CURRENT PRACTISES IN DESIGN OF 3D LAND SEISMIC PROGRAMS
or: "3D" stands for Design for Density and Diversity

Our industry is now into the fourth decade of recording 3D seismic programs. This talk will briefly summarize some of the milestones that have caused us to change the focus of our design criteria as geophysical methods evolved and matured. We will concentrate our talk on design factors that will optimize the value of land 3D programs using acquisition and processing technology available today.

Early designs focused on obtaining more spatial subsurface coverage rather than just the vertical profiles provided by 2D methods. We were still working with 120-channel recording systems and, at best, could master-slave two such systems. Designs focused on methods to obtain subsurface coverage in more than one spatial dimension.

We soon recognized phenomena such as geometric imprinting and learned that higher effort, more lines and more channels were required to stabilize the fold obtained. Then we learned (again) that offset distributions within bin gathers could have a dramatic impact on the outcome of our surveys. This was closely followed by some acknowledgment of the role of the "new" 3D parameter: azimuth.

By the early to mid '90s we were still focused on how to produce a good and stable stacked section. We would then post-stack migrate our volumes. We learned that spatial resolution of such a product was related to bin size. Up to this point, designs were driven by considerations of desired fold (determining line spacings) and post-migration resolution (determining bin size). Design philosophy could be summarized as: "design parameters that will produce a good stacked data volume, and account for the fact that post-stack migration will steepen dips and require smaller stacked trace intervals, therefore smaller bins"

Into the early part of this century, with increased computer power, we were finally able to process data the way geophysicists always knew should be the correct way. Pre-stack time migration became common place in 3D processing. Slowly, we realized that fold and bin-size were not the most important driving factors. Producing a data set that provides good sampling of migration operators in all domains will allow the migration process to output data of maximum resolution. No longer was bin-size a limiting factor in output trace spacing. Design philosophy shifted from a focus on fold and bin-size to a focus on trace density and statistical diversity (in offsets, azimuths and midpoints). In other words: "design parameters that deliver what is needed by a pre-stack migration operator and then let the migration produce the image we need".

For many years, processors have been experimenting with bin-balancing and interpretation algorithms, often under great suspicion on the part of interpreters. Recently, 5-component COV matrix completion data reconstruction algorithms have gained a lot of attention and are gaining confidence on the part of interpreters. This also has an impact on fundamental design philosophy. Now we can restate our objective as: "design parameters that deliver what is needed for robust interpolation, then the interpolator will provide the traces needed by a pre-stack migration operator and then the migration will produce the image we need".

Of course, available recording equipment must be considered. The advent of cable-free autonomous nodal recording systems has encouraged us to re-think previous limitations. Is the concept of a receiver "line" even necessary?

Well, design optimization is still a balance of imaging objectives, geophysical objectives, budget limitations, environmental impact, safety, project timing, and other factors. We work in a variety of basins with a broad range of structural and stratigraphic complexities. We work in all types of topography and geography. Each company has their own concept of project value (image quality versus cost).

Therefore, modern 3D designers must be well versed in all the tools available to us. The "best" design must consider all factors and will take advantage of the tools appropriate to each specific task. A log-home builder has little use for sand-paper and a violin maker has little use for a chain saw. And yet both are wood-workers and both have many wood-working tools to choose from. It is important that designers of 3D land seismic programs understand the objectives and context of each challenge, remain aware of all possible methods available, and understand the situations where each method may be appropriate.

We hope that this presentation will heighten the awareness of designers, processors and interpreters as to what might be expected from 3D programs.