Semantic GIS – GeoSPARQL

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Outline

How to link data without links

- Which bus stops are within 5 minutes walk from home?
- In which municipal district is the highest area of park areas?
- What historical monuments are visible from my hotel room?

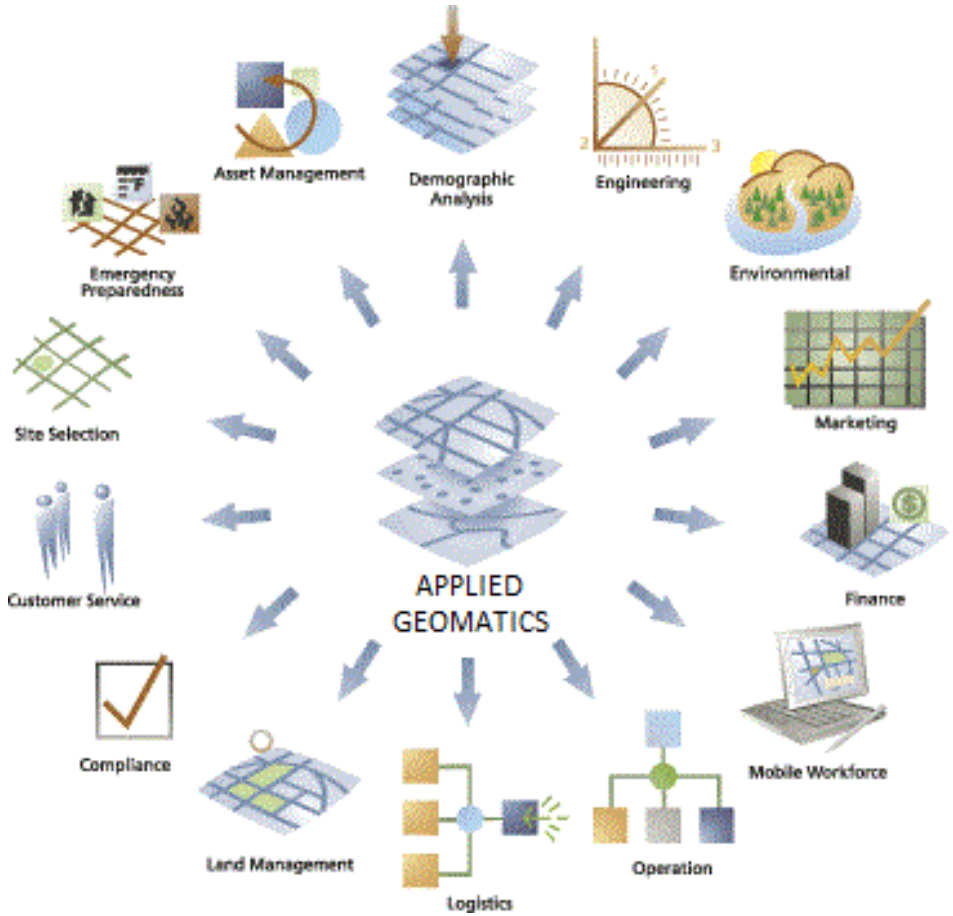
Spatial operations

WTF is GIS??

Geomatics

Geomatics – ISO/TC 211

Discipline concerned with collection, distribution, storage, analysis, processing, presentation of geographic data or geographic information.



GIS

Term Geomatics is often used in the meaning of Geographic Information System (GIS) and vice versa.

Geographic Information System

System designed to capture, store, manipulate, analyze, manage and present spatial or geographic data. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations.

Geographic Data

Also called:

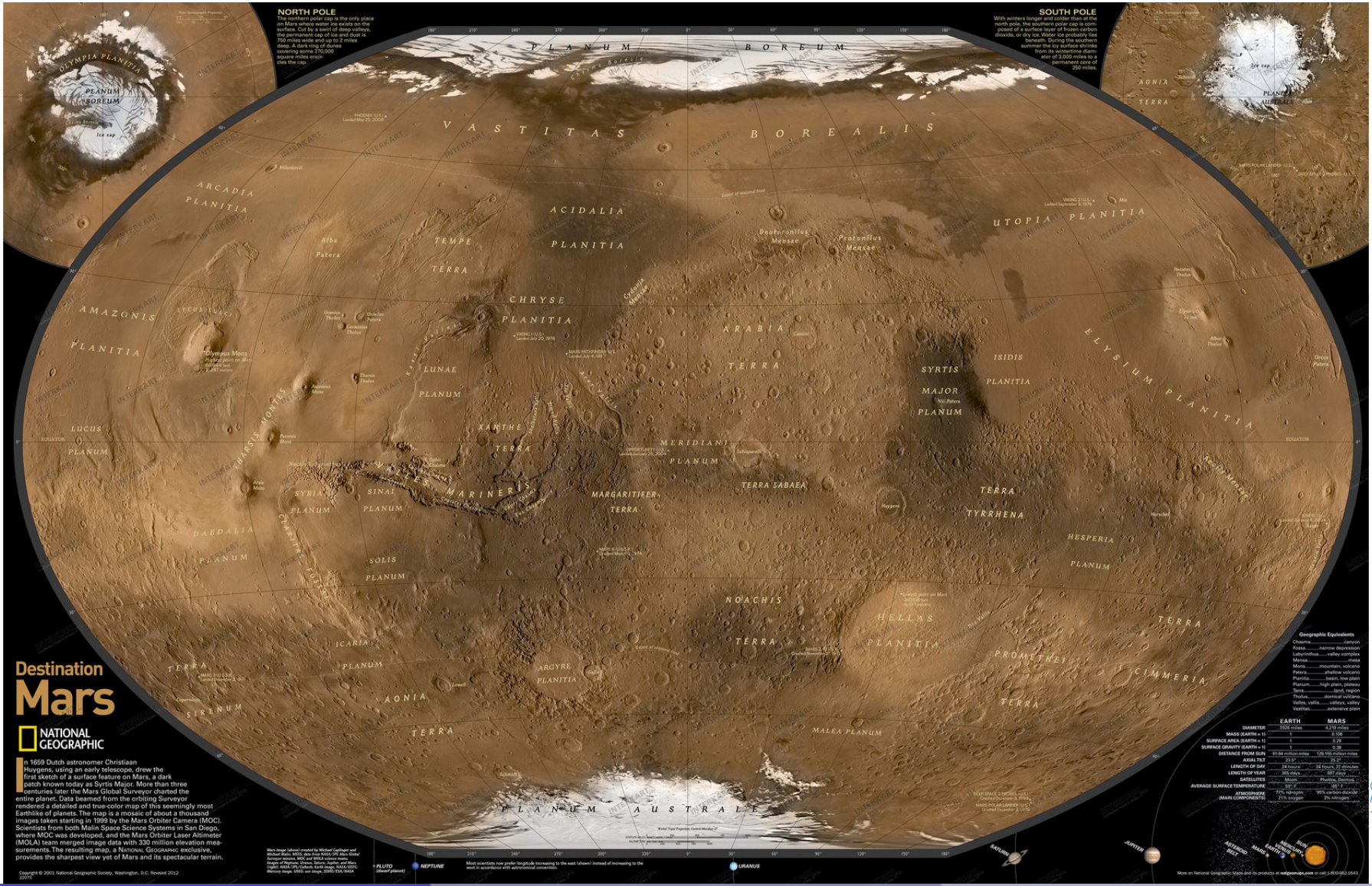
- Geospatial data and information,
- Georeferenced data and information,
- Geodata,
- Geoinformation,
- Spatial data.

Geographic Data – ISO/TC 211

Data and information having an implicit or explicit association with a location relative to the Earth.

Geographic Data

... or in wider context any other space object. (*Martian spatial data*)



Geographic Data

Geographic Data – ISO/TC 211

Data and information having an **implicit** or **explicit** association with a location relative to the Earth.

Implicit – coordinates, direction and distance,

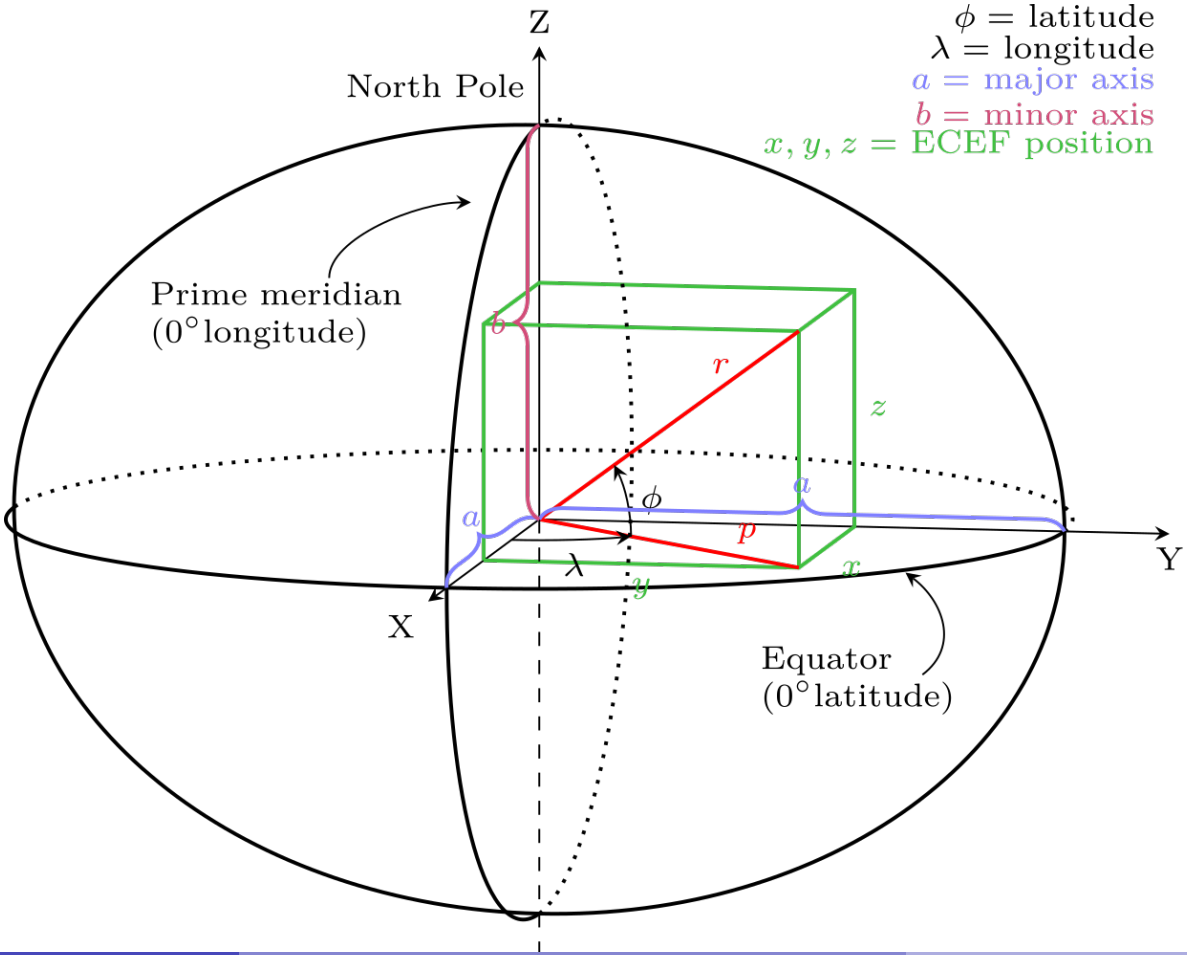
explicit – geographic name, address.

Depends on semantics.

Coordinates

Geographic Coordinate System

System that enables every location on Earth by set of numbers, letters and symbols.



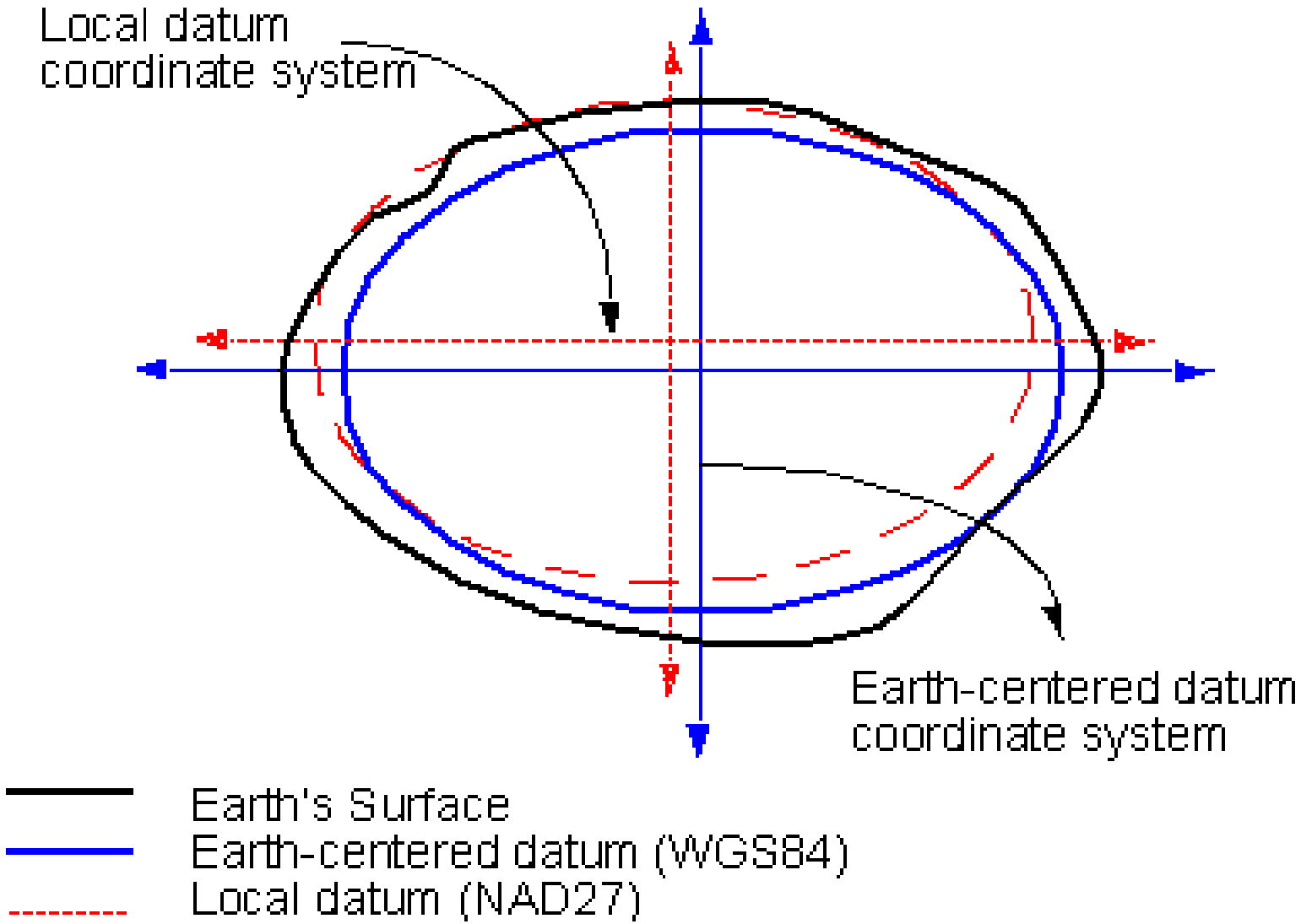
Coordinate Reference Systems

Reference ellipsoid – approximation of geoid,

geodetic datum – mapping of spherical coordinates onto ellipsoid,

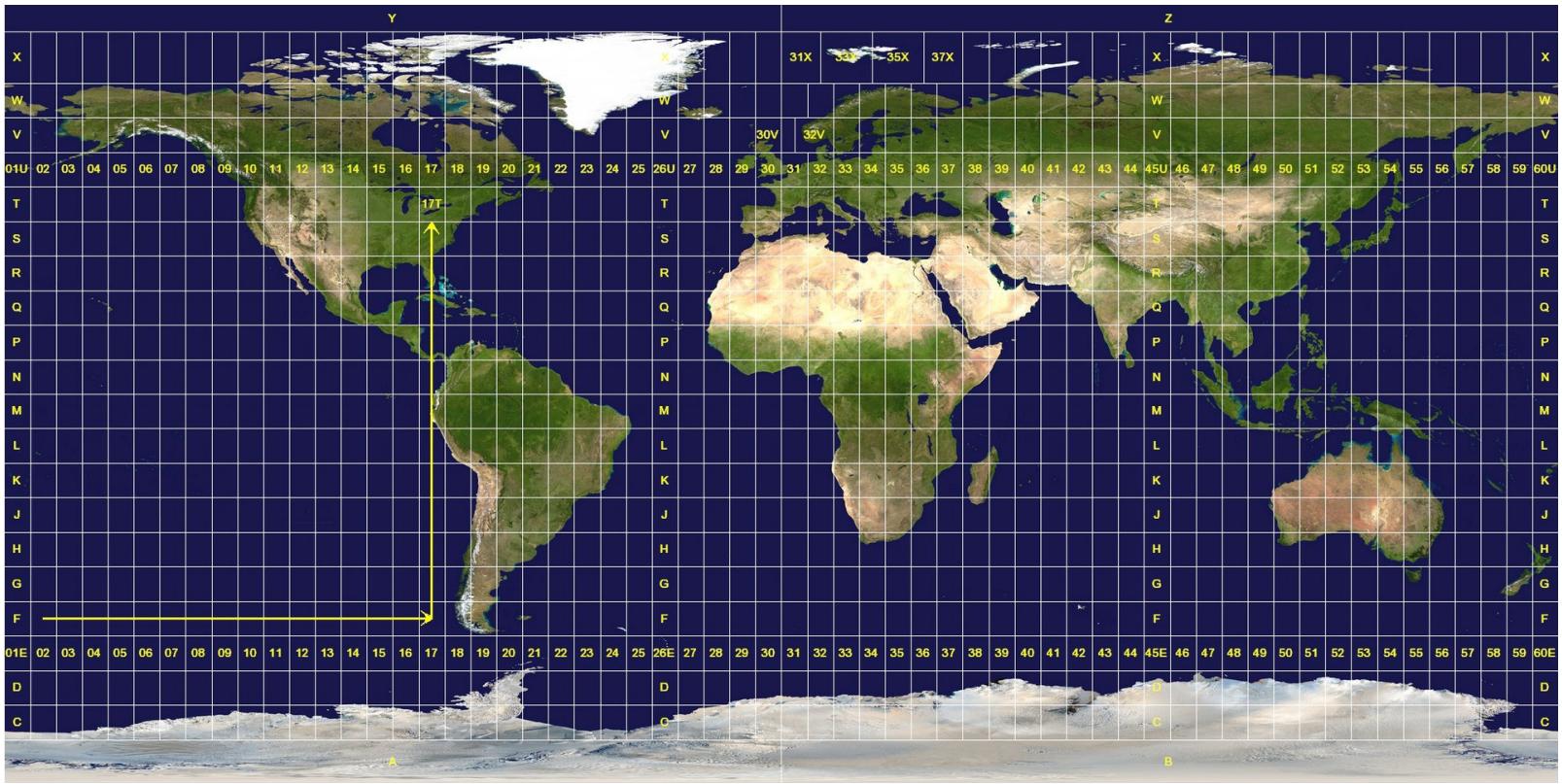
map projection – conversion of geodetic coordinates to the plain map.

Reference ellipsoid and datum

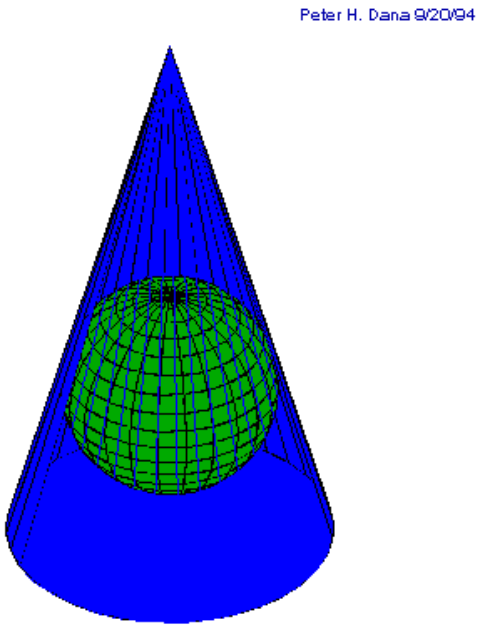


Projection

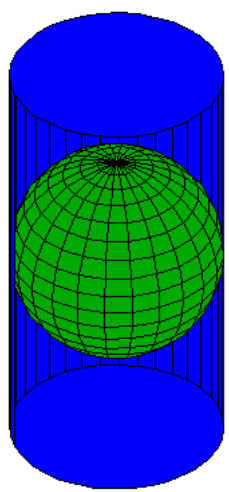
Best known coordinate system is WGS-84, also known as **GPS coordinates** in a form of latitude and longitude.



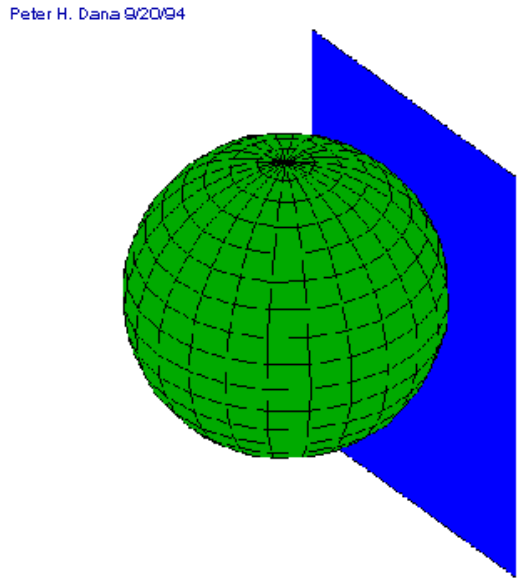
Projection



Conical Projection Surface



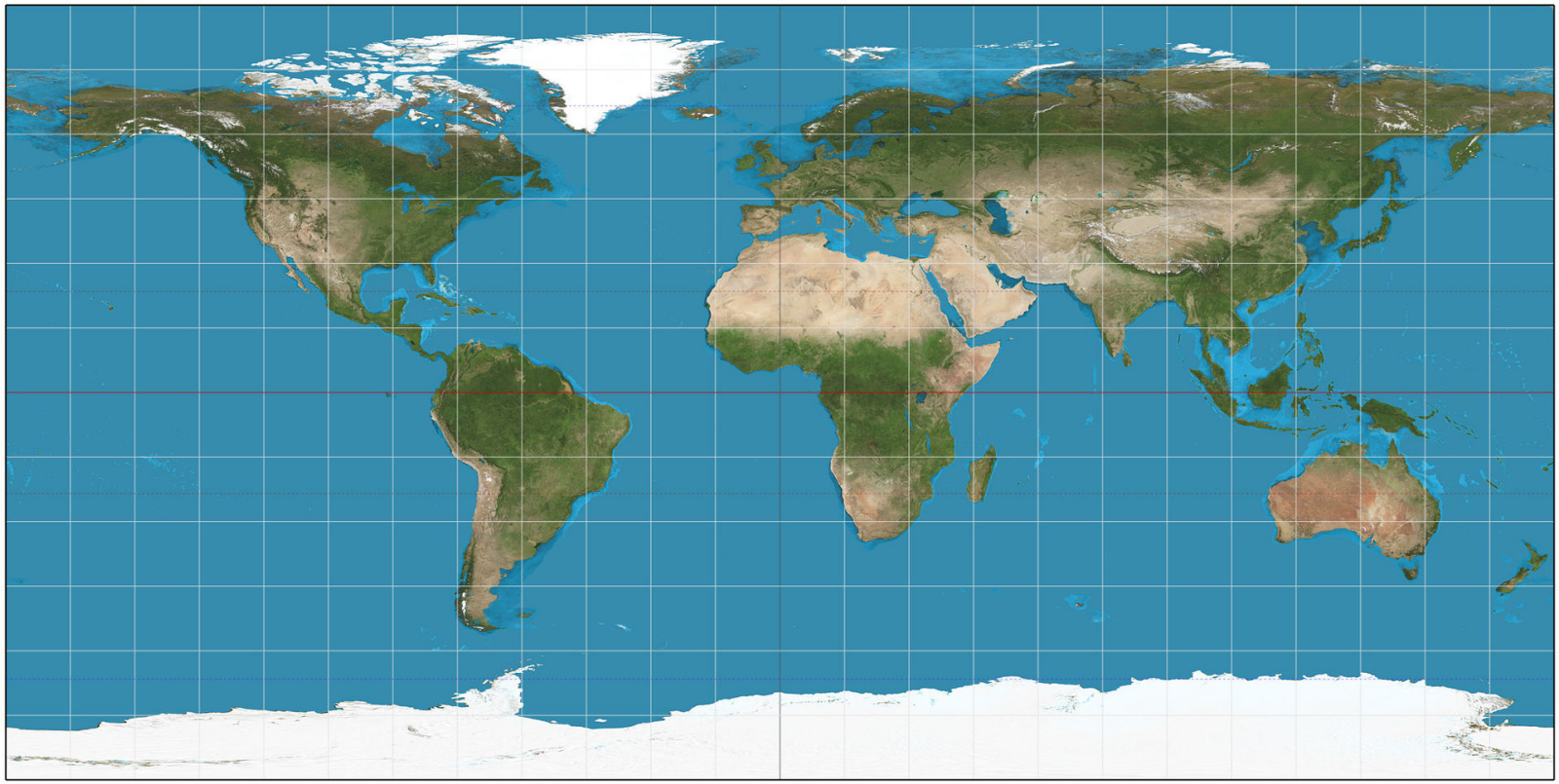
Cylindrical Projection Surface



Planar Projection Surface

Why is CRS important?

Same coordinate system may be projected differently.



EPSG codes

EPSG:4326

Geodetic coordinate system

WGS 84 -- WGS84 - World Geodetic System 1984, used in GPS

Transform coordinates | Get position on a map

Attributes

Unit: degree (supplier to define representation)

Geodetic CRS: WGS 84

Datum: World Geodetic System 1984

Ellipsoid: WGS 84

Prime meridian: Greenwich

Data source: OGP

Information source: EPSG. See 3D CRS for original information source.

Revision date: 2007-08-27

Scope: Horizontal component of 3D system. Used by the GPS satellite navigation system and for NATO military geodetic surveying.

Area of use: World.

Coordinate system: Ellipsoidal 2D CS. Axes: latitude, longitude. Orientations: north, east. UoM: degree

Covered area

Center coordinates
0.00000000 0.00000000

WGS84 bounds:
-180.0 -90.0
180.0 90.0

World.

http://epsg.io

Coordinate Reference Systems

WGS-84

World Geodetic System 1984, EPSG code 4326, used in GPS and Google maps.

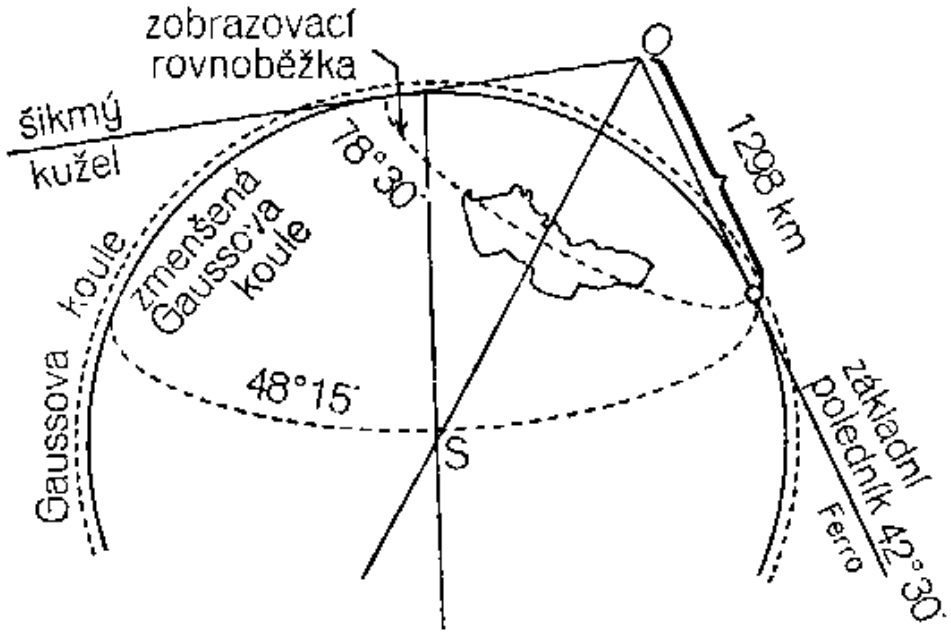
ETRS-89

European Terrestrial Reference System 1989, EPSG code 4258, based on GRS 1980 ellipsoid, made to be precise in Europe.

S-JTSK

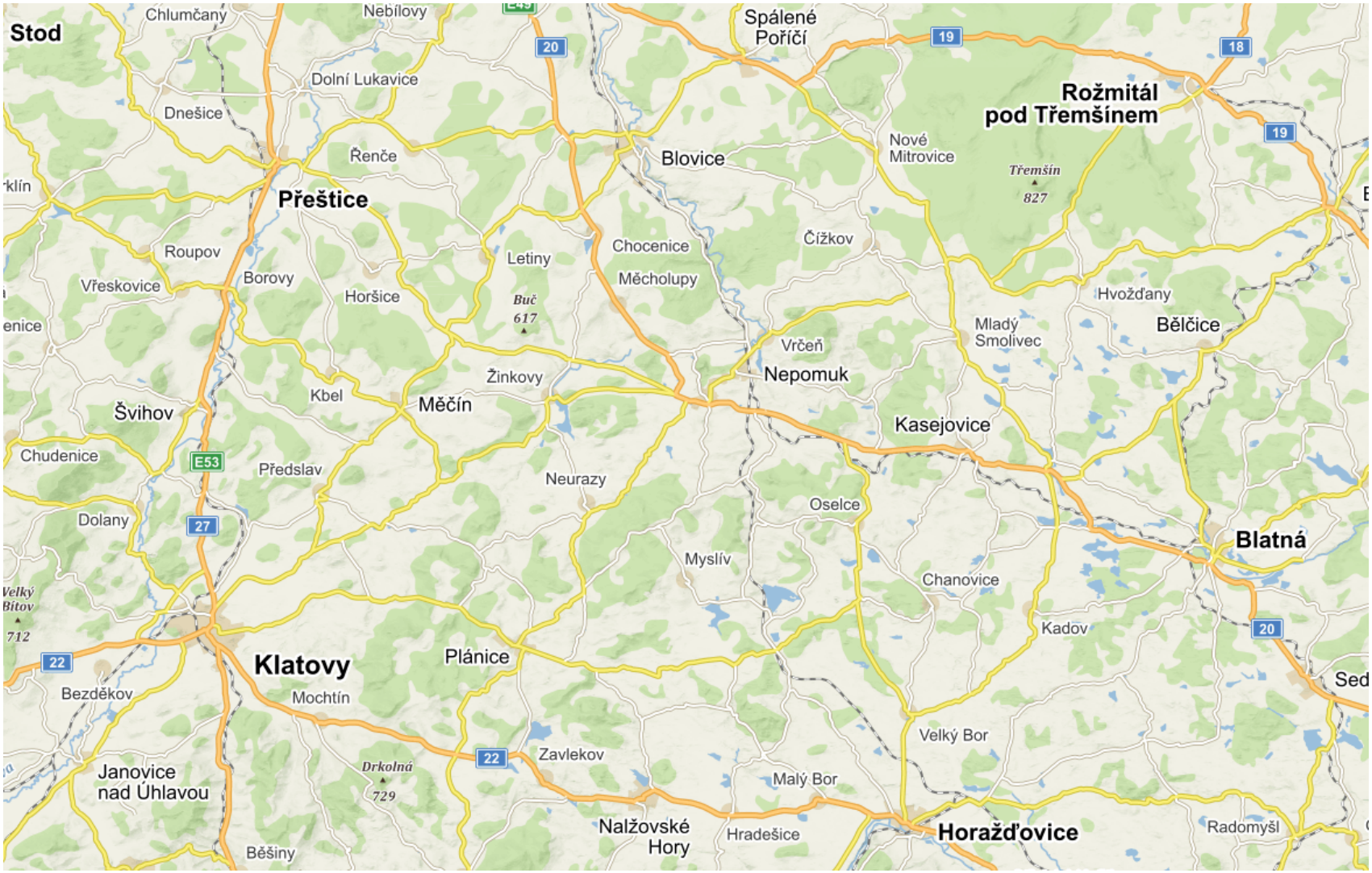
Systém jednotné trigonometrické sítě katastru, EPSG code 5514, cone based system with double transformation made for the Czechoslovakian area, using Křovák projection.

S-JTSK

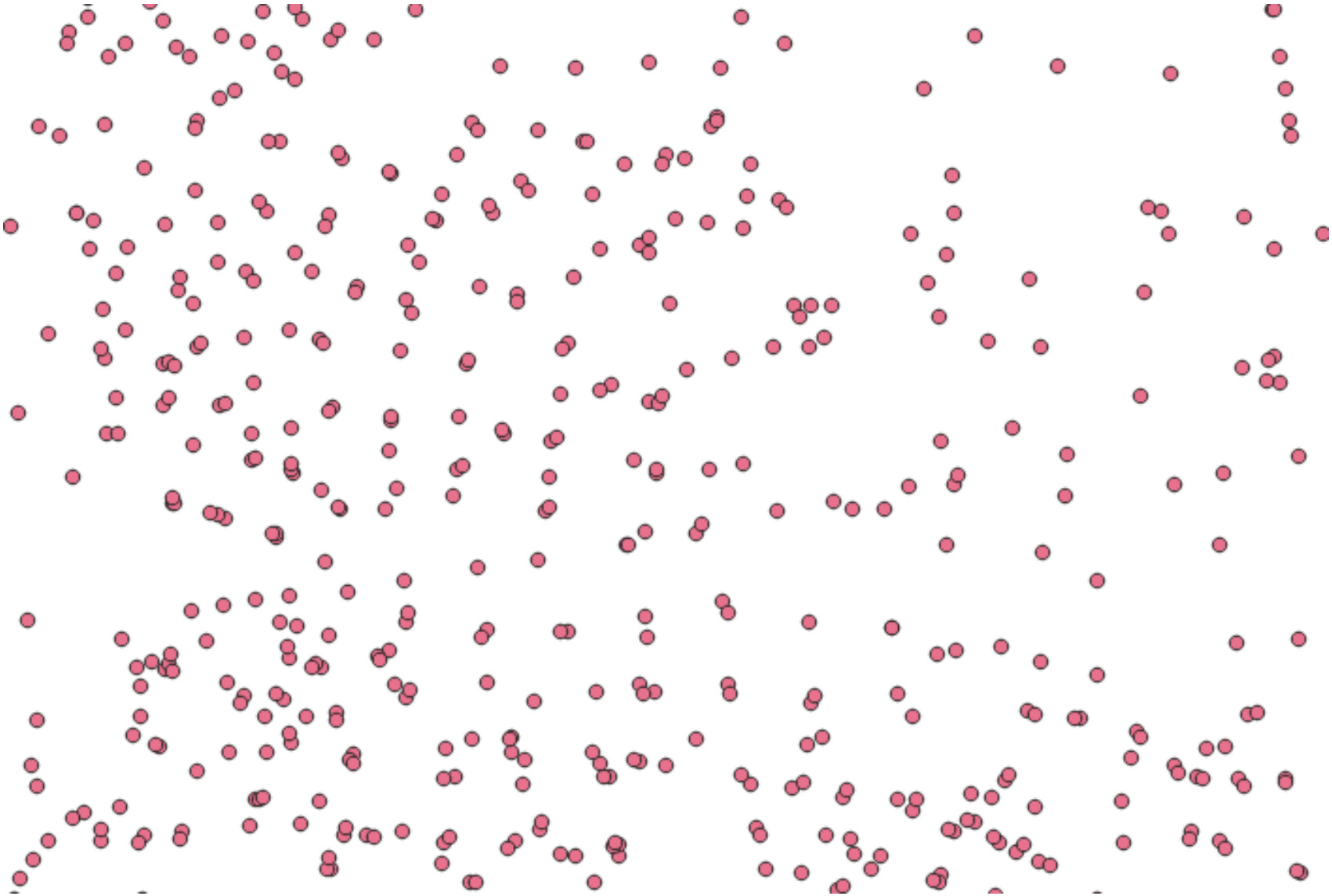

zobrazovací
rovnoběžka
šikmý
kužel
78°30'
1298 km
Gaussova koule
zmenšená Gaussova koule
48°15'
S
základní poledník 42°30'
Ferro

Usage of GIS

Geodata representation – raster



Geodata representation – vector



Geodata representation

id	x	y
102151	14.251	49.321
102152	14.632	48.956

Geodata representation

Geodata representation

Why?

Missing coordinate reference system,

expresses only points,

every single point has single id,

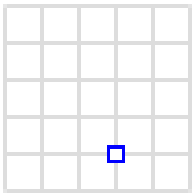
does not support any spatial operations.

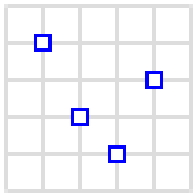
Certification and standards

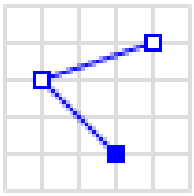
http://www.opengeospatial.org/

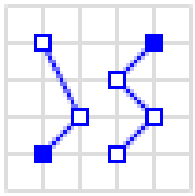
Spatial Objects

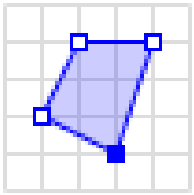
Geographic features are handled as objects:

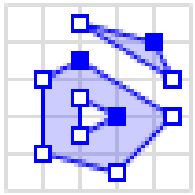

points


multipoints


lines


multilines


polygons


multipolygons.

Spatial objects representation

Well–Known Text (WKT)

```
POINT(50.056 14.434)
LINESTRING(50.056 14.434, 50.064 14.442, 50.042 14.445)
```

Geography Mark-up Language (GML)

```
<gml:Point srsName="http://opengis.net/def/crs/EPSG/0/4326" srsDimension="2">/
    <gml:pos>50.056 14.434</gml:pos>
</gml:Point>

<gml:Curve srsName="http://opengis.net/def/crs/EPSG/0/5514" srsDimension="2">
    <gml:segments>
      <gml:LineStringSegment>
        <gml:posList>-641126.76 -1093821.18 -641119.35 -1093831.05
                     -641109.75 -1093844.44</gml:posList>
      </gml:LineStringSegment>
    </gml:segments>
</gml:Curve>
```

Spatial data formats

Geography Mark-up Language

OGC standard and XML based format,

geometry described as GML objects,

complex format allowing any type of geometry object,

allows any type of attributes,

described by xml schema (XSD).

Spatial data formats – GML

```
<ad:Address gml:id="AD.22547665">
    <ad:inspireId>
        <base:Identifier>
            <base:localId>AD.22547665</base:localId>
            <base:namespace>CZ-00025712-CUZK_AD</base:namespace>
        </base:Identifier>
    </ad:inspireId>
    <ad:alternativeIdentifier>K Pitkovicům 1, Benice, 10300 Praha 10</ad:alternativeIdentifier>
    <ad:position>
        <ad:GeographicPosition>
            <ad:geometry>
                <gml:Point gml:id="P.AD.22547665" srsName="urn:ogc:def:crs:EPSG::5514"
                    srsDimension="2">
                    <gml:pos>-731037.56 -1053052.98</gml:pos>
                </gml:Point>
            </ad:geometry>
            <ad:specification
                xlink:href="http://inspire.ec.europa.eu/codelist/
                            GeometrySpecificationValue/entrance"
                xlink:title="entrance"/>
            <ad:default>true</ad:default>
        </ad:GeographicPosition>
    </ad:position>
    <ad:component xlink:href="#AA.MOP.108" xlink:title="Praha 10"/>
    <ad:component xlink:href="#AA.MOMC.538078" xlink:title="Praha-Benice"/>
    <ad:component xlink:href="#AA.2585" xlink:title="Benice"/>
    <ad:component xlink:href="#TF.498211" xlink:title="K Pitkovicům"/>
    <ad:component xlink:href="#PD.10300" xlink:title="10300"/>
</ad:Address>
```

Spatial data formats

GeoJSON

OGC standard and JSON based format,

records as single objects,

not so robust, but simpler,

CRS as object,

exchange format on the internet,

extension – GeoJSON–LD.

Spatial data formats – GeoJSON


```
{
  "geometry":{
    "coordinates":[
    14.419134,
    50.090122
    ],
    "type":"Point"
  },
  "crs": {
    "type": "name",
    "properties": {
      "name": "urn:ogc:def:crs:EPSG::4326"
    }
  },
  "properties":{
    "cislo_orientacni":"22",
    "cislo_popisne":"128",
    "druh_mista":"RESTAURAČNÍZAHRÁDKY",
    "druh_zbozi":"",
    "momc":"Praha 1",
    "ulice":"Pařížská"
  },
  "type":"Feature"
}
```


Spatial data formats

GeoPackage

OGC standard and SQLite based format,

allows both vector and raster data (embedded image file),

complex spatial structure may be inserted as attribute,

basically database file.

Spatial data formats

Comma Separated Values

table way of description,

rows of text file separated by UTF-8 character U+200C (,),

geometry object contains commas, therefore it has to be closed in quotation marks,

geometry recommended to be described as WKT,

not really recommended.

Spatial data formats – CSV

```
{
  Kód,Název ulice,Kód Obce,Název Obce,Kód Okresu,Název Okresu,WKT_Geometry,CRS
442666,Adamovská,554782,Praha,3100,Hlavní město Praha,"LINESTRING(14.45032 50.05789,
    14.45094 50.05791, 14.45121 50.058034, ...)",http://www.opengis.net/def/crs/EPSG/0/4258
442674,Africká,554782,Praha,3100,Hlavní město Praha,"LINESTRING(14.34946 50.09616,
    14.34978 50.09607, 14.34996 50.09575, ...)",http://www.opengis.net/def/crs/EPSG/0/4258
442682,Akátová,554782,Praha,3100,Hlavní město Praha,"LINESTRING(14.41953 50.07761,
    14.41979 50.07764, 14.42133 50.07749, ...)",http://www.opengis.net/def/crs/EPSG/0/4258
}
```

Linked Geo Data

How is it usually done?

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:geo="http://www.w3.org/2003/01/geo/wgs84_pos#">
  <geo:Point>
    <geo:lat>49.701</geo:lat>
    <geo:long>14.552</geo:long>
  </geo:Point>
</rdf:RDF>
```

How is it usually done?

What do we need to do it right?

coordinate system support,

spatial objects support,

spatial operations support,

ontology describing relations between objects.

GeoSPARQL

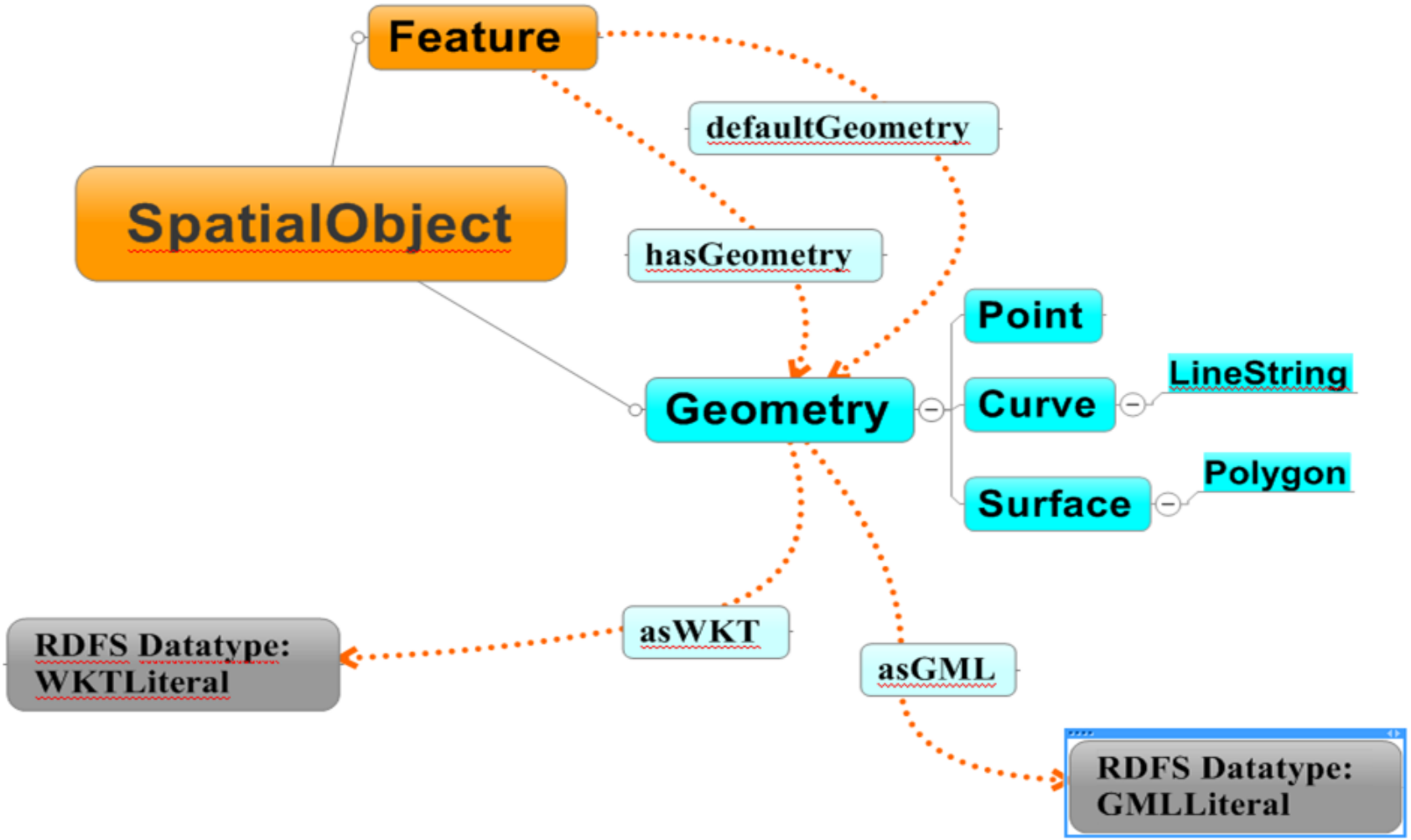
Why is it so great?

it is an ontology,

it is a query language supporting spatial operations,

it supports spatial objects in WKT and GML.

GeoSPARQL ontology



GeoSPARQL representation

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix geosparql: <http://www.opengis.net/ont/geosparql#> .
@prefix ds-par: <http://onto.fel.cvut.cz/ontologies/town-plan/parcely/> .
@prefix databaseTableParcely: <http://onto.fel.cvut.cz/ontologies/town-plan/databaseTableParcely/>
@prefix par-geometry: <http://onto.fel.cvut.cz/ontologies/town-plan/parcelakn_dokm_p/geometry/>
@prefix townplan: <http://onto.fel.cvut.cz/ontologies/town-plan/>

townplan:parcelakn_dokm_p/1/2018-01-29T14:36:24.178617 a ds-par:Parcely,
        geosparql:Feature ;
    rdfs:label "parcelakn_dokm_p/1/2018-01-29T14:36:24.178617" ;
    databaseTableParcely:dat_vznik "2008-09-25"^^xsd:date ;
    databaseTableParcely:existujedi "A" ;
    databaseTableParcely:id 2087553101.0 ;
    databaseTableParcely:id_poskyt 397 ;
    databaseTableParcely:katuze_kod 727164 ;
    databaseTableParcely:nazev_ku "Vinohrady" ;
    databaseTableParcely:ogc_fid 1 ;
    databaseTableParcely:par_id 2087553101.0 ;
    databaseTableParcely:parcela "1057" ;
    databaseTableParcely:shape_area 260.475900002 ;
    databaseTableParcely:shape_length 65.6304823872 ;
    databaseTableParcely:tid_parcelakn_dokm_p 61534.0 ;
    databaseTableParcely:vymera 260 ;
    geosparql:hasGeometry par-geometry:1/2018-01-29T14:36:24.178617 .

    par-geometry:1/2018-01-29T14:36:24.178617 a geosparql:Geometry ;
    rdfs:label "parcelakn_dokm_p/geometry/1/2018-01-29T14:36:24.178617" ;
    geosparql:asWKT "MULTIPOLYGON(((-742241.02 -1045480.81,-742242.84 -1045482.35,
                    -742257.059 -1045469.76,-742246.0798 -1045456.9,-742237.98
                    -1045465.82,-742241.02 -1045480.81)))" .
```

GeoSPARQL querying

```
geo:<http://www.opengis.net/ont/geosparql#>
geof:<http://www.opengis.net/def/function/geosparql/>
```

GeoSPARQL querying

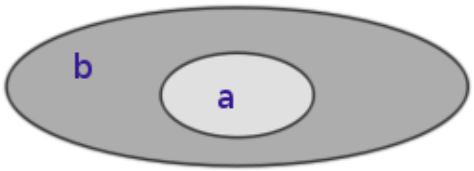
```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX geo: <http://www.opengis.net/ont/geosparql#>
PREFIX geof: <http://www.opengis.net/def/function/geosparql/>
PREFIX vocab-vyuziti: <http://onto.fel.cvut.cz/ontologies/town-plan/
                       resource/vocab/urk_ss_vyuzitizakl_p/>
PREFIX vocab-fvu: <http://onto.fel.cvut.cz/ontologies/town-plan/
                   resource/vocab/pvp_fvu_p/>

SELECT ?var1 ?var2
WHERE  {
        ?var1 vocab-fvu:wkb_geometry ?geometry1.
        ?var2 vocab-vyuziti:wkb_geometry ?geometry2.
        ?geometry1 geof:intersects ?geometry2
}
```

GeoSPARQL spatial relations

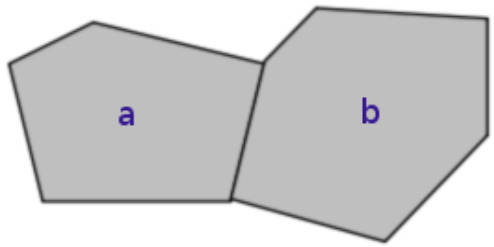
ogc:equals

Two objects have the same geometry.

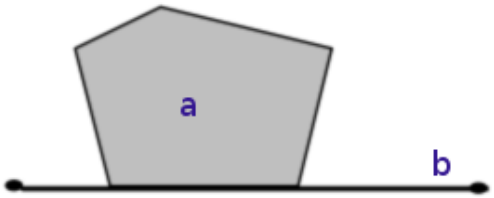
Within(a,b)



Touches(a,b)

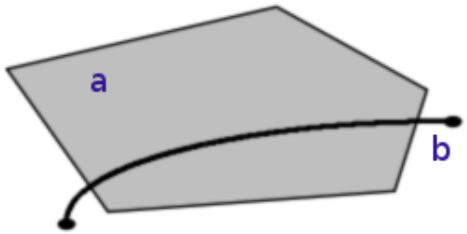


Touches(a,b)

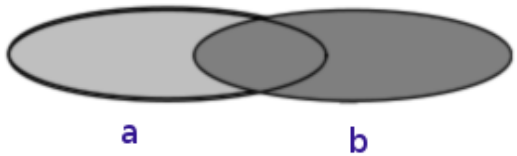


Crosses(a,b)

Crosses(a,b)



Overlaps(a,b)



GeoSPARQL filter functions

ogc:relate

Returns true if two objects are spatial related.

```
ogcf:relate
(geom1: ogc:GeomLiteral, geom2: ogc:GeomLiteral,
relation: xsd:anyURI): xsd:boolean
```

ogc:distance

Returns distance in given units between two objects.

```
ogcf:distance
(geom1: ogc:GeomLiteral, geom2: ogc:GeomLiteral,
units: xsd:anyURI): xsd:double
```

GeoSPARQL filter functions

ogc:buffer

Returns geometric object representing all points whose distance from geom1 is within radius in units.

```
ogcf:buffer
(geom: ogc:GeomLiteral, radius: xsd:real,
units: xsd:anyURI): ogc:GeomLiteral
```

ogcf:convexHull

Returns geometric object representing all points in convex hull of geom1.

```
ogcf:convexHull
(geom1: ogc:GeomLiteral): ogc:GeomLiteral
```

GeoSPARQL filter functions

ogcf:intersection

Returns a geometric object that represents all Points in the intersection of geom1 with geom2.

```
ogcf:intersection
(geom1: ogc:GeomLiteral, geom2: ogc:GeomLiteral,
): ogc:GeomLiteral
```

ogcf:union

Returns a geometric object that represents all Points in the union of geom1 with geom2.

```
ogcf:union
(geom1: ogc:GeomLiteral, geom2: ogc:GeomLiteral,
): ogc:GeomLiteral
```

GeoSPARQL filter functions

ogcf:difference,

ogcf:symDifference,

ogcf:envelope,

ogcf:boundary.

GeoSPARQL documentation

GeoSPARQL filter example

```
PREFIX my: <http://example.org/ApplicationSchema#>
PREFIX geo: <http://www.opengis.net/ont/geosparql#>
PREFIX geof:
        <http://www.opengis.net/def/function/geosparql/>

SELECT ?f
WHERE {
     ?f my:hasPointGeometry ?fGeom .
     ?fGeom geo:asWKT ?fWKT .
     FILTER (geof:sfWithin(?fWKT, '''
         <http://www.opengis.net/def/crs/OGC/1.3/CRS84>
             Polygon ((-83.4 34.0, -83.1 34.0,
                       -83.1 34.2, -83.4 34.2,
                       -83.4 34.0))
         '''^^geo:wktLiteral))
}
```

GeoSPARQL query example

```
PREFIX my: <http://example.org/ApplicationSchema#>
PREFIX ogc: <http://www.opengis.net/ont/geosparql#>
PREFIX ogcf:
       <http://www.opengis.net/def/function/geosparql/>

SELECT ?f ?fWKT
WHERE {
  my:A my:hasExactGeometry ?aGeom .
  ?aGeom ogc:asWKT ?aWKT .
  ?f my:hasExactGeometry ?fGeom .
  ?fGeom ogc:asWKT ?fWKT .
  ?aGeom ogc:sfContains ?fGeom.
  }
}
```