

# A-C

### **Seismic Interference**

The perspective of the site surveys

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How to remove



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### **Fugro Survey AS**



- Responsible for Site Surveys in Norwegian waters
- Operates together with our sister company in Aberdeen 6 survey vessels
- Does approx 30 site and route survey reports yearly



### Why Do Site Surveys?



"Site surveys are performed to **minimise the risk** of harm to personnel and equipment, and to protect the natural environment. The objective of any site survey is to **identify all possible constraints and hazards** from man-made, natural and geological features which may affect the operational or environmental integrity of a proposed drilling operation..."

OGP Guidelines for the conduct of offshore drilling hazard site surveys, 2011



### Why do a site survey

- Meet requirements
  - Authority regulations
    - Ptil: Aktivitetsforskriften
    - KLIF guidelines
    - Sjøfartsdir: Ankringsforskriften
  - Operator policy
  - Rig Insurance requirements
- Minimize your costs
  - Avoid over engineering
  - Avoid costly unwanted incidents





### You should do a site survey before

- Drilling a well
- Laying pipelines and cables (route survey)
- Engineering activity on the seabed





### **Typical potential hazards**



Unknown infrastructure, boulders, corals, spounges ..





Source	Function	Frequency	Penetration through Seabed
Echo Sounder – <u>Multibeam</u>	Ascertain water depth	200 kHz	-
Side Scan Sonar	Identify seabed features	100 – 500 kHz	-
Sub-bottom Profiler – Pinger	Identify very shallow soils	1.4 – 4.5 kHz	10 – 30 m
Sub-bottom Profiler – MAG	Identify intermediate soils	0.4 – 3 kHz	60 – 100 m
Multi-channel Seismic	Identify deep soils and drilling hazards	0.05 – 0.25 kHz	1500 m

### **Tools for seabed survey**









- To investigate sub-seabed hazards and soil instability
  - sub-bottom profilers (e.g. pinger, sparker and mini air gun)
  - digital high resolution multi-channel 2D seismic

Typical acquisition parameters site survey:

- Active streamer length : 1200 m
- Dist. between groups : 12.5 m
- No. of groups : 96
- Sampling rate : 1 ms
- Recording length : 2.5 sec
- Shot point distance : 12.5 m
- Streamer depth : 2.5 m (± 0.5 m)
- Source towing depth : 2.5 m (±1 m)
- Depth sensors on each section



Site-survey perspective

### How to remove





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- Statistics from Fugro Survey:
  - 1. North Sea March 2012, 5% of operational time
  - 2. North Sea autumn 2011, 10% of operational time
  - 3. North Sea North summer 2011, >20% of operational time

### **SI-Solutions**



### Traditional:

- Timesharing
  - Problem:Cost
  - Advantage:
    Perfect results

### **New solution:**

- Ignore SI. Attenuate in processing
  - Problem:Does not always work
  - Advantage:Low cost

### The third option:

Plan ahead and coordinate, to avoid timesharing

### **Site-Survey vessels**



# Versatile:

- If on standby, they can do:
  - Sea-bottom profiling
  - Geotechnical surveys
  - Environmental surveys
- Typical short lines
  - Can take advantage of line-changes

Need to plan aheac

# Small:



- Often difficult to agree on time-sharing
  - Unclear rules

Time-share pr vessel or pr operating company in an area???

 Sometimes difficult to obtain accurate info on seismic activity in an area



### **Onboard QC/processing**

- Only basic QC is standard on site survey vessels
- Advanced QC or full onboard processing can help evaluate if SI is acceptable or not
  - Direction
  - Amplitude
  - Time
  - And one other nice thing (next slide)



Left : Difficult to attenuate Right: Easy to attenuate



### **Onboard QC/processing**

- Site-survey shot-point interval: ~3s
- Conventional seismic shot-point interval: 8-15s
- Sort data to CMP
  - →Apply de-noising algorithms to remove the SI



Site-survey data sorted to CMP-domain





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- Transform and/or sort the data into a domain where we can separate SI from the seismic data.
- 2. In this new domain: Remove the SI.
- 3. Transform and/or sort the data back to the normal (shot/cmp) domain.

The challenge is to identify the most suitable domain where the denoising should take place!



- We present a few examples on how Fugro Seismic Imaging through careful processing have removed SI
- Specialized software modules and processing flows





- Strong SI + some swell-noise.
- SI comes from the front, and has similar move-out as the data.
- SI is visible on all shots.



Shot-gathers



### **Parameters : Seismic Interference removal**

- 1. Mild swell-noise attenuation in CO-domain using Fugro Statistical de-noising methods.
- 2. Make a model of the SI from the data using a Stationary Wavelet transform:
  - Apply NMO to shot record
  - Transform shot records using a Stationary Wavelet transform
  - Mute the SI (examples will follow)
  - Transform data back to time-frequency, keeping the SI
  - Remove NMO
  - Apply Random noise attenuation to improve the model of SI
  - Output SI model
- 3. Subtract the output model 2. from the Input data 1.
- 4. Output shot with SI removed.
- 5. Additional swell-noise/SI attenuation



# 1. Shots : Input





### After final noise attenuation



### Difference





### 1. Stack : Input





### 4. Stack : After noise attenuation





### Difference



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- Examples from site-survey processing in the North and Barents Sea.
- The flows are based on combining Tau-p muting and Fugros statistical denoising methods.

# Shot gathers



SEISMIC INTERF WITH OPPOSIT DIP





# R. Q. Q. R. CHARMA (20200) 18 States. 1 18 10 108 104 100 105 108 207 205 SEISMIC INTERF NOT EFFECTED WITH MUTE

### SEISMIC INTERF REMOVED WITH TAUP MUTE

NOISE ATTENUATED BUT STILL PRESENT

### Difference







### CDP's after Tau-p mute





### **CDP's after Fugro statistical de-noising**



### Difference



### A new algorithm



Transform the DATA into a domain where we can separate the NOISE from the SIGNAL

In this new domain, remove the NOISE

Transform the de-noised DATA back to the time-domain

1. Tau-p transform

2. Statistical de-noising

Combinations of the algorithms above + sorting to make the SI random. (Elboth et.al. EAGE 2009)

Getting the best of both worlds!



## An advanced SI removal algorithm:







Before, after and difference from TFDN on common-p gathers.

### Algorithm:

- Apply a tau-p transform on the gathers
- Sort the tau-p gathers into common-p, and identify where the SI is
- Apply TFDN on the common-p gathers
- Sort back to tau-p
- Transform data back to t-x





Before, after and difference from TFDN on tau-p gathers



### TFDN + tau-p – SI removal



Site-survey data drowning in SI from a large 3-D vessel

### SI in the near future

- In some ways, SI removal looks a bit like deblending.
- Problems:
  - We do not control when the SI arrives.
  - We do not control where it comes from.

HOWEVER,







 By iterating carefully, we can gradually separate SI and DATA



Algorithm after Maraschini et. al. (EAGE 2012)



### This type of INTERFERENCE might be difficult to handle.





- Can we drop timesharing when we have SI?
  - In most cases YES, (but need advanced onboard QC to be sure!)
  - The short shot-point interval of site surveys compared to conventional seismic is advantageous when we want to attenuate SI
- Great need to plan/coordinate surveys to avoid unproductive standby
  - Site survey vessels can often do other types of activity when they are on seismic standby due to SI





Thank you