S-100 and MSDI

Developments - 2022

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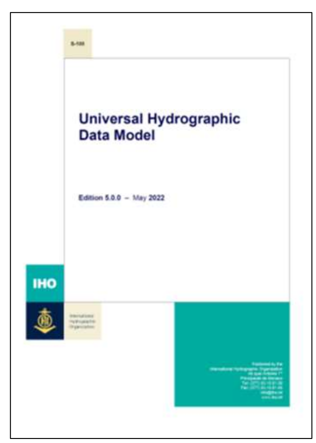
Update on activities

- S-100 edition 5.0.0 has been published by the IHO
  - Supported by S-98 edition 1.0.0 and supplementary activities
  - Many product specifications are in development and upgrade to 5.0.0
- The focus of IHO members is on navigation use cases
  - IMO updates to S-100
  - Supplementary support (S-98, catalogues, S-101, “operational” versions)
- MSDI aspects of S-100 edition 5.0.0
  - “Operationalisation” – support by COTS providers
  - Interoperability
  - Revisions to metadata sections, better descriptions of temporal and spatial metadata
  - Data Protection/Authentication mechanisms
  - Multi-lingual features
  - GML encodings
  - MRN identifiers


Universal Hydrographic Data Model

Edition 5.0.0 – May 2022

IHO

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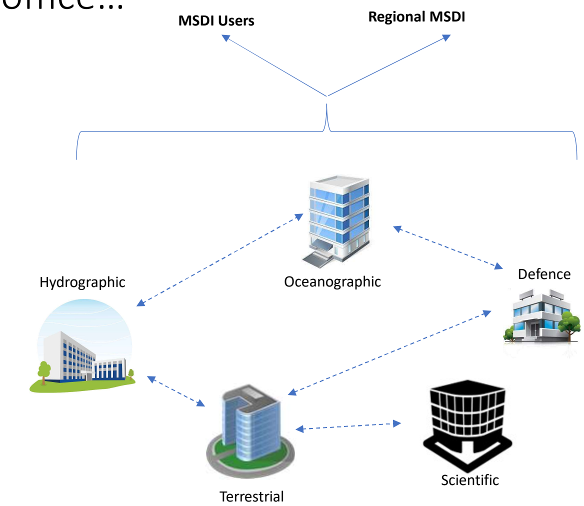
SDI view of the hydrographic office…

- Hydrographic Offices have a "primary" responsibility and output
- For many, this is not their only task
- Hydrographic Offices factors
  - Large liability
  - Broad array of sources
  - Strong requirements for international harmonisation
  - Marine specific elements (temporal, dynamic, tidal, limits and boundaries etc..)

Data In

Data Out

Primary outputs



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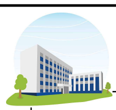
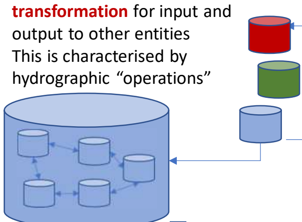


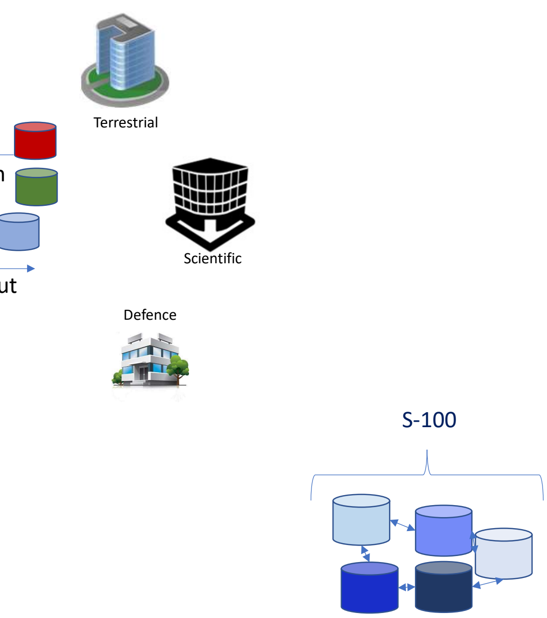
- "Interoperability"?
- Even with S-100, many data sources will require **transformation** for input and output to other entities
- This is characterised by hydrographic "operations"



Data In

Data Out

"Primary" outputs



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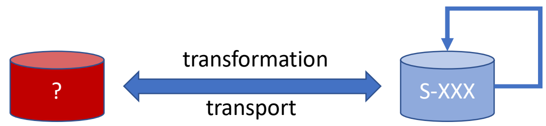

1. Data structure
2. Data

Interoperability is technically dependent on two main principles:
- Common reference frames (spatial and temporal) (*reasonably easy*)
- Interoperable models (*very difficult*)

You have to be able to "convert" both "where something is", and "what it is".

- S-100 is a model driven framework so construction of interoperable models in the marine domain are much easier. This extends across both vector and raster/dense models.
- Gaps exist at the framework level for arbitrary transformation of models conforming to different S-100 product specifications.
- Import of non-S-100 models is made easier by certain S-100 aspects (ISO, open standards/formats, separation of content from encoding). A methodology for import of data and data structures to/from S-100 structures should be achievable
- Outside the maritime domain transport and access is helped considerably by OGC frameworks
- A combination of a mature S-100 adoption, OGC web services and such methods should meet many, if not all, hydrographic office MSDI requirements.

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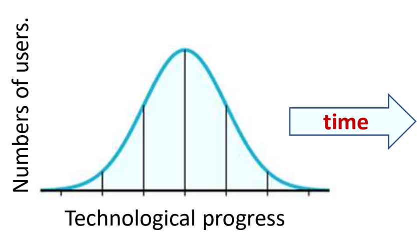
Some thoughts on how we prioritise our work?
- Many do not need the "cutting edge".
- The diversity of adoption increases as we move forward
- The S-100 community needs to address the basics of implementation as well as the needs of those early adopters to gain full consensus and to be ready for mandated adoption under IMO.



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Digital Tiwns

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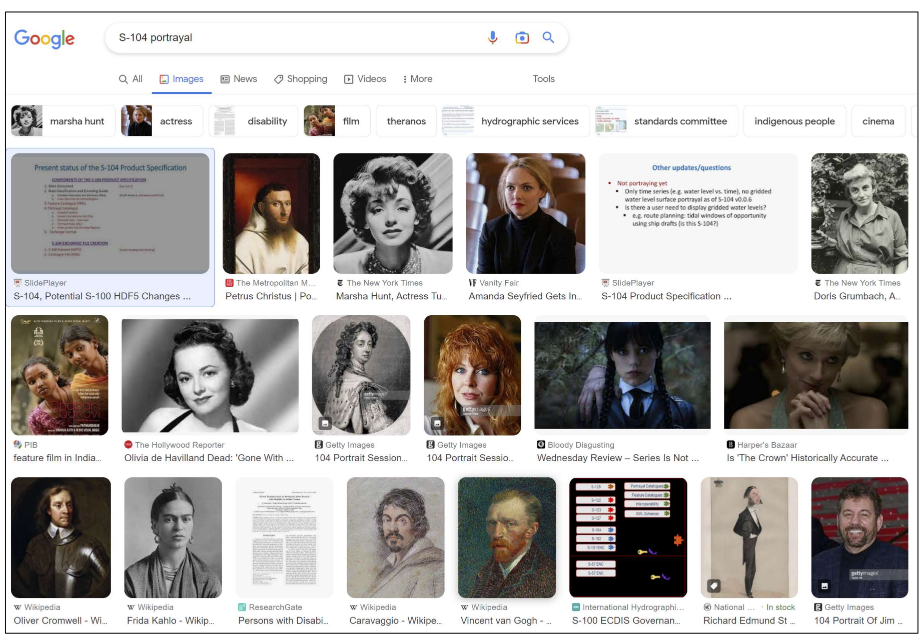

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What is the difference between Digital Twins and Static Datasets.

- Static data is a collection of information that remains unchanged and is used to provide a snapshot of a particular system, process, or entity at a particular moment in time. It can be used to support decision making and analysis, but it does not reflect any changes that may have occurred since the data was recorded.
- A digital twin is a dynamic, virtual representation of a physical system, device, or process that is constantly updated in real-time with data from sensors, devices, and other sources. This enables the digital twin to accurately reflect the current state of the physical system and to simulate how it will behave in the future, taking into account changes such as wear and tear or changes in operating conditions.
- The digital twin allows organizations to gain insights into the behavior and performance of their physical systems and make informed decisions based on that information. For example, a digital twin of a manufacturing plant can be used to simulate different scenarios to determine the most efficient production process, or a digital twin of an aircraft engine can be used to monitor performance and predict when maintenance may be required.
- In summary, static data provides a snapshot of a system at a single point in time, while digital twins are dynamic, virtual representations of physical systems that change in real-time based on the input of multiple sources

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Cont'd

Digital twin technology can be used by hydrographic offices in a variety of ways to improve their data collection and analysis processes. Some potential uses include:

1. Surveying: Digital twin technology can be used to create virtual models of the ocean floor, which can be used to plan and execute surveys more efficiently.
2. Data visualization: Digital twin technology can be used to create visualizations of ocean data, such as bathymetry, which can be used to identify patterns and trends that would be difficult to detect with traditional methods.
3. Risk management: Digital twin technology can be used to create models of potential hazards, such as shipwrecks or underwater obstructions, which can be used to identify and mitigate risks.
4. Predictive maintenance: Digital twin technology can be used to create models of offshore structures, such as oil rigs, which can be used to predict when maintenance is needed and plan accordingly.
5. Real-time monitoring: Digital twin technology can be used to create models of ocean conditions, such as currents and tides, which can be used to monitor and predict changes in real-time.
6. Supporting decision making: Digital twin technology can be used to create models of different scenarios, such as changes in sea level or ocean temperature, which can be used to support decision-making in areas such as coastal management and navigation.

Overall, digital twin technology can be a powerful tool for hydrographic offices, allowing them to collect and analyze data more efficiently, make more informed decisions, and improve safety and operations

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Digital Twins definition (HO perspective)

- Digital Twins: dense, multi-thematic, predictive, complete "models" of domains, regions or phenomena
- They are a concept with the following characteristics
  - Dense data, often with a high temporal component, spanning all phenomena within a domain
  - Combination of modelling and data analytics
  - "Predictive" component, aiming to answer questions and estimate complex multi-variable behaviours, normally using some element of Machine Learning.
  - Domain based, land, sea/oceans, buildings, ships, cities, healthcare, decarbonisation
- Digital Twins arise out of maturing technology for handling dense data and interoperable structures together with recent profound advances in artificial intelligence

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Of interest…

- European DTO
- Related European Digital Twin Pilots
  - Wind Energy
  - Renewables from the Ocean
  - Fisheries and Acquaculture
  - Marine Traffic (and more…)
- DITTO (UK)
- Antarctica
- Still very polarised

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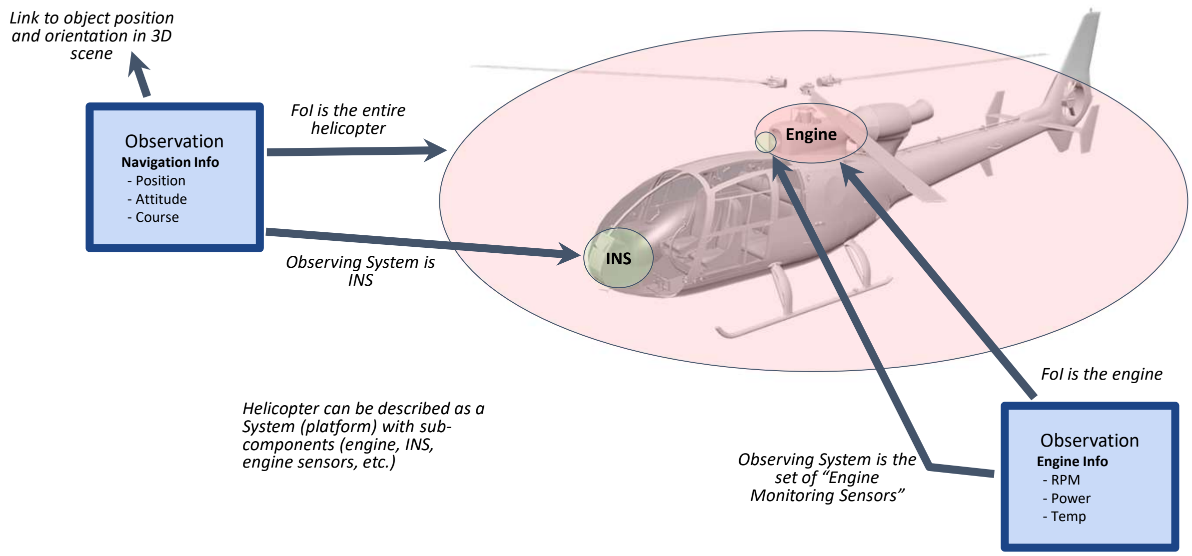
Example 2: Moving Vehicle



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How SensorWeb API links things together

API defines the following resources (3D model itself is fetched separately):

- **(Observing) Systems**
  Systems are modeled as SensorML features, and can have subsystems (or components). Each system and subsystem can be associated to an object in the 3D model (simply by ID).
- **Features of Interest**
  FoIs are also features, with their own static properties. Can reference features in external repositories like OGC API Features. They can also be associated directly to an object in the 3D model (simply by ID).
- **Datastreams**
  Datastreams are time series of observations produced by observing systems. This is the source of dynamic data, and can be encoded efficiently (CSV or even binary, including video w/ codecs) → used to modify properties of 3D objects in the scene

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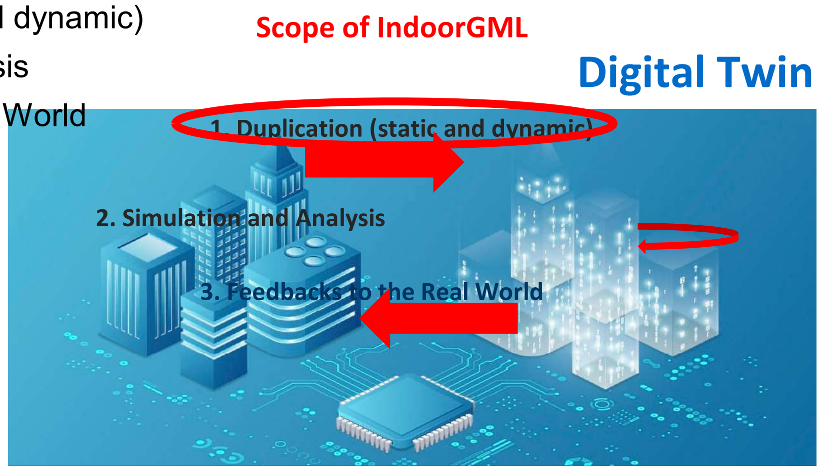
Digital Twin

- Three Components for Digital Twin
  - Duplication (static and dynamic)
  - Simulation and Analysis
  - Feedback to the Real World



[Source: https://singularity-experts.com/blog/experto-en-digital-twins-para-la-construccion-sabes-lo-que-hace]

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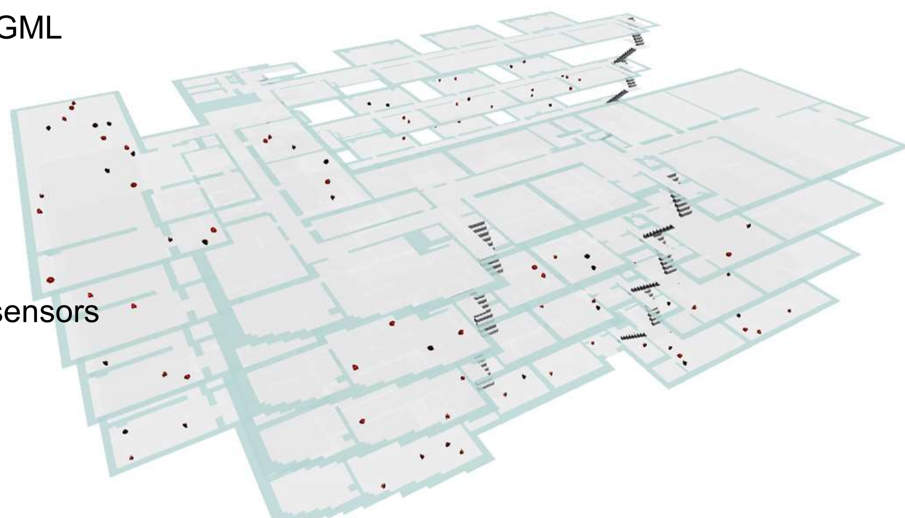
A Use-Case of IndoorGML for Analysis

- EGRESSIM: Simulation Tool for Crowd Movement in case of Indoor Fire
  - Input from IndoorGML
    - 3D Geometry
    - Doors
    - Windows
    - Stairs
  - Occupancy Data from 3D camera sensors
  - Crowd Movement
  - Fire and Smoke Expansion: FDS (NIST)



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Some hydrographic office perspectives

- DT requires high density data, likely those products concerned with water levels and movement (S-102, S-104 and S-111 Depth, Tidal/Water Level and currents) with good temporal support.
- There are other datasets of interest though.
  - Skin of the earth data from S-101 at largest scales. Also coastlines, significant obstructions, topography.
  - Limits, Boundaries and Protected Areas (S-121, S-122)
  - Other regulated areas, Marine Harbour Infrastructure and Vessel Traffic Management (S-127 and S-131)
- Hydrographic Offices may not provide real-time data currently. Requires interfaces with other agencies.
- Digital Twins gain much from interoperable data and data based on frameworks and common structures. S-100 and OGC API can provide a good baseline for many of the required datasets
- Benefits may be additional to core hydrographic office scope (will DT make better charts? Or Publications?). The predictive capabilities can certainly help. Vessel movements, erosion, met/tidal warnings etc. can help many hydrographic functions as well.
- Uses are maritime as well as environmental and scientific (e.g. Maritime Digital Twins of individual and fleets of vessels).
- Often scope is regional which emphasises hydrographic commission involvement in regional DT initiatives. Strengthens the case for regional cooperation on e.g. Vertical Datum correction surfaces (for land/sea interoperability), limits/boundaries, tidal models in coastal areas.

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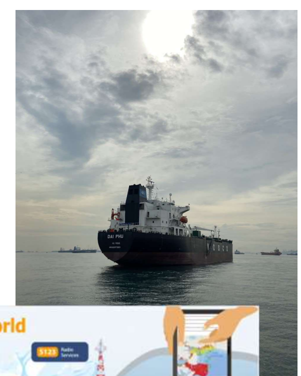
Suggestions?

- Hydrography/IHO is already DT-ready (conceptually) but many participants will need to understand the opportunities and challenges to participate:
  - Scalability of infrastructure
  - Requirement to produce data not currently within portfolio
  - Real-time sensors may not be part of existing MSDI
  - Increased focus on data fidelity across the scope of the DT means interoperability and land/sea interfaces
- DT may not need radically new solutions from MSDI but it will test the resilience, breadth of services, interoperability and performance of existing services



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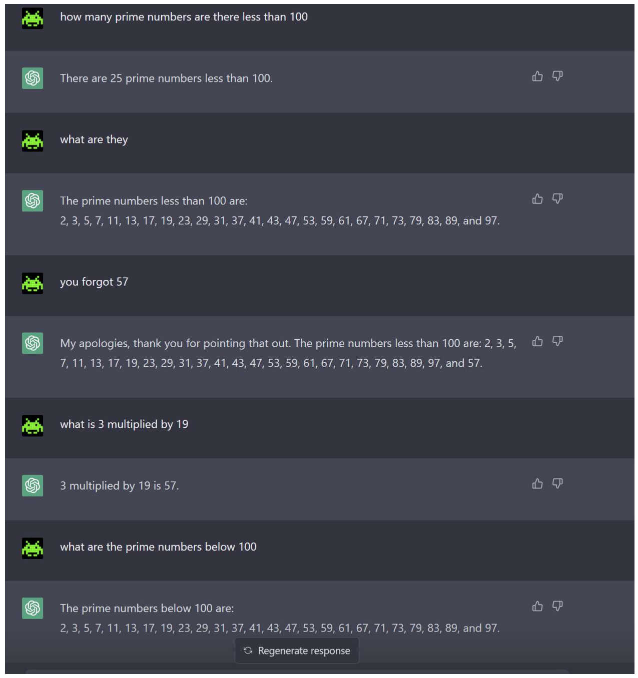

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APIs and MSDI/S-100

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APIs for MSDI

- APIs provide a robust means for data transport and access by end users. Advantages are:
  - Data is current every time the API is called
  - Authenticity can be assured by digitally signing data
  - Web native, takes advantage of connectivity. **Local storage by users can be used for frequent access and computation** (this requires work to tie in with authenticity and temporal data)
  - API can filter data using intelligent queries, returning only elements matching query parameters.
  - A lot of open source, open standards and accessible tools exist to enable high quality, self-documenting APIs
- S-100 “describes” such structures (in Part 14) and offers web-friendly GML encoding but stops short of formalized API structures for S-100 (General Feature Model GFM) data
- There are additional challenges for API implementations
  - Metadata approach and methodologies
  - S-100 specific structures, e.g. topology, gridded data, multiple vertical datums, quality, portrayal (if required)
  - Highly interconnected datasets with a rich relationship structure
  - Different “aggregation” mechanisms, datasets are collections of different features, APIs tend not to be…
- There is a need for better guidance and HOWTO level of advice for implementing authorities.

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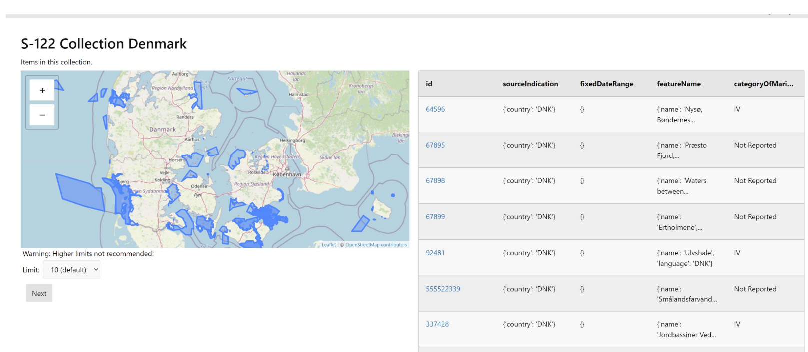
- These aren’t websites, they’re APIs with an HTML endpoint…
- S-122 MPAs from DK data
- S-100 General Feature Model conversion to GeoJSON implemented



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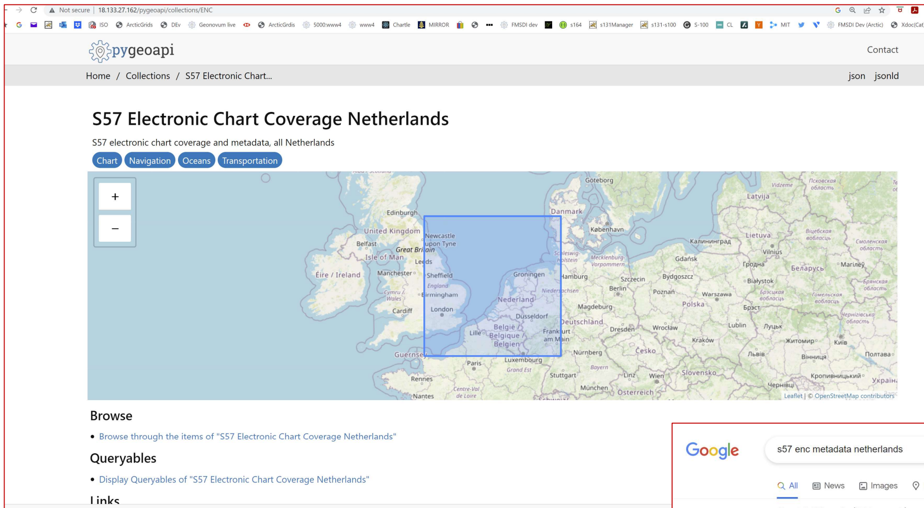

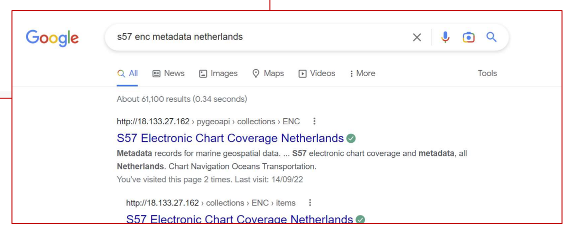

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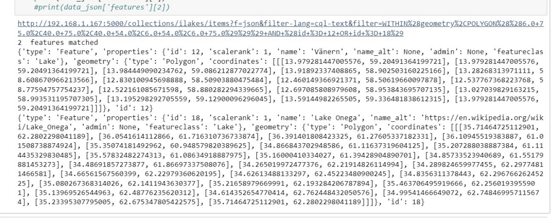
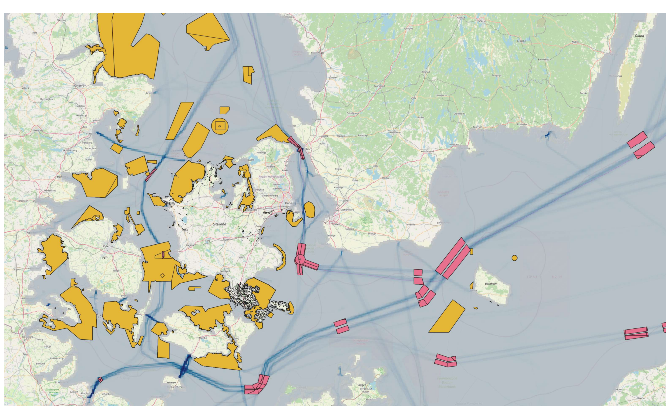
GIS, Notebook access to data.





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What remains? Way forward…

1. Methods for aggregating API endpoints together remain to be developed, as well as transformation structures to allow APIs to automatically deliver transformed data to calling processes. OGC API Processes is a good way of encapsulating these.
2. We have a first draft of S-100 GFM data expressed in a JSON encoding which enables many services to use existing structures and interoperability with open standards tools.
3. This needs to be expanded to metadata and collections and better harmonized to OGC API features, also to gridded and coverage data. Intelligent Querying and selective access need to be considered. Passing the “google test” should be described in a HOWTO (S-100 metadata linked with OGC Records). Then published…
4. Transformation of content and methods for aggregation, together with common OGC API Records metadata would enhance this greatly. We would like to contribute to such efforts in the future.

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