



stowa

Deltares
Enabling Delta Life



JIP Energiebesparing Gemalen #Slim_Malen

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Gebruikersgroep, Almere
26 September 2016

TU/e Technische Universiteit
Eindhoven
University of Technology

Nelen & Schuurmans

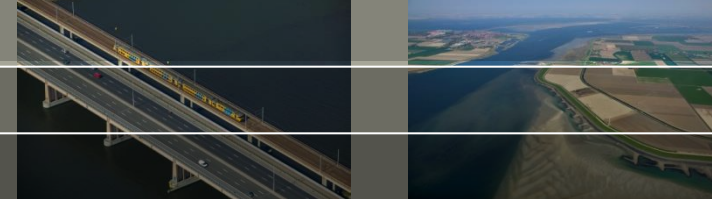


WATERSCHAP
ZUIDERZEE LAND
UW WATERSCHAP



 **eRisk Group**
Energy & Finance

Introduction



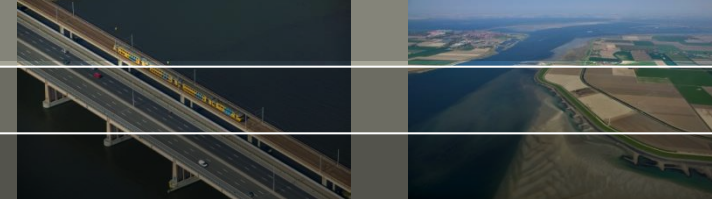
- Environmental Engineering, BSc
Budapest University of Technology, Faculty of Chemistry



- EuroAqua – Water Management and Hydroinformatics
 - University of Newcastle
 - Brandenburg Technical University (BTU) (Cottbus, Germany)
 - Technical University of Catalonia (Barcelona, Spain)
- Model predictive control of irrigation canals, PhD cum laude (Barcelona, Spain)



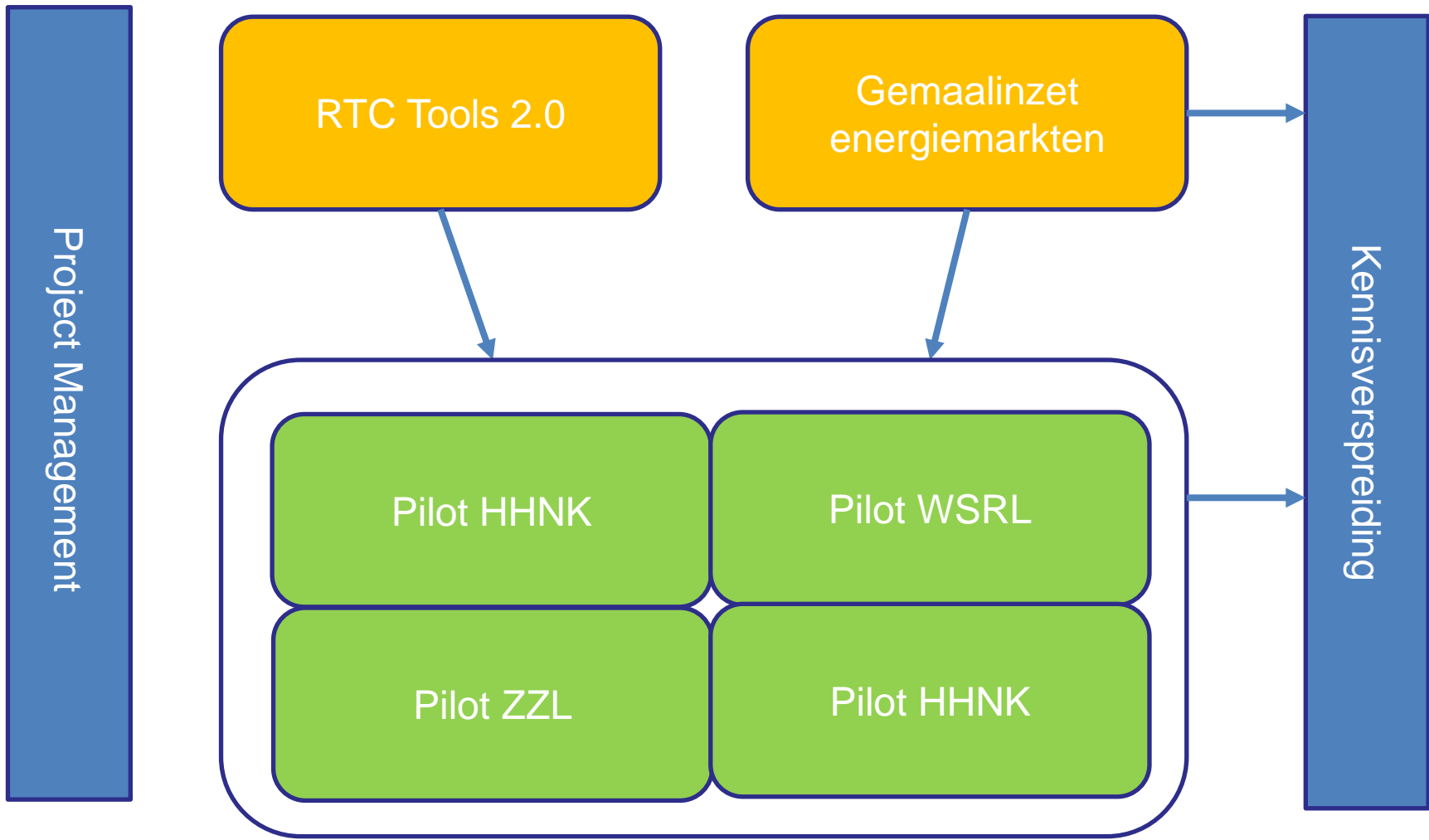
Work experience



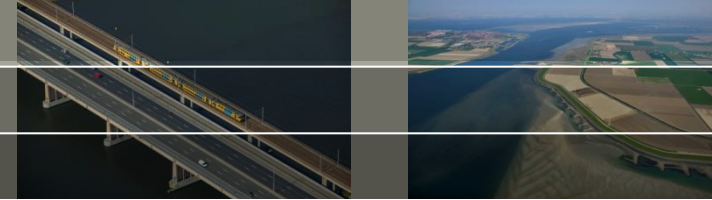
- Ecole des Mines de Douai (Douai, France), in cooperation with the French waterways
- Incas3, Assen, Modelling and control of drinking water networks
- Deltares – River Dynamics and Inland Shipping



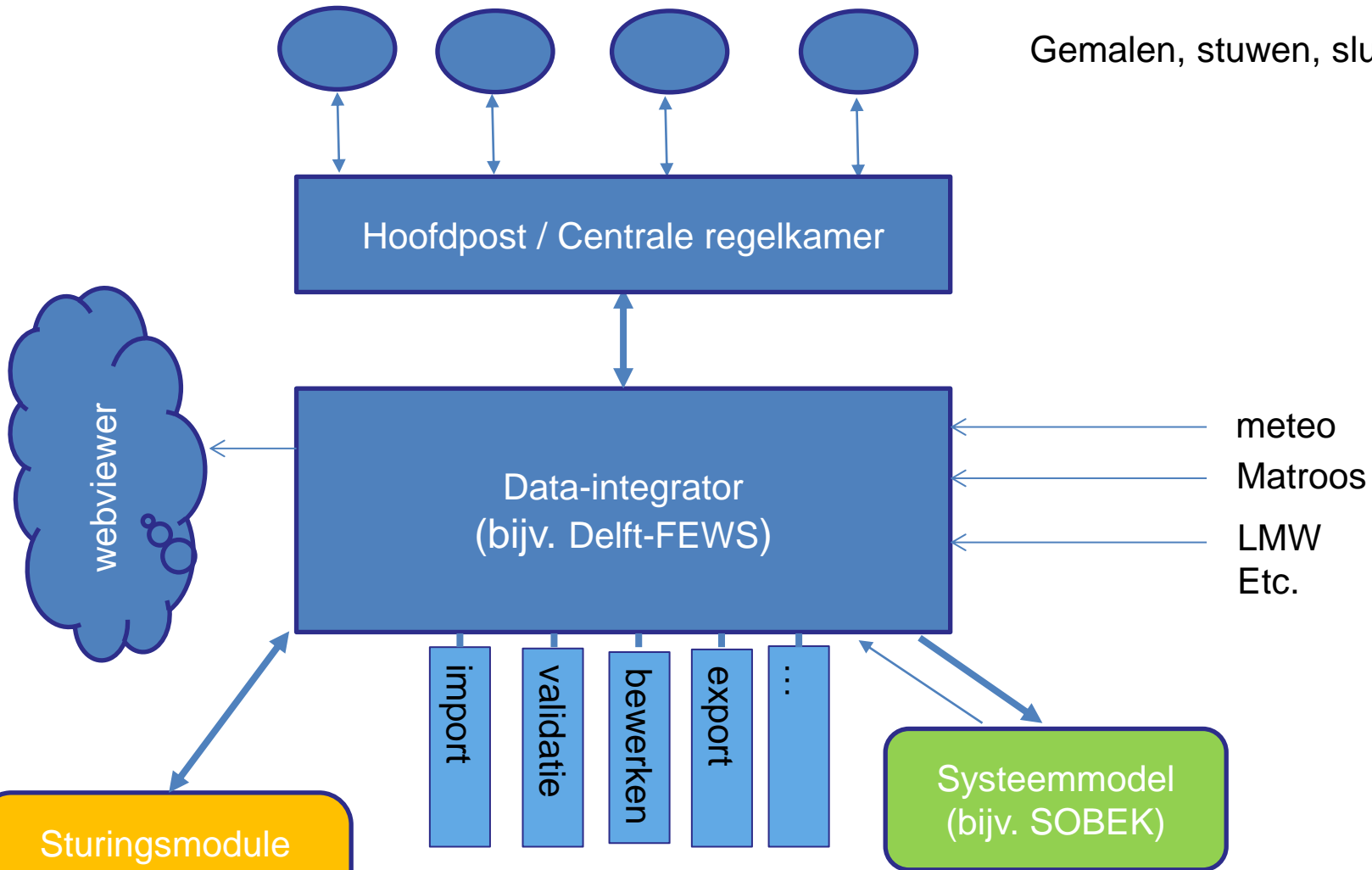
Samenhang activiteiten



Operationeel Waterbeheersysteem



Gemalen, stuwen, sluizen, etc.



Sturingsmodule
(bijv. RTC-Tools)

Intern model

Goals within the project

- Hydraulic modelling (simple) for optimization purposes
- Pump modelling for optimization purposes
- Building up and testing the optimization

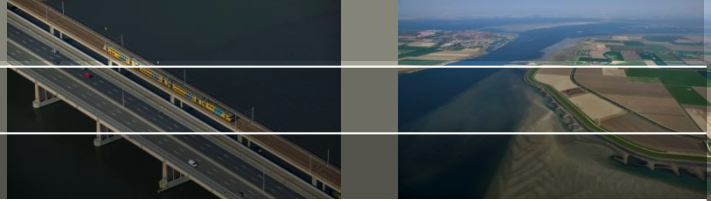


Offset-free MPC-IR:

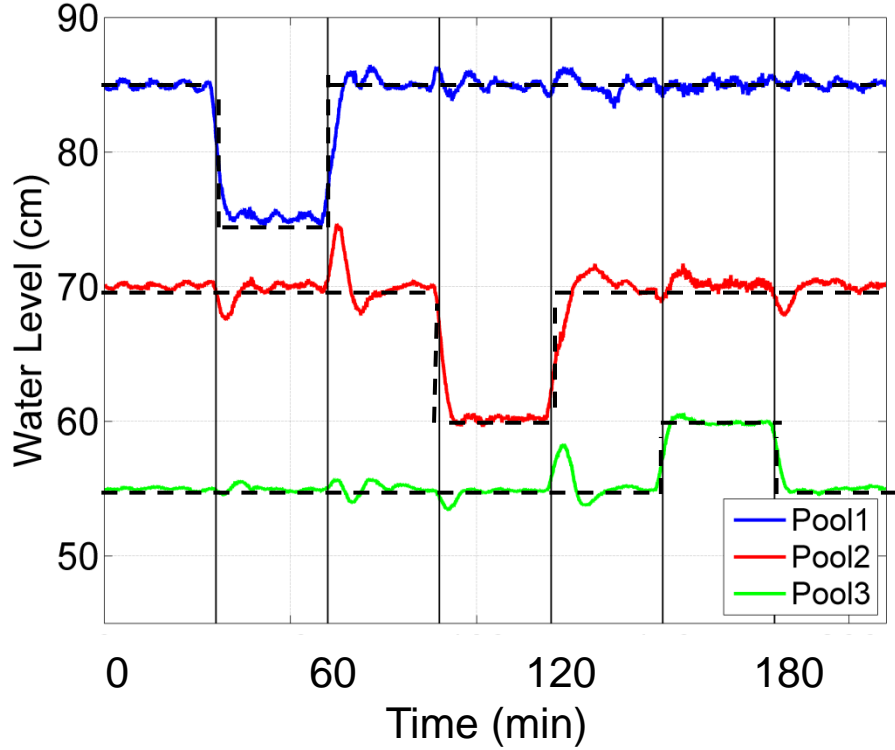
Sp 1 = 85 cm

Sp 2 = 70 cm

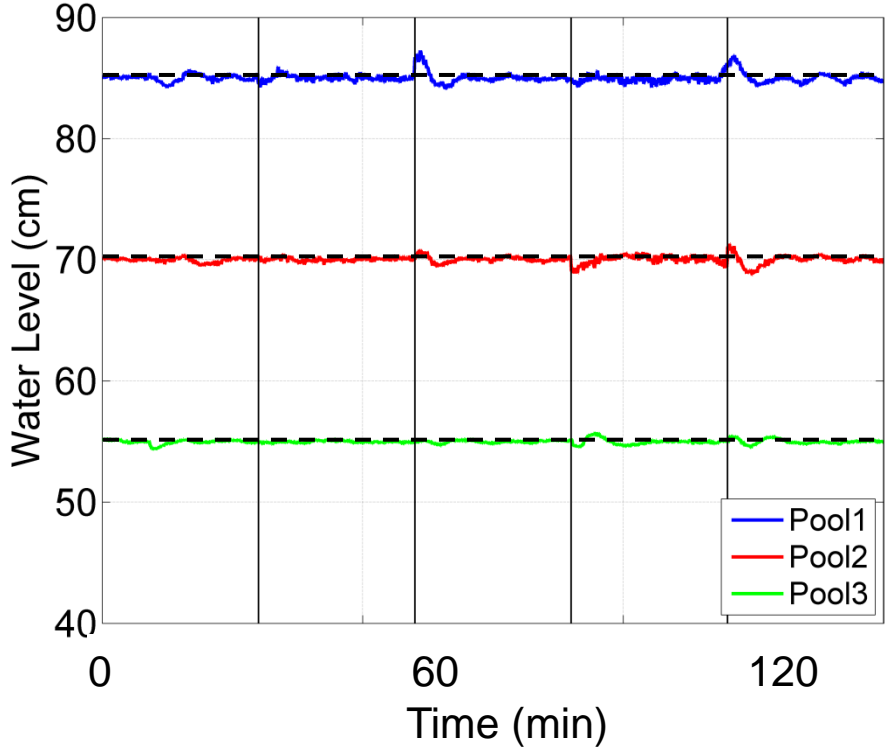
Sp 3 = 55 cm



Laboratory experiment - Water level

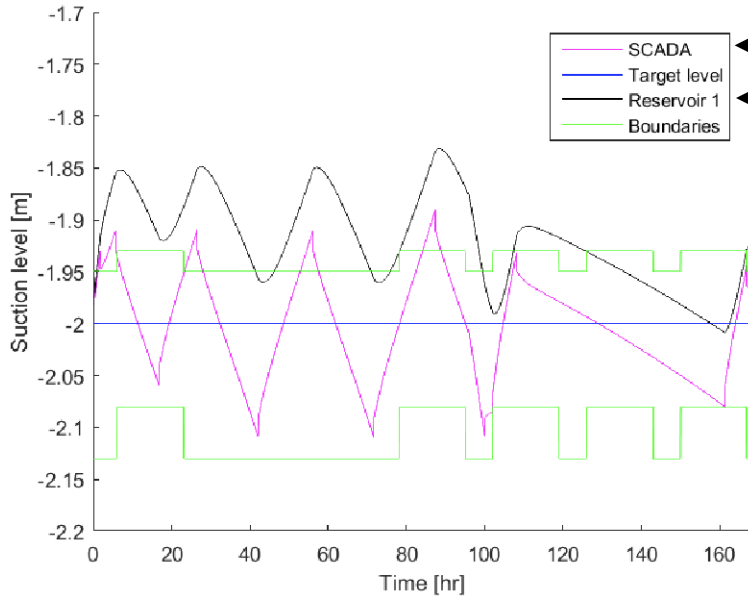
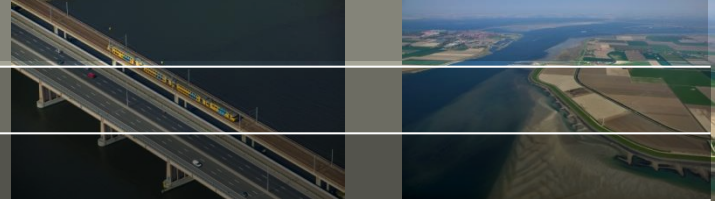


Laboratory experiment - Water level



- Setpoints were followed, some overshoot
- Disturbance: water level was kept at setpoint

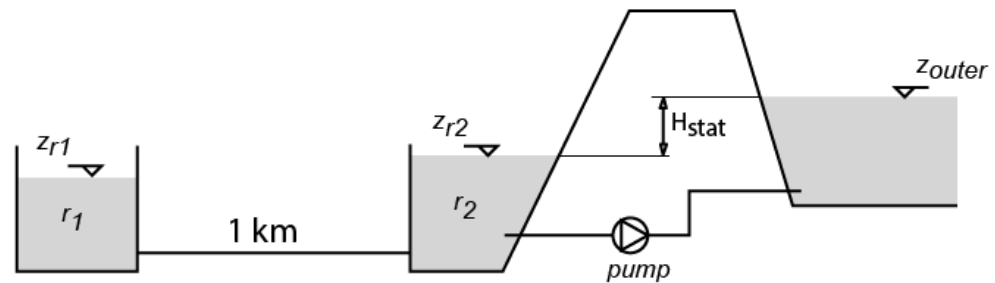
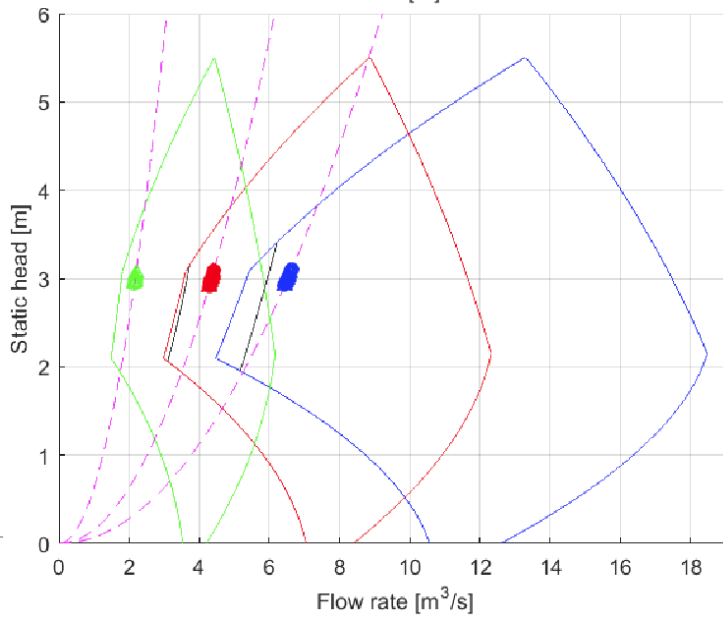
Minimalisatie algoritme



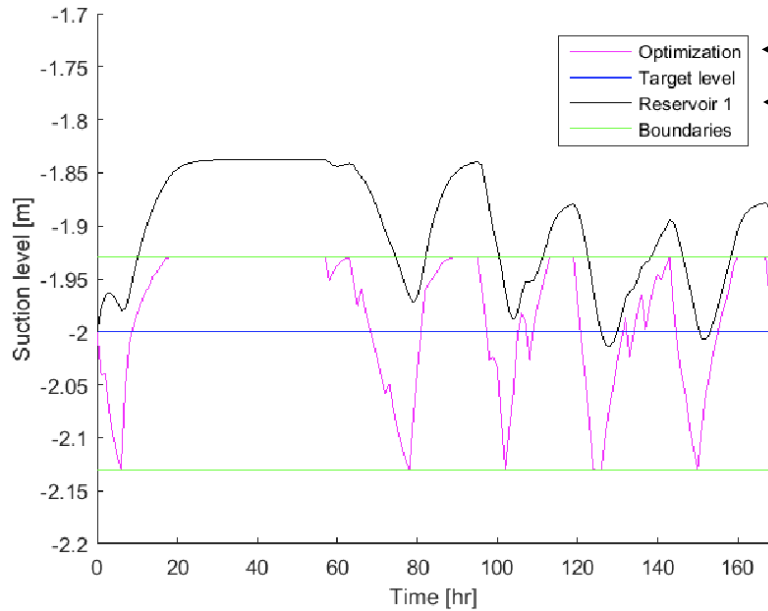
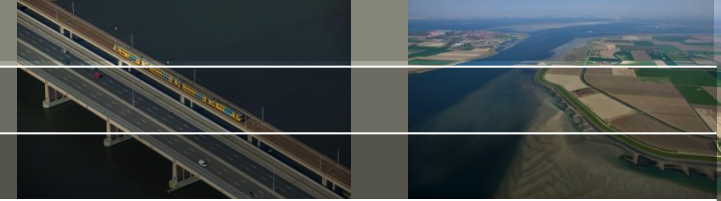
z_{r2} (magenta line)

z_{r1} (black line)

• € 1871,70



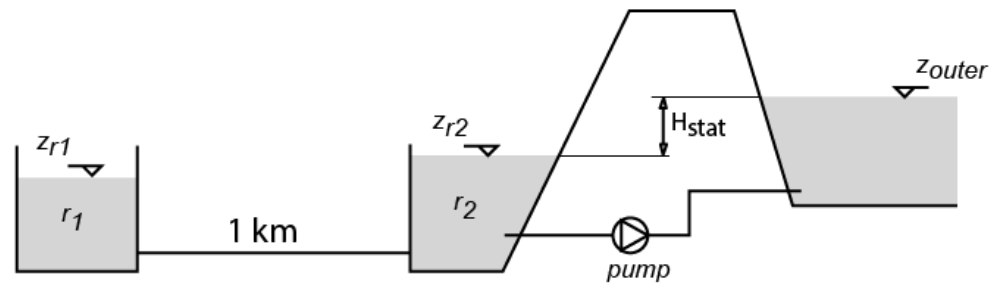
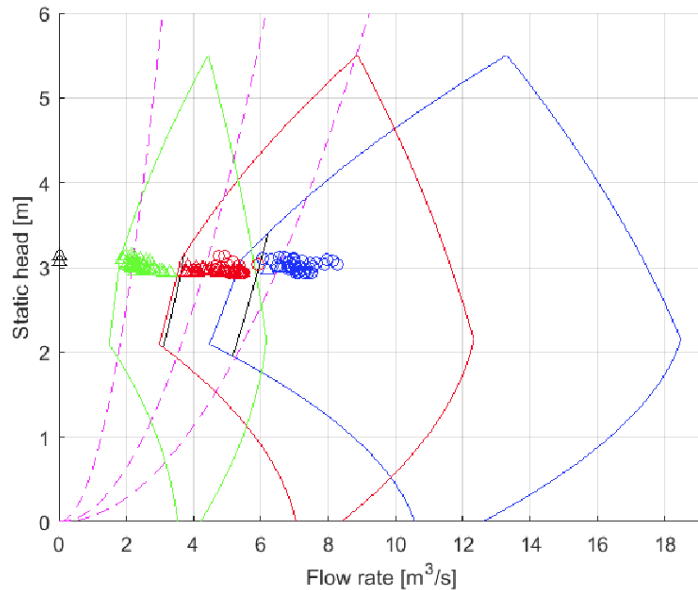
Minimalisatie algoritme



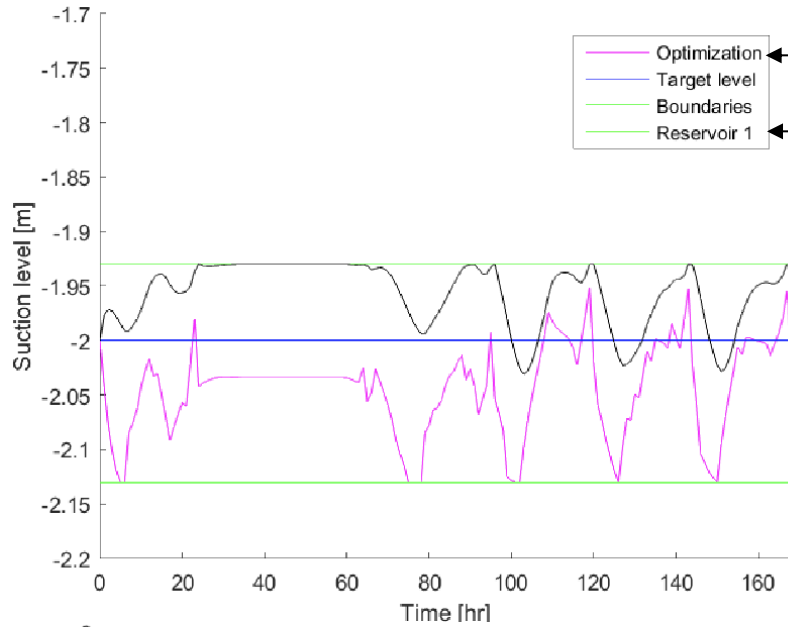
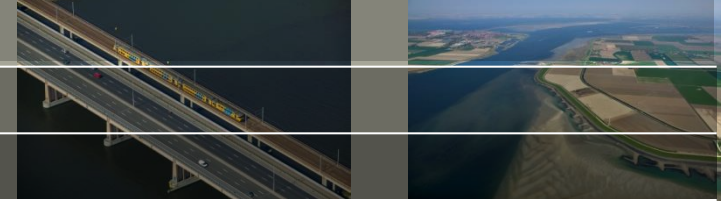
z_{r2} (magenta line)

z_{r1} (black line)

• € 1746,90 (-6.7%)

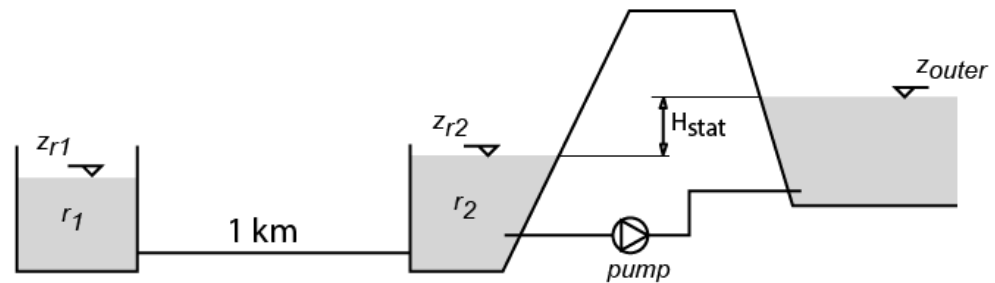
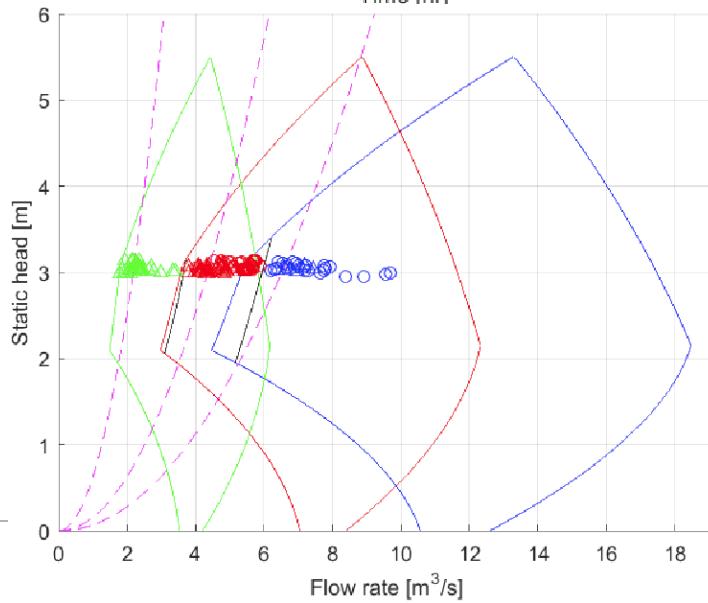


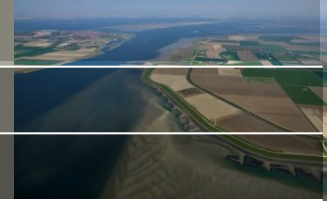
Minimalisatie algoritme



Optimization z_2 (magenta line)
Target level
Boundaries
Reservoir 1 z_{r1} (black line)

• € 1821,00 (-2.7%)





$$J = \sum_{j=1}^{\lambda} x_{gen}(k+j|k)^T P_j x_{gen}(k+j|k) + \sum_{j=0}^{\lambda-1} u_{gen}(k+j|k)^T R_j u_{gen}(k+j|k)$$