

# Fieldlab – CAMINO Water

Almelo Rioolsysteem

Toepassing van Machine Learning in het Real Time Control (RTC) systeem

4 juni 2019, Amersfoort

*Benchmark Electronics: Jan Nijeboer en Davey Oudshoorn*  
*Nelen & Schuurmans: Jeroen de Koning*

# Agenda

- Introductie
- Almelo Infrastructuur & Control
- Machine Learning
- Samenvatting & Vervolgstappen



# Introductie

Jan Nijeboer – Benchmark Electronics

# Introductie

## Trends:

- Veranderingen van het klimaat
  - Extreme regenval => overlast door water op straat
- Kosten van onderhoud nemen toe
- Klimaatverdrag
  - CO2 reductie => efficiënt gebruik van de energie



## Hulpvraag van de Gemeente Almelo (CAMINO-water project):

- Hoe kunnen wij de aansturing van het huidige rioolsysteem verbeteren om op deze veranderingen (trends) te anticiperen?

## Onderzoeksvraagstuk (zelflerend RTC):

- Kan het real-time regelsysteem van het riool verbeterd worden door gebruik te maken van moderne kunstmatige intelligentie technieken (Machine Learning)?

## Projectdoelstellingen:

- a) Geen water-op-sstraat (*optimalisatie waterstromen*)
- b) Onderhoud beter voorspelbaar maken (*optimalisatie onderhoud*)
- c) Energieverbruik reduceren (*optimalisatie energieverbruik*)



# Project partners



## Partij

Gemeente Almelo

## Rol

Opdrachtgever (1<sup>e</sup>)



Waterschap vechtstromen

Opdrachtgever (2<sup>e</sup>)



World Class Maintenance

Project Management

Nelen & Schuurmans



Nelen & Schuurmans

Modelbouw en validatie



Deltares

SOBEK-model



InterAct

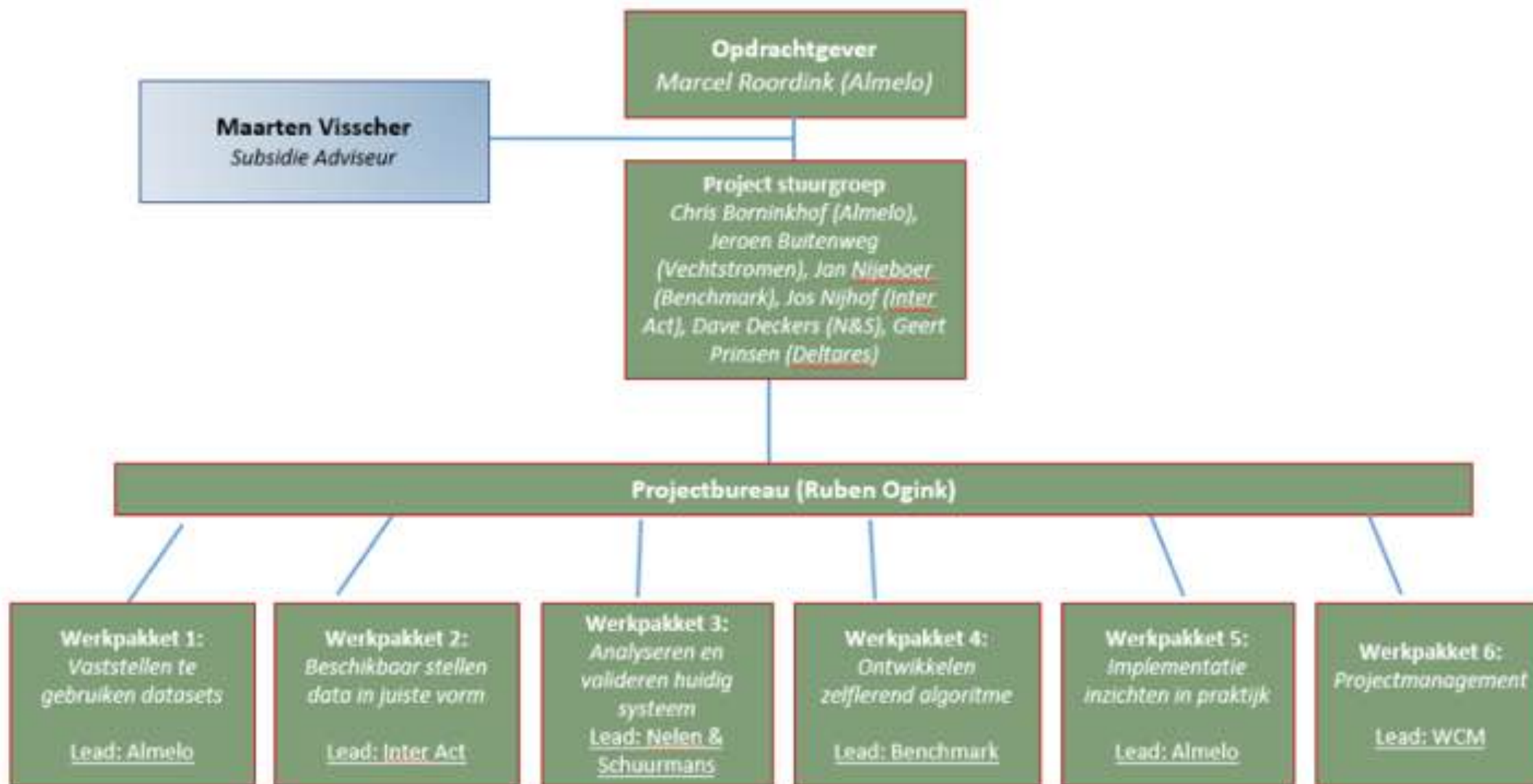
Real Time Control System



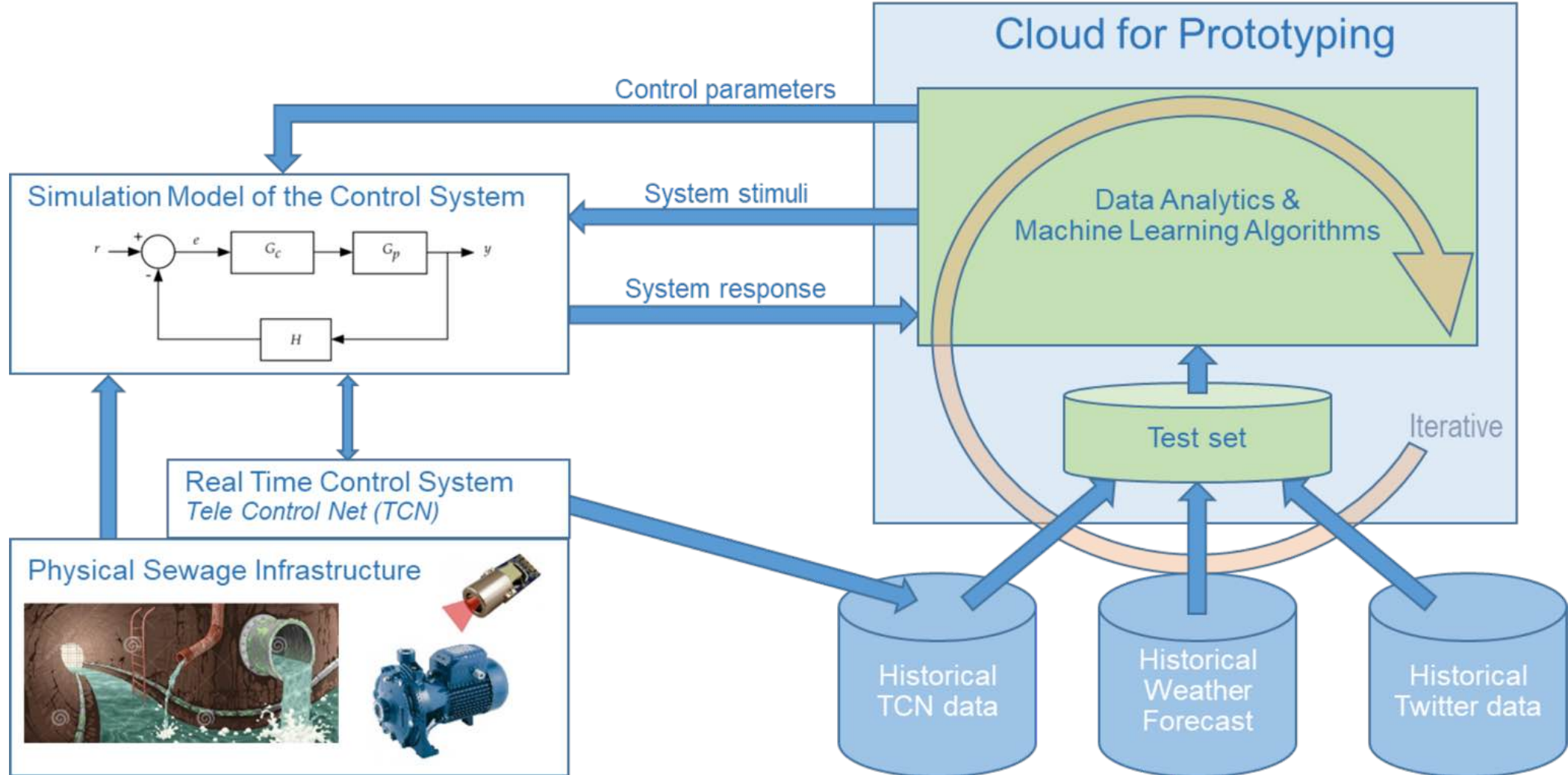
Benchmark Electronics

IoT & Machine Learning

# Projectorganisatie - werkpakketten



# Ontwikkelmodel



# Almelo Infrastructuur & Control

Jeroen de Koning – Nelen & Schuurmans

Nelen & Schuurmans



# Wateroverlast 31 mei 2018



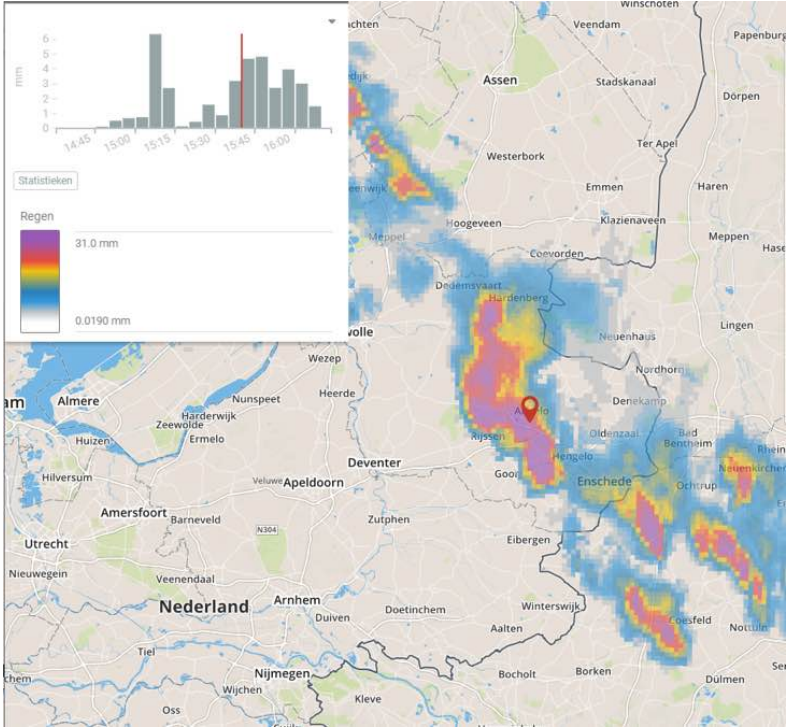
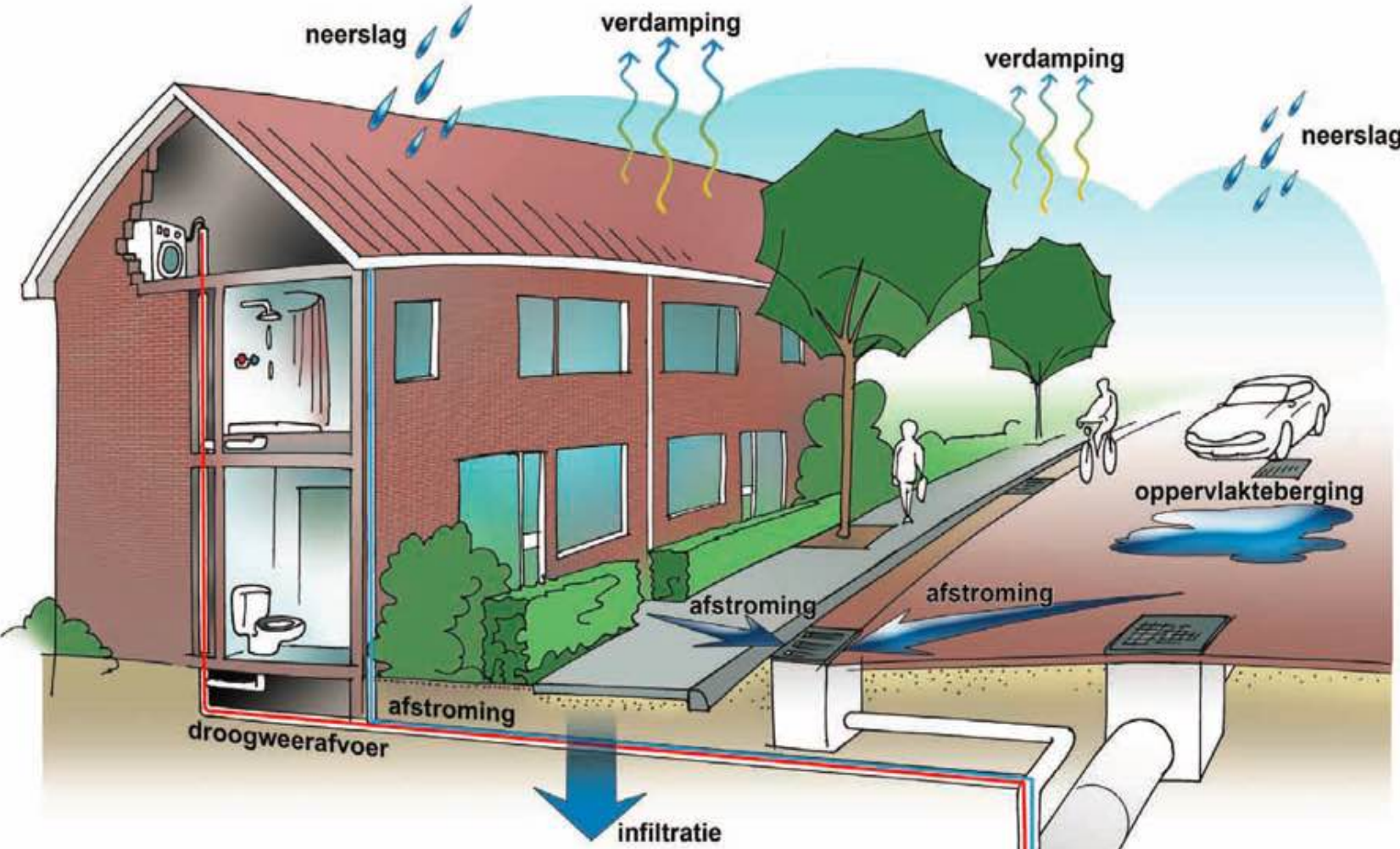
Regio Algemeen Sport Video 🔍

Abonneren





# Riolering



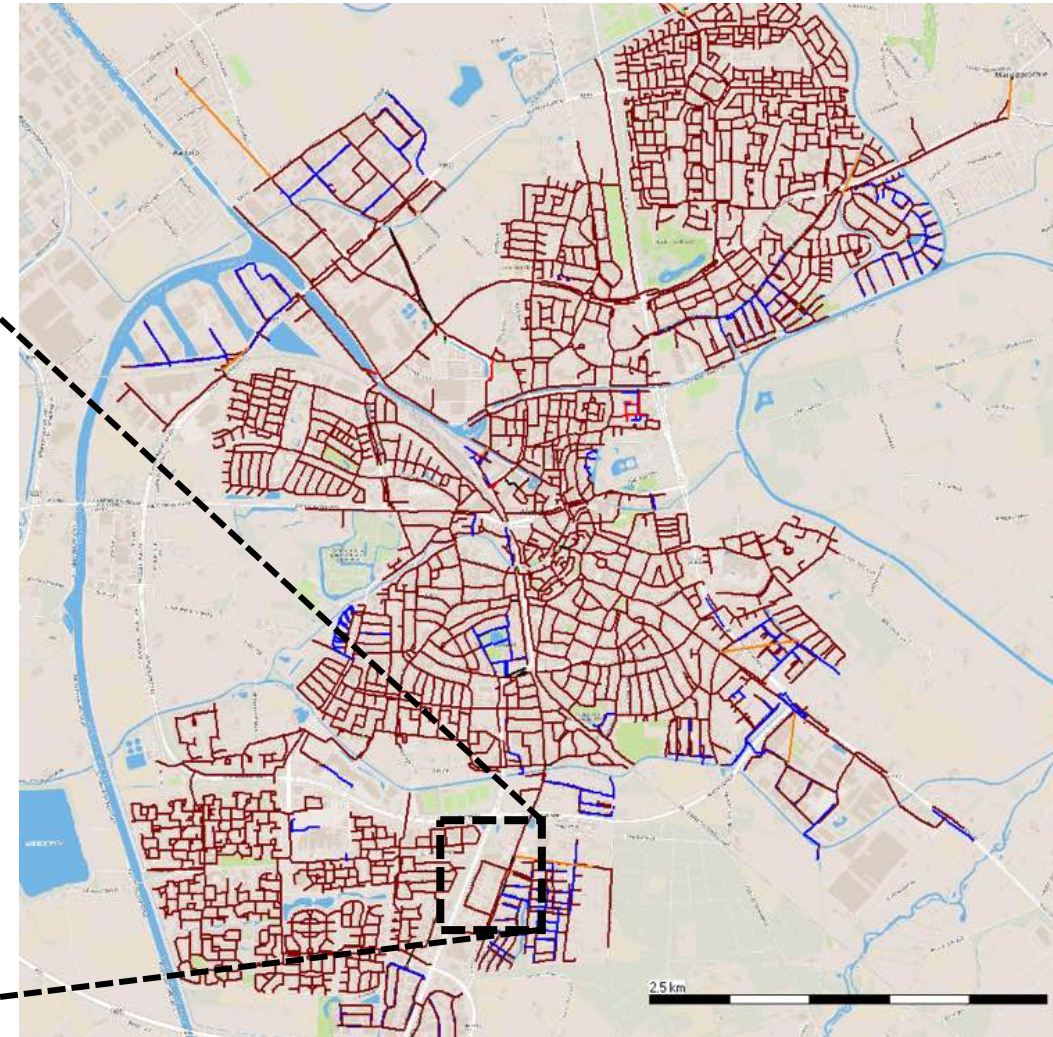
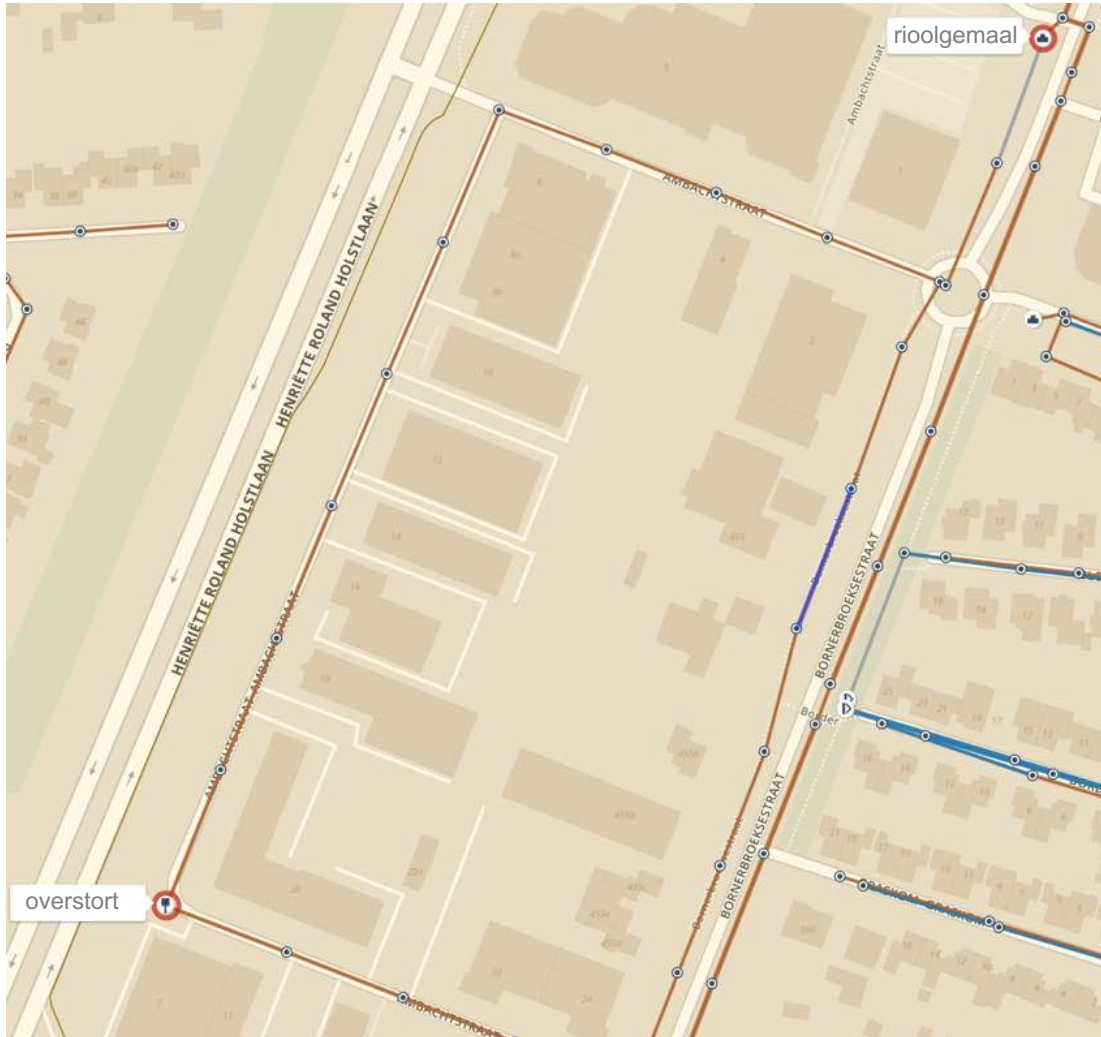


# Riolering





# Ambachtstraat - Almelo

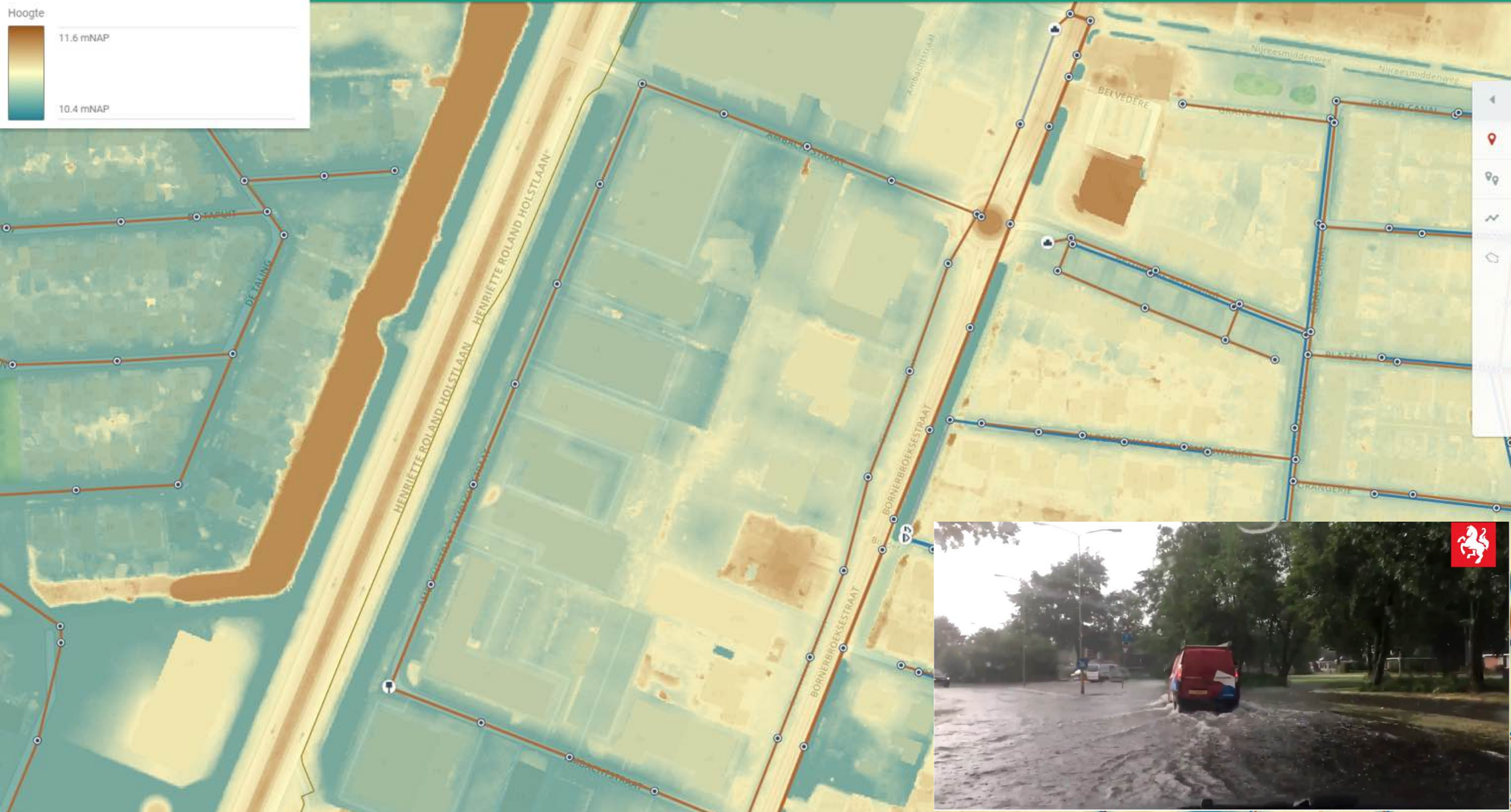




Hoogte

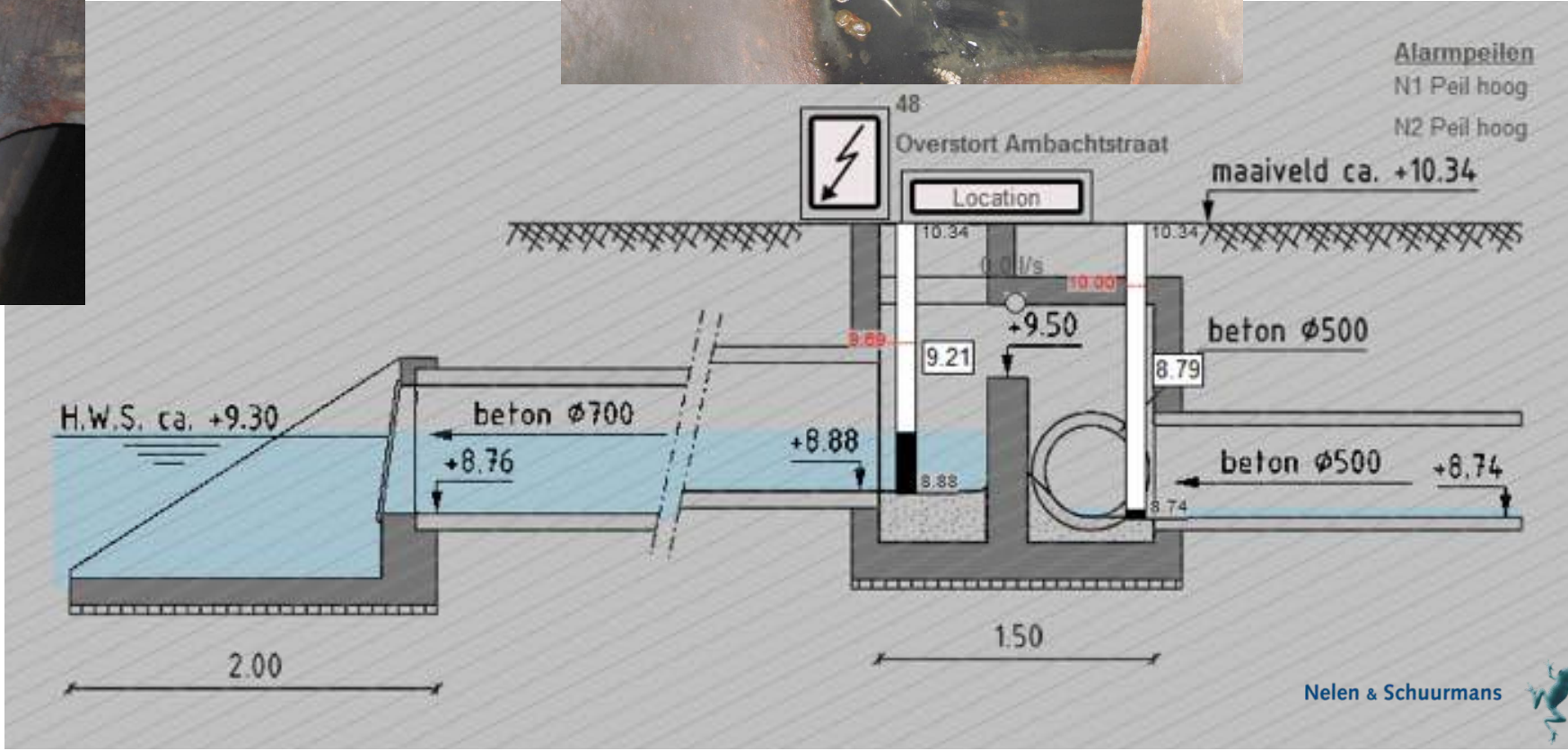
11.6 mNAP

10.4 mNAP





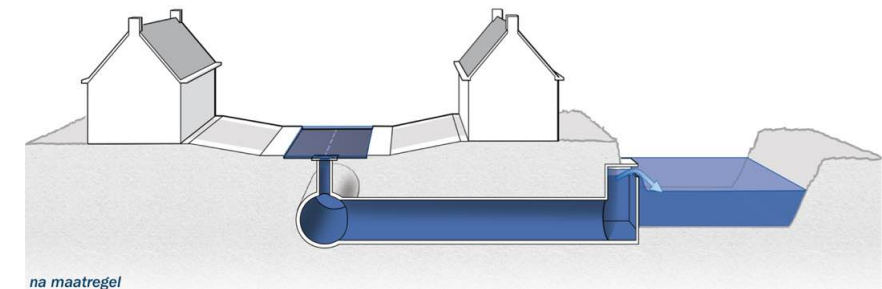
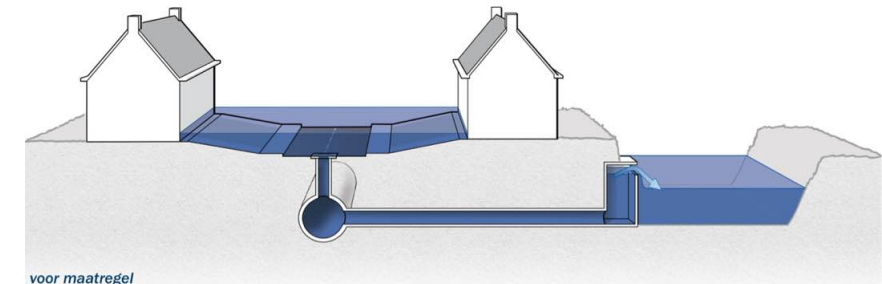
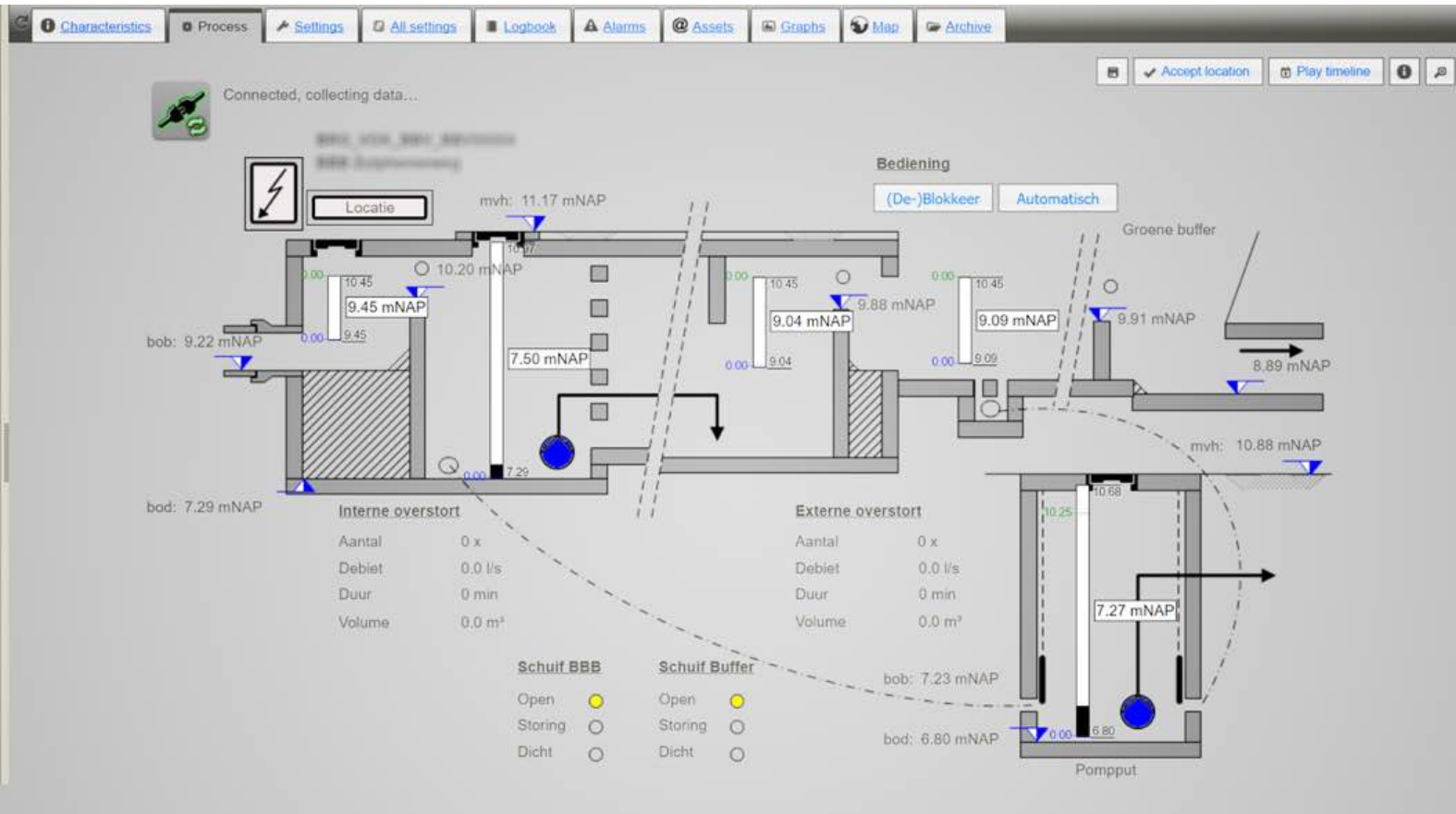
# Overstort Ambachtstraat



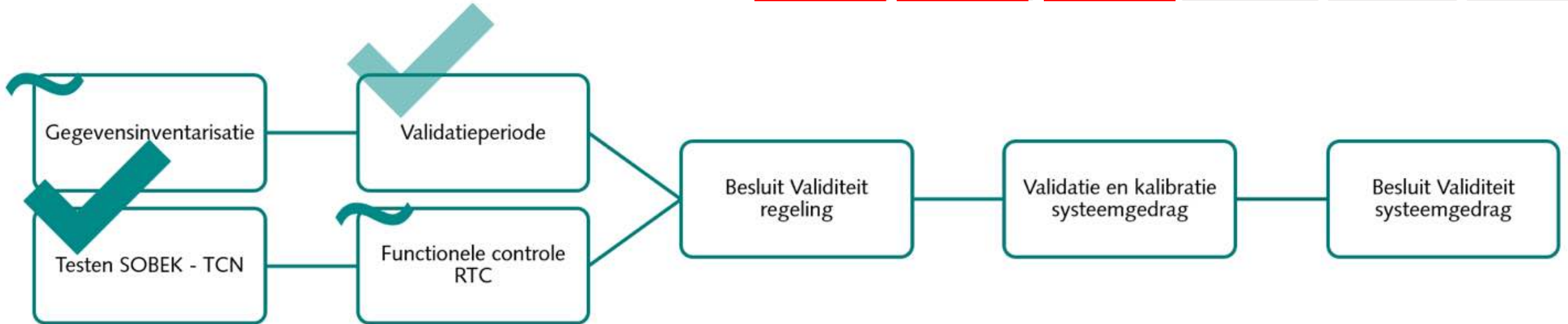
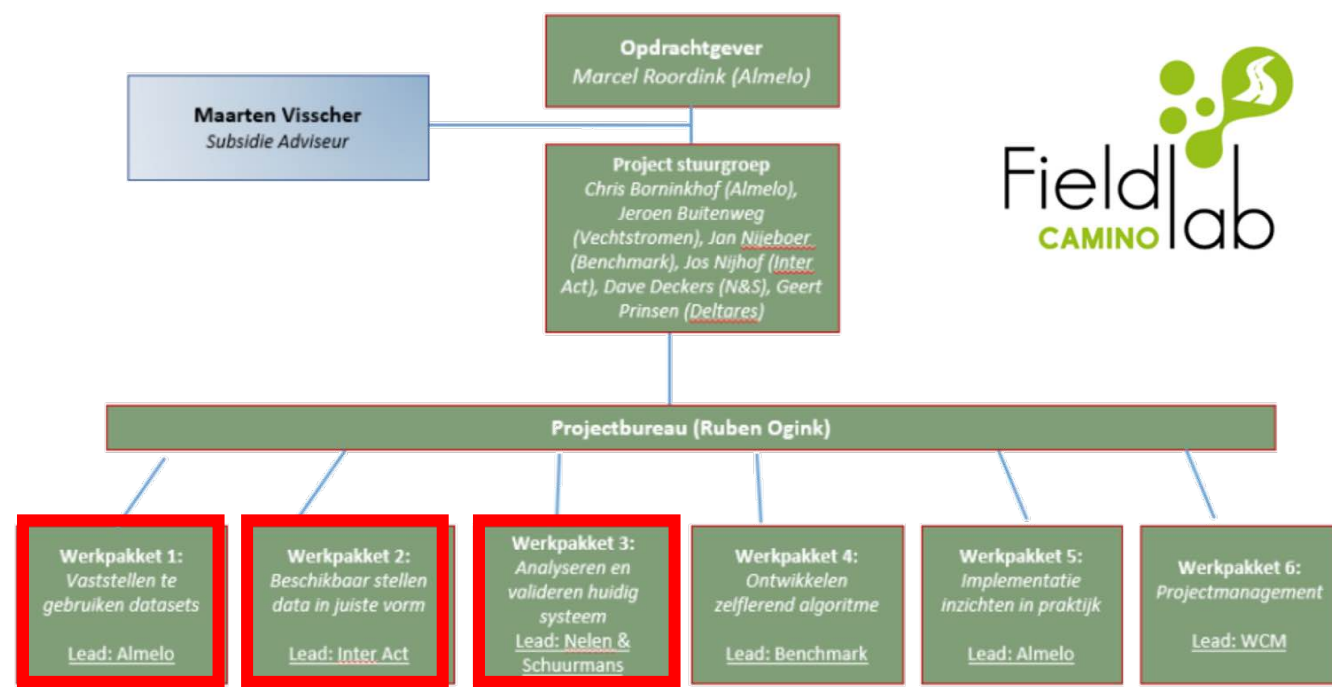


# Voorkomen wateroverlast

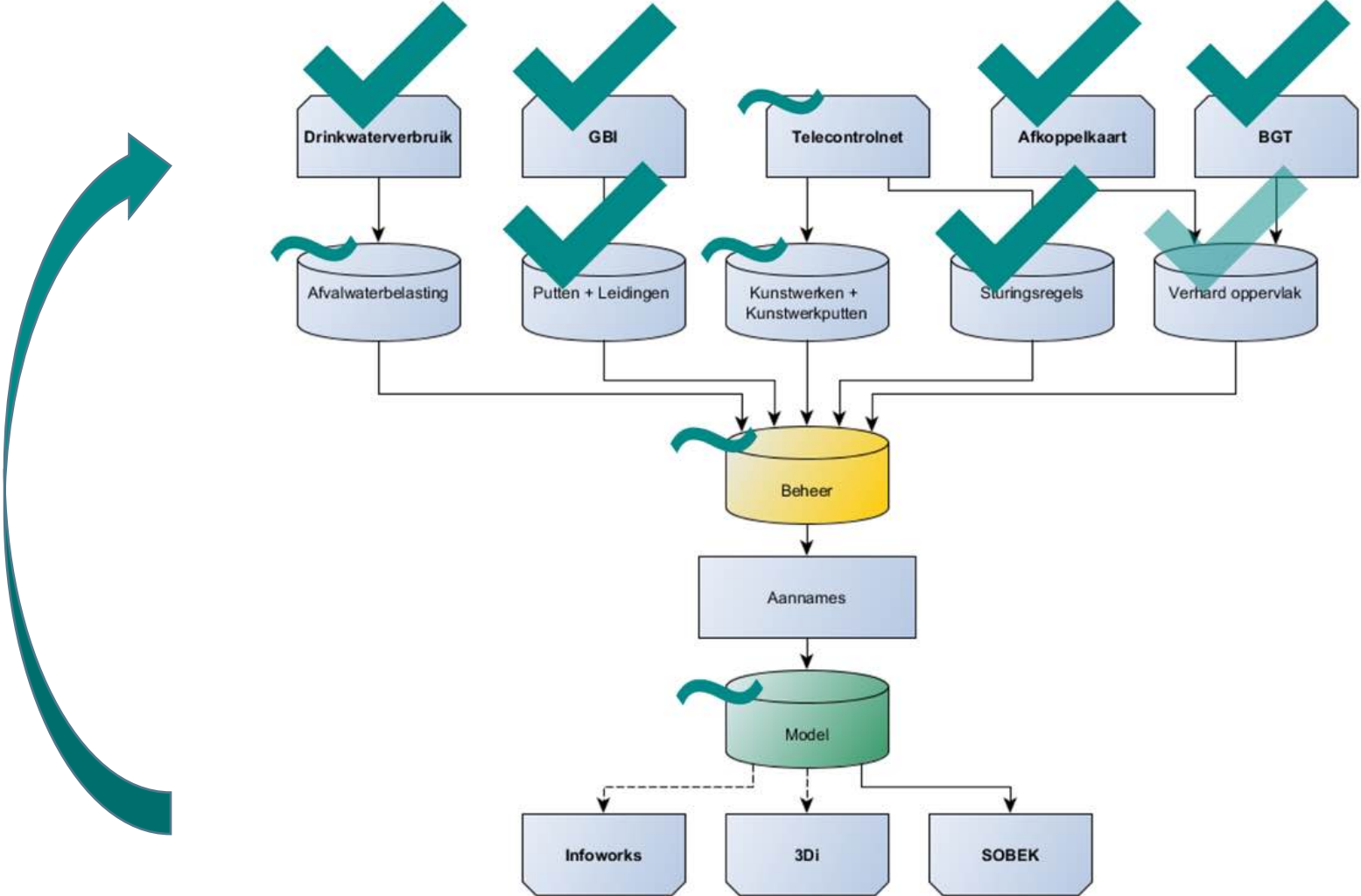
TeleControlnet – Inter Act



# Proces



# Model actualisatie

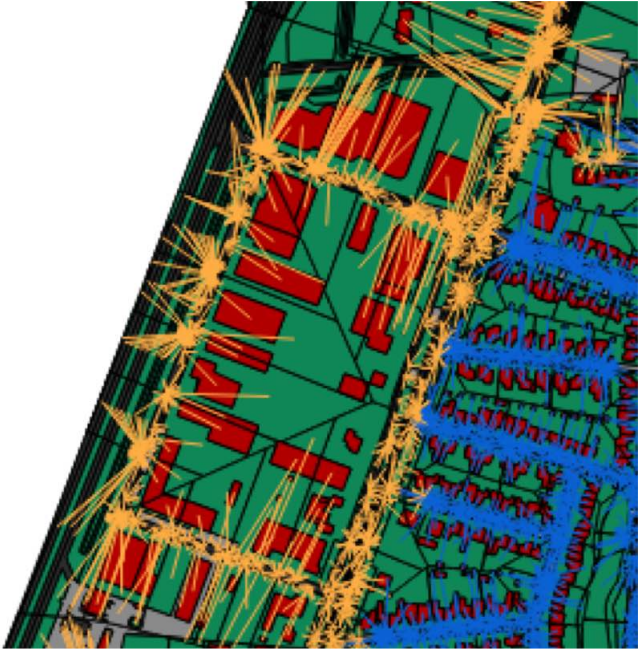




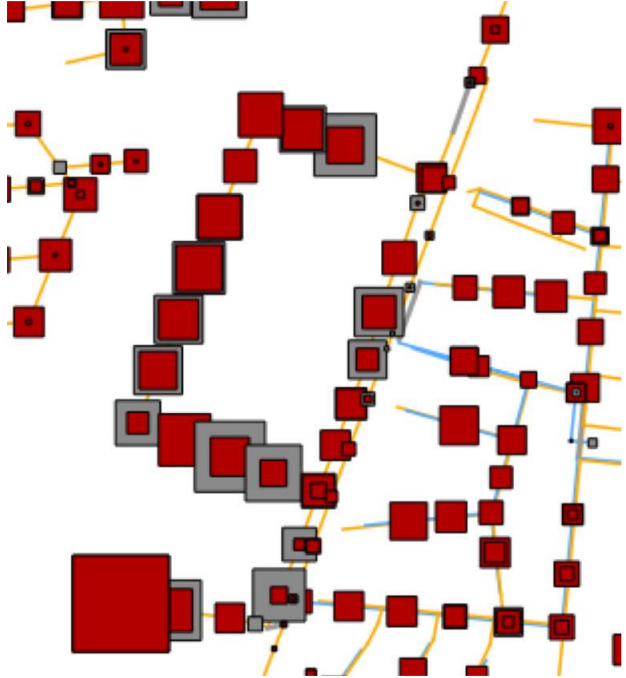
# Model



Na



Voor









# Machine Learning

Davey Oudshoorn – Benchmark Electronics

# Machine Learning – Deep Learning

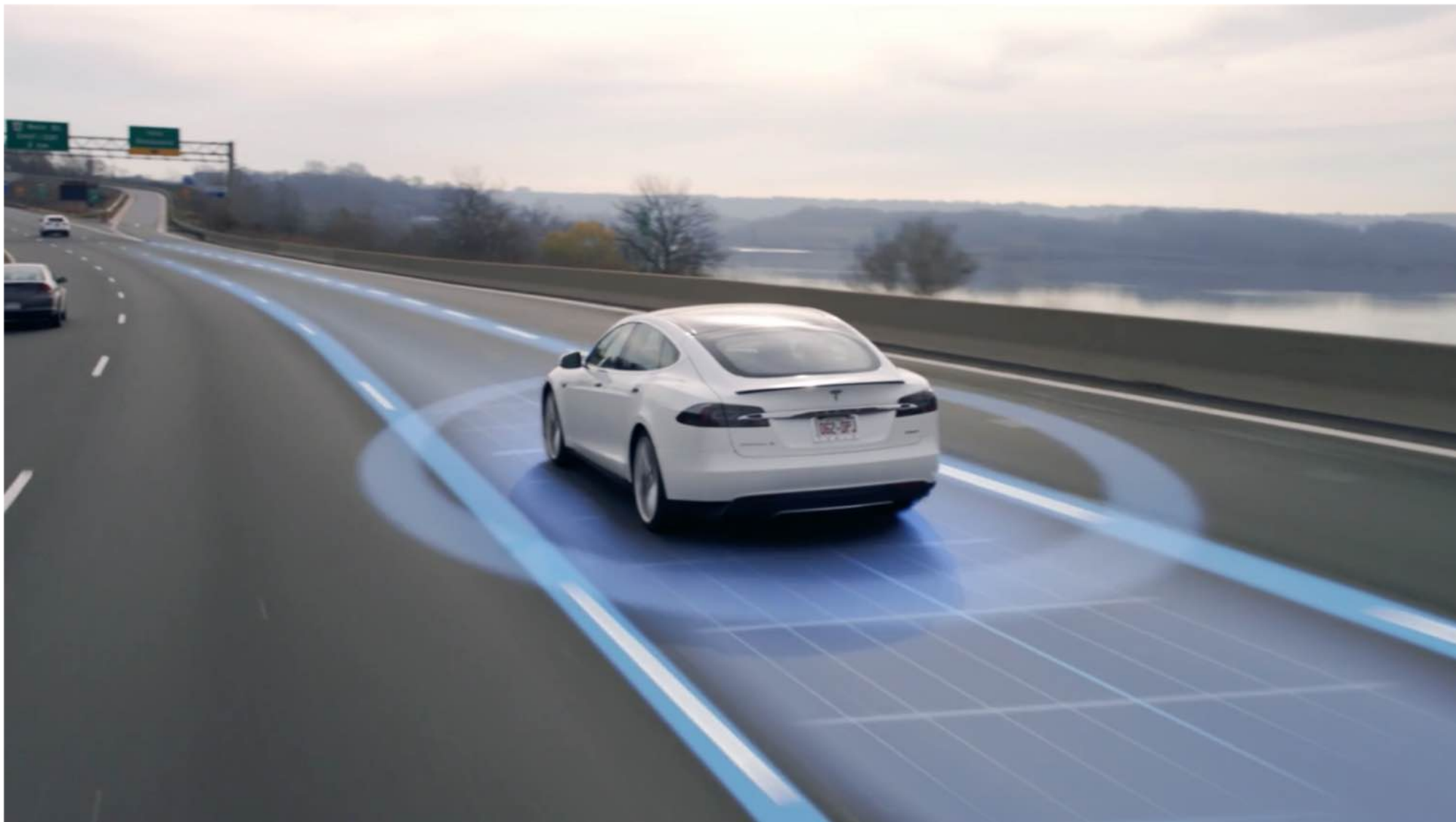
## Index

- Use cases
- What is Deep Learning?
- Types of Deep Learning
- Reinforcement Learning
- The Camino System
- Where are we now?

# Machine Learning

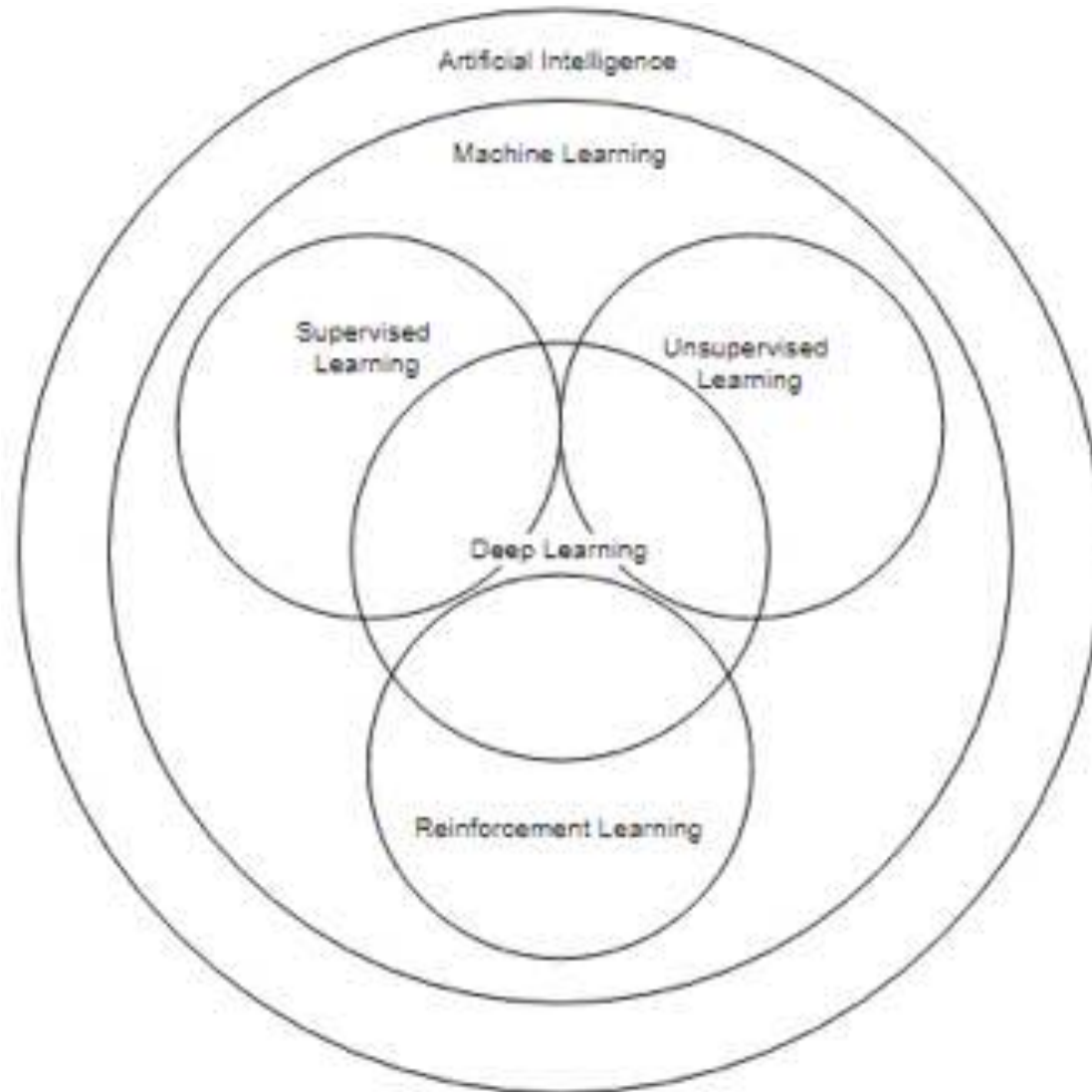
## Use Cases

- Image Recognition
- Data Analytics
- Recommendation systems
- Prediction Systems



# What is Deep learning?

The AI diagram

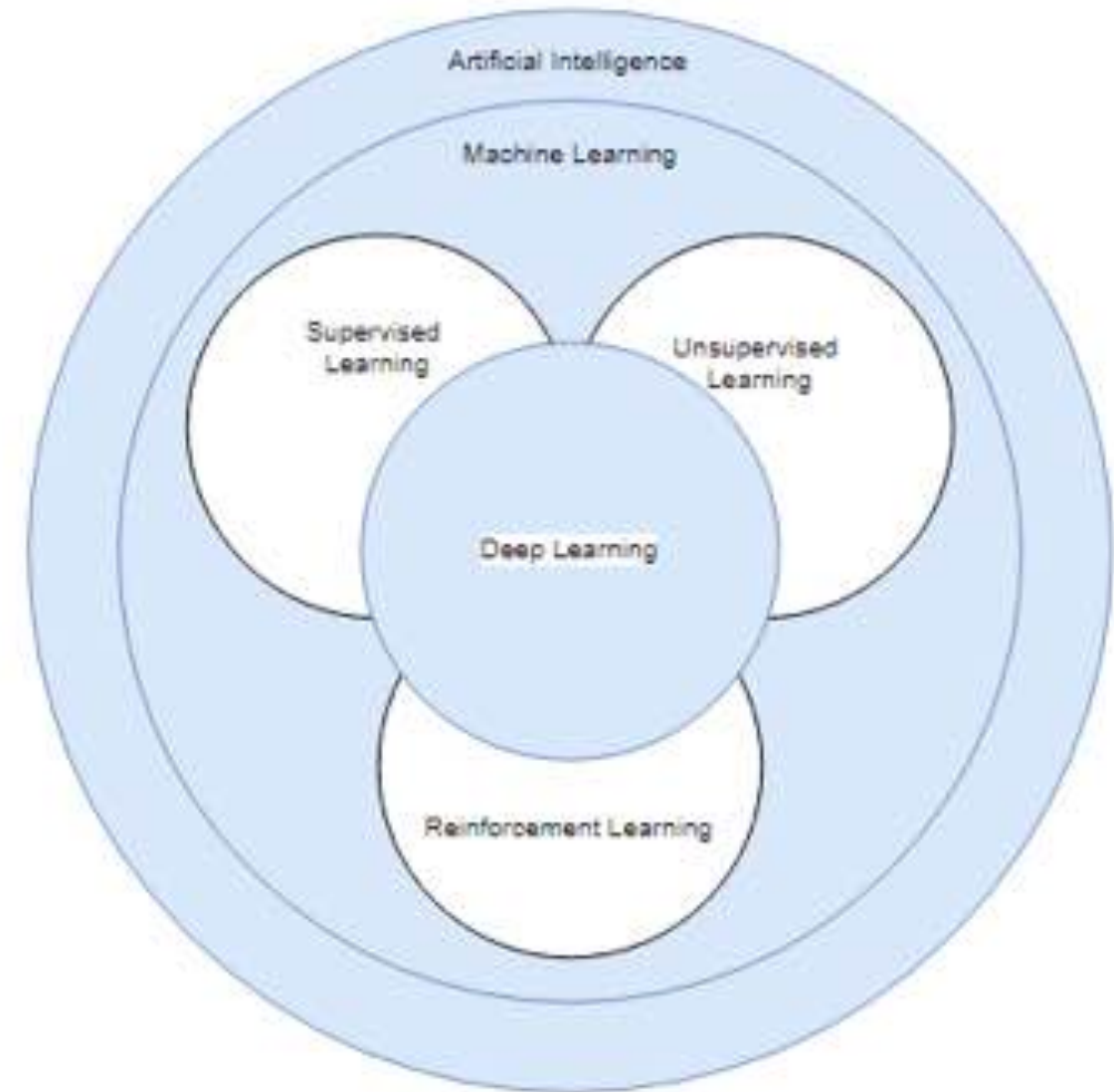




# What is Deep learning?

Getting the terms straight

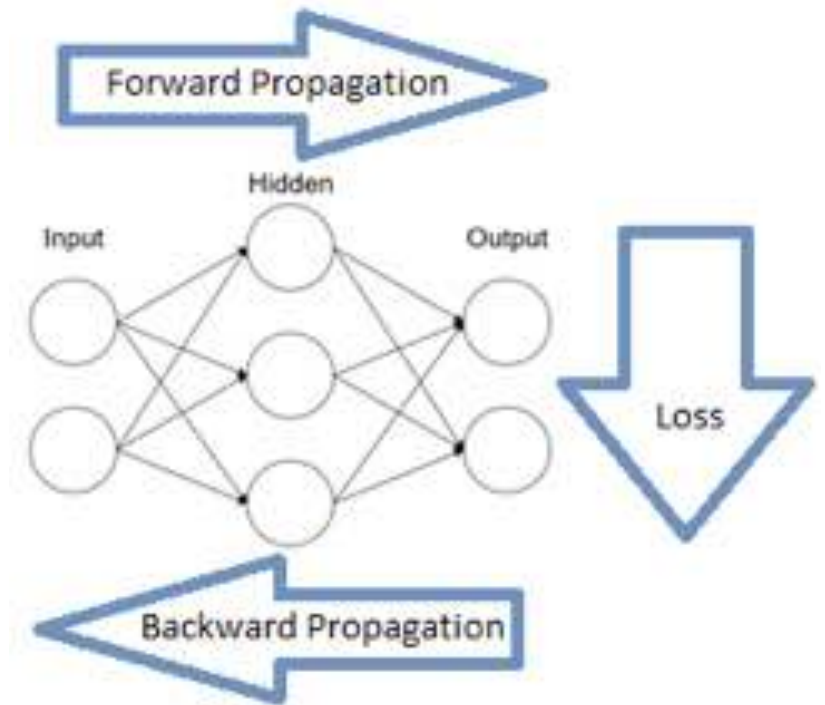
- **Artificial Intelligence**  
*Systems capable of making their own decisions*
- **Machine Learning**  
*Systems capable of learning*
- **Deep Learning**  
*Systems that learn using artificial neural network*



# What is Deep learning?

## In-depth

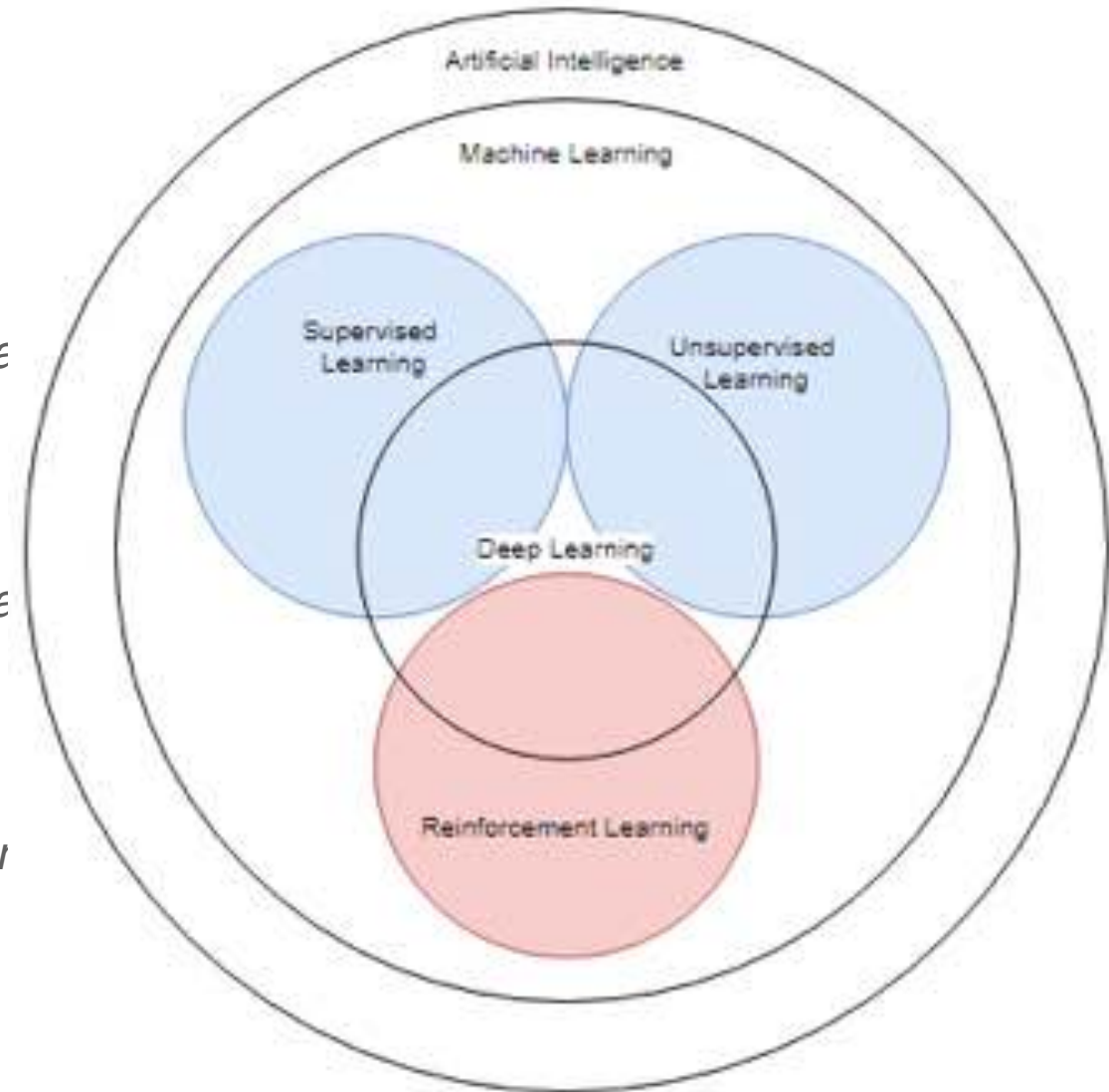
- (Deep) Artificial Neural Networks
  - A deep network has multiple hidden layers*
- Three step learning process:
  1. Forward Propagation
    - Data goes from input to output*
  2. Loss Calculation
    - Calculate how wrong the output was*
  3. Backward Propagation
    - The error goes back through the network, telling each node it's error*



# Types of Deep Learning

Supervised, Unsupervised & Reinforcement Learning

- **Supervised Learning**  
*Recognizing known patterns through labeled data*
- **Unsupervised Learning**  
*Finding unknown patterns through unlabeled data*
- **Reinforcement Learning**  
*Learning the best behavior through trial-and-error*

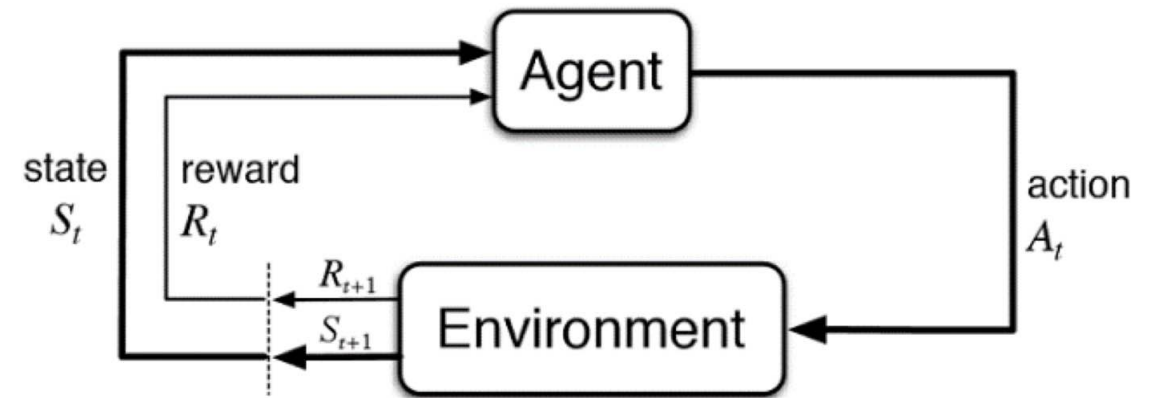




# Reinforcement Learning

## Key Terms

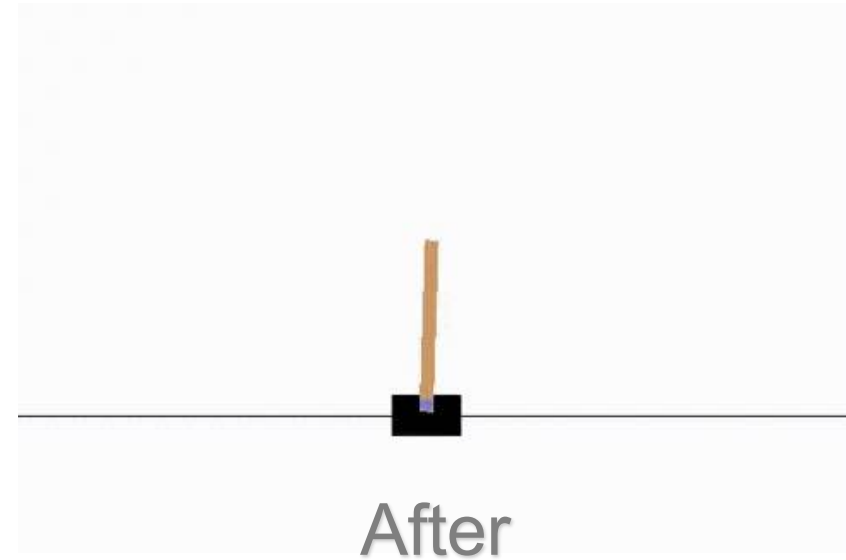
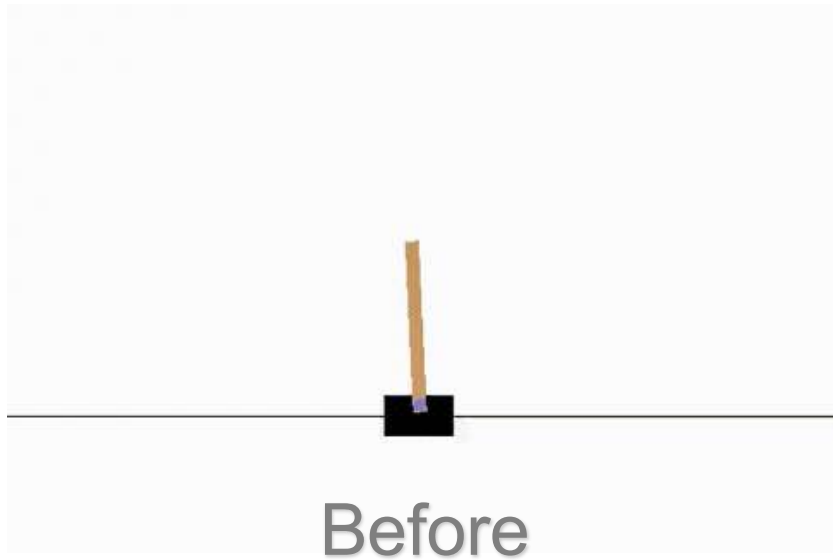
- Agent - *The algorithm*
- Policy - *The agent's behavior*
- Environment – *The world the agent “lives” in (Sobek)*
- Action - *Steps preformed by the agent (Target levels)*
- Reward - *How “good” the agent's action was*



# Reinforcement Learning

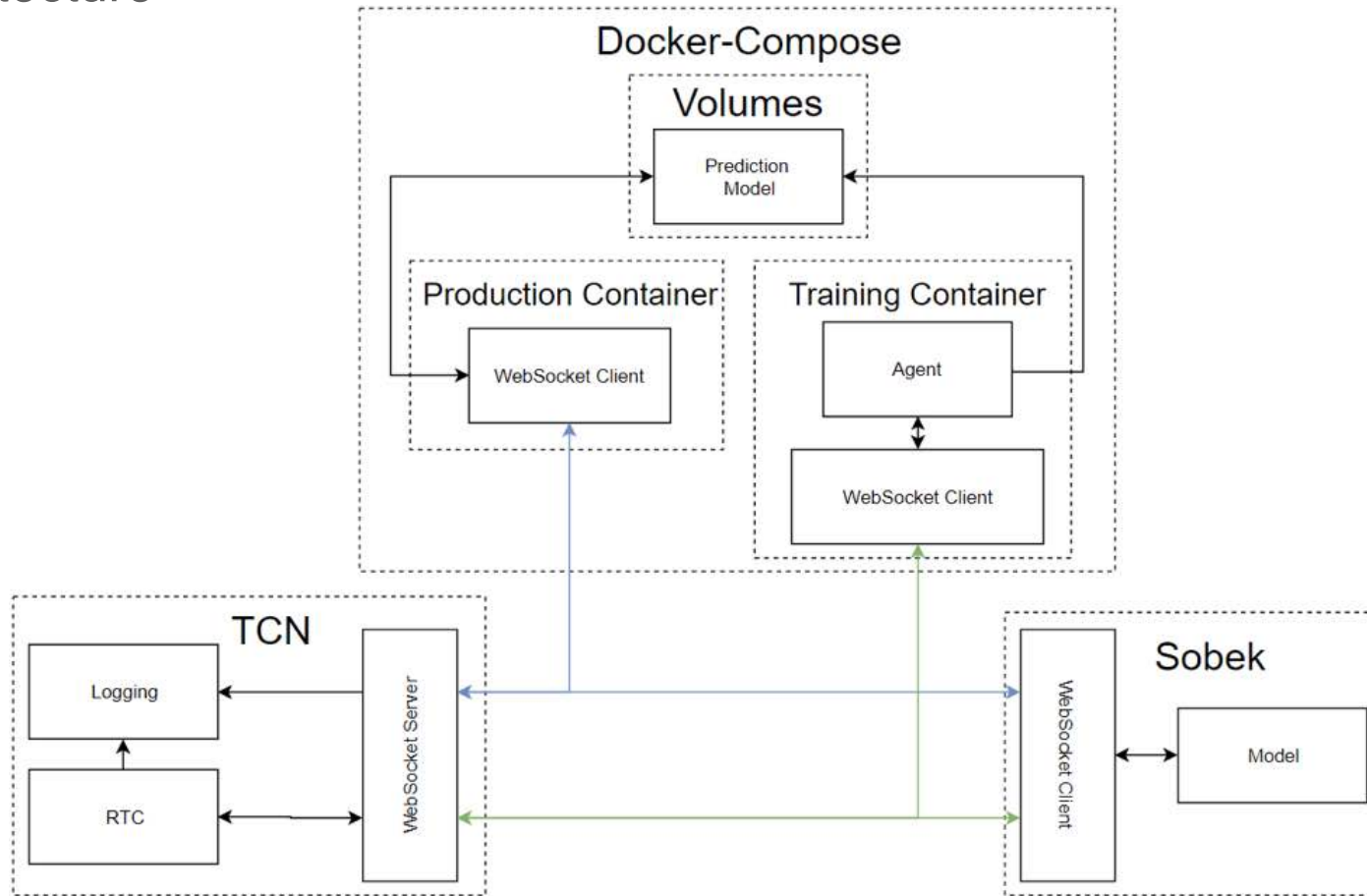
## Example

- The CartPole problem



# The Camino System

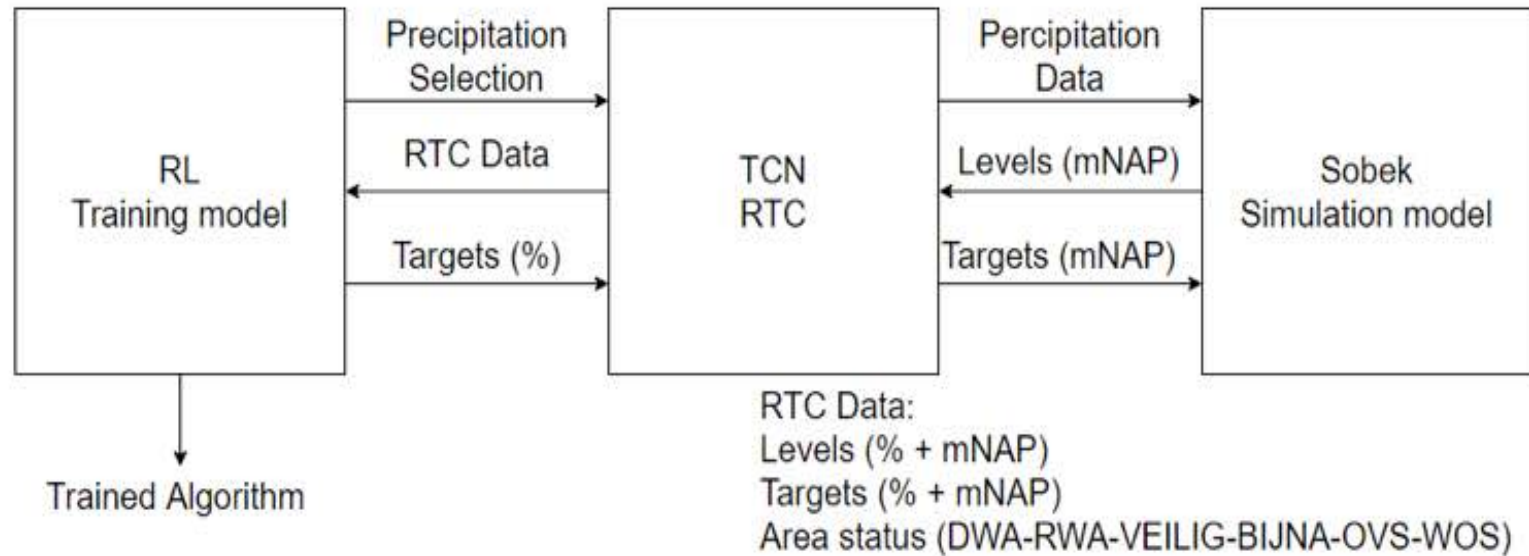
## System Architecture





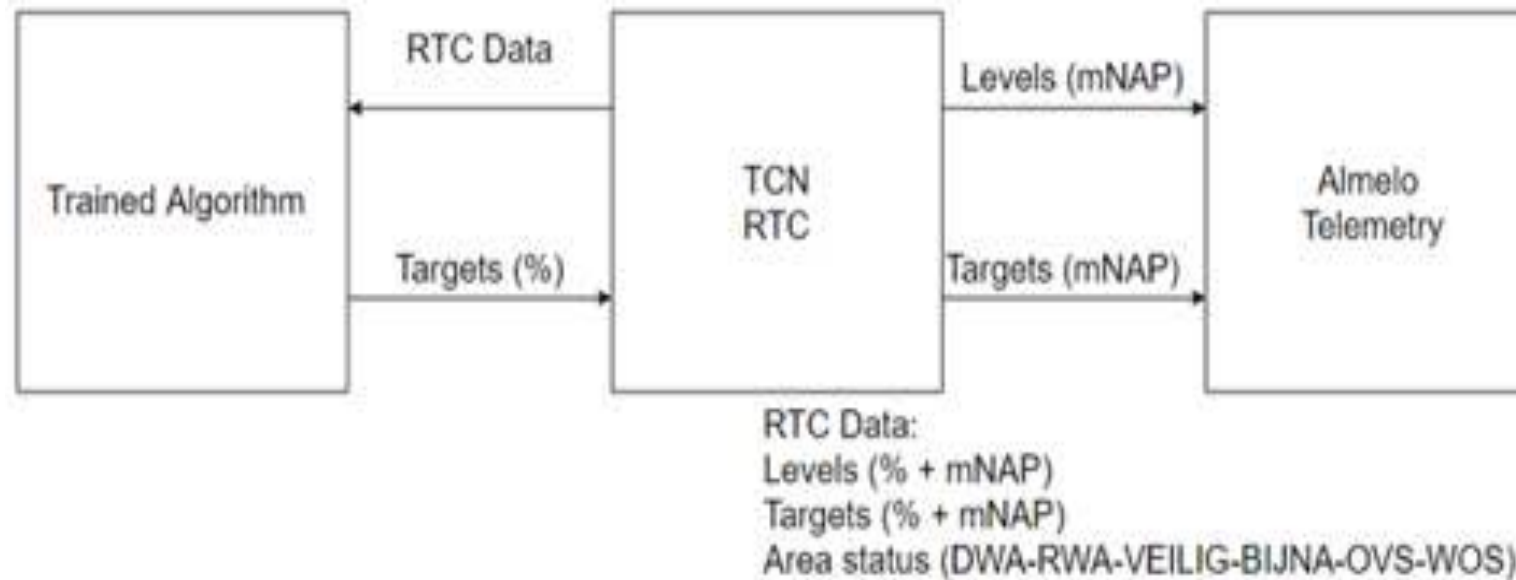
# The Camino System

## Data Flow – Training Container



# The Camino System

## Data Flow – Production Container



# Project status

Where are we now?

- Done:
  - Architecture
  - Training Code
- These next couple weeks:
  - Downpour selection
  - Training
  - Testing and optimizing



# Resultaten & Vervolgstappen

Jan Nijeboer – Benchmark Electronics

# Samenvatting & vervolgstappen



## Resultaten tot dusver:

- De datasets zijn gedefinieerd
- De simulatieomgeving is beschikbaar en wordt gevalideerd
- Alle systemen zijn via WebSockets gekoppeld

## Vervolgstappen:

- Trainen van het systeem op de geselecteerde deelgebieden (iteratief)
  - met verschillende ML algoritmes
  - met verschillende beoordelingscriteria
  - geoptimaliseerd voor de 3 doelstelling
- Selectie van het(/de) beste algoritme(s) en dit toepassen op het hele systeem
- Evaluatie en vastleggen van de resultaten
- Opstellen van een implementatieplan

# Vragen

