Norwegian Coastal Highway Route E39

Mr. Olav Ellevset, Project Manager Coastal Highway Route E39, NPRA
Route E39

E39 Kristiansand-Trondheim about 1100 km

E39 Ferry Link Kristiansand-Hirtshals in Denmark

E39 connects with E45 in Aalborg, Denmark
Government’s and Parliament’s Ambition

- Replace all ferries and upgrade corridor within 20 years
- Cost frame of NOK 150 billion (US$ 25 billion)
- From 2014
Coastal Highway Route E39 Project

Infrastructure Project

Knowledge Creation Project

Construction Industry Development Project

17.11.2014

Mr. Olav Ellevset, Project Manager Coastal Highway Route E39, NPRA
50% of Norwegian Traditional Export Value from this area (2010)
Coastal Highway Route E39

E39 Kristiansand - Trondheim

1100 km

8 Ferry links remaining

8 of 17 national ferry links

US$ 25 billion over 20 years (2014-33)
Magnificent Landscapes
... but challenges abound
Fjord Crossings

Key Figures (Width, Depth)

- Halsafjorden, 2 km, 5–600 m
- Moldefjorden, 13 km subsea tunnel – 330 m + 1,6 km bridge, 5–600 m
- Storfjorden/Sulafjorden, 3,4 km, 500 m
- Voldafjorden, 2,5 km, 600 m
- Nordfjorden, 1,7 km, 3–500 m
- **Sognefjorden, 3,7 km, 1250 m**
- Bjørnafjorden, 4–5 km, 5–600 m
- Boknafjorden, Rogfast Subsea tunnels, 26,7 km, – 390 m (Floating bridge option, 7,5 km, 550 m depth)
E39 Fjord Crossings

Main Concepts Sognefjord
Depth 1300 m

Main span 3700 m
Length 4000 m

Links to Video animations:

Norwegian, short (02:30) and long (06:21)
http://www.vegvesen.no/Vegprosjekter/ferjefriE39/Film

English (06:20)
http://www.vegvesen.no/Vegprosjekter/ferjefriE39/English/Film
E39 Fjord Crossings

More Typical Depths are 5–600m

Bjørnafjord Crossing
Length 4–5 km
LMG Marin’s proposals for various fjords
Fjord Crossings Component

Artificial Seabed

Reinertsen Olav Olsen Group
Fjord Crossings Component
Floating Bridge and SFT anchored to Artificial Seabed
Fjord Crossings

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  (Floating bridge option, 7,5 km, 550 m)
E39 Bokna Fjord (Rofast)

- 27 km, world’s longest road tunnel
- Gradient 5 % max.
- Depth 390 m below sea level, will become world’s deepest subsea tunnel
- Two tubes (4 lanes)
- Tendering expected 2016
Fjord Crossings Component

Bridge Concept for The Boknafjord in Rogaland

Possible, but not recommended!

7.5 km Multi-Span Suspension Bridge on Floating Foundations
Recent Developments – Offshore Structures

Ekofisk tank: 70 m depth (1973)

Troll platform: 303 m depth (1995)

Buoyant platforms (TLP) moored at depths of more than 1500 m
Research & Development

Technology does not come by its own!
Coastal Highway Route E39

Research and Development (R&D) Programme

- To build infrastructure with improved life time, less life cycle costs, less accidents, and less emissions
- Forefront of technology, create and utilize last and updated knowledge
- Service Life Design up to 200 years
  - fib Bulletin No. 34: Model Code for Service Life Design
- Prepare corridor for vehicles powered by electricity or hydrogen
Fjord Crossings

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The R&D Needs are Obvious

Suspension bridge option with two towers on floating platforms/TLPs
Current Activities Bjørnafjord

- Preliminary design Floating bridge Bjørnafjord
  - Aas–Jakobsen, Johs Holt, Cowi & Others

- Preliminary design Submerged floating tunnel
  - Bjørnafjord: Reinertsen, Olav Olsen, Norconsult & Others

- Assistance with developing the TLP–concept for suspension bridge on floating foundations:
  - TDA A/S, Aker Solutions

- Risk analyses for ship collisions: SSPA Sweden AB

- Data collection:
  - Wind: Kjeller Vindteknikk
  - Currents and waves: DHI Norway
  - Seismic and sediments
E39 Fjord Crossings

Long Span Suspension Bridges Wind Tunnel Testing

- Julsundet Suspension bridge
  - to be completed 2014

- Halsafjorden Suspension bridge
  - to be completed summer 2015

At Copenhagen Wind Tunnel (Sven Ole Hansen ApS, DK)
### E39 Fjord Crossings

Halsafjorden – Eigen-frequencies and Flutter

<table>
<thead>
<tr>
<th>Mode</th>
<th>Frequency [Hz]</th>
<th>Period [T]</th>
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<tbody>
<tr>
<td>HS1</td>
<td>0.039</td>
<td>25.67</td>
</tr>
<tr>
<td>HA1</td>
<td>0.074</td>
<td>13.46</td>
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<tr>
<td>VA1</td>
<td>0.084</td>
<td>11.91</td>
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<tr>
<td>VS1</td>
<td>0.103</td>
<td>9.74</td>
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<tr>
<td>HS2</td>
<td>0.115</td>
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<tr>
<td>VS2</td>
<td>0.138</td>
<td>7.25</td>
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<tr>
<td>TA1</td>
<td>0.156</td>
<td>6.40</td>
</tr>
<tr>
<td>VA2</td>
<td>0.157</td>
<td>6.37</td>
</tr>
<tr>
<td>TS1</td>
<td>0.158</td>
<td>6.32</td>
</tr>
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</table>

\[
\hat{E}_\eta(\omega, V) = \begin{bmatrix} 1 - \kappa_{ae} - \omega \cdot \text{diag} \left[ \frac{1}{\alpha} \right]^3 + 2i\omega \cdot \text{diag} \left[ \frac{1}{\alpha} \right] \cdot (\xi - \xi_{ae}) \end{bmatrix} \quad \text{det} \left( \hat{E}_\eta(\omega, V) \right) = 0
\]
Among the Key goals by 2050:

- No more conventionally-fuelled cars in cities
- 40% use of sustainable low carbon fuels in aviation; at least 40% cut in shipping emissions
- A 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport
- All of which will contribute to a 60% cut in transport emissions by the middle of the century.
Famous Atlantic Road
Energy Component
Contributing to Meeting Climate Goals?

Potentials look larger than previously anticipated!
Project 11  
The E39 as a renewable European electricity hub

ELIN – long-term investments

EPOD – hourly dispatch
Project 13  Graphene feasibility and foresight study for road infrastructure

Roadmap for how graphene can be utilized for Statens Vegvesen and the E39 Coastal Highway Route initiative

Graphene-based composites

- Reinforcement of concrete to increase tensile strength and ductility
- New and revolutionary structural engineering paradigms
- Super capacitor based systems for inductive charging of electric vehicles
- Graphene-based solar panels for production of electricity
- New sensor systems and new electronics concepts

2020
- Composites available for R&D needs
- Proof of concept of sensor platform

2030
- Composites in XXX road application
- Sensor in XXX road application
E39 Energy Component
Contributing to Meeting Climate Goals?

May start talking about:
• Passive Roads
• Plus Roads, or
• Power Roads

Potentials look larger than previously anticipated!
<table>
<thead>
<tr>
<th>Road Section Type</th>
<th>Contracting Approach</th>
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<tr>
<td>Fjord Crossings</td>
<td>Design–build (DB)</td>
</tr>
<tr>
<td>Road Section w/many structures</td>
<td>Design–build (DB)</td>
</tr>
<tr>
<td>Upgrading and new sections along existing corridor</td>
<td>Bid–Build (BB) or Design–bid–build (DBB), w/Improvements Detailed design</td>
</tr>
</tbody>
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Different types of Contracts

- Size of contracts
  - < Euro 100 million to >1 billion
  - Up to 100 kilometer
  - Content and duration to allow innovation, R&D, and industrialisation for larger contracts

- D–B w/Competitive dialogue, Alliance– or comparable types of contracts with substantial content of dialogue to find optimal Technical solutions and sort out Risk distribution

- Risk well balanced between Client and contract Consortium

- Tendering approach to utilize joint competence of client, consultants and contractors when beneficial
Different Project Models used in Norwegian Road Projects

- Bid – Build (BB)
- Design – Build (DB)
- Design – Build – Operate (DBO)
- Design-Build-Finance-Operate (DBFO), Private Public Partnership (PPP)