We have developed key technologies in noise removal, deghosting and designature, 3D demultiple, data regularisation, imaging and post-migration processing to meet this goal.

**DUG HAS A COMPREHENSIVE PROCESSING TOOLKIT WHICH INCLUDES:**

- DUG Deblend – Inversion-based deblending of shot records
- DUG Broad – wave-equation-based deghosting and redatuming
- Source signature deconvolution using near-field hydrophone recordings
- SRME and IME – 3D true-azimuth, surface-related and interbed multiple elimination respectively
- DUG SW-SRME – 3D shallow water surface-related multiple elimination
- Time-space and curvelet domain simultaneous adaptive subtraction
- Surface consistent processing (statics, amplitudes, deconvolution)
- DUG Reg – 2D/3D/4D/5D interpolation and regularisation (offset-azimuth and COV)
- Various noise removal techniques including multi-dimensional Cadzow filtering
- Wide-azimuth tools including COV processing and anisotropic, azimuthal moveout corrections
- Time tomography for building accurate anisotropic PreSTM models
- Comprehensive post-migration workflows

Our experienced teams process huge datasets of all types - 2D, 3D, 4D, land, marine and ocean bottom, narrow, wide and multi-azimuth data, single and dual sensor - within our own interactive and interpretive processing system. We have state of the art, highly parallel processing codes that take advantage of our supercomputing facilities which utilise the latest in co-processor technology.

DUG’s supercomputers in Perth (Bruce), Houston (Bubba), London (Bazza), and Kuala Lumpur (Bhodi) ensure we can deliver large projects with turnaround times faster than you’ve ever imagined.

We are committed to delivering broadband data of the highest quality - ready for quantitative interpretation and tailored to suit the needs of our clients.
Blended seismic acquisition is enjoying increasing popularity in recent times because it is realising the potential economic and sampling benefits it has always promised (fold, crossline sampling, acquisition efficiency). However, shots that overlap in time need to be separated (deblended) so that they can be processed in a conventional manner (as if they had been acquired without overlap).

The simple objective of the DUG Deblend inversion algorithm is to explain all the input data as unblended records so when (re)blended they will accurately reproduce the input. When a shot is fired on top of a weak signal from an earlier shot, recovery of the weak signal is a well-known and significant challenge. We have designed an inversion-based deblending algorithm that performs exceptionally well to recover both the weaker and stronger parts of the wavefield.

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**SHOT GATHER BEFORE AND AFTER DUG DEBLEND**

01. Polarcus XArray™ - Penta source data before (left) and after (right) DUG Deblend.

**BRUTE STACK WITH REPRESENTATIVE CMP GATHER BEFORE AND AFTER DUG DEBLEND**

02. Polarcus XArray™ - Penta source data before (left) and after (right) DUG Deblend.
DUG Broad’s deghosting technology: DUG Broad removes the amplitude and phase distortion caused by both source and receiver ghosts.

The DUG Broad process results in a broadening of the spectrum as frequencies (both high and low) corrupted by the ghost wavefield are restored. This has a number of advantages for seismic interpretation through to quantitative inversion studies. The method is applicable to the processing of data from both the latest broadband acquisition systems and conventional (legacy) streamer data. DUG Broad accurately formulates the forward ghost model using the wave equation in the f-p domain, fully incorporating arbitrary receiver and/or source depth profiles and a directional expression of stochastic free-surface reflectivity. DUG Broad accurately deghosts all events, offsets and dips. The algorithm has no dependency on the earth model, other than knowledge of the water velocity. Benefits include robust and stable deghosting behaviour and the availability of output data referenced to the free-surface for all subsequent processes such as SRME, velocity analysis and migration.

DUG recognises many opportunities to use high-quality relevant signatures in the effective deconvolution of the source wavelet from seismic data. In particular, bubble periods are strongly affected by temperature and shooting speed. It is therefore preferable to use the signature information recorded as the survey is acquired - which can potentially vary from shot to shot. We use the NFH data to calculate notional signatures for every shot and subsequently use these for signature deconvolution and zero-phasing.

Our method is based on the work of Ziolkowski et al (1982). We use a conjugate gradient least-squares approach to the solution of their equations. This is based upon previous experiences with some instabilities in their original iterative method and the fact that a least-squares solution permits the use of more hydrophones than air guns. We have incorporated an additional feature into the bubble motion logic to handle guns fired at different times, such as over-under airgun arrays of various designs.
Comparison between Kirchhoff PreSDM stack from legacy processing (top) and after DUG reprocessing including DUG Broad (bottom) highlighting the significant increase in resolution and data quality. Data courtesy of Dynamic Data Services.
SRME is now a well-established and routine process that accurately models multiples associated with the free surface. However, in shallow water it relies more heavily on nearer offset data, which is difficult to acquire. As a result, we have developed methods to help tackle this issue. In this variant of SRME we utilise a model of the sea-bed reflection which can be calculated for any offset - although the need is greatest for nearer offsets. The method is very good at predicting shallow water-layer multiple models (both source-side and receiver-side). This process may be followed by traditional SRME for the longer period multiples.

**NEAR STACK SECTION BEFORE AND AFTER DUG SW-SRME**

![Near stack section before and after DUG SW-SRME](image)

**DUG IME (INTERBED MULTIPLE ELIMINATION)**

![DUG IME section](image)

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<td>06.</td>
<td>NOVAR MC3D dataset courtesy of Multi-Client Resources (MCR).</td>
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<td>07.</td>
<td>Stack section before (left) and after (middle) DUG IME. The predicted interbed multiples are shown in the far right figure. In this case the water bottom horizon is acting as the multiple generator. Time range of the data shown is from 5300-6400 ms. Data courtesy Spectrum Geo.</td>
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08. Timeslice [400 ms] before [left] and after [right] acquisition footprint removal.

09. Timeslice before [left] and after [right] anisotropic azimuthal moveout correction. This data is from Australia’s southern margin [courtesy Origin Energy].