Open Geospatial Consortium, Inc.

Date: 18-August-2010

Reference number of this document: OGC 10-074

Category: Public Engineering Report

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OGC® OWS-7 Feature and Statistical Analysis Engineering Report

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Document type: OpenGIS® Engineering Report
Document subtype: NA
Document stage: Approved for public release
Document language: English

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OGC® OWS-7 Feature and Statistical Analysis Engineering Report

1 Introduction

This Engineering Report (ER) is a deliverable for the OGC Web Service 7 testbed. The focus of this ER is using the OGC Web Processing Service (WPS) interface standard for Feature and Statistical Analysis (FSA). Specifically, the ER documents how to enhance interoperability of FSA processes that are hosted as WPS processes on the Web. This ER is coordinated with the Feature and Decision Fusion (FDF) WPS Profiling ER.

In particular, this ER documents Feature and Statistical Analysis (FSA) by defining WPS profiles to enhance interoperability. This ER further reports on the FSA demonstration scenario.

FSA is a multidisciplinary scientific approach to describe and predict spatial and temporal patterns of human behavior by analyzing the attributes, actions, reactions and interactions of groups or individuals in the context of their environment. FSA incorporates elements of Human Geography in a spatial, temporal context. FSA includes aspects of Socio-Cultural Dynamics (SCD), which is defined as information about the social, cultural and behavioral factors characterizing the relationships and activities of the population of a specific region. FSA also requires geospatial vector and topology processing operations.

1.1 Scope

This ER applies the WPS standard for web-based geoprocessing. To ensure interoperability between different implementations of processes, WPS profiles have been identified as applicable. The WPS Profiles are specified for FSA processes.

1.2 Document contributor contact points

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

Name	Organization
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1.3 Revision history

Date	Release	Editor	Primary clauses modified	Description
24.2.2010	Initial draft	TF, BS	ALL	
6.4. 2010	1st Official draft		ALL	Content section created & structure defined
26.5.2010	2nd draft		ALL	Profiles & Scenario added
30.6.2010	Final		ALL	Outlook added, content reworked based on demo input
Aug 4 2010	For posting	C. Reed	Various	Prepare document for posting as a public ER

1.4 Future work

Improvements described in this document are desirable to ensure interoperability of the processes described in this engineering report.

1.5 Forward

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Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.

2 References

The following documents are referenced in this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

OGC 06-121r3, *OpenGIS® Web Services Common Standard*

NOTE This OWS Common Specification contains a list of normative references that are also applicable to this Implementation Specification.

OGC 05-007r7, *OpenGIS® Web Processing Service*

OGC 04-094, *Web Feature Service Implementation Specification*

ISO/IEC 10746, *Reference Model of Open Distributed Processing (RM-ODP)*

3 Terms and definitions

For the purposes of this report, the definitions specified in Clause 4 of the OWS Common Implementation Specification [OGC 06-121r3] shall apply. In addition, the following terms and definitions apply.

3.1 Feature and Statistical Analysis (FSA)

FSA is a multidisciplinary scientific approach to describe and predict spatial and temporal patterns of human behavior by analyzing the attributes, actions, reactions and interactions of groups or individuals in the context of their environment. FSA incorporates elements of Human Geography in a spatial, temporal context. It includes aspects of Socio-Cultural Dynamics (SCD), which is defined as information about the social, cultural and behavioral factors characterizing the relationships and activities of the population of a specific region. FSA also requires geospatial vector and topology processing operations.

3.2 Web Processing Service (WPS)

For the purposes of this document, yhe term Web Processing Service (WPS) describes a service instance of a WPS server. A WPS is a container for one or many processes. The capabilities of a WPS contain the list of services that are hosted by the WPS. Each process is further described by a Process Description.

3.3 WPS Profile

According to the OGC WPS standard (OGC 05-007r7), a WPS Application Profile should be defined as a standalone document containing:

- An Universal Resource Name (URN) that uniquely identifies the process
- A reference response to a DescribeProcess request for that process (reference process schema),
- A human-readable description of the process and its implementation (optional, but recommended).
- A Web Service Description Language (WSDL) document for that process (optional).

3.4 Web Feature Service

The OGC Web Feature Service (WFS) allows a client to retrieve and update geospatial data encoded in Geography Markup Language (GML) or some other encoding payload from multiple Web Feature Services.

4 Conventions

4.1 Abbreviated terms

FSA Feature and Statistical Analysis

GML Geography Markup Language

RM-ODP Reference Model of Open Distributed Processing

WFS Web Feature Service

WPS Web Processing Service

4.2 UML notation

Most diagrams that appear in this standard are presented using the Unified Modeling Language (UML) static structure diagram, as described in Subclause 5.2 of [OGC 06-121r3].

5 ER Topic overview

This document describes the results of the Feature and Statistical Analysis (FSA) thread of OWS-7.

The document is structured regarding the different viewpoints of RM ODP to examine the FSA architecture comprehensively. The different viewpoints of RM ODP are depicted in Figure 1.

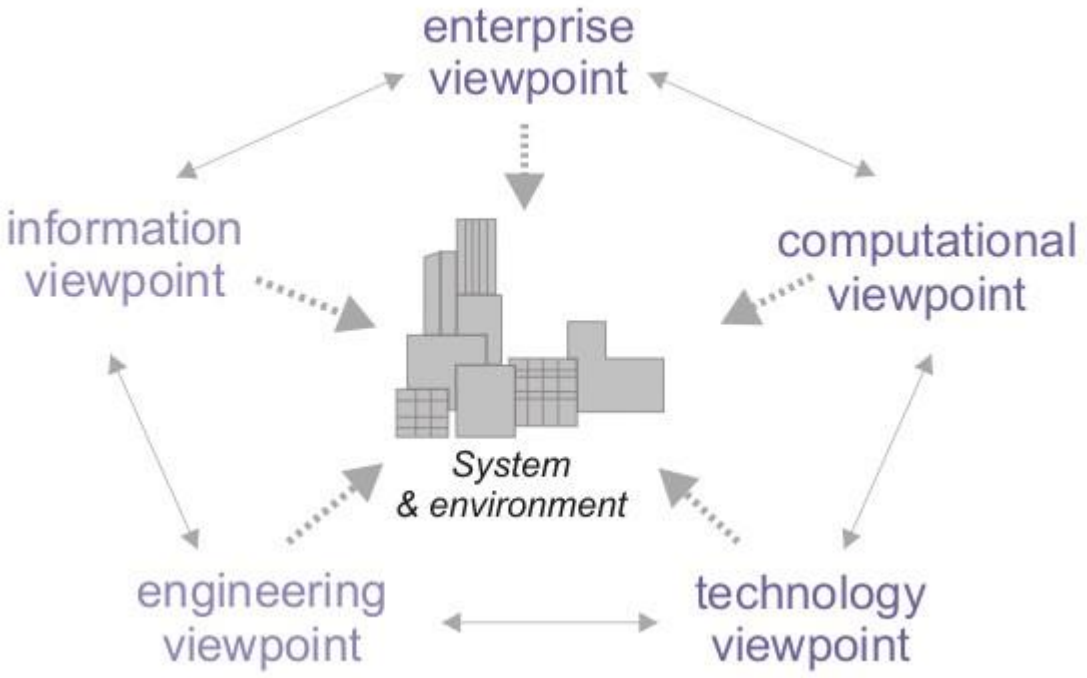

Figure 1: The viewpoints of RM-ODP.

Based on the scenario presented in Section 6 (enterprise viewpoint), the involved data is described in Section 7 (information viewpoint). In Section 8, the different classifications of processes are presented and some profiles are described (computational viewpoint). In Section 9, the specific services are introduced offering the data and the processes (technology viewpoint). In Section 10, the actual workflow is described for determine possible camp sites (engineering viewpoint). Section 11 summarizes the report.

6 FSA scenario (Enterprise viewpoint)

The FSA scenario is based on the Haiti relief case. On January 12th 2010, Haiti experiences a magnitude 7 earthquake. This massive earthquake caused severe damage to the capital Port-au-Prince. To support human aid, geodata needed to be analyzed to get an overview about the current situation and to take well-informed decisions. The FSA scenario is embedded in a chain of actions taken by an Emergency Response Analyst using also Sensor Fusion Enablement capabilities. In particular, this scenario aims at the Emergency Response Analysts to determine suitable camp locations for displaced persons. In addition, a radiological plume detected by deployed sensors as part of the SFE activities has to be taken into account.

7 FSA data (Information viewpoint)

The data used in the Feature and Statistical Analysis thread of OWS-7 is described in this section. The data selected for this thread is based on the Haiti relief scenario described in

Section 6 and therefore covers the area of Haiti´s capital city Port-au-Prince. A map of some of the data as used for this scenario is depicted in Figure 2.

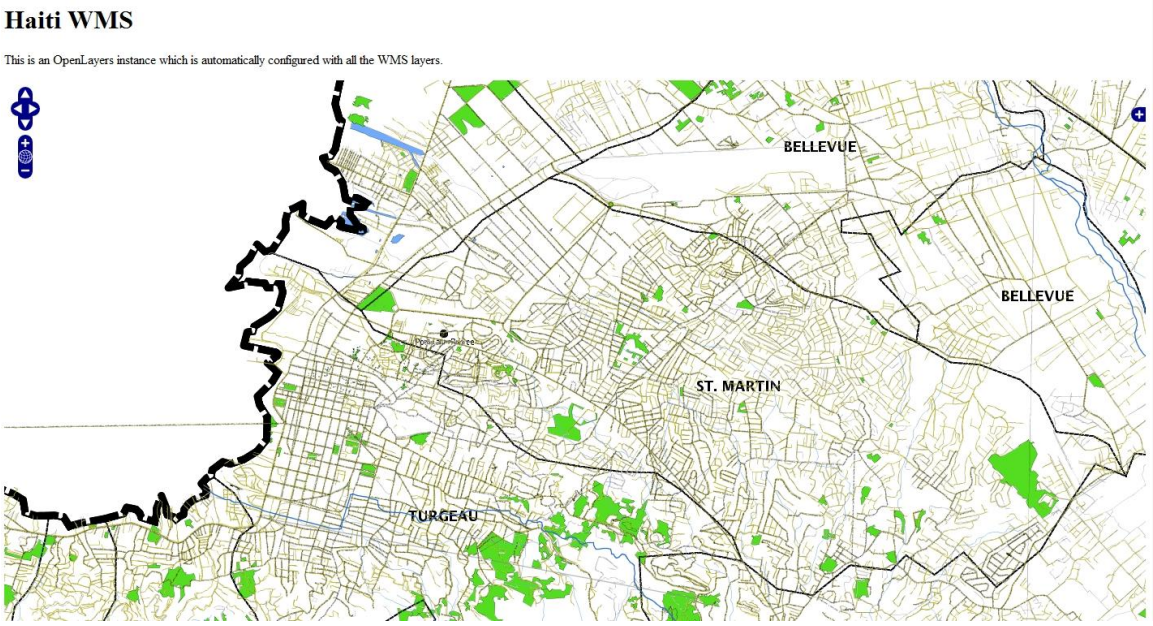

Figure 2: Overview of OWS-7 data as used in the scenario located around Port-au-Prince, Haiti (themes: boundaries, rivers, roads).

Table 1 lists the data involved in FSA and applied in the scenario.

Type of data	Type of geometry	Thematic attributes
Land use	Polygon	Shape area
Flood plains	Polygon	Floodplain
Steep slopes		
High crime	Polygon	Crime_Area, IDP_Groups
Radiation plume	Polygon	
Medical supply	Point	
Food & Water supply	Polygon	
Bad/damaged roads	Lines	

Table 1: List of involved FSA data.

8 FSA processes (computational viewpoint)

This section provides the classification for FSA processes. The FSA processes can be categorized into feature and statistical analysis. It is important to note, that these types of processes have sub-types which provide more specific functions.

8.1 Classification for Feature Analysis

The classification for Feature Analysis is twofold. One part covers Topology analysis. The other part covers Vector analysis (Section 8.1.1). The statistical analysis is described in Section 8.1.2.

8.1.1 Topology Analysis

Topology analysis is inspired by database processing. It has to be note, that classic database functionality only checks and selects data, but is not intended to process data (create new entities) in the first place. The processes for topology analysis are based on ISO 19125 (OGC Simple Feature) and are the following:

- equals
- disjoint
- intersects
- touches
- crosses
- within
- contains
- overlaps
- relate (generic)

A profile for the topology analysis is presented in Annex 12.1.

8.1.2 Vector Analysis

The classification for spatial analysis according to ISO 19125 is:

- Distance (Geometry, Geometry) -> double
- Buffer (Geometry, double) -> Geometry
- ConvexHull (Geometry) -> Geometry
- Intersection (Geometry, Geometry) -> Geometry
- Difference (Geometry, Geometry) -> Geometry
- SymDifference (Geometry, Geometry) -> Geometry

The different processes are exemplified in Figure 3.

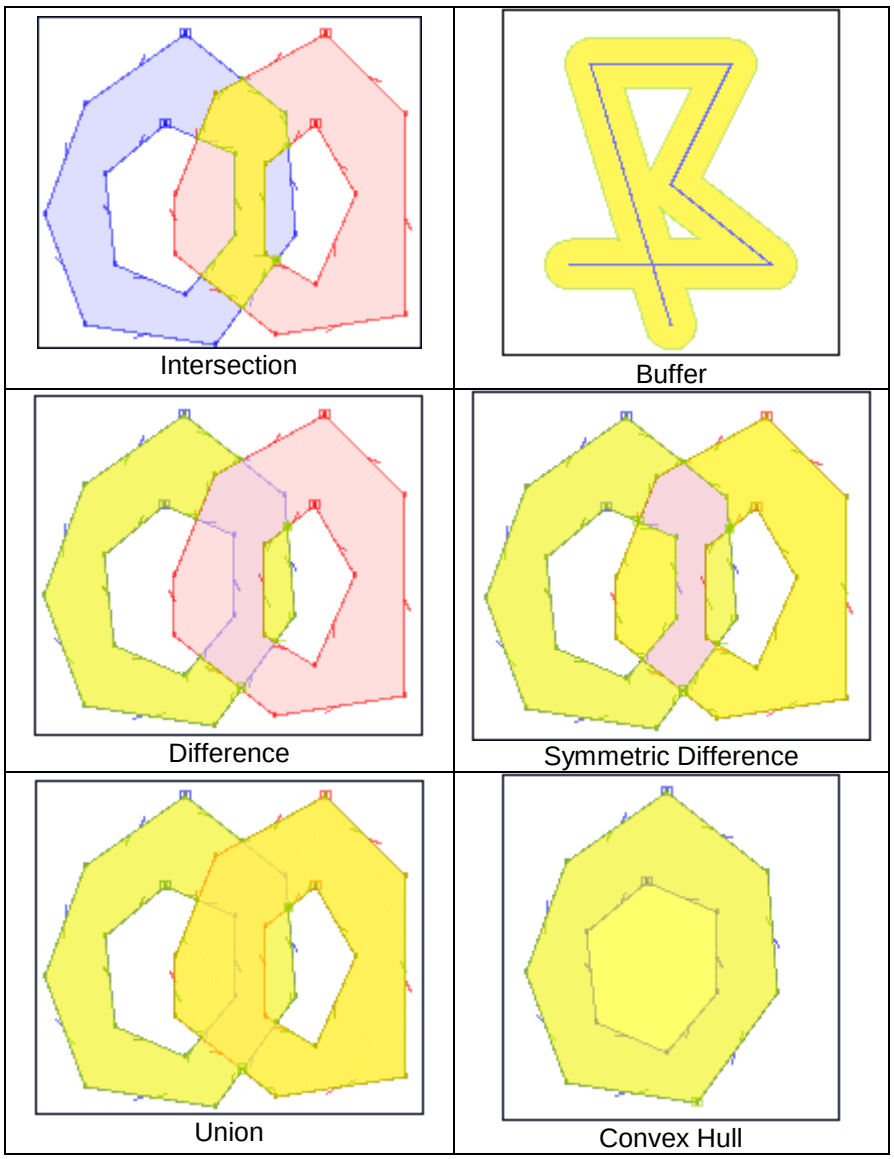

Figure 3: Examples of vector analysis (source: JTS documentation).

The profile for vector analysis can be found in Annex 12.2.
Additional classes of vector analysis can be:

- Generalize
- Routing
- Raster-to-Vector-conversion

8.2 Classification for Statistical Analysis

The classification for statistical analysis can be based on the complexity of the input parameters (see Table 2). Based on the different type of input parameter and based on the number of parameters required the different processes are classified. Different types of input parameters are: Dichotomy (true/false), Nominal, Ordinal and interval/ratio.

Measurement level of first variable	**Single variable procedures**	**Two-variable procedures**			
		Measurement level of second variable			
		Dichotomy	Nominal	Ordinal	Interval and ratio
Dichotomy	*Proportions, percentages, ratios*	*Difference of proportions*	…	…	…
Nominal	*Proportions, percentages, ratios*	*Chi square*	*Chi square*	…	…
Ordinal	*Medians, quartiles, deciles, quartile deviations*	*Mann-Whitney, runs, Smirnov, signed ranks*	*Analysis of variance with ranks*	*Rank-order correlation*	…
Interval and ratio	*Means, medians, standard deviations*	*Difference of means*	*Analysis of variance, interclass correlation*	…	*Correlation and regression*

Table 2: Classification of Statistical Analysis.

During OWS-7 also other classifications for statistical analysis have been discussed, such as described in Table 3, but have not been investigated further.

descriptive statistics	compute means Variances Frequencies Tables cross tables
descriptive graphs	histogram scatter plot
Modeling	Regression Correlation analysis of variance

Table 3: Alternative classification of statistical analysis.

9 FSA service components (technology viewpoint)

To perform the given scenario, a Web Feature Service (WFS) for providing the spatial data and Web Processing Service for transforming the data have been identified as suitable.

9.1 Web Feature Service

The OGC Web Feature Service (WFS) allows a client to retrieve and update geospatial data encoded in Geography Markup Language (GML) from multiple Web Feature Services.

9.2 Web Processing Service

A Web Processing Service (WPS) defines a standardized interface that facilitates the publishing of geospatial processes, and the discovery of and binding to those processes by clients. Processes include any algorithm, calculation or model that operates on spatially referenced data. Publishing means making available machine-readable binding information as well as human-readable metadata that allows service discovery and use. A WPS can be configured to offer any sort of GIS functionality to clients across a network, including access to pre-programmed calculations and/or computation models that operate on spatially referenced data. A WPS may offer calculations as simple as subtracting one set of spatially referenced numbers from another (e.g., determining the difference in influenza cases between two different seasons), or as complicated as a global climate change model. The data required by the WPS can be delivered across a network, or available at the server.

10 FSA architecture (Engineering viewpoint)

This section describes the engineering viewpoint by the process scenario and different components realizing the FSA scenario.

10.1 Process scenario

The scenario for FSA is described in Section 6. To support the camp site selection a process workflow has been designed. It includes the following steps:

- Land use analysis
- Exclude bad areas
- Medical facility access
- Food and water distribution access
- Transportation.

The course of action is also depicted in Figure 4.

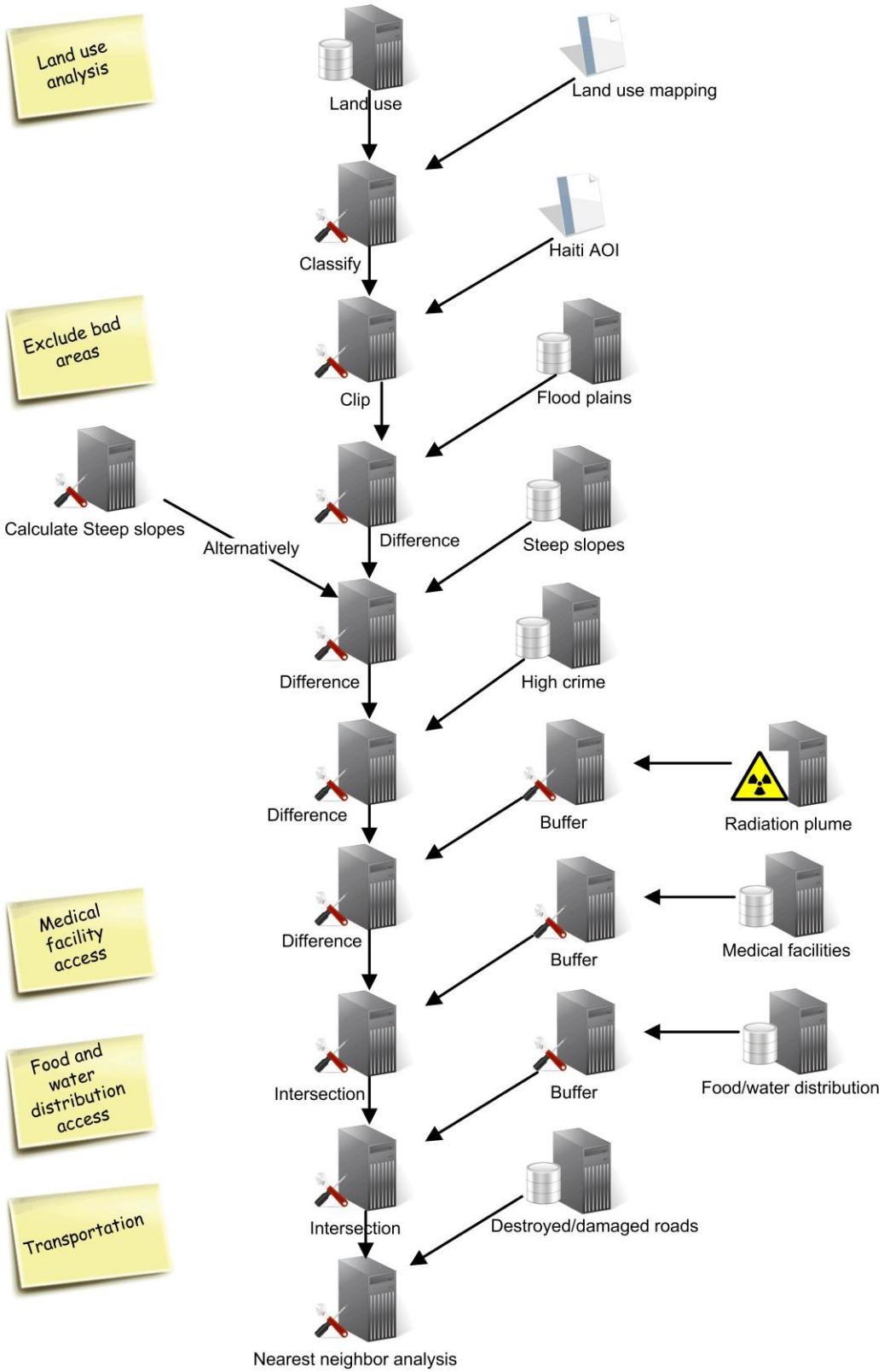

Figure 4: Workflow scenario for FSA.

10.1.1 Land use analysis

This step analyzes suitable areas for camp site relocation based on the type of land use. Therefore, the different land uses are *classified* in low, medium and high (suitability) based on the landuse type as presented in Table 4. Afterwards the data is *clipped* by the Area of Interest of Port-au-Prince.

landuse_type	Suitability
industrial-factory	Low
industrial-industrial	Low
industrial-warehouse	Medium
Openspace	High
openspace-agriculture	Medium
openspace-forest	Medium
openspace-natural	High
openspace-openspace	High
openspace-recreation	High
openspace-industrial	High
residential-high	Low
residential-low	High
residential-medium	Medium
transportation-airport	Low

Table 4: Landuse type to suitability mapping.

10.1.2 Exclude bad areas

To further extract suitable areas for camp site relocation, bad areas are excluded. Therefore, areas in flood plains, areas with potentially high crime and close to a radiation plume are excluded (*difference*). To ensure, that future camp sites will not be in danger of the radiation plume, the geometry of the radiation plume is process with an appropriate buffer.

10.1.3 Medical Facility Access

To ensure medical facility access for the camp site, the different geometries of the medical facilities are processed with different *buffers*. These different buffers are *intersected* with the already processed data to grade the specific areas in terms of their medical accessibility.

10.1.4 Food and Water distribution access

Besides sufficient medical facility access, also food and Water distribution access is required for potential camp sites. First different *buffers* for the food and water facilities will be created. These buffers are used to be *intersected* with the already processed data. Based on this data, the analyst is able to select the appropriate camp site.

10.1.5 Transportation

Based on the selected camp site, a *nearest neighbor search* will be performed to avoid damaged roads when accessing the camp site.

10.2 FSA components

The described workflow (Section 10.1) is deployed based on the services depicted in Figure 5. The functionality or data offered by the specific service is described in Table 5. The workflow is then performed by one of the integrated client depicted in Figure 5.

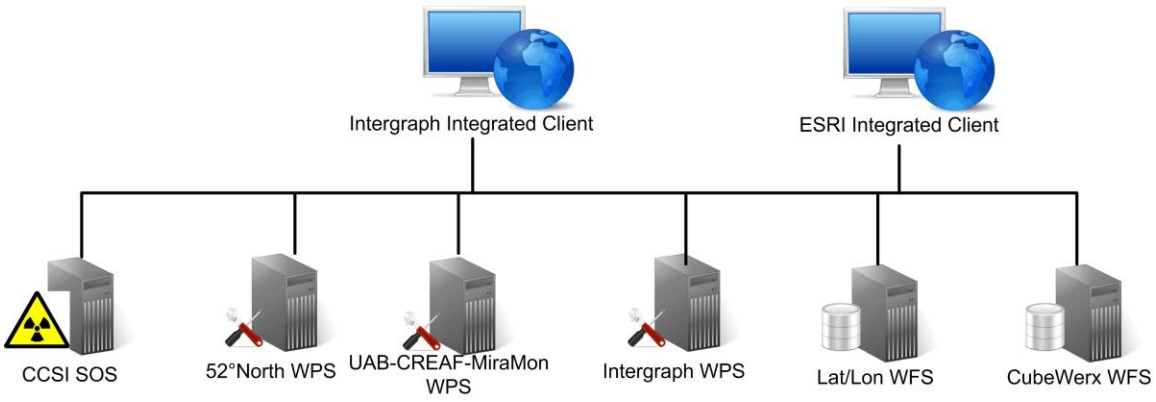

Figure 5: Overview of FSA components.

Organization	Component type	Data/functionality
Lat/Lon	WFS	All except radiation
Cubewerx	WFS (based on SOS)	Radiation layer
52°North	WPS	All functionality for vector and topology analysis
Intergraph	WPS	None
UAB	WPS	Slope processing (alternative to slope data)

Table 5: FSA components and their functionality.

Figure 6 shows the workflow created by the integrated client using the Model Builder.

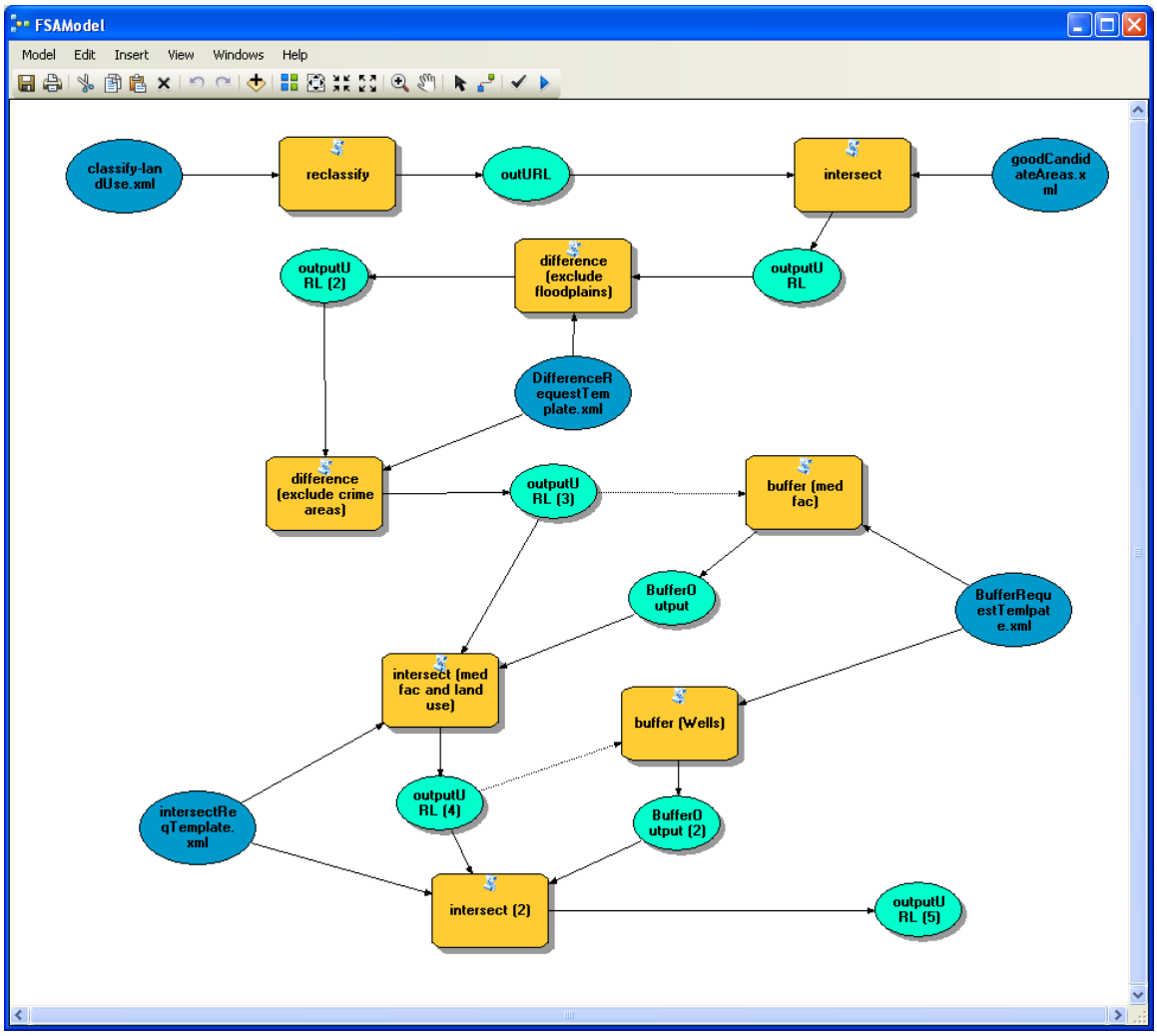

Figure 6: The workflow created with ESRI Model Builder.

The result of the workflow as performed by one of the integrated clients is portrayed in Figure 7.

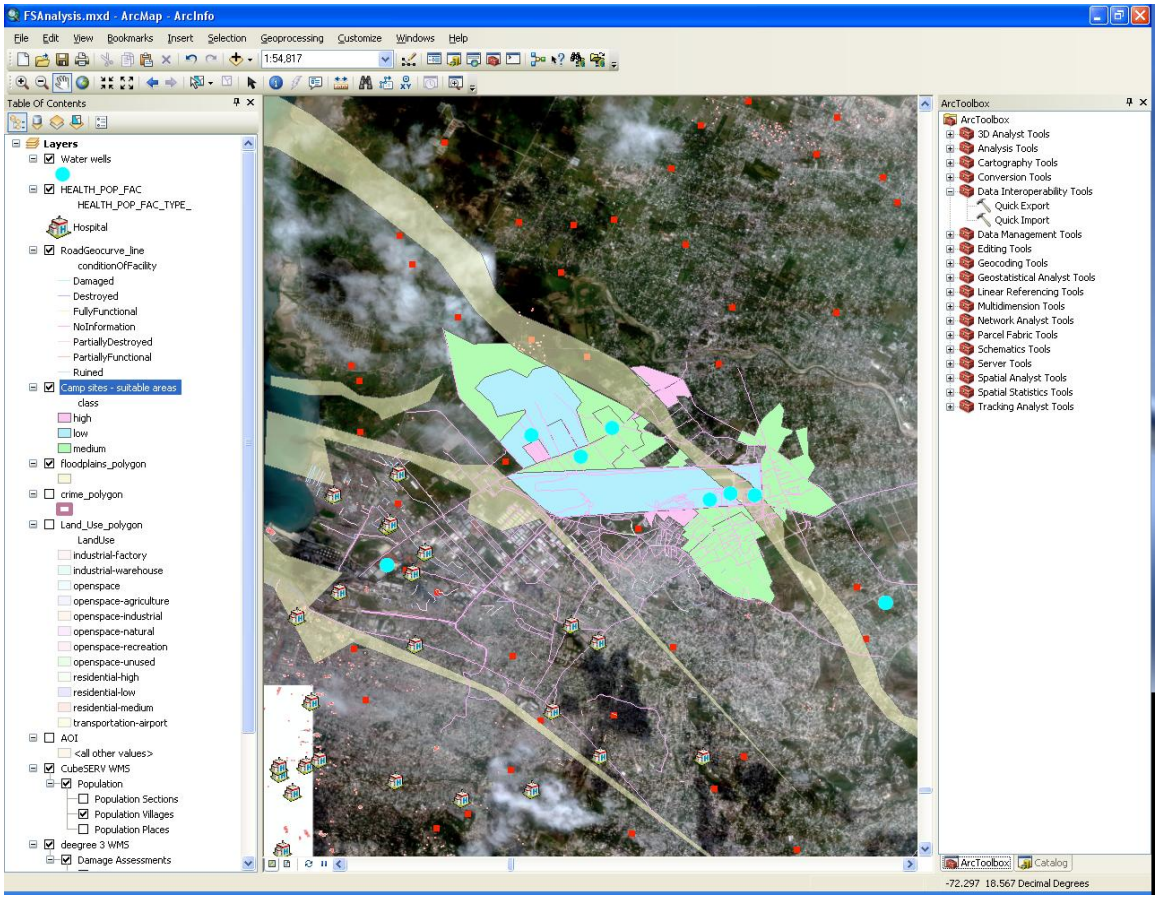

Figure 7: Result of the workflow as portrayed in one of the integrated clients (example created by ESRI).

11 Lessons Learned

This section summarized the lessons learned from this testbed in regard to Feature and Statistical Analysis.

11.1 Organizational Level

On the overall organizational level, the whole FSA group spent more than 50% of the project time on defining the scenario and finding applicable data. This allowed only less than 50% of the project time to be spend on actual FSA engineering. Independent of the nature of FSA, we concluded that for future testbeds, scenario and dataset need to be available at least in a rough format in advance in order to spend more time on the actual goals of the project.

11.2 Technical Level

On the technical level, several challenges have been encountered.

Interoperability

Many participants developing and using client- and server-side components were facing problems in reading and writing valid GML SF-Level 0. This seems to be related to many reasons:

- maturity of GML tools
- complexity of GML specification
- number of supported and available GML versions.

Special problems arose around:

- What is the correct srsName? OGC defined a solution, but not every available service and dataset supports that.
- The schemaLocation URL was sometimes given as a relative path, which is a valid behavior but caused problems in GML packages. Also available datasets, which were not served by WFS, pointed to not existing schemas.

Chaining

The chaining of the different service was done in a transparent way on the client side. Different georesources coming from static files (SHP and GML format), WFS and WPS services were included.

Even though no BPEL approach as in previous testbeds was applied, the chaining went fine across the different georesources and domains. Problems were encountered due to the fact that some services were hosted in very restrictive environments which could not be reached from the outside either directly or referenced schemas. As a lessons learned, we can conclude that keeping security in mind and especially asking the OGC Securitiy DWG for a harmonized approach.

WPS Profiles

The WPS Profiling ER handles this aspect in detail. The FSA group especially had problems with defining and resolving URNs.

The question of the importance of profiles for interoperability reasons was also discussed. Opinions varied but it became clear that WPS profiles are less important for syntactical interoperability as for semantical interoperability. Syntactical interoperability is reached due to WPS ProcessDescriptions with or without labeling it as a profile. But the question of “What does a process semantically do?” can only be answered 100% with profiles. From work in the FSA thread, we suggest to add a metadata tag to the WPS ProcessDescription which allows the semantic description of processes. This description shall give insight in the used algorithm and can vary from simple text over literature references to encodings from the semantic world including ontologies. These approaches should be tested and verified in future testbeds.

WPS

In terms of WPS, the FSA group encountered that the use of Unit of measurement is important and not constantly used by current implementations. Semantic annotation were suggested and are explained above.

We encountered that metadata profiles for registering WPS in OGC Catalogs are still missing and hinder the use of the publish-find-bind pattern.

Axis Order

Axis order seems to be still a problem through OGC Web Services. As mentioned above, the correct use of srsName identifier is not supported by the available implementations. Different WFS vendors offered data in two different axis orders with the same srsName. Problems with processing of two input datasets with different axis order were surprisingly not encountered. As a suggestion, the topic of axis order must be clarified on a more public level to improve interoperability.

Visualization

The visualization of processed data was discussed in this group. Opinions varied from visualization on the client side to the server side by use of SLDs. For this testbed, the visualization and styling of processed data was done on the client side. It is also imaginable to process data and push it to a dedicated service such as WMS to style the data with i.e. bar charts or different colors.

11.3 Open Issues

The FSA group encountered several open issues that could not be solved in this testbed. At first, by the use of profiles, standardization on the semantics of GIS operations can be reached. The question is:

- Does the OGC really want to standardize GIS operations?
- GIS vendors have done their way of GIS operations since decades. Is interoperability necessary on this level?

Other open issues are the introduction of profile hierarchies not only plain profiles as well as the registration of profiles and metadata in registries and catalogues.

Even though feature and topological operators were used in this testbed, due to the lack of time (explained above), the group did investigate Statistical Analysis thoroughly (possible classifications are described in Section 8.2). This has to be done in future testbeds.

Also the group had no time to spend on profiles for raster-based processes (only vector data was used). Uncertainty and error propagation as important aspects in models were not tackled. This is also true for the increasing of geoprocessing efficiency by use of streaming technologies. Performance and scalability were also not handled but could be targeted by means of grid and cloud computing technologies in future testbeds.

12 Annex

12.1 Topology Profile

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topological awareness</ows:Abstract>
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    <ows:Metadata xlink:title="geometry"/>
    <ows:Metadata xlink:title="disjoint"/>
    <ows:Metadata xlink:title="GML"/>
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            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
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   <Schema>http://schemas.opengis.net/gml/2.1.2/feature.xsd</Schema>
                   </Format>
                </Default>
                <Supported>
                   <Format>
                      <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                   </Format>
                </Supported>
             </ComplexData>
          </Input>
          <Input minOccurs="1" maxOccurs="1">
             <ows:Identifier>LAYER2</ows:Identifier>
             <ows:Title>input feature 2</ows:Title>
             <ows:Abstract>feature</ows:Abstract>
             <ComplexData>
                <Default>
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   <Schema>http://schemas.opengis.net/gml/2.1.2/feature.xsd</Schema>
                   </Format>
                </Default>
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earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                   </Format>
                </Supported>
             </ComplexData>
          </Input>
       </DataInputs>
       <ProcessOutputs>
          <Output>
             <ows:Identifier>RESULT</ows:Identifier>
             <ows:Title>disjoint</ows:Title>
             <ows:Abstract>Boolean indicating whether the input
features are disjoint.</ows:Abstract>
             <LiteralOutput>
                <ows:DataType ows:reference="xs:boolean"/>
             </LiteralOutput>
          </Output>
       </ProcessOutputs>
   </ProcessDescription>
   <ProcessDescription wps:processVersion="2" storeSupported="true"
statusSupported="false">
       <ows:Identifier>Distance</ows:Identifier>
       <ows:Title>DistanceAlgorithm</ows:Title>
       <ows:Abstract>Uses JTS implementation. Does not support
topological awareness</ows:Abstract>
```



```
      <ows:Metadata xlink:title="spatial"/>
      <ows:Metadata xlink:title="geometry"/>
      <ows:Metadata xlink:title="distance"/>
      <ows:Metadata xlink:title="GML"/>
      <DataInputs>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER1</ows:Identifier>
            <ows:Title>input feature 1</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
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                     <MimeType>text/XML</MimeType>

   <Schema>http://schemas.opengis.net/gml/2.1.2/feature.xsd</Schema>
                  </Format>
               </Default>
               <Supported>
                  <Format>
                     <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                  </Format>
               </Supported>
            </ComplexData>
         </Input>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER2</ows:Identifier>
            <ows:Title>input feature 2</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
                  <Format>
                     <MimeType>text/XML</MimeType>

   <Schema>http://schemas.opengis.net/gml/2.1.2/feature.xsd</Schema>
                  </Format>
               </Default>
               <Supported>
                  <Format>
                     <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                  </Format>
               </Supported>
            </ComplexData>
         </Input>
      </DataInputs>
      <ProcessOutputs>
         <Output>
            <ows:Identifier>RESULT</ows:Identifier>
            <ows:Title>distance</ows:Title>
            <ows:Abstract>The distance between the input
features.</ows:Abstract>
            <LiteralOutput>
               <ows:DataType ows:reference="xs:double"/>
```



```
            </LiteralOutput>
         </Output>
      </ProcessOutputs>
   </ProcessDescription>
   <ProcessDescription wps:processVersion="2" storeSupported="true"
statusSupported="false">
      <ows:Identifier>Equals</ows:Identifier>
      <ows:Title>EqualsAlgorithm</ows:Title>
      <ows:Abstract>
         Uses JTS implementation. Does not support topological
         awareness
      </ows:Abstract>
      <ows:Metadata xlink:title="spatial"/>
      <ows:Metadata xlink:title="geometry"/>
      <ows:Metadata xlink:title="equals"/>
      <ows:Metadata xlink:title="GML"/>
      <DataInputs>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER1</ows:Identifier>
            <ows:Title>input feature 1</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
                  <Format>
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                     <Schema>

   http://schemas.opengis.net/gml/2.1.2/feature.xsd
                     </Schema>
                  </Format>
               </Default>
               <Supported>
                  <Format>
                     <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                  </Format>
               </Supported>
            </ComplexData>
         </Input>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER2</ows:Identifier>
            <ows:Title>input feature 2</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
                  <Format>
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                     <Schema>

   http://schemas.opengis.net/gml/2.1.2/feature.xsd
                     </Schema>
                  </Format>
               </Default>
               <Supported>
                  <Format>
```

```
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earth.kml+xml</MimeType>

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                    </Format>
                </Supported>
            </ComplexData>
         </Input>
      </DataInputs>
      <ProcessOutputs>
         <Output>
            <ows:Identifier>RESULT</ows:Identifier>
            <ows:Title>equals</ows:Title>
            <ows:Abstract>
               Boolean indicating whether the first input feature
               equals the second.
            </ows:Abstract>
            <LiteralOutput>
               <ows:DataType ows:reference="xs:boolean"/>
            </LiteralOutput>
         </Output>
      </ProcessOutputs>
   </ProcessDescription>
   <ProcessDescription wps:processVersion="2" storeSupported="true"
statusSupported="false">
      <ows:Identifier>Intersects</ows:Identifier>
      <ows:Title>IntersectsAlgorithm</ows:Title>
      <ows:Abstract>
         Uses JTS implementation. Does not support topological
         awareness
      </ows:Abstract>
      <ows:Metadata xlink:title="spatial"/>
      <ows:Metadata xlink:title="geometry"/>
      <ows:Metadata xlink:title="intersects"/>
      <ows:Metadata xlink:title="GML"/>
      <DataInputs>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER1</ows:Identifier>
            <ows:Title>input feature 1</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
                  <Format>
                     <MimeType>text/XML</MimeType>
                     <Schema>

   http://schemas.opengis.net/gml/2.1.2/feature.xsd
                     </Schema>
                  </Format>
               </Default>
               <Supported>
                  <Format>
                     <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                  </Format>
               </Supported>
```



```
            </ComplexData>
         </Input>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER2</ows:Identifier>
            <ows:Title>input feature 2</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
                  <Format>
                     <MimeType>text/XML</MimeType>
                     <Schema>

   http://schemas.opengis.net/gml/2.1.2/feature.xsd
                     </Schema>
                  </Format>
               </Default>
               <Supported>
                  <Format>
                     <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                  </Format>
               </Supported>
            </ComplexData>
         </Input>
      </DataInputs>
      <ProcessOutputs>
         <Output>
            <ows:Identifier>RESULT</ows:Identifier>
            <ows:Title>intersects</ows:Title>
            <ows:Abstract>
               Boolean indicating whether the first input feature
               intersects the second.
            </ows:Abstract>
            <LiteralOutput>
               <ows:DataType ows:reference="xs:boolean"/>
            </LiteralOutput>
         </Output>
      </ProcessOutputs>
   </ProcessDescription>
   <ProcessDescription wps:processVersion="2" storeSupported="true"
statusSupported="false">
      <ows:Identifier>Overlaps</ows:Identifier>
      <ows:Title>OverlapsAlgorithm</ows:Title>
      <ows:Abstract>Uses JTS implementation. Does not support
topological awareness</ows:Abstract>
      <ows:Metadata xlink:title="spatial"/>
      <ows:Metadata xlink:title="geometry"/>
      <ows:Metadata xlink:title="overlaps"/>
      <ows:Metadata xlink:title="GML"/>
      <DataInputs>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER1</ows:Identifier>
            <ows:Title>input feature 1</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
```



```
                    <Format>
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   <Schema>http://schemas.opengis.net/gml/2.1.2/feature.xsd</Schema>
                    </Format>
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earth.kml+xml</MimeType>

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                    </Format>
                </Supported>
            </ComplexData>
         </Input>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER2</ows:Identifier>
            <ows:Title>input feature 2</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
                <Default>
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   <Schema>http://schemas.opengis.net/gml/2.1.2/feature.xsd</Schema>
                    </Format>
                </Default>
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                        <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                    </Format>
                </Supported>
            </ComplexData>
         </Input>
      </DataInputs>
      <ProcessOutputs>
         <Output>
            <ows:Identifier>RESULT</ows:Identifier>
            <ows:Title>overlaps</ows:Title>
            <ows:Abstract>Boolean indicating whether the input
features overlap each other.</ows:Abstract>
            <LiteralOutput>
                <ows:DataType ows:reference="xs:boolean"/>
            </LiteralOutput>
         </Output>
      </ProcessOutputs>
   </ProcessDescription>
   <ProcessDescription wps:processVersion="2" storeSupported="true"
statusSupported="false">
      <ows:Identifier>Touches</ows:Identifier>
      <ows:Title>TouchesAlgorithm</ows:Title>
      <ows:Abstract>Uses JTS implementation. Does not support
topological awareness</ows:Abstract>
      <ows:Metadata xlink:title="spatial"/>
```



```
      <ows:Metadata xlink:title="geometry"/>
      <ows:Metadata xlink:title="touches"/>
      <ows:Metadata xlink:title="GML"/>
      <DataInputs>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER1</ows:Identifier>
            <ows:Title>input feature 1</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
                  <Format>
                     <MimeType>text/XML</MimeType>

   <Schema>http://schemas.opengis.net/gml/2.1.2/feature.xsd</Schema>
                  </Format>
               </Default>
               <Supported>
                  <Format>
                     <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                  </Format>
               </Supported>
            </ComplexData>
         </Input>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER2</ows:Identifier>
            <ows:Title>input feature 2</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
                  <Format>
                     <MimeType>text/XML</MimeType>

   <Schema>http://schemas.opengis.net/gml/2.1.2/feature.xsd</Schema>
                  </Format>
               </Default>
               <Supported>
                  <Format>
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earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                  </Format>
               </Supported>
            </ComplexData>
         </Input>
      </DataInputs>
      <ProcessOutputs>
         <Output>
            <ows:Identifier>RESULT</ows:Identifier>
            <ows:Title>touches</ows:Title>
            <ows:Abstract>Boolean indicating whether the input
features touch each other.</ows:Abstract>
            <LiteralOutput>
               <ows:DataType ows:reference="xs:boolean"/>
            </LiteralOutput>
```

```
         </Output>
      </ProcessOutputs>
   </ProcessDescription>
   <ProcessDescription wps:processVersion="2" storeSupported="true"
statusSupported="false">
      <ows:Identifier>Within</ows:Identifier>
      <ows:Title>WithinAlgorithm</ows:Title>
      <ows:Abstract>
         Uses JTS implementation. Does not support topological
         awareness
      </ows:Abstract>
      <ows:Metadata xlink:title="spatial"/>
      <ows:Metadata xlink:title="geometry"/>
      <ows:Metadata xlink:title="within"/>
      <ows:Metadata xlink:title="GML"/>
      <DataInputs>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER1</ows:Identifier>
            <ows:Title>input feature 1</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
                  <Format>
                     <MimeType>text/XML</MimeType>
                     <Schema>

   http://schemas.opengis.net/gml/2.1.2/feature.xsd
                     </Schema>
                  </Format>
               </Default>
               <Supported>
                  <Format>
                     <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                  </Format>
               </Supported>
            </ComplexData>
         </Input>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER2</ows:Identifier>
            <ows:Title>input feature 2</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
                  <Format>
                     <MimeType>text/XML</MimeType>
                     <Schema>

   http://schemas.opengis.net/gml/2.1.2/feature.xsd
                     </Schema>
                  </Format>
               </Default>
               <Supported>
                  <Format>
                     <MimeType>application/vnd.google-
earth.kml+xml</MimeType>
```



```
   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                  </Format>
               </Supported>
            </ComplexData>
         </Input>
      </DataInputs>
      <ProcessOutputs>
         <Output>
            <ows:Identifier>RESULT</ows:Identifier>
            <ows:Title>within</ows:Title>
            <ows:Abstract>
               Boolean indicating whether the first input feature
               is within the second.
            </ows:Abstract>
            <LiteralOutput>
               <ows:DataType ows:reference="xs:boolean"/>
            </LiteralOutput>
         </Output>
      </ProcessOutputs>
   </ProcessDescription>
</wps:ProcessDescriptions>
```

12.2 Vector Analysis Profile

```
<?xml version="1.0" encoding="UTF-8"?>
<wps:ProcessDescriptions xmlns:wps="http://www.opengis.net/wps/1.0.0"
xmlns:ows="http://www.opengis.net/ows/1.1"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/wps/1.0.0
http://schemas.opengis.net/wps/1.0.0/wpsDescribeProcess_response.xsd"
service="WPS" version="1.0.0" xml:lang="en-US">
   <ProcessDescription wps:processVersion="2" storeSupported="true"
statusSupported="false">
      <ows:Identifier>Distance</ows:Identifier>
      <ows:Title>DistanceAlgorithm</ows:Title>
      <ows:Abstract>Calculates the distance between two
geometries</ows:Abstract>
      <ows:Metadata xlink:title="spatial"/>
      <ows:Metadata xlink:title="geometry"/>
      <ows:Metadata xlink:title="distance"/>
      <ows:Metadata xlink:title="GML"/>
      <DataInputs>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER1</ows:Identifier>
            <ows:Title>input feature 1</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
                  <Format>
                     <MimeType>text/XML</MimeType>

   <Schema>http://schemas.opengis.net/gml/2.1.2/feature.xsd</Schema>
                  </Format>
               </Default>
               <Supported>
```

```
                    <Format>
                       <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                    </Format>
                 </Supported>
              </ComplexData>
           </Input>
           <Input minOccurs="1" maxOccurs="1">
              <ows:Identifier>LAYER2</ows:Identifier>
              <ows:Title>input feature 2</ows:Title>
              <ows:Abstract>feature</ows:Abstract>
              <ComplexData>
                 <Default>
                    <Format>
                       <MimeType>text/XML</MimeType>

   <Schema>http://schemas.opengis.net/gml/2.1.2/feature.xsd</Schema>
                    </Format>
                 </Default>
                 <Supported>
                    <Format>
                       <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                    </Format>
                 </Supported>
              </ComplexData>
           </Input>
        </DataInputs>
        <ProcessOutputs>
           <Output>
              <ows:Identifier>RESULT</ows:Identifier>
              <ows:Title>distance</ows:Title>
              <ows:Abstract>Value of calculated distance.</ows:Abstract>
              <LiteralOutput>
                 <ows:DataType ows:reference="xs:double"/>
              </LiteralOutput>
           </Output>
        </ProcessOutputs>
    </ProcessDescription>
    <ProcessDescription wps:processVersion="2" storeSupported="true"
statusSupported="false">
        <ows:Identifier>Buffer</ows:Identifier>
        <ows:Title>BufferAlgorithm</ows:Title>
        <ows:Abstract>
           Calculates a Buffer geometry, using the designated buffer
distance.
        </ows:Abstract>
        <ows:Metadata xlink:title="spatial"/>
        <ows:Metadata xlink:title="geometry"/>
        <ows:Metadata xlink:title="buffer"/>
        <ows:Metadata xlink:title="GML"/>
        <DataInputs>
           <Input minOccurs="1" maxOccurs="1">
              <ows:Identifier>LAYER1</ows:Identifier>
```



```
            <ows:Title>input feature 1</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
                  <Format>
                     <MimeType>text/XML</MimeType>
                     <Schema>

   http://schemas.opengis.net/gml/2.1.2/feature.xsd
                     </Schema>
                  </Format>
               </Default>
               <Supported>
                  <Format>
                     <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                  </Format>
               </Supported>
            </ComplexData>
         </Input>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>BufferDistance</ows:Identifier>
            <ows:Title>Buffer Distance</ows:Title>
            <ows:Abstract>Value according to which the buffer geometry
is calculated</ows:Abstract>
            <LiteralData>
               <ows:DataType ows:reference="xs:double">
            </ows:DataType>
               <ows:AnyValue/>
            </LiteralData>
         </Input>
      </DataInputs>
      <ProcessOutputs>
         <Output>
            <ows:Identifier>RESULT</ows:Identifier>
            <ows:Title>Buffer geometry</ows:Title>
            <ows:Abstract>
               Buffer geometry</ows:Abstract>
            <ComplexOutput>
               <Default>
                  <Format>
                     <MimeType>text/XML</MimeType>
                     <Schema>

   http://schemas.opengis.net/gml/2.1.2/feature.xsd
                     </Schema>
                  </Format>
               </Default>
               <Supported>
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earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                  </Format>
               </Supported>
```

```
            </ComplexOutput>
         </Output>
      </ProcessOutputs>
   </ProcessDescription>
   <ProcessDescription wps:processVersion="2" storeSupported="true"
statusSupported="false">
      <ows:Identifier>ConvexHull</ows:Identifier>
      <ows:Title>Convex Hull</ows:Title>
      <ows:Abstract>Calculates a Convex Hull geometry</ows:Abstract>
      <ows:Metadata xlink:title="spatial"/>
      <ows:Metadata xlink:title="geometry"/>
      <ows:Metadata xlink:title="convexHull"/>
      <ows:Metadata xlink:title="GML"/>
      <DataInputs>
         <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER1</ows:Identifier>
            <ows:Title>input feature 1</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
               <Default>
                  <Format>
                     <MimeType>text/XML</MimeType>

   <Schema>http://schemas.opengis.net/gml/2.1.2/feature.xsd</Schema>
                  </Format>
               </Default>
               <Supported>
                  <Format>
                     <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                  </Format>
               </Supported>
            </ComplexData>
         </Input>
      </DataInputs>
      <ProcessOutputs>
         <Output>
            <ows:Identifier>RESULT</ows:Identifier>
            <ows:Title>Convex hull geometry</ows:Title>
            <ows:Abstract>Convex hull geometry</ows:Abstract>
            <ComplexOutput>
               <Default>
                  <Format>
                     <MimeType>text/XML</MimeType>
                     <Schema>

   http://schemas.opengis.net/gml/2.1.2/feature.xsd
                     </Schema>
                  </Format>
               </Default>
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                     <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

   <Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
```



```
                    </Format>
                </Supported>
            </ComplexOutput>
        </Output>
    </ProcessOutputs>
</ProcessDescription>
<ProcessDescription wps:processVersion="2" storeSupported="true"
statusSupported="false">
    <ows:Identifier>Intersection</ows:Identifier>
    <ows:Title>Intersection Algorithm</ows:Title>
    <ows:Abstract>
        Calculates the intersection of two Geometries
    </ows:Abstract>
    <ows:Metadata xlink:title="spatial"/>
    <ows:Metadata xlink:title="geometry"/>
    <ows:Metadata xlink:title="intersection"/>
    <ows:Metadata xlink:title="GML"/>
    <DataInputs>
        <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER1</ows:Identifier>
            <ows:Title>input feature 1</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
                <Default>
                    <Format>
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                    </Format>
                </Default>
                <Supported>
                    <Format>
                        <MimeType>application/vnd.google-
earth.kml+xml</MimeType>

<Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
                    </Format>
                </Supported>
            </ComplexData>
        </Input>
        <Input minOccurs="1" maxOccurs="1">
            <ows:Identifier>LAYER2</ows:Identifier>
            <ows:Title>input feature 2</ows:Title>
            <ows:Abstract>feature</ows:Abstract>
            <ComplexData>
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                    </Format>
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                <Supported>
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earth.kml+xml</MimeType>

<Schema>http://schemas.opengis.net/kml/2.2.0/ogckml22.xsd</Schema>
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geometries
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earth.kml+xml</MimeType>

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    <ProcessOutputs>
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geometries
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