# ASSET MANAGEMENT @ POR

## DON'T PLAN REPAIRS. PREDICT THEM

**Port of Rotterdam's road to world-class asset management**

AAPA 2019 Facility Engineering Seminar, Jacksonville (FL), April 25th, 2019

Port of Rotterdam

# Port of Rotterdam in figures

## Port of Rotterdam engine of the economy

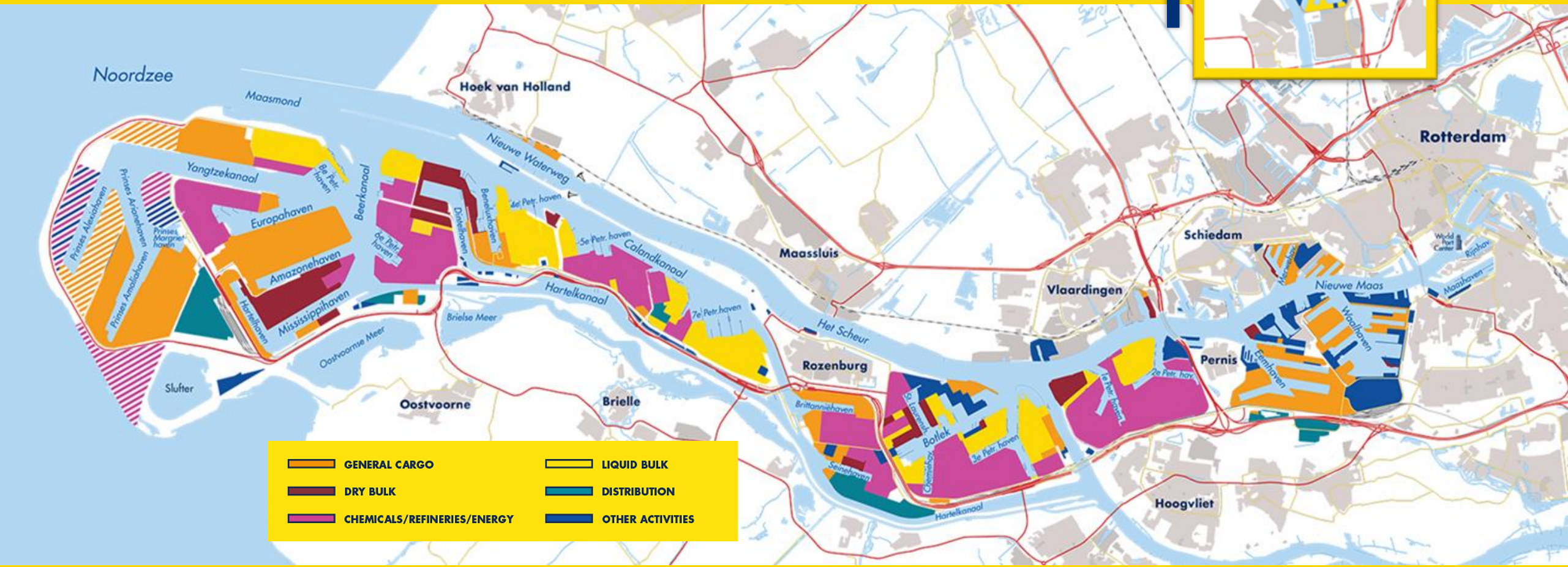
- Total port area 12,643 ha (net 6,046 ha)
- Total employment 385,000 people*
- Total added value € 45 billion (6.2% GNP)*
- 3,000 companies
- Largest port in Europe, 10th port worldwide
- Throughput 2018: 469 mln tons; 14.5 million TEU
- Depth up to 75 ft (= 24 m)
- Visits (2018): 29,475 sea-going vessels
  120,000 inland navigation

Employment



Port of Rotterdam

# Port and industrial area

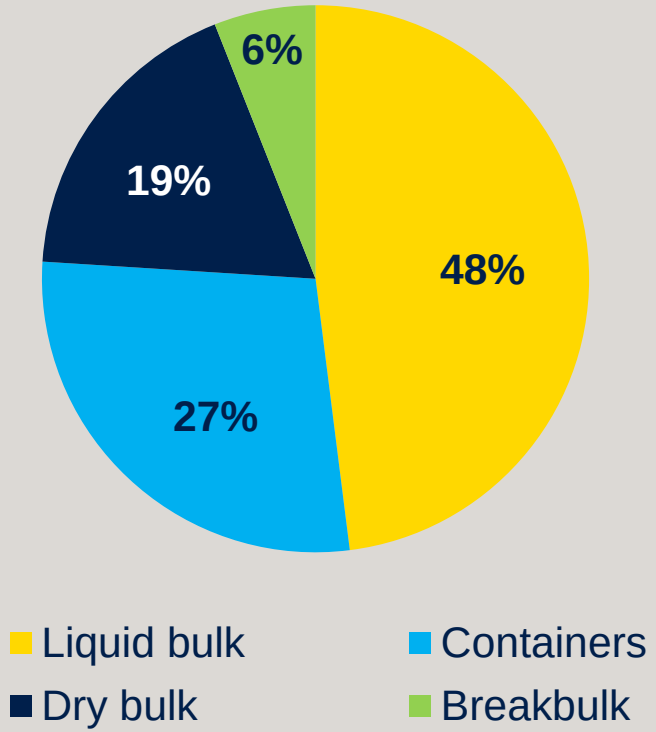





Port of Rotterdam

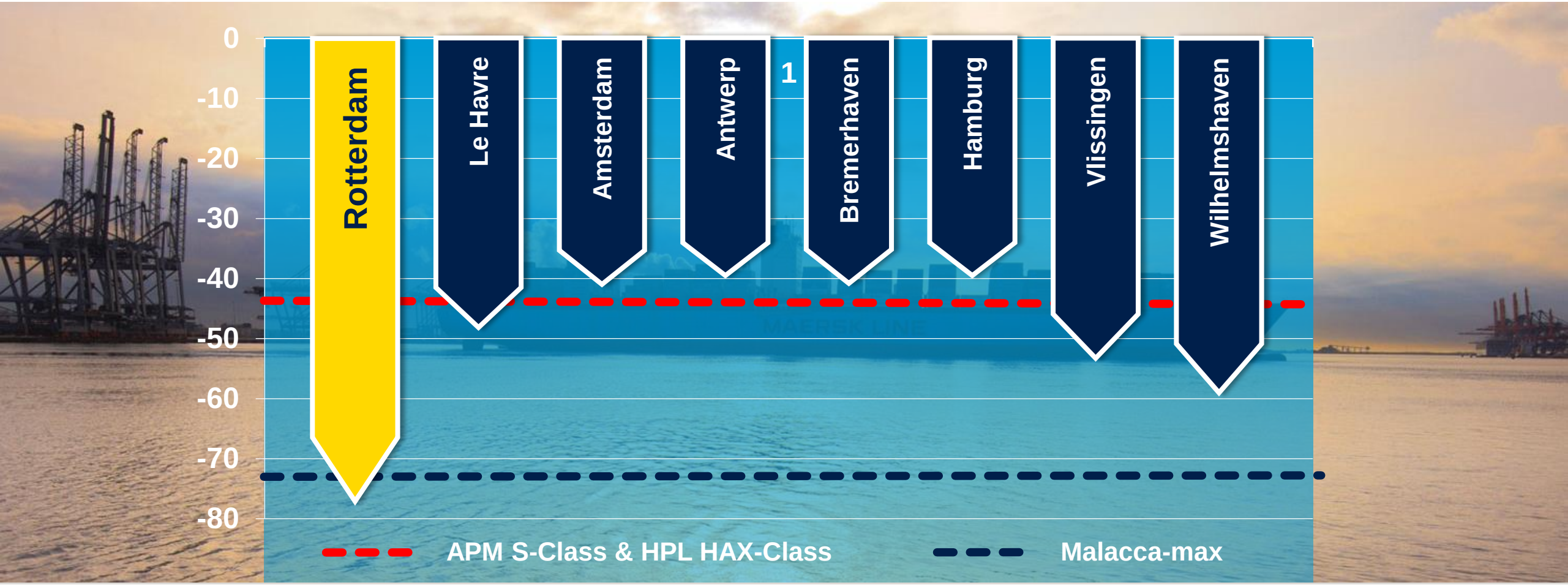
# Dominated by fossil fuels and logistics

## Cargo ratios in 2016



Port of Rotterdam

# Water depth European ports



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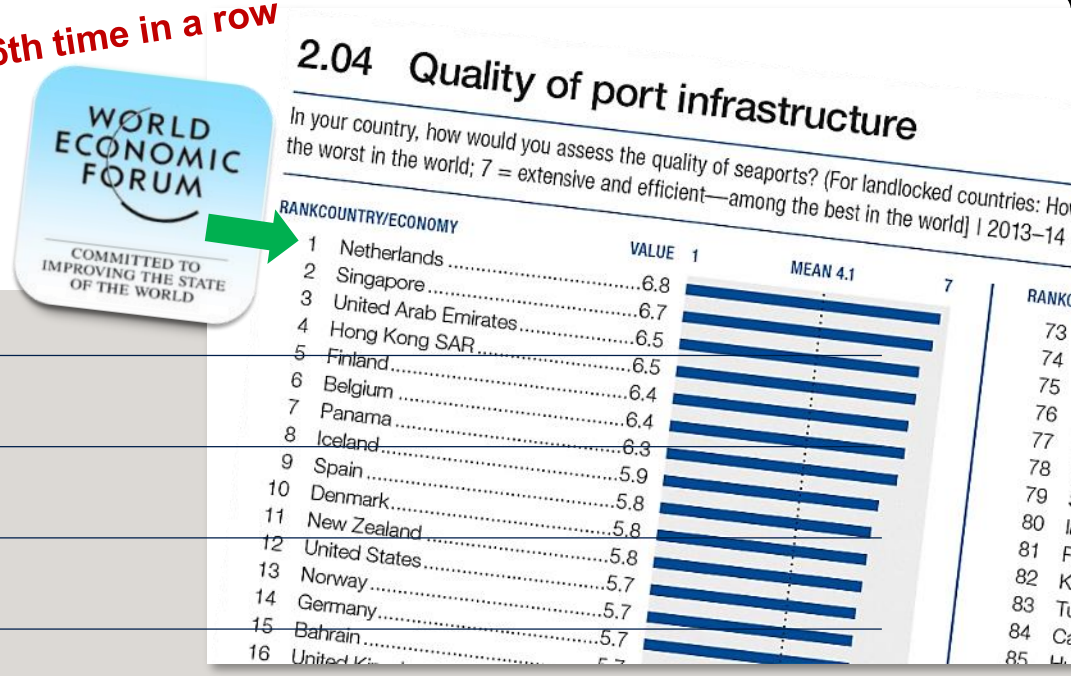
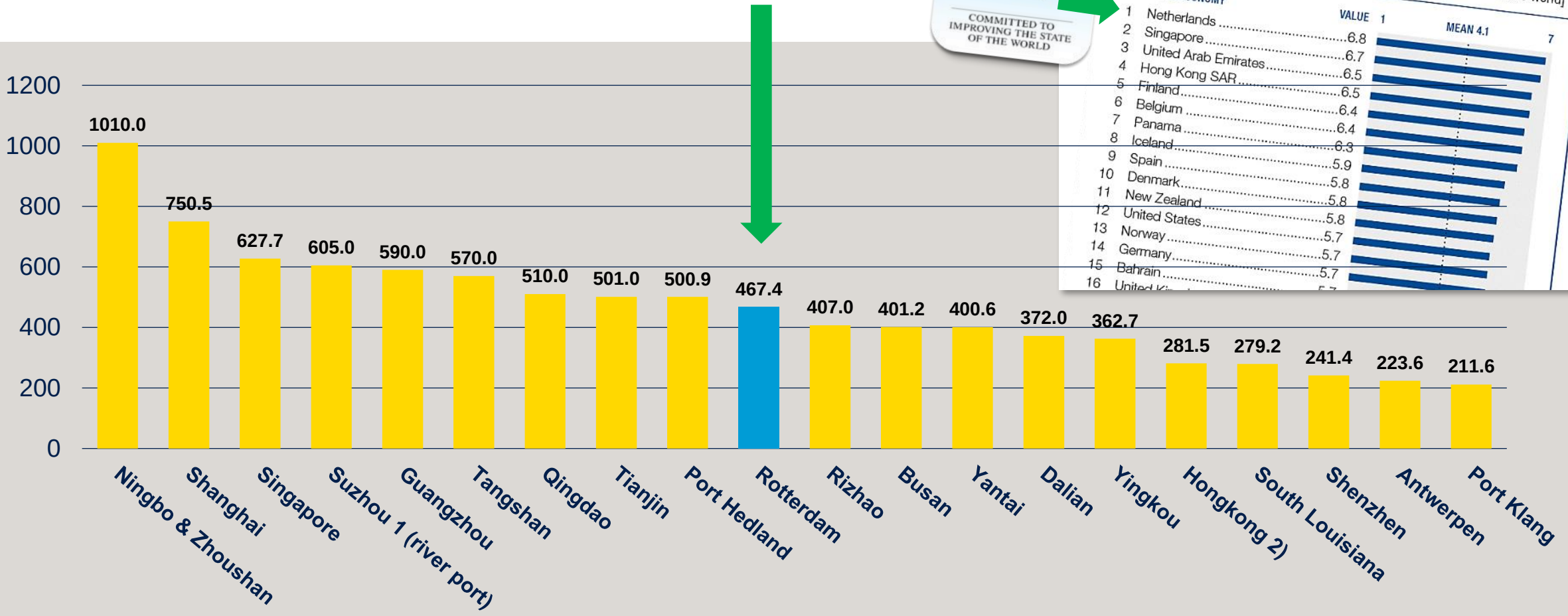
# Top 20 world ports

#1 for 6th time in a row



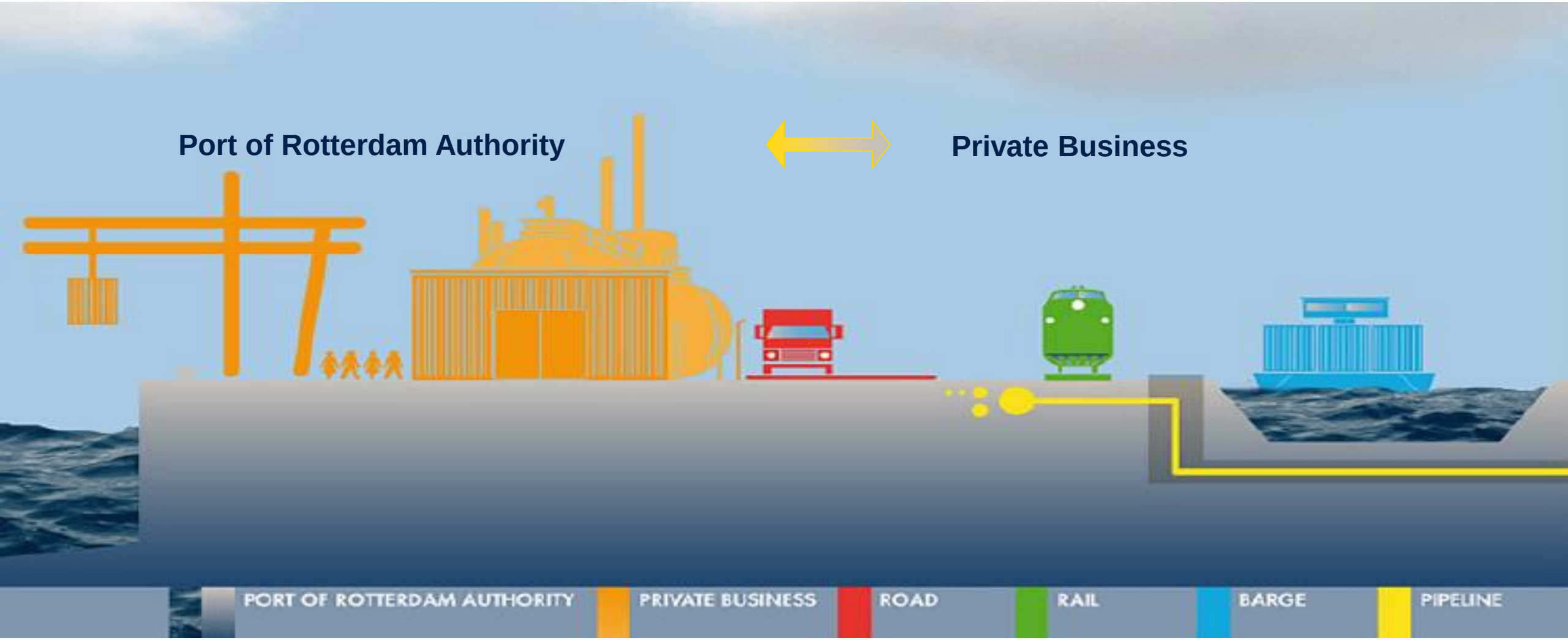

x 1 million tons (2017)

*Source: Port Authorities*



Port of Rotterdam

# Landlord port model




Port of Rotterdam

# The assets of PoR

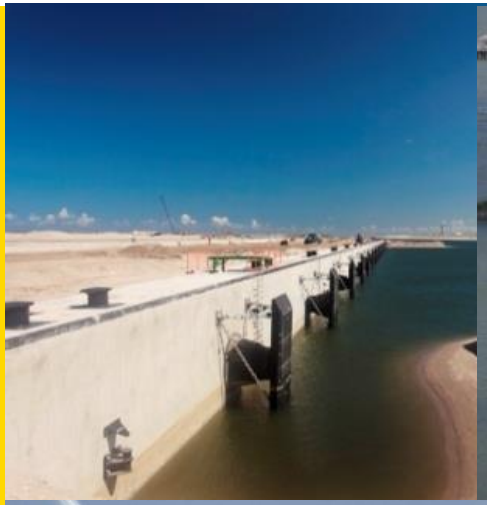
**Total of 32 asset types**

- 70,5  km Quay walls
- 180 km Embankment
- 310 ha Roads
- 3.500 ha Sea bed
- Civil Structures, Buildings, Vessels etc.

**Invested Capital € 3,66 Billion**

**Maintenance budget € 72 Million**

**Approx. 120 employees in AM**



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# Deterioration of Infrastructure Assets

- Deferred maintenance costs
- Inadequate capital allocation
- Run-to-failure repair & maintenance programs
- Inspections based on random observations
- Loss of competitive edge and productivity
- Safety/security concerns

Port of Rotterdam

# Asset Management : A Strategic Imperative

Waterfront structures like quays, jetties and wharves are the pivot of the business case

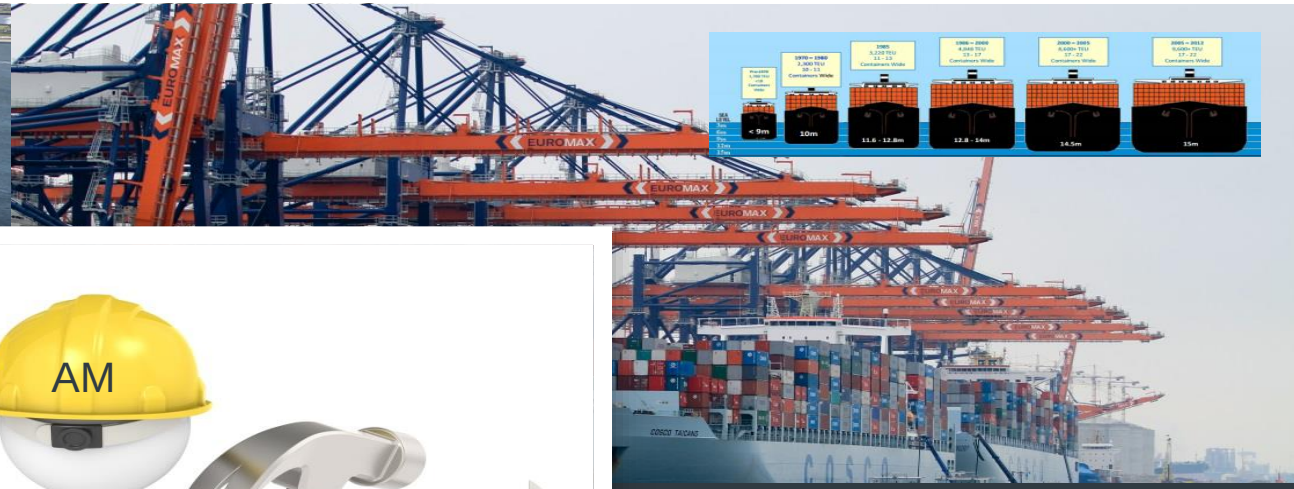
Income of the Port depends on the availability of the asset

Loss of profit will decrease cash flow and thus the opportunity to invest in the future

Disruption to the tenant’s business is the most unwanted situation

# Asset Management - More Challenges

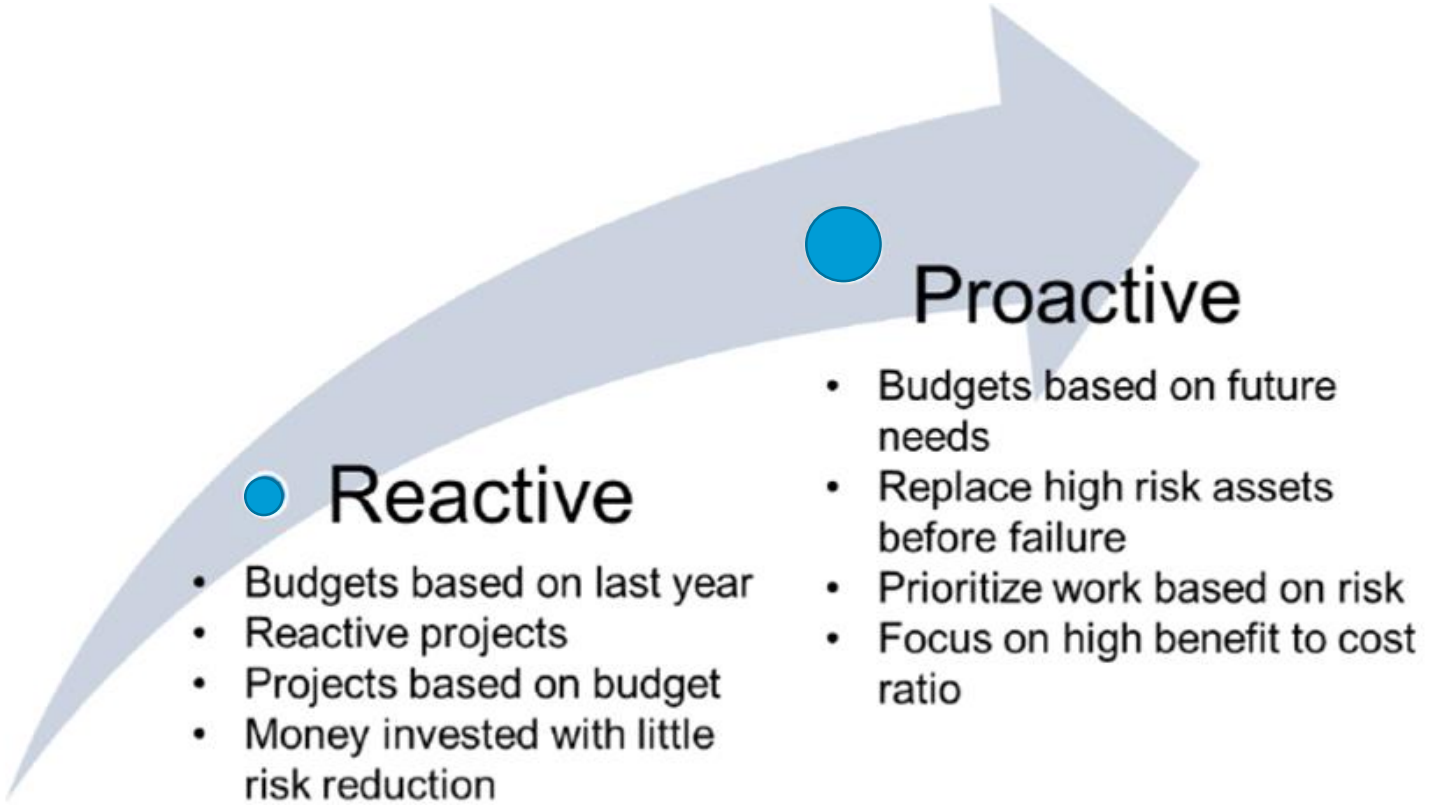
More intensive use of assets



Justification of maintenance plan to board of directors

Extension of tenant leases

# Objective in Asset Management Culture



# Asset Management Program: Stepstones

Step 1 : Document  the assets owned and managed

Step 2 : Understand the current condition of the assets

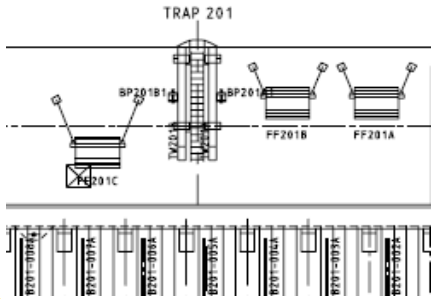
Step 3 : Understand what budget is needed to catch up, keep up and move forward

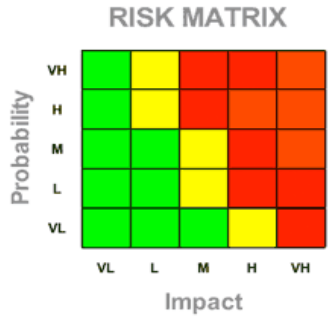
Step 4:  Understand what endangers the functionality : risk analysis

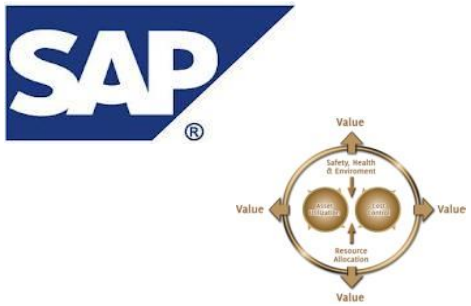
Step 5 : Understand the business value, what the contribution of an asset to the business goals

Step 6 : Establish the level of service for an asset and calculate the cost of service

Step 7:  Prioritize the needed budget based on risk and business value



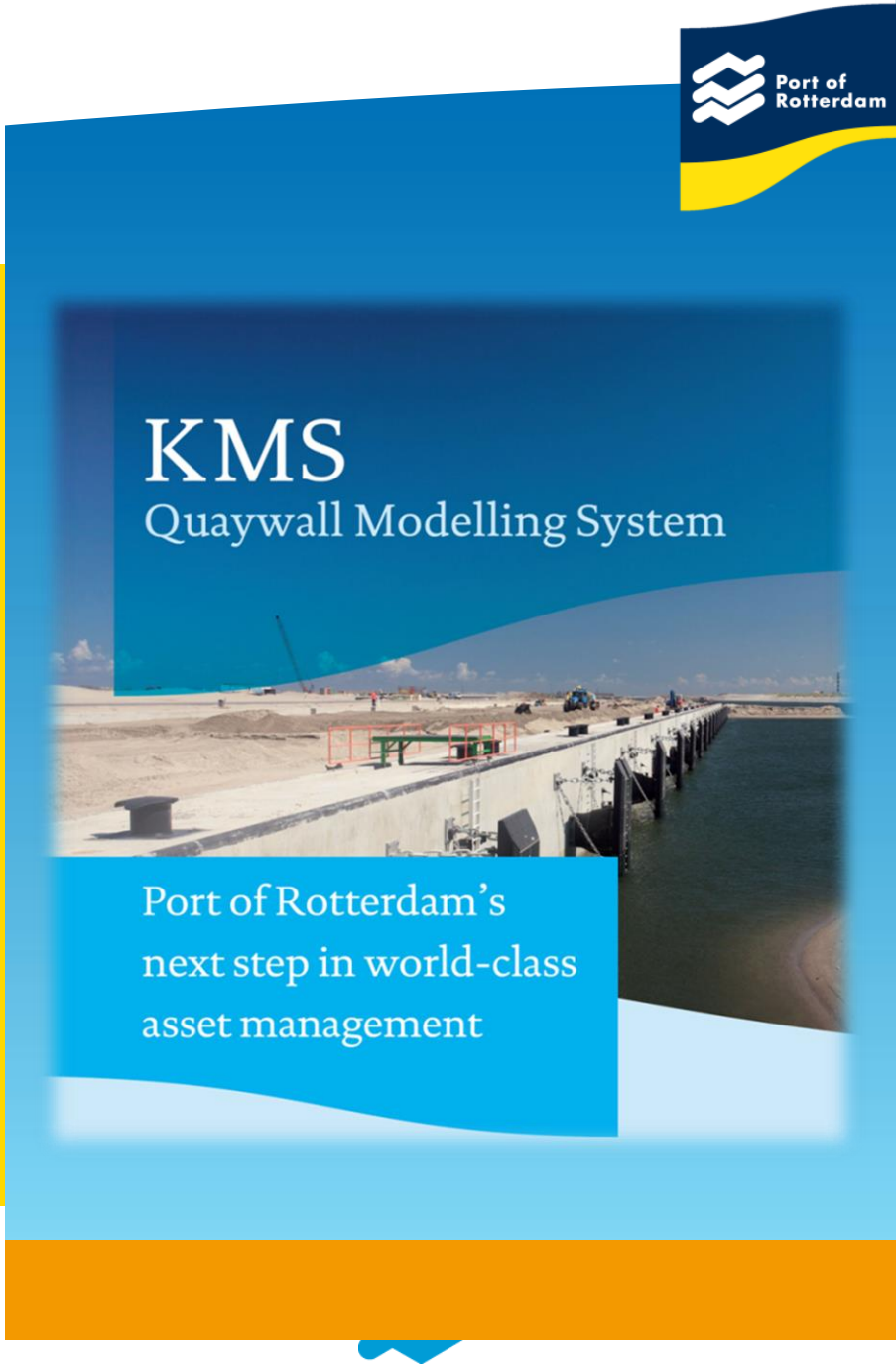



Port of Rotterdam

# Expert system: KMS

- Port of Rotterdam developed in partnership an asset management tool called KMS, which is the Dutch abbreviation of Quay wall Modeling System that:
  - Uses the results of **detoriation models for concrete and steel** and compares it with the “end of contract” date
  - Identifies and ranks **the risks** that endanger all the functionalities of the structure
  - Uses the **business value** of a quay wall to clarify its maintenance priority



# The KMS system

F spatial related data

D prioritized maintenance tasks

SAP®

Legacy systemen

A integrity inspection tasks

E master data & maintenance tasks

KMS

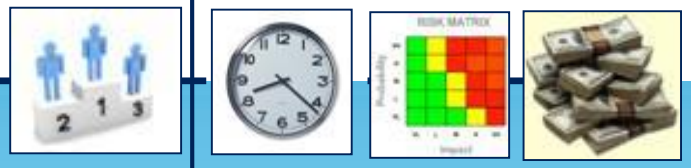
C integrity related risks & tasks

B inspection results

Risk Analysis Module

STADIUM® A SIMCO SOLUTION

Inspection module



F spatial related data

Port of Rotterdam PORTMAPS

ArcGIS ESRI

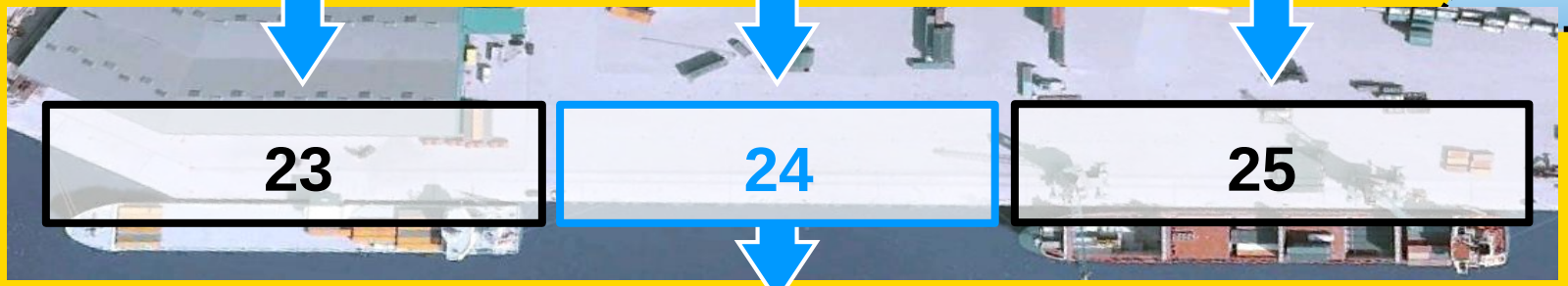
# Asset Management on Quay Walls

- A quay wall's remaining lifetime and system integrity is mainly determined by the quality of the sub and superstructure.
- When the quay wall's integrity is in danger, it's often due to:
  - accelerated low water corrosion occurring at the substructure or
  - concrete deterioration in the superstructure

Beerkanaal, Rotterdam

# Inspection module

STEP 1




**Inspection Request**

- **Concrete**
  - Coring
    - Full Analysis
    - Chemical Analysis
  - Visual Inspection
- **Steel**
  - Cathodic Protection
  - Corrosion Measurements

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# STADIUM® Expert System

STEP 2

**Degradation Analysis per Zone and Element**

Evaluate Degradation with STADIUM®

Post Treatment Analysis

For each Zone/Element combination

Select the most critical Zone/Element combination

Critical Year (Trigger/Intervention)

Maintenance Proposal

Schedule Next Inspection

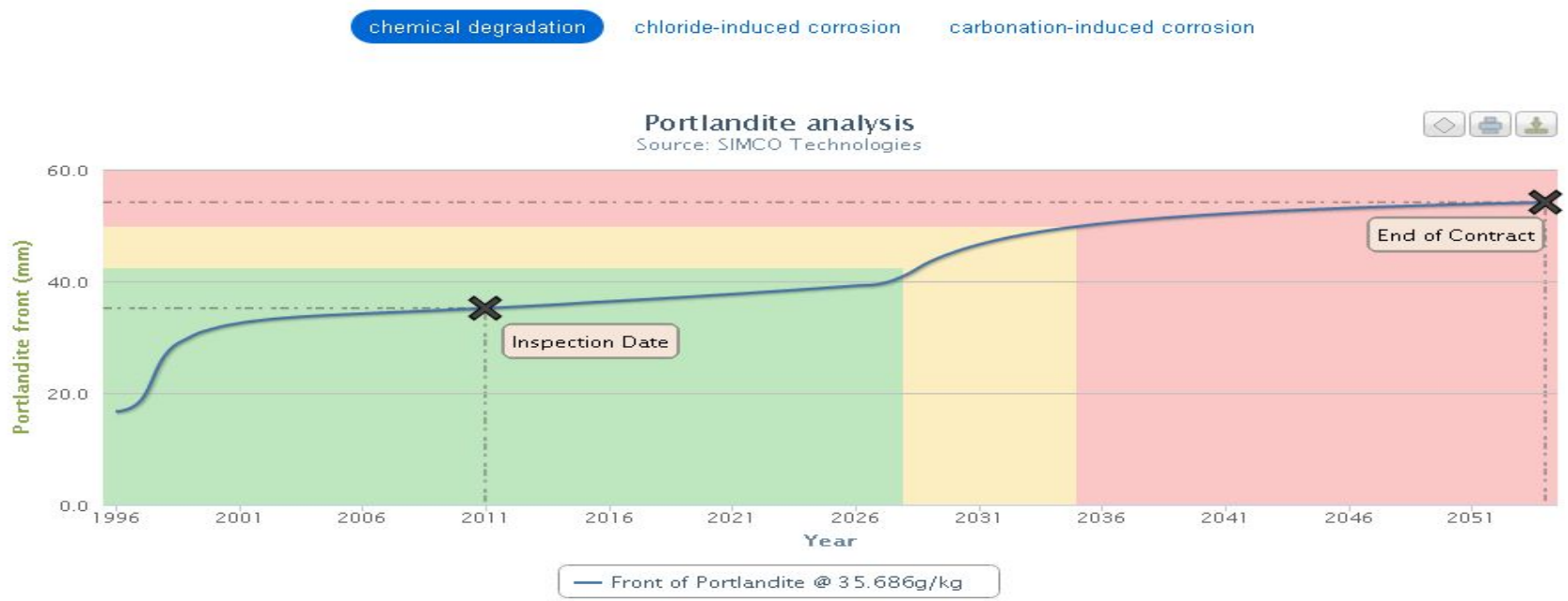
Close Monitoring Required

Repair

Port of Rotterdam

# STADIUM® Expert System

**Graph for harbour "Hartelhaven" and section "H-L-N-MV-047-KAD-004-A" (150101/49)**




**Input Data**

| | | |
|---|---|---|
| Initial Portlandite Content: | 39.7 | g/kg |
| Portlandite Content Dissolution Threshold (90% Initial Content): | 35.7 | g/kg |

**Analysis Data**

| Portlandite Dissolution Depth | | |
|---|---|---|
| Inspection Year: | 35.2 | mm |
| End of Contract Year: | 54.1 | mm |

**Flags**

| | |
|---|---|
| Yellow Flag Reached In: | 2028 |
| Red Flag Reached In: | 2035 |

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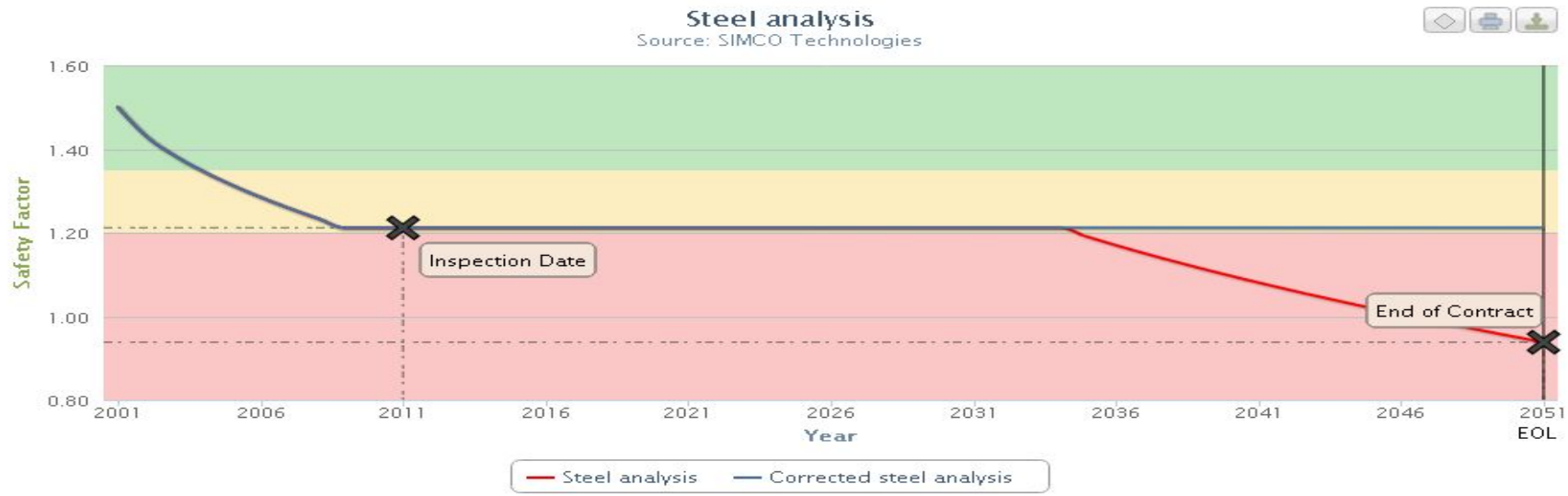
# STADIUM® Expert System

**Evaluation Order "150085" on Section "H-L-N-MV-037-KAD-008-A"**

| Current Analysis Year | 2011 | Inspection Date Year | 2011 | Corrosion Scale | 8.585 | Construction Year | 2001 |
|---|---|---|---|---|---|---|---|




**Alert 0**

| Safety Factor | |
|---|---|
| Initial (2001) | 1.500 |
| Inspection (2011) | 1.212 |

| 1st hole | | | | |
|---|---|---|---|---|
| | Strength | | Ground | |
| | Global | Local | Global | Local |

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# Risk Management

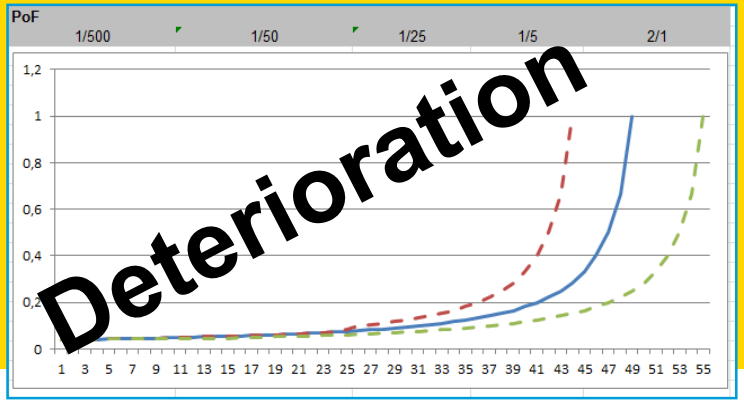
Business Value

| Aspect | Weighting | Relevance | Appreciation | Effect score |
|---|---|---|---|---|
| Commercieel belang / risico derving inkomsten | 30 | gemiddeld - hoog | | 21 |
| Bezettingsgraad scheepvaart | 20 | hoog - zeer hoog | | 18 |
| Maatschappelijk belang | 15 | hoog - zeer hoog | 90 | 13,5 |
| Functie / Soort gebruik | 15 | droge bu | 50 | 7,5 |
| Gebruiksdruk terrein | 10 | middeld - hoog | 70 | 7 |
| Representatief voor HbR / zichtlocatie | 1 | laag - zeer laag | 30 | 3 |

| Critical Im t Fact | Kademuren | Wegen | Groen | Waterbodem |
|---|---|---|---|---|
| Afname n lading | 1,0 | 1,0 | 0,1 | 1,0 |
| Financieel verlies | 1,0 | 0,8 | 0,1 | 0,9 |
| Aansprakelijkstelling | 0,2 | 0,4 | 0,1 | 0,2 |
| Reputatie- & Imagoschade | 0,5 | 0,7 | 0,5 | 0,1 |

Risk Analysis

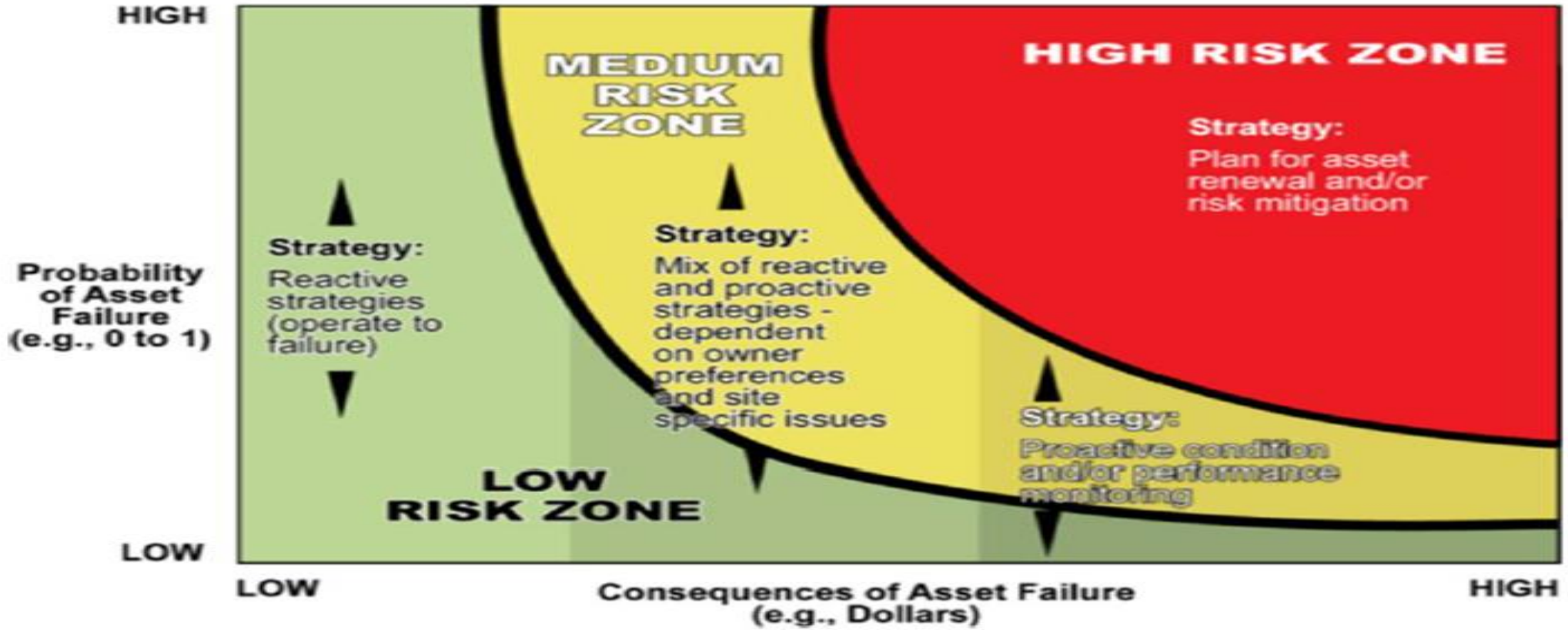
| (MENS) Veiligheid | Duurzaamheid / MILIEU | Reputatie \ esthetica / IMAGO | Beschikbaarheid / CORE \ BUSINESS | Directe technische kosten | Beeldkwaliteit | Restlevensduur |
|---|---|---|---|---|---|---|
| Ernstig letsel met slachtoffers | verlies vergunning | internationale media, grote imagoschade | > maand niet beschikbaar | € 500.000 | Mogelijk / denkbaar kans op een zeer hoog effect op de | Mogelijk / denkbaar kans op grote afname van de restlevensduur, |
| Letsel zonder invaliditeit | ernstige vervuiling, calimitiet | landelijke media, claims, imagoschade | 2 weken tot 1 maand niet beschikbaar | € 100.000 | Mogelijk / denkbaar kans op een hoog effect op de beeldkwaliteit | Mogelijk / denkbaar kans op beperkte afname van de |
| Licht letsel, kort verzuim | melding, vervuiling opruimen | lokale media, c | 1 week tot 2 weken niet beschikbaar | € 50.000 | Mogelijk / denkbaar kans op gemiddeld effect op de | Mogelijk / denkbaar kans op grote aanpassing van het PvE met |
| Melding, geen Verzuim | melding, geri vervuilin | imagoschade | 1 dag tot 1 week niet beschikbaar | € 5.000 | Mogelijk / denkbaar kans op een matig effect op de beeldkwaliteit | Mogelijk / denkbaar kans op kleine aanpassing PvE met beperkte |
| EHBO | geen vervuiling / melding | interne melding | <1 dag niet beschikbaar | € 500 | Mogelijk / denkbaar kans op een klein effect op de beeldkwaliteit | Mogelijk / denkbaar kans op afname van de constructieve |




Deterioration

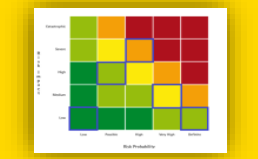
PoF × CoF = Risk

# Risk Strategy

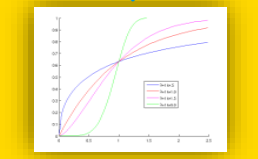


# Risk Analysis Expert System

## From Risk Analysis to Prioritization of the Maintenance Plan



Determine generic risk, effect, financial risk and probability (FMECA/RCM)



Combine asset & generic risk for a specific risk factor

BV

One factor to express the economical added value of an asset

Prioritization of the maintenance plan based on the risk factor and business value

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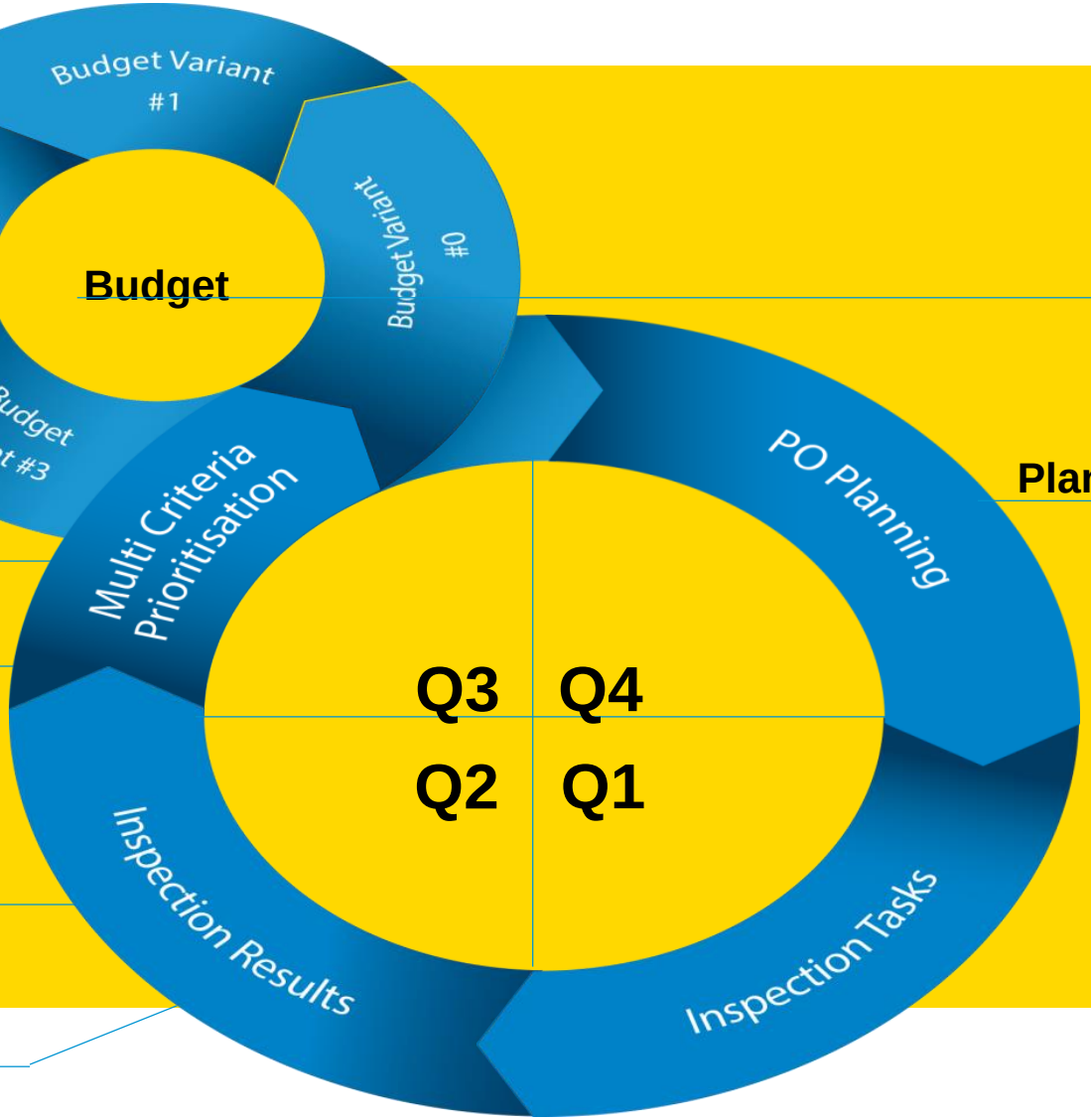
# Annual Maintenance Cycle

Prioritizing

Risk Analyzing

Simulating

Predicting



Planning

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# Long Term Asset Planning

| Year of Activity | Asset ID | Asset Name | Activity Name | Activity Type | Activity Description | Activity Cost |
|---|---|---|---|---|---|---|
| 2015 | PARK3568 | Prep Table | | Replacement | | $1,000.00 |
| 2015 | PARK3564 | Barbeque Grills -... | | Replacement | | $1,000.00 |
| 2015 | PARK3563 | Walkway Lighting... | Change Bulb | Maintenance & Inspection | | $110.00 |
| 2015 | PARK3563 | Walkway Lighting... | Change Bulb | Maintenance & Inspection | | $110.00 |
| 2015 | PARK3563 | Walkway Lighting... | Change Bulb | Maintenance & Inspection | | $110.00 |
| 2015 | PARK3563 | Walkway Lighting... | Change Bulb | Maintenance & Inspection | | $110.00 |
| 2015 | PARK3563 | Walkway Lighting... | Change Bulb | Maintenance & Inspection | | $110.00 |
| 2015 | PARK3562 | Trash Bins - Lid | | Replacement | | $1,100.00 |
| 2015 | PARK3561 | Prep Table | | Replacement | | $1,000.00 |
| 2015 | PARK3557 | Barbeque Grills -... | | Replacement | | $1,000.00 |
| 2015 | PARK3553 | Gazebo Structure | Rehabilitation - Wood | Rehabilitation | | $750.00 |
| 2015 | PARK3551 | Barbeque Grills -... | | Replacement | | $1,000.00 |
| 2015 | PARK3550 | Trash Bins - Lid | | Replacement | | $4,400.00 |

Port of Rotterdam

# KMS Benefits

- Short term:
  - Transparency in annual budget for maintenance
- Mid - Long Term:
  - Insight on residual service life and maintenance costs per structure
  - Insight on total port concrete and steel costs
- “Just in time” inspections
- Proactive, prioritized and risk-based maintenance
- Save $$$

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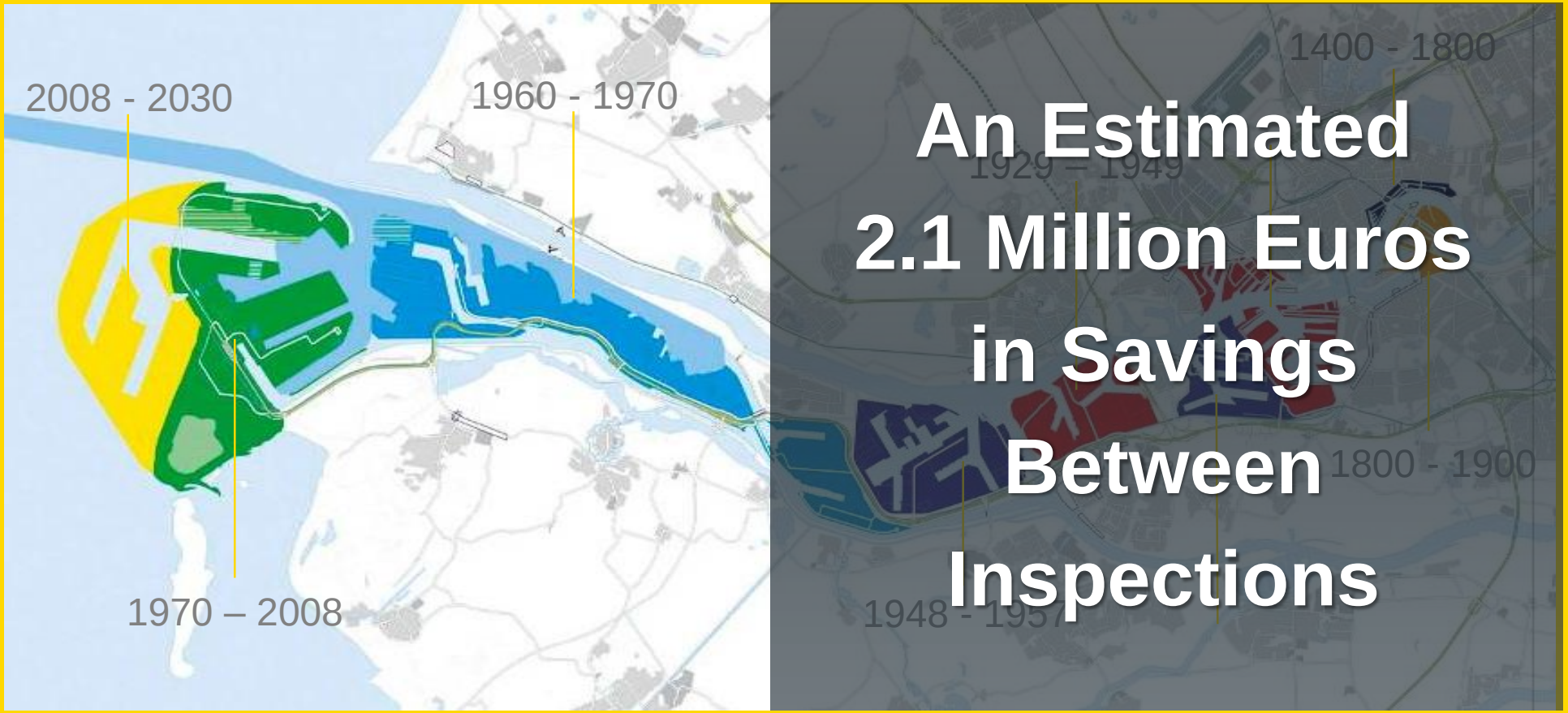
# Return on Investment (ROI)

## With More than 70 KM of Quay Walls…




**An Estimated 2.1 Million Euros in Savings Between Inspections**

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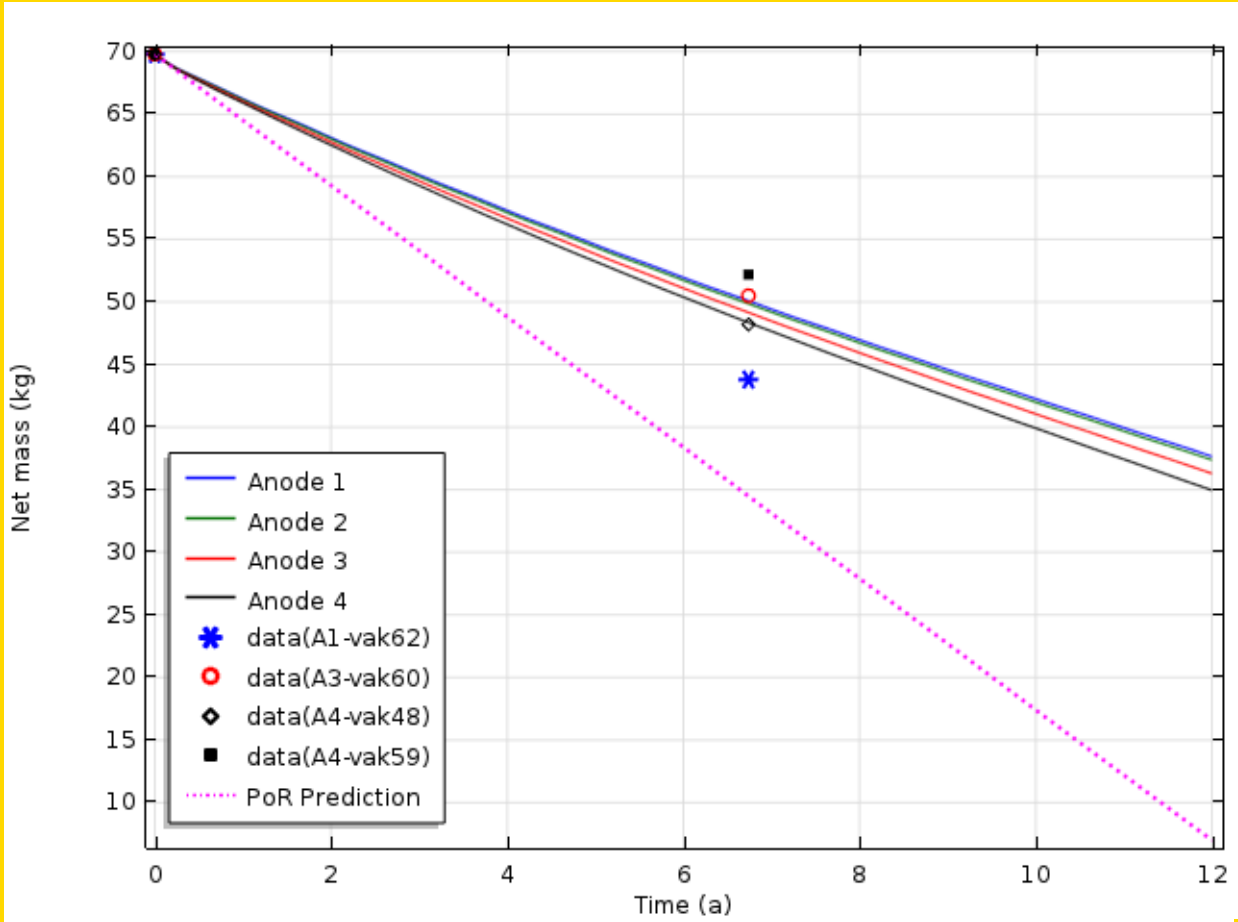
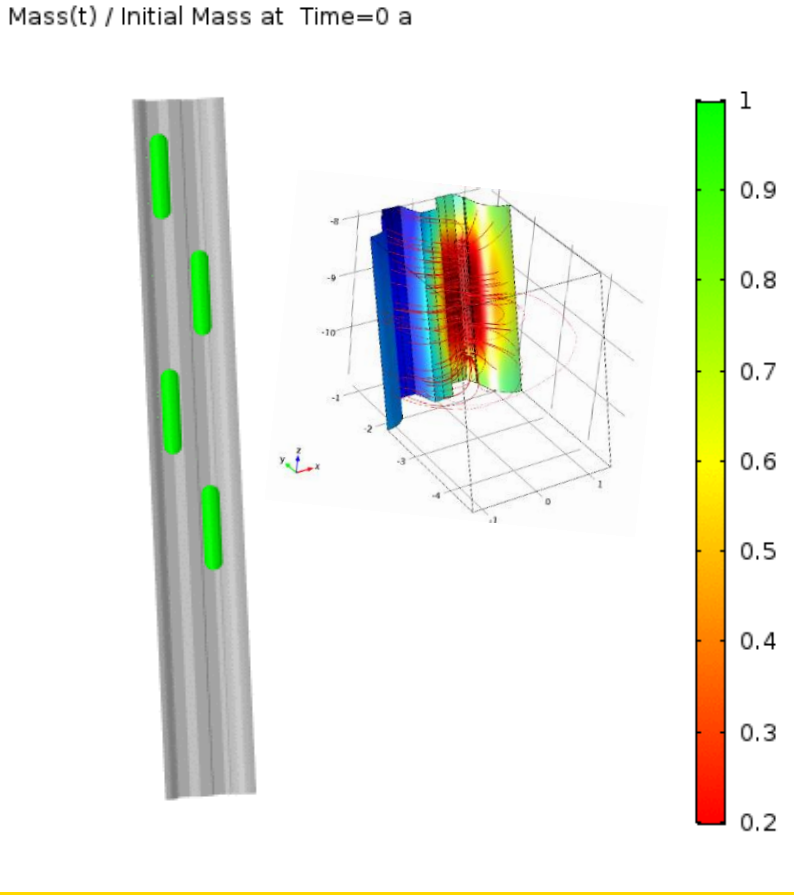
# Improvements in modelling: Anode lifetime

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# Smart Infrastructure : Inspection vs sensoring

"The inspector of the future is a sensor"



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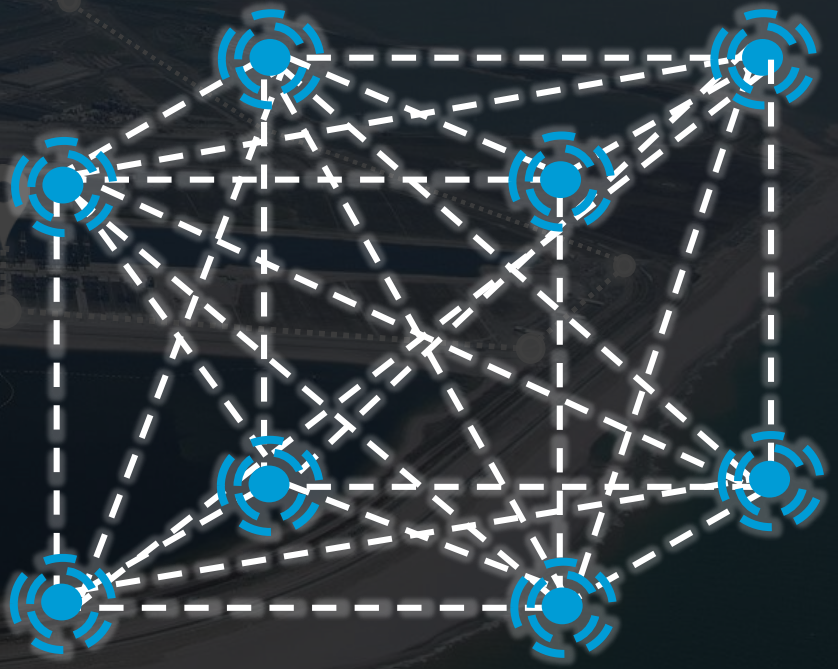
## Port of Rotterdam

Transformation

## Digital Port of Rotterdam

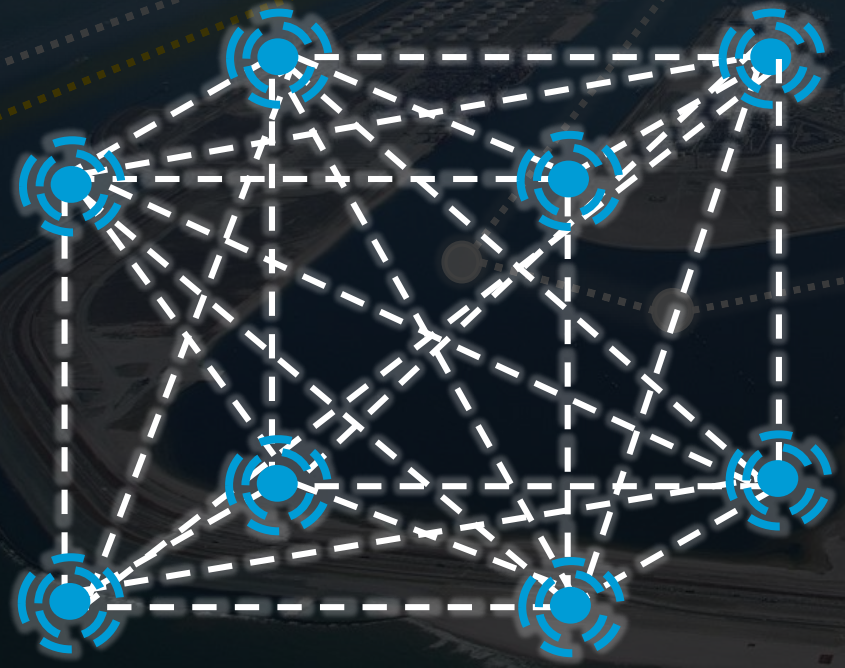


Port of Rotterdam

37MW
VITTORIA
Bulk Carrier
DREDGE
PLANNED
PROJECT
I.0201809
UNAUTHORIZED
CONTAINER
Container: PONU0408148
Shipment: 962354649
Origin: Maersk Line
Time: 47:16:55
Destination: Gdansk, PL
HOLLANDIA
General Cargo
DREDGE
PLANNED
CMA CGM MOLIERE
Container Ship
PROJECT
I.0201854
STATUS OK
ETD 14:42
18,1m
24,1m
ETA 12:31
0.61 m/s
ROUTE OK
$CO_2$ 956 ppm
Container: YAKU0908852
Shipment: 762384641
Origin: MOL
Time: 11:36:28
Destination: Shanghai, CN
COLLISION
RISK
19,8m
INSPECTION
STATUS FAULT
NETWORK OK
Container: HYDA02257814
Shipment: 142933420
Origin: Hyundai
Time: 148:22:39
Destination: Rotterdam, NL
48m
0.398 m/s
124 kN/m2
98 kN/m2
21,8m
56m
42 kN/m2
AVAILABLE
Port of
Rotterdam

# DIGITAL TWIN

## … AND THE FOUR DIMENSIONS



1. Length
2. Width
3. Height / Depth
4. Time
   - Real-time
   - Historical
   - Prediction

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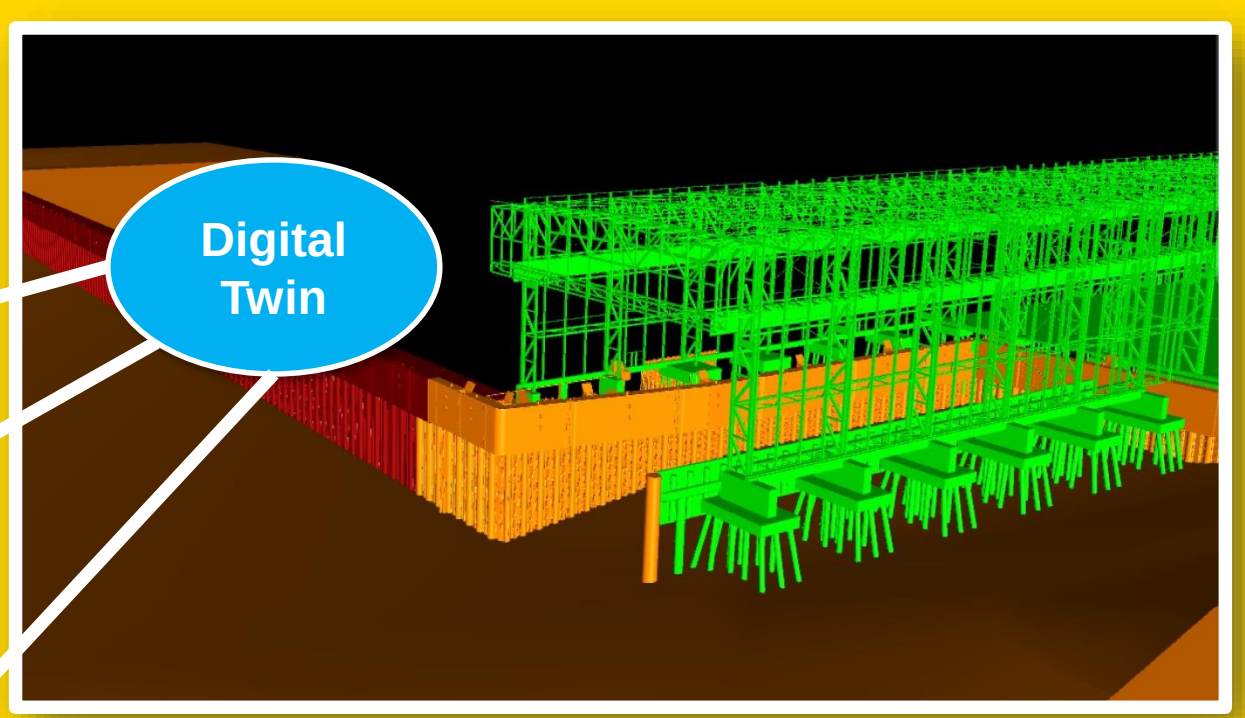
# Next step: stucture predicts its own maintenance



Asset

Digital Twin

Historical, Real Time & Predictive data

Intelligence

IBM Watson



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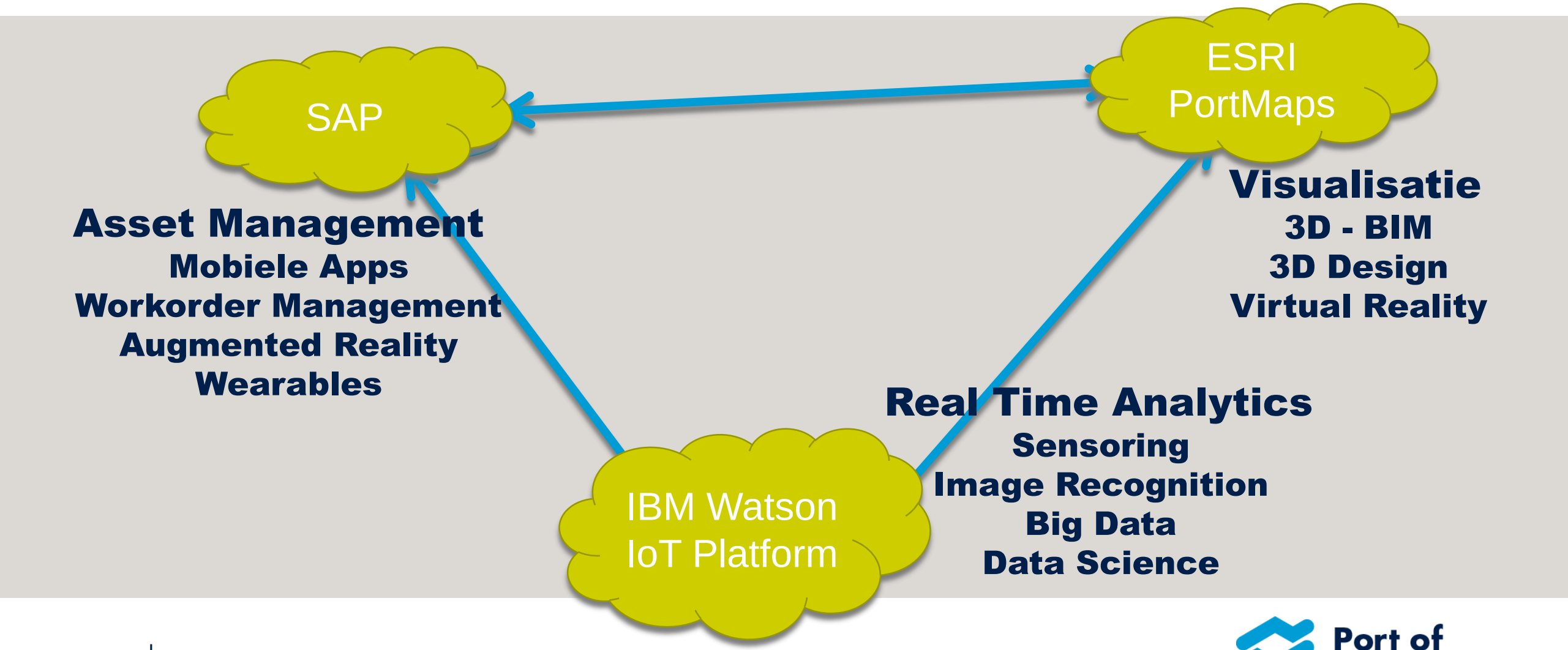
# Data Driven Asset Management



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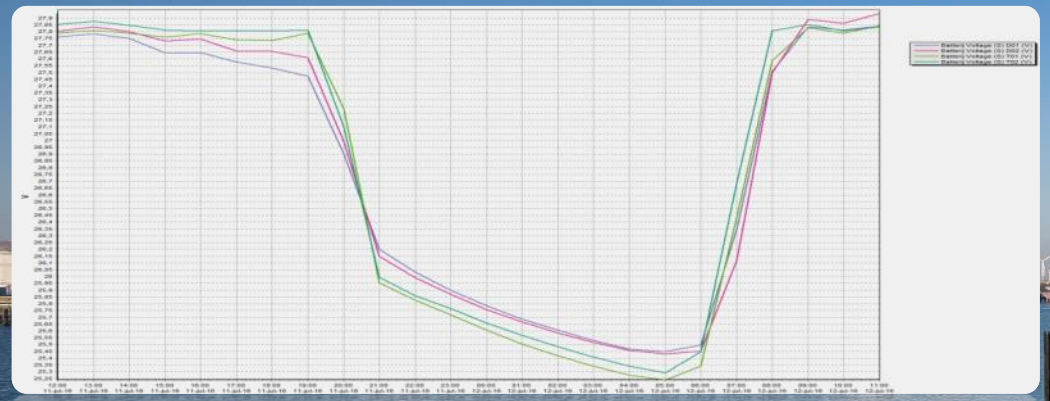
# STATUS APS'S



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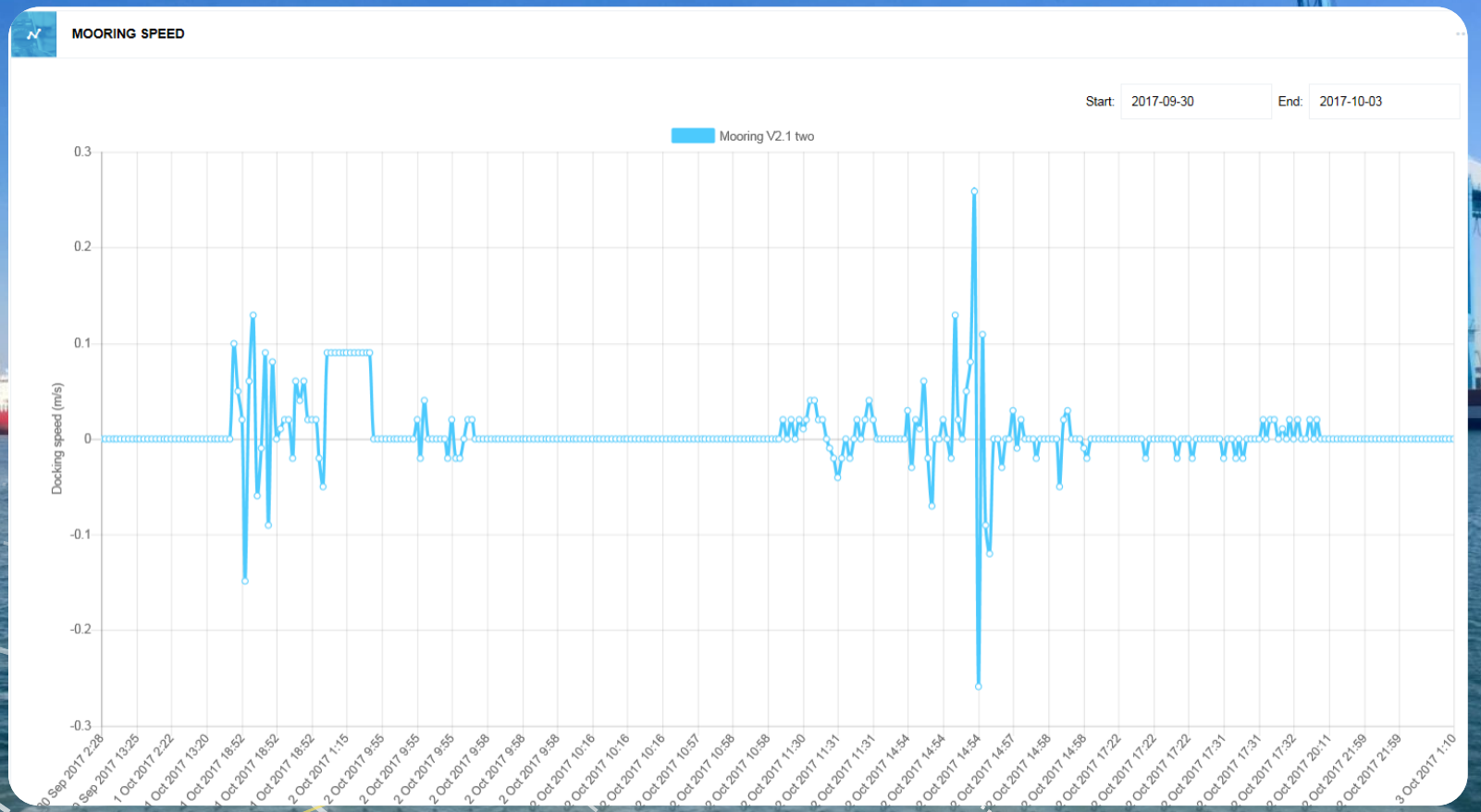
# MOORING SPEED

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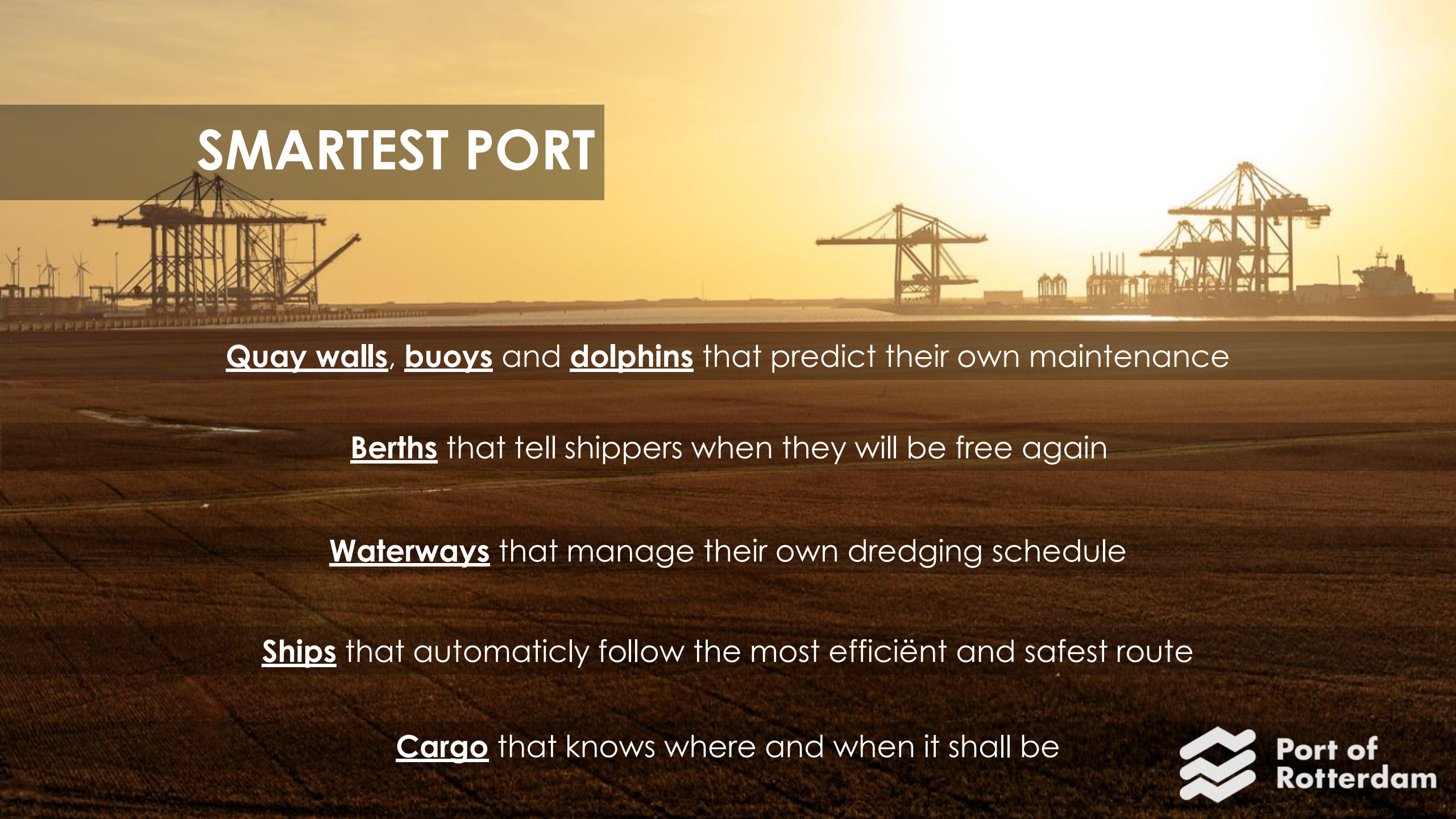

# SMARTEST PORT

**Quay walls**, **buoys** and **dolphins** that predict their own maintenance

**Berths** that tell shippers when they will be free again

**Waterways** that manage their own dredging schedule

**Ships** that automaticly follow the most efficiënt and safest route

**Cargo** that knows where and when it shall be

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# Proactive, Predictive & Smart Waterfront Asset Management
# A Strategic Imperative for the Port of Rotterdam

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