Noise Reduction in Air-Launched Horn Antennas used for GPR Evaluation of Roads and Bridges

Geophysical Survey Systems, Inc

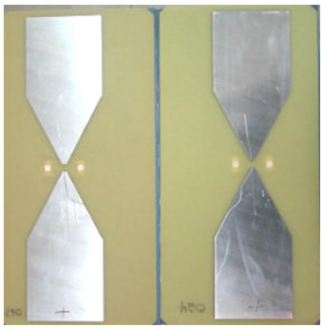
Jeffrey Feigin, Roger Roberts,
Robert Parrillo, Jami Harmon

www.geophysical.com
sales@geophysical.com

GPR Antennas

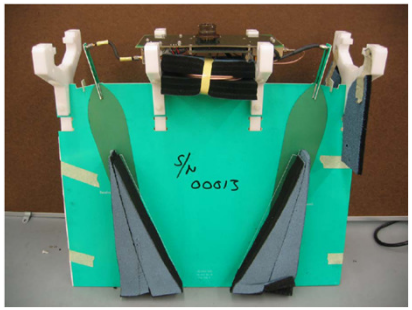
Ground Coupled

- Designed to be in contact with the ground
- May be *slightly* air-launched for road applications
- Require periodic core data for calibration
- Can not resolve thin layers
- Shielded – less susceptible to RF interference



Air-Launched Horn

- Designed to be air-launched
- Safely operate at highway speeds
- Automatic velocity calculation at each scan location
- Able to resolve thin layers
- Unshielded – more susceptible to RF interference

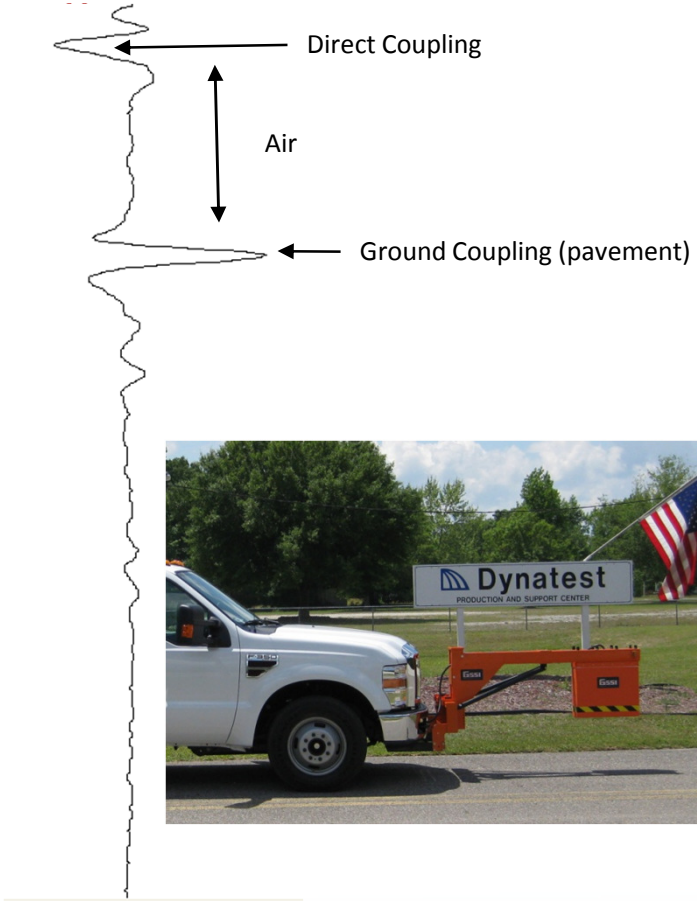


GPR Antennas

Ground Coupled

Direct Coupling & Ground Coupling

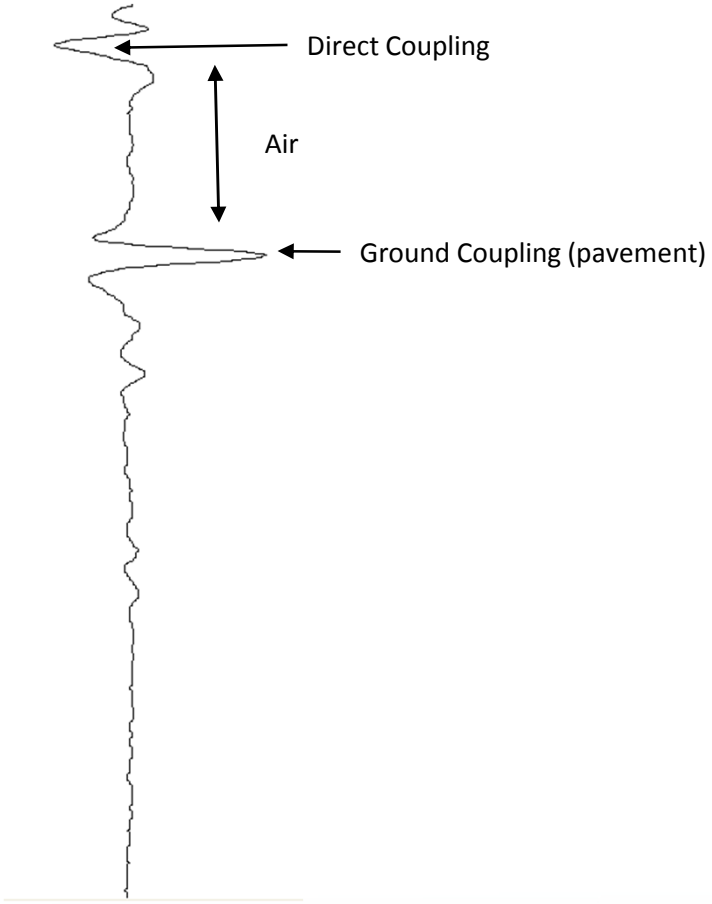
Air-Launched



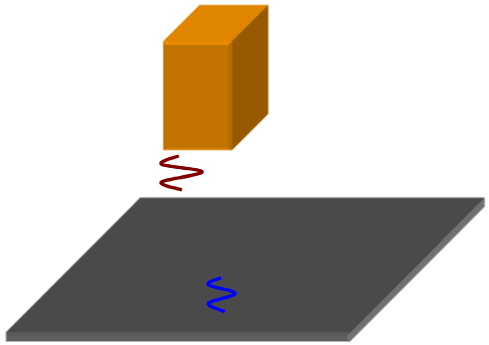
GPR Antennas

- The separation of the direct coupling from the ground coupling permits automatic velocity calculation at each scan location
- Eliminates the need for frequent calibration cores
- The high ground clearance permits data collection at highway speeds

Air-Launched Horn



Air-Launched Horn Antenna - Calibration

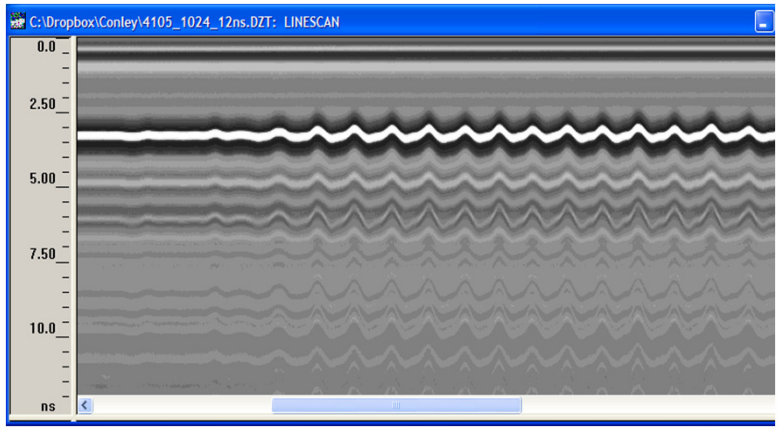


An antenna calibration file is collected using a metal plate as a perfect reflector

Metal plate reflections are collected at the different heights that will occur during data collection

"Bumper Jump"

Bumper Jump file

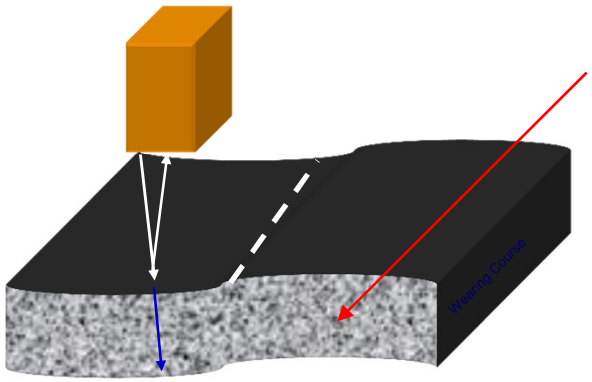


Antenna Calibration file

Air-Launched Horn Antenna
Calculating Pavement Velocities

Calibration cores are not required

Velocity re-calculated at each scan location



Thickness = (2WTT x velocity)/2

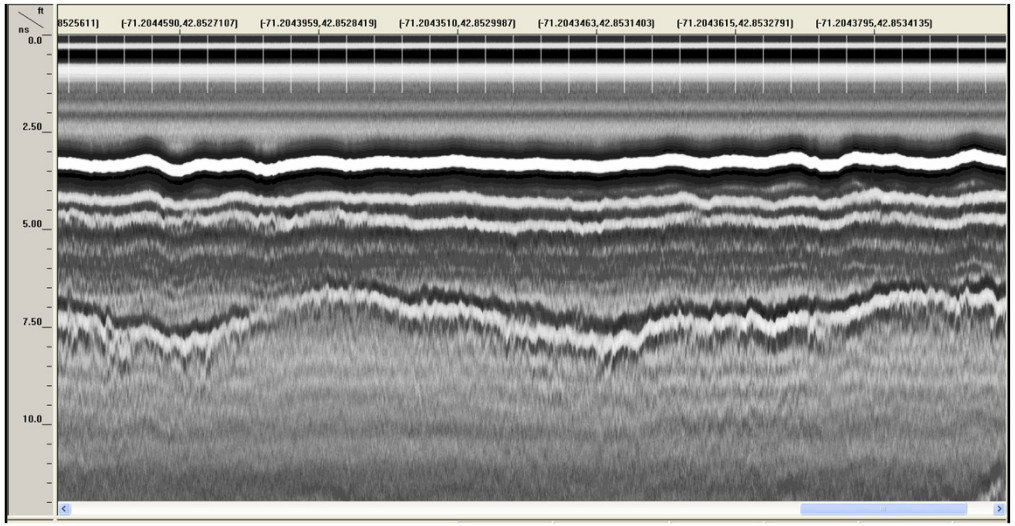
$$V_L = \frac{V_{AIR}\left(1-\frac{A_p}{A_m}\right)}{\left(1+\frac{A_p}{A_m}\right)}$$

VL = velocity of layer
Ap= Amplitude of pavement reflection
Am= Amplitude of metal plate reflection
VAIR = propagation velocity in air
11.811 in/ns or 0.3 m/ns

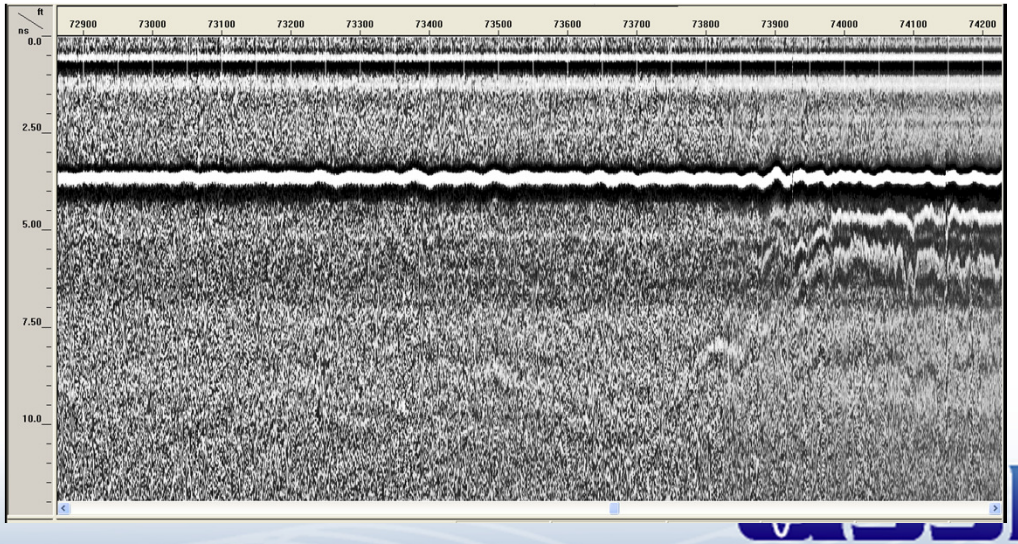
Pavement layer velocities are calculated based on the pavement reflection and the metal plate reflection.
(Equation above assumes no separation distance between transmit and receive antennas. Actual equation used for antennas requires finding the roots of a 4th order polynomial equation.)

RF Interference

Clean horn antenna data:



RF Interference:



RF Interference

The cause is RF interference.
But where does it come from?

<u>Most common sources of RF Interference include:</u>

FM Radio Towers
Television Towers
Security Systems
2 way radios

<u>Not a significant source of interference:</u>

Cell Towers
Power lines

RF Interference

Previous efforts of attempting to shield the antenna have been unsuccessful and compromised data quality.

A new approach was required.

The new approach consisted of two separate Noise Rejection techniques:

1. A hardware component consisting of an RF filter implemented into the antennas receiver electronics

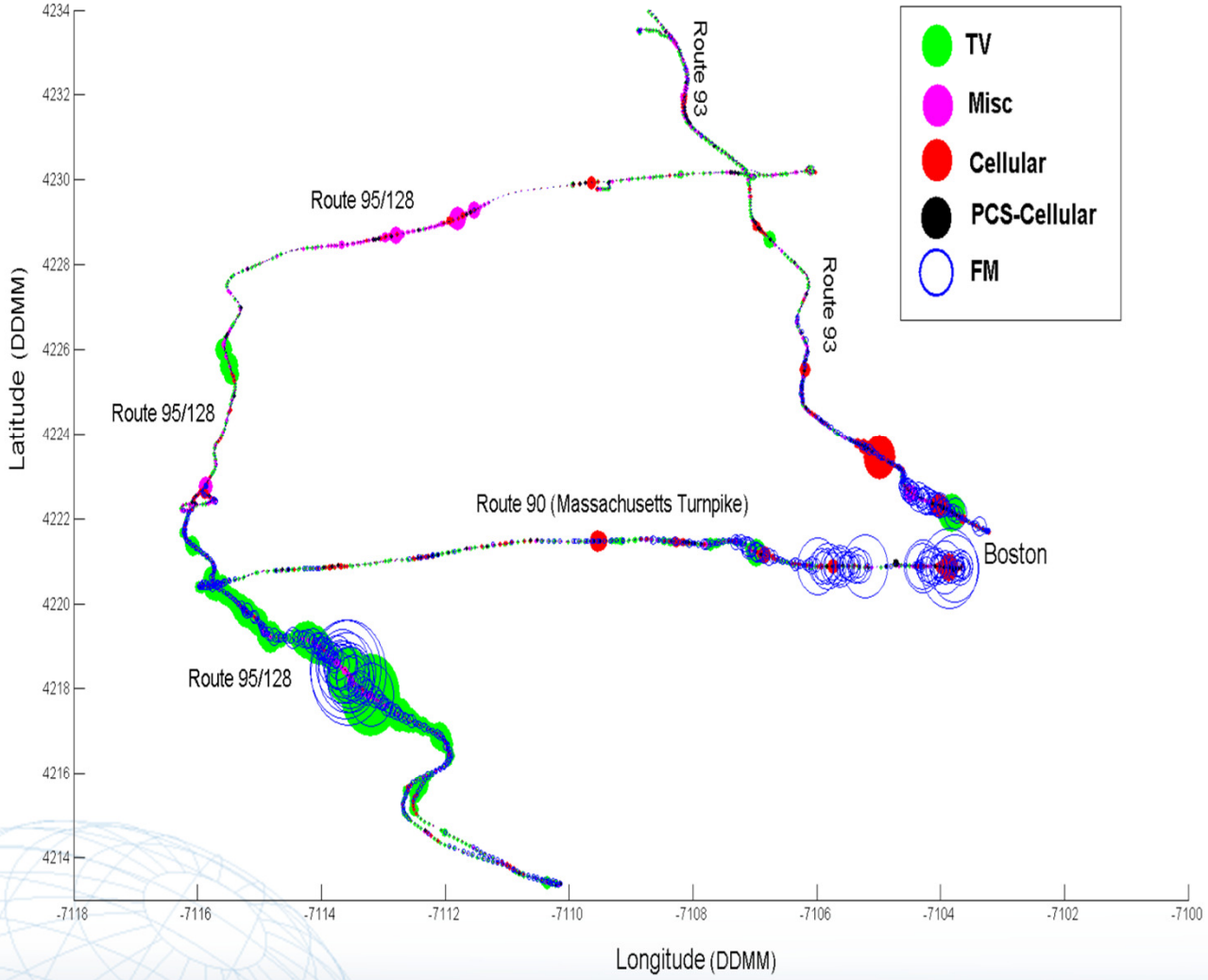
2. A software component consisting of antenna specific coefficients
   Antenna specific coefficients remove the undesirable effects introduced by the hardware filter.

Characterizing and Evaluating Interference

Data Collection Vehicle Configured with 3 Antennas:

- Conventional 4105 horn antenna
- 4105NR horn antenna with interference rejection technology
- Interference measurement antenna (measures environmental noise)

Data Collection Route

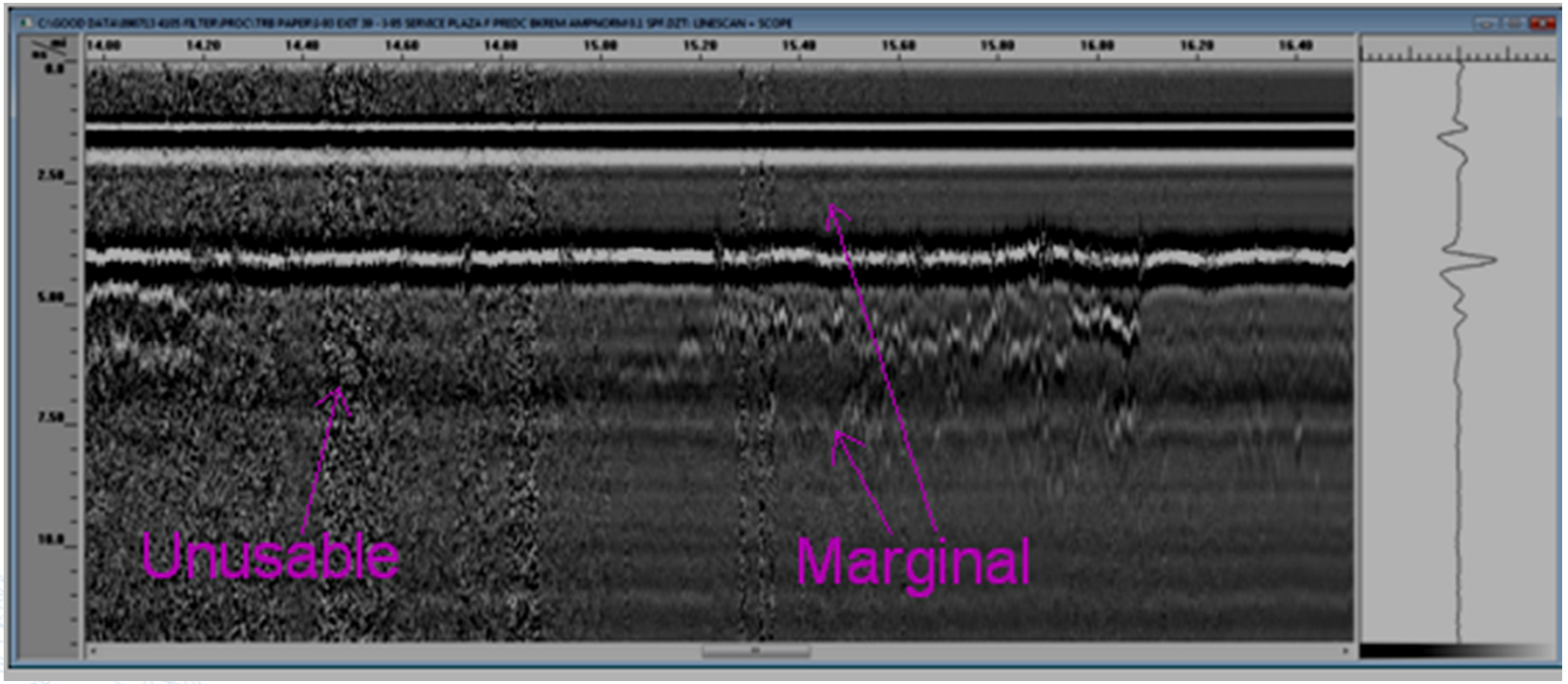


- Route chosen to include noisiest locations (around Boston)
- Radio interference automatically measured and logged using a spectrum analyzer and GPS
- Conventional and interference rejecting RADAR measurements are recorded

Data Analysis

RADAR data was classified as:

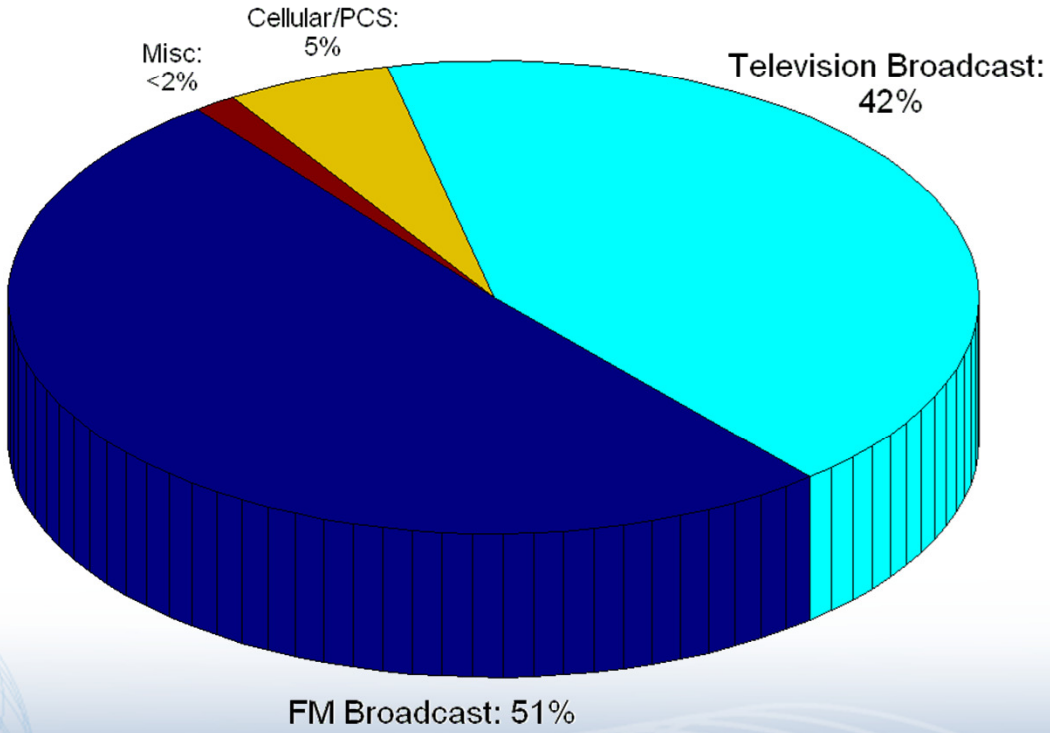
- **Excellent :** **noise level is <-44 dB**
- **Acceptable :** **noise level is -44 to -38dB**
- **Marginal:** **noise level is -38 to -32dB**
- **Unusable:** **noise level is >-32 dB**



Excellent and acceptable useful for 1” layer thickness resolution

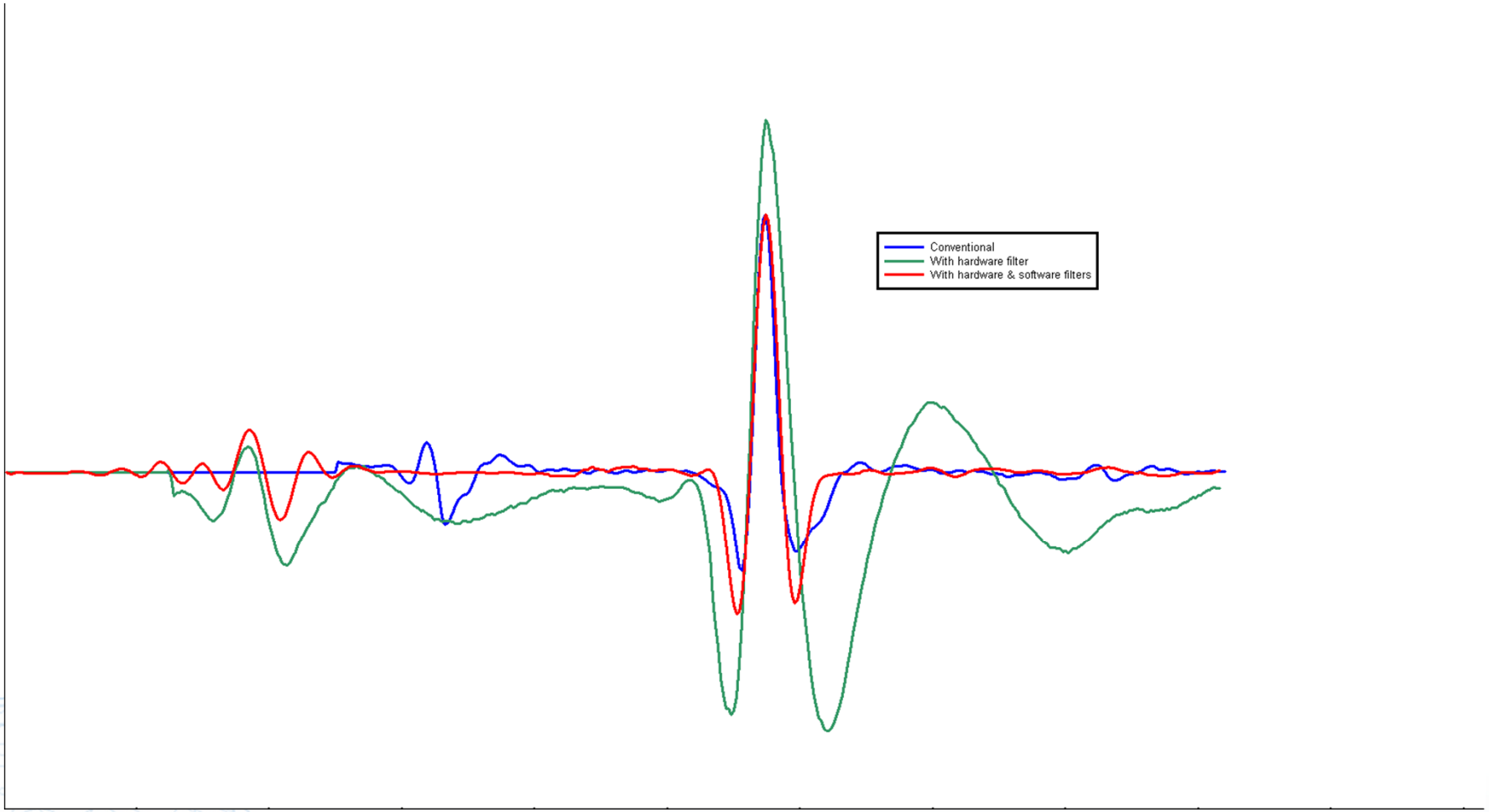
Results

- Marginal/acceptable data is correlated with the interference source
- TV, FM broadcasting is primary cause
- Some very localized noise due to cellular base stations

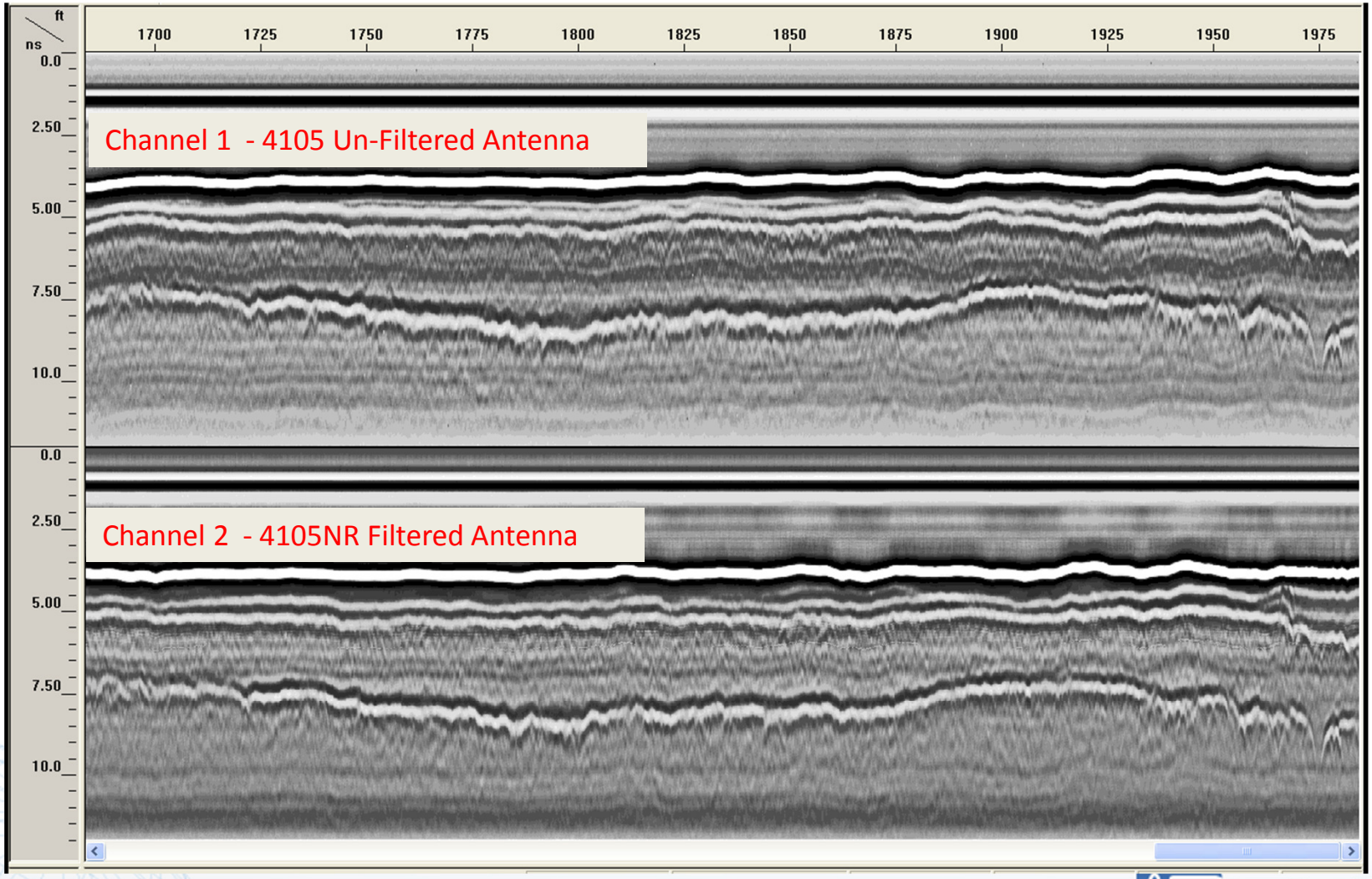


RF Interference

- Patented technique relies on both hardware and real time signal processing algorithms:

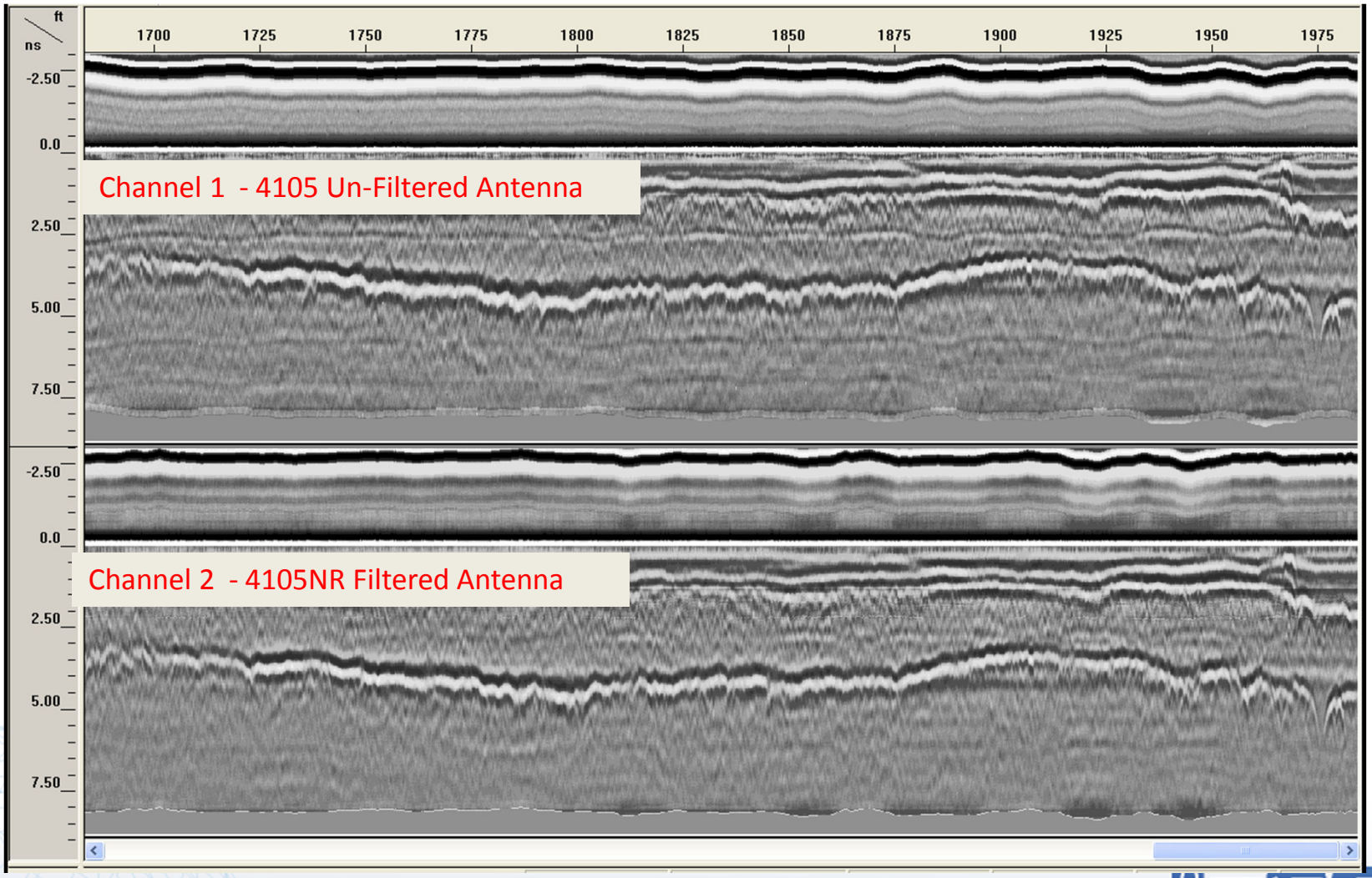


Raw Data



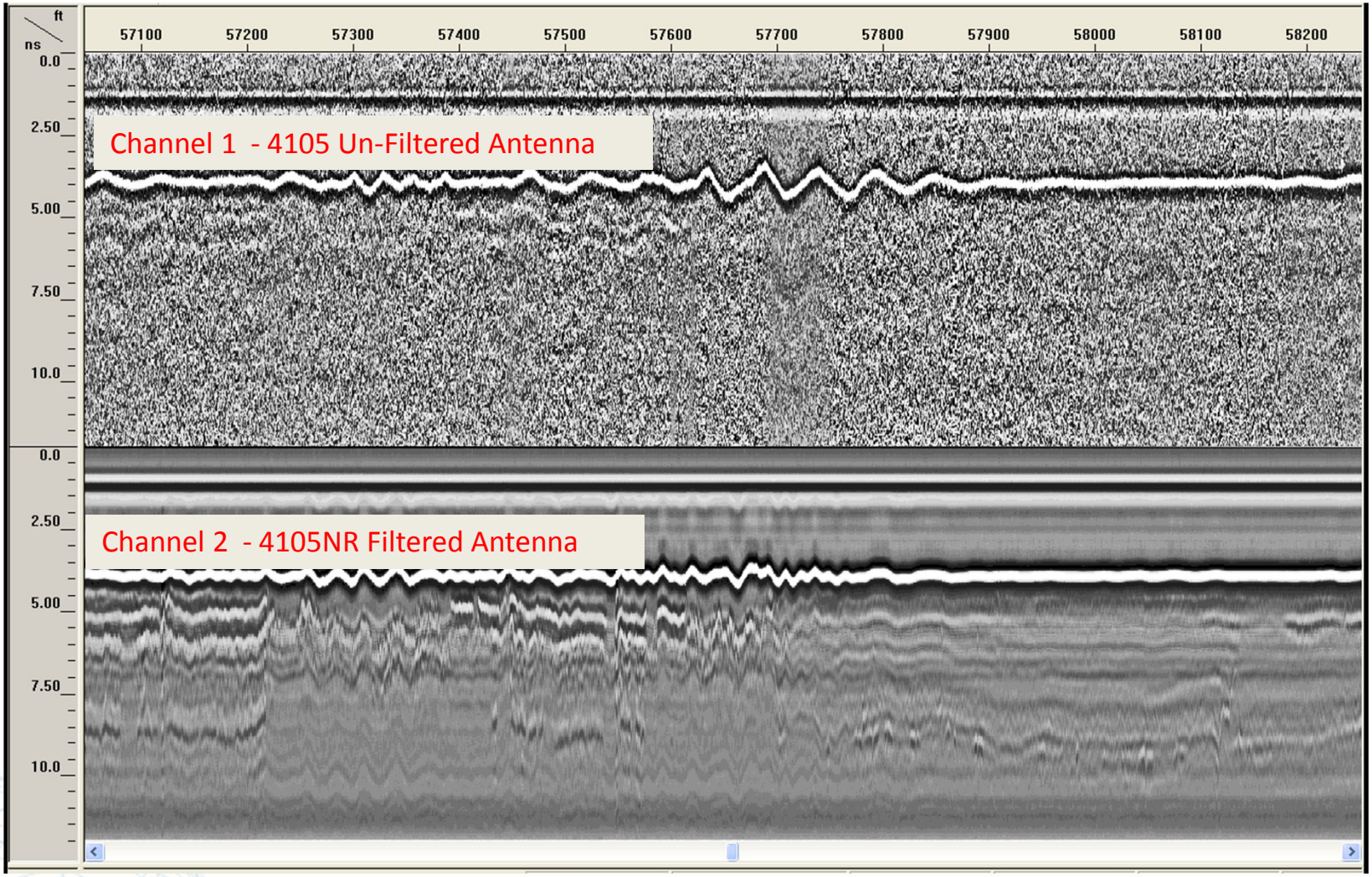
Dual Channel file: - area of no visible interference

Processed Data



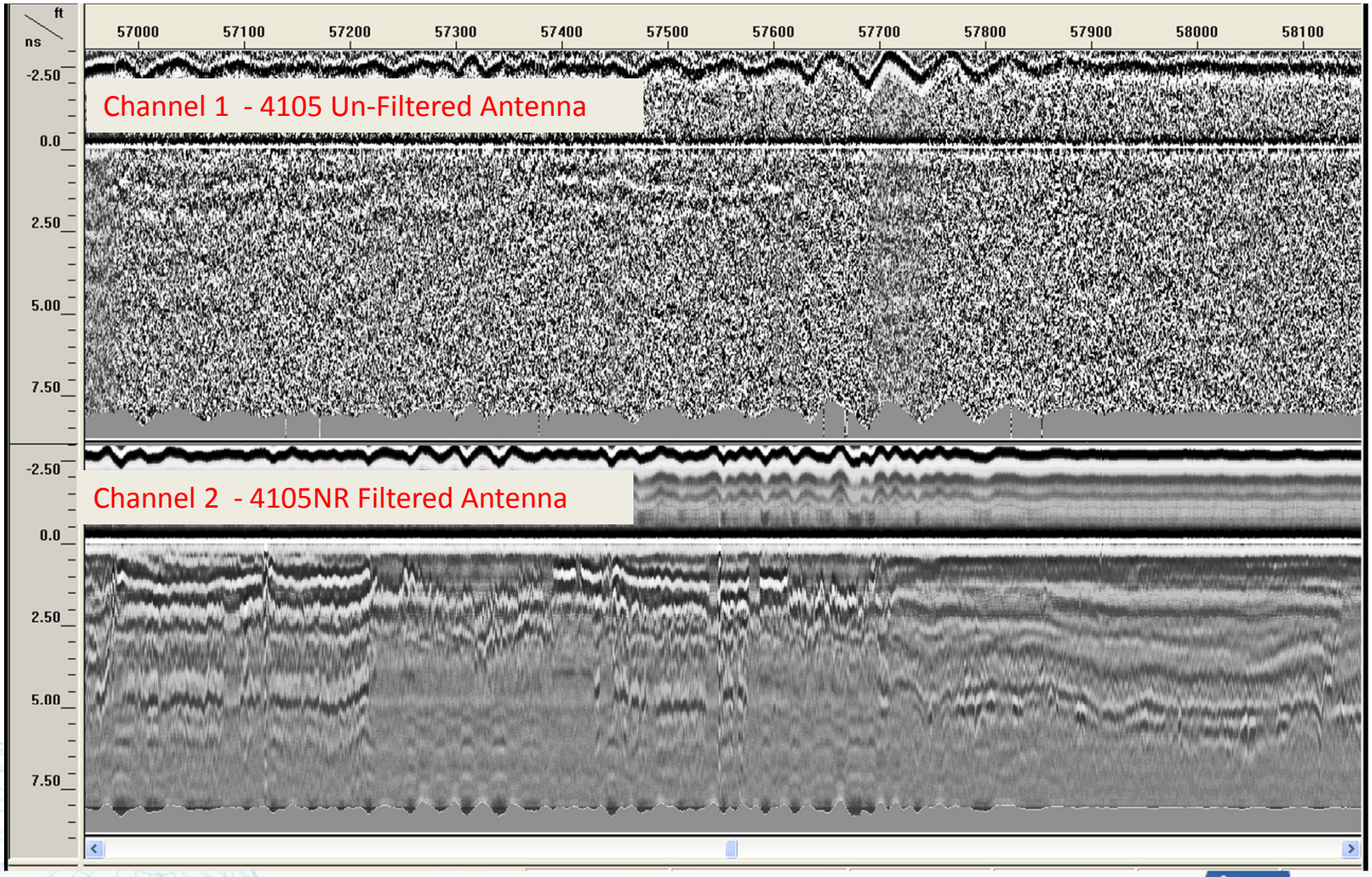
Dual Channel file: - area of no visible interference

Raw Data



Dual Channel file: - area of visible interference

Processed Data



Dual Channel file: - area of visible interference

2 GHz Air-Launched Antenna with Noise Rejection

Availability:

As a new antenna – GSSI Model 4105NR (Noise Rejection)

As a retrofit:

For S/N 30 (~Feb 05) and up

Conclusions

- New interference rejecting technology retains advantages of horn antennas
- Allows operation in noisy environments
- Most interference due to FM broadcast towers
- Operation of 4105NR is transparent and interference rejection occurs in real time (not post processing)

Thank You!