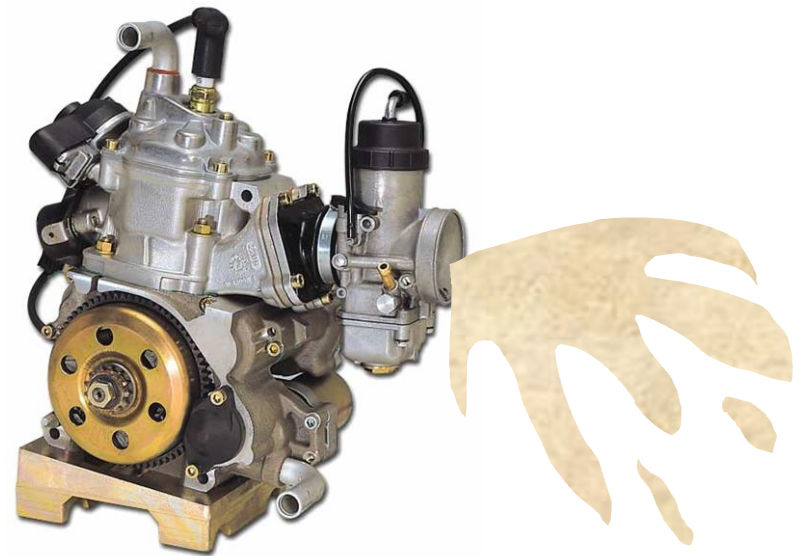




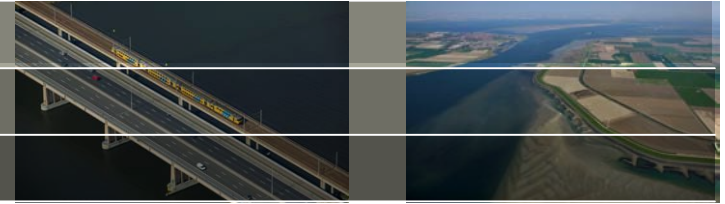
The “Sand Engine” - Zandmotor: a mega-sand nourishment for Delfland

Pieter Koen Tonnon, Jan van Dalssen,
Bert van der Valk, Jan Mulder,
Arjen Boon, Herman Gerritsen
and many more colleagues

KfKI, 2 November 2011



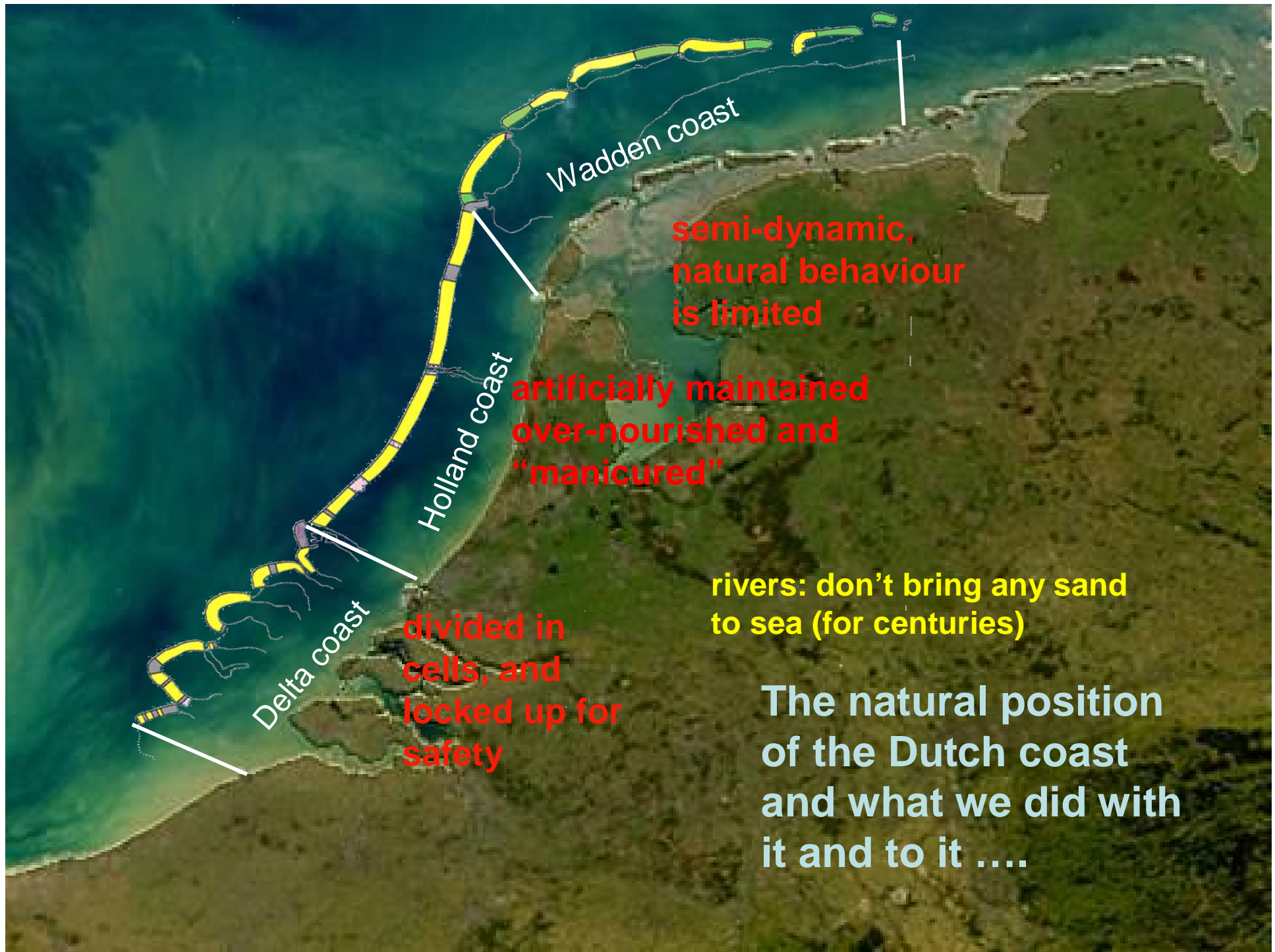
Outline



- **Introduction**
 - **The Netherlands coast**
 - **Delfland coast**
 - **Sand Engine**

- **History**
 - preliminary design
 - feasibility study – modelling
 - EIA
 - monitoring elements

- **First pictures**



Wadden coast

semi-dynamic,
natural behaviour
is limited

Holland coast

artificially maintained
over-nourished and
"manicured"

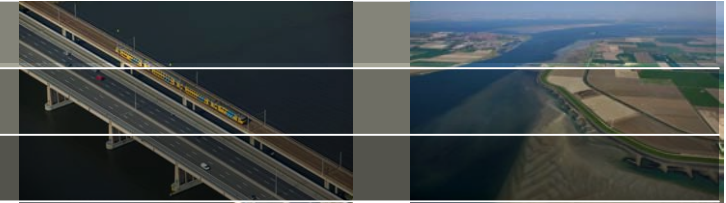
Delta coast

divided in
cells, and
locked up for
safety

rivers: don't bring any sand
to sea (for centuries)

The natural position
of the Dutch coast
and what we did with
it and to it

Coastal management in 2011

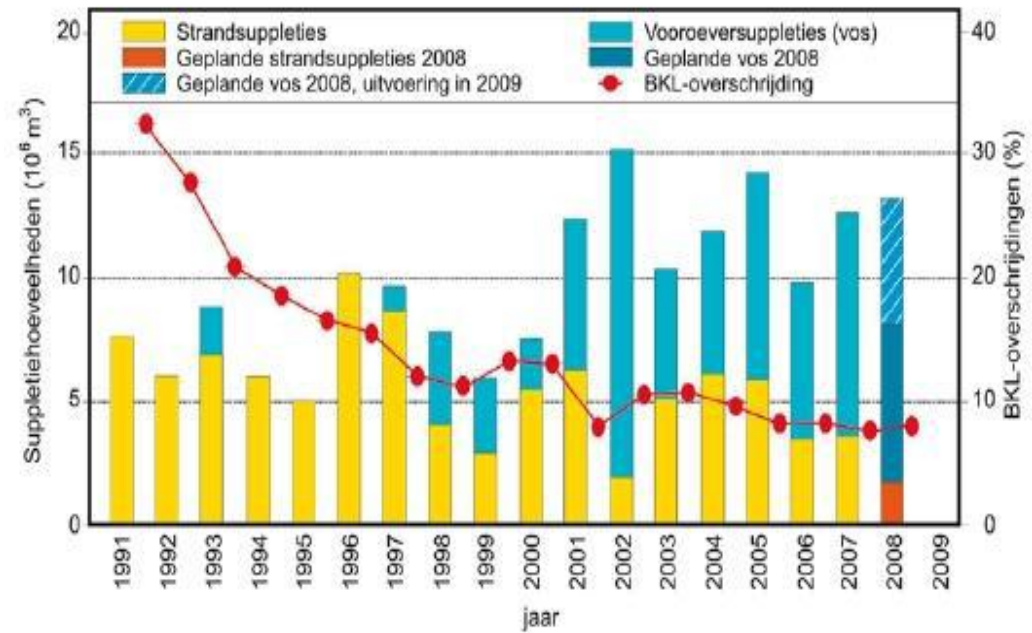


coastal nourishments and the annual revision

Methods:

Preliminary designs,
Morphological and dynamic
coastal development on
different temporal and spatial
scales,

Model development,
Hydraulic scale experiments,
Nourishment,
Monitoring and Evaluation,
Reporting,
Adjustment of procedures

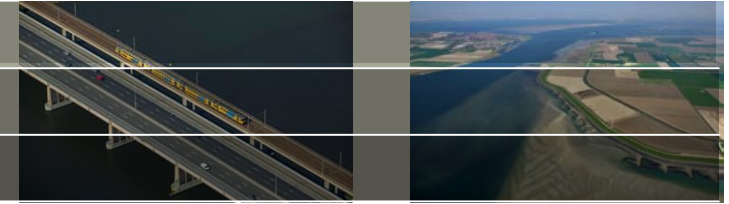


Participants:

Rijkswaterstaat,
Regional and local authorities,
Research institutes,
Private contractors / Market parties

Deltares

Coastal maintenance in NL



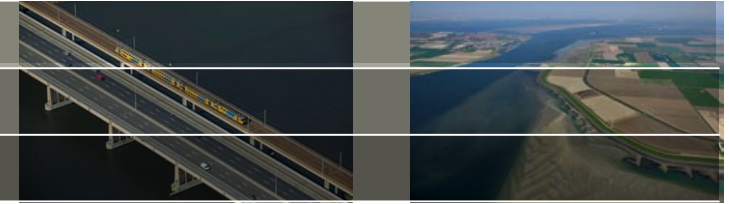
- sand nourishments:
 - since 1990
 - about 12Mm³/year
 - what about:
 - not 12 but 20 Mm³/year?!
 - ? scaling up to even 85Mm³/year

(Delta Programme!)

environmental impact?!



Concept of the Sand engine



- **mega-nourishment of 21,5 Mm³ sand**
- **alternative for repeated, smaller nourishments**
- **‘self-distribution = BwN’ including dune growth by natural processes**
- **should be effective over “20 years”**

- **objectives:**
 - **safety**
 - **nature (-development)**
 - **recreation**

- **pilot project: obtaining experience AND knowledge**

Delfland coast

•Delfland coast

- narrow dune strip
- erosive for centuries
- nourished for many years: since the mid 1970-ies



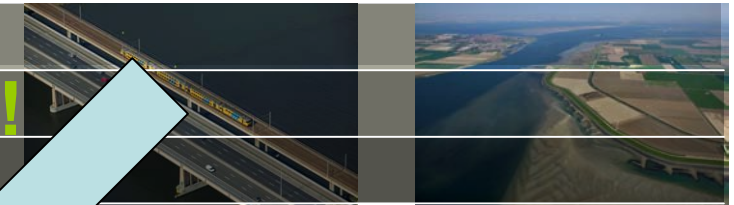
Coastline development since the Middle Ages



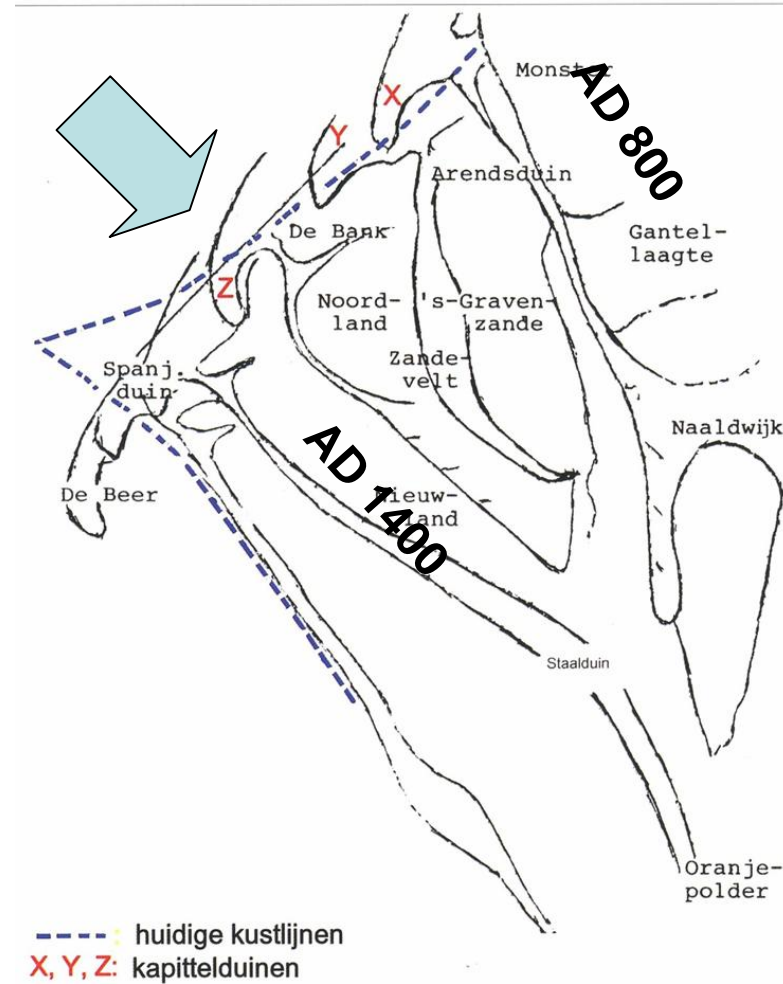
A.A.Beekman, 1919

Deltares

two simultaneous processes !



pressure on
the coastline
by waves
and currents



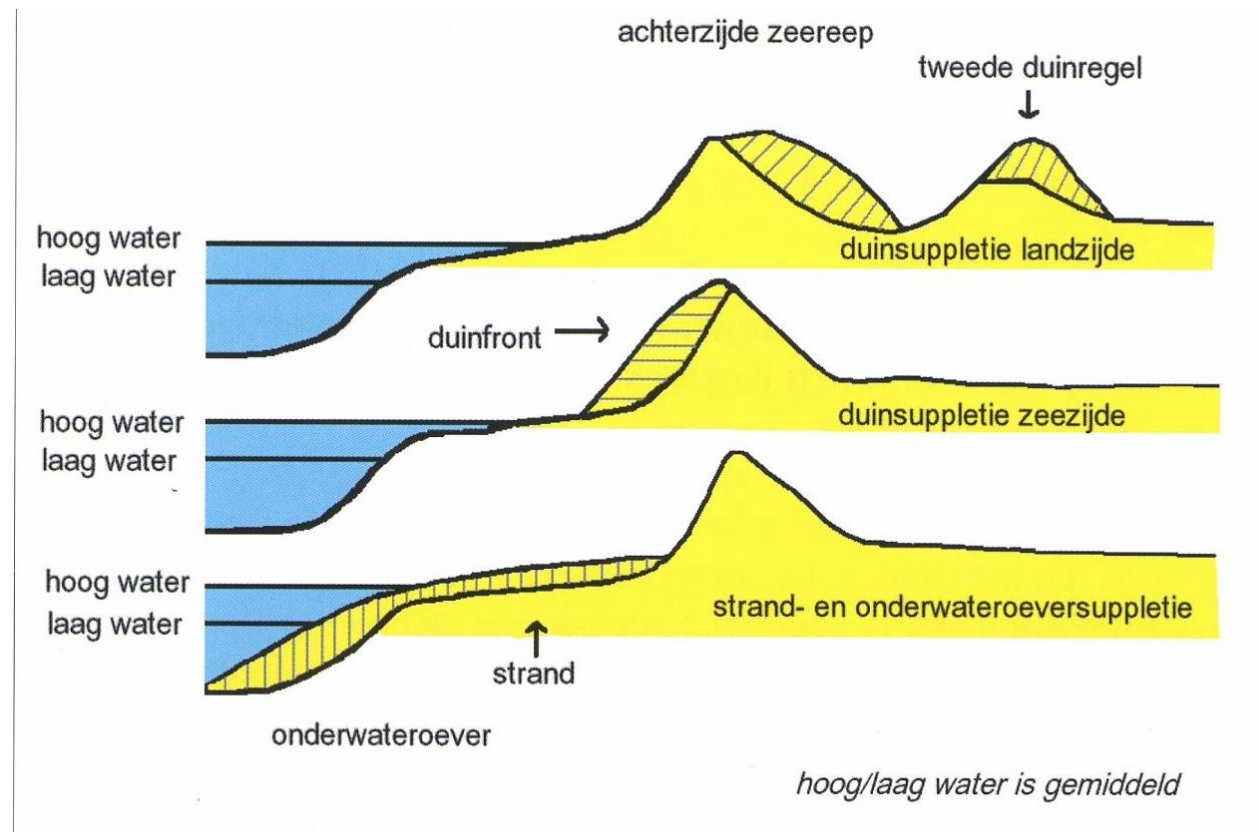
formation of beach hooks

Coastal protection: it is all human intervention

1: landward nourishment

2: seaward nourishment

3: beach- and underwater nourishment



Afb 42: Zandsuppletie in dwarsprofiel. (Naar: Schets uit Geografisch Tijdschrift)



1993

effects of previous nourishments



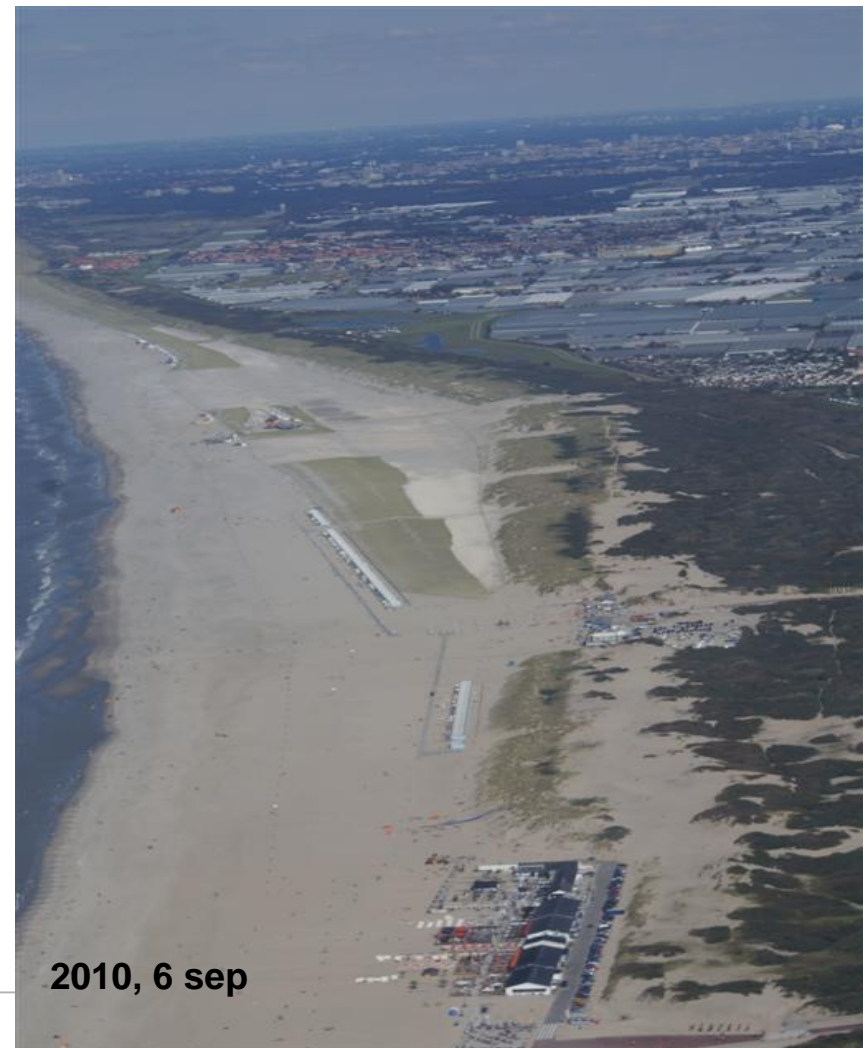
2005

dune front growth Delfland 1993 - 2005

Delfland coast **before** and **after** the 2008-2010 intervention



Coastal protection and
Dune compensation (for MV2)

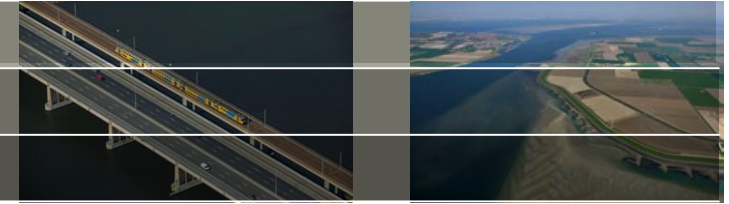


Sand engine: Preparation and implementation

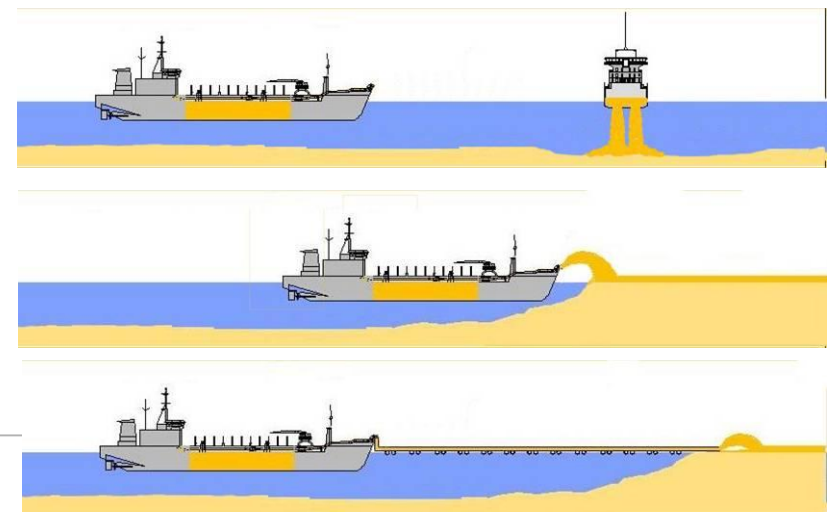
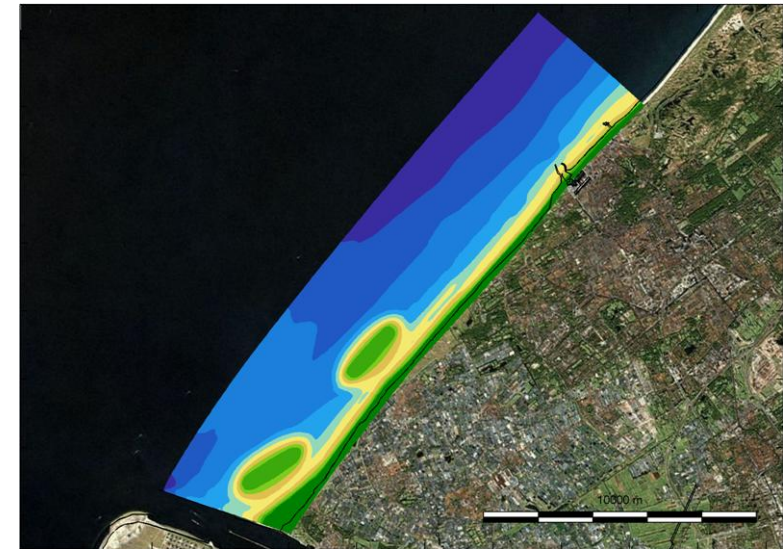


- **2007 – Preliminary design** (RIKZ)
- **2008 – Feasibility study** (Province Zuid-Holland)
- **2009 – Environm. Impact study** (Province Zuid-Holland)
>> DHV
- **2010 – Design of Monitoring Programme**
(Waterdienst) >> Deltares/IMARES
- **2011-2016: 1st phase Monitoring Programme (market parties)**

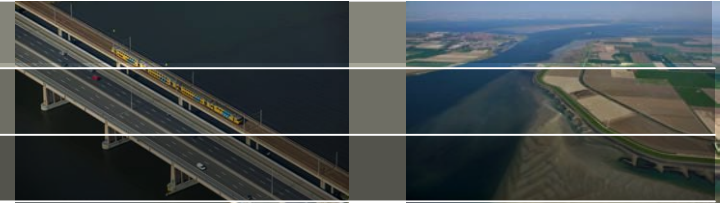
2007 – Preliminary design



- objectives:
 - safety
 - nature
 - recreation
- investigation of alternative designs and locations
 - technical feasibility and cost
 - morphology and safety
 - ecology
 - recreation
 - innovation



2008 – Feasibility study

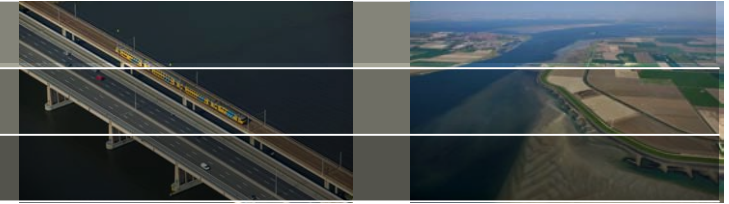


long term morfological model ("50 years")

- dune growth
- nourishment volume
- "self distribution"



2009 – EIA study



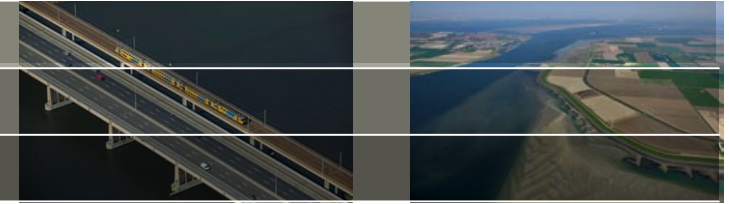
- ? additional nourishments
- organic enrichment of fine grained sedimentation in the lagoon (? smell)
- swimming water safety
- ground water

outcome

- beach hook alternative and the location



Morphodynamic model



objectives:

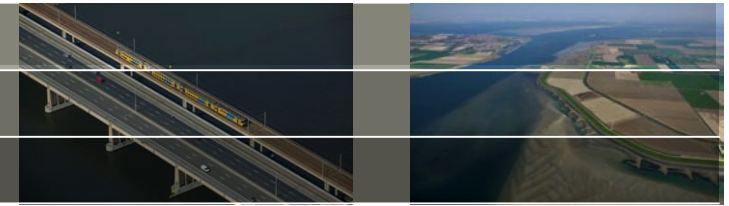
design & impact assessment (dune development + additional nourishment requirements)

model set-up: (Delft3D)

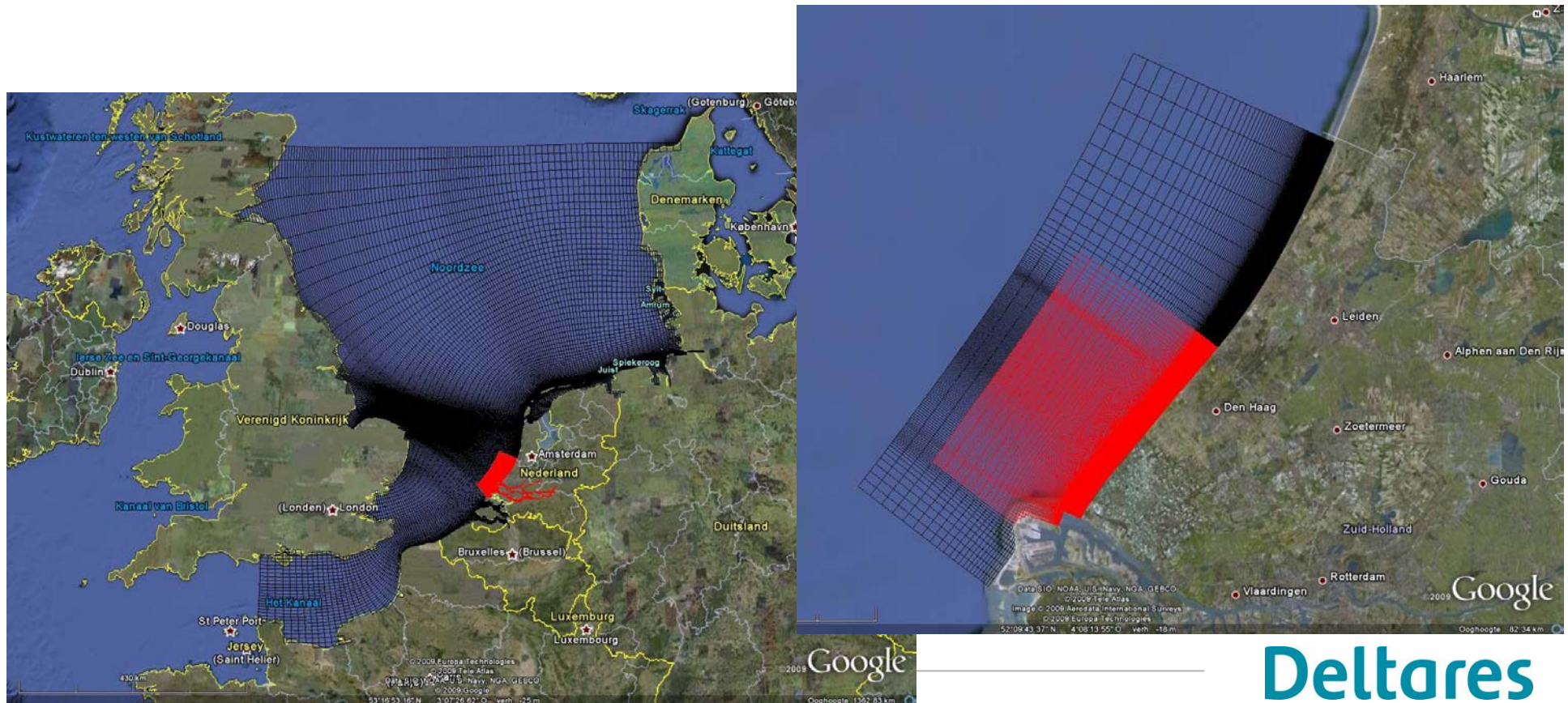
- “opti” schematization
- parallel-online
- dune development
- nourishment schemes (for the alternatives)



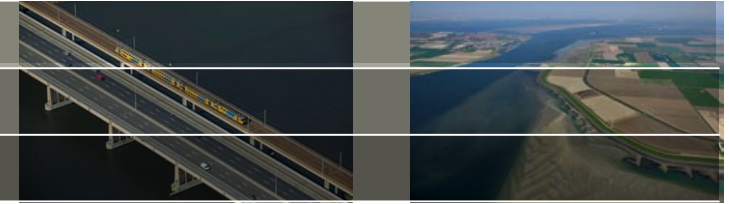
Model: set-up



nested in large-scale regional models, water level + Neumann boundaries,
depth-averaged, flow-wave coupled, morphological scaling

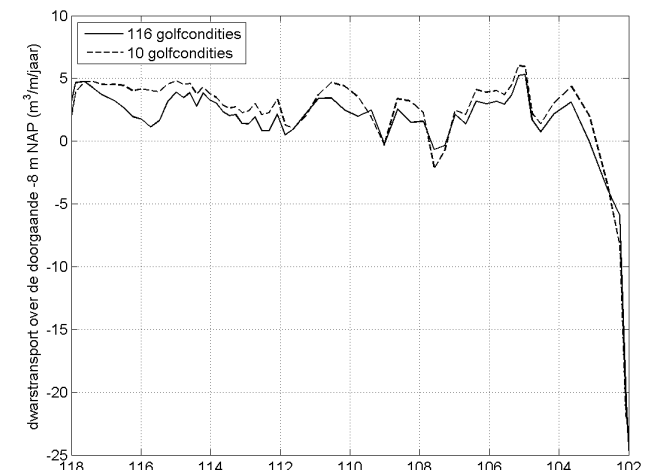
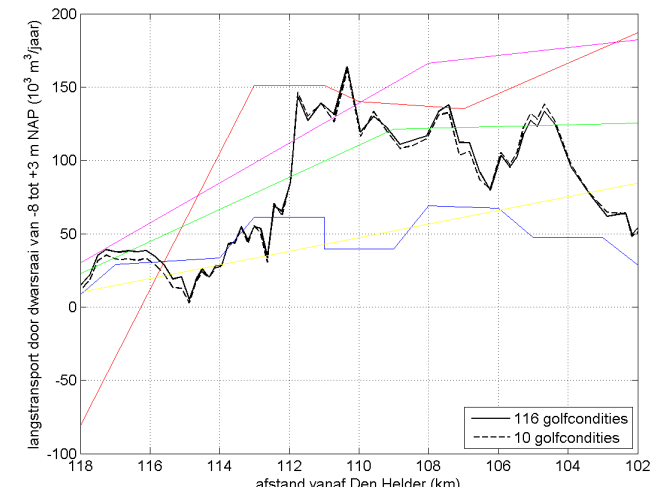
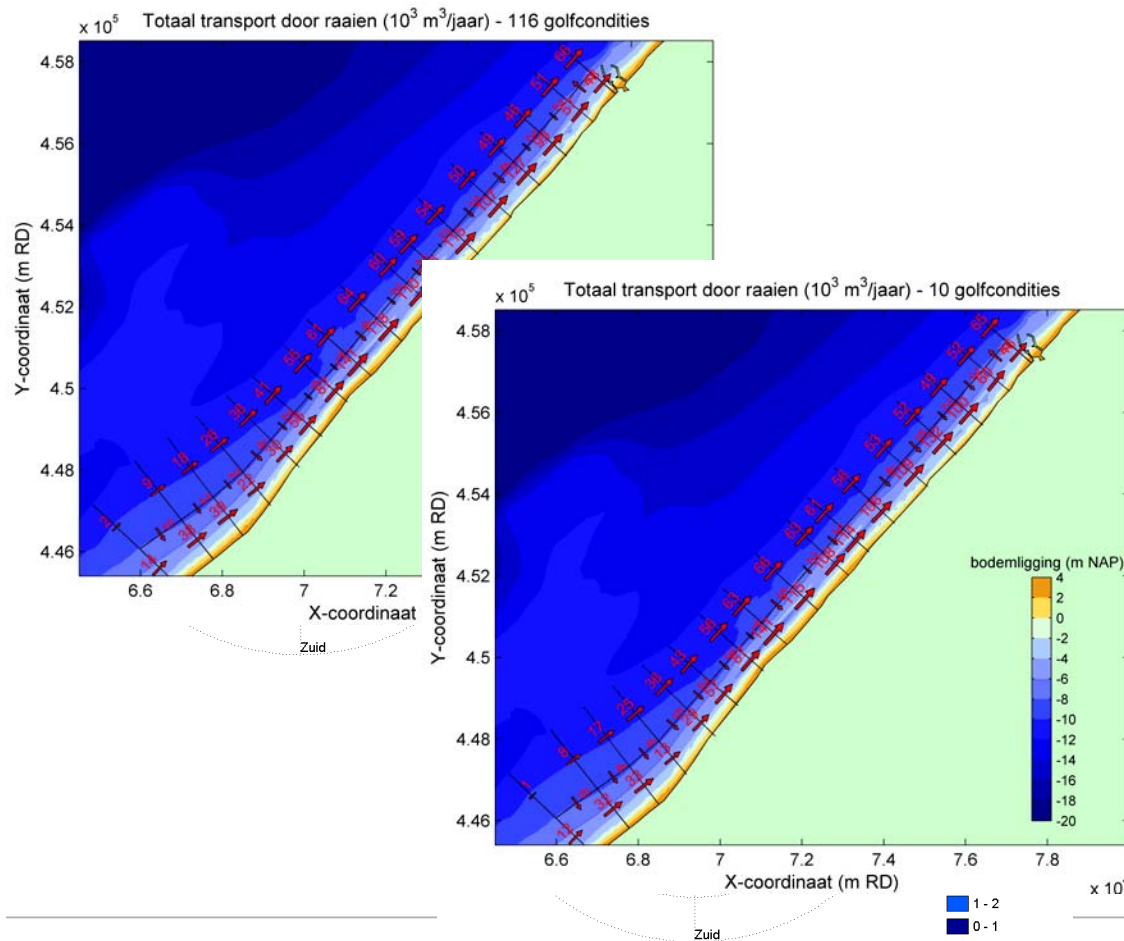


Model: 'opti' schematization

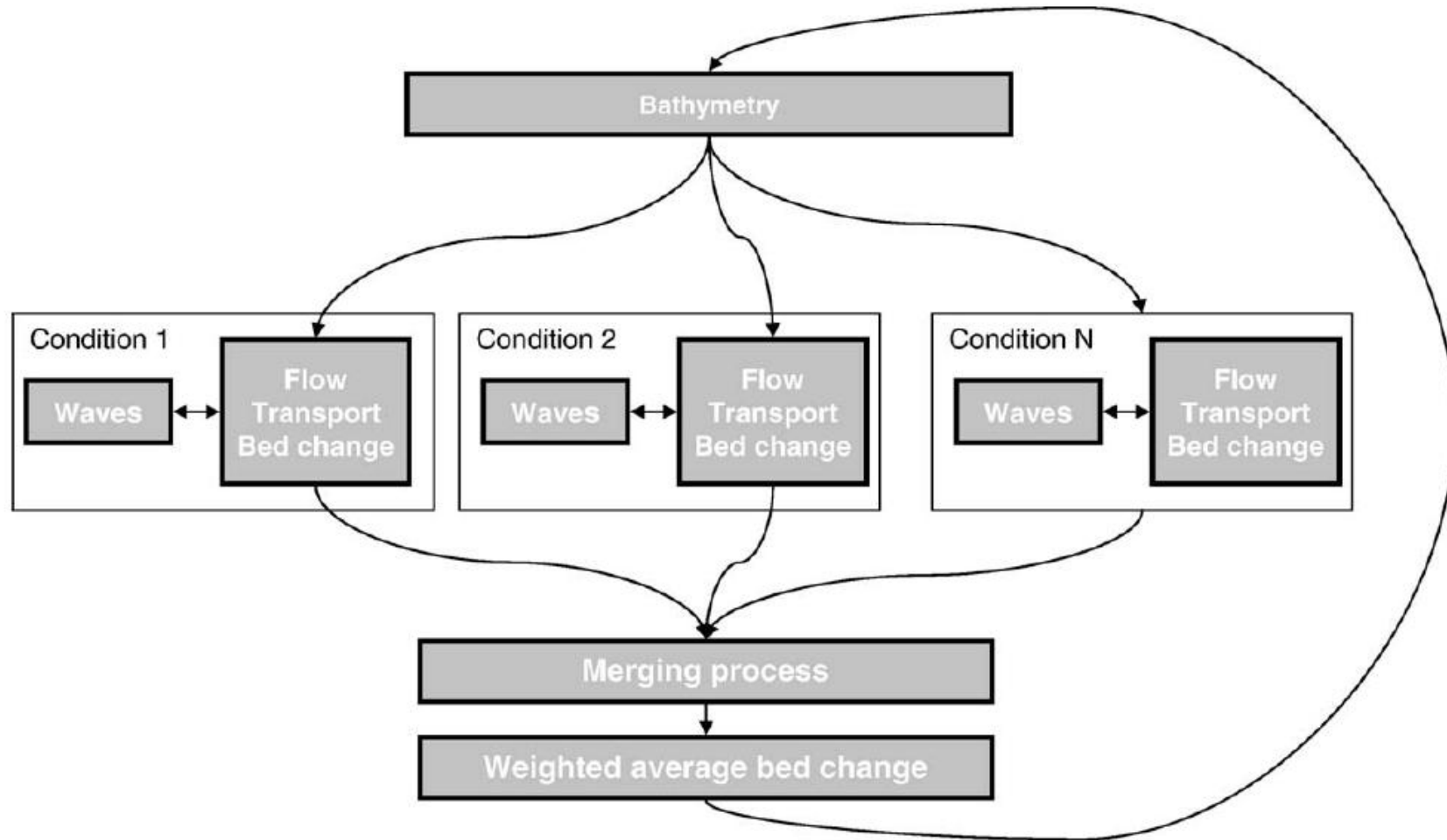
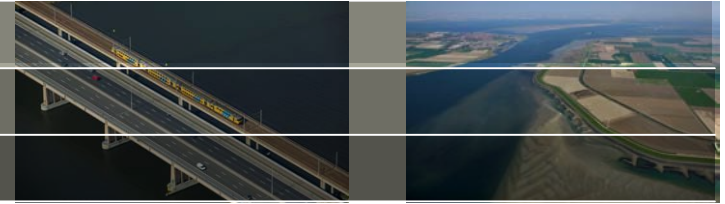


least important wave conditions determined, removed and represented by weight modification of most closely correlated conditions.

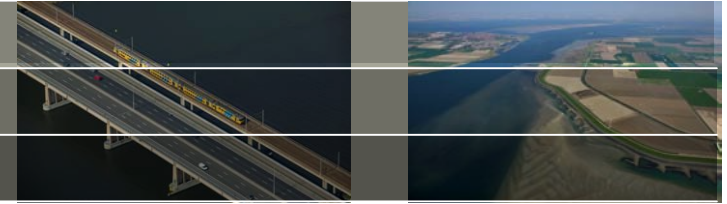
reduced wave climate with 10 wave conditions represents yearly sand transport rates computed using 116 wave conditions



Model: parallel-online



Morphodynamic model



validation:

hydrodynamics: validated regional models

sand transport rates, coast line development & erosion

rates: existing studies and field data

implemented nourishment scheme maintains coast line through shoreface nourishments

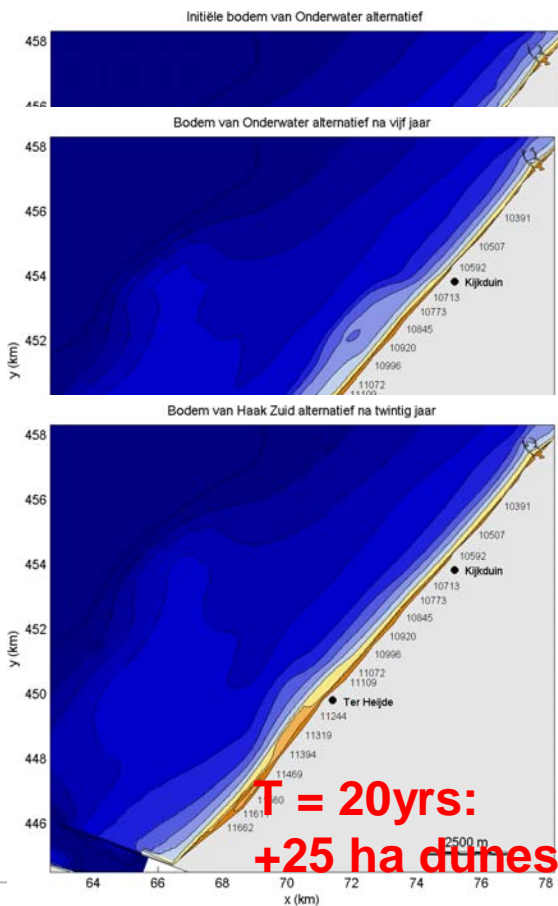
Model results for three alternative forms



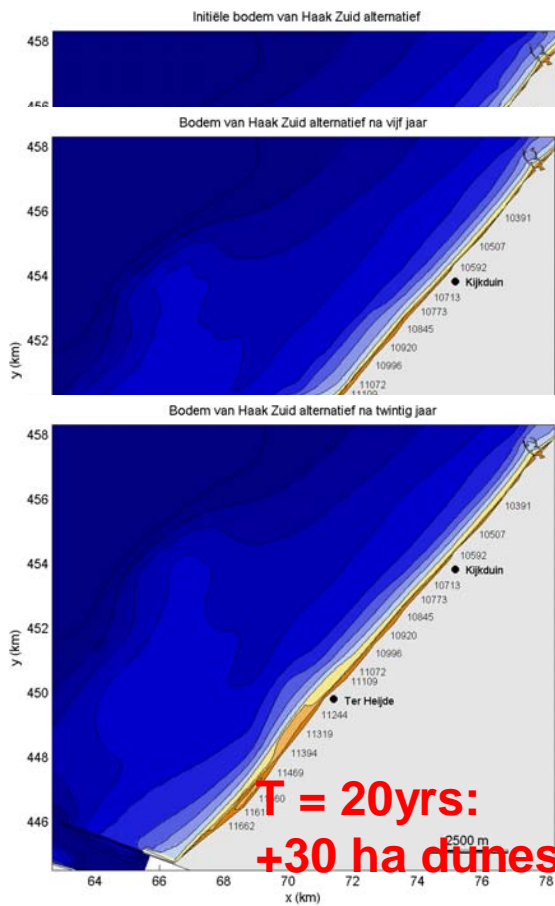
shoreface:

bell-shaped:

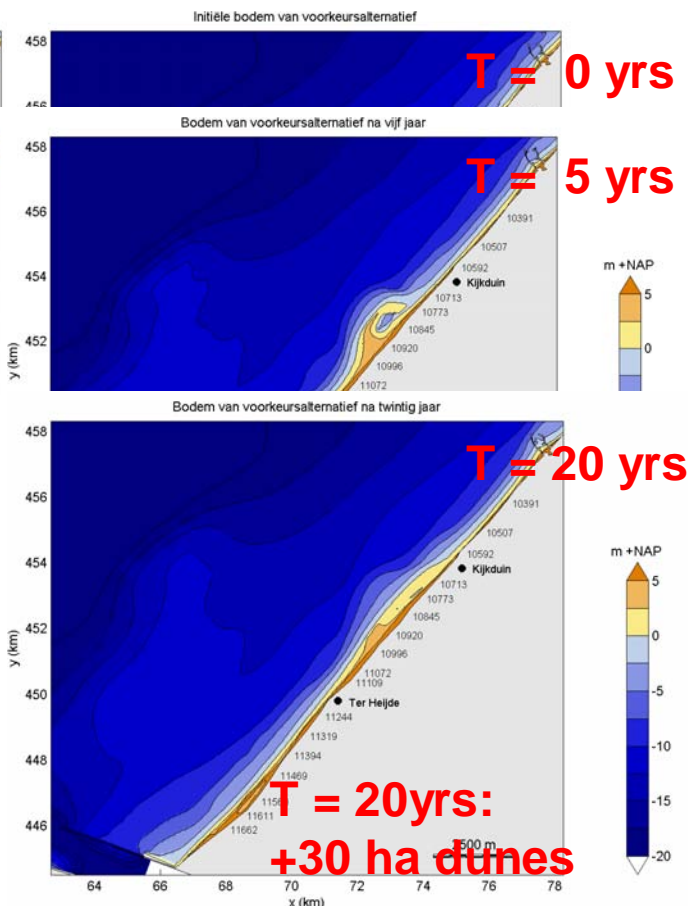
hook-shaped:



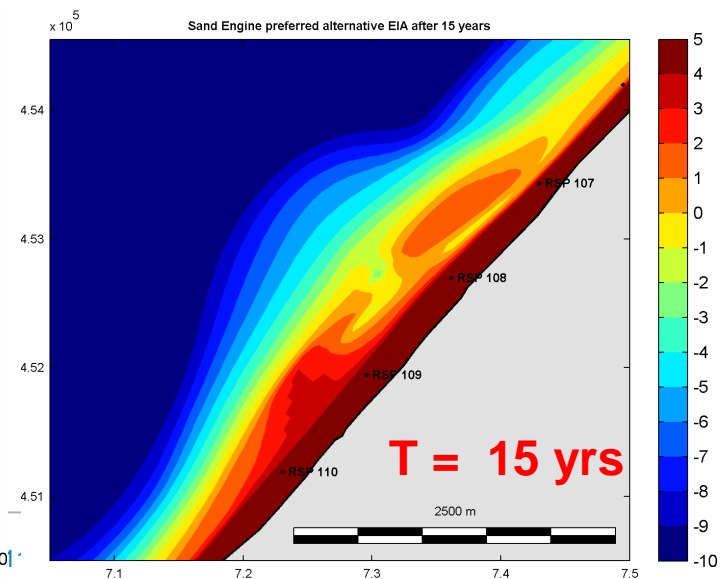
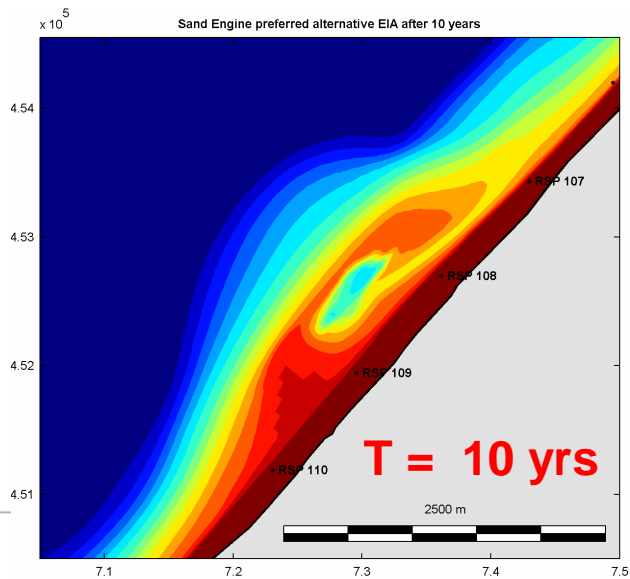
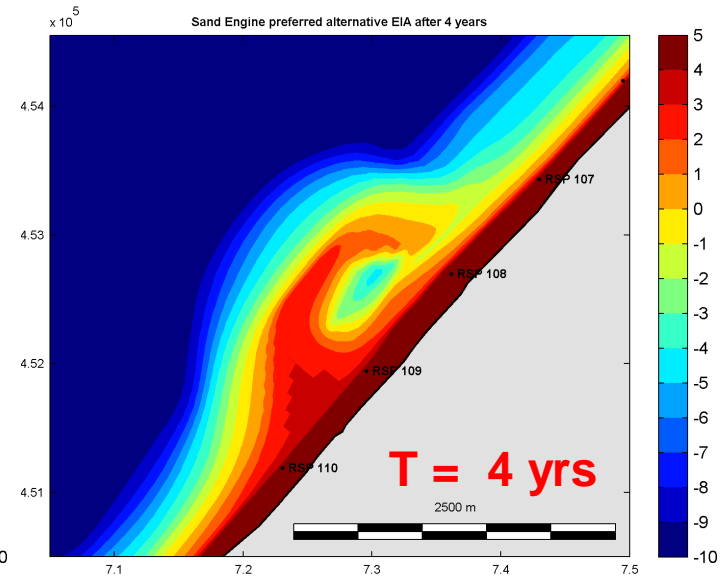
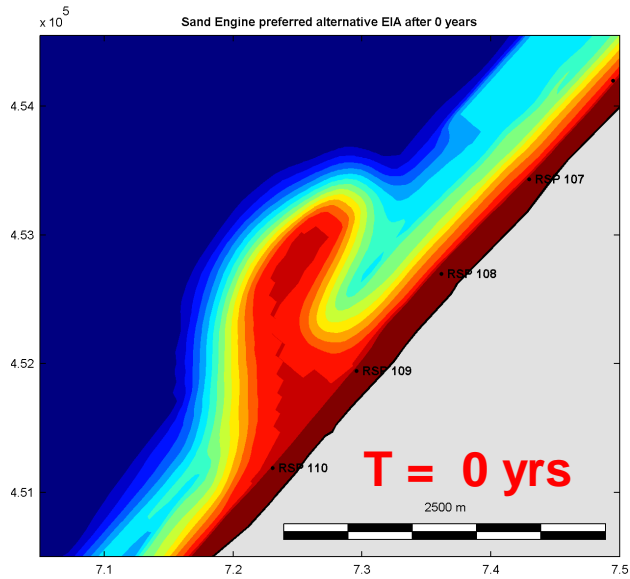
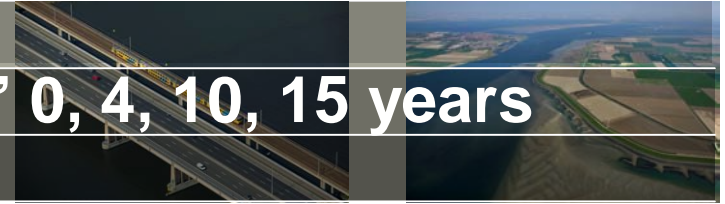
KIKI, Bremerhaven



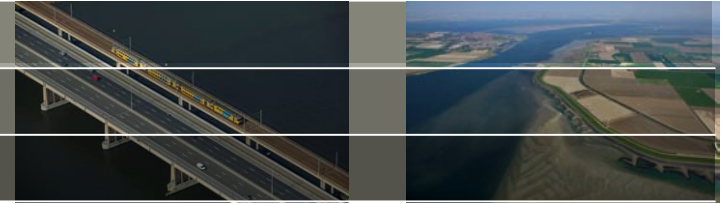
2 November 2011



Model results for the “beach hook” 0, 4, 10, 15 years



Further criteria / results



design optimization

- beach width at Kijkduin (near The Hague)
- geohydrology (ground water levels)

swimmer safety concerns

- lifeguard station at Sand Engine

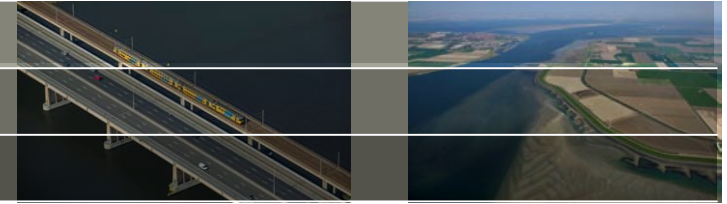
mud/siltation sheltered area

- budget reserved for removal

beach erosion from channel meandering

- prevented by existing groins and additional underwater nourishments

Conclusions

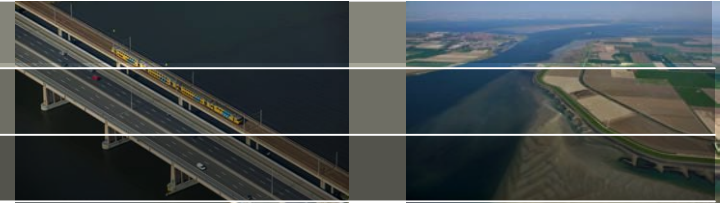


models were successfully used in design process and EIA

alternatives show similar long-term development with wide beaches and dune growth

additional nourishments required to compensate for erosion of adjacent coast

Conclusions

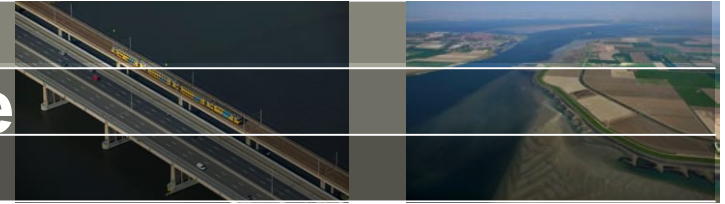


the created initial, temporary dry beach area serves recreational purposes

temporary shallow/sheltered area of hook alternative is ecologically valuable

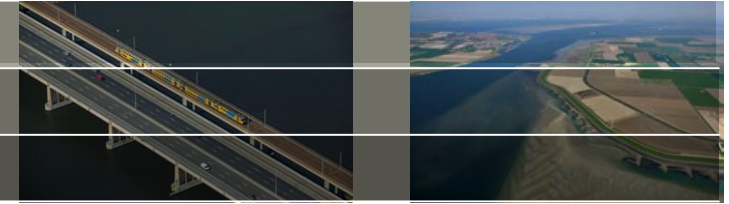
measures designed for swimmer safety, mud/siltation and channel meandering

2010 – Monitoring programme



- 2011-2021 , €4.5M
- Jarkus (ship-based and jetski bathy measurements, LIDAR)
- sediment composition
- benthos sampling
- sand- and salt “spray”
- dune vegetation
- swimming water safety (environment) Argus, xband-radar
- recreation
- data management
- ground water (drinking water - Dunea: important stakeholder)
- evaluation, integration and reporting

Deltares' involvement:

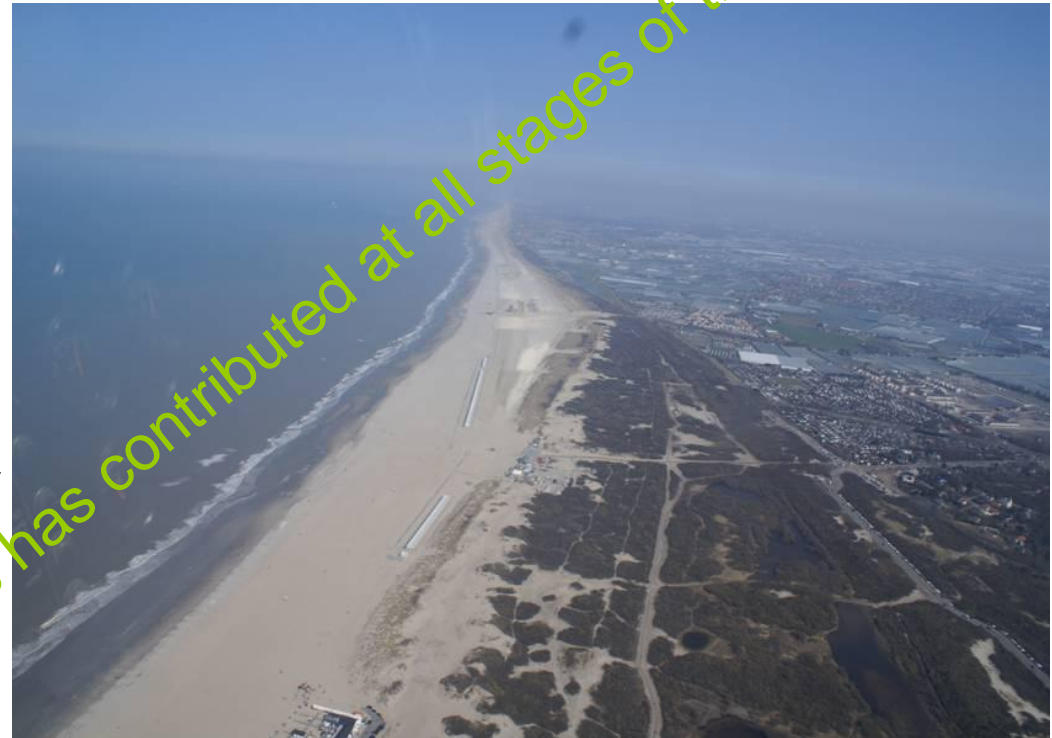


General:

- support to Rijkswaterstaat and the Province of Zuid-Holland

Specific:

- modelling
- specialist advice
- integration
- data management
- knowledge broker
- >> bringing parties together
- >> intermediate between project office and outside world



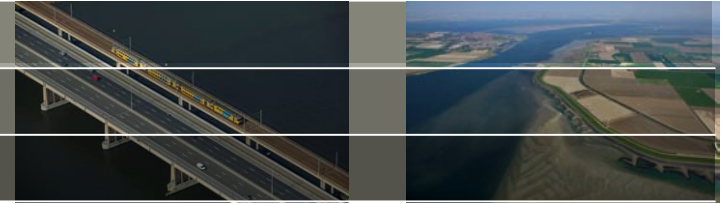
So how do we expect it will develop



ARTIST IMPRESSIONS



And how ?



with suction dredgers, slowly !



End of March 2011.....

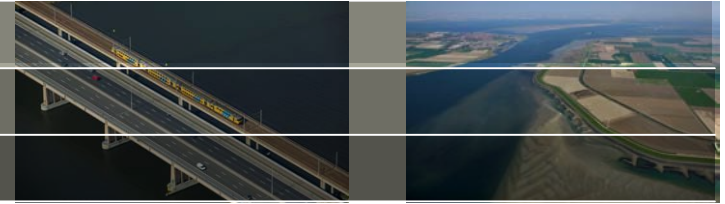
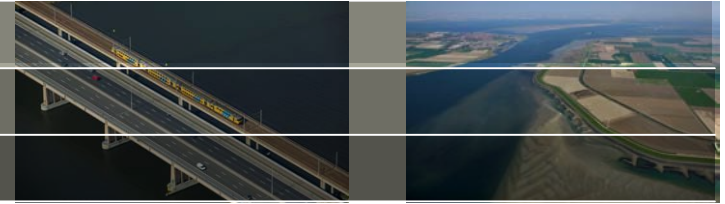


photo: Pieter Kroes, Twynstra Gudde

7 June, 11 July, 9 August, 27 September 2011



End of Presentation



Questions?