

The background of the slide is a photograph of a large-scale port construction project. In the foreground, a concrete quay wall is visible. Beyond it, a body of water is filled with various construction equipment, including cranes and barges. In the distance, a long pier extends into the water, and more industrial structures are visible under a clear blue sky with some light clouds. The overall scene depicts a busy and active port environment.

Asset Management - Quay Walls

Don't plan repairs. Predict them.

Port of Rotterdam's next step in world-class asset management
2013 Facilities Engineering Seminar, Vancouver, November 8, 2013



Presenter:

Mr. Henk VOOGT

Asset Manager,

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Mr. Henk Voogt has started his career in the design and construction of quay walls and has since 2001 worked as an asset manager for marine structures at the Port of Rotterdam.

Since the very beginning, Henk has been involved in investigating and solving the problem of corrosion in Rotterdam as well as in the development of the KMS solution, a world-class asset management tool.

Quay walls @ PoR

- Quay walls are the pivot in our business model
- 65 km length (41 miles); up to 24 m deep (75 ft)
- Approx. 95% of the asset is submersed
- Asset replacement value: € 1,45 billion



Amazonehaven, Rotterdam

Why Asset Management on waterfront structures ?

- The maritime assets of ports (mostly quay walls and jetties) add enormous value to the business of the port, but due to the function these structures serve, as well as their location in the marine environment, these assets are relatively costly to construct and maintain.



Mississippihaven, Rotterdam

Today's topic of Panel X

Enterprise Asset Management — A Strategic Imperative at Ports

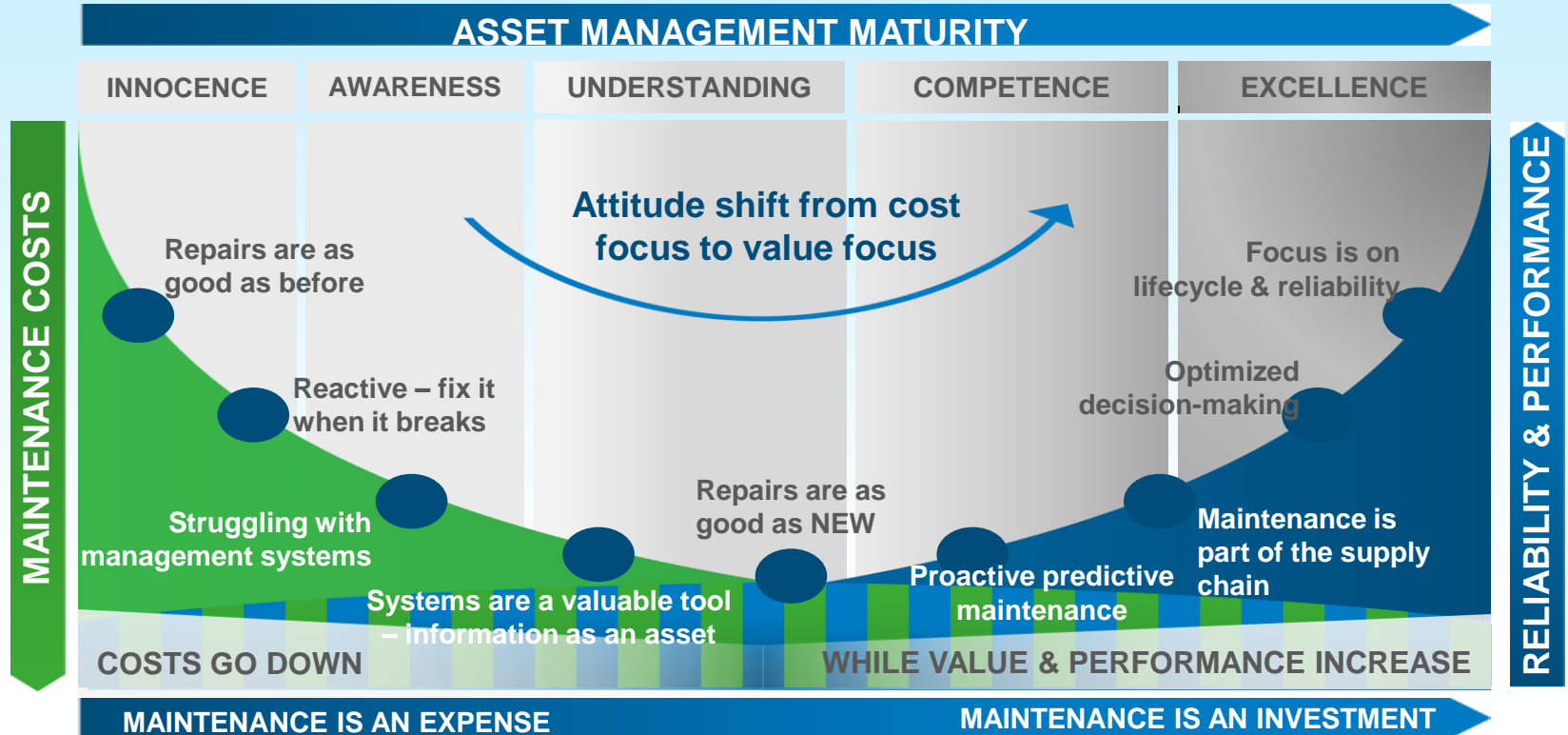
Transportation infrastructure owners world-wide are improving their understanding of the life-cycle position of their broad portfolio of assets and developing risk-based approaches to the allocation of the organization's scarce capital resources. The seminar's wrap-up session will explore this emerging port management imperative, why it has become a critical management function, global best practices and how the port industry is approaching EAM with a focus on the experiences of ports, including lessons learned.

emerging port management imperative

Asset Management: The imperative

- **The increase of transshipment**
 - Technical deterioration is accelerated by more intensive use than originally built for.
- **The question of the c-level:**
 - What will happen if the proposed budget is not granted ?
 - Can we avoid budget peaks ?
- **The questions of the commercial dep.**
 - Does the remaining useful life of the asset reach the end of contract with the tenant ?
 - Can we prolong the contract without major investments ?
- **The problem of the asset manager:**
 - What assets do I put the money on?
 - What risks do I have if I postpone maintenance works?
 - And in the long term, how does it influence the remaining lifetime of the assets

Asset Management



The Foundation

- **Master Data**

- *How long, how wide, how many?*

- **Business Value**

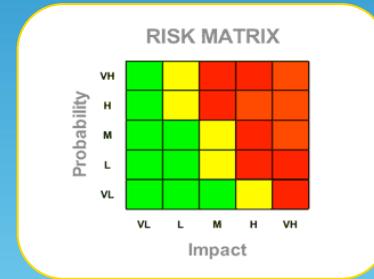
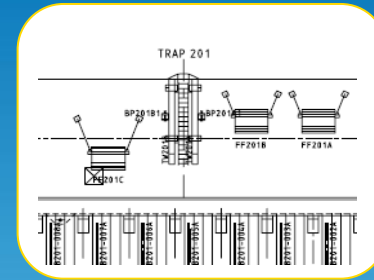
- *What's the contribution to the goals of the organization?*

- **Risk Analysis**

- *What endangers the functionality?*

- **Processes**

- *Is the workflow adequate?*



But then?

- After putting the inventory in place, connecting that to asset management is quite another challenge.
 - How safe is the structure and what does it mean for the port's tenants?
 - Will it reach the end of its potential lifespan?
 - When is the best moment to invest in maintenance work?
 - And with a finite budget, which areas of spending should be prioritized



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

From Model to 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 **deterioration models for concrete and steel** and compares it with the “end of contract” date
 - Identifies and ranks **the risks** that endanger the functionalities of the structure
 - Uses the **business value** of a quay wall to clarify its maintenance priority

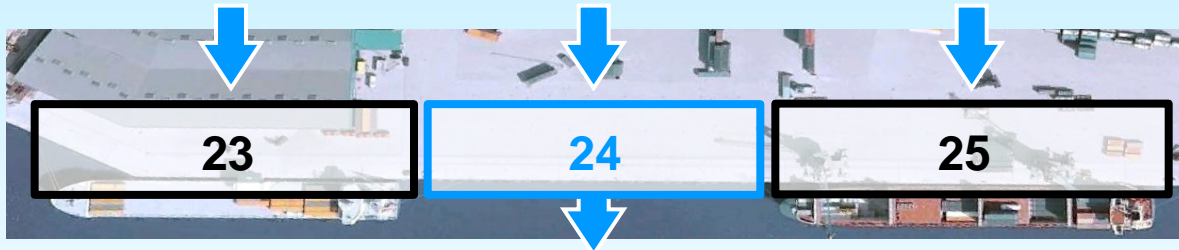


KMS
Quaywall Modelling System

The graphic features a photograph of a long concrete quay wall extending into the water. A blue semi-transparent banner is overlaid on the top left of the image, containing the text 'KMS Quaywall Modelling System'. A smaller blue banner is overlaid on the bottom right of the image, containing the text 'Port of Rotterdam's next step in world-class asset management'.

Port of Rotterdam's
next step in world-class
asset management

Inspection module

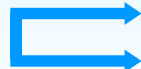


Inspection Request



→ **Concrete** →

→ **Steel** →



Coring

Visual Inspection

Cathodic Protection

Corrosion Measurements

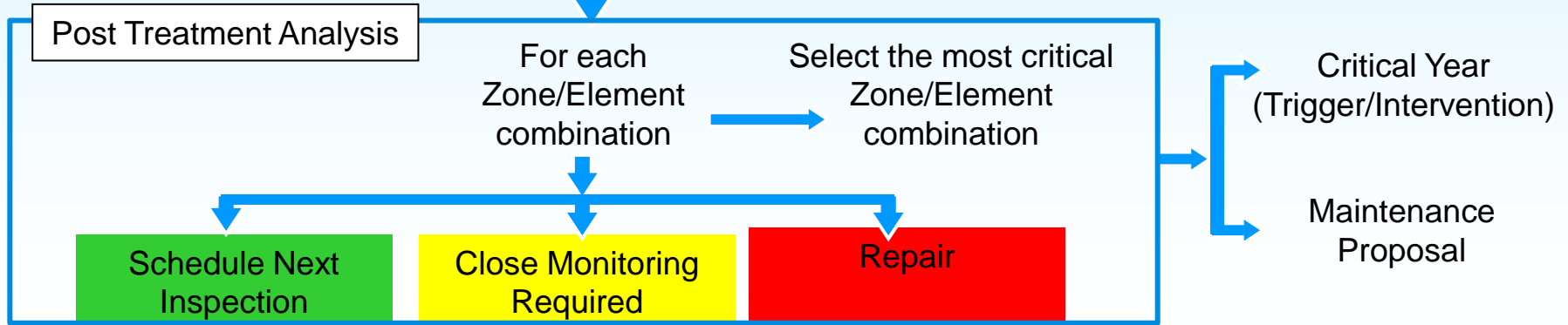
Full Analysis
Chemical Analysis

STADIUM[®] Expert System



Degradation Analysis per Zone and Element

Evaluate Degradation
with STADIUM[®]



STADIUM[®] Expert System

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

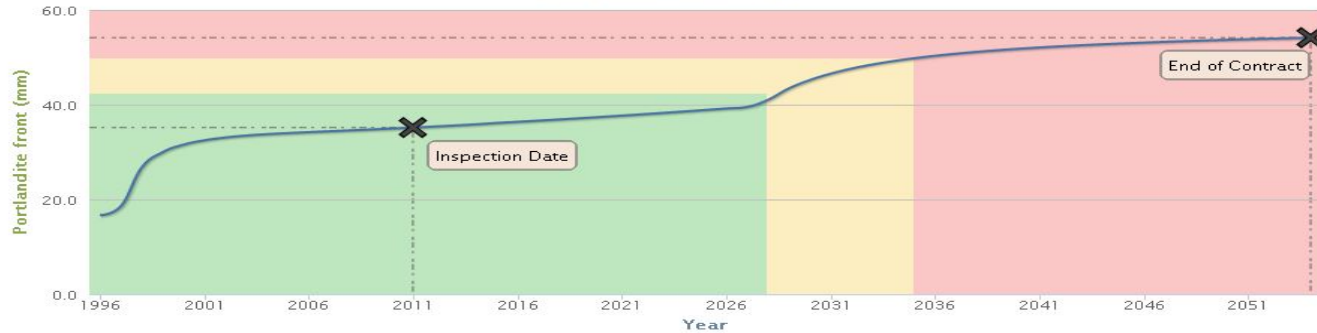
chemical degradation

chloride-induced corrosion

carbonation-induced corrosion

Portlandite analysis

Source: SIMCO Technologies



— Front of Portlandite @ 35.686g/kg

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

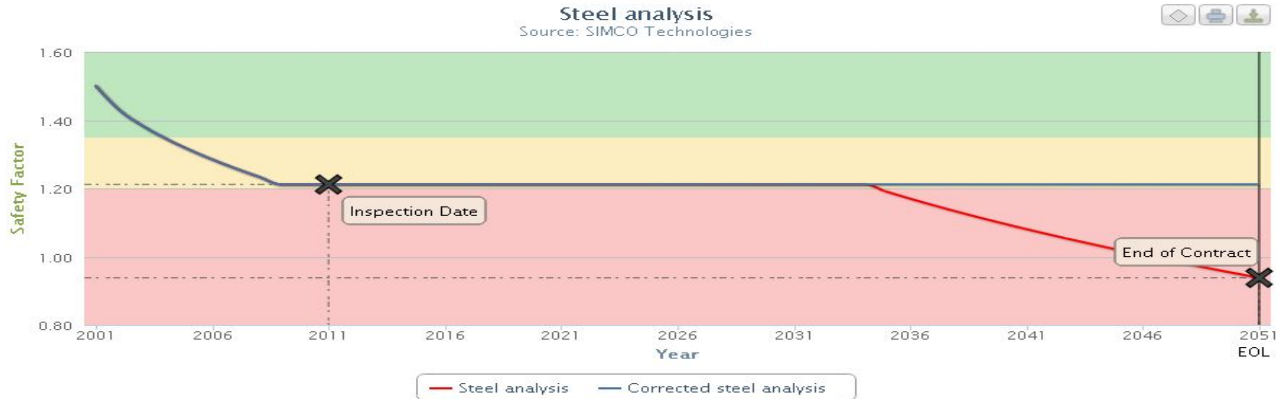
Flags

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

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

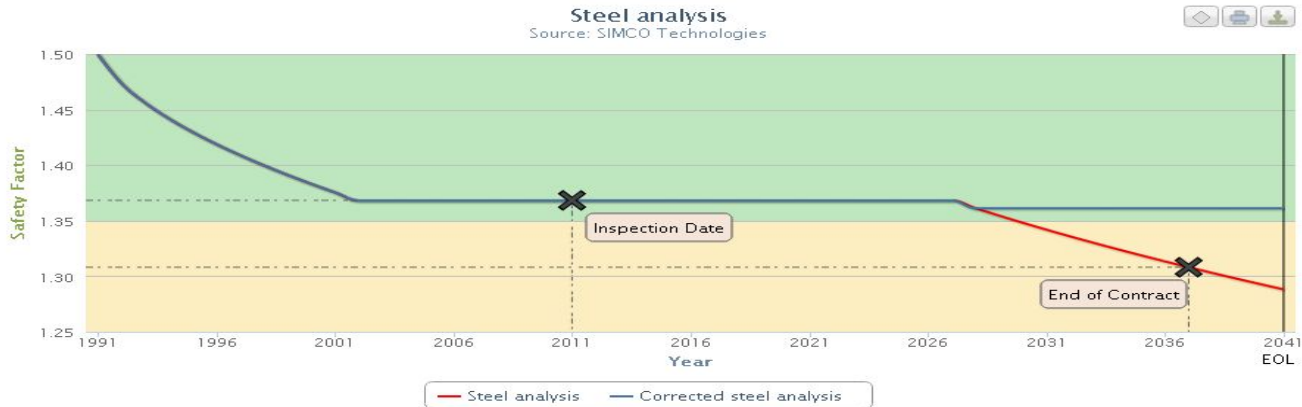
Safety Factor	
Initial (2001)	1.500
Inspection (2011)	1.212

1st hole				
	Strength		Ground	
	Global	Local	Global	Local

STADIUM[®] Expert System

Evaluation Order "150057" on Section "H-L-N-MV-037-KAD-002-B"

Current Analysis Year: 2011 Inspection Date Year: 2011 Corrosion Scale: 2.862 Construction Year: 1991

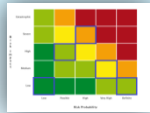


Alert 0

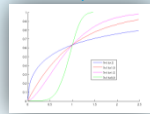
Safety Factor	
Initial (1991)	1.500
Inspection (2011)	1.368
EOC (2037)	1.308

	Strength		Ground	
	Global	Local	Global	Local
Critical Zone	4	4	3	1

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

AMprover[®] Expert System

Amprover next (Server: \SQLEXPRESS database: AMDB301_HbR)

Home Master data Risk analysis Rams analysis Clusters Life cycle cost Priority box Reports

Risks van 112

Risk properties Bindings Optimize RBI Assigned significant items

ID: 495 Failure mode: Algemeen Failure category 1: normatief
 Name: Schade/ aantasting bolder Failure category 2: verborgen
 Description: Schade/ aantasting bolder

Cause Remarks Used by log

Cause:
 Nummering niet leesbaar

Consequences:
 Insnijding bolder. Bepering gebruik kade/steiger. Economisch verlies klant/HbR.

Results

Risk before prev. actions
 € 231
 Preventive action costs
 € 5
 Risk after prev. actions
 € 46

Fmeca without prev. actions Preventive actions Prev. actions table Fmeca with preventive actions

Veiligheid	Duurzaamheid	Reputatie \ esthetica	Beschikbaarheid	Directe technische kosten	10.000 jaar	5000 jaar	500 jaar	100 jaar	15 jaar	5 jaar	jaarlijks	<maand
geen melding	geen vervuiling / melding	geen gevolgen	beschikbaar	0								
melding, geen verzuim	melding, geringe vervuiling	interne melding	beschikbaar	500,-								
licht letsel, kort verzuim	melding, vervuiling opruimen	imago schade	>1 uur niet beschikbaar	5.000,-								
letsel zonder invaliditeit	ernstige vervuiling	lokale media, claims	>1/2 dag niet beschikbaar	20.000,-				0,120*				
ernstig letsel met?	ernstige vervuiling, calamiteit	landelijke media, claims en imago schade	<1 week niet beschikbaar	75.000,-								
mortaliteit	verlies vergunning	internationale media, grote imago schade	>2 maanden niet beschikbaar	200.000,-								
€ 100		€ 5.000	€ 500	€ 17.500								
1	1	3	7									

Show values (default) Show custom values

Mtbf: 100 Emphasize

Prioritization



Amprover next (Server: \SQLEXPRESS database: AMDB301_HbR)

Home Master data Risk analysis Rams analysis Clusters Life cycle cost Priority box Reports

Priority Filters

Version: Normal

- Unassigned
 - H-L-N-MV
 - H-L-N-MV-171
 - H-L-N-MV-171-KAD-001
 - H-L-N-MV-171-KAD-002
 - H-L-N-MV-171-KAD-005
 - H-L-N-MV-010
 - H-L-N-MV-010-KAD-001
 - H-L-N-MV-010-KAD-002
 - H-L-N-MV-010-KAD-010
 - H-L-N-MV-037
 - H-L-N-MV-047
 - H-L-N-MV-072
 - H-L-N-MV-180
 - H-L-N-MV-172

PriorityBox 4 van 29

Select tasks based on priority

ID: 4497 Name: H-L-N-MV-171-KAD-001 Version: 2012001

Category: Kademuur Part of: H-L-N-MV-171 Budget: Budget sum of parts: Budget available:

Status: Responsible:

Budgeted cost Priority cost and risk Remarks Used by log

Enable task selection Task selection dirty

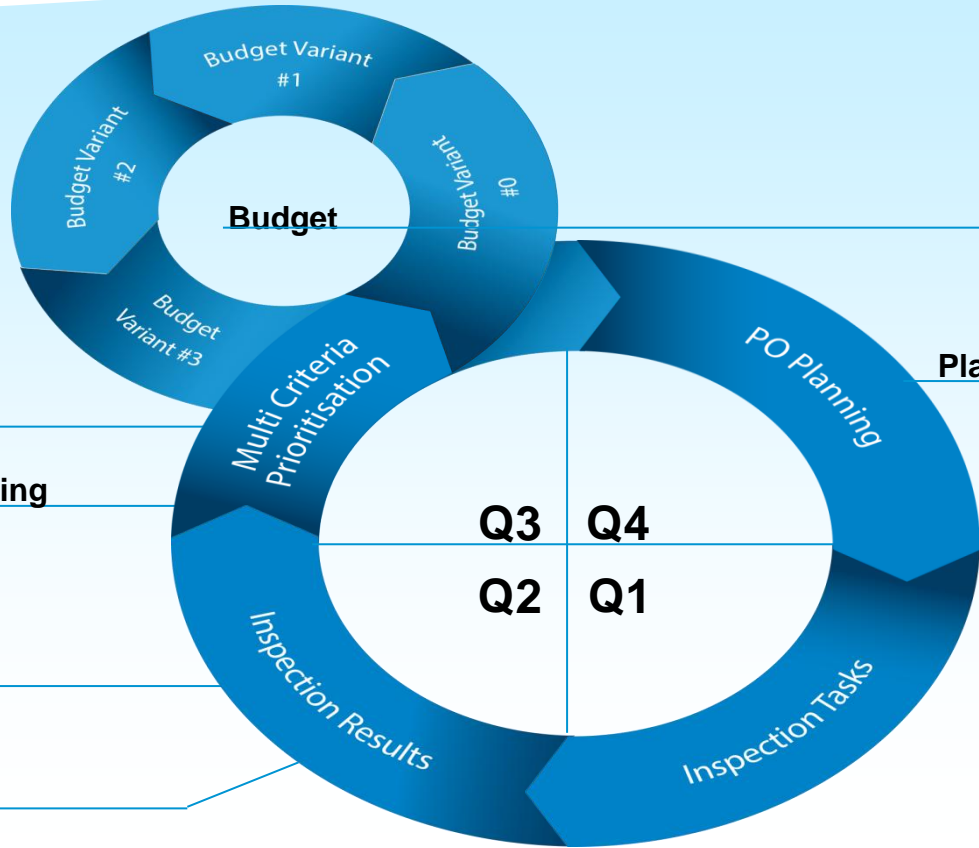
Totals Budget costs: € 299.417 Cost selected: Cost not selected: € 299.417 Risk delta: € 258 Risk current year: € 8.266

Priority groups Priority tasks Priority tasks without inspection

Find on: ID Selection:

Sequen generat	Task description	Risk	Si description	Qualit score	Risk factor	Priori code	Execute status	Risk this year	Risk	Slack	Slack interval	Risk delta	2012	2013	2014	2015	2016	Number of times	Exec year	
	Install / replace KB	Corrosion of bolts	H-L-N-MV-171-KAD-001-A	89	0.046	1.00	Standard time	€ 17	€ 52									1,000	2017	
	Install / replace KB	Corrosion of bolts	H-L-N-MV-171-KAD-001-E	89	0.046	1.00	Standard time	€ 17	€ 52									1,000	2017	
	Clean drainage outlets	Drop in ground level	H-L-N-MV-171-KAD-001-B	89	0.036	1.00	Standard time	€ 38	€ 113								€ 31	1,000	2016	
	Clean drainage outlets	Drop in ground level	H-L-N-MV-171-KAD-001-C	89	0.036	1.00	Standard time	€ 38	€ 113								€ 31	1,000	2016	
	Clean drainage outlets	Drop in ground level	H-L-N-MV-171-KAD-001-D	89	0.036	1.00	Standard time	€ 38	€ 113								€ 31	1,000	2016	
	Replace rubber fender	Fender-partial damage /	H-L-N-MV-171-KAD-001-A	89	0.330	1.00	Standard time	€ 46	€ 551									1,000	2017	
	Replace rubber fender	Fender-partial damage /	H-L-N-MV-171-KAD-001-E	89	0.330	1.00	Standard time	€ 46	€ 551									1,000	2017	
235	Replace rubber fender	Fender-partial damage /	H-L-N-MV-171-KAD-001-A	89	0.330	1.00	Execute	€ 46	€ 551			€ 20.000						1,000	2012	
	Replace rubber fender	Fender-partial damage /	H-L-N-MV-171-KAD-001-B	89	0.330	1.00	Standard time	€ 46	€ 551									€ 23.039	1,000	2016
	Replace rubber fender	Fender-partial damage /	H-L-N-MV-171-KAD-001-C	89	0.330	1.00	Standard time	€ 46	€ 551									€ 23.039	1,000	2016
	Replace rubber fender	Fender-partial damage /	H-L-N-MV-171-KAD-001-D	89	0.330	1.00	Standard time	€ 46	€ 551									€ 23.039	1,000	2016
	Replace rubber fender	Fender-partial damage /	H-L-N-MV-171-KAD-001-E	89	0.330	1.00	Execute	€ 46	€ 551				€ 20.000					1,000	2012	
253	Addition of repair plates	Breaking of bolts	H-L-N-MV-171-KAD-001-A	89	0.150	1.00	Execute	€ 35	€ 70			€ 198	€ 36.187					1,000	2012	
254	Addition of repair plates	Breaking of bolts	H-L-N-MV-171-KAD-001-E	89	0.150	1.00	Execute	€ 35	€ 70				€ 249					1,000	2012	
	Replace expansion joint	Drop in ground level	H-L-N-MV-171-KAD-001-A	89	1.350	1.00	Standard time	€ 1.153	€ 2.305									1,000	2017	
	Replace expansion joint	Drop in ground level	H-L-N-MV-171-KAD-001-E	89	1.350	1.00	Standard time	€ 1.153	€ 2.305									1,000	2017	
	Replace stairs	Damage to safety stairs	H-L-N-MV-171-KAD-001-A	89	0.076	1.00	Standard time	€ 13	€ 26									1,000	2017	
	Replace stairs	Damage to safety stairs	H-L-N-MV-171-KAD-001-E	89	0.076	1.00	Standard time	€ 13	€ 26									1,000	2017	

Annual Maintenance Cycle



Prioritizing

LIKELIHOOD	CONSEQUENCES			
	INSIGNIFICANT	MINOR	MODERATE	SEVERE
ALMOST CERTAIN	4	3	2	1
LIKELY	3	2	1	0
POSSIBLE	2	1	0	0
UNLIKELY	1	0	0	0
RARE	0	0	0	0

Risk Analyzing



Simulating



Predicting



Planning



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 \$\$\$**

KMS - Awards

At the iMaintain Infrastructure Congress that took place in November 2012, by the Dutch Association for Effective Maintenance (NVDO), Port of Rotterdam's KMS system is awarded "Project of the Year 2012".



At the 2013 ACEC Engineering Excellence Awards, Port of Rotterdam' Quaywall Modeling System (KMS) receives the 2013 ACEC New York Gold Award



KMS 2.0

- **Improving KMS:**
 - Develop deterioration models for rubber (fenders) and timber
 - Implement experiences
 - Validate the steel deterioration model in other conditions
- **And spread worldwide**
 - Applicable in every port
 - Available for every port

