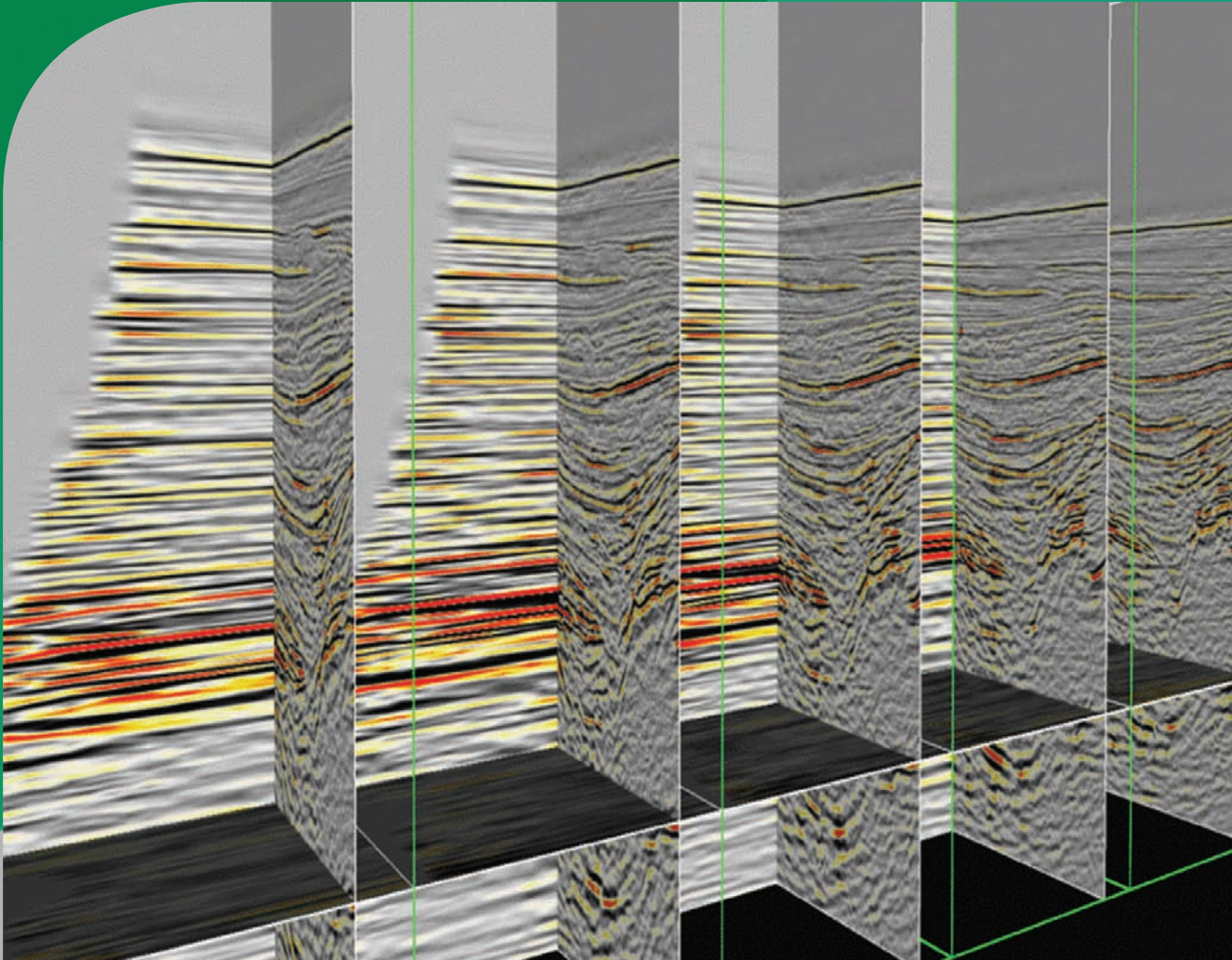


Echos[™]

Seismic Processing



Echos

The industry standard for seismic processing and data analysis

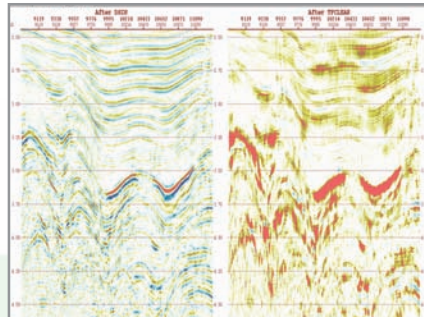
An Efficient and Versatile Solution

Paradigm™ Echos™ is the oil and gas industry's leading seismic processing system for generating 2D and 3D seismic images of the subsurface. Its popularity is based on its breadth of geophysical applications, its leading edge geophysics, its transparent blending of batch interactive processing, its architecture for computation parallelization, and its versatile programming development kit for client customization.

Echos is the cornerstone of Paradigm's seismic data analysis offering, for the performance of advanced seismic processing and imaging tasks such as 3D surface-related multiple suppression, challenging noise suppression, curved ray pre-stack time migration and Reverse Time Migration. As a member of the Paradigm seismic data analysis family, Echos is used routinely to condition data for depth imaging, seismic characterization (AVO and inversion), seismic interpretation, and pore pressure prediction projects carried out with the Paradigm suite.

Full Scalability

Through its modular design, open architecture, and adherence to standards, Echos IT professionals and geophysicists can configure and optimize the system according to their throughput requirements, user requirements and business objectives. Running on Linux® 64-bit operating systems, and deployed on the Paradigm Epos® infrastructure, Echos is fully scalable, from a single laptop to high-



Echos seismic data analysis with relative permeability extractions

performance computing clusters. The system is easily adaptable to multiple users performing multiple tasks.

Innovation in Seismic Data Analysis

Echos is widely appreciated for its highly interactive approach to job building, parameter testing and interactive data analysis. Special interactive and data comparison windows are designed to allow users to quickly see the impact of new processes, parameters and workflows on their seismic data. The outcome of operations performed with these windows includes fully parameterized job flows that can be applied immediately to the entire dataset, with no disruption on hundreds of compute nodes.

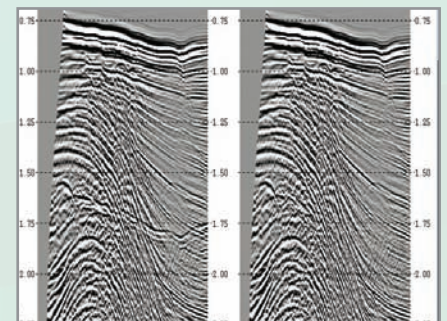
Additionally, the Echos system is fully equipped with a rich set of interactive data analysis applications for velocity analysis, geometry definition, geometry QC, signal analysis, trace header analysis, first break picking and QC, and trace editing and muting. All of these applications produce results that can be immediately used in batch processing.

Advanced Geophysical Applications

Echos includes a comprehensive library of close to 400 modules for geometry definition, amplitude scaling, wavelet extraction, deconvolution, multiple suppression, noise suppression, statics estimation, interpolation, velocity analysis, seismic imaging and seismic attribute extraction. These applications are based on a robust infrastructure that includes dynamic trace header interpolation, high-fidelity trace sample interpolation, and advanced interpolation methods that handle coordinate data with high precision. The system also supports second, fourth and sixth order normal moveout corrections (NMO).

Surface Related Multiple Attenuation (SRMA)

Surface multiples from irregular 2D and 3D water bottoms are best predicted by the convolution of pre-stack seismic traces from all possible surface multiple reflection locations, and best removed by adaptive subtraction procedures. The Echos SRMA solution is designed for 2D and 3D seismic surveys. It incorporates a true azimuth implementation and is able to handle in-fill



Surface-related multiple attenuation



High-performance computing with Echos

and feathering. The application requires minimum data preparation requirements, eliminates the sparse inversion step, and is optimized for cluster computing.

In addition to SRMA methods, the Echos system also includes high-resolution Radon transforms and wave equation techniques for the suppression of multiple energy.

Intelligent Noise Suppression with LIFT

Seismic noise sources are highly variable and generate noise trains that are frequently difficult to predict and remove. The application of standard noise suppression techniques may attenuate only some of the noise, and attempts to apply stronger noise suppression filters may adversely affect amplitude quality. LIFT is a proprietary process that attenuates noise and better preserves the amplitude

integrity of primary reflectors. The process uses a general method for “lifting” noise while reconstructing the signal to its original form. LIFT sequences are adaptable to all classes of noise, including random noise, coherent noise and multiples. The outputs of LIFT sequences are highly suitable to AVA techniques and other seismic characterization procedures.

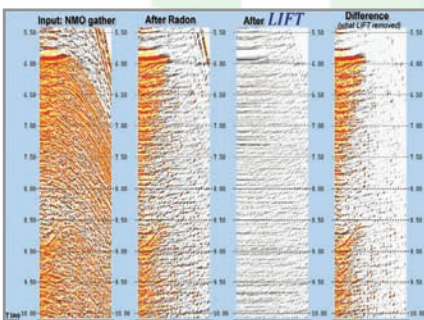
Time-Frequency Analysis

The time-frequency transform and domain describe the energy density of a signal simultaneously in time and frequency. The mapping process from signal space to time-frequency space is performed by decomposing the trace into several discrete frequency components over small running time windows. In the Echos system, this decomposition is performed with Gabor-Morley filters, resulting in a high-resolution and stable decomposition.

In Echos, the time-frequency decomposition is used for:

- Sample-by-sample noise suppression to remove noise bursts from seismic data
- Spectral Decomposition for thin bed detection and attenuation analysis
- Frequency band extension for high-resolution signal analysis
- Dual porosity relative permeability estimation

Serving the oil and gas industry for over twenty-five years, Echos enjoys widespread usage among international and domestic oil companies, seismic contractors, universities and research institutions. The system is ideal for customers needing reliable, 24x7 computations on high-performance computing clusters, as well as the interactivity required for detailed analysis and continuous image improvement. Echos is routinely deployed to condition seismic data for depth imaging, seismic characterization, interpretation and pore pressure prediction projects.



LIFT Technology attenuates multiples that even two passes of Radon demultiple could not handle, while still preserving primary reflection amplitudes

Curved Ray Pre-stack Time Migration

Echos can serve as host for the GeoDepth® pre-stack time migration add-on module, one of the most popular choices for Kirchhoff imaging in the industry.

Parameterized like a standard Echos module, this pre-stack time migration includes options for:

- Acquisition footprint suppression using Voronoi scaling
- Imaging from floating datum and surface topography
- Image gather, target line or full volume output
- 2nd or 4th order traveltimes solutions
- Isotropic or anisotropic curved ray solutions

Reverse Time Migration (RTM)

Reverse Time Migration (RTM) is a preferred solution for imaging seismic data in areas of complex wave phenomena. It is able to handle the most severe combinations of structural dip with high velocity contrast,

conditions common in salt basins and other geologic basins with complex structures and velocity distributions. Developed in conjunction with Acceleware® Corporation, the Echos RTM solution includes:

- 2D and 3D imaging
- Streamer, OBC and onshore solutions
- Isotropic and anisotropic imaging
- Common Image Gather output
- Surface seismic and subsurface (VSP) seismic imaging
- Imaging or forward modeling
- Multi-core CPU or GPU processing

Multi-Component Processing

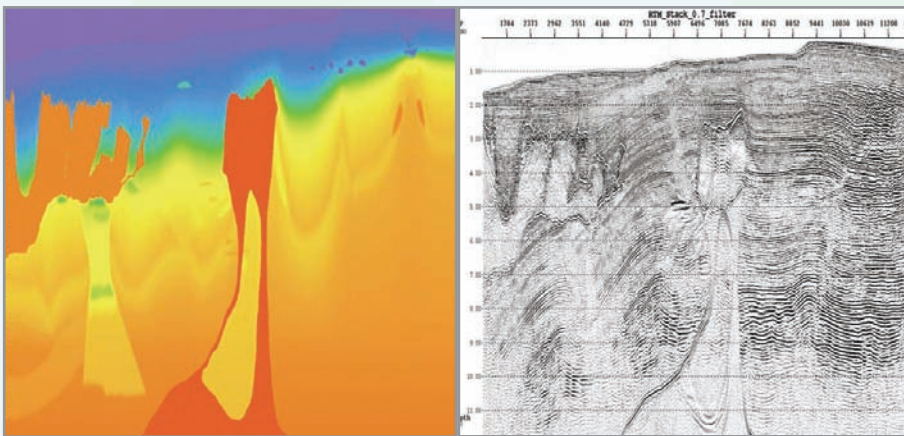
Echos is equipped with a full suite of seismic processing modules to transform converted wave recordings to interpretable images of the subsurface. The system includes applications for ocean bottom cable deghosting, coupling analysis and correction, rotations to obtain horizontal and vertical shear wave fields, common conversion point binning, converted wave velocity analysis, non-hyperbolic moveout and stacking.

Output gathers can be used to initiate 3D converted wave time or depth migrations in the GeoDepth velocity model building and depth imaging system. In addition, many of the Echos geometry QC applications have been enhanced to support the QC of converted wave data.

Production Monitoring

Echos includes a rich set of utilities used to monitor the progress of jobs running on clusters and the cluster performance. These include:

- System CPU and memory usage display for network parallel jobs
- Network-wide job monitoring in a single window
- Job summary list with job display filters
- Composite parallel job performance display
- Per module and per host oriented parallel job display
- Job performance information, including time displays and throughput information



BP 2004 salt model and Paradigm RTM image

Interoperability
All Epos-based applications enable interoperability with third-party data stores, including:

- OpenWorks® 2003.12, R-5000
- GeoFrame® 4.5
- OpenSpirit® 3

System specifications

- All 64-bit, for x64 architecture processors
- Red Hat® Enterprise Linux® 5.3 and above, 6.0 and above

The Paradigm Advantage

- + Geophysical integrity obtained in over 25 years of customer usage.
- + State-of-the art seismic processing and imaging solutions, including SRMA and RTM.
- + The industry's best interactive link between seismic applications, parameters and data.
- + Data compatibility with other Epos-based products, for expanded workflows and project coverage.
- + An open solution with programming libraries and tool kits for client customization.
- + A highly efficient parallel framework and infrastructure for cluster optimization.