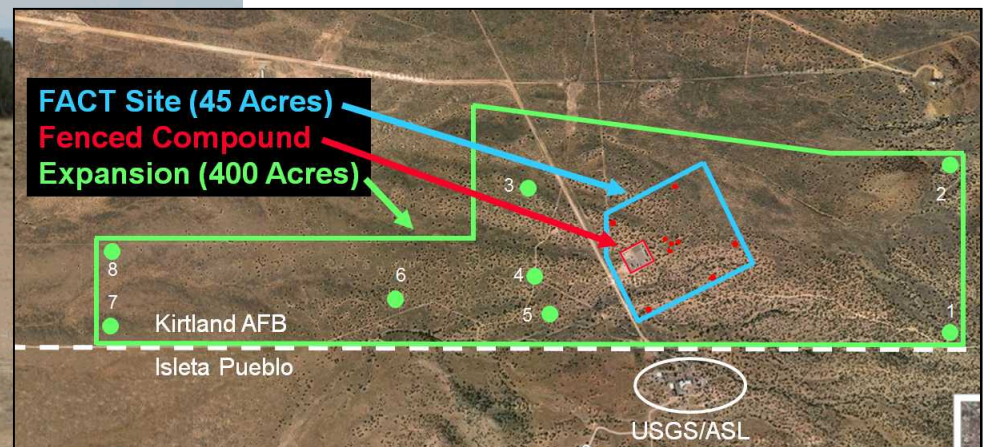


# FACT Site Array (FSA)

- FACT has 8 field sites with up to a 3 km aperture
  - Geometry limited by KAFB land-use agreements and road access
  - Support deployments of complete infrasound & seismic systems



- All sites have:
  - Solar power / battery
  - Surface vault & pad
  - Communication link



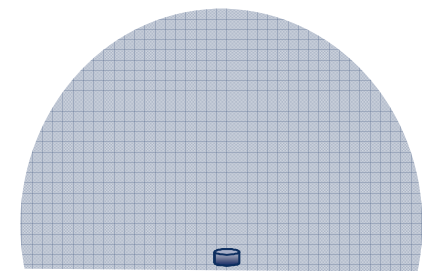
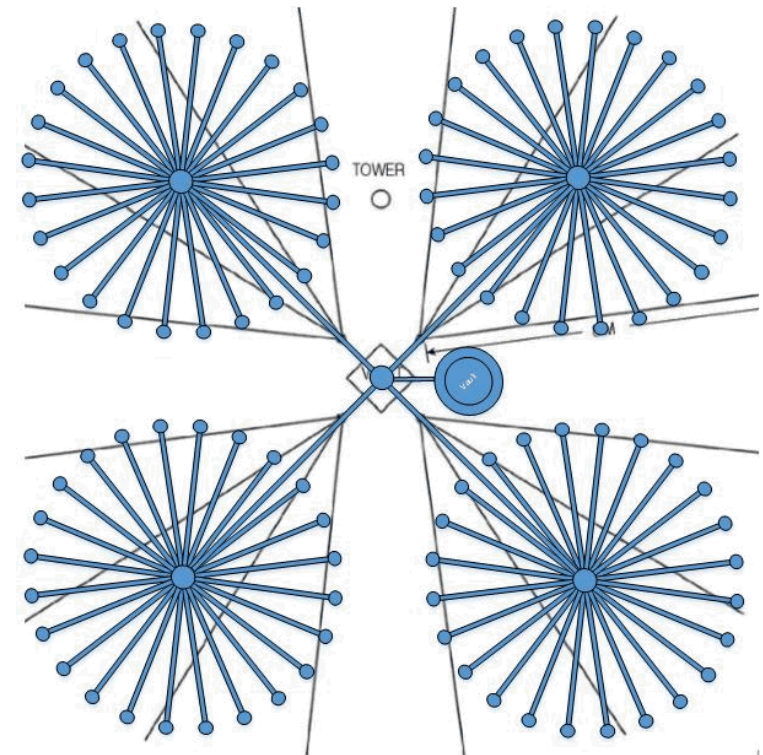
# FACT Array Field Sites

- DTRA funding Sandia and University of Alaska, Fairbanks
- Established prototype US IMS sites at FACT:
  - 2 Auxiliary Seismic
    - Quanterra Q330 & STS2.5
  - 2 Primary Seismic
    - Geotech Smart24 & GS13s / CMG-3T
  - 4 Infrasonic
    - Geotech Smart24, Chaparal 50A, Hyperion 5113
- Purpose is to evaluate:
  - Site upgrades prior to use on actual US IMS sites
  - Performance of various wind-filter designs
  - Future system configurations...



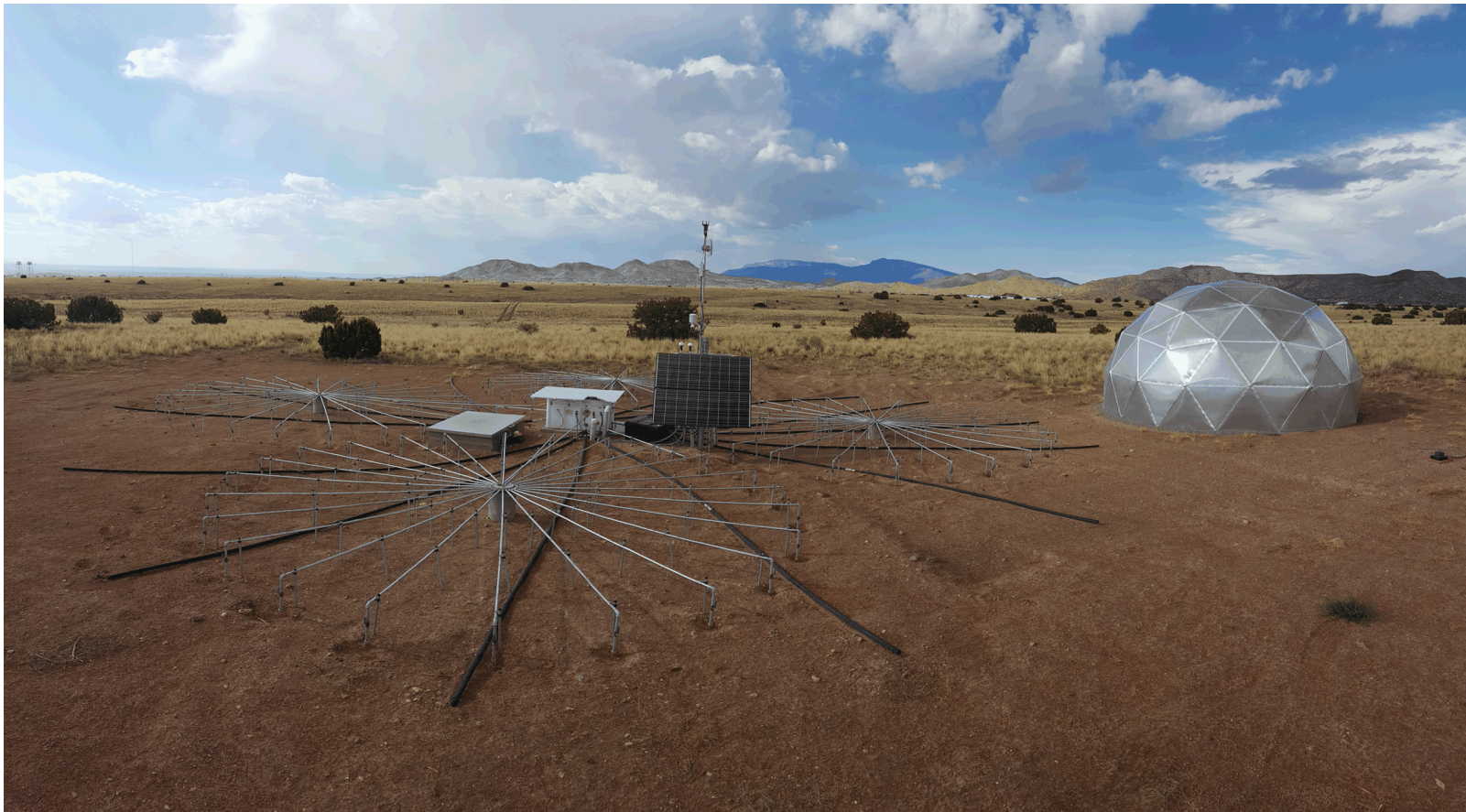
# SNL FACT Infrasond Arrays

- Co-located different wind noise reduction systems (WNRS):
  - Two open-port Hyperion's without WNRS for reference
  - Traditional 18 meter, 96-port steel pipe rosette
    - Chaparral 50A
  - University of Alaska-Fairbanks (UAF) polyethylene pipe design
    - Chaparral 50A
  - NCPA 6 meter steel dome
    - Hyperion in the center



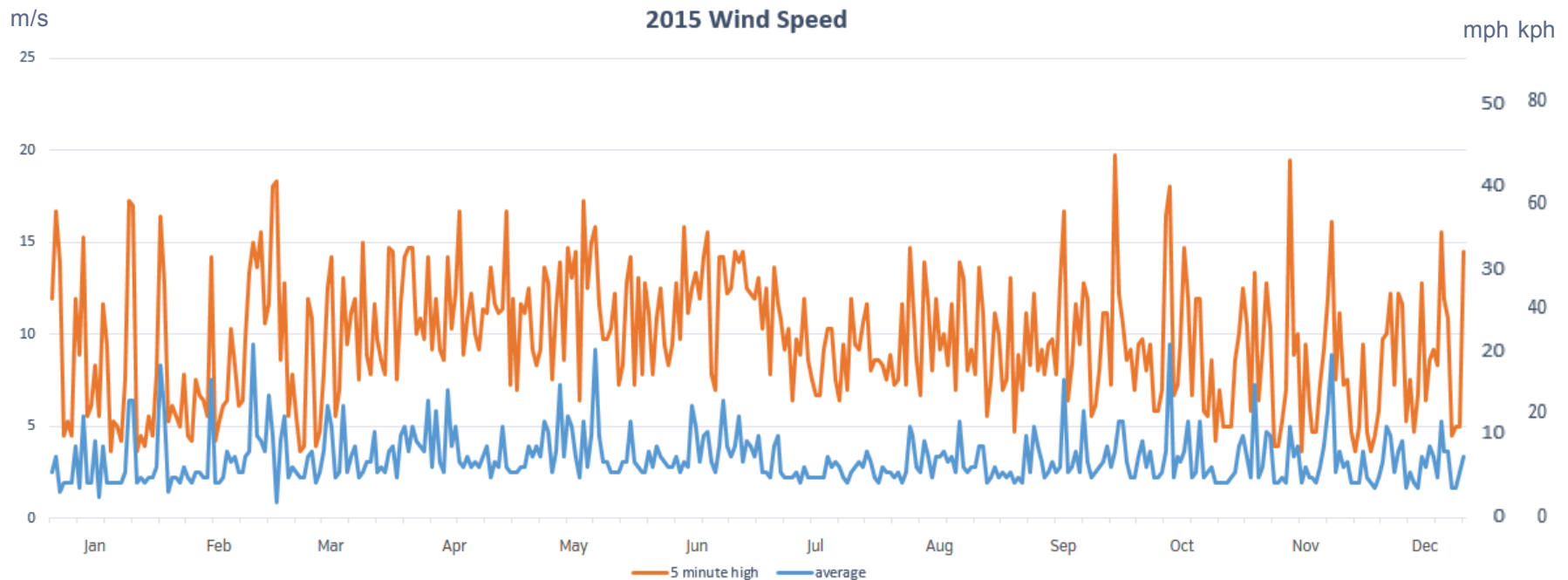
# Prototype infrasound arrays

Flat terrain, exposed location: worst-case for wind-noise



# SNL FACT ambient conditions

- Weather stations at all of the sites
- ~ 1800 m (6000 ft) elevation
- 810 – 820 hPa ambient pressure
- Historic wind speed:



# Wind Noise Reduction System

- Comparison study
  - Variable wind-conditions over the course of multiple seasons
  - Several WNRS designs in place
  - Additional future configurations
  
- Nearby explosive sources:
  - Kirtland AFB ordinance disposal, < 5 km, multiple per week
  - Energetic Materials Research and Testing Center (Socorro, NM), 100km, throughout the year
  
- David Fee (University of Alaska, Fairbanks) will be presenting preliminary results

# Questions?