Permanent Monitoring – *Do it with Nodes!*

Finding Petroleum Seminar
Stavanger, June 13th 2012

Dr Chris Walker
FairfieldNodal

Permanent Monitoring – *Do it with Nodes!*

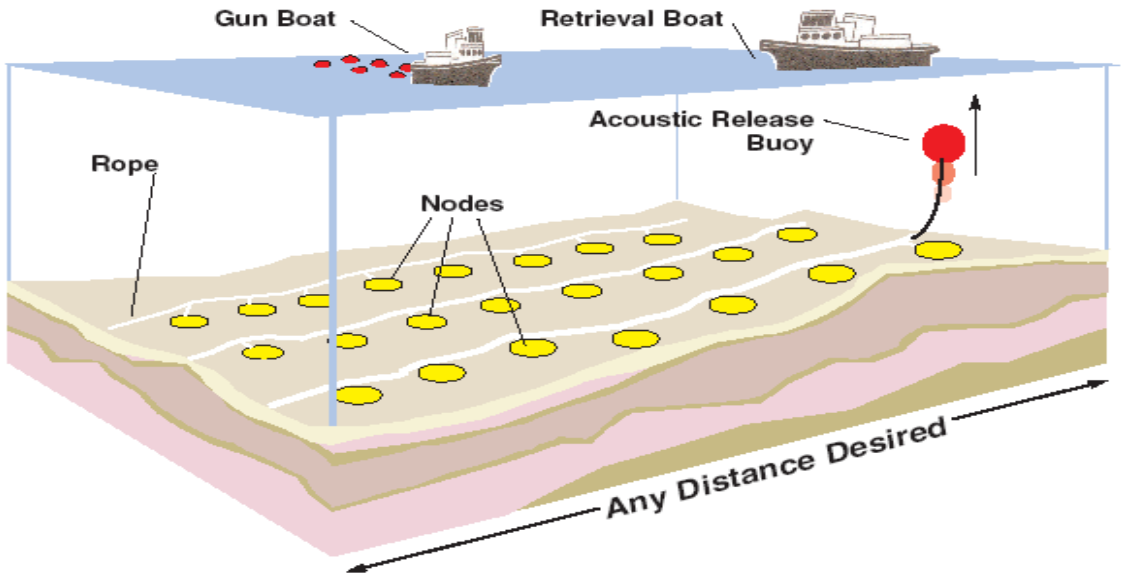
- Introduction
- Z3000 Deep Water Node System
- Operational Experience
- 4D Performance
- Future Application
- Conclusions

Marine Nodes are not new!
SGR – Seismic Group Recorder

Z Marine History

Marine Nodal type and description	Dates	Day @ Sea	Node Deployments	Shots
24 BOX Units deployed to test coupling and vector fidelity with Node sensor	Nov, 2002	7	24	520
20 Z-700 Units Deployed in soft and hard bottom conditions	July,2003	10	80	1,820
10 Z-3000 Units Deployed to Validate Timing and Methods in 1,200 to 2400 meters of water	May, 2004	11	10	1,820
10 Z-3000 Units Deployed in 1200 meters of water for Vector Fidelity testing.	Aug,2004	10	10	2,600
900 Z-3000 Units Deployed for BP in their Atlantis Field	Sept,2005 - March,2006	168	1,628	458,098
3 Z-700 and 9 Z-3000 Units, 2D Source Line to Test Vector Fidelity Hydrophone channels and 15Hz Omni	June,2006	3	12	780
850 Z-3000 Units Deployed for Shell in their Deimos Field	Sept.2007 - Nov,2007	99	802	185,180
50 Z-700 Units, Deployment alongside operating Box Crew to test Hardware and Software Design, Back Deck Equipment, Crew	April, 2008 - Oct.2008	213	5,320	318,000
200 - Z3000 Units- 2D Long Offset - North Sea	Oct.2009	14	200	2,500
1450- Z700 Units- 2D - Red Sea (BGP)	Oct.2009 - Jan.2011	456	102,000	147,200
1200 - Z3000 Units - 3D-4D G.O.M. (Shell, Marathon)	Dec.2010 – Apr .2012	766	9,973	2,663,492
2200 - Z700 Units- 3/4D, N Sea (CoP, Statoil, Valiant)	Mar. 2011 – Apr 2012	435	36,072	661,955
	Summary	2,587	160,480	7,107,457

Z700 Nodal OBS System - “Node-on-a-Rope”



Z700 Node Operation

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Z3000 Nodal System

System Description

- Operating Depth: 3000 Metres
- 571.5mm by 254mm High
- Weight: 96.6kg Dry; 45.5kg Wet
- Battery Life 60 days (@2ms/32Gb)
- 4C Sensors
  - 3 non-gimbaled 10Hz orthogonal geophones
  - Spectrally matched hydrophone
- Synchronization of unit at deployment / retrieval, Data collection via USB 2.0, Recharge batteries
- Tilt / Compass
- Precision Clock – Double Oven Crystal Oscillator
- Flash Memory (32Gb)
- Deployed using ROV
- Two vessel operation – one deployment/retrieval vessel; one source vessel

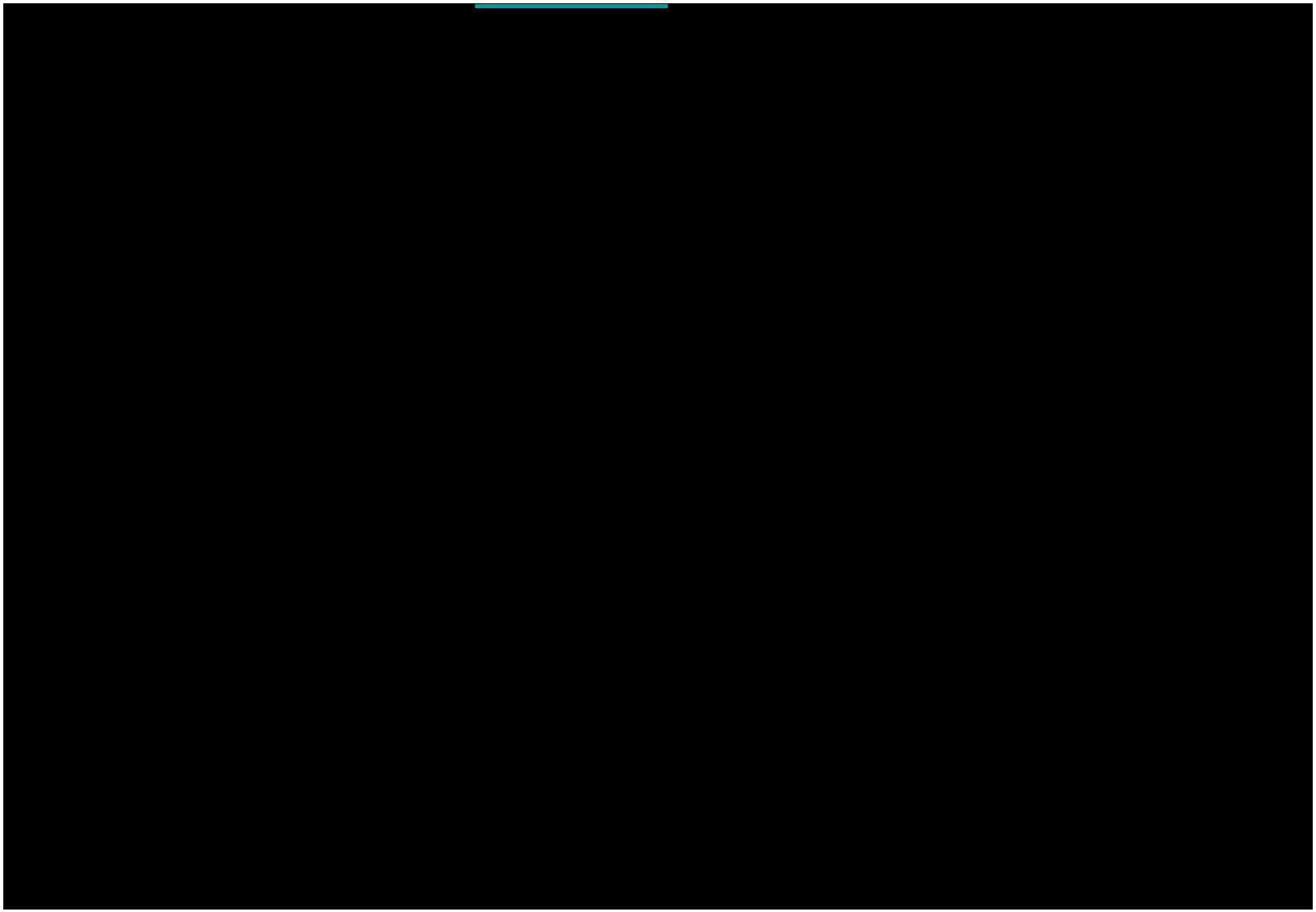
Z3000 Crew - GoM


ROV Vessel: Carolyn Chouest


ROV Vessel: Fairfield Pursuit

Z3000 Nodal System

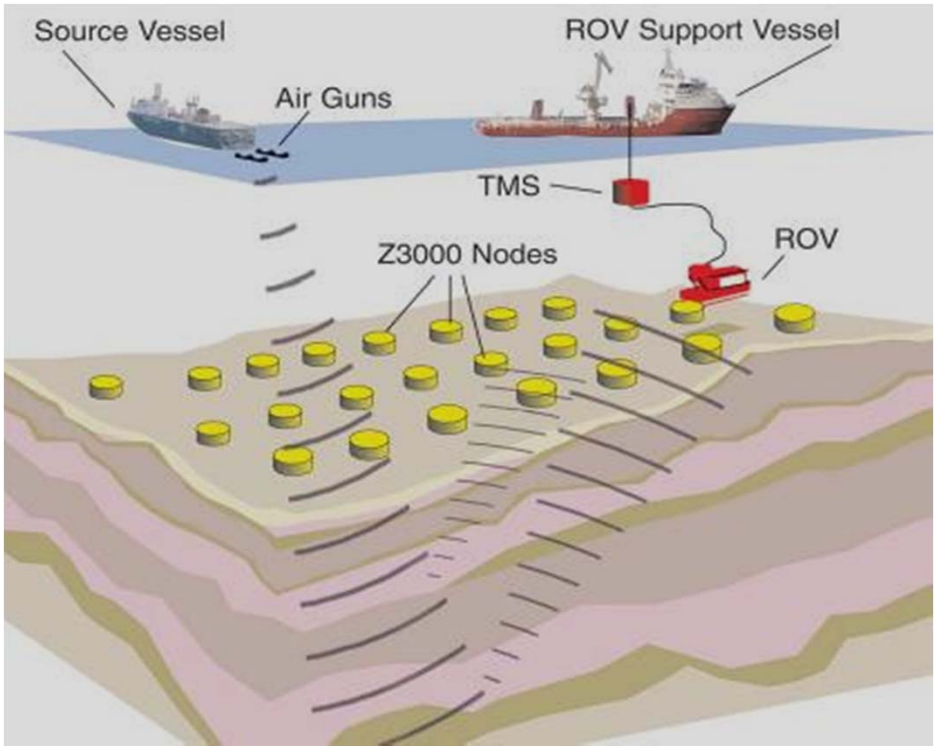
Video - GOM



Z3000 Nodal System
Two Vessel Operation

Z3000 Node Handling Vessel

- Dual ROV deployment
- Navigation / Positioning Systems
- Storage/Handling for up to 1250 Z3000 units
- On Board Data Transcription (Data Recorder)
- On Board automated battery charging
- Automated Deployment/Retrieval system
- High speed loader

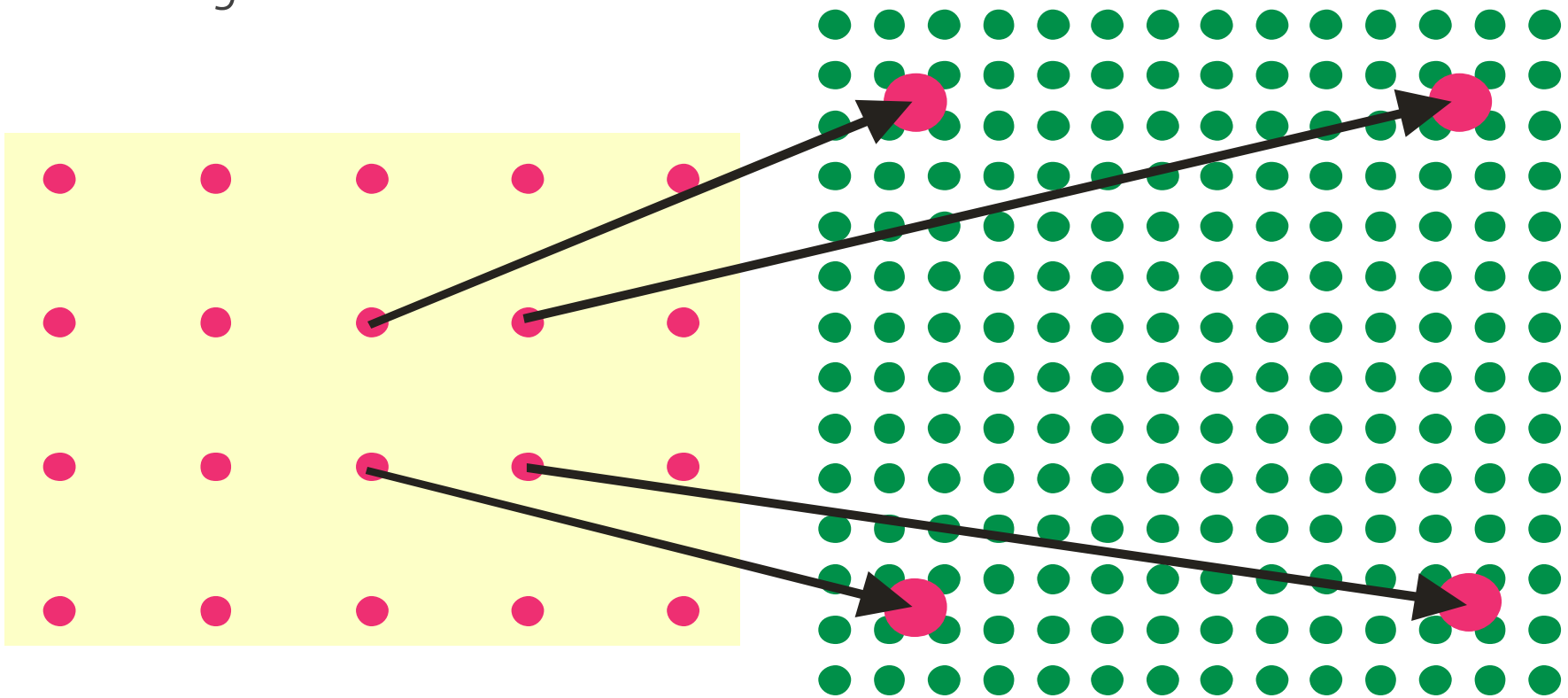


Dual Source Shooting Vessel

Z3000 Nodal System

Example Survey Geometry

Note: drawings not to scale…



Z Nodes in 400m grid

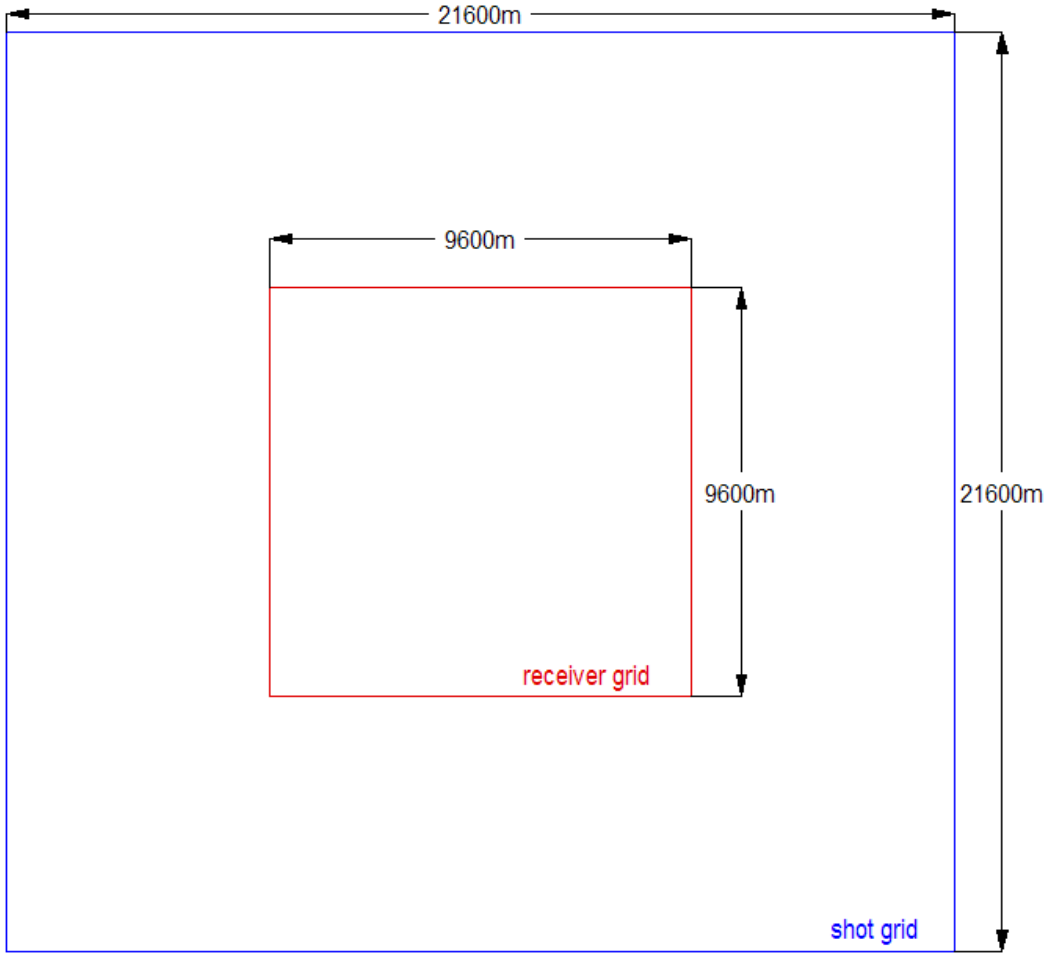
Shots 25m x 25m grid

Z3000 Nodal System

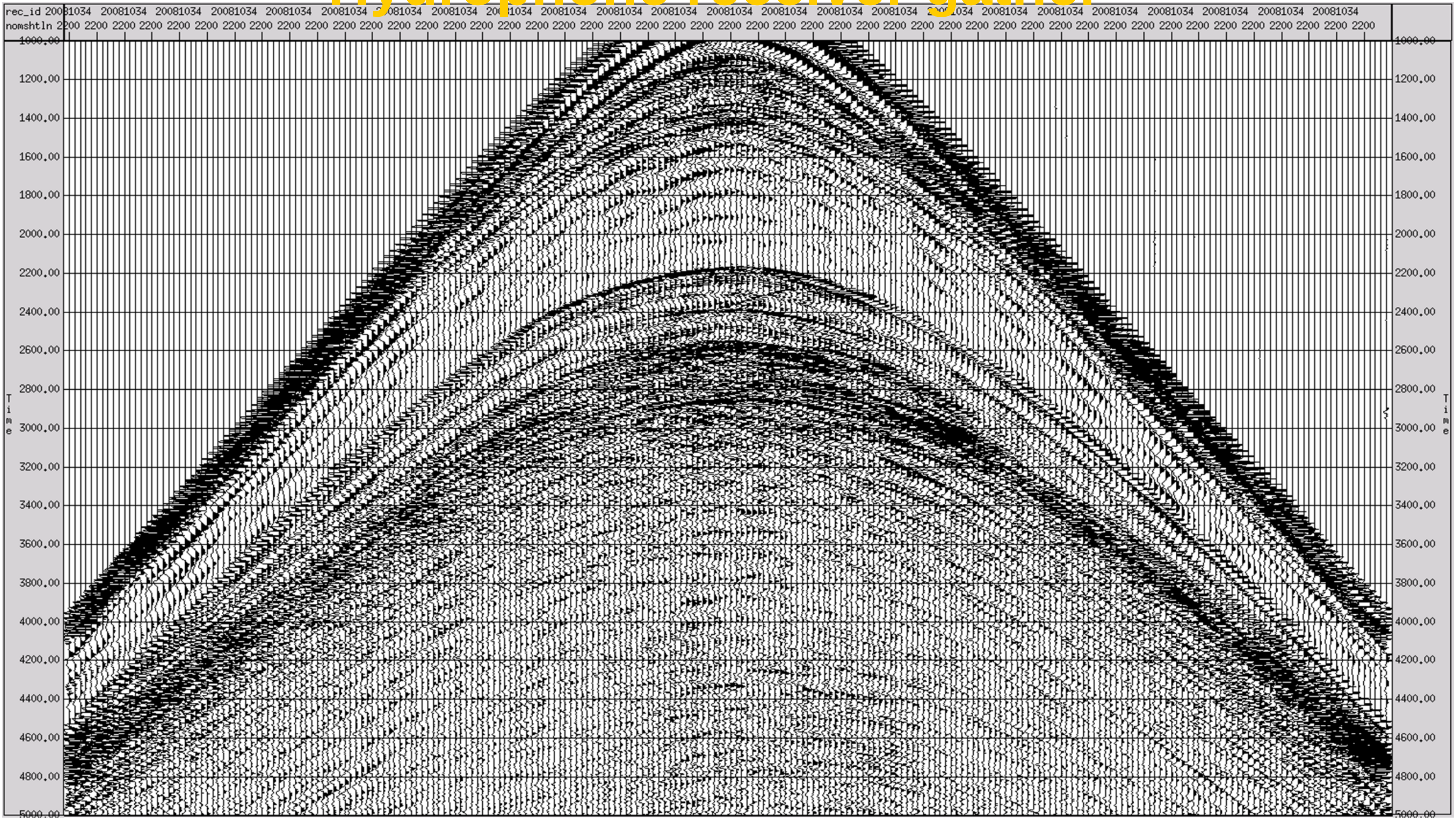
Example One Patch Survey

- **400m x 400m receiver grid**
- 6000m source offset (dual source)
  - 625 remote units
  - 187,000 shot points
  - 32 days to acquire at 100% efficiency

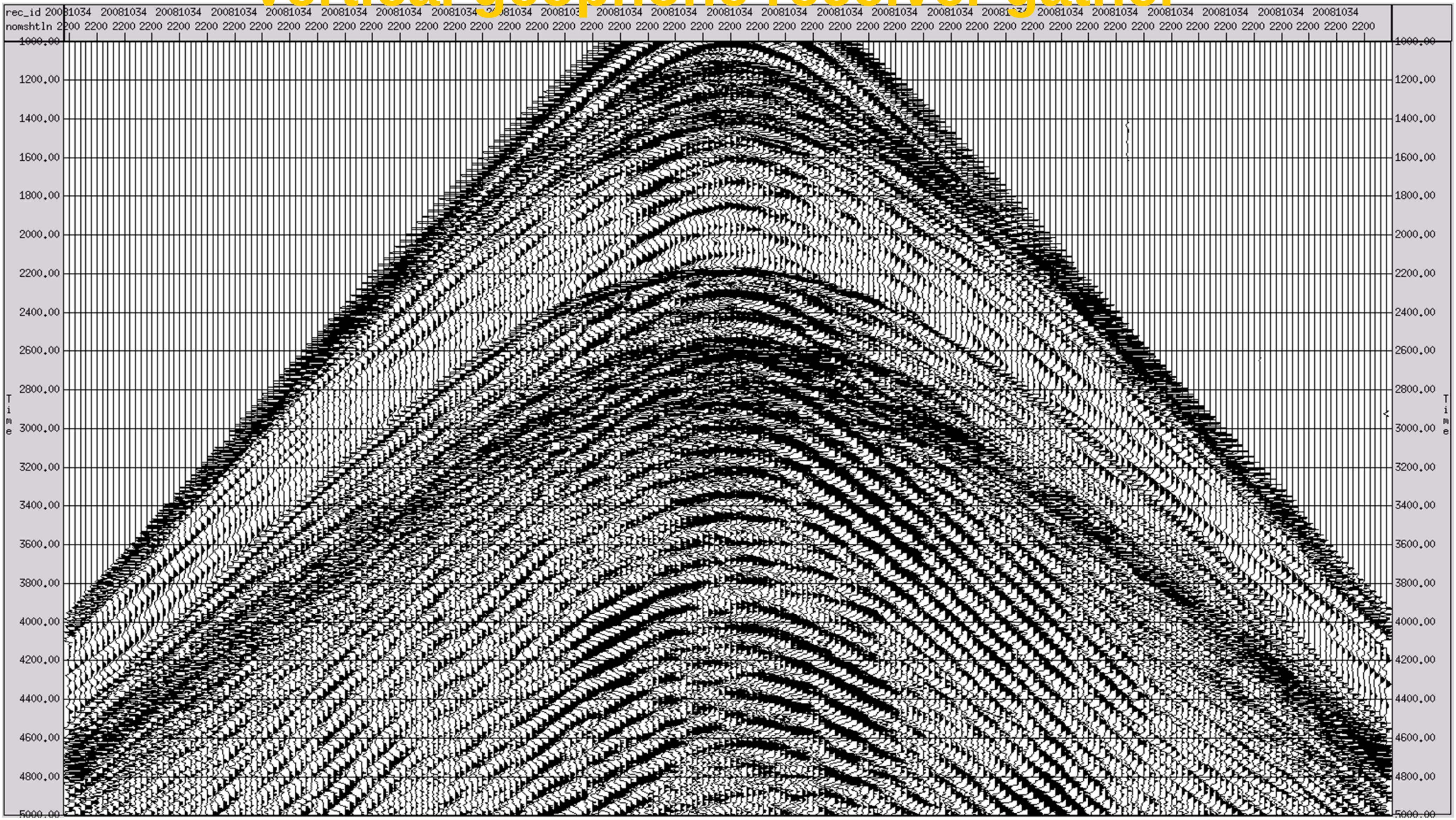
- **300m x 300m receiver grid**
- 6000m source offset (dual source)
  - 1089 remote units
  - 187,000 shot points
  - 40 days to acquire at 100% efficiency



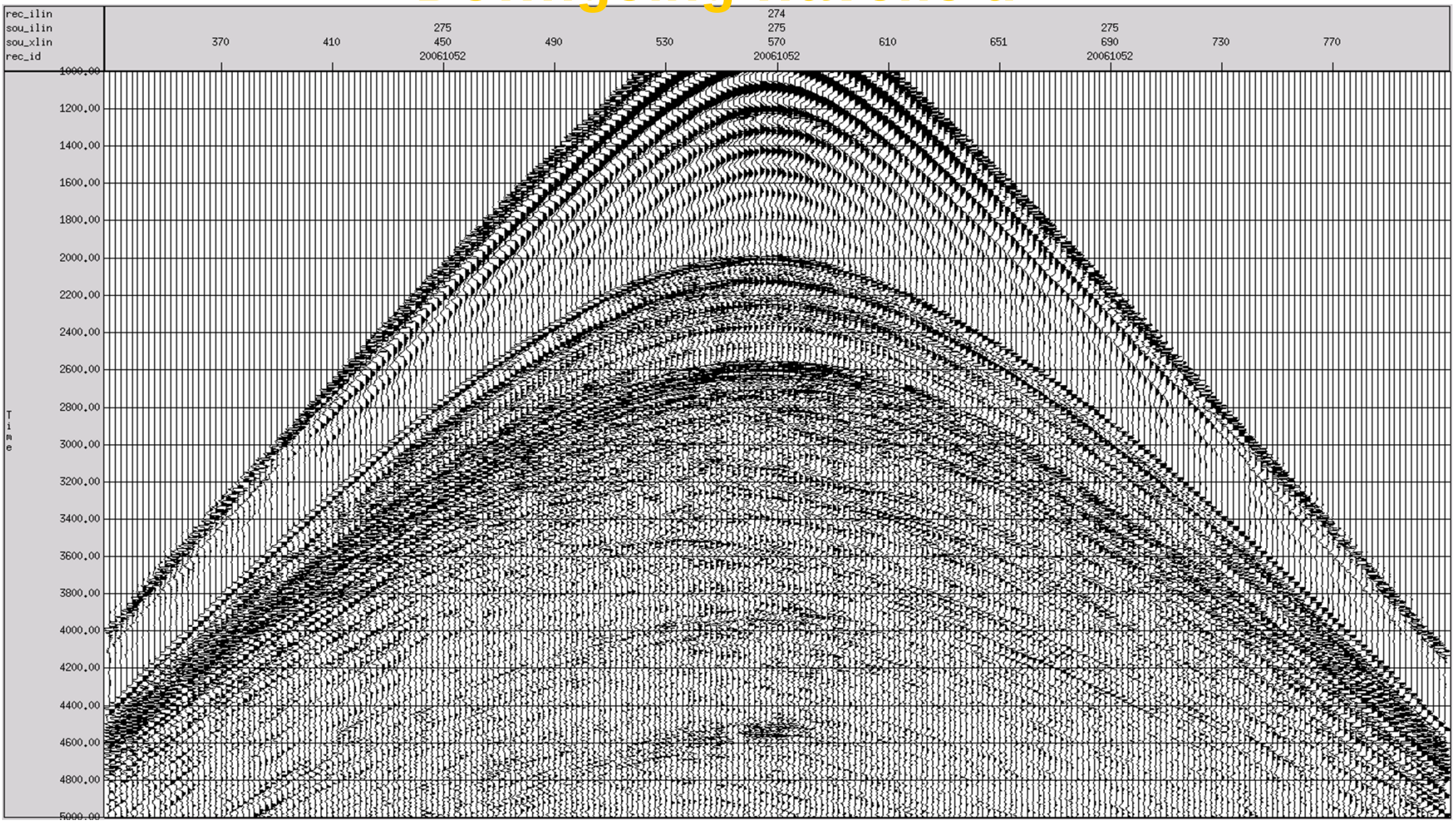
Hydrophone receiver gather



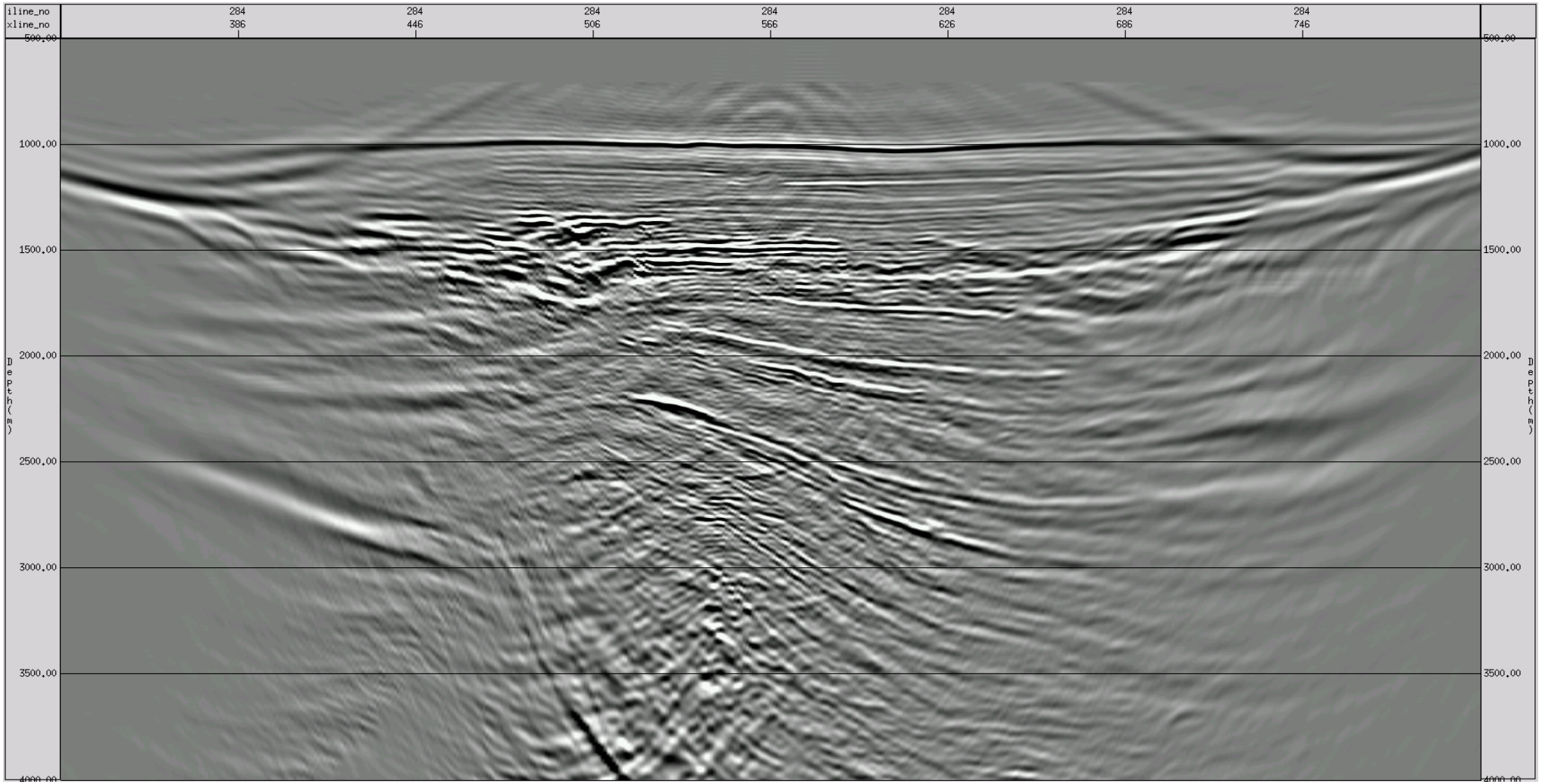
Vertical geophone receiver gather



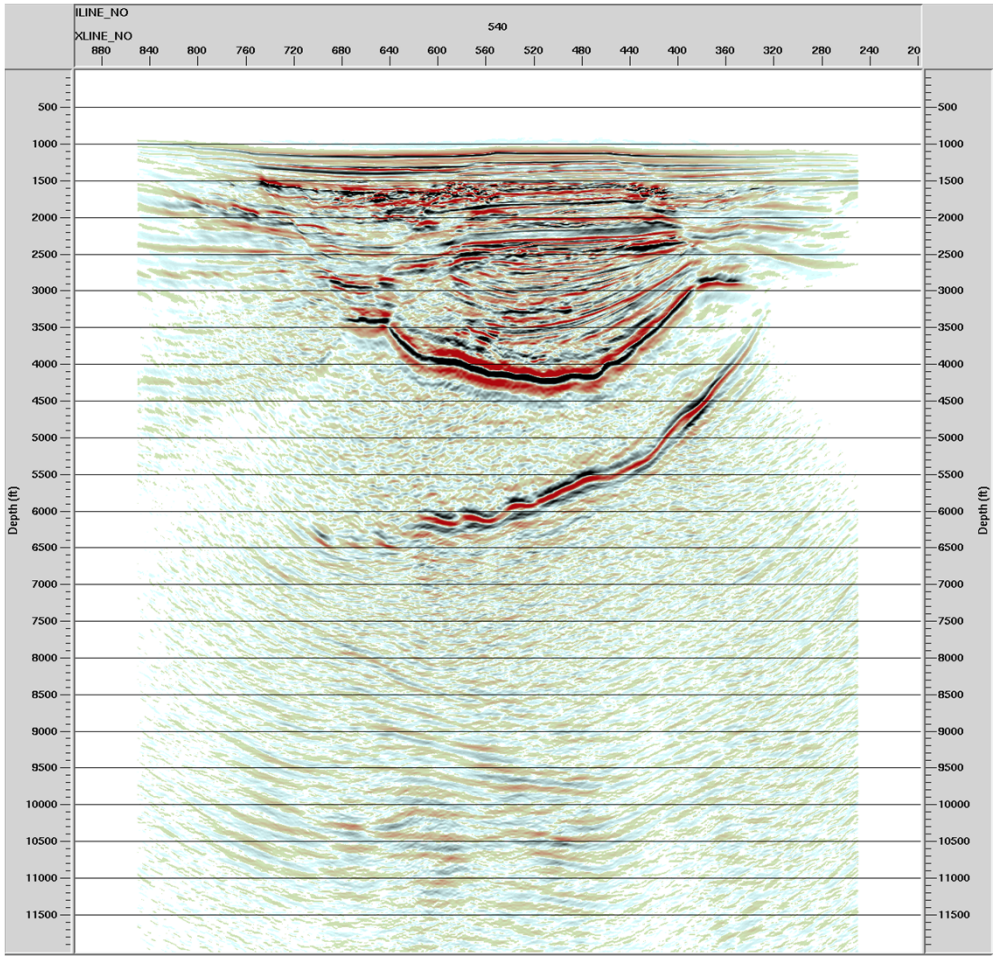
Downgoing wavefield



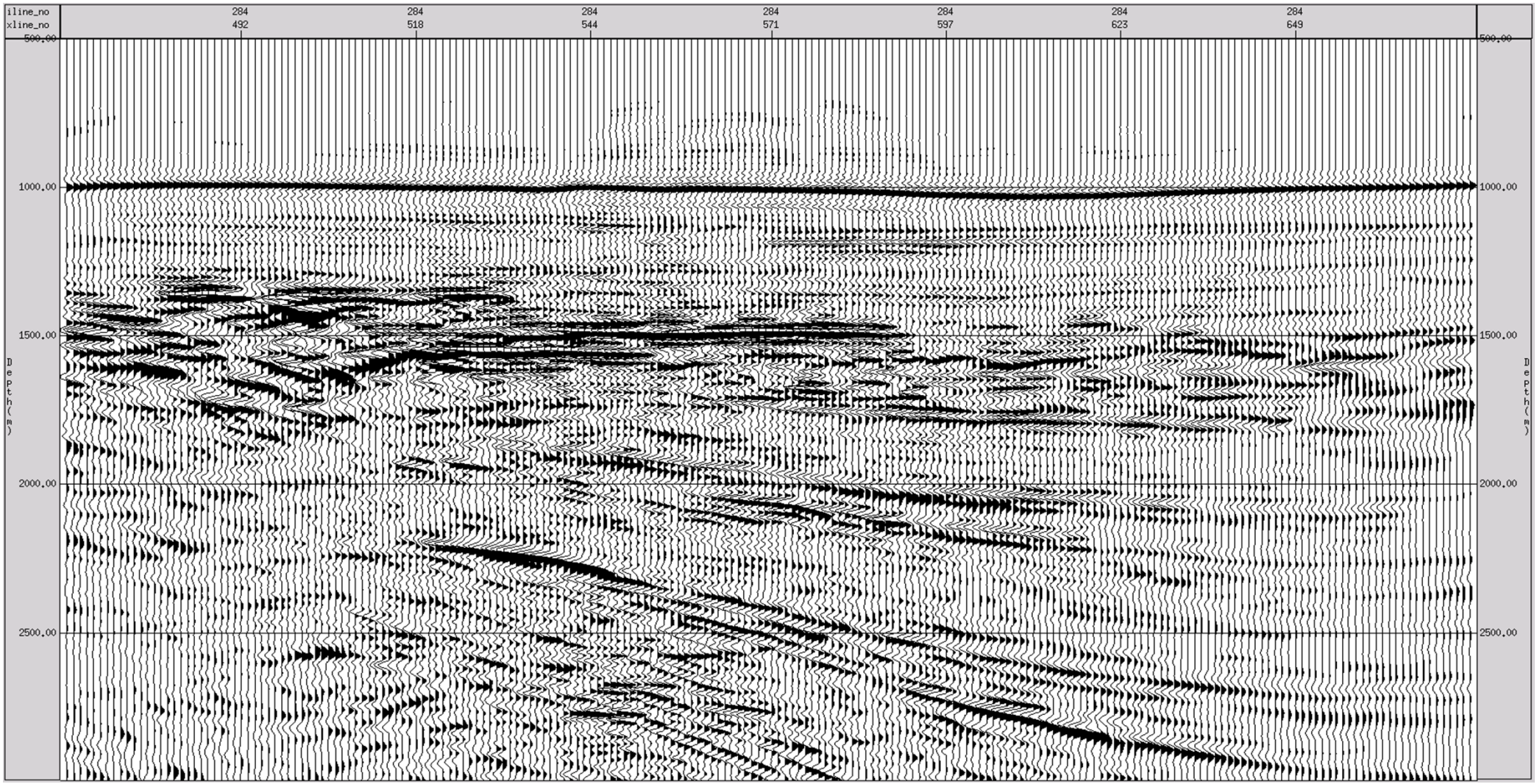
Single node mirror migration



2D Section from 3D Volume



Shallow detail



Carolyn Chouest
Node Handling Vessel

Carolyn Chouest (1994)

- Owner: Edison Chouest Offshore
- Builder: North American Shipbuilding
- Status: Dual ROV set-up on seismic nodal crew
- Displacement: 1599 ton
- Length / Beam / Draft: 240' /52` / 17'
- Installed power: two 12-cylinder Caterpillar diesel engines providing a total of 10,800 HP
- Propulsion: two Kort Nozzle variable pitch propellers , Stern & Bow Thrusters, One Drop down AZ thruster
- Speed: 17 knots
- Dynamic Positioning: DP2 certification

Carolyn Chouest
Node Handling Vessel

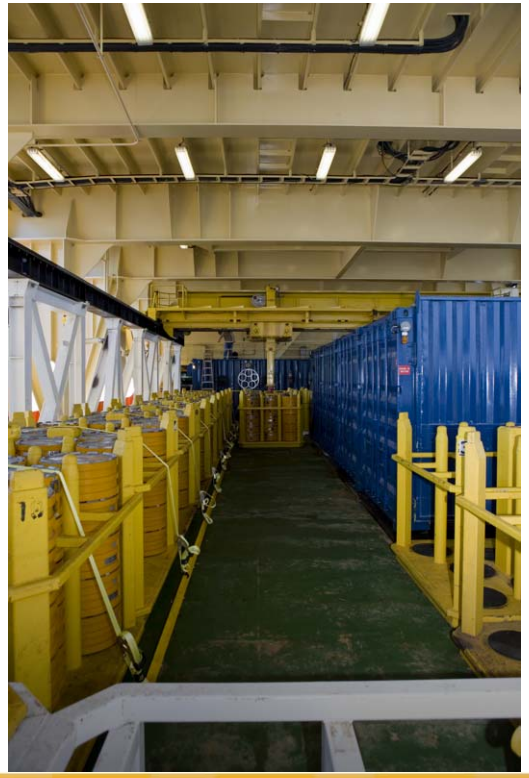
- Purpose built node handling vessel rig up in Port Fourchon, Louisiana – 5 April 2010
- Nodes and node handling equipment mid deck, ROV and ROV deployment systems on top deck, providing state-of-the-art flexibility for node deployment

View from Port side showing node handling deck and top ROV deck

View from Starboard side showing node handling deck (mid) and top ROV deck

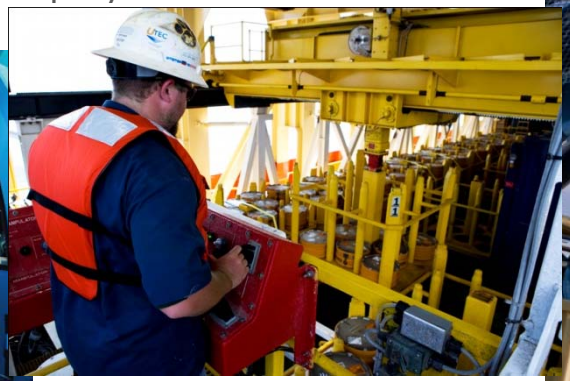
Carolyn Chouest
Node Handling Vessel

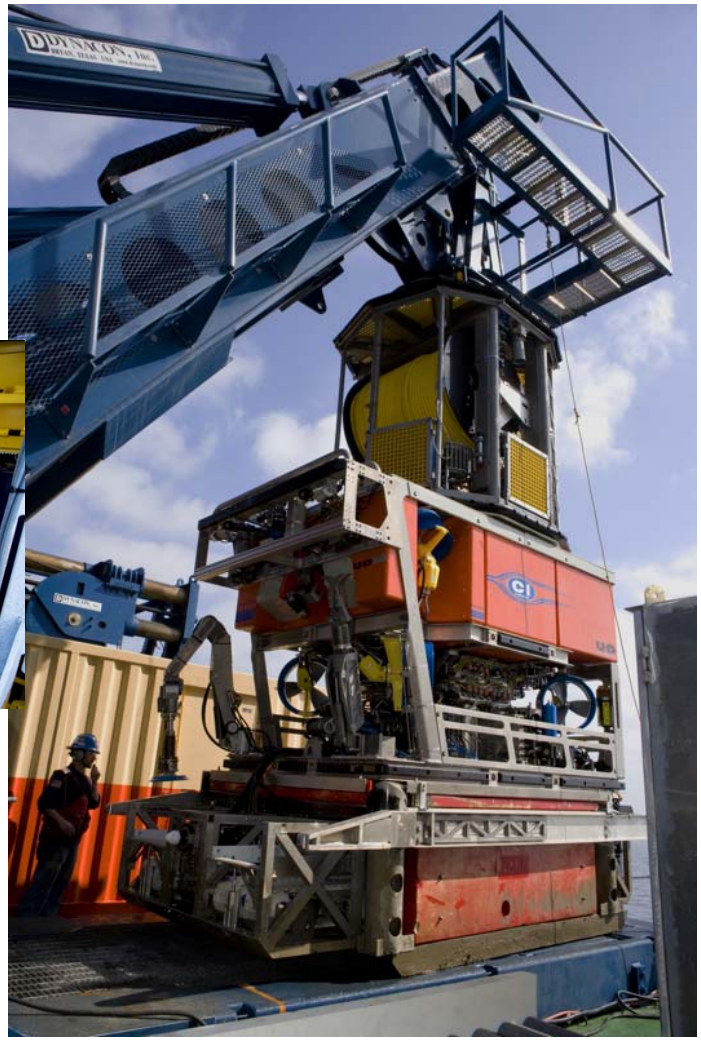
Custom built Node Handling Deck
Overhead gantry for handling bulk nodes (baskets) and manipulator for handling individual nodes



Schilling ROVS

- Starboard ROV/node sled and TMS – identical ROVs are mounted port and starboard top deck for ultimate maneuverability and ROV launch / recovery
- All bulk node handling is carried out by one back deck crew using hydraulic controls
- ROV control has been customized for node deployment / retrieval





Carolyn Chouest
Node Handling Vessel

Dual ROVs

- Identical Schilling UHD (C I – Chouset)
- 200 horsepower
- Remote variable pressure & flow control / aux hydraulics (vegetable based hydraulic oil)
- 4,000 meter standard depth rating
- Standard quick-connect on-board and skid-based tooling package interfaces
- 250 kg standard payload (additional payload optional)
- **Trip time to 1000m water depth: approx. 45min.**

Carolyn Chouest
Node Handling Vessel

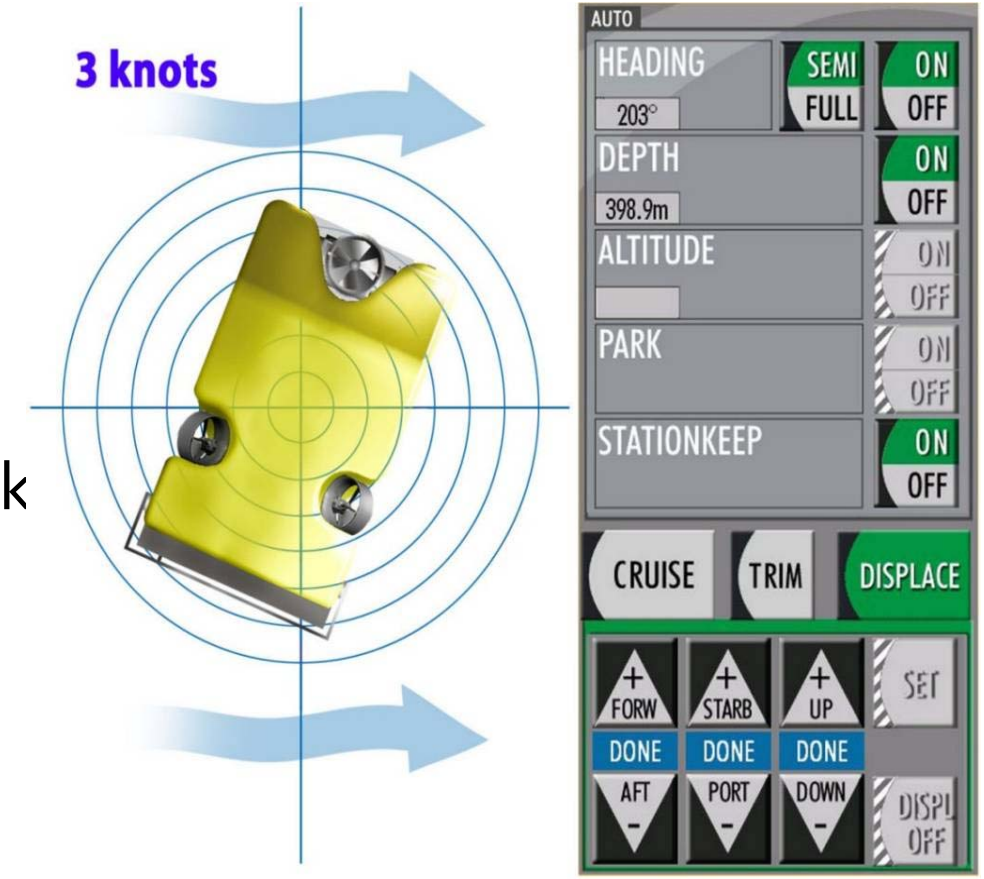
ROV Extended-excursion tether management system

- 650 meter excursion capacity
- Stainless steel frame (low maintenance)
- Variable-speed winch operation up to 75 meters per minute
- Significant parts commonality with ROV
- Navigation using transponder

Carolyn Chouest
Node Handling Vessel

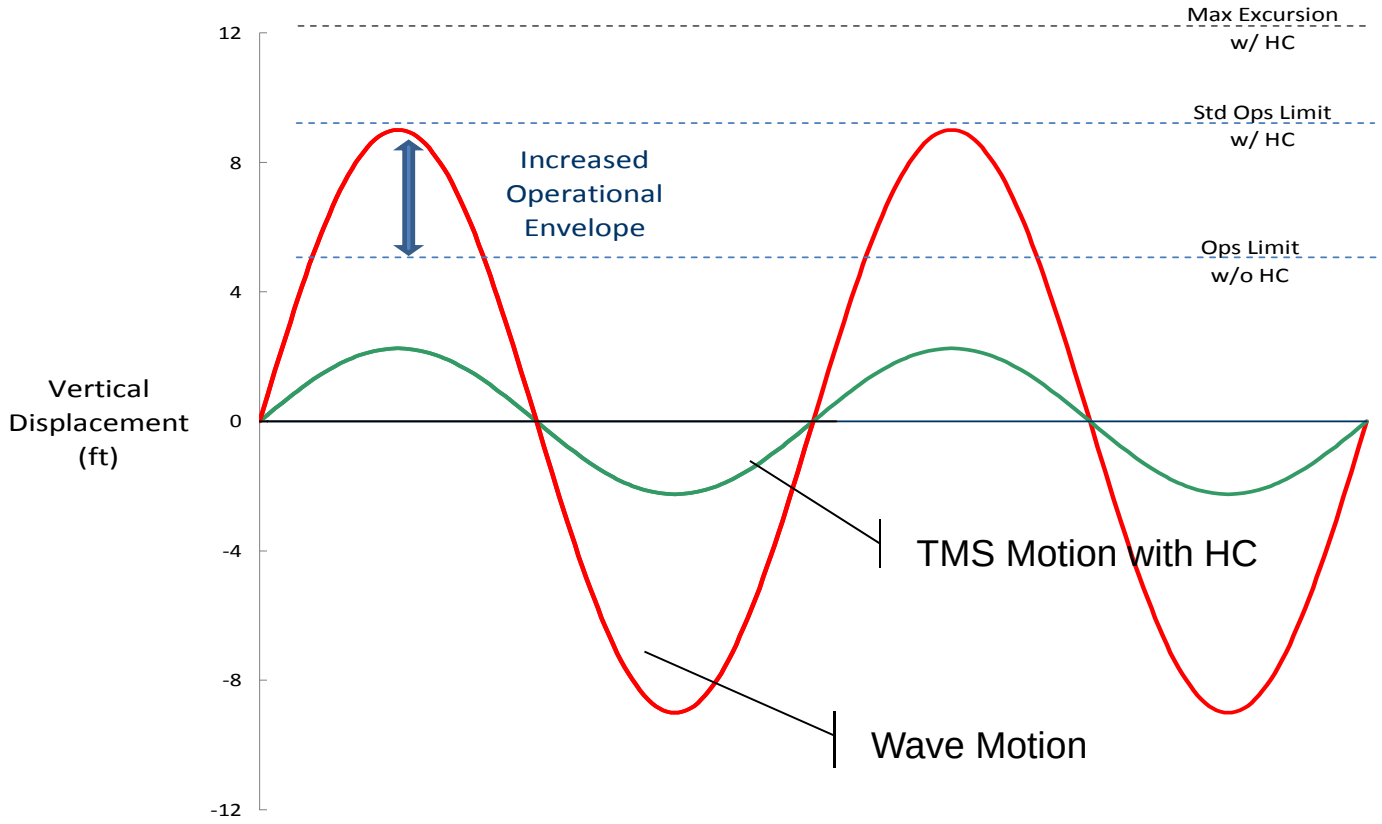
ROVs - StationKeep™

- Subsea DP
- DVL-based (3 beam Doplar)
- Allows operators to focus on task while the vehicle holds position



Carolyn Chouest
Node Handling Vessel

ROVs – Heave Compensation

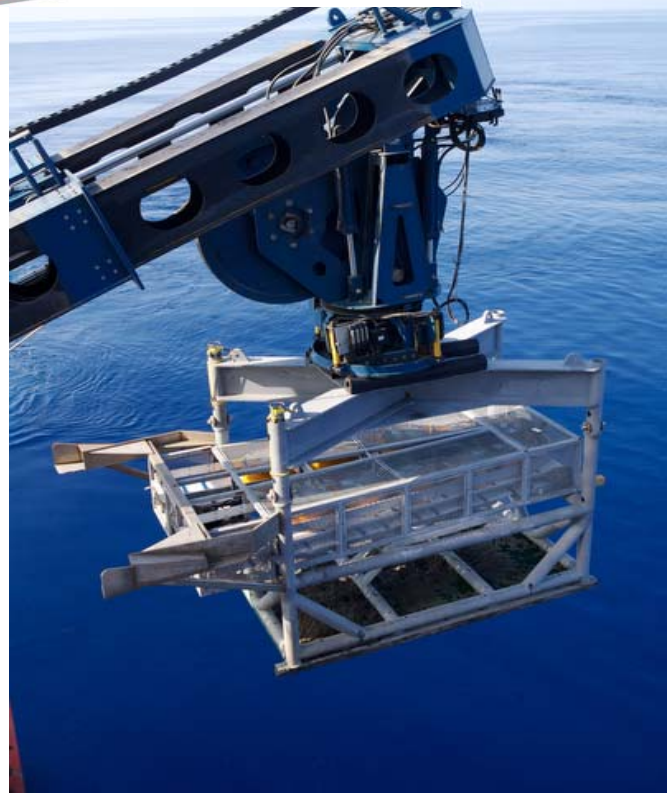


Heave Compensation reduces TMS vertical motion

Z3000 Nodal System
ROV with Node Skid and Speed Loader

ROVs / High Speed Loader

- The Node Skid is attached to the ROV and holds up to 12 nodes
- High Speed Loader (HSL) greatly reduces the number of dives per ROV
- Designed to keep the ROV sub-sea; increased efficiency with less down-time
- Allows 12 – 24 nodes to be loaded subsea
- Multiple Speed Loaders can be launched separately from the ROVs with single point lift with docking
- Reloading time reduced from 3 hours to 45 minutes versus ROV returning to vessel
- High Speed Loader can be placed either on the seabed or suspended in the water column



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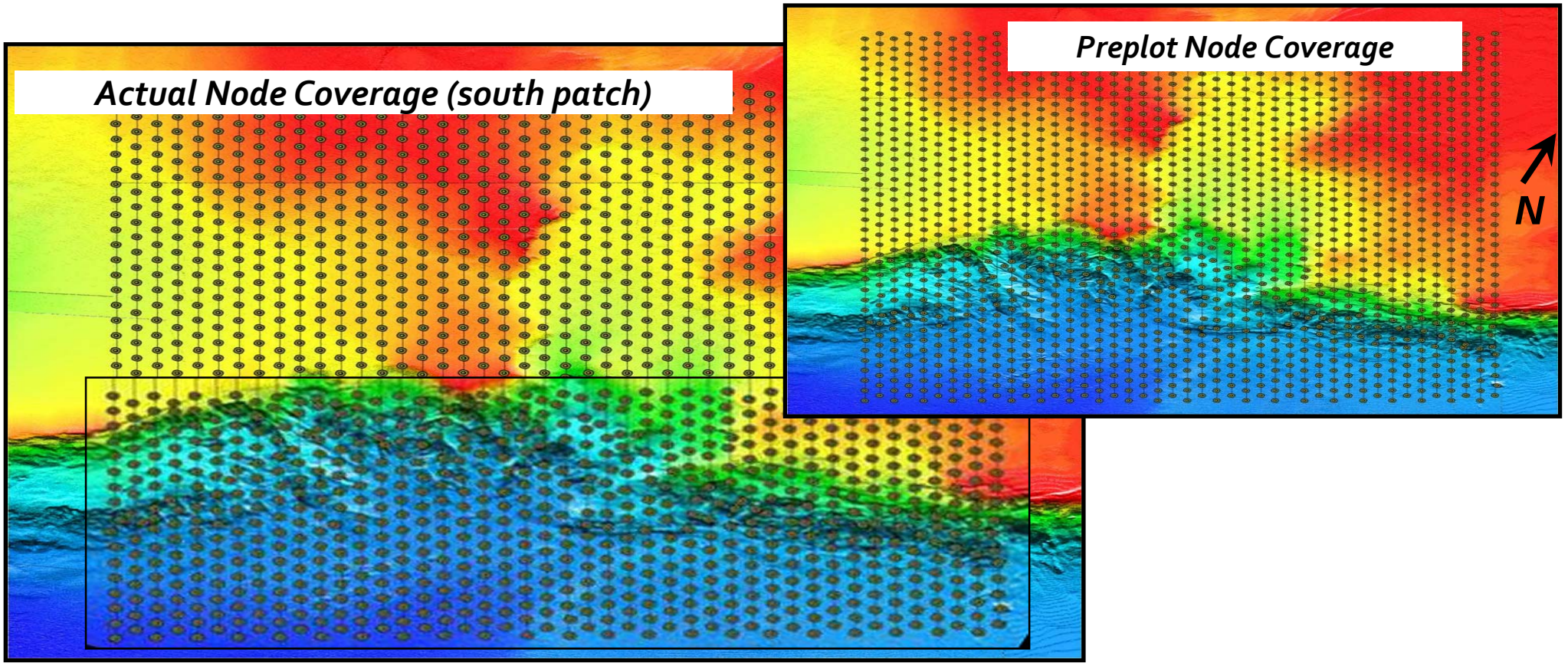
Z3000 Nodal System
Proven Technology

Client	Project	Area	Number of Node Locations	Survey Shot Area	Total Shot Points	Total number of Days	Water depths (metres)
BP	Atlantis	GoM	1628	654 km2	458098	168	2156
Shell	Deimos	GoM	802	462 km2	185180	99	850
Shell	Shell	Brunei	10	2D test	1000	14	1100
Shell	Micro Queen	GoM	454	528 km2	197581	62	840
Chevron N. Sea	Vooring	Norway	200	670 km 2D	2500	14	1400
Shell	Mars	GoM	1097	667 km2	266427	78	896
Shell	Cardamon	GoM	924	572 km2	229004	56	872
Shell	Ursa	GoM	937	720 km2	290117	78	1159
Shell	Vito-11	GoM	937	750km2	314617	92	1234
Shell	Appomatox	GoM	1065	650km2	311208	70	2400
Marathon	Lobster	GoM	1065	435 km2	284286	60	400
Shell	Hablano/Cardomom	GoM	1654	545km2	433671	118	1579
Shell	Glider	GoM	1089	660km2	185000	46	1006
Shell	Europa	GoM	Next survey to start approx. 24 April				

Z3000 Nodal System

Navigation, coverage and repeatability

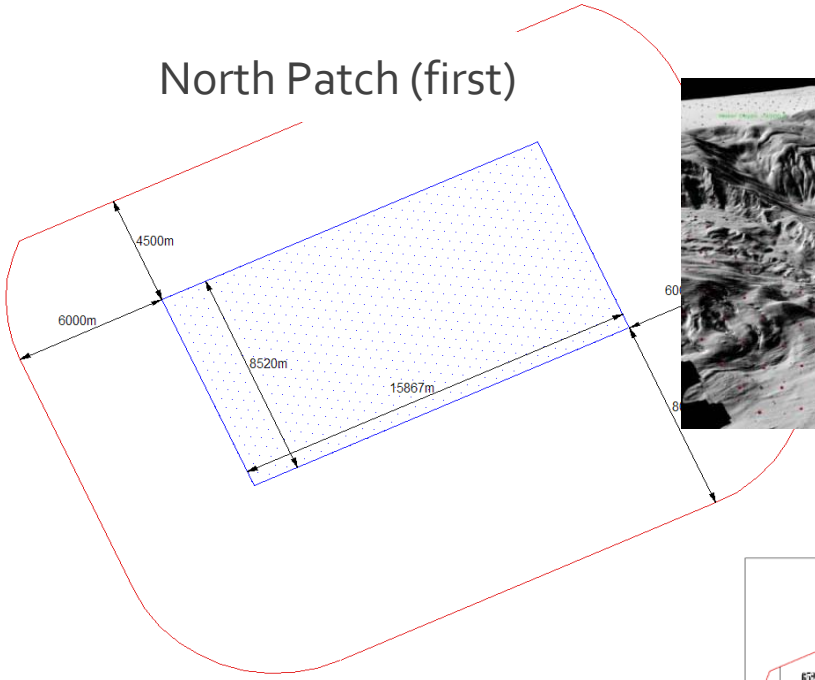
- Excellent coverage and positioning in difficult terrain
- Real time positioning within 2-3 meters in up to 2400 meters water depth

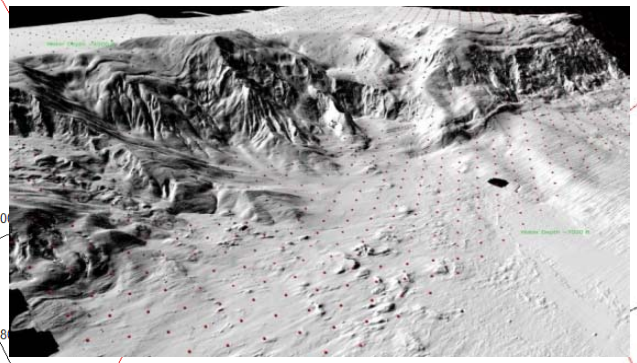


Z3000 Nodal System

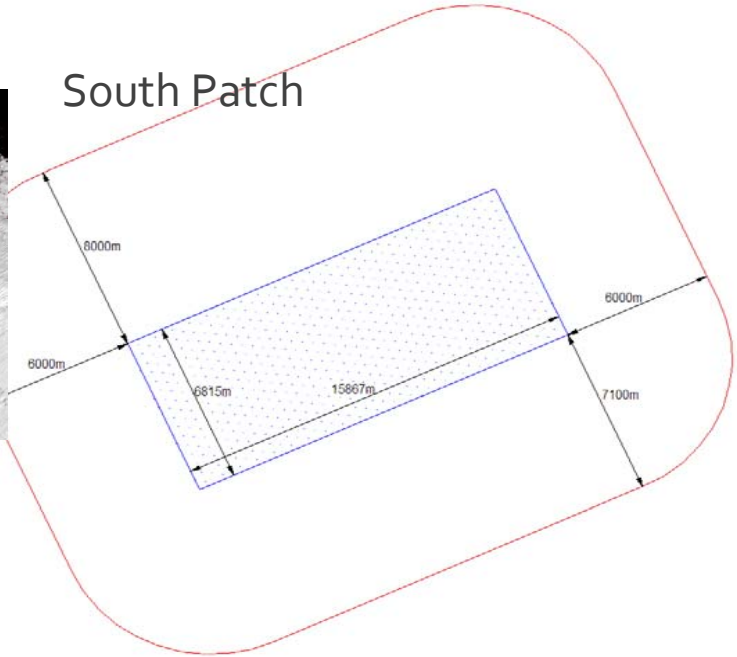
BP Atlantis GOM Statistics

North Patch (first)

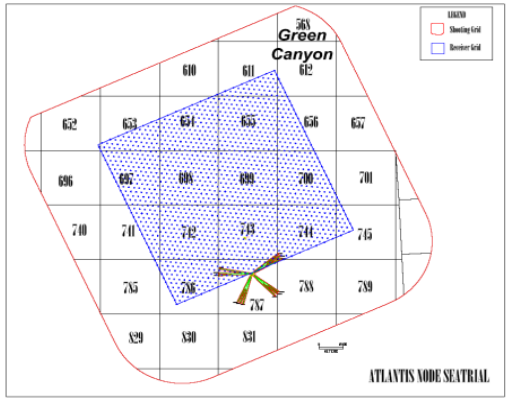




South Patch



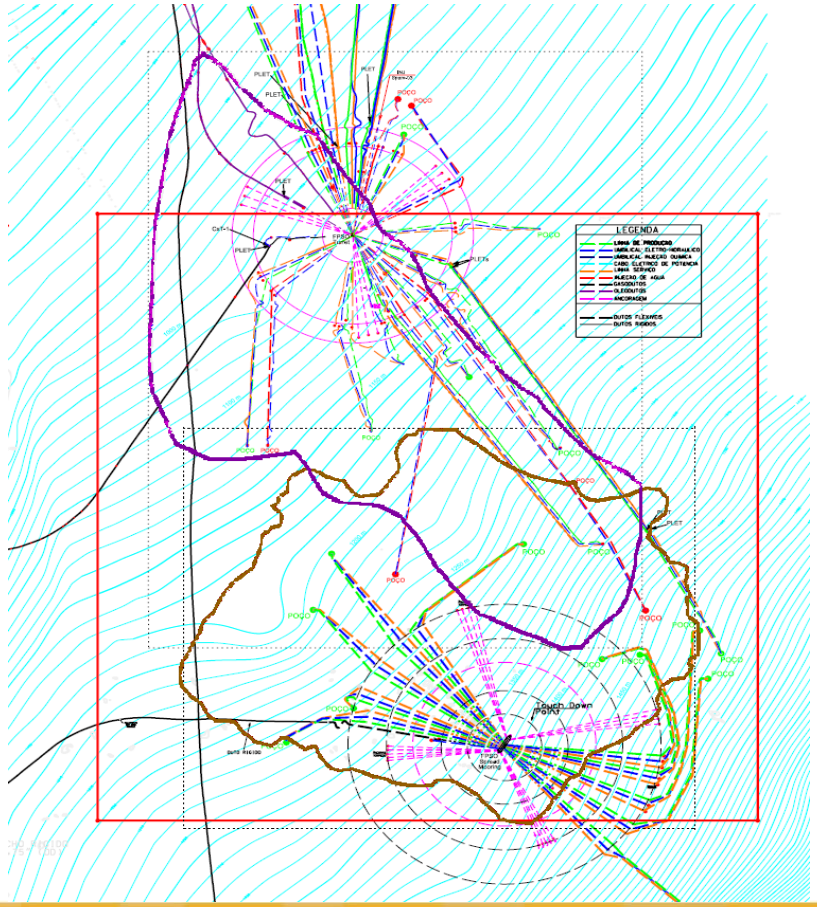
Duration : 62 Days
Deployed : 902 Nodes
135 Km2
Approx 250,000 shot points
1100 – 1800 m water depths
Data Recovered: 99.2%
Dual ROV

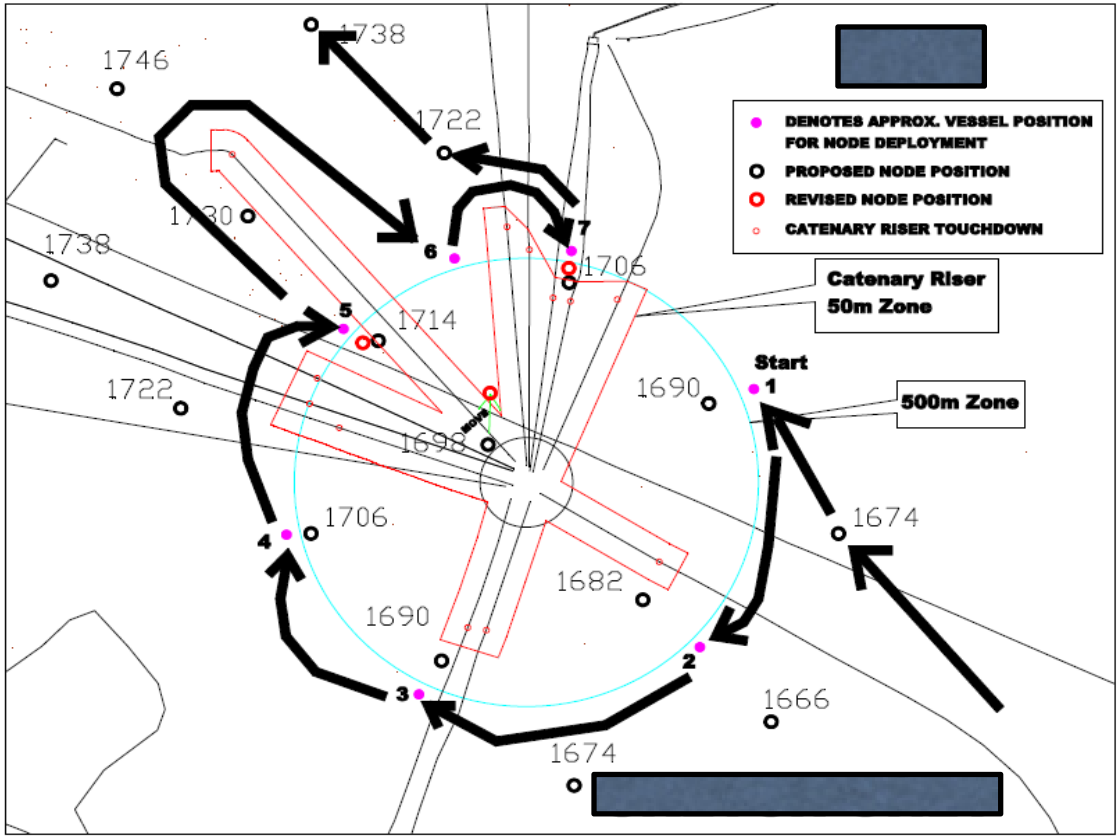


Duration : 89 Days
Deployed : 728 Nodes
108 Km2
Approx. 230,000 shot points
up to 2400m water depths
Data Recovered: 98.6%
Dual ROV

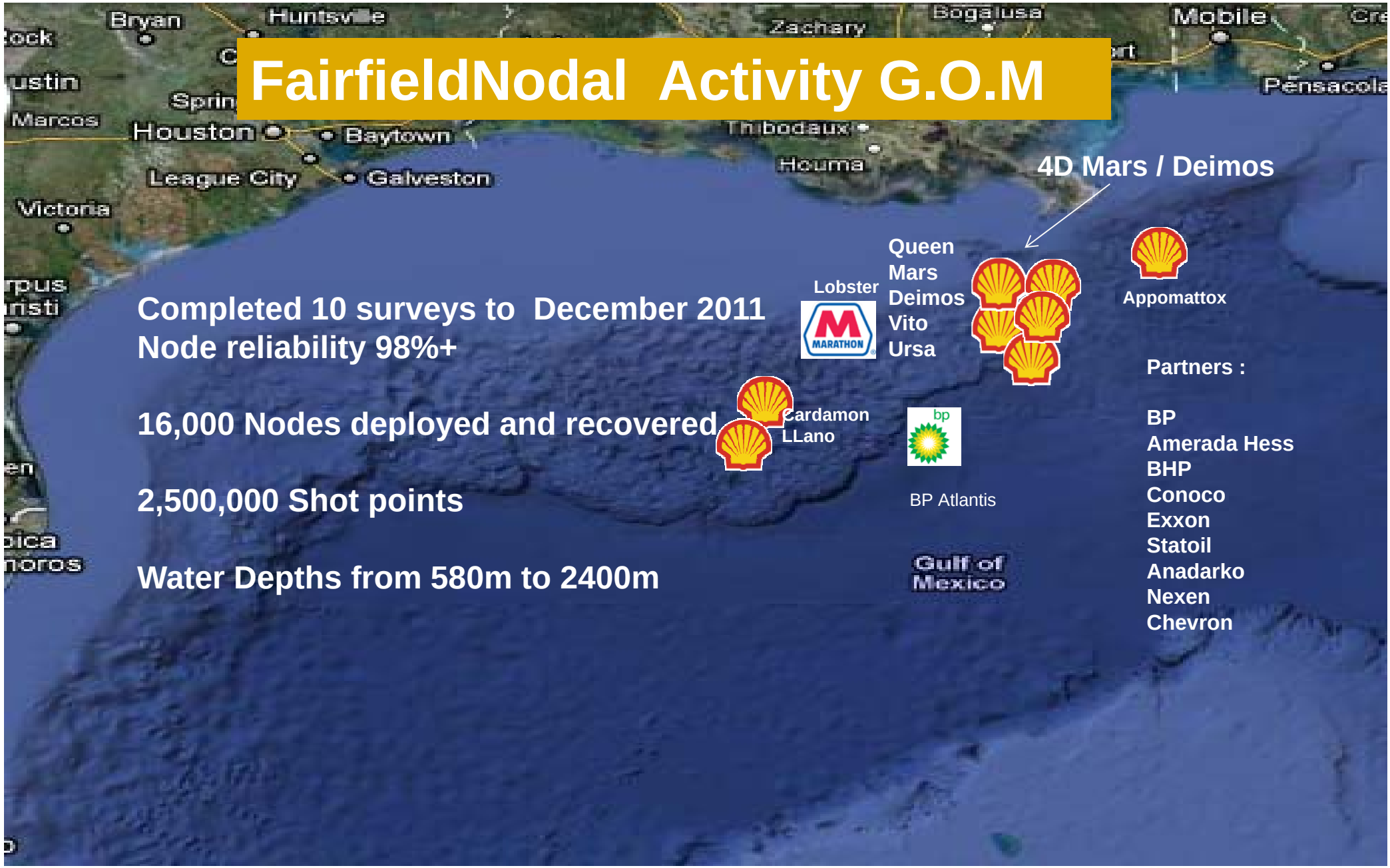
Project Planning - Navigation

- Mitigation strategies under/around infrastructure - Planning and submission of layout plan to the SIMOPS group for review and acceptance is critical to project efficiency and HSE requirements





FairfieldNodal Activity G.O.M



Completed 10 surveys to December 2011
Node reliability 98%+

16,000 Nodes deployed and recovered

2,500,000 Shot points

Water Depths from 580m to 2400m

4D Mars / Deimos

Lobster

Queen
Mars
Deimos
Vito
Ursa

Appomattox

Cardamon
LLano

BP Atlantis

Partners :

BP
Amerada Hess
BHP
Conoco
Exxon
Statoil
Anadarko
Nexen
Chevron

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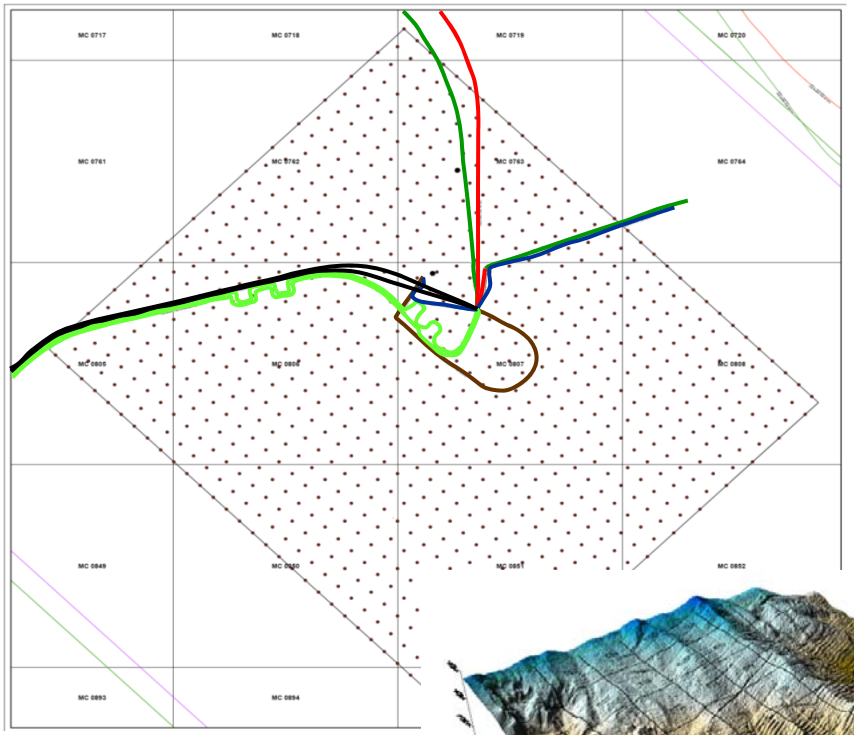
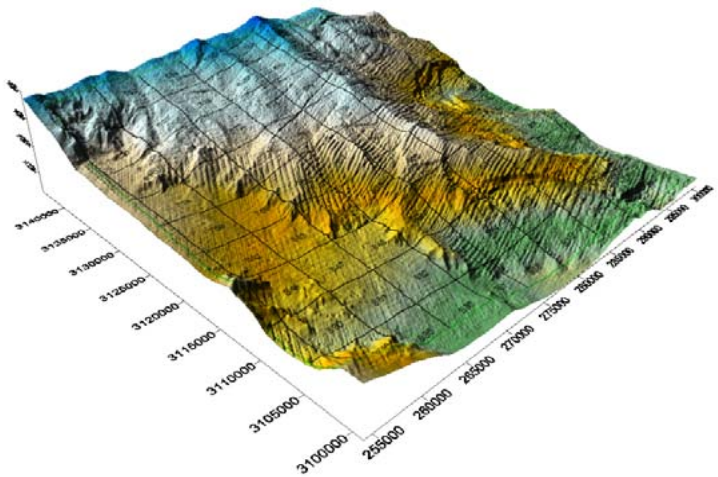
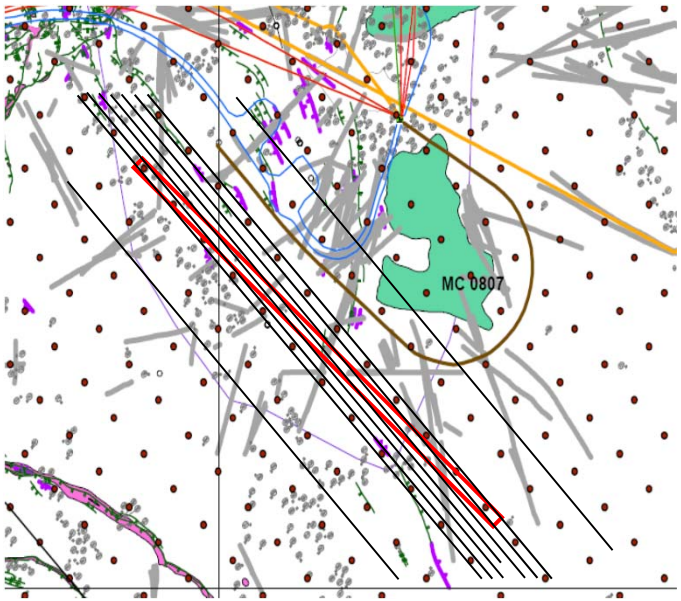
ZMarine 3000 Nodal System

Shell Deimos GOM Survey Statistics



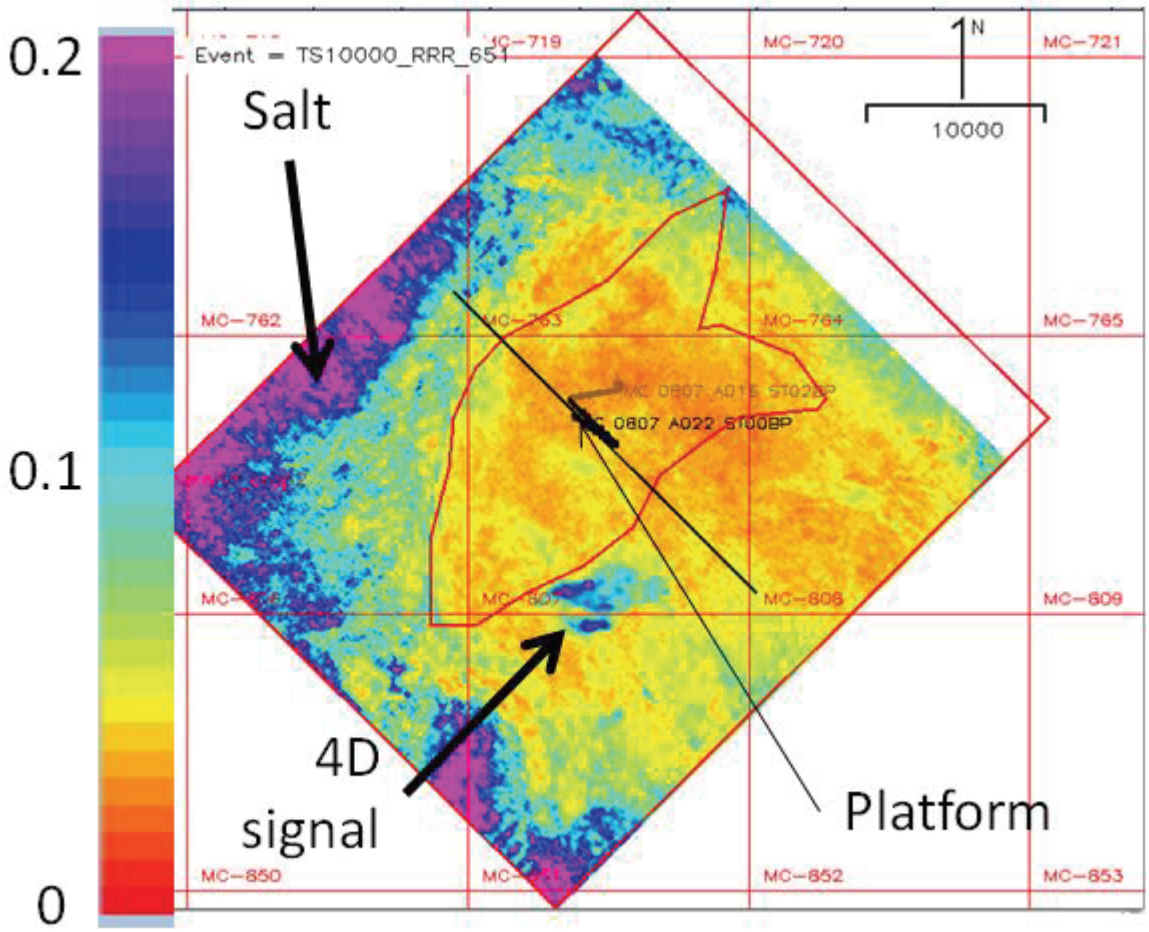


Duration : 96 Days
Mobilization: 7.5 Days
Deployed : 828 Nodes
135Km2
Approx 200,000 shot points
800-1100mt operating depth
Data Recovered: 98.2%
Single ROV



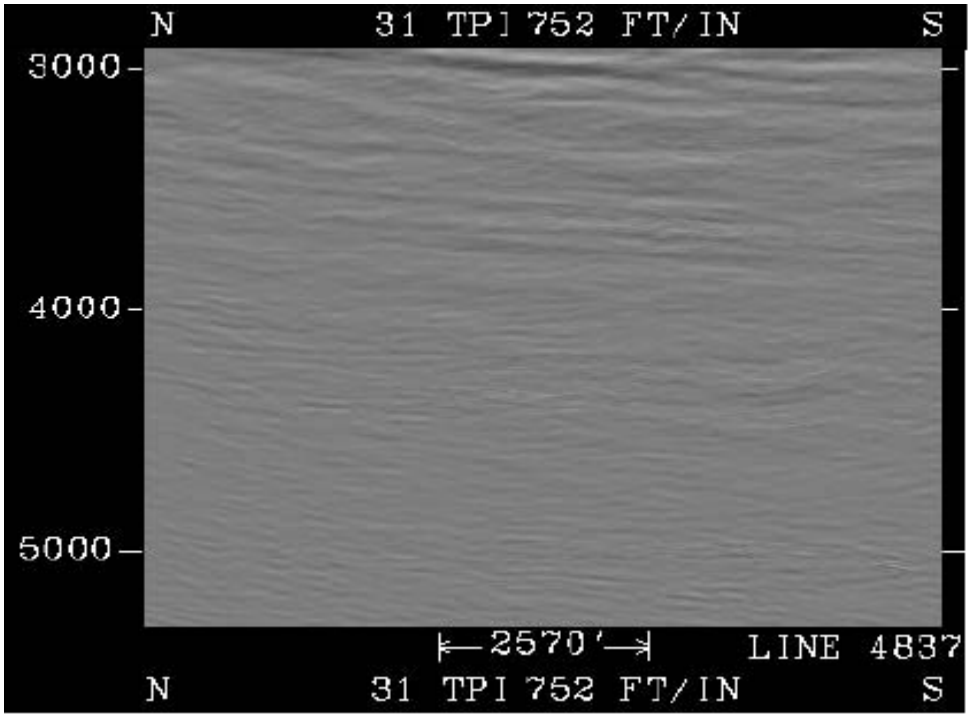
Deimos Node-on-Node 4D

Depth slice at 10000ft through the NRMS volume. Very low values of 6% are achieved which enables 4D signal to clearly stand out.



Results from the First OBS to OBS Time-lapse Survey in the Mars Basin – *EAGE Vienna, 2011*
Stopin, Hatchell, Beal, Gutierrez, Soto and Corcoran, Shell

Atlantis 4D



difference section (Figure 5b). Time-lapse noise measurements taken within the overburden, in terms of the Calibrated Difference in Reflectivity (CDR, Dyce et al, 2004), are the among the lowest in BP's experience even when compared to permanent installation surveys.

Reasnor et al, SEG Abstracts, Denver , 2010

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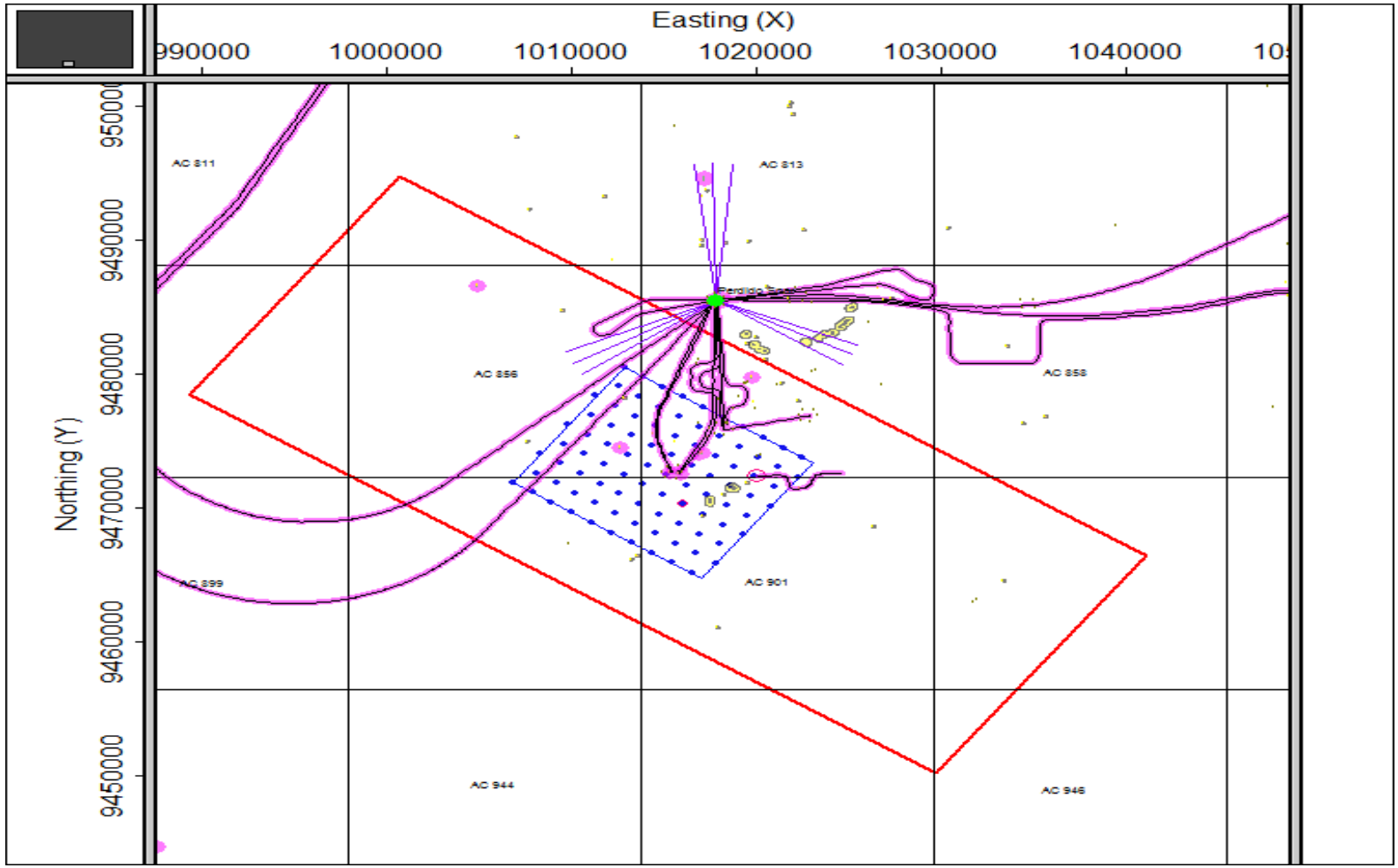
Z3000 Nodal System
Additional Capacity

- FairfieldNodal have recently mobilised a ***single vessel operation - source / node handling vessel*** equipped with a single Schilling ROV and configured as follows:
  - 200 - Z3000 Nodes
  - Fairfield's node skid for the ROV and basket system for delivery of nodes sub-sea
  - Single Source portable gun system, Installed onboard the ROV vessel
  - Crew is ideally suited for on-demand mini 4D surveys and conducting streamer infills.

Z3000 Nodal System

Single Vessel Operation – I4D / Water Injection Monitoring



90 nodes
56 nodes first
36,661 shots
7450 – 8600 feet
45% Slope
2950 Array @ 8 Meters
400X400
50X50 Shots
61 sail lines

Z3000 Nodal System
Single Vessel Operation – Damon Chouest

US flagged DP2 Vessel

Dimension: 240' X 52' X 18.5'

Clear Deck: 135' X 44'

Fuel Capacity: 178,000 Gallons

Accommodation: 41

Damon Chouest

Deck Layout

Z3000 Nodal System
Portable Node Containers

Storage: 150 Nodes

Z3000 Node Containers

- Total capacity: 250 Nodes
- Standard Shipping type containers 8'x20'
- Can add capacity as needed (scalable)

Data/ Charging = 100 Nodes

Z3000 Nodal System
Portable Source

- 2950 in3 Gun Array
- 4 Gun reels , 3 ton pull with slip rings, capacity 200 meters (3 Active and one Spare)
- Hydraulic power pack
- 3 Strings
- Depth, Pressure and Hydrophones per gun plate

Z3000 Nodal System
Portable Source

- Portable Air Compressors
- 2 - 600 CFM LMF Units in 20 foot containers
- Electrical driven
- 2950 - source can cycle every 24 seconds with one compressor and 12 seconds with two compressors running

Z3000 Continuous Improvement

As part of the FairfieldNodal "continuous improvement program", a number of new and innovative technical applications are planned, including but not limited to the following:

- Faster and more efficient deployment and retrieval with mid-water loading
- Improved use of two ROVs for simultaneous deployment/retrieval
- **Improved internal clock design**
- Dense node storage – vessel (smaller footprint on vessel)
- Simultaneous source acquisition
- Improved onboard data processing – faster turnaround
- ***Optical nodes***

Z700 / Z3000 Continuous Improvement
New clock implementation

- Stable and more accurate clock performance without double oven
- More efficient on-board data retrieval time
- **Lower power consumption – nodes can utilize sleep mode**
- **Increased Z3000 battery life ~ 180 days**

Z3000 Optical Nodes

- Ability to turn nodes on and off - sub-sea (sleep mode)
- Leave the node on ocean floor for 3-4 years
- Repeat surveys every 5-6 months (on-demand)
- Multi-component recording – selective component extraction using underwater optical communications hydrophone only, hydrophone and vertical geophone, shots only or continuous dataset, etc…

Z3000 Optical Nodes Advantages

- "Optical Node" greatly reduces installation/overall costs, and therefore asset risk.
- ON offers greater flexibility – recording template can be changed at little cost / risk - optimized survey design
- Subsequent survey costs are low with near real-time data collection
- Not necessary to plough-in; reduced cost and environmental impact
- Excellent node-on-node NRMS
- Proven operational capability
  - Nodes can be placed around infrastructure – no data holes
  - 4C recording with excellent vector fidelity – no cables!
  - Full azimuth illumination
- Significantly less up-front investment

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Permanent Monitoring – *Do it with Nodes!*

- Autonomous nodes are a proven solution for full azimuth 3D imaging in deep water
- Node-on-node 4D results show excellent repeatability – *6% NRMS!*
- New clock technology permits extended seabed lifetime
- Underwater optical communications allows remote data extraction
- ROV deployment/recovery reduces installation costs/allows for spread flexibility/ease of repair/upgrade

- *……a commercially viable alternative to LOFS/PRM systems?*

Reservoir Monitoring Systems vs Optical Nodes