Digital Twin - SALTISolutions

Prototype of a Delft-FEWS based Digital Twin

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Date: 09 November 2022

What is VORtech?

- **Developing scientific software**

  Including the development of mathematical models and algorithms for various applications.

- **Accelerating and improving scientific software**

  By enhancing algorithms, using high performance computing, porting to modern programming languages, and adding documentation.

- **Consultancy on scientific software**

  By identifying and analyzing the code and the corresponding algorithms and underlying mathematical models.

- **Maintenance of scientific software**

  By using advanced software engineering tools.

- **Data science**

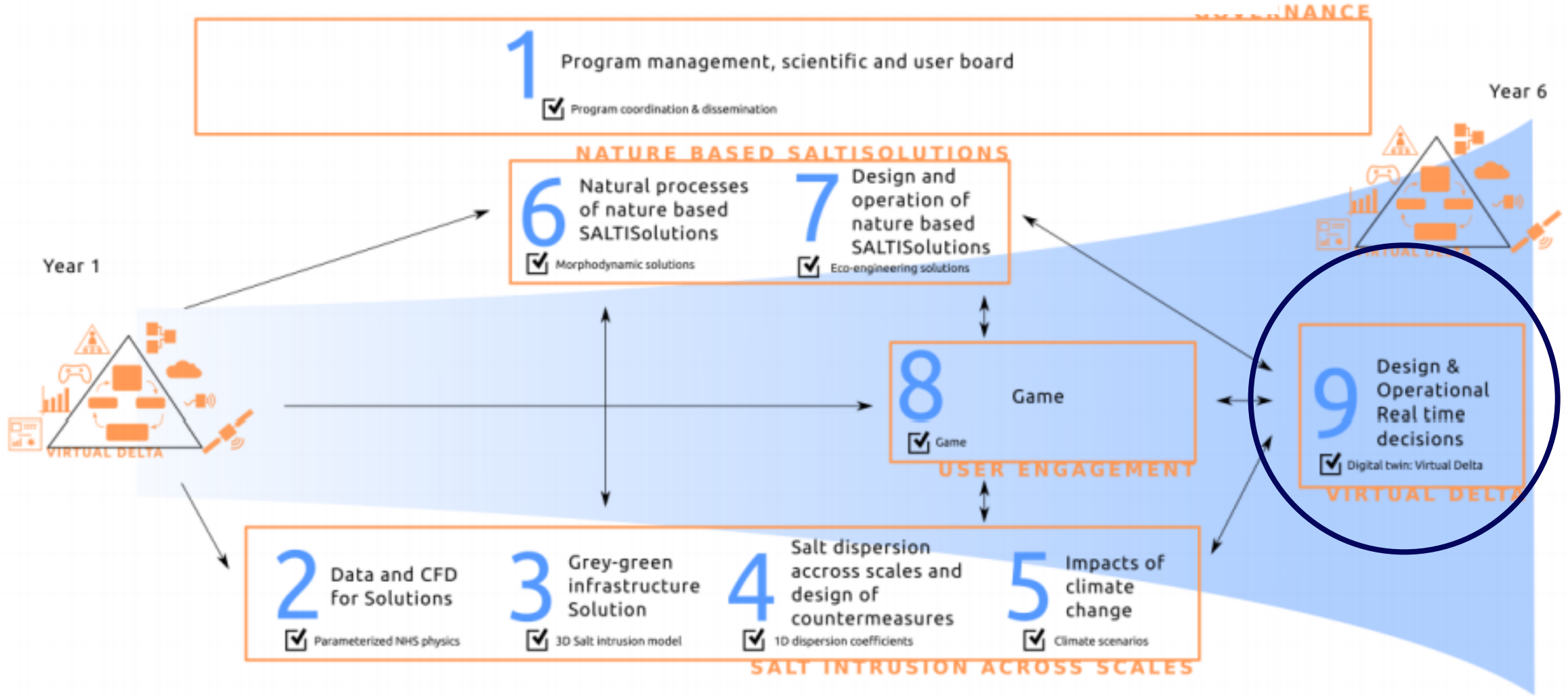
  Analytics, machine learning, time series analysis

Outline

1. Introducing Digital Twins & SALTI Solutions
2. Digital Twin SALTI Solutions
3. Interactive Interface
4. Future developments

21 oktober 1970, Rijnmondmodel , WL Delft

SALTISolutions



What is a Digital Twin?

Just a model?

A buzzword?

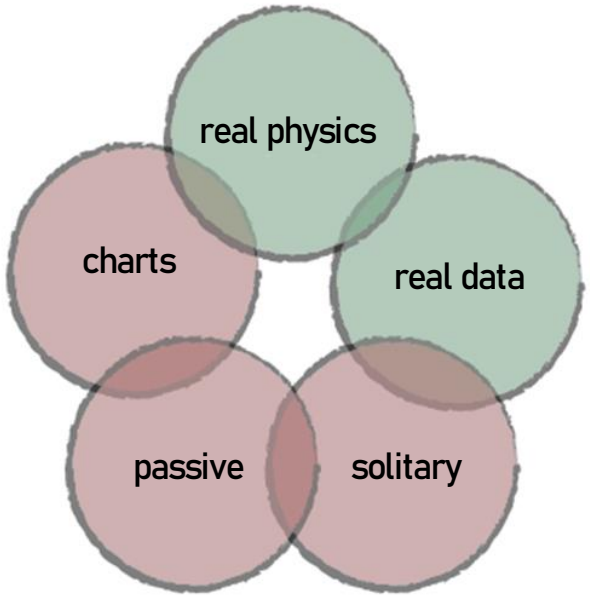
Introduced in manufacturing world:

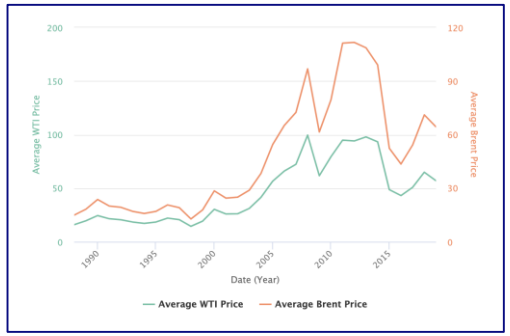
- Product development
- Predictive maintenance

Wikipedia: "A digital twin is a virtual representation of a real-world physical system or product that serves as the indistinguishable digital counterpart of it for practical purposes, such as system simulation, integration, testing, monitoring, and maintenance"

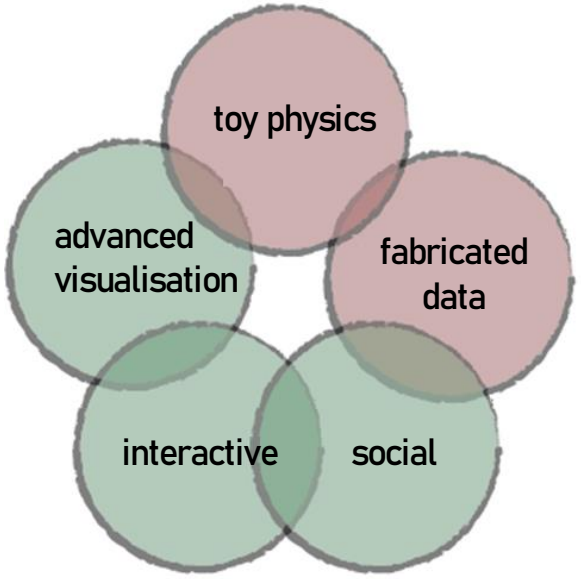
What we think defines a Digital Twin

Simulation

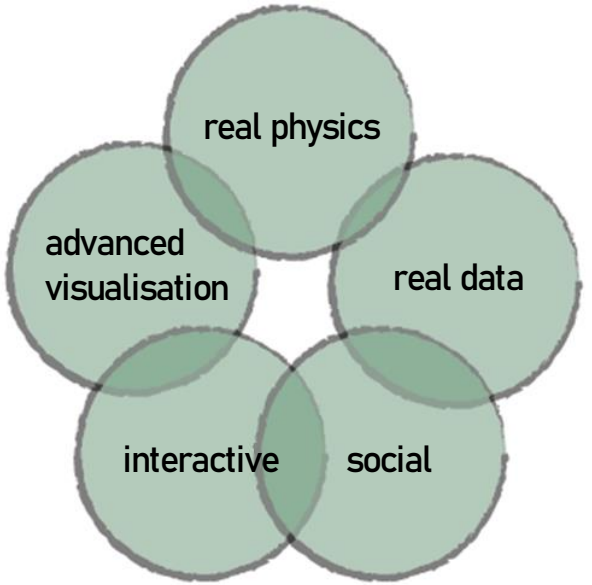




Serious Game



Digital twin



Deltares

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Virtual Delta: final objective

A digital twin of the delta for short, medium and long term decision making.

Requirements:

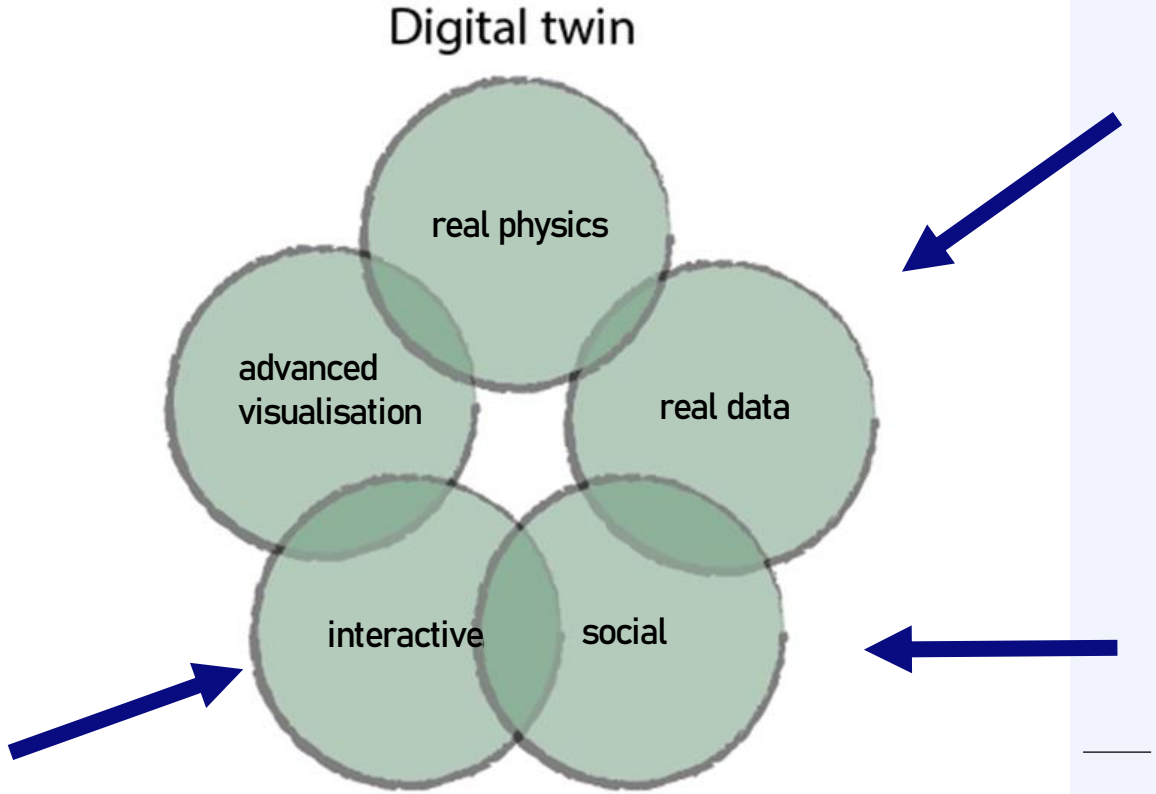
- Based on physical processes
- Incorporating realistic measures, interventions and developments
- Facilitate discussion on measures/interventions/estuarine ambitions and invite interaction
- Based on real-time conditions
- Serves as an integrator of new knowledge and accelerator of research

Prototype

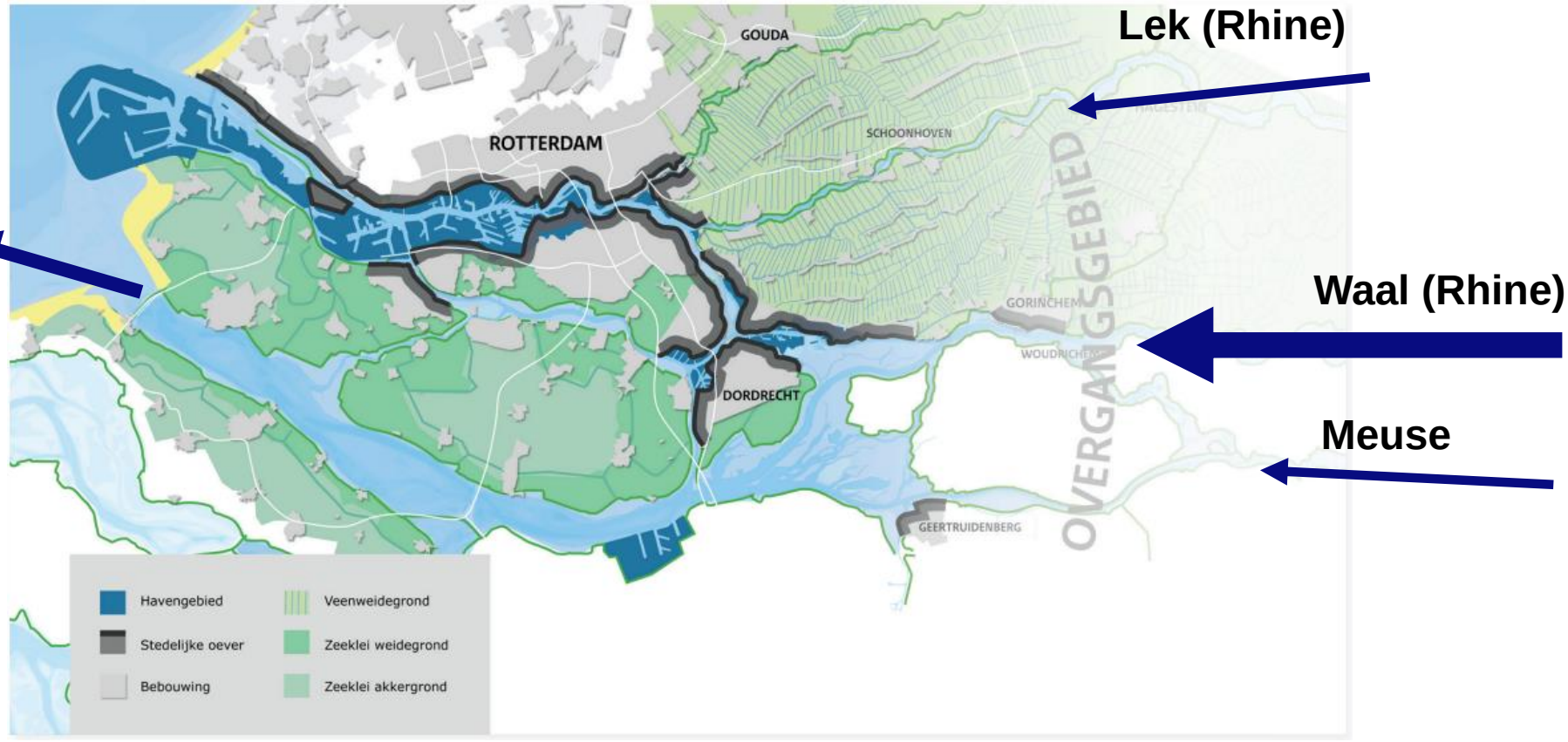
A digital twin of the **Rhine Meuse Delta** for short~~, medium and long~~ term decision making.

Requirements:

- Recognizable system: Rhine-Meuse Delta
- Focussed on short-term
- Facilitate discussion towards end result
- MVP with architecture that can be build upon
- Real-time data
- Real interventions
- Interactive, non-expert interface



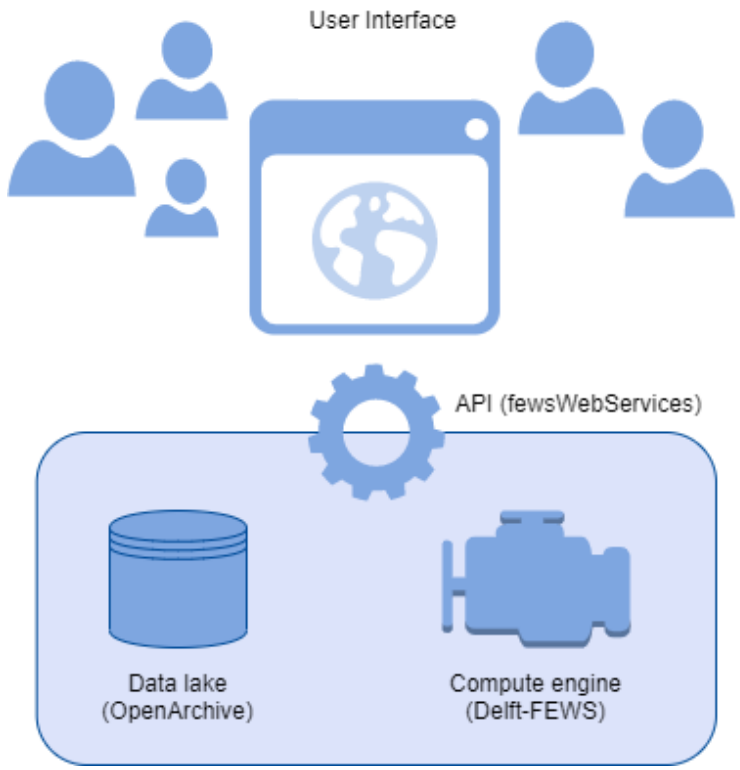
We are talking about the Rhine-Meuse Delta



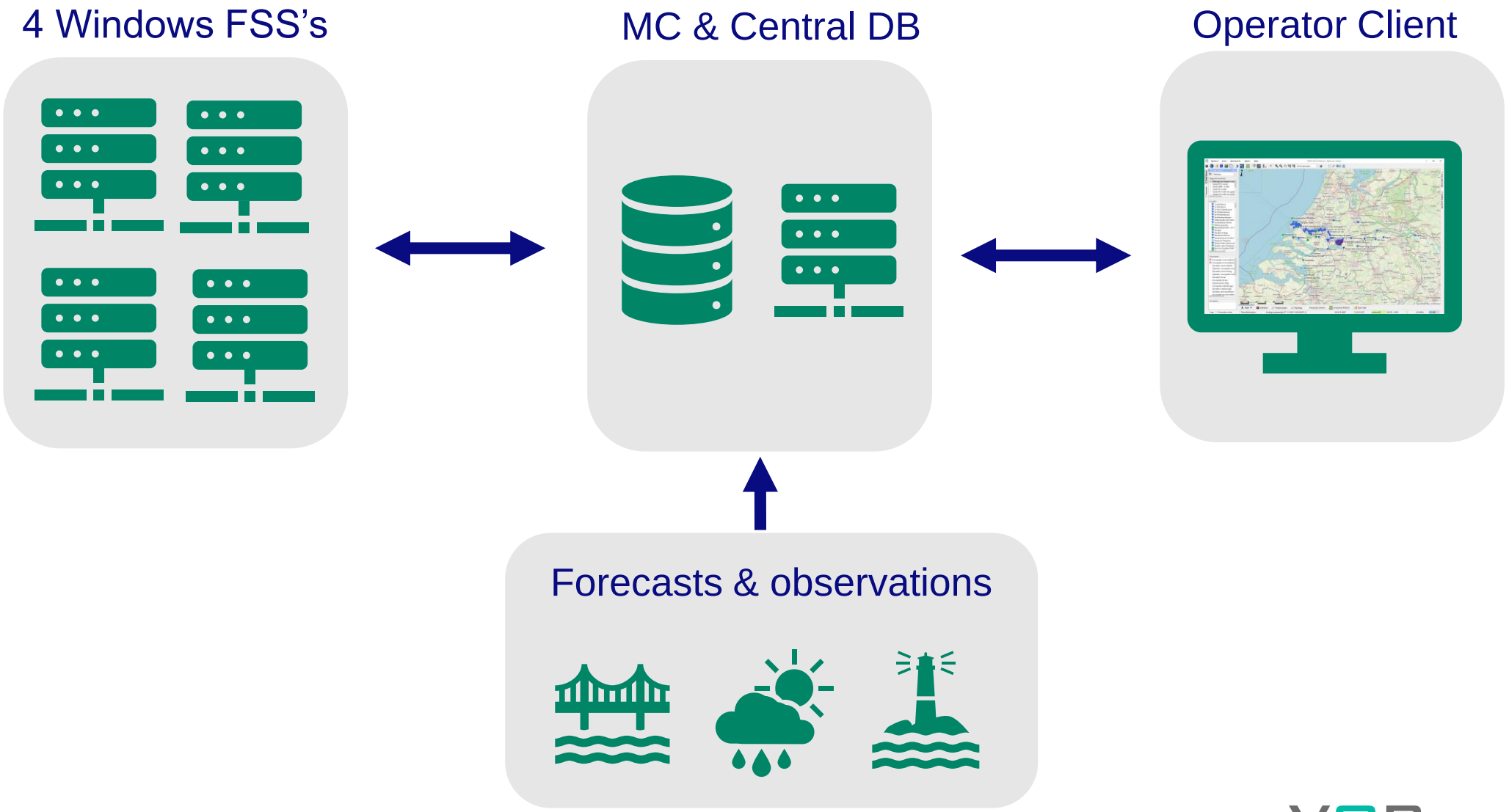
Graphic from: *Het verhaal van de Rijn-Maasmonding, platform Rivieren 2019*

Prototype Architecture

1. Computing Engine: Delft-FEWS
2. Data Lake: Deltares Open Archive
3. API: FEWS Web Services
4. Interactive Interface: to be developed



Component 1: Delft-FEWS System



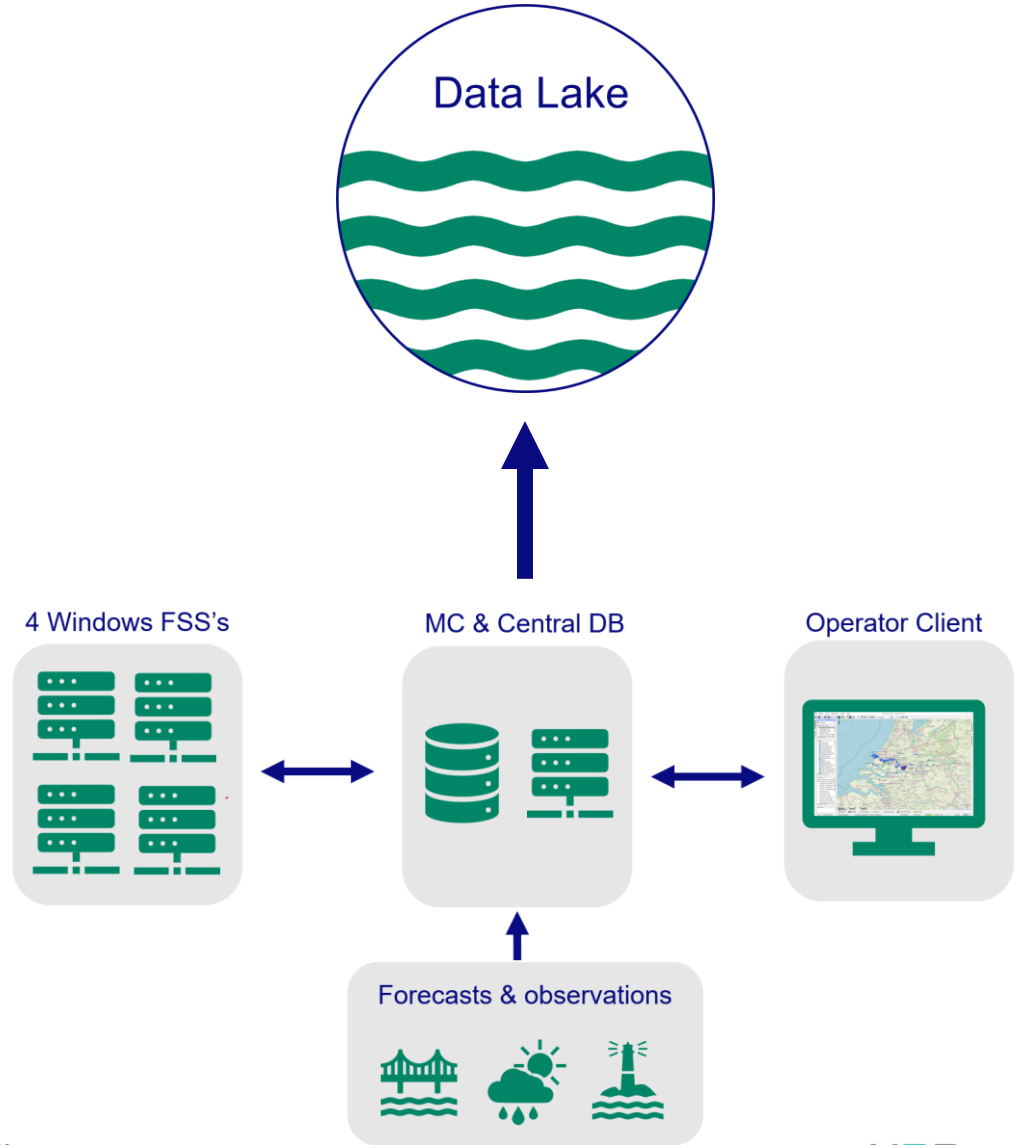
Delft-FEWS Config: Model

- 1D Sobek3
- Model forcing adjustable:
  - Downstream waterlevel
  - Upstream discharge
  - Water inlets and water outlets
  - Salinity on boundaries
- For prototype model with open barriers
- Model is scheduled every 6 hours
- Hindcast + Forecast (7 days)

```
<!-- edited with XMLSpy v2009 sp1 (http://www.altova.com) by ICT (Stichting Deltares) -->
<workflow xmlns="http://www.wldelft.nl/fews" xmlns:xsi="http://www.w3.org/2001/XMLSchema-insta
http://fews.wldelft.nl/schemas/version1.0/workflow.xsd" version="1.1">
    <properties>
      <string key="FC_END" value="7"/>
      <string key="MULTIPLIER_HAGESTEIN" value="0.5"/>
      <string key="MULTIPLIER_TIEL" value="0.5"/>
      <string key="MULTIPLIER_MEGEN" value="0.5"/>
      <string key="MULTIPLIER_LOBITH" value="0.5"/>
      <string key="ADD_HAGESTEIN" value="0"/>
      <string key="ADD_TIEL" value="0"/>
      <string key="ADD_MEGEN" value="0"/>
      <string key="ADD_LOBITH" value="0"/>
      <string key="INZET_KWA" value="0"/>
      <string key="ONTTREKKING_VOLKERAK" value="0"/>
      <string key="SALINITY.DS.MULTIPLIER" value="1.0"/>
      <string key="SALINITY.US.MULTIPLIER" value="1.0"/>
      <string key="H.DS.OFFSET" value="0.0"/>
      <string key="SCENARIO_TYPE" value="basic"/>
    </properties>
  <activity>
    <moduleInstanceId>determine_salti_scenario_model</moduleInstanceId>
  </activity>
  <activity>
    <runIndependent>false</runIndependent>
    <workflowId>Scenario_Sobek3_RMM_Hindcast_LPH2012_HA_OK_SALTI</workflowId>
  </activity>
  <activity>
  <properties>
    <string key="START" value="0"></string>
  </properties>
    <runIndependent>false</runIndependent>
    <workflowId>Scenario_Sobek3_RMM_Forecast_LPH2012_HA_OK_SALTI</workflowId>
  </activity>
  <activity>
    <runIndependent>false</runIndependent>
    <workflowId>SALTI_Export_Scenario_Sobek3_RMM_LPH2012_HA_OK</workflowId>
  </activity>
</workflow>
```

Deltares

Architecture



Deltares

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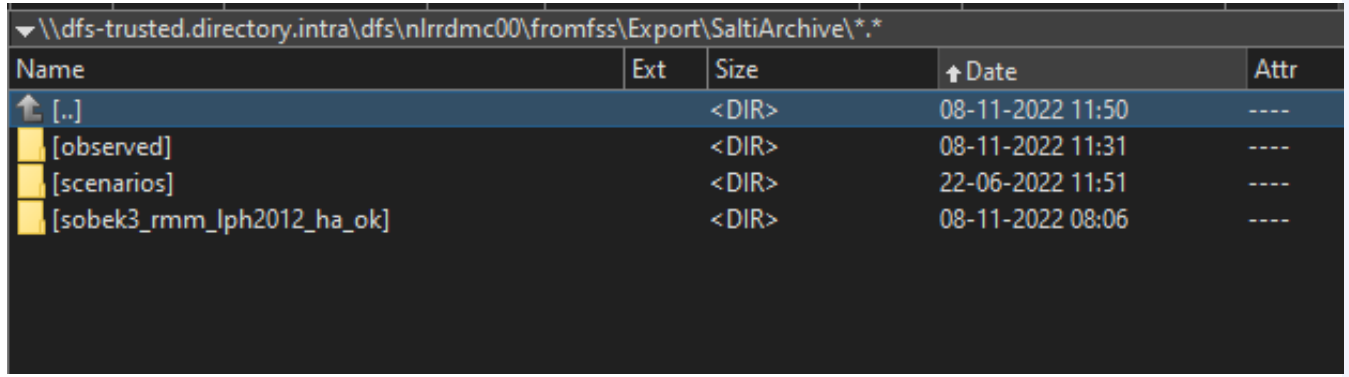
Component 2

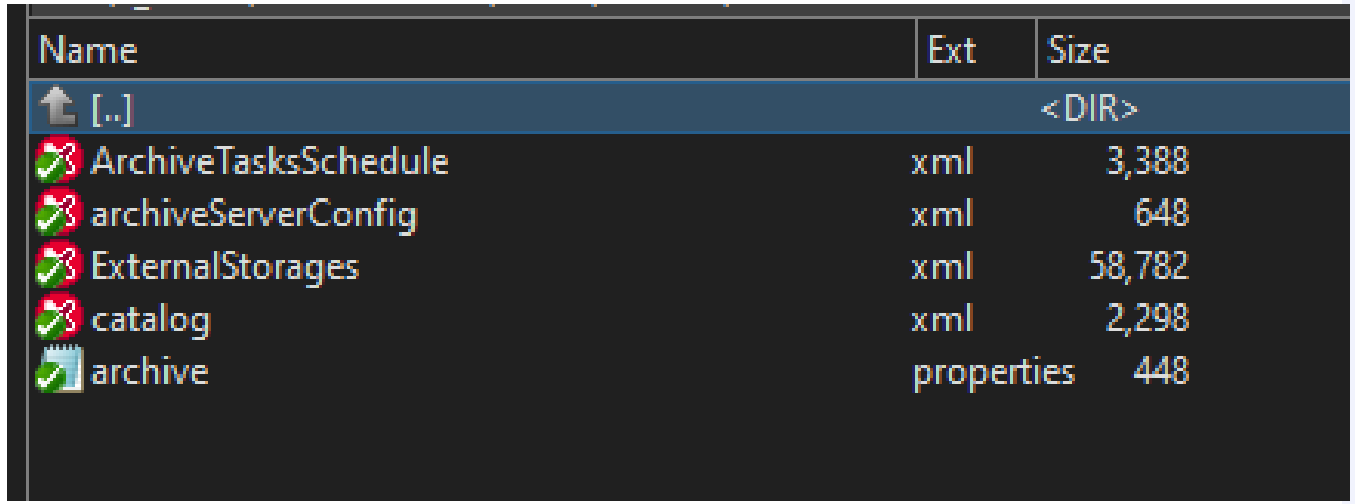
Deltares Open Archive

- Document-oriented, NoSQL database
- Data is stored in an unstructured way
- All kinds of data can be stored
- Access to data through API
- High Delft-FEWS integration
- Storage of third party NetCDF files

Simple set-up

- Filestorage
- Open Archive Server
- FEWS Web Service
- Configured through xml

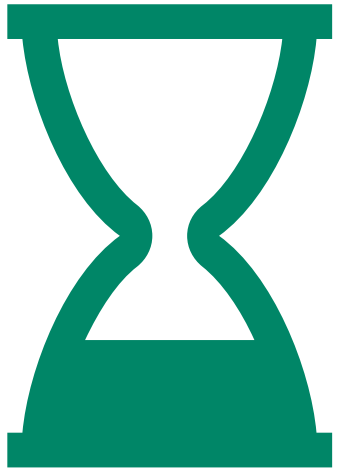




Open Archive Developments

Data & scenario results must be available as soon as possible!

1. For data available on fixed times/intervals:
   → Specify Harvester interval per ExternalStorageId
2. For unpredictable (w.r.t. timing) data
   → Immediate harvester



Configuration example

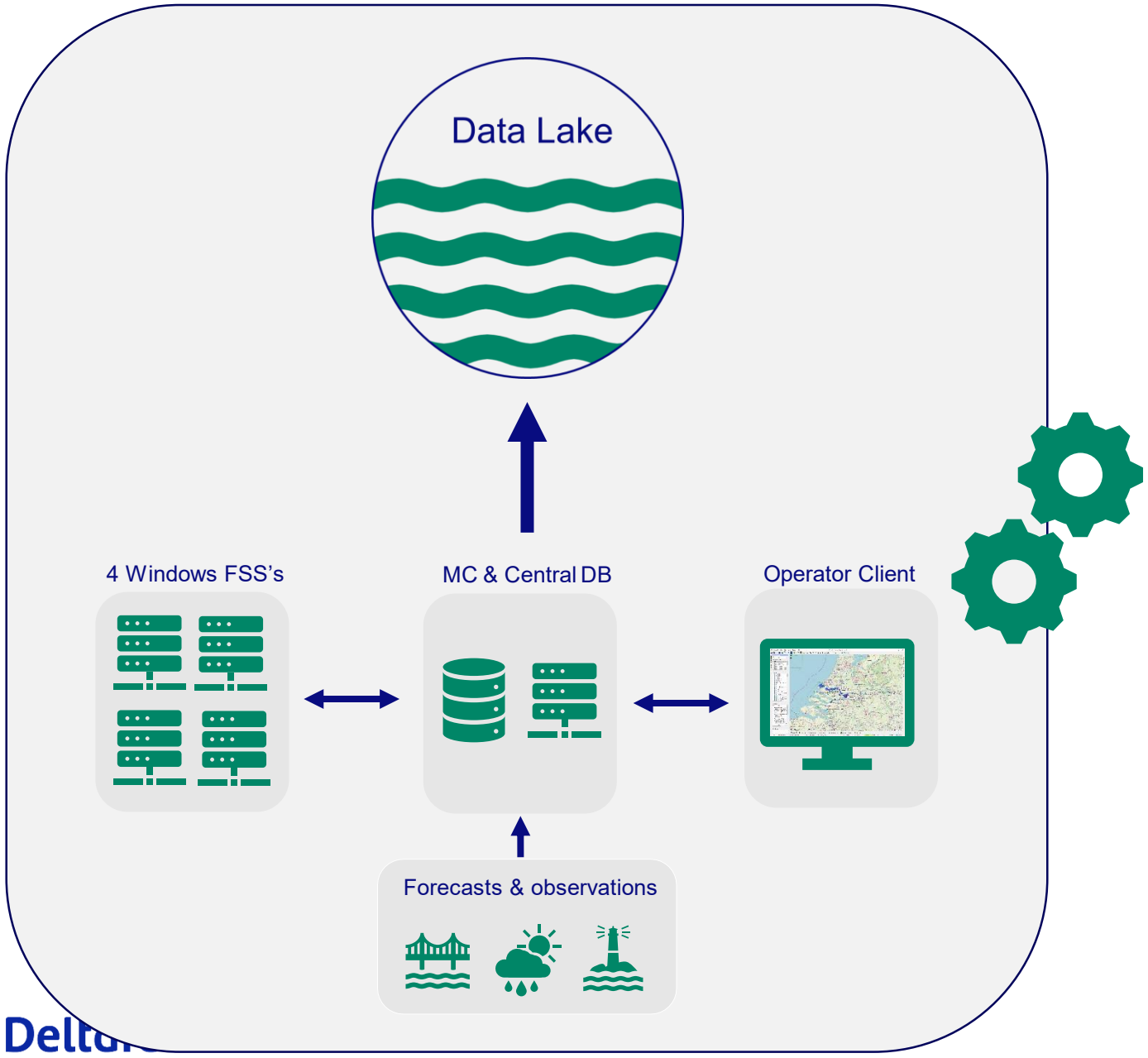
1)

```
<scheduledArchiveTask>
<externalNetcdfHarvestTask id="salti_data">
<netcdfStorageId>salti_observed</netcdfStorageId>
<netcdfStorageId>sobek3_rmm_lph2012_ha_ok_hindcast</netcdfStorageId>
<netcdfStorageId>sobek3_rmm_lph2012_ha_ok_forecast</netcdfStorageId>
</externalNetcdfHarvestTask>
<description>harvester for general SALTI data</description>
        <startTime>03:00:00</startTime>
        <endTime>23:59:00</endTime>
        <runIntervalInSeconds>900</runIntervalInSeconds>
        <active>true</active>
</scheduledArchiveTask>
```

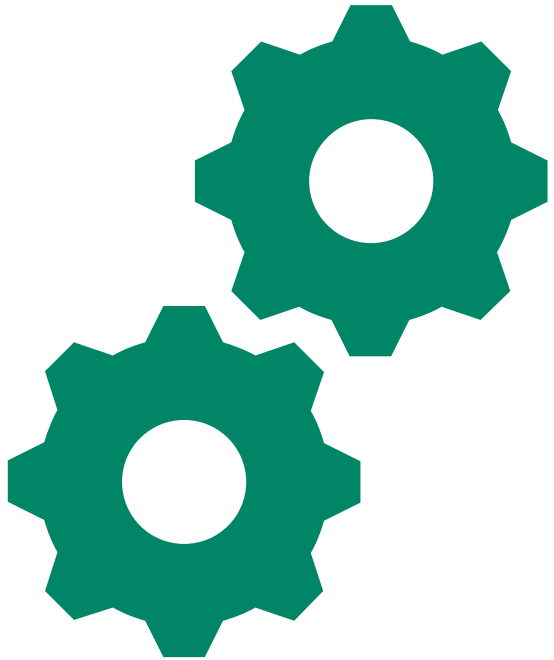
2)

```
<scheduledArchiveTask>
        <predefinedArchiveTask>immediate harvester task</predefinedArchiveTask>
        <description>immediate</description>
        <startTime>03:00:00</startTime>
        <endTime>20:30:00</endTime>
        <runIntervalInSeconds>3</runIntervalInSeconds>
        <active>false</active>
</scheduledArchiveTask>
```

Architecture



Component 3: FEWS PI REST Web services



Through the API access of:

1. Delft-FEWS Client-Server System

   Mainly to run the model(s)

2. Deltares Open Archive

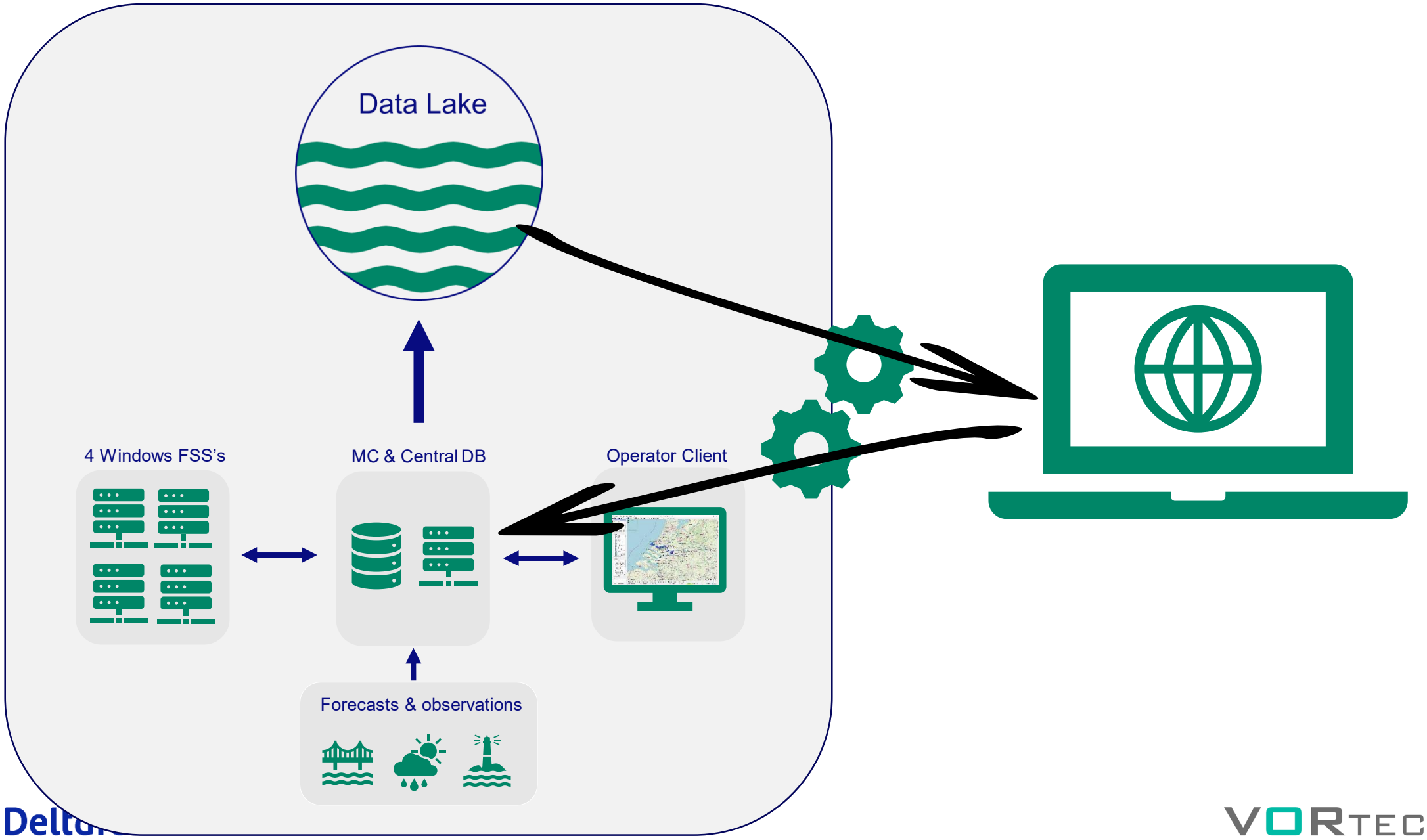
   To retrieve data

FEWS PI REST Webservice API - Development

Most important: Post runtask extended with properties:

&property(fileName)=exportFile&property(outputValue)=9.0

Architecture



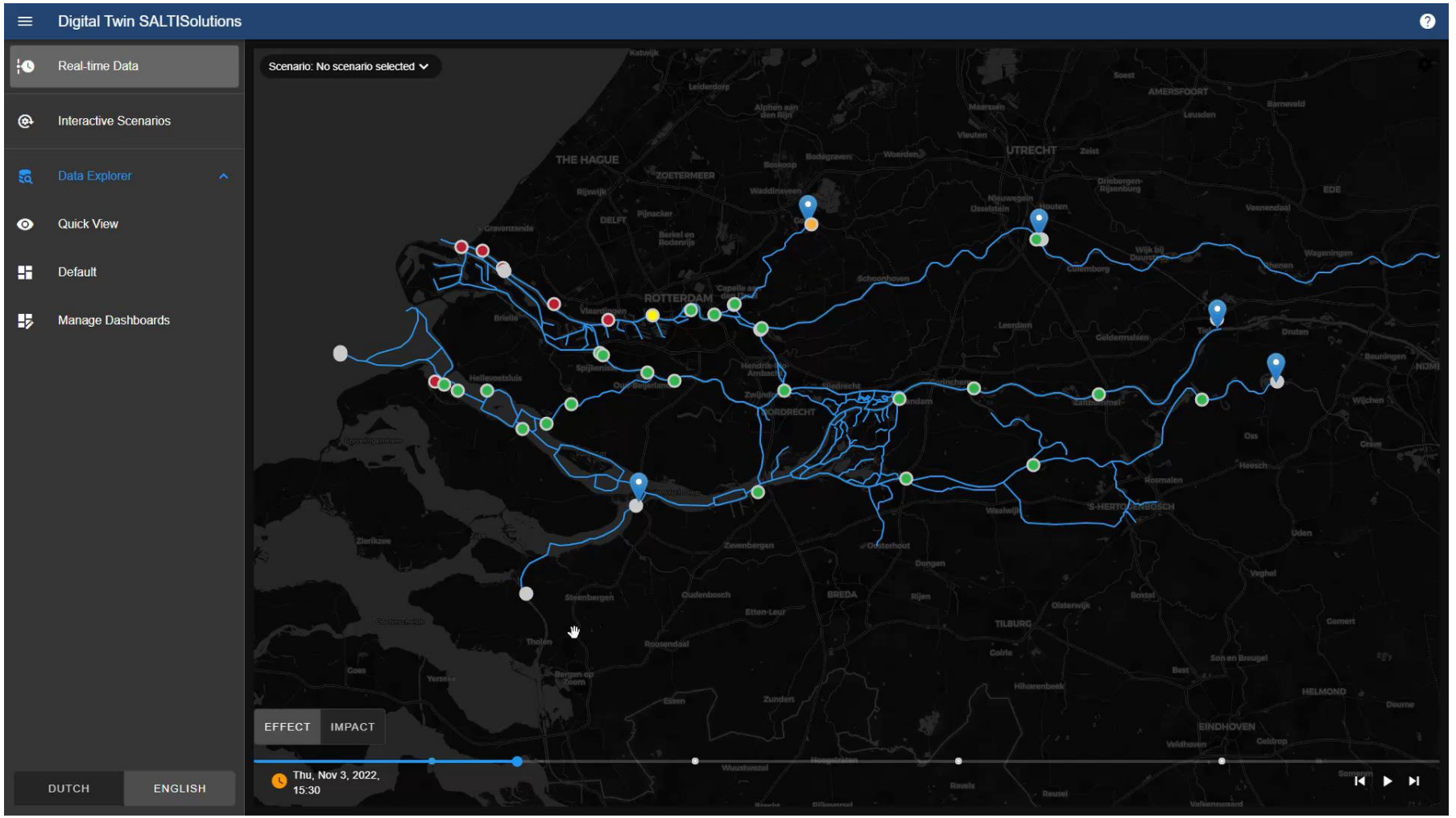
Interactive interface for SALTI DT

- Requirements
  - Should be usable by non-FEWS experts
  - Allow exploring current measurement and simulation data
  - Allow starting what-if scenarios
  - Allow exploring and comparing the results of what-if scenarios

Technology

- Web-based: cross-platform, no installation, instantly usable
- Front-end web application without dedicated back-end
  - All rendering is done in the user's browser
  - Data are retrieved from FEWS PI REST Web Service as JSON
  - Needs only a simple web server and access to FEWS Web Services
- Uses Vue.js with Vuetify
  - Rapid development with many pre-made components
  - Same technology as WebOC

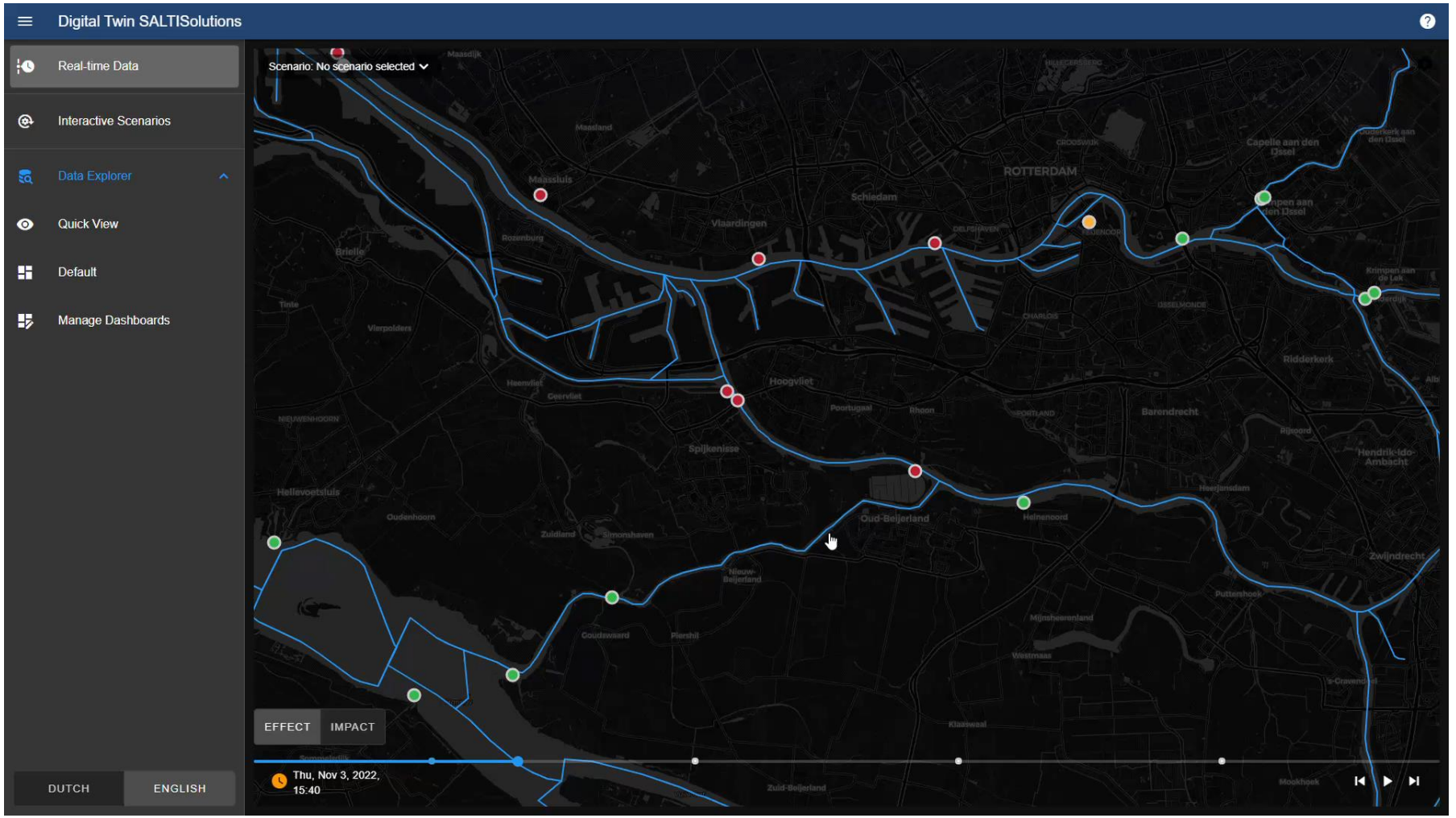
Exploring data



FEWS PI endpoints:

- `/locations`
- `/timeseries`

Starting what-if scenarios



FEWS PI endpoints:

- `/locations`
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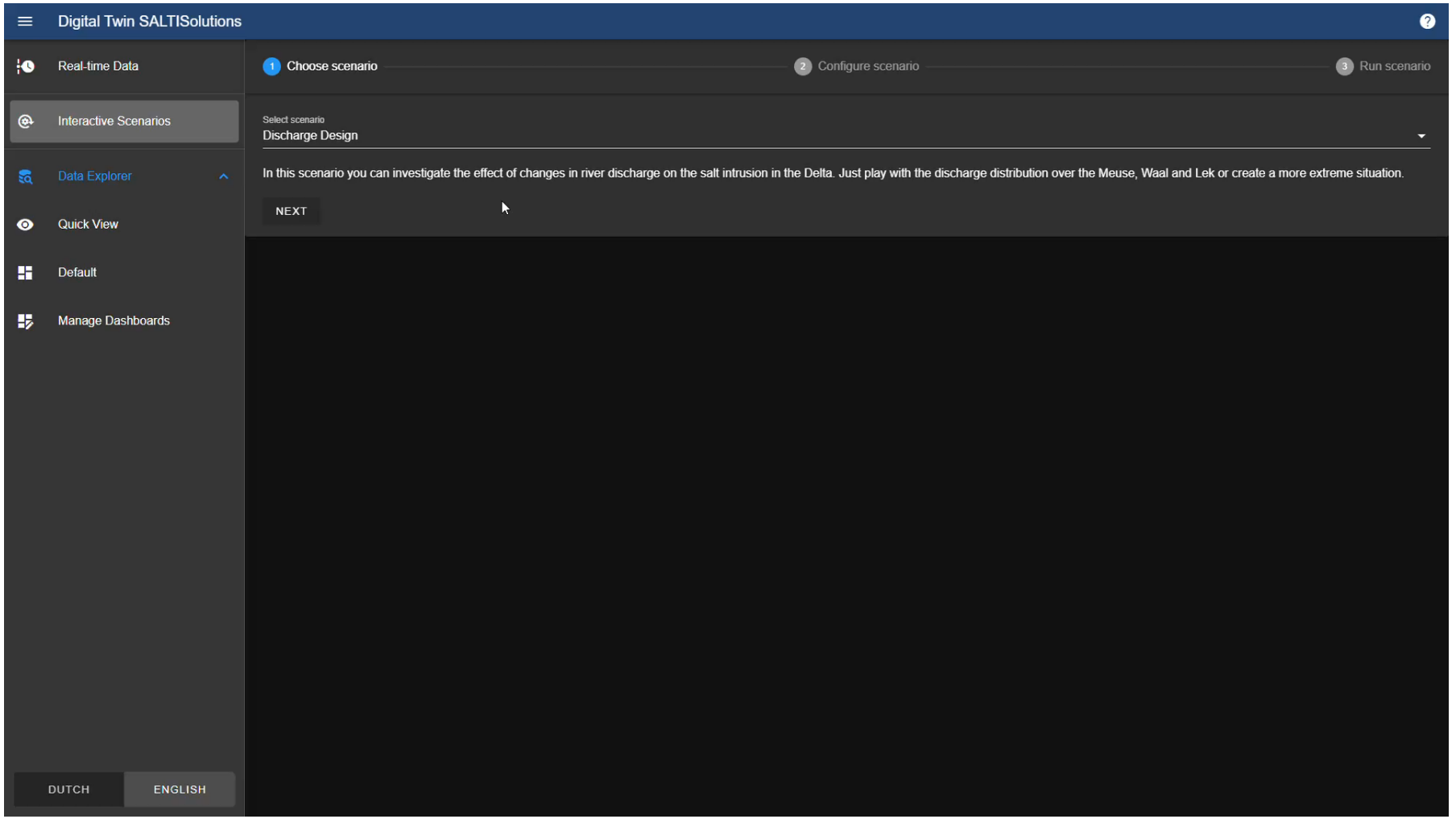
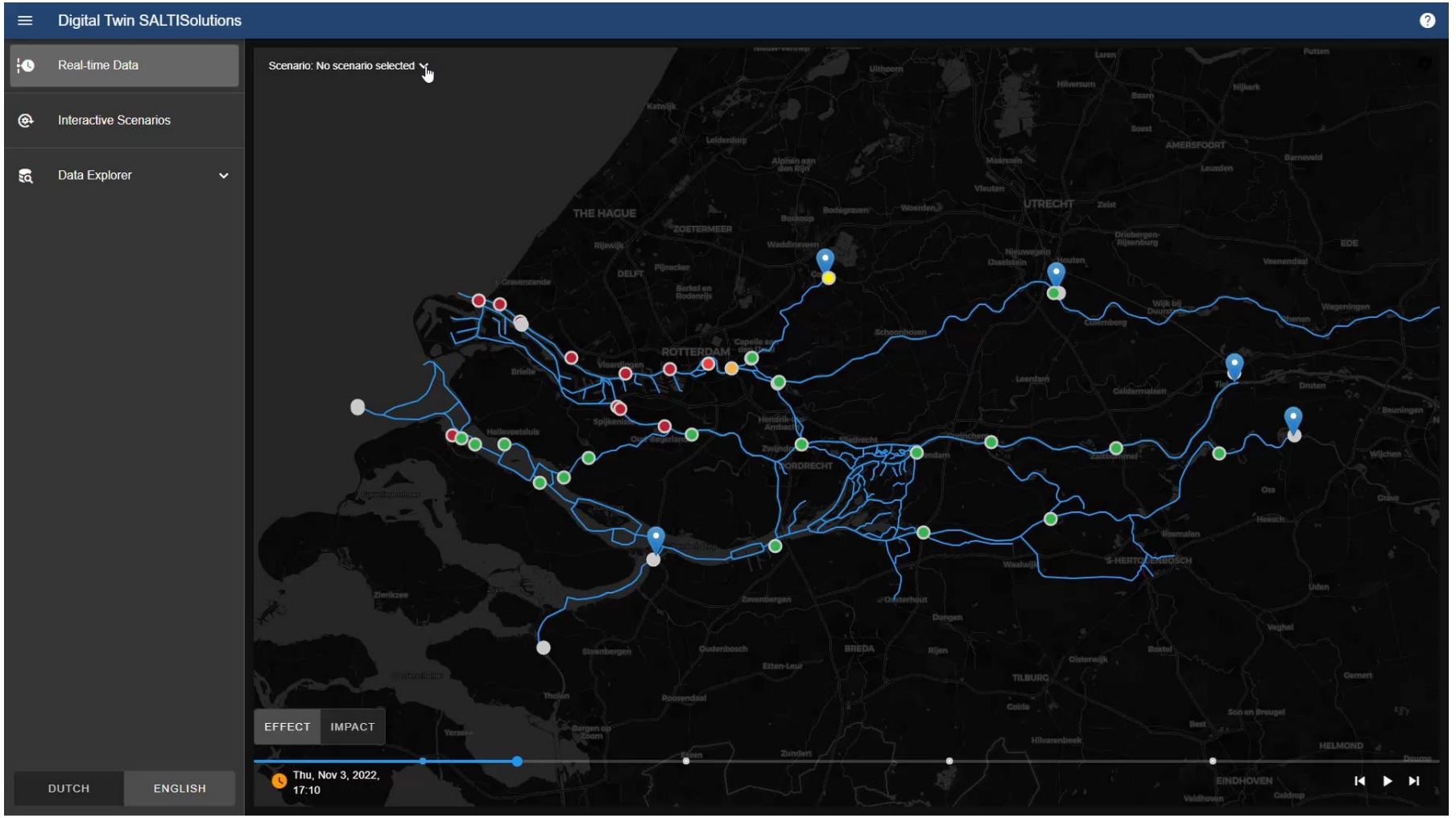
Starting what-if scenarios



FEWS PI endpoints:

- `/runtask`
- `/taskrunstatus`

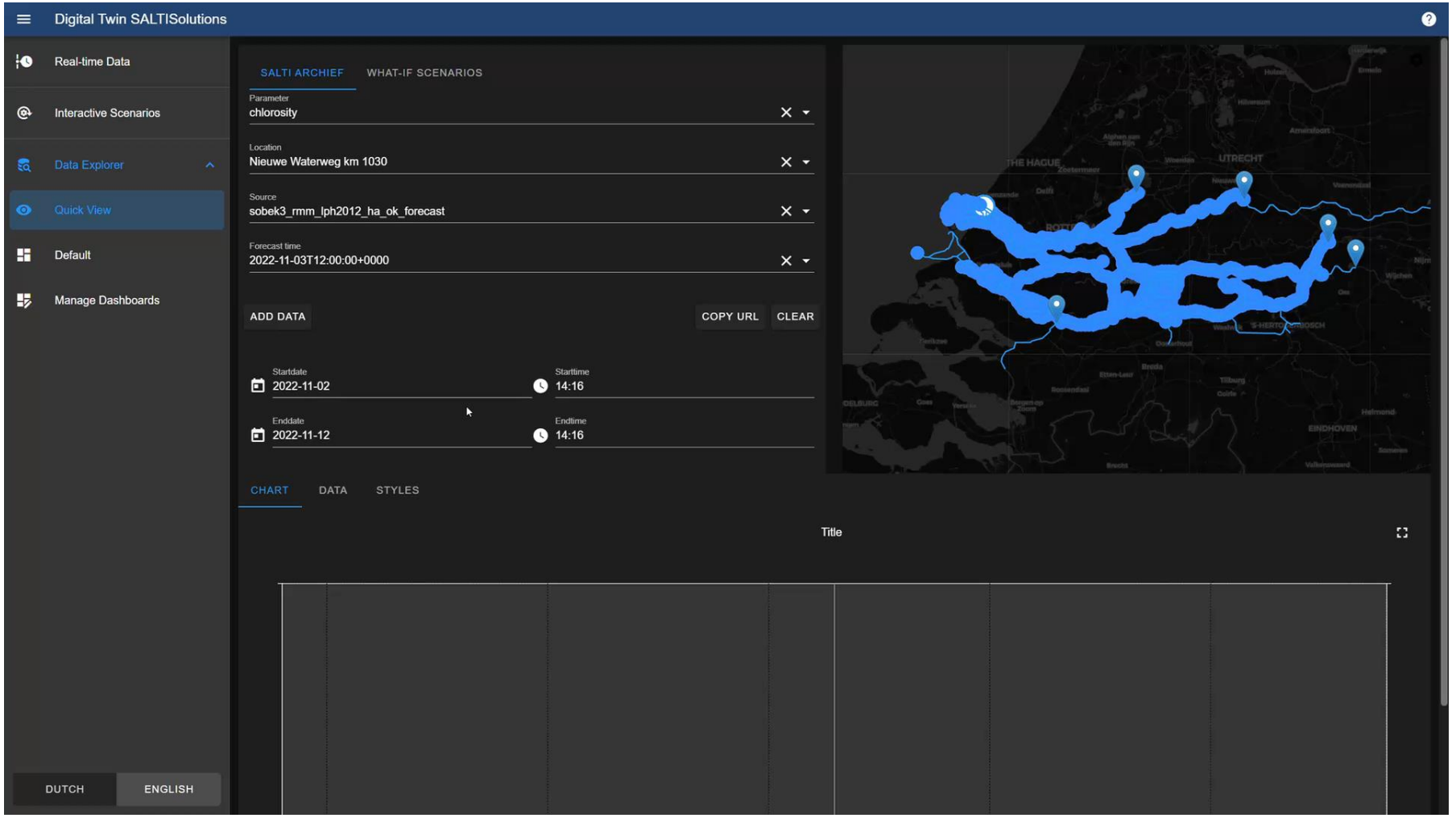
Exploring scenario results



FEWS PI endpoints:

- `/locations`
- `/timeseries`
- `/netcdfstorage forecasts`
- `/taskruns`

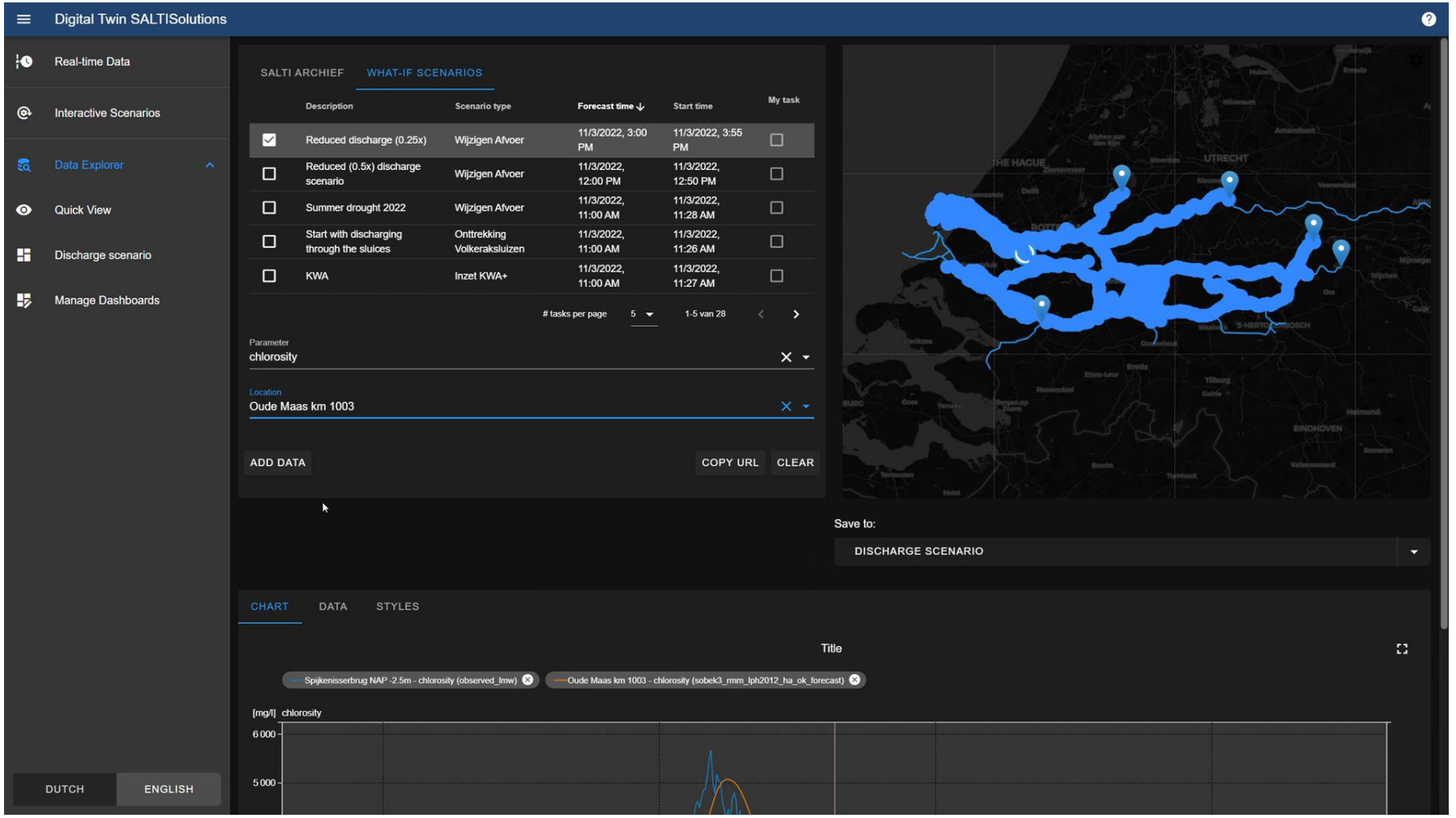
Exploring scenario results



FEWS PI endpoints:

- `/attributes`
- `/parameters`
- `/locations`
- `/timeseries`
- `/netcdfstorage forecasts`
- `/taskruns`

Exploring scenario results



FEWS PI endpoints:

- `/attributes`
- `/parameters`
- `/locations`
- `/timeseries`
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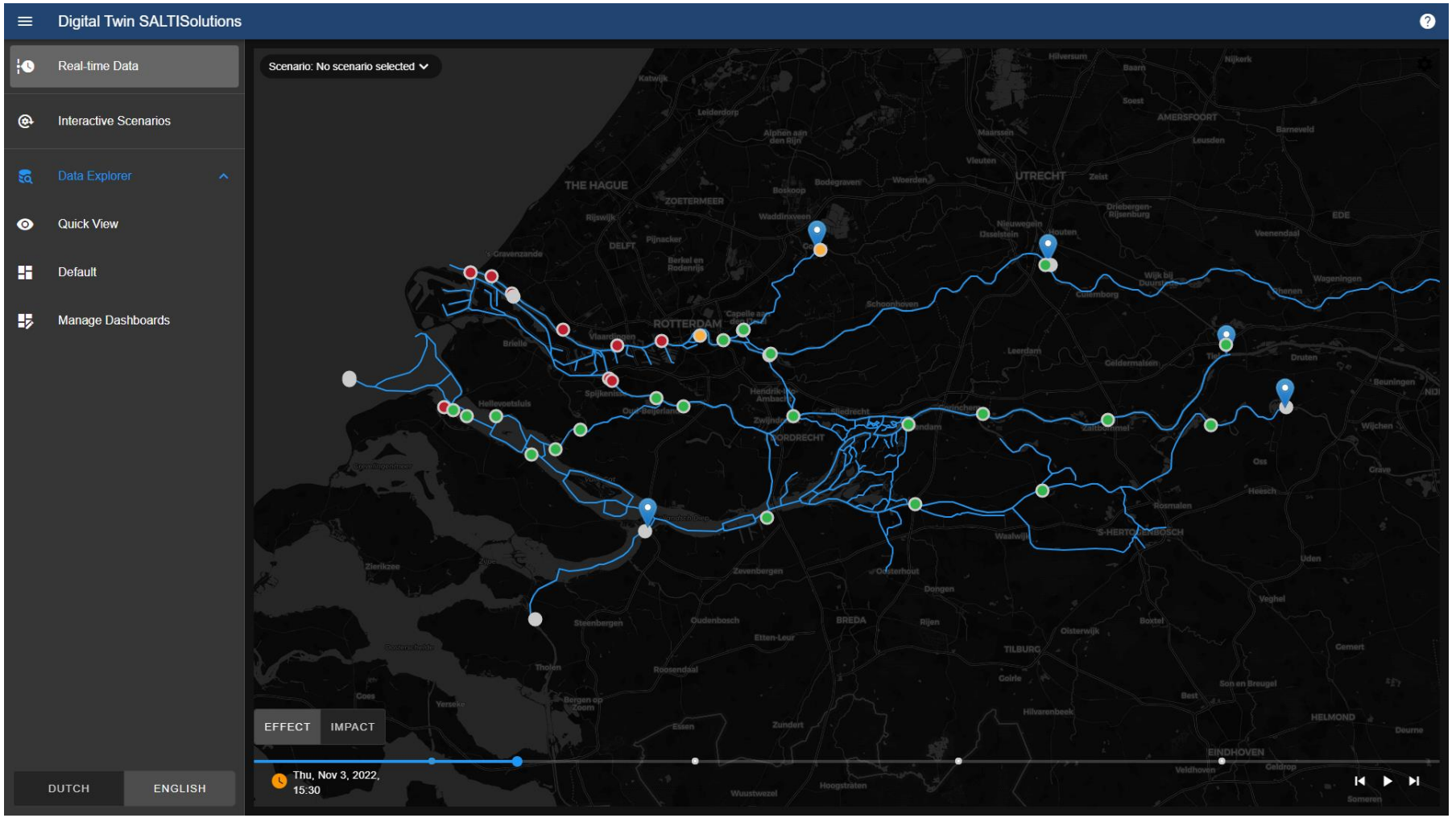
- `/taskruns`

On to a new scenario!



FEWS PI endpoints:

- `/locations`
- `/timeseries`

Future Developments

Physics & models:

- 2D/3D and data-driven models, hybrid modelling
- Accelerate research: opening DT up for models in development.
- Salt intrusion around structures

Visualisation

- Representing 1D results spatially
- 2D/3D visualization
- Visualisation of structures and interventions

Increase immersiveness / interactiveness

- Through data driven modelling, hybrid modelling & batch forecasting

Future Developments

Real Data: Remote Sensing, Data on structures such as sluices

Increase number of interventions and freedom in scenario development

Contact

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