

FEMERN BÆLT LINK LANDWORKS

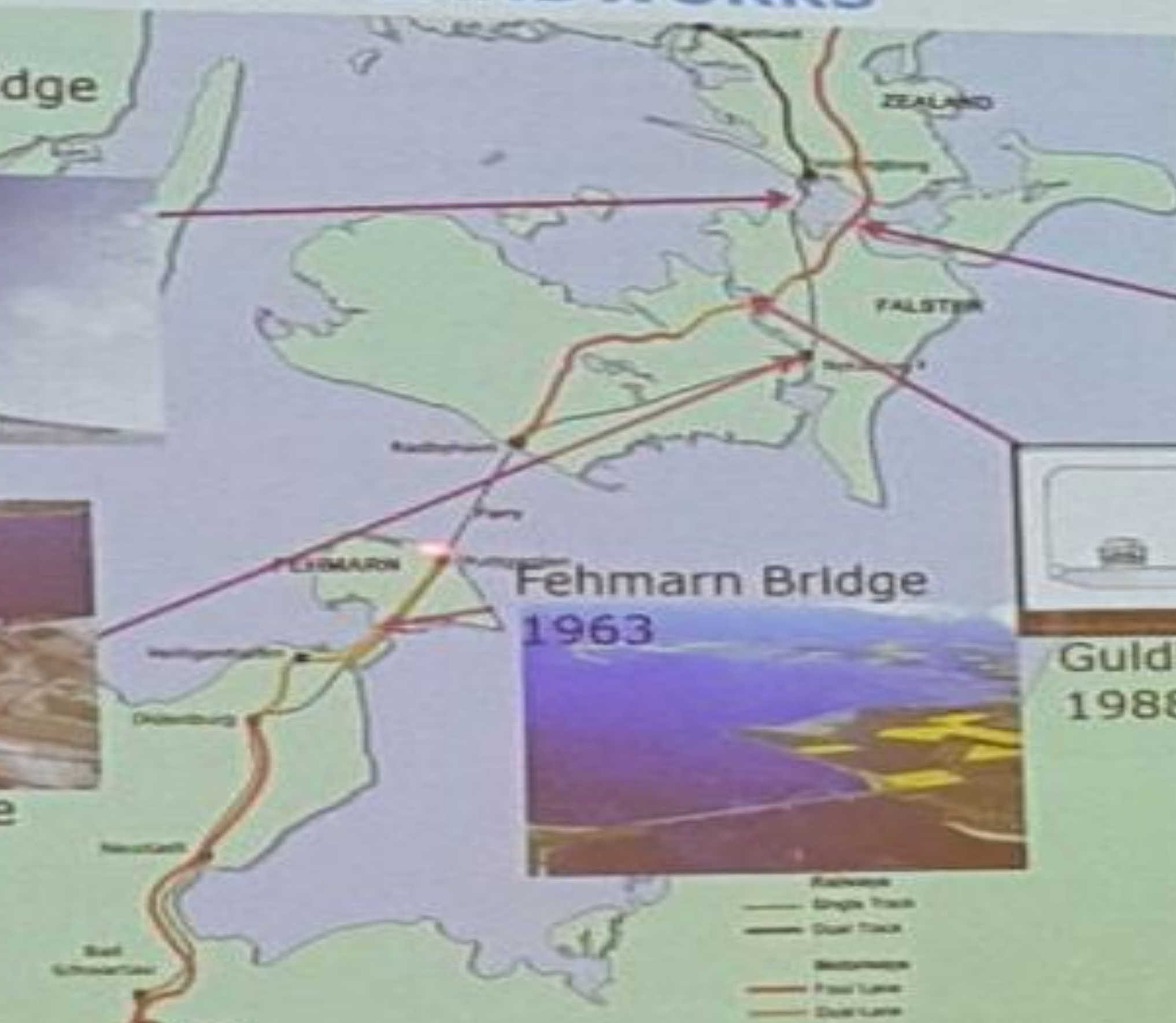
New Storstrøm Bridge
2021



Faro Bridges
1985



Frederik IX Bridge
Extension



Fehmarn Bridge
1963



Guldborgsund Tunnel
1988

RAMBOLL

FEMERN BÆLT TUNNEL KEY PROJECT FEATURES

Standard tunnel element length:	217 m
width:	42.2 m
height:	8.9 m
weight:	76,600 t
number:	79
Special tunnel element number:	10
Structural concrete:	2,600,000 m ³
Reinforcement:	300,000 t
Tie-down anchors (Lolland ramp):	1,400
Dredged volume:	15,500,000 m ³
Trench backfill:	6,800,000 m ³
Reclaimed land:	3,300,000 m ²

FEMERN BÆLT LINK FINANCING

100% Danish owned Company
Danish State Guarantee

Danish
Landworks

Appr.
EUR 1300
million

Financed by
the fixed
link user
fees

Coast to Coast
Fixed Link

Appr. EUR 7400 million

Financed by the fixed
link user fees

100% German
Company

German
Landworks

Appr.
EUR 1500
million

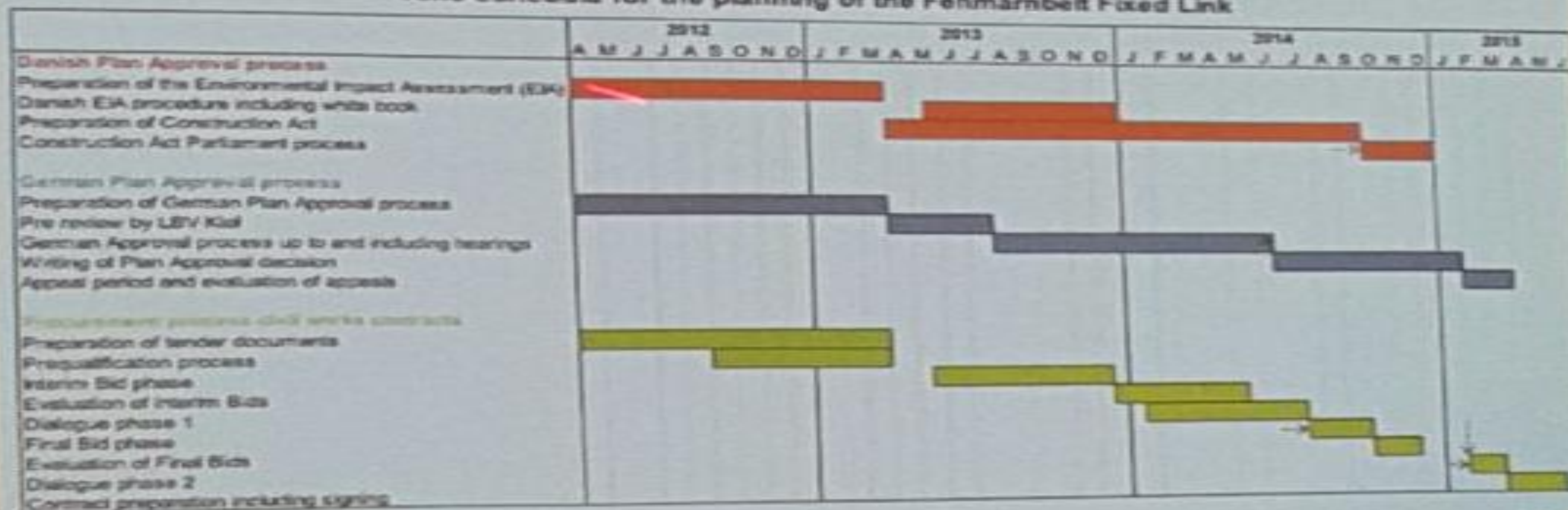
FEMERN BÆLT LINK OWNERSHIP



PROJECT SCHEDULE

Appendix 1.

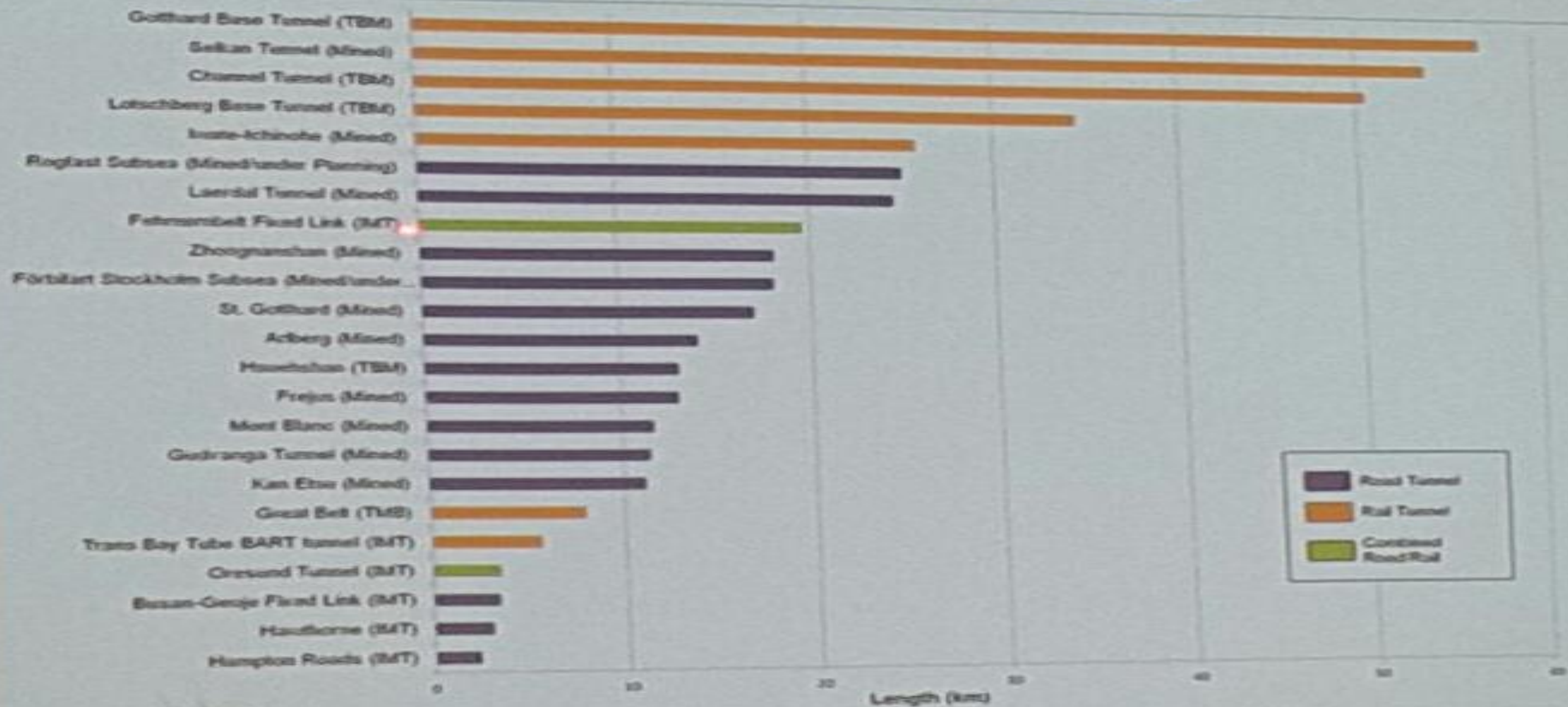
Time schedule for the planning of the Fehmarnbelt Fixed Link



Expected opening: End of 2021.

Postpone till 2014?

WORLD'S LARGEST TRAFFIC TUNNELS



COAST-COAST: BRIDGE OR TUNNEL?

Parallel Designs
2009 - 2010

Concerns:

- Ship collision
- Pier foundations
- Weather sensitivity
- Environmental Impact

Concerns:

- Tunnel ventilation
- Economy

Immersed tunnel selected

Design team:

PARISEL, Arup, TEC



ELEMENT FABRICATION (ØRESUND TUNNEL)



Temporary mooring in dock

Outfitting outside dock

Element Fabrication



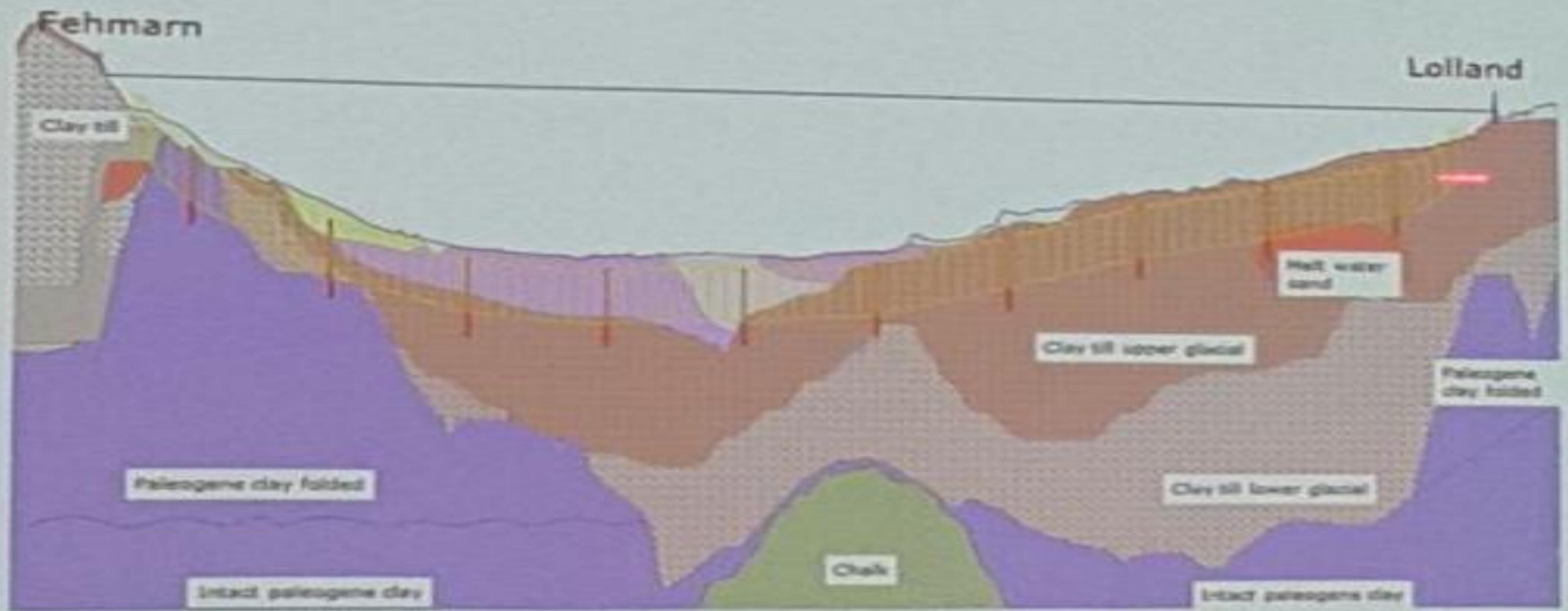
Tunnel Element 2

ELEMENT TOW-OUT (ØRESUND TUNNEL)



LONGITUDINAL PROFILE

Water depth 29 m



CONCRETE STRATEGY

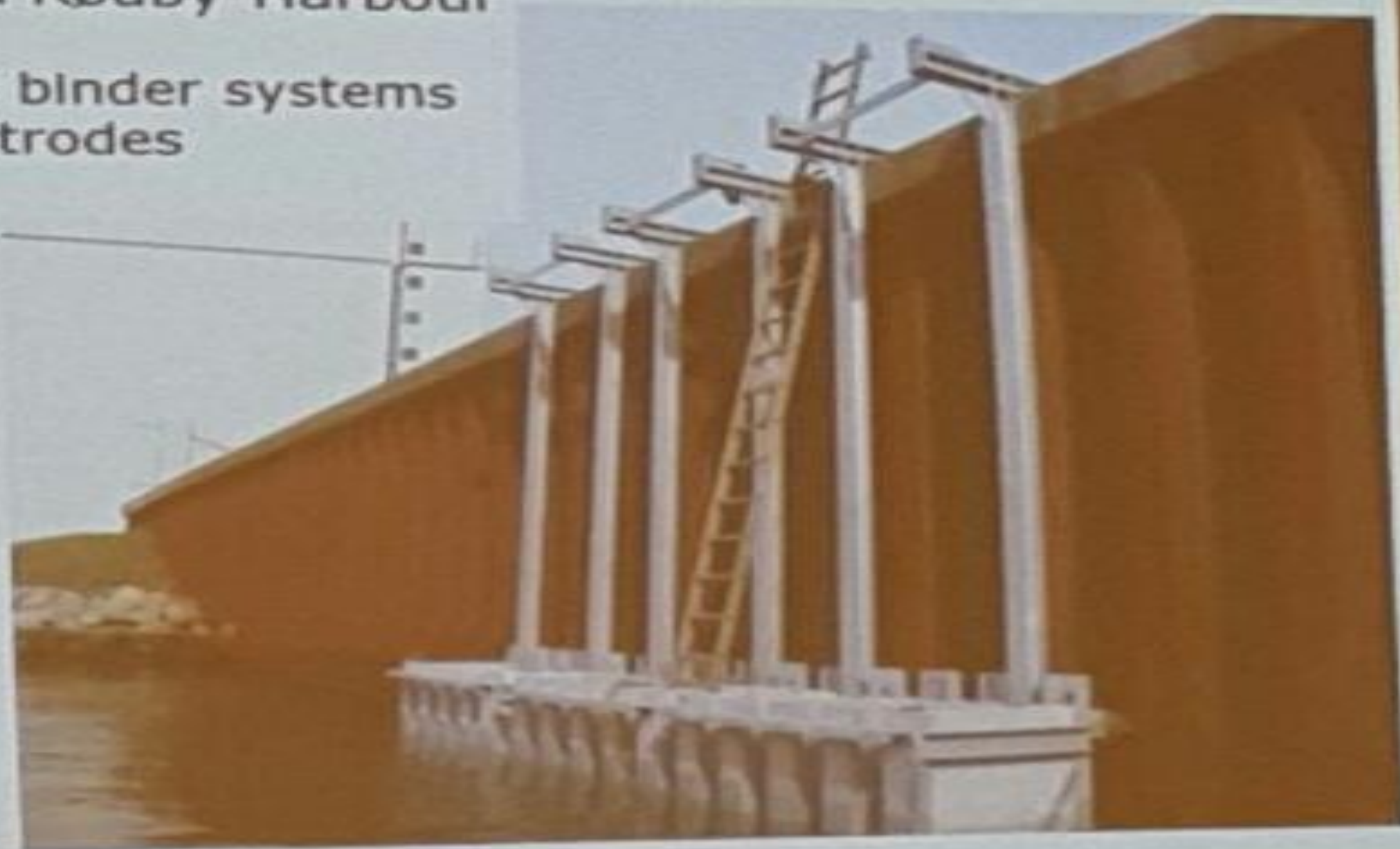
- 2,600,000 m³, 120 years design life
- No Initiation of corrosion or major repair works

Field Exposure Site in Rødby Harbour

15 blocks with different binder systems
7 with sensors and electrodes

Testing:

- At casting 2010
- 28 days
- 6 months
- 2 years
- 5 years
- At completion 2021

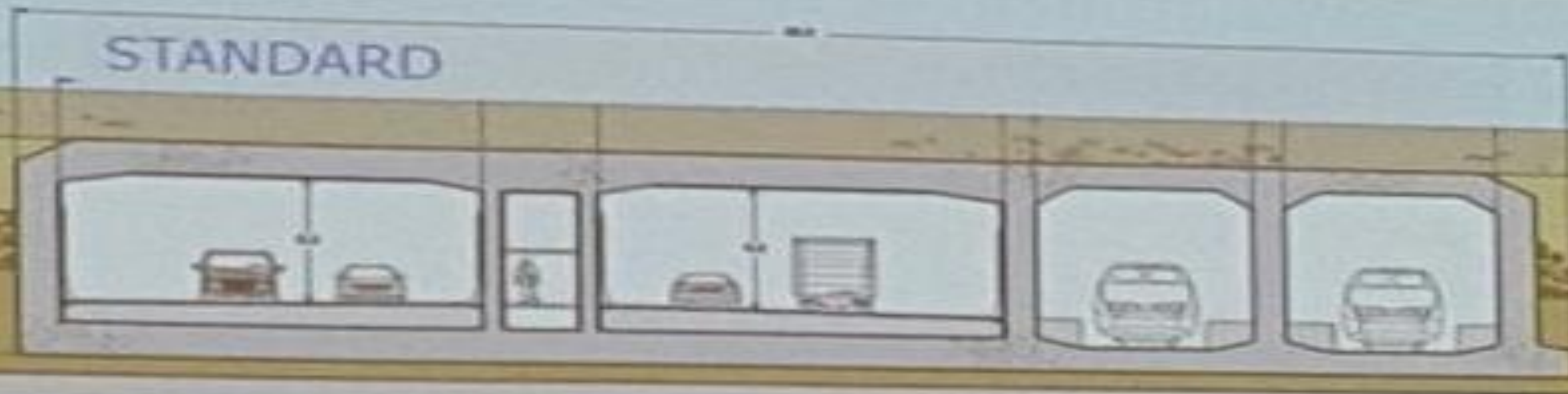


TUNNEL ELEMENT FACTORY

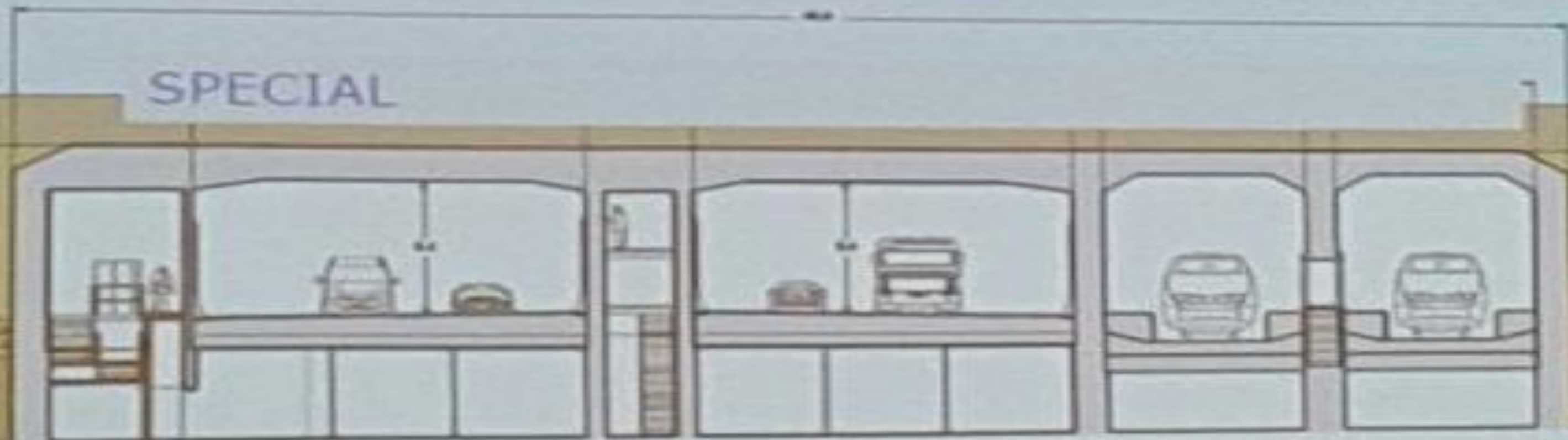


TUNNEL ELEMENTS

STANDARD



SPECIAL



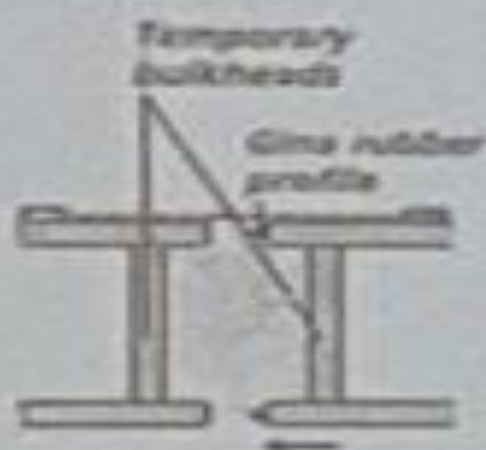
ELEMENT INSTALLATION (ØRESUND TUNNEL)



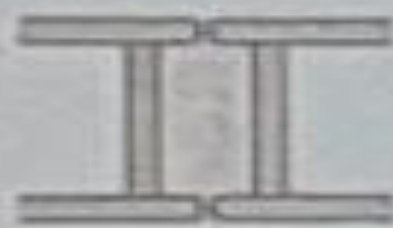
The floating tunnel element is now moved from the casting yard at the North Harbour to the tunnel reach



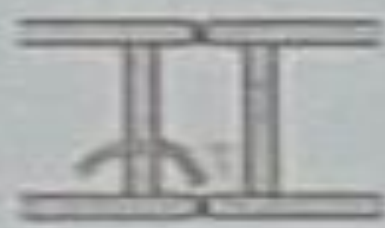
A gravel bed is placed at the bottom of the tunnel reach. The tunnel elements are ballasted and lowered into the reach



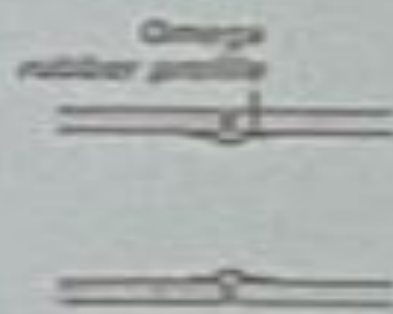
The immersed element is pulled against the previously installed one



The rubber profile (GINA) forms a reservoir between the two bulkheads



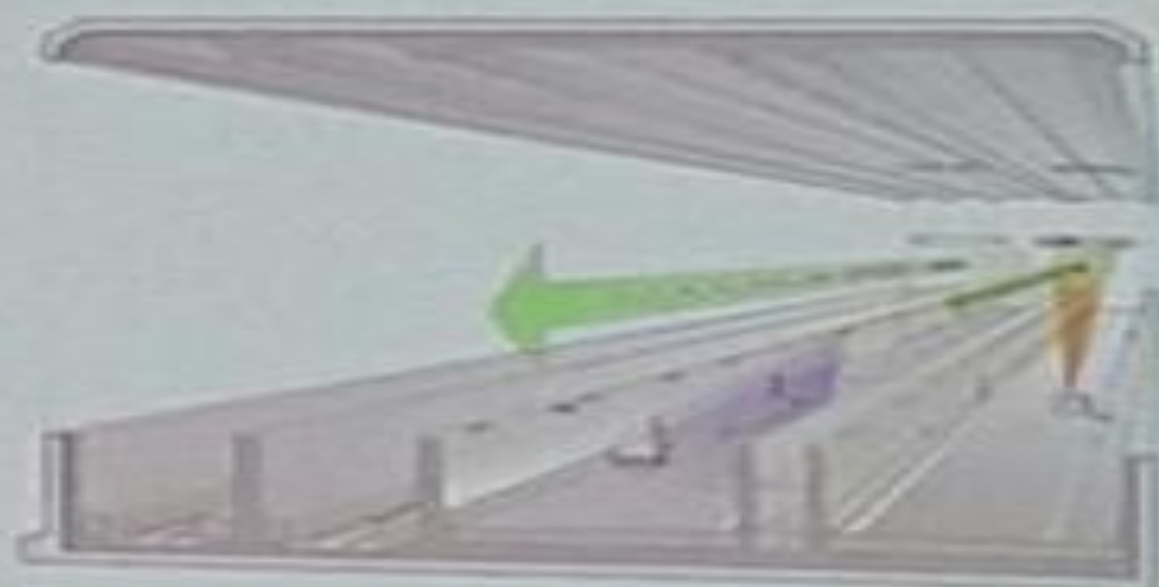
Water is pumped out of the reservoir causing the GINA to compress and seal the joint



The bulkheads are removed and a second rubber profile (OMEGA) completes the joint

FEMERN BÆLT TUNNEL KEY SAFETY ASPECTS

- No queuing up (rural tunnel and intelligent traffic management)
- Full emergency lane in each direction
- Unidirectional traffic (road and rail)
- Robust longitudinal ventilation
- Escape per 110 meters to central gallery or parallel safe tube
- Deluge fire suppression systems
- High level monitoring, detection and control
- 24/7 Traffic control operation



FEMERN BÆLT LINK IMMERSSED TUNNEL



2013-04-16
UNIVERSITY OF MICHIGAN

ELEMENT PRODUCTION SITE



ELEMENT FABRICATION (ØRESUND TUNNEL)

Element fabrication



Reinforcement cages

8 Segments

Element length 175 m

Weight 50.000 t

Concreting

2800 m³ In 30 hours

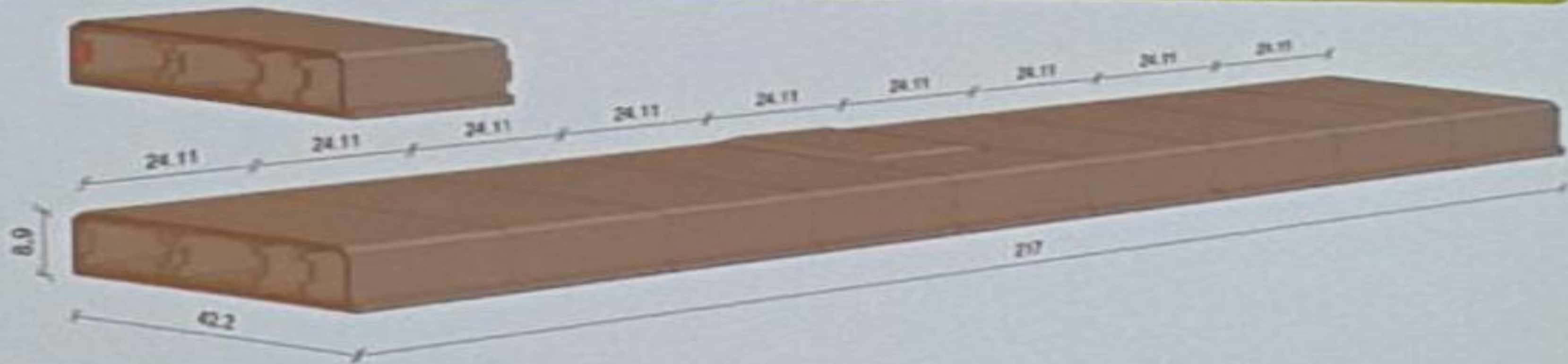
RAMBOLL

2015-04-16

UNIVERSITY OF MICHIGAN

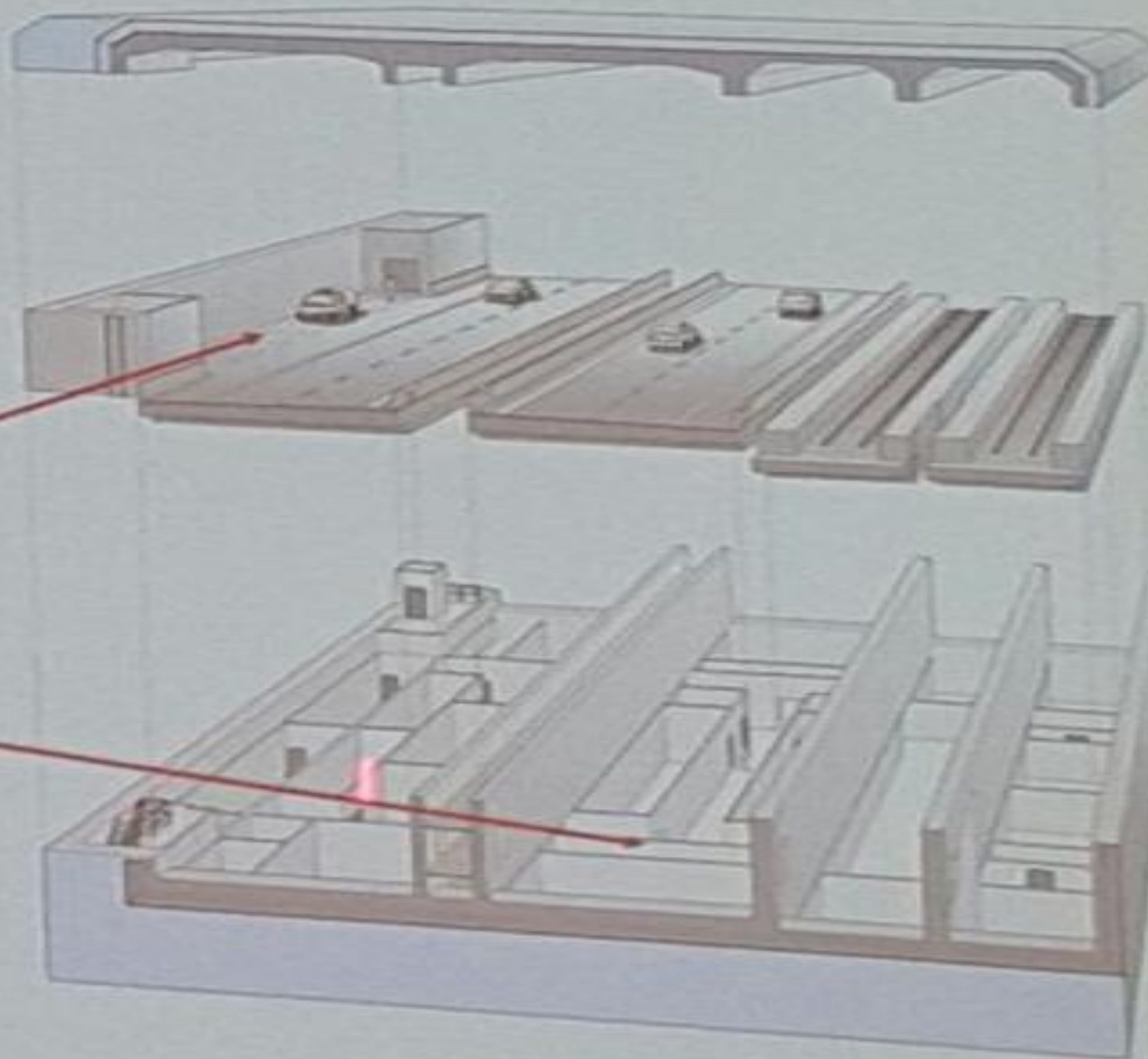
STANDARD ELEMENT

- 79 standard elements divided into 9 segments of 24.11 m, weight 76,600 tons
- Niche at centre of the element for ventilation or traffic information signs
- Same layout for all standard elements e.g. Box-outs, cast-in items, cable ducts, etc.



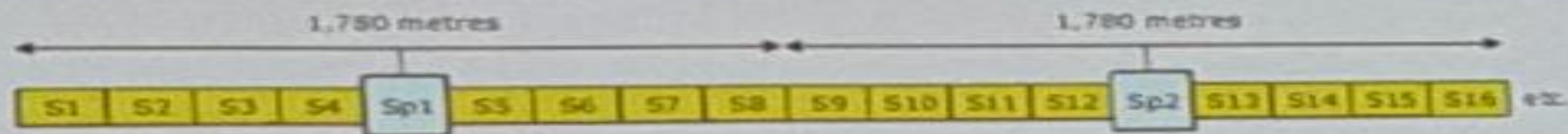
SPECIAL ELEMENT

- 10 Special elements
Size [l/b/h]:
46 m/ 45 m/ 13 m
- Lay by for parking of
maintenance staff
- Access to all rooms and
tubes above



SPECIAL ELEMENT

- Need for transformers and other equipment in the tunnel
- Standard elements do not have sufficient space.
- Special elements to cluster mechanical and electrical equipment



- Maintenance staff better working conditions and higher safety
- Installations and system divided into units
- Concentrate extra space in the tunnel at special elements

LANDSCAPE AND ENVIRONMENT (LOLLAND)

Dredged material from tunnel trench: 15.5 million m³

Reclaimed Land: 3.3 km²



COAST-COAST: BRIDGE OR TUNNEL?



Feasibility Study
1996 - 1999

- Cable-stayed bridge
- Suspension bridge

Preferred Solution:

- Cable-stayed bridge

- Immersed tunnel
- Bored tunnel

Preferred alternative:

- Immersed tunnel



ELEMENT INSTALLATION (ØRESUND TUNNEL)



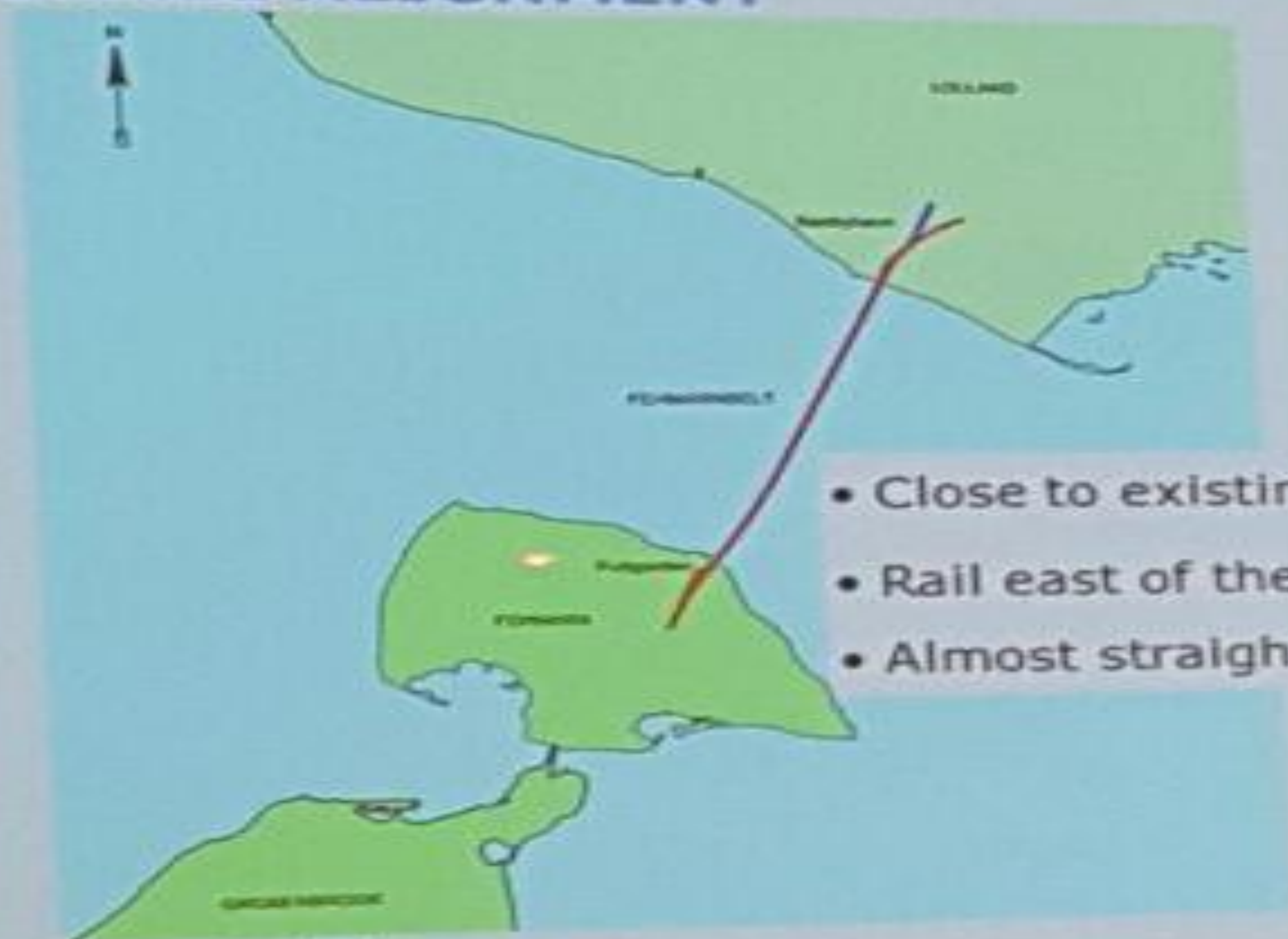
*Following the
positioning of the
elements, the tunnel
void is backfilled*

Red protection layer



*A red protection layer
is placed on top of the
elements*

TUNNEL ALIGNMENT

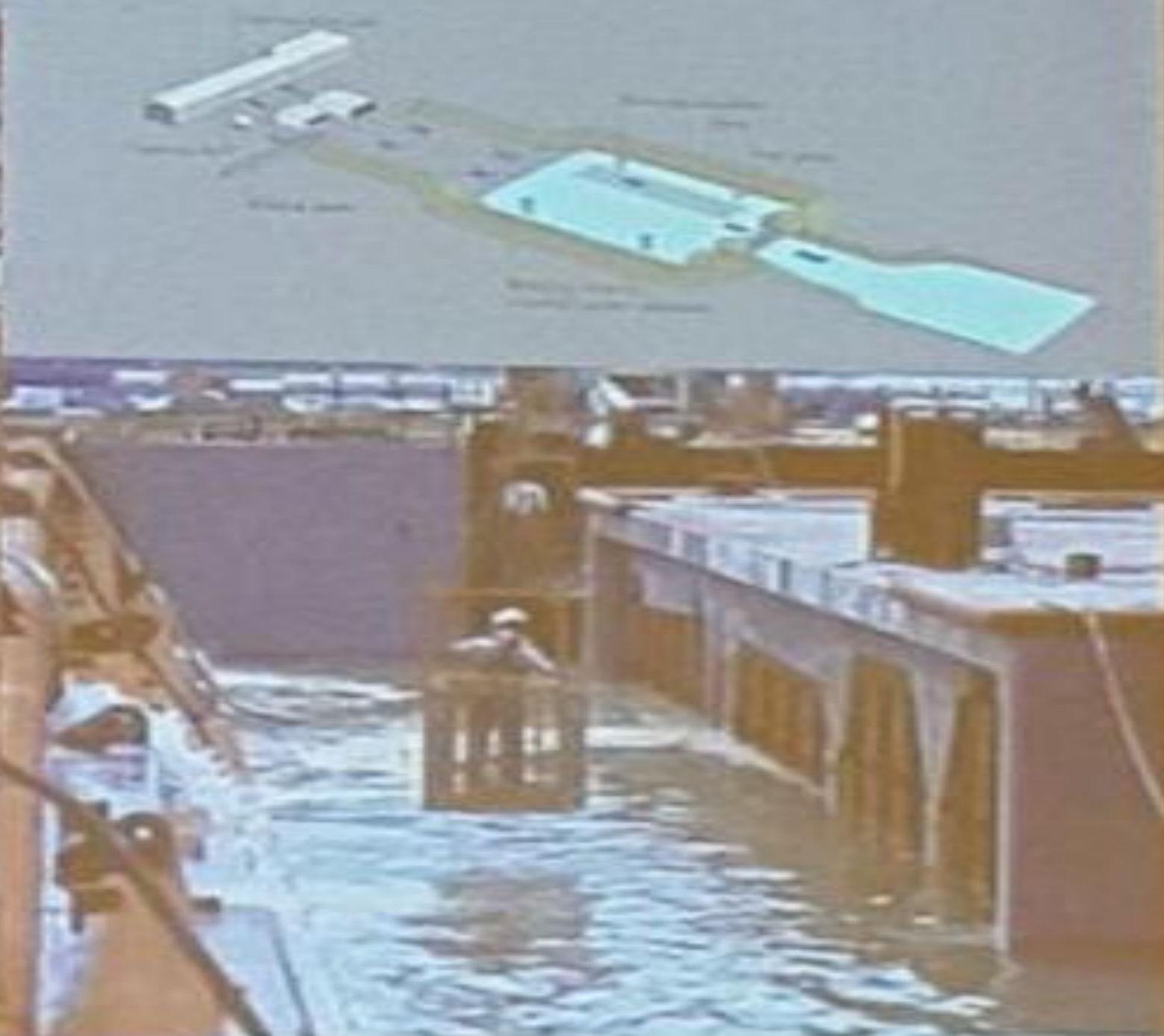


- Close to existing Infrastructure
- Rail east of the road, same as on land
- Almost straight alignment

ELEMENT FABRICATION (ØRESUND TUNNEL)



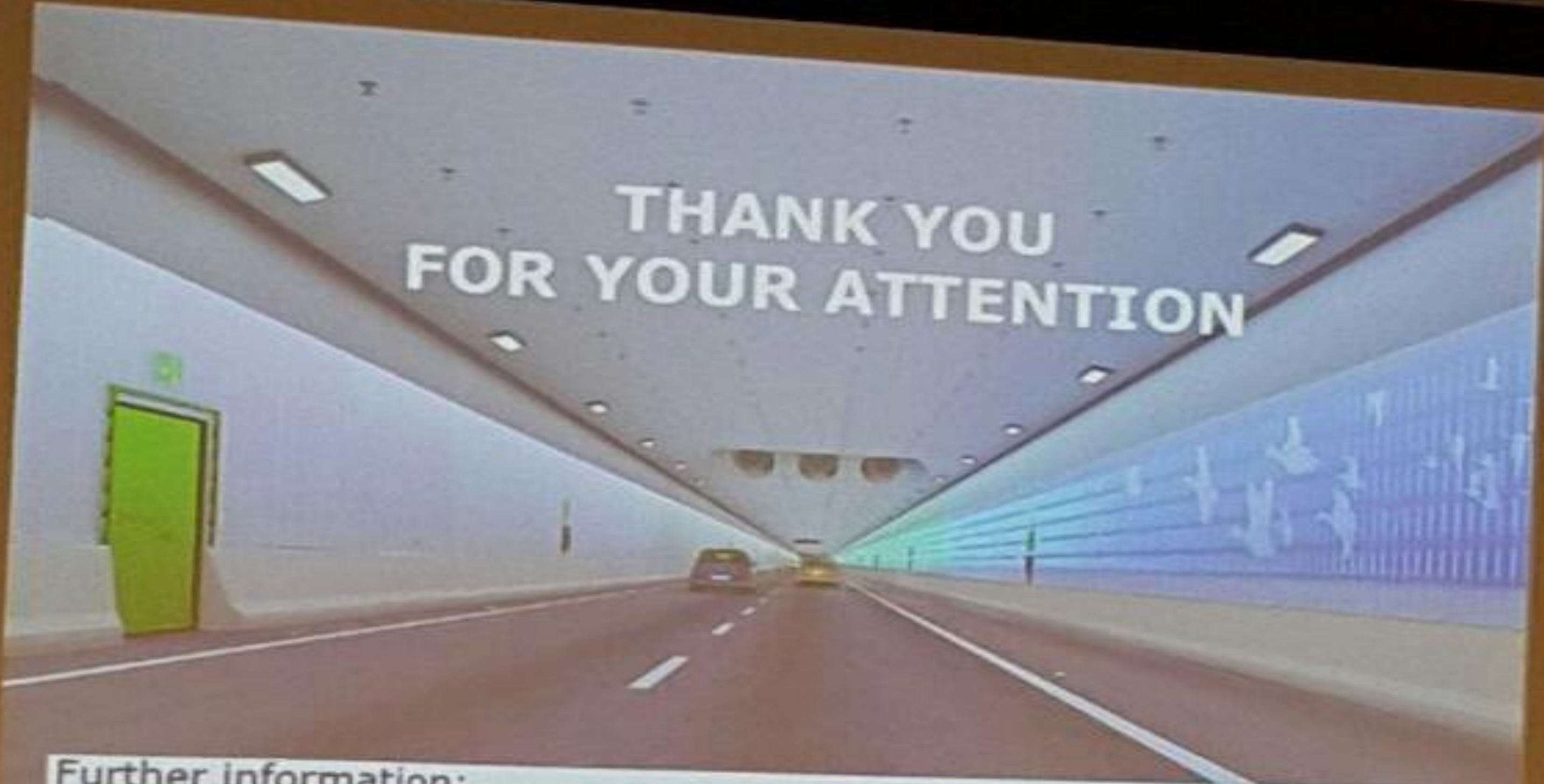
Element fabrication



RAMBOLL

Production rate
2 elements in 8 weeks

2013-04-18
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A photograph of a modern tunnel interior. The road is dark asphalt with white lane markings. The ceiling is white with recessed rectangular lights. On the left wall, there is a bright green door. On the right wall, there is a blue decorative panel with a pattern of white figures. The text "THANK YOU FOR YOUR ATTENTION" is overlaid in white, bold, sans-serif font in the upper center of the image.

THANK YOU
FOR YOUR ATTENTION

Further information:

- www.femern.com
- Lykke & al: *Latest Developments in the Tunnel Design of the Fehmarnbelt Fixed Link*
STUVA Conference December 2011
- Mangor & al: *Landscaping in Connection with the Immersed Tunnel under Fehmarnbelt Between Denmark and Germany*
World Dredging Vol 46, Nos 9/10