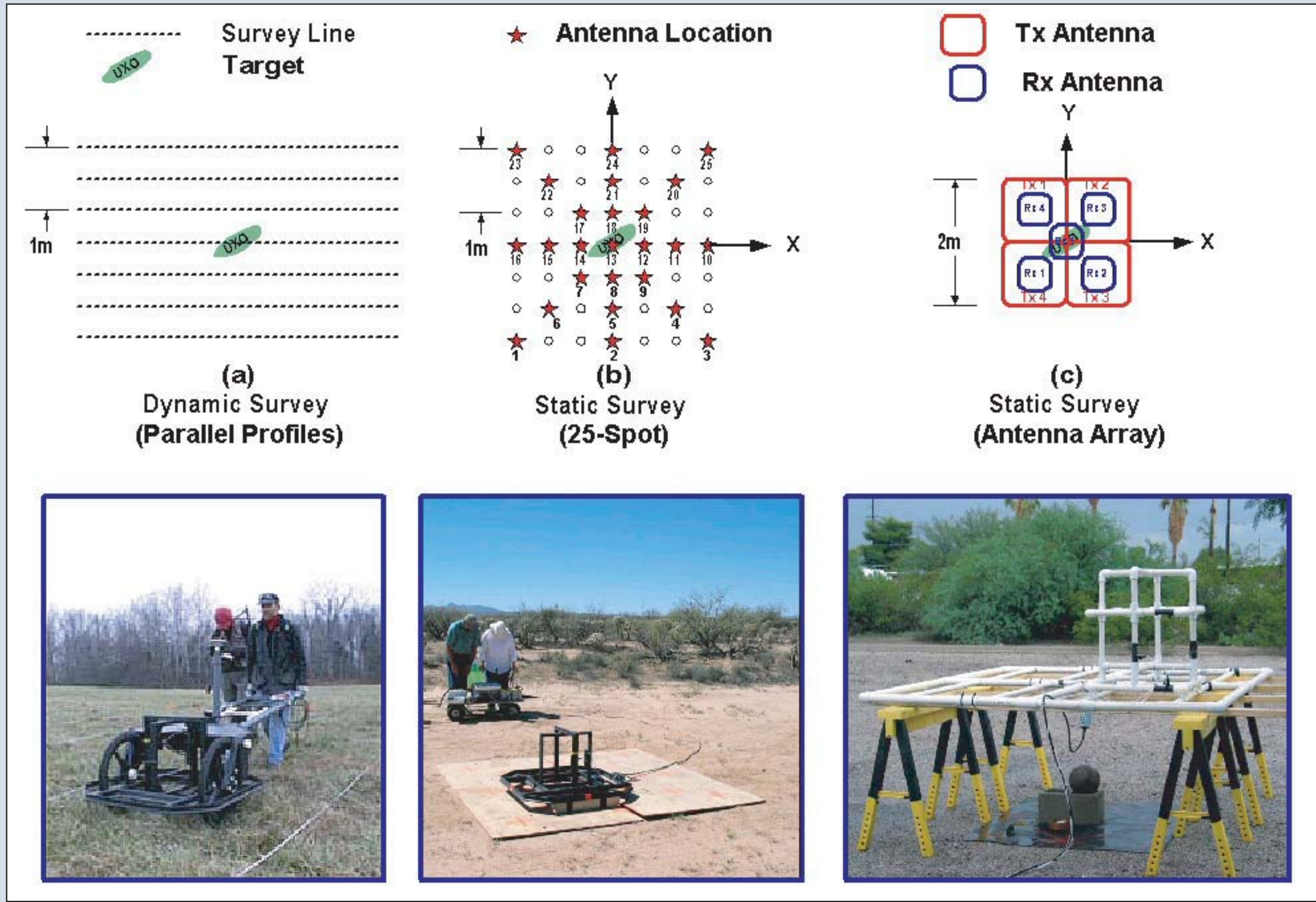# Static TEM Antenna Array

ZONGE

Introduction

Static TEM measurements remove position uncertainty and significantly improve the SNR through synchronous smart stacking. Zonge is developing hardware and software that efficiently exploit the advantages of static-mode TEM measurements as a means of queued target identification. The apparatus features a configurable transmitter antenna allowing the illumination of a target centered beneath it from three orthogonal directions. The transmitter is combined together with one or more multi-component receiver antennas to form a static antenna array that allows the interrogation of an unknown target centered beneath the array. Data acquisition and antenna array configuration will be controlled remotely. Zonge is assembling an integrated data processing system that includes basic reduction processing, target parameterization, and target classification to provide rapid target interpretation.
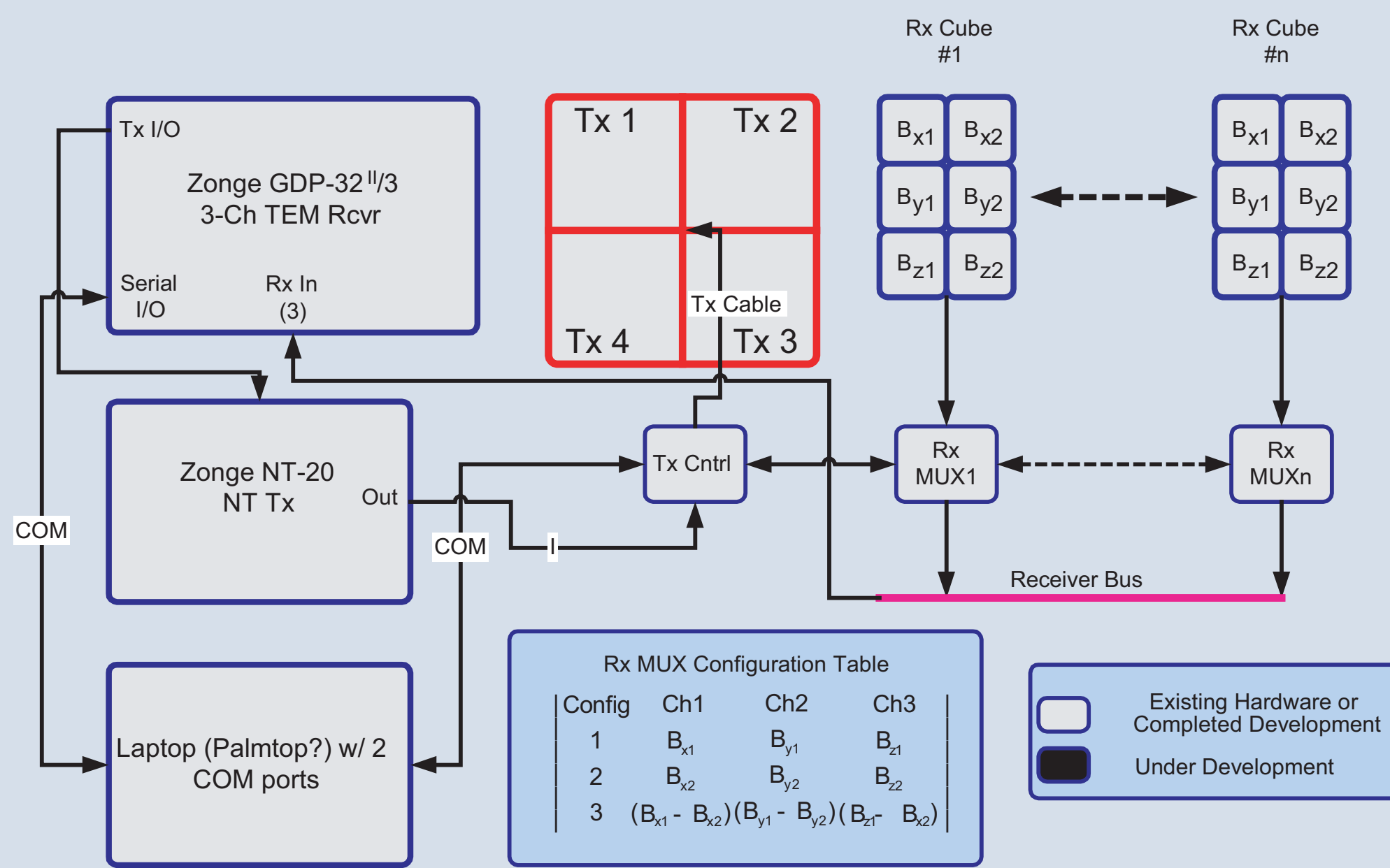
Three Different TEM Survey Methods

Static EM measurements can be applied to the classification of a target located independently by another method. Typically, EM measurements are made over a grid centered over the target as illustrated in the figure below (Part B). Grid points that generally cover the area of anomalous response are required in order to assure that the target is illuminated from different directions from the EM transmitter. Since errors in antenna position and its attitude can be greatly reduced, the results of model-based target parameterization and classification are significantly improved. With SERDP funding, Zonge is developing an alternative way of acquiring static TEM data that eliminates the need for any antenna translation. The method employs a rigid antenna assembly consisting of an array of 4 transmitters and an arbitrary number of receivers. With a transmitter antenna configuration switch, the magnetic field beneath the antenna array may be 'steered' in different directions. The figure at right and below right illustrate how current is driven into the 4 transmitter loops in various prescribed directions to steer the magnetic field in either of 3 orthogonal directions.

(a) Dynamic Survey (Parallel Profiles)
(b) Static Survey (25-Spot)
(c) Static Survey (Antenna Array)

Transmitter Array Configurations

A) Tx Configuration for X Illumination
Arrows show direction of current circulation in each transmitter loop

B) Tx Configuration for Y Illumination

C) Tx Configuration for Z Illumination

Vector plot showing field directions beneath the transmitter array for configurations A & C (above)

TEM Array Prototype Hardware

Principal Rx 50 cm Cube 6 Loops — Satellite Rx 25cm Cube — Tx Array — Principal Investigator

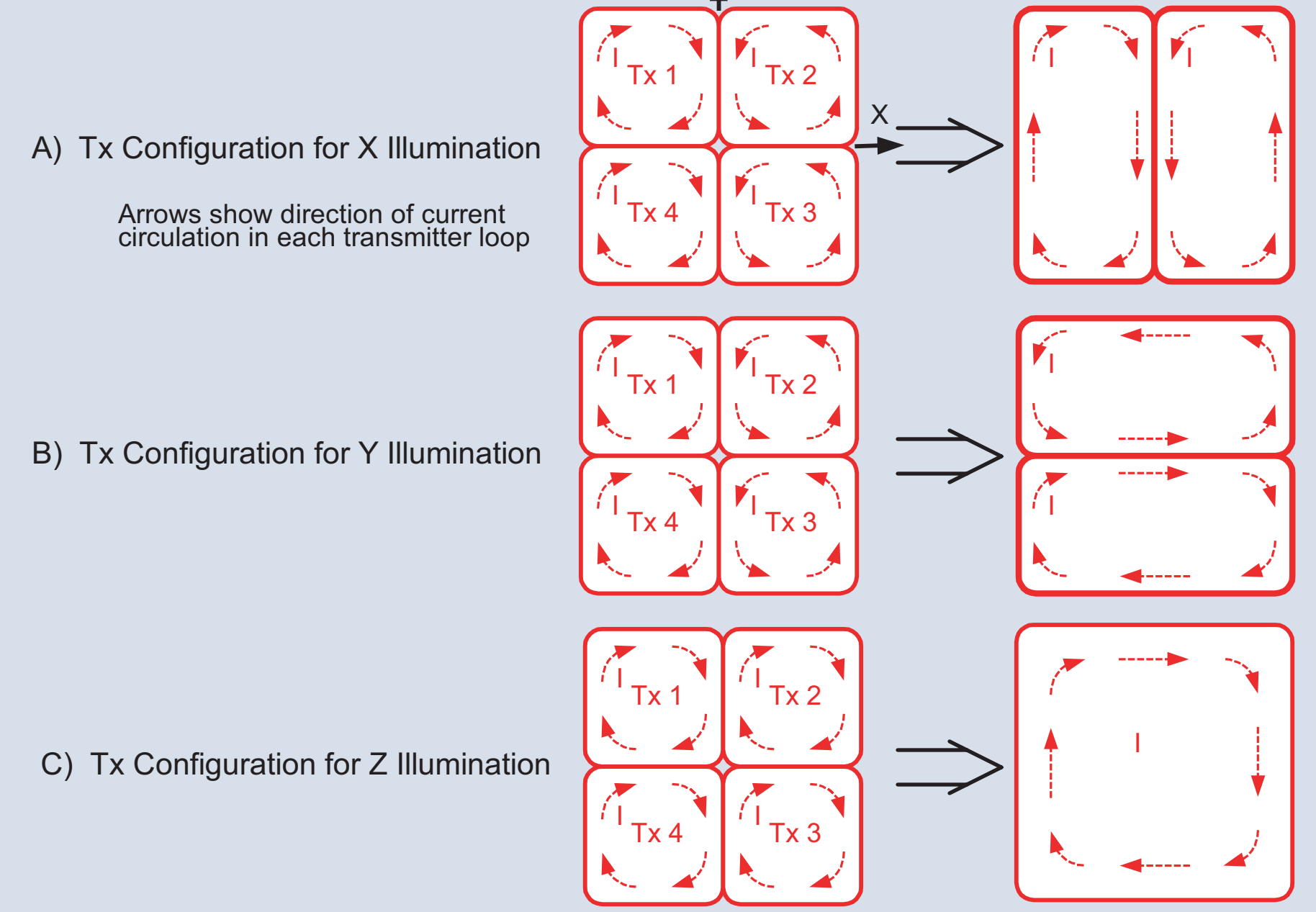PDA Controller — Rx GDP-32^{II} — Tx

Tx Mux — Rx Mux

TEM Array Hardware Components

The photograph above (Part C) shows an early version of the transmitter array together with one of the receivers. Below is a block diagram of the recently completed automated TEM array system. Using external computer control (a laptop PC or PDA), the system performs the following operations:
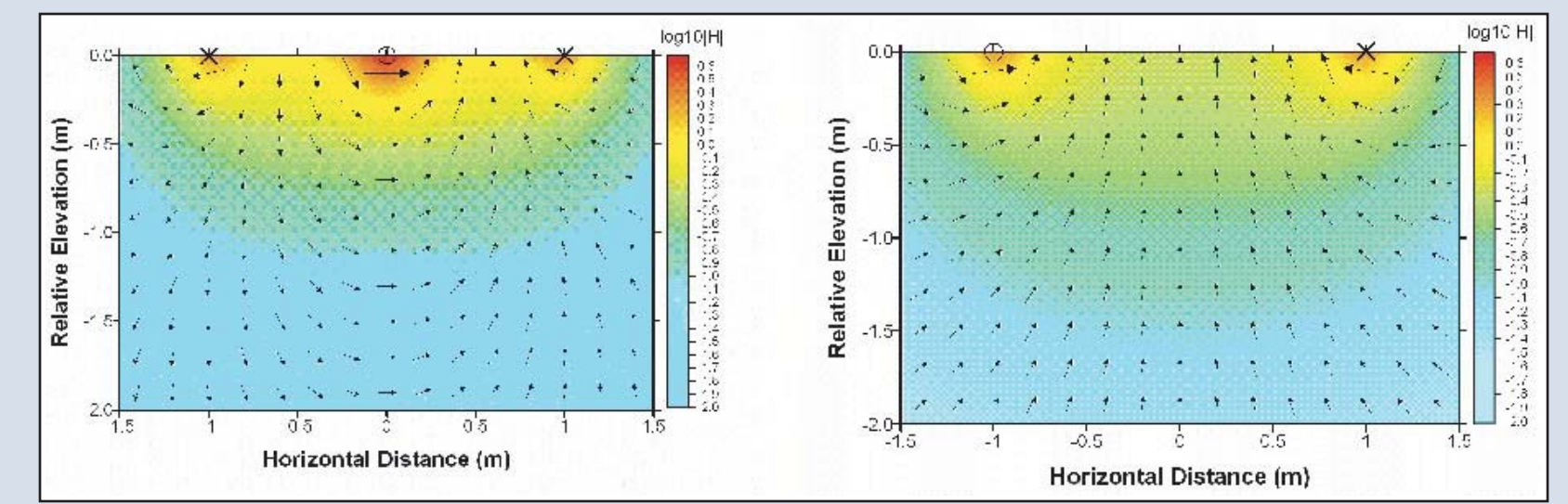
- Configures the transmitter loop array.
- Selects the Rx node and connects 3 of 9 possible receiver configurations onto the 3-channel receiver bus.
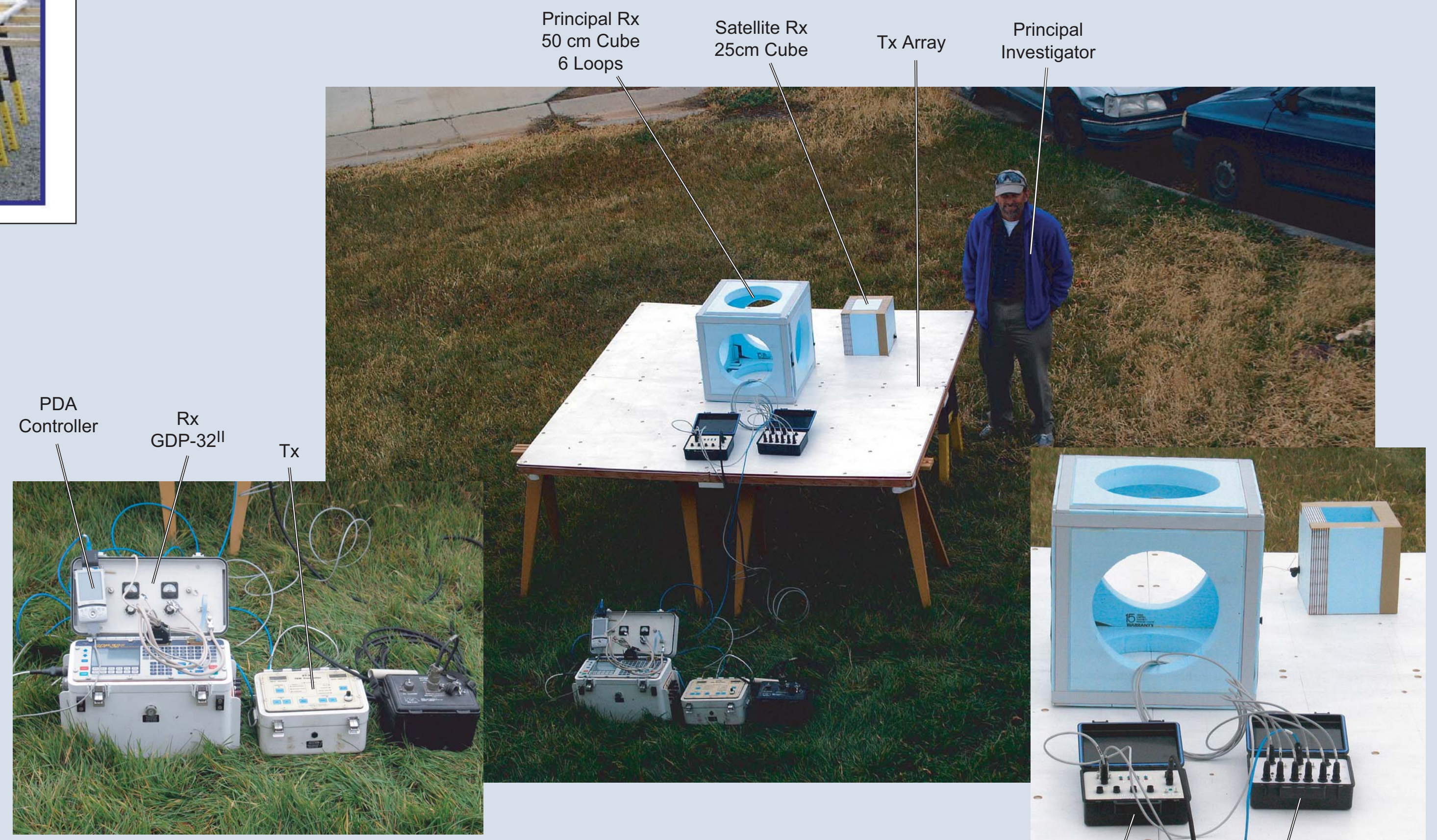- Provides the necessary command and control to the Zonge GDP-32^{II} for data acquisition and storage.

Rx MUX Configuration Table

Config	Ch1	Ch2	Ch3
1	B_{x1}	B_{y1}	B_{z1}
2	B_{x2}	B_{y2}	B_{z2}
3	$(B_{x1} - B_{x2})$	$(B_{y1} - B_{y2})$	$(B_{z1} - B_{z2})$

Existing Hardware or Completed Development
Under Development
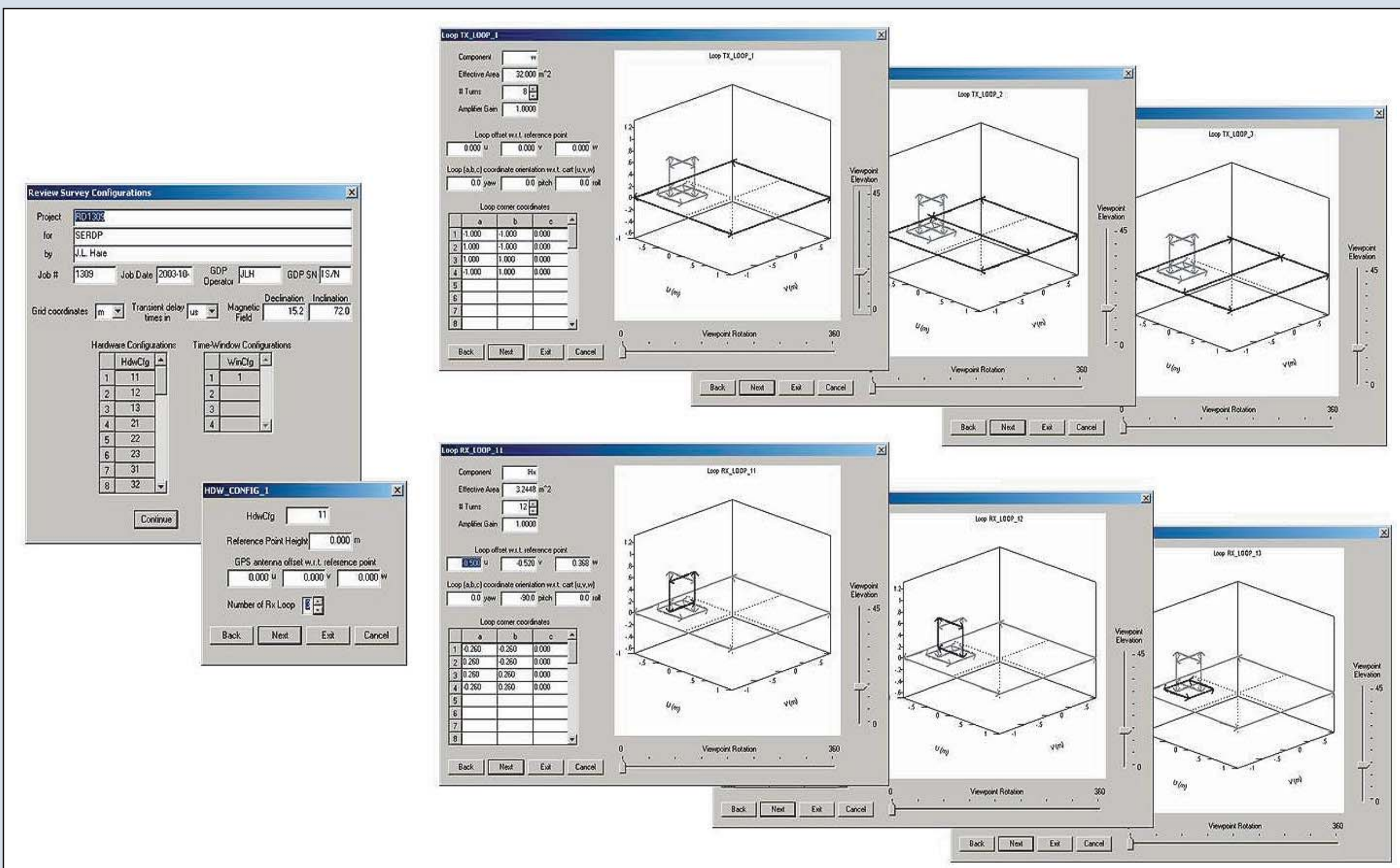
TEM Data Reduction and Parameterization

Program DNTreduce Hardware Configuration Setup

Program DNTreduce

Zonge's DNTReduce can handle an unlimited number of antenna configurations (i.e., Tx and Rx loop offsets, orientations, current sense, etc) using a text-based configuration file. As we illustrate in the figure to the left, the hardware configuration may be created using the DNTReduce GUI. Alternatively, it can be created independently using a text editor.

Once the hardware configuration is defined, the raw TEM data are loaded into Oasis Montaj using DNTreduce. Each stacked transient data block is linked to a specific hardware configuration via a unique identifier (HDW-CFG). For example, a 9-spot, 3-component Rx Cube using the 3 standard "Figure 8" Tx configurations, has a total of 27 unique hardware configurations:

(27 = 1 multi-channel Rx option X 9 Rx Offset Spots X 3 Tx options)

The fully automated TEM array system (block diagram and photo above) will automatically acquire data from a total of 45 different hardware configurations:

(45 = 3 multi-channel Rx options X 5 Rx Offset Spots X 3 Tx options).

Once loaded into Oasis, standard and custom Geosoft executables (GX's) are available for background removal, creating composite time-gate channels, analyzing transient curves, gridding data etc. The transient curves may be analyzed in time-domain, or contour plots can be created of the induced transient field for various time-gates. The color-contour 'butterfly map' shown below left is from static, 25-spot TEM data, using a vertical-field Tx, over various test targets at Zonge's Ajo test site.
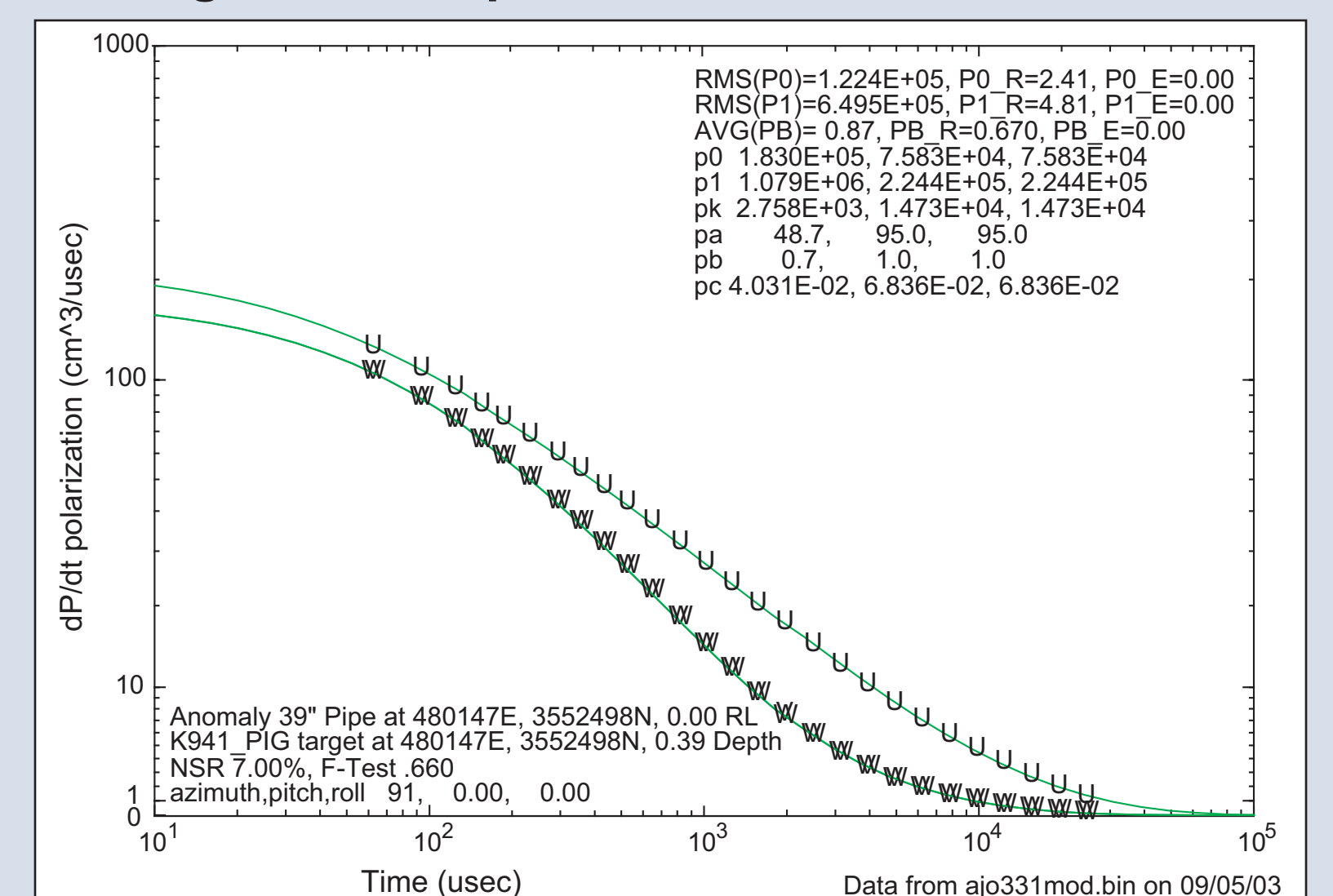
39" x 7" Pipe at 30cm Depth

T = 62 usec — T = 4.9 msec — T = 24 msec
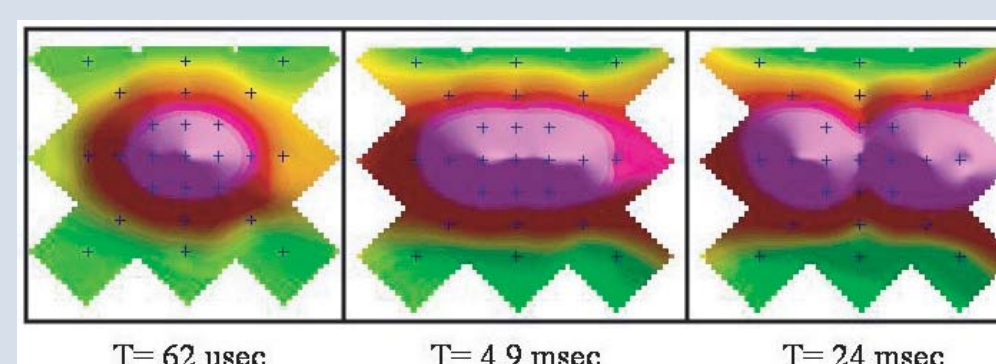
Program DNTdipole

Program DNTdipole inverts multi-component transient data for an anisotropic dipole model. The inversion yields estimates of parameters for the magnitude and orientation of the 3 principal polarizations (eigenvectors of the polarization tensor) and other components of the decay transient. An example of the dipole model polarizability curves for a 39" buried pipe are shown below. The output from DNTdipole is a parameter set (*mod.csv file) that is the input to one or more Classifiers. Results from two classification methods (multivariate statistics-based and knowledge-based methods) are discussed in the next panel.

Buried Ordnance Test Site, Ajo AZ

ChromeSphere — 39inchPipe — Vert. Loop — Horz. Loop
60mm — 75mm — 81mm — Rocket — 155mm — 105mm

Filtered SZT Data, Hz, Win 2-5
Ajo Test Site SZT Data
Mar. 31, 2003

Scale 1:92
NAD83 / UTM zone 12N

Program DNTdipole Polarization Parameters

RMS(P0)=1.224E+05, P0_R=2.41, P0_E=0.00
RMS(P1)=6.495E+05, P1_R=4.81, P1_E=0.00
AVG(PB)=0.87, PB_R=0.870, PB_E=0.00
p0 1.830E+05, 7.583E+04, 7.583E+04
p1 1.079E+06, 2.244E+05, 2.244E+05
pk 2.758E+03, 1.473E+04, 1.473E+04
pa 48.7, 95.0, 95.0
pb 0.7, 1.0, 1.0
pc 4.031E-02, 6.836E-02, 6.836E-02

Anomaly 39" Pipe at 480147E, 3552498N, 0.00 RL
K941 PIG target at 480147E, 3552498N, 0.39 Depth
NSR 7.00%, F-Test .660
azimuth,pitch,roll 91, 0.00, 0.00

Data from ajo331mod.bin on 09/05/03