Maeslant Barrier
History, Present & Future

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Maeslant Barrier . . . . more in detail
Maeslant Barrier

- 1997
- 2 gates
- no sluice
Maeslant Barrier - Final part of Delta Works

- Preparation started in 1987
- Competition
- 6 alternative designs
- Design, construct and maintenance
Maeslant Barrier - Final part of Delta Works
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Maeslant Barrier
Construction of the Maeslant Barrier
Filterbed, sand, gravel, big stones

15 x 5 x 3 m each

64 threshold parts, submerged

630 tons each

Maeslant Barrier - Sill
Maeslant Barrier - Ball joint

- 10 m diameter
- 680 tons
- 3 directions of movement
- Revision in 2003/04
- 52,000 tons foundation
Maeslant Barrier - Retaining Wall

- 210 m wide
- 22 m high
- 13 compartments
- Depth 17 m
- 26 valves & 30 pumps per wall
Maeslant Barrier - Locomobile

6 engines

6,000 kN pulling force

Electro/hydraulic propulsion unit

Rack and pinion

For horizontal movement and fixation
Maeslant Barrier - Trusses
Maeslant Barrier - Trusses

- 20 m high
- 90 mm thickness
- 1.80 m diameter
- 237 m long
Maeslant Barrier -
Dock and Dock Doors

10 m deep

Collision protection

Maintenance retaining walls

Regular and anchored walls
Maeslant Barrier - Support and Control Systems

Hydro meteo forecast

BOS
Decision support system

BES
Control systems

Dock

Locomobile

Retaining Wall

Ball Joint

Utilities
Impression of closure
Information center
Various groups of visitors
... and high officials
Introduction to Risk Based Asset Management
Frontpage news

**Rotterdams Dagblad**

*1 maart 2006*

**Veel fouten in Maeslantkering**

**Hollands Glorie?**

*Frontpage*

**Windows Media Player**

**Doet ie het of doet ie het niet?**

**Maeslantkering nog niet goed**

*3-6-2019*
Changes in Maintenance and Operations from three new perspectives

1. **Focus on reliability related issues and operational use**

2. **Trained Staff contributes to reliability**
   - Technical expertise and safety awareness
   - Training and exerzise
   - Procedures and instructions (to prevent failures)
   - Tests and exams

3. **Probabilistic maintenance and operations**
   - Corrective maintenance
     - failure? → repair
   - Preventive maintenance
     - example: Exceeded mileage? → replace
   - Predictive maintenance
     - example: maintain only when failure may occur
   - Choice of strategy depends on risk analysis and type and contribution of component to the operational use of the barrier
Reliability dock door
Fault tree analysis - example

Barrier does not retain

Failure propulsion system

Failure winch

Dockdoor does not open

Blockage safety catch

No power

Failure software

Breakdown winch
... down to maintenance level

**Pump characteristics**
- Failure probability (demand): $8.6 \times 10^{-6}$ / each time
- Failure probability (mission): $3.0 \times 10^{-6}$ / hr
- Mission duration: 8 hours

**Maintenance characteristics**
- Test frequency: 1 / month
- Inspection frequency: 1 / year
- Replacement interval: 30 years
- Maximum repair time: 48 hours

2 Flood defense walls
13 compartments
Total 60 pumps
Introduction to Risk Based Asset Maintenance

Spare parts on site
Fault tree includes

- Redundancy
- Software and hardware failure
- Absence of data on water levels
- Level of training and expertise
- Human error and human corrective capabilities
- External influences (lightning, collision, wind mills)

Approach
- Regular updates (monthly/annually)
- Measures to be taken if actual failure rate is worse than required failure rate
9,000 Basic Events
- 5,000 related to components
- 4,000 modeling events (e.g. fraction of time leading to failure)

210 maintenance groups (clustering of similar components)

3 top events:
- Failure to close
- Failure to retain water
- Failure to re-open

Roughly 1,600 * A4

Updated twice a year
Introduction to Risk Based Asset Maintenance

Maintenance Plan

Maintenance & Operations

Monitoring Achievement

Fault tree analyses vs Achievement

Safety levels stated in Dutch Flood Defence Act
Reality can be hard to model: Human error

- All bolts tightened too hard
Introduction to Operational Team
Introduction to Operational Processes

Closure schedule

- Staff alerted
- Docks level
- Walls submerged
- Barrier stand-by
- Pre-warning
- Surfacing walls
- Shipping halted
- Preparation of closure
- Closure
- Opening

Predicted closure time
Start moving walls
Introduction to Operational Processes

Press and camera crew

VIP Program

Access road: traffic jam and almost inundated (by water and spectators)

The audience
Necessary knowledge and expertise is scarce
Can often only be gained through active involvement in operational work.
Every SSB has his own specific characteristics
SSB may be subject to inadequate attention to knowledge development and knowledge retention
Risks could lead to high costs and reputational damage (political governance) and pressure on the flood barriers.

This requires a robust strategy of what knowledge where and how to secure
Knowledge Strategy

Knowledge Strategy Storm Surge Barriers

Knowledge development and retention for Storm Surge Barriers

Date: April 2018
Status: Final
Version: 1.0
Knowledge Strategy

Scope: Defining knowledge areas

Impact: Effect of knowledge on performance barrier

Where: Presence of knowledge
  - Operational deployment
  - Management & maintenance
  - Long-term

How?: Knowledge assurance within RWS
  - Inside RWS
  - Inside/outside RWS
  - Outside RWS
Future
Antarctic model raises prospect of unstoppable ice collapse

Sea levels could rise by more than 15 meters by 2500 if greenhouse-gas emissions continue to grow.

If we do nothing......
Future has started

New policy principles on flood safety since 1995

- Rivers area: Room for the River
- Coastal zone: nature based solutions
- National policy document spatial planning:
  - Spatial planning based on water
- Flood safety act (1996):
  + Regular assessment of levees
  + flood protection program
  + funding
- Water management 21st Century
  - Retain – store – discharge
- National policy document on Water
  - Multi-layer safety
- Delta programme
  - Risk based Flood safety standards
Future impact on Maeslant Barrier

Closing frequency Maeslant Barrier

Sluitfrequentie
incl voorspelling (μ, σ)

zeespiegelrijzing [m]

100,0
10,0
1,0
0,1

sluitfreq [1/jr.]

μ: -0,09m σ: 0,18m
verbeterd μ: -0,07m σ: 0,12m

1x 10x 20x 30x
Future studies have been started
Thank you
Any questions?