Multi-streamer Short Offset High Resolution 3D Seismic Acquisition

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Background

West Vanguard

Petromar V
Background

Ekofisk Subsidence
Solutions

Safety at and Below the Seafloor

• Initial high resolution surveys allow the identification of potential risk areas on the seafloor.
• Monitoring changes in the overburden allows a more proactive approach to the safe design and positioning of production equipment as the reservoir matures.
• Results in 3D remove risk from these processes by discovering and monitoring changes in x, y, and z.
Objectives

Develop a high resolution system that is truly 3D. The system is:

- Fully robust and commercialized, meets standards set by OGP, IAGC, etc,
- Operable with a variable range of field parameters such as sensor depth and spacing, etc,
- Useable for methods such as zero-offset, staggered depth, multi-azimuth, etc,
- Produce High Resolution 3D results within a traditional budget.
Approach

Create a system that mimics that of multi-streamer seismic

- Adapt and inherit methods from multi-streamer seismic
  - Proven both procedurally and in HSE
- Derive from market-proven components
  - Seismic COTS
- Optimize for reduction in drag
  - Take advantage of HR geometries and the effect they may have of equipment selection
Challenges

1. **Physical** – In a 3D survey, multiple acquisition passes at very short spacing are required to acquire data. For this and other reasons, a multi-streamer technique must be used.

2. **Positioning** – Navigation sensor accuracy must be proportional to the spatial accuracy of the geophysical instrument.

3. **Geophysical** – The geophysical instrument must have a noise floor sufficient as not to defeat the advantage of its higher hydrophone density.

4. **Cost** – Solving 1-3 is pointless unless it can be done at a reasonable cost, and within a reasonable timeframe.
Challenges - Physical

*The multi-streamer technique is necessary to economically produce surveys within time and cost budgets.*

Assumptions and Givens:

- A minimum of 20 streamers balances the acquisition cost/benefit
- A minimum group-length/streamer-length ratio of 10 provides sufficient redundancy and provides for deterministic data (velocities)
- Available streamer components are similar in terms of drag
Challenges - Physical

*The x&y streamer and group density allows the use of multi-streamer lead-in cables

- 20 digital streamers at 12 or 24 channels/streamer
- 2 Lead-ins, Port and Starboard, provide redundancy and simplify operations
- Reduction of the cross sectional drag of the eliminated lead-ins iteratively reduces the size and drag of other in-water components
Challenges - Physical

*The cross sectional area of the spread solves all unknowns of the hydrodynamic model

- The multi-streamer lead-in-driven reduction in drag trivializes the streamer component contribution
- Catenaries can be optimized for common offset or common geometry
- Drag at full spread @ 6 knots: 11T
Challenges - Physical

*Hydrodynamic model results lead to platform selection
Challenges - Physical

*The equipment requires a modest amount of deck machinery

- Vessels of opportunity are not limited to dedicated seismic, AHTS or other high propulsion power (cost) vessels
- Working deck real estate and required propulsion allow the use of varied vessels
  - PSV’s
  - Chase Boats
  - Trawlers
Challenges - Navigation

*The navigation precision needs to be proportional to the spatial resolution.*

Assumptions and Givens:

- Zero manual observations, offsets or static laybacks
- Error ellipses must be within the bin dimensions
- Minimum of x, y, and z positioning for each hydrophone group
- Independent positioning sensors (i.e. not tied to the streamer spread) to augment areas of weak geometry
Challenges - Navigation

*The navigation model identifies 200 unique observations.*

- RGPS and Acoustics are used prominently at the head and tail of the spread.
- Compasses at head and tail of each streamer (with depth control)
Challenges - Navigation

*Surface navigation buoys are required in areas of poor geometry.*

- Buoys are independently positioned within the spread.
- The lack of lead-ins means that these can be flown to any position port or starboard
Challenges - Navigation

*Active positioning (and hydrophone redundancy) show value in unexpected geometries.

- Stationary laybacks would have resulted in mis-positioned groups
- While lower fold, redundant groups allowed data binning
Challenges - Instrumentation

The Geophysical Instrument needs to fulfill the desired spatial resolution while maintaining a extremely low noise floor.

Assumptions and Givens:
• Modular system to enable component replacement, calibration,
• Telemetry that serves the multi-streamer lead-in concept
• Variable hydrophone grouping
Challenges - Instrumentation

*Hydroscience Seamux*

- 240 channels / Lead-in
- Gel and EF Fluid-filled sections @ 75m
- Single digitizing module per streamer
Challenges - Instrumentation

*Rigging separated into mechanical and electrical components

- Separation allows the isolation of electrical and mechanical components
  - All COTS
- Resultant system requires only one custom component that serves as the electro-mechanical merge point

6.25m, 12.5m, 25m
In Use

Production Survey

- Deployment of 20 streamers
- Streamer length of 150 meters
- 24 groups of 6.25 meters each
- Streamer separation 12.5 meters
- Survey size of 5.5 square kilometers
- Total acquisition time was 4 days, including deployment and retrieval
Results – Inline line 1160
Results – Inline line 1160 – Timeslice at 210ms
Results

Example: Shallow Square Feature

- 210ms
- 100m’s x/y, 10’ms z

Resolved by HR2D? Yes, in Y
Resolved by Reprocessed 3D? Yes
Results – Inline line 1160 – Timeslice at 262ms
Channel Feature
Results

Example: Channel Feature

- Sedimentation resolved within the feature
- Resolved at depth

Resolved by 2D? Possible
Resolved by Reprocessed 3D? Probable
- But at what cost?
Results – Inline line 1160 – Timeslice at 415ms
Results

Example: Bright Spots

- <10 to 10’s of meters in x/y/z
- >400ms deep

Resolved by 2D? Possible, but in Y only
- Feeling Lucky?

Resolved by Reprocessed 3D? Possible, but smeared/misinterpreted?
Conclusions

*The system and method both proved viable

- Using COTS components removed most of the uncertainty regarding system design.
- Using a systematic approach to sea trials allowed the isolation of unknowns and refinements.
- The first production survey experienced no failed components or technical downtime.
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