

## Guest Editorial

# Free and Open Source Software for Geospatial Applications (FOSS4G): A Mature Alternative in the Geospatial Technologies Arena

The creativity, dynamism and high-profile success stories of the Free and Open Source Software (FOSS) and FOSS for Geospatial applications (FOSS4G) movements are attracting increasing attention from end users, developers, businesses, governments, educators and researchers around the world (e.g. Weber 2004, Walli et al. 2005, CRM-Reviews 2006, Faber 2007). Free Software refers to liberty, not price. It means that the program's users have the freedom to run the program for any purpose, access the code to study how it works and change it, redistribute copies, and redistribute copies of modified versions of the software (GNU Project; <http://www.gnu.org/philosophy/free-sw.html>). To be considered Open Source, software must offer more than just access to the source code, it must comply with 10 criteria listed in the Open Source Initiative (<http://www.opensource.org/docs/osd>) (Appendix 1). FOSS spans these two concepts. Today there are mature FOSS4G projects and software stacks ready to support stakeholders in addressing the most pressing social, economic and environmental challenges of the twenty-first century.

The FOSS movement has 20-40 years of history (DiBona et al. 1999, 2005; Raymond 2001; Lagesse 2002; Moody 2002; Williams 2002). There is a mature FOSS project for almost every software need and application. As of December 2011 Freecode (<http://freecode.com>) tracks 45,000 and Sourceforge (<http://sourceforge.net>) 326,613 FOSS projects varying in quality, completeness, and stability. Even if only 10% of these projects are active and stable as suggested by Daffara (2007), the numbers are staggering, as are the number of times they are downloaded. For example, Sourceforge reported more than 4 million downloads in one day (13 December, 2011), and the most requested project of all time (eMule, <http://sourceforge.net/projects/emule/>) has been downloaded over 600 million times. Currently there are 355 FOSS4G projects listed in FreeGIS.org (<http://freegis.org>) and Open Source GIS (<http://opensourcegis.org>). Some of these projects have a history that dates back to the early 1980s such as the GRASS Geographic Information System (<http://grass.osgeo.org/>; Mitsova and Neteler 2004).

In recent years there has been an exponential growth in the number of studies in the fields of economics, psychology, anthropology, law, software development, and computer

science which aim to understand the motivation of contributors as well as the development process and impacts of the FOSS movement (Krogh and Hippel 2003, Spenellis and Szyperski 2004, Rossi 2004, Bitzer et al. 2007, Schweik et al. 2009, Host and Orucevic-Alagic 2011, Crowston et al. 2012). There is increasing support for and endorsement of FOSS projects by large private hardware and software companies (C/NET News 2005, Babcock 2006). There are calls by national and local governments, international organizations, scientific advisory boards to presidents, and development officials to support the use and development of such projects (e.g. Wade 2005, Lowe 2002, Schenker 2003, PITAC 2000, and Wambui 2004, respectively).

FOSS/FOSS4G alternatives have been declared crucial for the developing world because they enable emerging countries to develop their own technology instead of having to import it; provide a path to close the digital divide between rich and poor countries; create healthy competition for proprietary software; may lead to affordable pricing and increased access; address some national security concerns; and can be the base for creating Spatial Data Infrastructures in these countries (Naronha 2002, 2003; Rajani et al. 2003; Schenker 2003; Wambui 2004; Holmes et al. 2005; Camara and Fonseca 2007). In addition, there is interest in FOSS on the part of developed countries such as France (Marson 2005, Kaneshige 2008), Germany (Gillespie 2000), UK (Lettice 2004), and Australia (Coonan 2004) just to name a few.

FOSS and FOSS4G under certain circumstances can be superior alternatives to their proprietary counterparts (Moreno-Sanchez et al. 2007, Wheeler 2007). A growing number of commercial services, studies, and resources are available to assist potential users in choosing and deploying the best FOSS/FOSS4G for their specific informational needs (e.g. Holck et al. 2005; Woods and Guliani 2005; Ven et al. 2008; The FOSS Evaluation Center, <http://foss.technologyevaluation.com/>; OpenGeo, <http://opengeo.org/products/suite/>). Though findings are varied as to the strengths and weaknesses of FOSS for specific contexts and purposes (Erlich and Aviv 2007, Ven et al. 2008), today it is clear that FOSS/FOSS4G not only provide healthy competition for proprietary solutions but also opportunities for mutual benefit and complementarity.

The reasons for FOSS adoption vary from pragmatic to ideological, but they should be based not only on their technical merit, their no-cost feature, or their access to the source code. Adopting FOSS for the wrong reasons can have unintended consequences, while not adopting them might leave considerable opportunities and benefits unused. FOSS and FOSS4G should be evaluated at par with commercial off-the-shelf (COTS) software in terms of their technical features, reliability, ease of use, documentation, technical support, customizability and extensibility, costs of training, support and maintenance, and management requirements (e.g. budget, in-house development team expertise, long-term maintainability) (Wang and Wang 2001, Woods and Guliani 2005, Ven et al. 2008). Wheatley (2004) provides examples that dispel some of the most common concerns about FOSS in regard to some of these criteria (e.g. 'FOSS has no support'; 'FOSS is not for mission-critical applications'). The evaluation of FOSS4G also should include the following questions (Ramsey 2005):

- Is the software well documented?
- Is it clear who the core development team is?
- Is the software modular?
- How wide is development community?
- How wide is the user community?

Positive answers to these questions indicate a healthy and mature FOSS4G project which provides a greater degree of confidence in its use.

For almost every geospatial software need and niche (e.g. desktop GIS, spatial extensions to Database Management Systems, WebGIS, code libraries) there is at least one mature FOSS4G project with a well-documented record of successful application in diverse contexts (some of the most frequently used are listed by Holmes et al. 2005; Bruce 2007; Saenz-Salinas and Montesinos-Lajara 2009; Steiniger and Bocher 2009; Garbin and Fisher 2010; Tsou and Smith 2011; Steiniger and Hunter 2011; OSGeo-Live DVD, <http://live.osgeo.org/en/index.html>). In 2006 the Open Source Geospatial Foundation was created to support and promote the collaborative development of open geospatial technologies and data (<http://www.osgeo.org/>). There is a growing number of books, online materials, workshops and commercial services available to learn specific FOSS4G and software stacks. Geographic information science and technology educators from around the world are increasing their communication and coordination to improve access and systematization of materials and data for teaching and curriculum development using FOSS4G (e.g. OSGeo Educational Content Inventory, [http://www.osgeo.org/educational\\_content](http://www.osgeo.org/educational_content); E-learning for the Open Geospatial Community, <http://elogeo.nottingham.ac.uk/xmlui/>; GeoTech Center, <http://www.geotechcenter.org/>).

The interest in FOSS4G is reflected in the growing number of presentations and increased attendance at the annual FOSS4G international conference. The 2011 event held in Denver had over 900 participants from 42 countries, 24 workshops, and 150 presentations. The presentations and discussions made evident the speed of progress, high level of maturity and advanced capabilities of many FOSS4G projects. This special issue is dedicated to articles selected from the Academic Track of this conference. They exemplify the diversity and sophistication of FOSS4G applications around the world. These articles were reviewed and chosen for this issue by the 2011 International Scientific Committee of this track.

The first three articles present the development of geoportals. Geoportals are World Wide Web gateways that organize content and services such as directories, search tools, community information, support resources, data and applications related to geographic information (GI). They provide capabilities to query metadata records for relevant data and services, and then link directly to the on-line content services themselves. Geoportals are making a major contribution to simplifying access to GI, and in so doing are helping to encourage and assist people who want to use GI concepts, databases, techniques and models in their work (Maguire and Longley 2005, De Longueville 2010).

The first article by Supak et al. developed a flexible framework for the creation of geoportals using PostgreSQL/PostGIS, GeoServer, and a customized GeoExplorer map viewer. They exemplify the flexibility of their framework by developing two applications, one for public health information and another for the management of forest landowner information in North Carolina, USA. Fry et al. describe the development of a geoportal to enhance the capability of researchers to discover and access socio-economic research data related to Wales, United Kingdom. The geoportal offers access to a rich meta-database of government surveys, geo-referenced qualitative data, “grey” data (e.g. from transcripts, journal publications, books, PhD dissertations) and Government administrative data. Finally, Brovelli et al. digitized, georeferenced, and created metadata for historical maps from the State Archive of Como, in northern Italy. A geoportal was created to provide access to an application for the query and exploration of this metadata, and also to a visualization application capable of comparing the historical maps to current maps.

The next two articles demonstrate the use of FOSS4G to process and manage very large data sets. Fujioka et al. developed a system capable of efficiently handling over 31 million records from the worldwide Census of Marine Life in a Cloud computing environment. This approach has markedly improved the performance of the system and

online user experience while providing a scalable, standards-compliant and interoperable framework. Next, Newcomb shows how GRASS was used to process numerous very large elevation raster data layers (with 765 million cells each) required to model state-wide solar irradiation on North Carolina (USA) aquatic habitats throughout the year.

The article by Rice et al. describes how a combination of proprietary and FOSS4G were used to create a system capable of collecting, processing and distributing Volunteered Geographic Information (VGI) to assist blind and visually-impaired people in dealing with transitory hazards (e.g. construction, temporary obstacles) in urban environments. The system is capable of receiving and processing voice, text message and e-mail reports. The VGI is georeferenced using a gazetteer of local place names and commonly-used variants of feature names in several languages spoken by students in a university campus in Virginia, USA.

The articles by Cannata et al. and Molinari et al. present the calibration and implementation of models in FOSS4G systems. The former created two new routines for GRASS that implement models used in assessing the risk of landslide-generated tsunamis. They demonstrate their application in Lake Como, northern Italy. Molinari et al. improved the calibration of a model implemented in PCRaster (<http://pcraster.geo.uu.nl/>) for simulating runoff and deposition of landslide phenomena over complex topography. They tested their enhancements in a case study in the Canaria Valley, Switzerland.

The last two articles explore FOSS, Open Specifications and technologies used to facilitate access to distributed data and computing resources. First van Zyl et al. from South Africa extended an Open-Source scientific workflow and provenance management system that provides support for simulations, data exploration and visualization (Vistrails, <http://www.vistrails.org>) to allow for geospatial processing, multi-tasking, and distributed processing. In the last article, Baart et al. compared the performance, usability, and features of the most mature Open Specifications for the distribution of gridded data over the World Wide Web. Their comparisons were performed in the context of the Dutch National Model and Data Centre.

The articles in this special issue showcase the power, adaptability and sophistication of FOSS4G. Today the question is no longer if FOSS4G are mature or capable, but how to take advantage of their features and development philosophy to deliver the systems and geospatial information demanded by citizens, businesses, governments, educators and researchers around the world.

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## Appendix 1

The distribution terms of open-source software must comply with the following criteria (Open Source Initiative, <http://www.opensource.org/docs/osd>):

### 1. *Free Redistribution*

The license shall not restrict any party from selling or giving away the software as a component of an aggregate software distribution containing programs from several different sources. The license shall not require a royalty or other fee for such sale.

## 2. *Source Code*

The program must include source code, and must allow distribution in source code as well as compiled form. Where some form of a product is not distributed with source code, there must be a well-publicized means of obtaining the source code for no more than a reasonable reproduction cost preferably, downloading via the Internet without charge. The source code must be the preferred form in which a programmer would modify the program. Deliberately obfuscated source code is not allowed. Intermediate forms such as the output of a preprocessor or translator are not allowed.

## 3. *Derived Works*

The license must allow modifications and derived works, and must allow them to be distributed under the same terms as the license of the original software.

## 4. *Integrity of the Author's Source Code*

The license may restrict source-code from being distributed in modified form *only* if the license allows the distribution of "patch files" with the source code for the purpose of modifying the program at build time. The license must explicitly permit distribution of software built from modified source code. The license may require derived works to carry a different name or version number from the original software.

## 5. *No Discrimination Against Persons or Groups*

The license must not discriminate against any person or group of persons.

## 6. *No Discrimination Against Fields of Endeavor*

The license must not restrict anyone from making use of the program in a specific field of endeavor. For example, it may not restrict the program from being used in a business, or from being used for genetic research.

## 7. *Distribution of License*

The rights attached to the program must apply to all to whom the program is redistributed without the need for execution of an additional license by those parties.

## 8. *License Must Not Be Specific to a Product*

The rights attached to the program must not depend on the program's being part of a particular software distribution. If the program is extracted from that distribution and used or distributed within the terms of the program's license, all parties to whom the program is redistributed should have the same rights as those that are granted in conjunction with the original software distribution.

## 9. *License Must Not Restrict Other Software*

The license must not place restrictions on other software that is distributed along with the licensed software. For example, the license must not insist that all other programs distributed on the same medium must be open-source software.

### 10. License Must Be Technology-Neutral

No provision of the license may be predicated on any individual technology or style of interface.

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