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Cost Effective Land Seismic Data Acquisition by Geophysical Services of WON Basin, Gujarat, India

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Summary

The cost of land seismic data acquisition of international crews depends upon productivity, raising and winding up of crews, permit (land leasing, crop compensation), technological upgradation, investment on Health, Safety Environment (HSE) and wages to employees.

The Geophysical Services (GS) of Western Onshore (WON) Basin, ONGC, Gujarat, India deployed a minimum of five parties and maximum of eight parties during the period 2002-07 to acquire 3D seismic data using explosive as source (fig 2), one geophysical field party was deployed to acquire VSP data and the one was deployed to carry out 3D seismic work using vibrator as source in Rajasthan desert. These geophysical parties acquire data for the national oil company - ONGC. The seismic data acquisition work is planned for two years in advance. The land seismic data acquisition crews of Geophysical Services are earmarked for fulfilling the departmental needs as such these parties are deployed on regular basis to acquire the seismic data. Therefore, the cost structure differs with the international private company's crews, which do not get work on regular basis. The raising and winding up of crews, hiring of skilled persons for short term do not fall in the purview of the cost structure of GS, WON basin.

The cost of land seismic data acquisition is reduced by Geophysical Services, WON basin, Gujarat by improving productivity, award of contractual services for 2 years, improvement in the operational processes, technical upgradation and deploying departmental crews with higher number of channels by pooling resources of various crews.

1. Introduction

Under the regime of New Exploration Licensing Policy (NELP) in India, ONGC has to bid for exploration blocks along with other International Oil Companies. The blocks awarded to ONGC are to be explored as per the stipulated time of the contract. Exploration of hydrocarbon includes acquisition, processing and interpretation of the data (API) and drilling of wells.

For seismic data acquisition in general and 3D seismic data acquisition in particular, the Geophysical Services of WON basin, ONGC, Gujarat has formulated a plan to acquire seismic data at low cost. An independent Quality Control Group monitors the quality of the data. The steps taken for cost reduction are:

1. Improvement in productivity by
    a. Acquiring higher number of seismic traces each year (fig 3).
    b. Award of the Integrated Seismic Job Services and Seismic Drilling Services Contract in place of departmental crews for seismic jobs and contract for Seismic Drilling Services.
    c. Improvement in operational processes.

2. Up gradation of technology
3. Improvements in designing of 3D survey geometry
4. To award Integrated Seismic Job Services and Seismic Drilling Services contract for a period of 2 years.
5. To deploy a departmental crew in areas earlier envisaged for outsourcing by pooling resources of different crews.

All the above steps have helped in acquiring good quality data at higher rate of productivity. The cost has two components fixed cost and variable cost. The variable cost is proportionate to the volume of work whereas the fixed cost remains constant in a project. With the increase in volume of work the fixed cost was distributed over large number of shots, thereby reducing the cost/trace.

2. Methodology

2.1. Improvement in Productivity:

The variable cost of seismic data in geophysical field parties of WON basin, Gujarat, India are under the heads of contractual payments to shot hole drilling and Seismic Job Services contractor, explosives and detonators, land and crop compensation, security payments, miscellaneous expenditure. The fixed cost consists of depreciation overhead and pay & allowances to employees.

The pie chart of the data show that contractual payments to Seismic Drilling Services Contract and Seismic Job Services contractor and fixed cost consisting of depreciation, overhead and pay & allowances to employees are the major contributor to the cost (fig 1).

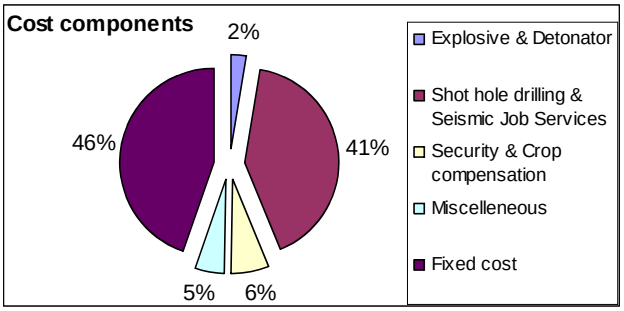

Fig 1: Major Cost components of a geophysical field party

The analysis of the last five years of cost data of geophysical field parties of WON basin, Gujarat, India shows that the **cost per trace** of the land 3D seismic data acquisition **is reduced from Rs 14.34** to **Rs 8.13** (fig. 4) i.e., cost is reduced by 43% (nearly half) by improvement in productivity. Number of seismic field parties has varied from 5 to 8 during the period of 2002-07 (fig 2). The number of traces has increased from 22.2 million to 76.7 million, (a three and half fold increase) from 2002 to 2007 (fig. 3). The improvement in productivity is achieved by acquiring higher number of traces each year (fig 3). Number of traces is a product of number of channels and number of shots. Both factors were improved in successive years. The award of Seismic Job Services contract in place of departmental crews have taken away the burden of recruiting unskilled workers to the order of 400 for short period, maintenance of a fleet of departmental vehicles to transport man and material to the site. The technical work force of the party got more time to concentrate on matters relating to improvement of productivity. The crew size decreased to nearly half thus saving money on pay and allowances.

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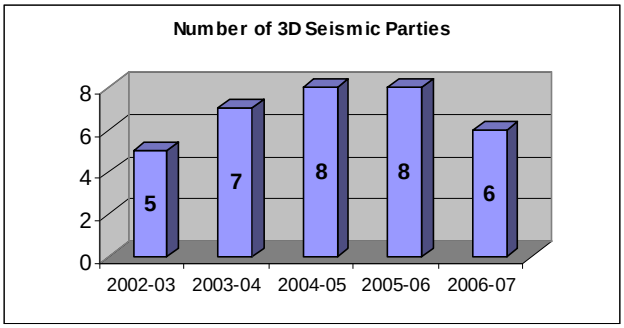

Fig 2: Number of 3D seismic field parties in GS, WON basin

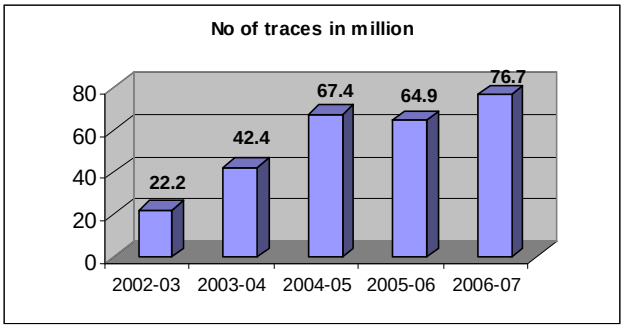

Fig 3: Number of 3D seismic traces in GS, WON basin

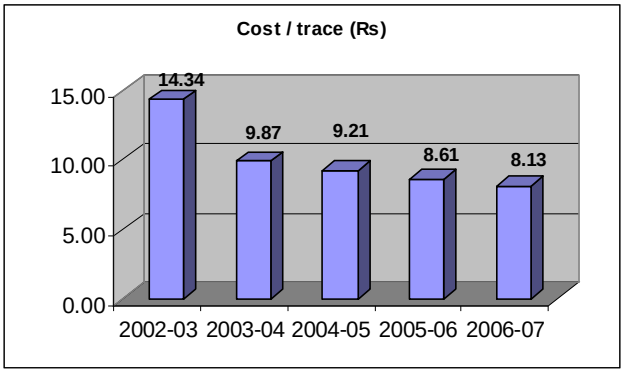

Fig 4: Cost per trace of 3D seismic data in GS, WON basin

The Integrated Seismic Drilling Services and Seismic Job Services contract has further improved the productivity. The contractor could increase the coordination between shot hole drilling crew and laying of cables and geophones crew, as a result of which the manpower for every day work could be assessed in

advance. The extra cost incurred due to lack of coordination is saved.

The Minimum Guaranteed Hole (MGH) by the contractor was increased from 80 to 150 as a pilot project in one of the 3D seismic field party during the field season 2006-07. The productivity of the party improved by 119% (number of shots increased from 11,194 - field season 2005-06 to 24,478 - field season 2006-07).

The process of preparing near surface models, preparation of DPR and Depth register have been improved by replacing the manual work by use of computer programmes and software. The near surface models are prepared by using Surfer Programme. Daily Progress Report (DPR), Depth register is updated on Excel sheets. The quality of data is checked online by use of SQC-Pro software provided in 408 UL instrument. This improvement in the operational processes have helped in making more time available to field geophysicists to concentrate on work related to increase in volume and quality.

2.2 Upgradation of Technology:

It is often said, "**The most expensive data we acquire is the data which can not be interpreted."** So, the efforts are made to acquire the high quality data at low cost, which is evident from the fact that the cost of acquiring the state of art technology was offset by improvement in productivity. The number of traces recorded increased from 22.2 million to 76.7 million (fig 3) nearly a three and half fold increase whereas the cost has decreased by 43% (fig 4).

The technological upgradation is done to mitigate risk and increase productivity. The improvements in the instruments of Surveying, Data recording were utilized. The Field Processing Units, Mobile Processing Unit, GEOLAND, SUPPLANT, MESA software's' for designing of field geometry and modeling of complex geological set up had reduced cost and improved quality.

2.2.1. Improvements in data quality by use of advanced Vibrators and field lay out

The quality of seismic data of Rajasthan party is improved (figs 5 & 6) by use of new vibrators (drive force of 62,000 psi) with non linear sweep of varying frequency in place of old vibrators (drive force of 30,000 psi) with linear sweep of up frequency. Number of geophones was increased to 20 per channel from 8 per channel. The line of sight optical survey instruments were also replaced with DGPS survey instrument.

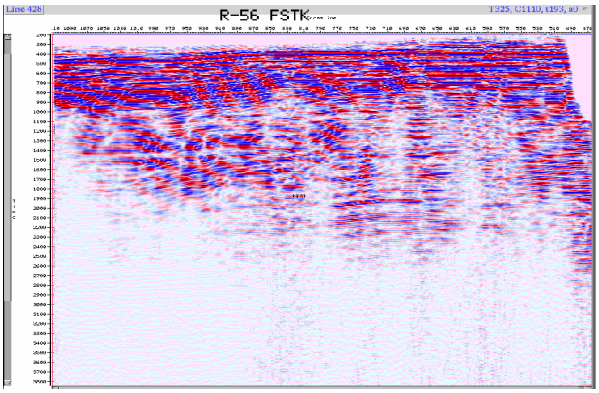

Fig 5: Final stack section of a line of Rajasthan area.

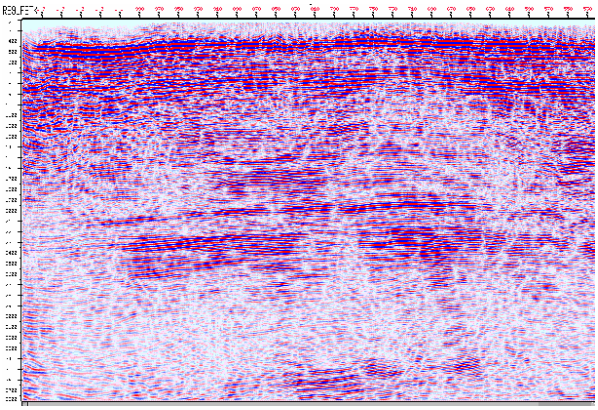

Fig 6: Final stack section of a CDP line of Rajasthan area after use of advanced vibrators and improved field lay out.

2.2.2 Surveying: The DGPS (Differential Global Positioning System) gives easting, northing and elevation of the pickets in cm accuracy after applying the Carrier Phase corrections. The GIS (Graphical Information System) and Remote Sensing data are being used to calculate positioning of shot points and recovery points well in advance at Headquarters i.e., before moving to the actual location. The survey planed in advance will reduce cost.

The vibrators are equipped with GPS to know the actual position in real time.

2.2.3. Data Recording: The instruments used are geophones and recorder.

2.2.3.a Geophones: The P-wave moving coil geophones (marshy and land type) used over last 15 years have acquired consistently good quality data. 6 and 12 geophone strings used were heavy to carry to field. The cost of carrying geophone strings to field for plantation is directly related to weight. Accelerometer with MEMS (Micro Machined Electromechanical Sensor) technology acquired by Geophysical Field Parties of WON Basin. These are lightweight and are capable of recording full seismic wave field.

Use of these accelerometers will further reduce cost of transportation and will increase data quality.

2.2.3.b Recorder: The Geophysical Field Parties of WON Basin have upgraded the recording instruments in last 10 years from DFS V to SN 388 to MDS 16 to 408 UL to Scorpion. The channel capacity has increase from 100 channels to 2000 channels; the dynamic range has increase from 72 db to 120 db. The use of Sigma Delta technology in 24-bit A/D converter in the FDU has increased the data quality by improving the dynamic range at the ground for each channel before digitizing. The snaking, multi path routing, handling of hydrophone, geophone in the same survey has given added advantage of recording data across big rivers, transition zone and express highways (fig 7).

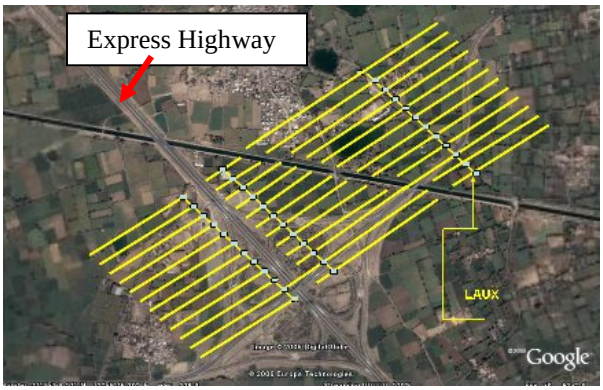

Fig 7: Single cable crossed across Express Highway and data from all channels were recorded

The data quality is monitored throughout the day by SQC-Pro software provided with 408 UL systems. The attributes displayed on workstation in the instrument truck are seismic trace frequency analysis, signal to noise ration, automatic first break picking, detailed QC of each trace, trace energy and ambient noise value etc. Scorpion system handles digital 3C component accelerometers (with micro machined electromechanical seismic sensor technology) and analog geophones together.

2.2.4 Online Recovery shooting

The villages, industrial campus, oil companies' installations, dry river beds, ravines etc. do not allow the regular drilling of shot holes in on land seismic data acquisition work. In 3D seismic surveys a gap of 30-40 continuous regular shot holes creates a hole in the subsurface coverage. Now days these gaps are present in every campaign of 3D survey. The fold loss recovery plan is made using GEOLAND and MESA softwares. The recovery plan is implemented along with the regular shooting to cover the fold loss (figs 8 & 9).

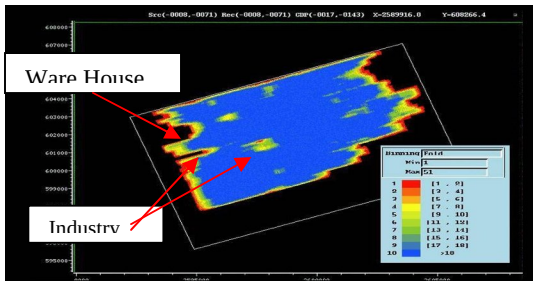

Fig 8: Fold map before recovery planning

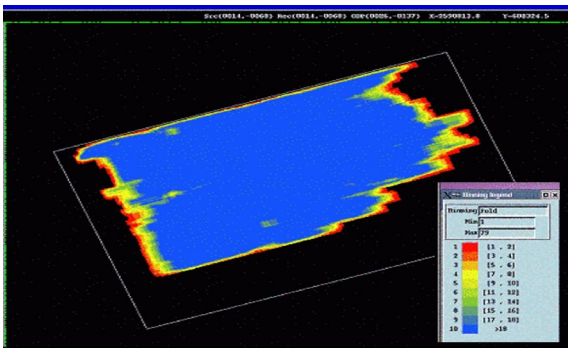

Fig 9: Fold map after recovery planning

2.3 Improvements in designing of 3D seismic survey geometry:

Well-designed orthogonal 3D land geometry also fails the map various geological formations from top to trap (0.5 sec to 5 sec level) in a complex geological set up. The area in West of Mehsana Horst, District Mehsana, Gujarat, India, has a complex geological set up. The Ray Trace Modeling was carried out to optimize the shooting geometry.

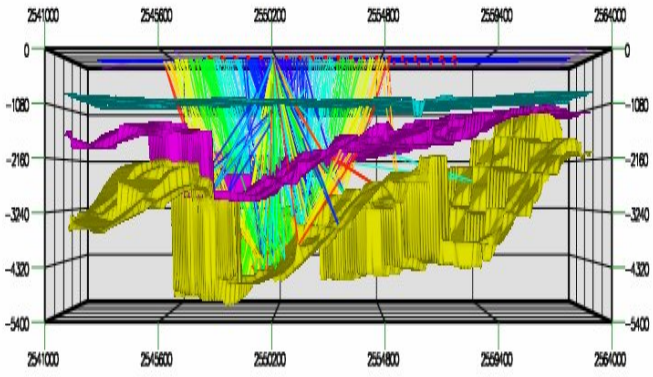

Fig 10: Ray Trace model

A geological model based on interval velocity and density was constructed showing the various formations present in the West of Mehsana area (fig. 10). By using MESA software on the model the requisite bin size and offsets were determined to illuminate the subsurface points at the target depth (figs 11 &12). The different shooting geometries planned were tested for their

efficacy by comparing the attributes e.g., Common Reflection Point (CRP) fold, Average Amplitude, Common Mid Point (CMP) to CRP displacement (fig 13).

The synthetic seismograms were also generated to see the resolution, continuity and frequency content of different horizons/formations present in the area.

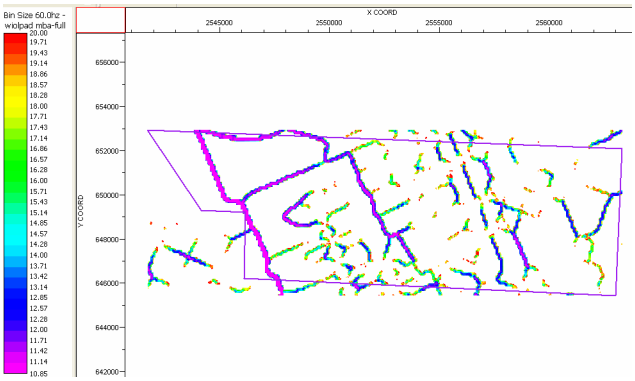

Fig 11: Bin size determination. The white colour inside the trapezium show the illuminated area at the target depth.

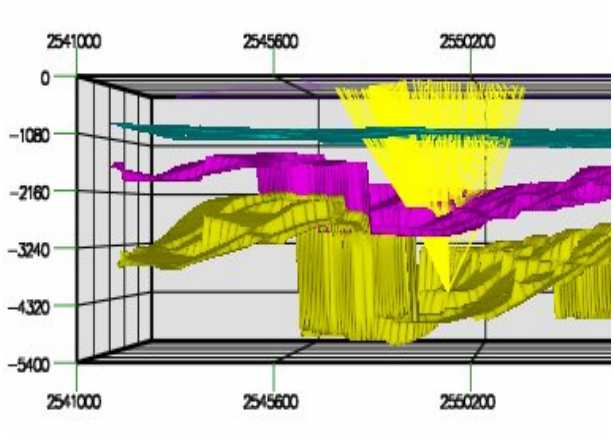

Fig 12: Maximum Offset determination

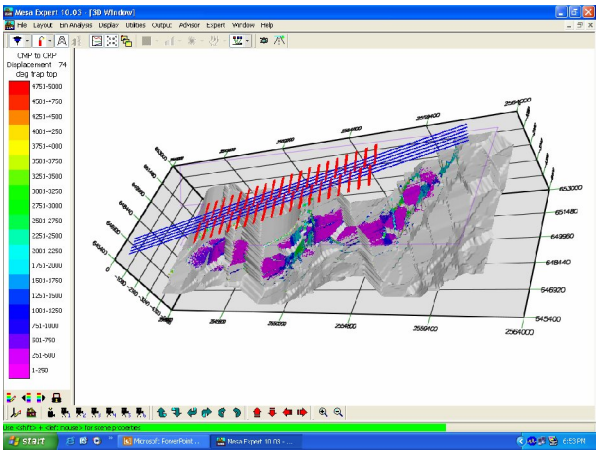

Fig 13: CMP to CRP displacement at target depth along dip direction for a given geometry

2.4. Award of Integrated Seismic Job Services and Seismic Drilling Services contract for a long period

The award of Integrated Seismic Job Services and Seismic Drilling Services contract for a period of 2 years has helped the contractor to plan effectively for man and material resources. The advantage in cost obtained by the contractor is partially passed on to Geophysical Services, WON Basin, Gujarat, India.

2.5. Deployment of a departmental crew in areas earlier envisaged for outsourcing by pooling resources of different crews.

GP-85, GS, WON Basin was deputed to take up the 3D seismic survey jobs in Cauvery Basin of Tamilnadu, India for 2 consecutive years so as to expedite the exploration work in NELP blocks of Tamilnadu, India. The resources of three 3D seismic parties of Gujarat were clubbed together during the period July-Oct. The period of July-Oct is rainy season in Gujarat and hence Off period for geophysical parties of GS, WON Basin, Gujarat.

The Vanagiri (197 SK), Kuthalam (139 SK) and Narashimapuram (78 SK) areas were covered with departmental crews, which otherwise would have been outsourced and would have incurred huge expenditure.

3. Future Plans:

a) Increase in Minimum Guaranteed Holes (MGH) from 80 to 150 of the Integrated Seismic Drilling Services Contract and Seismic Job Services.

b) Increase in number of channels

c) Use of state of art technology

d) Use of slip-sweep recording technique at a small additional capital expenditure to improve productivity

of Vibroseis crew to one thousand vibration points (VP's) daily.

e) Use of advanced 3D acquisition systems in which telemetry cables are not required (e.g., 'firefly' seismic data acquisition system developed by I/O). The data from accelerometer using MEMS technology will be transferred to a recorder via blue tooth and from recorder to main instrument using VHF frequencies.

4. Conclusion:

The technological upgradation is done to mitigate risk and increase productivity. The state of art instruments of Surveying, Data recording were procured and utilized. The Field Processing Units, Mobile Processing Unit, GEOLAND, SUPPLANT, MESA software's' for designing of field geometry and modeling of complex geological set up had reduced cost and improved quality.

The **cost per trace** of the land 3D seismic data acquisition of geophysical field parties of WON basin, Gujarat, India **is reduced by 43%** (nearly half) by improving productivity.

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