ASSET MANAGEMENT @ POR
DON’T PLAN REPAIRS. PREDICT THEM
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
Dominated by fossil fuels and logistics

Cargo ratios in 2016

- Liquid bulk: 48%
- Containers: 27%
- Dry bulk: 19%
- Breakbulk: 6%

29 April 2019
Water depth European ports

[Diagram showing water depth in various European ports, with depth markings from -80 to 0, and port names including Rotterdam, Le Havre, Amsterdam, Antwerp, Bremerhaven, Hamburg, Vlissingen, Wilhelmshaven, APM S-Class & HPL HAX-Class, and Malacca-max.]
Top 20 world ports

Source: Port Authorities

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Value (2017)</th>
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<td>20</td>
<td>Port Klang</td>
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Landlord port model

Port of Rotterdam Authority

Private Business
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
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
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

But what do we focus on first?
Objective in Asset Management Culture

Proactive
- Budgets based on future needs
- Replace high risk assets before failure
- Prioritize work based on risk
- Focus on high benefit to cost ratio

Reactive
- Budgets based on last year
- Reactive projects
- Projects based on budget
- Money invested with little risk reduction
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
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

- **A** integrity inspection tasks
- **B** inspection results
- **C** integrity related risks & tasks
- **D** prioritized maintenance tasks
- **E** master data & maintenance tasks
- **F** spatial related data

KMS components:

- **Risk Analysis Module**
- **Inspection module**
- **Legacy systemen**
- **SAP**
- **STADIUM**
- **Port of Rotterdam**
- **ArcGIS**
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
Inspection module

STEP 1

Inspection Request

Concrete

Steel

Coring

Visual Inspection

Cathodic Protection

Corrosion Measurements

Full Analysis

Chemical Analysis
For each Zone/Element combination

Degradation Analysis per Zone and Element

Evaluate Degradation with STADIUM

STADIUM® Expert System

STEP 2

Post Treatment Analysis

For each Zone/Element combination

Select the most critical Zone/Element combination

Schedule Next Inspection

Close Monitoring Required

Repair

Critical Year (Trigger/Intervention)

Maintenance Proposal
STADIUM® Expert System

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

- Chemical degradation
- Chloride-induced corrosion
- Carbonation-induced corrosion

**Portlandite analysis**
Source: SIMCO Technologies

**Input Data**
- Initial Portlandite Content: 39.7 g/kg
- Portlandite Content Dissolution Threshold (50% Initial Content): 35.7 g/kg

**Analysis Data**
- Portlandite Dissolution Depth
  - Inspection Year: 36.2 mm
  - End of Contract Year: 54.1 mm

**Flags**
- Yellow Flag Reached In: 2028
- Red Flag Reached In: 2035
Evaluation Order "150085" on Section "H-L-N-MV-037-KAD-008-A"

Steel analysis
Source: SIMCO Technologies

Safety Factor

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<th>Year</th>
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Alert 0

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Risk Strategy

- **High Risk Zone**
  - Strategy: Plan for asset renewal and/or risk mitigation

- **Medium Risk Zone**
  - Strategy: Mix of reactive and proactive strategies - dependent on owner preferences and site specific issues

- **Low Risk Zone**
  - Strategy: Proactive condition and/or performance monitoring

- **Probability of Asset Failure** (e.g., 0 to 1)
- **Consequences of Asset Failure** (e.g., Dollars)
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

One factor to express the economical added value of an asset

Prioritization of the maintenance plan based on the risk factor and business value
Long Term Asset Planning

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<th>Year of Activity</th>
<th>Asset ID</th>
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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 $$$
Return on Investment (ROI)

With More than 70 KM of Quay Walls…

An Estimated 2.1 Million Euros in Savings Between Inspections
Improvements in modelling: Anode lifetime
Smart Infrastructure: Inspection vs sensoring

“The inspector of the future is a sensor”
Custom (Wit) Port of Rotterdam Transformation Digital Port of Rotterdam
DIGITAL TWIN

... AND THE FOUR DIMENSIONS

1. Length
2. Width
3. Height / Depth
4. Time

Real-time
Historical
Prediction
Next step: structure predicts its own maintenance

Historical, Real Time & Predictive data

Asset

Intelligence

Digital Twin
Data Driven Asset Management

Asset Management
Mobiele Apps
Workorder Management
Augmented Reality
Wearables

Visualisatie
3D - BIM
3D Design
Virtual Reality

Real Time Analytics
Sensoring
Image Recognition
Big Data
Data Science

SAP

IBM Watson
IoT Platform

ESRI
PortMaps
STATUS APS'S
MOORING SPEED
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 automatically follow the most efficient and safest route

**Cargo** that knows where and when it shall be
Proactive, Predictive & Smart Waterfront Asset Management
A Strategic Imperative for the Port of Rotterdam

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