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DATA-ENHANCED RELIABILITY ASSESSMENT OF TUNNELS WITH RESPECT TO MAINTENANCE AND RENOVATION

▶ DIEGO ALLAIX

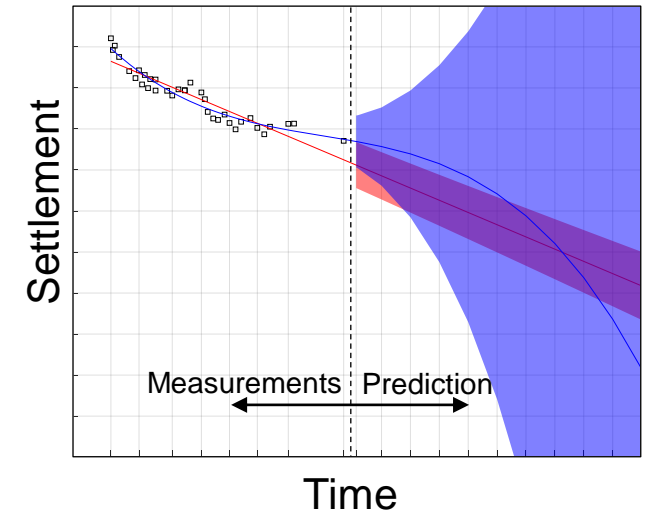
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› WHAT IS NEEDED FOR DATA-ENHANCED MODELLING?

› Predictive performance models based on physics

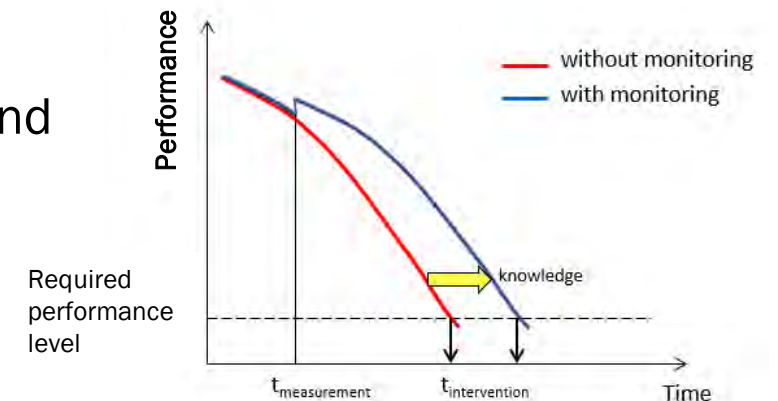
- › Physics-based models are used for design and reassessment
- › Pure data-driven approaches are characterized by large uncertainties



› Updating of predictive models based on monitoring data

› Reliability-based approach based on a 1-year reference period

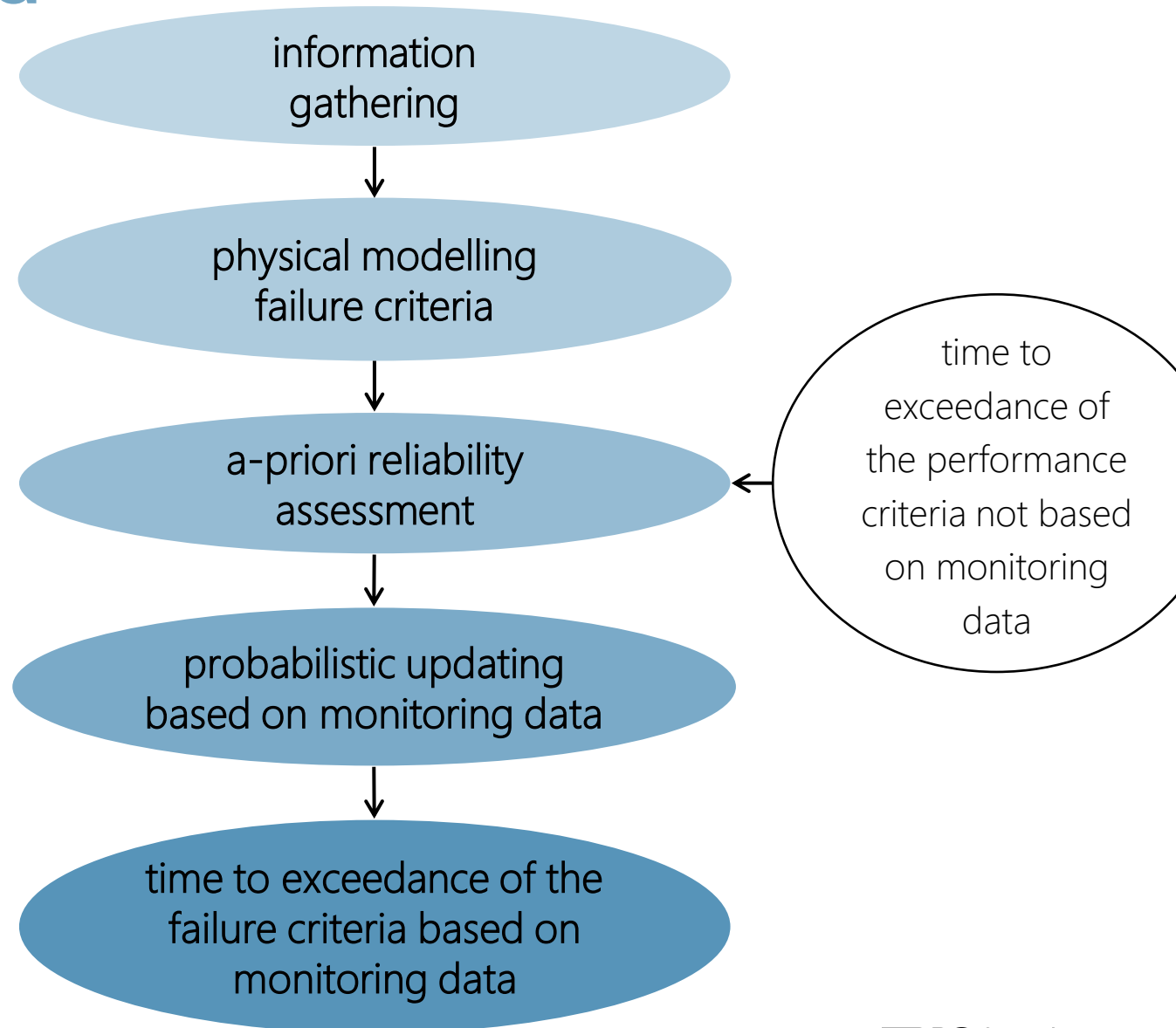
- › It allows to account for the uncertainties of physical parameters and models
- › It enables the updating of the uncertainties as soon as new data become available



› DATA ENHANCED MODELLING APPROACH

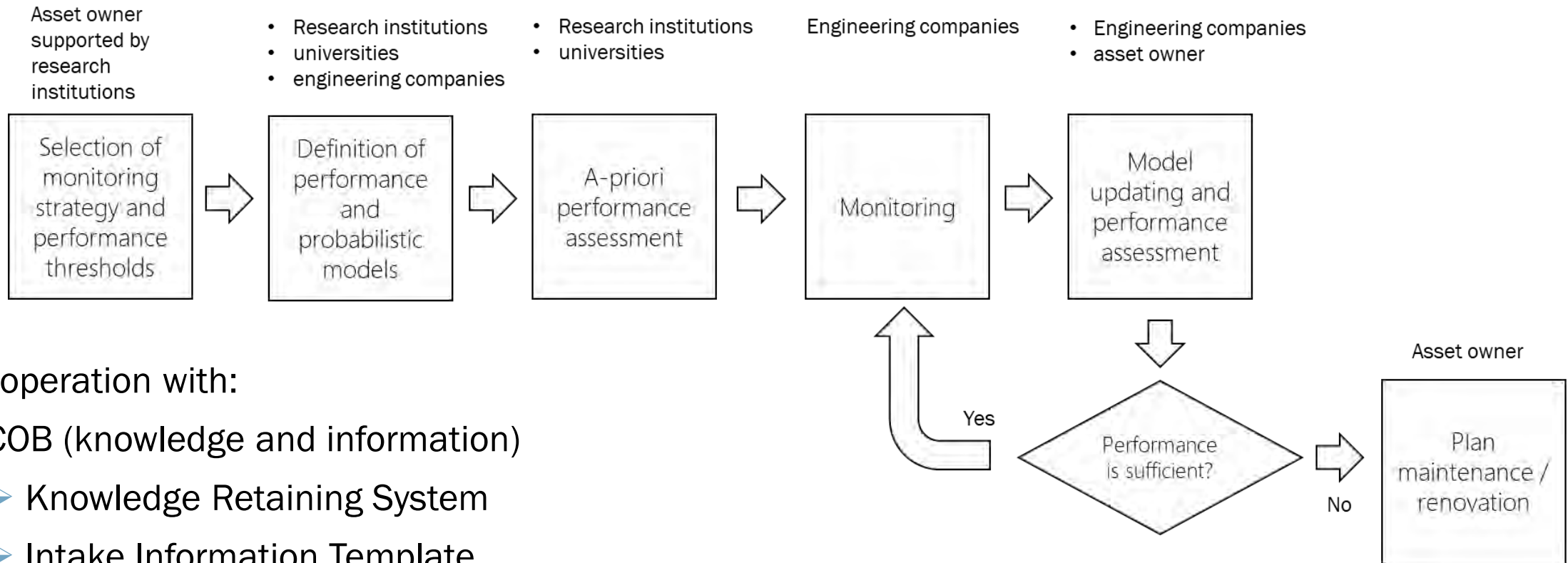
› The framework is based on:

- › tunnel specific information
- › FE modelling of the tunnel (including soil)
- › failure mechanisms and criteria
- › probabilistic updating of the most relevant uncertainties regarding the assessment of the adverse condition based on monitoring data
- › probabilistic updating of the tunnel condition based on monitoring data
- › evaluation of the time variation of the reliability from the point of view of tunnel maintenance



DATA ENHANCED MODELLING

IMPORTANCE OF COORPORATION



› Cooperation with:

› COB (knowledge and information)

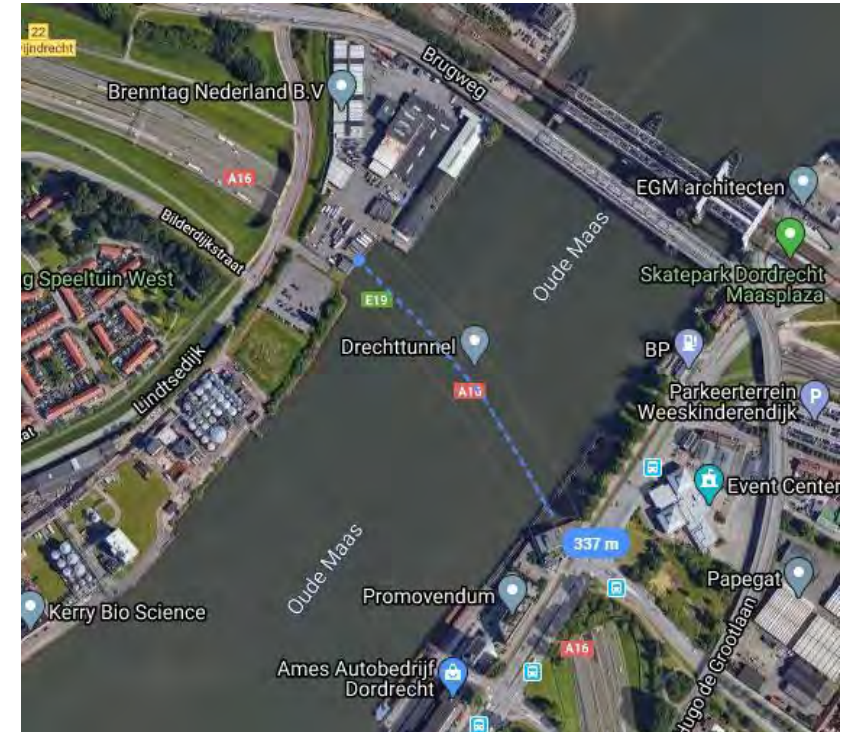
- Knowledge Retaining System
- Intake Information Template
- Structural Health Analyses

› Rijkswaterstaat and other asset owners (performance levels and criteria)

› CASE STUDY: THE DRECHTTUNNEL

DESCRIPTION

- › The tunnel is located on the A16 and contains 8 lanes
- › Opened to public in 1977, renovated in 1990
- › Length of 823 m (569m enclosed part)
- › Three immersed tunnel elements, 6 segments each
- › Only one leakage reported (2002, leakage of a dilatation joint in the roof)



› CASE STUDY: THE DRECHTUNNEL CHOICES

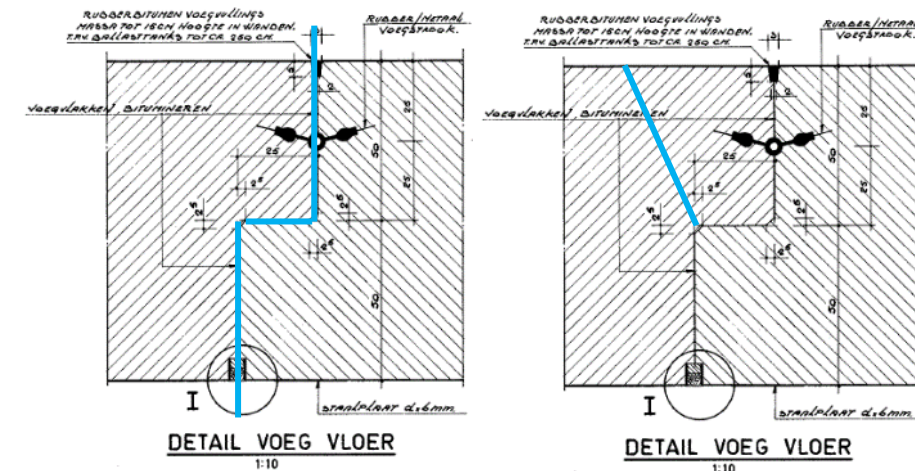
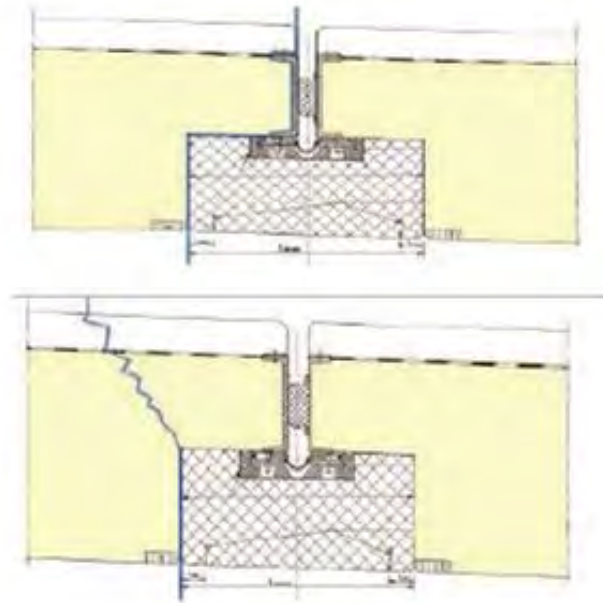
› Focus on leakage through immersion and dilatation joints:

› Immersion joints:

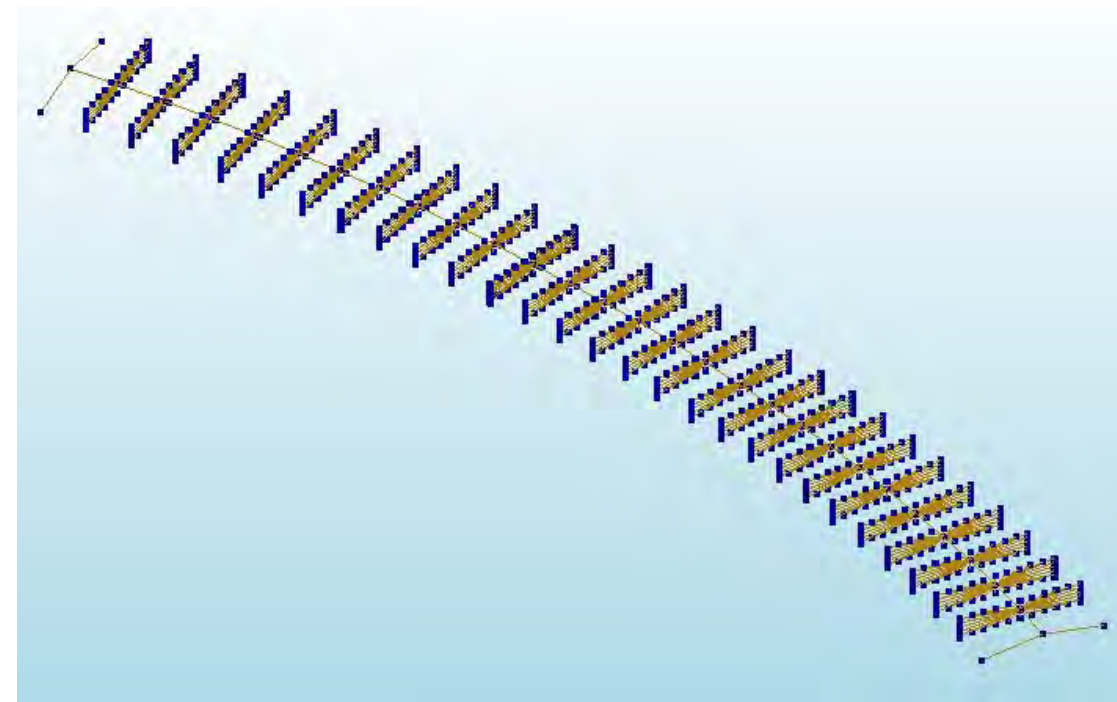
- Failure of the Gina profile due to reduction of pressure
- Failure of the shear key (floor)

› Dilatation joints:

- Failure of the rubber profile due to opening of the joint
- Failure of the shear key (floor, outer walls, roof)



› CASE STUDY: THE DRECHTUNNEL PERFORMANCE PREDICTION MODELLING

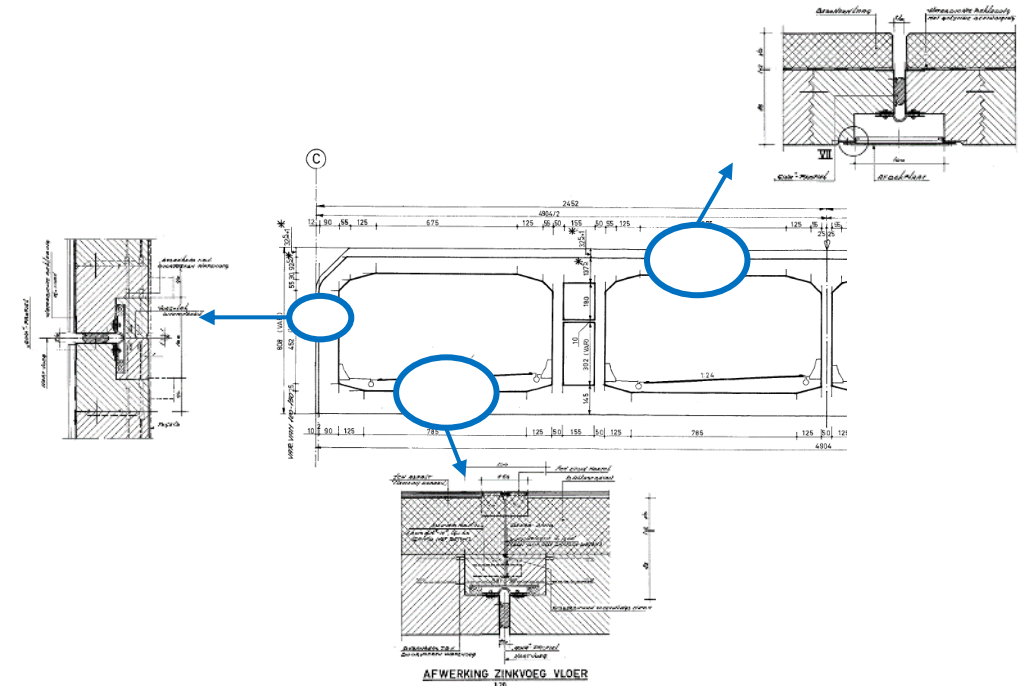


› Modelling requirements

- › Time-dependent settlements
- › Global deformation of tunnel segments
- › Deformation capacity of joints

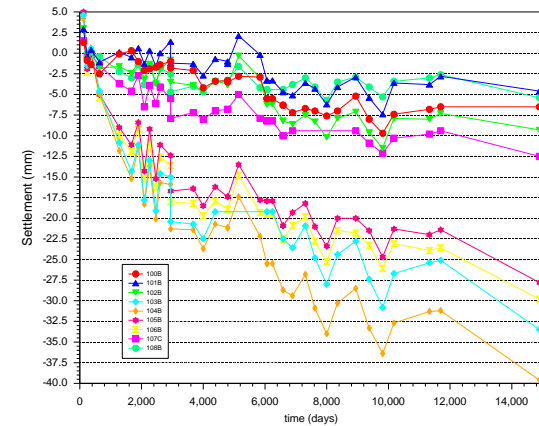
› Uncertainties:

- › Loads (self weight, water level, temp. variations)
- › Model parameters for predicting the settlements
- › Performance of the Gina profile (immersion joints)
- › Performance of the shear keys (immersion and dilatation joints)

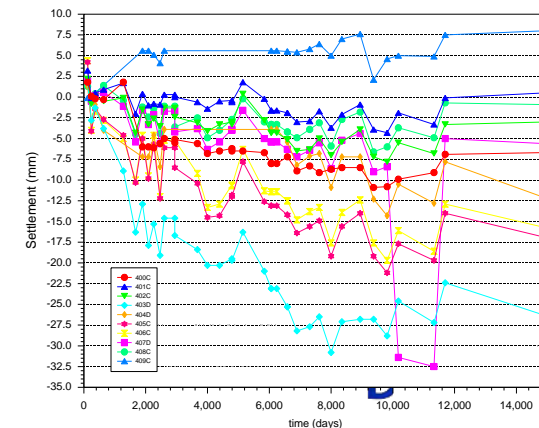
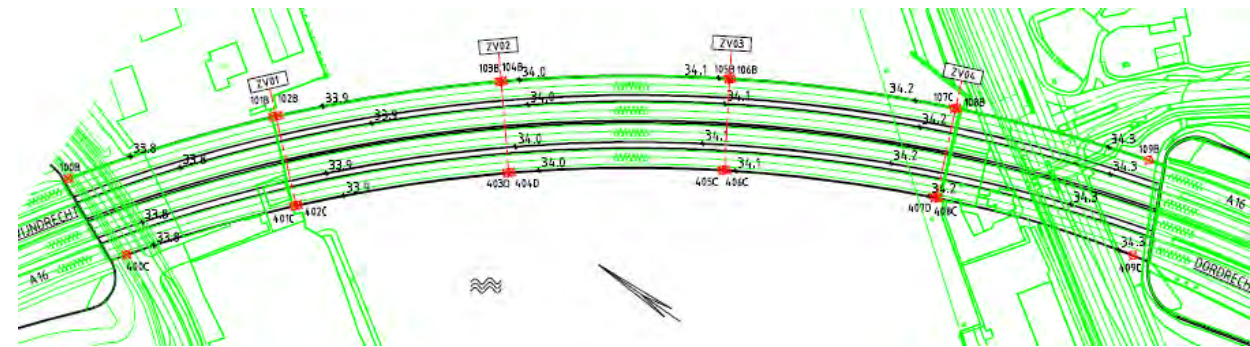


› CASE STUDY: THE DRECHTUNNEL MONITORING DATA

- › Measurements of the vertical displacements of the 4 corners of each tunnel element
- › In total 35 measurements from 1977 to 2018
- › Measured values are beyond the design assumptions



East side



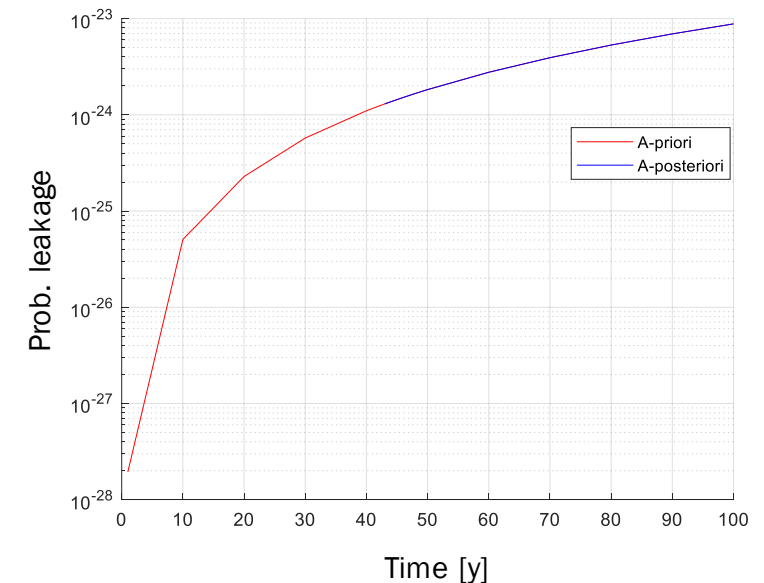
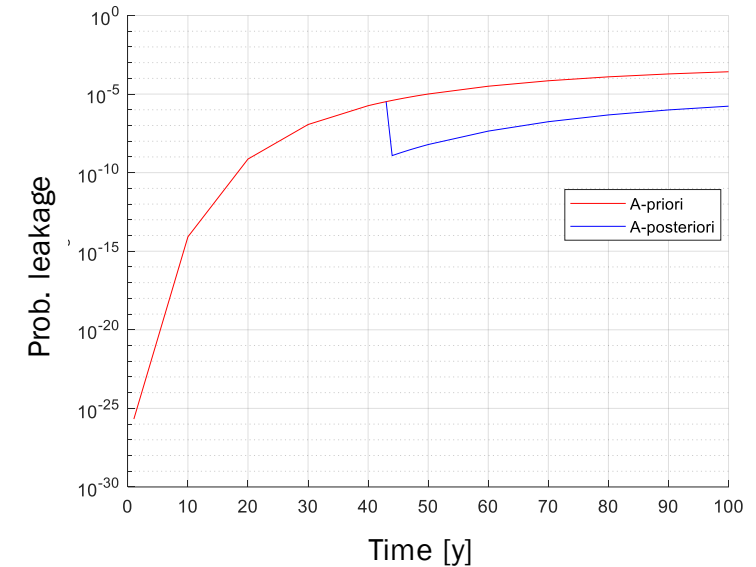
West side

› CASE STUDY: THE DRECHTUNNEL

PRELIMINARY RESULTS

- › Failure of the shear key of immersion joint
 - › monitoring allows to reduce uncertainties on the capacity of the joint to sustain deformations

- › Failure of the Gina profile due to reduction of pressure
 - › no added value of monitoring due to over-conservative design approach



› CONCLUSIONS

- › Planning of renovation requires knowledge about the actual conditions and future performance of the tunnel
- › Monitoring data of structural response becomes information when combining with prediction models
- › The proposed data-enhanced reliability assessment approach enables the updating the performance predictions and the associated uncertainty → input for asset management on:
 - › Actual and future condition of the joints
 - › Scope and extent of renovation
- › The collaboration of experts in various knowledge domains (performance modelling, analysis of monitoring data, model updating, reliability analysis, asset management) is and remains required for optimal decision-making concerning renovation based on monitoring

ONZE TUNNEL...

WORDT FEESTELIJK HEROPEND!

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