Xcite^{TM}: Great results require more than good data

***Magdel Combrinck**
Tau Geophysical Consultants
1409, 13104 Elbow Drive SW
Calgary, Canada
magdel.tau@gmail.com

Richard Wright
New Resolution Geophysics
Unit 1, Stand 98, Tijger Vallei Office Park
Silver Lakes Rd, Pretoria
richard.wright@nrgex.co.za

SUMMARY

Successful interpretation of airborne electromagnetic data depends strongly, but not exclusively, on the quality of data. The ability to accurately describe the system, knowledge of the data processing procedures as well as an understanding of the geological targets all contribute to deriving accurate models. Xcite^{TM} is a recently developed helicopter time domain electromagnetic system featuring an inflatable frame that is light, quick to assemble, easy to transport and efficient in flight, producing high quality data. However, low noise levels alone do not guarantee successful modelling of AEM results. An accurate system description as well as transparency in the data processing phase combines to get the most value from Xcite^{TM} data.

Key words: Xcite, TDEM, airborne, electromagnetic

INTRODUCTION

Successful interpretation of airborne electromagnetic data depends strongly, but not exclusively, on the quality of data. The ability to accurately describe the system, knowledge of the data processing procedures as well as an understanding of the geological targets all contribute to deriving accurate models. Operating an AEM system is a highly specialized undertaking involving pilots, engineers, geophysicists and field operators. Not only should these people perform their individual functions to the highest standard, but they also need the ability to communicate their contributions clearly for an interpreter to best utilize the acquired data.

Xcite^{TM} is a relatively new helicopter borne time domain electromagnetic (TDEM) system and the purpose of this paper is to provide an introduction to the system and highlight the care that has been taken by the design and operating teams to ensure:

- high quality data
- an accurate system description
- transparency and integrity in data preparation and processing.

Good signal:noise is achieved through an innovative inflatable frame, the system description through controlled ground loop measurements and comparisons between raw and processed are data are shown illustrating noise reduction without compromising the geological response.

SYSTEM DESCRIPTION

The Xcite system is light (~450kg), featuring a fully inflatable frame and packs into 3 small (<2m x 2m x 1m) boxes for easy shipping. The loop setup takes two hours and the full system installation can be completed in eight. In flight the transmitter and receiver are suspended on a 28m cable below the helicopter and nominal terrain clearance is 30m.

Transmitter:
• 18.4m loop diameter, with 4 turns
• single turn bucking/reference coil
• 210 A (up to 350A)
• 220,000 NIA (up to 372,000 NIA)
• 25 or 30Hz Base Frequency programmable waveform
• Typically between 4 – 7ms on-time with 16 to 13ms off-time
Receiver:
• 0.97m diameter, 100 turns
• Central loop configuration (Concentric)
• Z component data (X in development)
• Rx signal (as well as Tx current) digitally sampled
• Adjustable Rx gates extracted from streamed data; typically 42 gates extracted from 0.05 ms to > 12ms
• Integrated B-field
• Low late time noise levels (0.04 pV/Am^4)

Figure 1: Xcite^{TM} system in flight

HIGH QUALITY DATA

Significant noise reductions were achieved since the system was first introduced in 2015 (Combrinck et. al , 2015). This was done through improved mechanical stability and post-processing incorporating the advantages of streamed data.

Receiver pod suspension:

The receiver of the original (2015) system was suspended from the inner inflatable ring by bungee cords to isolate the pod from any frame vibrations. In flight video recording of the system showed that the inflatable frame was in fact more stable than the receiver pod and alternative suspension options were investigated. A test using PVC pipes to stabilize the receiver indeed resulted in lower noise levels. This led to the final design of inflatable beams to support the receiver pod in flight. This improvement (Figure 2), combined with better support of the coil inside the receiver pod, dramatically decreased the late time noise levels at high altitude. Figure 3 illustrates data from the same line flown with the original and new inflatable beam structure.

Figure 2: Receiver suspension improvements. Top left: Bungees only. Bottom left: Bungees and PVC pipes. Right: Bungees and inflatable support beams.

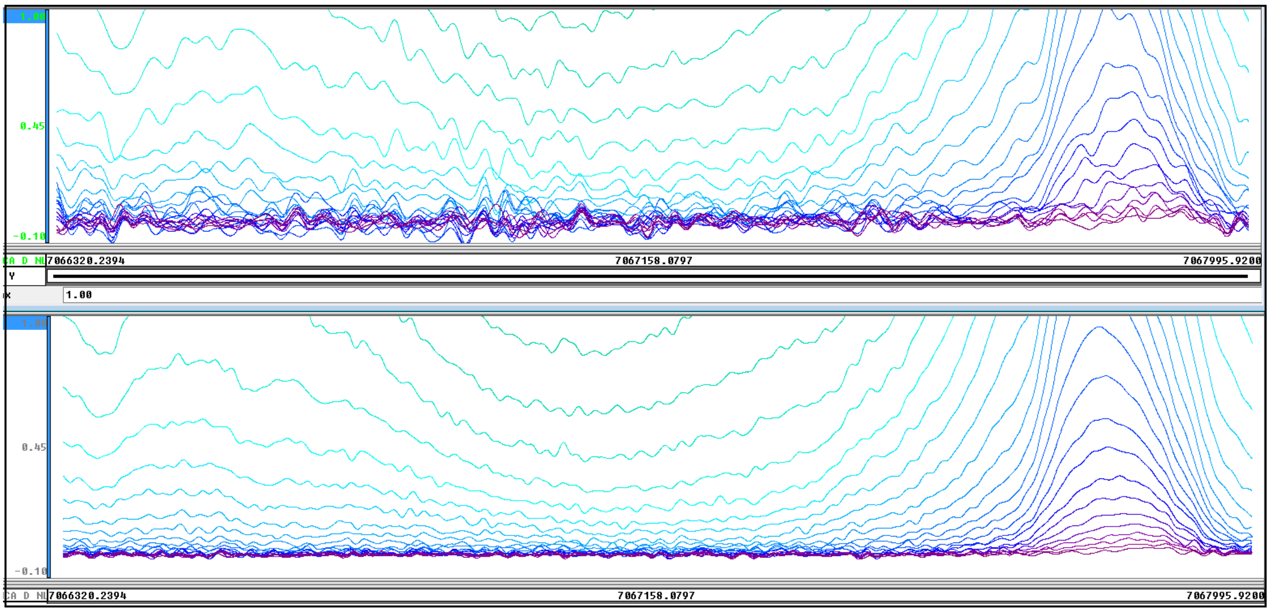

Figure 3: Late time dB/dt data [pV/Am^4] acquired with receiver suspended from bungees (top) and inflatable beam structure (bottom). The same scale is used on both panels.

Processing:

The 25 Hz full cycle streamed data are sampled at 625 ksps and decimated to 156.25 ksps for recording. This results in half cycle data (one decay) of alternating signs at 50 Hz. Sampling at this frequency and flying at an average of 25m/s (groundspeed) results in data recorded at 0.5m station intervals. Typical geological EM responses do not require such dense sampling rates and it is common practice to stack data during acquisition in order to reduce random noise and also to reduce storage requirements. The advantage of recording and storing data at these high intervals is that noise reduction can be customized during post-processing, e.g. removing spikes prior to stacking.

Recording the full waveform also allows a better understanding of the system response that needs to be removed from the total measured field in order to isolate the earth response. An example of this is shown in Figure 4, where the B-field data was significantly improved applying a correction made possible using the streamed data.

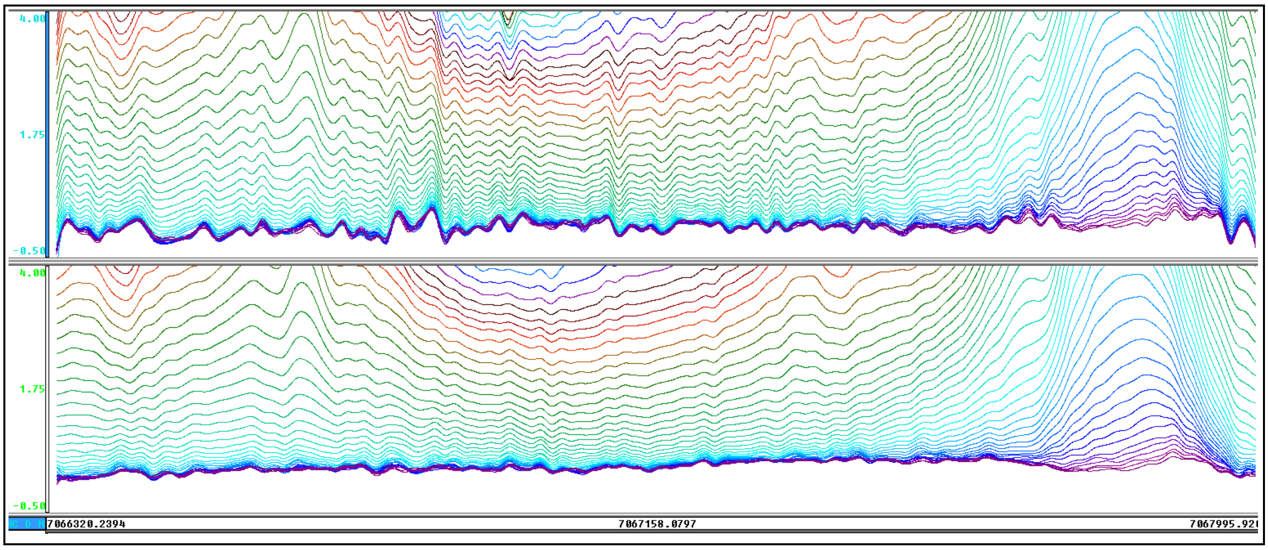

Figure 4: Improvement in B-field data made possible with corrections applied using streamed data. Top: Late time B-field channels [fT/Am^2] without correction. Bottom: Corrected B-field data on the same scale.

ACCURATE SYSTEM DESCRIPTION

Modelling of time domain electromagnetic data is critically dependent on an accurate system description. This includes transmitter-receiver geometry relative to each other and the earth, the transmitter waveform as well as any filters altering the earth response. In addition to accurately describe and publish these parameters it is also advantageous to keep the system design simple so it can be described accurately in commercial software. For example, intricate gating schemes or complex waveforms might provide smoother data or enhance specific frequency ranges, but if these factors cannot be implemented in modelling software there is no benefit to the interpreter when it comes to the modelling phase.

The Xcite^{TM} system default time gates are calculated as the mean of values between the published start and end times. However, the flexibility of recording streamed data allows any extraction scheme to be implemented if required. The transmitter waveform is basically square with a variable width and turn-off time. Accurately predicting the waveform that induces currents into the earth is difficult to determine analytically based on the input current and loop geometry alone, especially with the addition of a bucking coil to the system. The waveform can be derived from measuring the primary field at high altitude but not without effects from the bucking coil, designed to remove as much of the primary field as possible at the receiver position. A more accurate way to determine the transmitter waveform was proposed by Aaron Davis (2007) using a loop of wire laid out over resistive geology.

The ground loop test was thus performed to determine the most accurate transmitter waveform shape. We followed the procedure outlined by Davis (2007). The test area was a runway underlain by Lebowa granite just north of Pretoria, South Africa. The granite outcrop is flat and highly resistive providing a perfect setting to perform ground loop tests as the earth response is minimal.

The system current waveform as measured in the ground loop is compared with the current waveform that can is typically measured using the receiver at high altitude (Figure 5). The fast turn-off time of 350 micro seconds is evident here. A fast turn-off time results in excellent excitation of both weak and strong subsurface conductors.

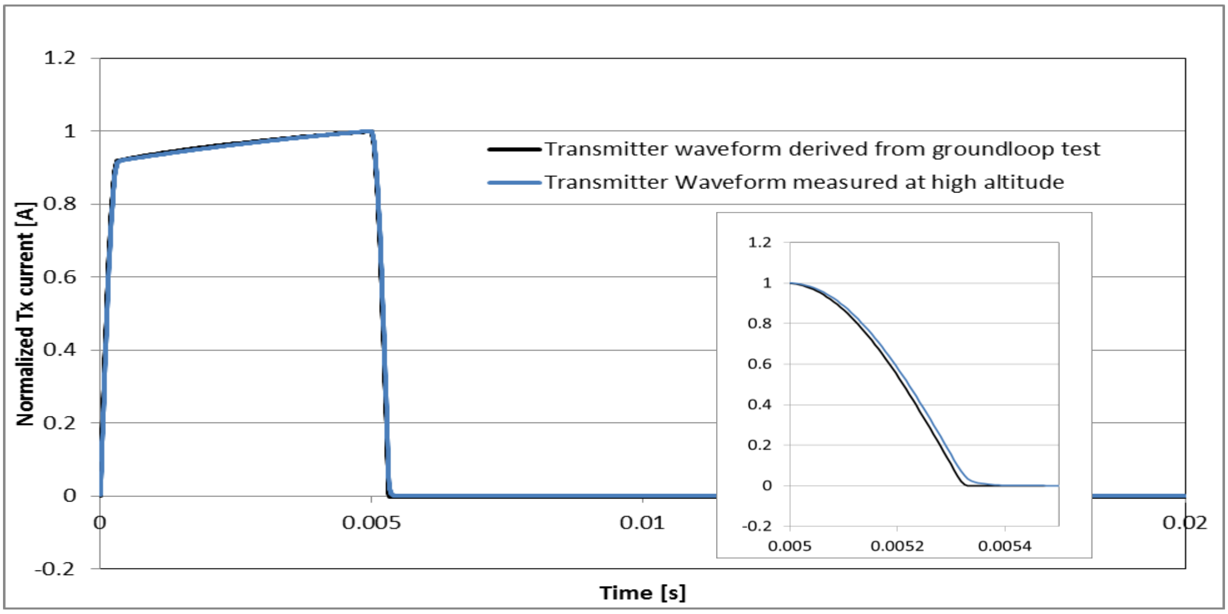

Figure 5: Transmitter waveforms measured at high altitude and in the ground loop calibration test. No difference is visible at full scale, but the inset illustrates the difference at turn-off.

TRANSPARENT DATA PROCESSING

Xcite^{TM} data are processed in the following steps:

- Removal of low frequency and DC offset signals
- Removal of system response (remnant primary field in early channels and drift) as measured at high altitude
- Optional stacking, non-linear and low-pass filters

The final processing steps of stacking and filtering are useful for removing high frequency noise but also has the potential to change anomaly shapes if applied indiscriminately.

Providing both pre- and post-filtered data allows the interpreter to confirm that geological source anomalies have not been essentially changed in shape or amplitude and also to double check the origin of small, isolated anomalies. An example of pre- and post-filtered data is shown in Figure 6.

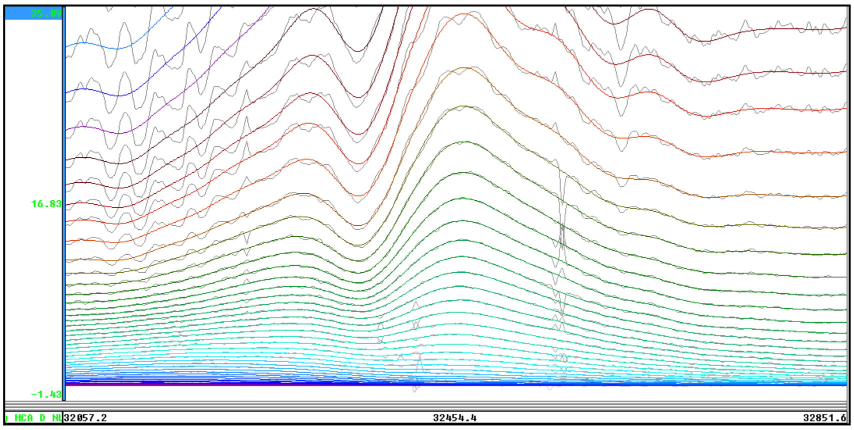

Figure 6 : Pre-filtered dB/dt [pV/Am^4] data (gray) and post-filtered data (colour).

CONCLUSIONS

A new technically advanced helicopter-borne time-domain electromagnetic system is introduced by New Resolution Geophysics (NRG™), South Africa. The main innovation which sets this system apart from existing technologies is the inflatable bird. The result is a helicopter time domain electromagnetic system that is light, quick to assemble, easy to transport and efficient in flight, producing high quality data. However, low noise levels alone do not guarantee successful modelling of AEM data. High quality data, a system description as well as transparency in the data processing phase all combine to get the most value from Xcite^{TM} data.

REFERENCES

Combrinck, M., Wright, O., Wright., R. S. , Wright, R., 2015, Xcite™: Introduction to a new airborne HTDEM system: 14th Biennial Conference and Exhibition, SAGA, Drakensberg, South Africa, Expanded Abstracts

Davis, A. C.,2007,Quantitative characterization of airborne electromagnetic systmes:Ph.D. Thesis, RIMT University.