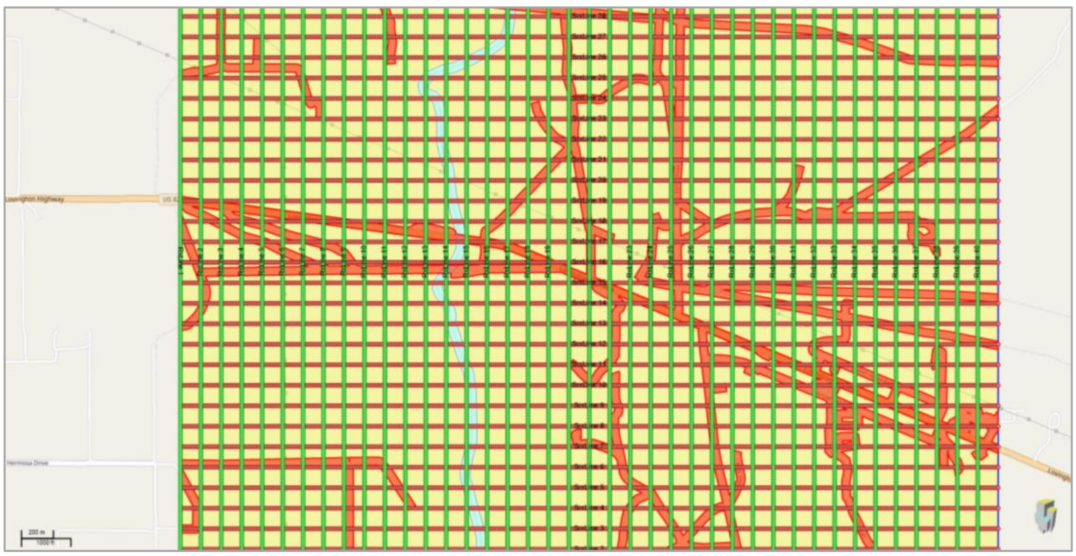
TesserACT tools for compressive sensing

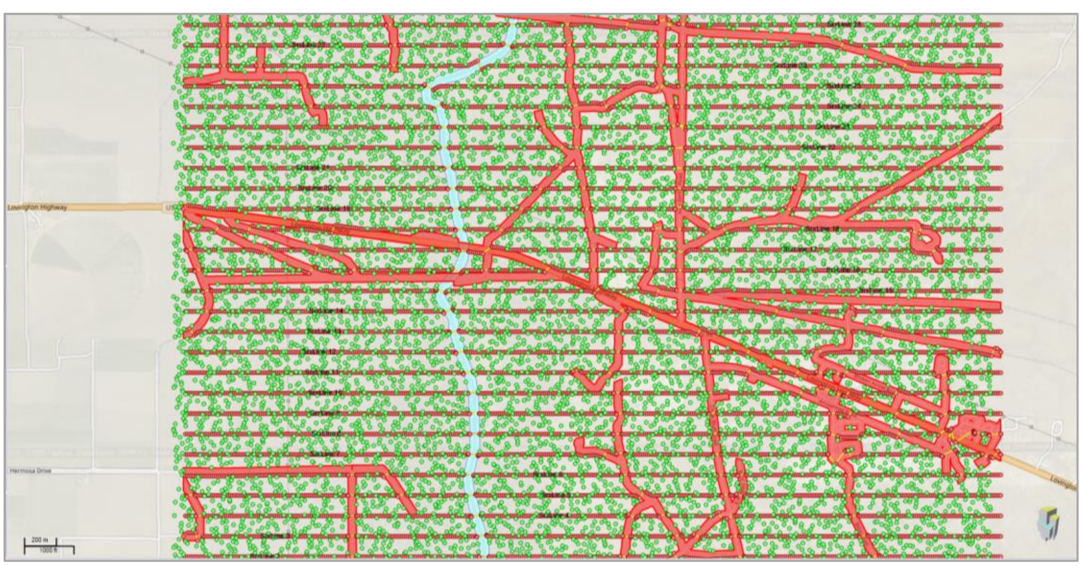
For most of my 40 year career in the geophysical industry, Nyquist's theorem has been the guiding force behind a relentless striving to achieve ever more regular sampling geometries. Over the last few years, compressive sensing has challenged this orthodoxy. In lay man's terms, compressive sensing offers the promise of stretching Nyquist a little in order to achieve better data quality (or lower cost) by removing the artifacts created by regular grids.

Each form of acquisition offers unique challenges and opportunities for compressive sensing, and ACTeQ has implemented a number of tools in it's TesserACT survey planning software that make it easy to create designs and estimate/minimize project cost and HSE exposure. This article explains some of these tools.

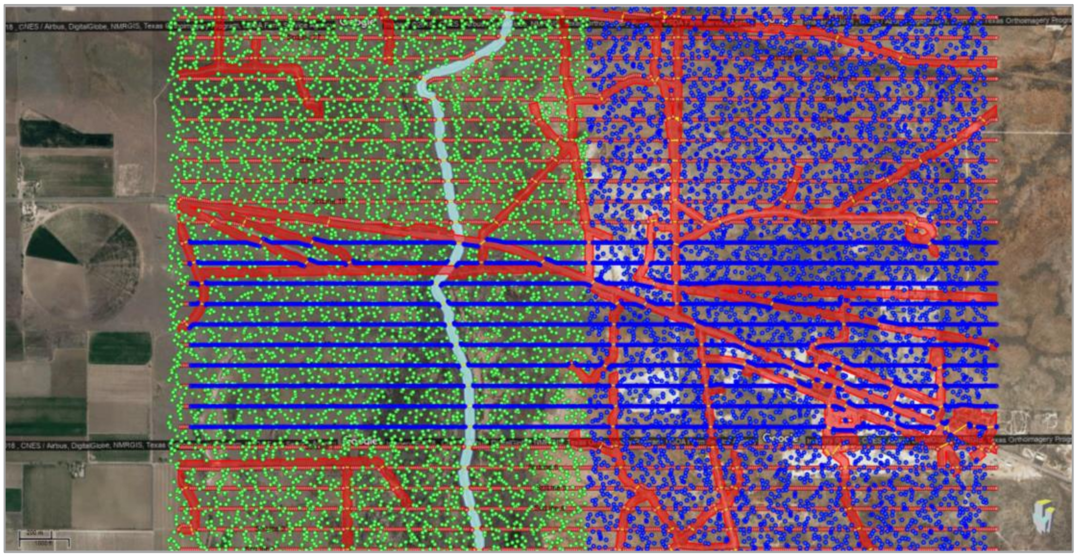
First let's consider the onshore example shown below. The original (traditional) design proposal was a 125m line spacing and 12.5m station spacing for both shots and receivers. Acquisition is complicated by a number of roads and a major river.



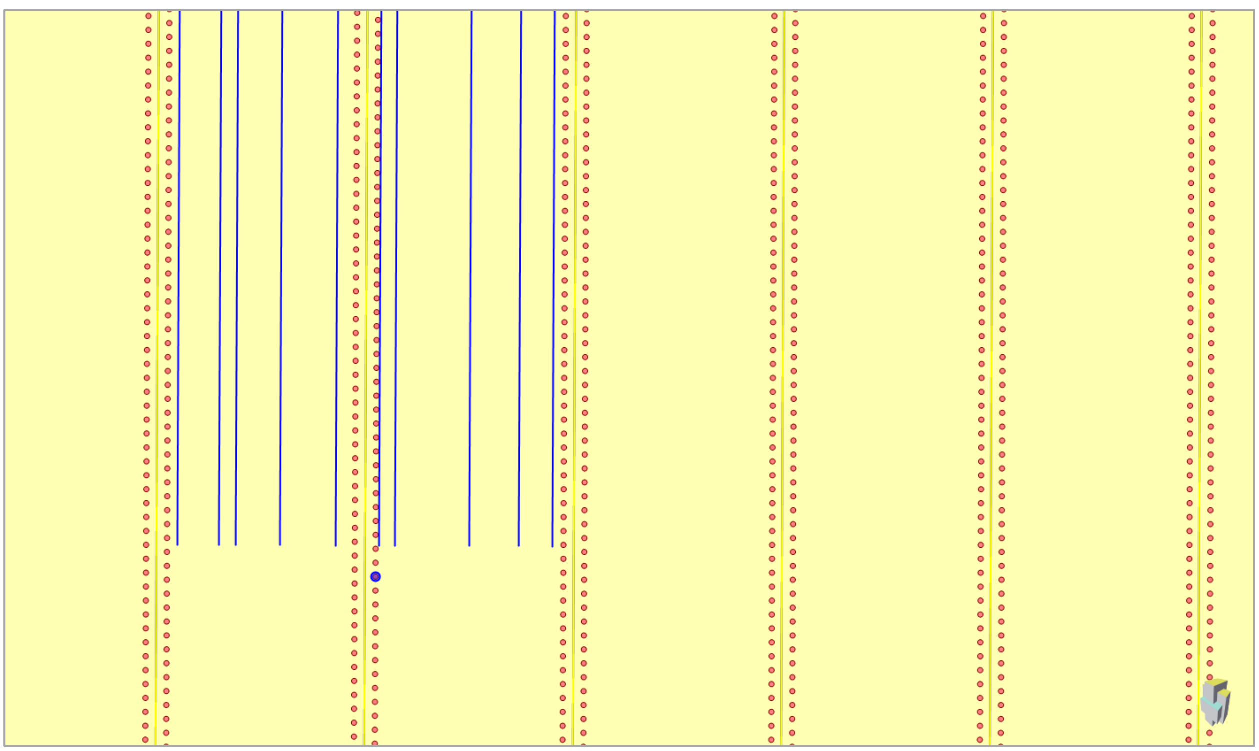
For logistical and environmental reasons, it was decided not to randomize the vibrator lines, but with modern node technology, randomization of the receivers is relatively easy. A number of random and pseudo-random schemes are available in TesserACT, and user defined algorithms can be imported with minimal effort. Exclusion areas for roads and rivers were created, and automated tools to exclude sources and/or receivers can be used to create the final design with minimum user effort.



Finally, a roll pattern was created such that the project could be acquired with 2 swaths using 96,000 receiver nodes. The resulting high resolution, long offset, full azimuth design delivers trace densities up to 70M traces per square kilometer. Note that this technique can also be used for seabed node projects.

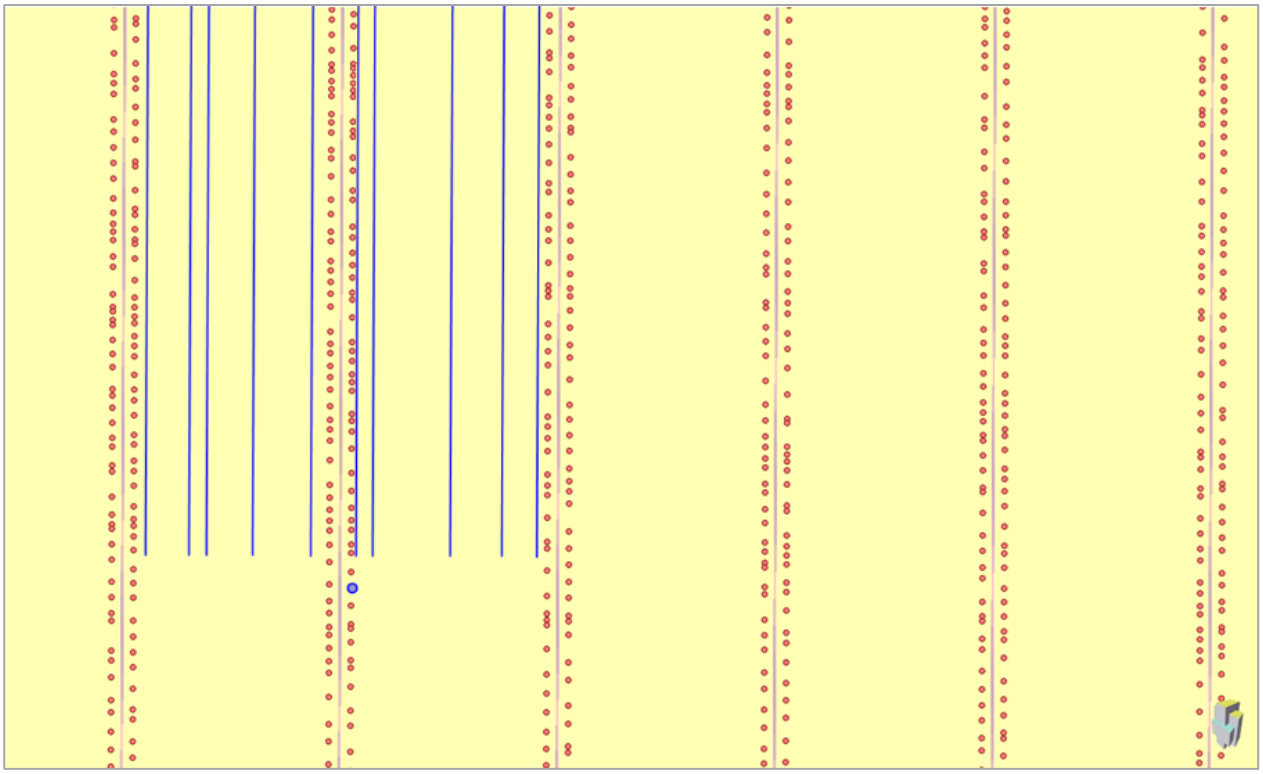


Offshore towed streamer projects present different challenges. Pseudo-randomization of receiver locations can be accomplished by using novel vessel paths such as circles, cycloids, sine waves and multi-arcuate tracks. Another twist is to change the tow points on multistreamer operations to achieve irregularly spaced streamers as shown below. (See Mosher et al)



Dithering marine sources in the crossline direction can be achieved for both streamer and seabed operations using novel vessel tracks, but the most common dithering technique in use today was devised by Dave Monk and Mike Bahorich at Apache. Many source controllers can be modified to fire shots at a random time. (Back in the 80’s, I worked with a few source controllers that fired at random times without any special programming !)

The problem with truly random firing is that airguns require some time to fill after firing a shot. An algorithm to handle this is well described in US Patent 9188693. An example is shown below.



Finally, a reminder that acquisition and processing using compressive sensing is covered by an extensive array of intellectual property, and where appropriate this must be licensed from the patent owners.

For more information on TesserACT, visit ACTeQ's web site at ACTeQ.net.

For more information on compressive sensing we recommend

"Operational deployment of compressive sensing systems for seismic data acquisition"

Charles C. Mosher, Chengbo Li, Frank D. Janiszewski, Laurence S. Williams, Tiffany C. Carey and Yongchang Ji (ConocoPhillips)

The Leading Edge, August 2017

"Compressive seismic imaging: Land acquisition case study and operational considerations"

Millis Keith (SAExploration)

Presentation at SEG 2018 (Anaheim), October 2018

"Pseudo-Random Blended Source Tests Offshore Abu Dhabi"

Chris Walker*, Ghiath Ajlani (Seabed Geosolutions), Mike Hall (GeoVectra); Saif Al Mesaabi, Abdulla Al Kobaisi, George Casson, Hiroshi Hagiwara (ADNOC)

Presentation at SEG 2017 (Houston), September 2017