

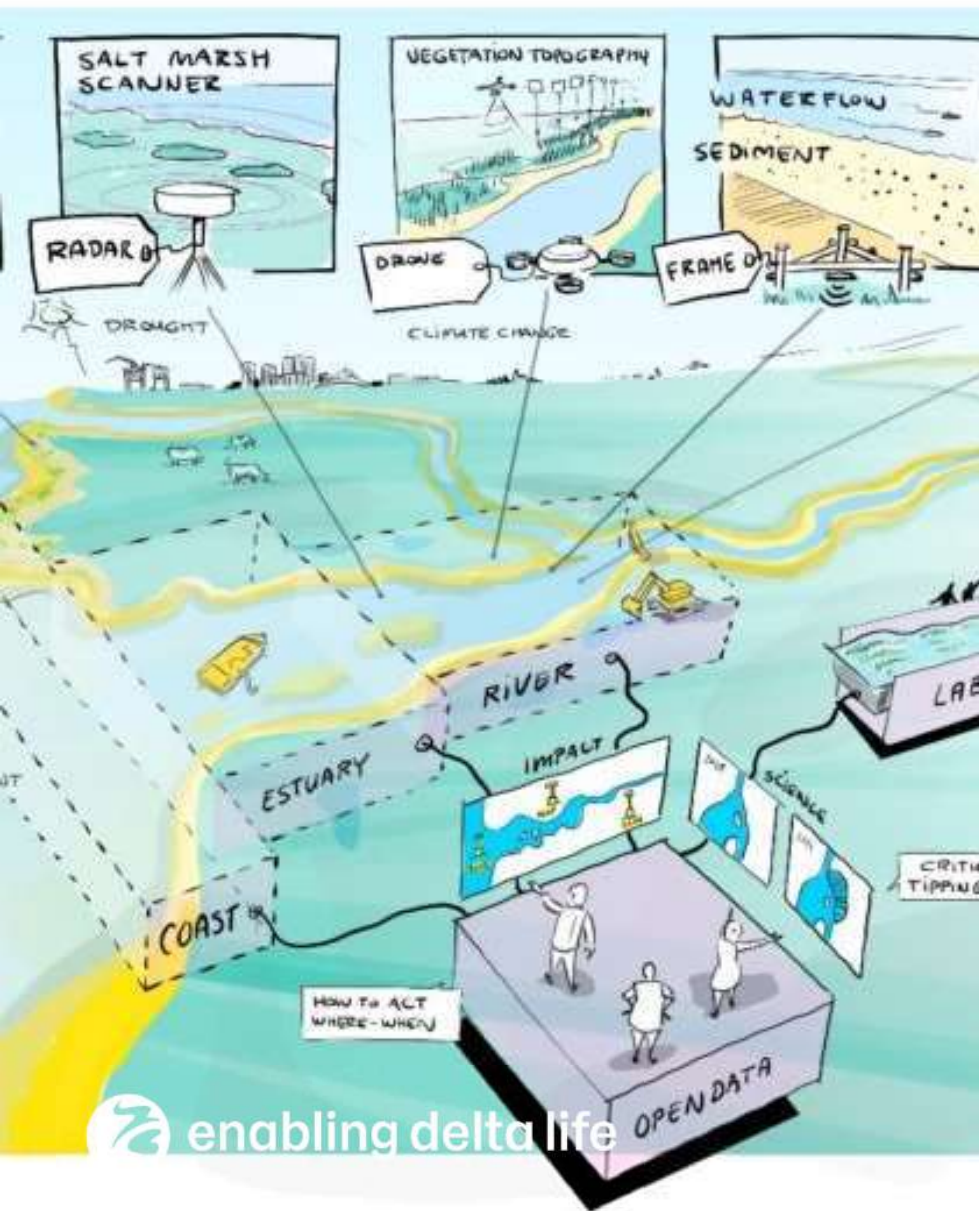
Deltares

Δ Enigma

Keeping the Dutch delta livable

Gert-Jan Schotmeijer

24-09-2024



Problem statement approx. 2 years ago

“We do not yet have the models to accurately predict changes in deltas in the coming years to decades, mainly because our knowledge of the interaction between physical and ecological processes in the formation of deltas is insufficient.”

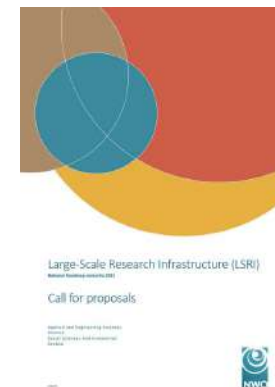


Nederlandse Organisatie voor Wetenschappelijk Onderzoek

NWO call for proposals: Large-Scale Research Infrastructure (LSRI)

- Large-scale scientific infrastructure is essential for Dutch science.
- Highly specialized devices, such as large telescopes, high-field magnets or advanced sensors and monitoring networks necessary for biological and earth science research.
- 'Virtual' facilities, such as extensive databases, scientific computer networks, or data and sample collections.
- NOT allowed: funding research

For all conditions NWO-site: [NWO terms and conditions](#)



Ambition; Becoming the best observed delta in the world

- Build up a database of measurements that is freely available to scientists, policymakers and delta managers. In the ten years that the project will be running.
- Due to the fact the data collected will be open and FAIR and the laboratory facilities will be accessible to others the project will strengthen national and international cooperation

Becoming the best geo-observed Delta in the World

Δ-ENIGMA aims at **bringing biogeomorphology research** in the Netherlands **to the next level**, by providing a unique research infrastructure to understand how organisms, currents, waves, wind and sediment load together shape the delta landscape, including during extreme events. The infrastructure will support the **interdisciplinary character of the research field** at the interface of geomorphology, hydraulics, ecology and engineering. It will sustain and strengthen the prominent Dutch modelling tradition, **by providing 'big data' to improve existing model approaches**, but also push the current physics-based deterministic modelling to a new generation of data-driven approaches.

Objectives



Unravelling the biogeomorphologic **processes** that of coupled river-estuary-coast system



Basis for **improved management** of deltas worldwide

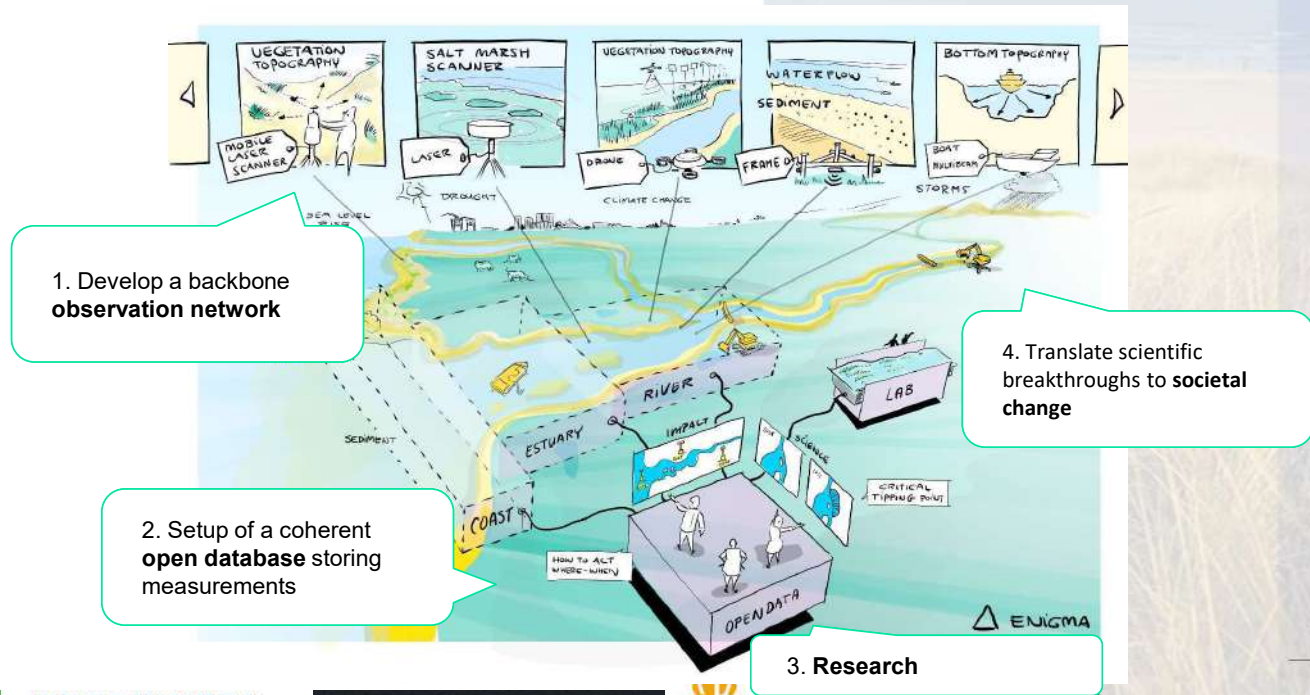


Moving biogeomorphology of deltas into the era of **big-data & predictive models**



Quantifying the importance of **extreme events** that shape deltas under climate change

Through



ΔEnigma; Keeping the Dutch delta livable

Our four major objectives:

1. Unravelling the biogeomorphologic processes that build deltas, in an integrated perspective on the coupled river-estuary-coast system
2. Moving biogeomorphology of deltas into the era of big-data as a crucial step towards developing a new generation of predictive models
3. Quantifying the importance of extreme events in the biogeomorphologic shaping of deltas under climate change
4. Providing the basis for improved management of deltas worldwide, including the application of nature-based solutions that need to be rooted in deep system understanding

ΔEnigma; Keeping the Dutch delta livable

- Awarded in 2023
- Started end of 2023
- *“To intensify international cooperation, Delta ENIGMA will be integrated into DANUBIUS-RI, the pan-European research infrastructure for advanced studies on river-sea systems.”*
ΔEnigma = Danubius-NL

Structure/topics of the project

ΔEnigma; Five coherent blocks

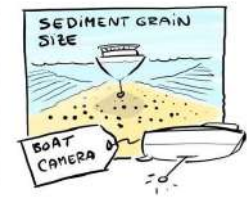
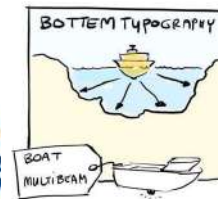
1. A backbone observation network
in a long-term (10-year) deployment at key locations across rivers, estuaries and beach-dune systems. The instruments will measure the slow but cumulative processes during normal and extreme conditions.
2. A rapidly deployable set of specialized instruments, to cover floods, droughts and storms.
3. Advanced laboratory facilities for experimental biomorphological process studies,
to study events and conditions that are presently unobservable in the field.
4. A coherent open database of the measurement results, accumulating over the 10-year period
5. A Productive Knowledge Interaction Facility to boost interactions between biogeomorphology experts, policymakers and delta managers, to quickly bring our new insights to the world.

ΔEnigma; 1. Observation network

- Rivers - WP1: Sustained high-resolution field observations in rivers
- Estuaries - WP2: Sustained high-resolution field observations in estuaries
- Beach Dunes - WP3: Sustained high-resolution field observation on beaches and dunes

ΔEnigma; Observation network Rivers WP1

- Responsible partner: WUR (Prof dr. A.J.F. Hoitink)
- The core of the observation infrastructure that complement the existing monitoring station at Lobith
 1. Upper Merwede, close to the tidal limitet
 2. Lower Merwede tidal river,
 3. New Waterway near the outlet, where flow is highly stratified.
- Collect horizontal profiles of velocity and suspended sediment, based on acoustics at multiple frequencies, optical monitoring and water sampling.



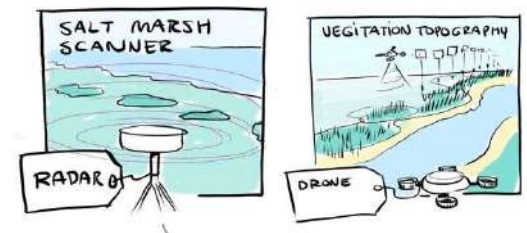
ΔEnigma; Observation network Rivers WP1

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 3. New Waterway near the outlet, where flow is highly stratified.
- Collect horizontal profiles of velocity and suspended sediment, based on acoustics at multiple frequencies, optical monitoring and water sampling.
- Two key **river bifurcations** and two key **tidal channel junctions** will be subject to a periodic survey program with multiple ships, to monitor flow, bedload and suspended load sediment transport, grain size information of bed samples and suspended sediment, and salinity profiles at the junction where salt intrudes.



ΔEnigma; Observation network Estuaries WP2

- Responsible partner: NIOZ (Prof. dr. T.J. Bouma)
- Intense long-term observations will focus on the intertidal area in the transition from channel onto the salt marsh. Two contrasting sites will be observed: a sheltered managed realignment site where vegetation expansion is expected but has not yet occurred, versus a wind-swept high-dynamic site with a broad flat-marsh transition.
- Deploying frames for hydrodynamic forcing and sediment transport rates in the water column, on landscape-scale topographic dynamics and developments, and on biotic developments in vegetation and benthos (sediment-dwelling animals and microbes) on the tidal flats.



ΔEnigma; Observation network Beach Dunes WP3

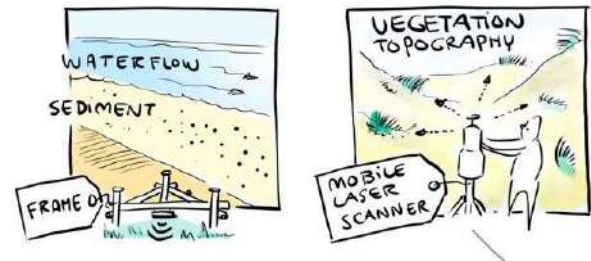
- Responsible partner: UT (K.M. Wijnberg)
- The long-term observations focus on the physical and bio-geomorphological processes that result in dune building and growth. Identical instrument packages will be deployed at three sites:
 - Site 1 is a wide nourished beach fringed by a tall, uniform and densely vegetated ridge of sand.
 - Site 2 is a natural beach with buildings at the beach-dune transition. Aeolian sand transport on the foredune is possible but is affected to an unknown extent by the buildings.
 - Site 3 is a natural beach where artificial blowouts have been created to stimulate an efficient sand transport pathway from the beach well on the backdunes.



ΔEnigma; Observation network Beach Dunes WP3

To measure:

- Topography and bathymetry observations, using 3D laser scanning, a video imaging system and regular ground-truthing with jet-ski surveys.
- Collection of physical process data from beach to dune, through sediment sampling surveys and deploying a weather station on the upper beach.
- Measuring Vegetation dynamics and bio-geomorphological interactions using vegetation cameras, Groundwater-, soil moisture- and salinity sensors, drone surveys, and detained sampling vegetation quadrants, for ground truth vegetation data.



ΔEnigma; Rapidly deployable set of instruments WP4

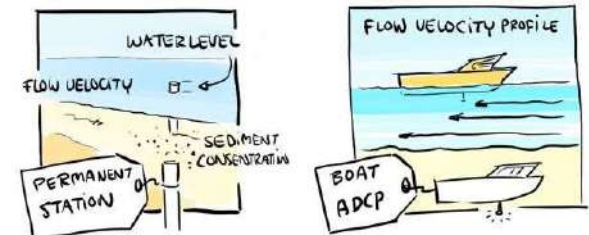
Observing extreme events

- Responsible partner: TUD (Dr. B. van Prooijen)

In the various deltaic systems, the morphological effect of extreme events depends on the local bathymetry or topography, the spatial distribution of vegetation and the specifics of the storm or flood. These effects cannot be extrapolated from normal conditions.

- The set of instruments* will consist of frames for measuring hydrodynamics and sediment transport during events as well as instruments to map (changes in) topography and bathymetry. These data will complement the data obtained from the permanent installations.

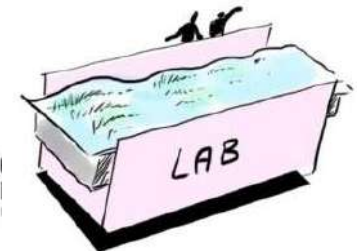
*=Cost-efficient sensors?



Δ Enigma; Laboratory equipment for process studies WP5

- Responsible partner: UU (Prof. dr. M.G. Kleinhans)

An essential step here is linking observed patterns in the field with concepts and knowledge translated into functional relations used in modelling. As an intermediate step in this translation, experimental approaches, in which single factors are varied and their influence on sediment dynamics precisely determined, are indispensable.



ΔEnigma; Laboratory equipment for process studies WP5

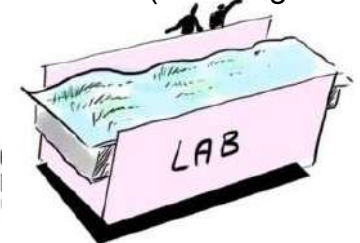
1. Facilities for sediment tracing:

- Sediment tracing by luminescence (WUR). Extending current methods with new promising developments based on the detection of feldspar infrared photo-stimulated luminescence signals (IRPL).
- Sediment tracing by geochemistry (UU).
- Sediment tracing by grain size analysis (TUD) using Camsizers and optical grain microscopy.

2. Flume facilities for sediment transport and biogeomorphology studies. Upgrades and new investments:

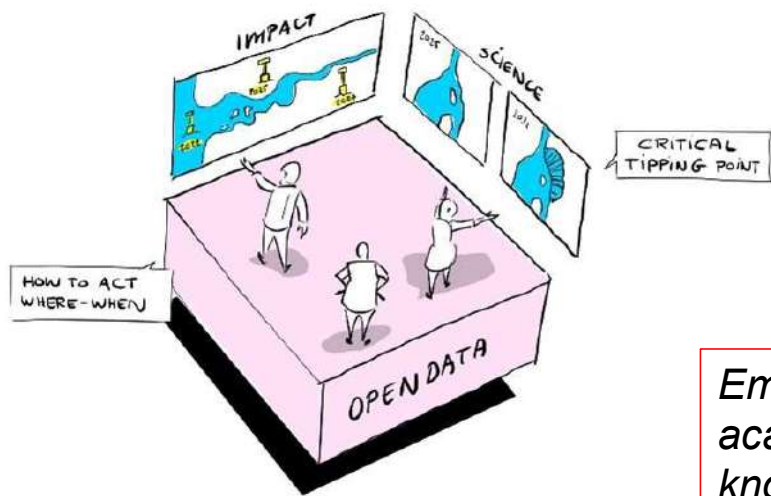
- Current Flume (WUR) for analysis of sediment transport in rivers, with acoustic velocity profilers and a Particle Image Velocimetry (PIV).
- Wave Flume (TUD), to study sediment transport under wave processes with weak currents, now with a true sediment floor.
- Wind tunnel (UT) to investigate the role of variable soil-moisture levels on the initiation of sand transport.
- BioLiveFlume (NIOZ) to study living biota under different salinities and wave-flow conditions.
- Metronome (UU) for experiments on systemic effects of physical and biological processes and their boundary conditions (including subsidence) on the development of entire estuaries.

3. Global change mesocosms for intertidal estuarine conditions, and for dune vegetation.



ΔEnigma; Productive Knowledge Interaction Facility WP6

- Responsible partner: Deltares (G.-J Ellen)



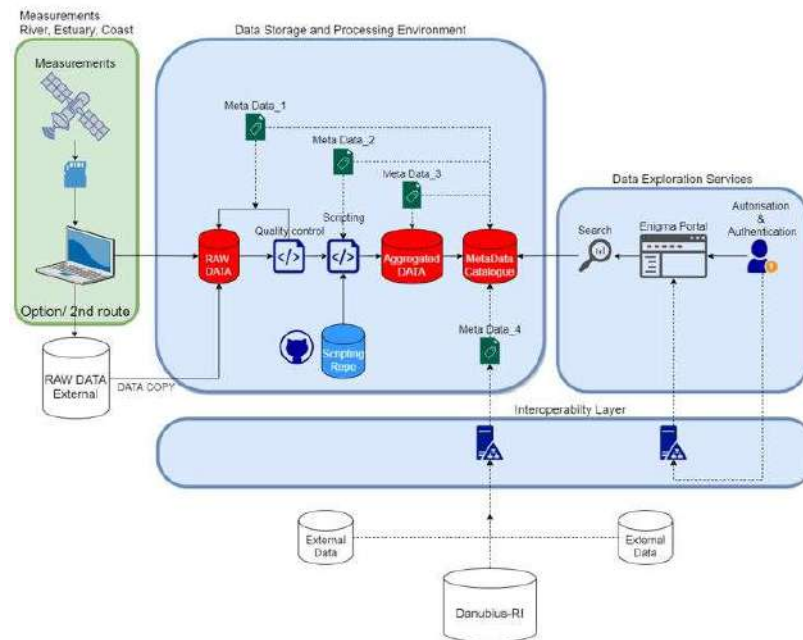
Delta management involves dealing with inherent scientific uncertainties on the one hand, and complexity of stakeholders and their interests on the other hand. In this complex landscape, it is not sufficient to ‘communicate’ scientific findings as an end-of-the-pipe and one-way activity.

Empirical evidence shows that active involvement of non-academic stakeholders with their experience and practical knowledge at different stages of knowledge creation, promotes the real-world relevancy of research outcomes.

ΔEnigma;

A coherent open database of the measurement results, accumulating over the 10-year period, WP7

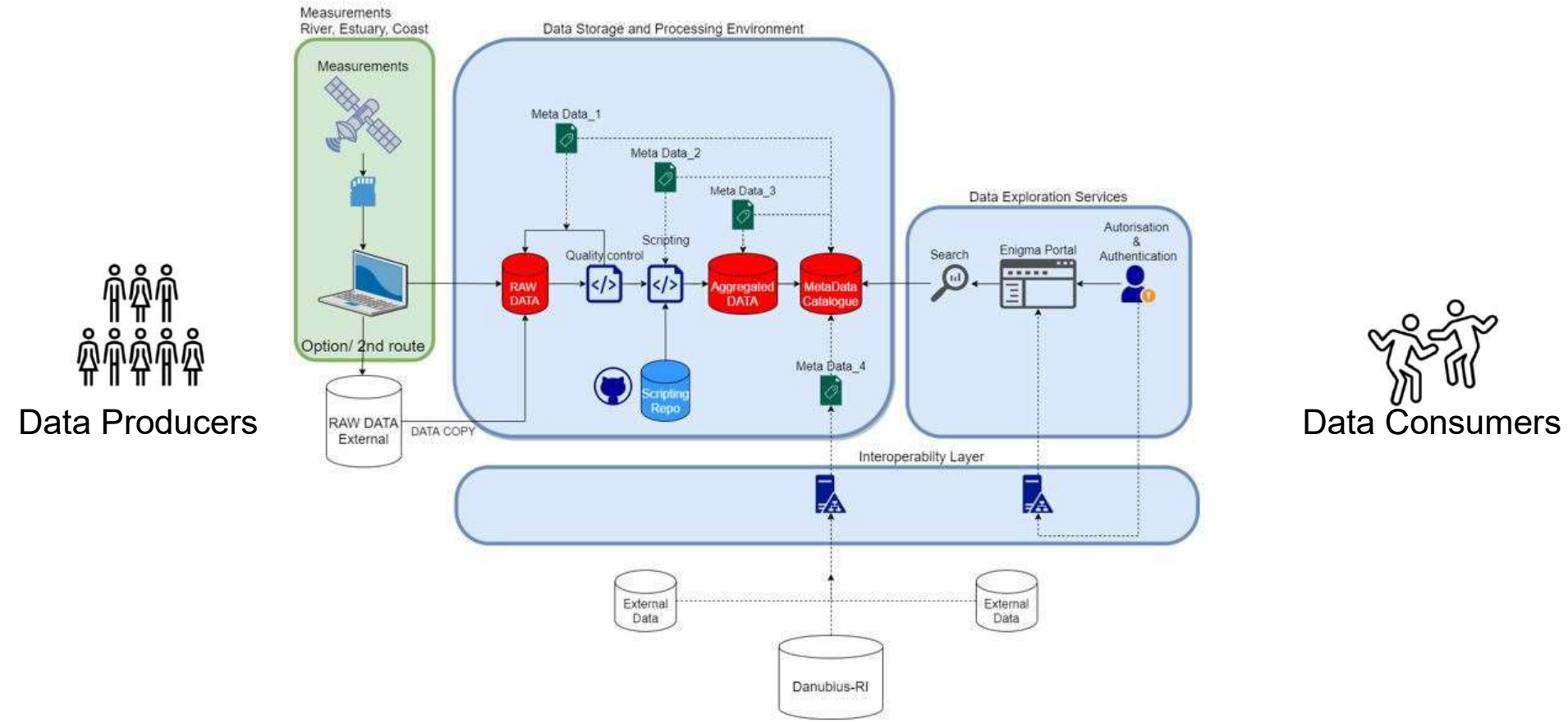
- Responsible partner: Deltares (G.-J. Schotmeijer)



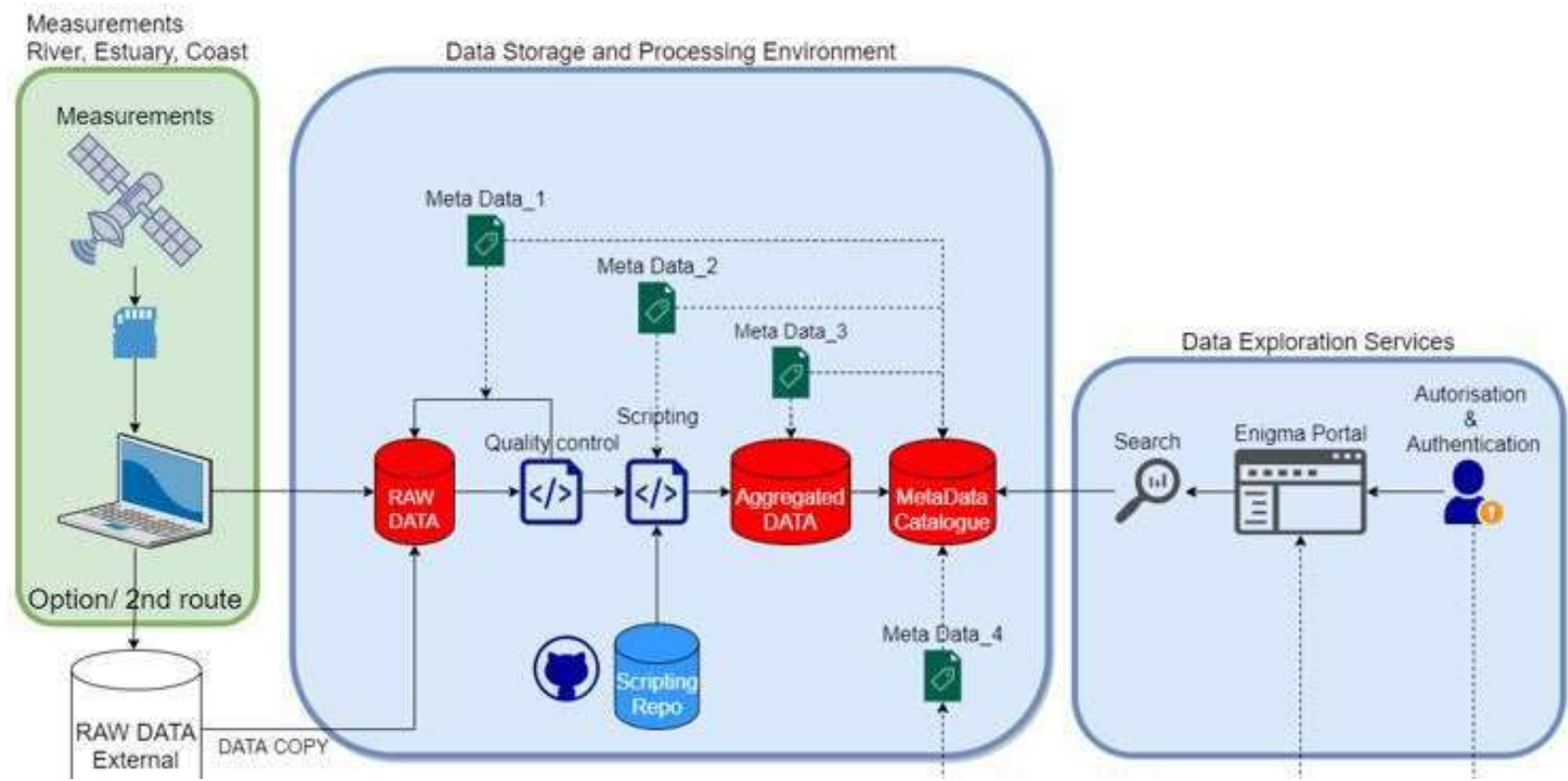
IT-Backbone

A coherent open database of the measurement results, accumulating over the 10-year period,

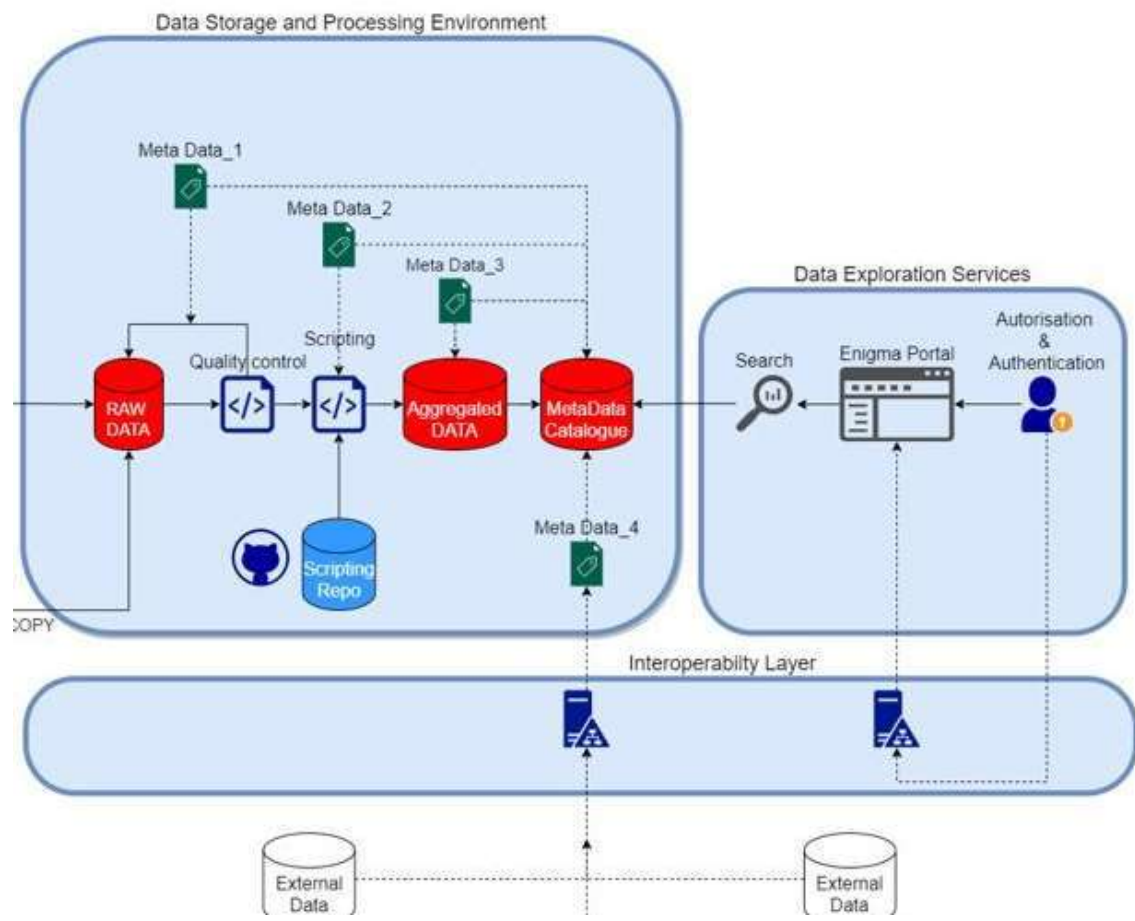
ΔEnigma; ICT backbone for FAIR data management



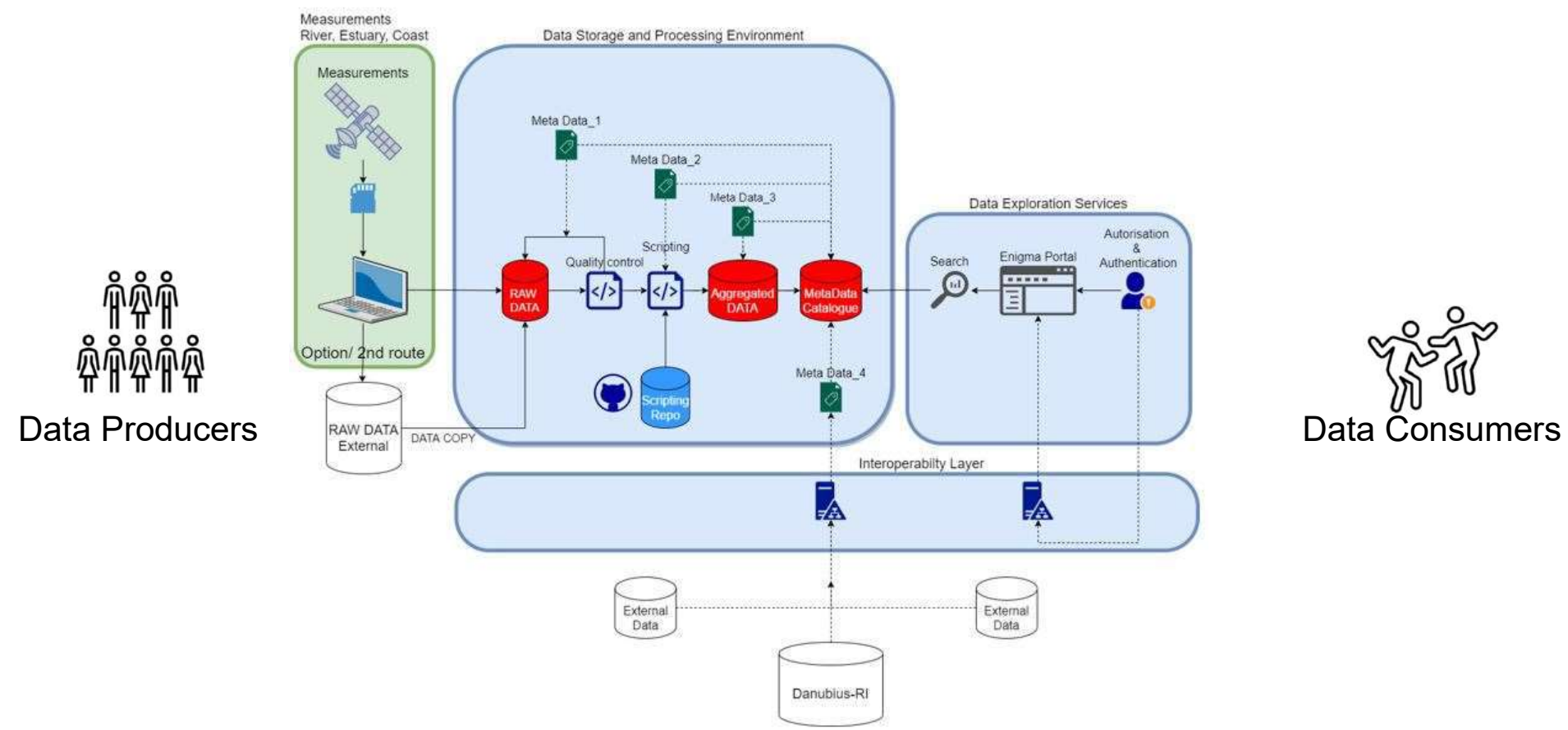
ΔEnigma; ICT backbone for FAIR data management



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ΔEnigma; ICT backbone for FAIR data management



ΔEnigma; WP7 Data consumers

- Data should be in its **raw format (level 0)**, or the processing **steps are clearly traceable**.
 - Access to researchers' data transformation steps via a well-organized Git repository.
- **Clearly described (meta)data** viewable (sensor type, depth, location, DOI reference, etc.).
 - Researchers want to have great search options, where they want to know, what hardware, when collected, what data fields, what calibration settings, contact person
- **Standardized vocabulary** for effective data combination across sensors, no preference for a particular standard yet (see OGC overview)
- Interaction via a **frontend web portal where one can search and inspect** the data
 - **Preview of data** available before downloading the file (timeseries graph, picture of ADCP)
 - Time-based data selection through visual sliders or API.
- Single platform that **integrates well** with other (external) data sources
- Etc.



Data Consumers

ΔEnigma; ICT backbone for FAIR data management

- Aiming at Dutch existing standards (map these on int. standards)
- Meta data standards
- Standardized vocabulary
- Automated quality control
- Federated environment (for future extension)
- Pipelines for (meta) data ingestion
- Jupyter notebooks to interact with the data

ΔEnigma; ICT backbone for FAIR data management



- Looking forward for your feedback as
 - A data producer
 - A data consumer

- Explore the options to create a DigiShape proposition

Contact

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