Pipelaying – example from Ormen Lange
Development concept
Pipeline routing

Shelf (-250m)

Development area (-900m)
Free spans – Early routing

[Graph showing water depth vs. KP for Route 2000 and Route B]
Early route alternative – Distribution of free spans

Typical maximum

Span Height [m]

Span Length [m]

0.5

5.5

10.5

15.5

20.5

40 140 240 340 440
S – laying versus J - laying
Critical length – a fatigue issue

Critical length depends upon natural frequencies and current velocity:
- Length
- Diameter
- Support conditions
- Fatigue capacity
Vortex induced vibrations (VIV) of free spanning pipelines

- Induced by current.
- Simplistic estimation tools
- Determines maximum length of free spans.
  - Fatigue
- Puts severe constraints on pipeline routing
- Cost driver: Intervention work in deep water.
- Ormen Lange:
  - Pioneer project.
  - Basis for improved future methods
Span rectification several options

- Rocks supports (Pre/Post dumping)
- Submerged floating pipeline
- Dredging/Trenching

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SHORT versus LONG FREE SPANS

SHORT SPAN
L/D ≈ 100

- BEAM BEHAVIOUR GOVERNING
- SINGLE HALF WAVE MODE
- EXISTING DNV - G14

LONG SPAN
L/D ≈ 200

- CABLE DOMINATED BEHAVIOUR
- MULTIPLE MODE EXCITATION
- NOT COVERED BY EXISTING DNV - G14
Cable, beam and sag effect on 1st natural frequency, Large sag, high axial stiffness

Eq 2:

\[ f_{1,CF} = \frac{1}{2L} \sqrt{\frac{N_{eff}}{m_e}} \left( 1 + \frac{P_e}{N_{eff}} + \frac{\pi^2}{4L} \frac{k_0^2 \delta_0^2}{N_{eff}} \right) \] (Hz)
Reliability analysis & RP-F105

- IL vibration controls fatigue life.

- Single (idealized) span length can be increased from 40 – 60 m to 80 – 110 m (Shortest in slide area, longest in development area)
Shoulder contact force. Soft versus stiff soil

Note: KP values referring to KP 0.000 at Template B – Route South-East December 2002.
Improved routing & intervention work

- Shorter spans with short shoulders. I.e. interaction between spans.
- Max. allowable length of a span depends upon neighbouring spans and shoulder properties (stiffness & geometry)
- Improved current and soil information
Figure 5-1  Classification of free spans DNV-RP-F105
S – laying versus J - laying
## Characteristic forces S- versus J-lay

### S-Lay

<table>
<thead>
<tr>
<th></th>
<th>Submerged Weight (N/m)</th>
<th>Water Depth (m)</th>
<th>Barge Tension (kN)</th>
<th>Residual Tension (kN)</th>
<th>Overbend Strain (%)</th>
<th>Touchdown Distance (m)</th>
<th>Pipe Span (m)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>920</td>
<td>1100</td>
<td>2100</td>
<td>1000</td>
<td>0.25</td>
<td>1490</td>
<td>2000</td>
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</table>

1) Tension in pipe on bottom  
2) Horizontal distance from last tensioner  
3) Length of pipe from stinger to touch down.

### J-Lay

<table>
<thead>
<tr>
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<th>Submerged Weight (N/m)</th>
<th>Water Depth (m)</th>
<th>Barge Tension (kN)</th>
<th>Residual Tension (kN)</th>
<th>Max. BM Sagbend (kNm)</th>
<th>Touchdown Distance (m)</th>
<th>Pipe Span (m)</th>
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<td>529</td>
<td>392</td>
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</tbody>
</table>

1) Tension in pipe on bottom  
2) Maximum bending moment in sagbend. The maximum allowable bending moment is 1620 kNm.  
3) Horizontal distance from last tensioner  
4) Length of pipe from stinger to touch down.
Simulation of marine operations
Pipelaying
Simulator for complex marine operations

- SIMULATOR CONTROL
- High level architecture (HLA) / Run-Time Infrastructure (RTI)
- Visualization
- Terrain module
- GL view
- ROV control and visualization
- RIFLEX
cables and risers
- SIMO
vessel INC. DP
- SIMLA
Pipelaying
Free spans
Pipe Laying
Gravel supports in Bjørnsundet
Basis for laying analysis
Virtual ROV picture
Rock installation