



## ***GEodata Openness Initiative for Development and Economic Advancement in Romania***

*Joint Research Project under the Romanian-Swiss Research Programme*

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PROGRAMUL DE COOPERARE ELVEȚIANO-ROMÂN  
SWISS-ROMANIAN COOPERATION PROGRAMME

## **Report on FOSS solutions available to create, maintain and publish open geodata**

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<b>GEOIDEA.RO Report</b>		
<b>GRANT AGREEMENT NR:</b>  IZERZO-142129	<b>SUBJECT:</b>  Report on FOSS solutions available to create, maintain and publish open geodata	<b>PROJECT COORDINATOR:</b>  ETH Zurich
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<b>ABSTRACT:</b>  Free and open source software development is emerging as an alternative approach for developing large software systems. The document makes a review of the relevant free and open source geospatial solutions, available on the market, solutions that can be used to create the necessary software infrastructure for open data publication and maintenance. The identified software solutions are classified in five categories: core libraries, desktop, data stores, web services and web clients. General information is provided for each application (project name, author/maintainer, website, license, development platform, main functionalities, etc.).		
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## 1. INTRODUCTION

### 1.1 Purpose of the document

The GEOIDEA.RO project is based on the premise that publishing public geodata on the Internet, under an open license and in a reusable format can strengthen citizen engagement and yield innovative businesses, bringing substantial social and economic gains. Thus, the main objective of the project is to improve the scientific basis for the adoption of an open geodata model in Romania, on the technical and social side.

The document makes a review of the relevant free and open source geospatial solutions, available on the market, solutions that can be used to create the necessary software infrastructure for open data publication and maintenance.

### 1.2 Abbreviations

ADL	Alexandria Digital Library
API	Application Program Interface
ASCII	American Standard Code for Information
BSD	Berkeley Software Distribution
CAD	Computer-Aided Drafting
CGI	Common Gateway Interface
CSS	Cascading Style Sheets
CSV	Coma Separated Values
CSW	Catalogue Service for Web
DB	Database
DBF	DataBase File
DGN	MicroStation Design File
DOM	Document Object Model
DTM	Digital Terrain Model
DWG	AutoCAD Drawing Database

DXF	Drawing eXchange Format
ebRIM	Registry Information Model
ECW	Enhanced Compressed Wavelet
ECWP	Enhanced Compression Wavelet Protocol
EPSG	European Petroleum Survey Group
ESRI	Environmental Sciences Research Institute
FE	Filter Encoding
FME	Feature Manipulation Engine
GeoJSON	Geo JavaScript Object Notation
GeoTIFF	Geo Tag Image File Format
GML	Geography Markup Language
GNU	Gnu's Not Unix
GPL	General Public License
GPS	Global Positioning System
GPX	GPS Exchange Format
GUI	Graphical User Interface
HTML	HyperText Markup Language
IGC	International Glider Commission (file format)
IHS	Intensity-Hue-Saturation
ERDAS IMG	ERDAS Imagine (file format)
JDBC	Java Database Connectivity
JPEG	Joint Photographic Experts Group
JSON	JavaScript Object Notation
KML	Keyhole Markup Language
LGPL	Lesser General Public License



LiDAR	Light Detection and Ranging
MIF	MapInfo (file format)
MIT	Massachusetts Institute of Technology (license)
MNDNR	Minnesota Department of Natural Resources
MPL	Mozilla Public License
MrSID	Multi-Resolution Seamless Image Database
MS	Microsoft
MVCC	Multi-Version Concurrency Control
NASA	National Aeronautics and Space Administration
NetCDF	Network Common Data Form
ODBC	Open Database Connectivity
OGC	Open Geospatial Consortium
OM	Observations and Measurements (OGC standard)
OOP	Object Oriented Programming
OSGeo	Open Source Geospatial Foundation
OSM	OpenStreetMap
OSX	Macintosh Operating System X
PCA	Principal component analysis
PDF	Portable Document Format
PNG	Portable Network Graphics
RGB	Red-Green-Blue
SDE	Spatial Database Engine
SDI	Spatial Data Infrastructure
SDTS	Spatial Data Transfer Standard
SFQL	Simple Features for SQL

SHP	Esri Shapefile
SLD	Style Layer Descriptor
SOS	Sensor Observation Service
SQL	Search and Query Language
SRW	Search/Retrieve Web service
SVG	Scalable Vector Graphics
Tcl	Tool Command Language
TIFF	Tag Image File Format
UMN	University of Minnesota
WCS	Web Coverage Service
WFS	Web Feature Service
WFS-G	Web Feature Service Gazetteer
WFS-T	Web Feature Server Transactional
WKB	Well Known Binary
WKT	Well Known Text
WMS	Web Map Service
WMS-C	Map Server Cache
WMTS	Web Map Tile Service
WPS	Web Processing Service
XML	Extensible Markup Language

## 2. STATE OF PLAY

Free and open source software development is emerging as an alternative approach for developing large software systems. New types and new kinds of software processes are emerging within FOSS projects, as well as new characteristics for development project success, when compared to those found in traditional industrial software projects and those portrayed in software engineering textbooks. As a result, FOSS offers new types and new kinds of processes to research, understand, improve, and practice. The main advantages of FOSS software are:

The availability of the source code and the right to modify and use the software in any way;

- Not tied to a single vendor;
- Big community to support;
- Good security, reliability & stability;
- Very good standard compliancy;
- Lower implementation cost.

The open source geospatial space includes products to fill every level of the spatial data infrastructure stack. Open source software can provide a complete alternative to proprietary software in most system designs. A number of robust free and open source software solutions were already identified at the writing of the project proposal. The following pages include detailed review for all the identified applications, classified in five categories: core libraries, desktop, data stores, web services and web clients.

### 3. CORE LIBRARIES

The core libraries provide common capabilities across the various applications, allowing applications to easily add features that would ordinarily involve a great deal of implementation.

Project/software name	<b>GDAL/OGR</b>
Author/Maintainer	Initial author was Frank Warmerdam. Now GDAL is an OSGeo project lead by GDAL Project Steering Committee.
Website	<a href="http://www.gdal.org">www.gdal.org</a>
License	MIT
Devel platform	C++
Description	GDAL/OGR is one of the oldest and most used GIS libraries. GDAL provides an abstraction library for raster data and modules for reading and writing various raster formats. OGR provides an similar behavior for vector data and modules for reading and writing vector formats. GDAL/OGR power and flexible license lead to adoption in well know proprietary GIS packages like: ArcGIS, FME, GoogleEarth Pro, etc.
Functionality	<ul style="list-style-type: none"> <li>• Report detailed informations about a geospatial file or database</li> <li>• Translate raster and vector geospatial data from/to a huge number of file and database formats</li> <li>• Re-projection of raster and vector data</li> <li>• Extract contours from digital elevation models</li> <li>• Create raster data mosaics</li> <li>• Vector to raster conversion</li> <li>• Create raster data tiles and pyramids</li> <li>• Create raster from the scattered data</li> </ul>

	<ul style="list-style-type: none"> <li>• Create raster tile index</li> <li>• Create vector data index</li> </ul>
Observations	GDAL/OGR is build on C++ but supports CSharp, Java, Perl, and Python bindings

Project/software name	<b>FDO (Feature Data Objects)</b>
Author/Maintainer	Initial author was Autodesk. Now FDO is an OSGeo project lead by FDO Project Steering Committee.
Website	<a href="http://fdo.osgeo.org">http://fdo.osgeo.org</a>
License	LGPL
Devel platform	C++
Description	FDO is an API, similar with GDAL/OGR, for manipulating, defining and analyzing geospatial information regardless of where it is stored. FDO uses a provider-based model for supporting a variety of geospatial data sources, where each provider typically supports a particular data format or data store.
Functionality	<ul style="list-style-type: none"> <li>• Translate raster and vector geospatial data from/to a huge number of file and database formats</li> <li>• Re-projection of raster and vector data</li> </ul>
Observations	-

Project/software name	<b>PROJ.4 (Cartographic Projections Library)</b>
Author/Maintainer	Initial author was Gerald Evenden from USGS. Important later development was done by Frank Warmerdam.
Website	<a href="https://github.com/OSGeo/proj.4">https://github.com/OSGeo/proj.4</a>
License	MIT
Devel platform	C
Description	Is a coordinate re-projection library, capable of executing transformations between cartographic projection systems, and also between different spheroids and datums.
Functionality	Re-projection of geospatial data
Observations	-

Project/software name	<b>GeoTools</b>
Author/Maintainer	GeoTools Project Management Committee
Website	<a href="http://www.geotools.org">www.geotools.org</a>
License	LGPL
Devel platform	Java
Description	GeoTools is an Java code library which provides standards compliant methods for the manipulation of geospatial data. GeoTools library implements Open Geospatial Consortium (OGC) specifications. It has a modular (the main modules are described in the functionality section

	below) architecture that allows extra functionality to be added or removed easily. The GeoTools project comprises a core API of interfaces and default implementations of those interfaces.
Functionality	<ul style="list-style-type: none"> <li>• Render (for drawing maps)</li> <li>• JDBC (for reading spatial information from a database)</li> <li>• Data (for reading spatial data)</li> <li>• Main (implements filter, feature)</li> <li>• Coverage (read raster data)</li> <li>• API (public interfaces)</li> <li>• Referencing (defines where coordinates show up on a map)</li> <li>• Metadata (identity, description, and so on)</li> </ul>
Observations	GeoTools is used by an important number of projects as core library (e.g.: uDig, gvSIG, GeoServer, MyMap, GeoVista Studio)

Project/software name	<b>GeoApi</b>
Author/Maintainer	OGC
Website	<a href="http://www.geoapi.org">www.geoapi.org</a>
License	OGC license (BSD-like)
Devel platform	Java
Description	GeoAPI aims to reduce duplication and increase interoperability by providing neutral, interface-only APIs derived from OGC/ISO Standards.
Functionality	-

Observations	-
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Project/software name	<b>GEOS (Geometry Engine - Open Source)</b>
Author/Maintainer	Initial author was Refractions Research. Now GEOS is an OSGeo project lead by GEOS Project Steering Committee.
Website	<a href="https://trac.osgeo.org/geos">https://trac.osgeo.org/geos</a>
License	LGPL
Devel platform	C++
Description	Is a C++ port of the Java Topology Suite (JTS). As such, it aims to contain the complete functionality of JTS in C++.
Functionality	<ul style="list-style-type: none"> <li>• Geometries: Point, LineString, Polygon, MultiPoint, MultiLineString, MultiPolygon, GeometryCollection</li> <li>• Predicates: Intersects, Touches, Disjoint, Crosses, Within, Contains, Overlaps, Equals, Covers</li> <li>• Operations: Union, Distance, Intersection, Symmetric Difference, Convex Hull, Envelope, Buffer, Simplify, Polygon Assembly, Valid, Area, Length,</li> <li>• Prepared geometries (pre-spatially indexed)</li> <li>• STR spatial index</li> <li>• OGC Well Known Text (WKT) and Well Known Binary (WKB) encoders and decoders.</li> <li>• C and C++ API (C API gives long term ABI stability)</li> <li>• Thread safe (using the reentrant API)</li> </ul>
Observations	-



Project/software name	<b>JCS Conflation Suite</b>
Author/Maintainer	Vivid Solutions
Website	<a href="http://www.vividsolutions.com/JCS">www.vividsolutions.com/JCS</a>
License	LGPL
Devel platform	Java
Description	Is an API and a set of interactive tools which perform conflation on spatial datasets
Functionality	<ul style="list-style-type: none"> <li>• Coverage Cleaning Functions (find gaps, remove gaps)</li> <li>• Coverage Alignment Tools</li> <li>• Road Matching Operations</li> <li>• Precision Reduction Function</li> <li>• Geometry Difference Detection Function</li> </ul>
Observations	The development of JCS was sponsored by a joint project of the following organizations: GeoConnections, British Columbia Ministry of Sustainable Resource Management (MSRM), Canadian Centre for Topographic Information - Sherbrooke (CTI-S) and Ontario Ministry of Natural Resources (OMNR)

Project/software name	<b>JTS Topology Suite</b>
Author/Maintainer	Vivid Solutions
Website	<a href="http://www.vividsolutions.com/jts">www.vividsolutions.com/jts</a>

License	LGPL
Devel platform	Java
Description	Is an API providing spatial object model and fundamental geometric functions. It implements the geometry model defined in the Open Geospatial Consortium Simple Features Specification for SQL.
Functionality	<ul style="list-style-type: none"><li>• Spatial predicates (based on the DE-9IM model),</li><li>• Overlay functions (intersection, difference, union, symmetric difference), buffer,</li><li>• Convex hull,</li><li>• Area and distance functions, and</li><li>• Topological validity checking</li></ul>
Observations	The development of JTS was sponsored by a joint project of the following organizations: GeoConnections, British Columbia Ministry of Sustainable Resource Management (MSRM) and Centre for Topographic Information - Sherbrooke (CTI-S)

## 4. DESKTOP APPLICATIONS

Classical desktop GIS clients that can be used to view, create, edit, analyse and publish geospatial data.

Project/software name	<b>GRASS GIS (Geographical Resources Analysis Support System)</b>
Author/Maintainer	GRASS GIS is an OSGeo project lead by GRASS Project Steering Committee.
Website	<a href="http://grass.osgeo.org">http://grass.osgeo.org</a>
License	LGPL
Devel platform	C++
Description	GRASS is the oldest FOSS4G application. GRASS is a raster/vector GIS combined with integrated image processing and data visualization subsystems. It includes more than 350 modules for management, processing, analysis and visualization of georeferenced data. GRASS is currently used in academic and commercial settings around the world, as well as by many governmental agencies and environmental consulting companies.
Functionality	GRASS is a full GIS/RS application. Includes support for all traditional features found in proprietary GIS/RS packages: <ul style="list-style-type: none"> <li>• Raster analysis: Automatic rasterline and area to vector conversion, Buffering of line structures, Cell and profile dataquery, Colortable modifications, Conversion to vector and point data format, Correlation / covariance analysis, Expert system analysis , Map algebra (map calculator), Interpolation for missing values, Neighbourhood matrix analysis, Raster overlay with or without weight, Reclassification of cell labels, Resampling (resolution), Rescaling of cell values, Statistical cell analysis, Surface generation from vector lines.</li> </ul>

	<ul style="list-style-type: none"><li>• 3D-Raster (voxel) analysis: 3D data import and export, 3D masks, 3D map algebra, 3D interpolation (IDW, Regularised Splines with Tension), 3D Visualization (isosurfaces), Interface to Paraview and POVray visualization tools.</li><li>• Vector analysis: Contour generation from raster surfaces (IDW, Splines algorithm), Conversion to raster and point data format, Digitizing (scanned raster image) with mouse, Reclassification of vector labels, Superpositioning of vector layers.</li><li>• Point data analysis: Delaunay triangulation, Surface interpolation from spot heights, Thiessen polygons, Topographic analysis (curvature, slope, aspect), LiDAR.</li><li>• Image processing: Support for aerial and UAV images, satellite data (optical, radar, thermal), Canonical component analysis (CCA), Color composite generation, Edge detection, Frequency filtering (Fourier, convolution matrices), Fourier and inverse fourier transformation, Histogram stretching, IHS transformation to RGB, Image rectification (affine and polynomial transformations on raster and vector targets), Ortho photo rectification, Principal component analysis (PCA), Radiometric corrections (Fourier), Resampling, Resolution enhancement (with RGB/IHS), RGB to IHS transformation, Texture oriented classification (sequential maximum a posteriori classification), Shape detection, Supervised classification (training areas, maximum likelihood classification), Unsupervised classification (minimum distance clustering, maximum likelihood classification)</li><li>• DTM-Analysis: Contour generation, Cost / path analysis, Slope / aspect analysis, Surface generation from spot heights or contours</li><li>• Geocoding: Geocoding of raster and vector maps including (LiDAR) point clouds</li><li>• Visualization: 3D surfaces with 3D query (NVIZ), Color assignments, Histogram presentation, Map overlay, Point data maps, Raster maps, Vector maps, Zoom / unzoom -function</li></ul>
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	<ul style="list-style-type: none"> <li>• Map creation: Image maps, Postscript maps, HTML maps</li> <li>• SQL-support: Database interfaces (DBF, SQLite, PostgreSQL, MySQL, ODBC)</li> <li>• Geostatistics: Interface to "R" (a statistical analysis environment), Matlab, ...</li> <li>• Temporal framework: support for time series analysis to manage, process and analyse (big) spatio-temporal environmental data. It supports querying, map calculation, aggregation, statistics and gap filling for raster, vector and raster3D data. A temporal topology builder is available to build spatio-temporal topology connections between map objects for 1D, 3D and 4D extents.</li> <li>• Furthermore: Erosion modelling, Landscape structure analysis, Solution transport, Watershed analysis.</li> </ul>
Observations	-

Project/software name	<b>QGIS</b>
Author/Maintainer	QGIS is an OSGeo project lead by QGIS Project Steering Committee
Website	<a href="http://www.qgis.org">www.qgis.org</a>
License	GPL
Devel platform	C++
Description	QGIS is a user friendly GIS applications that runs on Linux, Unix, Mac OSX, and Windows. QGIS supports vector, raster, and database formats. Comes with a plugin that provides access to GRASS from within QGIS. This includes the ability to view, edit, and create data, as well as perform analysis using the GRASS geoprocessing modules.

Functionality	<p>View data:</p> <ul style="list-style-type: none"><li>• Spatially-enabled tables and views using PostGIS, SpatialLite and MS SQL Spatial, Oracle Spatial, vector formats supported by the installed OGR library, including ESRI shapefiles, MapInfo, SDTS, GML and many more.</li><li>• Raster and imagery formats supported by the installed GDAL (Geospatial Data Abstraction Library) library, such as GeoTIFF, ERDAS IMG, ArcInfo ASCII GRID, JPEG, PNG and many more.</li><li>• GRASS raster and vector data from GRASS databases (location/mapset).</li><li>• Online spatial data served as OGC Web Services, including WMS, WMTS, WCS, WFS, and WFS-T.</li></ul> <p>Explore data and compose maps:</p> <ul style="list-style-type: none"><li>• File browser</li><li>• On-the-fly reprojection</li><li>• DB Manager</li><li>• Map composer</li><li>• Overview panel</li><li>• Spatial bookmarks</li><li>• Annotation tools</li><li>• Identify/select features</li><li>• Edit/view/search attributes</li><li>• Data-defined feature labeling</li><li>• Data-defined vector and raster symbology tools</li><li>• Atlas map composition with graticule layers</li><li>• North arrow scale bar and copyright label for maps</li><li>• Support for saving and restoring projects</li></ul> <p>Create, edit, manage and export data:</p> <ul style="list-style-type: none"><li>• Digitizing tools for OGR-supported formats and GRASS vector</li></ul>
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	<p>layers</p> <ul style="list-style-type: none"><li>• Ability to create and edit shapefiles and GRASS vector layers</li><li>• Georeferencer plugin to geocode images</li><li>• GPS tools to import and export GPX format, and convert other GPS formats to GPX or down/upload directly to a GPS unit (On Linux, usb: has been added to list of GPS devices.)</li><li>• Support for visualizing and editing OpenStreetMap data</li><li>• Ability to create spatial database tables from shapefiles with DB Manager plugin</li><li>• Improved handling of spatial database tables</li><li>• Tools for managing vector attribute tables</li><li>• Option to save screenshots as georeferenced images</li><li>• DXF-Export tool with enhanced capabilities to export styles and plugins to perform CAD-like functions</li></ul> <p>Analyse data:</p> <ul style="list-style-type: none"><li>• QGIS currently offers vector analysis, sampling, geoprocessing, geometry and database management tools. Is also possible to use the integrated GRASS tools, which include the complete GRASS functionality of more than 400 modules. Another option is the Processing Plugin, which provides a powerful geospatial analysis framework to call native and third-party algorithms from QGIS, such as GDAL, SAGA, GRASS, fTools and more.</li></ul> <p>Publish maps on the Internet:</p> <ul style="list-style-type: none"><li>• QGIS can be used as a WMS, WMTS, WMS-C or WFS and WFS-T client, and as a WMS, WCS or WFS server (See QGIS Server item in Server section Working with OGC Data.) Additionally, is possible to publish data on the Internet using a webserver with UMN MapServer or GeoServer installed.</li></ul> <p>Extend QGIS functionality through plugins:</p> <ul style="list-style-type: none"><li>• QGIS can be adapted to special needs with the extensible plugin architecture and libraries that can be used to create</li></ul>
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plugins. Is possible to even create new applications with C++ or Python. QGIS offers a growing number of external Python plugins that are provided by the community. These plugins reside in the official Plugins Repository and can be easily installed using the Python Plugin Installer. Core plugins include:

- Coordinate Capture (Capture mouse coordinates in different CRSs)
- DB Manager (Exchange, edit and view layers and tables; execute SQL queries)
- Dxf2Shp Converter (Convert DXF files to shapefiles)
- eVIS (Visualize events)
- fTools (Analyze and manage vector data)
- GDALTools (Integrate GDAL Tools into QGIS)
- Georeferencer GDAL (Add projection information to rasters using GDAL)
- GPS Tools (Load and import GPS data)
- GRASS (Integrate GRASS GIS)
- Heatmap (Generate raster heatmaps from point data)
- Interpolation Plugin (Interpolate based on vertices of a vector layer)
- Metasearch Catalogue Client
- Offline Editing (Allow offline editing and synchronizing with databases)
- Oracle Spatial GeoRaster
- Processing (formerly SEXTANTE)
- Raster Terrain Analysis (Analyze raster-based terrain)
- Road Graph Plugin (Analyze a shortest-path network)
- Spatial Query Plugin
- SPIT (Import shapefiles to PostgreSQL/PostGIS)
- Topology Checker (Find topological errors in vector



	<p>layers)</p> <ul style="list-style-type: none"> <li>○ Zonal Statistics Plugin (Calculate count, sum, and mean of a raster for each polygon of a vector layer)</li> </ul>
Observations	

Project/software name	<b>gvSIG</b>
Author/Maintainer	gvSIG Association
Website	<a href="http://www.gvsig.com">www.gvsig.com</a>
License	GPL
Devel platform	Java
Description	gvSIG is a tool oriented to manage geographic information developed and supported by Valencian Regional Council for Infrastructures and Transportation (CIT). It is characterized by a user-friendly interface, with a quick access to the most usual raster and vector formats. In the same view it includes local as well as remote data through a WMS, WCS or WFS source.
Functionality	<ul style="list-style-type: none"> <li>• Provides common GIS tools like data loading, map navigation, query map information like alphanumeric information, distance measurement, thematic cartography, legend edition using common legend types, labelling, feature selection by many selection types, data tables with statistics, ordering, table relations, table linking, layout manager, geoprocessing tools, CAD, raster processing, etc.</li> <li>• Interoperable: able to work with most known data formats:</li> </ul>

	<ul style="list-style-type: none"><li>○ Raster : ecw, ENVI HDR, ERDAS IMG, (Geo)TIFF, GRASS, NetCDF...</li><li>○ Vector &amp; CAD: Shapefile, NetCDF, GML, KML, DGN, DXF, DWG</li><li>○ Databases: PostGIS, MySQL, Oracle, ArcSDE</li><li>○ Remote: OGC standards (WMS, WMTS, WFS, WCS), OSM, ECWP, ArcIMS</li><li>• Discovery services client to localize data resources within an SDI (catalogue and gazetteer services)<ul style="list-style-type: none"><li>○ Catalogues: Z3950, SRW, CSW (ISO/19115 and ebRIM)</li><li>○ Gazetteers: ADL, WFS, WFS-G</li></ul></li><li>• More than 300 geoalgorithms via SEXTANTE library</li><li>• Integrated advanced CAD tools:<ul style="list-style-type: none"><li>○ Vector data: modify, create and delete elements</li><li>○ Command console typical element in CAD software</li><li>○ Tools like help, grid, command stack, complex element selections</li><li>○ Tools for inserting elements like points, polygons, lines, ellipses, etc...</li><li>○ Tools to modify its rotation, scale, symmetry,...</li></ul></li><li>• Integrated advanced raster tools:<ul style="list-style-type: none"><li>○ Georeferencing and reprojecting</li><li>○ Export, clipping</li><li>○ Look up tables, histogram</li><li>○ Filters, vectorization</li><li>○ Overviews and regions of interest management</li></ul></li><li>• Other features: scripting support (for both vector and raster data); reprojection engine via PROJ.4; import/export symbol sets; map sheets composer; charts; advanced symbology tools, advanced labelling tools</li></ul>
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Observations	
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Project/software name	<b>SAGA (System for Automated Geoscientific Analyses)</b>
Author/Maintainer	Institute of Geography - University of Hamburg
Website	<a href="http://www.saga-gis.org">www.saga-gis.org</a>
License	LGPL v2.1 (api); GPLv2 (GUI and modules)
Development platform	C++
Description	<p>SAGA Is an open source geographic information system used for editing and analysing spatial data. It includes a large number of modules for the analysis of vector (point, line and polygon), table, grid and image data. Among others the package includes modules for geostatistics, image classification, projections, simulation of dynamic processes (hydrology, landscape development) and terrain analysis. The functionality can be accessed through a GUI, the command line or by using the C++ API.</p> <p>SAGA has been in development since 2001, and the centre of SAGA development is located in the Institute of Geography at the University of Hamburg, with contributions from the growing world wide community.</p>

<p>Functionality</p>	<ul style="list-style-type: none"> <li>• Access to a large number of scientific modules via the Graphical User Interface or the command line: <ul style="list-style-type: none"> <li>○ Import/Export to different file formats</li> <li>○ Reprojection/Resampling of data</li> <li>○ Manipulation of vector data (merging/intersection/attributes)</li> <li>○ Manipulation of point clouds from lidar data</li> <li>○ Raster data: interpolation, cost analysis, ...</li> <li>○ Image analysis: filters, edge detection, cluster analysis, segmentation</li> <li>○ Digital Terrain Analysis: generate geomorphometric indexes, channel networks, profiles, contour lines, ...</li> <li>○ Geostatistics: modules for variogram fitting and kriging</li> </ul> </li> <li>• Fast user interface for managing and visualising data</li> <li>• 3D visualisation</li> <li>• Straightforward C++ API for creating new modules</li> <li>• Scripting through command line, bindings for Python</li> <li>• SAGA can be accessed from the R statistical language through the RSAGA module</li> </ul>
<p>Observations</p>	<p>SAGA is coded in the widespread and powerful C++ programming language and has an object oriented system design. Since version 2 SAGA uses the cross platform GUI library wxWidgets for user interface functionality. Because wxWidgets enables operating system independent software development, SAGA can run with MS-Windows as well as with Linux.</p>

<p>Project/software name</p>	<p><b>uDig (User-friendly Desktop Internet GIS)</b></p>
<p>Author/Maintainer</p>	<p>Refractions Research</p>

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Website	<a href="http://udig.refractions.net">http://udig.refractions.net</a>
License	Eclipse Public License (EPL)
Devel platform	Java
Description	uDig is an open source spatial data viewer/editor, with special emphasis on the OpenGIS standards for internet GIS, the Web Map Server (WMS) and Web Feature Server (WFS) standards.

<p>Functionality</p>	<p>Core features:</p> <ul style="list-style-type: none"> <li>• Desktop Client with Drag and Drop integration for File explorer and Web Browser</li> <li>• Integrate with other existing infrastructure: ArcSDE, Oracle, DB2 and more</li> <li>• Work with local files: Shapefile, JPEG, PNG, TIFF and more.</li> <li>• Work with advanced spatial raster formats: ECW, MrSID, JPEG 2000</li> <li>• Support for compliant Web Map Servers (GeoServer, MapServer tested)</li> <li>• Integrated Web experience with an embedded browser that recognises OGC web services and smoothly adds links to the onscreen map</li> <li>• Style Layer Descriptor control of rendering allowing to publish maps online using the same settings in uDig as with popular Web Map Servers</li> <li>• Deep integration of standards allowing the application to swap between the appropriate service as required for display, interaction and editing</li> <li>• Printing and PDF Generation</li> </ul> <p>Implemented Standards:</p> <ul style="list-style-type: none"> <li>• OGC Web Map Server (WMS)</li> <li>• OGC Web Feature Server (WFS)</li> <li>• OGC Web Feature Server Transactional (WFS-T)</li> <li>• OGC Simple Features for SQL (SFQL)</li> <li>• Web Map Server Cache (WMS-C)</li> <li>• OGC Style Layer Descriptor (SLD)</li> </ul>
<p>Observations</p>	

Project/software name	<b>OpenJUMP</b>
Author/Maintainer	Initial author is Vivid Solutions. OpenJUMP is a fork from the original JUMP GIS framework maintained by the community.
Website	<a href="http://www.openjump.org">www.openjump.org</a>
License	GPL
Devel platform	Java
Description	OpenJUMP is an easy to use and powerful desktop GIS that enables users to display, edit, analyse and conflate geographic data. It comes in a CORE and a PLUS edition, with the latter adding lots of useful plugins. OpenJUMP is excellent for data editing and rapid prototyping of GIS functions.
Functionality	<p>Data Formats:</p> <ul style="list-style-type: none"> <li>• Reads (files): GML, SHP, DXF, MIF, CSV, KML, OSM &amp; TIFF, ASCII Grid, JPG, PNG, JPEG2000+, MrSID, ECW</li> <li>• Reads (DB): PostGIS, ArcSDE, Oracle, MySQL and SpatiaLite</li> <li>• Reads (OGC standards): WKT, WMS, KML</li> <li>• Writes: GML, SHP, WKT, DXF, CSV, PostGIS &amp; JPG, TIFF, ASCII Grid, SVG</li> </ul> <p>Editing &amp; Conflation</p> <ul style="list-style-type: none"> <li>• Drawing points, lines, polygons, multi-geometries, geometry collections and circles (eventually mixed in a single layer)</li> <li>• Adding, moving, deleting vertices</li> <li>• Rotating, scaling, auto-complete polygon</li> <li>• Cut, merge, simplify polygons and lines</li> <li>• Warping, quality assurance tools</li> </ul> <p>Analysis &amp; Query</p>

	<ul style="list-style-type: none"> <li>• Spatial and attribute query functions</li> <li>• Analysis : buffer, union, overlay, centroid, convex hull...</li> <li>• Statistics : length, area, layer statistics, attribute statistics, plots.</li> <li>• Editing tools : converter, noder, polygonizer, planar graph, topology cleaning</li> <li>• Attribute transfer tools : join, matching</li> <li>• SEXTANTE raster analysis toolbox</li> </ul> <p>Customization</p> <ul style="list-style-type: none"> <li>• Internationalization (cz, de, en, es, fi, fr, hu, it, ja, pt, ta, zh)</li> <li>• Provides an API, scripting via BeanShell and Java Python/Ython</li> <li>• (Java) plugin-system</li> </ul> <p>Implemented Standards</p> <ul style="list-style-type: none"> <li>• OGC standards supported: GML2, SFS, WMS, KML and SLD;</li> </ul>
Observations	

Project/software name	<b>MapWindow</b>
Author/Maintainer	Idaho State University
Website	<a href="http://www.mapwindow.org">www.mapwindow.org</a>
License	MPL 1.1
Devel platform	C++



Description	MapWindow is a ready-to-use spatial data viewer, and a tool that can be modified into a new custom GIS application. The core MapWindow component is the ActiveX control, "MapWinGIS.ocx". This is an programming object that can be added to a form in Visual Basic, Delphi, or other languages that support ActiveX, providing a built-in GIS data map.
Functionality	MapWindow includes standard GIS data visualization features, spatial analysis, hidrological analysis as well as DBF attribute table editing, shapefile editing, and data converters.
Observations	

## 5. DATA STORES

Solutions for storing and querying geospatial features inside object-relational database systems.

Project/software name	<b>PostgreSQL</b>
Author/Maintainer	PostgreSQL Global Development Group
Website	<a href="http://www.postgresql.org">www.postgresql.org</a>
License	PostgreSQL license
Devel platform	C
Description	PostgreSQL is a powerful open source object-relational database system, with an emphasis on extensibility and standards-compliance. It has a development history of almost 20 years and therefore it has become widely used by individuals and companies due its reliability, data integrity and correctness. It runs on major operating systems: Linux, UNIX and Windows.
Functionality	<ul style="list-style-type: none"> <li>• Highly scalable both in the sheer quantity of data it can manage and in the number of concurrent users it can accommodate</li> <li>• Includes most SQL:2008 data types, including INTEGER, NUMERIC, BOOLEAN, CHAR, VARCHAR, DATE, INTERVAL, and TIMESTAMP</li> <li>• Fully ACID compliant</li> <li>• Support for foreign keys, joins, views, triggers, and stored procedures</li> <li>• Supports storage of binary large objects, including pictures, sounds, or video</li> <li>• Native programming interfaces for C/C++, Java, .Net, Perl,</li> </ul>

	<p>Python, Ruby, Tcl, ODBC</p> <ul style="list-style-type: none"> <li>• Multi-Version Concurrency Control (MVCC)</li> <li>• Point in time recovery</li> <li>• Asynchronous replication</li> <li>• Nested transactions (savepoints)</li> <li>• Sophisticated query planner/optimizer</li> <li>• Write ahead logging for fault tolerance</li> <li>• Its catalog is also accessible through the Information Schema as defined in the SQL standard</li> <li>• Full support for subqueries (including subselects in the FROM clause)</li> </ul>
Observations	<ul style="list-style-type: none"> <li>• For geospatial applications, PostGIS support should be added</li> </ul>

Project/software name	<b>PostGIS</b>
Author/Maintainer	PostGIS is an OSGeo project lead by PostGIS Project Steering Committee
Website	<a href="http://www.postgis.net">www.postgis.net</a>
License	GPLv2
Devel platform	C
Description	PostGIS is a spatial database extender for PostgreSQL object-relational database, meaning it adds support for geographic objects. PostGIS follows the Simple Features for SQL specification from the Open Geospatial Consortium (OGC). Using PostGIS one can perform location queries in SQL.

<p>Functionality</p>	<ul style="list-style-type: none"> <li>• Processing and analytic functions both vector and raster data for splicing, dicing, morphing, reclassifying, and collecting/unioning with the power of SQL</li> <li>• Raster map algebra for raster processing</li> <li>• Spatial reprojection SQL callable functions for both vector and raster data</li> <li>• Support for importing / exporting ESRI shapefile vector data via both commandline and GUI packaged tools and support for more formats via other 3rd-party Open Source tools</li> <li>• Packaged command-line for importing raster data from many standard formats: GeoTiff, NetCDF, PNG, JPG etc and rendering it in various formats using SQL</li> <li>• Rendering and importing vector data support functions for standard textual formats such as KML,GML, GeoJSON,GeoHash and WKT using SQL</li> <li>• Raster/vector SQL callable functions for extrusion of pixel values by geometric region, running stats by region, clipping rasters by a geometry, and vectorizing rasters</li> <li>• 3D object support, spatial index, and functions</li> <li>• Network Topology support</li> <li>• Geocoder/ Reverse Geocoder</li> </ul>
<p>Observations</p>	<p>PostGIS depends on:GEOS (for many geometry processing algorithms), Proj.4 (for coordinate re-projection functions), (GDAL for raster processing and format support), LibXML2 (for XML parsing), JSON-C (for JSON parsing)</p>

## 6. WEB SERVICES

Applications that can be used to publish geospatial data through Internet using standard web services (e.g. WMS, WFC, WCS) defined by OGC/ISO/CEN/INSPIRE.

Project/software name	<b>QGIS Server</b>
Author/Maintainer	QGIS Server is an OSGeo project lead by QGIS Project Steering Committee
Website	<a href="http://www.qgis.org">www.qgis.org</a>
License	GPL
Devel platform	C++
Description	QGIS Server provides web map and feature services (WMS & WFS) using the same libraries as the GIS (QGIS) desktop application. Maps and print templates created in QGIS desktop can be published as web maps simply by copying the QGIS project file into the server directory. The resulting web maps look exactly the same as in the desktop. QGIS Server is usually run as CGI/FastCGI module within the Apache Webserver.
Functionality	<ul style="list-style-type: none"> <li>• Enhanced WMS (Web Map Service) via HTTP GET. Supports GetCapabilities, GetMap, GetStyle, GetFeatureInfo and custom styling with Styled Layer Descriptor (Supported standards: WMS 1.3.0, WMS 1.1.1, and SLD 1.0.0).</li> <li>• SOAP via HTTP POST. Compatible with the ORCHESTRA and SANY Service Oriented Architecture.</li> <li>• Native configuration with SLD. User friendly map symbolisation with QGIS Desktop.</li> <li>• Cartographic extensions to SLD (diagrams, patterns and custom symbols with Scalable Vector Graphics). Exchange of</li> </ul>

	cartographic rules with the GetStyle operation.
Observations	

Project/software name	<b>GeoServer</b>
Author/Maintainer	GeoServer is an OSGeo project lead by GeoServer Project Steering Committee
Website	<a href="http://www.geoserver.org">www.geoserver.org</a>
License	GPLv2
Devel platform	Java
Description	GeoServer is a web server that allows you to serve maps and data from a variety of formats to standard clients such as web browsers and desktop GIS programs. Data is published via standards based interfaces, such as WMS, WFS, WCS, WPS, Tile Caching and more. GeoServer comes with a browser-based management interface and connects to multiple data sources at the backend.
Functionality	<p>Serve data from a variety of data stores:</p> <ul style="list-style-type: none"> <li>• Vector <ul style="list-style-type: none"> <li>○ Shapefiles, External WFS</li> <li>○ PostGIS, ArcSDE, DB2, Oracle Spatial, MySql, SQL Server</li> </ul> </li> <li>• Raster <ul style="list-style-type: none"> <li>○ GeoTiff, JPG and PNG (with world file), image pyramid, GDAL formats, Image Mosaic, Oracle GeoRaster</li> </ul> </li> </ul> <p>Data is served as safe and quick images using WMS and WMTS</p>

	<p>protocols:</p> <ul style="list-style-type: none"><li>• As the data is served up as an image your data is completely safe and secure. Unless they redigitise your data there is no way to steal the data. The appearance of each map layer can be controlled using the SLD standard which allows features to be coloured and labeled. By combining these rules with OGC Filters scale dependent styling can be implemented allowing more detail to be added as a user zooms in. Label collision management, grouping and priorities are also implemented.</li></ul> <p>Full vector data can be sent to a client using the WFS protocol:</p> <ul style="list-style-type: none"><li>• A WFS client can download vector data and use it for mapping, spatial analysis and other operations. Also if authorised the user can modify the data and send it back to the server to update the stored data using the WFS-T protocol. The data can be transmitted using GML (compressed) as well as other standard data formats like Shapefile and JSON.</li></ul> <p>Raster data values can be sent to a client using the WCS protocol:</p> <ul style="list-style-type: none"><li>• A GIS client can request the actual raster data for use in spatial analysis. This allows a user to create applications which can model the process described by your data.</li></ul> <p>On the fly reprojection:</p> <ul style="list-style-type: none"><li>• GeoServer supports the majority of the EPSG database of projections and can reproject to any of them on demand to allow clients with limited reprojection support to pass the load to the server.</li></ul> <p>Tiling Cache</p> <ul style="list-style-type: none"><li>• GeoWebCache, which is integrated into GeoServer, tiles and caches map images from a variety of sources such as WMS. It implements various service interfaces (such as WMS-C, WMTS, TMS, Google Maps KML, Virtual Earth) in order to accelerate and optimize map image delivery. It can also recombine tiles to work with regular WMS clients.</li></ul> <p>Web Processing Service (WPS)</p>
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	<ul style="list-style-type: none"> <li>• Geospatial algorithms, including those from JTS, can be called through GeoServer's WPS interface. This includes the chaining of processes, and using rendering transformations to create powerful visualisations through the WMS interface.</li> </ul> <p>Implemented Standards:</p> <ul style="list-style-type: none"> <li>• Support of numerous Open Geospatial Consortium (OGC) standards:</li> <li>• Web Map Service (WMS)</li> <li>• Web Map Tile Service (WMTS)</li> <li>• Web Feature Service (WFS), WFS-T (transactional)</li> <li>• Web Coverage Service (WCS)</li> <li>• Web Processing Service (WPS)</li> <li>• Filter Encoding (FE)</li> <li>• Style Layer Descriptor (SLD)</li> <li>• Geography Markup Language (GML)</li> <li>• KML Encoding Standard (KML)</li> </ul>
Observations	Active development of modules and plug-ins

Project/software name	<b>MapServer</b>
Author/Maintainer	MapServer is an OSGeo project lead by MapServer Project Steering Committee
Website	<a href="http://www.mapserver.org">www.mapserver.org</a>
License	MIT
Devel platform	C



<p>Description</p>	<p>MapServer is an Open Source geographic data rendering engine written in C. Beyond browsing GIS data, MapServer allows you create “geographic image maps”, that is, maps that can direct users to web content. The same application serves as a “map engine” for other portions of the site, providing spatial context where needed.</p> <p>MapServer was originally developed by the University of Minnesota (UMN) ForNet project in cooperation with NASA, and the Minnesota Department of Natural Resources (MNDNR). Later it was hosted by the TerraSIP project, a NASA sponsored project between the UMN and a consortium of land management interests.</p>
<p>Functionality</p>	<p>Advanced cartographic output:</p> <ul style="list-style-type: none"> <li>• Scale dependent feature drawing and application execution</li> <li>• Feature labeling including label collision mediation</li> <li>• TrueType font support for labeling and symbolization</li> <li>• Map element automation (scalebar, reference map, and legend)</li> <li>• Thematic mapping using logical or regular expression-based classes</li> <li>• Pluggable renderer support with drivers for AGG, Cairo, GD and OpenGL and others</li> <li>• Special provisioning for tiled output generation</li> <li>• Mask Layers</li> <li>• Precise Symbol Placement</li> <li>• Complex Multi Label/Symbol Symbology</li> <li>• Vector Fields</li> <li>• Label Leader Offsetting</li> <li>• SVG Symbology</li> <li>• Multiple Font Support</li> </ul> <p>Sophisticated spatial query support:</p> <ul style="list-style-type: none"> <li>• Identify features by attributes, point, bounding box or</li> </ul>

	<p>geometry across one or more layers</p> <ul style="list-style-type: none"> <li>• Support for raster queries</li> <li>• Fully customizable, template driven output</li> <li>• OGR-based query output generation</li> </ul> <p>Support for popular scripting and development environments:</p> <ul style="list-style-type: none"> <li>• CGI/FastCGI</li> <li>• PHP, Python, Perl, Ruby, Java, and .NET</li> </ul> <p>Cross-platform support:</p> <ul style="list-style-type: none"> <li>• Linux, Windows, Mac OS X, Solaris, and more</li> </ul> <p>A multitude of raster and vector data formats</p> <ul style="list-style-type: none"> <li>• Native support for ESRI shapefiles, PostGIS, ESRI ArcSDE and Oracle Spatial</li> <li>• Many other formats via GDAL and OGR</li> </ul> <p>Map projection support:</p> <ul style="list-style-type: none"> <li>• On-the-fly map projection with 1000s of projections through the Proj.4 library</li> </ul> <p>Implemented Standards:</p> <ul style="list-style-type: none"> <li>• Support of numerous Open Geospatial Consortium (OGC) standards <ul style="list-style-type: none"> <li>○ Web Map Service (WMS) (client/server), Web Feature Service (WFS) (non-transactional, client/server), WMC, Web Coverage Service (WCS), Filter Encoding (FE), Style Layer Descriptor (SLD), Geography Markup Language (GML), SOS, OM</li> </ul> </li> <li>• INSPIRE View Service compliant</li> </ul>
Observations	Active development of modules and plug-ins

Project/software name	<b>deegree</b>
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Author	deegree is an OSGeo project lead by deegree Project Steering Committee
Website	<a href="http://www.deegree.org">www.deegree.org</a>
License	LGPL
Devel platform	Java
Description	deegree is a standards-based Java framework for spatial data infrastructures and the geospatial web. It includes the OGC Web Map Service (WMS) reference implementation, a fully compliant Web Feature Service (WFS) as well as packages for Catalogue Service (CSW), Web Coverage Service (WCS), Web Processing Service (WPS) and Web Map Tile Service (WMTS).
Functionality	<ul style="list-style-type: none"> <li>• Geospatial data management: data access, visualization, discovery and security</li> <li>• WMS, WFS, WCS, WMTS and CSW compliant</li> <li>• Supported encodings (excerpt): GML, KML, CityGML, CS-W ISO19115/ISO19119 AP 1.0</li> <li>• Vector data sources: ESRI Shapefile, PostgreSQL/PostGIS, Oracle Spatial/Locator, MIF, ArcSDE, all relational databases supporting JDBC</li> <li>• Raster data sources: PNG, GIF, JPEG, BMP, TIFF as well as GeoTIFF, ECW, Oracle GeoRaster</li> <li>• Wide variety of spatial and attribute-based queries</li> <li>• Full object-relational support for complex geospatial database schemas</li> </ul>
Observations	-

## 7. WEB CLIENTS

JavaScript/HTML5 client libraries that can be used to build interactive webmapping applications.

Project/software name	<b>OpenLayers 3</b>
Author	OpenLayers is an OSGeo project lead by OpenLayers Project Steering Committee
Website	<a href="http://www.openlayers.org">www.openlayers.org</a>
License	BSD
Devel platform	JavaScript
Description	<p>OpenLayers3 is a light-weight mapping library for web and mobile clients which users modern browser technologies, such as HTML5, WebGL and CSS3.</p> <p>OpenLayers3 is a complete rewrite the previous robust and widely deployed OpenLayers2 library. They both offer an extensive set of features that cover basic to advanced web mapping and GIS requirements.</p>

<p>Functionality</p>	<p>Layers:</p> <ul style="list-style-type: none"><li>• Raster: WMS/WMTS, OpenStreetMap, MapQuest, Stamen, Bing, static images, etc.</li><li>• Vector: WFS, KML, GeoJSON, TopoJSON, GPX, and IGC.</li><li>• Heatmaps.</li><li>• Render vector layers as raster.</li></ul> <p>Controls and Interactions:</p> <ul style="list-style-type: none"><li>• Map overview, zoom slider, zoom in/out buttons, scale line, rotation, etc.</li><li>• Map pan, zoom and rotation, feature selection, modification, etc.</li></ul> <p>Styling and customization:</p> <ul style="list-style-type: none"><li>• Powerful styling of features: points, lines, polygons and icons.</li><li>• Customize controls look and feel using CSS3.</li></ul> <p>Overlays:</p> <ul style="list-style-type: none"><li>• Render any DOM element at any place on the map.</li><li>• Great flexibility to create tooltips and markers.</li><li>• Mix the power of HTML5 capabilities with a mapping application.</li></ul> <p>Events:</p> <ul style="list-style-type: none"><li>• Attach listener functions to react against map events.</li><li>• Create your custom controls or interactions.</li></ul> <p>Misc:</p> <ul style="list-style-type: none"><li>• Mobile browser support.</li><li>• Light weight library. Build customized packages to reduce size.</li><li>• Render maps using different technologies: Canvas, WebGL, DOM.</li><li>• Raster analysis (change hue/saturation).</li></ul>
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Observations	-
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Project/software name	Leaflet
Author	Vladimir Agafonkin
Website	<a href="http://www.leafletjs.com">www.leafletjs.com</a>
License	BSD
Devel platform	JavaScript
Type	Web client
Description	Leaflet is a light-weight library used for building mobile-friendly interactive maps. It works across all major desktop and mobile platforms. The simplicity of the library makes it perfect for not very complicated web-mapping tasks. It has a well-documented API and a simple source code.
Functionality	<p>Map Layers:</p> <ul style="list-style-type: none"> <li>• Tiles, Markers, Popups, Image overlays, WMS, GeoJSON</li> <li>• Vectors: polylines, polygons, circles, rectangles, circle markers</li> <li>• Layer groups</li> </ul> <p>Customization Features:</p> <ul style="list-style-type: none"> <li>• Pure CSS3 popups and controls for easy restyling</li> <li>• Image- and HTML-based markers</li> <li>• Custom map layers, controls, projections</li> <li>• Powerful OOP facilities for extending existing classes</li> </ul> <p>Interaction and Visual Features:</p> <ul style="list-style-type: none"> <li>• Drag panning with inertia</li> </ul>

	<ul style="list-style-type: none"><li>• Keyboard navigation</li><li>• Multi-touch</li><li>• Zoom/Panning animation</li><li>• Very nice default design for markers, popups and other map controls</li><li>• Retina resolution support for tile layers and markers</li></ul> <p>Performance Features:</p> <ul style="list-style-type: none"><li>• Hardware acceleration</li><li>• Utilizing CSS3 features to make panning and zooming really smooth</li><li>• Smart polyline/polygon rendering</li><li>• Modular design allows including only required features</li><li>• Tap delay elimination on mobile devices</li></ul> <p>Map Controls:</p> <ul style="list-style-type: none"><li>• Zoom buttons, Attribution, Layer switcher, Scale</li></ul> <p>Misc:</p> <ul style="list-style-type: none"><li>• Extremely lightweight — around 34 KB of gzipped JS code</li><li>• No external dependencies</li></ul>
Observations	Its basic functionalities can be extended through the use of an impressive amount of plug-ins.