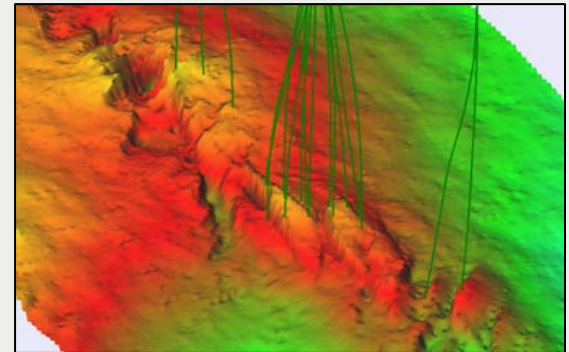
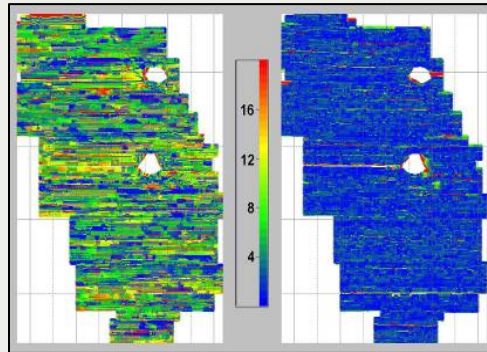
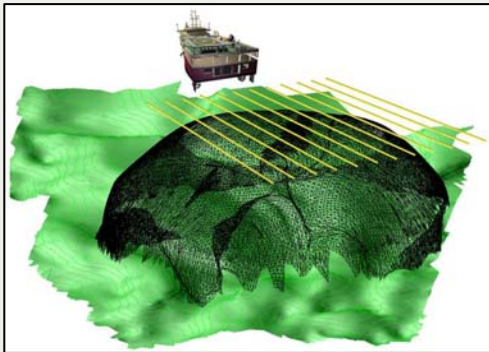


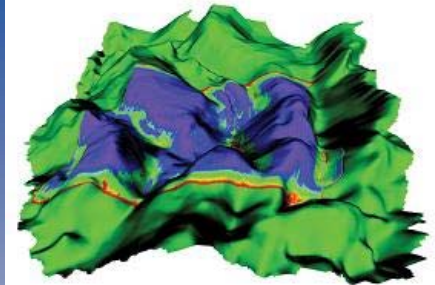
Synergies between high-end seismic acquisition and processing technologies: How to plan for success

Andrew Long, PGS Marine Geophysical

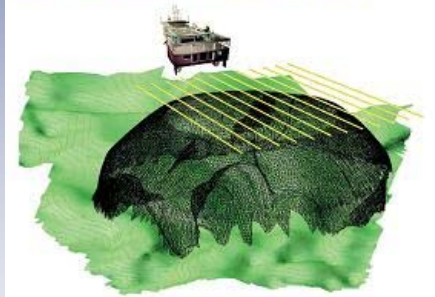


- **Introduction**
- **The perfect 3D seismic survey**
- **Fundamentals of pre-survey planning**
- **High resolution imaging**
- **Imaging in complex geology**
- **Imaging in complex anisotropy**
- **4D reservoir monitoring**
- **Conclusions**

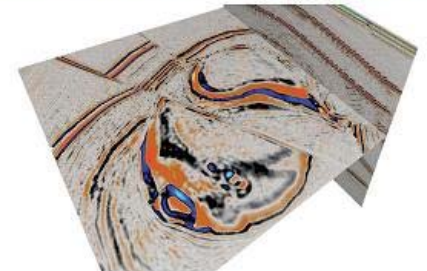
1. Uniform target illumination



2. Dense wavefield sampling



3. Accurate processing and imaging



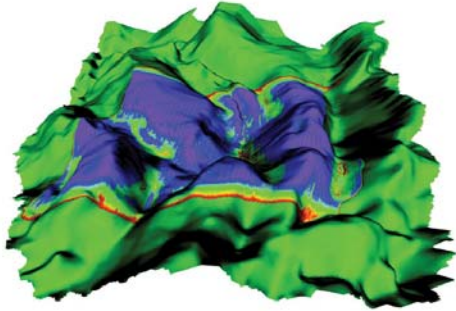


What impacts the resolution of the target geology?

- Frequency bandwidth recorded for primary reflections
- Ability to preserve frequency bandwidth throughout the entire processing flow
- Quality of target illumination
- 3D spatial sampling of upgoing seismic wavefield
- Nature of (2D vs. 3D) noise wavefields and our ability to suppress them during processing
- Accuracy of the 3D velocity model used for processing
- Specular aperture size available for processing and imaging
- S/N quality output from imaging
- Ability to minimize artefacts during processing and imaging

The ideal 3D seismic survey

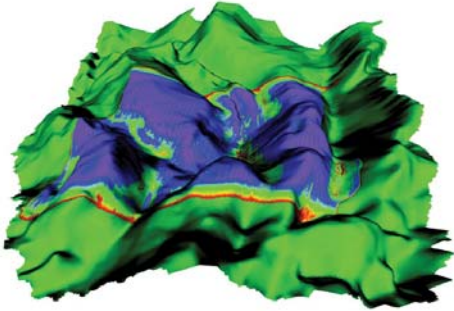
1. Uniform target illumination



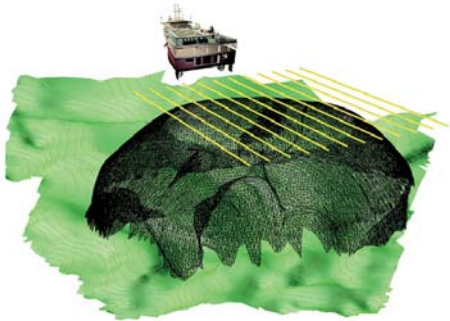


The ideal 3D seismic survey

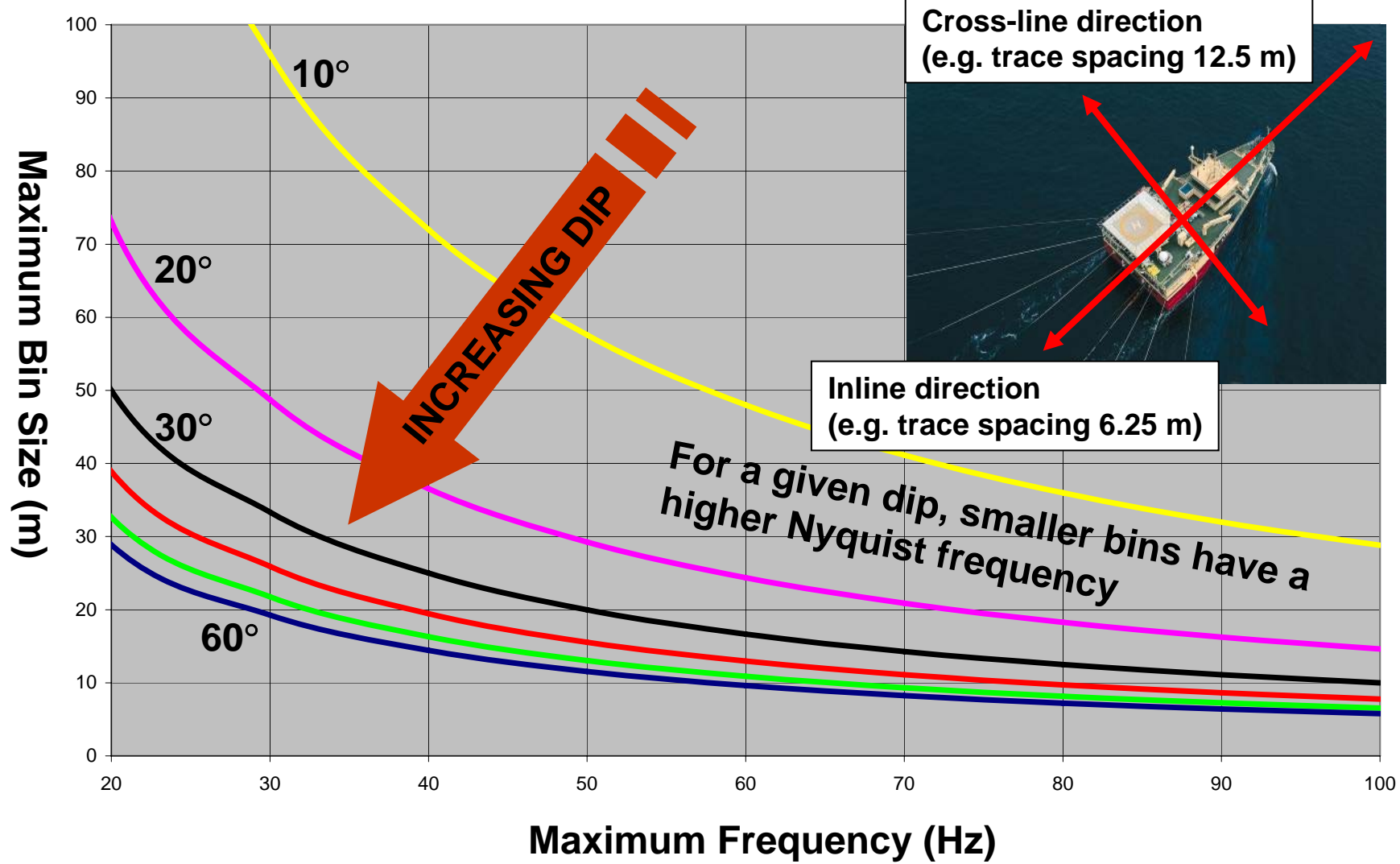
1. Uniform target illumination



2. Dense wavefield sampling

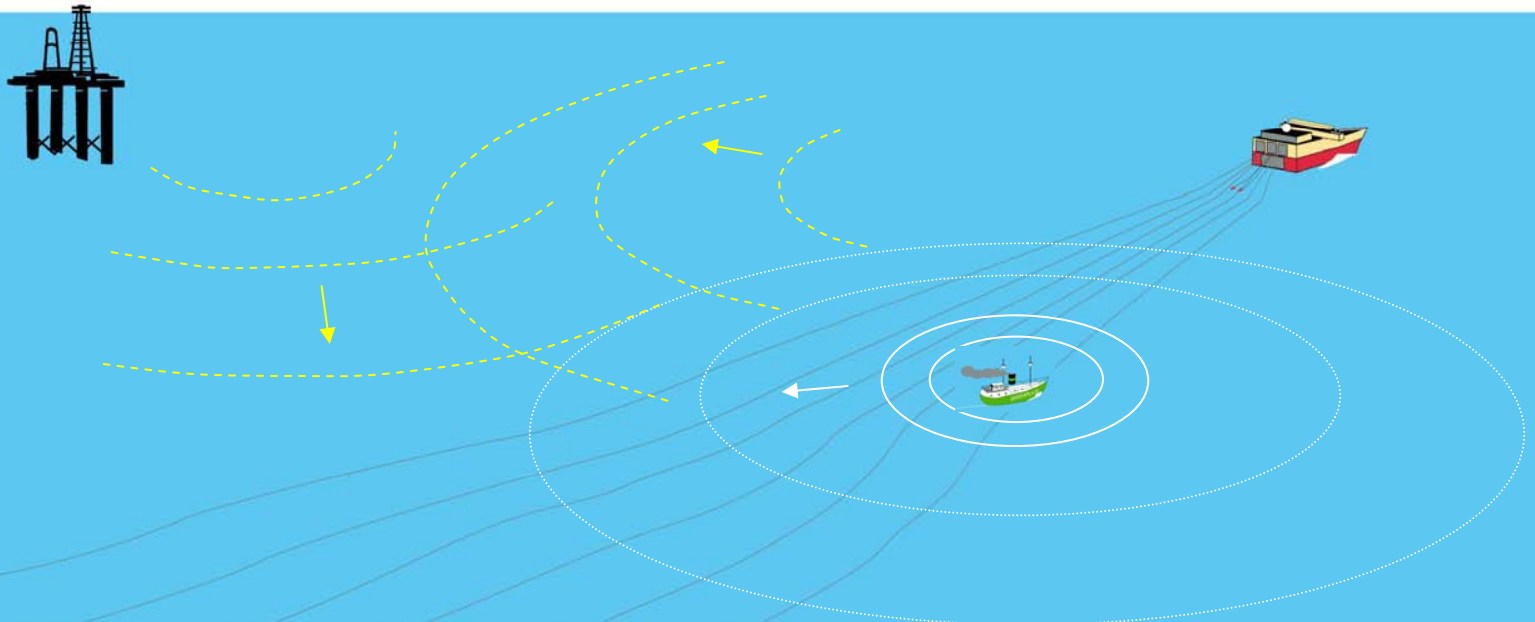


Resolution according to Nyquist





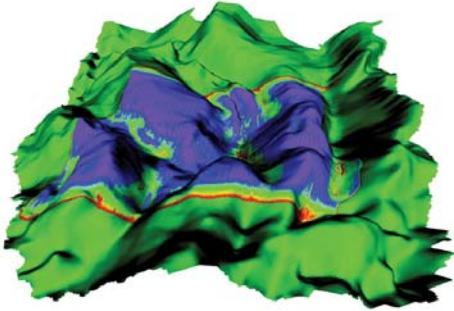
Acquisition noise: Many source mechanisms



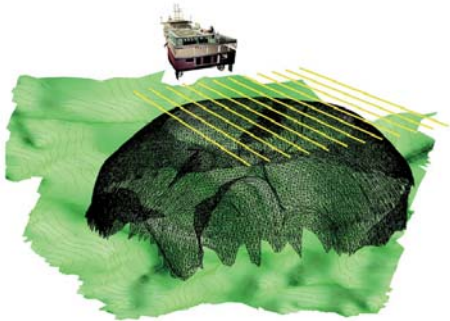
Requires true 3D sampling to enable accurate description and removal during processing.

The ideal 3D seismic survey

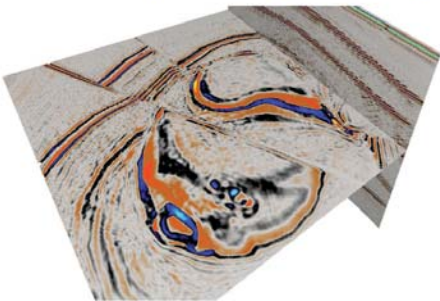
1. Uniform target illumination



2. Dense wavefield sampling



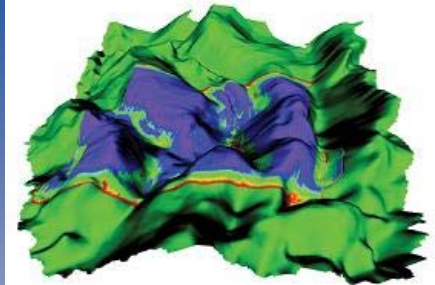
3. Accurate processing and imaging



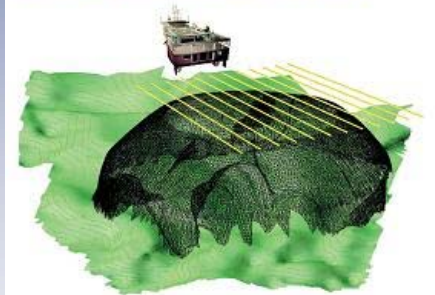
- Requires accurate velocities
- Benefits from regularized data
- All artifacts must be minimized

- Introduction
- The perfect 3D seismic survey
- **Fundamentals of pre-survey planning**
- High resolution imaging
- Imaging in complex geology
- Imaging in complex anisotropy
- 4D reservoir monitoring
- Conclusions

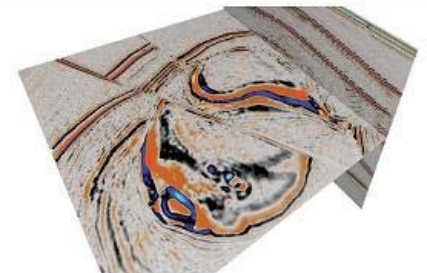
1. Uniform target illumination



2. Dense wavefield sampling



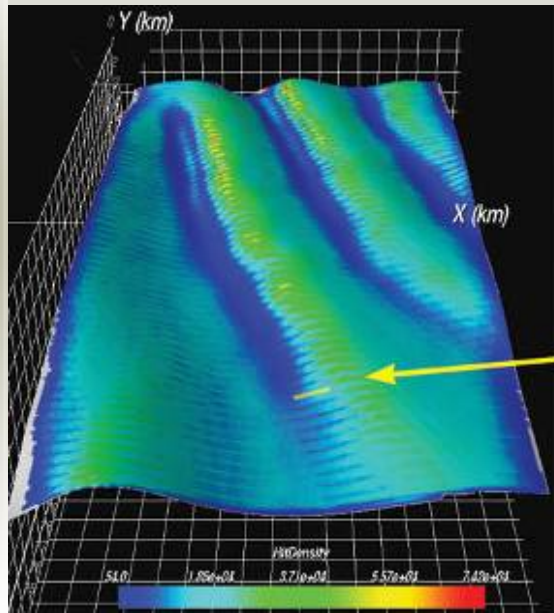
3. Accurate processing and imaging



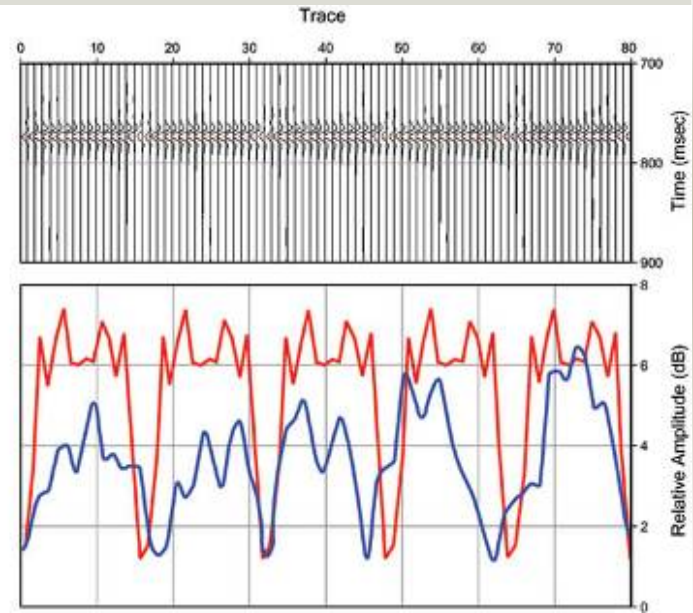
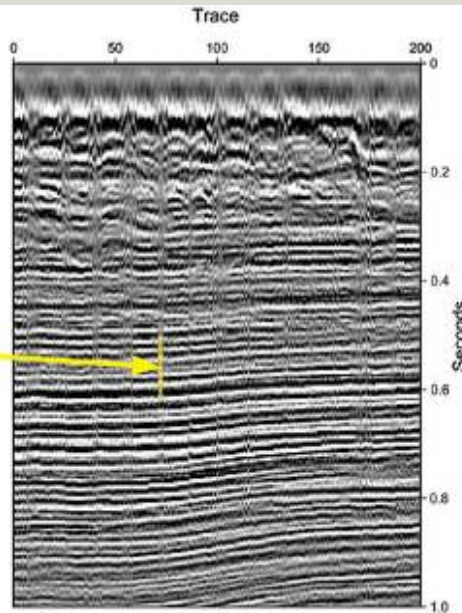


Nominal streamer configuration



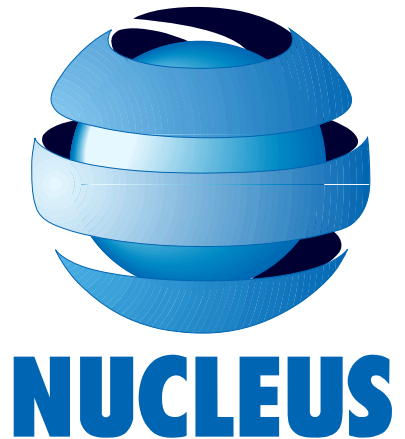


CROSS-LINE FOOTPRINT

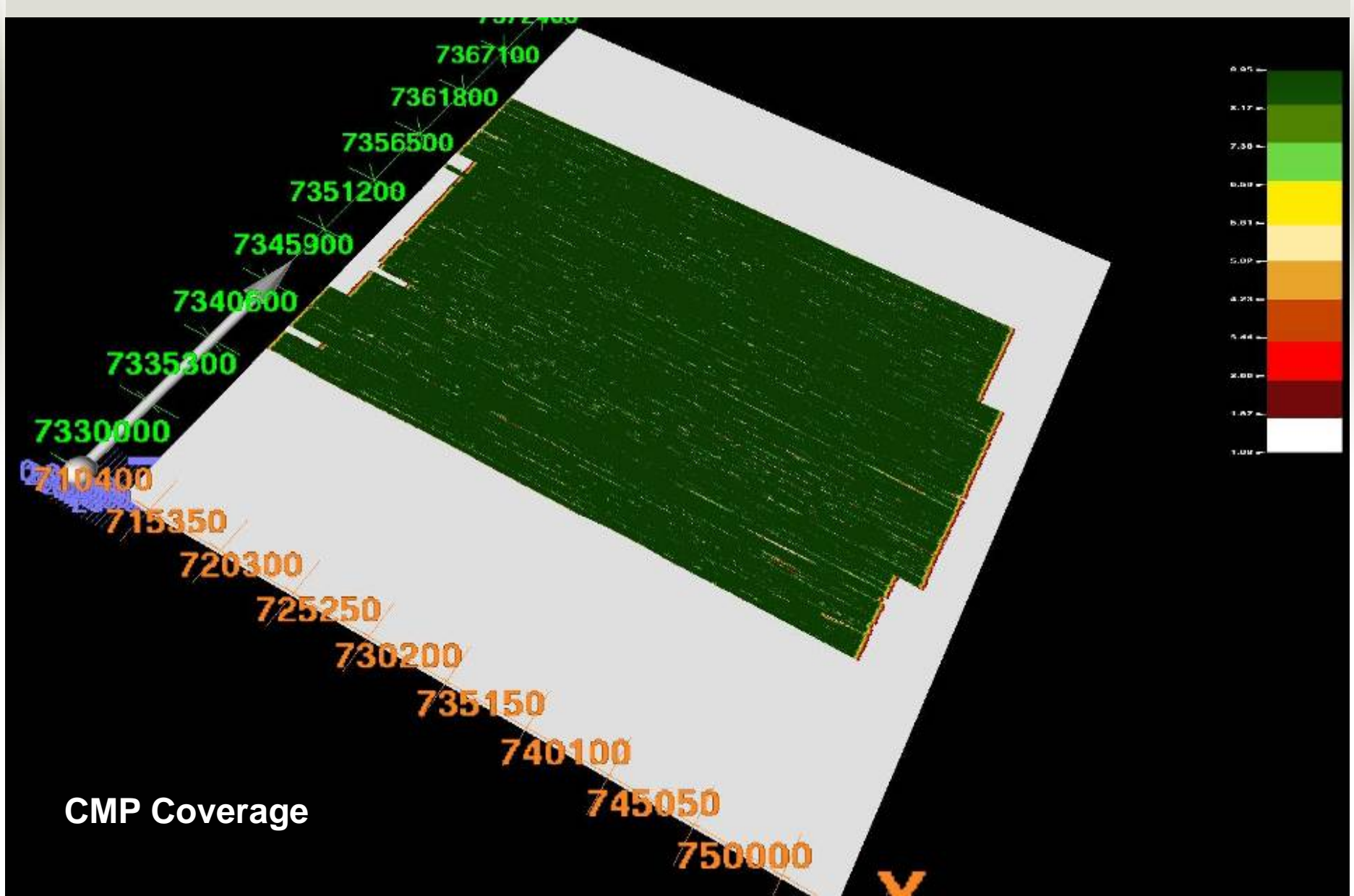


Flexible and comprehensive software including all elements of survey planning

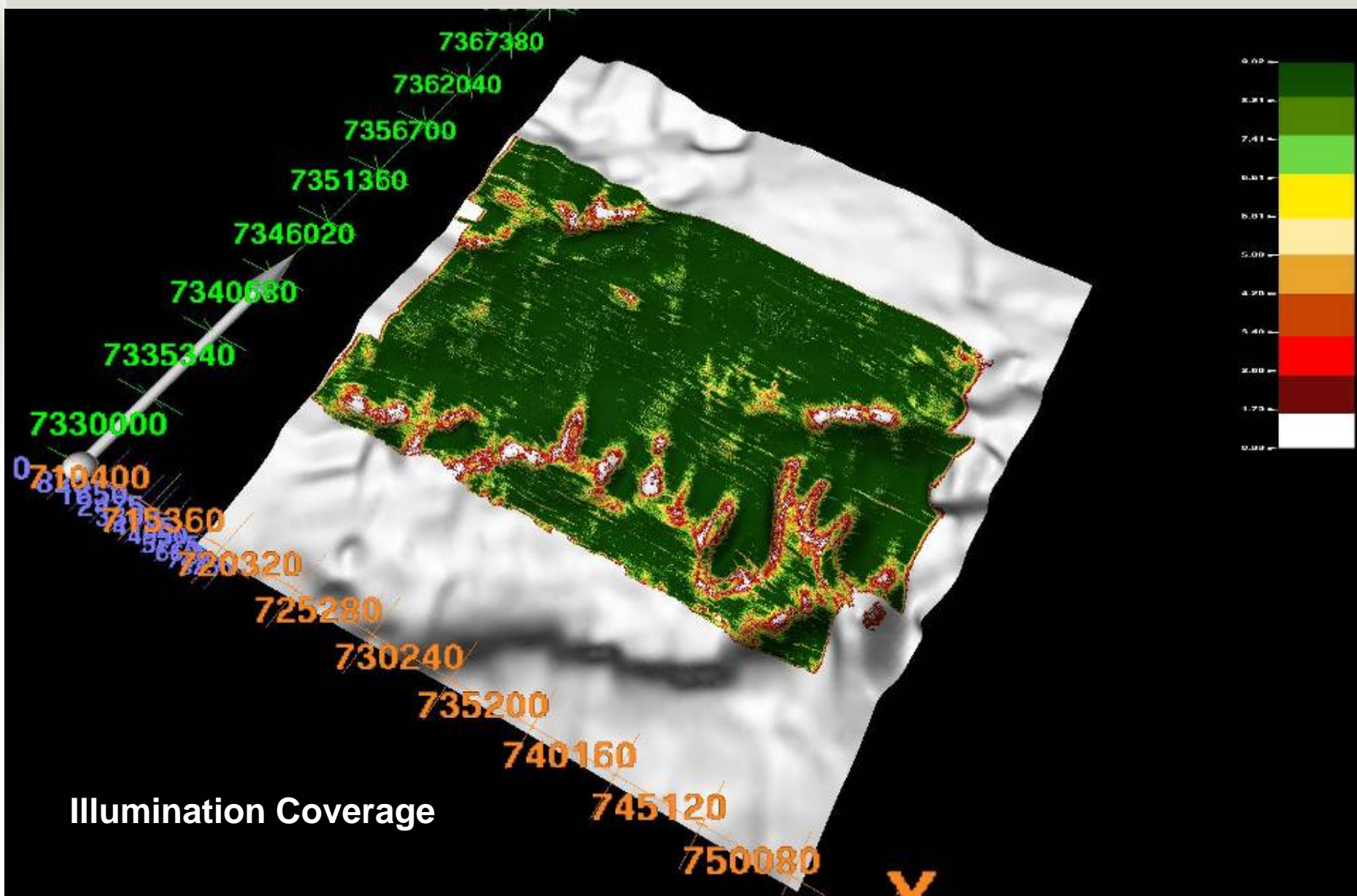
- All source, streamer and recording system responses
- Full anelastic 3D wave propagation
- Calibrated to real Earth and seismic data effects



“Real time” acquisition monitoring and modeling

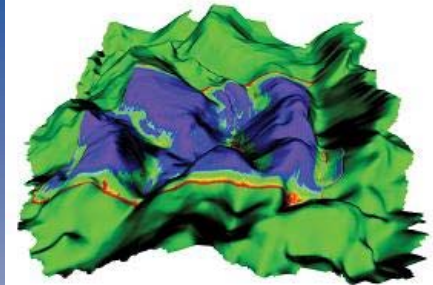


“Real time” acquisition monitoring and modeling

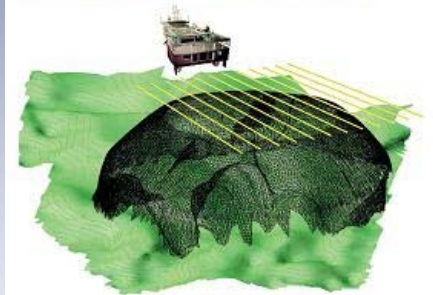


- Introduction
- The perfect 3D seismic survey
- Fundamentals of pre-survey planning
- **High resolution imaging**
- Imaging in complex geology
- Imaging in complex anisotropy
- 4D reservoir monitoring
- Conclusions

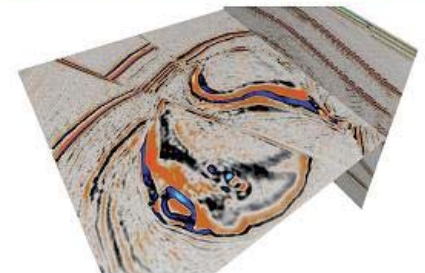
1. Uniform target illumination



2. Dense wavefield sampling



3. Accurate processing and imaging





High resolution imaging

Vertical resolution: Recoverable frequency bandwidth

Spatial resolution: Dense 3D spatial sampling

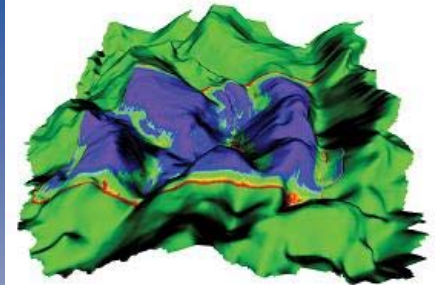
Linked by the success of high frequency focusing and imaging.

Pre-survey planning priorities:

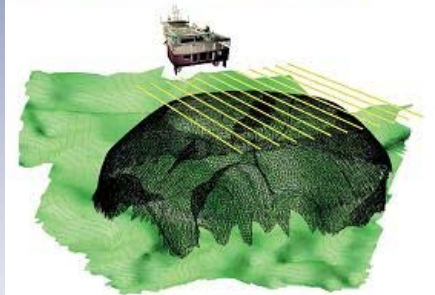
- **3D spatial sampling requirements**
- **Source array design**
- **Source and receiver depth optimisation**

- Introduction
- The perfect 3D seismic survey
- Fundamentals of pre-survey planning
- High resolution imaging
- **Imaging in complex geology**
- Imaging in complex anisotropy
- 4D reservoir monitoring
- Conclusions

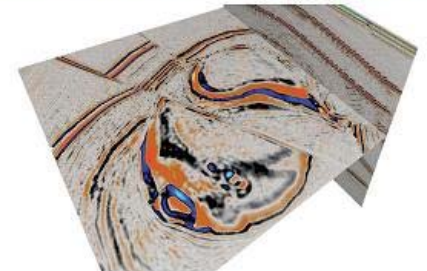
1. Uniform target illumination



2. Dense wavefield sampling



3. Accurate processing and imaging





Imaging in complex geology and poor illumination

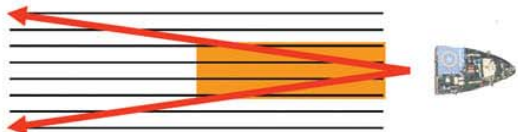
Several factors affect target illumination:

- Surface or water bottom topography
- 3D velocity model between the surface and the target
- Target topography

Pre-survey planning priorities:

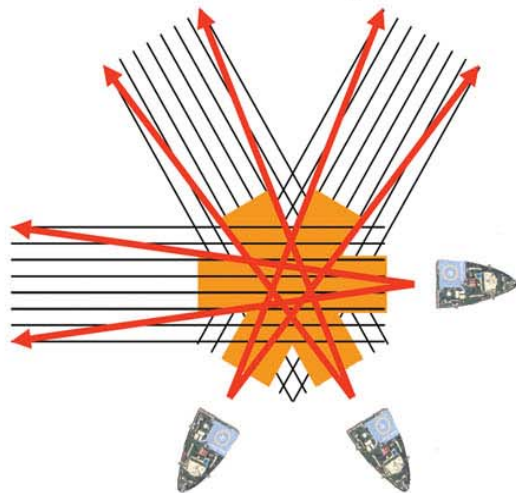
- **Improve specular aperture at all critical target locations**
- **Shooting direction, Multi-Azimuth (MAZ), Wide-Azimuth (WAZ)**
- **Consider cost implications for pre-stack imaging (PSDM+)**

Narrow-Azimuth (conventional)



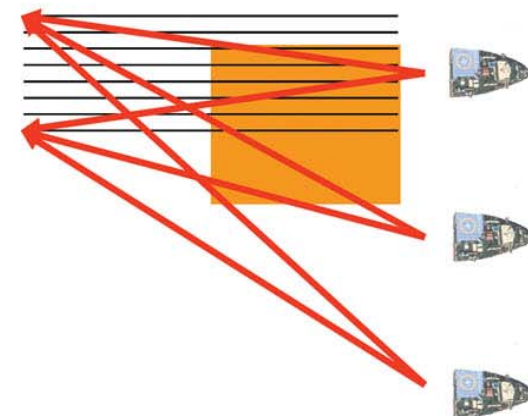
Narrow range of azimuths

Multi-Azimuth Acquisition



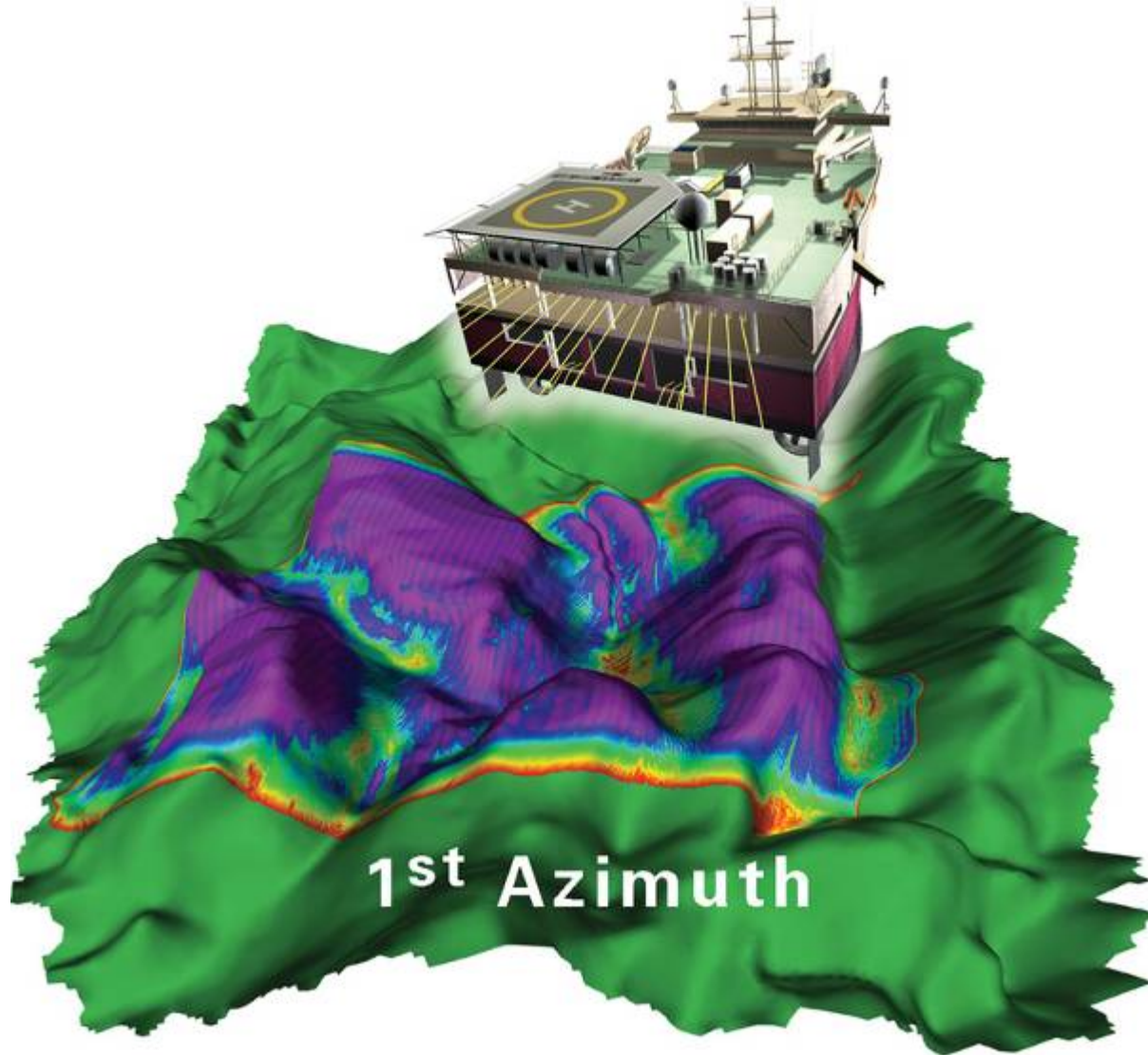
Multiple range of azimuths

Wide-Azimuth Acquisition

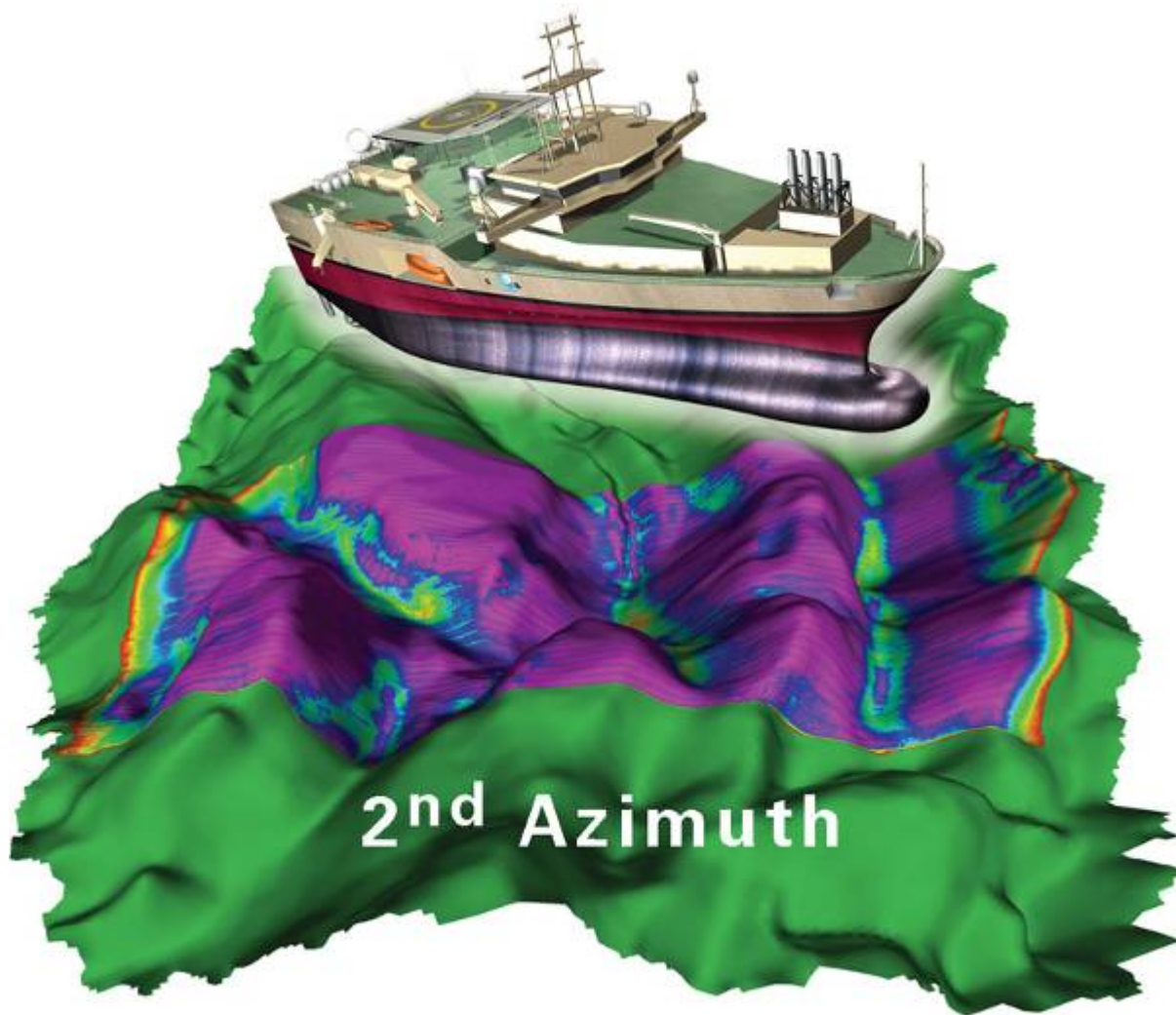


Wider range of azimuths

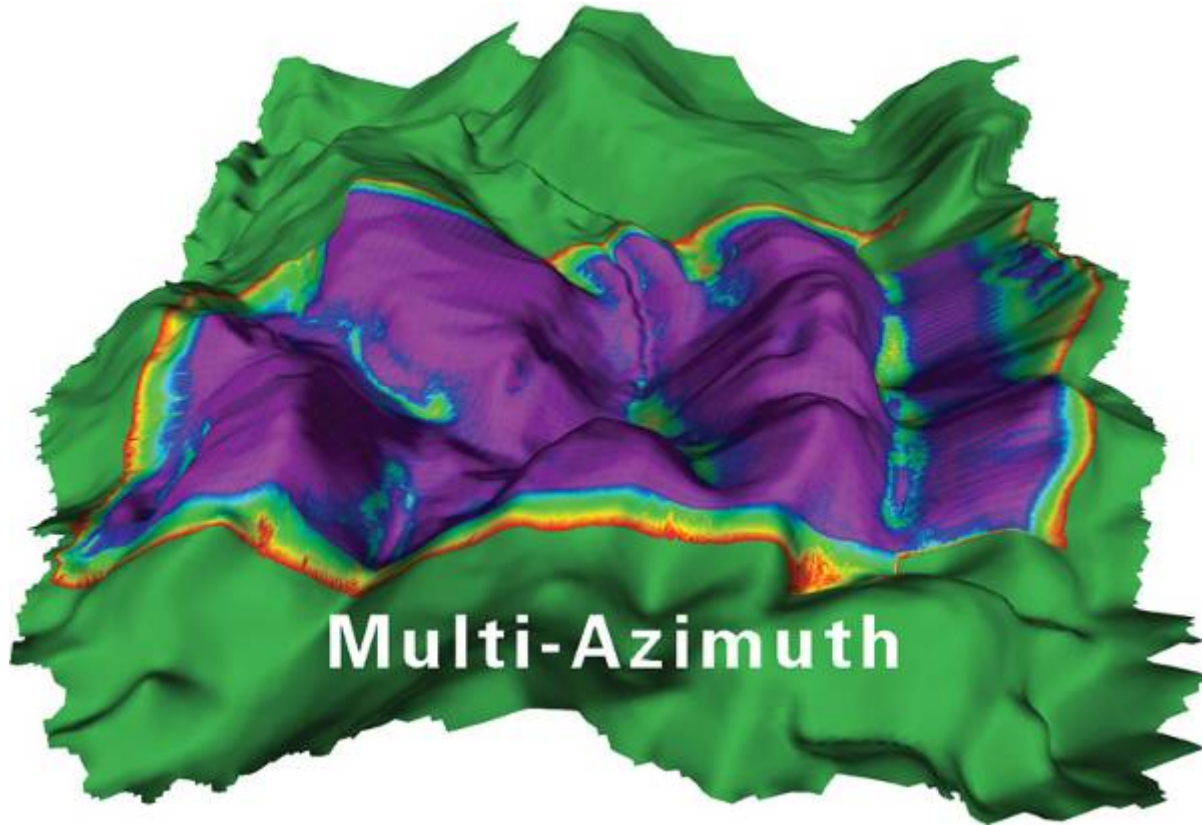
Multi-Azimuth: Optimal target illumination



Multi-Azimuth: Optimal target illumination

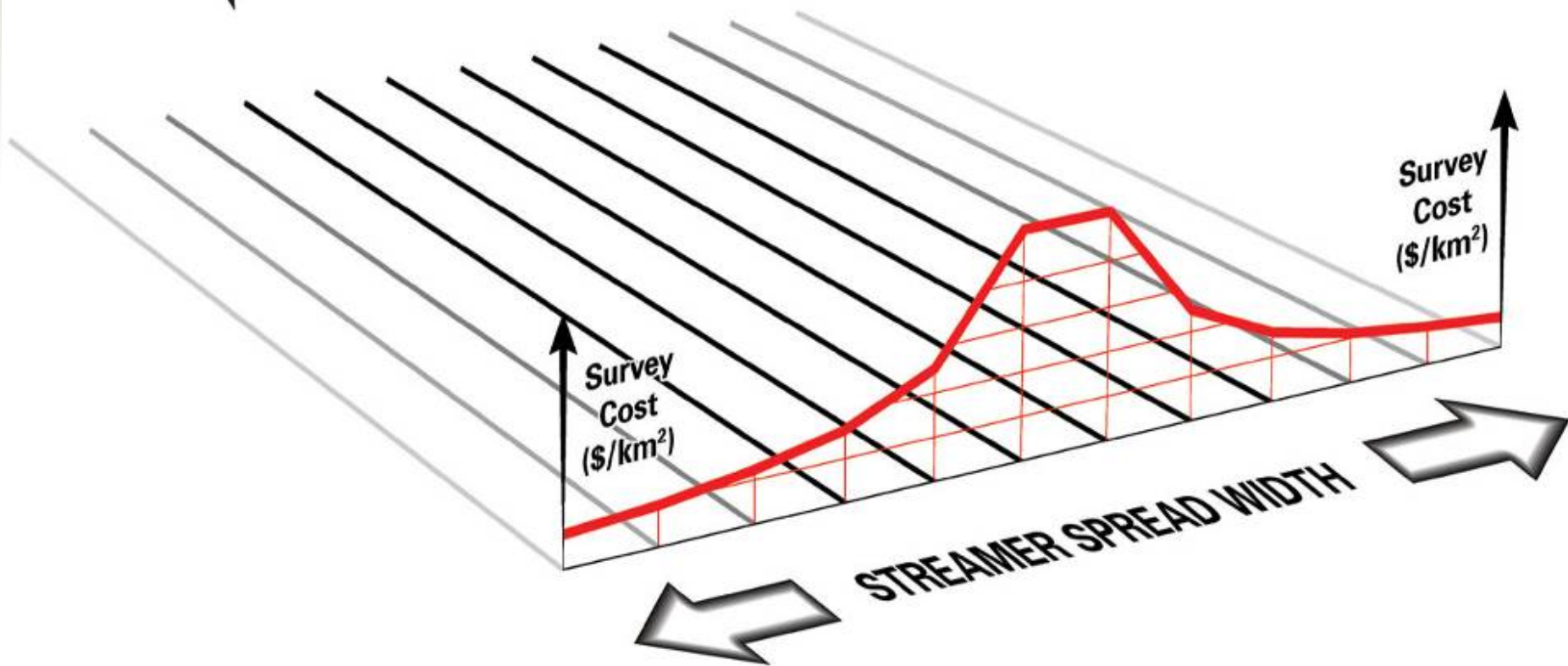


Multi-Azimuth: Optimal target illumination



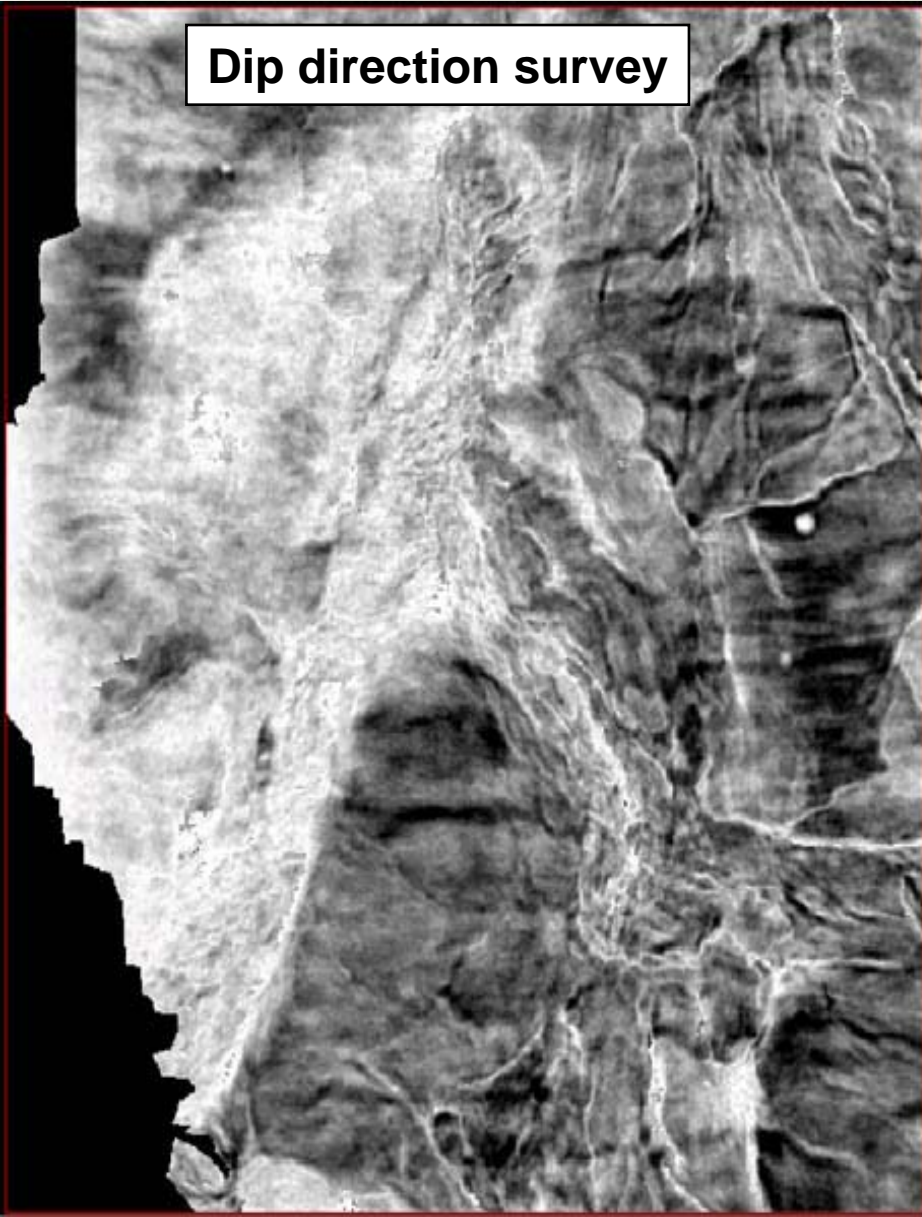


Efficiency is very important

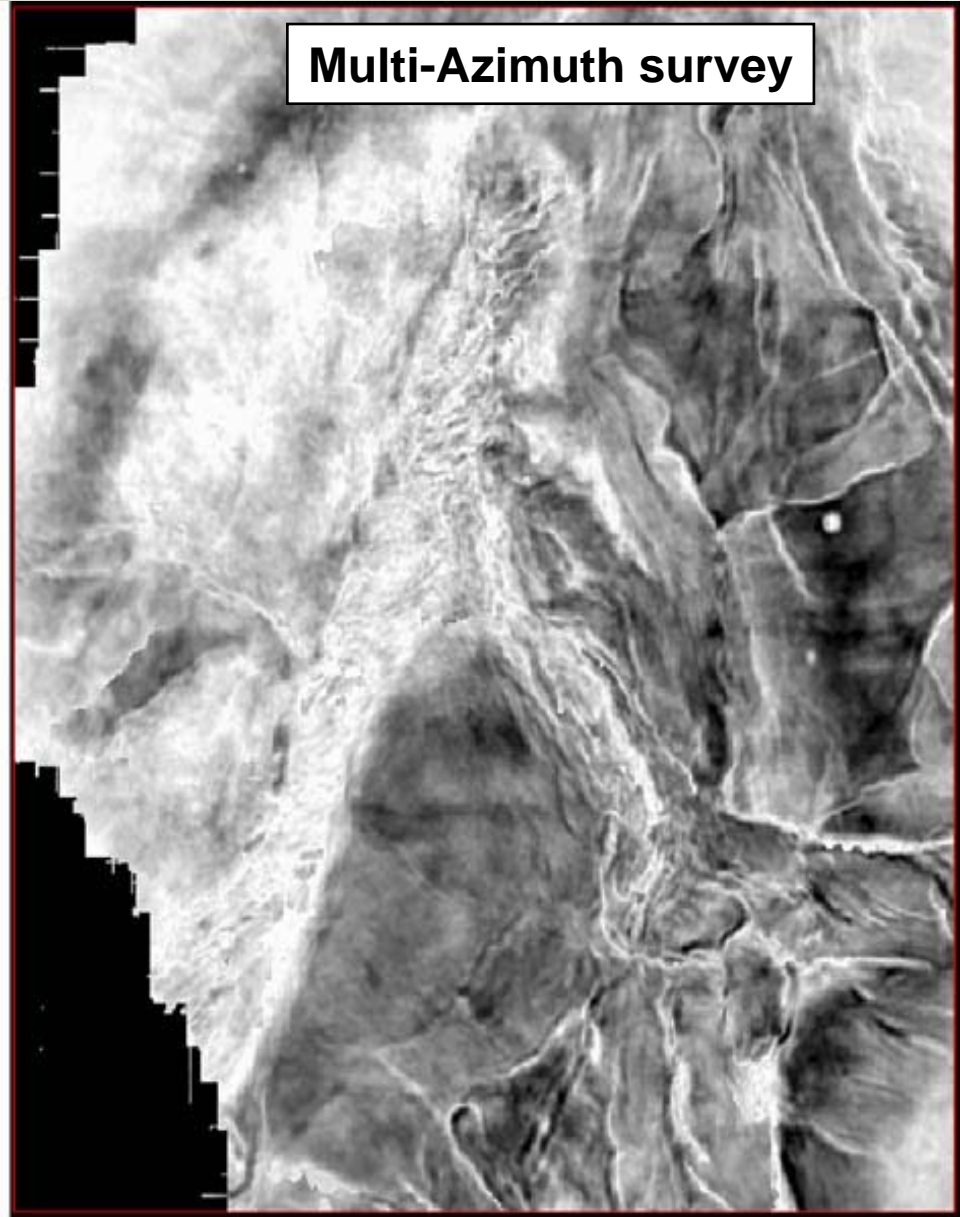


Poor target illumination: North Sea

Dip direction survey

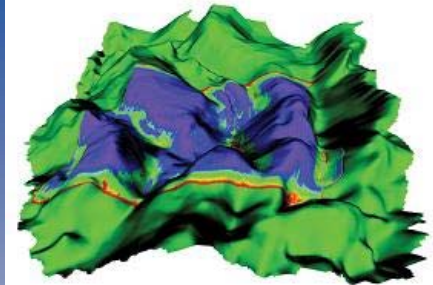


Multi-Azimuth survey

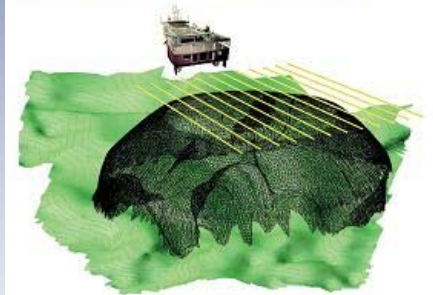


- Introduction
- The perfect 3D seismic survey
- Fundamentals of pre-survey planning
- High resolution imaging
- Imaging in complex geology
- Imaging in complex anisotropy
- 4D reservoir monitoring
- Conclusions

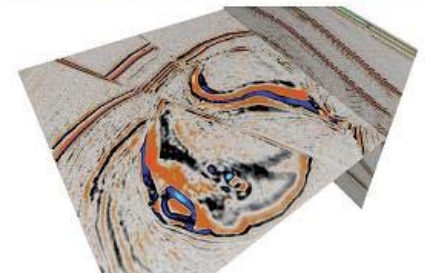
1. Uniform target illumination



2. Dense wavefield sampling



3. Accurate processing and imaging





Imaging in complex anisotropy

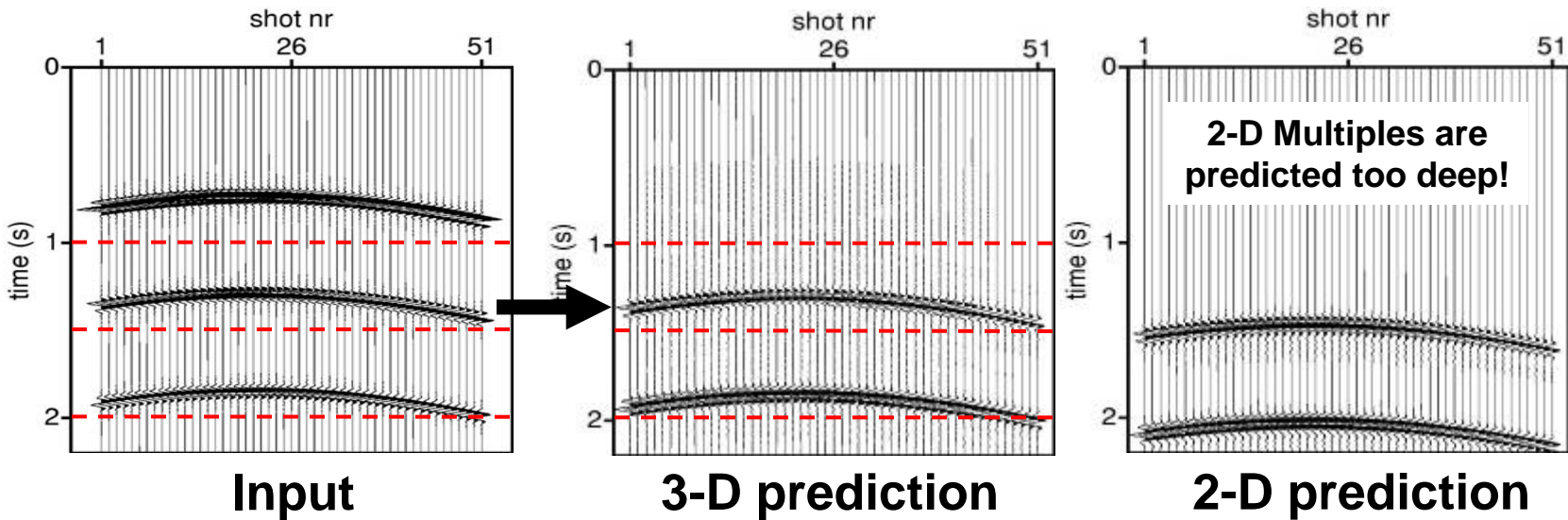
Require precise imaging, free of artifacts.

Pre-survey planning priorities:

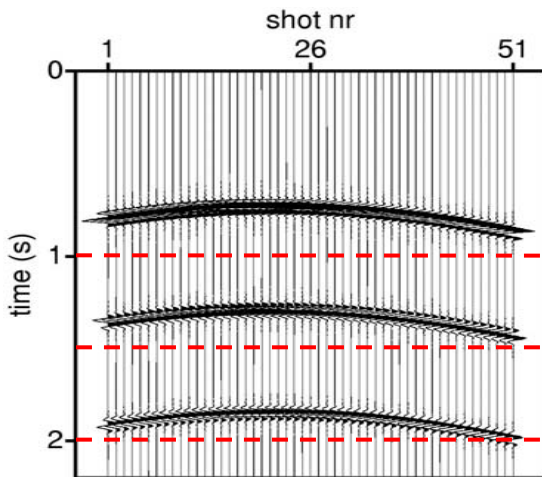
- **Longer offset requirements**
- **Remove all complex multiples**
- **Appropriate target illumination**
- **Dense 3D sampling to optimise pre-stack imaging**

Standard SRME vs. 3D SRME

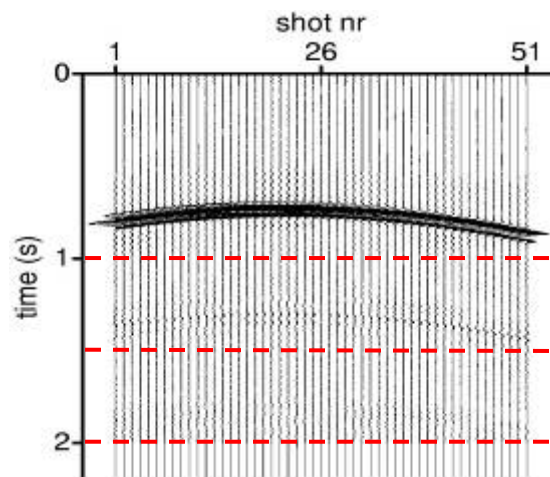
Note that the 3D SRME multiples are predicted with a correct arrival time, even when cross-line structure exists.



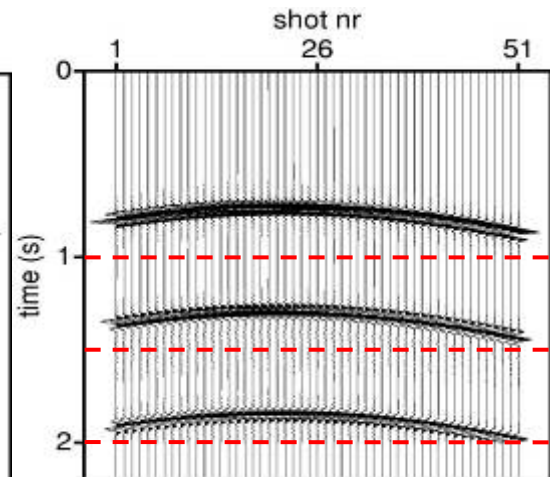
Consequently, 3D SRME should create no residual multiple errors.



Input



After 3-D SRME



After 2-D SRME

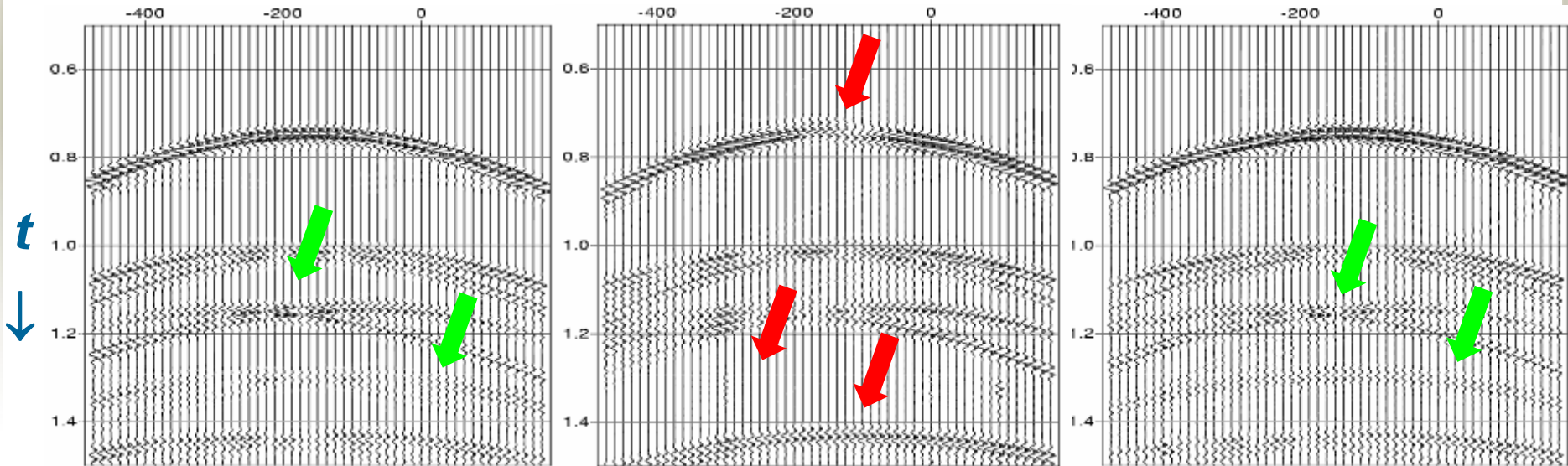
Optimized HD3D acquisition for 3D SRME

$y \rightarrow$

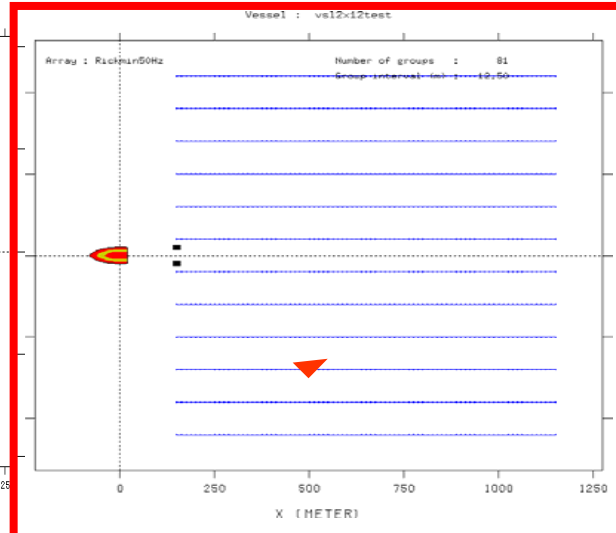
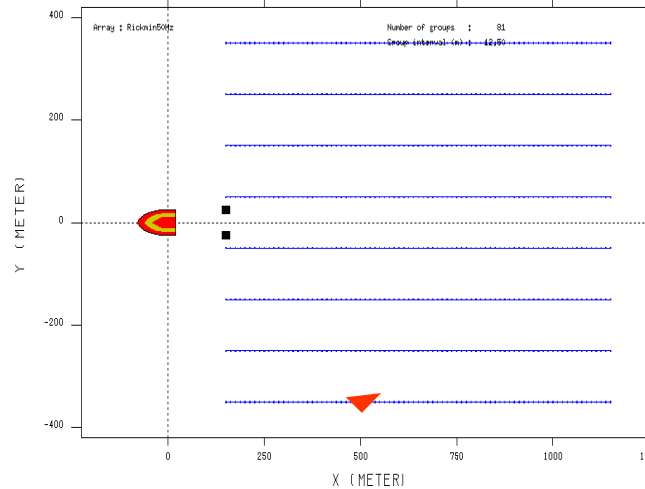
Ideal

Geometry 1

HD3D Geometry

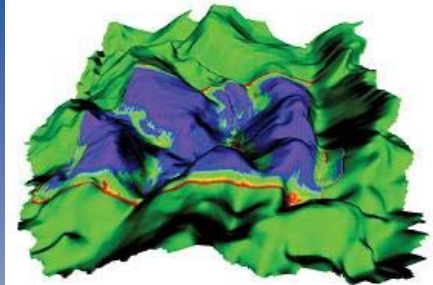


Vessel : vs12x8test

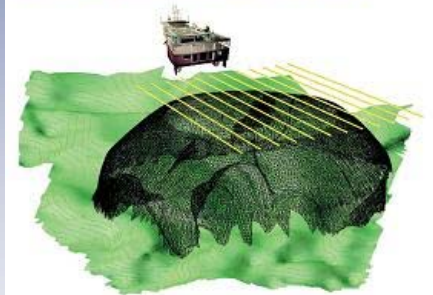


- Introduction
- The perfect 3D seismic survey
- Fundamentals of pre-survey planning
- High resolution imaging
- Imaging in complex geology
- Imaging in complex anisotropy
- **4D reservoir monitoring**
- Conclusions

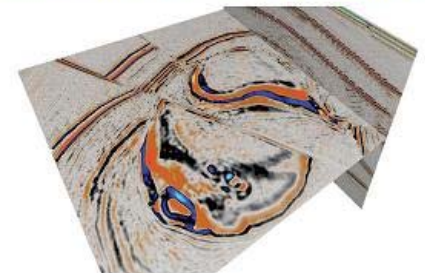
1. Uniform target illumination



2. Dense wavefield sampling



3. Accurate processing and imaging





4D time-lapse reservoir monitoring

Proven robust 4D acquisition strategy:

- Repeat all shot lines and shot locations
- Use streamer overlap shooting
- Use a HD3D strategy to optimize 3D spatial sampling
- Sophisticated real-time QC and processing

Pre-survey planning priorities:

- **Consider all environmental and operational factors**
- **Stick to the 4D strategy above**
- **Prepare to have an ongoing contribution to management**

4D processing QC strategy

Base Survey

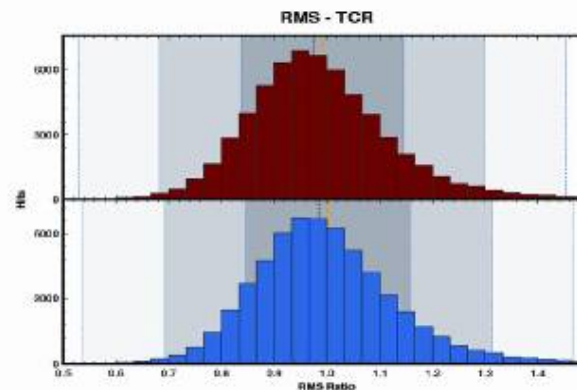
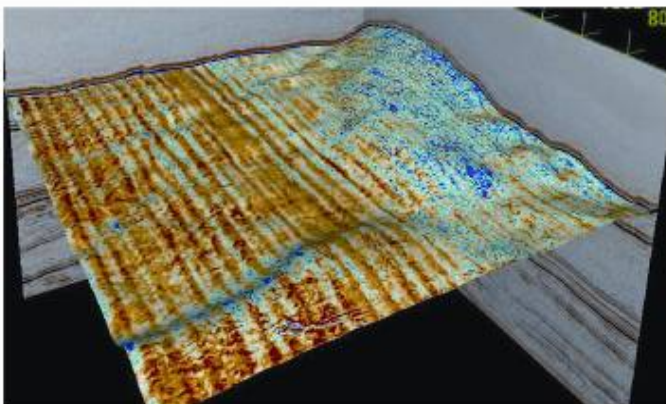
Monitor Survey

4DQC Toolbox

holoSeis

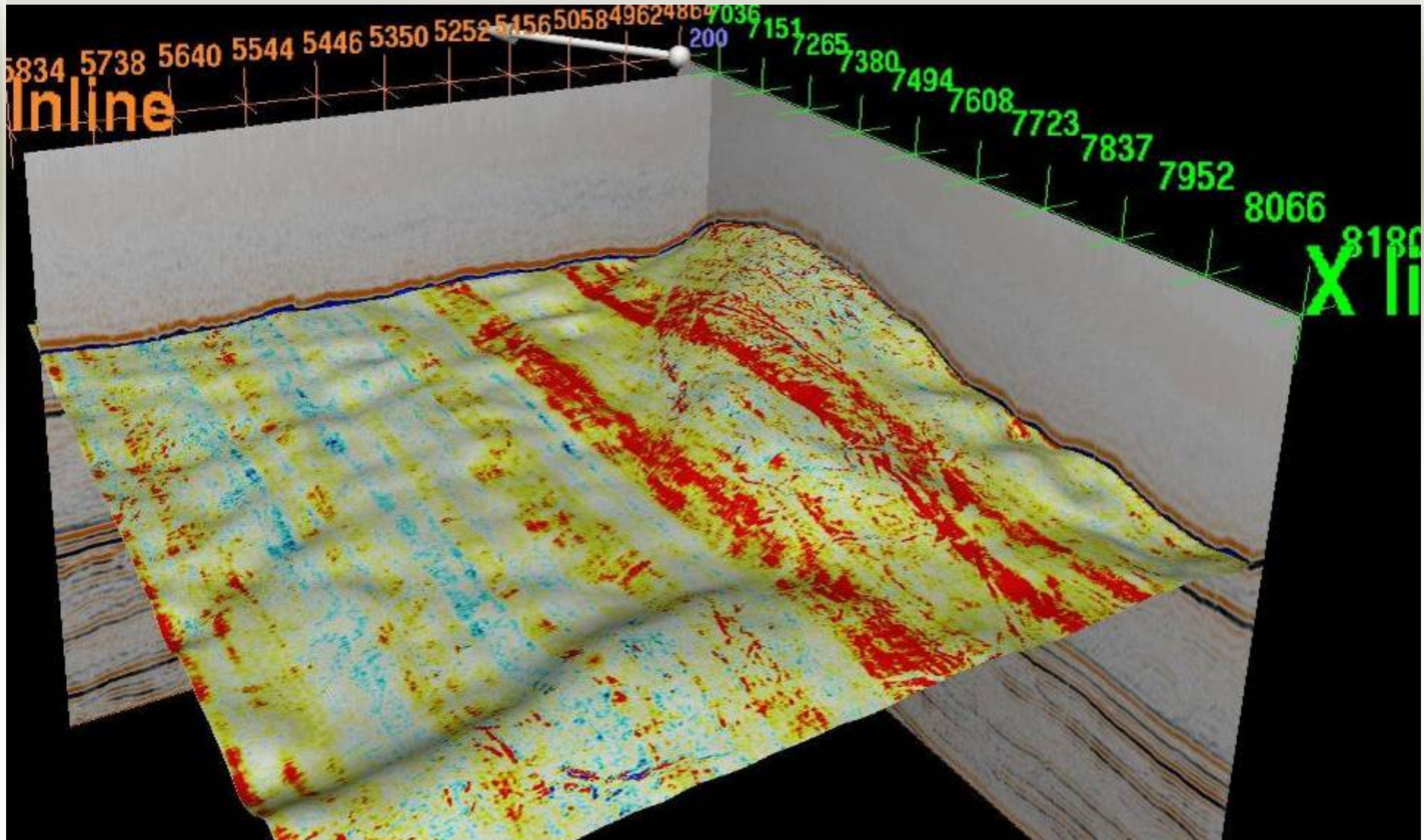
2D/3D display

histogram display





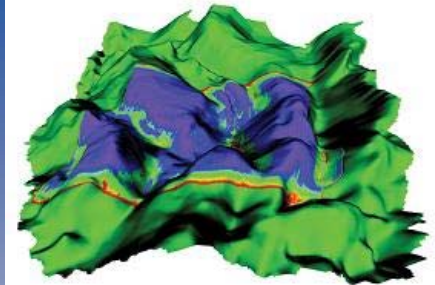
4D processing QC strategy



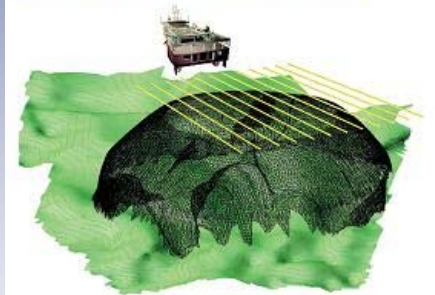
Time shift 4D-QC attribute at the water bottom

- Introduction
 - The perfect 3D seismic survey
 - Fundamentals of pre-survey planning
 - High resolution imaging
 - Imaging in complex geology
 - Imaging in complex anisotropy
 - 4D reservoir monitoring
- Conclusions

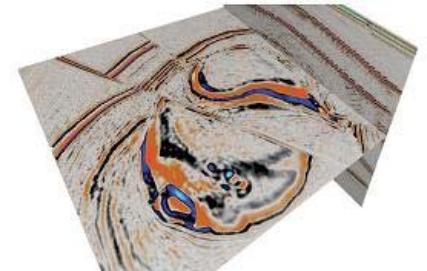
1. Uniform target illumination



2. Dense wavefield sampling



3. Accurate processing and imaging





Customize each acquisition + processing solution

- 1. Customize shooting template to optimize target illumination**
- 2. Customize wavefield sampling to avoid aliasing of all primaries, noise and multiples**
- 3. Customize processing and imaging to exploit the full frequency bandwidth, aperture and reservoir signal:**
 - High Frequency Imaging**
 - Deep Target Spatial Continuity and Resolution**
 - High 4D Repeatability**
 - Better Regularization**
 - 3D SRME**
 - Wave Equation PSDM**
 - Reservoir Characterization/Quantitative Interpretation**



Thank you for your attention

