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Data Visualisation Tools: Part 2 – Spatial Data in a Web 2.0 Environment and Beyond

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1. Introduction

Part 1 of this briefing paper showcased examples of collaborative web services which use 'community-driven' Web 2.0 technologies to visualize or 'mash' numeric data. These mashups (web application that combines data and/or functionality from more than one source) allow researchers to upload and analyse their own data in 'open' and kinetic environments.

Part 2 on the other hand is a snapshot in time of a range of dynamic and innovative developments which are shaping the ever-evolving geo-web environment.

The UK's National Geospatial Data Framework (NGDF) estimates that as much as eighty per cent[1] of the information collected in the UK today is geo-referenced in some form. Each photograph held in Flickr or Panaramio for example, has a spatial element (the geographical location of where the photo was taken). There are a whole range of spatial visualisations or mashups using mapping tools, earth viewers or open geo-browsers such as Google Earth, MS Virtual Earth, NASA's World Wind, OpenStreetMap, Open Layers, and Yahoo Maps which capitalize on and utilize the preponderance of location-based information. The content used in mashups is typically sourced from a third party Web 2.0 service via a public interface through 'screen scraping' or Application Programming Interfaces (APIs) and can be achieved with very basic programming skills.

Over recent years we have seen an increase in both research and domestic use of personal computing, social networking tools, web utilities and services. The resultant rise in computer literacy brings with it certain expectations regarding what can or should be realised in terms of functionality in a desktop, web or e-research environment. What is also evident is that access to free or 'open' spatial data facilities and tools to manipulate, share and visualise geo-referenced data is gathering momentum.

[1] Reid, J., 2002. geoXwalk – A Gazetteer Server and Service for UK Academia. IASSIST Quarterly, Vol. 26, Issue 3 - http://iassistdata.org/publications/iq/iq26/iqvol263reid.pdf

Thus Part 2 aims to discuss and highlight some of the many examples of spatial (or geographic) data mashups using Web 2.0 technologies and geo-browsers and how they are or can be utilised in an institutional or collaborative research realm. It will also touch on *neo-geography* and Volunteered Geographic Information (VGI) in addition to other open geo-processing tools and organisations which publish and support the use of spatial data in open ways.

As with Part 1 this paper does not intend to conduct an investigation into the definitive merits of each mashup, utility or service but merely report on what's out there, how it is being used and for what purposes within the realms of academic research. Mashups range from the ad-hoc to the formal within an academic setting. This paper is inclined to focus on the latter.

As indicated in Part 1, researchers will have to take into account the inconstant nature of the web; resources such as those described above may not be around in two, five or ten years. Not only will there be further advances in web technologies but services merge, are bought out or indeed cease to exist. Services that start off open or free may become 'closed'. Resources may start up with a particular rationale but may evolve into a completely different service or resource. Issues regarding the cultural and technical aspects surrounding the sharing and publishing of spatial data produced from personal or academic research abound.

In the wider arena there are current concerns and confusion over the assertion of IPR and copyright of derived geospatial data particularly where third party data are included. The document 'Designing a licensing strategy for sharing and re-use of geospatial data in the academic sector'[2] (Waelde & McGinley, 2006) goes some way to discussing and addressing certain issues as part of the JISC-funded GRADE project.

JISC TechWatch have also commissioned a report into the use of licensed spatial data in Web 2.0 mashups which hopefully will offer clarity and perhaps discuss flexible mechanisms for sharing spatial data visualisations e.g. through 'Click-Use' or 'Science Commons[3]' agreement.

Thus as with Part 1, this paper does not purport to provide solutions but aims to show what is possible.

2. Mashups - locating

http://www.programmableweb.com/tag/mapping

Programmableweb describes itself as 'where you can keep-up with what's new and interesting with mashups, Web 2.0 APIs (Application Programming Interface), and the new Web as Platform.' It acts as a directory, a news source, a reference guide, a community and upon registration provides resources on how to use APIs and build applications.

[2] http://edina.ac.uk/projects/grade/gradeDigitalRightsIssues.pdf
[3] http://sciencecommons.org/projects/publishing/open-access-data-protocol/

Currently there are 1740 (August 2008) spatial mashups that utilise a whole range of Web 2.0 services, examples include:

- 3D Geology Maps - http://www.3dgeomaps.com/
- Cool Maps :: 7 Wonders - http://coolmaps.7wonders.googlepages.com/
- Blogabond - http://www.blogabond.com/Home.aspx
- Climate Change 2030 - http://www.mibazaar.com/nationundersiege/
- Earth Shots Earth Explorer - http://www.earthshots.org/earth-explorer/
- World Airport and Airspace Database - http://www.roborg.co.uk/airport/
- Weather Bonk - http://www.weatherbonk.com/weather/index.jsp
- Twittervision - a real-time geographic visualisation of posts to Twitter - http://twittervision.com/ (see also GeoTwitter – http://geotwitter.net)
- Census Dashboard - http://www.cynergysystems.com/blogs/blogs/andrew.trice/strikeiron/Dashboard.html

EVERYTHING 2.0 http://bobstumpel.blogspot.com/

Bob Stumpel's blog Everything 2.0 describes itself as 'The most complete directory of Web 2.0 initiatives (well over 7,500 indexed)'. Posts labelled Geo2.0 for example, return an impressive range of links to mapping mashups.

http://www.webmashup.com/

Webmashup.com is an Open Directory for locating and adding mashups and Web 2.0 APIs. Registration is free.

3. Mashups - creating

http://geocommons.com/

GeoCommons in a sense formalises a spatial approach to data visualisation and mashups. It describes itself as 'a place where anyone can explore, create and share maps and data'.
Finder, the first application of the GeoCommons Suite is a free application built to enable anyone to locate, import, export and mashup geodata for numerous types of applications. Users can create a personal library of their own spatial data and work with any of the 5000 GeoCommons datasets. All of the datasets on Finder can be downloaded as KML, Shapefile or CSV. The second utility of the GeoCommons Suite is *Maker*[4], a cartographic tool that enables users to create, stylize, publish and share both their own spatial data and GeoCommons open data.

[4] To be launched Autumn 2008

http://www.openstreetmap.org/

Licensed under the Creative Commons Attribution-Share Alike 2.0 license **OpenStreetMap** (OSM) or 'the Free Wiki World Map' is a free editable map of the whole world which allows user to view, edit and use geographical data in a collaborative way from anywhere on earth. Unlike Google Map and Google Earth the user-generated geo-content is made freely available to all.

The maps are created using data from portable GPS devices, aerial photography and other free sources. Registered users can upload GPS track logs and edit the vector data using the editing tools provided.

The **Freemap project** (http://www.free-map.org.uk) currently uses OSM to freely create and annotate maps of the UK countryside. Freemap interactive maps aim to show not only the official rights of way, but all paths with public access, blocked or new routes, viewpoints in addition to other 'Volunteered Geographic Information' from users. Currently Freemap coverage is limited to certain areas.

In August 2008 Google launched **Mapmaker** (http://www.google.com/mapmaker) – a web-based 'wiki-map' tool that allows registered users to add features to certain countries in Google Maps that Google feel are poorly covered (*note:* the current list of countries is mainly small island communities although this may change in time). Currently there's no API to expose Mapmaker derived data.

There is a range of other standalone utilities which offer similar functionality such as:

OS OpenSpace - a JavaScript® Application Programming Interface (API) which allows you to build Web 2.0 applications using Ordnance Survey data. Non-commercial users can register for a free API key which allows them to interact, collaborate and share geographic content with other developers and the wider community.

OS OpenSpace allows you to add markers, lines and polygons on top of Ordnance Survey maps, and also conduct gazetteer place name searches. Users are restricted to 30000 tiles of data per day and up to 1000 place name look-ups.
(http://openspace.ordnancesurvey.co.uk/)

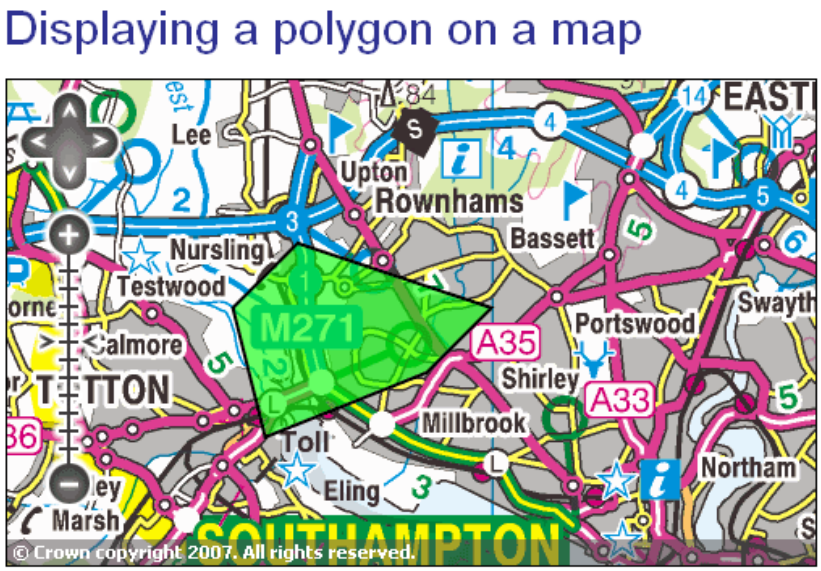

Fig. 1 Displaying a polygon on a map through OS OpenSpace

In addition to OS OpenSpace API, Ordnance Survey has another Web 2.0 utility **OS Explore** which allows users to share, comment on, blog and rate routes (up to scale 1:50,000) although users cannot access the underlying data.

Mapufacture – 'helping build the geospatial web'. Mapufacture allows the user to create a new map, add feeds and add data. Maps can be used in other applications by using the GeoRSS or KML feeds. It also aims to provide a large repository of geographic data sources including GeoRSS feeds, KML, Shapefiles, and triple-tagged feeds and pages.
(http://mapufacture.com/)

Note: At the time of publishing Mapufacture and FortiusOne (the 'next-generation intelligent mapping solution' behind GeoCommons) are in the process of merging.

Platial – 'the people's atlas' – a combination of social networking and mapping APIs.
(http://www.platial.com/)

mapbuilder.net which describes itself as a 'rapid mashup development tool to build custom Google and Yahoo maps without any knowledge of the Google/Yahoo Maps API and JavaScript.' It provides a straightforward Graphical User Interface (GUI) for the map building process with geocoding and import features. Users can tag locations on their maps, and publish and share their maps either on MapBuilder.net or their own website. As with many of these tools and services registration is free.
(http://www.mapbuilder.net/).

Such utilities empower the novice user by enabling the creation of spatial representations and visualisations with a minimal knowledge of the underlying technology. This does however warrant mention of the statement 'if it is computer generated and looks good it must be right!' For example, GIS users are all too aware as to how easy it is to create meaningless or misrepresentative cartographic output. A level of statistical[5] and spatial literacy[6] is required in order to add intelligence to interpretation.

Other utilities with notable and novel spatial creations and visualisations include:

- quikmaps – 'Maps for the masses' – http://quikmaps.com/
- FlashEarth – satellite and aerial maps of the earth from multiple sources inside a single Flash-based interface - http://www.flashearth.com/
- Breathing Earth - http://www.breathingearth.net/
- Wikimapia – 'Let's describe the whole world' - http://wikimapia.org/
- ocarto – 'Maps made easy' - http://www.ocarto.com/
- Danny Dorling's Worldmapper – 'The world as you've never seen it before' - 600 or so cartograms where territories are re-sized on each map according to statistical values on demographic topics - http://www.sasi.group.shef.ac.uk/worldmapper/index.html
- Open Air Traffic Control (ATC) - a worldwide network of receiver stations, permitting anyone to see where planes were located 5 minutes ago - http://www.openatc.com/
- Plazes – 'Right Plaze, Right People, Right Time' - http://plazes.com/
- Planiglobe – 'Make your own digital vector map' - http://www.planiglobe.com/
- Wayfaring – 'Follow you, follow me' - http://www.wayfaring.com/
- DIY Map – 'Create clickable maps in Flash' - http://backspace.com/mapapp/
- MAPLight.org – 'Money and Politics: illuminating the connection' - http://www.maplight.org/
- OnionMap – 'Global People Map' - http://us.onionmap.com/web/us/

[5] http://wordpress.com/tag/misleading-statistics/
[6] http://www.spatial-literacy.org/

4. Spatial Visualisation and Research Organisations

Web2.0 technologies and interactive earth viewers or geo-browsers such as Google Earth and MS Virtual Earth have paved the way for research and governmental organisations to explore and expose their findings in new and innovative ways:

- The SRON Netherlands Institute for Space Research and the KNMI (Royal Netherlands Meteorological Institute) have produced several data products via their SCIAMACHY Google Earth network. (http://www.sron.nl/index.php?option=com_content&task=view&id=1506&Itemid=588)

- The British Oceanographic Data Centre have written a Keyhole Markup Language (KML[7]) generator application to automatically provide a KML file with each data request in order to enhance their spatial information. (http://www.bodc.ac.uk/about/news_and_events/google_earth.html)

- The Office of the United Nations High Commissioner for Refugees (UNHCR) uses Google Earth to focus on refugees and displaced people located in remote areas of the world by introducing a number of themed layers complete with video, images, news and links to related resources including statistical databases. (http://www.unhcr.org/events/47f48dc92.html)

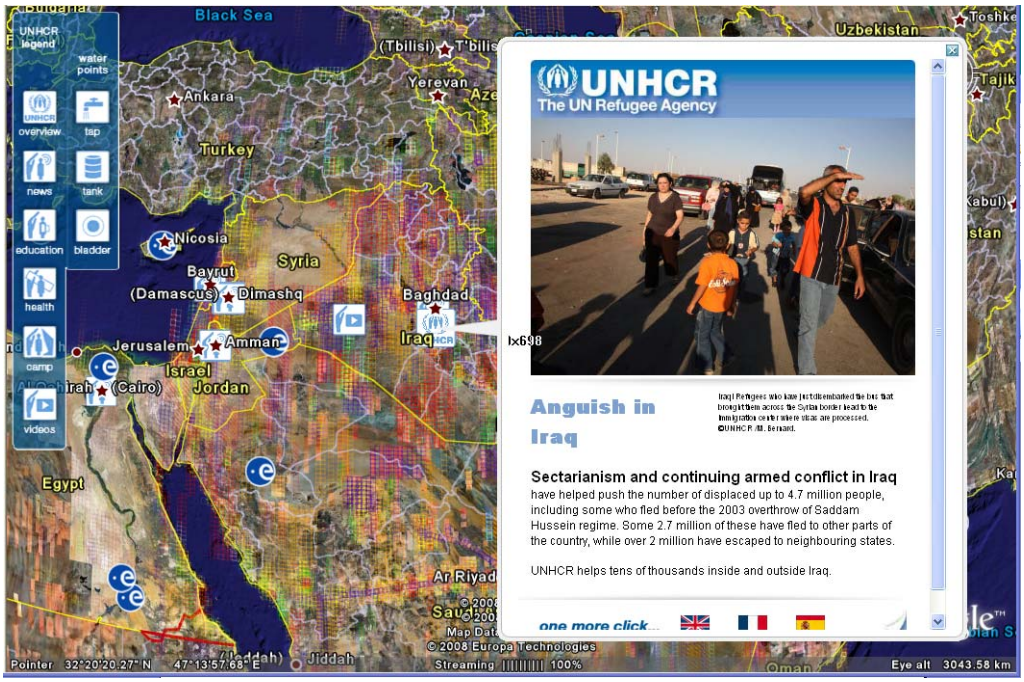

Fig. 2 The UN Refugee Agency – Sectarianism and continuing armed conflict in Iraq

- The U.S. National Snow and Ice Data Center offer Google Earth files that allow users to overlay a range of data-based images such as iceberg tracks, glaciers, glacier footprints onto a virtual globe. (http://nsidc.org/data/virtual_globes/)

[7] KML is an XML-based Open Geospatial Consortium (OGC) standard format for managing spatial data across a variety of mapping applications.

- NASA's Goddard Earth Sciences Data and Information Services Center has established a portal which provides access to NASA imagery downloadable as KML files for importation into Google Earth. (http://daac.gsfc.nasa.gov/googleearth/index.shtml)

- In order to get a better understanding of atmosphere volume the European Space Agency DS3D script produces semi-transparent polygons in KML format. Each polygon represents a three-dimensional view from a series of meteor cameras. (http://www.rssd.esa.int/index.php?project=METEOR&page=ds3d)

- The James Reserve at the Centre for Embedded Networked Sensing at UCLA. The James Reserve Environmental Observatory is using Google Earth to display and make available sensor data and webcam views of the Reserve. (http://dms.jamesreserve.edu/)

- The USGS Earthquake Hazards Program display real-time earthquakes and plate boundaries in Google Earth. (http://earthquake.usgs.gov/research/data/google_earth.php)

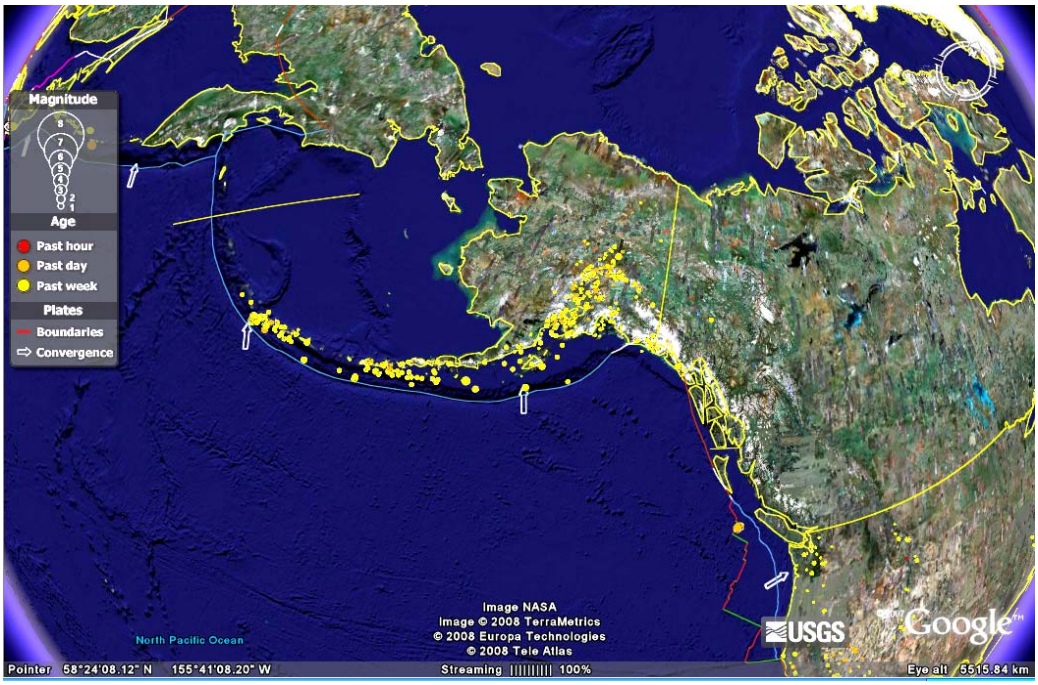

Fig. 3 USGS Earthquake Hazards Program - Real-time earthquakes and plate boundaries coloured by age

- AntWeb (California Academy of Sciences) have developed tools to facilitate the use of ants in inventory and monitoring programs, and to provide ant taxonomists with access to images of type specimens. Users of Google Earth can now plot all the ant species known to AntWeb on a 3-dimensional interactive globe of satellite images. (http://www.antweb.org/)

- The SensorBase project based at the Center for Embedding Networked Sensors (CENS) at UCLA publish, share, and manage users' sensor data. SensorBase also acts as a centralized hub for data from many different sensor networks. (http://sensorbase.org/)

Géoportail is a web mapping service of the French government. It was developed by France's National Geographic Institute (IGN) and Office of Geological and Mineral Research as part of an INSPIRE (INfrastructure for Spatial InfoRmation in Europe) directive to develop an online administrative mapping service.
(http://www.geoportail.fr/)

Géoportail features Google Earth or Google Maps style localisation positioning and map search services which will enable users to view high resolution images of locations throughout mainland France and its territories.

The Spanish General Directorate of Cadastre also use Google Earth for example, to visualise the spatial data it administers to governmental bodies, citizens and corporations.

One could imagine that such visualisations, new data products, geo-processing tools and practices produced by large research and governmental organisations are amongst many converging precursors to a whole new mode of co-operative 'meta-research'.

For example, the JISC-funded EDINA National Data Centre are currently investigating through two projects[8][9], access to their geospatial data services via the National Grid Service (NGS) using open interoperability standards. Social networking services and technologies are being employed to enhance research output, create inter and intra-disciplinary collaborations which make services and new resources (and ultimately new knowledge) available to a completely new and potentially cross-disciplinary audience within an e-Research framework. Google and its upcoming Android mobile software and Nokia's Navteq[10] mobile navigation service are currently leading the way in mobile mapping. There's the concept of the 3D Geoweb and geo-collaborations via GEON[11], data mining technologies and spatiotemporal visualisation. There are also the enabling technologies of the Semantic web, reasoning engines and the Resource Description Framework (RDF) in addition to Web 3.0 software agents that know how to reason over activities, events, locations, people, organisations, and their inter-relationships.

5. Web 2.0 mapping utilities and academic research

Academic research groups and departments are utilizing open spatial data, GIS and Web 2.0 technologies such as RSS feeds, podcasts, wikis, commenting and tagging in new and innovative ways to enhance and report their findings.

The mashing of data from disparate sources and disciplines has the potential to open up new avenues of thought, investigation and meaning. In the broader realm of e-science/e-research Dave de Roure (Southampton University) talks about 'reducing time-to-discovery by reducing time-to-experiment[12]', and states that e-research will have succeeded 'when there are routine scientific advances that would not have happened otherwise[13].' Web 2.0 mapping utilities and spatial visualisations form an integral part of this process as distinctions between web sites and web services are blurring with content becoming more and more remixable, services and tools more freely available. The approach to knowledge generation, exchange and publication by a new generation of researchers, conversant with open data, tools and methodologies may facilitate new and routine advances to address major societal issues.

[8] SEE GEO - http://edina.ac.uk/projects/seesaw/seegeo/index.html
[9] GEESE - http://edina.ac.uk/projects/geese/
[10] Nokia Maps 2.0 provides vector data supplied by Navteq and TeleAtlas. Geographic data for over 200 countries are available, 70 of those countries have navigable data. Travel data will be supplied by Lonely Planet.
[11] GEON - http://www.geongrid.org/
[12] http://www.eresearch.edu.au/docs/270607/Dave_De_Roure_V1.pdf
[13] http://www.slideshare.net/dder/the-new-science-bangalore-edition

Current examples of researchers' use of geo-referenced data and open utilities include:

- http://thematicmapping.org - a project (initiated as part of an MSc in GIS at University of Edinburgh) to investigate the use of geo-browsers for thematic mapping based on the OGC KML standard and open source toolkits. Visualisations include proportion symbol maps, animated prism maps, charts, 3D maps.
  Earth Atlas (http://www.earthatlas.info/) was launched recently by thematicmapping.org allowing users to upload KML data for use with statistical content, background imagery using Google earth in a web browser.

- Princeton University's International Networks Archive
  New systems of cartography including *non-geographic mapping*, and the interactive mapping experiment *dynamic mapping* - http://www.princeton.edu/~ina/interactive_maps/index.html

- John Hopkins University's Interactive Map Tool
  Supports digital field assignments allowing users to create custom mashups using a variety of digital media, text and data - http://www.cer.jhu.edu/index.cfm?pageID=351

- Minnesota Interactive Internet Mapping Project
  A mapping application that provides maps and imagery similar to Google Maps – claims to be data rich, interactive, secure, easy to use, have analytical capabilities - http://maps.umn.edu/

- Research at Pompeu Fabra University, Barcelona
  Researchers mining spatial-temporal data provided by geotagged Flickr photos of urban locations – http://www.giradin.org/fabien/tracing/

- ABC Earth
  The Archaeological Computing Laboratory at the University of Sydney have devised a programming interface that integrates spatially referenced news feed data (video, images, news content) from the Australian Broadcasting Corporation Archive with Google Earth - http://www.abc.net.au/apps/earth/

world freedom atlas

World Freedom Atlas - http://freedom.indiemaps.com/

The World Freedom Atlas was completed over the summer of 2007 by Zachary Johnson as part of a final project at the University of Wisconsin. This geovisualisation tool describes itself as being designed for those who 'wish to have a better understanding of issues of freedom, democracy, human rights, and good governance.' Over 300 variables from NGOs and IGOs are currently available although this was mostly harvested from the Quality of Government Institute's Time Series Dataset[14]

[14] Teorell, Jan, Soren Holmberg & Bo Tothstein. 2007. The Quality of Government Dataset, version 1. Goteborg University: the Quality of Government Institute, http://www.qog.pol.gu.se

6. UCL Centre for Advanced Spatial Analysis -
http://www.casa.ucl.ac.uk/

The Centre for Advanced Spatial Analysis (CASA) is based at University College London. It aims to develop nascent computer technologies in several disciplines which deal with geography, space, location, and the built environment. As an interdisciplinary research centre, expertise is drawn from a range of subject areas. These include archaeology, architecture, cartography, environmental science, geography, planning, remote sensing, and transport studies.

CASA participate in a range of national and international research projects[15] and programmes including **GeoVUE**, one of seven nodes in the National Centre for e-Social Science whose mission is to develop grid and web-based technologies for the social sciences via geographic simulations. GeoVUE aims to develop new kinds of virtual urban environments (VUEs) through which users can participate and collaborate in furthering their understanding of cities by linking an array of freely available spatial data to GIS-related software.

Note: Another research node of the National Centre for e-Social Science dealing with geographic simulations is **MoSeS** – http://www.ncess.ac.uk/research/geographic/moses/
- a three year project running at the University of Leeds whose objective is to develop representation of the entire UK population as individuals and households using genetic algorithms. Modelling tools are being developed to address a range of research and policy-related questions such as healthcare provision, transport and housing. Simulated demographic data is also being visualized using geo-browsers.

Demonstrators developed at CASA include:

MapTube - http://www.maptube.org/ - a free resource for viewing, sharing, mixing and mashing maps created with the GMapCreator software, released by CASA.

MapTube allows users to share maps and overlay them to compare the data visually e.g. *London Output Area Classifications* and the *Percentage of the population in London who are Irish in origin*. Maps can be viewed by everybody without logging in, but to create a map requires an account thus ensuring that only the owner of a map can edit content.

[15] http://www.casa.ucl.ac.uk/projects/index.asp

London Profiler –
http://www.londonprofiler.org/

London Profiler enables users to create a geodemographic profile of Greater London from data on population attributes such as cultural/ethnicity, deprivation, level of higher education, and health together with the synthetic freely available *UK geodemographic classifications*.

London Profiler allows users to visualize themes at different scales, to search by postcode or zoom at borough level, to change the layer's transparency and to add other KML layers.

Virtual London (http://www.casa.ucl.ac.uk/projects/projectDetail.asp?ID=55) developed over a period of 6 years at CASA created a mechanism whereby OS MasterMap data and Info Terra height data was piped into Second Life via ArcGIS to create a scrolling 3D map of London complete with 3 million plus buildings. Second Life's claim that the importation of data direct from a GIS into 'an environment that is ripe for public participation and collaboration type outreach activites' may yet be tested in a court of law as Ordnance Survey have removed Virtual London on the basis of breach of copyright.

Geographers at UCL have also been responsible for a number of other initiatives which explore and exploit the power of spatially referenced information including:

publicprofiles - http://www.publicprofiler.org/?page_id=29

The concept behind the publicprofiles website is to deliver a picture of UK neighbourhoods using multiple public domain or free data. Information is free and easy to digest using a range of Web 2.0 utilities, maps, charts, statistics and text descriptions. Profiles include: neighbourhood; deprivation, property, higher education.

Publicprofiler are also responsible for **publicprofiler/worldnames** which utilises a range of data sources to examine where in the world people with a chosen surname are found with implicit implications for population and migration flows –
http://www.publicprofiler.org/worldnames/

OnoMAP Area Profiles which combine the OnoMap ontology of ethnicity (based on language, religion, spatial region, and culture encapsulated in people's names) with electoral roll data to create a range of **areal** estimates for the multicultural composition of local areas. Although academic use is via subscription - http://www.onomap.org/Software.aspx

7. Neo-geography, Citizen Science and Volunteered Geographic Information (VGI)

The term neo-geography has been described by Andrew Turner[16] as 'geographical techniques and tools used for personal activities or for utilization by a non-expert group of users, not formal or analytical' and as described above there has been an explosion of interest in use of such tools and techniques in a web environment to create, assemble, and disseminate geographic information provided voluntarily by individuals.

It is now possible to find out an enormous amount about the geography of an area from such sources, provided they can be synthesized, verified, integrated, and distributed. Such sources have earlier precursors in so-called citizen science or citizens as sensors!

Another term, Volunteered Geographic Information, has been attributed to Michael Goodchild (UCSB Center for Spatial Studies and the National Center for Geographic Information and Analysis). He says that 'very few people know the latitude and longitude of their home, let alone its UTM [Universal Transverse Mercator] coordinates. To enable the creation of geographic data by the general public, therefore, it is necessary to have a range of readily available tools for identifying the coordinates of locations on the Earth's surface. Several tools now supply this need, and collectively enable VGI.'[17]

Next generation mobile mapping, personal navigation devices, digital cameras and digital sound recorders that use Global Positioning System (GPS) and non-satellite positioning system technologies are ubiquitous, easy-to-use and are increasingly being used by non-geographers to 'volunteer' information based on their local expertise and understanding of the local geography. Some GPS receivers store entire tracks that can later be uploaded in digital form, and similar capabilities can be built into mobile phones including matching coordinates to street addresses etc.

In July 2007 TomTom introduced its Map share technology which enables TomTom users to correct information on street data and Points of Interest (POI) and share it with the TomTom community. In February 2008 they initiated a collaborative platform which enabled the sharing of a whole range of content freely between users including routes, POIs, voice recordings, cartographic symbols. Users can also comment, rate and tag uploaded content and receive updates on new content that may be of interest to them.

As indicated by Brady Forest[18] most of the data behind Google Maps comes from Tele Atlas (recently purchased by TomTom) and Nokia's Navteq. Google has recently enabled registered users to update and edit content (subject to acceptance) to make it available via Google Maps. Thus road or address-related data updated will flow back to Tele Atlas (and onto TomTom GPSs) to improve the currency and accuracy of their data. Whether such consolidation has implications for the 'openness' of spatial data, licensing and the altruism displayed by service providers such as Google time will tell.

An example of a VGI project is **Participatory Avenues** run by Integrated Approaches to Participatory Development (IAPAD - http://www.iapad.org/). It acts as a resource for sharing expertise and innovation in 'ethically-conscious community mapping' through Public Participation GIS (PPGIS) thus adding value and authority to people's spatial knowledge.
It hosts P3DM Where? - an interactive world map based on Google Map technology operated collaboratively by mapping practitioners and serves at locating 'participatory 3D modelling (P3DM[19]) exercises' world wide - http://www.p3dm.org/

[16] http://highearthorbit.com/introduction-to-neogeography/
[17] Citizens as Sensors: The World of Volunteered Geography - http://www.ncgia.ucsb.edu/projects/vgi/docs/position/Goodchild_VGI2007.pdf
[18] Google's GeoData, Open StreetMap and TeleAtlas - http://radar.oreilly.com/2008/07/google-mapmaker-open-street-map-data.html
[19] Participatory 3-D Modeling (P3-DM) is a community-based tool which merges conventional GIS and 'peoples' knowledge' via GPS to produce tangible and meaningful scaled and geocoded visualisations of indigenous spatial knowledge.

Another interesting example of VGI or 'citizen as sensor' is **geograph** or **Geograph British Isles** which describes itself as 'a geography project for the people' or a 'national photography project'.

Sponsored by the Ordnance Survey, geograph aims to collect geographically representative photographs and information for every kilometre grid square of Great Britain and Ireland (currently over 70% of the total grid squares are covered). Registration is free and all submitters must adopt a Creative Commons Attribution-ShareAlike licence on their photographic submissions

The geograph submissions are a potential source of field images for archaeology, geography and other land-based research and by contacting geograph photos can be converted into GIS point data (for use with ArcGIS). The points can be displayed as clickable items linking to each photograph's page on the geograph website. There are also Layer files containing the symbology information.

Other examples include:

OpenAerialMap (http://openaerialmap.org/) - Open Aerial Map (OAM) describes itself as 'a non-profit, open access, meeting place for the aerial imaging community.' The project provides a freely available image map of the world created solely by community contribution, and facilitates free exchange of imagery, technology, and ideas. In order to provide an unrestricted, free, and unbiased view of the world, OAM encourages the free exchange of imagery, without restriction through the Creative Commons Attribution License[20] or the Public Domain Dedication[21].

The **eWorld project** at Hasso-Plattner-Institut für Softwaresystemtechnik (http://eworld.sourceforge.net/) enables data imported from open mapping tools such as OpenStreetMap to be edited and enhanced with environmental events such as weather conditions, roadworks, traffic behaviour etc and then passed onto traffic simulators such as the open source Simulation of Urban MObility (SUMO) package and other applications.

There are also a variety of (predominantly US-centric) utilities that enable users to share and upload GPS data including:

GPS Visualizer (http://www.gpsvisualizer.com/) which allows users to upload and view their GPS tracks, point data and GPX files (an open GPS data exchange format) in addition to geotagged photographs, sound recordings, events , ASCII/XML/Excel format addresses, coordinates, scientific observations and data in a range of other GPS formats. Other facilities include: a quantitative data plotter for Google Earth or Google Maps; geoconversion utilities that convert GPS tracks or waypoint data to tab-delimited, CSV text , KML or to a GPX file; elevation profiles created from GPS tracks. There's also set of free geocoding utilities which convert street addresses (ZIP/Postcodes etc) to coordinates or latitude/longitude.

GPXchange (http://www.gpxchange.com/) - a facility for sharing and managing location-based information contained within GPX files. Registered users can create or upload files for private use, or make them publicly available for download or viewing by anyone.

The **MapGeneration Project** (http://mapgeneration.berlios.de/tiki/tiki-index.php) whose aim is to collect data that people have recorded using their GPS-receivers from all over the world and combine it to create a digital road map that is freely available for everybody

OpenStreetMap also allows users to upload, share and edit their GPS traces - http://www.openstreetmap.org/traces

[20] http://creativecommons.org/licenses/
[21] http://creativecommons.org/licenses/publicdomain/

8. 'Open-Geo' Organisations and Projects

The following organisations are instrumental in not only advocating, supporting and developing open data but also standards, interoperability and specifications, open source spatial software, desktop applications, geospatial libraries and geo-portals.

The Open Geospatial Consortium -
http://www.opengeospatial.org/

The Open Geospatial Consortium (OGC) is an international consortium of companies, government agencies and universities who collaborate to develop publicly available interface specifications. OpenGIS Specifications support solutions that 'geo-enable' the Web, wireless and location-based services, and mainstream IT. The specifications empower technology developers to make complex spatial information and services accessible, interoperable and useful with all kinds of applications.

The Open Source Geospatial Foundation -
http://www.osgeo.org/

The Open Source Geospatial Foundation, or OSGeo, is a not-for-profit organisation whose mission is to support and promote the collaborative development of open geospatial technologies and data. It does not provide access to open spatial data nor provide map visualisation through geo-browsers. However, it has been established to support and build quality open source spatial software in addition to providing advocacy, organisational and legal support to the broader open source geospatial community.

OSGeo also support open GIS applications for the desktop such as **GRASS** and **Quantum GIS**.

Web mapping utilities include:

- **MapBuilder** (http://communitymapbuilder.osgeo.org/) – a free standards compliant geographic mapping client which runs in a web browser (not to be confused with mapbuilder.net - see page 6)
- **Mapbender** (http://www.osgeo.org/mapbender)
- **OpenLayers** (http://openlayers.org/) - a free utility for displaying map data in most modern web browsers, with no server-side dependencies with the intention to separate map *tools* from map *data* so that all the tools can operate on all the data sources.

The Center for Spatially Integrated Social Science - http://www.csiss.org/

Funded by the National Science Foundation the Center for Spatially Integrated Social Science (CSISS) 'seeks to develop unrestricted access to tools and perspectives that will advance spatial analytic capabilities of researchers throughout the social sciences.'
Spatial tools include open source GIS utilities such as **GeoDa**, an interactive environment that combines maps with statistical and exploratory data analysis (EDA) graphics.

The Open Planning Project (TOPP) – http://topp.openplans.org/

TOPP describes itself as a 'non-profit incubator for projects and technology to catalyze large scale social change' with a range of software products 'released under open source licences....designed for reuse in a variety of civic efforts.'

The OpenGeo tool builds open source software to help governments make their geospatial information more accessible to citizens.

Where as OpenPlans is a toolbox and network for participating in community initiatives. The software suite is available at www.openplans.org as a free, hosted service. It is currently powering online collaboration for the Livable Streets Network (http://www.livablestreets.com/) , other social change groups, and scientific research communities.

Commons of Geographic Data (CGD) – http://geodatacommons.umaine.edu/

Currently in development mode Commons of Geographic Data (CGD) is a research project funded through the Institute of Museum and Library Services and the University of Maine which aims to provide the infrastructure required to store and make accessible currently "invisible" locally-generated spatial data which is stored on local hard drives or servers and not available via the internet. The CGD aims to help data contributors and users manage their data through Creative Commons, create standards-based metadata, and evaluate

GeoVISTA – http://www.geovista.psu.edu/main.jps

The GeoVISTA Center, based at the Pennsylvania State University, is the home of the Geosciences Network (GEON) and iGEON (international GEON) - collaborative projects to develop cyberinfrastructure (e-research) in support of an environment for integrative geoscience research. The GEON portal enables registered users to share, publish and integrate with data held over a number of distributed sites and service providers that operate in the service-oriented architecture (SOA) environment of GEON. There's also a range of tools, web services, controlled vocabularies, ontologies in addition to the GeoVISTA Studio - an open source, programming free environment designed for geospatial data visualisation and analysis.

Maps 2.0 – http://maps2.humaninet.org/

Established in 2008 Map 2.0 is an online collaborative workspace established by Humaninet.org to enable humanitarian organisations and NGO partners to post, share, modify, and use critical, geo-referenced information in emergency responses in addition to sharing best practices in GIS mapping.

Project SAXTA - http://saxta.geog.umd.edu/

Based at the University of Maryland SAXTA is an open network dedicated to the sharing of high-resolution Earth observation data sets such as Landsat and ASTER data.

9. Summary

Spatial data lends itself to visualisation. All of us have an innate appreciation of space and location, where we come from, where we live, where we work, where we socialise in relation to our local neighbourhood and the wider national and international environs.

The data, tools and technologies described in this briefing paper inhabit the Geo Web or Geo 2.0. They highlight the mass appeal of mapping and spatial representation of geo-referenced knowledge and facts however subjective. After all, should only one person find a mashup or visualisation useful irrespective of content this arguably validates it in terms of its usefulness.

'We built them and they didn't come' is the statement used by Dorothea Salo to describe the existing Institutional Repository environment in her keynote at the recent Edinburgh Fringe Repository conference[22]. By opening up their code to repository developers (e.g. through APIs) numeric and spatial data tools could be utilised further within this environment to engage potential depositors, to enhance output, and to provide analysis and visualisations as part of 'value-added' functionality.

The web as a platform is becoming ever more sophisticated as semantic reasoning, wikitecture and the Grid converge. The position paper 'Next-Generation Digital Earth' (Craglia et al, 2008) states that geobrowsers 'have created the informational and technical infrastructure, with hundreds of thousands of computers organised in server farms (the so-called 'cloud computing' architectural style) upon which many other applications can be built, including VGI.' It also envisions 'multiple connected globes/infrastructures addressing the needs of different audiences: citizens, communities, policy makers, scientists, educationalists' in addition to 'the visualisation of abstract concepts and data types' for the purposes of awareness raising and informed decision making.

We may well be seeing the tip of the iceberg in terms of what can be done, shown, shared and experienced geographically. What is exciting is that due to human ingenuity and curiosity the geo-arena is democratizing itself through the use of the Web 2.0 tools, technologies and services described. This role is integral in facilitating collaboration across disciplines and physical boundaries and the consequent cross-fertilisation of ideas which may ultimately yield new knowledge and pioneering evidence required to address 'grand challenge[23]' and societal problems.

[22] 'Le IR, c'est mort. Vive le IR!' - http://www.era.lib.ed.ac.uk/handle/1842/2416
[23] http://en.wikipedia.org/wiki/Grand_Challenge_problem

Further Reading

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Appendix I - Blogs

As of December 2007, blog search engine Technorati was tracking more than 112 million blogs. Blogs are increasingly used as reliable and interactive discussion, commentary and current awareness tools. Within the geospatial arena there are many such blogs covering open source GIS, visualisations, open standards, Geo 2.0, the Geo Web, and VGI.

Examples include:

OpenGeoData – '...a blog about open maps, geographical data and openstreetmap' - http://www.opengeodata.org/

indiemaps.com blog – 'flash, mapping + information visualisation' – the notebook of cartographer Zachary Forest Johnson - http://indiemaps.com/blog/

Digital Urban – Used as a means to disseminate and discuss research at UCL's Centre for Advanced Spatial analysis (CASA), Andrew Hudson-Smith's blog provides commentary on cutting edge digital technologies used to visualize urban environments - http://www.digitalurban.blogspot.com/

edparsons.com – Ed Parsons is the Geospatial Technologist of Google. edparsons.com is written by Ed Parsons, so the views expressed in this blog are his and not necessarily those of Google - http://www.edparsons.com/

James Fee GIS Blog – 'Geospatial Technology, Web Mapping and Spatial Services' - James' blog is an attempt at helping others navigate the huge changes to GIS and mapping that have occurred over the last few years. James also contributes to **Planet Geospatial** – 'a window into the world of geospatial technology' - http://www.planetgs.com/

The AnyGeo Blog – A blog about 'GIS, the Geo web2.0, GPS, maps, google maps, google earth & anything geospatial - for GIS / Geospatial users and enthusiasts' - http://gisuser.blogspot.com/

BlinkGeo – 'GIS 2.0?' - http://www.blinkgeo.com/

Virtual Earth / Live Maps – A Microsoft blog about developments in Web 2.0 mapping and open browsers - http://virtualearth.spaces.live.com/

Mapperz – The 'Map and GIS News finding blog... for UK, Europe and Worldwide Maps' - http://mapperz.blogspot.com/ -

Very Spatial – 'Geography in Stereo' - http://veryspatial.com/

Google Lat Long Blog – 'News and notes by the Google Earth and Maps team' - http://google-latlong.blogspot.com/

Leszek Pawlowicz's blog '**Free Geography Tools**' covers a range of free tools for GIS, GPS, Google geo-browsers, neogeography, etc - http://freegeographytools.com/

Slashgeo – 'In+ersec+ion for Spatial people' – http://slashgeo.org/

Off the Map –Sean Gorman's (FortiusOne) blog - http://blog.fortiusone.com/

Appendix II - Standards

Georeferenced Web 2.0 mashups employ and combine many standards (at different levels). A lot of ad-hoc and defacto standards seem to have emerged although some like Keyhole Markup Language (KML) are now 'official' i.e. an official OGC standard with many applications now able to display KML, including Google Earth, Google Maps, Google Maps for mobile, NASA WorldWind, ESRI ArcGIS Explorer, Adobe PhotoShop, AutoCAD, and Yahoo! Pipes as indicated above. Thus the protocols and specifications mentioned in this appendix are not meant to represent a comprehensive listing.

The Open Geospatial Consortium's Web Map Service/Web Feature Service(OGC WMS/WFS) has arguably had a major influence upon the spatial mashup arena enabling the dynamic production of maps on the web using parameters, such as map layer order, symbolization, mapped extent, data format, projection, etc. although opinions are divided with regards to the suitability of and the effort involved in the implementation of OGC WMS/WFS for certain applications. Typical image formats from WMS Server generated maps include the standard graphics formats of PNG, GIF, TIFF and JPEG (for raster files), and SVG or PDF for vector files.

Users wanting to personalize web maps (i.e. to apply his/her own data filtering, selective content and the application of personal styling and map symbolization) can employ the OGC SLD standard (Styled Layer Description) that may be sent to a WMS server for the application of individual styles.

Spatial databases behind many of the Geo 2.0 services implement the OGC Simple Features for SQL Specification, a standard geometry data model and operator set for spatial databases.

Standard Javascript APIs from e.g. Google and Virtual Earth, Microformats (open data formats built upon existing standards) and GeoJSON (a format for encoding a variety of geographic data structures) have empowered neo-geographers as has the development of AJAX (Asynchronous JavaScript and XML - a group of interrelated web development techniques used for creating interactive web applications) which allows web applications to retrieve data from the server asynchronously in the background without interfering with the display and behaviour of the existing page.

There's also the SOAP protocol for exchanging XML-based messages over computer networks, normally using HTTP. For example, a correctly formatted request for information could be sent to a Web Service enabled web site e.g. a geospatial database. The site could then return a formatted XML document with all the required results and associated data (attributes, location, features, etc). These could then be integrated directly into a third-party site (i.e. mashed).

From a licencing perspective many of the services use Creative Commons, for example OpenStreetMap maps are created using data from portable GPS devices, aerial photography and other free sources. Both rendered images and the vector dataset are available for download under a Creative Commons Attribution-ShareAlike 2.0 licence (as is the case in a number of other such utilities e.g. geograph,OpenAerialMap).

And finally there's web feed formats used to publish frequently content such as GeoRSS (GeoRSS-simple and GeoRSS-GML - a GML application profile) - ways to encode location in RSS feeds in an interoperable manner so that applications can request, aggregate, share and map geographically tagged feeds - and KML feeds which allows users to share and explore your map content (in KML format) through tools such as, Google Earth and Google Maps.