OGC API Hackathon 2019 Engineering Report

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Chapter 1. Subject

The subject of this Engineering Report (ER) is a hackathon event that was held from June 20th to 21st, 2019 to advance the development of OGC Application Programming Interface (API) specifications. An API is a standard set of documented and supported functions and procedures that expose the capabilities or data of an operating system, application or service to other applications (adapted from ISO/IEC TR 13066-2:2016). The OGC API Hackathon 2019, as the event was called, was hosted by the Geovation Hub in London, United Kingdom. The event was sponsored by the European Space Agency (ESA) and the Ordnance Survey.

Chapter 2. Executive Summary

The following is, as all texts in double square brackets, a helper text. Please remove this and all other helper texts once done.

The Executive Summary clause shall contain the key findings and results in a concise form. A more detailed description of the findings should be in the body of the report.

The Executive Summary shall contain a business value statement that should describe the value of this Engineering Report to improve interoperability, advance location-based technologies or realize innovations.

This section shall include precise descriptions of the requirements that have been addressed by the work documented in this Engineering Report; together with the research motivation that answers the fundamental question: What motivated us to address this topic in this report?

This section provides an overview of recommendations on how to further proceed with the achievements documented in this ER.

This section shall be between 1-3 pages.

2.1. Document contributor contact points

All questions regarding this document should be directed to the editor or the contributors:

Contacts

Name	Organization	Role
Gobe Hobona	Open Geospatial Consortium	TBA
Scott Simmons	Open Geospatial Consortium	TBA
Michael Gordon	Ordnance Survey	TBA
Simon Green	Ordnance Survey	TBA
Clemens Portele	interactive instruments GmbH	TBA
Jorge Samuel Mendes de Jesus	ISRIC - World Soil Information	TBA
Peter Baumann	rasdaman GmbH	TBA
Francesco Bartoli	Geobeyond	TBA
Dirk Stenger	lat/lon GmbH	TBA
Chuck Heazel	Heazeltech LLC	TBA
Matthias Mohr	University of Münster	TBA

Name	Organization	Role
Robin Houtmeyers	Hexagon Geospatial	TBA
TBA	TBA	TBA
TBA	TBA	TBA
TBA	TBA	TBA

NOTE Role = Editor and/or Contributor

2.2. Foreword

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Chapter 3. References

The following normative documents are referenced in this document.

NOTE: Only normative standards are referenced here, e.g. OGC, ISO or other SDO standards. All other references are listed in the bibliography. Example:

- OGC: OGC 06-121r9, OGC® Web Services Common Standard [https://portal.opengeospatial.org/files/?artifact_id=38867&version=2]
- OGC: OGC 17-069, OGC Web Feature Service 3.0: Part 1 - Core, Version 3.0.0-draft.1 [https://cdn.rawgit.com/opengeospatial/WFS_FES/3.0.0-draft.1/docs/17-069.html]
- OpenAPI Initiative: OpenAPI Specification 3.0.1 [https://github.com/OAI/OpenAPI-Specification/blob/master/versions/3.0.1.md]
- OGC: OGC 09-146r6, OGC® Coverage Implementation Schema, version 1.1, 2017 [http://docs.opengeospatial.org/is/09-146r6/09-146r6.html]
- OGC: OGC Web Coverage Service (WCS) 2.1 Interface Standard - Core, 2018 [http://docs.opengeospatial.org/is/17-089r1/17-089r1.html]
- OGC: OGC 14-065r2, OGC® WPS 2.0.2 Interface Standard Corrigendum 2, 2018 [http://docs.opengeospatial.org/is/14-065/14-065.html]
- OGC: OGC OGC 07-057r7, OpenGIS® Web Map Tile Service Implementation Standard, 2010 [http://portal.opengeospatial.org/files/?artifact_id=35326]
- OGC 09-025r2, OGC® Web Feature Service 2.0 Interface Standard – With Corrigendum, 2014 [http://docs.opengeospatial.org/is/09-025r2/09-025r2.html]

Chapter 4. Terms and definitions

For the purposes of this report, the definitions specified in Clause 4 of the OWS Common Implementation Standard OGC 06-121r9 [https://portal.opengeospatial.org/files/?artifact_id=38867&version=2] shall apply. In addition, the following terms and definitions apply.

- **application programming interface**

  standard set of documented and supported functions and procedures that expose the capabilities or data of an operating system, application or service to other applications (adapted from ISO/IEC TR 13066-2:2016)

- **feature**

  abstraction of real world phenomena (source: ISO 19101-1:2014)

- **OpenAPI definition | OpenAPI document**

  a document (or set of documents) that defines or describes an API and conforms to the OpenAPI Specification [derived from the OpenAPI Specification]

- **coverage**

  feature that acts as a function to return values from its range for any direct position within its spatiotemporal domain, as defined in OGC Abstract Topic 6 (OGC 07-011).

- **Regular grid**

  grid whose grid lines have a constant distance along each grid axis

- **process**

  A process p is a function that for each input returns a corresponding output

  $$p: X \rightarrow Y$$

  where X denotes the domain of arguments x and Y denotes the co-domain of values y. Within the Web Processing Service (WPS) standard, process arguments are referred to as process inputs and result values are referred to as process outputs. Processes that have no process inputs represent value generators that deliver constant or random process outputs.

- **service**

  distinct part of the functionality that is provided by an entity through interfaces (source: ISO/IEC TR 14252)

- **operation**

  specification of a transformation or query that an object may be called to execute (source: ISO 19119)

- **request**

  invocation of an operation by a client

- **response**

  result of an operation, returned from a server to a client

4.1. Abbreviated terms

- API Application Programming Interface
- CRS Coordinate Reference System
- GML Geography Markup Language
- HTML Hypertext Markup Language
- HTTP Hypertext Transfer Protocol
- JSON Java Script Object Notation
- WCS Web Coverage Service
- WFS Web Feature Service
- WMTS Web Map Tile Service
- OWS OGC Web Services
- REST Representational State Transfer
- XML Extensible Markup Language

Chapter 5. Overview

Section 6 introduces the OGC API Hackathon by describing the challenge, the scenario adopted, and the infrastructure used by the participants. The section also presents overviews of the datasets and services identified to support participants during the Hackathon. The section also presents a list of the organizations represented by the participants.

Section 7 presents the solution architecture developed in this hackathon. The section identifies the client and service implementations of the OGC API specifications.

Section 8 describes each of the OGC API specifications that were involved in the hackathon.

Section 9 provides summary of the main findings and discusses alternative approaches that could have been taken, as well as experiences and lessons learnt.

Appendix A provides reports from each participating organisation, covering their motivation for participating, a description of their implementation of the OGC API specifications, alternative approaches, their experiences, impressions and recommendations.

Chapter 6. Introduction

The development of OGC API specifications is not a new activity within the Consortium, as OGC members and staff have been investigating OpenAPI (and its commercial equivalent, Swagger) in a concentrated effort since 2016. This effort was the result of a recognition that although the existing OGC web service standards are in effect web APIs, there are a number approaches adopted by modern web API frameworks that would require a fairly fundamental change in underlying design.

Two documents really provided the initial energy to get serious about redesign: the OGC Open Geospatial APIs White Paper, edited by George Percivall [1], and the Spatial Data on the Web Best Practices, jointly developed by OGC and the World Wide Web Consortium (W3C) [2]. These documents highlighted how geospatial data should be more native to the web. Further, OGC staff were working on “implementer-friendly” views of OGC standards and experimented with an OpenAPI definition for the Web Map Tile Service (WMTS).

But perhaps the most important impact was the leap of the OGC Web Feature Service (WFS) and Filter Encoding Service (FES) Standards Working Group (SWG) that rebuilt the WFS standard with an integrated OpenAPI definition as core to description of how to build against the standard. The work on WFS, which has resulted in the OGC API - Features specification (formerly called WFS 3.0), benefited from a two-day Hackathon held in 2018. Since then, other OGC web service SWGs have begun to independently develop API specifications based on their relevant OGC web service standards.

Numerous discussions occurred at OGC quarterly Technical Committee (TC) Meetings to consider those elements being developed in each SWG which should be common to all web API standards. These discussions came to a head at the February 2019 TC Meeting in Singapore, where a series of working group meetings and common sessions for the whole TC Membership reinforced the desire to work on a common framework for many OGC web standards and to develop a nomenclature for labeling these standards. Thus, the pattern “OGC API [resource]” was coined. The discussions in Singapore also resulted in the planning of the OGC API Hackathon to define and test common elements from Coverages, Map Tiles, and Processing standards work using foundational material from the Features work.

The OGC API Hackathon 2019 was hosted by the Geovation Hub in London, United Kingdom, from June 20th to 21st, 2019. The hackathon was sponsored by the European Space Agency (ESA) and the Ordnance Survey. The goal of the hackathon was to advance the development of OGC API specifications. The output of this hackathon should lead to a solid, common core and advancement of a whole new generation of OGC standards that are flexible in modern IT environments.

6.1. Overview of the Challenge

The challenge of the Hackathon was to define and test common elements from Coverages, Map Tiles, and Processing standards work using foundational material from the Features work. The magnitude of this challenge was reflected by the fact that the OGC API specifications for Coverages, Map Tiles, and Processing were all at different stages of development. Therefore the Hackathon had to advance the development of all of the specifications to a stage where common elements across all of the specifications could be identified.

6.2. Scenario

NOTE This section is a working draft.

To facilitate the development of the OGC API specifications, the scenario presented in this section was provided as a reference for the teams. The scenario is based on flood risk management and is motivated by recents events such as the 2018 floods that affected parts of Europe (including the United Kingdom, Italy, France, Spain and Portugal) [3] and the 2019 floods that affected parts of the United States [4]. The scenario draws from the OGC's Disasters Interoperability Concept Development Study (CDS) which assessed geospatial Web services across the disaster domain, defining the core components of National Spatial Data Infrastructure (SDI) architecture for disasters (Disasters SDI), and defining use cases and scenarios for future implementations as part of a follow-on pilot phase [5].

Risk mitigation is one of the phases in the 'life cycle' of disaster management [5], which includes the steps shown in Figure 1. *Mitigation* refers to taking sustained actions to minimise or completely eliminate the long-term risk from hazards and their effects to individuals and property. *Preparedness* refers to building the emergency management capabilities to respond effectively to any hazard, as well as to recover from the hazard. *Response* refers to conducting emergency operations that reduce the hazard to acceptable levels (or eliminate it entirely) in order to save lives, through evacuation of potential victims, and provision of food, water, medical care and shelter to those affected by the disaster. *Recovery* refers to the rebuilding of communities that have been affected by a disaster so that those communities, as well as their governments, can return to normality and function on their own. A more detailed discussion on disaster management can be found in the OGC Development of Disaster Spatial Data Infrastructures for Disaster Resilience Engineering Report [5].

Figure 1. Disaster management cycle

As part of Government flood risk management policy, Local Authorities have to carry out a

preliminary flood risk analysis. Using satellite imagery, flood risk data, along with asset information, vulnerable property information and topographic data, Local Authorities carry out analysis to improve resilience and promote a more efficient use of resource.

A Local Authority is tasked with identifying at-risk residential properties in order to assist in flood prevention and amelioration. By carrying out this task, the Local Authority aims to reduce the number of residential properties affected by floods, as well as to decrease the economic and social costs associated with such devastating events. The Geospatial Specialists at the Local Authority embark on the steps presented in Table 1 in order to carry out the task.

Table 1. Steps in the flood risk management scenario

Step	Description	Notes
1	Receive satellite imagery, digital terrain model, Flood Risk Zone, address, and topographic data	
2	Overlay flood assets such as culverts, levees etc.	
3	Combine multiple datasets together.	
4	Data analysis to assess/quantify flood risk.	A number of hydrology approaches may be applied e.g. run-off modelling
5	Identify at risk properties and possible remediation strategies.	
6	Execute cost-benefit analysis to determine priorities.	
7	Commission work for on-the-ground implementation. This may be carried out by internal or external teams.	
8	Impact of remediation work assessed by external engineering consultant.	

The illustration in Figure 2 shows the Area of Interest (AOI) that was selected to facilitate prototyping, demonstration and briefings. The AOI covered the region of Carmarthenshire, Wales and focused on the town of Carmarthen. The region was the site of significant flooding in October 2018 and hence provided an appropriate location to based the flood-based scenario adopted for the Hackathon.

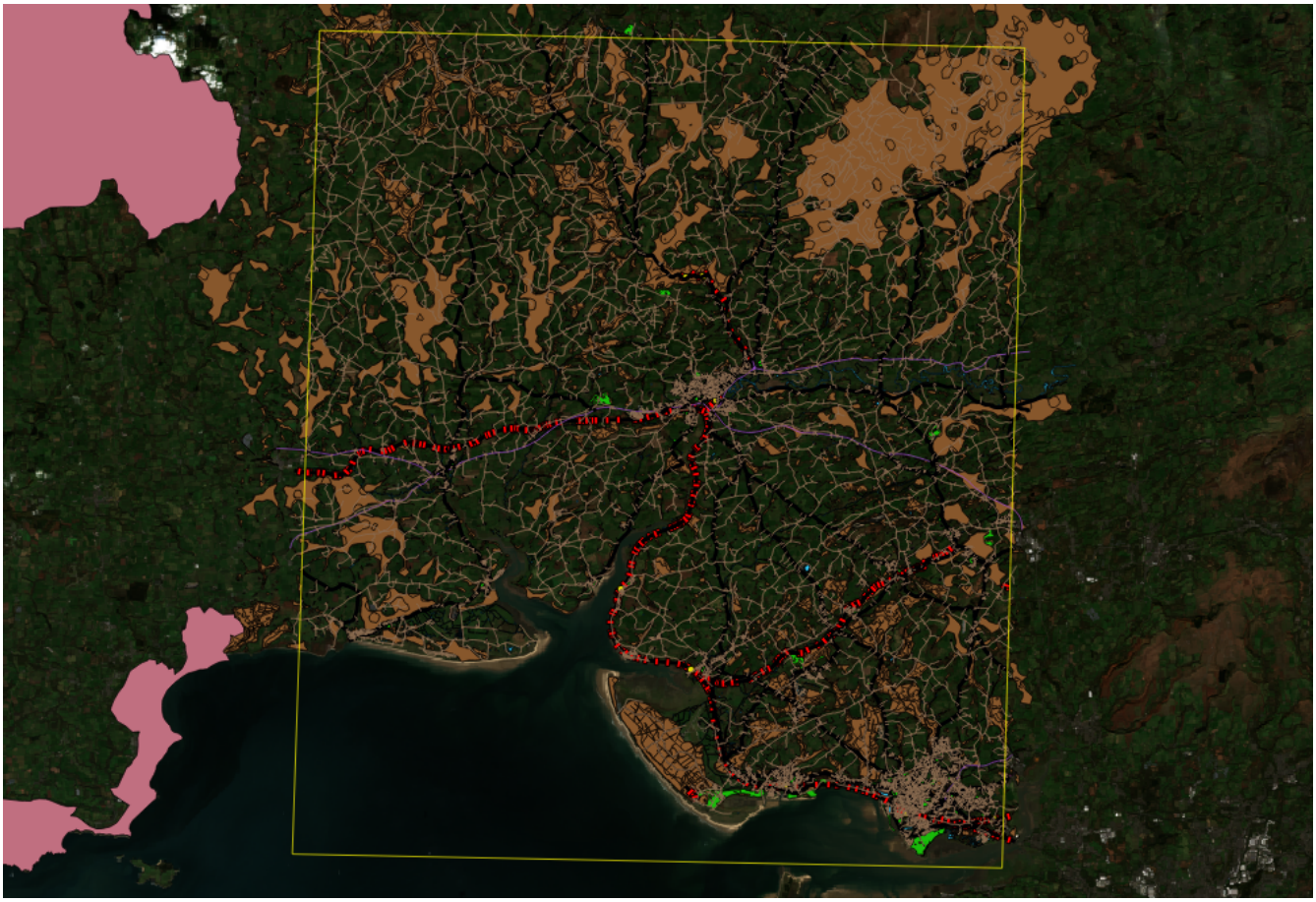

Figure 2. Area-of-Interest (Contains OS data © Crown copyright and database right 2019; Satellite image: ESA Copyright)

Whereas the Time-Of-Interest (TOI) was October 2018, the AOI had the polygonal bounds in World Geodetic System 1984 (WGS84) coordinates:

```
-4.09247619415462,51.6507504017036
-4.59606172257991,51.6468710002251
-4.59750580025958,52.0105126182078
-4.09303085864973,52.0127870676365
-4.09247619415462,51.6507504017036
```

6.3. What was provided

6.3.1. Supporting Datasets

The following datasets were identified as relevant to the scenario, and thus recommended for testing implementations of the specifications.

- ESA Sentinel Data: The Sentinels are a family of missions developed by ESA for Corpenicus, the European Union's Earth Observation programme. The data supplied to the OGC API Hackathon included imagery from the Sentinel-2 mission. Launched on 23 June 2015, the Sentinel-2 mission is a polar-orbiting, multispectral high-resolution imaging mission for land monitoring to support emergency services, imagery of vegetation, soil and water cover, inland waterways and coastal areas [6]. The Sentinel imagery was supplied by Sinergise, the providers of

sentinelhub.com [7].

- UK Met Office DataPoint: DataPoint is a freely available service that offers meteorological feeds for use by professionals, the scientific community, and developers. It is an unsupported service, with a primary goal of facilitating research, development and innovation [8].
- UK Met Office Atmospheric Deterministic and Probabilistic Forecasts: This dataset includes atmospheric deterministic and probabilistic forecasts provided as downloadable gridded data [9]. The data includes 2km deterministic high-resolution atmospheric data for the UK and 10km deterministic high-resolution atmospheric data for the Globe. There is also data from the Global and Regional Ensemble Prediction System.
- Ordnance Survey - OS Open Zoomstack: This dataset provides a single, customisable map of Great Britain to be used at national and local levels. The dataset is available in OGC GeoPackage format. The dataset includes vector data at a variety of scales, from a whole-country view to a street-level view (1:10,000) [10].
- Meteorological Service of Canada Datamart: A variety of raw meteorological data types and forecast data provided by the Meteorological Service of Canada (MSC). It is aimed at specialized users with good meteorological and Information Technology knowledge. The datasets are available through direct download from an HTTP server, as well as through a Web Map Service (WMS) [11].

6.3.2. Supporting Services

The following datasets were identified as relevant to the scenario, and thus recommended for testing implementations of the specifications.

- Meteorological Service of Canada Geospatial web services: This service provides access to the MSC's open data, including raw numerical weather prediction (NWP) model data layers and the weather radar mosaic. The service provides meteorological layers through a Web Map Service (WMS) interface to enable end-users to display meteorological data within their own tools, on interactive web maps and in mobile apps [12].
- National Oceanic and Atmospheric Administration (NOAA) National Weather Service Data as OGC Web Services: These web services provide meteorological data covering the United States, through interfaces that conform to the Web Map Service (WMS), Web Feature Service (WFS) and Web Coverage Service (WCS) standards of the OGC [13].

6.3.3. Deployment Infrastructure

Participants were advised to bring their own laptops to the hackathon. To support testing, the following infrastructure options were available to participants:

- Participants could deploy services into their own computers.
- Participants could deploy services into their own Cloud infrastructure.
- By prior arrangement, participants could deploy services into Ordnance Survey-sponsored Cloud infrastructure.

6.4. Hackathon Participants

NOTE	This list will be updated at the start of the Hackathon

The Hackathon was sponsored by the European Space Agency (ESA) and the Ordnance Survey.

The following organizations participated in the Hackathon:

- 52°North GmbH
- akouas
- ARC
- Arup
- blockdore
- Board Adviser
- British Antarctic Survey
- Cicy
- CREAF
- CubeWerx Inc.
- Deimos Space UK
- developer
- District Government Cologne - Geobasis NRW
- Defence Science and Technology Laboratory (Dstl)
- Duisburg Essen university
- Ecere Corporation
- ECMWF
- El Toro
- EOS Data Analytics
- EOX IT Services GmbH
- Esri UK
- Eurac Research
- European Space Agency (ESA)
- Geobeyond
- GeoCat B.V.
- GeoLabs
- GeoSeer
- GeoSolutions
- Geovation

- Heazeltech
- Helyx SIS
- Hexagon
- Infinity Corporation Limited
- interactive instruments GmbH
- ISRIC - World Soil Information
- Jet Propulsion Laboratory (JPL)
- JRC, European Commission
- Land Information New Zealand
- Landcare Research, New Zealand
- lat/lon GmbH
- Met Office
- Meteorological Service of Canada
- National Aeronautics and Space Administration (NASA)
- National Geospatial Intelligence Agency (NGA)
- National Land Survey of Finland
- Natural Resources Canada
- NOAA/NWS
- Open Geospatial Consortium
- Ordnance Survey
- OSGeo
- Princeton University
- Princeton University Library
- Quick Caption
- rasdaman GmbH
- Secure Dimensions
- Simms Reeve
- Sinergise
- Solenix
- Strategic Alliance Consulting Inc
- University College London
- University of Birmingham
- University of Münster
- University of Notre Dame
- WebGeoDataVore

- West University of Timisoara

Chapter 7. Architecture

The focus of the hackathon was on development of the OGC API - Common, the OGC API - Features, OGC API – Processes, the OGC API – Coverages and the OGC API – Map Tiles standards. Implementations of these specifications were deployed in the Hackathon infrastructure in order to build a solution with the architecture shown in Figure 3. As shown on the illustration, the architecture adopted a multi-tier approach that included one or more implementations of each OGC API specification deployed on the wider Internet (e.g. in participants' own Cloud environments), as well as some implementations deployed in the Ordnance Survey's Cloud which is hosted on Microsoft Azure.

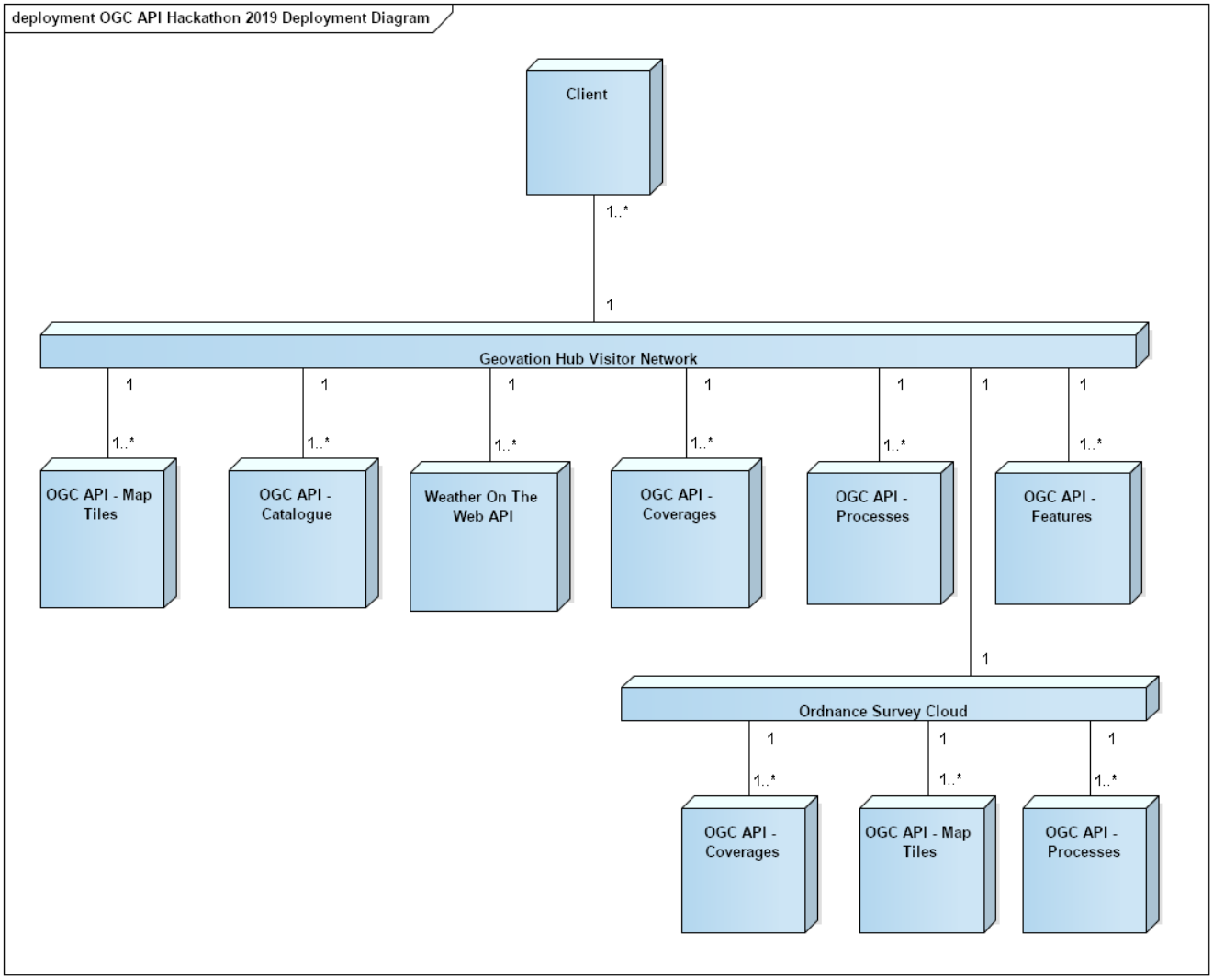

Figure 3. Solution Architecture of the OGC API Hackathon

The OGC API - Common specification documents the set of common practices and shared requirements that have emerged from the development of Resource Oriented Architectures and Web APIs within the OGC. The specification serves as a common foundation upon which all OGC APIs will be built. The OGC API - Processes specification defines how a client application can request the execution of a process, how the inputs to that process can be provided, and how the output from the process is handled. The OGC API - Map Tiles specification defines an OGC standard for a Web Map Tile API that can serve map tiles of spatially referenced data using tile images with predefined content, extent, and resolution. The OGC API - Coverages specification defines a Web API for accessing coverages that are modelled according to the Coverage Implementation Schema (CIS)

1.1 [http://docs.opengeospatial.org/is/09-146r6/09-146r6.html]. The hackathon also sought to maintain consistency between the aforementioned specifications and the OGC API - Features specification. The OGC API - Features specification offers the capability to create, modify and query geospatial feature data on the Web.

7.1. Service Implementations

7.1.1. pygeoapi

pygeoapi is a Python server implementation of the emerging OGC API specifications. Early versions of this software implemented the OGC API - Features specification (formerly WFS 3.0). Recent versions of the software have included support for both the OGC API - Features and the OGC API - Processes specifications. Support for these specifications makes it possible publish feature data and geospatial processes. As the name suggests the software is built using the Python programming language and is supported by a developer toolchain that includes Docker and Git/Github.

7.1.2. 52°North JavaPS

The 52°North JavaPS product is an open source implementation of both the Web Processing Service (WPS) standard and the OGC API - Processes specification. JavaPS enables the deployment of geospatial processes on the Web in a way that conforms to OGC standards. The software is built using the Java programming language and is supported by a developer toolchain that includes Maven and Git/Github. The software features a pluggable architecture for processes and data encodings that is based on the 52°North Iceland [https://wiki.52north.org/SensorWeb/Iceland] project which represents a generic Java framework for OGC Web Services. By virtue of being based on the Iceland project, JavaPS provides components that are associated with processing geospatial data, for example request objects, response objects, decoders, encoders, parsers.

7.1.3. TBA

TBA

7.2. Client Implementations

7.2.1. TBA

TBA

7.2.2. TBA

TBA

Chapter 8. OGC API Specifications

This chapter describes each of the OGC API specifications that were advanced by the Hackathon. The section presents an overview of each specification and is not intended to be a substitute for reading the complete specification.

8.1. OGC API - Common

The OGC API - Common specification documents the set of common practices and shared requirements that have emerged from the development of Resource Oriented Architectures and Web APIs within the OGC. The specification serves as a common foundation upon which all OGC APIs will be built. As such, the OGC API - Common standard serves as the "OWS Common" standard for OGC Resource Oriented APIs. Consistent with the architecture of the Web, this specification uses a resource architecture that conforms to principles of Representational State Transfer (REST). The specification establishes a common pattern that is based on OpenAPI [https://www.openapis.org/].

In addition to identifying core resources, the OGC API - Common specification goes on to specify HTTP status codes that may be supported by an OGC API, as well as how to handle web caching, coordinate reference systems and encodings. The specification also describes how to handle common parameters such as bounding boxes and date-time constraints.

The following subsection presents a summary of the core resources.

8.1.1. Key Resources

A summary of the paths offered by the OGC API - Common specification is presented below:

- Path = /
  - Returns landing page
- Path = /api
  - Returns API Description document (OpenAPI)
- Path = /conformance
  - Returns a set of conformance class URIs.
- Path = /collections
  - Returns metadata describing the collections accessible through this API
- Path = /collections/{collectionId} **Returns metadata describing the collection identified by {collectionId} *Path = /collections/{collectionId}/items
  - Returns --- TBD. This may be where Common leaves off and resource specific standards take over.

8.2. OGC API - Features

The OGC API - Features specification offers the capability to create, modify and query spatial data on the Web. This standard specifies requirements and recommendations for APIs that want to

follow a standard way of sharing feature data. The specification is a multi-part document. The Core part of the specification describes the mandatory capabilities that every implementing service has to support and is restricted to read-access to spatial data. Additional capabilities that address specific needs will be specified in additional parts. Envisaged future capabilities include, for example, support for creating and modifying data, more complex data models, richer queries, and additional coordinate reference systems. This specification builds on the Web Feature Service (WFS) standard and has previously been referred to as WFS 3.0.

8.2.1. Key Resources

A summary of the paths offered by the OGC API - Features specification is presented below:

- Path = /
  - Returns the landing page of this API (inherited from OGC API - Common)
- Path = /conformance
  - Returns information about standards that this API conforms to (inherited from OGC API - Common)
- Path = /collections
  - Returns a description of the feature collections in the dataset (inherited from OGC API - Common)
- Path = /collections/{collectionId}
  - Returns a description of the {collectionId} feature collection (inherited from OGC API - Common)
- Path = /collections/{collectionId}/items
  - Returns features of feature collection {collectionId}
- Path = /collections/{collectionId}/items/{featureId}
  - Returns a feature; using content negotiation to request HTML, GeoJSON or other

8.3. OGC API - Processes

The OGC API - Processes specification provides defines how a client application can request the execution of a process, how the inputs to that process can be provided, and how the output from the process is handled. The specification allows for the wrapping of computational tasks into an executable process that can be invoked by a client application. Examples of computational processes that can be supported by implementations of this specification include raster algebra, geometry buffering, constructive area geometry, routing and several others. This specification builds on the Web Processing Service (WPS) standard.

8.3.1. Key Resources

A summary of the paths offered by the OGC API - Processes specification is presented below:

- Path = /

    - Returns landing page (inherited from OGC API - Common)
- Path = /api
    - Returns API Description document (OpenAPI) (inherited from OGC API - Common)
- Path = /conformance
    - Returns a set of conformance class URIs. (inherited from OGC API - Common)
- Path = /processes
    - Returns available processes
- Path = /processes/{id}/
    - Returns a process description
- Path = /processes/{id}/jobs
    - Returns the list of jobs for a process.
- Path = /processes/{id}/jobs/{jobID}
    - Returns the status of a job
- Path = /processes/{id}/jobs/{jobID}/result
    - Returns the result(s) of a job

8.4. OGC API - Map Tiles

The OGC API - Map Tiles specification defines an OGC standard for a Web Map Tile API that can serve map tiles of spatially referenced data using tile images with predefined content, extent, and resolution. The specification describes the discovery and query operations of an API that provides access to Map Tiles in a manner independent of the underlying data store. The discovery operations allow the API to be interrogated to determine its capabilities and retrieve metadata about the organisation and distribution of tiles. The query operations allow tiles to be retrieved from the underlying data store based upon simple selection criteria, defined by the client. This specification builds on the Web Map Tile Service (WMTS) standard.

8.4.1. Key Resources

A summary of the paths offered by the OGC API - Processes specification is presented below:

- Path = /
    - Returns landing page (inherited from OGC API - Common)
- Path = /conformance
    - Returns a set of conformance class URIs. (inherited from OGC API - Common)
- Path = /collections
    - Returns metadata describing the collections accessible through this API (inherited from OGC API - Common)
- Path = /collections/{collectionId}
    - Returns metadata describing the collection identified by {collectionId}

- Path = /collections/{collectionId}/queryables
  - Returns the queryable properties of the feature collection
- Path = /collections/{collectionId}/items
  - Returns features of the feature collection
- Path = /collections/{collectionId}/items/{featureId}
  - Returns a feature
- Path = /tileMatrixSet
  - Returns all available tile matrix sets (tiling schemes)
- Path = /tileMatrixSet/{tileMatrixSetId}
  - Returns a tiling scheme by id
- Path = /tiles/{tileMatrixSetId}/{tileMatrix}/{tileRow}/{tileCol}
  - Returns a tile of the dataset
- Path = /collections/{collectionId}/tiles/{tileMatrixSetId}/{tileMatrix}/{tileRow}/{tileCol}
  - Returns a tile of the collection with or without style
- Path = /tiles/{tileMatrixSetId}/{tileMatrix}/{tileRow}/{tileCol}/info
  - Returns information on a point of a tile with or without style
- Path = /collections/{collectionId}/tiles/{tileMatrixSetId}/{tileMatrix}/{tileRow}/{tileCol}/info
  - Returns information of a point in a tile of the collection with or without style
- Path = /tiles/{tileMatrixSetId}
  - Returns tiles from several collections.
- Path = /collections/{collectionId}/tiles/{tileMatrixSetId}
  - Returns tiles of a collection
- Path = /map
  - Returns a map of collections with or without style
- Path = /collections/{collectionId}/map
  - Returns a maps from the collection with or without style
- Path = /map/info
  - Returns information about a map of the collection with or without style
- Path = /collections/{collectionId}/map/info
  - Returns information about a map from the collection with or without style

8.5. OGC API - Coverages

The OGC API - Coverages specification defines a Web API for accessing coverages that are modelled according to the Coverage Implementation Schema (CIS) 1.1 [http://docs.opengeospatial.org/is/09-146r6/09-146r6.html]. Coverages are represented by some binary or ASCII serialization, specified by some data

(encoding) format. Arguably the most popular type of coverage is that of a gridded coverage. Gridded coverages have a grid as their domain set describing the direct positions in multi-dimensional coordinate space, depending on the type of grid. Satellite imagery is typically modelled as a gridded coverage, for example. The OGC API - Coverages specification builds on the Web Coverage Service (WCS) standard.

8.5.1. Key Resources

A summary of the paths offered by the OGC API - Coverages specification is presented below:

- Path = /
  - Returns landing page (inherited from OGC API - Common)
- Path = /api
  - Returns API Description document (OpenAPI) (inherited from OGC API - Common)
- Path = /conformance
  - Returns a set of conformance class URIs. (inherited from OGC API - Common)
- Path = /collections
  - Returns metadata describing the collections accessible through this API (inherited from OGC API - Common)
- Path = /collections/{collectionId}
  - Returns metadata describing the collection identified by {collectionId}
- Path = /collections/{collectionId}/coverages
  - Returns metadata about each coverage in the collection
- Path = /collections/{collectionId}/coverages/{coverageID}
  - Returns the coverage itself. Typically as an image file.
- Path = /collections/{collectionId}/coverages/{coverageID}/metadata
  - Returns metadata about a coverage.
- Path = /collections/{collectionId}/coverages/{coverageID}/domainset
  - Returns a description of the domain set of the coverage
- Path = /collections/{collectionId}/coverages/{coverageID}/rangetype
  - Returns a description of the range type of the coverage

Chapter 9. Key Findings

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9.1. Results

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9.2. Alternatives

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9.3. Experiences

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9.4. Lessons learnt

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9.5. What occurred

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9.6. What are the next steps?

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Appendix A: Implementations of OGC APIs

A.1. 52°North GmbH

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A.1.1. Motivation to Participate

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A.1.2. Implemented Solution

52°North implemented and deployed an instance of the 52°North JavaPS software, which is an implementation of the OGC Web Processing Service (WPS) standard and the OGC API - Processes specification. A screenshot of the deployed service is shown in Figure 4. The software was configured to offer an interface that conforms to the OGC API - Processes specification.

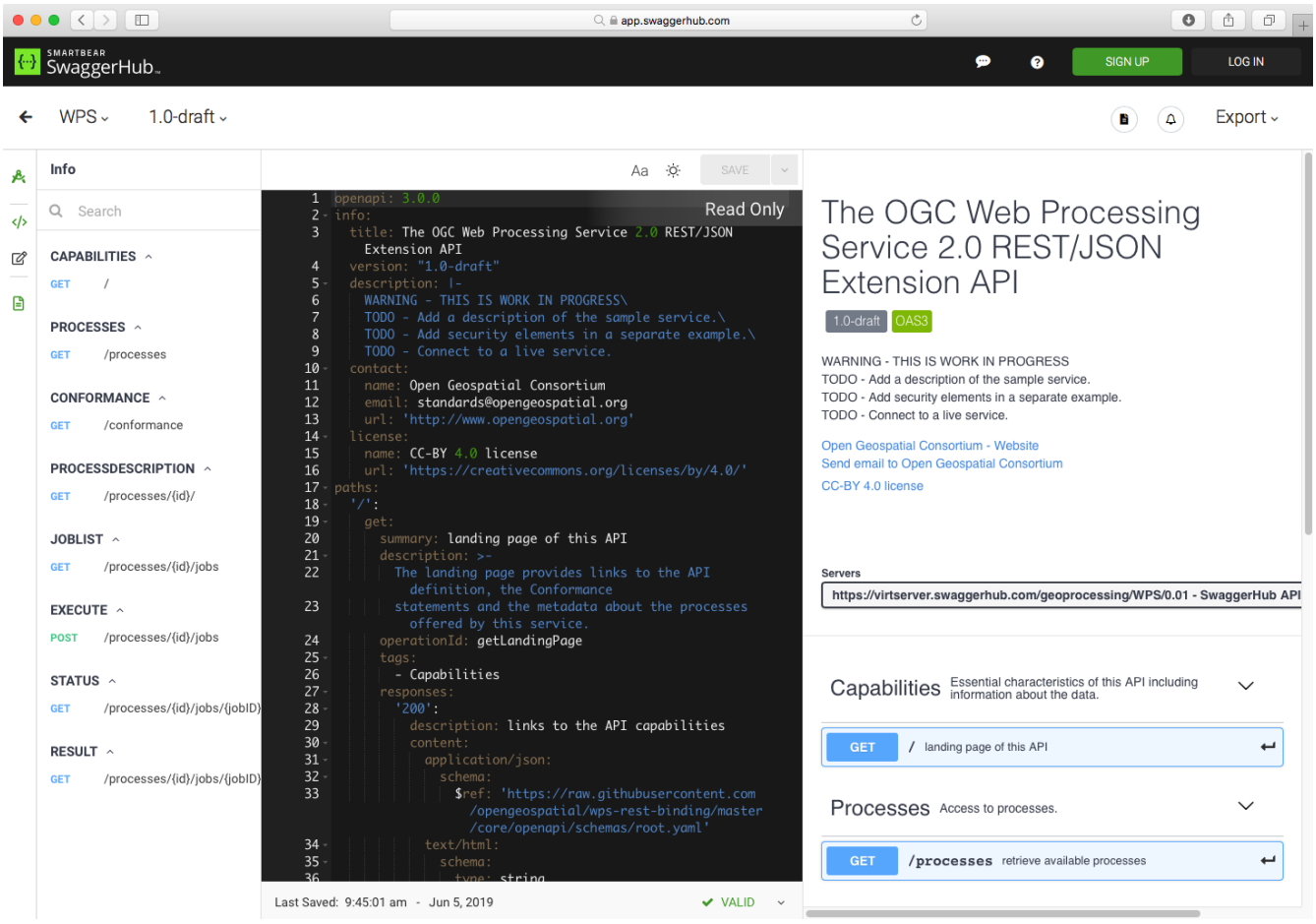

Figure 4. Swagger Hub page of the OGC API - Processes implementation deployed by 52°North GmbH

A.1.3. Proposed Alternatives

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A.1.4. Experiences with OGC API Specifications

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A.1.5. Other Impressions & Recommendations

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A.2. akouas

TBA

A.2.1. Motivation to Participate

TBA

A.2.2. Implemented Solution

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A.2.3. Proposed Alternatives

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A.2.4. Experiences with OGC API Specifications

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A.2.5. Other Impressions & Recommendations

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A.3. ARC

TBA

A.3.1. Motivation to Participate

TBA

A.3.2. Implemented Solution

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A.3.3. Proposed Alternatives

TBA

A.3.4. Experiences with OGC API Specifications

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A.3.5. Other Impressions & Recommendations

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A.4. Arup

TBA

A.4.1. Motivation to Participate

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A.4.2. Implemented Solution

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A.4.3. Proposed Alternatives

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A.4.4. Experiences with OGC API Specifications

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A.4.5. Other Impressions & Recommendations

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A.5. blockdore

TBA

A.5.1. Motivation to Participate

TBA

A.5.2. Implemented Solution

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A.5.3. Proposed Alternatives

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A.5.4. Experiences with OGC API Specifications

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A.5.5. Other Impressions & Recommendations

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A.6. British Antarctic Survey

TBA

A.6.1. Motivation to Participate

TBA

A.6.2. Implemented Solution

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A.6.3. Proposed Alternatives

TBA

A.6.4. Experiences with OGC API Specifications

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A.6.5. Other Impressions & Recommendations

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A.7. Cicy

TBA

A.7.1. Motivation to Participate

TBA

A.7.2. Implemented Solution

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A.7.3. Proposed Alternatives

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A.7.4. Experiences with OGC API Specifications

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A.7.5. Other Impressions & Recommendations

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A.8. CREAF

TBA

A.8.1. Motivation to Participate

TBA

A.8.2. Implemented Solution

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A.8.3. Proposed Alternatives

TBA

A.8.4. Experiences with OGC API Specifications

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A.8.5. Other Impressions & Recommendations

TBA

A.9. CubeWerx Inc.

TBA

A.9.1. Motivation to Participate

TBA

A.9.2. Implemented Solution

TBA

A.9.3. Proposed Alternatives

TBA

A.9.4. Experiences with OGC API Specifications

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A.9.5. Other Impressions & Recommendations

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A.10. Deimos Space UK

TBA

A.10.1. Motivation to Participate

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A.10.2. Implemented Solution

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A.10.3. Proposed Alternatives

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A.10.4. Experiences with OGC API Specifications

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A.10.5. Other Impressions & Recommendations

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A.11. District Government Cologne - Geobasis NRW

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A.11.1. Motivation to Participate

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A.11.2. Implemented Solution

TBA

A.11.3. Proposed Alternatives

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A.11.4. Experiences with OGC API Specifications

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A.11.5. Other Impressions & Recommendations

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A.12. Dstl

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A.12.1. Motivation to Participate

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A.12.2. Implemented Solution

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A.12.3. Proposed Alternatives

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A.12.4. Experiences with OGC API Specifications

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A.12.5. Other Impressions & Recommendations

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A.13. Duisburg Essen university

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A.13.1. Motivation to Participate

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A.13.2. Implemented Solution

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A.13.3. Proposed Alternatives

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A.13.4. Experiences with OGC API Specifications

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A.13.5. Other Impressions & Recommendations

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A.14. Ecere Corporation

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A.14.1. Motivation to Participate

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A.14.2. Implemented Solution

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A.14.3. Proposed Alternatives

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A.14.4. Experiences with OGC API Specifications

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A.14.5. Other Impressions & Recommendations

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A.15. ECMWF

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A.15.1. Motivation to Participate

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A.15.2. Implemented Solution

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A.15.3. Proposed Alternatives

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A.15.4. Experiences with OGC API Specifications

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A.15.5. Other Impressions & Recommendations

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A.16. El Toro

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A.16.1. Motivation to Participate

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A.16.2. Implemented Solution

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A.16.3. Proposed Alternatives

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A.16.4. Experiences with OGC API Specifications

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A.16.5. Other Impressions & Recommendations

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A.17. EOS Data Analytics

TBA

A.17.1. Motivation to Participate

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A.17.2. Implemented Solution

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A.17.3. Proposed Alternatives

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A.17.4. Experiences with OGC API Specifications

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A.17.5. Other Impressions & Recommendations

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A.18. EOX IT Services GmbH

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A.18.1. Motivation to Participate

TBA

A.18.2. Implemented Solution

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A.18.3. Proposed Alternatives

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A.18.4. Experiences with OGC API Specifications

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A.18.5. Other Impressions & Recommendations

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A.19. European Space Agency (ESA)

TBA

A.19.1. Motivation to Participate

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A.19.2. Implemented Solution

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A.19.3. Proposed Alternatives

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A.19.4. Experiences with OGC API Specifications

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A.19.5. Other Impressions & Recommendations

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A.20. Esri UK

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A.20.1. Motivation to Participate

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A.20.2. Implemented Solution

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A.20.3. Proposed Alternatives

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A.20.4. Experiences with OGC API Specifications

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A.20.5. Other Impressions & Recommendations

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A.21. Eurac Research

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A.21.1. Motivation to Participate

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A.21.2. Implemented Solution

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A.21.3. Proposed Alternatives

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A.21.4. Experiences with OGC API Specifications

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A.21.5. Other Impressions & Recommendations

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A.22. GEOBEYOND

Participant: Francesco Bartoli

A.22.1. Motivation to Participate

- Port the GEE-Bridge API to OGC API - Commons and OGC API - Processes.
- Discuss with the community how to handle WPS remote processes and process chaining (local and remote)
- Understand and find the way how to implement several specifications together for the new GeoNode API
- Align with the CSW community about the new OpenAPI based specification

A.22.2. Implemented Solution

- GeoNode API draft work of OGC API - Processes which would implement a generic solution for algorithms as functions

A.22.3. Proposed Alternatives

- Process chaining and consequently workflows should be part of the perimeter of the specification or can be an abstract concept within GeoNode?
- Processing from cloud infrastructure (Google Earth Engine, IBM Geoscope, etc) have to be considered remote or local? Sort of WPS Cascading?

A.22.4. Experiences with OGC API Specifications

- Basic experience with OGC API - Features
- Basic experience with OGC API - Commons and OGC API - Processes

A.22.5. Other Impressions & Recommendations

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A.23. GeoCat B.V.

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A.23.1. Motivation to Participate

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A.23.2. Implemented Solution

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A.23.3. Proposed Alternatives

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A.23.4. Experiences with OGC API Specifications

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A.23.5. Other Impressions & Recommendations

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A.24. GeoLabs

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A.24.1. Motivation to Participate

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A.24.2. Implemented Solution

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A.24.3. Proposed Alternatives

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A.24.4. Experiences with OGC API Specifications

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A.24.5. Other Impressions & Recommendations

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A.25. GeoSeer

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A.25.1. Motivation to Participate

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A.25.2. Implemented Solution

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A.25.3. Proposed Alternatives

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A.25.4. Experiences with OGC API Specifications

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A.25.5. Other Impressions & Recommendations

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A.26. GeoSolutions

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A.26.1. Motivation to Participate

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A.26.2. Implemented Solution

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A.26.3. Proposed Alternatives

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A.26.4. Experiences with OGC API Specifications

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A.26.5. Other Impressions & Recommendations

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A.27. Geovation

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A.27.1. Motivation to Participate

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A.27.2. Implemented Solution

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A.27.3. Proposed Alternatives

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A.27.4. Experiences with OGC API Specifications

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A.27.5. Other Impressions & Recommendations

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A.28. Heazeltech

TBA

A.28.1. Motivation to Participate

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A.28.2. Implemented Solution

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A.28.3. Proposed Alternatives

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A.28.4. Experiences with OGC API Specifications

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A.28.5. Other Impressions & Recommendations

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A.29. Helyx SIS

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A.29.1. Motivation to Participate

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A.29.2. Implemented Solution

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A.29.3. Proposed Alternatives

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A.29.4. Experiences with OGC API Specifications

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A.29.5. Other Impressions & Recommendations

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A.30. Hexagon

Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications. Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous — ensuring a scalable, sustainable future.

Within Hexagon Geospatial, we create solutions that visualize location intelligence. From the desktop to the browser to the edge, we bridge the divide between the geospatial and the operational worlds.

A.30.1. Motivation to Participate

Hexagon Geospatial has been an active supporter of OGC and OGC standards for many years. Next to implementing a wide range of OGC standards, we have ample experience in applying OGC standards within industry solutions for a variety of domains, such as Aviation, Defense & Intelligence, Maritime, Transportation, Mining or Disaster Management. By being part of many testbeds and interoperability experiments the past decade and contributing numerous software components and engineering reports, we also learned that cooperation with other people on real-world use cases is an excellent way of testing and improving specifications. Hexagon Geospatial is motivated to share its expertise as long-term implementer and user to support the advancements of OGC standards related to map tiles, coverages and processes.

A.30.2. Implemented Solution

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A.30.3. Proposed Alternatives

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A.30.4. Experiences with OGC API Specifications

The Hexagon Geospatial product portfolios applied OGC standards from the start and currently implement more than a dozen OGC standards and candidate standards, including implementations of WFS, WMS, WCS, WMTS, WPS, CSW, GeoPackage, Filter Encoding, SLD / SE, GML, KML, 3D Tiles and NetCDF.

A.30.5. Other Impressions & Recommendations

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A.31. Infinity Corporation Limited

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A.31.1. Motivation to Participate

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A.31.2. Implemented Solution

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A.31.3. Proposed Alternatives

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A.31.4. Experiences with OGC API Specifications

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A.31.5. Other Impressions & Recommendations

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A.32. interactive instruments GmbH

TBA

A.32.1. Motivation to Participate

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A.32.2. Implemented Solution

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A.32.3. Proposed Alternatives

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A.32.4. Experiences with OGC API Specifications

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A.32.5. Other Impressions & Recommendations

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A.33. ISRIC - World Soil Information

TBA

A.33.1. Motivation to Participate

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A.33.2. Implemented Solution

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A.33.3. Proposed Alternatives

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A.33.4. Experiences with OGC API Specifications

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A.33.5. Other Impressions & Recommendations

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A.34. Jacobs University

TBA

A.34.1. Motivation to Participate

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A.34.2. Implemented Solution

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A.34.3. Proposed Alternatives

TBA

A.34.4. Experiences with OGC API Specifications

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A.34.5. Other Impressions & Recommendations

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A.35. Jet Propulsion Laboratory

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A.35.1. Motivation to Participate

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A.35.2. Implemented Solution

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A.35.3. Proposed Alternatives

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A.35.4. Experiences with OGC API Specifications

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A.35.5. Other Impressions & Recommendations

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A.36. JRC, European Commission

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A.36.1. Motivation to Participate

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A.36.2. Implemented Solution

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A.36.3. Proposed Alternatives

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A.36.4. Experiences with OGC API Specifications

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A.36.5. Other Impressions & Recommendations

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A.37. Landcare Research, New Zealand

TBA

A.37.1. Motivation to Participate

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A.37.2. Implemented Solution

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A.37.3. Proposed Alternatives

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A.37.4. Experiences with OGC API Specifications

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A.37.5. Other Impressions & Recommendations

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A.38. Land Information New Zealand

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A.38.1. Motivation to Participate

TBA

A.38.2. Implemented Solution

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A.38.3. Proposed Alternatives

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A.38.4. Experiences with OGC API Specifications

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A.38.5. Other Impressions & Recommendations

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A.39. lat/lon GmbH

TBA

A.39.1. Motivation to Participate

TBA

A.39.2. Implemented Solution

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A.39.3. Proposed Alternatives

TBA

A.39.4. Experiences with OGC API Specifications

TBA

A.39.5. Other Impressions & Recommendations

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A.40. Meteorological Service of Canada

The Meteorological Service of Canada (MSC) is the national meteorological agency of Canada. It is a division of Environment and Climate Change Canada. The MSC primarily provides public meteorological information, weather forecasts, and warnings of severe weather and other environmental hazards.

A.40.1. Motivation to Participate

TBA

A.40.2. Implemented Solution

The MSC implemented and deployed an instance of pygeoapi - a Python server implementation of the emerging OGC API specifications. A screenshot of the landing page of the deployed service is shown in Figure 5. The software was configured to offer an interface that conforms to the OGC API - Features and OGC API - Processes specifications.

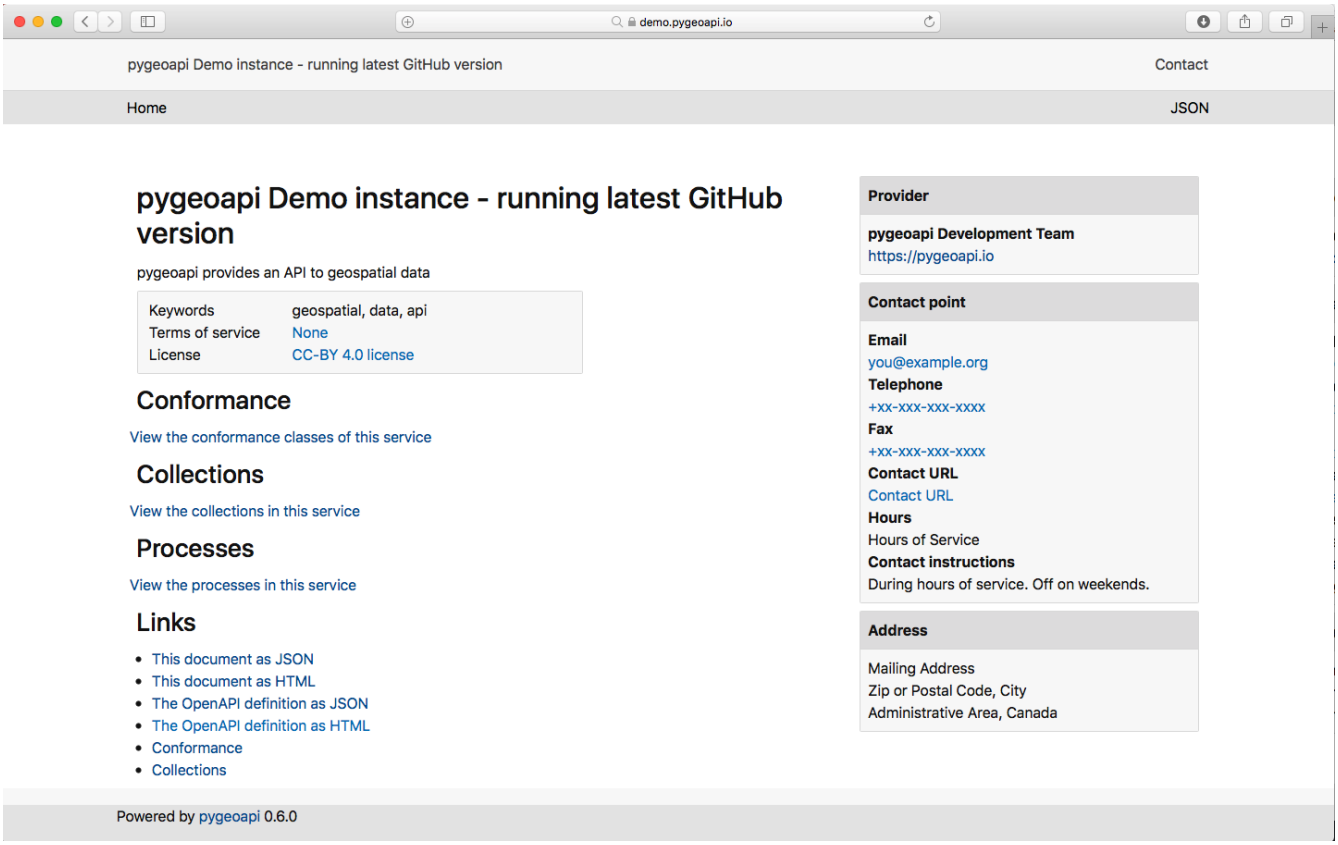

Figure 5. The landing page of the pygeoapi instance deployed by the Meteorological Service of Canada

A screenshot of the OpenAPI page of the deployed service is shown in Figure 6.

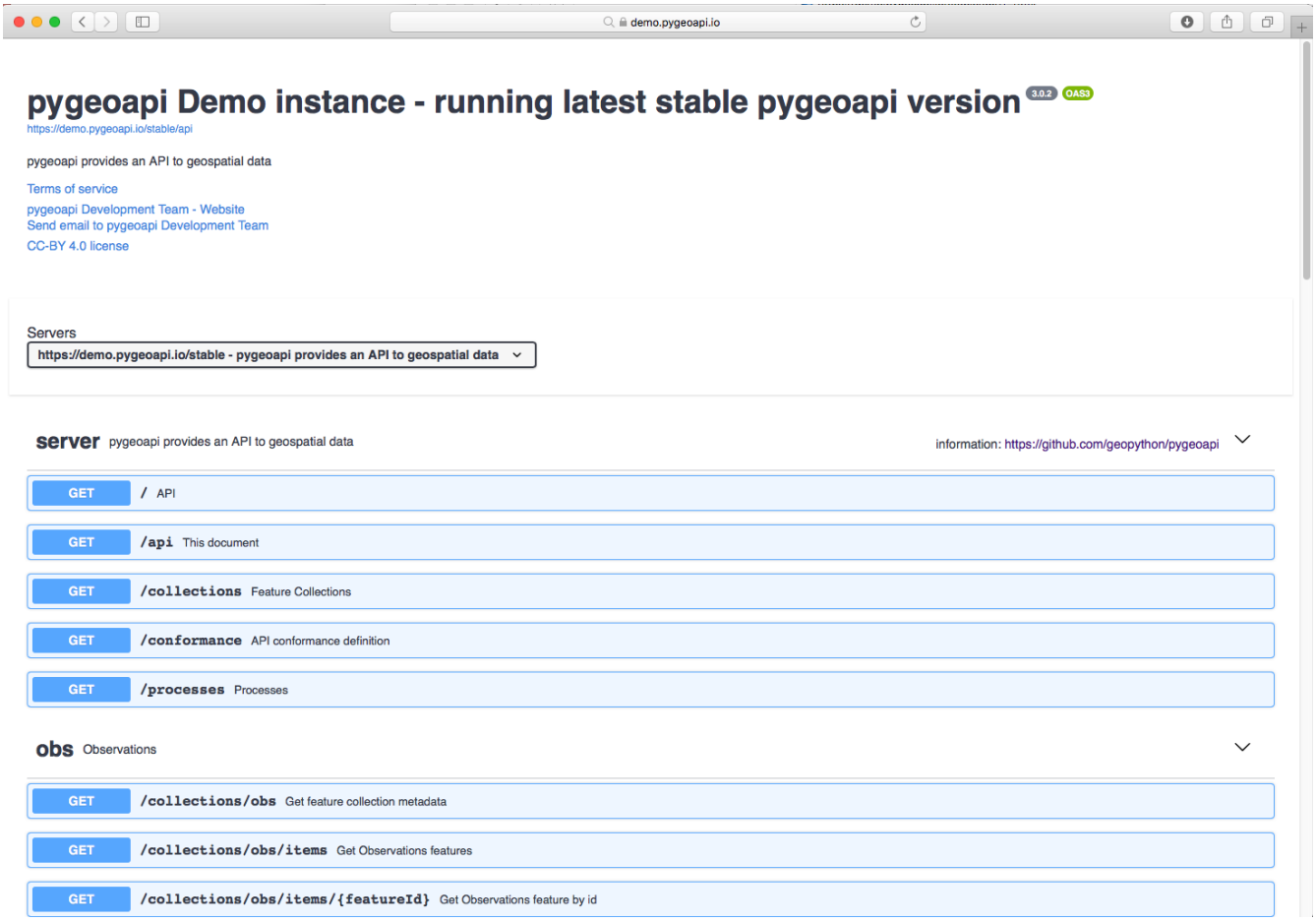

Figure 6. The OpenAPI definition of the pygeoapi instance deployed by the Meteorological Service of Canada

A.40.3. Proposed Alternatives

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A.40.4. Experiences with OGC API Specifications

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A.40.5. Other Impressions & Recommendations

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A.41. Met Office

TBA

A.41.1. Motivation to Participate

TBA

A.41.2. Implemented Solution

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A.41.3. Proposed Alternatives

TBA

A.41.4. Experiences with OGC API Specifications

TBA

A.41.5. Other Impressions & Recommendations

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A.42. National Aeronautics and Space Administration (NASA)

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A.42.1. Motivation to Participate

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A.42.2. Implemented Solution

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A.42.3. Proposed Alternatives

TBA

A.42.4. Experiences with OGC API Specifications

TBA

A.42.5. Other Impressions & Recommendations

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A.43. National Land Survey of Finland

TBA

A.43.1. Motivation to Participate

TBA

A.43.2. Implemented Solution

TBA

A.43.3. Proposed Alternatives

TBA

A.43.4. Experiences with OGC API Specifications

TBA

A.43.5. Other Impressions & Recommendations

TBA

A.44. Natural Resources Canada

TBA

A.44.1. Motivation to Participate

TBA

A.44.2. Implemented Solution

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A.44.3. Proposed Alternatives

TBA

A.44.4. Experiences with OGC API Specifications

TBA

A.44.5. Other Impressions & Recommendations

TBA

A.45. NOAA/NWS

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A.45.1. Motivation to Participate

TBA

A.45.2. Implemented Solution

TBA

A.45.3. Proposed Alternatives

TBA

A.45.4. Experiences with OGC API Specifications

TBA

A.45.5. Other Impressions & Recommendations

TBA

A.46. OSGeo

TBA

A.46.1. Motivation to Participate

TBA

A.46.2. Implemented Solution

TBA

A.46.3. Proposed Alternatives

TBA

A.46.4. Experiences with OGC API Specifications

TBA

A.46.5. Other Impressions & Recommendations

TBA

A.47. Princeton University

TBA

A.47.1. Motivation to Participate

TBA

A.47.2. Implemented Solution

TBA

A.47.3. Proposed Alternatives

TBA

A.47.4. Experiences with OGC API Specifications

TBA

A.47.5. Other Impressions & Recommendations

TBA

A.48. Princeton University Library

TBA

A.48.1. Motivation to Participate

TBA

A.48.2. Implemented Solution

TBA

A.48.3. Proposed Alternatives

TBA

A.48.4. Experiences with OGC API Specifications

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A.48.5. Other Impressions & Recommendations

TBA

A.49. Quick Caption

TBA

A.49.1. Motivation to Participate

TBA

A.49.2. Implemented Solution

TBA

A.49.3. Proposed Alternatives

TBA

A.49.4. Experiences with OGC API Specifications

TBA

A.49.5. Other Impressions & Recommendations

TBA

A.50. Secure Dimensions

TBA

A.50.1. Motivation to Participate

TBA

A.50.2. Implemented Solution

TBA

A.50.3. Proposed Alternatives

TBA

A.50.4. Experiences with OGC API Specifications

TBA

A.50.5. Other Impressions & Recommendations

TBA

A.51. Simms Reeve

TBA

A.51.1. Motivation to Participate

TBA

A.51.2. Implemented Solution

TBA

A.51.3. Proposed Alternatives

TBA

A.51.4. Experiences with OGC API Specifications

TBA

A.51.5. Other Impressions & Recommendations

TBA

A.52. Sinergise

TBA

A.52.1. Motivation to Participate

TBA

A.52.2. Implemented Solution

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A.52.3. Proposed Alternatives

TBA

A.52.4. Experiences with OGC API Specifications

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A.52.5. Other Impressions & Recommendations

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A.53. Solenix

TBA

A.53.1. Motivation to Participate

TBA

A.53.2. Implemented Solution

TBA

A.53.3. Proposed Alternatives

TBA

A.53.4. Experiences with OGC API Specifications

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A.53.5. Other Impressions & Recommendations

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A.54. Strategic Alliance Consulting Inc

TBA

A.54.1. Motivation to Participate

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A.54.2. Implemented Solution

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A.54.3. Proposed Alternatives

TBA

A.54.4. Experiences with OGC API Specifications

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A.54.5. Other Impressions & Recommendations

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A.55. University College London

TBA

A.55.1. Motivation to Participate

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A.55.2. Implemented Solution

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A.55.3. Proposed Alternatives

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A.55.4. Experiences with OGC API Specifications

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A.55.5. Other Impressions & Recommendations

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A.56. University of Birmingham

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A.56.1. Motivation to Participate

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A.56.2. Implemented Solution

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A.56.3. Proposed Alternatives

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A.56.4. Experiences with OGC API Specifications

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A.56.5. Other Impressions & Recommendations

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A.57. University of Münster

Participant: Matthias Mohr

A.57.1. Motivation to Participate

- Align the openEO API with OGC API - Commons.
- Start discussions with the WPS community about alignment and their take on process chaining.
- Figure out future steps of WFS3 to port them back to the STAC specification.
- Discuss with CSW/CAT people about the planned steps and alignment with STAC.

A.57.2. Implemented Solution

- openEO API implementation, which partly implements and aligns with OGC API - Commons / WFS3.

A.57.3. Proposed Alternatives

- Workflows (process chaining) for WPS?
- Base CSW/CAT work on STAC?
- …

A.57.4. Experiences with OGC API Specifications

- WFS3 experience through STAC, contributed to WFS3 with some proposals for changes.
- Basic understanding of WPS and Commons

A.57.5. Other Impressions & Recommendations

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A.58. University of Notre Dame

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A.58.1. Motivation to Participate

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A.58.2. Implemented Solution

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A.58.3. Proposed Alternatives

TBA

A.58.4. Experiences with OGC API Specifications

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A.58.5. Other Impressions & Recommendations

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A.59. WebGeoDataVore

TBA

A.59.1. Motivation to Participate

TBA

A.59.2. Implemented Solution

TBA

A.59.3. Proposed Alternatives

TBA

A.59.4. Experiences with OGC API Specifications

TBA

A.59.5. Other Impressions & Recommendations

TBA

A.60. West University of Timisoara

TBA

A.60.1. Motivation to Participate

TBA

A.60.2. Implemented Solution

TBA

A.60.3. Proposed Alternatives

TBA

A.60.4. Experiences with OGC API Specifications

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A.60.5. Other Impressions & Recommendations

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Appendix B: Revision History

Table 2. Revision History

Date	Editor	Release	Primary clauses modified	Descriptions
June 2, 2019	G. Hobona	.1	5	Adapted Scott Simmons's blog
June 3, 2019	G. Hobona	.2	all	initial version
TBA	TBA	TBA	TBA	TBA
TBA	TBA	TBA	TBA	TBA

Appendix C: Bibliography

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