Cableless Confusion

无线采集设备之混淆

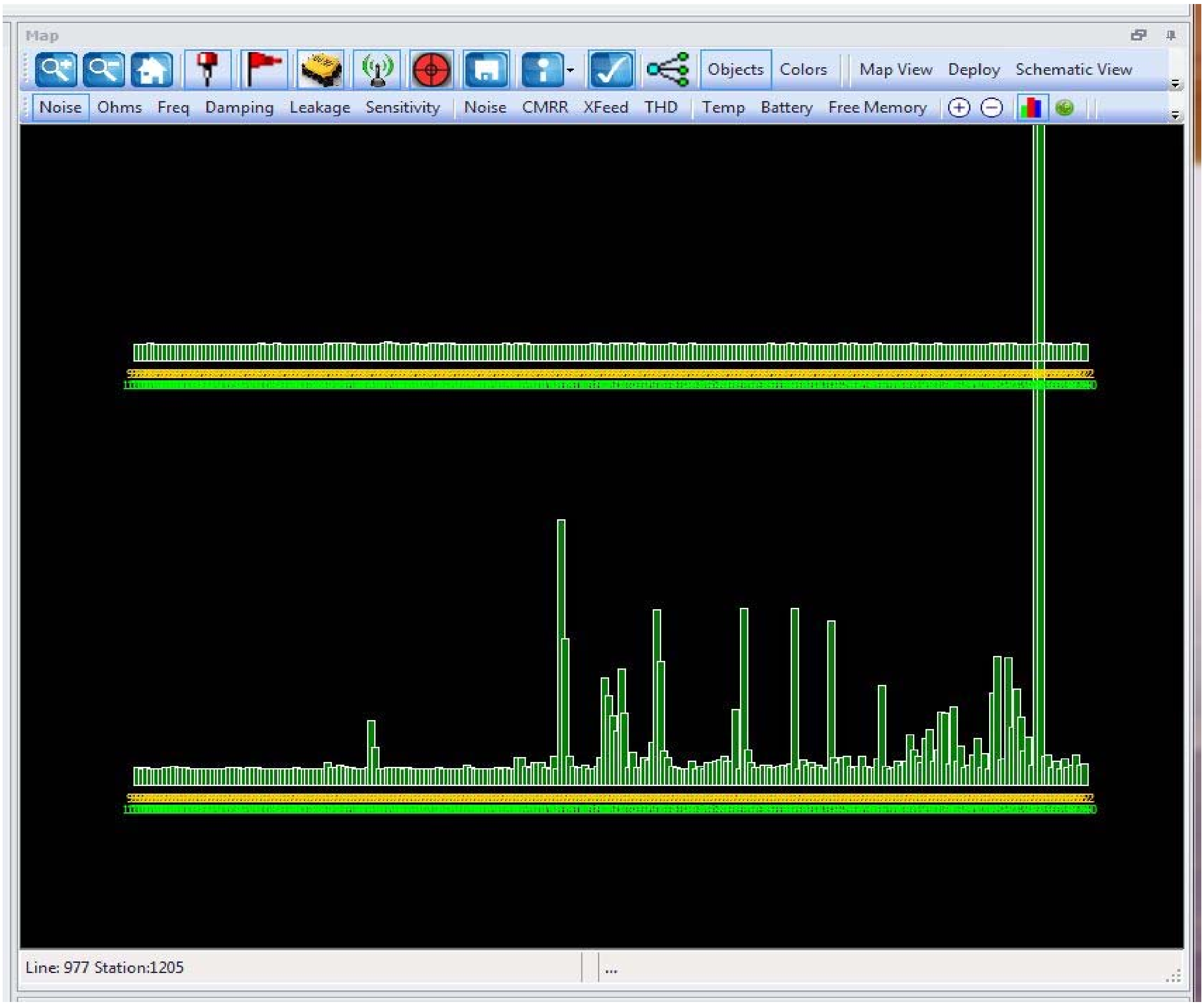
With around a quarter million cableless seismic channels sold in the last few years, there is no doubt that such equipment is here to stay. Most expect it to take an ever growing share of the land acquisition market. But with so many different types of system to choose from, do some approaches to cableless acquisition have advantages over others?

在过去的几年中， 共计大约有 25 万道无线地震采集设备销往物探设备市场，毫无疑问此类设备将会久居市场。大多数人预期这一设备在陆地采集设备市场中所占份额会不断扩大。但是，目前可供选择的无线采集系统种类很多，那么，是否其中的一些无线系统较之其他品牌确实具有其独到之处呢？

Nowadays, the industry accepts cableless with few questions asked, such is its desperation to get away from the disadvantages of cable. The main one of these was often said to be weight, and it was difficult to disagree. With the exception of some rather uncommon combinations of trace interval, sensor type and choice of cableless system to compare to a cabled one, a cabled crew is always going to be heavier. (For those who doubt this, it is suggested they review the First Break article of June 2010 "*Weighing the role of cableless and cable-based systems in the future of land seismic acquisition*" and do the maths themselves). But in these days of more complex acquisition, weight as the worst attribute of cable is now being surpassed as users find this old technology just too user-unfriendly to take on new types of exploration. Cable recorders were devised at a time when simple 2D or 3D CMP acquisition summed up the main types of survey being considered so flexibility did not need to be this equipment's trademark. However, today, inspired by the greater demands of this industry, novel geophysical techniques need recorders unrestricted in any way by hardware.

当前，无线采集技术在被物探行业认可的同时尚存在几点疑问，例如其是否能彻底摆脱有线采集系统的缺陷。其中大家一致认为的一个主要问题便是关于设备的重量。当采集项目遇到一些不正常的道间距和检波器类型的组合时，相比无线采集系统，有线设备地震队的装备重量总是变的更重。（如对此有质疑，可查阅在 2010 年 6 月出版的“地震波初至”杂志中发表的一篇题目为：“*权衡无线和有线采集系统未来在陆上地震采集中扮演的角色*”的文章，并可自行进行数学计算）。但是在采集项

目日益复杂的今天，对于有线系统而言最不利的重量特性现正在得以突破，因为客户们发现这种旧技术缺乏友好的界面，无法适用于各种新型的勘探。常规有线记录仪器是在仅考虑到简单的二维或三维共中心点（CMP）采集方式加上主要的测量手段时发明的，此类设备的商标可忽略其灵活性。而当今受地震采集设备巨大需求的启发，新的地球物理技术需要采用不受任何硬件限制的记录仪器。



But despite this, cableless kit should also come with a health warning for reasons which are not at first site obvious. Just as there is little to choose between the few different cable systems in terms of flexibility, so the way you might use each of tends to vary little. But there is much more choice when it comes to systems which allow operations without cables and it is this variety which can cause problems. There are about ten cableless recorders available nowadays and they differ rather greatly from each other in features and functionality. So suddenly it is essential to understand the difficulties that each type may bring.

尽管如此，由于一些并非显而易见的原因，无线采集设备整体系统包的应用也应含盖健康警示。正如在灵活性方面在为数不多的各类有线系统之间选择性不大那样，其操作手段也十分单一，变化不大。然而对于那些可允许使用无线采集系统作业的项目来说， 可供选择的无线设备种类繁多，设备的多样性也会产生问题。目前，市场上大约有 10 余种无线记录仪器可供选用，它们在各自特性和功能方面差异很大。因此提前了解各类无线设备可能会带来的问题至关重要。

Such problems are best understood if we consider what is inherently different between a generic cable system and a cableless one, and the different ways this forces us to operate. Cables were there for a reason - three reasons in fact. The first was to send out timing to remote units, the next was to send out remote controls commands and the third was to carry back along the cable any QC, status information and lots of seismic data. Every cableless system manufacturer had to consider whether to incorporate some wireless method to mimic these functions, or come up with a reason why it's no longer needed.

只要我们能充分考虑常规有线系统与无线系统之间存在的内在差异，以及不同仪器所需采取的不同操作方式，就可以得到这些问题的最佳答案。有线设备中电缆的使用基于下属三个原因。第一，向远程采集站发送计时信息；第二，发送远控指令；第三，通过电缆传回质量控制（QC）、采集状态信息及大量地震数据。无线系统的制造商都要考虑是否要结合一些无线方法来模拟这些功能，或直接提出舍弃这些常规做法的原因。

There is a common belief that this problem timing is entirely solved by putting a GPS receiver inside each remote unit. Where ever you can pick up GPS signals - problem solved. But that is not everywhere. GPS receivers have become very sensitive, you can bury them some centimetres down and still pick up GPS as long as the dielectric properties of the ground permit. But a sudden rain storm can change all that, and GPS has also been reported lost for conditions ranging from freak weather to sand storms. The lesson here is that the seismic environment can always find way to fool us. Making a system reliant on GPS reception means you might end up with no useful data at all when GPS is not available.

大家普遍认为，计时问题已经通过在各远控采集箱体内安装一台 GPS 接收器的做法完全得到了解决。在能接收到 GPS 信号的采集区域这个问题引刃而解。但该问题并不是在任何地方都能解决。GPS 接收器十分敏感，将它们埋置在数厘米的地下，只要地面的介电性能允许，仍能接收 GPS 信号。但是在突如其来的暴风雨条件下会改变这一切，在恶劣天气或沙尘暴条件下，GPS 信号会接收不到。由此可以得出一条经验：地震环境总会"愚弄"我们。如果采用一个依赖于 GPS 接收方式的系统，那么只要 GPS 无法工作，最终采集的地震数据都是毫无意义的。

So do we do nothing about this and hope for the best, or can some insurance be built in? The first thing to do is incorporate a clock in each ground unit which remains accurate even over long periods with no GPS signal, ideally a few hours. As this costs money and takes extra power, few systems bother. The next issue is to cope with is when there is no GPS at all. A handful of products were devised to work without GPS timing believing that some other form of radio-based synchronisation was always going to be a better bet. For example, they used a VHF frequency which can naturally penetrate further through foliage than any GPS signal as it has longer wavelength. One system, the Sigma system from iSeis, has the best of all worlds by use of GPS and a very accurate clock as the basic system, thus being able to cope with intermittency, and the option of VHF-based timing for when GPS is illusive. In all cases, given seismic data's dependence on very accurate timing, surely the most important thing is to be able to monitor when the grounds units are getting no synchronisation signal. However, very strangely, few new products have made this available - again Sigma has.

那么，我们对此只能束手无策或期待奇迹发生呢还是可以在 GPS 接收器内安装一些保险装置？首先要做的是在每一个地面 GPS 接收装置中设置一台时钟，这个时钟应能保证在没有 GPS 信号的情况下仍能保持长时间精确计时，理想状态是能保持几小时。由于这种做法成本高，且耗能大，几乎没有厂家的无线系统采用此计时方法。另一个问题是解决根本没有 GPS 信号的问题。很多同类产品都是针对没有 GPS 计时的情况所设计的，因为人们都坚持认为基于无线电的同步计时器更可靠。为此，他们采用一种超高频（VHF）频率同步器，由于其波长更长，比 GPS 信号更容易穿透叶丛。而 iSeis 公司开发的 Sigma 无线采集系统则具备全球最佳的兼容性，该系统既可采用 GPS 和一台非常精确的时钟作为基本接收系统来应对 GPS 信号时断时续情况，也可以在 GPS 信号非常微弱的情况下采用基于超高频（VHF）的计时方式。这样即可在各种情况下依赖十分精确的计时装置，保证采集的地震数据的可靠性，当然另一个至关重要的事情就是能在地面无线采集箱体得不到同步信号

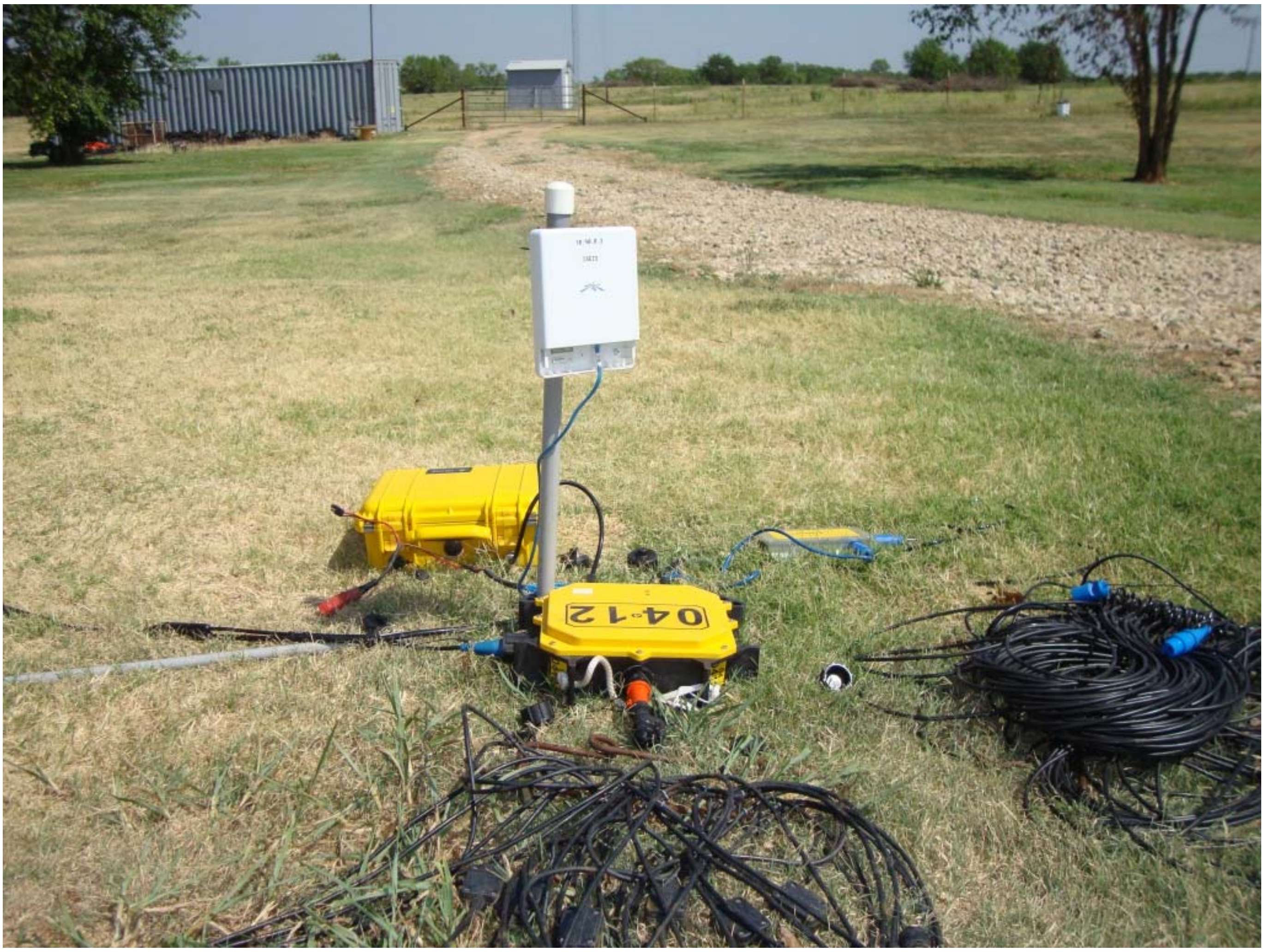
的情况下能够对其实施监控。纵观无线采集设备市场，奇怪的是鲜有其他品牌的同类产品能够实现上述功能，但是只有 Sigma 系统具备此先进特性。

The next function performed by cable was sending out remote control commands. Some systems have decided not to bother with this, claiming it is not necessary to change any settings during acquisition. But this misses the point. Remote control in cableless recorders is to deal with power consumption. Whether batteries are a great advantage or a huge hindrance in cableless recording depends on whether you can control how much power is used. Cabled systems come with the choice using fewer batteries but which are be very large and require changing rather regularly, or smaller batteries which are greater in number but last longer. Each method has pros and cons but in all cases cableless systems allow users to switch off when power is not needed, and also to monitor remotely how much power remains in each battery.

通过有线电缆实现的另一功能是发送远程控制指令。某些系统已经决定不再关注于此，声称没有必要改变采集过程中的任何设置。但此类系统却没有领会要点。无线记录仪器中的远程控制主要应对解决能耗问题，蓄电池对于无线采集系统而言是一大优势还是巨大障碍取决于你能否对能耗进行控制。有线系统所提倡的是应用数量较少但体积较大且需要定期更换的蓄电池组，或体积小但数量众多的能够持续时间更长的蓄电池组。两种方法各有利弊，但是在任何情况下，无线系统可以允许用户在不需要供电时关闭电源，而且还可以远程监控每个蓄电池组中的剩余电量。

To go cableless, which inherently requires many more batteries than almost any cabled configuration, and not be able to control or monitor power is asking for trouble. Some say that problem is made even worse by the use of lithium based batteries. The extra power density of lithium is often cited as the thing that overcomes the power wastage if not able to remotely switch off the ground unit but reliance on this battery chemistry is a risky thing since it tends to be fussier about operating temperature and way it's charged. It is also much more expensive as are the chargers, and there are reports of lithium batteries exploding which is why some airfreight companies will not carry them. The worst of all worlds is probably the use of an internal lithium battery which seems to be just asking for trouble giving its predilection for erupting.

对于无线系统而言，它需要比任何有线采集配置更多的蓄电池组，若不能对其实施控制或监控其能耗，将会是自寻烦恼，有些人表示采用锂蓄电池会使问题变的更糟。如果不能通过远程控制来关断地面采集箱体的电源，则为了避免电能浪费，常会采用更大的蓄电池功率密度，但是依赖于蓄电池化学成分是有一定风险的，因为它对作业温度和充电方式要求苛刻。充电器价格也十分昂贵，有很多关于锂蓄电池爆炸的报道导致一些航空运输公司严格禁运锂蓄电池。最坏的情况可能就是利用内置锂电池了，这有可能引发爆炸，造成麻烦。



Next is the issue of sending back QC, noise, status and seismic data. In the cable world, this can be considered as more or less one function but it would be a mistake to think of it in this way when coming to cableless. The reason is that the amount of data involved in sending QC, noise and status back from the spread to the observer is a tiny percentage of what is involved in carrying seismic data files. This is an essential distinction because wireless technology handles low bandwidth rather well whereas even today, high bandwidth transmission in the seismic environment comes with many hurdles.

下一步就是关于质量控制、噪声、状态及地震数据的回传问题。对于有线系统，这可以或多或少被看成是一项常规功能，但对于无线系统，依然这么想就是错误的。原因是从地震排列向仪器车传回的质量控制、噪声和状态数据的数据量仅占传送的地震数据资料的一小部分。这是一个本质上的差别，因为直至今日无线技术能够很好地处理低带宽传输，而在地震勘测环境中的高带宽数据传输依然存在诸多障碍。

Nevertheless, some systems force the operator to live without any QC, status or data at all, so-called shoot-blind operations. This used to have some advantages where the deployment of such ground units was simpler than deploying those where some form of complex radio comms had to be established. But nowadays, as some manufacturers recommend that their shoot blind units are buried to avoid theft, this seems to remove any advantage of rapid deployment, especially bearing in mind that systems do now exist with mesh radio networking technology built in. These are just as easy deploy as any shoot blind equipment, do not come with any recommendation to be buried and take away the risk of theft, and of recording bad data while not knowing about it. Such mesh radios can be used to send back all sorts of information including GPS reception strength, as well as have the benefit of allowing remote control of ground units, thus simultaneously solving the battery usage problem too.

然而，有些系统迫使操作人员在根本没有任何质量控制、状态或数据的情况下进行操作，即所谓的“盲采”作业。当与部署一些形式复杂的无线电指令相比，部署这样的地面装置更为容易时，此类操作会具有一定的优势，而目前由于一些设备厂商建议将“盲采”装置埋设在地面以下以防被盗，这似乎使得快速部署的优势不复存在了，特别要注意的一点是现在的无线系统均内置有网格无线电网络传输技术。它们和任何“盲采”设备一样易于部署，无需通过埋设来消除被盗的隐患和在不了解情况时记录不良数据的风险。这类网格无线电传输装置可用于传回各种信息，包括 GPS 接收强度，以及实现对地面采集箱体的远程控制，因此也可同时解决蓄电池使用的问题。

When it comes to real-time transmission of seismic data, there are various approaches on offer. Frankly, all of them have some level of drawback. Perhaps most capable is that demonstrated by iSeis’s Sigma system which can be used for both passive and active recording, e.g. it is currently being used to provide real-time transmission from a passive spread of 750 sq.km. for over two years, 24/7 - probably a world record.

对于地震数据的实时传输，有多种方法可以实现。坦率地讲，所有方法都有一定的弊端。iSeis 公司的 Sigma 系统所展示的数据实时传输方法应该是最有效的，这种方法可用于被动和主动采集，例如，目前 SIGMA 系统正被应用于一个面积达 750 平方公里的被动采集项目上进行数据被动采集和实时传输，该项目已开展了两年多，这可能创造了一项世界记录

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But if you choose hardware which either does not offer real-time data return, or you use it in a non real-time way, then sooner or later you have to retrieve data from the ground units. Here, there are two broad choices - systems where the units must be collected up and taken to a central location where they are attached to some sort of rack and the data sucked out, or those where you have the option to go to where the unit is deployed and copy the data while the box is still recording. Some obvious benefits of the latter approach are that it is much faster and that less equipment is needed. If you do not have to pick up boxes just to get your hands on the data they can stay doing the job they were purchased for.

但是如果你选用的硬件不能提供实时数据回传，或是不以实时的方式进行操作，那么人们为了得到采集的数据，迟早必将需要到野外从采集箱体中重新回收数据。此资料回收方式大致有两种选择——一种是要求必须将装置收集到一个中心位置，在此连接到某一机架上来获取数据；另一种则是，你可以到达部署装置的地方，在采集箱仍然记录数据的同时抄写数据。后一种方法具备几个明显优势，即速度快，所需设备少。如果你不需要拾取采集箱，只是人工抄写数据，那么设备可以这样一直不停地工作。

Then comes the issue though of how to get the data out, something which is usually referred to as harvesting. As almost all cableless recorders are continuous record systems, it is useful to have the option only to take out data relating to reflection seismic files, and to ignore all the stuff in between. On impulsive crews, this saves a significant amount of harvesting time and so may affect the choice of technology used in actually transferring data from the internal memory of the ground unit.

还有一个问题是关于如何读取数据的，即通常所指的“数据收集”。因为几乎所有无线记录仪器都是持续性记录系统，可以选择只读取有效反射地震数据的选项，忽略中间过程信息更为实用。对于脉冲地震对而言，这样能够节省很多数据读取时间，因此可能会影响在实际传输地面装置内部存储器的数据时采用什么样的技术。

So what is the ideal way to transfer data? The answer is that there is no single best way but to have only one method has been found to be a severe limitation when operating in different environments. A very useful option is the ability to record not just to internal memory but to some detachable external memory simultaneously. This enables data harvesting to be instant, which is especially useful when birddogs want to get their hands on data for QC, and it also overcomes the occasional problems of using wifi for harvesting. The iSeis company has just recently added this features to its Sigma system.

那么数据传输的理想方式是什么？答案是没有一种单独的最佳方案，但只采用一种传输方法对于在不同环境的作业来说是有着严重局限性的。有一项很有用的数据记录方式，不仅可把数据传输到内部存储器，同时还可以传输到可拆分式外部存储器。这能实现数据快速采集，这一点对于监控人员实施数据质量控制来说特别有用，还能克服有时利用 wifi 进行数据回收时出现的问题。近日，iSeis 公司已经在他们的 Sigma 系统中增加了这一性能。

As we see, there is great choice in cableless with some manufacturers having decided to offer much more versatility than others. If the future of a seismic contractor is in being able to get the greatest use out of one set of equipment, it seems that the most flexible systems are going to be the winners.

正如我们所见， 一些设备生产商决定开发能较之其同行设备更具多功能用途的无线设备。如果地震采集承包商的未来在于能最大程度地利用一套设备，那么似乎灵活性最好的系统可能会最终胜出。