



# › ASSET MANAGEMENT OF CIVIL INFRASTRUCTURES

Bleijenberg, A.N. (Arie)

**TNO** innovation  
for life

# INFRA PROVIDERS, INDUSTRY, RESEARCH



Rijkswaterstaat  
Ministerie van Infrastructuur en Milieu



World Class Maintenance Infrastructure

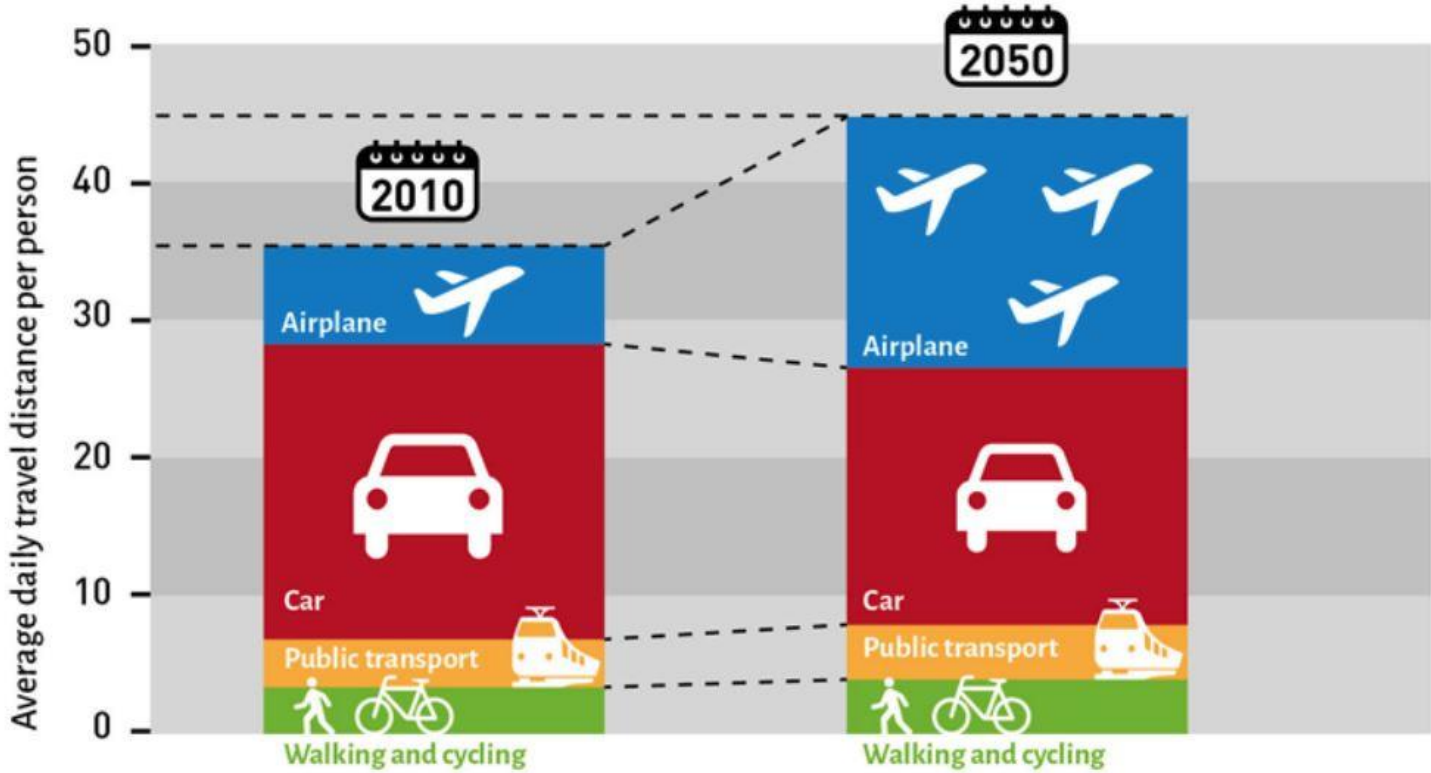


# VALUE DUTCH CIVIL INFRA 374 BILLION EURO MAINTENANCE/RENEWAL 6 - 9 BILLION EURO/Y

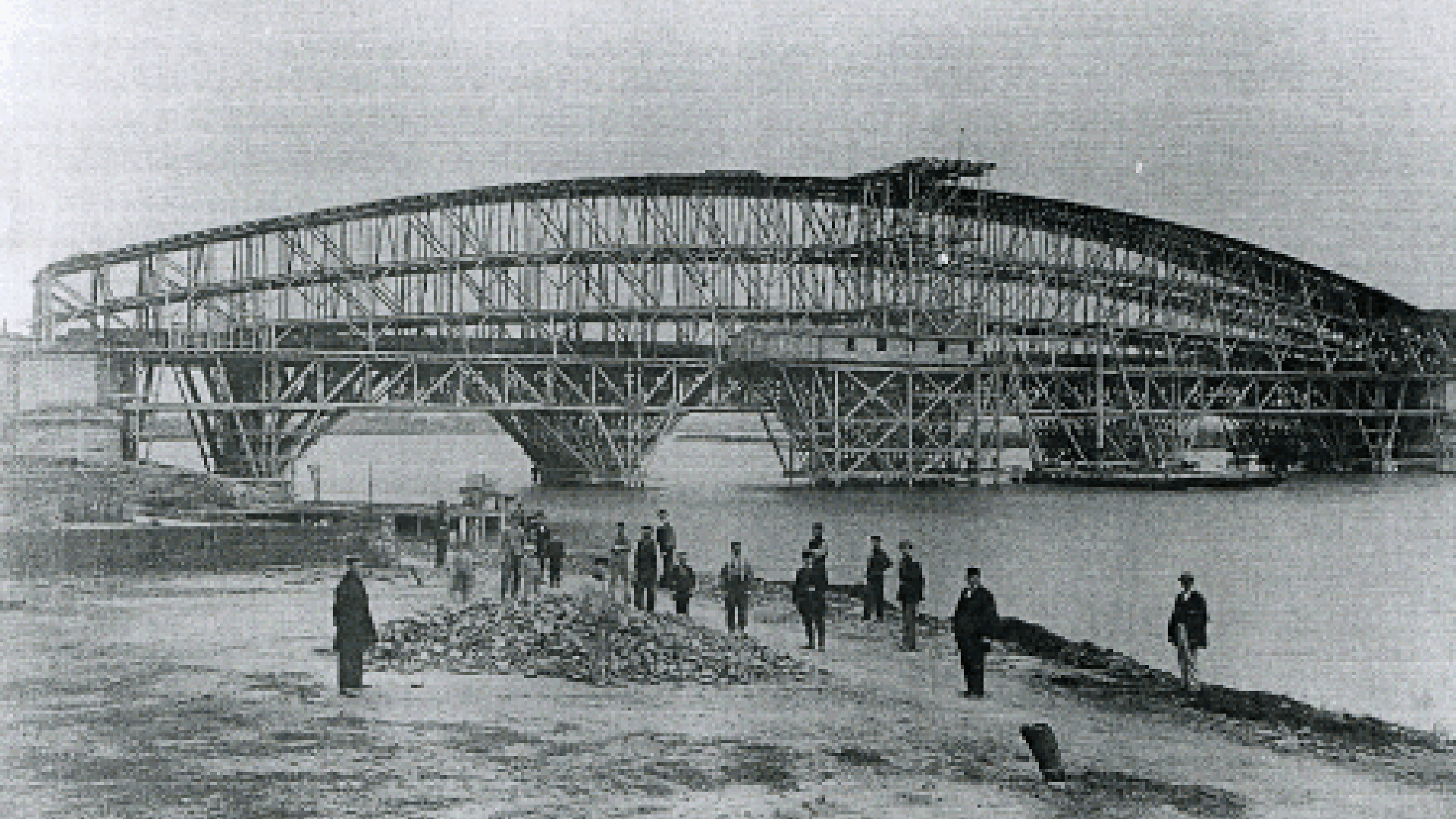


## PUBLIC BALANCE SHEET (2016)

	Billion Euro
Total assets	198
Financial assets (public debt)	- 285
Non financial assets	484
Infrastructures	268
Buildings	88
Oil and gas	41
Land	35
Other	104







# F16



## Operational:

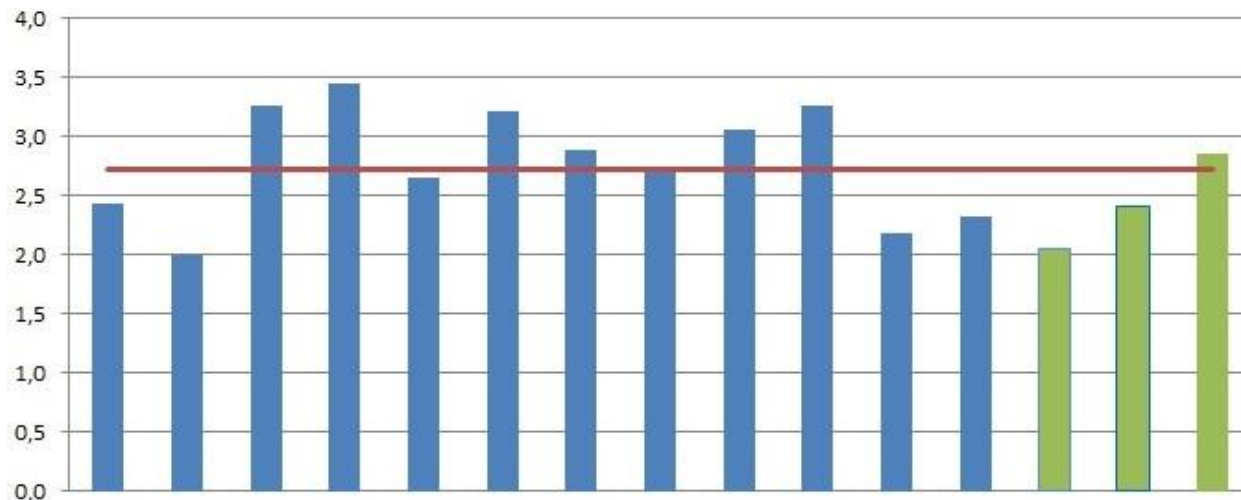
- 34% 2005
- 36% 2006

## Causes:

- Increasing number of exercises
- Priority operational during missions
- Many organizational changes
- Many different projects
- Reduced staff (quality and quantity)
- Insufficient operational budgets



# BENCHMARK ASSET MANAGEMENT



## QUOTES FROM SUPERVISING AUTHORITIES

- › “Main conclusion is that the structural safety of existing bridges and viaducts is insufficiently secured.”
- › “Systematic and central supervision of the maintenance condition of civil structures is not possible.”
- › “We can not judge whether policies for management and maintenance of civil structures is effective and efficient.”
- › “The administrator misses crucial information to make justified decisions tot postpone maintenance.”
- › “Insufficient budget for upkeep is a recurrent phenomenon and is to a large extent caused by insufficient knowledge of the size and condition of the network, including the objects.”

# PAVEMENT INSPECTION



Rijkswaterstaat  
Ministerie van Infrastructuur en Milieu

› 2009 - 2010: **Feasibility**



TRL – 1

› 2010 - 2011: **Proof of concept**



TRL – 2

TRL – 3

TRL – 4

› 2012 - 2013: **First generation**



TRL – 5

TRL – 6

› 2013-2014: **New vehicle**



TRL – 7

TRL – 8

› 2014-2015: **Update (colour)**



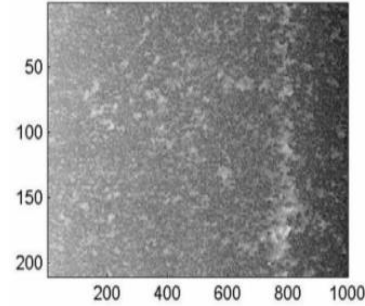
TRL – 9

# FROM ROAD MEASUREMENT DATA TO 3D MODEL

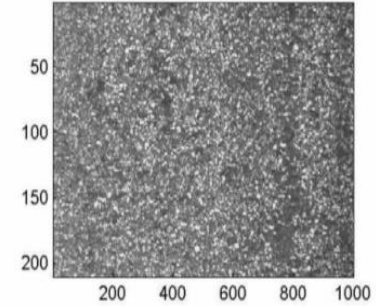
Road survey vehicle



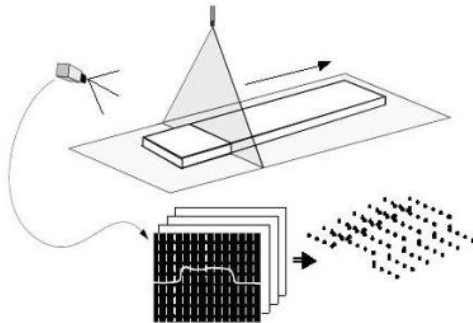
Range data



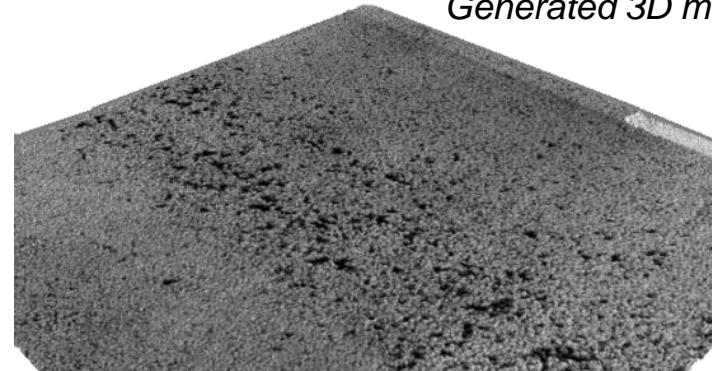
Intensity data



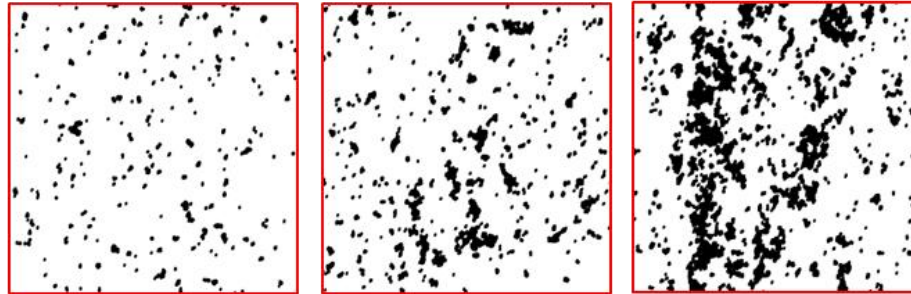
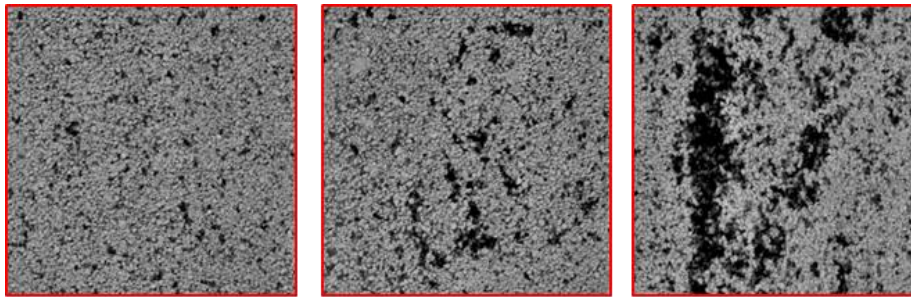
Laser triangulation



Generated 3D model



# CLASSIFICATION OF STONE LOSS



6%

Low (6-10%)



12%

Moderate (11-20%)

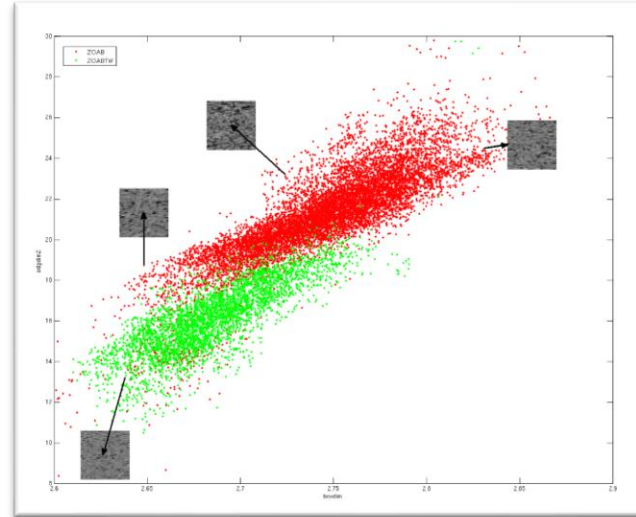
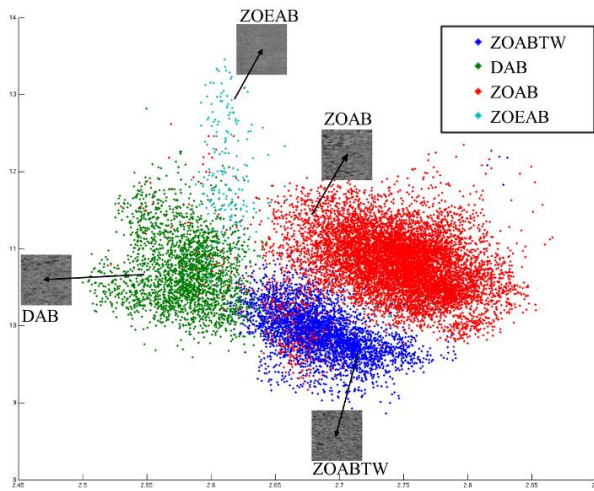


22,5%

High (>20%)

stone loss  
severity class

# PAVEMENT TYPE CLASSIFICATION



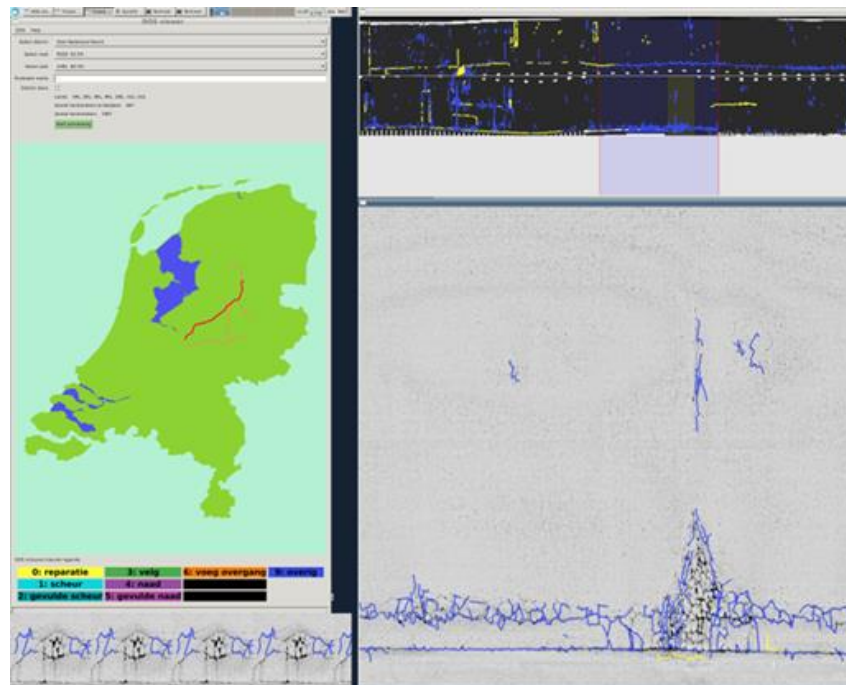
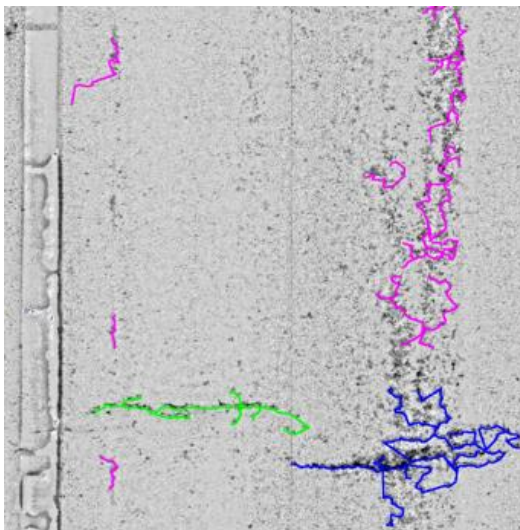
Results 27,128 road sections:  
Overall: > 98.8% correct  
Porous Asphalt: > 99,7 % correct

Texture analysis

COMBID	DAB	DAD	EAB	EOB	NOVACP	OAB	SMA	ZOAB	ZOABTW	ZOEAB

# CRACK CLASSIFICATION

- › Semi-automatic approach



## SUMMARY

- › Accurate measurement of ravelling on Porous Asphalt
  - › High speed and 'in-traffic'
  - › Good repeatability and reproducibility
- › System operational since 2012
  - › Replacing most visual inspections
- › Modelling maintenance intervals
  - › Based on ravelling & cracking
- › Accurate pavement type classification





# SEWER PIPELINES

## Current model

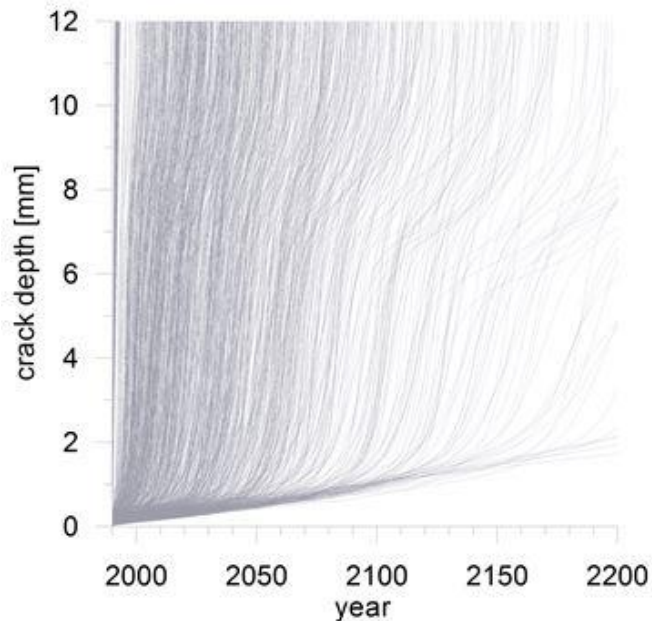
- › Age
- › Material

## Future model

- › Age
- › Material
- › + Soil structure
- › + Subsidence
- › + Configuration



# AGING STRUCTURES: MANY UNCERTAINTIES



- › Condition?
- › Failure mechanism?
- › Determinants of technical lifetime?
- › Loading history?
- › Repair and maintenance history?
- › Assessment method?
- › Technical lifespan?
- › Functional lifespan?



# ASSETS

- › Large societal value
- › Each year one year older
- › Many unknowns

## + MANAGEMENT

- › Knowledge
- › Organisation

## = CHALLENGE

- › How?
- › What is the benefit?



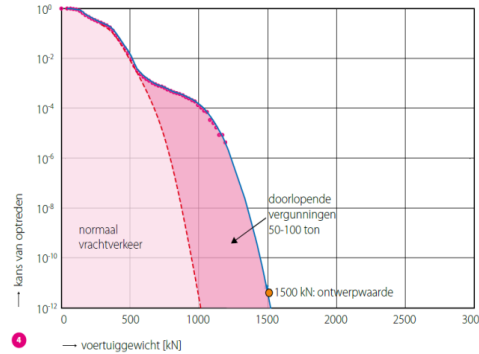
## REQUIRED KNOWLEDGE

- › Network and stock: length, number, location, age, condition
- › Register of failures, incidents and damages
- › Cost drivers
- › **Risks (= chance of failure x impact)**
- › **Hidden strength**
- › **Condition**
- › **Data management**
- › **Technical lifespan**
- › Functional lifespan

# RISK MATRIX

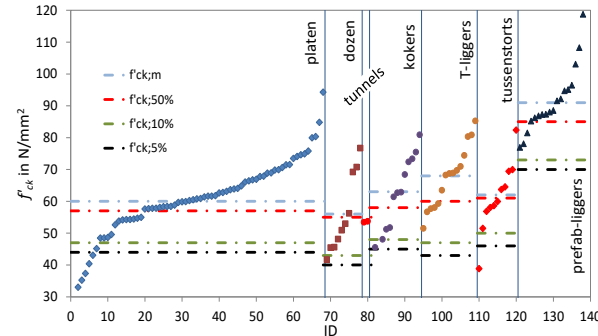
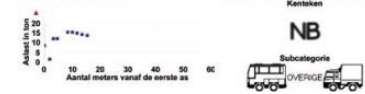
Potentiele gevolgen op de bedrijfswaarden												Frequentie of kans van optreden						
	Beschikbaarheid					Veiligheid	Milieu / gezondheid	Kwaliteit Leefomgeving	Imago	Wet & Regelgeving	Economie	Vrijwel onmogelijk	Zelden	Incidenteel	Jaarlijks	Maandelijks	Wekelijks	
												<0,003jr	0,003 - 0,03 jr	0,03 - 0,3 jr	0,3 - 3 jr	3 - 30 jr	>30 jr	
<b>Extrem</b>	Hoofdwatertekening buiten gebruik in stormseizoen > 100 dagen	Netwerkschakel niet beschikbaar >5.000.000 gebruiksdagen	nt	nt	nt	meerdere doden	Overstort droog weer situatie > 5.000 m3	Overstort neerslag situatie > 365.000 m3	Overlast van water op straat >2.500 gebruiksdagen	Opstappen wethouder	veroordeling	>€ 10.000.000,-	<b>M</b>	<b>H</b>	<b>ZH</b>	<b>O</b>	<b>O</b>	<b>O</b>
<b>Ernstig</b>	Secundaire watertekening /schutsluis buiten gebruik in stormseizoen > 100 dagen	Netwerkschakel niet beschikbaar < 5.000.000 gebruiksdagen	nt	nt	nt	een dode, blijvend ernstig letsel / invaliditeit	Overstort droog weer situatie > 5.000 m3	Overstort neerslag situatie > 365.000 m3	Overlast van water op straat >2.500 gebruiksdagen	Wethouder bengt / meerdere raadsragen in actualiteitsraad	strafzaak	€ 1.000.000,- tot € 10.000.000,-	<b>L</b>	<b>M</b>	<b>H</b>	<b>ZH</b>	<b>O</b>	<b>O</b>
<b>Betekentlijk</b>	Secund waterkern g buiten gebruik in stormseizoen 10 tot 100 dagen	Netwerkschakel niet beschikbaar 50.000 tot 500.000 gebruiksdagen	nt	Openbare groenvoorziening niet beschikbaar <100.000 gebruiksdagen	nt	ernstig gewond	Overstort droog weer situatie > 500 m3	Overstort neerslag situatie 3.650 - 36.500m3	Overlast van water op straat 25 tot 250 gebruiksdagen	Raadvragen	dwangbevel	€ 100.000,- tot € 1.000.000,-	<b>V</b>	<b>L</b>	<b>M</b>	<b>H</b>	<b>ZH</b>	<b>O</b>
<b>Middel</b>	Secund waterkern g buiten gebruik in stormseizoen 1 tot 10 dagen	Netwerkschakel niet beschikbaar 5.000 tot 50.000 gebruiksdagen	Openbare verlichting Niet beschikbaar zijn van > 1000 gebruiksdagen	Openbare groenvoorziening niet beschikbaar 10.000 tot 100.000 gebruiksdagen	Speelvoorziening niet beschikbaar >10.000 gebruiksdagen	gewond met verzuim	Overstort droog weer situatie > 5.00 m3	Overstort neerslag situatie 365 - 3.650 m3	Overlast van water op straat 2,5 tot 25 gebruiksdagen	Veel negatieve publiciteit	schikking	€ 10.000,- tot € 100.000,-	<b>V</b>	<b>V</b>	<b>L</b>	<b>M</b>	<b>H</b>	<b>ZH</b>
<b>Klein</b>	Schutsluis bereepsvaat buiten gebruik 1 tot 10 dagen	Netwerkschakel niet beschikbaar < 500 tot 5000 gebruiksdagen	Openbare verlichting Niet beschikbaar zijn van 100 tot 1000 gebruiksdagen, aaneengesloten langs een weg of fietspad	Openbare groenvoorziening niet beschikbaar 1000 tot 10.000 gebruiksdagen	Speelvoorziening niet beschikbaar <1000 gebruiksdagen	bijna ongeval	Overstort droog weer situatie > 0,5 - 5 m3	Overstort neerslag situatie 35 - 365 m3	Overlast van water op straat <0,25 tot 2,5 gebruiksdagen	Negatieve publiciteit	bete	€ 1.000,- tot € 10.000,-	<b>V</b>	<b>V</b>	<b>V</b>	<b>L</b>	<b>M</b>	<b>H</b>
<b>Uitsluitend</b>	Schutsluis bereepsvaat buiten gebruik 1 dag	Netwerkschakel niet beschikbaar < 5000 gebruiksdagen	Openbare verlichting Niet beschikbaar zijn van 10 tot 1000 gebruiksdagen, aaneengesloten langs een weg of fietspad	Openbare groenvoorziening niet beschikbaar < 10000 gebruiksdagen	Speelvoorziening niet beschikbaar <10000 gebruiksdagen	gevaaslike situatie	Overstort droog weer situatie > 0,5 m3	Overstort neerslag situatie < 36 m3	Overlast van water op straat <0,25 gebruiksdagen	Geringe publiciteit	waarschuwing / schade	< € 1.000,-	<b>V</b>	<b>V</b>	<b>V</b>	<b>V</b>	<b>L</b>	<b>M</b>

# PROVE HIDDEN STRENGTH

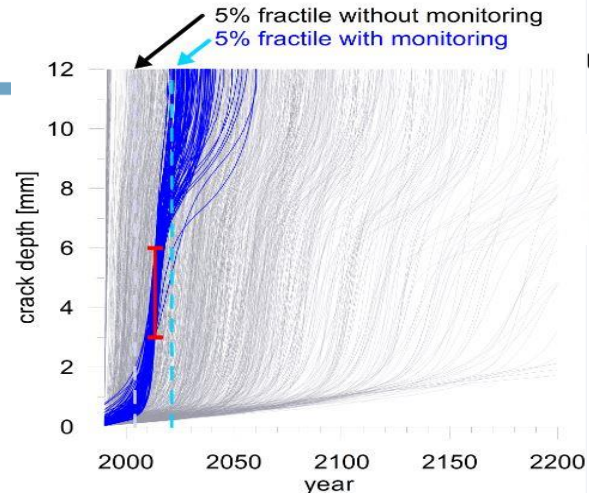


Datum	14 April 2008
Tijd	17:44:46
Rijstrook	5 R-R
Meetlocatie	RW 004 1 H81 R
Subcategorie	O13311
Soetheid (km/uur)	82

	asdruk (ton)		lengte (m)
	dynamisch	statisch	
<b>totaal</b>	<b>105.9</b>	<b>0.0</b>	<b>17.74</b>
aa 1	8.2	0.00	
aa 2	1.3	1.93	
aa 3	11.8	1.31	
aa 4	11.9	1.41	
aa 5	15.2	3.77	
aa 6	15.2	1.05	
aa 7	14.7	1.69	
aa 8	14.0	1.81	
aa 9	13.5	1.87	



# MONITORING



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Ministerie van Infrastructuur en Milieu



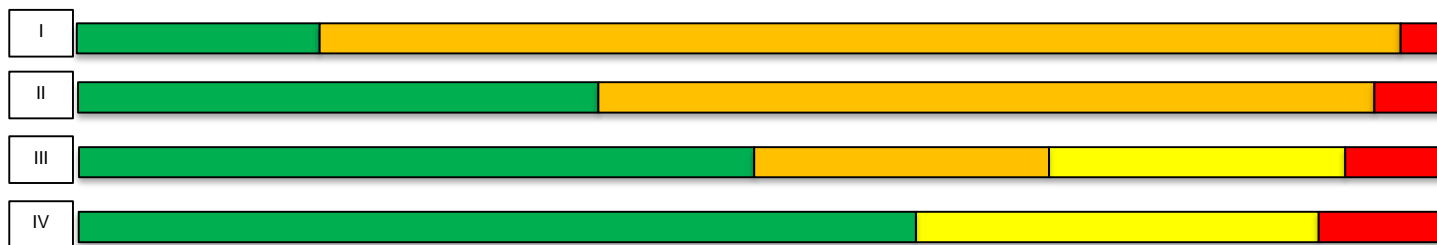




# KNOWLEDGE FOR MANAGEMENT

- › **Asset Management of entire network and stock of structures**
  - › **Sound long term budget planning**
  - › **Accountability for budget**
- 
- › Higher uptime
  - › Increased reliability
  - › Reduced lifecycle costs

# ASSET MANAGEMENT STOCK OF BRIDGES



Assessment levels:

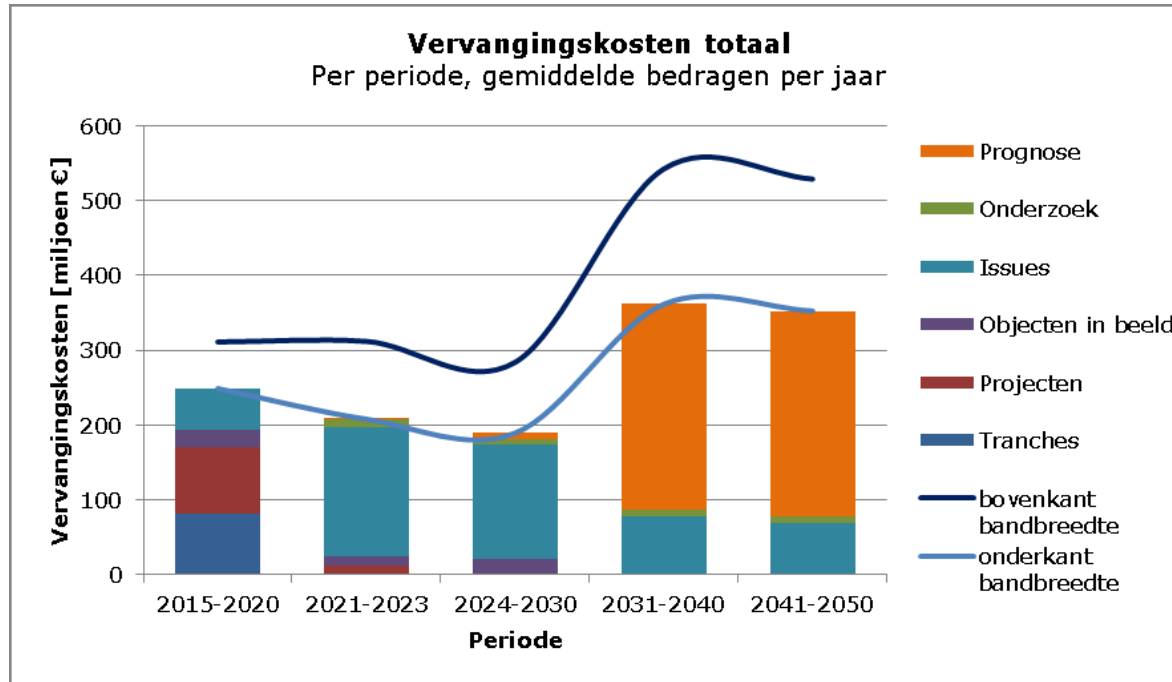
- I Standard assessment
- II Advanced assessment
- III Strain gauges and FEM calculations
- IV Monitoring (Acoustic emission, guided wave, phased array)

Proven structural safety:

- Satisfied
- Additional assessment required
- Permanent monitoring required
- Renovation or renewal required



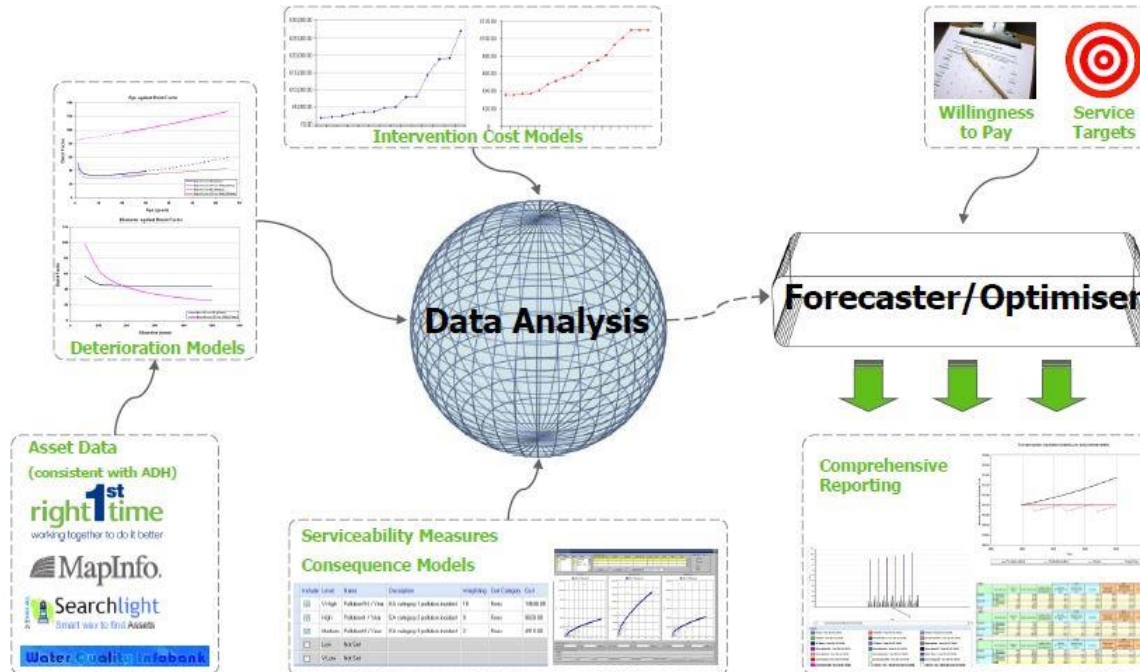
# LONG TERM BUDGET



# MAINTENANCE BACKLOG?

- › “Maintenance backlog and network enlargement should have been incorporated in the estimation of the required budget.”
- › “Consequence of the chosen maintenance approach is that the maintenance backlog has grown.”
- › Germany needs an additional 7,2 billion euro per year to dispose of backlog and for the replacement of aging infrastructures.
- › “The available budget determines the maintenance effort.”
- › “Based on available data, the method used and an analysis of 5 tracks, we cannot conclude that maintenance backlog exists”
  
- › We do not know!

# ASSET MANAGEMENT IN 2040



# ASSET MANAGEMENT TOWARDS 2040 (1)

- › “We have the impression that the process of implementing Asset Management has been – and maybe still is - underestimated.”
- › “According to our expectation this will take many more years.”
  
- › Advice supervisor:
  - › Do not reorganize frequently
  - › Use quantitative indicators
  - › Set up a central data house
  - › Incorporate replacement in Asset Management
  - › Speed up the process

## ASSET MANAGEMENT TOWARDS 2040 (2)

Now	In 2040
Incident driven	Anticipating
Rules of thumb	Condition based
Budget mechanism	Political choice KPI – LCC
Uncertainty about backlog	No or known backlog
Cost	Societal value
Project organization	Management organization



**LEADERSHIP FOR CHANGE !**

# THANK YOU FOR YOUR ATTENTION

Take a look:  
[TIME.TNO.NL](https://time.tno.nl)

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CINEMASSIVE