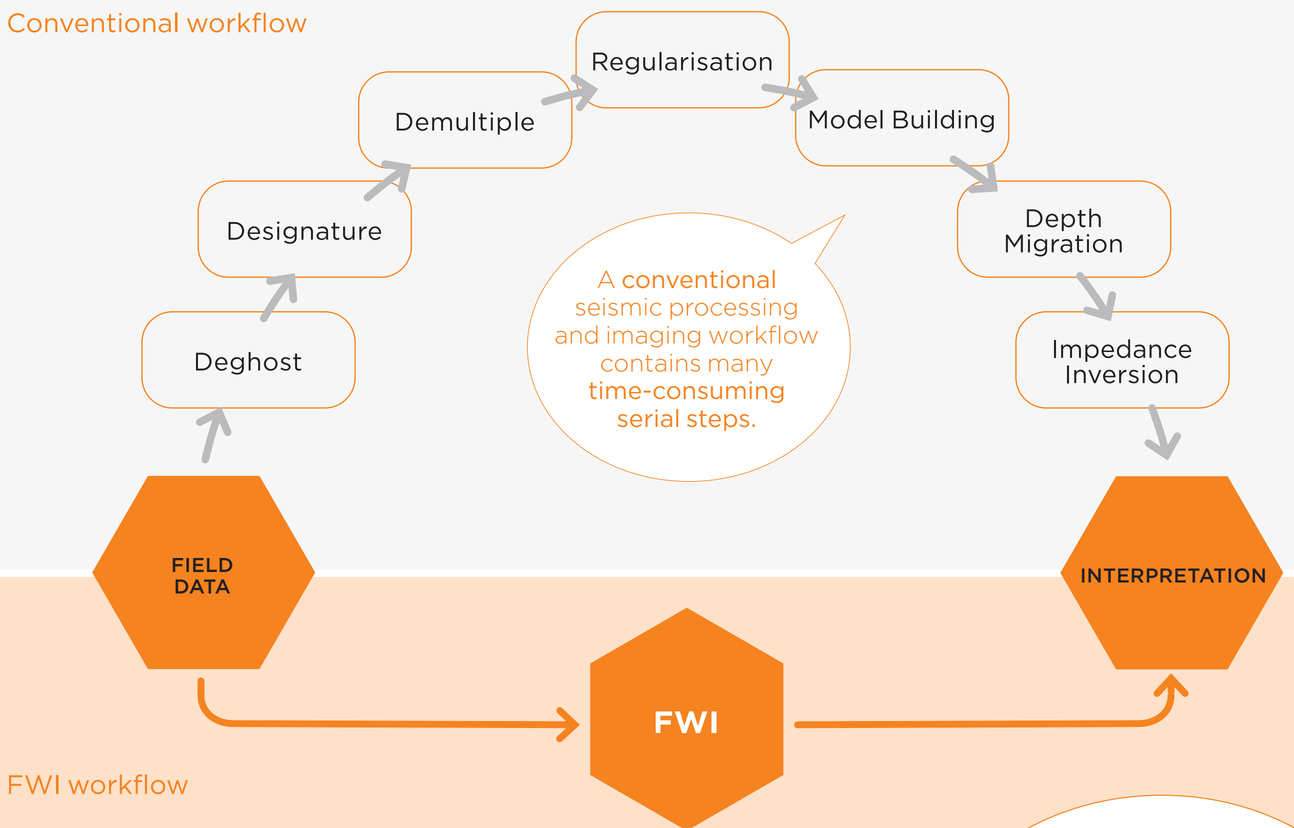
A ROO-VOLUTION IN SEISMIC IMAGING

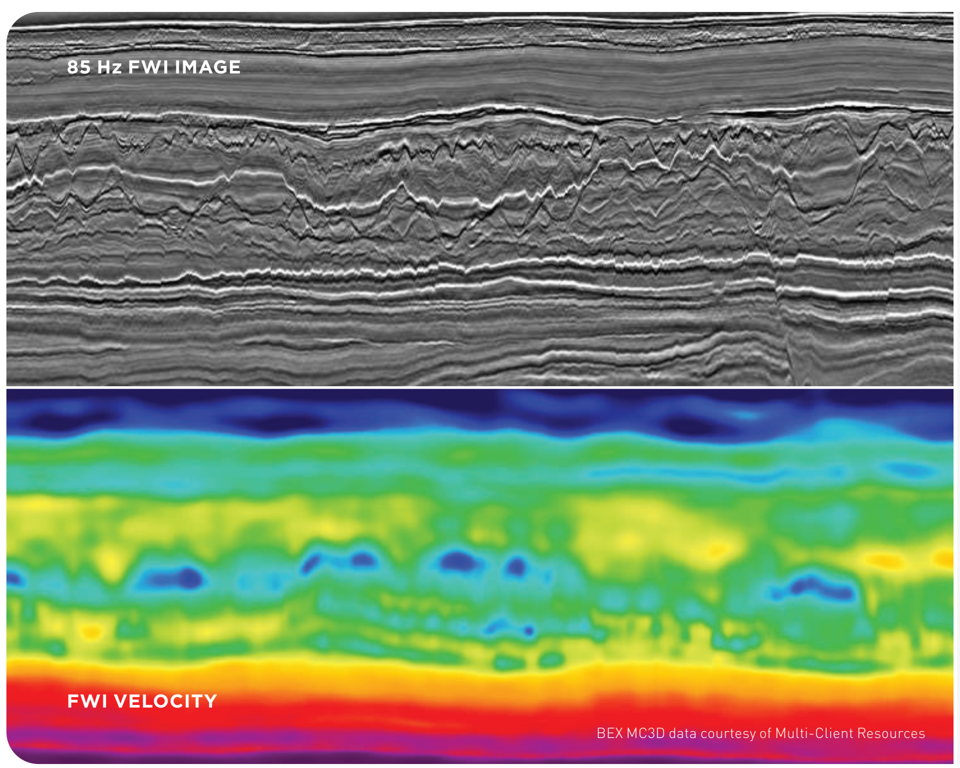
Simultaneous
model-building and
least-squares imaging
with **full waveform inversion**

Hop
inside and
see for
yourself!

dug

HIGH-FREQUENCY IMAGING WITH FWI





Powerful physics

More signal

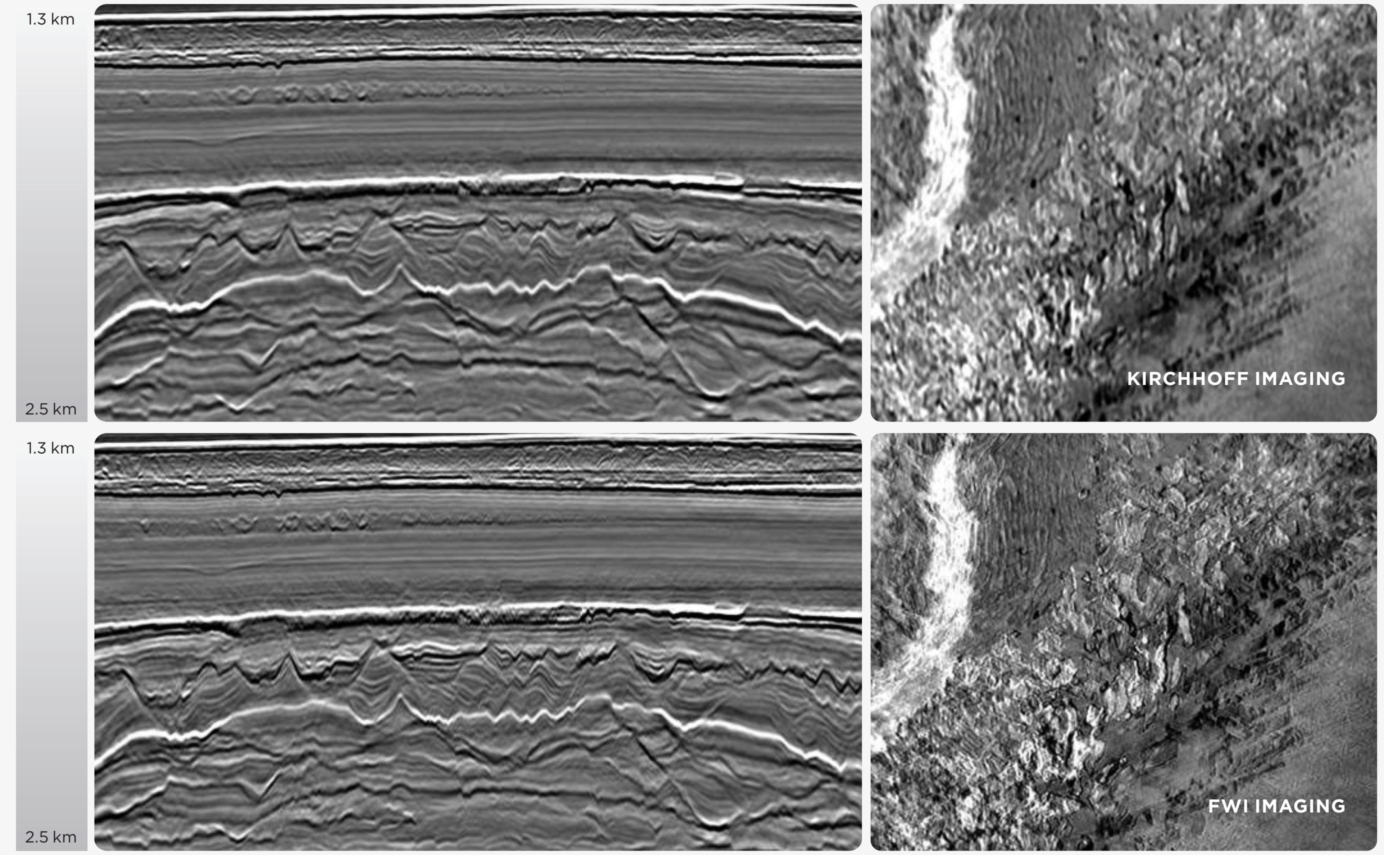
Superior images

Rapid turnaround

Get a better result, faster, with FWI.

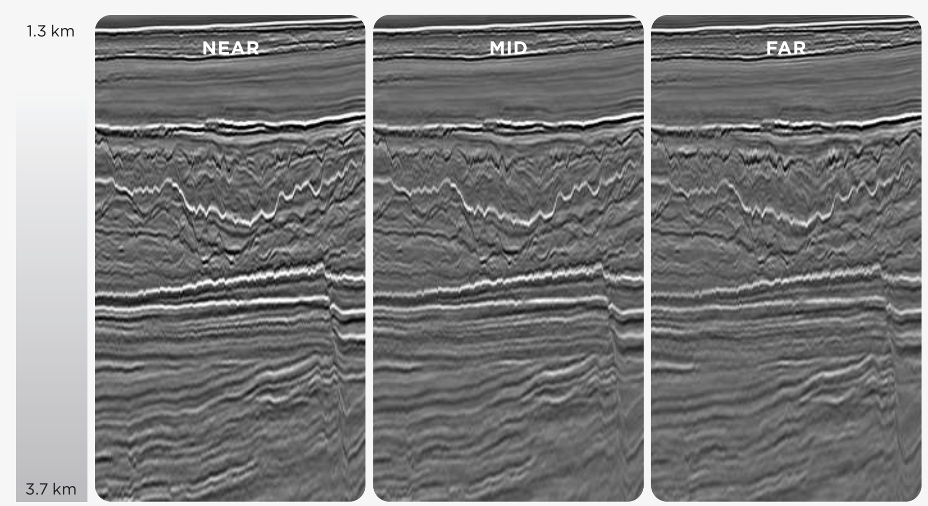
At high frequency, this roo-volutionary approach provides reflectivity images for both structural and quantitative interpretation, without the steps above. Leveraging full reflection apertures this least-squares imaging solution simultaneously accounts for ghosts, multiples and the source signature using field-data input.

LEAST-SQUARES IMAGING USING FIELD DATA



BEX MC3D data courtesy of Multi-Client Resources

TOP: A section and depth slice from a Kirchhoff migration of conventionally processed data. **BOTTOM:** FWI imaging at 85 Hz directly from field data. This least-squares solution uses the entire wavefield with appropriate imaging apertures to deliver a step-change in resolution in a small fraction of the time.



BEX MC3D data courtesy of Multi-Client Resources

DUG's unique wave equation formulation isolates the "roo ears" for high-resolution velocity updates beyond the diving-wave limit. It also enables least-squares imaging using the entire wavefield providing high-frequency reflectivity volumes for quantitative interpretation.

LEFT TO RIGHT: Pre-stack outputs, in this case, near, mid and far angle stacks allow for more advanced quantitative interpretation workflows.

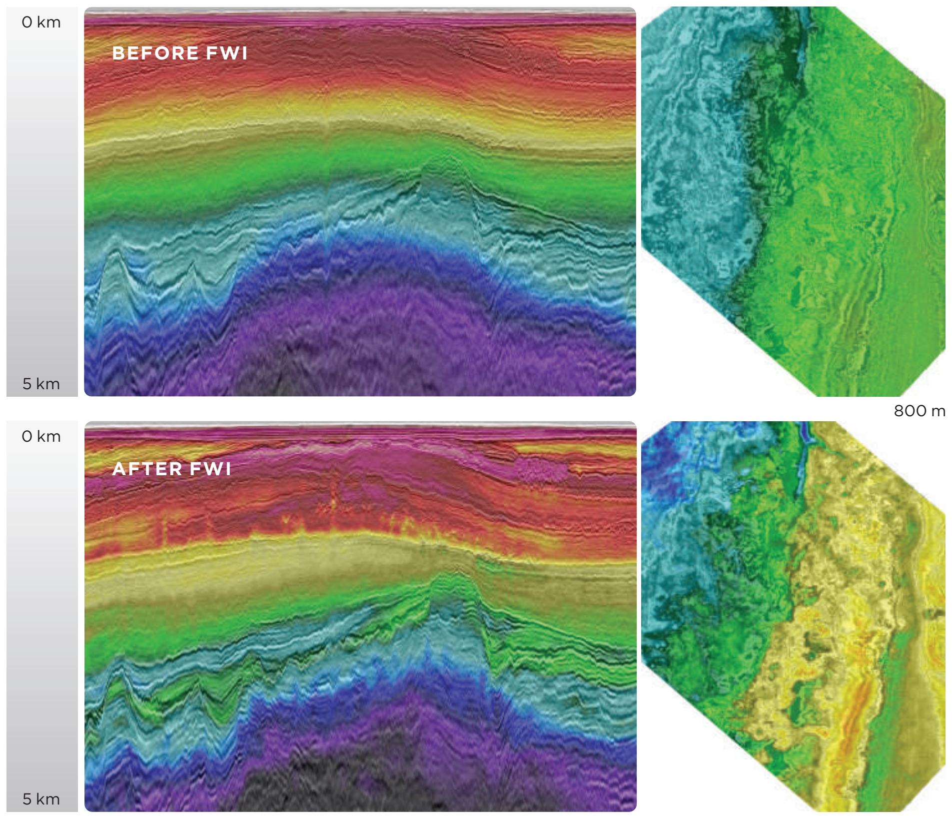
STATE-OF-THE-ART MODEL BUILDING

FWI inverts for high-resolution earth models using the entire seismic wavefield. It is an integral part of DUG's depth model-building strategies for both conventional and FWI imaging workflows.

Model-updates using diving waves (bananas) and reflections (roo ears)

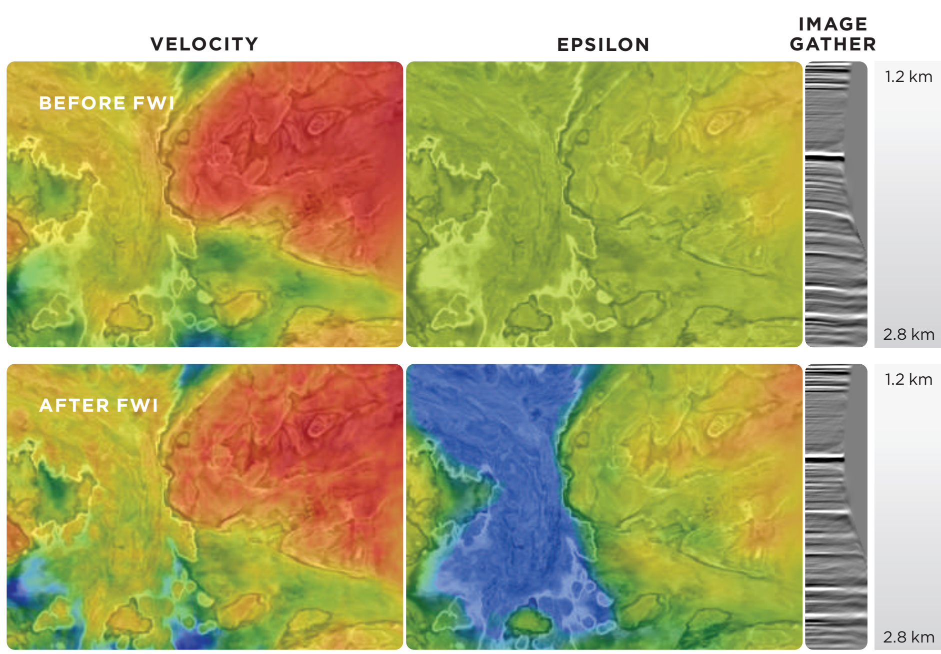
Multi-parameter: invert for source-signatures, reflectivity, velocity, anisotropy, Q and other parameters

RIGHT: Hybrid OBN and towed streamer FWI. Velocity updates beyond 5 km depth are achieved thanks to the diving wave penetration at long offsets from the OBN data. Co-rendered migrated image and velocity before FWI (top row) and after FWI (bottom row).

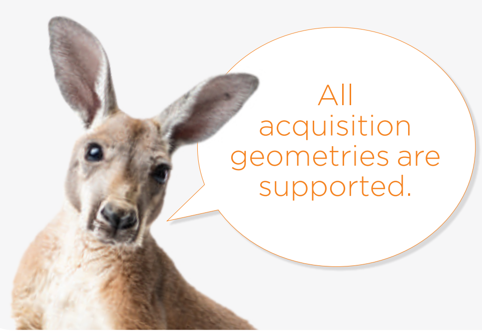


LumiSeis™ data courtesy of Geoex MCG

RIGHT: This multi-parameter inversion delivered an updated velocity model and a detailed epsilon volume resulting in much flatter gathers. A co-rendered depth slice of the migrated image with the velocity and epsilon parameters along with an image gather are shown. Co-rendered migrated image and velocity/epsilon before FWI (top row) and after FWI (bottom row).

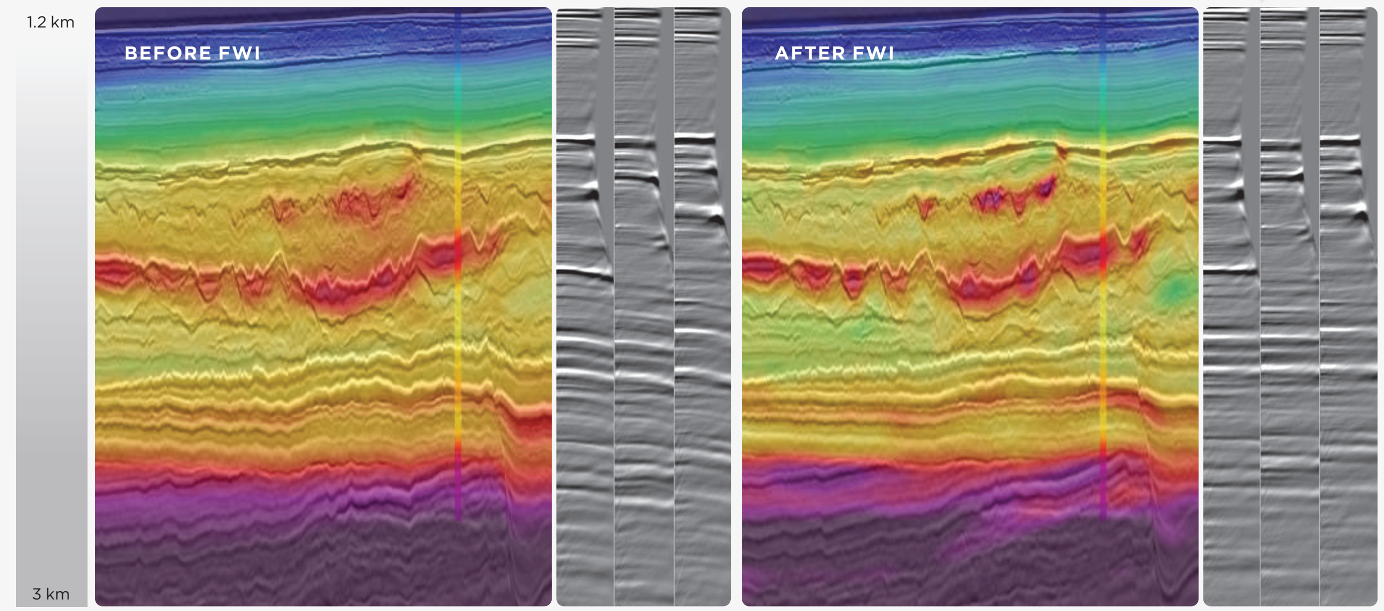


BEX MC3D data courtesy of Multi-Client Resources



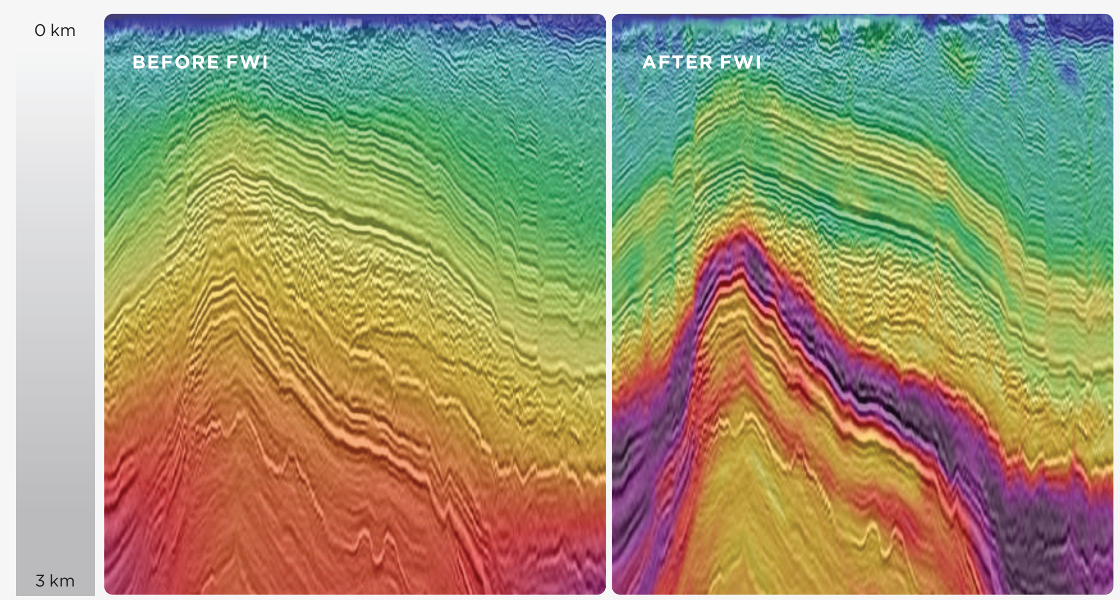
Isolating the roo ears allows much more of the wavefield to be used (primary, multiple and ghost reflections!) to derive velocity-model updates. In these examples the approach provided a detailed model that resolved lateral variations in the overburden resulting in flatter gathers, better imaging and simpler structures at depth.

Look at those flat gathers!

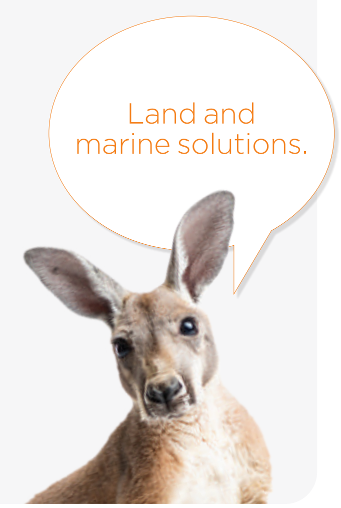


BEX MC3D data courtesy of Multi-Client Resources

LEFT: Initial velocity model co-rendered with a Kirchhoff depth-migrated stack and associated image gathers.
RIGHT: FWI velocity model co-rendered with a Kirchhoff depth-migrated stack and associated image gathers.



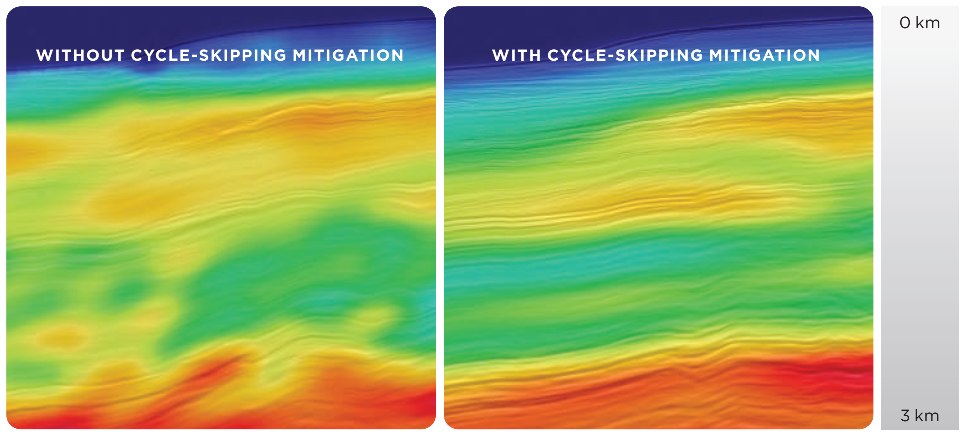
LEFT: This onshore vibroseis survey had favourable low frequencies, long offsets and full azimuth. However, the lack of offset in shallow resulted in the poor imaging of the overburden and the degradation of imaging quality at depth.
RIGHT: After FWI there are noticeable improvements throughout the section – with opportunity for interpretation of the near surface, improved imaging of events at all levels and better definition of a high velocity layer.



THE ENGINE ROOM

Designed for geoscience, not computer science

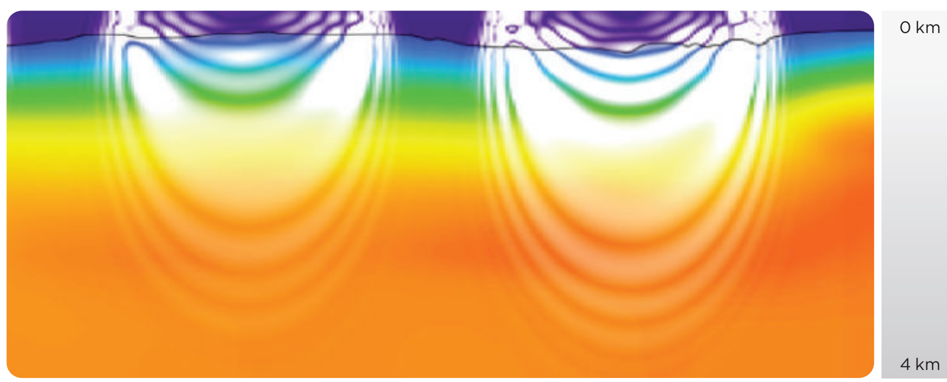
- Cycle-skipping mitigation
- Integrated footprint removal
- Multi-survey and multi-acquisition -geometry compatible
- Accelerated convergence using machine-learning techniques
- Domain decomposition for large apertures at very high-frequency
- Bespoke functionality for marine, land and ocean bottom surveys
- Invaluable for time-lapse and near-field exploration studies

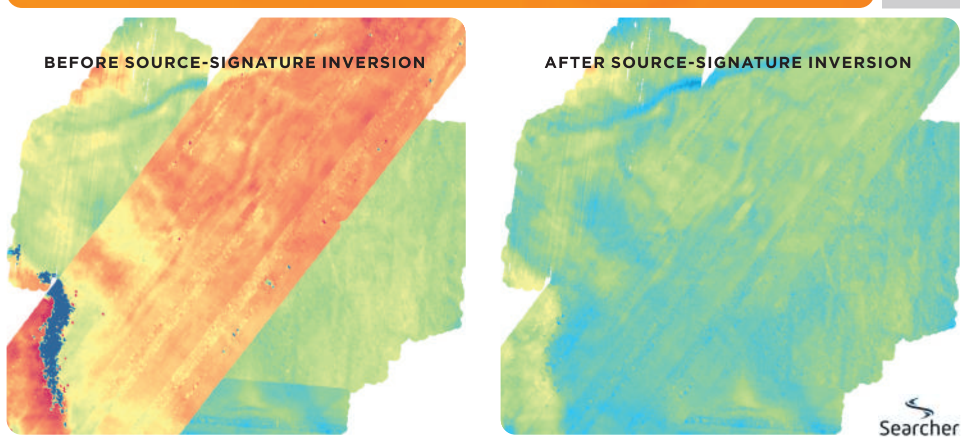


ABOVE: The phenomenon of cycle-skipping can result in inaccurate velocity models and poor imaging (left). Cycle-skipping mitigation overcomes this problem delivering accurate results (right) even from very simple starting models.

Quality Control

- Integrated QC products and data-manipulation with complete control of dataflow pipeline
- QC maps (including quantitative measures of objective function and phase)
- Synthetics-only (forward modelling) mode
- Source-signature inversion
- Diving-wave depth of penetration





MIDDLE: A diving-wave depth-of-penetration QC section highlighting the familiar banana shape.
BOTTOM LEFT: Cross-correlation QC maps prior to source-signature inversion.
BOTTOM RIGHT: Maps after source-signature inversion. Note the consistency between the four surveys in question after correctly accounting for the source-signatures.
Cool colours represent an improved tie between modelled and observed data.

Data courtesy of Searcher Seismic

FLEXIBLE SOFTWARE SOLUTIONS

You can run the software using your own hardware or using DUG's HPC.

OR

As a traditional service project.

DUG won the **2019 Enterprise Data Centre Design Award** for its patented, environmentally friendly cooling solutions.

Optimised for high-performance computing

- DUG designs, owns, and operates a network of some of the largest and greenest supercomputers on Earth
- Computer science and hardware interactions are managed by the software for maximum robustness and efficiency
- DUG's immersion-cooling technology slashes power consumption by up to 51%!
- Backed by DUG's world-leading, second-to-none support
- Secure. Reliable. Sustainable


RIDE THE
DUG WAVE
The future of seismic imaging is here!