Quality Control in Modern Recording Systems, Benefits Beyond Contract Compliance

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Summary

Quality control (QC) has generally been considered by the seismic data acquisition industry to be a method to determine if the recording system is performing within the tolerances of the instrument manufacturer's specifications and that the geophysical specifications of the survey design are being matched. With today's modern recording systems there is a large amount of information that is being recorded that can provide significant benefits beyond the normal QC perspective. Much of this information is frequently ignored or misunderstood and may never be reviewed after being recorded. There are system capabilities available today that can even improve the ability of the geoscientists from the oil companies and contractors to interact with the field crew in recording parameter determination. This paper will discuss this information and how it may be utilised to assist the field crew in improving their operational performance and the data processing geophysicists their understanding and analysis of the data.

Introduction

The oil industry has been recording 3D seismic surveys for more than three decades. In the early days, limitations in the capacity of the available recording systems led to very course spatial sampling and survey geometries that were inefficient and expensive to record. Over the last two decades the oil industry has seen a significant increase in the number of recording channels used for 3D surveys, both onshore and offshore. On land, we have seen an increase in the maximum offset being recorded in both the inline and crossline directions. The spatial sampling has also decreased, which results in an even more significant increase in the number of channels required. Modern seismic data recording systems are capable of recording tens of thousands of channels. To manually perform adequate quality control of the data acquisition would not only be extremely inefficient but also prone to errors.

Because of this, most modern recording systems have automated methods of testing and analysing performance. Beyond the usual instrument performance checks, quality control measurements of both the sources and the receivers can be generated and automatically logged into a database. Although "quality control" has traditionally been considered to be a tool for verifying compliance with contract specifications, this additional information can be extremely useful for improving the geophysicist's understanding of the data quality and, in some cases, the maintenance procedures on the crew. With the use of GPS and Geographical Information Systems (GIS) databases, the data can be analysed in both a temporal and geographical sense to understand whether any changes observed relate to differences in the geological environment or to operational, weather or other conditions that may be varying with time.

The excellent communications bandwidth that is accessible on the Internet today has also been incorporated into one of the quality control systems in widespread use today. All of the QC functions that are normally performed in the doghouse can now be viewed and analysed remotely in the crew's basecamp, the contractor's or the oil company client's office, or the data processing office. The analysis of geophysical field tests that once required the oil company and contractor's geophysical staff to travel to the field can now be undertaken in their offices, resulting in considerable savings of both time and money.

Discussion and examples

The additional quality control capabilities of these modern systems can be used to make improvements in three major categories related to crew operations, the understanding and optimization of the geophysical attributes for data processing, and analysis of field tests and field data quality issues. These will be discussed in more detail below.

Improved maintenance and operational efficiency

One example of these benefits is for crews that are working with seismic vibrators as the energy source. There are normally contract specifications for maximum phase error between the recorded ground force signals from the vibrators and the pilot sweep, and also for the fundamental ground force levels. However, the average and peak phase errors, the average and peak harmonic distortions and the average and peak ground force levels for every sweep of every vibrator are normally recorded, together with the geographical coordinate information and time. By comparing the performance of each vibrator against the others, small trends in the changes in these attributes with respect to time can lead to identification of problems before they exceed the contract limits or become catastrophic. Vibrators that show anomalous reported statistics can be withdrawn from production recording and sent for preventive maintenance before either the geophysical data quality is degraded or the mechanical system becomes damaged.

Comparisons of the values in a geographical sense using a GIS database and mapping system may demonstrate that observed variations correspond to unavoidable near-surface geologic conditions and may require adjustment of the source parameters or special consideration in data processing.

For crews using explosive sources, if the shothole depth is expected to be fixed, geographical mapping of the uphole times can reveal regional changes in the weathering velocity that can be later used to help in the determination of the near-surface model for static corrections in data processing. Anomalous uphole times that do not fit the regional trends may indicate either floating charges or incorrect drilling depths. Either of these problems would need to be corrected as soon as possible.

Improved understanding of geophysical attributes

An exciting example of this has been published by Al-Ali et al, 2003 and Ley et al, 2003. As part of the vibrator control of ground force phase and amplitude, estimates of the ground viscosity and stiffness below the vibrator baseplates can also be made. They demonstrated the application of these measurements to estimate the spatial variations in near-surface velocities. Their 3D survey designs have very high source densities and hence they therefore have very good statistics for these velocity evaluations. By incorporating these with their deep uphole information using geostatistics, they have shown significant improvement in the near-surface model for static corrections.

A second example demonstrates how the required data processing attributes of fold, offset and azimuth were analysed and their adequacy verified in an area where the data acquisition was being adversely affected by a large river that was overflowing its banks. One of the proposed interpretation methodologies in this area was amplitude versus both offset and azimuth. Because of the problems created by the river there was some question as to whether the offset and azimuth ranges of the recorded data would be sufficient to allow valid use of these geophysical attributes. The QC system in the recorder allowed the loss in fold, caused by the bad geophone plants and other problems, to be calculated (Figure 1a) and the resultant fold of the recorded data to be plotted (Figure 1b.) Additional displays of the azimuth and offset contributions were also made in order to verify that the recorded data would meet the processing and interpretation requirements.

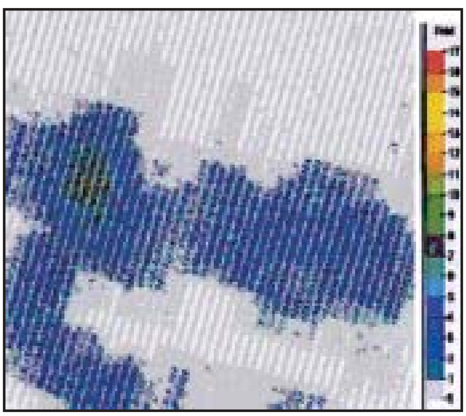

Fig. 1a Fold loss due to bad traces

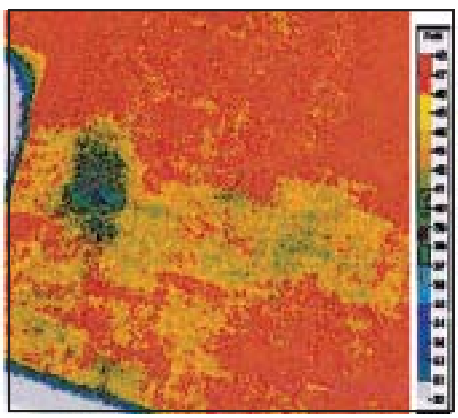

Fig. 1b. Resultant fold after removal of bad traces and missing shots

Analysis of field tests and data quality

When a seismic crew is starting a new survey it has been common practice for tests to be made of many of the basic geophysical parameters (eg. vibrator sweep frequencies, length, number of sweeps, number of vibrators, etc.) For this testing, the oil company geologist together with the contractor and oil company geophysicists may travel a considerable distance and spend much time in order to visit the crew. Frequently the actual time spent analyzing the tests may be very short in relation to the time spent on these other activities. In the past, the data processing and analysis may have been performed on a field processing system in the basecamp. In recent times much of this analysis has taken place with processing and display systems attached to, or integrated with, the recording system.

With the very high bandwidth internet capabilities and the high security that is available with today's systems, most of this wasted time can now be saved. Figure 2 show a diagram of some of the possible interfaces that can now be used to permit displays of the actual data to be distributed remotely to those that need to be able to review it. Different processing (eg. gain recovery, scaling, filtering, etc.) can be applied and viewed by the people located in the different locations without them having to travel to the crew.

The client-user software can be installed on any computer with a Java runtime environment. The client-server connection is protected by a user name and password provided by the server administrator (typically, the observer on the crew). All information that is transmitted through the web is binary encoded. In addition, only the seismic traces selected by the client are sent by the server, after lossy compression (up to 100 times) using a proprietary algorithm. Only the seismic attributes, computed on the original seismic traces, are not compressed before transmission. The client software includes different functionalities: a graphic user interface (GUI) with the same functions than in the recording truck (trace and scale selection, filtering, AGC…); a customizable high resolution display, independent from the one in the recording truck; and a browser to exchange mails and files with the administrator.

From the field tests already performed, this system has proven its ability to handle different network configurations, including satellites, intranet & internet, for real time transmission of compressed seismic traces and associated attributes.

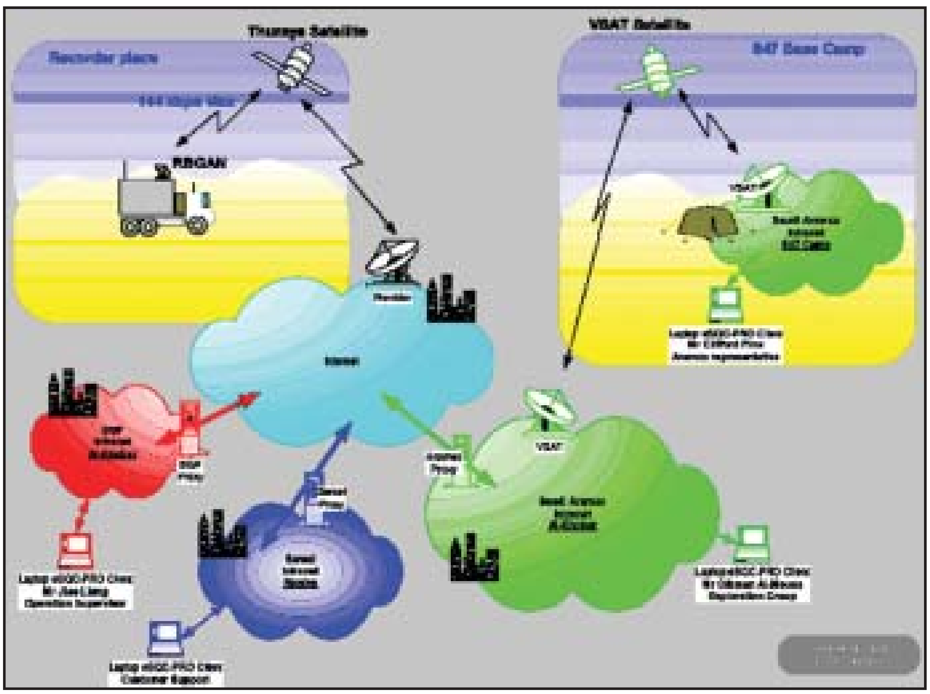

Fig.2 Some of the possible Internet/intranet/satellite configurations that can provide remote access to field QC and seismic data

Conclusions

There is a large amount of data that is currently being computed and recorded by field systems that is not being fully utilised. Some of this can be used to optimise the efficiency of the seismic crews and to improve the data quality. Much of this data can also provide an improved understanding of the geophysical attributes of the data and help in the initialisation of the data processing. For surveys acquired with vibrators in areas with complex near-surface geology, the near-surface model for static corrections can also be greatly improved.

The smart use of Internet technology has the potential to ease crew supervision by providing expert geoscientists with instantaneous access to both the seismic and quality control data. It should be extremely helpful for contractors that manage several large seismic crews, often located in remote locations worldwide, and to ease the travel burden for oil company personnel.

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