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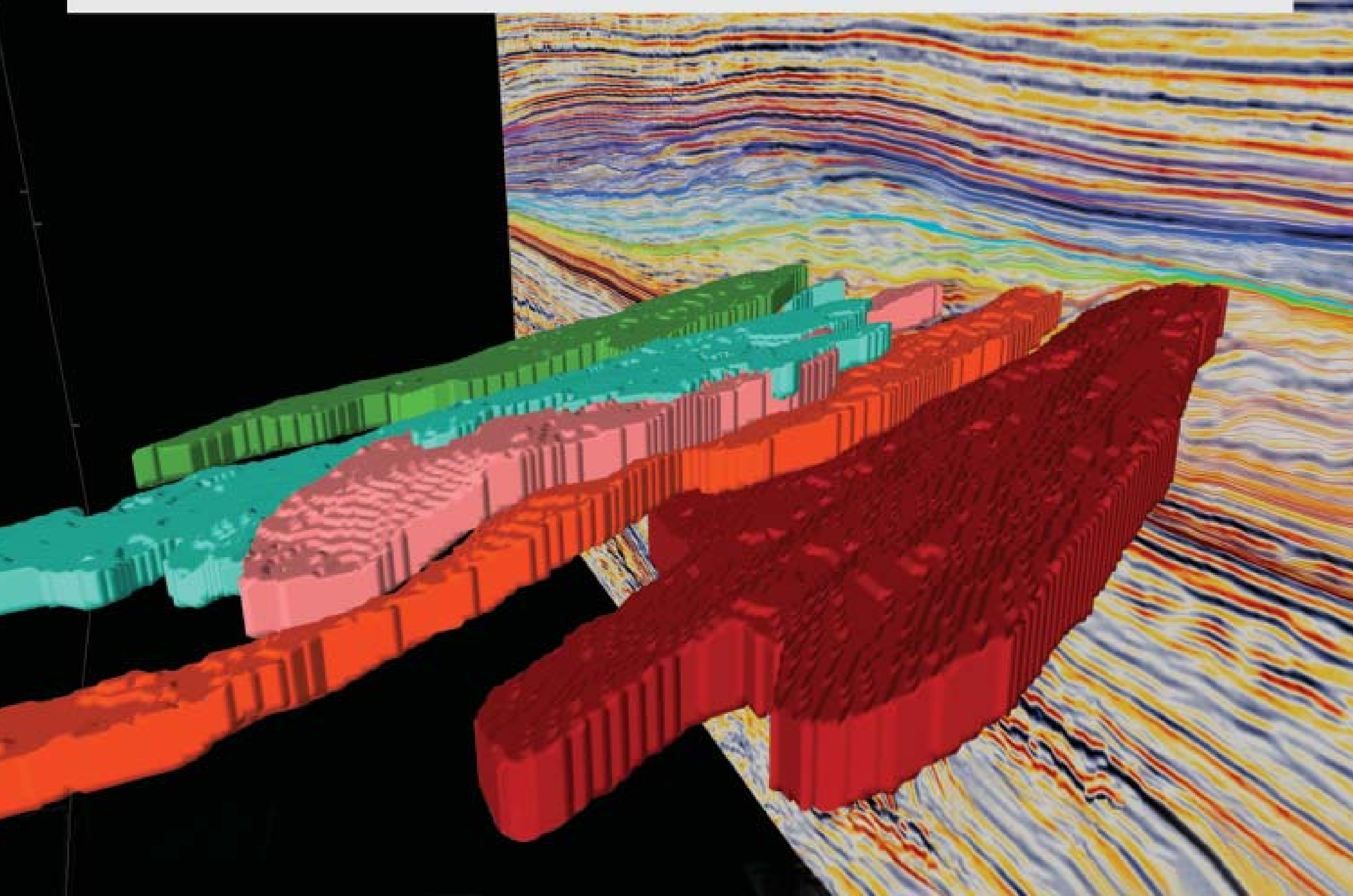
Global seismic interpretation techniques are coming of age

The advances in seismic technology over the last few years have been phenomenal, particularly in the areas of seismic acquisition, processing and interpretation. Global seismic interpretation include a variety of different methods, such as 'Age Volumes', 'PaleoScan', 'Volumetric Flattening' and 'HorizonCube'. Such techniques share a number of algorithms in common with their aim being to correlate seismic positions along geologic time lines to arrive at fully interpreted seismic volumes



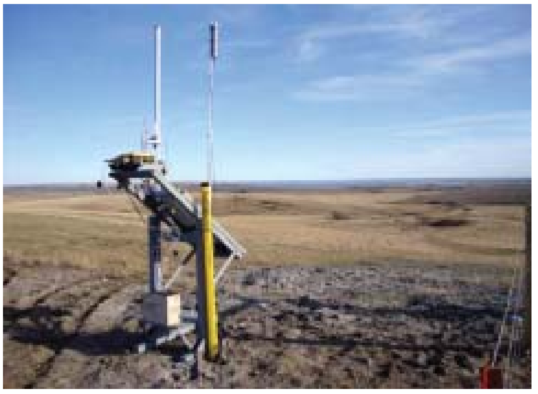
Passive seismic recording in S E Asia: A contractor's perspective

Colin Fleming, Managing Director & Partner, CellSeis Geophysical (CSG), UAE

CellSeis Geophysical is a seismic contractor which started operations by offering specialised marine data acquisition. A few years ago, it expanded its range of services to include land and shallow water seismic recording too in the environmentally challenging south and south east Asian regions. The growth of the company, as well as our reasons for choosing various pieces of recording and seismic source control hardware, were covered in an article published in DEW in June 2013.

The same piece made a few references to working in the field of passive seismic recording. Since the article's publication we have received a surprising number of enquires in respect of this form of geophysics. They cover requests for information about our reasons for hardware choice, how techniques can be carried out and the geophysical benefits such operations may bring especially to hydrocarbon exploration.

As we see growing curiosity in the industry in regard to what most people simple refer to as "passive", especially in the difficult geographical locations cited above, it seems appropriate to cover the subject in greater detail. It must be stressed that this is offered from the perspective of a geophysical services provider which, within certain commercial constraints, is happy to share its knowledge with others for the greater benefit of the local industry.



Permanent installation using Sigma cableless recording system. Long range wireless transmission of data made possible by antenna and comms architecture choice. It is imperative that a recording system provides such options.

The birth of passive?

We should commence by defining what passive seismic is and what benefits it can bring to the oil and gas exploration industry. In order to do that, it helps to understand a little of its history. It should then become apparent that what has made this new branch of geophysics viable for more contractors to undertake is primarily the recording technology and third party software which have recently become available. However, one must also recognise the various breakthroughs in the science of geophysics which allow us to gain in new ways from passive data.

It seems, a few years ago, "passive seismic" was primarily the domain of those interested in earthquakes and other forms of natural seismicity. Such groups tended to use their own bespoke recorders, which may have been developed in-house or provided by specialist system suppliers. They also had a preference for types of sensors which would not generally be considered suited to typical land reflection seismic acquisition. Theirs was usually the realm of long period waves with signal strengths lower than even our industry tends to worry about, and record lengths measured in minutes if not hours or days. Their interests were separate from ours in the exploration business.

However, very approximately a decade ago that began to change. From our perspective, there were a few drivers for this. One was the shale gas and hydraulic fracking business in the USA. The need to monitor the injection process while it is happening and then record the induced seismic events thereafter in terms of permanent monitoring set-ups lead to the birth of a few specialist companies which wanted to create businesses by bringing added value to these operations and reducing risk. As the already-existing passive recording equipment was not ideal for these new services, the interest was to find ways to employ to the greatest extent possible equipment which the exploration industry was already using.

Another driver was the growing interest in land 4D surveys. Obviously, this is not a passive technique but some of the ideas behind novel ways to deploy recording systems for 4D to acquire appropriate data sets (along with the capability of some new systems to be deployed in such ways), as well as the changes that needed to be made to improve source control systems such that they made 4D vibroseis more viable, have more in common with passive recording philosophy than they do with any active surveying. Finally, there was a synergy between what some university geophysics departments were researching and services being offered by recent graduates and others who saw that some types of passive data could be used to improve processing and/or interpretation of hydrocarbon exploration-related data acquired using active/controlled seismic sources.

Many of these concepts first grew in the United States, which probably remains the main incubator of such ideas. However, bit by bit they have been taken up in other countries and adapted to the peculiarities and difficulties of local situations. For example, the infrastructure in terms of electronic and vehicular communications, and that of operational security, is generally more advanced in the USA than in some south east Asian countries which is where our company prefers to work, and this can sometimes affect how one ideally would carry out some operations. It also is sometimes the case that new methods are apparently more readily accepted in the west than the east, which may be as much to do with knowledge of how available the right hardware and software is - perhaps word travels faster and information shared more readily in the USA! These and other issues seem reflected in that the way that passive operations, and their advantages when tied to active seismic surveying, are handled in Asia.

The value of passive recording for exploration

We stated that historically passive techniques were suited mainly to the geophysicist who is not interested in hydrocarbon exploration. But now there is also a growing number of such techniques which ought to be considered by those whose job it is to find oil. Our own company does not claim that the passive techniques we herein describe are the right ones or the only ones which can help us locate hydrocarbons. However, they are ones with some track record of success and although it seems we are the very first (or one of the first) to be associated with this type of passive in this part of the world, it is likely that as other companies and operators follow, they may decide to pick on alternative methods.

As we will show, if a conventional geophysical contractor, or acquisition department of an oil company wishes to start to acquire passive data, either separately from the active acquisition or as part of it, by far the most important issues to comprehend relate to the capabilities of hardware which makes that possible. Understanding how to use such flexible equipment for passive or joint active-passive operations is the next step. We think that any competent existing crew can learn the tricks of the trade fairly quickly if they have the right hardware. Obviously, one also requires access to the necessary software, processing services, or team of people who can develop such utilities. It may also require some additional experience among those who are responsible for interpreting data.

Of course, all this applies equally to active recording. There we also need appropriate equipment, people who can use the hardware properly, facilities in house or from a service provider for data processing, and the interpreters to make sense of the data. So when venturing into passive, which can be done very gradually and often with little or no risk, in many respects there is little to be afraid of. And as the level experience increases within each organisation and in our industry as a whole, companies are likely to find their preferred methods by trial and error in their environment. With these they perhaps then develop some special in-house expertise. The great thing about passive recording in some circumstances is that, with appropriate hardware, data can be acquired virtually for free and with no risk.

Having stated the passive acquisition often carries little of the cost of traditional active recording and if carried out as part of the active acquisition phase it has little risk, as with all other areas of geophysics, the passive data collection phase ideally must be undertaken in such a way as to give operators the widest range of choices in how to use recorded data. This is not only in terms of the immediate use of the information provided but also in regard to being able to return to it at some later point and apply new or different processing algorithms.

A very simple example of recording data which gives users the greatest range of opportunities to make use if it for multiple purposes might be that on a vibroseis active crew. One usually here sets the sample rate such to acquire only the bandwidth being swept by the vibrators, since generally to go to higher sample rates using oversampling analog to digital convertors can reduce the dynamic range of the data slightly. But perhaps the passive data one expects to acquire simultaneously may have a bandwidth which requires a higher sample rate so for dual (passive and active) simultaneous acquisition, one may change the sample rate accordingly. Another example would be that many seismic recording systems have a low cut filter set at 3 Hz. This is not a problem for most active data but many passive techniques record lower frequencies so if one is simultaneously recording data for active and passive purposes, the instrument must have the facility which lets the 3Hz filter be switched out. Nb: 10 Hz geophones are still good to acquire data below 3Hz if a good deconvolution is used and some companies are even moving to geophones with slightly lower natural frequencies for the joint active-passive work. However, in our case we operate primarily with 10 Hz geophones and so far these have worked fine for us but it is good to know that with our recorder we can use a wide variety of other sensors if the survey requires.

Standard Sigma system using non-standard sensor and low cost (non-lithium) battery. Such flexibility makes multiple operation types possible.

In summary, both the recording hardware instruments and how such equipment forces itself to be used must not restrict what can eventually be done with the acquired data. As was said to us: equipment must provide “uncommitted data” i.e. data which does not lack in some sense because of the way the system forced the operation to take place, or some specification of the equipment itself. It is only because there nowadays exists equipment which fulfils these particular requirements that companies such as ours can consider the passive recording field.

Passive techniques

As long as the equipment is capable of working to this “uncommitted” criteria, then there are many passive techniques which could be considered, and the number appears to be growing. As a company we obviously do not have experience of all of them. However, we have learned that flexibility in operation procedures, as well as the owning equipment with the necessary versatility is the key to undertaking anything new.

The idea of using passive techniques in the search for hydrocarbons is to improve the value, i.e. interpretability, of the active data. This may be by reducing uncertainties in the final section through improving surface statics, or even by acting at some level as a direct hydrocarbon indicator. From our previous article in DEW, readers will know that as a small company we were very fastidious in our choice of recording system, and also that we still have only one type of instrument in our inventory on which we rely to take on a large variety of acquisition roles, which is the Sigma cableless recorder made in the USA by The International Seismic Company - iSeis. This is the recorder we can use for active and passive, land and shallow water. Therefore, whatever passive technique is being suggested only one system is available to us and that is what has to be used, nothing more. Of course, processing of the acquired data may vary depending on the client’s requirements.

It is this ability of a single recording system to do everything that is the secret to conventional land seismic contractors, and indeed acquisition departments within oil companies, being able to take on the passive recording task efficiently and economically. It most definitely nowadays should not be necessary to have multiple types of equipment to take on multiple types of geophysics. We believe that profitability and operational flexibility may be severely affected if we buy hardware which does not have all the flexibility possible. We were even fussy about wanting to choose our own batteries for the recording system (especially since we were wary of lithium ion batteries given their dubious reputation) and we were very surprised to find out, prior to make our final decision in favour the of the Sigma system, that most manufacturers insist you to buy theirs, offering no choice!

Such an approach may suit the manufacturers but as customers we must expect and demand more. When our company buys laptops or mobile phones, they can take on multiple functions and are configurable to many different tasks. It is our belief that unless a seismic recorder has the same level of flexibility, it has no right to call itself modern. So we do not consider ourselves experts at the passive geophysics itself, but more in terms of how to acquire the best active and passive data in the most efficient and cost effective way in tough locations in S E Asia.

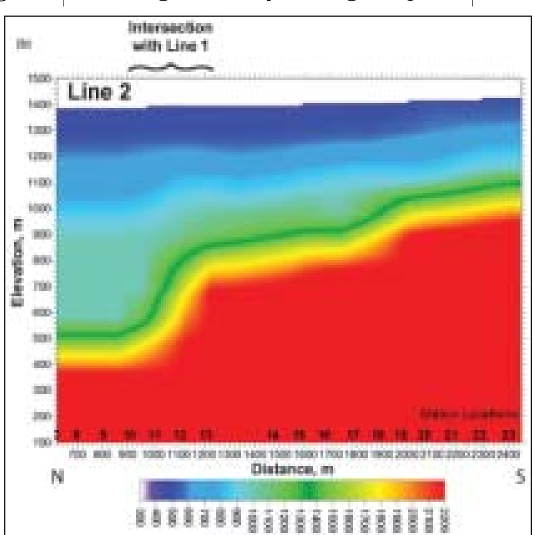
Before looking at some simple examples, it should be stressed that these are relatively new areas of geophysical endeavour to some. The industry may not have the knowledge today to get the most out of the it but the least we should do is to acquire data of the best quality so that when new processing and interpretation techniques emerge, as they seem to be doing rather rapidly, then the data is there is test the news ideas on. This is one reason why we chose a 32 bit system. A few 32 bit systems were on the market at the time we chose Sigma, and given their advantages, it is unlikely that any manufacturer will release a seismic recorder in future which is not 32 bit. This does not give us another 8 bits of useable signal over a 24 bit system (at best it's about 1-2 bits) but it does provide a number of benefits which are especially suited to cableless acquisition (and even more so to passive) including: better bit utilisation, lower power consumption, less worry about settings of preamp gain (particularly useful for joint active-passive) and better overscale recovery. These are not minor advantages.

ReMi operation using Sigma system, Old City, Quito, Ecuador. Courtesy iSeis.

Our first passive example is one called Refraction Microtremor which is used to reduce uncertainties about surface behaviour. For many locations, understanding the surface is one of the most challenging tasks in geophysics so any assistance that can be applied ought to be something everyone would gratefully accept, especially since acquiring the data often presents no extra difficulty over acquiring the active data which one is already committed to do. A similar technique is Multiple Analysis of Surface Waves, which we have not so far been engaged in, but MASW and ReMi have both been used in many places around the world to improve hydrocarbon exploration and for other work. Obviously, the processing used on these two techniques is different but the data acquisition phases have much in common. Therefore, should our company need to get involved in MASM, it is good to know we have the hardware already on hand.

The ReMi method makes use of lines of either single component or 3C sensors (preferably analog sensors due to their superior noise performance over digital sensors). These lines can be a low numbers of channels if undertaking passive-only survey, or can be many hundreds as these would simply be the same channels as are already being deployed for active exploration where the channel count is as high as the survey dictates. As the laws of physics do not change whether we acquire active or passive, of course the depth and resolution of the ReMi data is governed by the same rules which affect active data. But given the level of energy we need to record for this process, passive recording times may be long compared to active recording. This is generally not an issue as equipment just needs to be left on and digitising after the active recording has been switched off, perhaps overnight. The active and passive records are separated later - in fact the Sigma system has options to allow this to happen automatically. The ReMi process needs some level of noise being generated locally such a the movement of people or wind noise in trees, but this is generally not an issue for S E Asia. ReMi processing outputs shear wave profiles from shallow parts of the spread and compression waves velocities can be estimated using appropriate conversion factors.

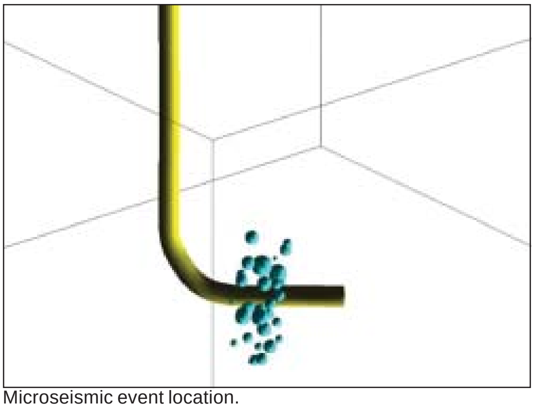
Many companies have other methods of picking statics but ReMi is a very low cost method of adding quality control to active data. By possibly adding to what is known about the surface, some see this as a way to improve some details at target depth too, such as layer thicknesses and velocities. Simultaneous active - passive recording can also use tomographic techniques based on the naturally generated energy at depth which again, making assumptions of how the energy travels, can be used to give information about deeper structures.



2D velocity model generated from Sigma deep ReMi profiles in an urban setting. SeisOpt ReMi software used for the analysis.

In terms of direct hydrocarbon indication, this seems to be an area which attracts some controversy. From our standpoint, the aim is just to acquire the necessary data and leave the rest to the geophysicists and their computers. But DHI processes always excite the industry so it is worth mentioning the broad principles of this from our own perspective.

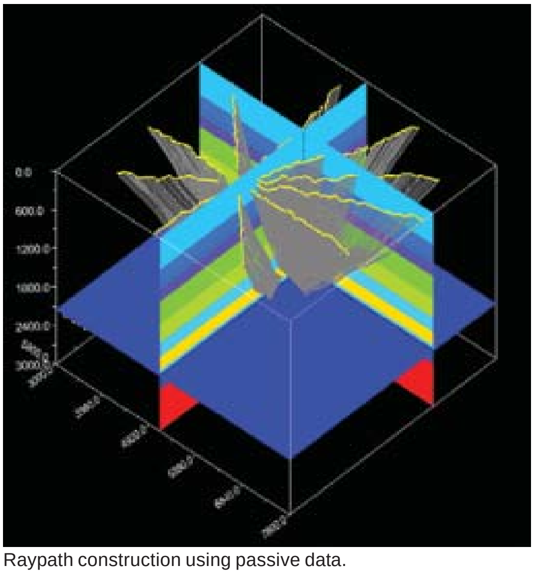
These techniques assume that a reservoir can react to external impulses in many ways, not just reflect P-waves off its surface during active acquisition. The most commonly cited example is that of the oceanic tides creating forces which transmit to hydrocarbon reservoirs. These in turn respond by emitting some characteristic signal which, it is claimed, can be recognised by those with the appropriate expertise and equipment. For the oil explorationist, the interest is probably more in line with seeing how the reservoir behaves over longer periods (minutes rather than seconds) after it has been hit by the shock waves created by some controlled seismic source. Here the expectation is to see frequencies below those we normally are interested in, namely less than 3 Hz.



Microseismic event location.
Courtesy GeoGiga.

Much of the industry already knows about frac monitoring at least at some basic level. This and micro-seismic monitoring related to fracking are growing businesses. It seems that many more contractors are likely to want to be involved in such recording in the next few years and third party software is already available for event detection and location. Again, the only issue is choice of suitable instrumentation.

As was mentioned, it is our impression that land 4D (time lapse 3D) surveys are also going to be an area which may just become naturally part of what many contractors offer. Such surveys have mostly been considered as useful for following the depletion of hydrocarbon reservoirs. However, we also see a growing interest in CO2 sequestration monitoring. In either case, such surveys on land present special challenges, which many have considered only in terms of issues relating to the source itself. Whereas we do not disagree that improving source characterisation is imperative if 4D is going to become more useful, some understanding of advanced source control and also how the 4D data is recorded is just as critical. Experience gained in the use of equipment for pure passive recording (i.e rather than active-passive) in which one can be more fussy about how equipment is deployed, potentially comes in most useful. Again, as we will describe in the final section of this article, equipment and how it is employed must be the main consideration. 4D relies generally on equipment being permanently deployed, or (much less favourably) the redeployment of equipment in the exact same locations at regular intervals. It is good to have hardware in one's inventory which allows both, and facilitates precise redeployment if that approach is chosen. Source control is the next issue.



Raypath construction using passive data.
Courtesy GeoGiga.

4D surveys attempt to see from one "snapshot" to the next changes in geophysical response which can be interpreted as fluid or gas movement in the reservoir. However, in many case, especially if reservoirs are large and thus being drawn down very slowly, these changes even on an annual basis can be extremely small compared to changes in source performance. Standard source control techniques, at least in as far as vibroseis is concerned for active recording, generally have not concerned themselves with the minutiae of source performance changes from one sweep to the next, whether it is on the same Vp or after move up. Source QC in active recording is looking at grosser issues such as distortion or difference in phase between vibrators in a group. 4D source control, needs to be much more accurate and the science seems to have made some progress in the last year.

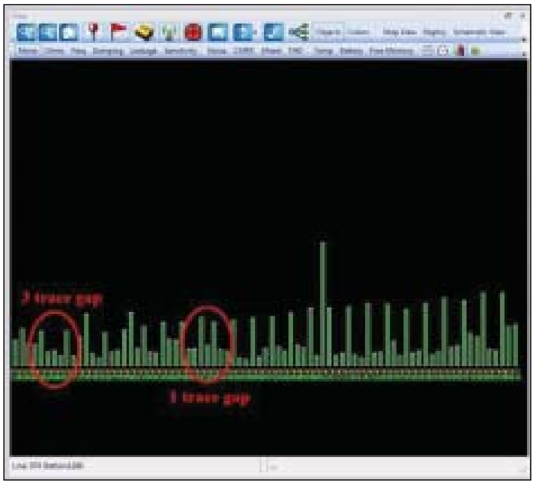
Given that such source control needs better data from the deployed arrays, then we see the synergy between good source control, the capability for the recorder to be used very flexibly for passive techniques. This is why we have included 4D in this article on passive.

Hardware for passive recording

Our previous DEW article went in to some detail about the reasons behind our equipment choice. It seems fair to say that our now proven ability to take on such a variety of geophysical acquisition techniques rather well vindicates the time we took to examine in great detail the claims made by the different recording system manufacturers about their various instruments which, as a new contractor to land and shallow water acquisition, were all then available to us. Therefore, it is worth briefly going over some of those thought processes again here before discussing in greater detail the hardware which is suited to both active and passive.

A new operator cannot afford to make the same sort of mistakes that bigger contractors can and do make. If we chose an instrument which restricted the variety of work we could bid for, or made it difficult to undertake such operations to the highest level of HSE requirement and data quality (as well as of course profit) then that inevitably sooner or later would seriously affect our viability as a company.

CellSeis's initial thoughts were in regard to wanting to be able to undertake the widest range of active acquisition that might be required in south east Asian environments and to be able to do them efficiently. These are generally not simple places to operate, often needing to deal with jungles, security issues, areas of elevation change, high population density, and work across rapidly changing water bodies, both fresh and salt water. All this requires hardware with the sort of flexibility which was not imaginable just a few years ago. Further, most such work requires impulsive sources and we were also very conscious, while source control does not get the same amount of column inches in geophysical magazines that recording systems does, that source control technology would also be an important part of the total flexibility equation. This meant we had to look at recording and source control systems individually in their own right and how well they were suited to our needs, but also in terms of how such systems could be interfaced to do provide the extra layers of flexibility we required.



Realtime noise monitor data supplied over Sigma mesh radio system. It also indicates any problems in the line.

It was rather easy for us to eliminate any telemetry cabled system from the products we had to select from. It is a simple matter to see that cables are still probably a good way to undertake acquisition in logistically simple locations such as deserts but we did not envisage tendering for much desert work. That meant we decided to work without cables and investigate only cableless systems. There are many types to choose from broadly fitting into those which are supposed to be able to communicate wirelessly and those that are designed not to, i.e. so-called shootblind systems. After some investigation, we found that the dividing line between these two groups can be rather unclear as it seems some systems which have been designed with a communication capability have had rather limited success is making it work in anywhere but the simplest of places. Obviously, we suspected that the manufacturers of some such systems tend to keep this sort of thing quiet but one increasingly hears tales of such cableless equipment owners being rather embarrassed about not checking out the technology sufficiently in advance. It seems, even when it comes to expensive seismic recorders, the old adage “let the buyer beware” also applies.

We could not envisage operating “in the dark” either with a cableless recording system which was deliberately shootblind or one which became so in anything but simple environments. We were already aware of companies which used this technology and came back from the survey with such poor data that they had to reshoot, or that the processing had become so troublesome as a result of their being no noise monitoring during acquisition. Such instruments also seemed not just to have an unenviable history of occasionally substandard data acquired but also a record of security issues with equipment theft. Perhaps large companies can afford to lose ground electronics, batteries etc, and be forced to re-record data, but this is not the case for CellSeis.

We thus only considered systems which could assure us they would provide at least some level of communication in the very tough locations we planned to operate while being simply to deploy, and demonstrate that they had done this already. This means being able to work in jungles and population centres where transmission problems in terms of interference and absorption for the 2.4 GHz licence-free band are the greatest. Once again, our decision to look only at hardware with a track record of being able to work in such difficult locations turned out to be fortuitous in more than one way: within the last month or two, it appears the system manufacturer whose equipment CellSeis ended up using has started to sell kits of their ground channels to users of "operate in the dark " cableless systems in order to "give some sight" to those recorders.

Having herein possibly appeared to be somewhat negative about both cabled telemetry and shootblind cableless systems, we appreciate that both technologies have their place but from our perspective that place is not in difficult environments or flexible passive acquisition. Nevertheless, it seems to us that the future is not one of only-cable or only-cableless. Both approaches have their advantages so the future is likely to be for hybrid instruments, or at least for instruments with hybrid capabilities. In this case hybrid not only means the ability for cableless and cabled units (including those from different manufacturers) to work side by side, it must also mean that even the cabled portion of the system must have levels of flexibility which currently are not common in most such recorders on the market - even some of those very recently introduced.

For example, being able to attach telemetry cables to cableless ground units has some advantages but being able to use such cables in a networkable fashion does away with the serial dependency issues which most cable systems and one or two cableless systems are still limited by. This networking capability would not only endow recorders with a sort traditional cabled system functionality but also enable telemetry cables to be used selectively on a spread in far more flexible ways. The idea here is for such cable networked section then to be part of a wider network, which may be wireless based. This after all is little more functionality than we expect inside buildings which have cabled ethernet and WiFi access points. We are pleased to see that such versatility now does exist in some equipment. Our broad choice of technology to use has also been further vindicated very recently because we have just been asked back to a jungle location to perform more work where other systems, apparently, struggled.

We stated in our previous article that we expected to have to undertake passive recording one day and wanted equipment which could cope, even though at the time we imagined it would be quite some while before we were called on to acquire such data. In fact, we should qualify this and state that the passive work is mostly really joint-active passive, i.e. gathering data for some of the passive types of geophysics described above. It should be clear that many types of passive recording place strains on recording equipment which active recording tends not to. Thus, we can make the sweeping statement that systems which successfully handle passive must generally be more capable than those just handing active. However, undertaking joint active-passive is a step further still in necessary flexibility.

The requirements for an ideal passive system were covered in First Break magazine, Vol 29 by R G Heath which we found a useful starting point. In our recent DEW piece we mentioned the sort of features to be considered when looking at instruments for active and passive in challenging locations. We stated that the most important issue is to understand the limitations imposed, not by engineering, but by the laws of nature on how we can reasonable expect systems to perform. Wireless communications must compromise between range, bandwidth and what is referred to as "ease of set up". We discovered this for ourselves operating in thick rain forest where there was no line of sight between adjacent ground units due to vegetation thickness, especially where ground box to ground box distance was large, as it can be in passive operations. The system we employ comes as standard with a mesh radio network (MRN) which does not claim high bandwidth but even with simple deployment effort it is able to transmit just about everything else one would typically expect from a fully fledged cabled system with huge data transfer capacity. This includes noise monitoring, security information, GPS, battery and sensor and system health etc. Everything except the seismic data file itself in fact.

When we needed to be more flexible with the mesh, then we could increase deployment effort on a channel by channel basis simply by adding an omnidirectional repeater wherever necessary. Literally this mostly meant nothing more than plugging in the repeater to a battery. It could then be put up in the lower branches of a tree or the repeater antenna pole located in the hole provided in the ground unit for this purpose.

Sigma system showing Mesh Radio repeater in thick jungle. Note: no line of sight exists to neighbouring ground units which in passive operations can be significant distances away, demonstrating the unique ability of the system to operate in such modes.

Sigma ground unit with ultra sensitive Guralp sensor attached. Ability to use wide variety of sensors, and (where appropriate) provide remote control for their power are unique features of Sigma system and essential when desirous to offer variety of passive services.

Ongoing testing and characterisation of Sigma system by manufacturer, this time in different cereal plantations. Here showing requirement for directional antenna for long range high bandwidth communications at 2.4 GHz. Omnidirectional antenna in this situation are unreliable due to signal absorption by green vegetation.

Sigma hyMesh option. Simply plugs into Sigma ethernet port to provide mesh topology ultra high bandwidth for realtime data (10 - 20,000 channels capacity claimed) even in tough environments.

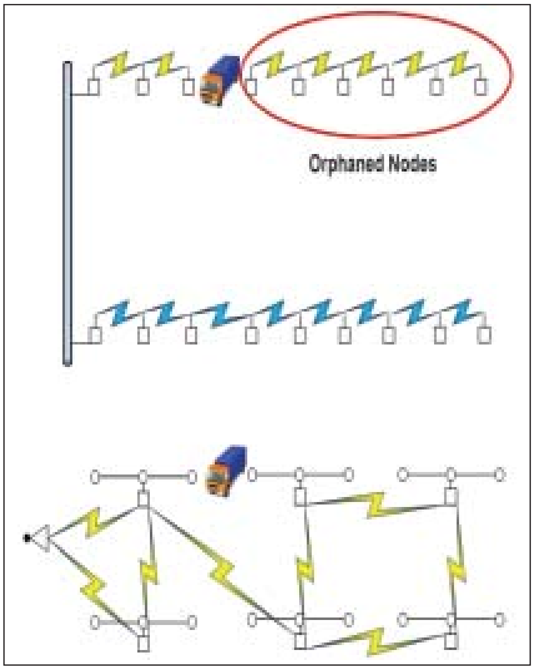
> "As CellSeis now recognises that more of its services may be taken up in passive recording we are pleased to see that iSeis has recently undertaken some testing of new technologies to extend yet further the flexibility of the system. There is a great deal of work going on around the world in new communications protocols and technologies, and most of them are likely to be industry standard"

This has provided great flexibility and, very importantly, overall ease of deployment for both active and passive operations.

When acquiring passive data on its own, it may be that trace intervals are much longer than is typical on an active survey. In this case, the equation linking range, data rate and equipment ease of set up means one may use more repeaters than otherwise but this is very simple to do and also low cost in terms of equipment and battery power. Therefore, it has become of such little consequence that we routinely employ them in almost all situations in jungle environments. But the important thing is that the system comes with this capability. If it did not, then active surveys may have been more difficult to undertake, but passive work may have been impossible. There are also passive surveys we are now considering where far greater transmission bandwidth is required in jungle and in this case we have the option to use different transmission protocols with the Sigma system (simple plug in to the Ethernet port of the Sigma ground unit) which support such bandwidth even in tough areas using a mesh topology rather than a point to point method, such as the SRD hyMesh option.

The system we use is also able to cope with a wide range of sensors, giving us the ability to record down almost to DC and with high sensitivity, as well as to provide remote control to the power of any active sensor attached to the ground unit - which is very important in terms of energy-saving. The downside of all cableless systems is the number of batteries they need. We have learned ways to handle large numbers of batteries in difficult areas, but energy usage is still something to be considered at all times and especially with passive surveys. A cableless system should offer the option of different battery chemistries, as this is very useful in passive recording. In our case, such choice meant we were not forced to use any lithium battery at anytime (which we were desperate to avoid given their cost, unreliability and other issues) and we could choose battery capacity to suit recording requirements, often from local suppliers.

As CellSeis now recognises that more of its services may be taken up in passive recording we are pleased to see that iSeis has recently undertaken some testing of new technologies to extend yet further the flexibility of the system. There is a great deal of work going on around the world in new communications protocols and technologies, and most of them are likely to be "industry standard". A seismic system which can make use of these has huge advantages not just for the relatively simple operation of active recording but also most importantly for the usually much more challenging passive recording. Here, as described, the industry does not know what new techniques will become common tomorrow, but any contractor trying to work within fixed budgets and ramin technically competitive would surely want to be have equipment which can keep up with the times by the use of plug in or plug in options.



Mesh topology versus point-to-point for wireless communications in difficult areas. Mesh based topologies offer multiple paths so provide much more reliable transmission.

Sigma central system in jungle environment, observer sees real time status of all equipment, essential for best quality data in passive operations.

Some of these new comms technologies may turn out not to be suited to the tough environments we have to work in, and that is another reason why we are pleased to see the trials that go on with such technology at the testing grounds of iSeis. However, for those existing or new technologies which can bring value to the services we offer, whatever they may be in the years to come, it is a great bonus to know they will be at our disposal, not just to assist us as a company in a competitive industry, but also to help the science of geophysics take its next steps.

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about the author

Colin Fleming is the Managing Director and equal partner of Cellseis Geophysical (CSG), which is a company, started in 2008 in Dubai, United Arab Emirates. Colin has 38 years experience in the Seismic industry, starting with Western Geophysical in London working on projects in the North Sea, Africa, Mediterranean, Iceland, Norway and India.

CSG in its first years carried out mainly marine Seismic in the MENA region. Three years ago. CSG decided there was a niche in the market for Smaller seismic surveys in more difficult areas and this is when CSG decided on Wireless systems and one in Particular, as this system had all the attributes that we required, such as online QC and easy to use systems with easy to use equipment and acquisition Software.