Distributed Field Measurements of Low Amplitude Sonic Booms

159th Meeting of the Acoustical Society of America
Baltimore Maryland, April 19-23, 2010

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NATIONAL INSTRUMENTS

NASA

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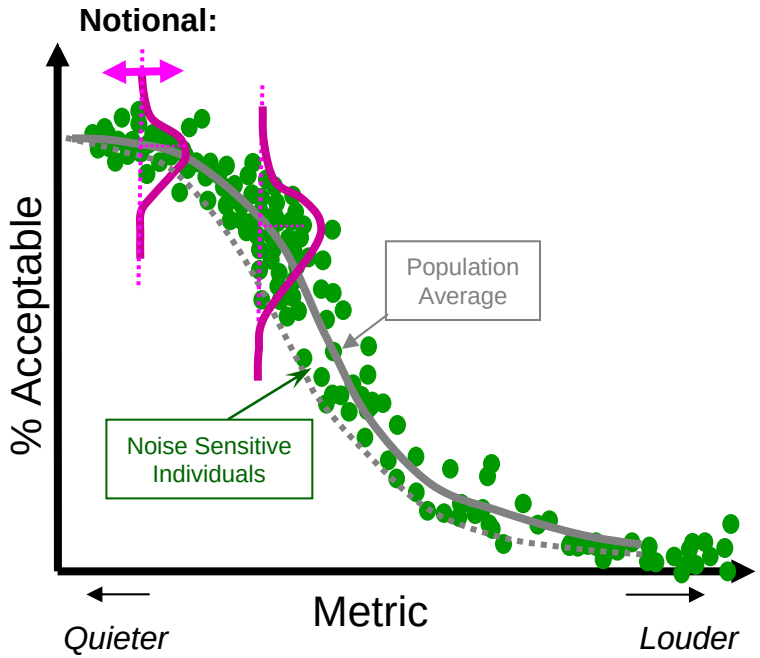
What Noise Level from Quiet Supersonic Flight Will Be Acceptable to the Public?

Both laboratory and field research will be required to develop the necessary scientific and social evidence.



This Presentation Describes a Distributed Measurement System For Capturing Signatures During Community Scale Surveys

There are Many Practical Challenges to Fielding Distributed Systems

The boom carpet is distributed with large gradients in loudness. These must be managed to ensure representative exposure.

PCBoom Calculated Contours of PLdB
Typical NASA Low Boom Dive

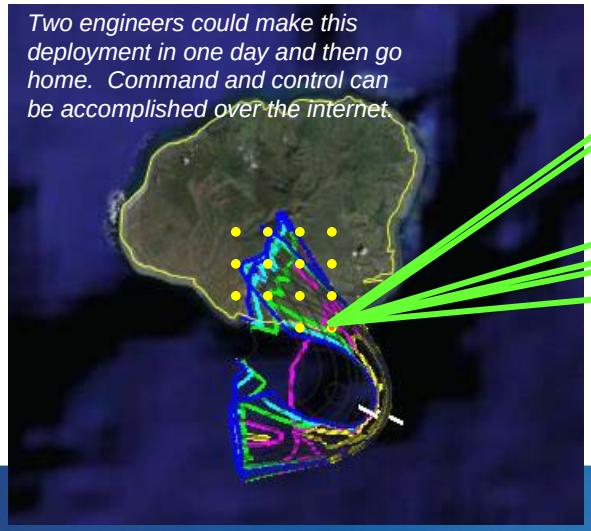
.... traditional approaches to distributed measurements have involved significant costs in both capital equipment and labor

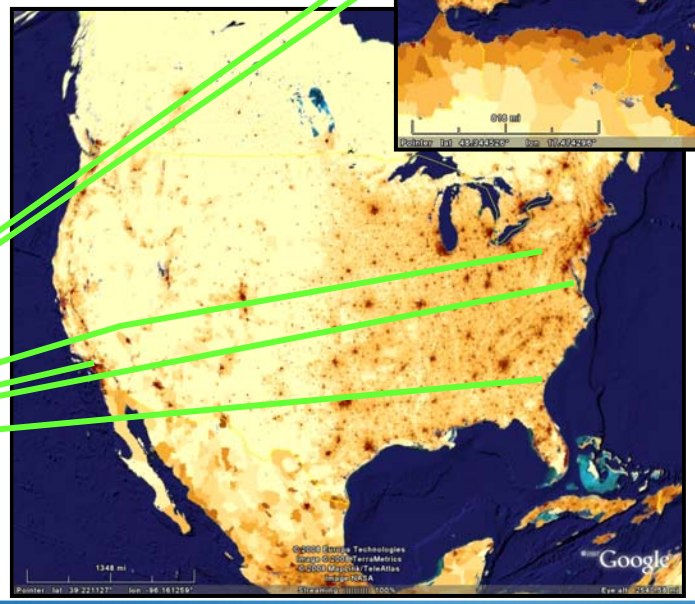
2 Mile Linear Array
~10 Man Days to Deploy

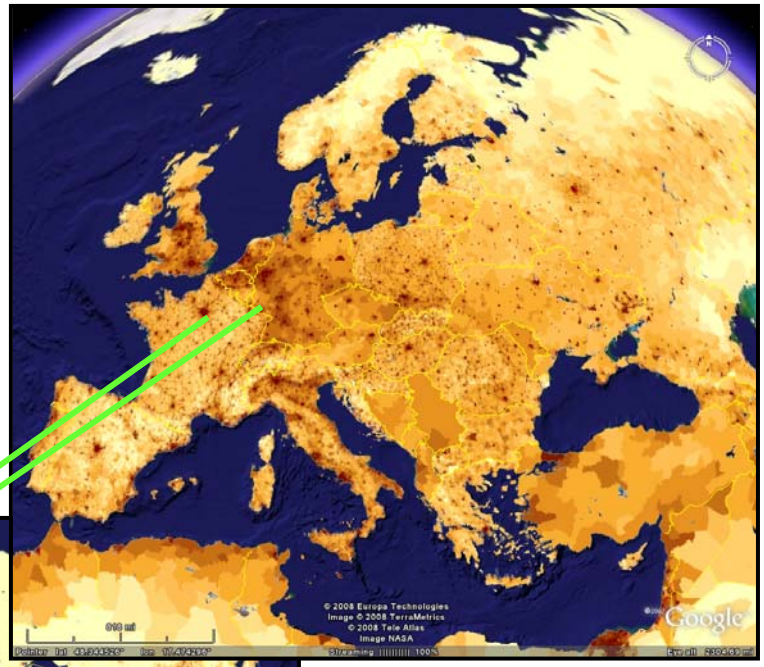
Can We Imagine a Way Forward to Provide High Quality Data While Reducing Test Labor Costs?

System Design Tenets:
- Highest quality data
- Rapid (low cost) deployments
- Low per unit hardware costs
- No software licensing fees
- Self sustaining footprint
- Open Architecture
- Scalable (10 to xx units)

Long Term Deployment Around a Coastal Community for Sonic Boom Acceptability Studies







Challenges:
- Consensus R'qmts
- Communications
- Endurance
- Cost

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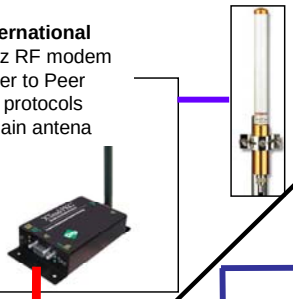
A Prototype System Architecture Built Around the Determinism of the National Instruments cRIO.

revDash Prototype

National Instruments cRIO
- *Embedded 400 MHz controller*
- *3M gate FPGA*
- *NI Proprietary real time operating system*
- *NI9234 A/D with optional IEPE power*
- *NI 4 channel serial module.*
- *NI DIO module (not shown).*

Digi International
900 MHz RF modem
With Peer to Peer
security protocols
+ high gain antena

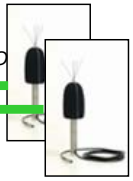


CNS Systems Clock II
w/ IRIG-B Option

GRAS Type 41AO-S1/CF
Pre-Polarized (CCP)
Mic with Desiccator

Coax (IEPE)

GRAS Type 41AO-S2**
Externally Polarized
Mic with Desiccator



LEMO

Coax

Coax

Serial

GRAS Type 12AQ
Programmable Power Supply**
Externally polarized or ICP.
Set filters and gains.

Serial

GARMIN GPS receiver
(16xHVS)
Position and NMEA timing
words w/ PPS output.
Serial connection + DO.
12v power.

Ethernet Router+
802.11b/g/n
2 USB ports
(normally off)

**** Alternate Mics**
B&K 4193 Externally
Polarized Mics
With 2 or 4 channel
programmable NEXUS
power supplies

Pole Mounted 30W Unbreakable
Solar Charger (12-18VDC)
6 hours sunlight
180W per day
~ 5hours nominal load/day
18"x25"x0.2"
Pole mount kit
12 lb
Part# BSP3012SS

Solar Controller (12VDC)
Low voltage disconnect
Part# SS6LVD

21AH High Rated 12V
Sealed
Weather rated
13 lb
7" x 3" x 7"

Typical Fiberglass
NEMA-4 Enclosure
Pole Mounted
Lock, handles, pole mount
3 weather tight cable grips

Target price $12k per site. Actual returns are closer to $15k (cost growth is mainly mic power supply). Actuals are about $9k without mic/power supply.

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Some Vital Statistics

- **Data Acquisition:**
  - 24 bit, AC/DC Coupling, program selectable IEPE power.
  - Variable Gain (-20 to +60), Variable filtering (linear, A, C)
  - Sample rates up to 51.2 kHz

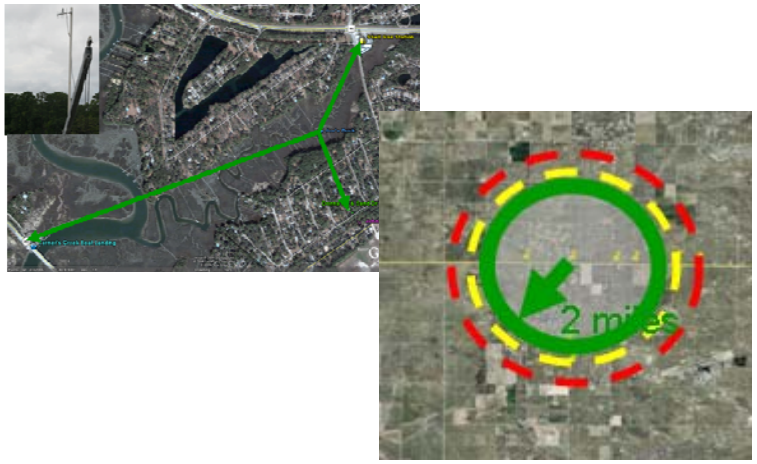
- **Frequency Response:**
  - Externally Polarized mics: (B&K 4193, GRAS 41AO-S1) 0.1 Hz to >10 kHz.
  - Pre Polarized mics (GRAS 41AO-S2) 0.5 Hz to >10 kHz.
  - Compatible with GRAS12AQ or NEXUS mic power supplies.

- **Synchronization Between Remote Units:**
  - Better than 1 miliSecond.
  - Rising edge of PPS trigger accurate to 10 microseconds.

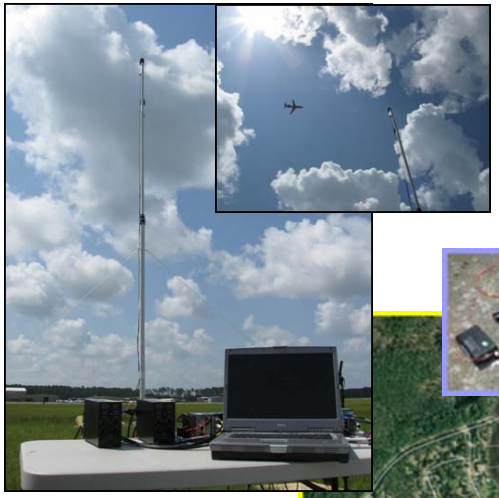
- **System:**
  - Deployment times of order 15 minutes per site including antenna/mast
  - Weight of order 40 pounds (mostly battery).
  - Battery life of order 24 hours active data logging.
    - Complete solar recharge possible in about 3 hours.
    - “Sleep” functionality possible to extend battery life during idle periods
  - Sufficient digital storage now for over 500 boom recordings (8 channels, 51.2 kHz, 60 seconds).

Thirteen Weeks for System Integration, Software Development and Risk Reduction Testing

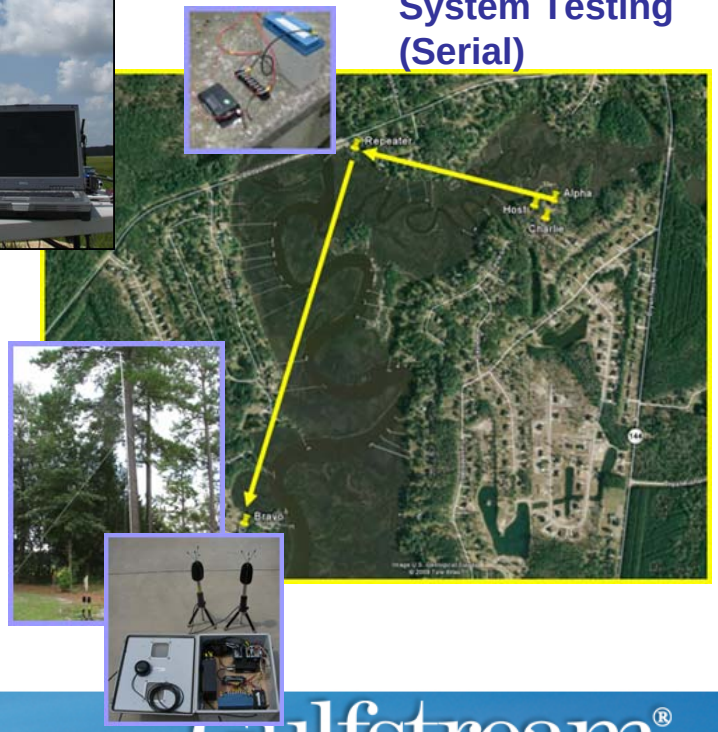
900 MHz Range Testing



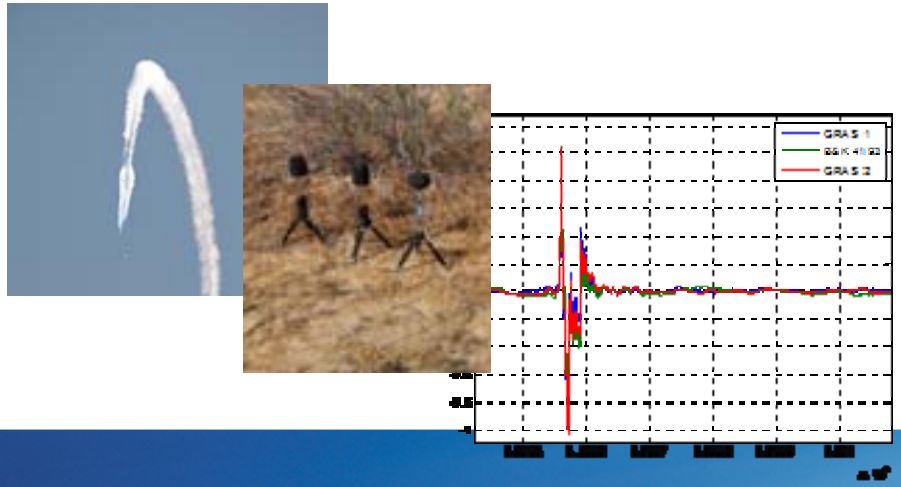
System Testing (TCP/IP)



System Testing (Serial)



Component Testing



Four Prototypes Were Evaluated at NASA DFRC Spanning a 4.5 Mile Communications Link

Community Deployment

Research Deployment

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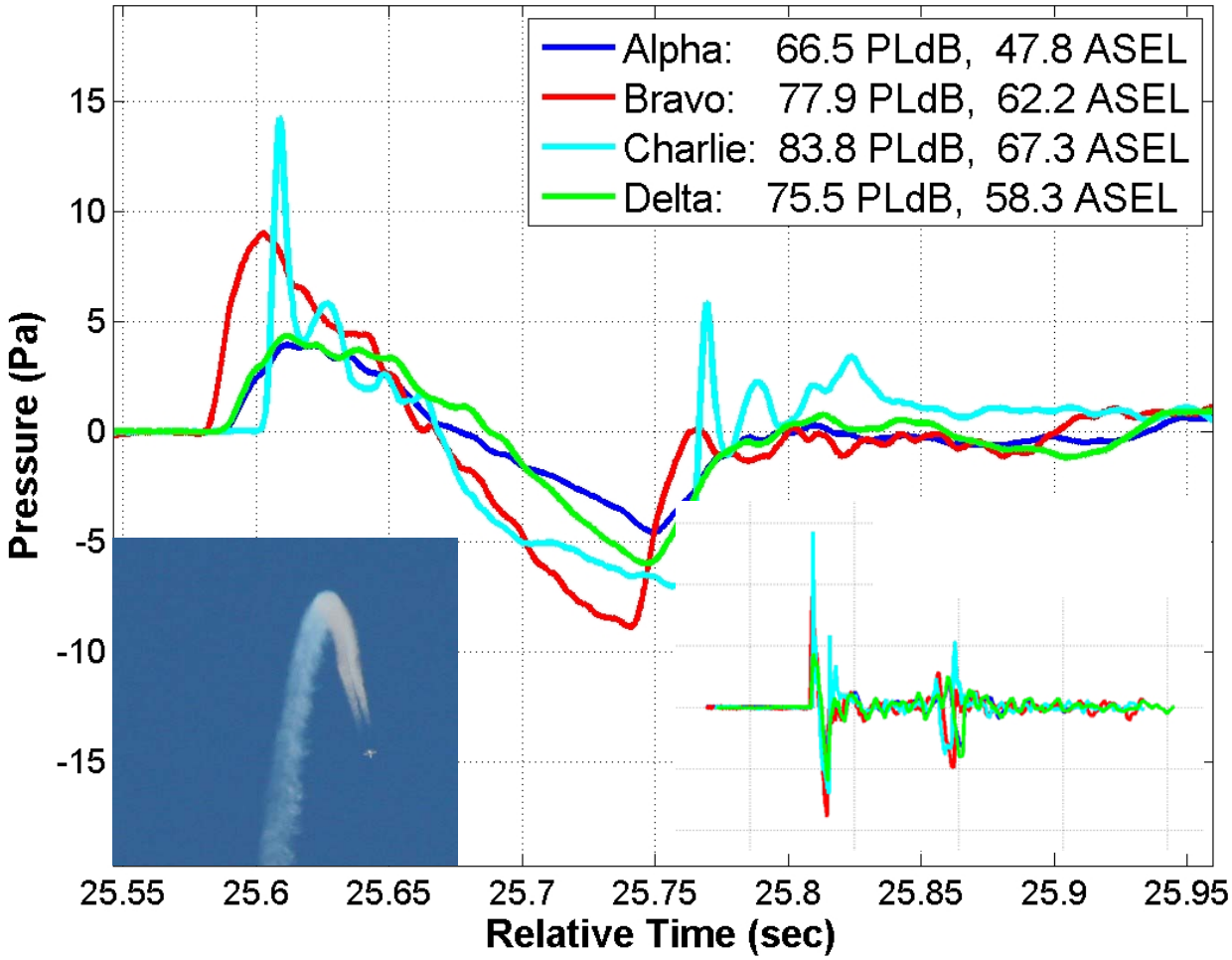
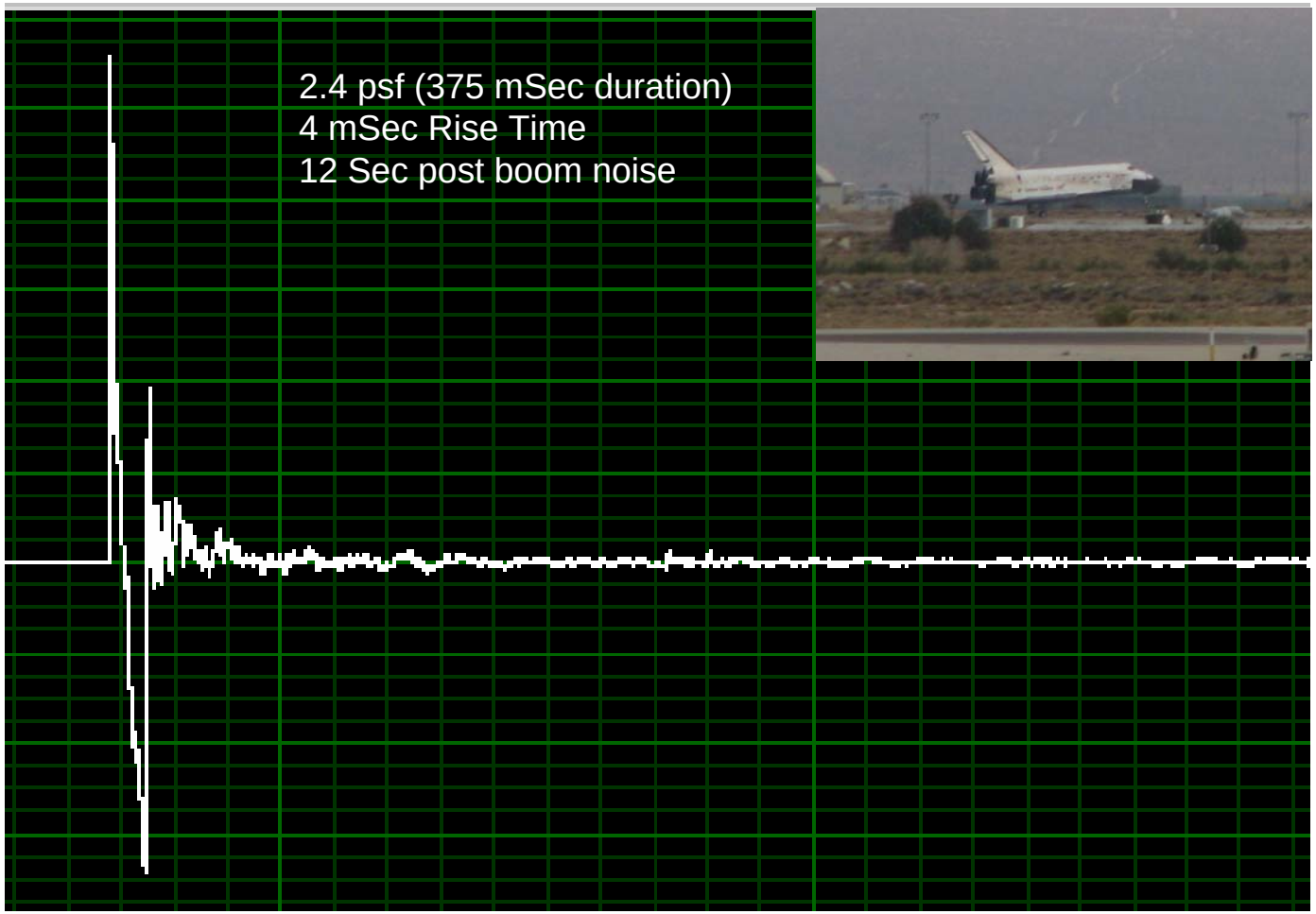
Measurements Highlight the Variability in Exposure Levels Across the Scale of a Community

Pass #7, Waypoint 1, Sonic Boom Measurements



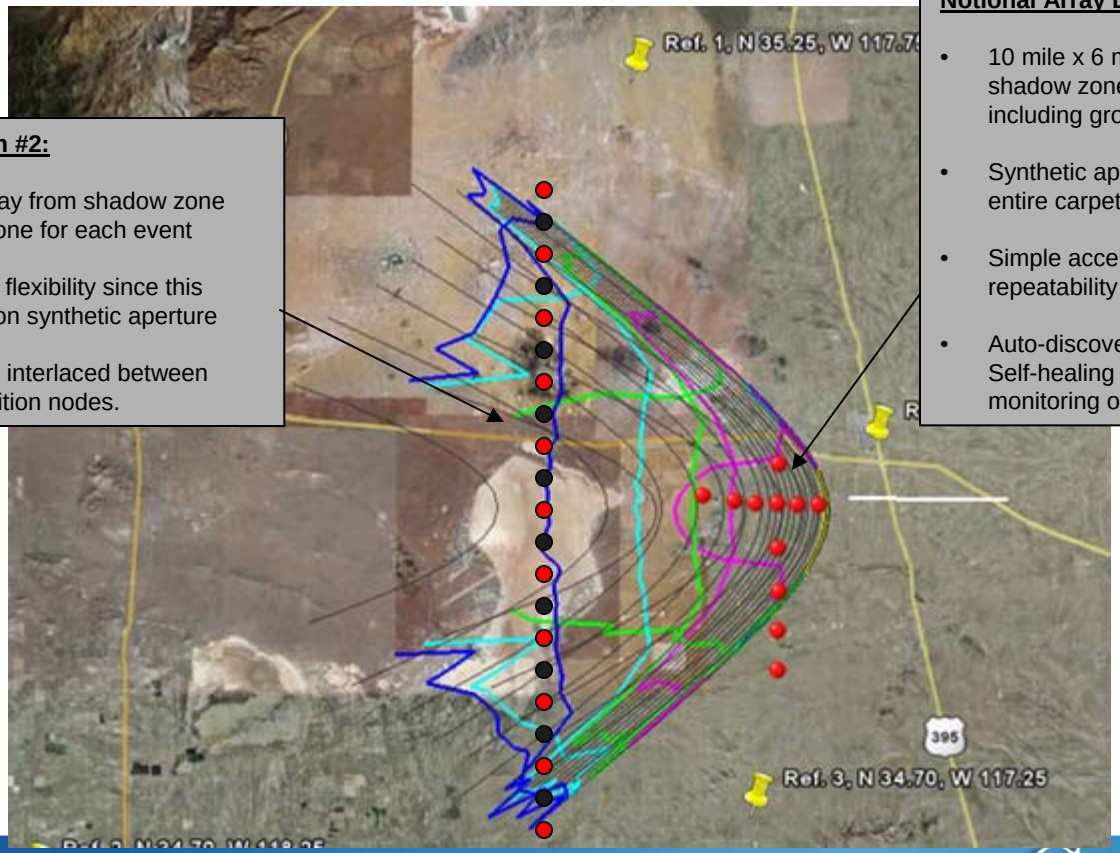
Data was also Acquired Autonomously as the Space Shuttle Landed at Edward's Air Force Base



Two Notional Deployments Highlight The Potential Future Capability

Notional Array Design #2:

- 35 mile+ linear array from shadow zone through shadow zone for each event
- Greater maneuver flexibility since this removes reliance on synthetic aperture
- Network repeaters interlaced between actual data acquisition nodes.



Notional Array Design #1:

- 10 mile x 6 mile cross…focus through shadow zone for 2D code verification including ground impedance effects
- Synthetic aperture enables msmt across entire carpet (eg pilot iterates way points).
- Simple accel/climb maneuver ensures repeatability for synthetic array
- Auto-discovery of optimal network routing. Self-healing within range. Indirect monitoring of solar cell voltage.

Similar Deployments Could Greatly Improve Signature Collection During Community Scale Surveys