Green Community Portal and Map Application of Bristol

Dissertation

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DECLARATION

“I, Monika Molnar, confirm that this work submitted for assessment is my own and is expressed in my own words. Any uses made within it of the works of other authors in any form (e.g., ideas, equations, figures, text, tables, programs) are properly acknowledged. A list of the references employed is included.

Place: Heriot-Watt University, Edinburgh”

Signed: .................................................................................
Date: ........................................................................................
Abstract

The objective of the MSc project is to develop the Green Community Portal and Map Application of Bristol. It is a company-based project, supported by Innogistic Ltd, a GIS software company from Bristol.

The aim of the project is to implement a web application, which motivates people to consider a more environmentally friendly lifestyle by providing “green” information such as National Cycle Routes, charity shops and recreational places. The community portal is unique in the way that it is developed by using the software of a Bristol based company and it has a specific topic – becoming more and more relevant – which is sustainable living.

The project consists of an ASP.NET website and an embedded GIS application, developed by using Cartology.NET. The main map data source is MasterMap and OpenData, provided by Ordnance Survey.
Acknowledgement

I would like to thank my supervisor, Dr Lilia Georgieva, whose encouragement, guidance and support from the initial to the final level enabled me to write the dissertation document.

I am also grateful to Dr Kieron Brown from Innogistic Ltd, who helped me to develop an understanding of the subject and to implement the map application.

Furthermore I also wish to thank Matt Bridges from Sustrans, who provided the National Cycle Routes map data files, and Graham Coleman who contributed to the project by supplying his photographs.
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Chapter 1: Introduction

The MSc dissertation is written to describe the development process of the Green Community Portal and Map Application of Bristol, which was implemented by using the GIS software of a Bristol based company: Innogistic Ltd [38]. The company’s main profile is to provide GIS applications for the government, e.g. land management systems, for emergency services, e.g. crime mapping applications for the police, and for utility companies, e.g. water storage systems.

The web portal is a collection of “green” information, such as contact details of organisations that are dedicated to improve the environment – e.g. Avon Wildlife Trust, Friends of the Earth Bristol – and places that provide opportunities for recreation, e.g. parks, gardens, and conservation areas.

The main purpose of the project is to develop an application that motivates people to choose the more sustainable alternatives in their lifestyle decisions, such as opting for public transport, walking or cycling to places instead of using the car or selecting and taking their household waste to the designated recycling places, instead of dumping everything to the general waste container. To make these decisions easier the community portal provides a map application, which enables users to find all these organisations and places within the city.

The web portal aims to help all those who live, work or study in Bristol and those who visit the city.

The project has two main parts: an ASP.NET website and an embedded GIS application, which was developed by using Cartology.NET (Innogistic Ltd).

The main map data sources are Ordnance Survey MasterMap and OpenData, accessed through the server of Innogistic Ltd.

The project development process followed the phases of the Rational Unified Process (RUP) framework.

The dissertation document has the following structure:

The first chapter – Introduction – describes the aim and objective of the project, and provides a short overview of the document structure.

The second chapter – Background – focuses on the recent literature of the topic: a brief introduction to the Geographical Information Systems (GIS), the description of similar web GIS applications, such as Google Maps and Google Earth, to the proposed system, and an overview of the topic related to the current environmental issues, such as climate changing.
The third chapter provides the analysis of the requirements – including functional and non-functional requirements. The related professional, legal and ethical issues are also explained in this section.

The fourth chapter introduces the technical options and the selected software development tools.

The fifth chapter provides a detailed description of the development process, following the phases of Rational Unified Process.

The sixth chapter of the dissertation evaluates the MSc project.

The final chapter gives a conclusion of the project, and it also suggests some possible future improvements.

The rest of the document includes the References and the Appendix – Initial Project Plan, Risk Plan – along with the UML Diagrams and the Online Survey.

As the document contains terminology – GIS and environmental – that has to be explained, a Glossary is included after the Appendix. In the text italic words indicates which terms can be found in the Glossary.
Chapter 2: Background

Introduction to Geographical Information Systems (GIS)

One of the main parts of the MSc project is a web based GIS application, therefore it is necessary to give an overview of what GIS is.

The roots of Geographical Information Systems can be found in cartography. Maps created by cartographers display the topography – surface shapes, landforms, built-up areas – of a region, whereas GIS goes further and by analysing maps it is able to highlight geographical dependencies within a location. As a result, statistical figures can be created to support decision making, which are useful in many related professions, such as natural resource management, urban planning or utility service management.

There are related technologies capable of doing similar things to GIS [17]. One of them is Computer Assisted Cartography (CAC), which is based on the traditional cartography – map making – but instead of drawing maps by hand the cartographer uses computer programs such as Corel Draw or Adobe (Macromedia) Freehand. These software tools are good for representing the surface and other topics e.g. choropleth or thematic maps, which can display the population density or the biodiversity within a certain country. CAC programs have their disadvantages though: they are lack of analytical facilities, e.g. they cannot be queried because they are not connected to a database that stores the attributes of the spatial entities [17]. Another related technology is Computer Aided Design (CAD), which is used to create blue prints by architects or engineers. Although CAD software tools, such as AutoCAD or Bentley MicroStation, are capable of drawing maps with limitations, similarly to CAC software they do not support analytical features [17]. By combining the advantages of CAC and CAD software, and adding database management system support to it, the first Geographical Information System was created by the Canadian Government’s Department of Forestry and Rural Development in 1960 (Canada Geographic Information System) GIS [17].

Figure 1. shows the type of information systems and the place of GIS within them. There are two main categories: non-spatial (e.g. Management Systems) and spatial information systems. Spatial systems can be non-geographical, e.g. CAC and CAD software applications and geographical (GIS). Geographical systems include parcel-based (e.g. cadastral systems) and non parcel-based (e.g. geological systems) Land Information Systems (LIS), and other GIS programs, such as those that are capable of analysing housing market trends.
Currently there are several GIS software tools available on the market. Some of them are commercial, e.g. ESRI ArcGIS, MapInfo or GeoMedia by Intergraph and some are open source, e.g. MapServer or MapWindow GIS. There are also companies, such as Innogistic Ltd which implement their own GIS software tools and use them to develop GIS application for their customers. An example for this is the program called YorMap [80], used by Yorkshire Water (a utility service provider), which is based on Cartology.NET.

To understand the working aspects of Geographical Information Systems, some basic concepts have to be explained. A GIS application consists of a map and the related database. First about maps: according to the International Cartographic Association (ICA) “a map is a symbolised image of geographical reality, representing selected features or characteristics, resulting from the creative effort of its author’s execution of choices, and is designed for use when spatial relationships are of primary relevance.” [46]

Maps are produced by cartographers and they graphically represent the components of the Earth. These components – called entities in GIS – are illustrated by using points, lines, polygons and volumetric objects (surfaces).

One of the main criteria of distinguishing between drawings and maps is that maps have to be measurable. This is only possible if the projection and the reference surface of the map is clearly declared. Map projection is needed in order to illustrate the Earth’s spherical shape in
two dimensions. To find the optimal projection for the area to be mapped, complex geometrical calculations have to be performed. As scientists have been interested in to find the solution for this problem for thousands of years, today we have a fairly good understanding of the Earth’s shape, geography and the different types of map projections [47].

The next paragraph provides an overview of these theories and discoveries. In the 6-7th centuries (BC) there were speculations whether the Earth has flat shape: the Greek Thales thought that the land where people live on is a drifting disk on the ocean. Then a century later two other Greek scientists, Pythagoras and Aristotle proved that the Earth has spherical shape. The first map projection was created by Ptolemy in the 2nd century. During the next period – especially between the 15-17th century, which is also called the Age of Exploration – Europeans discovered the other continents: America, Africa and Asia. Apart from trading, these long journeys to exotic places gave opportunities to revise old theories and gain new knowledge about the Earth, e.g. estimating the globe size after certain times circumnavigating it. From the 17th century European countries were in nearly continuous war with each other, e.g. Thirty Years’ War (1618-48), War of The Spanish Succession (1701-14), Napoleonic Wars (1803-15). To be successful in these wars, more and more accurate maps were needed, which led to the improvement of surveying equipments, e.g. theodolite, barometric level and map projections such as Lambert’s equal area cylindrical projection.

The technological progression in the 19-20th century – e.g. Zeppelin’s airship (1899), the invention of modern computers in the 1940s, spaceflights from the 1950s, using Global Positioning Systems (GPS) from the 1970s – helped to discover the Earth from different perspectives such as from the air or the space. There were complex map systems – e.g. Universal Transverse Mercator system (see description below) – created, which make the maps with different projections and reference surfaces (see next paragraph) compatible.

To categorise map projections, there are several characteristics that have to be considered, but all projections belong to one of these categories: cylindrical, conical or azimuthal projections. Figure 2. illustrates all three groups. The first picture shows the way how cylindrical projections are created. The middle picture symbolises the conical projections, and the third picture helps to imagine how azimuthal projections are derived.

As absolute map accuracy does not exist, the optimal projection depends on the area to be mapped, and it is always the one that contains the less distortion.

The term, Earth shape was mentioned above. This natural shape of the planet – consisting of mountains, valleys and lowlands – is almost spherical, however it is flattened at the poles. For this reason, there are many different reference ellipsoids or datums used for creating more accurate maps.

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Once the map projection and the reference surface are declared, the term map scale can be explained: map scale is the ratio of distance on the map to the same distance on the Earth [17]. When this ratio is small, the map is called small scale, e.g. 1:1 000 000 continent map. When the ratio is big, the map is called large scale, e.g. 1:1000 cadastral map. The larger the scale the more detailed the map is, however the area (km²) that the map represents is smaller.
Maps usually display the graphic scale (see Figure 3.) and the representative fraction, e.g. 1:25 000. The graphic scale helps users to perform distance measurements on the map, and it is particularly useful when both kilometres and miles are displayed, as users from different countries have different background to understand these measures (Metric/SI Systems vs Imperial System).

Maps are also used to identify spatial locations: absolute and relative. In order to find the absolute location of an object, a reference system – also called grid system or coordinate system – is needed. The system assumes that the Earth has spherical shape, on which parallels and meridians can be drawn. Parallels are concentric circles: starting at the Equator (0°) and finishing at the North and South Poles (± 90°). These circles help identifying the latitude of an object.
Meridians are half circles starting at one pole and finishing at the other. They are numbered from the prime meridian, 0° (Greenwich, Great Britain) to the International Date Line, +180° (Pacific Ocean). Meridians identify the longitude of an object.

These grid systems enable map users to find the absolute location of an object on the Earth by defining its coordinates (a latitude and longitude pair), and also to calculate the distance between two locations.

There are many different coordinate systems that can be applied, depending on which part of the planet is to be mapped. One widely used example is the Universal Transverse Mercator (UTM) grid system, which has relatively small distortion values, approximately 1m in every 2500 m distance [17]. It has its limitations though: it is not suitable for mapping polar areas [Clarke, 2003]. For polar regions, an amended version of the Universal Transverse Mercator system is used, which is called the Universal Polar Stereographic (UPS) coordinate system. Another example is the combination of UTM and UPS systems: the Military Grid Reference System (MGRS), which uses letters instead of numbers to identify locations.

In Great Britain maps are integrated into the British National Grid system, which divides the country into squares: 100 km x 100 km, 10 km x 10 km, 1 km x 1 km, 100 m x 100 m, 10 m x 10 m and 1 m x 1 m areas. These squares can be identified by their letter and number code combinations [9]. British National Grid is based on the Transverse Mercator Projection [10], which is a cylindrical projection suitable for areas with great north south extent. Figure 4. shows the position of the cylinder: it touches the ellipsoid at the poles. The meridian, which runs through these touching points, is optional. In Ordnance Survey maps this meridian is the prime meridian through Greenwich [10], whereas in Figure 4. it is the one that goes through the middle of North-America.

Figure 4. Transverse Mercator Projection [76]
The geographic information, that maps contain, can be collected in many different ways [17], such as aerial photographing, digital remote sensing (using satellite images), geodetic surveying or using Global Positioning Systems (GPS).

In GIS there are two main types of data models and formats to store geographical (map) information: raster and vector.

The raster data model has a grid structure [15]: grid cells represent map units and a value is assigned to each cell. This value can be a number or an index of an attribute, that is stored in the related database (for more about databases see the next paragraph: GIS database structures). Most raster data formats used in GIS are the same as those which can store image and picture files: JPG, GIF, TIFF. The advantages of the raster data format are the relatively high data volume and the great visual value. However there are some disadvantages too: raster files can be large, which makes the displaying process slow, and raster format does not store attribute information about the objects. For these drawbacks vector data model and format is more valuable in GIS: the units in this model represent spatial coordinates. A point has two or three coordinates (latitude, longitude and height), a line has a sequence of coordinate pairs (the points it consists of), and an area has the coordinates of the line it is surrounded by. Vector data formats have less data volume, so they can display information faster. They are usually “less pleasing to the eyes” [77], but they can store attribute details of the objects, which is a great advantage against raster formats.

The other main part of Geographical Information Systems is the database. There are three basic types of databases that can be used: hierarchical, network and relational database structures [17]. Hierarchical databases show one to one, many to one and parent-child relationships. Because of their rigid key structure they do not allow to search relationships within GIS that contains various data types (point, line, area). For this reason hierarchical databases are rarely used in GIS.

Network systems are less rigid, and they can handle many to many relationships. However in the case of complex GIS systems there are disadvantages: the database can become large, which requires greater storage capacity.

The relational database structure contains tables (relations) with records (rows or tuples) and columns (attributes). The basic concept has roots in relational algebra. To be able to identify entities, a primary key – a unique identifier field – has to be set in each relation. To connect two tables, a foreign key – a field that is primary key in another relation – is also necessary.
Web GIS Applications

As part of the MSc project is a web based GIS application, it is important to research some similar products available and compare their working aspects and basic concepts to each other. Two Google products are described: Google Maps [29] and Google Earth [25].

Google is a well-known multinational – originally US based – company, which provides many Internet applications without charge for non-commercial use, such as Google search engine, Google Chrome web browser, Google Talk instant messaging application, Google Maps and Google Earth. The company gains most of its profits from the AdWords [24] program, which enables businesses to select the key words that best describe their activity, decide how much money they are willing to invest in advertising, and then let the program do the rest for them: any time a user performs a search the links of these companies are displayed as first results (“sponsored links”) [33].

Google Maps is one of Google’s free web applications, which can be used to find the direction to a searched location (country, town or city name, street, postcode, certain businesses within a city e.g. restaurants, hotels etc.). To perform a search the user simply has to enter the keyword to the search box, and then the program lists all the results on the left hand side of the web page (see Figure 5.). After that the appropriate one can be selected from the list and the map displays the location on the right hand side [34].

Another facility is to get directions (as well as reverse directions) by entering the start and the end location to the search boxes. Google then shows the routes on the map along with some useful instructions to help users to navigate through the suggested path. Usually there is more
than one available route, depending on the selected transport option: by car, by public transport, by bicycle or on foot, as a sample is shown on Figure 6. The instructions to navigate the user from Heriot-Watt University to the Edinburgh Airport are on the left hand side and the map result is also displayed on the right hand side.

![Google Maps Directions](image)

Figure 6. Get Direction (Google Maps)

Google Maps also offers four alternatives of displaying the results: map view (see Figure 5. and 6.), street view (Figure 7.), Earth view – connecting to Google Earth – and satellite view – showing areas by aerial images. Additionally, when the map view is selected the user can choose the terrain view, which shows the geographical features, such as mountains and valleys, in 3D [32].

Street view provides 360° horizontal and 290° vertical view, using photographs captured by special cameras placed on a moving van or car. These images are positioned by using GPS devices. Street view is currently limited, only available for most European countries, the United States, Mexico, South Africa, Japan, nearly all Australia and New Zealand [31].
While Google Maps is a web-based application, Google Earth is a stand-alone program (but it also requires Internet access ~ 128Kbit/s) which has to be installed to the computer and has the following minimum requirements: at least 2.4GHz processor speed, the minimum of 512MB RAM, 2GB hard disk space and 3D graphics card [34]. Google Earth also provides the searched directions and local information, but it has extra facilities, such as 3D guided flying tours around the Earth and sky mode to show other planets within the Solar System. The example shown on Figure 8. proves that Google Earth is also capable of displaying Mars.

The program has three versions: Google Earth with basic installations for free; Google Earth Pro, which has extra features, such as GIS data importer, for an annual subscription fee (currently $399, but there is a 7 days trial period), and Google Earth Enterprise, which is designed for GIS businesses and organisations [26].
So what are exactly these Google products and how do they work?

Google Maps has a DHTML (Dynamic Hypertext Markup Language, which is able to combine HTML, JavaScript, CSS codes) background.

The map – as an image – sliced into 256x256 absolutely positioned pixel tiles. When the user performs a search, Google Maps starts communicating with the server: first to find the appropriate map tile(s), and then to request the search results. As the map slices are previously determined (pre-rendered), they have a fixed URL with latitude, longitude and zoom values. For returning the search results, Google Maps uses a hidden IFrame, which retrieves the information stored in XML (eXtensible Markup Language) [30].

Google Maps uses the Mercator projection which is shown on Figure 9. In the conformal version of the projection the cylinder touches the ellipsoid at the Equator. This cylindrical projection has been used since the 16th century. It shows loxodromes – rhumb lines – as straight lines, which explains its popularity in marine navigation (e.g. creating navigational charts) [12].

The projection is suitable for the areas between + and – 85°, however for higher latitudes (towards the Poles) the distortions are significantly higher [53].
Google Earth displays medium and high resolution satellite imagery (0.15 - 2.5 m/pixel), although the program does not provide real time images: most of them are one to three years old, and some of them are only available at lower resolution.

Google Earth uses Keyhole Markup Language (KML) which is based on XML [27]. The language was introduced by Keyhole, Inc. to enable developing three dimensional GIS applications. The company was bought by Google few years ago, and KML became the basis of Google Earth.

Google Earth uses a different projection, called Simple Cylindrical Projection or Lat/Long WGS84 [28]. According to Snyder this is one of the Equidistant Cylindrical Projections (see Figure 10): “if the Equator is made the standard parallel, true to scale and free of distortion, the meridians are spaced at the same distances as the parallels and the graticule appears square. This Form is often called the Plate Carrée or Simple Cylindrical projection.” [71] The projection – first introduced by Eratosthenes (275? – 195? B. C.) – is suitable for global and regional mapping because of its simple construction, e.g. poles drawn as lines.

Both Google Maps and Google Earth are based on the WGS84 (World Geodetic System 84) reference ellipsoid, which is a geodetic datum developed by the USA with cooperation of other countries. The main goal was to implement a standard and compatible reference surface to help combining geo-data from different geodetic systems and to promote global surveys. This geodetic datum is also used by the Global Positioning Systems (GPS).
To summarise the differences between the described examples and comparing them to the MSc project Figure 11, provides an overview of the most important characteristics of the applications.

<table>
<thead>
<tr>
<th>Google Maps</th>
<th>Google Earth</th>
<th>MSc Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web based</td>
<td>Stand-alone program, but requires Internet access</td>
<td>Web based</td>
</tr>
<tr>
<td>Free</td>
<td>Basic version is free</td>
<td>Non-profit</td>
</tr>
<tr>
<td>Mercator Projection</td>
<td>Simple Cylindrical Projection</td>
<td>Transverse Mercator Projection</td>
</tr>
<tr>
<td>WGS84 reference ellipsoid</td>
<td>WGS84 reference ellipsoid</td>
<td>OSGB36 ellipsoid</td>
</tr>
<tr>
<td>XML, JavaScript</td>
<td>KML</td>
<td>Cartology.NET, ASP.NET</td>
</tr>
</tbody>
</table>

Figure 11. Comparison of the Similar GIS Applications

Environmental Issues

As the aim of the project is to motivate people to consider a more sustainable lifestyle, it is important to highlight some issues related to the current state of the environment. First we have to see what causes the problems exactly, and why these things are issues. Once we know the answers to these questions, we can find solutions to the problems.

In 2000 the 47 percent of the 6 billion people (Earth population) lived in cities, whereas in 1900 the global population was 1.5 billion and only 15 percent of them were urban citizens [23]. The number of people living in urban environment increases year by year, therefore it is crucial to understand the importance of the related problems by presenting some facts. According to David Rudlin and Nicholas Falk, the authors of the book “Building the 21st Century Home” [69], there are several issues, which have significant impacts on the cities’ environment. One of them is the carbon dioxide emission, which is also responsible for the global warming and climate change. 30 percent of CO₂ discharge is related to housing and 23 percent to transport, which is growing rapidly as the car use has risen from 219 billion km/year (1981) to 330 billion km/year (1990) and it is predicted to increase. Through sulphur dioxide, smoke and nitrogen oxides emission, cars are also responsible for acid rains, which affect 20 percent of the trees in the United Kingdom.
Another problem in cities is the loss of ecosystems and diversity, which is caused by the increasing level of \textit{green field development}.

The amount of domestic waste produced by citizens is huge: in the UK this number is 20 million tonnes per year – only 5 percent of it is recycled, the rest is placed to landfill sites or gets incinerated. The last two methods are less sustainable ways to manage waste, as they produce methane and other pollutants that contribute to the global warming.

These issues become more and more serious and as part of the global climate change they affect our everyday life [43].

Figure 12. shows an interesting statistic about the change of transporting methods: while in 1870 91 percent of the population living in Western European cities used to walk or cycle, in 1990 only 10 percent of them did so. In contrast car use increased from 7 percent to 71 percent during this period. This led not only to the problems mentioned above (e.g. air pollution), but the more frequent car use also increases the number of accidents and collisions; congestions, and through air pollution it causes health problems such as asthma, heart attacks and in long term cancer. As cars offer a convenient door to door travel option, people do less physical activities, which contributes to another health issue: obesity.

\begin{center}
\begin{tabular}{|l|c|c|c|}
\hline
\textbf{Mode} & \textbf{1870} & \textbf{1930} & \textbf{1990} \\
\hline
Walk/Cycle & 91 & 29 & 10 \\
Public Transport & 5 & 61 & 19 \\
Other Private e.g. car & 4 & 10 & 71 \\
\hline
\end{tabular}
\end{center}

\text{Figure 12. Per cent modal share of person movement in Western European cities, 1870-1990 [44]}

As the facts mentioned above show, these environmental issues have been causing problems for years. People from different backgrounds tried to find solutions to them. There are conferences and regular climate summits, when scientists and leaders from all around the world gather and discuss the current state of the environment. One of them was the World Commission on Environment and Development in 1987 (Brundtland Commission), when the following was revealed: “humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.” [78]

This emphasises the importance of minimising the negative human impact on the environment. To achieve this it is necessary everyone to understand their own responsibility. Individuals such as city residents, including adults and children through their parents, and people who are in leading positions, such as company managers and ministers are all responsible for the environment. The reason for that is because little steps – recycling domestic waste, using less
water, buying fair-trade products, choosing public transport or bicycle – can be done by ordinary people, but to give them opportunities – providing recycling facilities within cities, changing policies and laws to protect cyclists’ interests – the government’s help is also needed. Figure 13. shows the waste hierarchy, which starts with reducing the waste by buying less, then comes re-using and recycling, recovering energy and finally the landfill disposal as the less green option.

![Waste Hierarchy](image)

Figure 13. Waste Hierarchy [68]

As part of the collective responsibility for the environment, the community portal of Bristol city aims to help residents and visitors to choose the more sustainable ways. It provides a collection of information about all related topic, such as enabling users to find organisation that protect the environment, and motivating them to cycle by showing the Sustrans [75] routes on the map application. When we talk about motivation there are some issues that have to be considered. One thing is providing information, but this knowledge also has to reach those who are likely to get involved. This can only be achieved slowly, step by step, as for some people these changes mean a huge alteration in their lifestyle, e.g. generations grew up without caring for recycling or having to walk further than the shop at the end of the street. To improve the current situation, it is important to educate children by parents and schools, and train adults by stressing problems, that are related to their own area – “think globally, act locally” mentality [78]. Many people think that they do not have power on their own to make significant changes, so why make the effort to do anything at all. The truth is, that they are more powerful than they think, for example when a group of people decide to boycott a certain product the manufacturer will not produce it, because the market controls the demand. There are certain factors that are incompatible with sustainability though [78]. One of them is poverty. When people struggle to meet their basic needs such food, water and shelter, then their priority is survival and nothing else – they will not be sensitive to environmental problems. Poverty also increases the feeling of hopelessness and the doubts
that any positive change can be done. People become isolated, and less likely to get involved in community activities, which are the bases of many environmental events, such as practical conservation days. To create jobs and therefore help minimising unemployment and poverty, the government and the private sector have to take their responsibility.
Chapter 3: Analysis of Requirements

Background
The project is developed with the support of Innogistic Ltd, Bristol. The application consists of an informative website linked to a mapping application. The map data sources are Ordnance Survey MasterMap and OpenData, covering the areas within the boundaries of Bristol City Council.

Aim and Objectives
Aim: to motivate people to consider a more sustainable lifestyle by providing “green” information, e.g. cycle routes, charity shops, recycle places.

Objectives: to develop a non-profit, web-based community portal, consisting of:

- website (ASP.net)
- mapping application (Cartology.net)
- map source (Ordnance Survey)

Stakeholders
- Software provider and data supplier: Innogistic Ltd
- Heriot-Watt University: project supervisor, lecturers, students
- Website and map application users: residents of Bristol, tourists, cycle forum visitors

Functional Requirements
Website
- The site is linked to the mapping software, and it is capable of doing the followings:
  - providing information by categories e.g. electric waste recycling points
  - by clicking the selected category the list of facilities – along with address and postcode – are displayed
  - the user also has the option to see where these facilities are on the map
- The user is able to navigate between pages via hyperlinks
- The user can send email to the website administrator

Mapping Application
- Spatial and attribute queries e.g. the nearest recycling facility within a location (postcode, address)
- Showing the shortest route between the locations (get direction function)
- Showing National Cycle Routes within the city
- Navigation (pan, zoom) within the map
- Making layers visible/invisible
- Printing query reports
- Printing PDF documents of the queries

**Non-functional Requirements**

*Hardware and Software Requirements:*
- At least 1024MB RAM
- Web browser e.g. Mozilla Firefox, Internet Explorer

*Accessibility*
- All pages follow the W3C Web Content Accessibility Guidelines
- The CSS document is validated by the W3C standards

*Usability*
- Providing a user-friendly, easy-to-use application
- Ensuring that the interaction between the site and the user is as simple as possible
- Page download is quick
- Applying appropriate font sizes and colours for text and background to ease reading
- Links are easy to identify
- Navigation between pages is possible for all directions
- Being consistent with style and colour usage
- Using appropriate page titles

*Performance*
- Response time and processing time should be as short as possible

*Availability*
- The website and the mapping application operate in parallel – the complete system fails only if both of its components fail
- The complete application has to comply with the standard availability [72]: 99.99% with 52 minutes downtime considering the whole year

*Reliability*
- The number of failures during the application availability should be zero or minimal
- When an error occurs the system inform the user about it
Maintainability

- Correcting errors and bugs when they occur
- Easy maintainability to help regular updating in order to prevent failures and adapt to changing environment e.g. new browser version

Professional, Legal and Ethical Issues

The project is not related to any professional or legal issues, however there is an ethical issue that might have a negative impact and therefore it has to be considered.

As part of the project, the map application provides detailed information about green facilities e.g. recycling points, cycle routes at each area of Bristol city. This can lead to environmental segregation – a term used in sociology which is closely related to another term: white flight – as people who are most likely to be conscious about their surroundings and nature are usually those who have higher income [79]. These people can afford to move to less polluted parts of the city, e.g. suburbs, which increases the property prices at those areas. In contrast people with lower income have no choice but live in the centres of the city, where the environment is less healthy.
Chapter 4: Technical Details and Options

This chapter sets out the technical options associated with the website development and web GIS application implementation. Each option has a brief description, including its advantages and disadvantages related to the Bristol project.

Web Development Options

There are several ways to develop websites and web applications. This section describes two methods − HyperText Markup Language (HTML)/ eXtensible HyperText Markup Language (XHTML) and ASP.NET − and justifies the selected option.

HTML and XHTML
It is possible to develop websites to use HyperText Markup Language (HTML), which is a Standard General Markup Language (SGML) − originally designed for document archival, processing and exchange [70]. HTML specifies the order and the format of the content − text, image − inserted into the document, and provides clickable hyperlinks to help navigation between pages.

There are six HTML versions: HTML1, HTML2, HTML3.2, HTML4.0, HTML4.01, HTML 5.0 and the eXtensible HyperText Markup Language (XHTML). The technology made a spectacular progress through these versions: HTML1 was a simple tool to develop websites with limited design capabilities, whereas HTML4.01 supports style sheets, e.g. Cascading Style Sheets (CSS), client and server side scripting, embedded frames and objects. HTML 5.0 defined new tags, such as <section> or <article> to make the .html document structure more logical. It also introduced the <audio> and <video> tags to embed multimedia content into web pages [59]. XHTML goes even further as it combines HTML and eXtensible Markup Language (XML).

Figure 14. shows an example of an XHTML code, which contains the document type declaration (<!DOCTYPE…>, the W3C validation type (Transitional) and all the required standard HTML tags such as <html></html>, <head></head> and <body></body>.
HTML and XHTML were potential web development options for the Bristol project because they have the advantage that their documents can be written by using Notepad or any simple text editor. These documents have the .html or .htm extensions. To test them a browser is also required. Another advantage of using HTML or XHTML is that depending on the operating

Figure 14. XHTML Example Code

As most web servers e.g. Apache and hosting services support HTML and XHTML, they can be published relatively easily.

The reason for not using HTML/XHTML for the Bristol portal is that there is another, more advanced technology available to develop websites: ASP.NET.

ASP.NET

ASP.NET is a server-side scripting technology, which was implemented by Microsoft. It is based on Active Server Pages (ASP), the company’s previous application [4].

HTML/XHTML supports client-side scripting, e.g. embedded JavaScript, and also server-side scripting, e.g. PHP, whereas ASP.NET as part of the Microsoft .NET Framework provides built-in client- and server-side scripting facilities which makes programming faster and it also reduces the amount of program code.

An ASP.NET document is an HTML file, which – along with the specific ASP.NET controls, event handlers – can contain HTML tags, such as <table> to create tables or <p> for new paragraphs. JavaScript and XML elements can also be embedded into ASP.NET documents. They have the extension: .aspx [6].

An ASP.NET application is always compiled first before running, because the background code is written in object-oriented, third-generation programming languages – C#, VB or J# – with the characteristic of compiling code instead of interpreting it [13].

ASP.NET has the following versions: ASP.NET 1.0, ASP.NET 1.1, ASP.NET 2.0, ASP.NET 3.0, ASP.NET 3.5, ASP.NET 3.5 with Service Pack 1 for Visual Studio 2008 (this version is used for the Bristol project) and ASP.NET 4.0 [45]. The first two versions – released in 2002 and 2003 – introduced the basic concept of web forms, that contain controls, such as <asp:
hyperlink> to redirect the user to another page or <asp: Button> to create submit button for forms. The next release, ASP.NET 2.0 added new, more complex features to the technology. Examples of these are the following: master pages which are useful for iterative content, e.g. the header, menu and footer section of a website, because they only have to be coded once and can be used many times; security and membership features, such as login control and role-based authorisation.

ASP.NET 3.0 is not a real version – Microsoft only released it in order to add some new technologies, such as WCF (Windows Communication Foundation) to the .NET framework. The two most significant improvements in ASP.NET 3.5 and ASP.NET 3.5 Service Pack 1 are the support for the Asynchronous JavaScript and XML (AJAX) techniques and the Language Integrated Query (LINQ). An example AJAX feature is AutoCompleter, which makes search easier by completing the words while typing them into search boxes. Language Integrated Query (LINQ) has extensions for VB, C# and SQL, which enables programmers to manipulate data similarly to database queries, e.g. using select, from operators [45].

ASP.NET 4.0 was released in 2010. It has new capabilities, such as permanent redirection of a page, which is useful when a website was moved to a different place. ASP.NET 4.0 supports the latest browser versions and devices, such as Google Chrome and Blackberry [5].

One of the main advantages of using ASP.NET for the Bristol project is the rich variety of built-in features available. Another asset of the technology is the fact that .NET Framework supports C# programming language which speeds up the development process because of previous experience and familiarity with the language. Chapter 5 (Development Process) contains detailed information – including screenshots of the program code – of how the .aspx pages were developed for the Bristol project.

Map Application Development Options

From the many options and tools available to develop web map applications, two technologies – including their advantages and disadvantages related to the project – are detailed in this section. One of them is MapServer, an open source platform and the other one is Cartology.NET, the product of Innogistic Ltd.

There is also a brief introduction of the map data source used for the web GIS application within this section.

MapServer

MapServer is a free web GIS tool, developed by the University of Minnesota in the 1990s. Since then the continuous improvements resulted many versions of the platform: in January 2011 MapServer 5.6.6 has been released. According to the official website “MapServer is an
Open Source platform for publishing spatial data and interactive mapping applications to the web” [48].

MapServer can also be defined as an engine, which renders maps and operates on the web as a Common Gateway Interface (CGI). When the application is accessed by scripting and web programming languages, such as PHP, Java or .NET, it is considered as a stand-alone program [40]. MapServer runs on all popular operating systems, including Windows, Mac OS and Linux. As an open source platform, anyone can copy, modify or add bits and pieces to the application.

Comparing MapServer to other commercial GIS products available on the market – such as ArcGIS from ESRI or MapInfo from the MapInfo Corporation – its main advantage is of being a free platform. However it has limited capabilities, “it is not a full-featured GIS” [40]. To understand the difference, first the basic features – included in all “full” GIS applications – have to be introduced: data manipulation, analytical capabilities, spatial referencing of attribute information and graphical input and output capability [40].

Data manipulation covers the maintenance and querying of databases, including spatial data, and the ability to import and integrate other data formats.

Analytical capabilities allow users to ask questions, which the application should process and answer as fast as possible. The user might want to know, for example where the nearest bicycle shops are from his/her home or the sort of recycling facilities available in his/her city.

Spatial referencing (georeferencing, geocoding) is a procedure when real-world coordinates – latitude and longitude pairs – are assigned to map objects. This is an advanced feature, which MapServer is currently unable to perform [40].

Graphical input and output capabilities are the features to build maps on georeferenced images.

As mentioned above one of the limitations of MapServer is the lack of georeferencing feature. Others are the limited querying capabilities and that it does not provide integrated database management system tools [40].

Figure 15. shows the anatomy of a MapServer application. One of the most important elements is the geographical data (input data). This data can be stored either in vector or in raster format in databases. It can also be accessed by using web services such as Web Map Service (WMS), Web Feature Service (WFS) or using tile-based maps, which divide large map files into smaller pieces. The most common vector format is the ESRI shapefile.

There are several ways to gather spatial data: some organisations – such as the Canadian Government or the U.S. National Atlas – make their information available free for the public [54]. Others – such as Landmap Services [41] – buy spatial data but provide it free for higher and further education institutions. Alternatively everyone can collect their own spatial data by
investing certain amount of money in GPS devices, although this can only be a viable option if the mapping is to be carried out within a limited area such as a town or a smaller city.

Apart from the input data, the other key element of MapServer is the map file, which is a structured text file with .map extension. It contains the definition of the map layers, the data sources, the symbology and the projections.

When the map file is configured, there are options to create a MapServer CGI application or a Mapscript application (see description of these options above).

To host (publish) the MapServer application, it is necessary to have a functioning web server, either an Apache server – runs on both Windows and Linux – or the Internet Information Service (IIS), which runs on Windows.

Output can be generated in different ways: MapServer can produce vector files [49] such as Scalable Vector Graphics (SVG), Shockwave Flash (SWF) or Portable Document Format (PDF); HTML documents with images to allow user to interact with the application; and raster files such as PNG, JPG or GIF. As MapServer adopts Open Geospatial Consortium (OGC) standards, it is possible to consider a MapServer application as client to OGC web services when it requests input data from remote servers and as server to OGC web services when it provides output data for other servers [50].

![Figure 15. The Anatomy of a MapServer Application](image)

Figure 15. The Anatomy of a MapServer Application [1]

Figure 16. shows a sample web GIS application developed by using MapServer. The left hand side of the browser displays the layer structure of the application and the right hand side contains the related map.
MapServer was a potential option for the Bristol project for its main advantages. One of them is the fact that it is open source tool, which fits with the non-profit criteria of the web portal. Another advantage is that it runs on different operating systems, such as Windows or Linux, which enables users of both platforms to use the web GIS applications. There are also useful tutorials available for MapServer developers: useful step-by-step guides of how to create and configure map applications.

The main reason for not using MapServer for the Bristol portal is that Innogistic Ltd supported the project by providing its web GIS tool, Cartology.NET—a well-tested and commercially used system, that provides full GIS features, including georeferencing of the map data, which is missing from MapServer (see MapServer description within this chapter above).

Cartology.NET

As Cartology.NET is the selected option for developing the map application, this section only provides a brief overview of the system. More detailed description of the developing process is available in the next chapter (Chapter 5: Developing Process).

“Cartology.NET is a web based Geographic Information System (GIS) developed by Innogistic Ltd” [14]. The system is based on the .NET architecture. It supports all standard GIS formats, such as .shp (ESRI shapefile) and .tab, .mif/.mid (MapInfo formats); all common CAD formats (.dxf, .dgw, .dgn); databases such as SQL Server and Oracle; open GIS formats such as GML and WMS, and all well-known raster file formats e.g. GIF.
As Figure 17. shows, Cartology.NET also provides support for the Ordnance Survey MasterMap (see Map Data Source section within this chapter below) product. Its main advantage is that it enables creating easy to use solutions by controlling map layers, scales and view set ups through administration pages. Users can add and remove layers; set up access rights for each layer, e.g. view, query; download or print query results into .pdf documents.

Map Data Source
The map data sources of the GIS application are MasterMap and OpenData, provided by Ordnance Survey (OS). OS is “Great Britain’s national mapping agency” [55]. As a government department, it focuses on definitive surveying, topographic mapping and maintaining geospatial databases within Great Britain [55]. All Ordnance Survey materials and products are protected by the Copyright, Designs and Patents Act 1998 and its regulation, called Crown Copyright, which “covers material created by civil servants, ministers and government departments and agencies” [58]. As a public sector body, Ordnance Survey has the obligation to provide information about its activities and schemes under the Freedom of Information Act 2000 [20]. Partly because it is obliged to comply with the European Union laws and also in order to help generating revenue, the government decided to make the geographical information – collected by OS – available for citizens and businesses upon request. It also covers materials produced by the mapping agency, such as topographic maps and databases in digital format. This rule is called the Re-use of the Public Sector Information Regulations 2005: “re-use means the use by a person of a document held by a public sector
body for a purpose other than the initial purpose within that public sector body’s public task for which the document was produced” [66].

Geographic information – addresses, postcodes, land ownership details – became more important over the years of technological progression. The collection of such data is expensive: before 2010 its cost for businesses varied [Longhorn and Blakemore, 2003]. Since 1 April 2010 most of Ordnance Survey data is available for free – this does not include the paper maps created for hill walkers and tourists – to attract “a new wave of entrepreneurs” [21].

Ordnance Survey announced the result of its study: an estimated £100 billion national income from the transactions and activities British companies carried out using OS geographic information [52]. The mapping agency has several products, such as historical maps, raster and vector data in different scales (1:25 000 to 1:250 000) and explorer maps for tourists (1:25 000) [57].

The next paragraph provides a brief overview of OS MasterMap.

“OS MasterMap is a continually updated and maintained database for the whole of Great Britain.” [56] It contains the following layers: Topography (buildings, county boundaries, fields), Integrated Transport Network (ITN), Address 2 and Imagery (aerial photographs) Layer. Apart from these, it is possible to build a specific layer – called “Your Layer” – with the information related to a particular business or organisation. Each feature within the database is identified by its Topographic Identifier (TOID) [56].

The Topography and the ITN layers stores data in Geography Markup Language (GML) format. The Address 2 layer contains information both in GML and Comma Separated Values (CSV) formats. The Imagery layer uses Tagged Image File Format (TIFF), Mr SID, Joint Photographic Experts Group (JPEG) and Enhanced Compression Wavelet (ECW) extensions [About Ordnance Survey MasterMap, 2011]. Most software – including Cartology.NET, FasterMap (both from Innogistic) or ArcGIS (ESRI) – are able to handle these in their native format, which means there is no risk of data loss. OS MasterMap – and all Ordnance Survey products – uses the British National Grid reference system (see Chapter 2: Background – Introduction to Geographical Information Systems (GIS)).

For the Bristol project, the Topography and the Address 2 layers are used from OS MasterMap and also some Ordnance Survey OpenData layers (see Chapter 5: Development Process – Map Application Development) have been linked to the map application. In addition to these, the National Cycle Routes – provided by Sustrans – are stored in three different layers (see Chapter 5: Development Process – Map Application Development), which are derived from the Ordnance Survey 1:10 000 Explorer Map.
Chapter 5: Development Process

Rational Unified Process

As the initial project plan indicated (see Appendix – Initial Project Plan), the project was developed by using the Rational Unified Process (RUP) framework [67], developed by IBM. This chapter first briefly introduces the advantages and the main concepts of RUP, then provides a description of how the Bristol project was completed – following the framework.

There are many advantages of applying RUP guidelines for the project. One of them is that it provides a clear structure for the development process: planning (inception phase), design (elaboration phase), implementation and testing (construction phase), delivering and maintenance (transition phase). Another asset is the emphasis on the importance of project feasibility: using cost-benefit analysis to decide whether it is worth to implement the application. The feasibility study also identifies the risk elements and the solutions to mitigate them, which relates the development process to the real world. The third reason to apply RUP for the project is the fact that the framework proved to be successful within Innogistic Ltd, as the company uses it for the development of its software products.

Rational Unified Process has two basic concepts: iteration and milestone. The next section describes both of them – first in general by referring to the RUP framework guidelines declared by IBM, and then explaining how these guidelines were applied to the development of the Bristol project.

Iteration – iterative implementation – means that the complex project is divided into smaller tasks and phases, and each phase ends with a deliverable, such as a document or an executable piece of software. Each task aims to mitigate the risk and to deliver working software (prototype), which tackles the user requirements and use cases. The iteration plan describes the phases; defines who is going to do what during the iterations; identifies a list of criteria by which the success can be measured, and defines the start/end dates and the clear deadlines of the project development process.

The other basic RUP concept is to break up the development process to phases and milestones: inception, elaboration, construction and transition.

The inception phase focuses on the understanding of the scope of the project: a business case is created to identify use cases, determine success criteria and assess the potential risk. An initial project plan is also necessary to show the iterations and cycles of the development process. This phase is critical to the future of the project, because stakeholders must be convinced by the estimated cost-benefit analysis that the software will be successful and that
it is worth to be implemented. To help to understand and demonstrate the requirements of the project, architectural prototypes can be developed at this stage. The phase is concluded with the Lifecycle Objectives Milestone.

The elaboration phase analyses the requirements and intend to eliminate those elements that are considered high risk to the project. It is necessary to view the system “mile wide and inch deep” [67], so the complete scope of the system has to be examined (functional and non-functional requirements) without precise, detailed description. After further feasibility studies an overall project plan, the rest of the uses cases and more prototypes are created at this phase, which is still crucial because the project can be terminated if the detailed analysis shows that the risk factors cannot be mitigated. The elaboration phase ends with the Lifecycle Architecture milestone.

At the construction phase all components and features are implemented and tested – in a cost-effective way within schedule – to achieve a complete, working product ready to use by the client. The user manual and software description also have to be created. Before releasing the product, “beta” testing is carried out. If the result of the testing is not satisfactory then the next phase – Transition – has to be postponed. The milestone of this phase is called the Initial Operational Capability.

The final stage of the Rational Unified Process is the Transition phase, which focuses on providing complete software to the clients who carry out more “beta” testing to check the software usability. While using the product new problems may arise, which require bug-fixing and occasionally new releases. The feedback from the users speeds up the software evaluation against the previous requirements. This phase also includes the parallel operation with the previous system and the user training. The phase ends with the Product Release milestone.

In the case of the Bristol project iterations meant that two website prototype (for more details see Chapter 5: Development Process) have been developed, tested and assessed against the client’s criteria until the last version was accepted.

The inception phase started with the project selection process. The initial idea was presented to and discussed with the clients – Innogistic Ltd and Heriot-Watt University – as project proposal. This was followed by the agreement on the project topic: a web community portal with mapping application, which provides “green” information. As the next step the functional and non-functional requirements were identified, which helped to establish the system boundaries in terms of available time and existing skills, e.g. ASP.NET experience.

The elaboration phase commenced with the analysis of the requirements (see Chapter 3: Analysis of Requirements), which was followed by the prioritisation of these specifications. An example of the primary requirements of the map application was to enable users to carry out spatial and attribute queries, e.g. finding the nearest recycling facilities within a certain
distance from a location. One of the secondary requirements was to provide a "Do PDF" option to print query results to a .pdf document. The main deliverable of this phase was the Research Report, which included a literature review (see Chapter 2: Background) with the description of similar web GIS applications such as Google Maps and Google Earth, and the relevant environmental issues. The report also contained the initial project plan (see Appendix – Initial Project Plan), the discussion of professional and ethical issues (see Chapter 3: Analysis of Requirements) and a risk assessment (see Appendix – Risk Plan). The initial project plan was amended at this phase: the design and test plan creation as well as the software installation were completed at the beginning of the next phase (Construction).

The construction phase started in the planned time, however as it was mentioned above the design, the test planning and the software installation were completed before the implementation process. At this stage two website versions – along with UML diagrams (see Appendix – UML Diagrams) – were designed and discussed with the clients. The second, detailed prototype was chosen because it satisfies the requirements of an informative website, which serves as a frame for the mapping application. All development issues that aroused were recorded in a diary to help the evaluation process at the next phase. The next subsection – Two Prototypes – provides a detailed description of the website versions.

The transition phase commenced with the delivery of the completed website and mapping application. As “beta” testing the clients and stakeholders – Innogistic Ltd employees, lecturers and students of Heriot-Watt University, cyclist forum visitors from Bristol – were asked to test the application by browsing it and provide feedback by filling online questionnaires or answering interview questions (see Appendix – Online Survey). These sets of feedback were used to evaluate the project and to complete the final chapters of the dissertation (Evaluation and Conclusion).

Comparing the RUP general guidelines to the real life development process of the Bristol project, there are certain tasks and deliverables that were unnecessary to complete or produce. One of them is the fact that the framework suggests further feasibility studies (see the general description of the Elaboration phase above). These would be essential in the case of a more complex project, e.g. implementing a completely new patient administration system for NHS, which would require thorough financial planning. The Bristol project has potentials to become marketable in the future (see Chapter 7: Conclusion), however at this stage it would have been unreasonable to carry out further feasibility studies.

Another one is the creation of a user manual. As the website and the map application are straight forward to use for anyone who is familiar with the basic Internet browsing methods, it is unnecessary to provide a detailed description of how the program works.
Two Prototypes

The project has two prototypes (called Version 1 and 2), which differ from each other in website layout and map application functionality. Both prototypes have use case diagrams (top level and detailed), use case descriptions and activity diagrams (see Appendix – UML Diagrams).

Project Version 1 (see Figure 18.) has a simpler website layout: it starts with the Home page, which also contains the map application. Apart from that the user has the option to navigate to the About and Contact pages. The map application provides the user the following features: Browse by Category or Location, Get Direction, Find Nearest and Print Query Report.

![Figure 18. Website and Map Application Version 1](image)

Figure 18. Website and Map Application Version 1

Figure 19. shows Version 2, which has a more complex website layout: it enables users to find more information than Version 1 by navigating to the About, Places, Organisations, Sustrans, Show on Map and Contact pages. This version provides a brief introduction the community portal (Home page), such as acknowledgements and where to find certain information within the website. The About page gives an overview about the project. The Places page helps users to find gardens, parks and recreational places within Bristol. The Organisations page provides contact details of charities, charity shops and other non-profit organisations, which aim to improve the environment. The Sustrans link describes how to find cycle routes within Bristol by using the map provided.
The Show on Map link takes the user straight to the map application (Figure 20.), which was developed by using Innogistic Ltd’s web server and Cartology.NET community map administrator. The map was then embedded into the Show.aspx page within an iFrame. The Contact page gives the website visitor the opportunity to email the site administrator via an online form.

After discussing the requirements with the client, project Version 2 was selected and implemented, as it provides the user with a wider range of information.
Website Development Process

The ASP.NET website was developed by using Microsoft Visual Web Developer 2008 Express Edition, which is available for free for non-commercial use. The web development process was started and finished in the planned time (see Appendix – Initial Project Plan).

Before describing the implementation stages two terms have to be explained: master page and content page. One of the greatest advantages of ASP.NET is the concept of using master page(s) for the repeating contents and content page(s) for unique information. An example for this is a company’s website, where the master page contains the main menu (Home page, About Us page, Services page, Products page, Contact page), which appears on each sub page, and all other information – related to only the sub pages – is placed to the content pages (Home, About, etc.). This concept is useful, because the recurring information has to be coded only once, which helps to avoid problems with duplicate code updates.

While developing the Bristol project website, the first step was to create the master page: “Home.master” – using ASP.NET front end code (see Figure 21.) – and the “Home.master.cs” page – C# code behind the ASP.NET front end (see Figure 22.).

The front end code contains basic information about the document such as language (C#) and the reference to its code file (CodeFile="Home.master.cs"). The document type declaration (<!DOCTYPE…>) is the same as one that is used with XHTML documents (see Chapter 4: Technical Options – Web Development, HTML/XHTML part).

```csharp
<html xmlns="http://www.w3.org/1999/xhtml">
<head runat="server">
    <meta http-equiv="X-UA-Compatible" content="IE=EmulateIE7" />
    <title></title>
</head>
<body runat="server">
    <form runat="server" enableviewstate="true">
        <div id="mainContainer"><div id="header">Green Bristol</div>
        <div id="menuBox">
            <asp:table runat="server" CellSpacing="10">
                <asp:TableRow runat="server">
                    <asp:TableCell runat="server">
                        NavigateUrl="/Home.aspx">Home</asp:HyperLink>
                    </asp:TableCell>
                    <asp:TableCell runat="server">
                        NavigateUrl="/About.aspx">About</asp:HyperLink>
                    </asp:TableCell>
                </asp:TableRow>
            </asp:table></div>
        </form>
    </div>
</body>
</html>
```

Figure 21. ASP.NET Front End Code (“Home.master”)
The `<link>` tag within the head section refers to the external Cascading Style Sheet (CSS) file, called “Project_Design.css” (see Figure 23.), which contains the design settings of the master and content pages.

```csharp
using System;
using System.Collections.Generic;
using System.Linq;
using System.Web;
using System.Web.UI;
using System.Web.UI.WebControls;

public partial class Home : System.Web.UI.MasterPage
{
    protected void Page_Load(object sender, EventArgs e)
    {
    }
    protected void btnLinkRefSustrans_click(object sender, EventArgs e)
    {
        string url = "ImageReferences.aspx";
        string fullURL = "window.open(" + url + ", '_blank',
        'height=300,width=700,status=yes,toolbar=no,
        menubar=no,location=no,scrollbars=yes,
        resizable= no,titlebar=no');"
        ScriptManager.RegisterStartupScript(this, typeof(string),
        "OPEN_WINDOW", fullURL, true);
    }
}
```

The main menu (Home, About, Places, Organisations, Sustrans, Show on Map, Contact) and the footer menu (Home, Contact, Image References) are embedded into an ASP.NET table (<Asp: Table...), which also includes their hyperlinks (<Asp: Hyperlink...) to the content pages.
The master page tag, called content place holder (<Asp: ContentPlaceHolder id="contentBoxCPH"…>) is left blank – it is filled with different information, depending on the content pages.

The C# code file has references to the .NET Framework library (using System.Web, using System.Web.UI etc.), which – similarly to Java class library – contains built-in functions to help programming. The file also includes a function (btnLinkRefSustrans_click), which enables users to see to the Image References page by opening it in a separate window with the given size (“height=300, width=700”).

After creating the master page the content pages – .aspx pages along with their background C# code files – had to be added to the project. Figure 24. shows the ASP.NET code of the “Home.aspx” page. The document declares the page title (“Home Page”), the language of the code file (C#) and the reference to the master page (MasterPageFile="~/Home.master"). The <asp: Content></asp:Content> tag has the content place holder id, which has to be the same as the one given on the master page (“contentBoxCPH”). The unique information is placed within this tag. The other content pages has the same syntax, the only difference between them is the content.

```csharp
<asp:Content ID="Content1" ContentPlaceHolderID="head" Runat="Server">
</asp:Content>
<asp:Content ID="Content2" ContentPlaceHolderID="contentBoxCPH" Runat="Server">
<br />
<p id="homeText">Welcome to <i>Green Bristol</i>, the city's green community portal and map.<br />
The website contains useful information about "green" <asp:hyperlink runat="server" NavigateUrl="~/Places.aspx"<b> places</b></asp:hyperlink> e.g. parks, gardens or recycling centres. It also provides details about <asp:HyperLink runat="server" NavigateUrl="~/Org.aspx"<b> organisations</b></asp:HyperLink> that are committed to helping improve the environment.<br /><br />
If you are a keen cyclist you might be interested in finding the National Cycle Routes within the city (see <asp:HyperLink runat="server" NavigateUrl="~/Sustrans.aspx"<b>Sustrans</b></asp:HyperLink> link). <br />
The <asp:HyperLink runat="server" NavigateUrl="~/Show.aspx" Show on Map)<b> mapping application helps you to find all these within the city.<br /><br />
<b>Acknowledgements</b><br />
I also would like to thank <asp:hyperlink runat="server" Target="_blank" NavigateUrl="http://www.grahamcolemanphotography.net/"<i>Graham Coleman</i></asp:hyperlink> for the beautiful photograph of Clifton Suspension Bridge (see on the right hand side).<br />
</p></asp:Content>
</div></asp:Content>

Figure 24. “Home.aspx”
Map Application Development Process

The Bristol project map application was developed by using Cartology.NET, which is a tool that enables users to access GIS data via a web site. Instead of using a central database that stores geographical data in one place, Cartology.NET has links to different databases and servers. This architecture has two main advantages. One is that more data source can be added or removed, depending on the system needs. The other one is that the data owner can control what sort of information is available for which system.

While implementing the Bristol project, all GIS data links have been set up by Innogistic Ltd. The data was accessible via an interface, called Community Map Administrator (see Figure 25.), which is available through the following URL:

http://demo.innogistic.co.uk/Monika/CommunityMapAdministrator

![Figure 25. Community Map Administrator Login Page](image)

After the login, the main menu is displayed (see Figure 26.). There are three options to select on the left hand side panel: General Settings, Menu Configuration and Open Community Map. The General Settings option – the same as the main menu shown by Figure 26. – enables users to configure all related settings to the map such as map scales, default map layers and boundary layers.
The next option is the Menu Configuration (see Figure 27.), which contains the map toolbar settings and stored in XML files (one file/each toolbar). These toolbars can be set up separately and they can also be switched off or hidden.

The third option is the Open Community Map, which opens a new tab within the browser and displays the community map in full screen (see Figure 28.).
There are several layers available through the Community Map Administrator, which are based on Ordnance Survey MasterMap and OpenData. The next paragraph provides an overview of these layers and shows how they were used for the Bristol project. The layer names are followed by another one in brackets, which is the official name given by Ordnance Survey.

The user has the choice to display two types of background maps (see Figure 29.). Default Map and Cycle Routes. For each background, different layers are defined.
First the Default Map layers are described.
When the user chooses the two smallest available scale options (1:1000 000 and 1:250 000), OS Miniscale Relief (OS MiniScale) is displayed (see Figure 30.). OS MiniScale is available in both raster and vector formats through OS OpenData. It is updated once a year and covers whole Great Britain [64]. OS Miniscale Relief is the same as OS Miniscale, but with shaded relief to show the terrain in three dimensions.

By selecting the next available scale (1:100 000), OS 250k Raster UK (1:250 000 Scale Colour Raster) is displayed (see Figure 28.). This map is the former Ordnance Survey Travel Map, which contains cities, towns, villages, roads, railways, boundaries and places of interest. The map – updated once a year – covers the whole Great Britain and it is free to use as part of the OS OpenData [61].

When the 1:25 000 scale is selected, OS VectorMap District England (OS VectorMap District) is displayed (see Figure 31.), which is a vector map from Ordnance Survey to cover whole Great Britain, containing boundaries, buildings, roads and railways as text, points, lines and polygons [65].
The largest available scales (see Figure 32.) are displayed by Streetview UK (OS Street View), which is an Ordnance Survey street-level map to cover Great Britain, showing roads, streets, water and woodland features. It is updated in every sixth month and available in raster format for free through OS OpenData [73].

Figure 32. Streetview UK in 1:10 000, in 1:5000 and in 1:2500 Scales

The other Background Map option is Cycle Routes, which contains three Sustrans layers: Bristol National Route, Bristol National Cycle Network Link and Bristol Regional Route. The layers are based on the Ordnance Survey 1:10 000 Scale Raster map. They contain National Routes, Regional Routes and National Cycle Network (NCN) links. The map application displays on-road routes as purple and traffic-free routes as green.

The smallest available scales for the Cycle Routes option are the same as those used for the Default Map (see Figure 30.). When the user selects the 1:100 000 scale, OS 250k Raster UK Greyscale is displayed (see Figure 33.), which is the greyscale version of OS 250k Raster UK.

Figure 33. OS 250K Raster UK Greyscale

The 1:25 000 scale option is the same as the one used for the Default Map (see Figure 31.). To display the 1:10 000 and 1:5000 scales, Streetview UK Greyscale is used (see Figure 34.), which is the greyscale version of Streetview UK. The 1:2500 scale is currently not available for Streetview UK Greyscale.
To be able to perform searches on the map, there are another three layers available for any scales and backgrounds. One of them is to find locations by street names (see Figure 35.): OS Locator – an Ordnance Survey OpenData layer that contains road names.

The layer is updated twice a year [63]. The results are displayed on the right hand side panel (see Figure 36.).
The second layer is OS Code Point (Code-Point Open), which is used for finding location by postcode (see Figure 37.). This is an OS OpenData layer that contains postcode units and covers whole Great Britain.

![Figure 37. OS Code Point - Find Postcode](image)

The layer is updated four times a year [62]. The results are displayed on the right hand side panel (see Figure 38.).

![Figure 38. Find Postcode Result](image)

The third layer is based on Ordnance Survey 1:50 000 Scale Gazetteer. It is used for finding locations by place names (see Figure 39.), e.g. city district names, towns, woodlands. The gazetteer is based on the 1:50 000 Scale Colour Raster and contains more than 250 000 place names, covers whole Great Britain. Ordnance Survey updates the data once a year [60].

![Figure 39. 50K Gazetteer - Find Location by Place Name](image)
Other options within the map application menu

The map application enables users to print the query results by saving them into a PDF file (Figure 40. and Figure 41.).

![Print Results](image)

**Figure 40. Print Results**

![Save Results into PDF File](image)

**Figure 41. Save Results into PDF File**

When the user selects the Home option the opening map is displayed (1:100 000), see Figure 28. above.

The Clear Map option removes all query results and the only the background map is displayed.

The Help option has not been completed yet; it is currently linked to the company’s website.

The About option displays the version number (2.0.2.6) in a pop-up window.

The Save option enables users to save the map and the query results as JPG or PNG images.
Problems and Difficulties Considered and Solved

Website Layout
There are three main website layout design: fluid, fixed or elastic [59].
Fluid layout – also called liquid layout – is popular, because it gives the flexibility to adapt to the user’s web browser. The content of the website is displayed in wider or narrower containers, depending on the screen size and resolution. The designer does not have to set minimum and maximum widths. The disadvantages: some browsers does not support this kind of layout, and when the site is displayed on a wider screen the content might be less readable.
Fixed layout is also often used, because it allows the developer to have a complete control over the design. Minimum and maximum widths have to be declared. The disadvantage of this layout is that blank spaces are left when the website is displayed on a wider screen.
Elastic design is less popular, because web browser do not support it well. It is based on percentage values and relative positions: when the user changes the font size, using his/her browser settings, the other contents of the site also adapt to the new text size..

As today most screens are capable of minimum 1024x768 pixels resolution, the green community portal has fixed layout. This way the design of the website can be controlled. The main container is positioned in the centre and it is 1000 pixel width, which does not leave too wide blank spaces on the left and right hand sides. Although the website looks best when it is displayed on a 1280x800 screen, those users who have monitors with 1024x768 pixels resolution are not disadvantaged either because they can still read the content of the main container.

Browser Compatibility
Another issue that had to be considered is the fact that there is more than one type of web browsers – and also many versions of each browser – available on the market. According to the World Wide Web Consortium (W3C), currently the most popular browser is Mozilla Firefox, followed by Microsoft Internet Explorer [11]. While developing a website, there are certain design solutions which can be displayed perfectly in one browser but not in another, e.g. Firefox is able to display boxes with rounded corners (“soft boxes”) but Internet Explorer cannot [59]. For these reasons it is always worth to test the web pages in two or more browsers.
The Bristol project was checked in Firefox and Internet Explorer and some initial solutions had to be replaced with others, because they did not work in both browsers, e.g. the ASP.NET built-in menu control.
Hosting ASP.NET Websites

There are some differences between retrieving .html and .aspx files. When the user wants to open an .html file in a browser, it can be done by right-clicking on the filename and then select Open, or by dragging and dropping it onto the browser [36]. These methods cannot be used with an .aspx file, because ASP.NET is a server-side technology, which does not allow the pages to be opened without first connecting to the server. If the user tries to open an .aspx page in the same way as an .html one, an error message occurs (see Figure 42.).

![Figure 42. Error Message - Opening .aspx Page the Same Way as .html One](image)

It is also possible that the browser simply displays the ASP.NET front end code, not the web page (see Figure 43.).

![Figure 43. Browser displays .aspx Code](image)

While using Microsoft Visual Web Developer 2008 Express Edition to develop ASP.NET pages, the only way to test without a web server (e.g. IIS or Apache, see explanation below) whether the .aspx files work is to right-click on the file name within Solution Explorer and select the View In Browser or the Browse with… options (see Figure 44.).
After opening the file the program displays the page within the selected browser (see Figure 45.).

Regardless whether the web pages are developed by using HTML, XHTML or ASP.NET, a web server is necessary in order to publish the website.

While looking for the right solution to host the website, an issue occurred related to the operating system on the computer (my computer), which was used for developing the application: Windows Vista Home Basic does not support Internet Information Services (IIS), which is a web server application provided by Microsoft to help publishing ASP.NET sites [39]. A possible option was to upgrade Windows Vista Home Basic to Home Premium or
above (e.g. Windows Vista Business version), but that would have not been feasible in the case of the Bristol project.

Another option was to use Heriot-Watt University’s Apache server (Apache 2.0.52) to host the website. Apache server is an open source [2] HTTP server, which is freely-available. The problem is that Apache does not support ASP.NET technology by default – a module, called “mod_aspdotnet” or “mod_mono” has to be installed and configured on the same computer, where the server is [3]. This module is not available on Heriot-Watt’s web server.

The solution was to find a web hosting service on the Internet. There are many services available – most of them offer different storage capacity and extra features, such as security via different hosting options, e.g. basic, professional for various fees. The selected host for the Bristol project is a free trial version (90 days), called ASPSpider.NET [7]. The service provides 10 MB storage space. The Bristol project can be found under the following URL: http://aspspider.info/mm564/Home.aspx.

Collecting Map Data for the Application

The main data sources for the map application – OS MasterMap and OS OpenData – were provided by Innogistic Ltd’s server. To be able access map data that contains the cycle routes within Bristol, Sustrans had to be contacted. After signing their data sharing agreement form (see Appendix – Sustrans Data Sharing Agreement), the three map layers (see Map Application Development Process section above) were provided.

One of the mapping application requirements was to enable users to find recycling facilities near their location (see Chapter 3: Analysis of Requirements – Functional Requirements/Mapping Application). To access the map layers that contain recycling places, there were several unsuccessful attempts to contact Bristol City Council by email and phone, therefore this part of the project could not be completed.

Finding Images for the Website

The photographs that were used for the website are from various sources. The Bristol Suspension Bridge image on the Home page is provided by Graham Coleman, who is a Bristol based photographer with an impressive online gallery. He agreed to send the selected image by email and as return his name and the hyperlink to his website is included within the Acknowledgements section of the Home page.

The photo on the About page (“Apples and Trees”) is available for free from an online gallery [22]. The image on the Places page (“Forest”) is also from the same online collection as well as the photographs on the Organisations page (“Butterfly”) and the Sustrans page (“Bicycle”, “Railway”). The picture on the Contact page (“English Summer”) was taken by Robert Bell and it is available through another free online gallery [19].

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Chapter 6: Evaluation

The feedback received from the stakeholders – Innogistic Ltd, Heriot-Watt University lecturers, students – provided information that was necessary to evaluate the project.

The full list of questions and answers of the questionnaire, along with column and pie charts, can be found in the Appendix – Online Survey subsection. The next paragraph summarises the results, the question numbers in brackets refer to the Appendix.

The results of the online survey indicate the following: 83 percent of the users said that the website is useful, 17 percent gave no answer to this question (Question 1.). 66.66 percent of the people rated the ease of navigation as excellent and 33.33 percent of them think that it is good (Question 2.). The accuracy of information was rated excellent by 33.33 percent of the users and as good by 66.66 percent. 50 percent of the people said that the organisation of information is excellent and 50 percent believes that it is good. The layout/design was rated as excellent by 66.66 percent, 16.66 percent said that it is good and 16.66 percent thinks that it is poor.

66.66 percent of the respondents believe that the web portal motivates them to consider a more environmentally friendly lifestyle (Question 3.). 33.33 percent answered that it motivates them but it should provide more information.

33.33 percent of the people would like to find information about “green” events and farmers markets, 16.66 percent wants to know about bicycle shops and 50 percent answered that it would be great to find details about ethical clothing on the website (Question 4.).

The question that asked for any suggestions for improvements (Question 5.) got two responses: one person would like the map to cover a larger area and another one said that it would be helpful to give instructions on how to use the map application.

As Question 6. shows, the majority of respondents (66.66 percent) were female, the rest were male (33.33 percent).

The people’s age who answered the questions varies: 16.66 percent of them are between 18-24 and 83.33 percent are between 25-34 (see Question 7.).
Does the website motivate you to consider a more environmentally friendly lifestyle?

- 33.33% Yes, it definitely motivates me.
- 66.66% Yes, although it should provide more information.
- No, it does not motivate me at all.

As the responses were mainly positive, the project can be considered effective, however some changes and improvements are necessary (see Chapter 7: Conclusion and Further Recommendations).

The evaluation of the problem solving activity – website and map application implementation; dissertation document writing – is considered effective: the selected project was manageable within the schedule, and all necessary knowledge and skills – ASP.NET programming skills, GIS background knowledge – were available to develop the practical part. The arranged meetings with the project supervisor were also helpful in order to finish the dissertation document in time. The user feedback has an overall positive tendency, which also indicates that the project was successful.
Chapter 7: Conclusion and Further Recommendations

The company-based MSc project was the development of the green community portal and map of Bristol. It aims to motivate people to consider an alternative, more sustainable lifestyle by providing “green” information. The objective of the project was to implement an ASP.NET website and an embedded map application, using Cartology.NET.

The first stages of the work were the following: literature review; the identification and analysis of requirements – both functional and non-functional; the creation of the initial project plan and the risk assessment plan. These documents were part of the research report, which was submitted without any difficulties adhering to the schedule.

During the next stages of the project the work included two parallel tasks: the practical development (design and implementation of the website and the map application) and the dissertation document writing. At this point the initial project plan had to be changed, due to problems in the map application development process. The reason for the delay was the difficulty to arrange access to the company’s server, as they were having a busy period.

Issues also occurred while gathering data for the map application (see Chapter 5: Map Application Development Process – Problems and Difficulties Considered and Solved), which caused not only delay but also alterations to the functional requirements (see Chapter 2: Analysis of Requirements): the map application currently does not have the feature to find the nearest recycling places within a certain distance from a postcode or address.

Despite the delay, the server setup had been completed and the map application was developed within the given dissertation time frame.

The project was published – along with an online questionnaire (see Appendix – Online Survey) – at the final stage of the work.

There are two tasks, which could have been done more efficiently. One of them is the analysis of the client requirements at the Inception stage: if at that point the available map data had been tested more thoroughly, then – with better time management – all the missing information, e.g. recycling facilities map layer from Bristol City Council, could have been collected. The other task is the online questionnaire: by publishing the survey earlier and giving more time to users to complete it, more feedback and therefore a more comprehensive result could have been achieved.

Considering the predominantly positive user feedback (see Chapter 6: Evaluation), the project achieved its aim: by providing a collection of organisations, places and cycling routes, it motivates people to choose an alternative lifestyle. Most of the respondents mentioned that they would like to receive more information about farmers markets, “green” events, bicycle
shops and ethical clothing. This indicates the demand for improvements of the project, which has the potential to become marketable, if bicycle shops, eco shops, restaurants and other businesses were allowed to advertise on the site.
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Appendix
Online Survey

The online questionnaire was created by using SurveyMonkey [74].

“Welcome to the Green Bristol Survey. Please take some time (approximately 10 minutes) to complete this questionnaire. Your responses will provide important information that will help me to evaluate my MSc project.”

Q1. Is the website helpful? Does it help you to find the information you look for?

Is the website helpful? Does it help you to find the information you look for?

<table>
<thead>
<tr>
<th>Percentage of Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes 83%</td>
</tr>
<tr>
<td>Some</td>
</tr>
<tr>
<td>No 17%</td>
</tr>
<tr>
<td>No answer</td>
</tr>
</tbody>
</table>

Q2. How would you rate the web portal in terms of the following?

How would you rate the web portal in terms of the following?

<table>
<thead>
<tr>
<th>Percentage of Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of Navigation 66.66%</td>
</tr>
<tr>
<td>Accuracy of Information 66.66%</td>
</tr>
<tr>
<td>Organisation of Information 50.00% 50.00%</td>
</tr>
<tr>
<td>Layout/Design 16.66% 16.66%</td>
</tr>
</tbody>
</table>

- 65 -
Q3. Does the website motivate you to consider a more environmentally friendly lifestyle?

![Pie chart showing the responses to Q3.](image)

- 33.33% Yes, it definitely motivates me.
- 66.66% Yes, although it should provide more information.
- No, it does not motivate me at all.

Q4. If you selected the second choice in the previous question, could you specify what sort of information you would want to find on the website?

![Bar chart showing the responses to Q4.](image)

<table>
<thead>
<tr>
<th>Information Type</th>
<th>Percentage of Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Green” events e.g. practical conservation opportunities</td>
<td>33.33%</td>
</tr>
<tr>
<td>Farmers markets</td>
<td>33.33%</td>
</tr>
<tr>
<td>Bicycle shops</td>
<td>16.66%</td>
</tr>
<tr>
<td>Ethical clothing</td>
<td>50%</td>
</tr>
</tbody>
</table>

Q5. Do you have any suggestions for improvements?

No of Responses: 2

- “Excellent idea, it will be good if a larger area is covered.”
- “Maybe some information on how to use the map. It took me a while to understand.”
Q6. What is your gender?

![Gender Survey](image)

Q7. Which range includes your age?

![Age Survey](image)

“Thank you very much for completing the survey.”
Sustrans Data Sharing Agreement

Data Sharing Agreement
Sustrans hereby grants the licensee a non-transferable licence to use the dataset supplied for its own internal business needs on the terms and conditions noted below;
The Licensee may only use the data in accordance with the relevant Crown Copyright and Ordnance Survey / Ordnance Survey of Northern Ireland Licence Agreement.

Crown Copyright
All paper and electronic copies of this data must include an acknowledgement to the provider, Sustrans, and Ordnance Survey / Ordnance Survey of Northern Ireland Licence Number.

Use
The licensee must not edit the data in any way.
The data is to be used only for the agreed purpose and is not to be published or used otherwise without Sustrans’ express permission.
Data, in the supplied state has been captured at a level of accuracy that is appropriate to the needs of Sustrans’ work, and cannot be guaranteed. It should therefore be used with caution.
Sustrans do not guarantee the integrity or absence of minor errors in the dataset. The data was originally captured at 1:10,000 scale against an Ordnance Survey background (1:50,000 scale Ordnance Survey of Northern Ireland background in Northern Ireland).

Termination
Either party shall have the right to terminate this Licence Agreement upon failure by the other party to fulfil any of its obligations. The party in default must be notified in writing, stating the infringement and the intent to terminate this Licence Agreement. They then have six weeks to satisfactorily correct the problem.
The termination shall become effective at the end of six weeks from the receipt of the letter stating the termination. The termination shall not however affect the validity of any provisions of the Licence Agreement which expressly extend beyond such termination.
Upon termination or on completion of the Duration of this Licence Agreement all Data provided shall be deleted from the Licence’s computer systems and/or returned to Sustrans.

Charges
No charges shall be liable to either party for the provision of data.
<table>
<thead>
<tr>
<th>Name of Licensor</th>
<th>Sustrans Ltd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Representative</td>
<td>Matt Bridges (GIS Department)</td>
</tr>
<tr>
<td>Address</td>
<td>Sustrans</td>
</tr>
<tr>
<td></td>
<td>2 Cathedral Square</td>
</tr>
<tr>
<td></td>
<td>Bristol, BS1 5DD</td>
</tr>
<tr>
<td>Telephone</td>
<td>(0117) 926 8893</td>
</tr>
<tr>
<td>Fax</td>
<td>(0117) 929 4173</td>
</tr>
<tr>
<td>Email</td>
<td><a href="mailto:matt.bridges@sustrans.org.uk">matt.bridges@sustrans.org.uk</a></td>
</tr>
<tr>
<td>Print Name</td>
<td>Matt Bridges</td>
</tr>
<tr>
<td>Signed</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>Representative</td>
<td></td>
</tr>
<tr>
<td>Licensee (organisation)</td>
<td></td>
</tr>
<tr>
<td>Address</td>
<td></td>
</tr>
<tr>
<td>Telephone</td>
<td></td>
</tr>
<tr>
<td>Fax</td>
<td></td>
</tr>
<tr>
<td>Email</td>
<td></td>
</tr>
<tr>
<td>Regular update needed</td>
<td>Yes / No (delete as applicable)</td>
</tr>
<tr>
<td>Format required</td>
<td>MapInfo/Arcview/CAD/Other</td>
</tr>
<tr>
<td>Dataset required</td>
<td>National Cycle Network</td>
</tr>
<tr>
<td>Area required</td>
<td></td>
</tr>
<tr>
<td>OS/OSNI Licence number</td>
<td></td>
</tr>
<tr>
<td>Print Name</td>
<td></td>
</tr>
<tr>
<td>Signed</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td></td>
</tr>
</tbody>
</table>
### Use Case Description – Show on Map (Version 1)

<table>
<thead>
<tr>
<th>Use Case ID:</th>
<th>Show on Map</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use Case Name:</td>
<td>Show on Map</td>
</tr>
<tr>
<td>Created By:</td>
<td>Monika Molnar</td>
</tr>
<tr>
<td>Last Updated By:</td>
<td></td>
</tr>
<tr>
<td>Date Created:</td>
<td>18/05/2011</td>
</tr>
<tr>
<td>Date Last Updated:</td>
<td>18/05/2011</td>
</tr>
<tr>
<td>Actor:</td>
<td>system, user</td>
</tr>
<tr>
<td>Description:</td>
<td>Browsing by category and location, getting direction from A to B, finding nearest place/event to a location/postcode, making layers visible/invisible, zooming in/out and printing query reports; user and system are involved</td>
</tr>
<tr>
<td>Trigger:</td>
<td>The results have to be displayed on map</td>
</tr>
<tr>
<td>Preconditions:</td>
<td></td>
</tr>
<tr>
<td>Postconditions:</td>
<td>Results are displayed</td>
</tr>
<tr>
<td>Priority:</td>
<td></td>
</tr>
<tr>
<td>Frequency of Use:</td>
<td></td>
</tr>
</tbody>
</table>
| Normal Course of Events: | **Use Case 1: Browsing by Category and Location**  
1. User selects a category or location from the list  
2. The system searches for result  
3. The result is displayed on map  

**Use Case 2: Getting Direction**  
1. User types in location A and B  
2. Route from A to B is displayed on map  

**Use Case 3: Find Nearest**  
1. User selects one or more place(s) or event(s)  
2. User types in postcode or location  
3. User selects the distance  
4. After clicking the “Find Nearest” button results are displayed on map |
| Alternative Courses: | **Use Case 1: Browsing by Category and Location**  
2.a If no result is found the system informs the user:  
   “No result for this category/location”  
2.b If result is found go to number 3.  

**Use Case 2: Getting Direction**  
1.a If location is invalid, the system informs the user:  
   “Invalid location, please try again”  
1.b If location is valid go to number 2.  

**Use Case 3: Find Nearest**  
4.a If location/postcode is not found or invalid the system informs the user:  
   “Location or postcode invalid, please try again”  
4.b If there is no place or event within the set distance, the system displays an error message:  
   “No such place or event found, please try another one”  
4.c If result is found system displays it on map |
<table>
<thead>
<tr>
<th>Use Case ID:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Use Case Name:</td>
<td>Contact</td>
<td></td>
</tr>
<tr>
<td>Created By:</td>
<td>Monika Molnar</td>
<td>Last Updated By:</td>
</tr>
<tr>
<td>Date Created:</td>
<td>18/05/2011</td>
<td>Date Last Updated:</td>
</tr>
<tr>
<td>Actor:</td>
<td>system, user</td>
<td></td>
</tr>
<tr>
<td>Description:</td>
<td>Sending email to website administrator</td>
<td></td>
</tr>
<tr>
<td>Trigger:</td>
<td>Email has to be delivered</td>
<td></td>
</tr>
<tr>
<td>Preconditions:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postconditions:</td>
<td>User is notified by the system when email is successfully sent</td>
<td></td>
</tr>
<tr>
<td>Priority:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of Use:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Normal Course of Events: | **Use Case 1: Email Administrator**  
1. User clicks the hyperlink on Contact page to send email to website administrator  
2. The system displays a form: user is allowed to type in his/her email address and the message, and send the message by clicking the “Send” button  
3. Confirmation is displayed: “Message delivered” |  |
| Alternative Courses: | **Use Case 1: Email Administrator**  
2.a If a connection error occurs system sends a message: “Connection error, try to send it again”  
2.b If message is sent go to number 3. |  |
<table>
<thead>
<tr>
<th>Use Case ID:</th>
<th>Show on Map</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use Case Name:</td>
<td>Show on Map</td>
</tr>
<tr>
<td>Created By:</td>
<td>Monika Molnar</td>
</tr>
<tr>
<td>Last Updated By:</td>
<td></td>
</tr>
<tr>
<td>Date Created:</td>
<td>18/07/2011</td>
</tr>
<tr>
<td>Date Last Updated:</td>
<td>18/07/2011</td>
</tr>
<tr>
<td>Actor:</td>
<td>system, user</td>
</tr>
<tr>
<td>Description:</td>
<td>Using map to find location, select background map, print query reports, zoom in/out using the scalebar; user and system are involved</td>
</tr>
<tr>
<td>Trigger:</td>
<td>The results have to be displayed on map</td>
</tr>
<tr>
<td>Preconditions:</td>
<td></td>
</tr>
<tr>
<td>Postconditions:</td>
<td>Results are displayed</td>
</tr>
<tr>
<td>Priority:</td>
<td></td>
</tr>
<tr>
<td>Frequency of Use:</td>
<td></td>
</tr>
</tbody>
</table>

**Normal Course of Events:**

**Use Case 1: Finding Streets and Postcodes; Searching for Place Names**

1. User types the street name or the postcode
2. The system searches for result
3. The results are displayed on the right hand side panel and on map

**Alternative Courses:**

**Use Case 1: Finding Streets and Postcodes; Searching for Place Names**

1. a If result is found the system informs the user: “No result found”
2. b If result is found go to number 3.
<table>
<thead>
<tr>
<th>Use Case ID:</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use Case Name:</td>
<td>Contact</td>
</tr>
<tr>
<td>Created By:</td>
<td>Monika Molnar</td>
</tr>
<tr>
<td>Date Created:</td>
<td>18/07/2011</td>
</tr>
<tr>
<td>Last Updated By:</td>
<td>Monika Molnar</td>
</tr>
<tr>
<td>Date Last</td>
<td>18/07/2011</td>
</tr>
<tr>
<td>Updated:</td>
<td></td>
</tr>
<tr>
<td>Actor:</td>
<td>system, user</td>
</tr>
<tr>
<td>Description:</td>
<td>Sending email to website administrator via web form</td>
</tr>
<tr>
<td>Trigger:</td>
<td>Email has to be delivered</td>
</tr>
<tr>
<td>Preconditions:</td>
<td></td>
</tr>
<tr>
<td>Postconditions:</td>
<td>User is notified by the system when email is successfully sent</td>
</tr>
<tr>
<td>Priority:</td>
<td></td>
</tr>
<tr>
<td>Frequency of Use:</td>
<td></td>
</tr>
<tr>
<td>Normal Course of Events:</td>
<td><strong>Use Case 1: Email Administrator</strong></td>
</tr>
<tr>
<td>Use Case 1: Email Administrator</td>
<td>1.User fills the form on Contact page to send email to website administrator</td>
</tr>
<tr>
<td></td>
<td>2.The system displays a form: user is allowed to type in his/her name, email address and the message, and send the message by clicking the “Send” button</td>
</tr>
<tr>
<td></td>
<td>3.Confirmation and hyperlink are displayed:</td>
</tr>
<tr>
<td></td>
<td>“Thank you for your email”</td>
</tr>
<tr>
<td></td>
<td>Return to the Contact page</td>
</tr>
</tbody>
</table>
Initial Project Plan

The project is going to be developed by using the Rational Unified Process (RUP) framework. The two basic concepts of RUP are the following: iteration and milestones.

Iteration – iterative implementation – means that the complex project is divided into smaller tasks and phases. Each task aims to mitigate the risk and to deliver working software (prototype) which tackles the user requirements and use cases. The iteration plan describes the phases; defines who is going to do what during the iterations; identifies a list of criteria by which the success can be measured and defines the start/end dates and the clear deadlines of the project development process.

RUP has the following milestones: inception, elaboration, construction and transition. The inception milestone focuses on the understanding of the scope of the project. The elaboration milestone describes the project architecture and understands the requirements. The construction milestone develops the software and the transition delivers it to the customer. The RUP background is based on David West’s white paper West, D., “Planning a Project with the IBM Rational Unified Process” [37].

Project Milestones

**Inception**
- Project selection – Agreement on topic
- Identifying system boundaries – considering the available time and existing development skills
- Identifying requirements – Heriot-Watt University MSc project standards; Requirements of Innogistic Ltd as customer
- Deadline: 11 February project proposal
- Start date: 1 February
- End date: 11 February
- Deliverable: project proposal

**Elaboration**
- Analysing requirements – identifying use cases
- Prioritising requirements – primary and secondary requirements
- Identifying dependencies between tasks
- Creating design
- Installing development tool – Cartology.NET
- Reading user manual for the development tool
Creating test strategy and test plan

Deadline: 18 April Research Report
Start date: 14 February
End date: 13 May
Deliverables: research report including requirement analysis, risk plan, project plan, ethical issues and literature review; software architecture document; test strategy; test plan

Construction
- Developing a series of website prototype
- Creating a series of mapping application prototype
- Documenting issues for evaluation and conclusion
Start date: 16 May
End date: 5 August
Deliverable: working mapping application and website

Transition
- Delivering application to Heriot-Watt University and Innogistic Ltd
- Submitting dissertation
- Evaluation
- Preparing presentation for the poster session
Deadlines: 18 August MSc dissertation, presentation
Start date: 8 August
End date: 25 August
Deliverables: MSc dissertation; presentation

Evaluation Plan
The project evaluation aims to find out how effective and useful the application is. There are stakeholders of the project such as project supervisor, lecturers of Heriot-Watt University, Innogistic Ltd as the customer of the project and those who are likely to use the application such as residents and visitors of Bristol.
In order to evaluate the project interviews and online surveys will be completed.
## Initial Project Plan – Gantt Chart

<table>
<thead>
<tr>
<th>Phase</th>
<th>Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inception</td>
<td>Project selection</td>
</tr>
<tr>
<td></td>
<td>Identifying system boundaries</td>
</tr>
<tr>
<td></td>
<td>Identifying requirements</td>
</tr>
<tr>
<td></td>
<td>Submitting project proposal</td>
</tr>
<tr>
<td>Elaboration</td>
<td>Analysing requirements</td>
</tr>
<tr>
<td></td>
<td>Prioritising requirements</td>
</tr>
<tr>
<td></td>
<td>Identifying task dependencies</td>
</tr>
<tr>
<td></td>
<td>Writing research report</td>
</tr>
<tr>
<td></td>
<td>Submitting research report</td>
</tr>
<tr>
<td></td>
<td>Creating test plan and test strategy</td>
</tr>
<tr>
<td></td>
<td>Installing Cartology.NET</td>
</tr>
<tr>
<td></td>
<td>Reading user manual for Cartology.NET</td>
</tr>
<tr>
<td></td>
<td>Creating software architecture document</td>
</tr>
<tr>
<td>Construction</td>
<td>Developing website and application prototype 1</td>
</tr>
<tr>
<td></td>
<td>Developing website and application prototype 2</td>
</tr>
<tr>
<td></td>
<td>Developing website and application prototype 3</td>
</tr>
<tr>
<td></td>
<td>Documenting issues for evaluation and conclusion</td>
</tr>
<tr>
<td>Transition</td>
<td>Delivering application</td>
</tr>
<tr>
<td></td>
<td>Evaluation</td>
</tr>
<tr>
<td></td>
<td>Preparing presentation</td>
</tr>
<tr>
<td></td>
<td>Submitting dissertation</td>
</tr>
</tbody>
</table>
Risk Plan

Project Risk Matrix

<table>
<thead>
<tr>
<th>Risk</th>
<th>Importance</th>
<th>Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mapping software unavailable</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>System performance poor</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>Developing the website prototype takes longer than expected</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Collecting information for the website takes longer than expected</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Printing query reports requirement proves impossible to implement</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>Licence period ends</td>
<td>H</td>
<td>L</td>
</tr>
</tbody>
</table>

H: High   M: Medium   L: Low

Controlling Risk

- Mapping software unavailable
  The software provided by Innogistic Ltd: Cartology.NET. If for any reason this tool is unavailable, there is an open source software, MapServer, that can be used to develop the mapping application.

- System performance poor
  The system performance can be improved by carefully writing code, e.g. using CSS div boxes instead of HTML tables. It is also essential to avoid too big images, which makes the website downloaING slow.

- Developing the website prototype takes longer than expected
  To avoid further delays, the dissertation document can be written in parallel, so by the time the prototype is completed the design and testing document is already available.

- Collecting information for the website takes longer than expected
  If there is not enough information to complete, the project as previously required then a limited version can be developed, e.g. using less hyperlinks

- Printing query reports requirement proves impossible to implement
  As this requirement is not crucial in terms of availability of the application, a section within the dissertation document can be included and list this task as a possible future recommendation

- Licence period ends
  If there is any problem related to the usage of Cartology.NET, an extended licence period can be negotiated with the company

Comment:
The project risk matrix is based on the lecture note – MSc Project Planning & Timetabling provided by Dr Helen Hastie.
Glossary

**Barometric level:** barometers are used to measure the atmospheric pressure. As they show the correlation between the changes in air pressure and altitudes (above sea level the pressure decreases, below sea level it increases), therefore they were used in cartography to measure heights in the 17-18\textsuperscript{th} century.

**Brown field development:** building houses, industrial estates on land that has been developed before. This type of development is considered to be more sustainable, as it does not require conquering more land from the nature.

**Cadastral map and systems:** cadastral maps are large scale maps and registers, which show land ownership details, exact locations of properties with coordinates and the boundaries of the land. Cadastral systems are parcel-based Land Information Systems which contain maps and database about land owners, property boundaries, etc.

**Common Gateway Interface (CGI):** as part of the Hypertext Transfer Protocol (HTTP), CGI is responsible for transferring user requests to the server. CGI applications can be written in many programming languages. They are the collections of facilities that allow user to interact with the server, e.g. online forms.

**Datum, reference ellipsoid:** a base reference level for the third dimension of elevation for the Earth’s surface. There are many reference ellipsoids – the difference between them is the length of the equatorial and polar axis, therefore the flatness ratio, e.g.

\[
F = 1 \div B/A
\]

One of the most widely used datums is World Geodetic System, introduced in 1984 (WGS84) by International Earth Rotation and Reference Systems Service (IERS): its flatness ratio is $1/298.257223563$.

**ESRI shapefile:** a vector file format, used to store geospatial information (location and attribute of an object), developed by the GIS software company, ESRI. The shapefile has three parts: shp (stores the geometry of the object), shx (object index), dbf (object attributes).

**Gazetteer:** a directory, which contains geographical place names, such as county, city, town, village, river, lake, and mountain names.
Global Positioning Systems (GPS): it was first developed by the United States Air Forces. The system is based on satellites that circle around the Earth, and devices that are used on the ground and able to send signals to the satellites. Once the satellites received the signals, they decode and send them back as coordinate pairs (latitude and longitude).

Green field development: also called green field project, which means building houses or establishing industrial estates on a land that has never been developed before. The opposite of this is brown field development (see above).

Latitude: the angular distance North and South from the equator.

Longitude: the angular distance East and West from the prime meridian.

Loxodrome: a line intersecting meridians at one and the same angle.

.NET architecture: .NET is a framework provided by Microsoft. It contains a Common Language Infrastructure to enable language-neutral application development. Class Libraries with the built-in functions are also included within the framework. The third most important part is the set of security features to restrict access to program code.

Open Geospatial Consortium (OGC) standards: Open Geospatial Consortium is an international group that aims to provide standards to share geospatial information. The most well-known standards are the following: Web Map Services (WMS), Web Feature Services (WFS) and Web Coverage Services (WCS).

Raster data formats: the most popular raster data formats are the following: JPG, GIF, TIFF.

 JPEG or JPG stands for Joint Photographic Experts Group, which is a relatively lossless and compressed file format, used for storing photographs.

 GIF means Graphic Interchange Format, which is useful to publish images on the Internet and also to create animations.

 TIFF means Tagged Image File Format, which is capable of compression without compromising the quality of the picture.

Relative location: a position described entirely with reference to another location.

Sustrans: a Bristol based charity that is encourages people to choose “healthier, cleaner and cheaper” ways to travel – ideally walking, cycling or using public transport. Sustrans coordinates the National Cycle Network – approximately 12 600 miles long routes across the Great Britain.
Theodolite: a precision tool – standing on tripod – to measure horizontal and vertical angles. It is a widely used instrument in geodesy e.g. land surveying and in civil engineering.

Vector Data Formats: some examples: CDR (Corel Draw format), SVG (Scalable Vector Graphics), DWG and DXF (AutoCAD formats).

W3C validation: World Wide Web Consortium (W3C) is an international organisation, which aims to provide web development standards and validation helpers. The most often used validation types of XHTML pages are the following: Basic, Transitional and Strict.

Web Coverage Services (WCS): OGC standard, shares raster features through multidimensional range of properties.

Web Feature Services (WFS): OGC standard to share features and attributes of vector data across remote server in the form of GML (Geographic Markup Language).

Web Map Services (WMS): OGC standard, used to share images (e.g. GIF, PNG, JPG) of spatial data through remote servers.

White flight: A sociological term, which describes the trend that people with higher income move out from cities to suburb or rural areas where house prices are also higher but the environment is healthier e.g. less pollution.