A declaration of independence for land seismic

Give me flexibility, or give me death! New acquisition systems offer unprecedented freedom.

AUTHOR

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Even though most land seismic recorders and source controllers in use today can be described as electronically sophisticated, many of the notions which led to their development are firmly embedded in the 1990s. We innocently thought then that we had foreseen everything that we would ever want to do in exploration, although nowadays the limitations are only too evident. So are the design philosophies we apply to equipment today any more forward-looking?

It seems that almost all recently proposed exploration methods may, at best, require a redesign of some part of the existing "exploration system" before advantage can be taken of what the technique offers or, at worst, cannot be tried at all due to equipment inflexibility. We usually blame slow adoption of the latest ideas on the conservatism of this business, but often it is because the technology simply can't hack it.

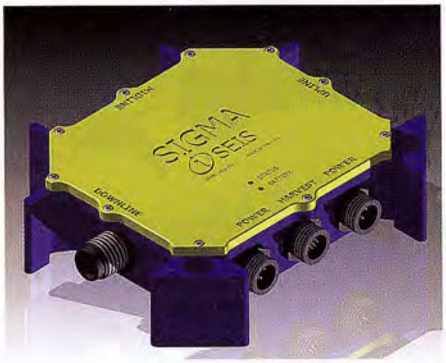

Figure 1. Second-generation independent cablefree hardware. (Images courtesy of iSeis)

Equipment independence

Until recently, almost all seismic recording was thought of as a duo of sources and receivers, the two operating as a single holistic harmonious system; equipment was designed this way because it was seen as an advantage. You do not even have to go very far back to find advertisements talking about how tightly integrated some hardware is, boasting how all items in the inventory are joined at the hip to all others. The sensors are part of the ground digitizing units, which are hardwired to a central system connected to a source controller communicating with sources. Almost every part of this varied collection of mechanical and electrical subsystems requires all others to work or the show is off. If exploration were a car, a problem with the CD player would cause the vehicle to grind to a halt.

Now we realize that this entire serially dependent setup is not only perilously vulnerable to the failure of just one minor part, but it also provides little flexibility when new exploration ideas need to be adopted. It is up to users to make the new techniques fit in the existing technology. But having to manipulate any piece of equipment unnecessarily so that a novel feature can be shoehorned in is not conducive to exploration progress. It was understandable that this tight integration was considered desirable when surveys were simple and relatively predictable. But what is needed now is equipment whose design has incorporated no assumptions about how sources or receivers will ever be used.

Fortunately, one of the latest nonconventional systems now offers an approach where each piece of recording and source control hardware has the built-in capability to be used however any technique demands, to act independently so that a person (or system?) endowed with the big picture can intervene, but only when necessary. Using again the automotive analogy, my car's dashboard provides me with red, amber, and green lights to tell me what's going on, but it is I who make the decision as to how to act on the information provided. If my car's onboard computer can do this, surely our industry can.

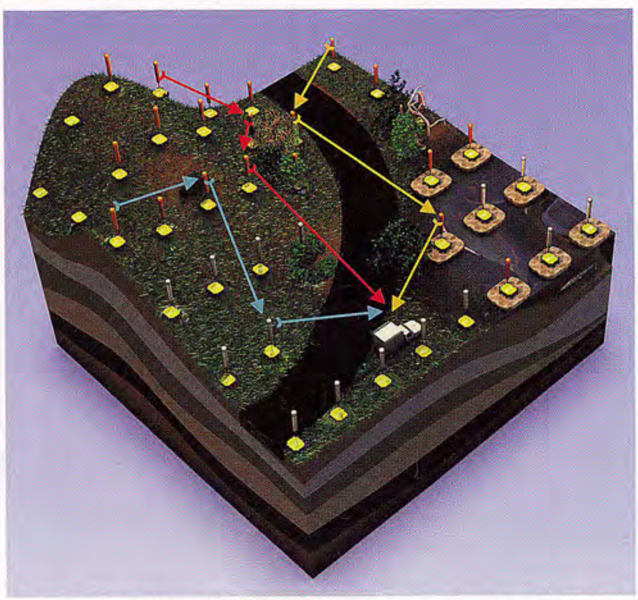

Figure 2. Mesh radio network used for monitoring independent receivers.

Receiver independence

Starting with receivers, the biggest restriction to freedom

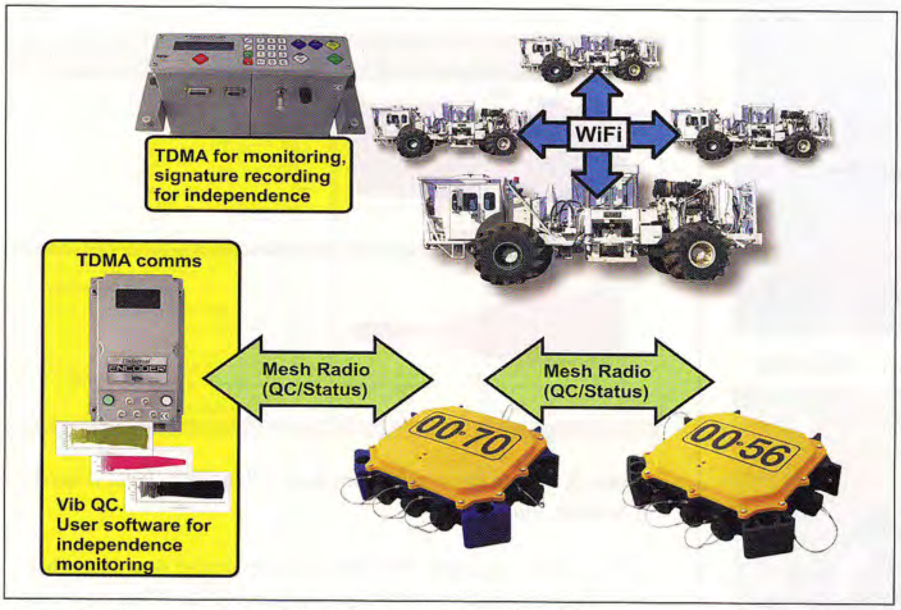

Figure 3. All source and receiver equipment must be able to operate with "monitorable independence."

is the telemetry cable. This industry has talked about "uncommitted data" for decades — where sensors and their digitizers are deployed so as to impose no essential change to the recorded signal. If receivers are to be endowed with all the flexibility possible, then they need to have the freedom to be placed precisely wherever is necessary and whenever we want to and not affected by the function of some other piece of hardware.

Where crews are not quite ready to let modern cablefree hardware take on the entire survey, they can use such equipment alongside their favorite cable system. This has advantages whether the cable system is set up to handle 1,000 channels or 100,000.

Doing away with cables provides receiver independence, but we still need to monitor what ground equipment is doing. This is not the same as getting all the data back in real time; it simply means showing where hardware is deployed, including batteries and sensors, and if it is all working well. License-free mesh radio networks are the answer here and are being used in second-generation cablefree systems already, taking away the anarchy of shooting blind and offering the security of knowing that channels are doing their bit for the good of the survey. With mesh radio networking, cableless no longer means QC-less.

Source independence

Now let us turn our attention to giving independence to sources. Here things are more complicated since nowadays sources require many degrees of freedom they did not need before, including in space (distance between active sources), in signature (what each source is actually putting into the ground), and in time (the relationship between each source starting/finishing).

When slipsweep was invented by Shell, it required one of these new types of independence — the freedom to control start time in a way which had not been needed previously to allow sweeps to overlap within certain frequency limits. In fact, not only had such freedom been unnecessary before, it was assumed simultaneous sweeping would never be needed. This feat did not come naturally to all seismic systems or source controllers, but independence in time is now not the only requirement.

We need sources to be able to act independently in terms of location, too, so that we can control the acquisition starts based on the physical locations of the shot points, for example, according to the spacing between certain objects

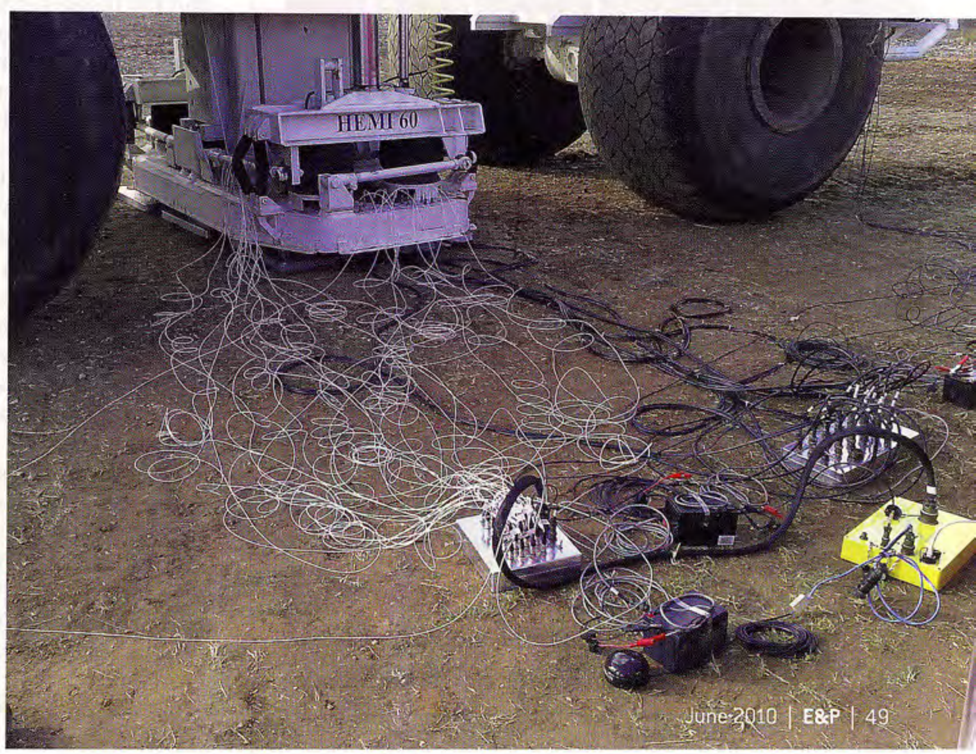

Figure 4. Load cell testing of vibrator performance.

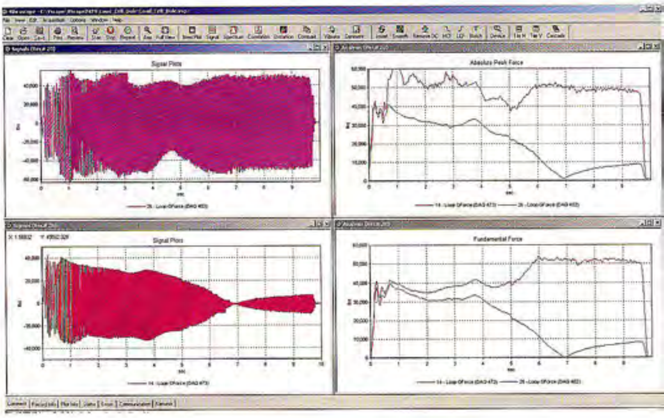

Figure 5. Vibrascope results from load cell testing. (Data courtesy of Seismic Source Co.)

such as other sources. The distance-separated simultaneous sweeping acquisition technique developed by BP is an example of such a requirement. Other variations in terms of relative source position and/or time have also been developed, including BP's independent simultaneous sweeping technology that uses simultaneous sources in a very novel but independent way.

Changes, as outlined above, provide great source independence, but we still want to be free of doubt about what they are doing. For example, with vibrators we need to monitor them for position, quality control, timing accuracy, radio simulations, etc. without tying up expensive and limiting hardware or using too many radio channels. Modern WiFi and the new-generation TDMA technology, which does not require additional frequencies on the crew, can make this monitoring function possible for up to 255 independent vibrators, just as mesh radio network makes monitoring possible for large numbers of receivers.

Finally, for hardware independence to work well, we need to be sure that our basic ideas about performance are reliable — the things we take for granted and usually do not bother to monitor. Can we assume that we know what vibrators are doing from a source signature point of view; can we even be sure that our notions about force are correct?

From research undertaken by Seismic Source Co., in Ponca City, Okla., it may be that we have some work to do before we can make this assumption. Using a system of load cells under the base plate indicates that even the force generated by a vibrator is often not what we expect. The standard weighted sum calculation looks like a rather bad estimation of force above 40 Hz, and even hold-down weight seems to be incorrect for some vibes.

So let us look forward to a new independent age in land seismic where we are unhindered by equipment-imposed restrictions and we can undertake any technique with independence and freedom. *Vive la Liberté.* E&P