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Report On Timing Errors Encountered During Undershoot And The Subsequent Corrections Applied To Data.

Client: Apache Energy
Area: VIC/P58
Job: 9429 / AP23
Recording Vessel: Western Trident
Source Vessel: Pacific Titan, operated by MGC
Date of undershoot: February 13^{th} –15^{th}, 2005

Introduction

This report details the both the issues regarding time synchronization and the subsequent corrections applied to the data at the Perth Data Processing Centre. Other important two-boat issues like data transmission have been omitted.
As per normal procedure, preparations for the undershoot started six weeks before the undershoot commenced. Technical solutions were worked out and necessary equipment was sourced.
To make sure all systems are configured and tested, 24 hours of mobilization time is normally required when using third party source vessels. When using our own source vessel, testing can be done over VSAT and doesn't require the vessels to be within radio range, hence the required mobilization and testing time is reduced.

Planned solution

The planned solution was to have a Master Truetime Box on the Trident and a Slave Truetime Box on both the Trident and the Titan. The purpose of the Master Truetime Box was to output the System Synchronization Start Message to the Slave Truetime Boxes, and to QC the timing on the source and recording vessels. The purpose of the Slave Truetime Box on the source vessel was to output the fire and arm pulses to the source controller and the Remote FTB Message to the Master Truetime Box. The purpose of the Slave Truetime Box on the recording vessel was to trigger the MSX recording system by outputting a time-break pulse. The Truetime Boxes are synched to GPS and provide very accurate timing. The block diagram in figure 1 shows the distribution of timing signals.

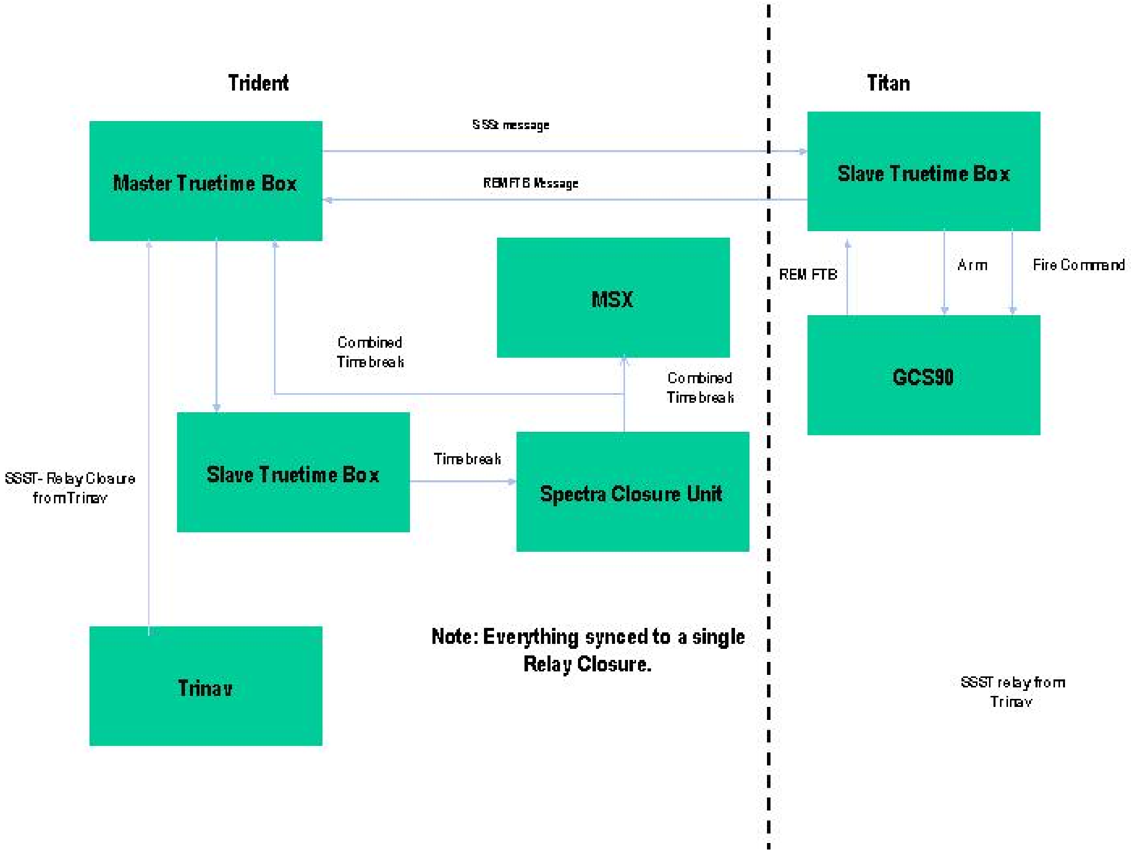


Figure 1

Modified solution

Once the Titan and the Trident came within range for radio communication, two-boat link testing commenced. The Truetime Box on the Titan was receiving satellites as normal, but it would not output Fire and Arm signals. After much trouble shooting, it was concluded to be faulty. No spare Truetime Box was available on the Titan so the Slave unit from the Trident was transferred to the Titan with the FRC. It was installed on the Titan and Arm and Fire signals now worked as normal.

With only one Truetime Box available on the Trident, a modified solution was required. After some discussion, it was decided to use a solution with two different relay closures triggering the recording system and the source controller. Figure 2 shows the block diagram of the modified solution.

Configuring the Spectra navigation system for two-boat operations was ongoing in parallel with the two-boat troubleshooting. The two-boat navigation system configuration was still not complete when the two-boat link was up and running. Faults with both the Spectra closure box and the cable between Trinav and the SSS box were also found and corrected.

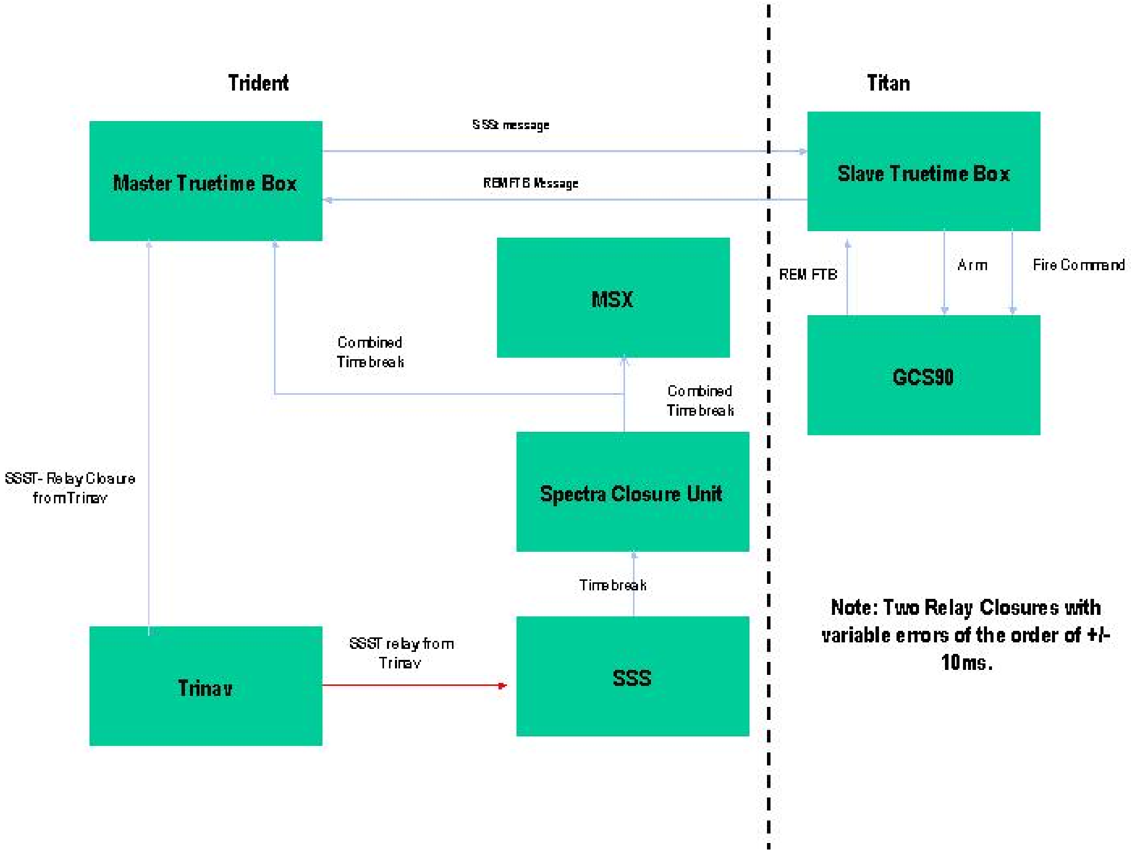


Figure 2.

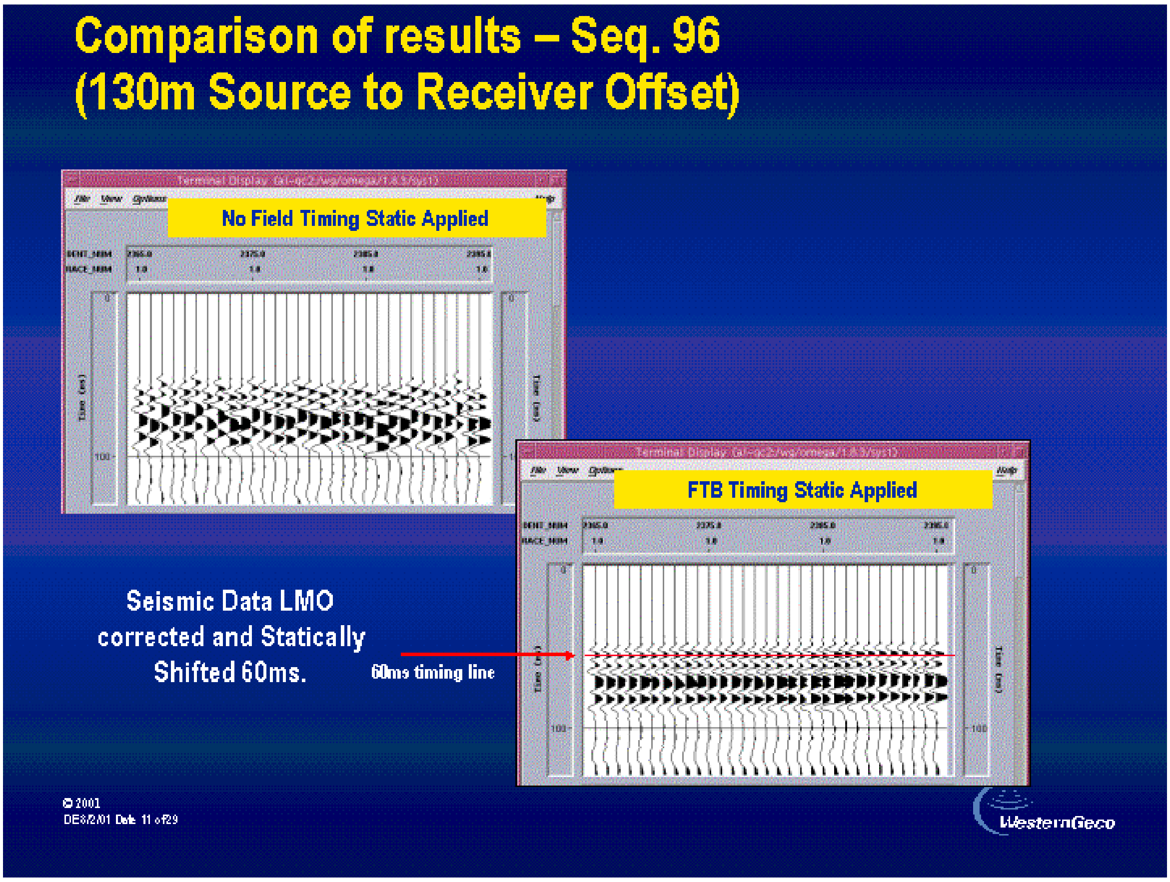
Timing Errors

As soon as shooting started, the Master Truetime Box reported inaccuracies of the timing caused by the relays. After consulting shore based support personnel, it was decided to bring the faulty Truetime Box from the Titan to the Trident and configure it as the Master Truetime Box. This would have worked, as the Master Truetime Box doesn’t need the Fire and Arm outputs. Unfortunately darkness and bad weather prevented the transfer, and the undershoot continued. While these variable errors are far from ideal it is possible to use the absolute times of the master and remote timebreak (recorded on the Master True Time receiver, to an accuracy of 100ns) to correct the data post acquisition. Applying these corrections will result in a perfectly synchronized seismic dataset. Due to the time constraints enforced by the source vessel, WG decided to acquire the data with this random error and correct the seismic dataset post acquisition.
Timing QC of the seismic data revealed an occasional timing burst of 10 ms in addition to the error reported by the Master Truetime Box. This was verified by making a dump of the ASCII file generated by the Master Truetime Box. The reason for the 10 ms burst was caused by the Slave Truetime Box on the Titan, which occasionally was triggering on the trailing edge of the FTB pulse rather than the leading edge. This pulse is 10ms in length.

Data corrections

The WesternGeco processing center in Perth has read all field tapes, applied static corrections and written the corrected data in SEG-Y format. To verify the correction, a test line with the vessels only 160 meters

apart was recorded. With the vessels that close, it is easy to verify that the first breaks line up after the static corrections have been applied.
Additionally, WG performed the standard navigation and timing QC on all undershoot lines after application of the deterministically computed time shifts. Below is an example of this QC pre and post application of the time correction.



Field Recording Delay Correction (2-boat shooting operation only)

In order to perform under-shooting of prospect areas that were inaccessible to the seismic vessel due to obstructions, an additional vessel was used to carry a seismic source. The timing of the remote source firing was controlled from the Western Trident that continued to operate as the streamer recording vessel. Because of the nature of the type of hardware used to control this timing there is the possibility for synchronization errors of the order of +/- 10ms. This error results in misaligned seismic records (as illustrated in Figure 2) and is obviously un-acceptable if not compensated for. However, the delay between Source firing time and recording system start time was measured to an accuracy of 0.01 ms. Compensating the seismic data with this measured delay resulted in a perfectly time-synchronized dataset.

The time corrections were supplied directly from the Western Trident in a series of ASCII text files. For each affected line a file containing the navigation system time, the recording system FTB (Field Time Break) and the remote system FTB was used to calculate the required static shift for each shot point. Each shot point was identified by a unique Field Shot Identifier. An example of one of these resulting static listings is included in Figure 1. A negative static correction results in an event appearing at a shallower time whilst a positive static correction results in an event appearing at a deeper time.

Figure 1: An extract from an example static correction supplied by the Western Trident.

Fieldshot ID	Static Correction (ms)
45185819	0.760
45185826	-7.290
45185835	-6.890
45185842	-4.460
45185850	-8.850
45185858	-7.080
45185906	-7.440
45185915	-8.680
45185923	-4.770
45185931	-4.960
45185939	-9.090
45185947	-7.010
45185955	-8.950
45190003	1.250
45190011	-7.340

Application

For each affected line the appropriate static correction values were loaded into the trace headers. All traces within a single shot gather were updated with the same value.
After shifting a trace, any samples falling outside of the normal record length were deleted whilst short records were padded with zero-amplitude samples.

QC

To QC that the supplied static corrections resolved the field timing error the near trace from each recording cable was first extracted. The direct-arrival energy is routinely used in timing and navigation QC as simply applying linear move out correction (LMO) using a constant water-velocity should result in the direct-arrival wavelet appearing at a constant time.
Due to the large near-trace offset values associated with under-shooting it is not always possible to see either a reliable water-bottom reflection or direct-arrival energy as it is often contaminated by the seismic reflections. To aid in the LMO QC the near trace gather data was first passed though a narrow bandpass filter tin order to try to attenuate the lower frequency seismic reflections compared to the higher frequency direct-arrival wavelet.
Two versions of the data were displayed comparing the LMO'd traces with and without the static correction applied. An example of these comparisons is shown in Figures 2 and 3.

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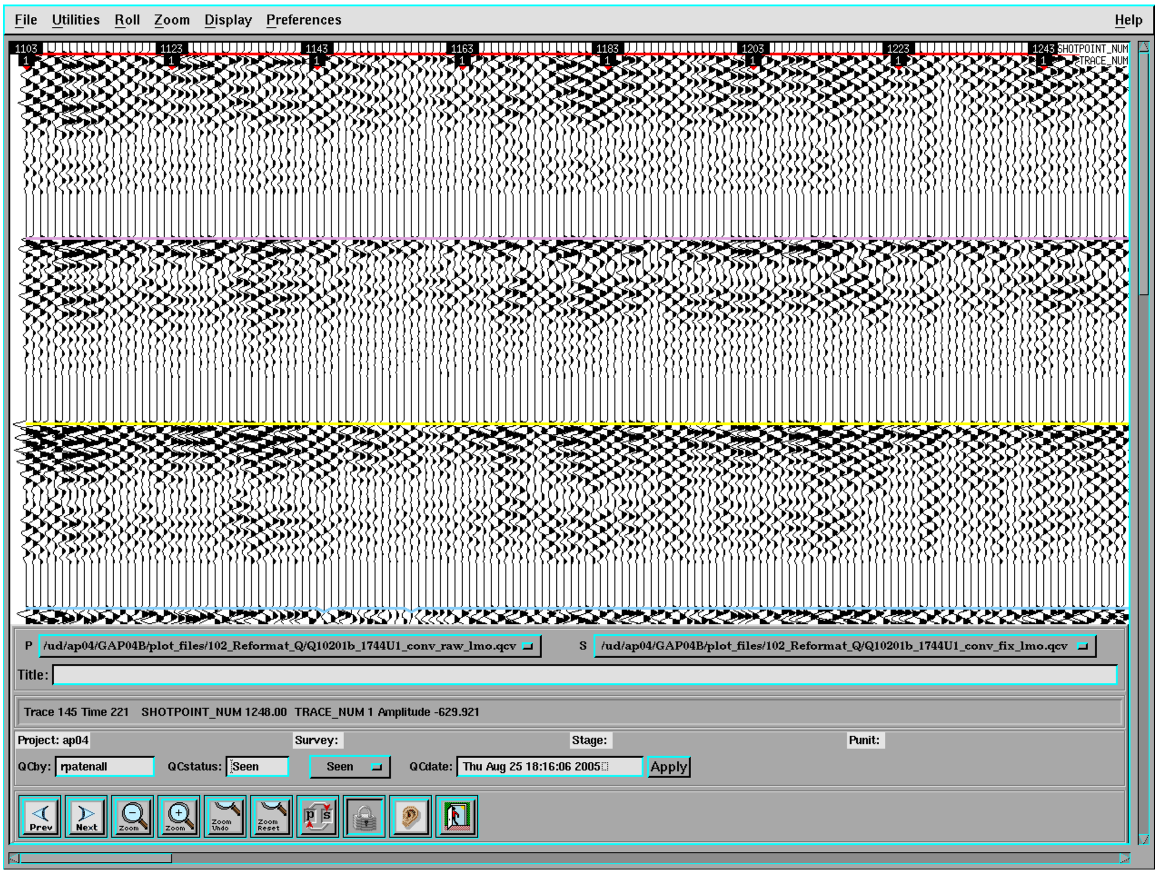

Figure2: An example of common near field channels extracted from a dual-vessel acquisition line and displayed before correcting for the field recording delays.

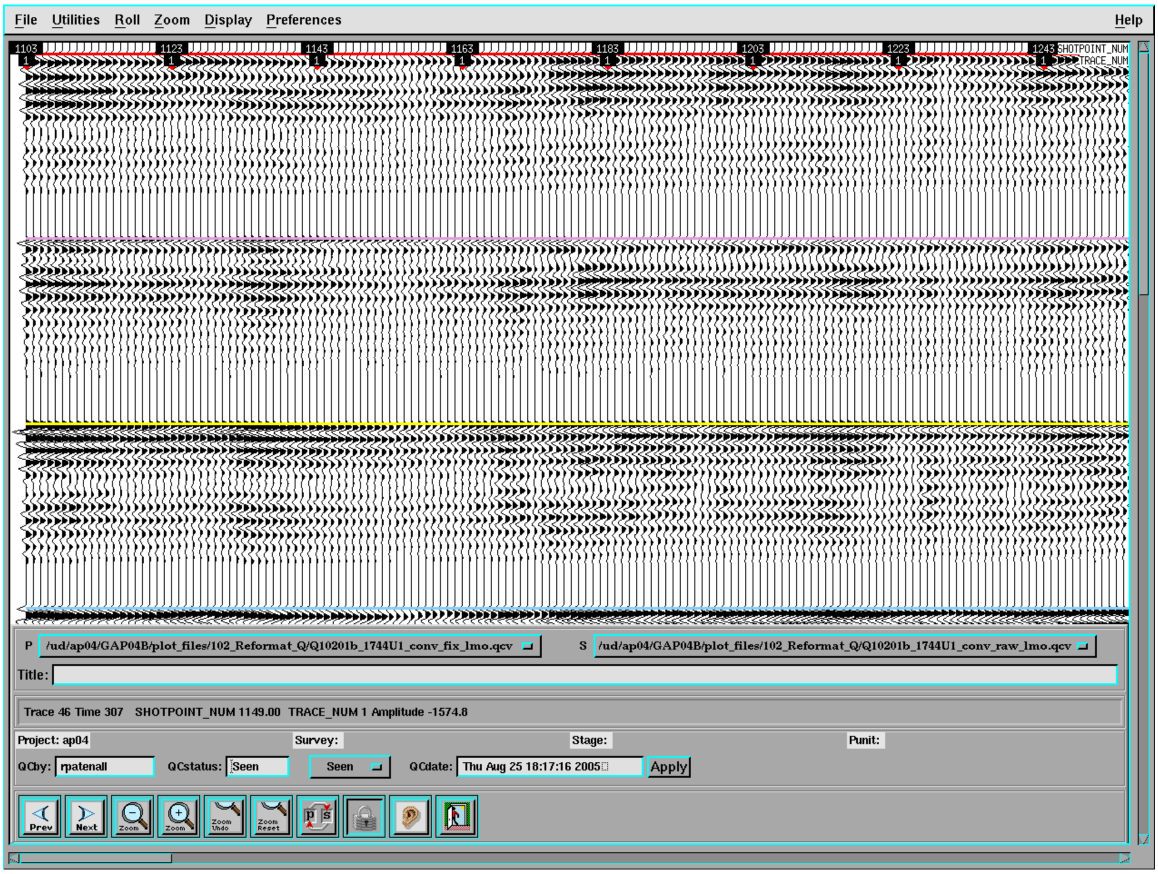

Figure3: An example of common near field channels extracted from a dual-vessel acquisition line and displayed after correcting for the field recording delays.

Additional SEG-Y Data

For each affected line a set of additional tapes were created in SEG-Y format. These tapes contain the reformatted field data after navigation update, with the field static correction applied and bad shot and trace edits applied.
Table 1 lists the affected lines and the tape numbers of these additional SEG-Y volumes.

Line Name	Field Sequence Number	Additional SEG-Y Tape Numbers
1632U1091	91	Q05266-Q05271
1632U2093	93	Q05273-Q05277
1632U3095	95	Q05279-Q05283
1632U4097	97	Q05285-Q05289
1744U1092	92	Q05291-Q05294
1744U2094	94	Q05297-Q05300
1744U3096	96	Q05311-Q05314
1744U4098	98	Q05316-Q05318

Table1: List of 2-boat acquisition lines that had the field static corrections applied and additional SEG-Y format tape volumes created.