Distributed Field Measurements of Low Amplitude Sonic Booms

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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.

Notional:

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.

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

PCBoom Calculated Contours of PLdB
Typical NASA Low Boom Dive

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)

**Challenges:**
- Consensus R’qmts
- Communications
- Endurance
- Cost

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

Two engineers could make this deployment in one day and then go home. Command and control can be accomplished over the internet.
A Prototype System Architecture Built Around the Determinism of the National Instruments cRIO.

**Essential Features:**
- **revDash Prototype**
- Ethernet Router+
  - 802.11b/g/n
  - 2 USB ports (normally off)
- CNS Systems Clock II w/ IRIG-B Option
- Typical Fiberglass NEMA-4 Enclosure
- Pole Mounted
  - 30W Unbreakable Solar Charger (12-18VDC)
  - 6 hours sunlight
  - 180W per day
  - 18’x25’x0.2” Pole mount kit
  - 12 lb
  - Part# BSP3012SS
- 21AH High Rated 12V Sealed Weather rated
  - 7” x 3” x 7”
- **GARMIN GPS receiver (16xHVS)**
  - Position and NMEA timing words w/ PPS output
  - Serial connection + DO
  - 12v power
- **Gulfstream®**

**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.**
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 millisecond.
  – 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)

Component Testing

System Testing (Serial)
Four Prototypes Were Evaluated at NASA DFRC Spanning a 4.5 Mile Communications Link
Measurements Highlight the Variability in Exposure Levels Across the Scale of a Community

Pass #7, Waypoint 1, Sonic Boom Measurements

- Alpha: 66.5 PLdB, 47.8 ASEL
- Bravo: 77.9 PLdB, 62.2 ASEL
- Charlie: 83.8 PLdB, 67.3 ASEL
- Delta: 75.5 PLdB, 58.3 ASEL
Data was also Acquired Autonomously as the Space Shuttle Landed at Edward’s Air Force Base

2.4 psf (375 mSec duration)
4 mSec Rise Time
12 Sec post boom noise
Two Notional Deployments Highlight The Potential Future Capability

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

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.
Similar Deployments Could Greatly Improve Signature Collection During Community Scale Surveys