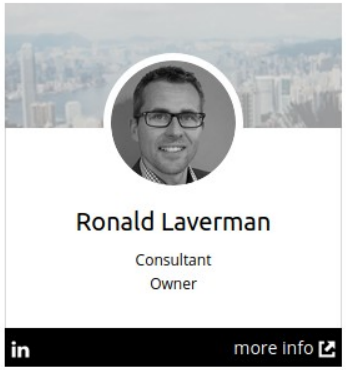
Calculating the optimal replacement moment of pipe assets

a risk based approach

Rolsch Assetmanagement, The Netherlands

Rolsch Assetmanagement BV

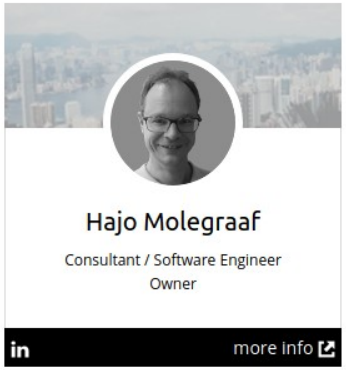
Software and consultancy company for infra world
Located in Enschede, The Netherlands



Ronald Laverman

Consultant
Owner

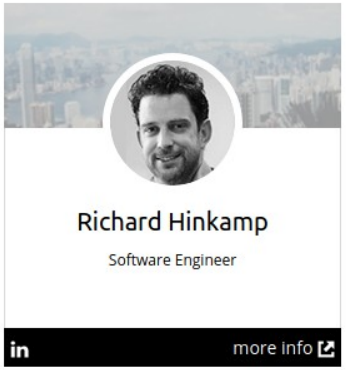
more info



Hajo Molegraaf

Consultant / Software Engineer
Owner

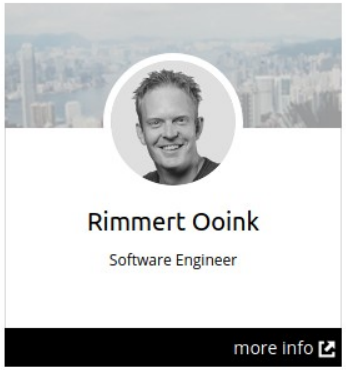
more info



Richard Hinkamp

Software Engineer

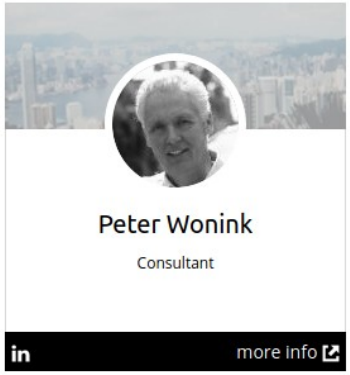
more info



Rimmert Ooink

Software Engineer

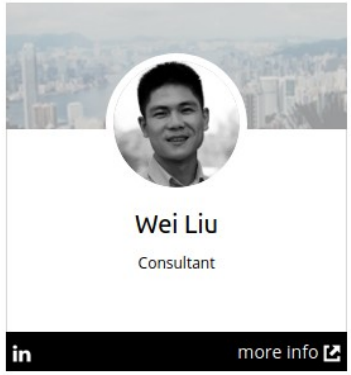
more info



Peter Wonink

Consultant

more info



Wei Liu

Consultant

more info

Inge La Rivière

Software Engineer

meer info

Our Clients

Water companies in the Netherlands

Some clients in the Netherlands:

Water companies:
Waternet, Evides, BrabantWater, WML, WBGR

Cities: Amsterdam, Apeldoorn, Assen, Breda, Hengelo, Haaksbergen, Leeuwarden, … >80 in total

Clients outside the Netherlands:

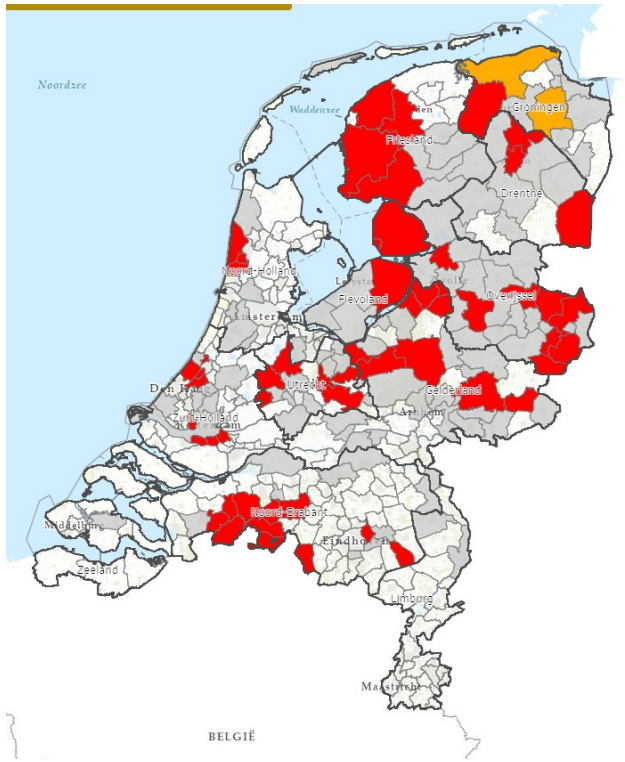
Frankfurt, Germany

Uganda
National Water and Sewer Company

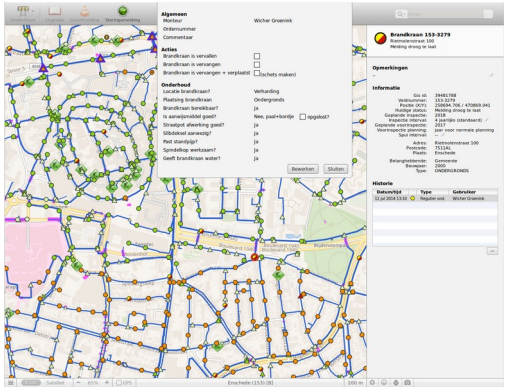
Changzhou, China

Yangzhou, China

Municipalities in the Netherlands

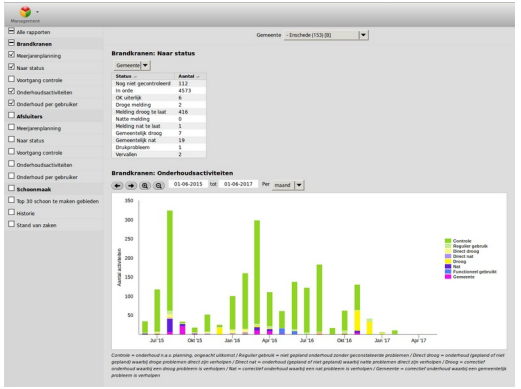


MapKit: web based maintenance application

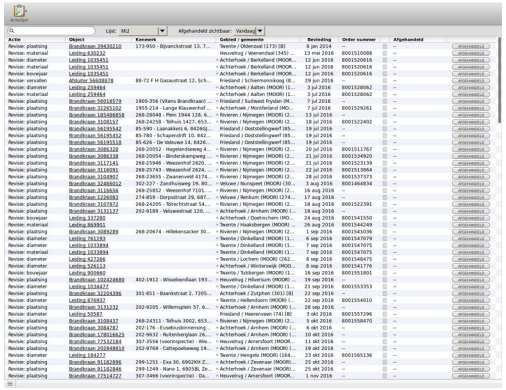


Cloud based, real time administration

Integrated maintenance registration of
- Pipes
- Valves
- Hydrants
- Fountains
- Flow meters
- etc etc



Risk based maintenance planning
Roadwork registration
Failure reporting
Network cleaning assistant

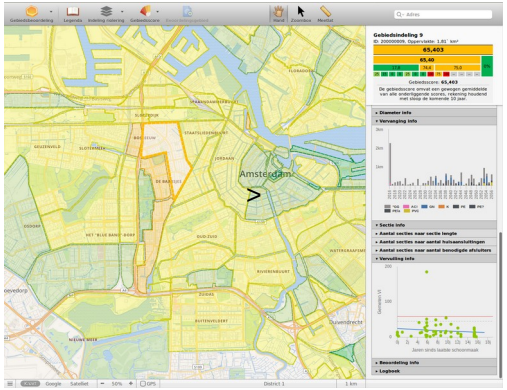


Valve manipulation assistant
calculates effect of closing a valve on the water availability

Progress overview

Task lists

Rating of specific areas



Integration with SAP
Future integration with ESRI

Rasmariant: maintenance prediction

Calculate replacement and inspection moments of pipe assets

Risk based

Two versions: rasmariant-water and rasmariant-sewer

Determination of surrounding objects

Hydraulic flow calculations

Estimation of possible damage

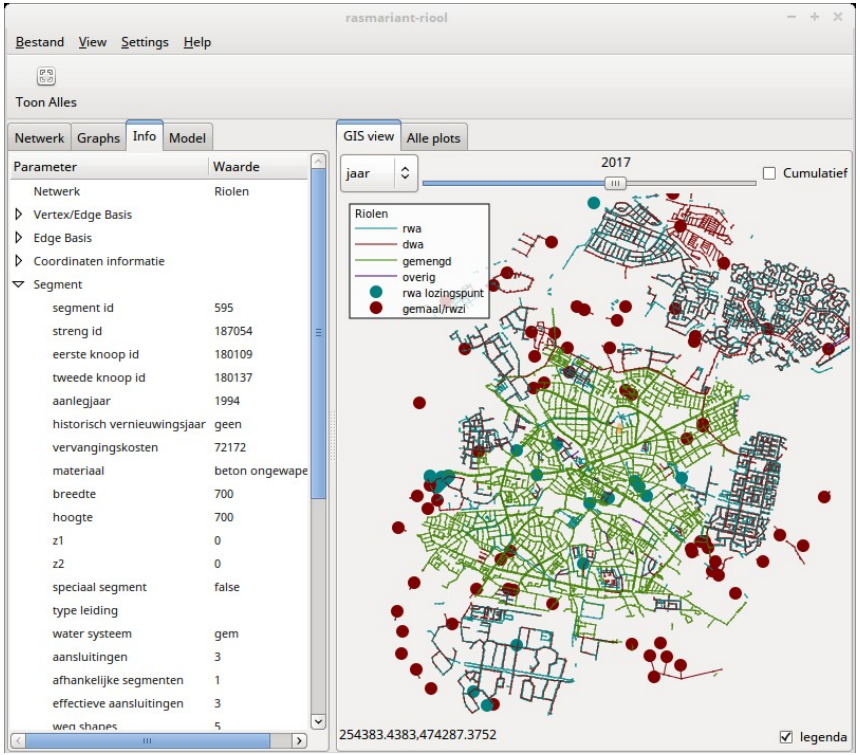
Statistical degradation analysis on measured data

Client specific additional requirements

Calculate financially optimal replacement year

Short term replacement schedule

Long term business strategy



Replacement strategies

1) **Replacement when pipe breaks**
   - Cheap, but system becomes progressively worse

2) **Age based replacement**
   - There is one age limit for all assets
   - Easy to determine, but can result in replacement of good assets

3) **Quality based replacement**
   - There is one quality limit for all assets
   - Age limit becomes dependent on asset quality.
   - Inspections are required

4) **Risk based replacement**
   - There is one risk limit for all assets.
   - Acceptable quality of assets becomes dependent on risk (surrounding and impact in case of failure)

5) **Risk cost versus replacement cost based replacement**
   - Relation between financial risk and replacement cost determine the moment of replacement
   - Risk limit becomes dependent on replacement costs

Rasmariant is capable of working with all of these strategies

Risk based replacement

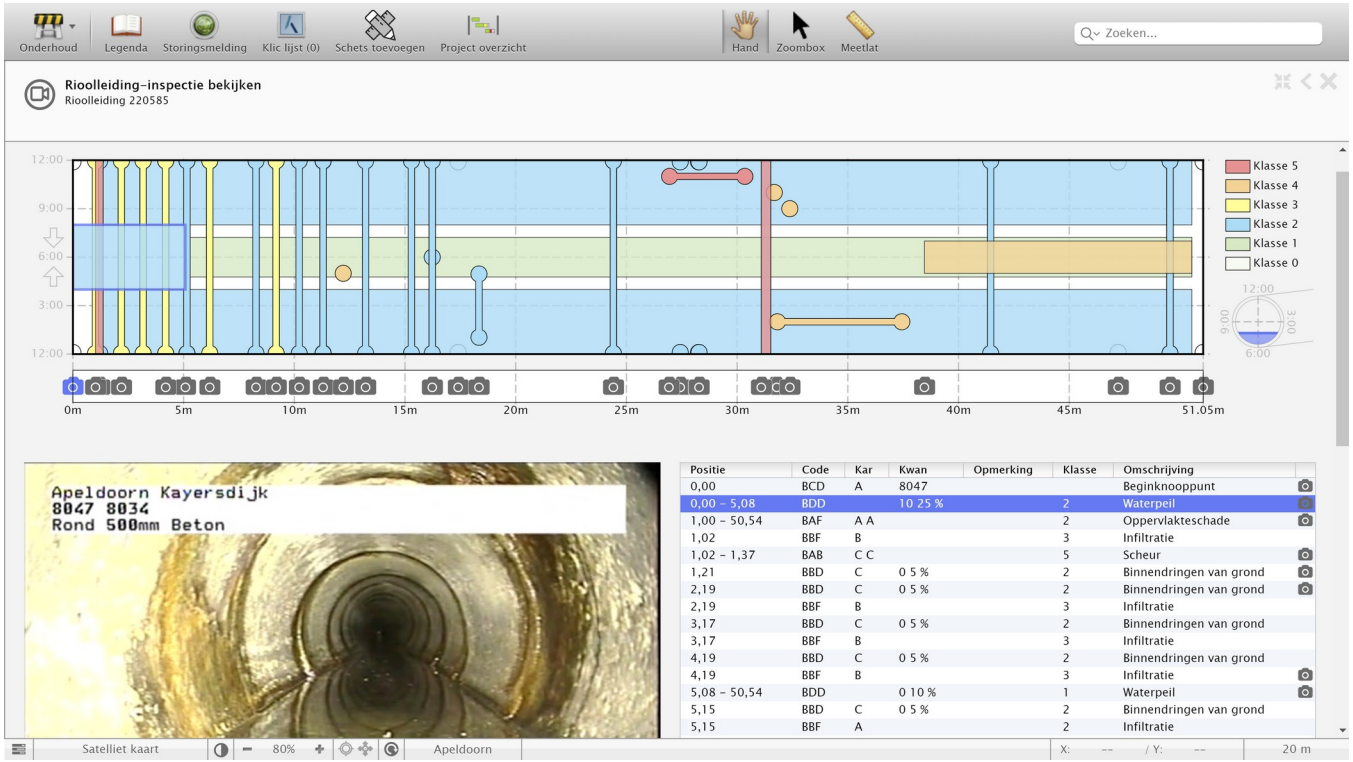
Failure probability		Economic effect	= Risk
	x		high prob x high effect = high risk
	x		low prob x high effect = medium risk
	x		high prob x low effect = medium risk
	x		low prob x low effect = low risk

Inspections

Inspection measurements or failure registrations are imported and processed

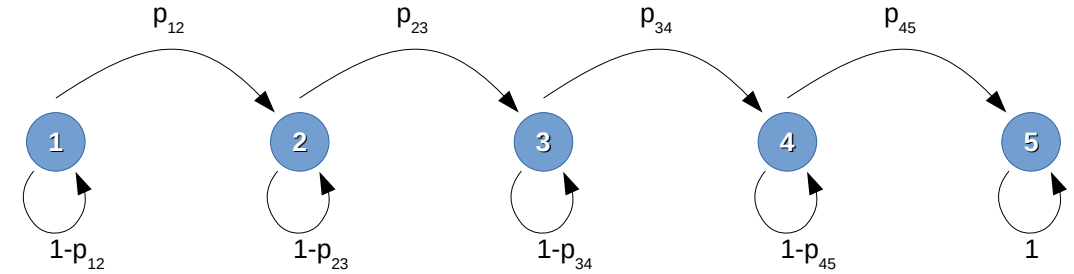
Schematic of pipe with damages

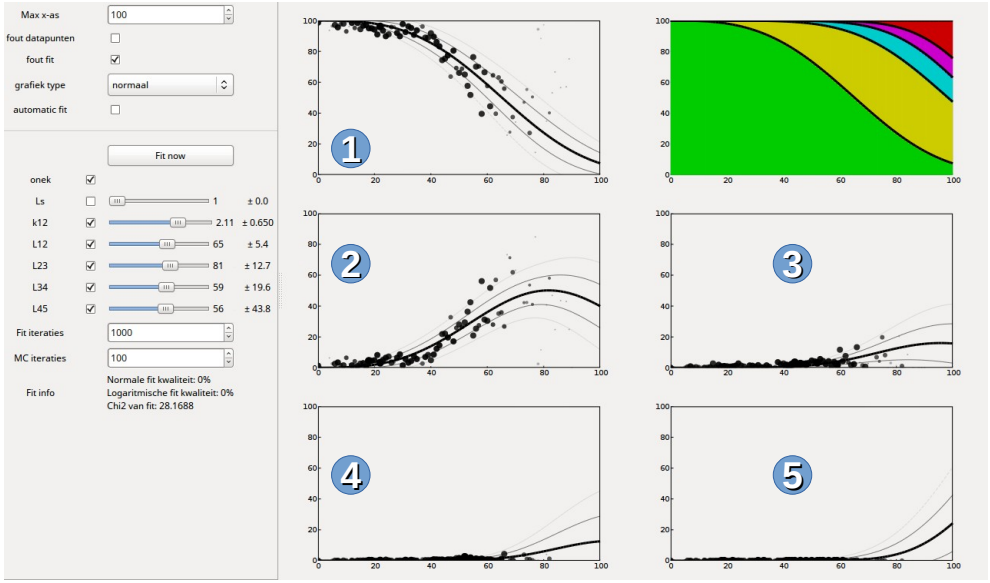
Video of inspected sewerpipe



Registered damages

Degradation analysis using Markov Chain





Degradation of chemical damage of the sewer pipe as a function of age. Going from state 1 (no damage) to state 5 (very serious damage)

Apeldoorn, beton, BAF

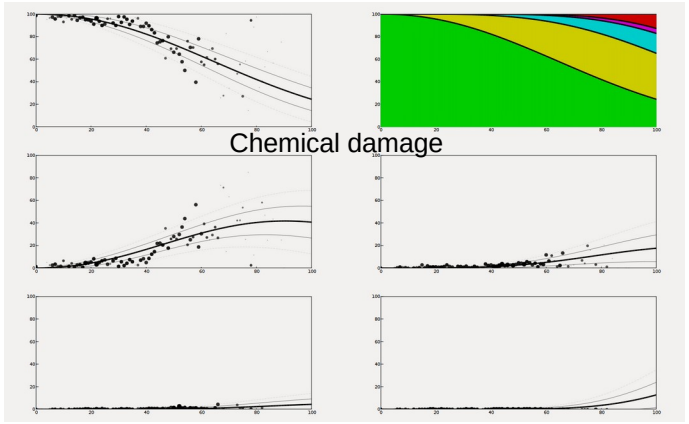
Degradation Analysis

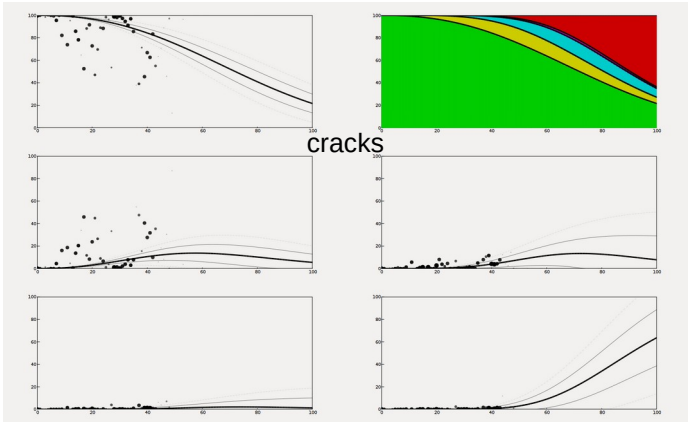
Degradation analysis for

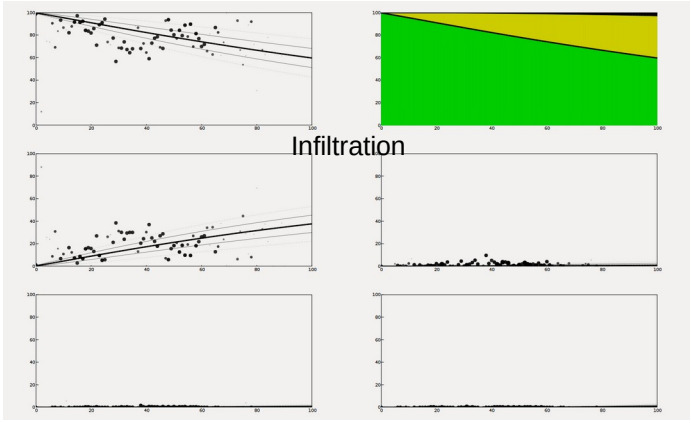
different

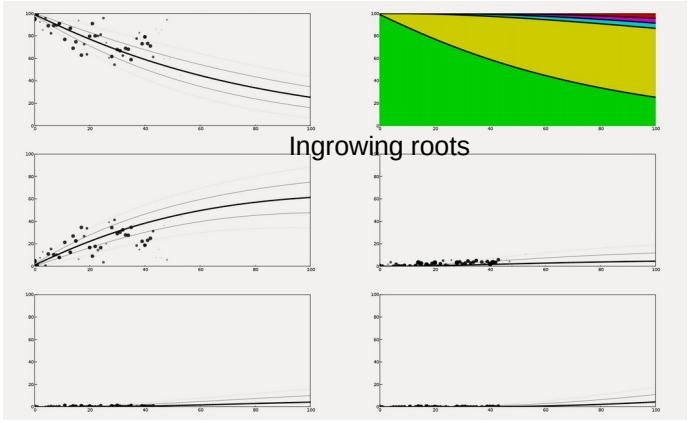
- materials
- diameters
- soils
- specific areas
- defect types
- …

All curves combined result in the failure rate of a class of pipes


Chemical damage

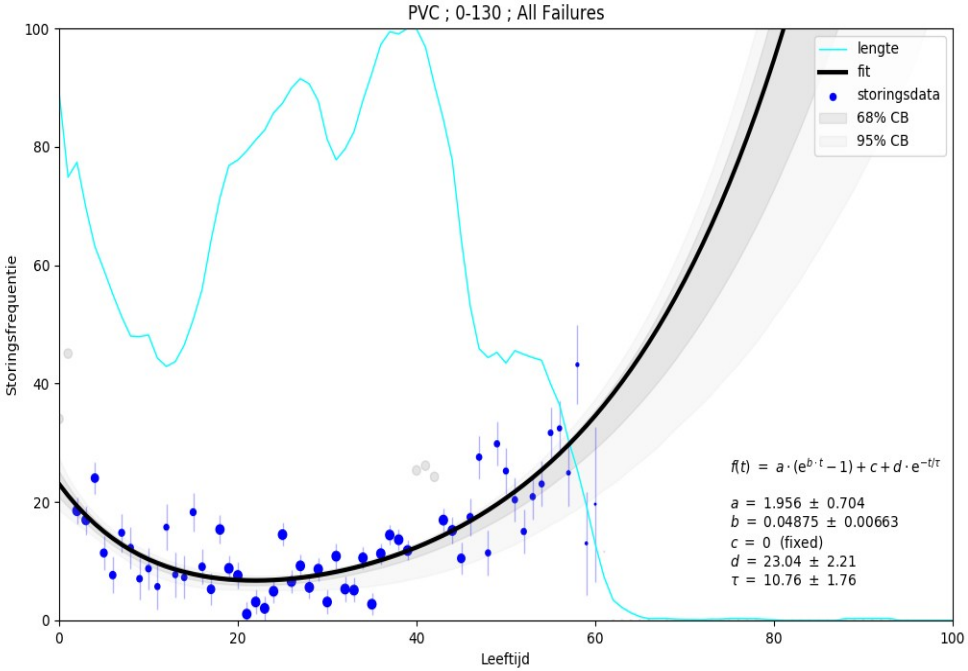

cracks

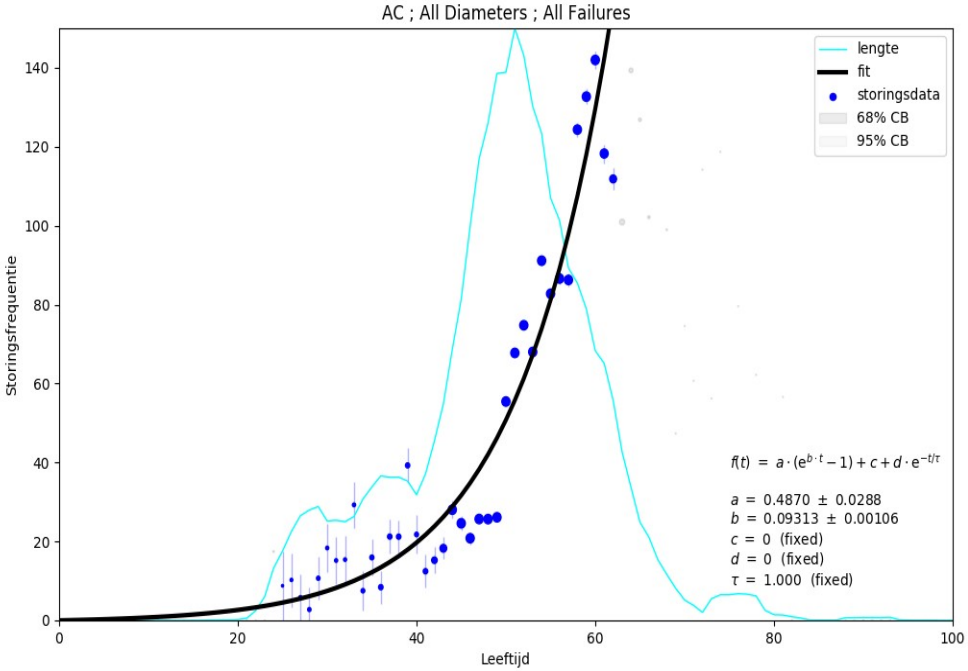

Infiltration


Ingrowing roots

Failure rate for water pipes

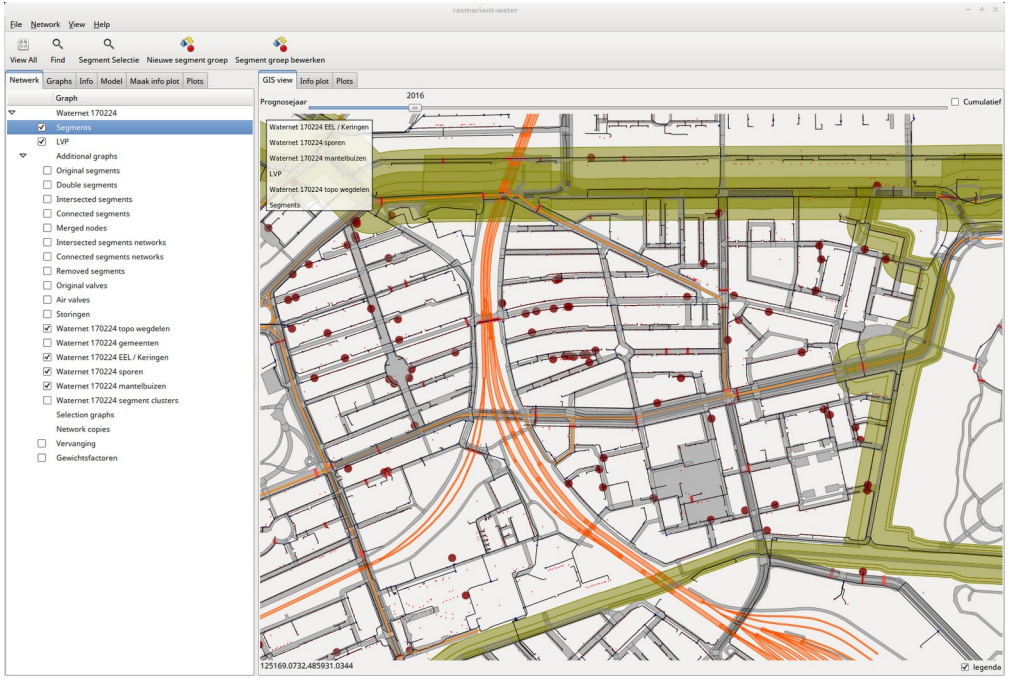
Analysis of historical failure data

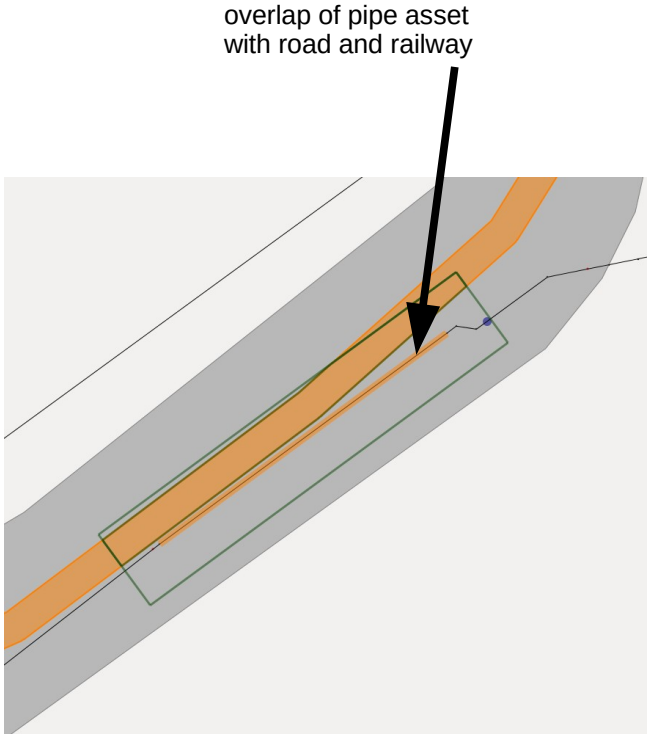




Surrounding factors

For every pipe asset the connection or overlap with other infrastructural element like roads, railways or other elements is determined





Effective number of connected households

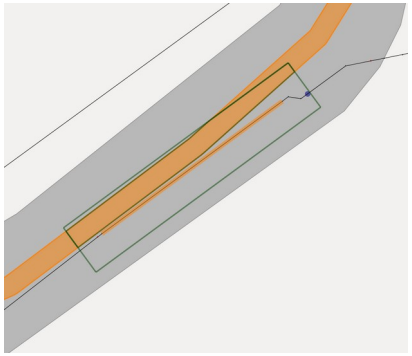
For every (combination of) pipes the effect on the households is calculated if the pipe(s) can not function properly.

Risk costs

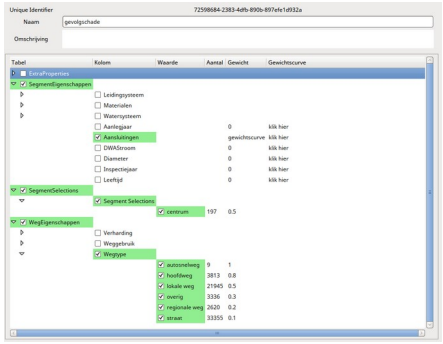
risk costs = failure rate x financial effect

Failure rate can be obtained from the degradation curves

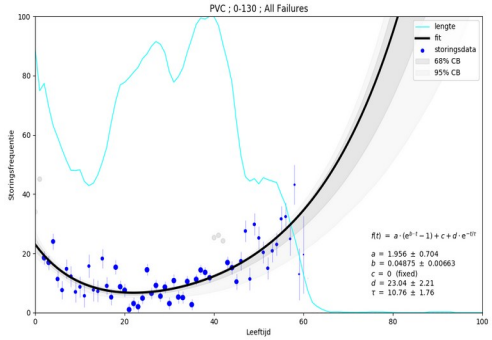
effect is the financial damage when the pipe asset fails



a pipe asset lies below a road (or railway, or ...)



the financial damage in case of failure is given in a damage table



degradation analysis results in the failure probability curve

Replacement age of assets

Costs of an pipe asset:

1. One time costs
2. Yearly reoccurring fixed costs
3. Age dependent costs

Criterium for maximum age of an asset:

Total costs must be minimal

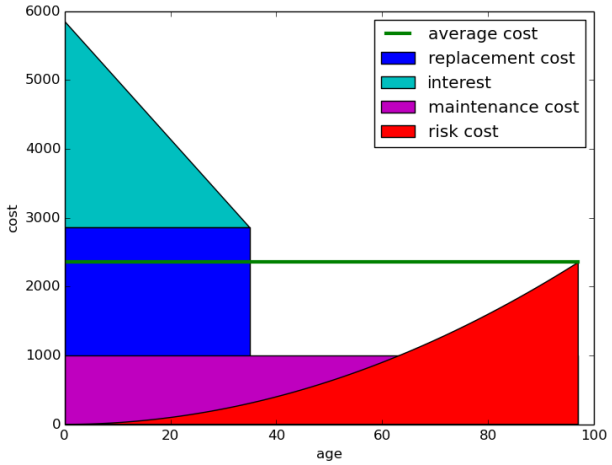
Which is equivalent to:

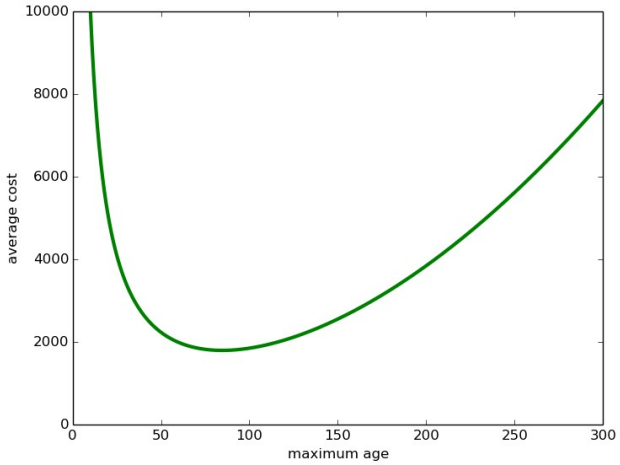
The average costs must be minimal

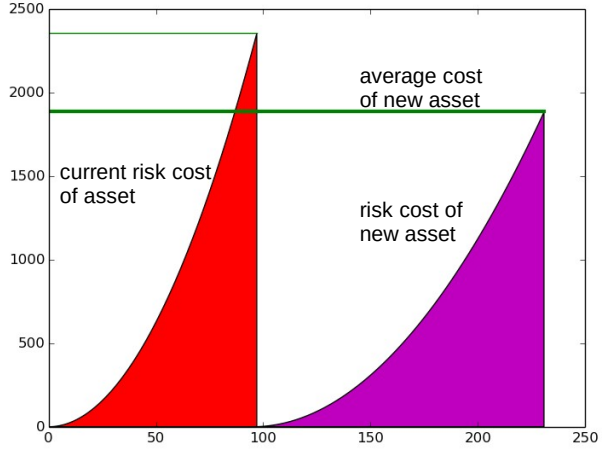
total costs : $K = V + M \cdot L + C \cdot F(L)$

average costs : $G = \frac{V}{L} + M + \frac{C \cdot F(L)}{L}$

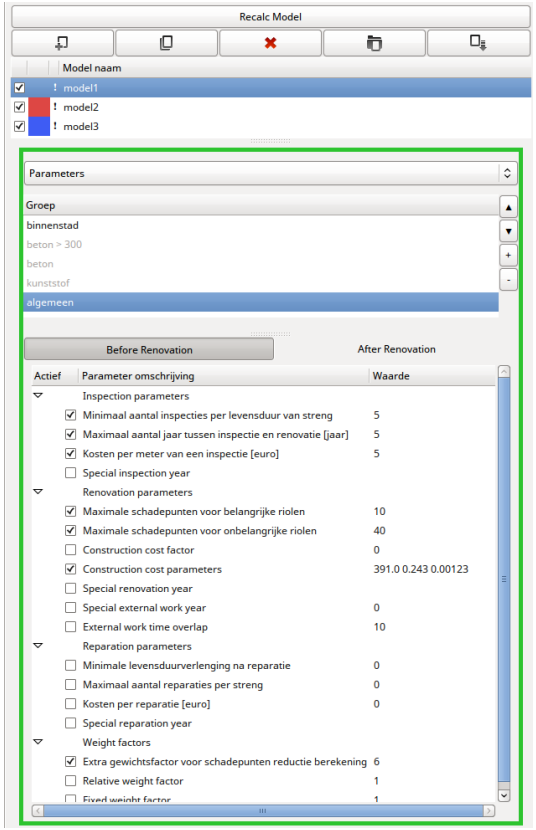
average costs minimum : $\frac{\partial}{\partial L} G = 0$





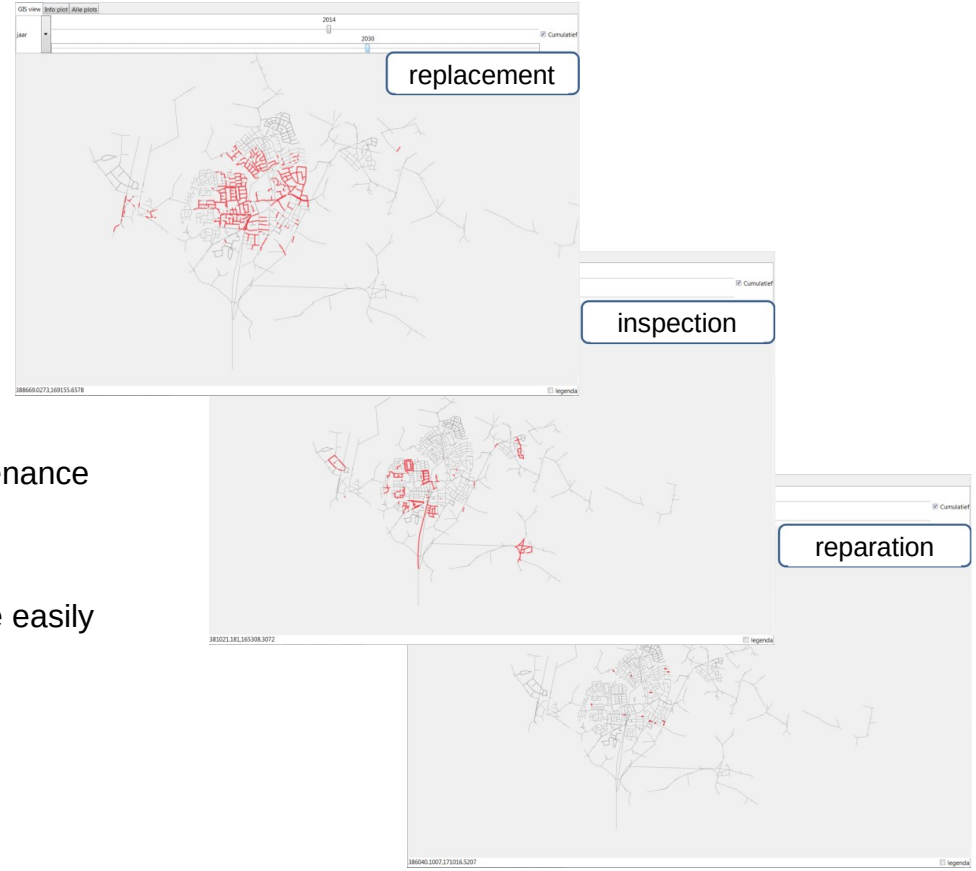


Model calculations and advices

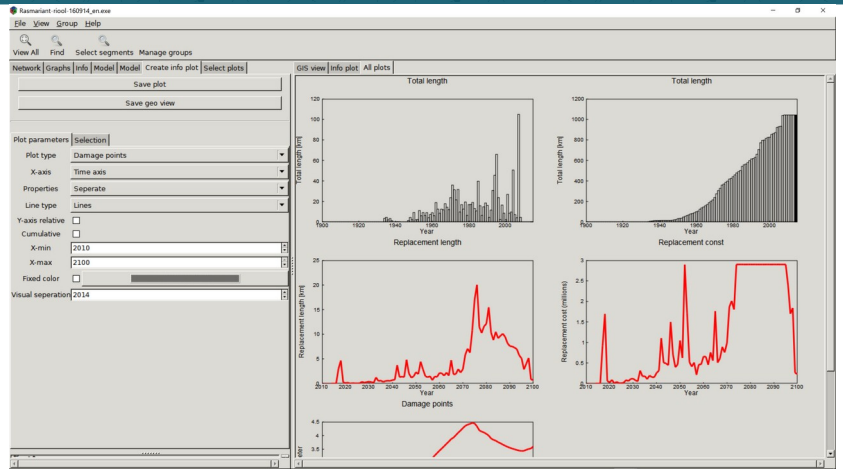


For each pipe asset a maintenance advice is calculated

All calculated parameters are easily checked

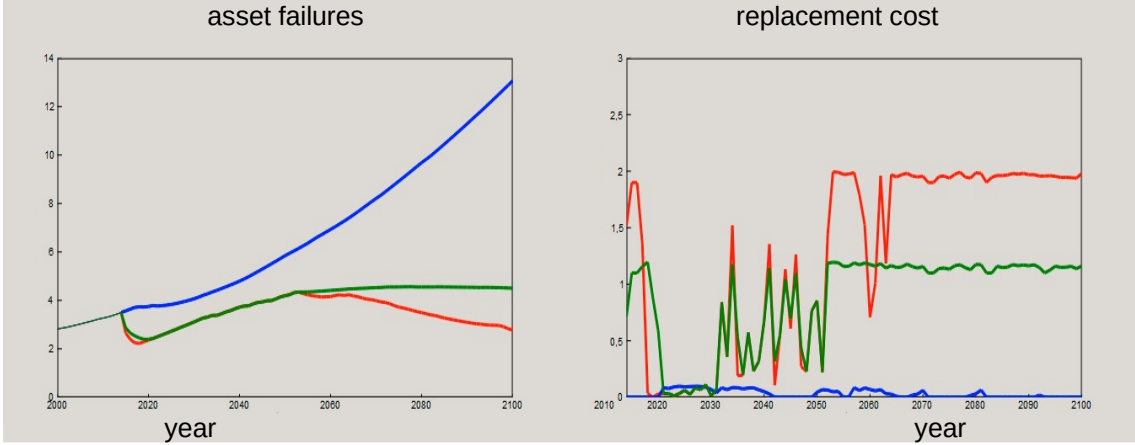


Model calculations



Different models with different specific parameters can be compared

Change in model parameters results in different replacement costs over the years but also in different estimated asset qualities.

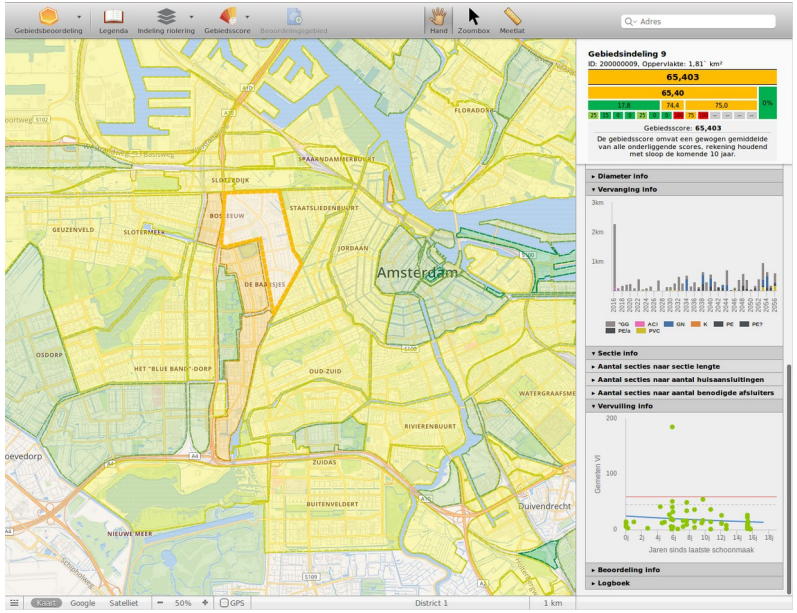


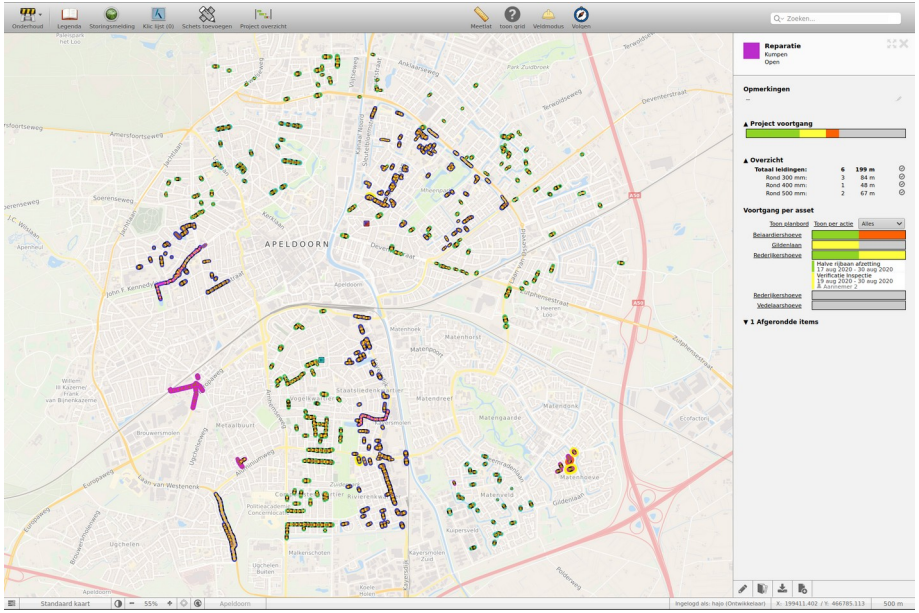
Integral planning

Results from Rasmariant are presented in MapKit, a webbased tool for practical maintenance and scheduling.

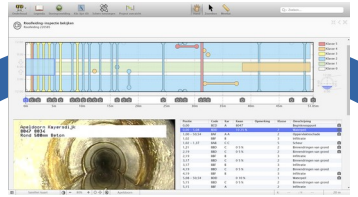
Managers can create an integral planning and make it accessible to the entire organization.

Contracters can register the work progress which is also accessible to the entire organization.

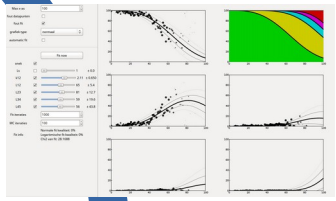




Maintenance Cycle

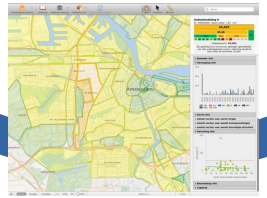


Inspection registration
MapKit

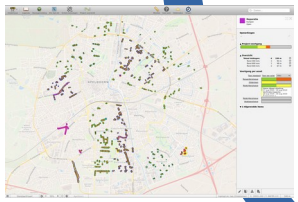


Degradation analysis
Rasmariant

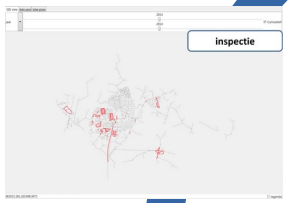
Maintenance prediction
Rasmariant



Integral maintenance planning
MapKit



Detailed maintenance
scheduling & progress
registration
MapKit



Inspection scheduling
Rasmariant

PrimaVera Research

There are many questions that we still have. Some of them are being worked on in the PrimaVera project:

- Extending the equation for replacement to multiple assets at once. If we have two or more pipes of different degradation next to each other, is there an optimal replacement moment for replacing them together?
  Zaharah Bukhsh, Nils Jansen, David Kerkkamp
- Relation between degradation curves for sewer pipes and failure probability.
- Can only a few damage types (like chemical damage) be used as an indicator for the sewer pipe quality?
- What does the client do with the results? What makes him deviate from the calculated replacement moments?
  Bas van Oudenhoven, Rob Basten, Philippe van de Calseyde
- Automated damage detection in video's of sewer pipes using Neural Network
- Improvement of existing video inspection data by advanced post-processing
- Effective number of households due to failing valves
  Lisandro Jimenez, Marielle Stoelinga