Introduction

During land seismic operations, it is common practice to perform QC operations on field equipment; however, with wireless systems in particular, there are different ways and means of undertaking this. A recent paper (Wilcox, 2015a) performed an analysis on the three most common approaches used in land seismic systems, and their applicability to the three most common types of acquisition programme. It is the purpose of this paper to develop on this work, focussing on wireless systems, providing a view on the reception of the market to these approaches, and on how this may influence equipment design in the future.

During research for this paper, it became apparent that there are some differences in the terminology used to describe the parameters reporting the status of wireless field equipment. Terms such as “equipment status”, “state of health” and “QC” are in common usage without differentiation. This can be misleading as the same term is employed for both wireless and cabled recorders, but with some differences in scope. For wireless systems, “QC” covers the condition of equipment (e.g. geophone condition, positioning error and possible theft, rather than electronics faults, which are rare in modern, high reliability equipment), and sometimes field noise monitoring, while for cabled systems it additionally covers the QC of seismic data in real-time. Throughout this paper it is proposed, however, to utilise the term “Equipment QC”, abbreviated to “QC”, in relation to wireless systems.

In the paper referenced above, 3 categories of existing wireless land seismic system are described:

- **Blind**: Characterised by systems that have no means of providing the system Operator with QC subsequent to deployment, and during system operation;
- **QC Capable**: Systems that make QC data available during acquisition, which must be collected in-field and transported to the system Operator for record and/or display;
- **Real-time QC**: Systems which incorporate a communications method capable of automatically transmitting QC data from equipment in the field to the system Operator for record and display with a reasonably short latency.

Current QC status with wireless systems

As discussed in the previous paper, Blind systems provide some operational efficiency at the cost of added risk to the quality of the data recorded. This could be viewed as making them more appropriate to Speculative programmes, as well as to those Proprietary programmes where additional measures are taken to mitigate the data quality risk. In the meantime, such Proprietary programmes have become much less common; however, some contractors are continuing to pursue Speculative programmes where low operating cost is a significant factor. Feedback from Geophysical contractors suggests that Blind systems are currently not a preferred option for their operations.

At the other extreme, despite their ability to offer continuous monitoring of field equipment performance, and hence the promise of high quality seismic data, wireless systems incorporating Real-time QC have not yet made a significant impact on the equipment market, and remain limited to niche applications. A possible explanation is that the equipment cost, weight, and battery autonomy necessitated by the complexity of such systems, along with the field effort required to establish a stable wireless network on an ever-moving spread, outweighs the operational benefit for most types of programme.

Although the level of activity is generally low, it appears that QC Capable systems are the preferred choice by most seismic contractors, and are widely in use in a variety of programme types. A likely explanation for this is that these systems, through their ability to provide a level of monitoring of equipment performance, offer a degree of confidence in the quality of the seismic data being recorded at a lower capital and operating cost than Real-time QC systems.

In the following section, the most common methods of QC collection used in QC Capable sections are described to illustrate the flexibility of this approach.

Application of QC Capable systems in various programmes

The defining feature of QC Capable systems is that, in order to retrieve QC from the equipment during acquisition, some resources must be used to traverse the prospect and collect the QC from the equipment in the field. The manufacturers of these systems have designed the collection equipment in such a way that the means of doing this is fairly flexible and can be adapted to suit the specifics of each project.

Some systems allow harvesting of seismic data during production, and it is therefore possible that in some projects, the QC data and seismic data are harvested simultaneously. This approach is normally undertaken only when there is a relatively small number of channels (less than 2,000), and when the source characteristics are such that the seismic data set is relatively small e.g. impulsive source or single fleet/short sweep. More typically, the tasks of QC data collection and seismic data collection are separated and different methods or teams applied to each task. As the collection of QC data from a single field unit takes only a few seconds as opposed to tens or hundreds of seconds for the collection of seismic data, this means that the efficiency and frequency of QC data collection can be improved and optimised for the requirements of the client. In some cases, oil industry clients insist on the harvesting of seismic data on a daily basis in a seismic campaign in order to perform data QC and satisfy themselves that the geophysical objectives of the project will be met, but in most cases this requirement is dropped after an initial period of one or two weeks.

Through experience, most system operators have discovered that using teams dedicated to the task of QC data collection is the most efficient method, and the number of teams and their deployment method can easily be adapted to suit the size and specific challenges of each project. In projects where vehicle access on the prospect is largely unobstructed, the QC collection equipment may be mounted in a vehicle and the QC data collection team can travel rapidly through the prospect. This was the approach taken on the Galaxia project in Mexico undertaken by Geokinetics in 2014, where Kubota all-terrain vehicles were used by the QC teams, and the entire spread of 13,000 field units was QC checked every 2 days. On a significant wireless project in France (Baris, 2014), however, the presence of intense agriculture combined with high levels of habitation, meant that a different approach was more practical, and the QC teams operated on foot. Despite this, they were still able to QC check the entire spread of 11,000 field units every 2 days.

Most seismic contractors take a practical approach and their QC teams adapt to the changing circumstances as a survey progresses through a prospect. In areas where vehicle access is possible, a truck or ATV (All-Terrain Vehicle) is used for QC data collection, and where agriculture or other impediments prevent this, the QC team reverts to operating on foot.

A logical progression of this is to use Unmanned Aerial Vehicles (UAV; also known as drones) to fly over the prospect and collect QC from the equipment on the ground. This has the advantages of being fast, vastly reduces crew effort and has very low environmental impact, but at the cost of requiring a specialist operator. Some of the seismic equipment manufacturers have recently announced miniaturized versions of their QC collection terminals with greatly reduced size and weight, which are more suitable for UAV-borne operations than the ruggedized handheld tablet computers commonly used. The much lighter weight in particular boosts the flight autonomy of the UAV and enables the use of smaller, less expensive aircraft.

In the USA, at least one seismic contractor, Paragon Geophysical of Kansas, has been conducting trial operations with QC collection by UAV (Wilcox, 2015b) alongside vehicle mounted and pedestrian carried methods, and it is expected that several others will follow suit in the near future. Maturing regulatory requirements for commercial UAV use combined with technological progress which has seen payloads and flight autonomy increase are creating an environment where the use of UAVs for the collection of QC data is becoming a realistic complement to the methods previously discussed.

Figure 1 shows the three methods of QC collection already discussed. In each case, the collection of QC data from each field unit takes only a few seconds, and as the wireless range is typically a few hundreds of metres, the operator or UAV can travel continuously without missing field units. Indeed, the enhanced wireless range offered by the altitude of the UAV can allow it to travel at higher speeds than is possible on the ground while still collecting QC from every field unit.

Figure 1 *– Examples of QC collection with dedicated teams: by foot, by vehicle, by UAV*

Another method of QC data collection that has been proposed in the past, but rarely implemented, is the so-called opportunistic method (Figure 2, left), whereby QC data collection equipment would be fitted to vehicles (such as vibrators, ATVs etc) and/or carried by field personnel, but would operate in an entirely autonomous manner. This would mean that wherever the vehicles or personnel travelled, QC data would be collected without any planning or involvement from the personnel. A potential benefit of the development of lightweight miniaturized equipment for use with UAVs is that this equipment would also be suitable for the opportunistic method, particularly for personnel operating on foot, and may well be the catalyst for widespread adoption of the opportunistic method.

A different approach has been taken by some seismic contractors where their QC Capable system has a high degree of compatibility with a cabled system. In this case, they have the ability to supplement their wireless system layout with one or two lines of a cabled system. This gives the flexibility of adding the capability of real-time monitoring of, for example, field noise from a snapshot of the spread. This is often sufficient to meet a client's specification for real-time noise monitoring. This configuration is illustrated in Figure 2, which shows a section of how such a spread may be deployed.

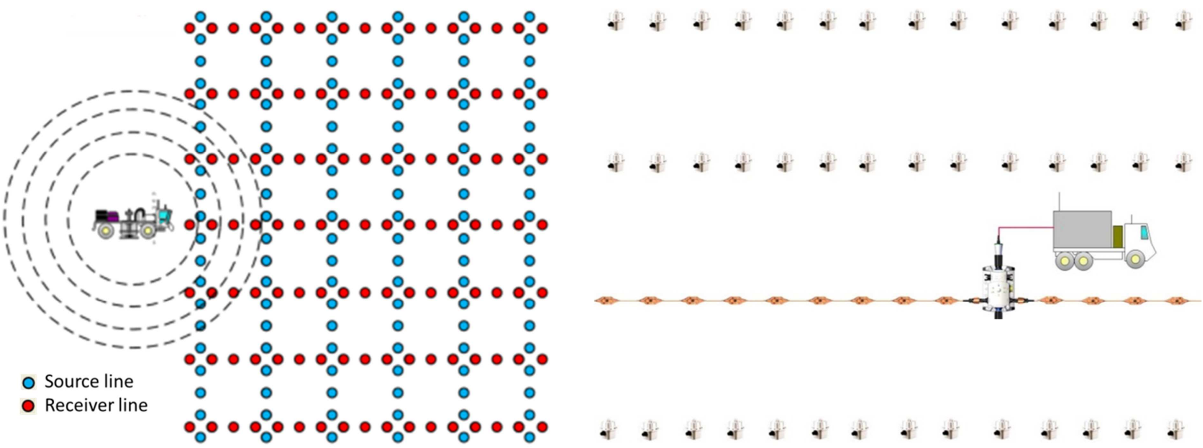

Figure 2 *- Illustration of (left) opportunistic QC and (right) wireless spread showing supplementary cable channels*

Conclusion and discussion

After more than a decade of wireless systems becoming a widespread method of land seismic acquisition there continues to be a divergence of opinion on the value to the system operator of having QC from the field equipment. Suppliers of Blind systems maintain that the reliability of modern electronics makes it redundant, while suppliers of Real-time QC systems suggest that continuous monitoring of equipment continues to be mandatory. The proponents of QC Capable systems argue a middle ground proposing that theft and equipment damage (accidental or malicious), as well as excessive field noise potentially degrading the quality of the seismic data acquired, cannot be ignored and must be mitigated through a level of monitoring, but also that the added cost and complexity of real time systems outweighs their benefit.

The apparent preference in the market for QC Capable system seems to suggest that their ability to mitigate some risk is a desirable feature for system operators, although, it is also clear that it would be highly beneficial to reduce the amount of resources required to collect QC from the equipment in the field. The development of QC collection by UAV may go some way to satisfy this desire, however, an ideal solution in the future may be found in a system that can deliver QC to the Operator without additional infrastructure or deployment complexity, with little or no additional power consumption.

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