Current cabled and cable-free seismic acquisition systems each have their own advantages and disadvantages – is it possible to combine the two?

Robin Ellis[*] discusses a new architecture that breaks the current paradigm in an attempt to offer the best of both worlds.

Current seismic acquisition systems can be separated into two distinct camps based on either cable or cable-free architectures. In recent years cable-free systems (often referred to as 'nodal' systems) have steadily increased their market share and now account for perhaps 20% of the world-wide inventory of seismic channels.

The rapid market penetration of nodal systems is a result of certain oft-discussed inherent logistical benefits gained from their use. However, there remain some significant short-comings, meaning that these systems fall short of what might be considered the 'ideal' tool for acquiring seismic data, and consequently limiting their potential to completely replace cabled systems.

Let's take a closer look at some of the key limitations of each system type.

The 'ideal' seismic acquisition system would overcome these limitations while meeting the needs of both the seismic contractors and oil companies. It is interesting to note that the contractors and oil companies have quite distinct needs, although a common goal is to reduce acquisition costs.

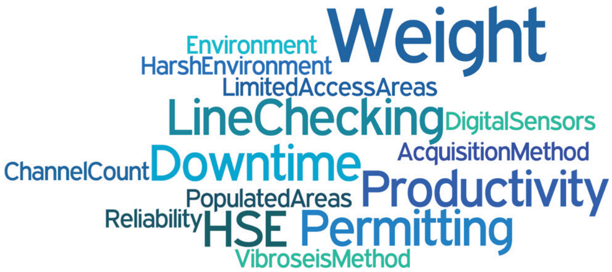

***Figure 1** Cabled systems – limitations.*

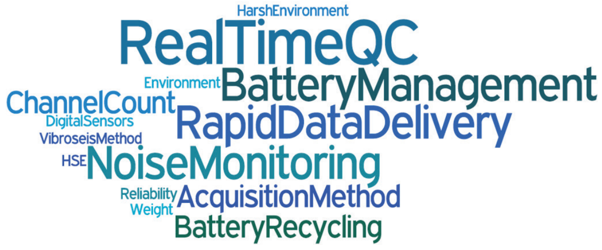

***Figure 2** Nodal systems – limitations.*

Sercel had this 'ideal' system in mind when it embarked on the design of its latest generation system. The company is well positioned to take advantage of its experience as a manufacturer of both cabled and nodal systems. The goal was to meld the best elements of both technologies. The result was a totally new architecture that the company will market as X-Tech (pronounced 'cross-tech').

The first system to incorporate this architecture will be the Sercel 508^{XT}. In this article we will review in more detail how such a system will address the needs of both the seismic contractor and oil company.

First let's consider the interests of the seismic contractor.

Fast operations

Probably the most attractive feature of nodal systems is that they enable considerably higher production levels for crews operating in complex or aggressive environments. With local data storage in on-board memory and no requirement for serial data transmission back to the recording truck, downtime due to field equipment issues can effectively be reduced to zero. This is in contrast to cabled systems whose reliance on serial data transmission makes them susceptible to downtime due to cable damage, particularly in areas populated by humans and animals. Cable systems can also be susceptible to 'line drops' which occur when data transmission is interrupted due to the atmospheric static bursts usually associated with thunder storm activity.

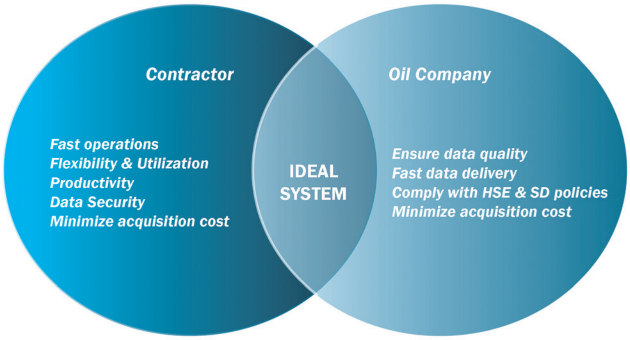

***Figure 3** What really matters.*

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Figure 4 The FDU-508 on the left, and the DSU1-508 on the right.

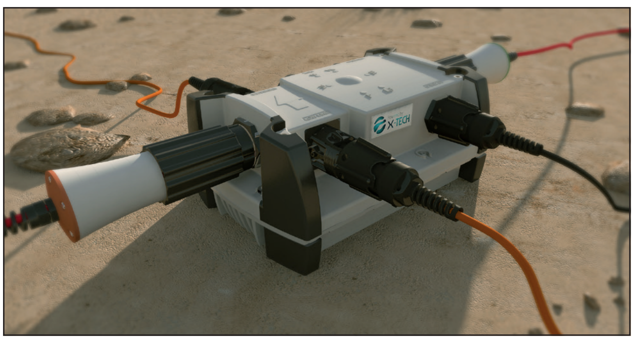

Figure 5 The CX-508.

Nodal systems do have several operational shortcomings. The most significant being the requirement to have a power source for each individual node. These usually take the form of comparatively expensive lithium chemistry batteries chosen for their reduced size and weight. On large 3D crews thousands, or even tens of thousands, of batteries have to be charged, deployed and charged again. This cycle is a significant logistical challenge and is unfeasible on the very high channel crews that are becoming quite common in the Middle-East. On many crews, nodes are transported along the line by vehicle. Their deployment requires the vehicle to stop at each location so that the node and its battery can be lifted out of the vehicle and placed on the ground. This can be a laborious process when compared with the normal method of cable equipment deployment. In open areas the cable can be deployed safely from a moving vehicle with no need to stop. With shorter receiver station intervals becoming increasingly common, this aspect of node deployment becomes a significant obstacle.

One of the attributes of the 508^{XT} system's X-Tech architecture is that it offers the same zero down-time operation that makes nodal systems so attractive, but it uses one battery for every 100 channels. This is made possible by incorporating memory into each field unit component, so that at its core the system operates like an autonomous nodal system. Installed on top of that core is a network that provides for power supply distribution similar to that of a modern cable system but with multiple layers of redundancy. An added advantage of the network is that it provides a communication path for seismic data and QC transmission back to the recording truck.

Let us take a closer look at the components that make up a X-Tech spread:

The basic building blocks of the spread are the FDU-508 (for analog sensors – geophones/hydrophones) and the DSU1-508 (equipped with next generation QuietSeis MEMs accelerometers).

These single channel acquisition base nodes are each equipped with a circular buffer memory that allows them to store and re-transmit seismic data as and when required.

CX-508 - Concentrator

The CX-508 'Concentrator' is the brain of each group of base nodes and forms what Sercel refers to as a 'X-Tech node'. The CX-508 receives the seismic data in real-time from a group of base nodes that can consist of as few as one or up to as many as 100 or more FDU-508s or DSU1-508s. The CX-508 stores the data received in its on-board memory. In the event that real-time transmission is corrupted for any reason (e.g., static burst), the buffer memory in the FDUs/DSUs allows the data to be re-transmitted.

Timing synchronization across the CX-508s deployed in the spread is ensured by each unit's on board GPS module.

The seismic data is transmitted to the CX-508 via cable connection from the base nodes associated with it. Various forms of transmission redundancy are employed to ensure safe storage of the data enabling the system to achieve one of its main design goals of zero down time acquisition. Key to this are:

- New cables – 10% lighter and 50% stronger than the previous generation's lightest cables.
- 4 Wire Smart Transmission – In the event of damage to as many as two of the wires in the quad, data can be still be transmitted at the full transmission rate on the two remaining wires.
- Dual X-Tech node configuration – Connecting a CX-508 at each end of a group of base nodes to create a dual X-Tech node configuration allows acquisition to continue even in the event that a cable is completely severed as data is retransmitted to whichever CX-508 is still available.

Data security

Existing nodal systems require that seismic data remains in each node's memory until the unit is physically picked up and

Figure 6 X-TECH Node.

taken to a central location for data download and transcription. In an aggressive environment, the owner of the data is exposed to risk of loss due to theft, vandalism, fire, flood, etc. This risk increases with each day the unit remains on the ground.

It is therefore attractive to be able to 'harvest' the data from each node on a regular basis. This should be performed often enough to avoid any need for an expensive and time-consuming reshoot in the event of significant theft or damage to units.

Existing harvesting protocols require that data be collected from each individual node. With the 508^{XT}, data is transferred from multiple base nodes (up to 100 or more channels) to an associated CX-508 Concentrator instantaneously. The data stored in the CX-508 Concentrator can then be uploaded to a mobile ruggedized tablet PC harvester and transferred to the Recording Truck or Base Camp 508^{XT} Central Unit (CU). This method of data acquisition and retrieval results in a substantial reduction in the number of data retrieval points, and is accomplished with no interruption to production.

This scenario corresponds to a system configured with autonomous X-Tech nodes. By design, the X-Tech nodes on each seismic line can be interconnected in the same manner as a traditional cable system. Moreover, each seismic line can be connected to adjacent lines and to the recording truck using Gigabit transverse cables. Meaning that, when conditions dictate, the system can transmit all of the seismic data to the recording truck in real-time.

Productivity

Eliminating down-time due to equipment problems during acquisition certainly contributes greatly to fast operation in the field. Another means to maximize production is to eliminate the time spent on spread QC and running instrument tests. That is not to say that we should eliminate spread QC completely as is the case with so-called 'blind' nodal systems.

It's important to remember that even though a CX-508 might have a direct cable connection to the recorder, it will still at its core continue to act as an autonomous node. For example, independent of any command from the Recording Truck CU, the CX-508 will wake up at a pre-defined time and run daily sensor and instrument tests on its associated group of base nodes. This could be scheduled to take place before the start of daily production. This flexibility also allows sensor and instrument tests to be performed on any portion of the inactive spread without any interruption to normal production.

The latest vibrator acquisition techniques such as Distance Separated Simultaneous Sweeping and Independent Simultaneous Sweeping have enabled levels of land production previously only obtainable on marine seismic surveys. The current record for a 24-hour production day stands at 40,000 VPs. It is therefore important that any modern acquisition system be able to control and QC large numbers of individual vibrators.

The Sercel VE464 vibrator control system was designed with this type of operation in mind and is today used on many such surveys. It was important that the 508^{XT} acquisition system be completely compatible with VE464. Sercel

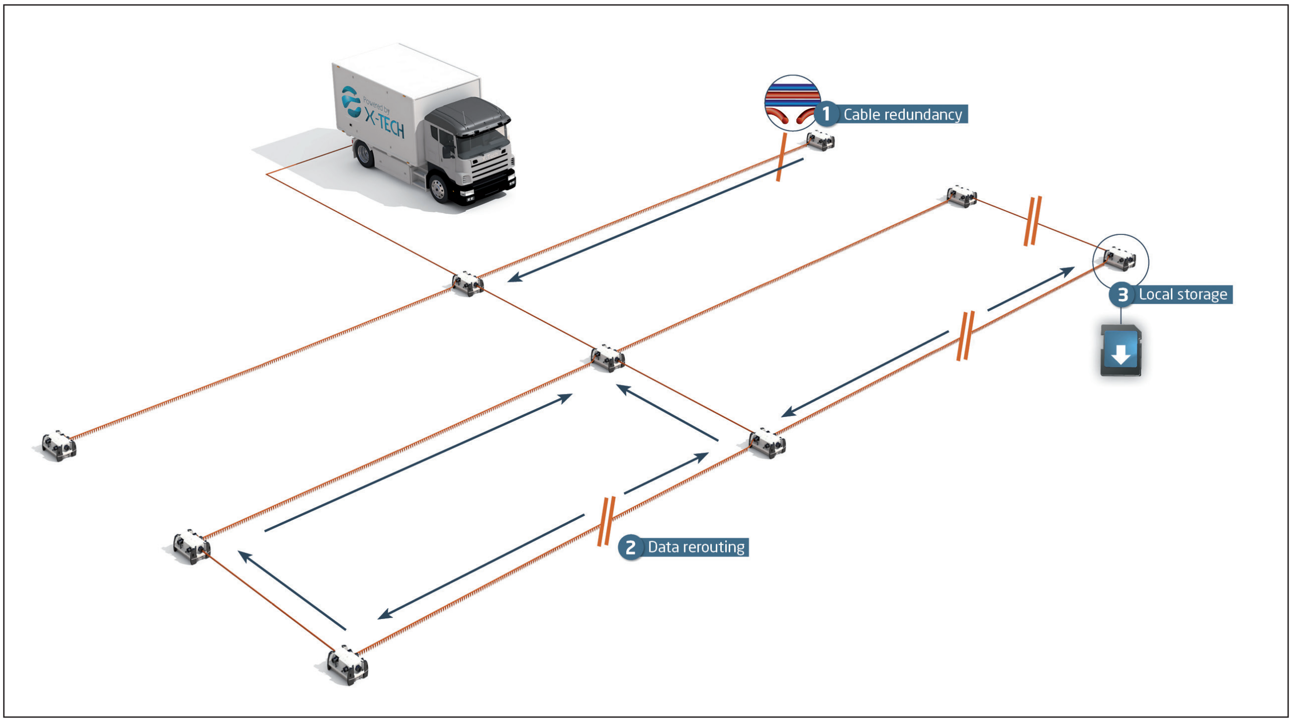

***Figure 7** Production whatever happens.*

took advantage of its experience with VE464 to implement a software interface that ensured compatibility and provided a level of user friendliness far surpassing the previous generation systems. The new user interface allows observers to see in graphical form and via smart icons, each vibrator's location on the prospect, its current status, its progression through each sweep and listen cycle, VPs already acquired and VPs to be acquired.

Flexibility and utilization

A seismic acquisition system is a substantial capital investment. It is therefore important that the system be as adaptable as possible. The core of the X-Tech architecture is an autonomous nodal system. Atop that framework are elements that are sourced from the most advanced cable systems. This naturally endows the 508^{XT} system with a great deal of flexibility in respect of its deployment across different environments and terrains. During its lifetime the system could be required to work in jungle heli-portable operations before being packed up and shipped to a desert location for use in high production vibroseis operations. In an aggressive jungle environment, the system would most likely be configured as an autonomous or partially autonomous nodal system, while for desert operations it would be reconfigured with gigabit transverse cables similar to a traditional cable system.

The number of channels deployed can vary significantly from crew to crew. In the above examples the 508^{XT} could be configured for portable 2D jungle operation with only a few hundred live channels connected to a ruggedized laptop based CU. For the desert environment the same field equipment could be connected to a scalable array of powerful blade servers that would enable it to acquire up to 1 million live channels at 2 ms.

Fans of cable-free nodal systems will be quick to point out that the architecture described will be to some degree limited in flexibility by the predefined cable lengths between the base nodes. This can be overcome, however, by taking advantage of the new design assemblies that surround each base node, allowing for quick connect/disconnect. Only two screws are used to securely hold each unit in place. (See Figure 9).

This design allows cable sections of differing lengths to be rapidly installed depending on each project's specific requirements. It also allows for the very quick change out of damaged sections, thus maximizing utilization of the base nodes available on the crew.

In the event that a change to digital sensor type is required, the cable sections are completely compatible with each type of base node. I.e., FDU-508, DSU1-508 and DSU3-508.

508^{XT} is completely compatible with Sercel's existing wireless node system UNITE. This is a significant advantage for any parts of a prospect where the complete elimination of line cables may be advantageous. Data from UNITE nodes (RAUs) can even be transmitted wirelessly in real-time to cellular access nodes (CANs) connected to CX-508s and then onwards by cable to the Recording Truck CU in real-time.

Now let's consider the interests of the oil company, the end user of the seismic data.

Ensure data quality

508^{XT} is equipped with a powerful quality control package integrated directly into the CU's standard software platform. It has all the tools that we have come to expect from a modern seismic data QC system, however, these tools would be of little use were it not possible to receive the data in a timely manner for analysis.

In a typical 508^{XT} spread configuration a significant portion, if not all of the data, can be acquired in real-time through gigabit transverse cables and/or wireless infrastructure. The retrieved data is immediately available for analysis by the CU.

It is also possible to monitor spread connections, sensor QC and battery voltages on autonomous portions of the spread by connecting small inexpensive wireless transceivers

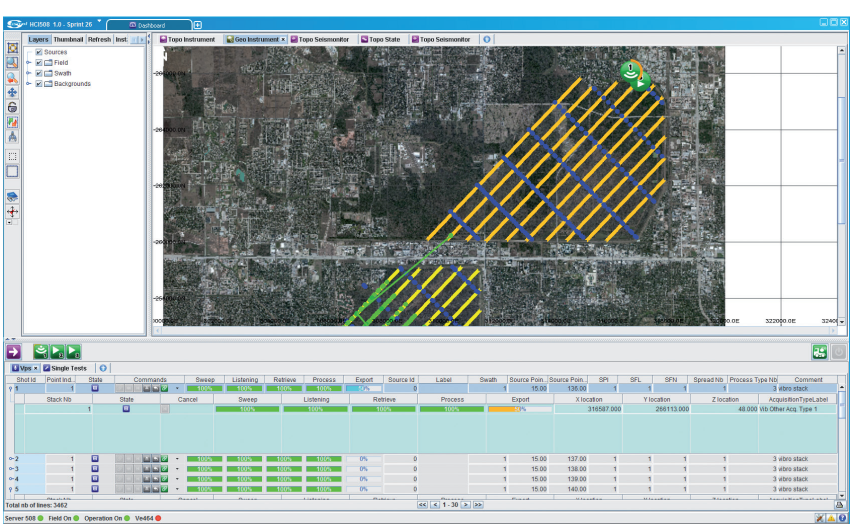

Figure 8 *Screenshot of the 508^{XT} software interface.*

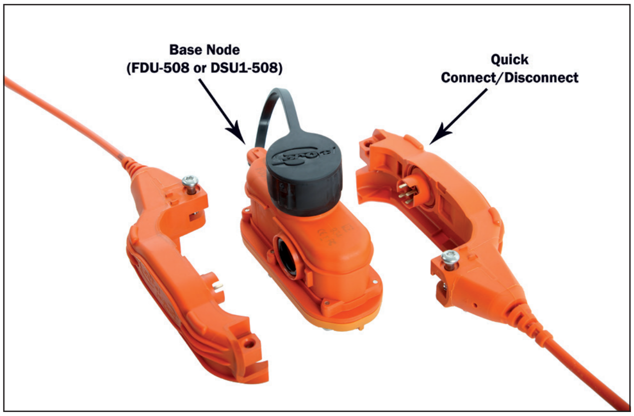

Figure 9 The exchangeability of field units.

to any convenient CX-508 that has line of sight communication with a partner unit connected to a CX-508 on a live spread. (See Figure 10.)

Fast data delivery

Whether data is harvested in real-time or harvested remotely, the 508^{XT} CU outputs fully transcribed shot gather SEG-D Rev 3 files that are ready for delivery to the processing centre. This is in stark contrast to the data produced by current autonomous nodal systems, which is generally delivered later in the life of the project and can require time-consuming transcription to be carried out on large volumes of data at the processing centre in addition to the typical processing flows.

Comply with HSE & SD policies

HSE

The X-Tech architecture's multiple levels of acquisition redundancy mean that line trouble shooters do not need to rush to respond to line faults, a potentially significant HSE risk. Flat batteries and cut cables are no longer reasons to halt production.

- The line crew can choose to either postpone the replacement of compromised equipment until it is picked up by the line crew. CX-508s outboard of any fault having automatically switched to autonomous mode and data will be safely stored in their memories.
- Alternatively, they can delay replacement of defective equipment until whenever convenient, e.g., when a line vehicle is due to pass close by on another mission. This is called 'opportunistic troubleshooting'. The advantage in this case is that as soon as the defective cable or battery is replaced data stored in the CX-508s outboard of the fault will automatically start to stream back to the Recording Truck negating any need for subsequent harvesting.

With as many as 100 times fewer batteries deployed, the incidence of discharged batteries will reduce correspondingly

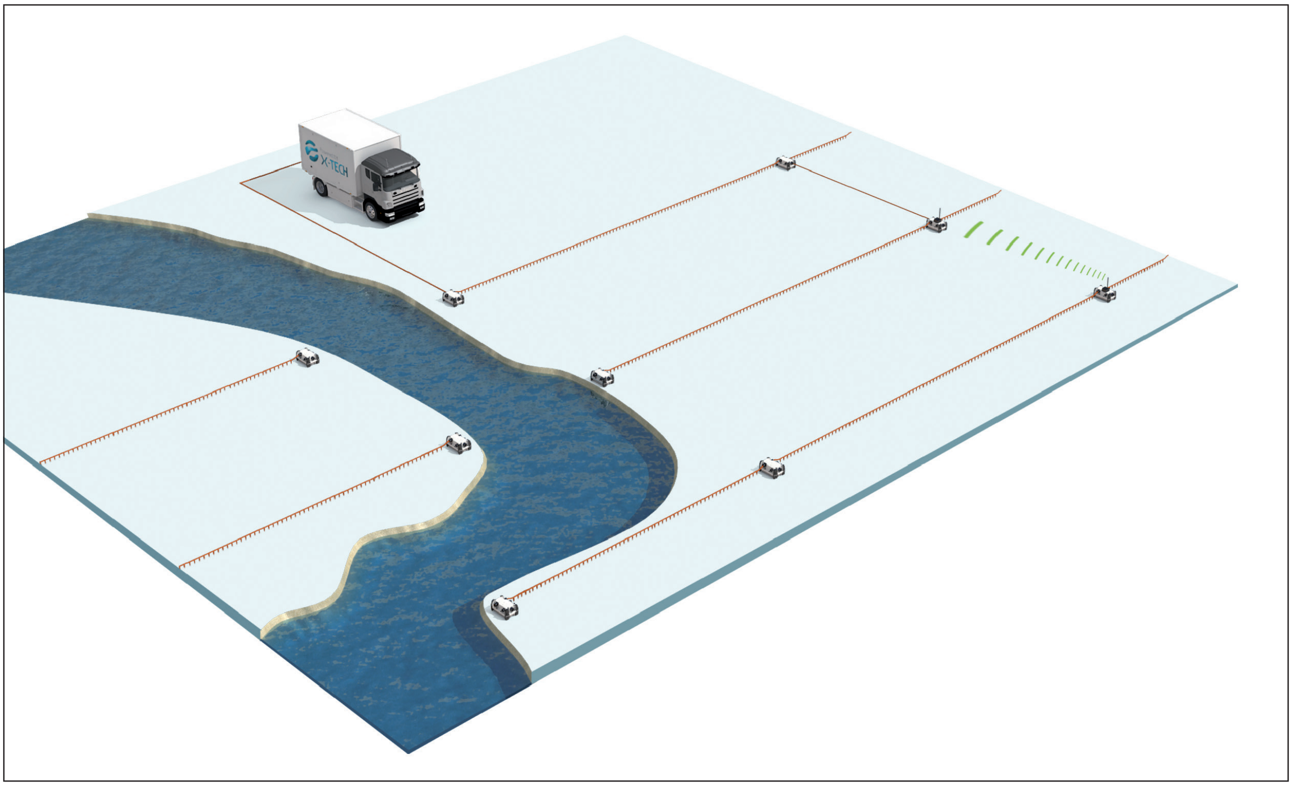

Figure 10 Unequalled data availability and integrity.

as will the requirement for line travel associated with servicing the regular battery charging cycle. Any means of reducing vehicular travel will correspondingly reduce HSE exposure.

Common with all nodal systems, the X-Tech architecture's ability to mitigate any requirement for cabled road and river crossings is another major contributor to reducing HSE risk.

Sustainable development

A typical 10,000 channel autonomous system using single channels nodes would actually require perhaps as many as 12,000 batteries to allow for a charging cycle that would guarantee reliable operations.

Disposal and recycling of spent batteries is an environmental concern. This is especially true given that experience is beginning to show that, due to rigours of life in the field, the life expectancy of each battery may only be of the order of half the life of the acquisition system itself. It is quite possible that a complete replacement of all 12,000 batteries will be the norm around the mid-life of each system.

To make matters worse many systems may be deployed in countries where facilities for proper disposal do not exist. The costly re-export of all this useless hardware for proper disposal is certainly something that will have to be taken into consideration.

This problem becomes more pronounced as channel counts increase.

By comparison a 508^{XT} system would require as few as 113 batteries to support 10,000 channels when deployed with a dense 12.5 m receiver interval and taking advantage of the extremely low power consumption of the DSU1-508. In the case of a more typical 50 m interval using geophones this number would increase to 188 batteries, still only 1.6% of the number required for the single-node configuration.

Given the reduced number of batteries required, battery size and weight are less critical, thus minimizing the appeal of lithium chemistry batteries. A sealed lead acid battery (SLA) of the type used in automobiles would be quite sufficient. This means that batteries could be sourced and disposed of locally, avoiding the requirement to ship them internationally, and resulting in a significant reduction in cost and carbon footprint.

Minimize acquisition cost

Faster operations, ensuring that a project is completed as quickly as possible, are fundamental in reducing overall acquisition cost.

However the number of people on a crew is also a key factor. There is a direct relationship between a crew's operating cost and the number of people it employs. Less people means less vehicles, less fuel, less wages, less food, less lodging, less HSE exposure.

With substantially fewer batteries to manage, no requirement to return boxes to a central location to download data and 'opportunistic troubleshooting' implemented, it is clear that the 508^{XT}'s X-Tech architecture affords it the ability to significantly reduce the number of line crew employees.

On crews using the DSU1-508 digital sensor, the geophone repair shop and its staff can even be eliminated completely.

Conclusions

It is clear that both cable and cable-free acquisition systems demonstrate distinct strengths and weaknesses. Arguably, existing nodal systems are limited by current battery technologies, the requirement of a power source at each receiver point, and the inability to supply real-time data. The weaknesses of cable systems include daily troubleshooting and additional HSE risks.

The primary goals of the 508^{XT} system with its X-Tech architecture are therefore to improve productivity through zero down-time, reduce the carbon footprint through fewer batteries, and minimize HSE exposure by allowing opportunistic troubleshooting.

We contend that it is currently impractical for cable-free systems to totally replace their cable counterparts but understand the advantages of having a nodal architecture integrated into a modern seismic acquisition system. Especially one that allows the user to choose between fully autonomous and real-time acquisition or a hybrid of both.

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References

Crice, D. [2011] Emerging market for seismic acquisition systems without cables still has problems to solve. *First Break*, **29**(2), 81-84.

Heath, B. [2008] Land seismic: the move towards the mega-channel. *First Break*, **26**(2), 53-58.

Smith, J. F. [2006] How a new cable-less land seismic survey acquisition system was born. *First Break*, **24**(2), 79-82