University of Antwerp
Faculty of Applied Engineering

University of Antwerp
M4S
Modelling For Sustainability

Peter Hellinckx

Green inland shipping

VLAIO
BLUE CLUSTER
collaborating for #stronggrowth

Who am I?

Peter Hellinckx

Prof distributed AI @ UAntwerpen

- **Education**
  - Faculty of Applied Engineering
  - Head of Dept. Electronics-ICT
  - Teaching: AI, Python, Media & Digital Society, Computer Graphics
- **Research**
  - Distributed AI systems
- **Industry**
  - Co-founder: Rollo.ai, Digitrans, Hysopt, HI10

Who are we?

1. M4S (Modelling For Sustainability)
2. Core is (data-driven) monitoring for sustainable control and decision support
3. Topics
   1. AI for Sustainable decision making
      1. Decision support
         1. Construction
         2. Mobility
         3. Logistics
      2. Control
         1. HVAC
         2. Facility management
         3. Renewables
         4. Shipping
   2. Climate change
      1. Weather prediction
      2. Climate change predictions
      3. Extreme Events
      4. Effects

Phd Students:

@ M4S

@ EMIB

Team:


Peter


Prof Tabari


DR. Massobrio


Dr. Van Den Bergh


Marco


Aaron


Pieter Jan


Benoit


Stijn


Takumi


Amirhossein


Nele


Rien


Alexander


Walter


Houssam


Senne

Open vacancies

Who are we?

1. M4S (Modelling For Sustainability)
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         1. Construction
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   2. Climate change
      1. Weather prediction
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      4. Effects

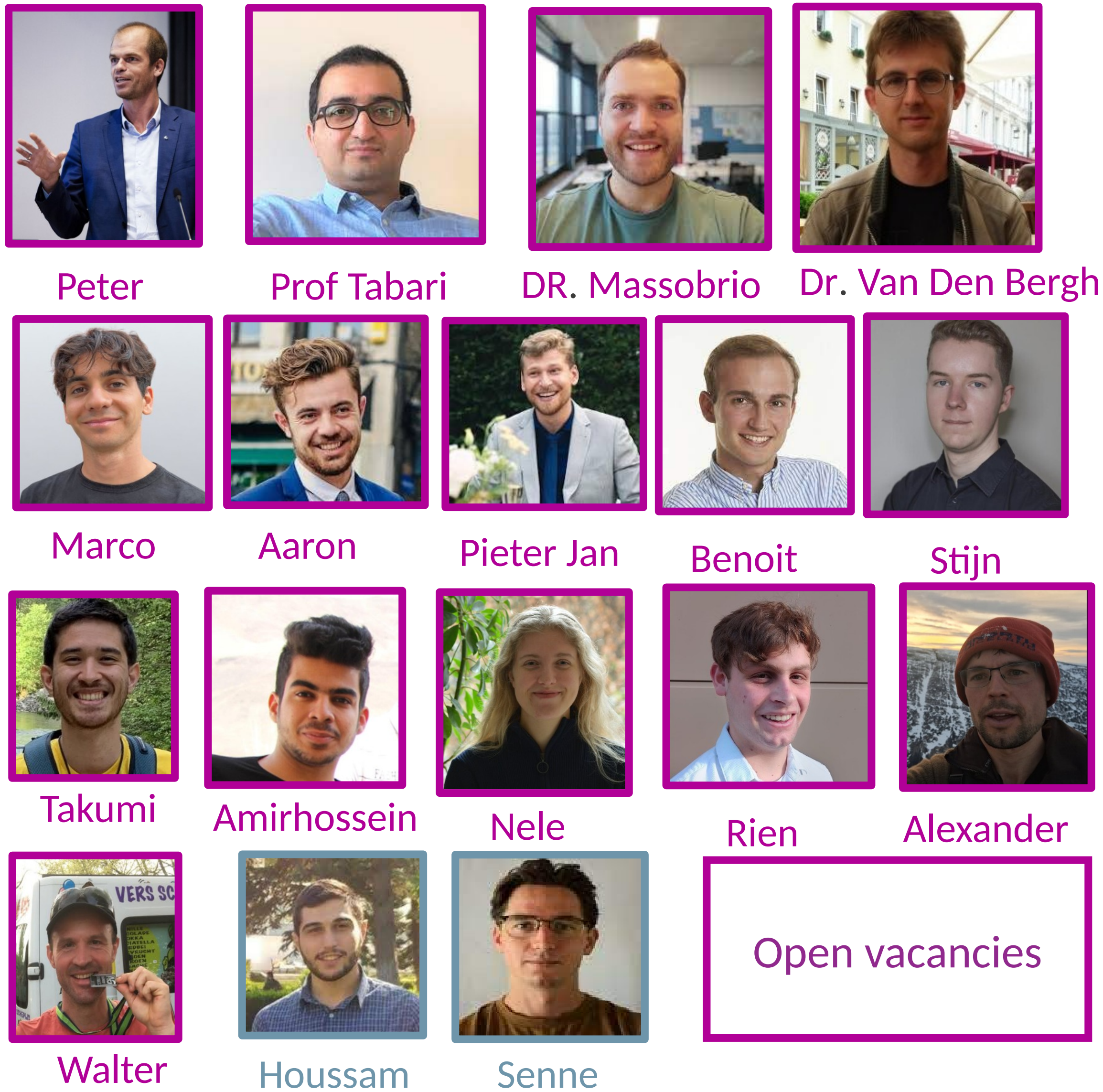
Geospatial Data

Phd Students:

@ M4S

@ EMIB

Team:



Universiteit Antwerpen

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Our USP: Where do we live?

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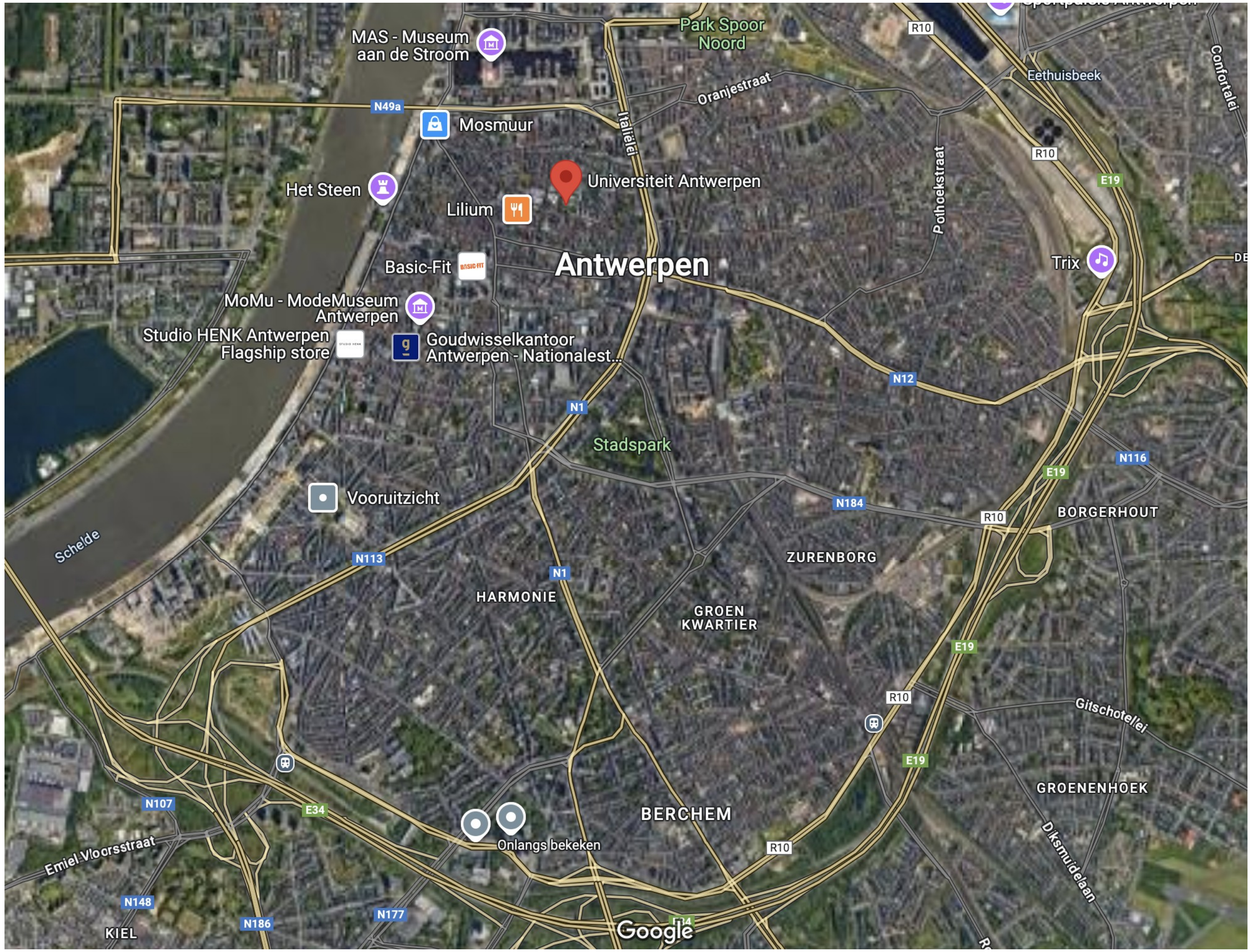
Our USP: Where do we live?



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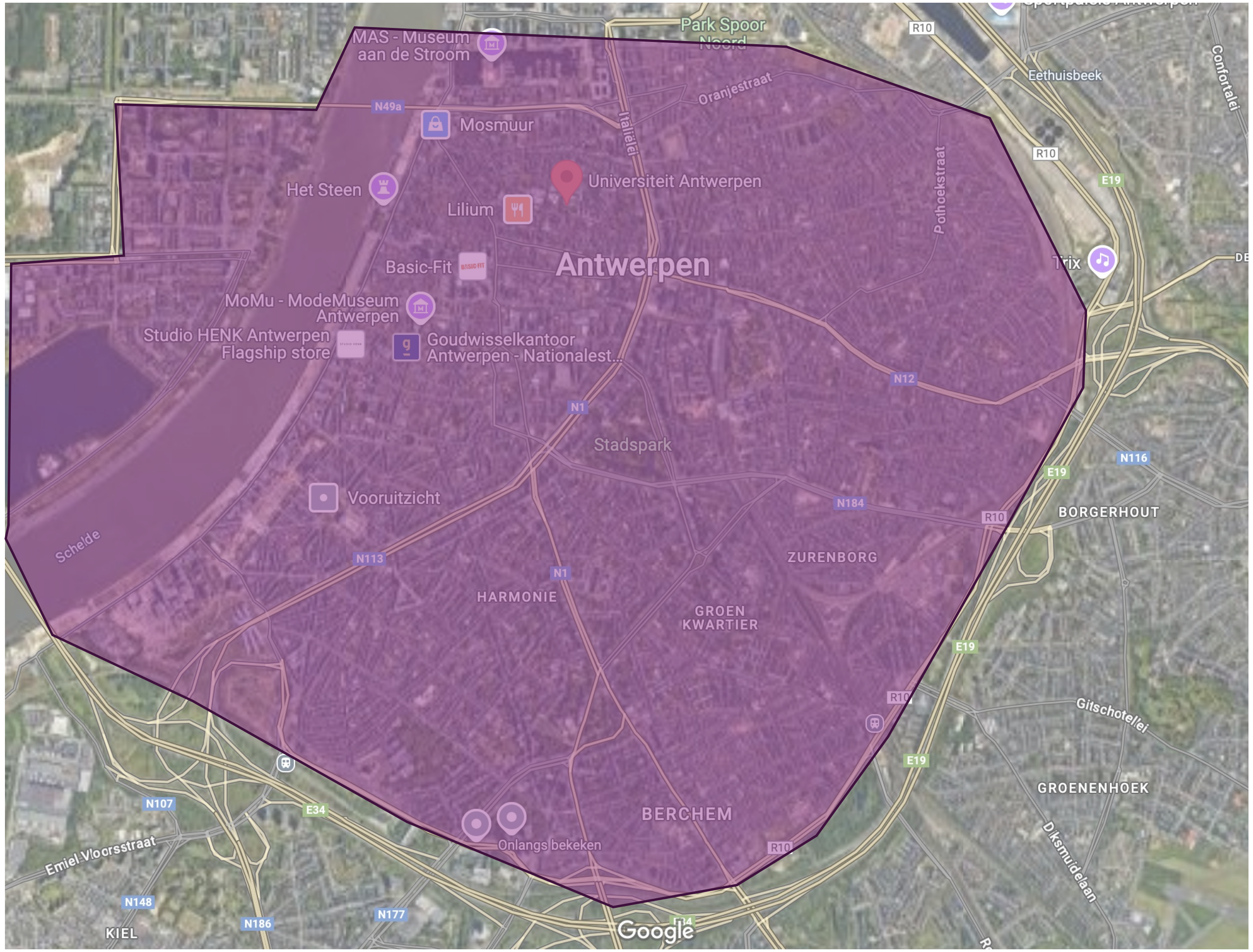
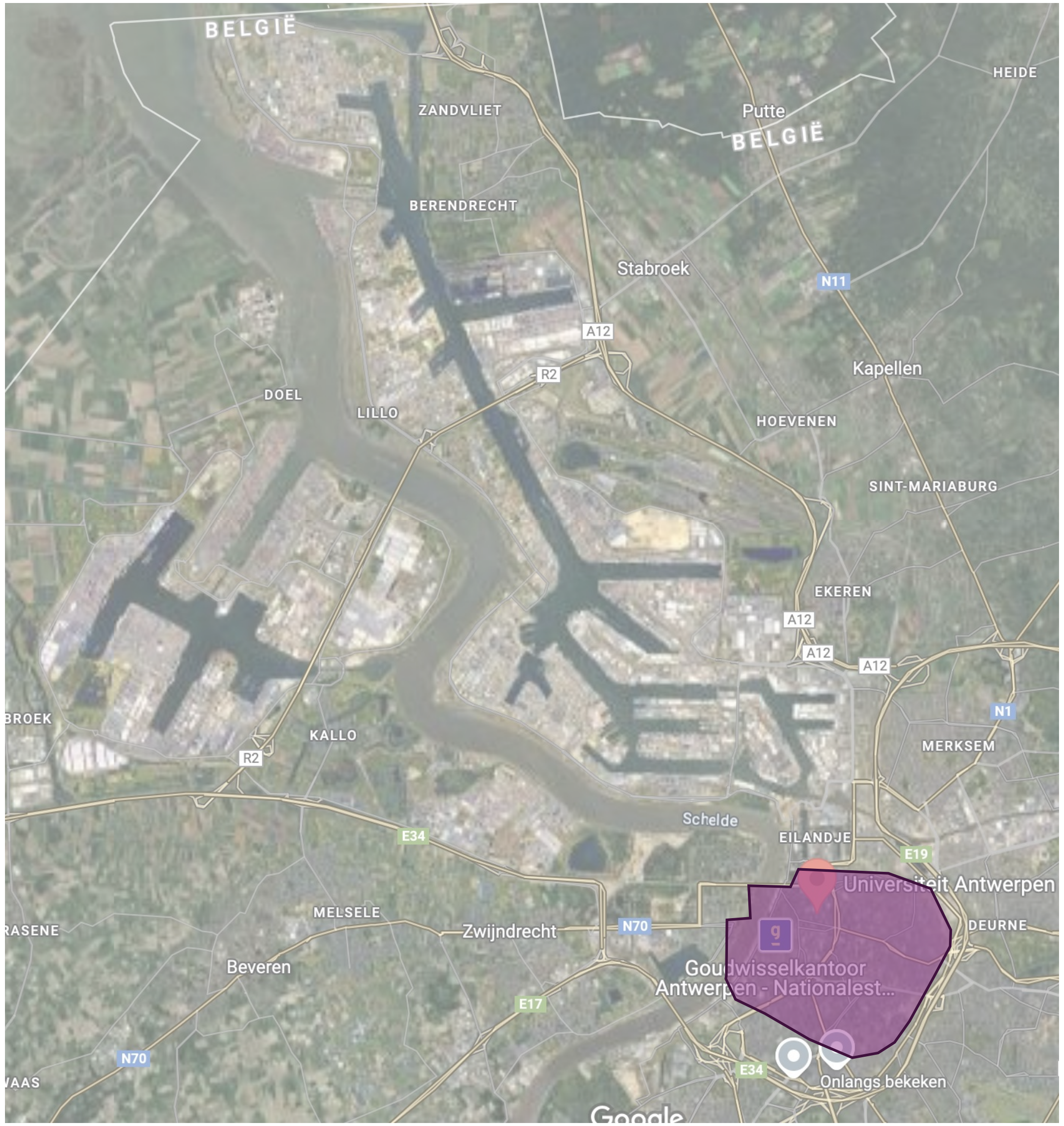
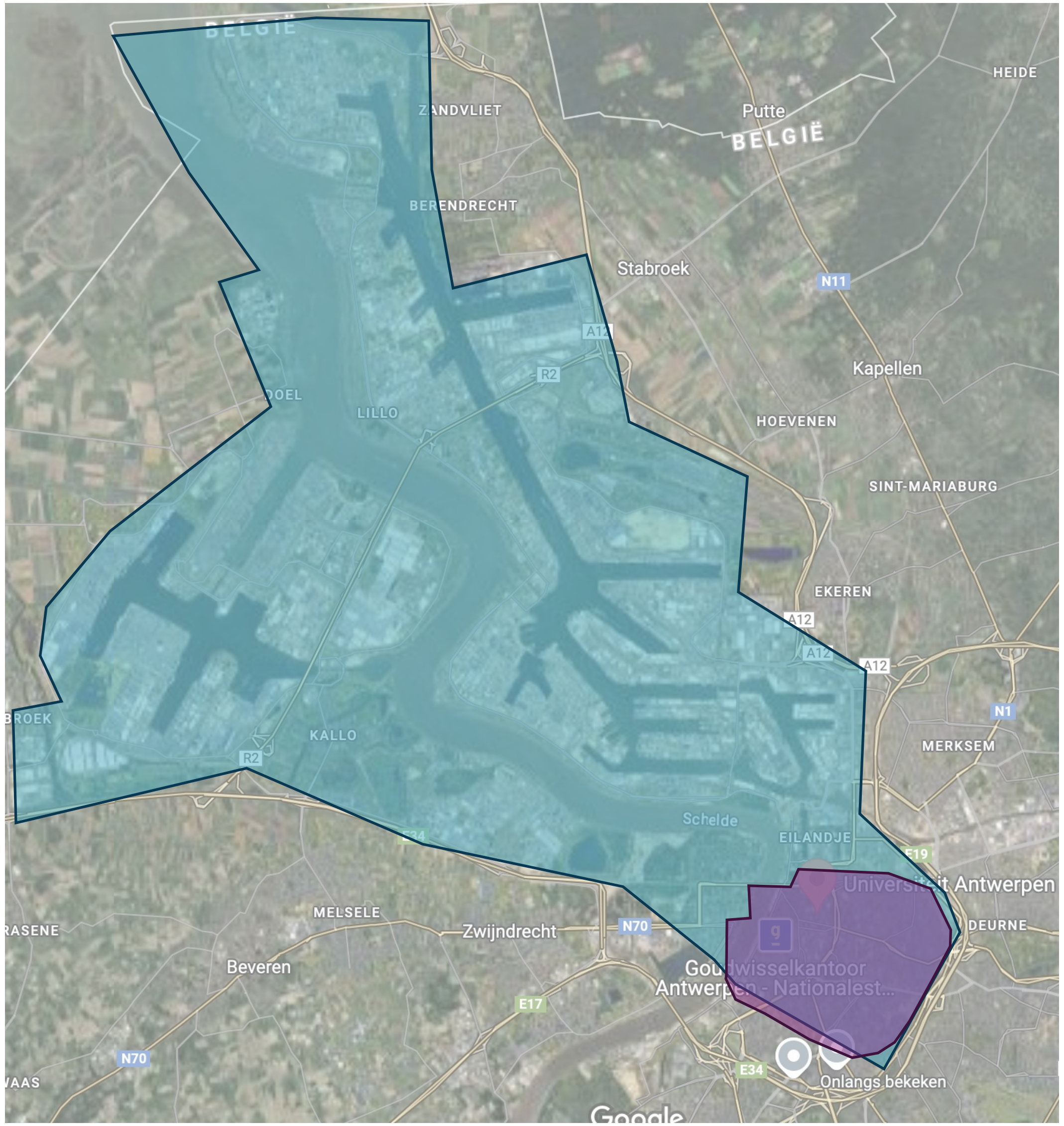
USP


MAS - Museum
aan de Stroom
Park Spoor
Noord
R10
Oranjestraat
Eethuisbeek
Confortalei
N49a
Mosmuur
Italiëlei
R10
Het Steen
Universiteit Antwerpen
Pothoekstraat
E19
Lilium
Basic-Fit
Antwerpen
Trix
MoMu - ModeMuseum
Antwerpen
Studio HENK Antwerpen
Flagship store
Goudwisselkantoor
Antwerpen - Nationalest...
N12
N1
Stadspark
N116
E19
Vooruitzicht
N184
R10
BORGERHOUT
Schelde
N113
ZURENBORG
N1
HARMONIE
GROEN
KWARTIER
E19
R10
Gitschotellei
E19
GROENENHOEK
N107
E34
BERCHEM
Onlangs bekeken
R10
Emiel Vloorsstraat
Diksmuidelaan
N148
N186
N177
KIEL
Google

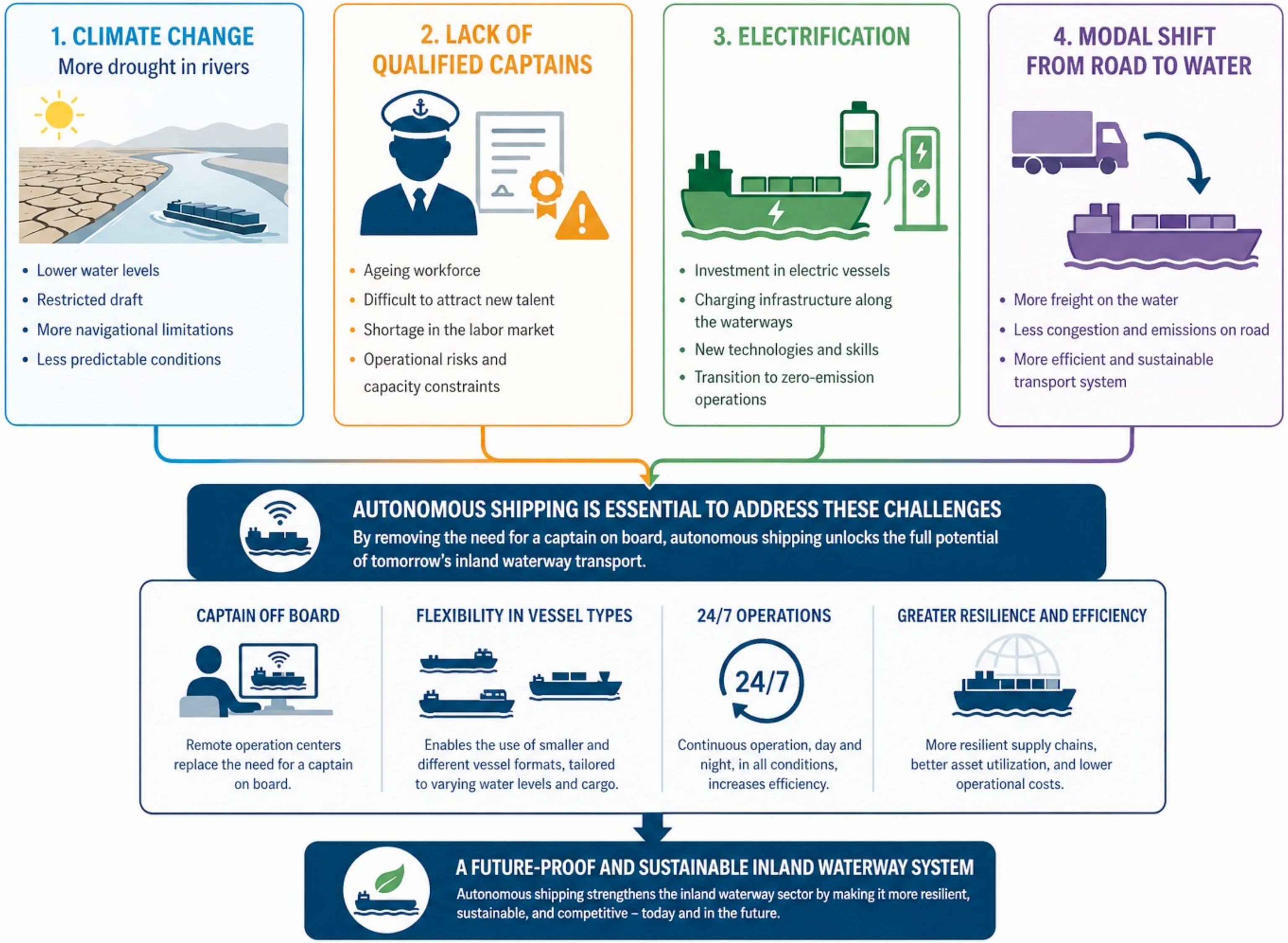
Our 2nd USP : Where do we live?



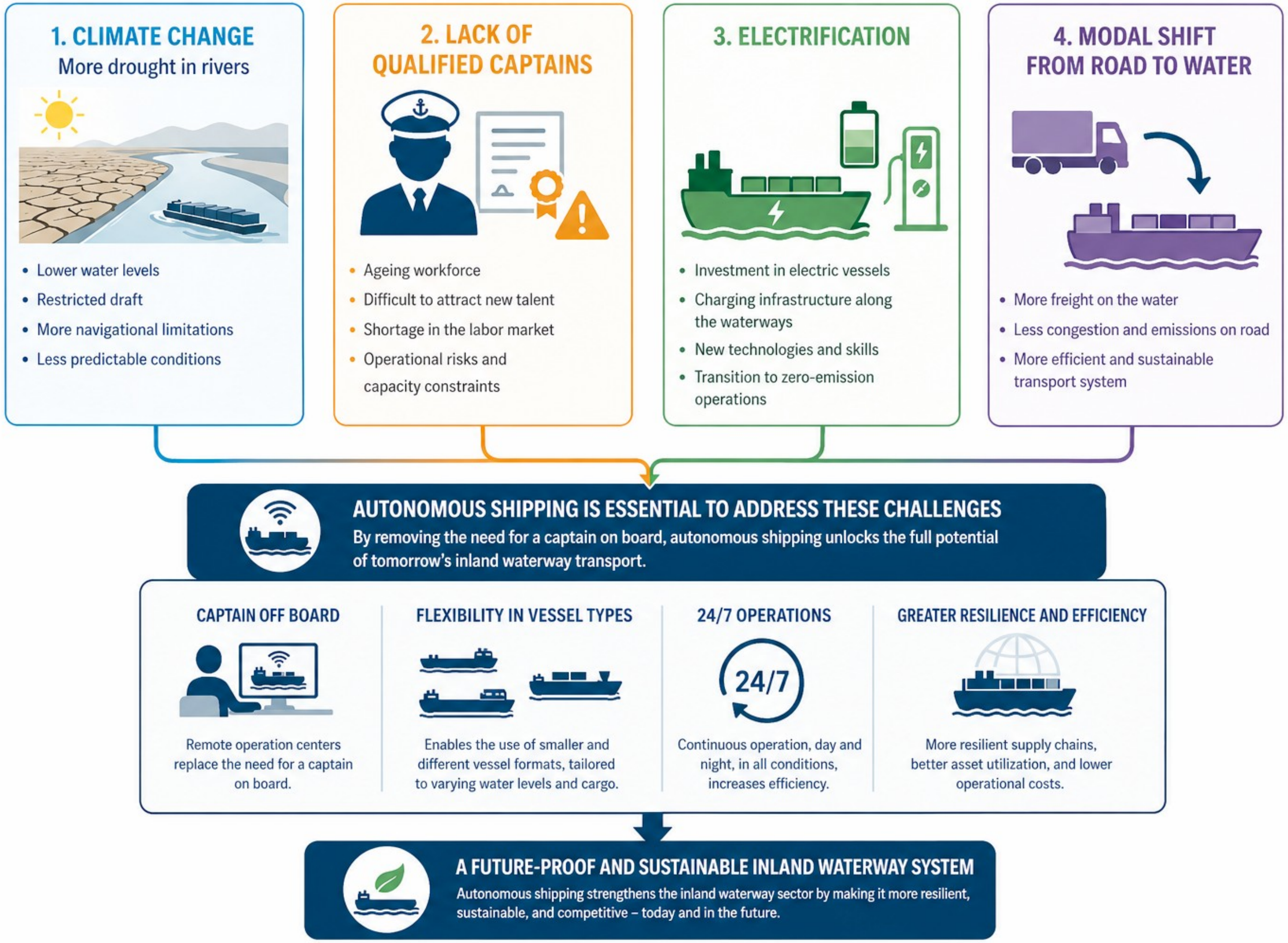
USP2: Testbed for maritime research

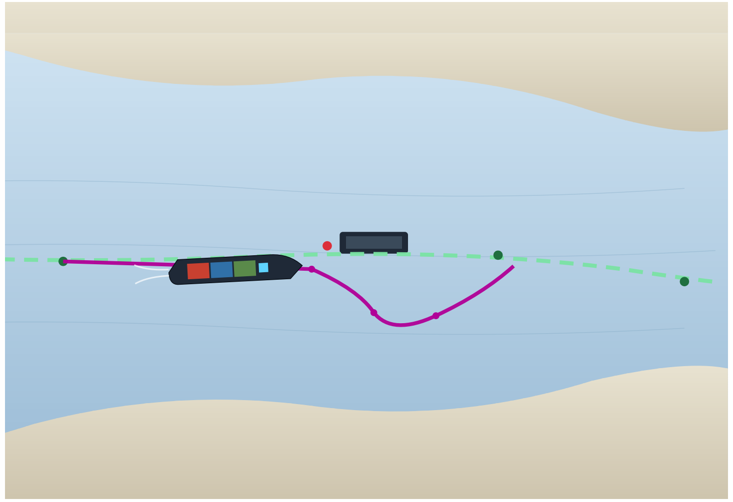


Inland shipping

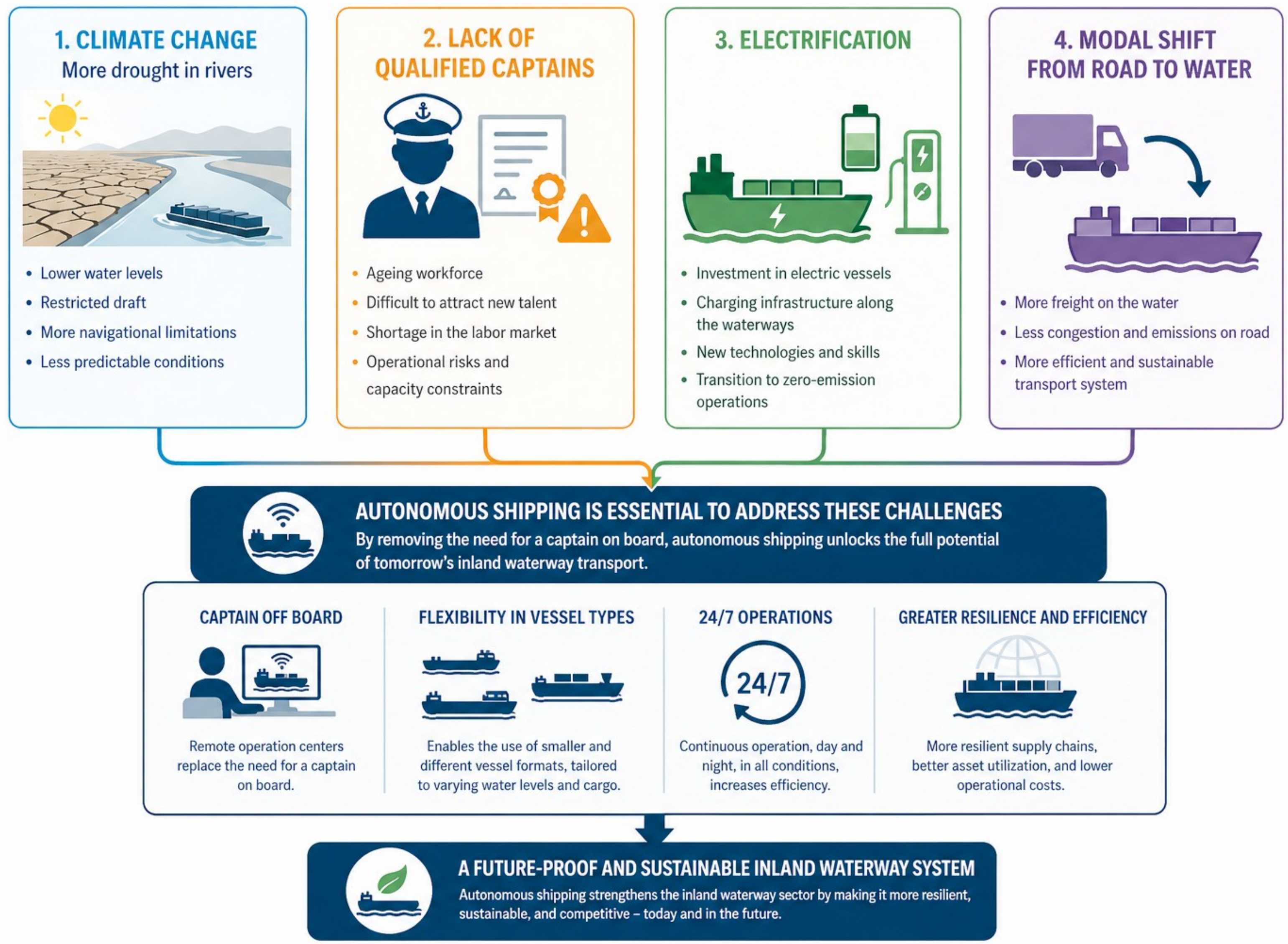


Inland shipping



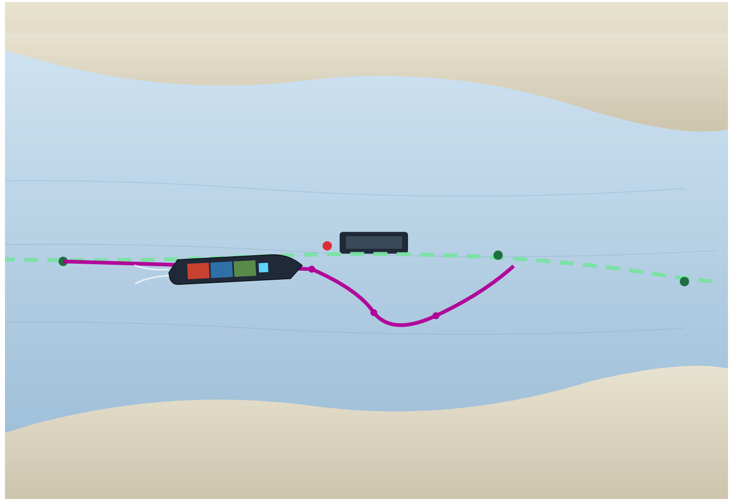


Inland shipping



<u>Train an AI agent</u>

- We need to know ship
- We need to know the environment
- We need data



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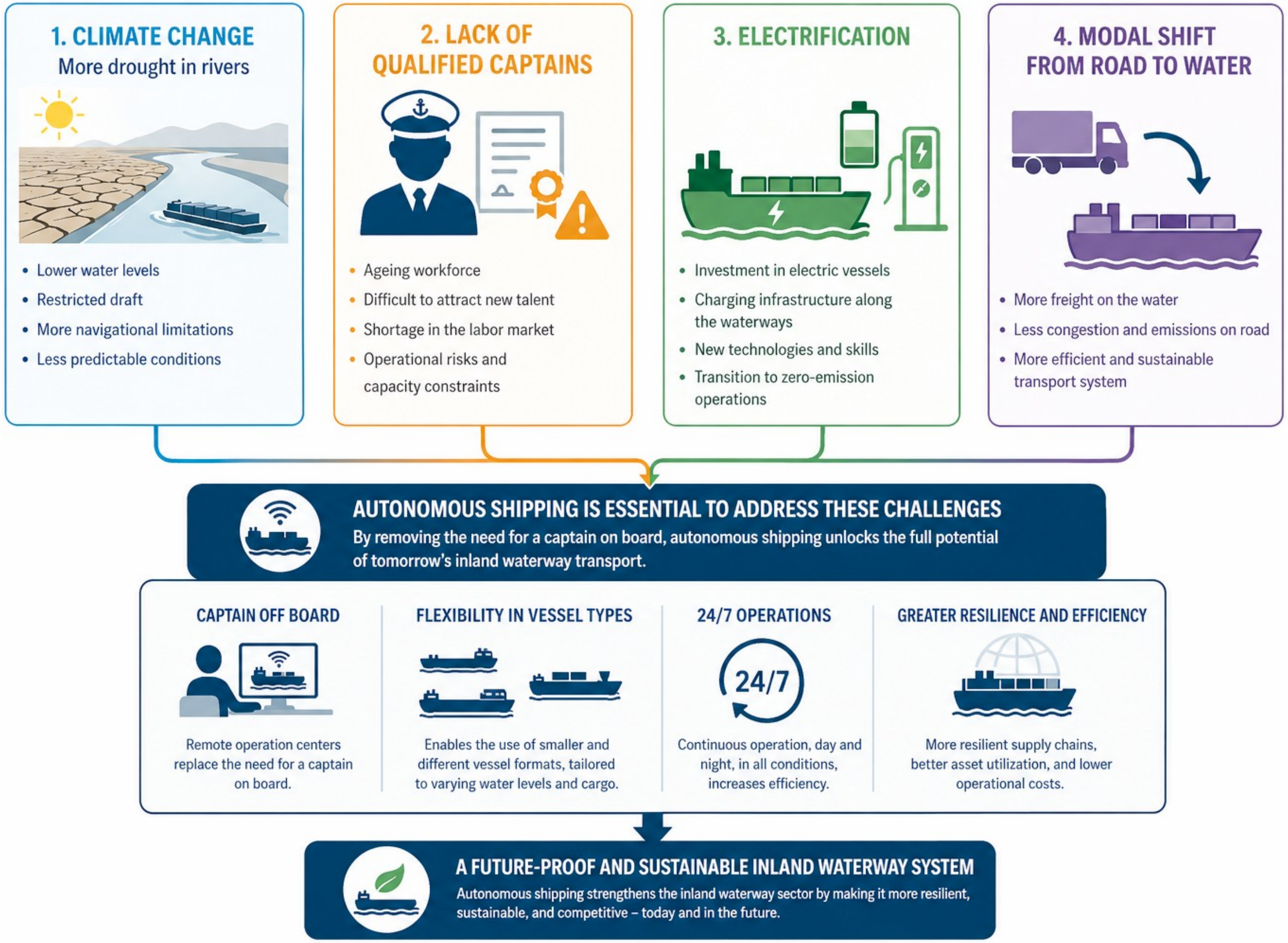
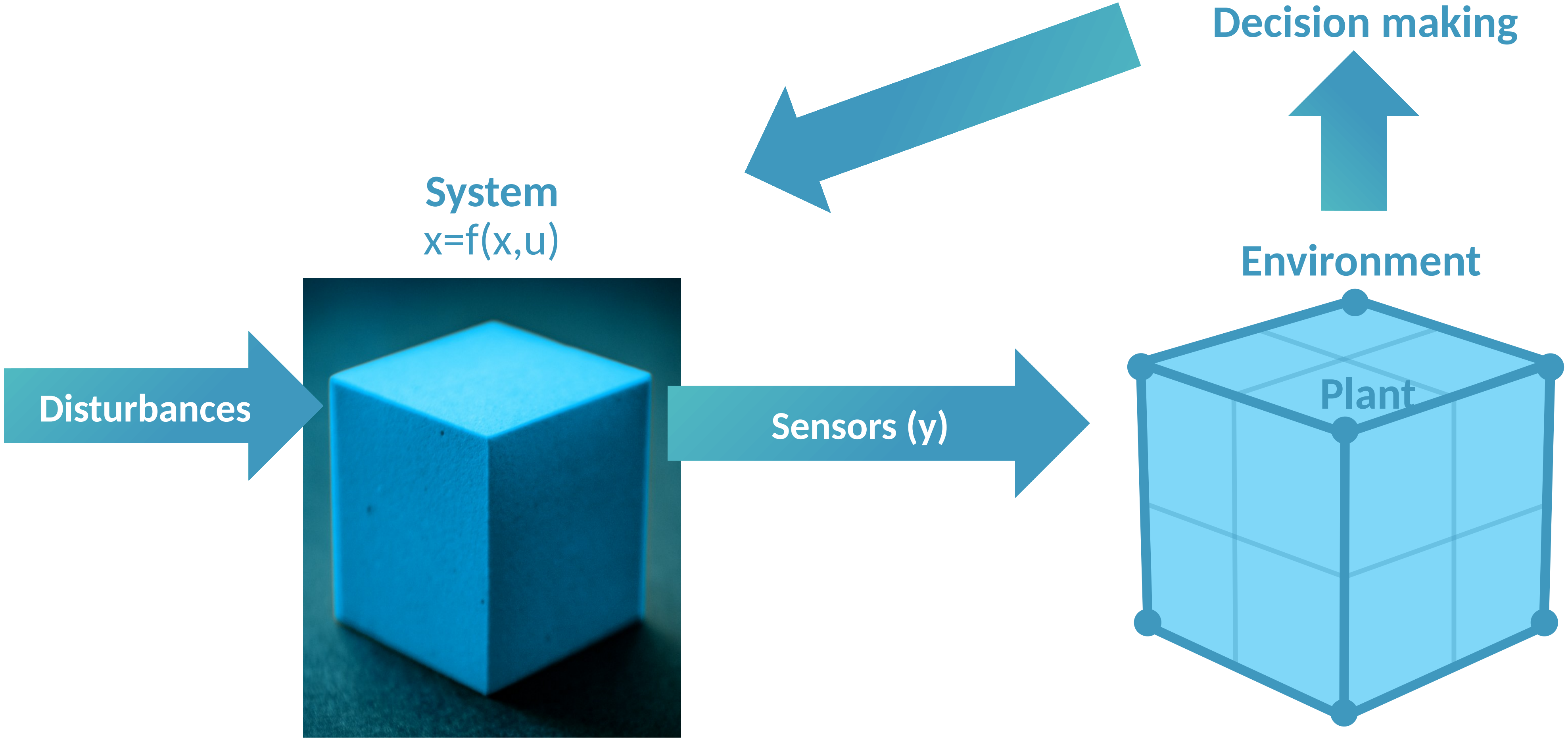
Inland shipping

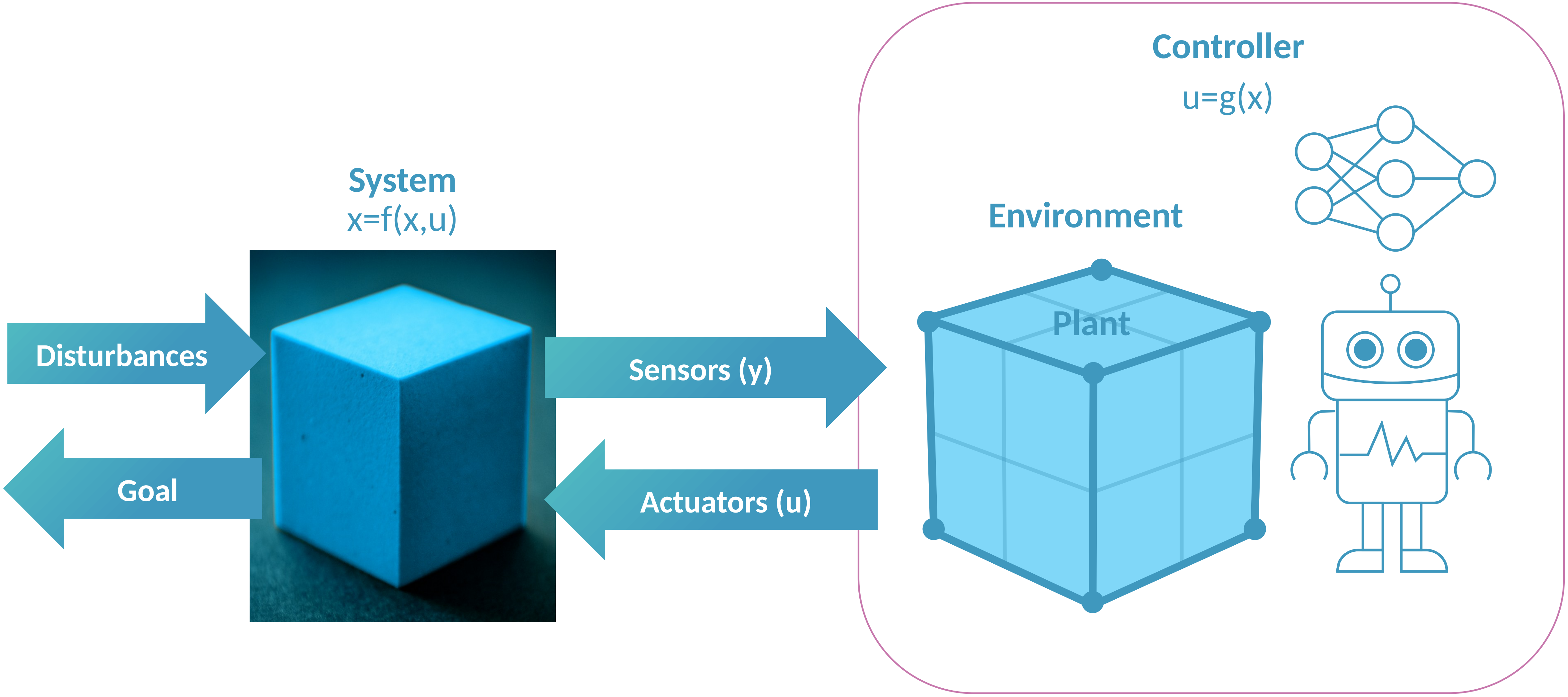


What is a Digital twin?

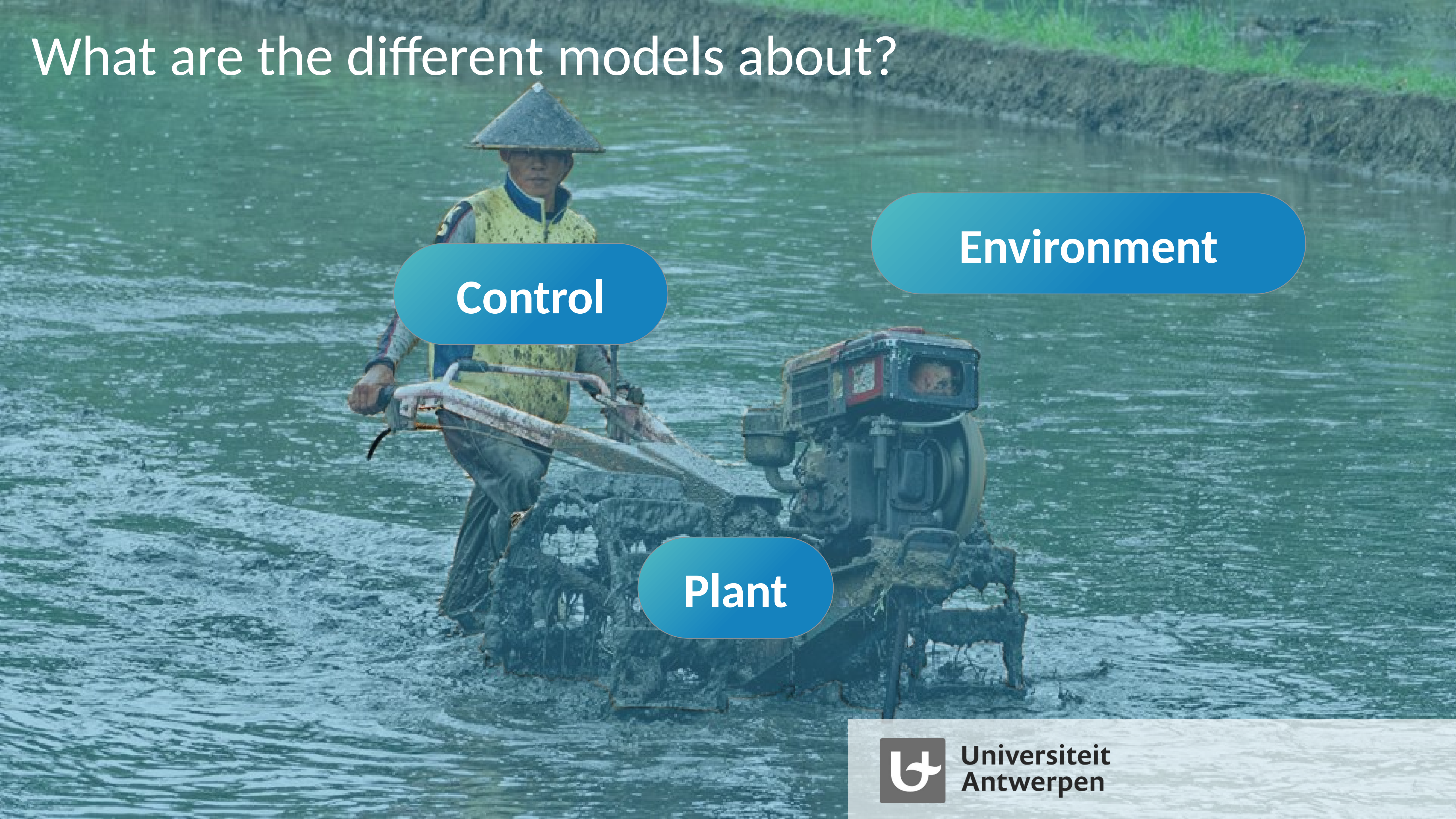


What is it to me?

MODELS

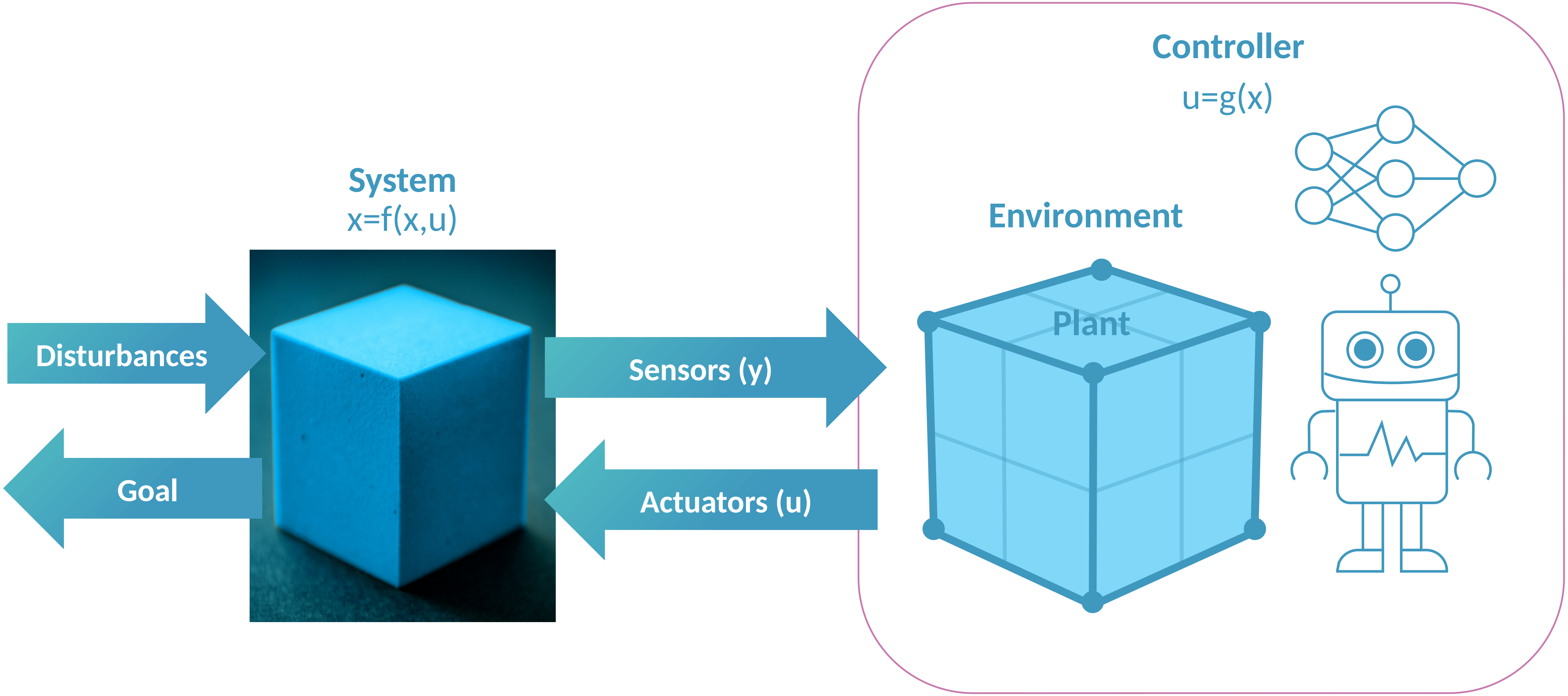


What are the different models about?

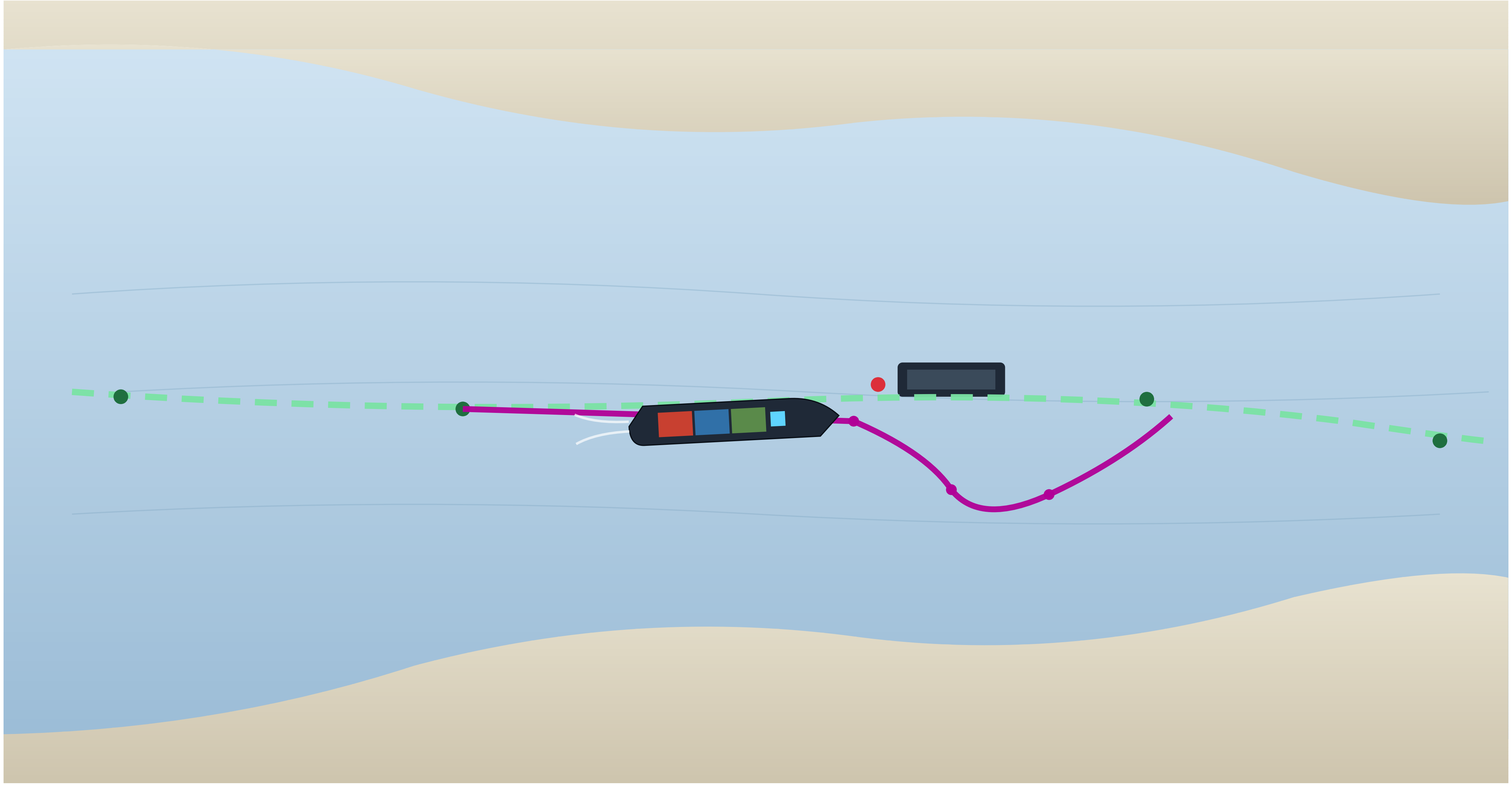


Data driven control

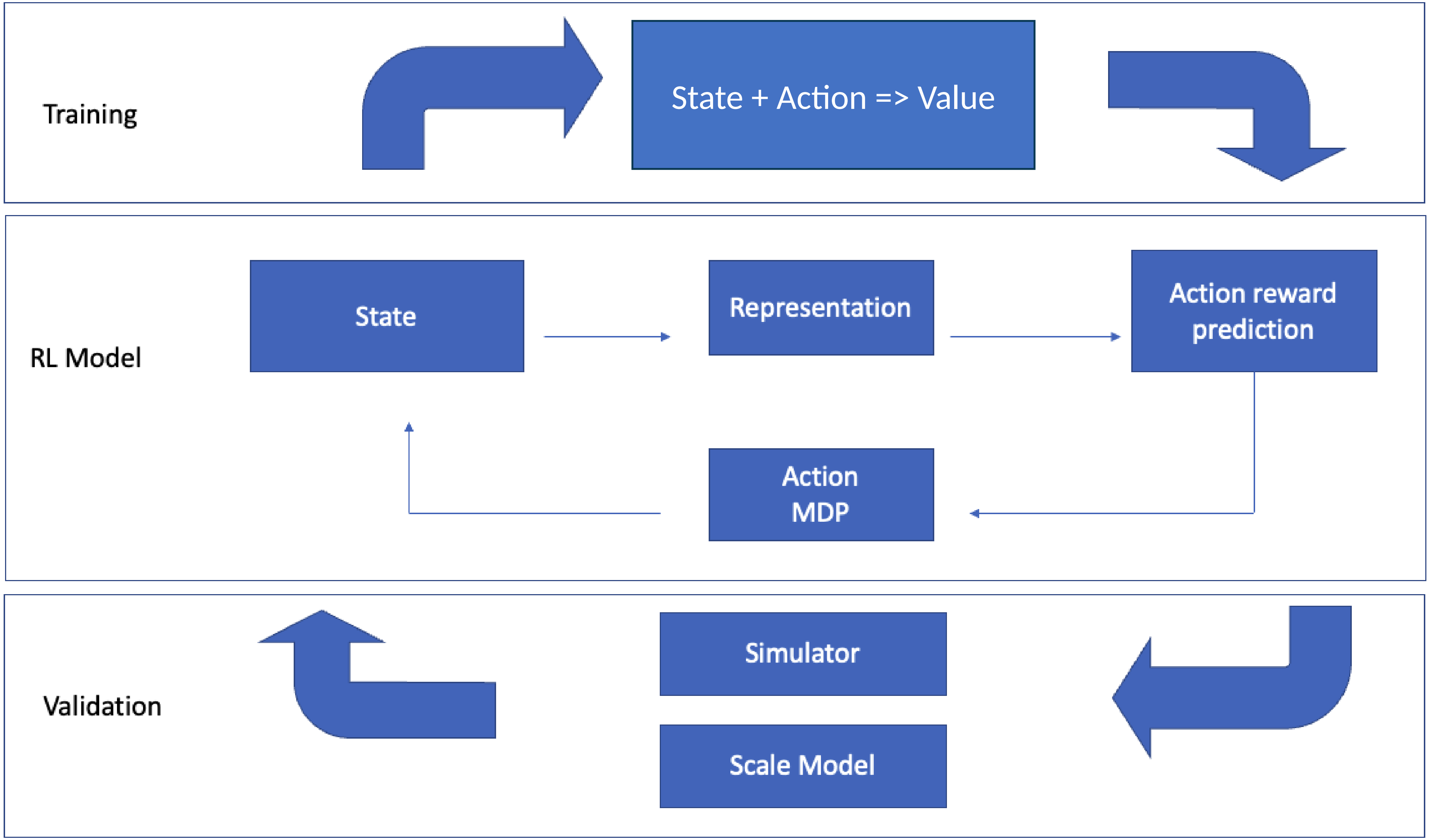
MODELS



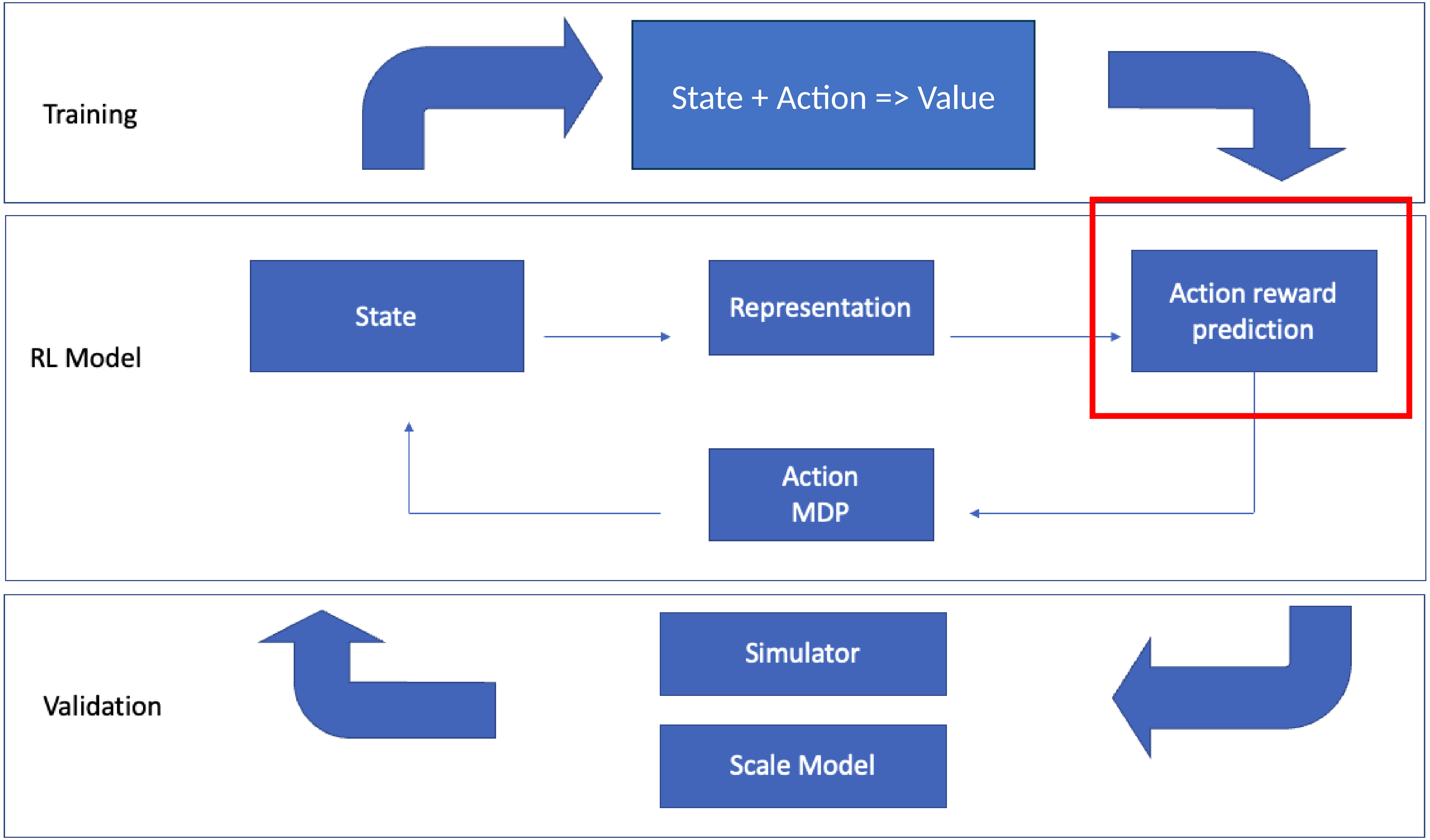
How to build a control model for a ship



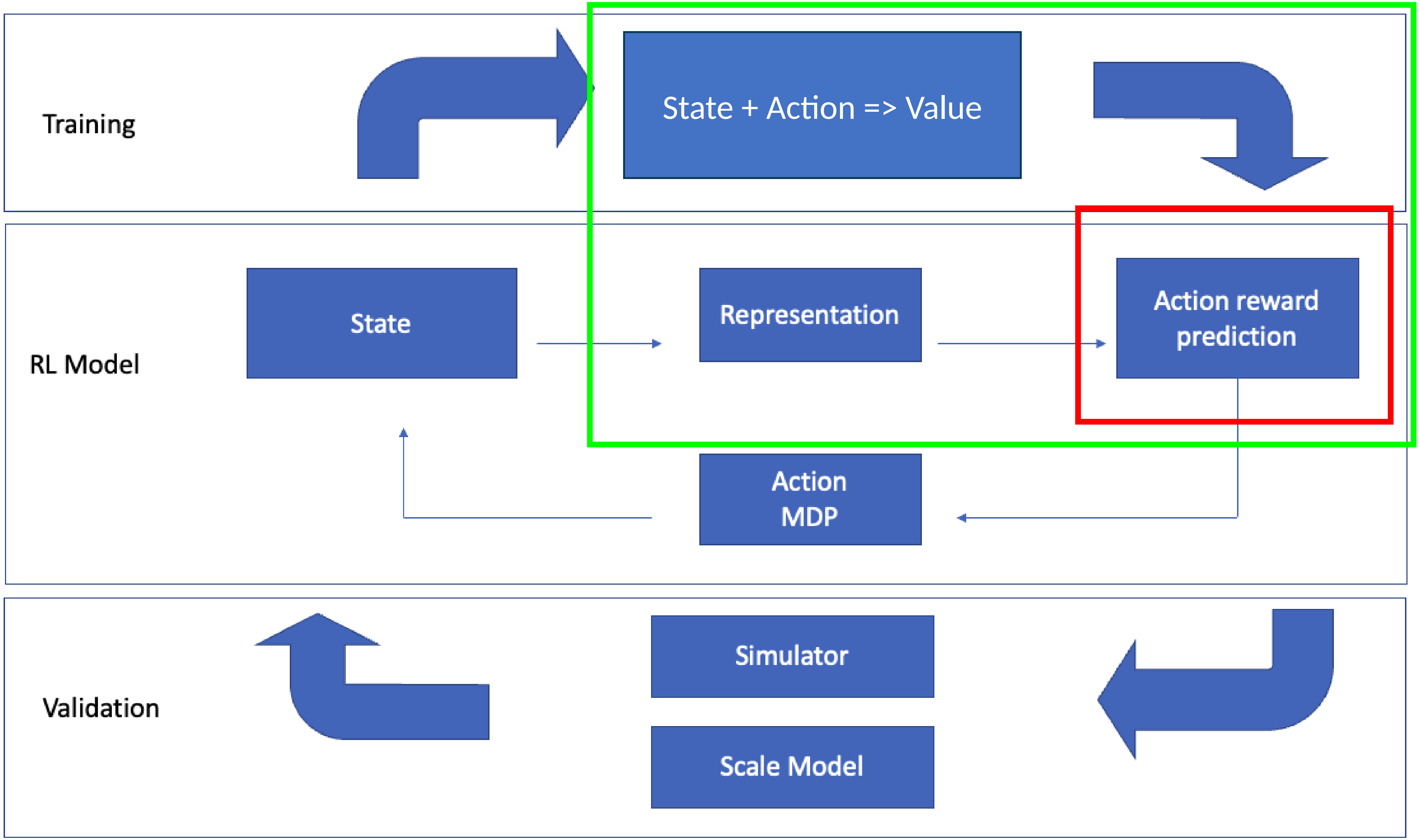
Data Driven Control



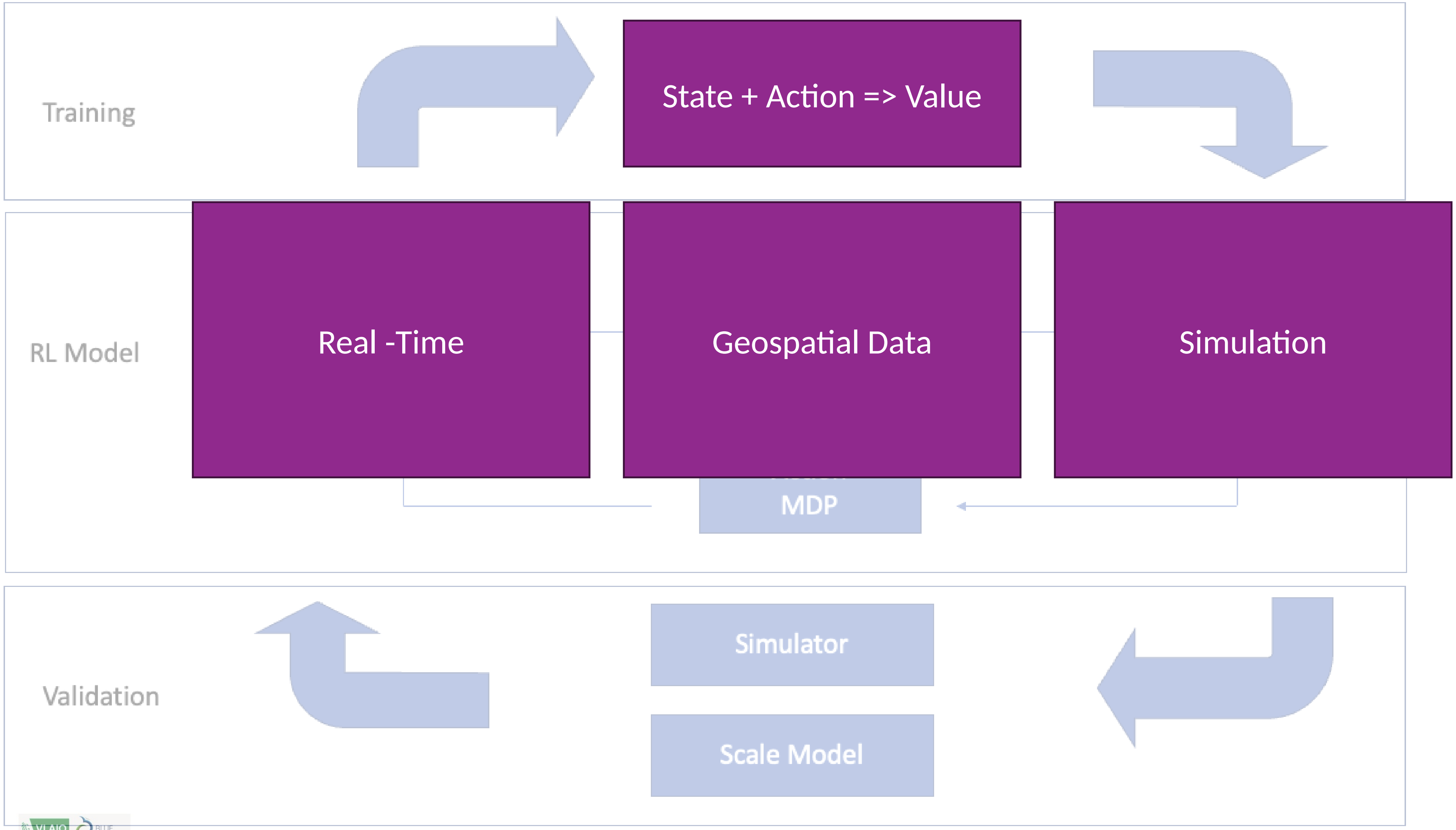
The clue of control is in the reward prediction



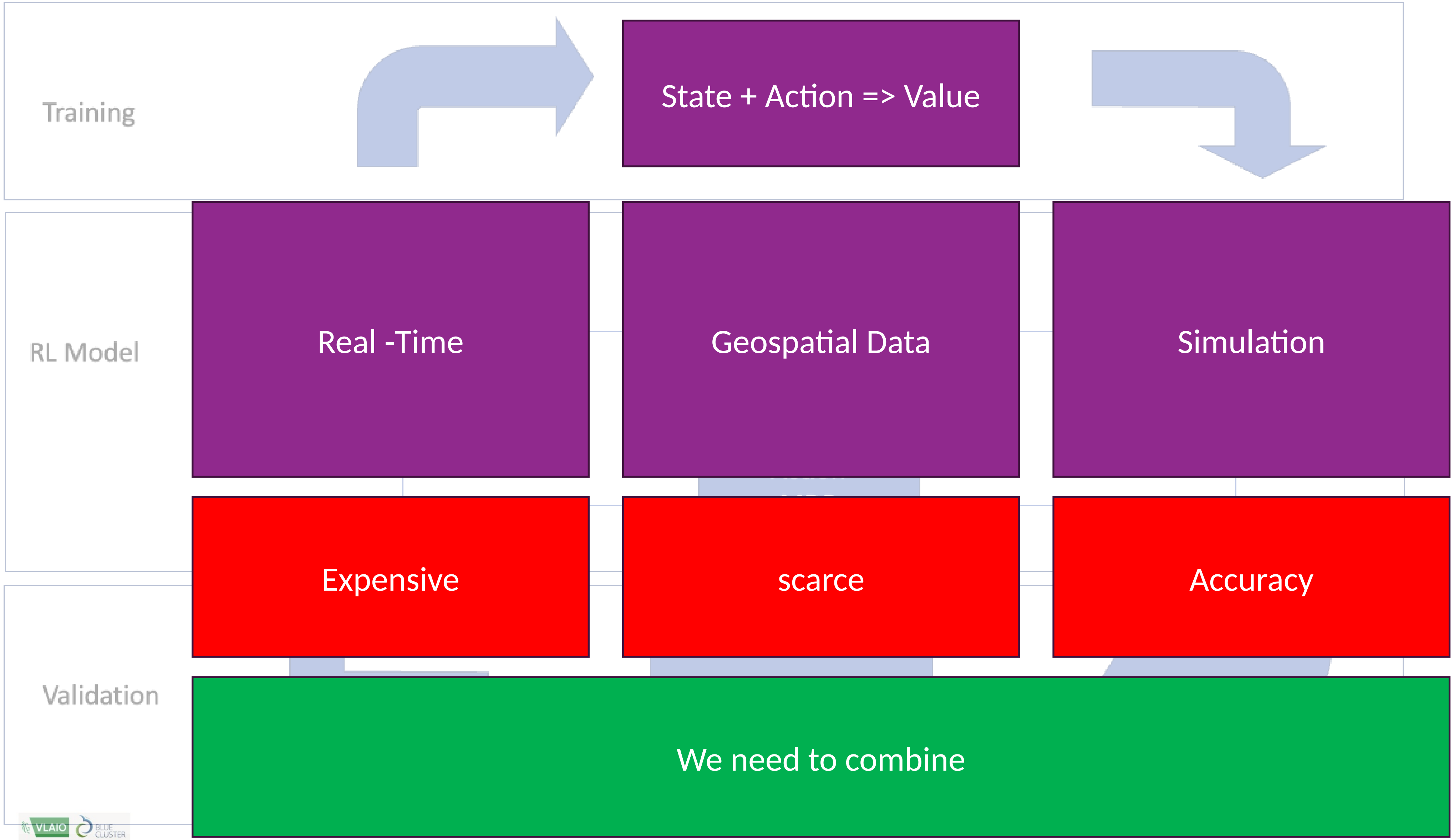
The issue is Data and Complexity



Data issue


Training
State + Action => Value
RL Model
Real -Time
Geospatial Data
Simulation
MDP
Validation
Simulator
Scale Model

Data issue

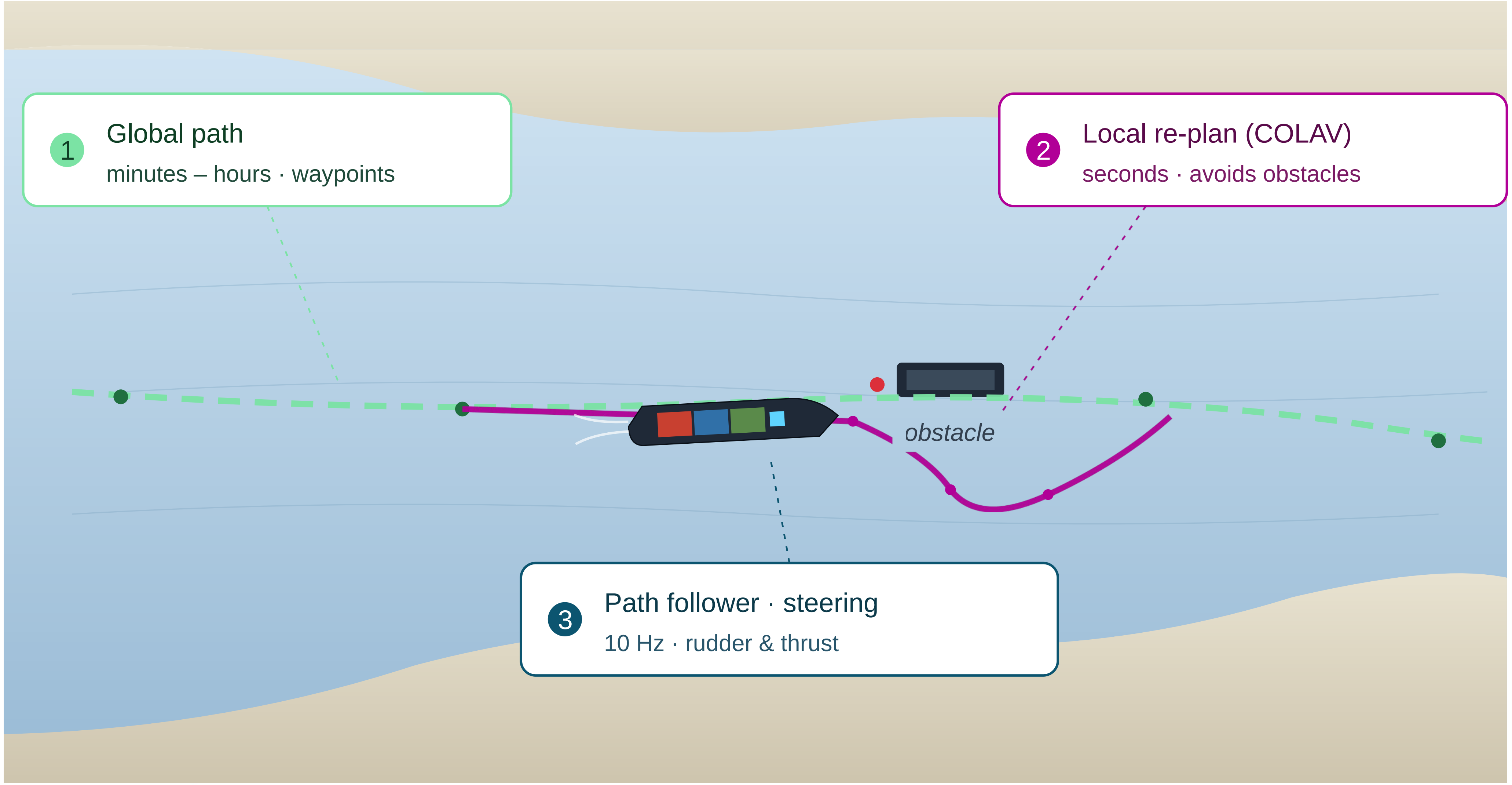

Training
State + Action => Value
RL Model
Real -Time
Geospatial Data
Simulation
Expensive
scarce
Accuracy
Validation
We need to combine

Complexity issue

- Split the problem
- Simulate what you need
- Multi agent approach

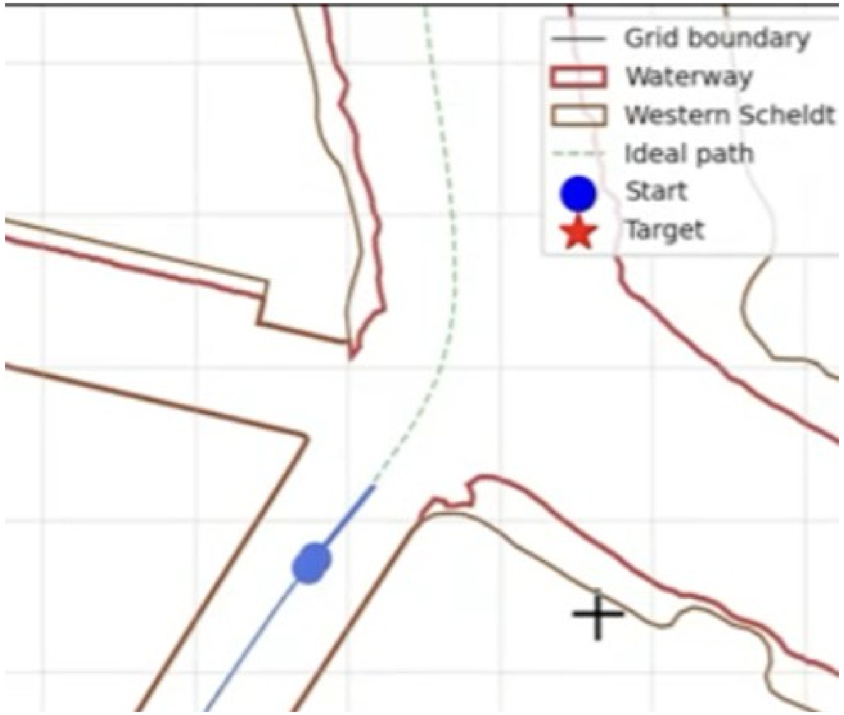
Complexity issue

Split the problem

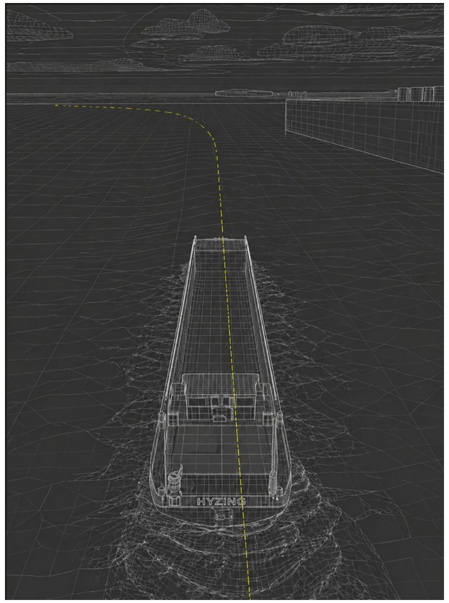


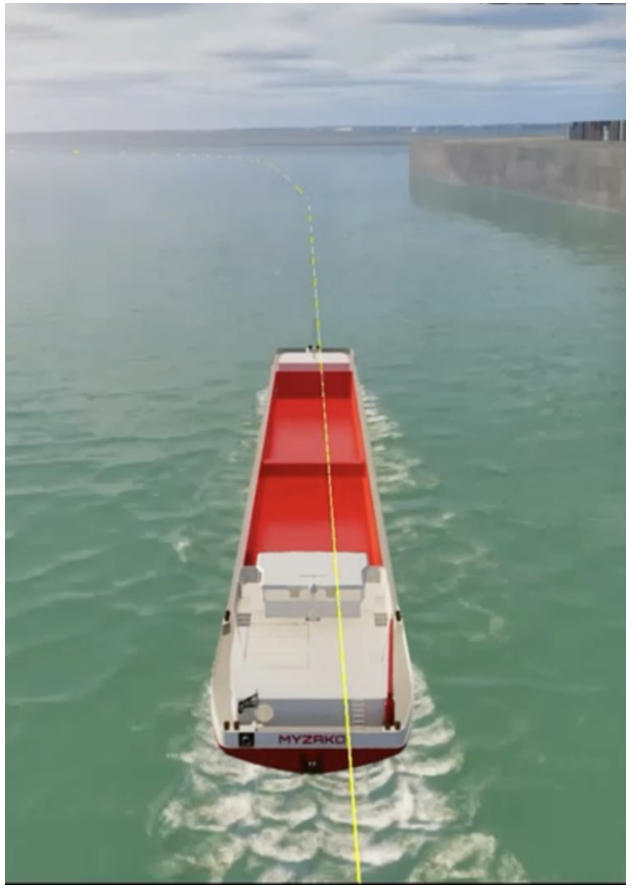
Complexity issue

- Simulate what you need



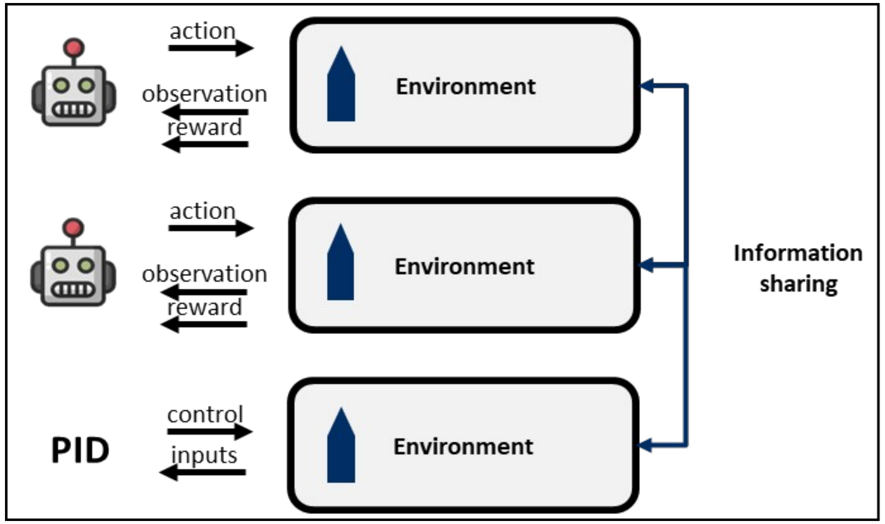
Surrogate models

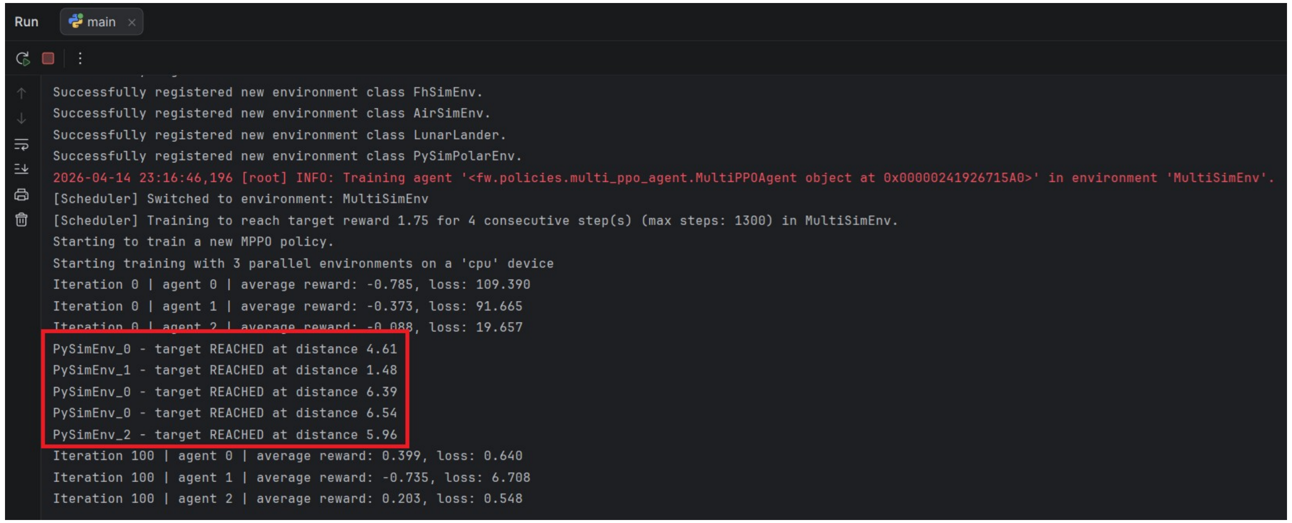


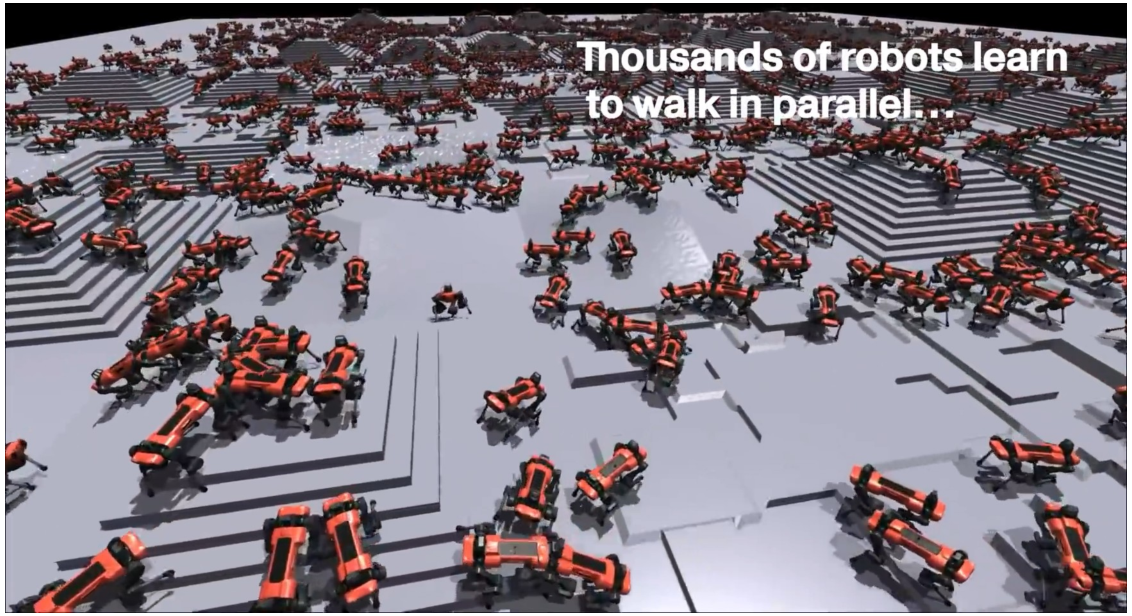


Complexity

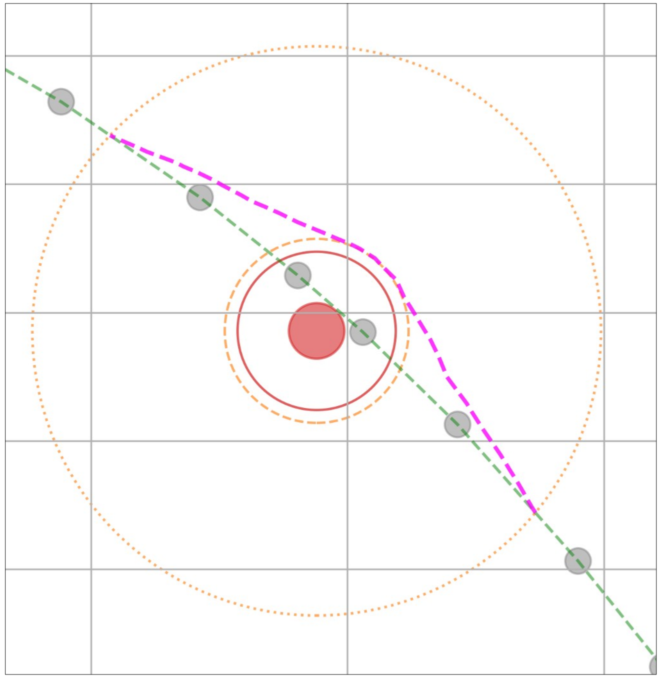
Multi Agent:


action
observation
reward
Environment
action
observation
reward
Environment
PID
control
inputs
Environment
Information sharing


Run
main
Successfully registered new environment class FhSimEnv.
Successfully registered new environment class AirSimEnv.
Successfully registered new environment class LunarLander.
Successfully registered new environment class PySimPolarEnv.
2026-04-14 23:16:46,196 [root] INFO: Training agent '<fw.policies.multi_ppo_agent.MultiPPOAgent object at 0x00000241926715A0>' in environment 'MultiSimEnv'.
[Scheduler] Switched to environment: MultiSimEnv
[Scheduler] Training to reach target reward 1.75 for 4 consecutive step(s) (max steps: 1300) in MultiSimEnv.
Starting to train a new MPPO policy.
Starting training with 3 parallel environments on a 'cpu' device
Iteration 0 | agent 0 | average reward: -0.785, loss: 109.390
Iteration 0 | agent 1 | average reward: -0.373, loss: 91.665
Iteration 0 | agent 2 | average reward: -0.088, loss: 19.657
PySimEnv_0 - target REACHED at distance 4.61
PySimEnv_1 - target REACHED at distance 1.48
PySimEnv_0 - target REACHED at distance 6.39
PySimEnv_0 - target REACHED at distance 6.54
PySimEnv_2 - target REACHED at distance 5.96
Iteration 100 | agent 0 | average reward: 0.399, loss: 0.640
Iteration 100 | agent 1 | average reward: -0.735, loss: 6.708
Iteration 100 | agent 2 | average reward: 0.203, loss: 0.548

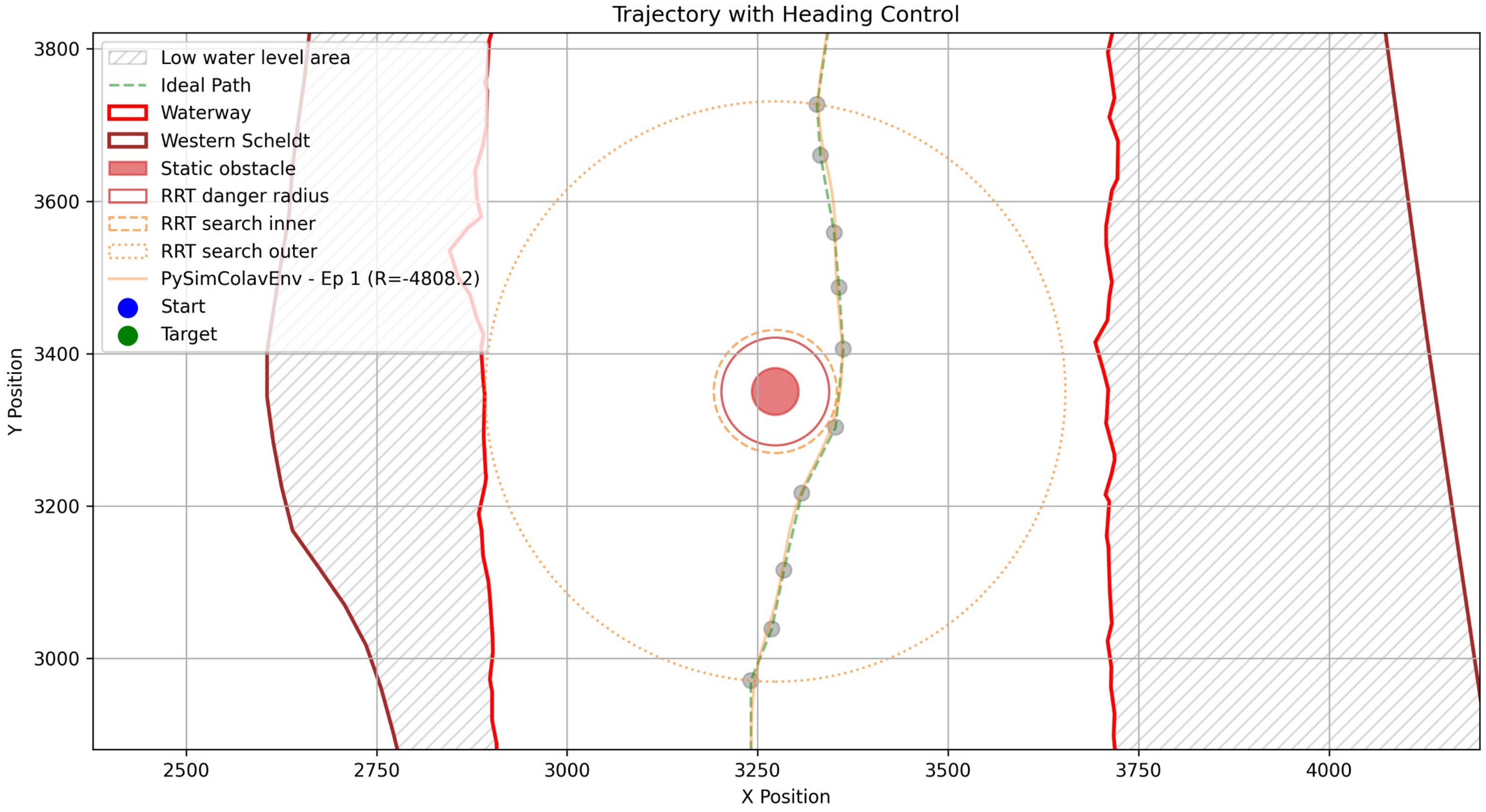

Thousands of robots learn
to walk in parallel...

Results



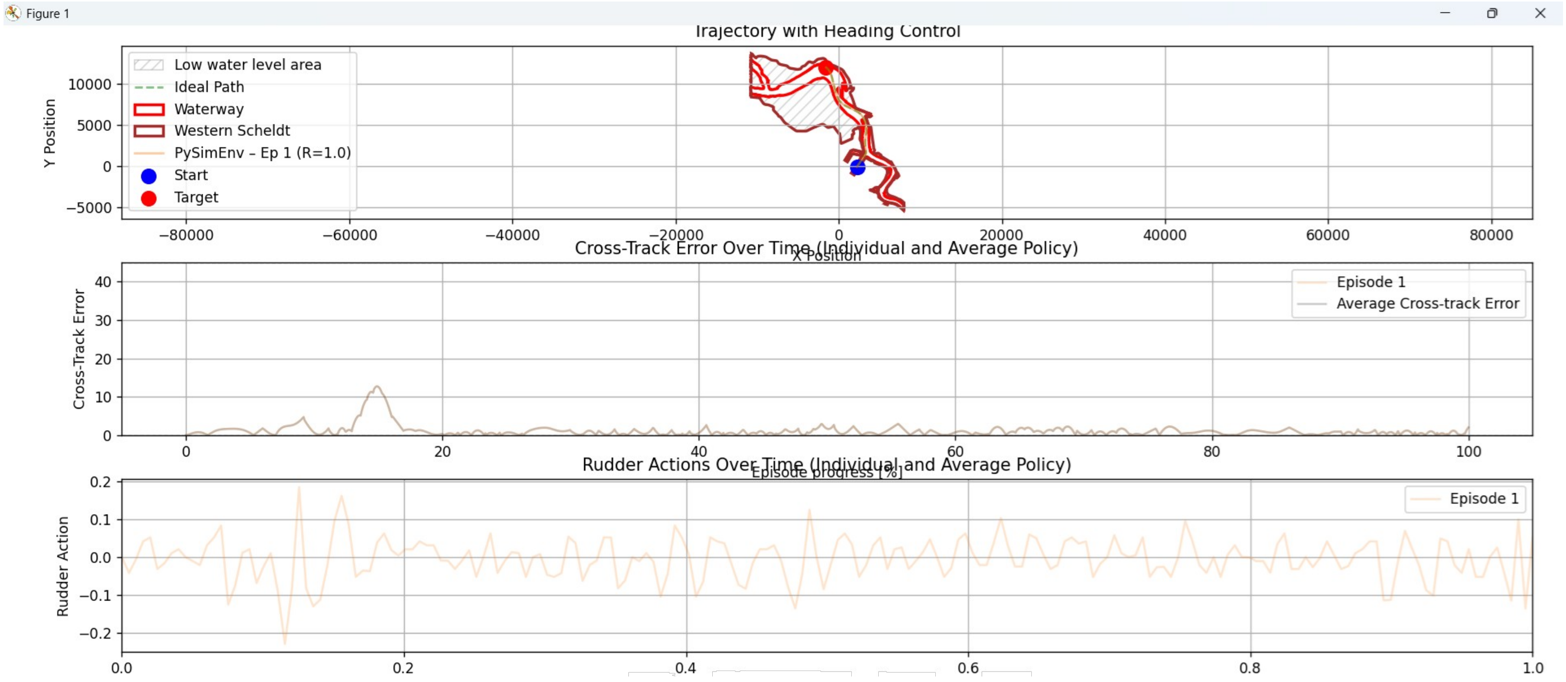
Green: standard path

Magenta: RRT path*



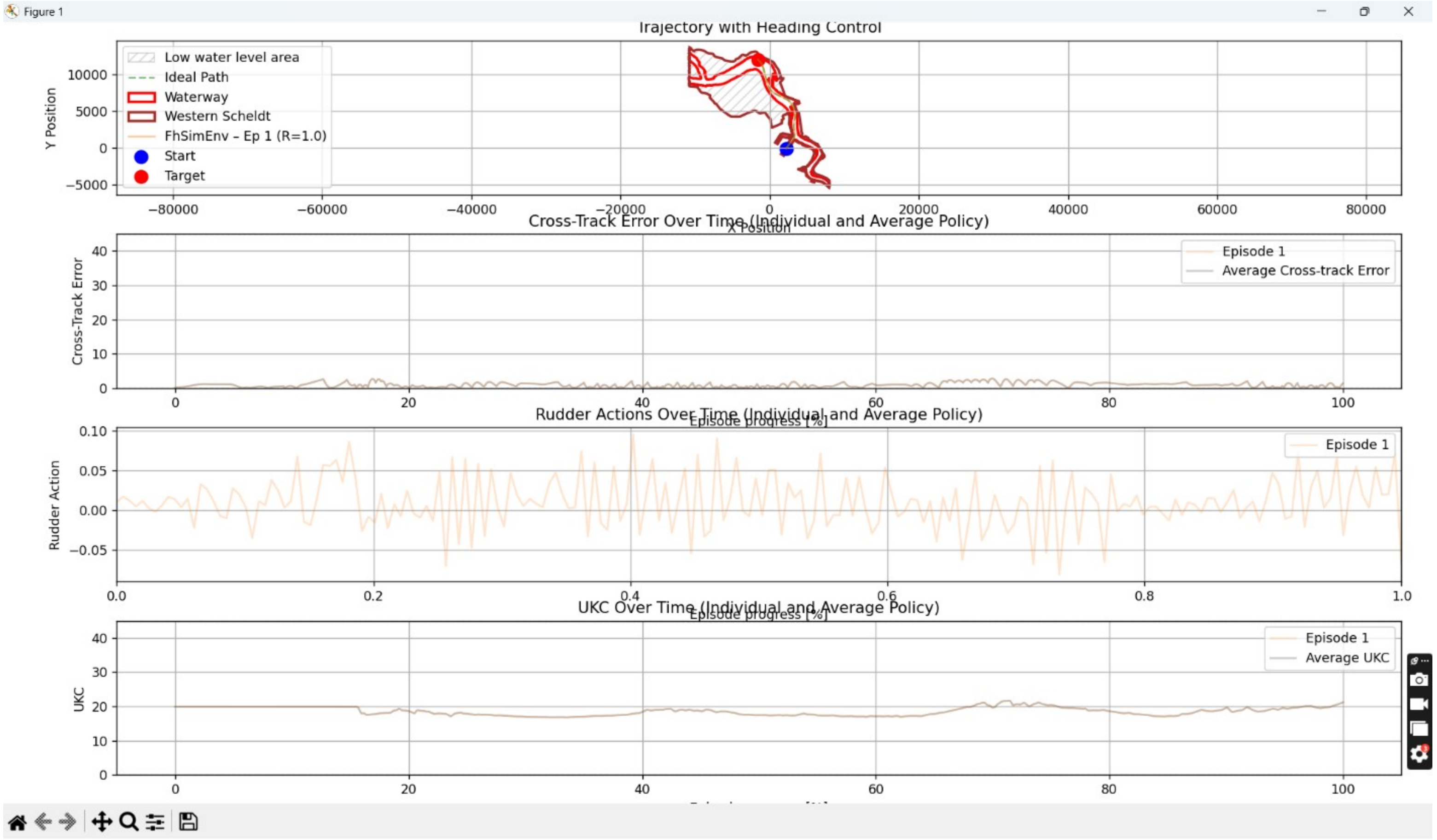
Results Surrogate model:

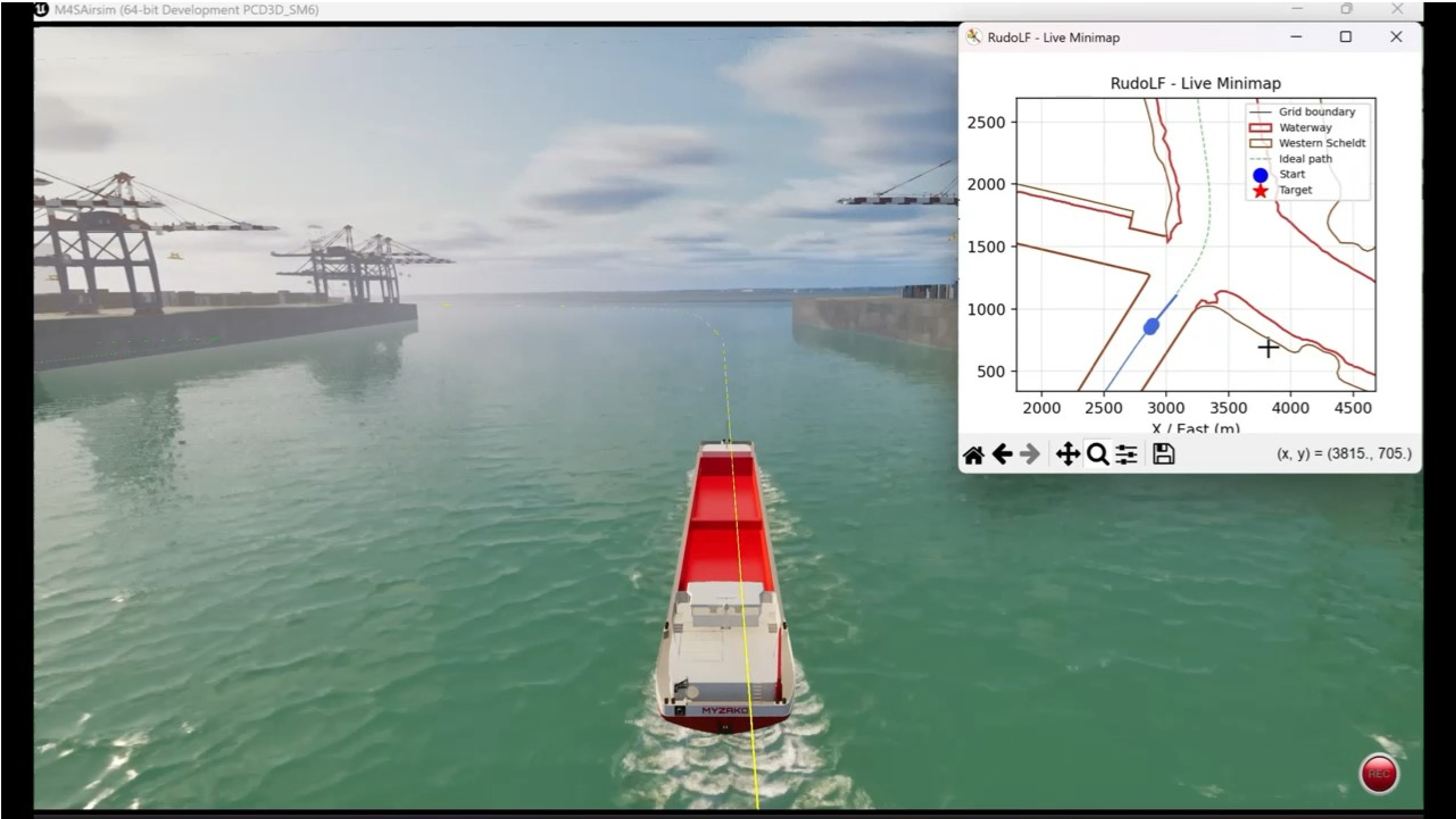
Metric	Value
Mean Track Error Integral (mTEI)	1.11 m
Maximum Track Error (MTE)	12.70 m
Mean Rudder Angle (mRA)	2.41°
Maximum Rudder Angle (MRA)	13.18°
Mean Rudder Angle Change (mRAC)	0.24°/s
Mean Surge Velocity (mu)	5.0 m/s
Maximum Surge Velocity (Mu)	5.0 m/s



Results full sim

Metric	Value
Mean Track Error Integral (mTEI)	0.93 m
Maximum Track Error (MTE)	2.77 m
Mean Rudder Angle (mRA)	1.49°
Maximum Rudder Angle (MRA)	5.96°
Mean Rudder Angle Change (mRAC)	0.24°/s
Mean Surge Velocity (mu)	4.69 m/s
Maximum Surge Velocity (Mu)	4.98 m/s




M4SAirsim (64-bit Development PCD3D_SM6)
RudoLF - Live Minimap
RudoLF - Live Minimap
Grid boundary
Waterway
Western Scheldt
Ideal path
Start
Target
2500
2000
1500
1000
500
2000
2500
3000
3500
4000
4500
X / East (m)
(x, y) = (3815., 705.)
MYZAKO

What to remember

- The future of inland shipping depends on Autonomous shipping
- Autonomous shipping depends on digital twins
- Environment models of digital twins depend on geospatial data
  - As data
  - As fundaments of the digital twin models

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