Invitation to tender

Testbed 2 – Adoption and Research topics

Geonovum

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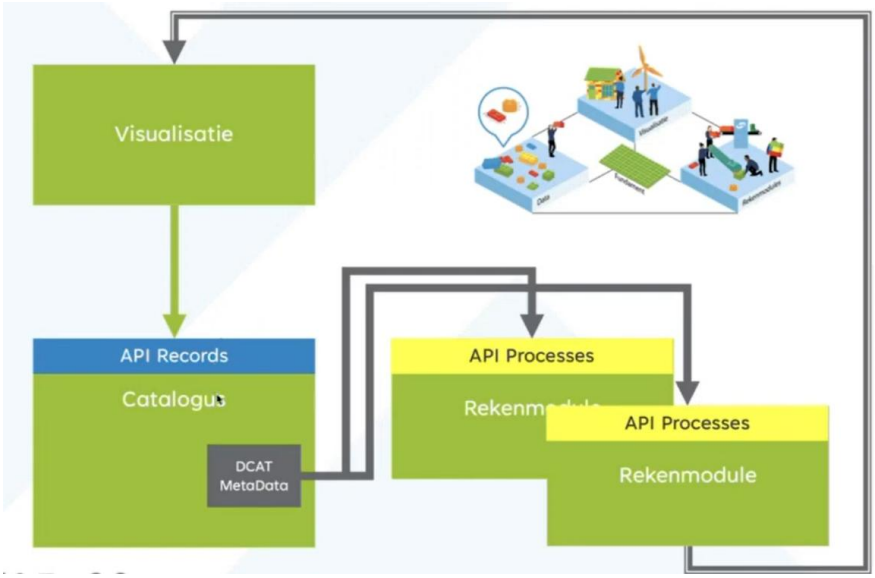
Chapter 1 - Introduction

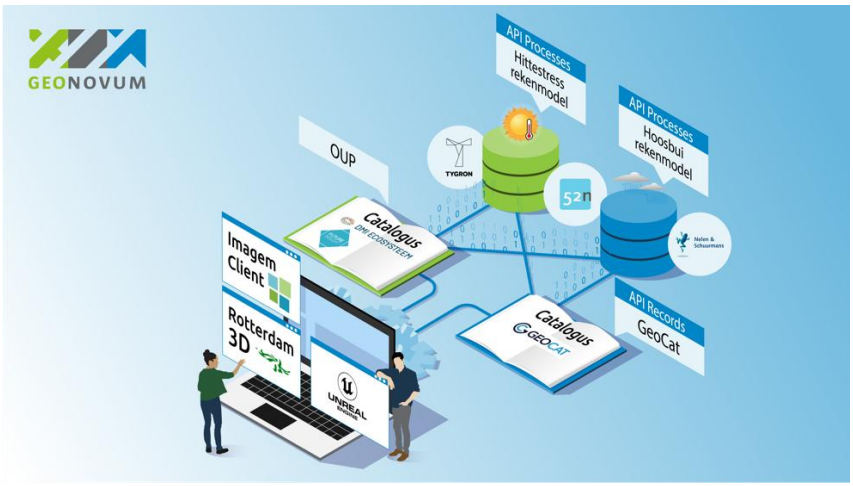
This chapter gives the general background to the testbed Geonovum is organizing and specifies its goals and scope.

Background

To test the concepts of interoperability between digital twins, we are organising testbeds. A first test to check the principles of the architecture was done in 2024 (testbed 1 – see below).

Overall components and (simplified) architecture:





Goal

With testbed 2 we want to stimulate further implementation of the architecture (visualisation, data, calculation interconnected with the fundament) to enable the realisation of a Dutch space for interoperable

Digital Twin applications. This testbed focusses on adoption for known components and further research for additional components.

The NLDT can only come to fruit if the multiple various Digital Twin initiatives can come together, forming a mathematical field. Only then can Digital Twins be part of the instrumentation that is used to tackle the complex and intricate issues in a densely populated country where activities come together on a limited area.

We want to intensify the testbed 1 architecture but also enable stakeholders new to the testbed to participate. We want to address the technical questions of this testbed in use cases with the intention to clarify user questions we have identified.

Geonovum, in line with its mission, is keen to get the answers; and it seeks to involve the market to do so. The actual questions and issues to be addressed are described in this document, combined into four topics.

Invitation to tender

This document gives information about the invitation to tender regarding the following topics:

- Topic #1: Foundation
- Topic #2: Visualization
- Topic #3: Data
- Topic #4: Calculation models

To each sub-topic in this tender, we have allocated a budget. The budget is mentioned in the description of each sub-topic. All given numbers exclude 21% VAT (see chapter 9).

This document

After this introduction, chapter 2 explains the tender procedure. Chapter 3 provides a detailed description of available use cases. Chapter 4 introduces the four topics. Chapters 5 through 8 describe the research and adoption topics in detail. Chapter 9 explains the organization of the testbed in more detail. Appendix A gives the metrics by which proposals are judged.

This document is a draft. Based on questions and comments during and after the tender period we will update this document to clarify questions and remove errors. A final draft will be made available within one week of the question period ending.

Chapter 2 - How to tender

This chapter provides information about the procedure of tender response.

Rules and procedure

On March 11 the Invitation to Tender is published on Geonovum's website, www.geonovum.nl. The submission period for the tender starts on March 14, 2025.

Who can participate?

The tender is open to private and public parties, and to combinations of parties (consortia). In the case of a consortium, there is one party who acts as the contact point and contractor on behalf of the consortium for the tender with Geonovum.

On Friday, March 14 and March 21 at 11:30 am we organise online sessions to introduce this testbed and answer questions. The minutes of these meetings will be published on the Geonovum website within three working days following the meetings. Further questions about the tender can only be asked by sending an e-mail to info@geonovum.nl, addressed to Bart De Lathouwer, coordinator of the testbed. These questions and our answers will also be published on the Geonovum website.

Roles

With this testbed we strive for a wide outreach. There are generic research questions that can be tendered for by international parties. For the Adoption topics only organisations working on the Dutch market can apply (this is a knock-out criteria).

You can participate in this testbed in different roles.

- Researcher/Engineer
- Observer
- In-kind contributors

What are In-kind contributors?

In-kind contributors can provide labor hours for an entire topic or for a sub-topic only (paid by the in-kind contributor), or data for a sub-topic. Typically, in-kind contributors have a great affinity to the (sub)topic and want to see it implemented.

How to apply?

Your tender must be submitted by sending an e-mail to info@geonovum.nl, addressed to Friso Penninga, director of Geonovum, subject 'NLDT-Architecture Testbed 2'.
The deadline for submitting a tender is Friday, April 4, 2025.

The tender is preferably written in English[1] and must at least contain:

- The Research or Adoption topic or topics you are applying for;
- Motivation for the Research or Adoption topic or – topics you are applying for;
- Plan of approach for each addressed Research or Adoption topic (maximum of four pages per topic);
- References (including e.g. publications, projects, blogs, code on GitHub) and curriculum vitae for performers of the research, showing enough relevant knowledge and experience;
- An indication of the in-kind investment;

[1] The alternative is Dutch

- Statement of agreement with the publication of the research results and deliverables under a CC/by license.

Geonovum will judge the received tenders in April 2025, according to the criteria stated in appendix A.

Important notes

Multiple parties can be funded for the Adoption topics, but only 1 party will be funded for the Research topics.

For the Adoption topics, only organizations that operate in the Netherlands are eligible for funding. For Research topics, all organisations are eligible for funding.

Parties are allowed to tender for more than one research sub-topic. However, a contractor is only awarded one research sub-topic, not several. The reason for this is our wish to gain different insights by different parties. The only exception to this rule is that additional sub-topics can be awarded to a single party if this party is the only bidder for an additional sub-topic. We will only do this if the bidder agrees.

Geonovum will announce which party is selected for which sub-topic within 3 working days after April 11. Note that reviewers of this document and Geonovum staff[2] are exempt from bidding.

All outcomes will be available at the Geonovum website. Deliverables of the Research and Adoption topics, in the form of published data, vocabularies, demonstrators, prototypes and the like, must remain available for at least six months after completion of the testbed.

All source code is preferably available under a "popular and widely used or with strong communities" open-source license as identified by the open-source initiative. The use of other (non-opensource) licenses will be considered only if well motivated.

Selection procedure

On April 4, 2025, Geonovum will make a first selection from all submitted proposals. This selection will be submitted to the NLDT Programme Expertise Group for final approval. The final selection will follow on 11 April, after which all submitting parties will be notified of the selection within three working days at the latest. All parties who have submitted a tender will be informed via e-mail.

We reserve the right to ultimately not award sub-topics if there is insufficient choice from submitted proposals.

Outcomes

The results of the research topics in this testbed are intended to contribute to further (international) standardisation and use in Digital Twin technologies. The outcomes will be further disseminated in the relevant International Standards Development Organisations (OGC, W3C, …) and European initiatives (e.g. OASC, LDT, EDIC) and Dutch initiatives (NLDT, Data bij de bron, Federatief Datastelsel, DMI).

The results of the adoption topics are meant to expand the provision of building blocks for data and services facilitating the Dutch ecosystem of Digital Twins and to 'broaden and strengthen the base' on which to build future initiatives, but also to align the European and Dutch to each other so that Digitals Twins become addable.

[2] Employees and Secondments

Chapter 3 - Use cases

Although the testbed is technology oriented, use cases will be used for communication and storytelling – where the technology is used to enable the use-cases.

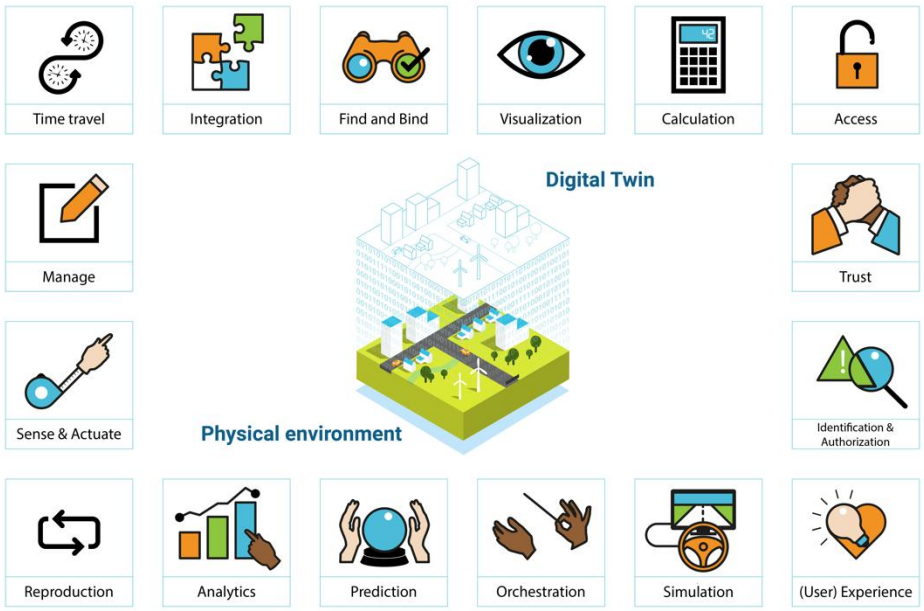
In the preparation process, two use-case have been suggested: Climate mitigation and climate impact analysis. Both suggestions include the use of climate models (e.g. CO2 monitoring, air quality, ...) and how to provide insight in the model output – combined with or in a sustainability monitor, for use in policy making. Data is provided through web-services (WFS, WMS, but also OGC API Features) and models are currently provided with bespoke API's – the aim of this testbed is to further align the data and models to be exposed through interoperable API's. The kennis platform APIs is a valuable asset in this alignment.

More use-cases are welcomed, preferably with the associated data and models. Reuse of the data and models by third parties can be managed under an NDA; to assure data and models are not used outside of the scope of this testbed.

The testbed team is available to create a storyline for use cases applicants to the testbed would like to suggest. Most important is that we can demonstrate the viability and useability of the (software) architecture via these use cases.

3.1 Digital Twin capabilities

In line with the recent published "policy and Digital Twins" report, the testbed architecture will use the below components to derive an architecture that is interoperable, flexible, usable and integrated. Fully in line with the work done in the NLDT working groups.

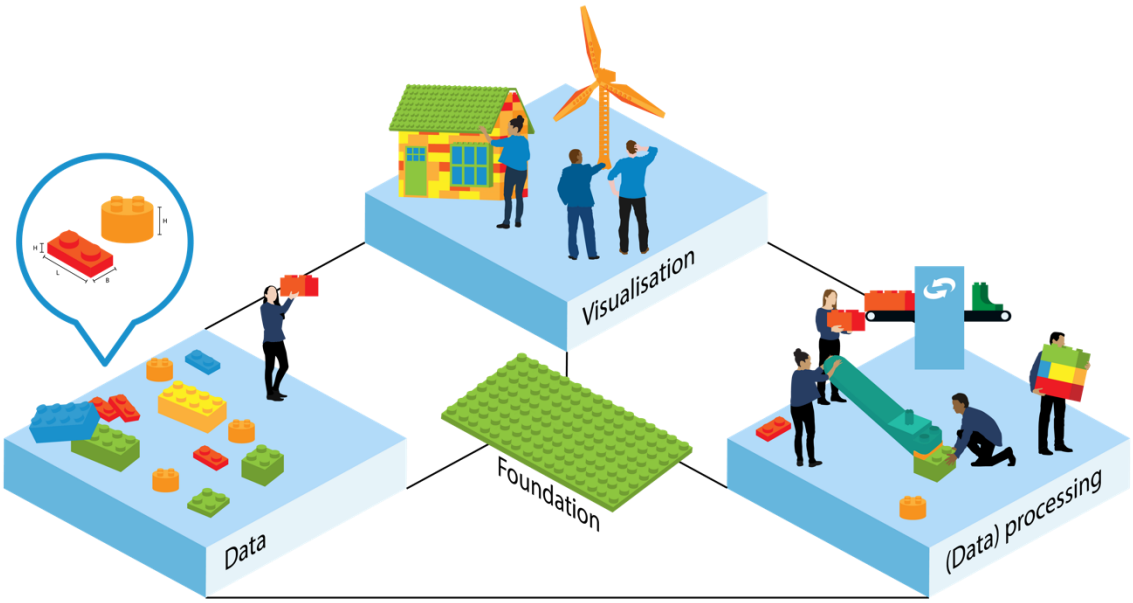


Chapter 4 - The topics

This chapter describes the topics that are part of the testbed. In chapters 5 till 8 you find the different questions we have for each topic.

Introduction to the topics

The topics, although overlapping in scope, are specifically chosen to address different leading perspectives and goals. Below these are spelled out, for each of the four topics.



Topic #1: Foundation: Catalogues with Interoperable API's and Data sharing under conditions

Topic #2: Visualisation: Find and bind, export and import scenes (include sensors and sensor testbed)

Topic #3: Data: BIM for Digital Twins, data downloads

Topic #4: Calculation models (data processing): Making calculation modules interoperable and Model orchestration, status quo

Important notes:

Multiple parties can be funded for the Adoption topics, but only 1 party will be funded for the Research topics.

Organisations can also provide in-kind contributions, either for an entire sub-topic or partially.

For the Adoption topics, only organisations that operate in the Netherlands are eligible for funding. For Research topics, all organisations are eligible for funding.

Chapter 5 – Topic #1: Foundation

5.1 Adoption sub-topic: Catalogues with Interoperable API

Goal

Catalogue with an Interoperable API

Description

To achieve the goals of "no wrong door" when performing a federated search for data (aka resources), meaning: it does not matter in what catalogue you start your search for your data, you should always be able to find your data – when the catalogues are 'connected'.

Catalogues come in various tastes and colours, and that is fine – however it is important that they can participate in a federation and find each other's resources.

This topic also continues the development of the application store (aka the app store): making calculation modules (processes) usable as seamless and easy to use as possible. Learnings from this testbed will be used to further develop the app store (see also how this plays together in a DataSpace environment in topic 5.2, below)

Task

Add a software component to existing catalogues that expose an OGC API Records interface (this could be alongside other interfaces exposed by the service).

Deliverable

A demo of a query to the catalogue, using OGC API Records, with a DCAT response, conforming to DCAT-AP-NL 3.0.

Budget

For this adoption topic a budget of 10.000 euro (exclude 21% VAT) is allocated per organisation, that meets the criteria and that is favourably ranked (max 3).

Requirements / standards / Open-Source software

Mandatory Standards

- OGC API Records - Part 1 (draft standard)
- DCAT-AP-NL 3.0

5.2 Research sub-topic: Data sharing under conditions

Goal

Demonstrate a workable data sharing environment under conditions (aka Dataspace), from a data consumer perspective.

Description

Sharing data over secure webservices is a well understood pattern. Recently the EU introduced the concept of DataSpaces, protocols that allow data to be shared under conditions, conditions set forward by the data provider. Data users must agree with the conditions before they are granted access to the data. This contract negotiation is done on the so-called Control Plane of the DataSpace (The Data Plane in the DataSpace is the well know mechanism of webservices giving access to data).

In this research topic we would like to see a data consumer search, find, negotiate and bind to a dataset in a Dataspace, using Dataspace protocols (or similar, e.g. iShare and or FSC).

The data producer side will be available for use and is supplied by DMI.

Task(s)

1. Query for data to be used
2. Receive metadata
3. Negotiate contract
4. Get access to the data, using key received during the negotiation phase

Deliverables

A working demo, from a data consumer point-of-view, where the user searches for a dataset using keywords, see the metadata, agree on the conditions, receive the hashed key and open the data in a viewer.

Budget

For this research topic a budget of 6.000 euro (exclude 21% VAT) is allocated. Dual funding (multiple funding sources) for this topic is not allowed.

Requirements / standards / Open-Source software

Depending on data producer, possibly iShare.

Mandatory Standards
- DCAT-AP-NL
- ODRL

Optional available Open-Source Software for demo and learning purposes
iShare, DMI PDx

Chapter 6 – Topic #2: Visualisation

6.1 Adoption sub-topic: Find and Bind

Goal

Find and Bind from within the (3D) viewer.

Description

Visualisation is an important aspect of a Digital Twin and is part of the basic expectation and user-experience with manipulating the Digital Twin to do policy making.

Many visualisation clients exist in the market, but each are made with a specific use-case or capability in mind. They all provide data (and results of calculation modules) and combine that data for insight and decision making. Importing the data is in some cases non-trivial, having to remember URLs, paths and queries.

The goal is to make the data better findable in the visualization client, but also bindable: the ability to bring in the found data and bring it in as a "layer" with the least clicks as possible.

Budget

For this adoption topic a budget of 12.500 euro (exclude 21% VAT) is allocated per organisation, that meets the criteria and that is favourably ranked (max 3).

Tasks

1. Add a visualisation pane in the client, that displays the metadata of the relevant data, calculation modules (processes) and other resources that can be bound to from a (federated) catalogue. The pane has a search part to specify a query.
2. The data (or processes, or resources) can be bound using the information in the metadata and shown in the client
3. In case of processes, the ability to listen to callbacks and act accordingly (e.g. refresh events, request for new parameters, …)

Deliverables

A demo of the visualisation client demonstrating the above.

Requirements / standards / Open-Source software

Mandatory Standards
The client uses OGC API Records or GeoSPARQL to query the catalogue (federated). The metadata arrives at the client (from the catalogue) as DCAT-AP-NL.

Data is brought in, preferably using the new OGC API's (albeit this is dependent on the data providers abilities) – OWS is also acceptable.

Processes are executed using the OCG API Processes (Part 1), including implementation of callbacks.

Optional available Open-Source Software for demo and learning purposes
Demo code of how the catalogue is called and how the processes are called and executed

6.2 Research sub-topic: Export & import scenes

Goal

Export – Import scenes **from a 3D viewer**

Description

Visualisation is an important aspect of Digital Twinning and is part of the basic expectation and user-experience interacting with the Digital Twin to do policy making.

Many visualisation clients exist in the market, but each is made with a specific use-case or capability in mind – and each one is very good at something, but not everything. Sometimes you start a scene in client A, because it is good in putting together the scene, then move on to client B to manipulate and do calculations in that client.

Many clients lack the ability to export scenes and import them in another client. (clarification: this does not mean exporting data/vertices from the client, but the reference to the service that brought in the data, including the query)

The idea here is inspired by the (old) OGC WMS Context document (describing the state, or "Context," of a WMS Client application in a manner that is independent of a particular client and that might be utilized by different clients to recreate the application state.), now extended to be used in 3D environments.

Tasks

1. Define a prototype description of the elements that need to be exported from the scene to build up the scene in client B
    a. E.g.: reference to the web services that build the original scene, camera parameters, datetime, …
2. Prototype the scene export in client A and optionally import the scene in client B
3. Bring the proposal to the OGC for consideration

Deliverables

1. A (draft) schema of the scene
2. A crude demo of the export/import

Budget

For this research topic a budget of 6.000 euro (exclude 21% VAT) is allocated.

Requirements / standards / Open-Source software

The output of this activity is input for a possible new OGC standard (like the OGC WMS Context document). This concept was already briefed at the OGC Architecture board in 2024, with favourable comments.

Chapter 7 – Topic #3: Data

7.1 Research sub-topic: BIM (Design information) for Digital Twins

Goal

Better integration of BIM models (larger: design information) into a Digital Twin environment

Description

BIM models and design information (models) are an integral part of our depiction of the physical living environment, like Geo information.

Data sources include IFC models, GLTF/GLB, TIN, CityJSON (as a format in 3D Tiles). These encodings should be made available using web-services.

Task

- Describe how to make native IFC models available in Digital Twins using web services
- Describe how to make transformed IFC models available in Digital Twins using web services

Deliverables

- Create a web service that serves IFC information to a 3D viewer in conjunction with non-BIM sources.
- Call and show the BIM information in a 3D viewer in conjunction with non-BIM sources.

Budget

For this research topic a budget of 12.500 euro (exclude 21% VAT) is allocated.

Requirements / standards / Open-Source Software

Mandatory Standards:

- 3D GeoVolumes (draft)
- 3D Tiles
- IFC (sources) (version 4.3) (ISO 16739) (other versions also allowed)
- GLTF/GLB (version 2.0, ISO/IEC 12113:2022)
- CityJSON (version v2.0)

7.2 Research sub-topic: Data downloads

Goal

Finding a best practice to download full datasets

Description

Albeit against the general idea of "data at the source", data downloads (for local processing) remain a very popular usage pattern. The OGC API's do not offer a full dataset download, prevented by the client and server restrictions (e.g. pagination).

What is a good and efficient way to provide a full dataset download? Through (a modified) OGC API (Features) or through alternative, parallel alternatives (e.g. Atom feeds, direct downloads, ...)?

This is also in support of the INSPIRE download service.

Task

- Describe an elegant and efficient way to achieve full dataset downloads.
- Show a local analysis and provide relevant results back upstream.
- Show a 'caching' mechanism to keep the local data source and its upstream parent in sync.

Deliverables

Description and demo of full dataset downloads.

Budget

For this research topic a budget of 6.000 euro (exclude 21% VAT) is allocated.

Requirements / standards / Open-Source Software

Mandatory Standards:

- OGC API Features (Parts 1, 2 and 3)
- OGC API Common (Part 1 and 2(draft))

Chapter 8 – Topic #4: Calculation models

8.1 Adoption sub-topic: Making calculation modules interoperable

Goal

Making calculation modules interoperable by fully implementing and exposing the OGC API Processes (Part 1: Core) standard.

Description

Calculation modules make up an important part of a Digital Twin, allow for simulation, time-travels etc. Having these functions available as an online interoperable service is a critical success factor for the ease of use of a Digital Twin – and – to allow for machine-machine (via API's) communication.

Tasks

1. Add a software component to an existing calculation model that exposes a full implementation of the OGC API Processes (Part 1: Core).
    a. Compliant with the OGC specification
        i. Async process execution
        ii. Including fully working callbacks

Deliverables

A working implementation of a calculation model using OGC API Processes.

Budget

For this adoption topic a budget of 15.000 euro (exclude 21% VAT) is allocated per organisation, that meets the criteria and that is favourably ranked (max 3).

Requirements / standards / Open-Source Software

Mandatory Standards

- OGC API Processes (Part 1: Core)

8.2 Research sub-topic: Model orchestration, status quo

Goal

Model orchestration, status quo.

Description

Calculation models serve an important role in Digital Twins: they allow for simulation, time travel etc. A single model is powerful, but chaining models is where the true added value lies. E.g. a weather model that feeds into a traffic model that feeds into e.g. a traffic rerouting plan.

What is possible today (the status quo) to achieve model orchestration (chaining), using what techniques or what standards really work?

Task

Describe today's status quo on model orchestration.

As this topic is possibly very large and deep, restrict the research to coupling 2 models: E.g. a meteorological model predicts excessive rain in a certain area – and to avoid traffic chaos in that area, takes the outcomes from the meteorological model and feed it as input into a traffic model. The outcomes of the traffic model will allow policy makers to shutdown roads and reroute traffic.

Deliverables

A report describing the various standards and techniques, including a maturity model.

Budget

For this research topic a budget of 6.000 euro (exclude 21% VAT) is allocated.

Requirements / standards / Open-Source Software

- OGC API Processes (Part 1: Core)

Chapter 9 - Testbed organization

This chapter describes the organization, conditions, finances and planning of the testbed.

Coordination

The coordinator on Geonovum side is Bart De Lathouwer (Geonovum), with support roles for:

- Niels Hoffmann (Geonovum)
- Gineke van Putten (Geonovum)

For every topic, there will be regular meetings in four weekly sequences on Fridays between Geonovum and the contractors, online. The agenda items of these meetings are the progress and any issues or technical questions concerning the details of the topic.

Open testbed sessions

Work on the Adoption & Research topics will be carried out in parallel. During this time, Geonovum wants the four topics to inform each other as much as possible. For this reason, Geonovum will organize an online meeting in a four-weekly sequence on Fridays, where all contractors can exchange information and share progress. This will be done for the purpose of aligning and sharing developments and knowledge between the research topics.

These sessions will be public; the contractors will present their intermediate results to each other and an open group. Anyone who is interested can attend these meetings. This group has the possibility to discuss in an open way the results with the contractors. The insights gained from this will be used as much as possible by the contractors in their further work on the topics.

In addition to these meetings, Geonovum will organise a larger public session after completion of the testbed, in which the contractors can present their final results.

Planning

Geonovum will announce which party is selected for which topic within 3 working days after Friday April 11. The testbed starts immediately afterwards. Geonovum will arrange (online) meetings in sequence of four weeks with each contractor as well as open testbed sessions. The open testbed sessions with all contractors will also take place in sequence of four weeks on a Friday from April until November.

The deadline for carrying out the Adoption and Research topics is November 4, 2025.

Hereafter a public, open session will be organized during SCExpo in Barcelona in which all results will be presented by the contractors and Geonovum.

Finance

These budgets are intended as a contribution towards the adoption or research activities of the contractor. The budgets allow each contractor to carry out adoption or research and exploratory activities and to develop demonstrators to try things out. The budget is not supposed to cover the entire expenses needed for the exploratory activities of the contractors; an in-kind contribution of the contractors is expected.

Appendix A: Metrics

The criteria by which proposals are judged are:

- The quality of the plan of approach
- The quality of the references and CVs
- Affinity with data (publication)
- Impact on existing workflow in terms of quality, cost, etc... and general architecture
- Contributions towards EU and NL govt. information services and flows
- Planned dissemination of the created work; documentation and `how to' documents, publication strategy relative to the community, licenses used

Adoption sub-topic Metrics

Adoption sub-topic proposals will be scored according to the following metrics:

	Weight
Contribute to the "Goal of the testbed"	15%
Applicability to the "Scope" as defined	5%
Fit with the NLDT Architecture and the different capabilities	15%
Re-useability after testbed ends	35%
Plan or approach	5%
Adhere to European ethics	5%
Conciseness and specificity of the plan	5%
Portfolio, References and CV	5%
Dissemination, Licenses, lasting effect of outreach beyond geo community	10%

A knock-out criteria for the adoption topics is that the organisation needs to operate in the Dutch market and adhere to European ethics frameworks.

Research sub-topic Metrics

Research sub-topic proposals will be scored according to the following metrics:

	Weight
Contribute to the "Goal of the testbed"	15%
Applicability to the "Scope" as defined	10%
Fit with the NLDT Architecture and the different capabilities	20%
Re-useability after testbed ends	25%
Plan or approach	5%
Adhere to European ethics	5%
Conciseness and specificity of the plan	5%
Portfolio, References and CV	5%
Dissemination, Licenses, lasting effect of outreach beyond geo community	10%