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# **Ship domain and Free Flow**

Aron Frank Sørensen, Chief Marine Technical Officer

#### What is the issue?

- Safety of Navigation in the Fehmarn Belt
- The Free Flow method for determining waterway efficiency





# **Safety of Navigation**



- 18 Km fixed link connecting Denmark and Germany
- Construction scheduled 2015-2020
- The link crosses the heavy trafficked Fehmarn Belt - the entrance to the Baltic sea



# **Fehmarn Belt Traffic**



- E/W bound Traffic 2010 (per year):
- 40,000 Ships
- 10,000 Tankers
- •Other traffic 2010
- 20,000 Ferries
- 2,000 Fishing
- 4,000 Pleasure crafts
- •Prediction for 2030:
- 90,000 Ships
- 16,000 Tankers



# Fehmarnbelt Fixed Link decision foundation



Risk assesment (Ramboll)

Resulted in a tunnel instead of a bridge

Free flow Calculations



Full Mission Simulations



Source: Fuji and Femarn

# Ship Domain theory verifcation

Navigators will try to avoid having other ships within their ships safety ellipse and will avoid entering into another ships safety ellipse by using evasive manoeuvres

Ok for fixed hard objects. Ships will avoid overlapping safety domains during passing or overtaking. The Fehmarnbelt Report indicated that ships were willing to let their safety domains overlap without maneuvering. However, a ship would maneuver to avoid having other ships inside its safety domain.

With this the Ship Domain theory gave good results. The size of the domain seemed to be very good neither an expansion nor a reduction would give better results.



3.2 L<sub>1</sub>





## Free flow: A Design tool for determining the necessary width



### **Free flow**

Ships sailing with sufficient • Dist distance to other ships or ships fixed objects will have • Traf **free flow** if they can pass a fairway without reducing speed

Required elements

- Distance between
- Traffic density
- Ship sizes and speeds



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#### Source: Ramboll



# Free flow explained



# Method ultra short version

- 1. Sample ship data with AIS
- Find ship locations in fairway
- 3. Find ellipse violations
- 4. Free flow percentages

Source: Ramboll





# **Free Flow** bridge design



## Conclusion

- Free Flow as a measure of water way efficiency
- Lack of Free Flow =
  Speed reductions + Close navigation
- If no free flow then mitigating measurers such as VTS, TSS to be considered
- May be use for other fixed objects such as lighthouses and no go areas







- Thank you
- Questions?

