# Ground Penetrating Radar Using Circular Data Acquisition

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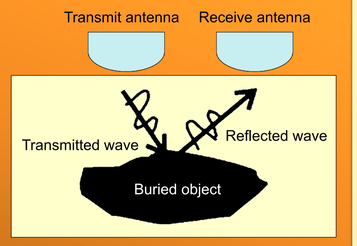
## What is Ground Penetrating Radar?

Ground Penetrating Radar (GPR) is a nondestructive method that uses electromagnetic radiation in the microwave band to reconstruct subsurface images. The radiation is emitted into the ground from a transmission antenna and a receiving antenna records any of the reflected radiation.




## Abstract

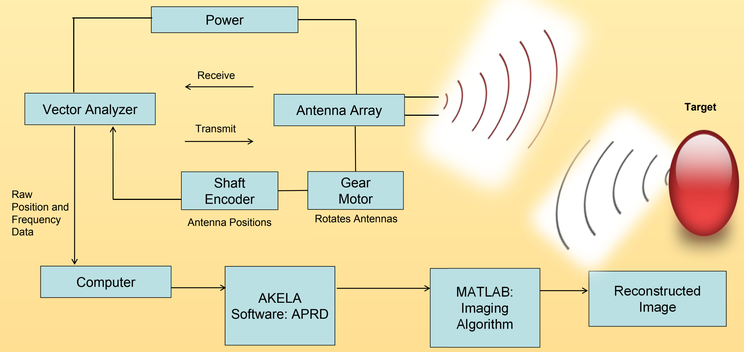
The majority of Ground Penetrating Radar systems today employ a linear multi-static antenna array, like the unit pictured on the right. To reconstruct images of underground objects, the entire system is moved along a series of parallel linear paths. This method can be inefficient and time costly.

Our solution to these problems is a multi-static Ground Penetrating Radar system with circular data acquisition as seen below. The system is rotated in a circular manner by a motor and its relative position is tracked, allowing for automated data collection. This unorthodox implementation can be used to quickly locate metallic obstacles such as piping before construction projects or precious metals within a potential geological dig site before actual excavation.

## Operation

The four Vivaldi antennas are placed in a linear array that is anchored to a base consisting of a gear motor and a shaft encoder. The antenna array emits 0.5GHz - 2GHz sine waves into the ground while being rotated by the gear motor to collect the necessary data for imaging. During operation, each possible antenna pairing acts as a transmit-receive pair for every angular step of rotation. This yields multiple data points throughout the circular pass, simulating numerous stationary antennas. The AKELA 4-Port Vector Analyzer powers the antennas and records the transmit-receive data as well as the relative position of the array tracked by the shaft encoder. The data is saved in the APRD software and exported to MATLAB. MATLAB then processes all the data using an imaging algorithm designed for ARRADIAN and outputs a final image reconstruction of the subsurface area.

## System Block Diagram



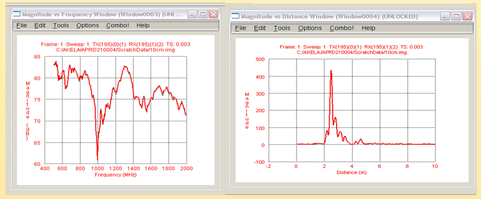

## Features

Ease of use was considered while developing ARRADIAN. The self-automated system minimizes user error and eliminates the need for manual labor.

Accuracy is a key factor in locating a target object. The shaft encoder allows for the scan location to be incorporated in the radar data to ensure precise image reconstructions.

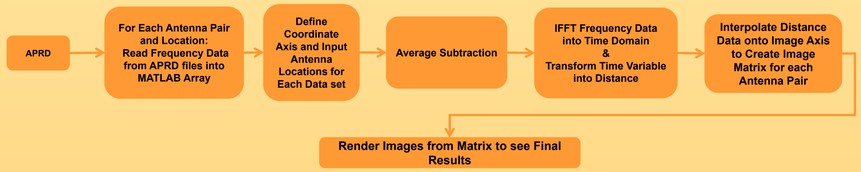
As technology advances, speed becomes a critical issue. ARRADIAN reduces the time and effort of subsurface imaging by utilizing a single circular sweep rather than multiple linear scans.

## APRD Data Acquisition

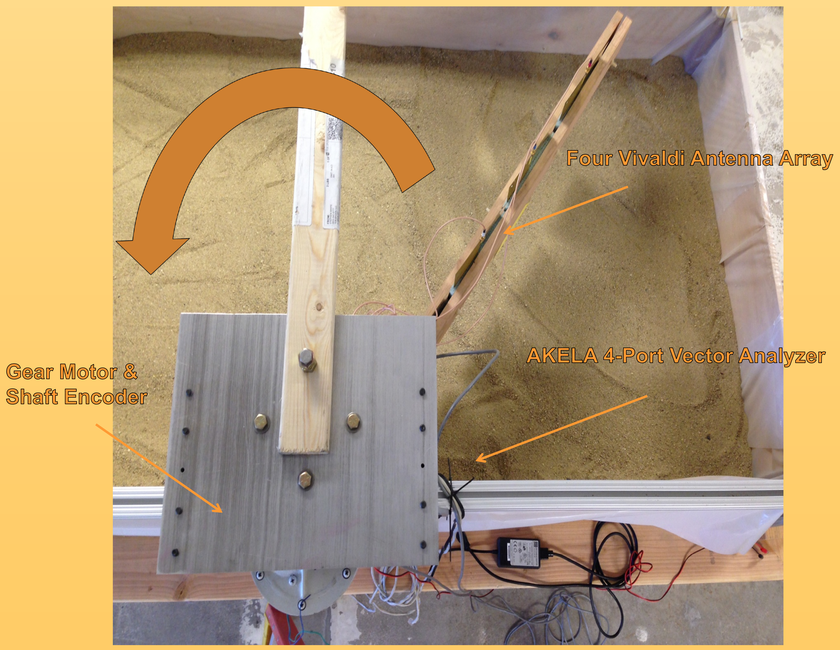


APRD software screenshot: The APRD software controls the AKELA Vector Analyzer, records the reflected signal data, and displays it in the frequency (left) or time/distance domain (right).

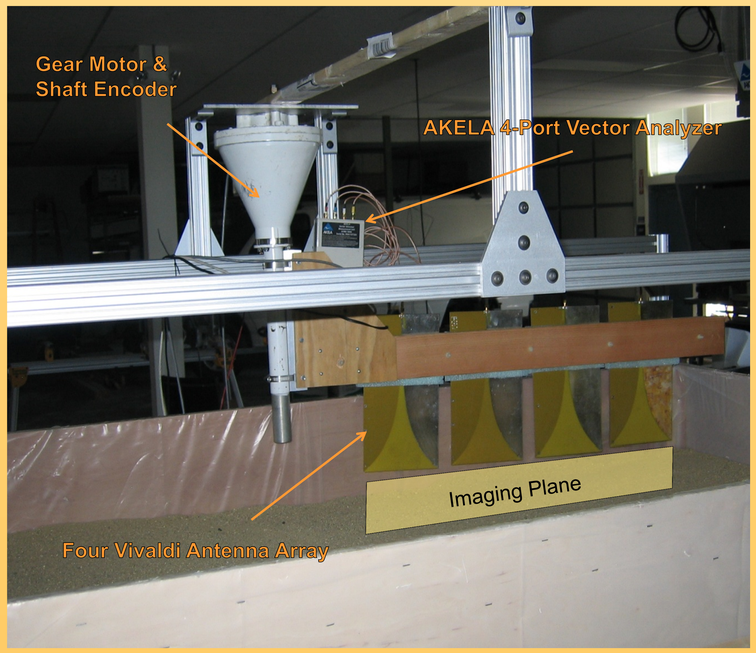
## MATLAB Imaging Algorithm



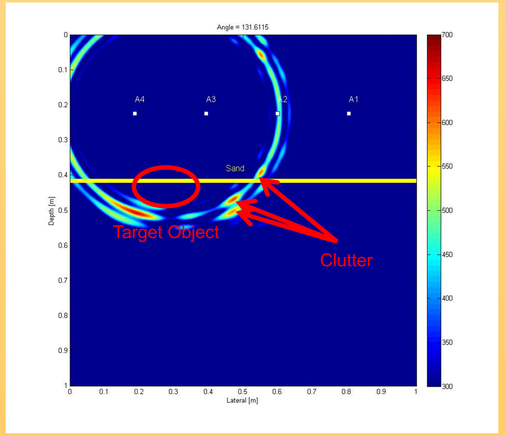

## Top View of ARRADIAN




## Front View of ARRADIAN




## 2-D Reconstruction




MATLAB image reconstruction: 2-D subsurface area parallel to the plane of the antenna array. The reconstruction images a metallic target. The clutter shown above is a possible result of antenna crosstalk and variations in the subsurface composition.