Introduction:

The troublesome nature of seismic cables is evident throughout the industry. The problems with seismic cables are manifest in the equipment design, field operations, survey design, data processing and interpretation.

The burden of the seismic cable is demonstrated in our approach to acquire data. A typical seismic prospect is composed of equally spaced receivers placed in-line, while a group of receiver lines are placed parallel to each other, also equally spaced apart. To acquire 3D seismic data we have evolved the practice of positioning multiple 2D lines into a Euclidian array on the Earth's surface. The decision for how far apart our receivers may be placed must be made well in advance and the seismic spread cables manufactured specifically to create this spacing. The fact that we deploy seismic spread cables in this fashion limits the options available to the survey design, inhibits the flexibility to overcome field obstacles for the contractor, constrains the capabilities for data processing and ultimately affects our capacity to interpret the acquired seismic data.

Seismic operations have been contending with the limitations and pitfalls of seismic cables since the first contractor began to acquire seismic data. Over time the problem of deploying, maintaining and retrieving the seismic cables has grown as the channel count has continued to increase. The trend of increasing the seismic channel count has shown no indications of flattening out. Indeed many in the industry are predicting tremendous increases in the near future (J. Norton, 1997, B. Heath, 2007, D. Freed, July 2008, L. Durham, Nov. 2007).

The initial cost of cables is only the starting point. The day to day activities of a typical field acquisition crew centers around the 'health' of the cables. Dealing with seismic cables impacts many aspects of a survey:

- Health, Safety & Environmental issues (HSE) due to the weight and cumbersome nature of the cables plus the need to visit receiver locations multiple times to deploy, troubleshoot and retrieve the cables
- Crew personnel and vehicles to deploy and retrieve the cables
- Additional personnel and vehicles to troubleshoot the defective cables and replace them prior to and during production
- Personnel to repair and maintain the cables
- Added expense to replace and maintain the defective cables
- Limitations as to how the equipment can be deployed when encountering no-permit zones or other obstructions
- Loss of communication to and from the seismic spread due to either defective or cut cables causes the acquisition process to be suspended until the problem is resolved, resulting in a loss of production
- Introduction of additional noise into the spread due to wind or other noises induced into the sensors due to the presence of seismic cables

Figure 1: *Seismic Cables on Land Crew*

Figure 2: *Geophone String for Land Crew*

Discussion:

The impact that seismic cables have on field acquisition personnel, contractors and data consumers can be measured in terms of time, money and data quality.

1. **Time**: Everyone is aware that 'time is money', and time consumed performing non-production activities can add substantial cost to a survey. The amount of time required for a field crew to acquire data is not only important to the contractor but also to the data consumer. The more time it takes a field crew to acquire data the higher the production cost. Also, there often is a limited window of time available to acquire the data at specific locations.

Land acquisition crews must often deal with extensive natural and culture-related damage to their environmentally exposed equipment. By an extremely large margin the equipment most often damaged is the array of seismic cables (spread cables, sensor cables or geophone strings, battery connection cables, cross line cables, jumper cables). This damage may come from either wild or domestic animals who chew the cables or become entangled in them and move the cables and attached equipment away from their assigned locations. The damage may also be caused by cultural forces, such as moving vehicles that can cut or abrade the cables, or even by vandalism. In any case this damage will affect the capability of the acquisition system to sense, acquire, store or transmit the seismic data. The potential for this damage is ongoing as long as the acquisition equipment is deployed.

Most land acquisition crews do not operate continuously for 24 hours a day. Most of the crews shut down at nightfall for safety and security reasons. Therefore the first daily activity necessary before production begins is to troubleshoot the spread, identify any defective equipment and deploy both personnel and replacement equipment to those locations to repair or replace the damaged equipment. This pre-production activity can cost the field crew several hours of lost production time.

The damage caused by nature and cultural forces is not limited to periods when the acquisition system is inactive. This same type of damage can occur during the time the field crew is troubleshooting what took place during the previous night, and it continues to happen during production. Ongoing damage to the deployed equipment can disrupt production at any time and will cause the field crew to transition from production to troubleshooting mode in order to repair the spread.

Troubleshooting the spread and maintaining sufficient active receivers is a never ending, time consuming task for the field crew. The time expended on non-production maintenance and troubleshooting is time permanently lost..

2. **Money:** Non-production activities can be expensive. If, for example, a field crew has 14 hours per day available for production, but it spends 4½ hours per day troubleshooting defective seismic cables then 30% of potential production time is lost. To put this in perspective, if this lost time could be recovered a prospect that took 180 days to complete might have been accomplished in 126 days, leaving 54 days that could be applied toward the next prospect.

Even if the capital expended to initially purchase the spread cables, strings and cross line cables were set aside then we are still left with a significant ongoing operational and maintenance costs.

Operational Costs

On average today's field crews typically move 13-14 pounds (6 Kg) of equipment for every receiver channel deployed. This includes laying out spread cables and geophone strings or other sensors. It also includes the deployment and rotation of batteries. For most field crews it will require the placement and deployment of crossing line units and crossing line cables. A typical field crew deploying 4,000 receiver channels and rolling 500 channels per day will retrieve 6,750 pounds (3,068 Kg) of equipment while simultaneously deploying 6,750 pounds of equipment. To move this much equipment requires significant manpower and vehicles. Vehicles and/or personnel must portage the cables up and down the receiver lines to deploy and retrieve the equipment. There are specific personnel assigned to the orderly retrieval and deployment of the equipment for normal spread roll activities.

In addition to the retrieval and deployment personnel there are people assigned to take on the task of troubleshooting. Their job is to move throughout the spread to wherever a breakdown has been noted and fix the problem by either repairing or replacing the defective equipment. Ordinarily this entails replacing either a defective spread cable, geophone string/sensor, cross line cable or battery. To accomplish this task, a mix of cables, sensors and batteries are carried or deployed from a base camp to the troubleshooting personnel. This activity requires the deployment of additional vehicles and manpower to maintain the spread in working order.

An additional cadre of individuals are typically assigned the task of orderly battery rotation. This activity usually occurs within the active spread that is not being retrieved or deployed by the initial group mentioned previously. This practice is necessary because a receiver often must remain at a specific location for a time interval that exceeds the life of the battery assigned to it. This activity also entails deployment of additional vehicles and manpower to maintain the spread in working order.

The amount of vehicle and foot traffic within the prospect often has a negative impact on the overall HSE of the field crew. The weight that must be managed and moved is one concern. This factor is compounded by the movement and number of vehicles and personnel within the various groups. This means increased risk for the Health and Safety of these individuals. Due to the amount of movement within the prospect boundaries, there is concern for the environmental impact on the area. Some sensitive areas restrict the number of passes up and down a seismic line in order to minimize the impact on that environment.

Maintenance Costs

Whenever seismic cables are used, the maintenance of this equipment enters the cost calculation. As the spread cables are damaged they must either be replaced or repaired. Often the repair of the spread cables is done on the crew or at a centralized location for the contractor.

If any of the seismic cables are damaged beyond repair the contractor is faced with:

- Environmental and safe disposal of the defective cable or geophone string
- Purchasing replacement cable or geophone string

If the seismic cables can be repaired, the contractor must either hire additional personnel to perform the repair and retest the cables or they must outsource this task. In either case there is additional material cost for the replacement cables, connectors and sensors needed to bring the defective equipment back to operational status. The maintenance personnel, spares, test equipment and repair material must be managed and warehoused.

The amount of money spent on maintaining seismic cables will vary greatly from region to region and for different types of systems deployed. However, if you were to ask any contractor they will tell you that this cost is far from insignificant and must be passed on to the data consumer as a cost of doing business.

3. **Data Quality:** In a perfect world deploying a seismic receiver at its designated position would be a one-time event. It would then consistently record all possible reflections generated by our exploration activities without injecting any noise into the signal. When its purpose was completed it would be retrieved and made ready for its next deployment. However, in our imperfect world, the seismic cables will inject noise into the seismic signals and generate spatial and time gaps in our data.

The impact of seismic cables on data quality can be assigned to three categories: activity, damage and injection.

Activity

People and vehicles are in constant motion throughout the spread performing various activities associated with deploying, retrieving, troubleshooting and maintaining the various seismic cable issues. Their presence will create random coherent seismic noise.

Cable deployment and retrieval, typically on a daily basis, together with the necessary troubleshooting and battery management activities, generates recorded and observable noise into the acquired data.

Damage

The longer a cable is exposed to the environment the greater the likelihood that it will be damaged either by natural or cultural causes. As noted previously in Section 1 it has been demonstrated that the use of cables in the field , in itself, creates a situation where prolonged exposure increases the possibility that damage may occur.

Partial damage to a seismic cable will cause a deterioration in the signal quality that is passing through the cable. This will result in lower amplitude or distorted signals. Total damage incurred by a cut cable will result in a complete loss of any signals from that point outward.

Impact can vary depending on which cable was damaged and where. The resulting distortion or absence of signal can range from a single receiver point up to vast patches of the spread suddenly becoming non-responsive. If only a few channels are affected, production may proceed with the resulting decrease in signal quality or loss of recording capability limited to those few channels. However, if the damage impacts too many receivers the production must cease until the damage is corrected.

Injection Noise

Injection Noise refers to inserting noise within the seismic band via the presence of seismic cables. Injection noise for land seismic includes electrical or interference caused by Common Mode Pickup this noise may also be mechanical in nature caused by cable movement induced into the sensor.

The most common type of electrically induced noise comes from Highline Pickup, and numerous attempts have been made over the years to reduce this type of noise. Highline notch filters, anti-phase summing and Twin recording techniques (A. Özkan, Z. Özer, February 2008) have been tried. Highline Pickup is not the only source of electrically induced noise pickup. Many other sources, including electrical fences or trains, anti-corrosion techniques used on pipelines, distant electrical storms, and even blowing sand or snow can induce moderate to severe electrical interference into the seismic cables. The more copper that is laid out on the ground the greater the 'antenna effect' is on the seismic signals.

Another cause of Injection noise can be attributed to mechanically inducing energy into the sensors from a moving cable that taps or pulls the sensor. The usual culprit for this is a poorly deployed geophone string where the string cable has come into contact with the sensor or has been stretched too tightly. In either case wind noise, that might not ordinarily cause a problem, may be coupled into the sensor creating noise that is within the seismic band.

Conclusion:

The industry needs to completely eliminate the use of cables for the acquisition of seismic data. The spread cable, the geophone string cable or any sensor connection cable, the cross line cable and the battery cable all must be relegated to obsolescence. When seismic cables are eliminated from our operations we can expect to see:

- Little to no troubleshooting
- Greatly reduced maintenance
- Increased production
- Lighter footprint
- Improved HSE
- Unlimited geometry options
- Reduction in the number of personnel and vehicles required per receiver channel

When the features of Cable-Free recording listed above become a reality, our efficiency and bottom line profitability will increase. (L. Durham, Sept 2007 & Nov. 2007, D. Freed, July 2008)

References:

Images

Figure 1: Seismic Cables – From Tucker Innis via Internet
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Figure 2: Geophone String – From Dynamic Technologies, via Internet
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