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Landscape Engineering – Landscape Planning



GIS APPLICATIONS TO ENHANCE THE STUDENT AND VISITOR
EXPERIENCE OF CRANFIELD UNIVERSITY

DIPLOMA THESIS

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DIPLOMA THESIS ASSIGNMENT

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Thesis title

GIS applications to enhance the student and visitor experience of Cranfield University

Objectives of thesis

The main aims of the thesis are:

- to develop a web-based GIS application for Cranfield University to help students and visitors with campus familiarisation, orientation around campus and to provide them with various up to date information;
- to develop a supporting web-based GIS application to help the University Professional Service Units attract potential students;
- to evaluate the utility of the developed tools.

Methodology

Existing data, including existing maps, university website, intranet and leaflets and students' data, will be analysed. New data will be gathered by GPS mapping, capturing images and other field data collection techniques. All data will be then processed, verified and assembled to create maps that will be used as a basis for designing the applications. ESRI's Web AppBuilder for ArcGIS and Story Map with embedded Time Aware App platforms will be chosen for this project. The developed applications will be consequently evaluated by user satisfaction survey.

The proposed extent of the thesis

50 – 60 stran

Keywords

GIS tools, interactive map, campus map, web-based application, Cranfield University

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Declaration

I hereby declare that the thesis titled “GIS applications to enhance the student and visitor experience of Cranfield University” is original work which I have completed independently under the direction of the supervisor. All the sources have been quoted and listed in References at the end of the thesis.

Prague, 5th April 2017

CRANFIELD UNIVERSITY

TEREZA RUZICKOVA

GIS APPLICATIONS TO ENHANCE THE STUDENT AND VISITOR EXPERIENCE
OF CRANFIELD UNIVERSITY

SCHOOL OF WATER, ENERGY AND ENVIRONMENT
Geographical Information Management

MSc THESIS
Academic Year: 2015 - 2016

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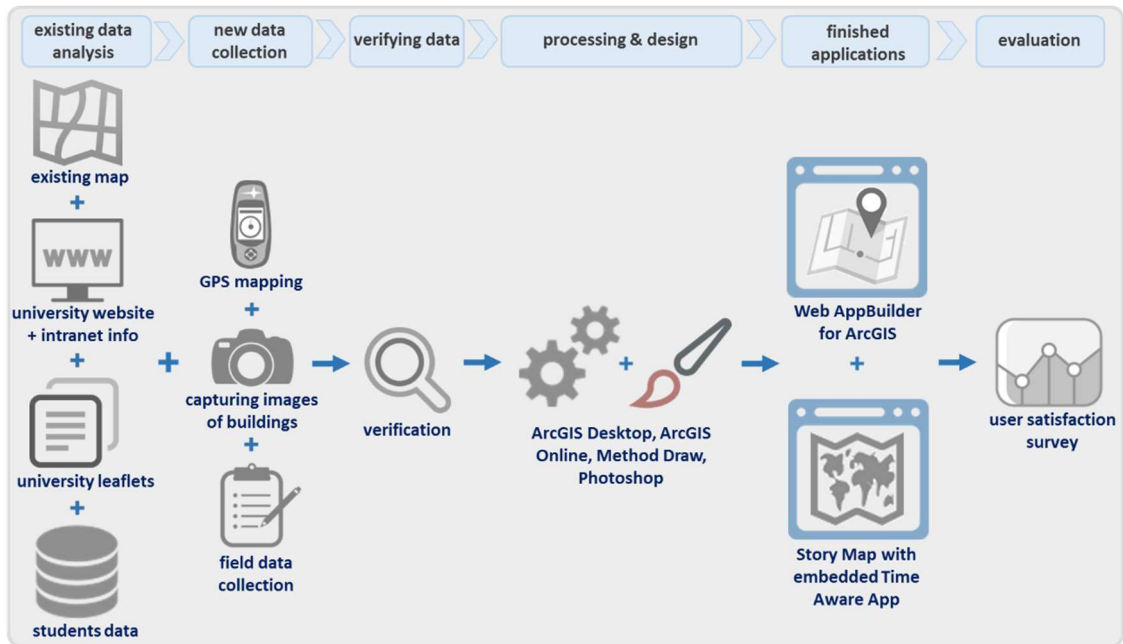
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GRAPHICAL ABSTRACT



ABSTRACT

Interactive maps are a great way of displaying useful information in an engaging way by inviting the user to take action. Universities using ArcGIS software are allowed to use the technology to help run their businesses but no institution in the UK is currently doing so for the purposes of providing a campus map app to help guide students and visitors around the university campus. Two web-based GIS applications were developed for Cranfield University: Cranfield Interactive Campus App to help students and visitors with campus familiarisation, orientation around campus and to provide them with various up to date information, and a supporting Cranfield Students App to help the University Professional Service Units attract potential students. ESRI's Web AppBuilder for ArcGIS and Story Map with embedded Time Aware App platforms were used in this project. The developed applications are easy to maintain and can be accessed on multiple devices – via web, smartphone or tablet. The application proved to be a valuable tool for the Cranfield community as a source of information based on positive feedback from the user satisfaction survey. The respondents also identified several opportunities for potential improvements. The project has gained a lot of interest and it has significant potential for expansion and development in the future, for example transforming the 2D representation into a 3D model, developing a downloadable mobile application or building a commercial case scalable to other universities.

Keywords:

GIS tools, interactive map, campus map, web-based application, Cranfield University

Word Count: 8043

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LIST OF ABBREVIATIONS

2D	Two-dimensional
3D	Three-dimensional
API	Application Programming Interface
ESRI	Earth Sciences Resources Institute
GIS	Geographic Information System
GPS	Global Positioning System
JPG/JPEG	Joint Photographic Experts Group
OS	Ordnance Survey
PDF	Portable Document Format
PNG	Portable Network Graphics
SHP	Shapefile
SVG	Scalable Vector Graphics
URL	Uniform Resource Locator
ZIP	Compressed File

GIS applications to enhance the student and visitor experience of Cranfield University

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ABSTRACT

Interactive maps are a great way of displaying useful information in an engaging way by inviting the user to take action. Universities using ArcGIS software are allowed to use the technology to help run their businesses but no institution in the UK is currently doing so for the purposes of providing a campus map app to help guide students and visitors around the university campus. Two web-based GIS applications were developed for Cranfield University: Cranfield Interactive Campus App to help students and visitors with campus familiarisation, orientation around campus and to provide them with various up to date information, and a supporting Cranfield Students App to help the University Professional Service Units attract potential students. ESRI's Web AppBuilder for ArcGIS and Story Map with embedded Time Aware App platforms were used in this project. The developed applications are easy to maintain and can be accessed on multiple devices – via web, smartphone or tablet. The application proved to be a valuable tool for the Cranfield community as a source of information based on positive feedback from the user satisfaction survey. The respondents also identified several opportunities for potential improvements. The project has gained a lot of interest and it has significant potential for expansion and development in the future, for example transforming the 2D representation into a 3D model, developing a downloadable mobile application or building a commercial case scalable to other universities.

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1 INTRODUCTION

A Geographic Information System (GIS) is a software tool for storing, analysing, managing and displaying geospatial data on the map (GIS Geography, 2014). In essence a GIS is a detailed mapping platform comprising various degrees of interactive layering. Data that are produced and used by these systems are in raster and vector format. Vector data are represented as points, lines or polygons. Raster data can be aerial images, digital elevation models or raster images that are generated from large vector data sets (Bing Maps Platform, 2008).

Rasters are composed of cells that are referred to as pixels that are organized in rows and columns. Every cell in the grid has a value that represents an area on the ground. Vector features have coordinates with locational information assigned to each point or group of points and its characteristics are stored in attribute tables (Mitchell, 2005).

GIS has many capabilities. Turk et al. (2014) listed the following advantages:

- GIS can classify and locate objects into different categories, which allows for thematic mapping.
- GIS can store data associated with visual representation in the spatial database.
- GIS can execute a spatial analysis.
- GIS can be implemented online, easily managed and the implementation costs are relatively low.

Understanding of mapping is crucial in order to fully appreciate the complexities associated with GIS. "A map is defined as a representation, usually on a flat surface, of a whole or part of an area. The job of a map is to describe spatial relationships of specific features that the map aims to represent" (Karpilo, 2016). What is understood by a "map" is in fact open to various interpretations as they can exist in multitude of forms. The most common depiction of a map is a 2D symbolic limited representation, however this is not solely restricted to "hand-drawn observations of the real world, transposed onto paper" (Mitchell, 2005). The limitation of an analogue map is that it is static in nature

and cannot accurately represent dynamic changes. For example, new maps are needed when geographic changes occur (Mitchell, 2005).

Digital mapping incorporates traditional elements from map making and overcomes such limitations by adding a dynamic layer. In other words, digital maps enable almost real time changes to be reflected. Rather than having to recreate a map entirely, digital renderings are able to minimise both man hours as well as keeping users up to date. Features such as distinctive layers stored as files within a database enable the creator to modify maps without having to shift attention from core activities. Computerized tools allow both creator and user to collect and interact with dynamic mapping data. Not only can this data be used to create maps but also to “create new data or produce statistical summaries” (Mitchell, 2005).

A user friendly distribution of digital mapping is to make it easily accessible via the internet. Digital mapping available through online resources can be distributed either through static or interactive applications. Maps that are accessed in this way are referred to as “web-based maps or simply web maps” (Mitchell, 2005).

This form of application allows the user to explore digital mapping through traditional means i.e. mapping and imagery but also incorporates additional layers such as geocoding as well as routing/directions/traffic. Advantages of web mapping include “rich mapping and imagery, services designed for the web, scalability, cloud computing and data maintenance” (Bing Maps Platform, 2008).

Depending on the available resources, it may be technically complex for a developer to implement these applications. Not only is mapping software needed to initialize the process, but also servers, maintenance and management of the underlying map data are required (Mitchell, 2005). Web technologies such as JavaScript, Flash/Flex or Silverlight can be used to develop web mapping applications (Bing Maps Platform, 2008).

One of the key differences between analogue and digital mapping is the degree of interactivity. Similar to conventional mapping, static digital maps are “just images of objects the user can only see and not touch and manipulate” (Gaffuri, 2012). An

interactive map simply implies the user can manipulate or control some aspect of the map. Crampton (2002) described the following types of interactivity: interaction with the data, interaction with the data representation, interaction with the temporal dimension and contextualizing interaction.

The degree of interactivity varies depending on the application of the map. An interactive map enables the end user to more accurately survey a given area while also greatly enhancing their ability to more precisely determine which area they are most interested in. For example, this could allow the user to zoom into a particular area. The developer may increase interactivity by including various layers and allowing the user to opt in and out. The developer can also allow the user to determine what degree of detail they wish to examine or even restrict the level of detail (Mitchell, 2005). Interactive maps are an attractive way of providing valuable information to users and inviting them to take action (Little, 2013).

The use of GIS in connection with marketing has gained a high significance recently (Gis.usc.edu, 2011). GIS technologies allow visualization of spatial data and building decision support systems that benefit organizations across various industries (Caliper.com, 2016). GIS tools are used in retail to locate customers or determine supermarket locations, in financial services to analyse customer financial behaviour, in real estate, government, telecommunications, transportation or education (ESRI, 2010).

ESRI provides a variety of GIS tools either desktop based and web based to create, view and use intelligent maps. The ArcGIS Online platform enables the uploading of geographic data to create web maps and embed them into websites or create web-based applications that can be run on multiple devices. Applications can be created by using diverse templates without needing special programming skills. The Developers' edition gives the opportunity for advanced users to build more customized web and mobile applications using ArcGIS API for JavaScript (ESRI, 2016).

ESRI Story Maps are one of the customizable interactive apps, and can be composed of several elements, such as a basemap, map services, tabular data, pop-up windows, title and text descriptions. There are several templates to serve various purposes, such as

describing a place or a series of locations, explaining a geography-related topic, comparing two or more themes, showing a distribution pattern, showing change over time, forecasting the future, providing a place-based narrative, summarizing a status or situation, enabling participation or presenting a briefing (ESRI, 2012).

Web AppBuilder for ArcGIS is a powerful tool for creating web mapping applications with customizable themes and widgets to suit any purpose. The applications can be hosted online or run on users' own server (Esri.com, 2016).

Universities using ArcGIS are licenced to use the technology to help run their businesses but no institution in the United Kingdom is currently doing so. Universities can use these facilities to help attract, retain and liaise with new, existing and alumni students and are beneficial for visitors. Most universities in the UK that have published campus maps are providing only a limited amount of information and interactivity. Some universities offer only a static map but most common is the use of Google maps with pin points or JavaScript based maps. Google maps serve as a good tool for wayfinding information, but it offers a limited functionality without programming skills, which makes it difficult to set it up. Similarly maps that are developed by JavaScript or other programming languages require a trained user to be implemented and maintained.

Interactive campus maps included in websites of educational institutions are nowadays an important marketing tool (Eder et al., 2015). They benefit not only students of the university but also the university itself, because an interactive campus map is a useful recruitment tool and also it helps to enhance the image of the university (James, 2012). It is crucial to stay competitive in the market as users have increasingly higher expectations of the amount, nature and presentation of the information they want to be provided with, because they are aware of the progress of web technologies (James, 2015). James (2012) states that prospective students are increasingly relying on interactive maps and virtual tours to choose their college or university rather than physically visiting them.

An interactive campus map enables prospective students to experience the campus and take a virtual tour. New students can rely on the interactive map in order to familiarize

themselves with the campus, for example it can help them locate buildings or find places to eat. It can be beneficial also to visitors and external audiences, for example to find out where a conference takes place or where to park. Alumni students can keep updated on the changes of campus and it can encourage them to reconnect with the university (James, 2015).

Providing students with rich up-to-date real-time information keeps students engaged and makes them to rely on the campus application as the main information hub (Modo Labs, 2015).

The aim of this project is to analyse the potential and demonstrate the usage of GIS tools in terms of enhancing the student and visitor experience of the university. Therefore the following objectives were identified:

- To develop a web-based GIS application for Cranfield University to help students and visitors with campus familiarisation, orientation around campus and to provide them with various up to date information.
- To develop a supporting web-based GIS application to help the University Professional Service Units attract potential students.
- To evaluate the utility of the developed tools.

To meet this aim a Web AppBuilder for ArcGIS and a Story Map configurable App tools powered by ESRI were selected to be used for this project.

2 METHODOLOGY

This project was carried out at Cranfield University in the United Kingdom. The university's site is campus based, which offers a variety of facilities including teaching and research areas, accommodation, sport facilities and services as shops, restaurants, bars and cafés, medical services, places of worship, academic services and family support. There are buses that connect the university with surrounding villages and towns. Almost three thousand students from over 100 nationalities, studying 123 courses are based at Cranfield campus, of which two thirds are studying full-time.

2.1 Interactive Campus App

At first it was essential to identify how the application would engage with potential, current and alumni students, as well as visitors and the administrator of the application. Types of interactions for each of these users are illustrated in the use case diagram in figure 1 below.

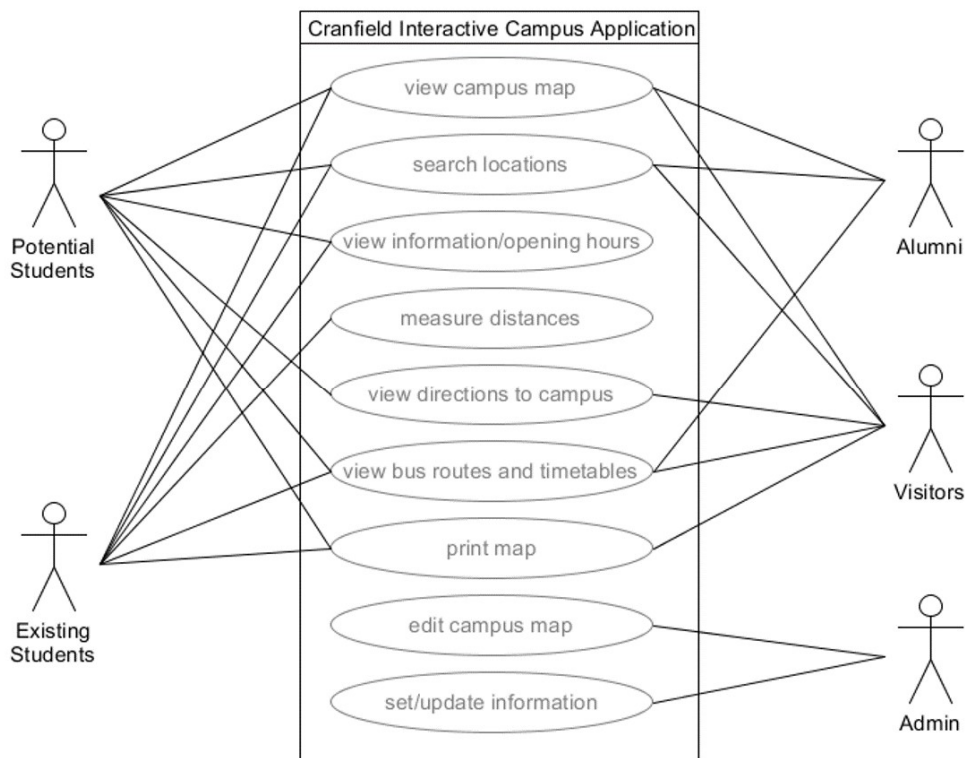


Figure 1: Use case diagram of Interactive Campus App

The users such as students and visitors can view the campus map with attached information, search for locations, view directions, bus routes and timetables, measure distances or print the map. The administrator of the system can set, edit and update information. These interactions identified were based on personal student experience.

Based on the diagram above a structure of elements to be present on the map was decided. The elements included were a base layer with roads and paths, buildings, parking, reception, library and academic services, food and drink, services, sport, medical services, places of worship and an additional layer with directions including bus stops and routes, railway stations and airports.

2.1.1 Existing data verification and new data collection

All existing data relevant to the project were assembled, verified and pre-processed. The data available comprised maps, shapefiles, website information, leaflets and internal documentation.

Existing pdf maps of the campus including a bicycle shelters map and existing shapefiles with building outlines and campus roads that were used for creation of these pdf maps were analysed. These data were verified in the field with the help of a map created by overlaying a basemap with the buildings and campus roads vector layers. The shapefiles were subsequently updated according to the current state in ArcGIS Desktop.

All information regarding opening hours, contacts, links, descriptions were collected from the university public website and the intranet website. Building information and lecture and meeting room locations with room capacity were provided by the university's Facilities team. Additional information was collected from various university leaflets and information sheets available. Information was also collected from external websites and leaflets, for example, the Uno bus leaflet with timetables, ticket pricing information and bus routes and contact information from the company's website.

New data collection involved GPS mapping of missing spatial data, capturing images of buildings, collecting information in the field regarding opening hours and contacts and also recording positions of benches.

A Trimble GeoExplorer 6000 series GeoXH handheld GPS device was used for mapping the newly opened parking lot and a new building (Appendix A).

The data were captured in OS National Grid coordinates and stored as a polyline file which was then converted to shapefile.

2.1.2 Data processing

2.1.2.1 Database creation - ArcGIS Desktop

The database was created in ESRI's ArcMap 10.3.1 software. Buildings and base layer polygon shapefiles were updated and new point, polygon and polyline shapefiles for the reception, library, academic services, food and drink, shop, cash machine, childcare, laundry, more services, sport, medical services, worship, standard car, disabled and bicycle parking, bus routes and bus stops, railway stations, airports, paths and campus location were created. The coordinate system was set to British National Grid. The shapefiles were then manually digitized with help of a basemap. Fields were created in the attribute table to store the information for each of the attributes associated with the mapped entities (Appendix B).

The shapefiles were sorted and compressed to zip archives according to the topic. The contents of each zip file are displayed in Appendix C.

2.1.2.2 Photos of buildings

Captured images were edited in Photoshop software in order to crop the images only to the extent of the buildings and adjust the brightness and contrast when needed to attain clearly visible photographs. The size of the images was reduced to 1000 pixels width and 750 pixels height, which was 25% of the original size, to ensure that the image will be displayed entirely and was easy to view. These modified images in JPG format were then uploaded to the Cranfield University's public webspace Home Directory Uploader. The URL link for each image was then copied to the picture field in the attribute table of the buildings shapefile.

2.1.2.3 GPS data

The data that were collected by GeoExplorer GPS device were downloaded as shapefiles through GPS Pathfinder Office software. The shapefiles were afterwards added to ArcGIS Desktop and overlaid by the buildings and base layers. The outlines were digitised according to the GPS shapefiles to update the current buildings and base layers.

2.1.2.4 Lecture and Meeting rooms

For each building Excel tables with meeting and lecture room names and occupancy numbers were created, exported as pictures in JPG format and uploaded to the Cranfield University's public webspace Home Directory Uploader. URL link for each table was then copied to the rooms field in the attribute table of the buildings shapefile.

2.1.3 Map creation - ArcGIS Online

The zipped files were uploaded to ArcGIS Online into the My Contents folder and the files published as a hosted feature layer allowing for future modifications. After upload, the first step was to create a map and add layers from My Contents. For each of the layers it was necessary to set its style, symbology, transparency, visible scales, create labels and configure pop-ups. Once complete each of the layers was saved. A Light Gray Canvas basemap was set as the default background. The layers were ordered and selected layers were turned on and some turned off in order to display only the main features as a default. Bookmarks of different zoom levels were added to the map and the default map extent was set up.

In My Contents all of the layers were shared as public and their settings were modified, namely items were prevented from being accidentally deleted, editing was enabled and layer drawing was optimized when applicable. The map was also shared and its settings modified, such as Delete Protection, Routing, Measure Tool, Basemap Selector and Find Locations were enabled. A description was added, the item was prevented from being accidentally deleted and tools and capabilities were enabled in applications that access this web map.

2.1.3.1 Creation of custom icons

Appropriate icons were downloaded from the Iconfinder website. Icons were compiled from various corresponding free for commercial use iconsets. The icons were downloaded in size of 128 pixels width and 128 pixels height in PNG format. These icons were afterwards converted to SVG format using the Convertio open-source web-based file converter. A free browser-based vector editor Method Draw was used to create custom designed icons for features where no suitable icons were available. Icons in SVG format were uploaded to the editor and placed over a colourful circle according to the theme. The resulting iconset is attached in Appendix D. The finished icons were exported as PNG and uploaded to the Cranfield University's public webspace Home Directory Uploader. URL link for each icon was then employed to define a symbol style of relevant layers in ArcGIS Online using a custom image.

2.1.4 App creation - Web AppBuilder

An app using Web AppBuilder was created in My Contents folder in ArcGIS Online. A Foldable Theme was chosen since it supports all widget types and can be used for the app with variety of tasks. The desired layout of the app was then selected. A custom colour style was set as #091932 hex colour code according to Cranfield University website to match the appearance. Cranfield University campus map created in previous step was selected, the initial map extent was set and the visible scales were customized.

Then the widget settings were modified. Firstly the Header Controller widgets were set, namely Legend and Layer List. Settings of the Legend widget were left as default. Only the 'Zoom to' action was enabled and base layer, buildings and campus location layers were disabled to be shown on the list in the Layer List widget settings. The Attribute Table was hidden from the preconfigured widget list. The Zoom Scale of My Location widget was set to 1:2000, the Scale Bar widget units were set to dual and the Overview Map widget was set to be initially expanded. The Search widget was configured in order to enable end users to find locations or features on the map by name or type. Feature Layers to be searched were selected. For each of them search fields and display fields were selected and a zoom scale was set. The content to be displayed on the splash

screen before the application loads was customized and the background colour was set to #091932 hex colour code to match the theme. Additional About, Basemap Gallery, Bookmark, Measurement and Print widgets were chosen. Instructions on how to navigate and information about the project were added to the About widget. Imagery with Labels, Light Gray Canvas and Streets basemaps were chosen in the Basemap Gallery widget. Thumbnails were added to bookmarks pre-set on the map to a Bookmark widget. The default area unit was set to sq meters and default length unit was set to meters in the Measurement widget. The default title, author and copyright in the Print widget were modified, the default format was set to PDF and the default layout was set to A4 Landscape.

The Coordinate, Home and Zoom Slider widget settings were left as default. The Cranfield University logo, title of the application and link to Cranfield University website were added to the Attribute tab. The application was then previewed, saved and shared as public.

2.2 Students App

A story map application was created to display Cranfield University students' nationalities, alumni work destinations, students' structure and Erasmus partner universities. A World Countries packaged dataset in GCS_WGS_1984 coordinate system published by ESRI Data and Maps was used to create these maps.

2.2.1 Student's Nationalities

The World Countries layer package was pre-processed in ArcMap in order to clear unwanted data. Only the relevant countries outlines were kept in the dataset. Fields containing the nationalities and number of students were added to the attribute table. The records containing numbers under the threshold value of 5 were exempted due to the Data Protection Act. The shapefile was compressed to a zip archive and uploaded to My Contents folder in ArcGIS Online. A map was created from the layer. A Dark Gray Canvas basemap without the Reference was set as a background. The symbology was set as graduated colour ramp according to the number of students, the layer

transparency was set and the pop ups were configured with the custom attribute display. The map was saved and both the map and the layer were shared as public. In the settings of the layer optimization of layer drawing was enabled to accelerate loading.

An app using a Story Map Series template was created in the My Contents folder. A Tabbed layout was selected. The nationalities map was selected, name of the tab was adjusted and a legend was enabled. The title of the Story map was set. Settings of the Story map application were modified. In the Layout options the Description Panel size was changed to small and Description Panel can overlap map location option was enabled, an Overview map was added in Map options and the Theme was selected. In the Header the Cranfield University logo with the link to the Cranfield University website was added and a link to the Cranfield Interactive Campus App was added. Descriptive text and chart were added to the Description Panel providing additional summarising information about students' structure and instructions on how to use the map.

2.2.2 Alumni Work Destinations

The alumni students' records were pre-processed in Excel in order to filter out the data with an unknown business location. The remaining records were divided into groups according to the year of graduation in 10 year time periods. A shapefile for each time period was created based on the World Countries outlines layer package. The start and end year Date type fields were added to the attribute table. The Merge tool was used to compile all the shapefiles into one dataset. The time was enabled in the Time tab in Layer properties. The merged shapefile was then compressed to a zip archive and uploaded to the My Contents folder in ArcGIS Online. Time settings were enabled on the layer and the time data recorded as time ranges with a start and end time option selected. In the settings of the layer optimization of layer drawing was enabled to accelerate loading. A map was created from the layer. The transparency of the layer was modified, labels were added and pop ups were configured with the custom attribute display. A Dark Gray Canvas basemap without the Reference was set as a background. The time slider settings were configured including Playback Speed, Time Span and Time Display intervals.

An app using a Time Aware template was created from the map. In the app configuration window options under the General, Options and Search tabs were disabled. Display time, Show navigation buttons and Add tick marks to slider were enabled under the Time Slider Options tab and the Date Format was set to display years. Once complete the layer, the map and the application were shared as public. The application was then embedded to the story map under a new tab as a Web page by adding the URL code of the app, the title was adjusted, the position was set to Fill and an accompanying text was added to the Description Panel.

2.2.3 Erasmus Partner Universities

A point shapefile was created. Fields containing the university name, city and country were created in the attribute table. The universities were digitized from a basemap according to their exact geographic position. The shapefile was then compressed to a zip archive and uploaded to the My Contents folder in ArcGIS Online. A map was created from the layer. The symbology was set for the layer and the pop ups were configured with the custom attribute display. The map extent was set as zoomed to the layer. A Dark Gray Canvas basemap without the Reference was set as a background. Both the map and the layer were shared as public. The map was then added to the story map under a new tab and the name was modified. Descriptive text and a chart were added to the Description Panel.

2.2.4 Students Structure by Continent

A shapefile with outlines of the continents (Africa, Asia, Australia and Oceania, Central/South America, Europe and North America) was created from the World Countries layer package for each of the student structures, namely Age, Gender, Mode, Theme and School. Fields for each respective structure were added to the attribute table of each shapefile and filled with numbers of students according to the continent. The structure can be found in Appendix E. The shapefiles were then compressed to zip archives and uploaded to the My Contents folder in ArcGIS Online. In the settings of the layers optimization of layer drawing was enabled to accelerate loading. A map was created for each of the layers. The colours representing the continents were used in the

layer symbology, the transparency was set and the pop ups were configured with attributes displayed as a list and a pie chart was added. A Dark Gray Canvas basemap without the Reference was set as a background. All the layers and maps were then shared as public and uploaded to the story map under new tabs. Their names were modified and accompanying text and charts were added to the Description Panel. Once complete the Cranfield Students App was shared as public and the URL link was added to the Cranfield Interactive Campus App in the Attribute tab.

2.3 Evaluation

A survey was conducted in order to evaluate the developed Cranfield Interactive Campus App and to explore students' interest in having an additional Cranfield Students App linked to it. Existing and prospective students were asked to preview the Cranfield Interactive Campus App and then to evaluate the functionality of the app by answering a questionnaire. The questions included appearance of the app, ease of use, quality and organization of provided information, utility, satisfaction with existing static map, accessibility via multiple devices, missing features, benefit to prospective students and interest in students' structure. The survey can be found in Appendix F. Qualtrics software was used to record the responses. Results were then analysed and conclusions were drawn from them.

3 RESULTS

3.1 Interactive Campus App

The developed interactive campus map application is publicly accessible via a web browser, available at: <https://cranfield-uni.maps.arcgis.com/apps/webappviewer/index.html?id=28457e6453de4ad19c4fe1c32022fa5a>. On screen, the campus layout displays a base layer with roads and paths, buildings, parking places (including disabled parking and bicycle shelters), points of interest and services and facilities, such as food and drink, shops, cash machines, bank, libraries, academic services, receptions, post office, sport facilities, medical services, accommodation office, nursery and pre-school, laundrettes, places of worship, petrol station and garage, playground or sitting areas. The objects displayed on the map are clickable items with descriptions, opening hours, contacts, pictures, URL links and other additional information helpful to the user. An additional directions layer displays bus routes and bus stops with timetables, train stations and airports with arrival information.

On the initial screen users can navigate to the About button with instruction on how to use the app. Users can filter information they are interested in by selecting layers, zooming in and out and clicking on features of interest. Users can display legend, search for places, change the basemap including imagery, measure distances and areas in various units, display coordinates for a point, use bookmarks with predefined zoom levels or create their own, or generate a PDF or JPEG file to print the map. An additional function allows users to locate their position on the map which is useful especially when using a mobile device. There is also a link to the Cranfield University website and a Cranfield Students App.

The application is shown in figure 2, additional screenshots can be found in Appendix G.

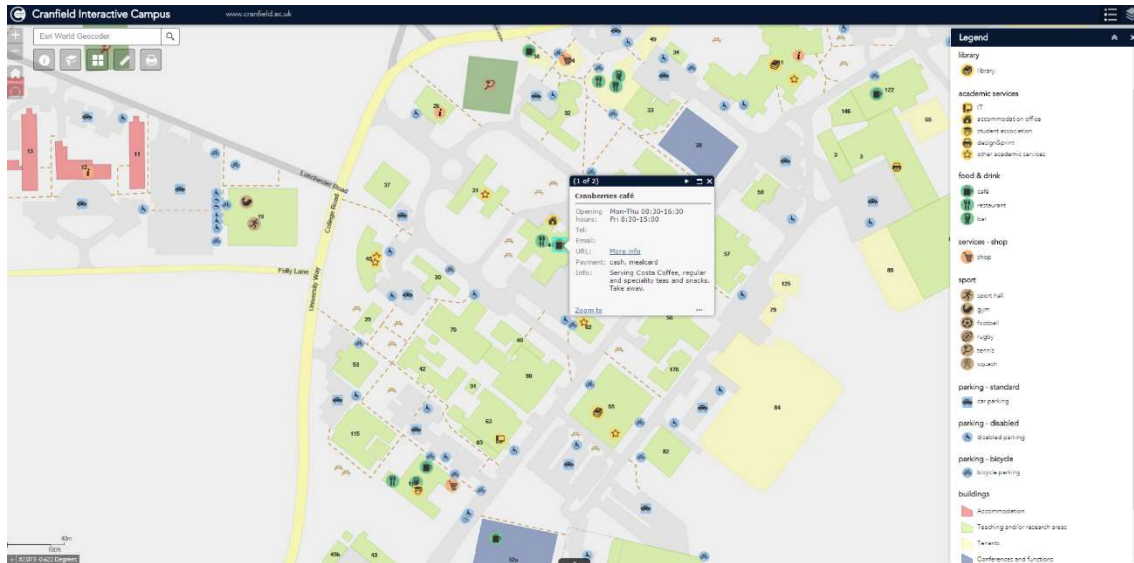


Figure 2: Cranfield Interactive Campus map application

3.2 Students App

The developed interactive student application provides additional value added information about Cranfield University students' structure, alumni work destinations and partner universities. Maps under individual tabs display the spatial distribution of the data.

The Students' Nationalities map shows countries distinguished by colour according to the number of students. The countries are clickable objects and descriptive text and chart are accompanying the map. The Alumni Work Destinations map represents job locations of alumni students according to the year of graduation in 10 year time intervals. The map includes a time slider that illustrates the change over time that can be run by the user or the time period can be set manually. A descriptive text is accompanying the map. The Erasmus Partner Universities map displays partner universities, the points are clickable items with the university name and its location. The map includes descriptive text and a chart. The other five maps illustrate the students' structure by age, gender, mode, theme and school for each continent. The maps are interactive, each of the continents can be clicked and it pops up the information on numbers and a pie chart. All of the maps include an accompanying text and charts in the Descriptive Panel.

The header of the application contains a link to the Cranfield University website and a link to Cranfield Interactive Campus App.

The application is shown in figure 3, additional screenshots can be found in Appendix H.



Figure 3: Cranfield Students application

3.3 Evaluation

Results from the survey conducted in order to evaluate the developed interactive campus application and to determine students' interest in an additional students' application are displayed in table 1 below. 54 responses were recorded from prospective and current students. 85% of the respondents liked the design of the application, almost all the respondents found the app user friendly, easy to use, being a good source of information, clearly organized and the symbology used appropriate. 67% of the respondents agreed on the ease of finding information, 28% neither agreed nor disagreed and 3 respondents disagreed. About a half of the respondents thought that the existing static map is not sufficient, 20% neither agreed not disagreed and 24% were happy with the existing map. 78% of the respondents would prefer to use the app rather than searching for the information on the university website. Almost all respondents

appreciated that the app is available for a mobile phone. Overall satisfaction with the app was 81%.

63% of the respondents did not identify any missing features, 6 respondents who disagreed and 14 respondents who neither agreed nor disagreed suggested improvements to the app. Most of the suggestions were related to the search bar, which included ability to search for rooms, staff members and their offices and acronyms. Two respondents would appreciate to be able to display a walking route. One respondent missed the airport details, another one suggested that the entrances to buildings could be marked. One respondent recommended to divide parking lots according to the student and visitor parking places and one recommended to include the one way road system. One respondent would like to be able to display the information without having to click on the feature.

85% of the respondents searched for information about the campus before they came and 87% thought that the app would help them with arrival and orientation around campus. Over two thirds of the respondents expressed their interest in having an additional application with students' structure linked to the campus app. Most of the respondents identified that the app would be most useful for visitors, prospective students and existing students respectively, only less than a half of the respondents found the app useful for alumni.

Table 1: Survey results

Question	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I like the design of the campus app.	17	29	6	2	0
The campus app is user friendly and easy to use.	16	33	4	1	0
The campus app is good at providing information.	16	32	5	1	0
It is easy to find the information I need.	13	23	15	3	0
The organization of the information is clear. The symbols used are self explanatory.	22	27	3	2	0
The existing static map of the campus is sufficient.	2	11	11	21	9
I would prefer to use the app rather than searching for the information on the Cranfield website/intranet.	22	20	10	2	0
I find it useful that the campus app is available on a mobile phone.	31	20	3	0	0
I am overall satisfied with the campus app.	14	30	9	1	0
There is nothing missing in the campus app.	4	30	14	6	0
I searched for information about the university campus prior to my arrival.	26	20	6	2	0
The app would help me as a prospective student with arrival and orientation around the campus.	33	14	5	2	0
As a prospective student I would be interested in having the campus app connected to another app that shows students structure and destinations of alumni students.	17	20	11	6	0
I think the campus app would be useful for:	Prospective students	Existing students	Alumni	Visitors	
	44	42	22	47	

4 DISCUSSION

The main objective of this project was to develop a web-based GIS application for Cranfield University to help students and visitors with campus familiarisation, orientation around campus and to provide them with various up to date information. The Cranfield Interactive Campus app was developed on ESRI's ArcGIS Online platform using Web AppBuilder. This tool enables the creator to develop a rich content interactive application without the need for programming skills. This is the main advantage in comparison with similar campus applications that are developed by JavaScript. Web AppBuilder also enables geocoding, tracking, directions and measurements. The developed application is easy to maintain in terms of removing old, editing existing and adding new features. There is also no requirement for a trained user who will be in charge of the maintenance because the software is easy to use. But an administrator, who should be informed when any changes occur, is needed in place to keep updating the application.

The universities in the UK are not taking advantage of ArcGIS, even when they have an ESRI licence to do so. Instead they are using Google maps, Google API or JavaScript, or a combination of those. These applications serve users with a limited amount of information, often only building names. For example, the campus maps of the University of York, the University of Sheffield and the University of Leeds are based on pin points only. The interactive map of the University of Manchester combines buildings outlines with pin points. The University of Birmingham displays buildings with information attached to them, but the application is not very user friendly. For example, selecting facilities from a drop-down list is rather chaotic. Campus map of the University of Leicester consists of buildings with attached links, combined with pin points offering a virtual tour in a form of 360 degree panoramas and video clips. There is a case of ESRI's technology being used by universities in the USA, namely The University of Minnesota and The University of Delaware. These universities are using Web AppBuilder, but the amount of information that is presented to the user is quite limited in comparison with the Cranfield Interactive Campus application that was developed in this project. The

Campus map of the University of Delaware lacks points of interest. Only buildings and parking lots are displayed on the map. Descriptive information and links are attached to these interactive features. In case of the University of Minnesota, the map provides users with richer content, but places of interest are not clickable items containing any information. The Cranfield Interactive Campus is an application “by students for students”. It attempts to include all the information that students would be looking for, not only when they arrive but also during their whole stay, for example information on opening hours, contacts, laundry view or timetables.

The application has two major limitations, namely it does not enable a hover function and the fields of String type in the attribute table can hold only up to 255 characters. This is the case of the meeting/lecture rooms that were displayed as a table via link, so therefore the rooms are not searchable. Such a problem can be overcome by simplifying the labelling system of the rooms. For example, short combinations of letters and numbers would allow to fit them in the attribute table.

The second objective was to develop a supporting web-based GIS application to help the University Professional Service Units attract potential students. The developed Cranfield Students App provides information on the spatial distribution of student structure, alumni work destinations and Erasmus partner universities. As the results show that the students would be interested in this information, it is clear that such an application can be beneficial for Professional Service Units in order to attract potential students. The information presented in the application can be misleading due to the Data Protection Act in it that restricts the display of data under threshold of 5 students. The disadvantage of the application is that the Alumni work destinations map is loading relatively slowly because the dataset is large, even though the layers were optimized to allow faster drawing.

It is not common to see students’ structure on university websites, but some of them have an alumni map. JavaScript is better tool for such maps, because it enables a hover function or animations that Story Maps are not capable of.

The user satisfaction survey on the Cranfield Interactive Campus app exhibits positive feedback. The users were satisfied with the application regarding design, ease of use, quality and organization of provided information. Mobile phone availability of the application was appreciated by almost all respondents, because they can physically locate themselves on the campus. Only 25% of the respondents consider the existing campus map sufficient and 81% are satisfied with the new application, which is a significant improvement. However the app is meeting needs of its users, several of suggestions for improvement were obtained, namely to include walking directions, entrances to buildings, one way road markings, parking lots differentiation and search bar amendments.

The students reported that they searched for the campus information prior to arrival, which means that potential students would seek for the application. The respondents of the survey identified visitors as the most likely to be relying on the app, but they also assigned a high utility to the prospective and current students. This proves that the application is capable of combining all different needs of these different groups of users. The application can be embedded into the university website to make it freely accessible by everyone.

The project has a potential for future development. The Developers' edition enables the application to be made more sophisticated, it allows to even develop personalized widgets. This option however requires skilled users. The 2D interface could be transformed to 3D model with insights into buildings. As the availability on mobile phone gained significant interest, the users would benefit from a downloadable application. Another potential for the future of the project is to build a commercial case scalable to other universities.

5 CONCLUSION AND RECOMMENDATIONS

Two web-based GIS applications were developed for Cranfield University: Cranfield Interactive Campus App to help students and visitors with campus familiarisation, orientation around campus and to provide them with various up to date information, and a supporting Cranfield Students App to help the University Professional Service Units attract potential students. The Interactive Campus app is a valuable tool for the Cranfield community as a source of information which is linked directly to places on campus. This intuitive and user-friendly platform can be easily edited and updated and it is available on multiple devices – via web, smartphone or tablet.

The user satisfaction survey proves that the aim of the project was met as the obtained feedback was very positive. The respondents confirmed that the application would benefit not only students but also visitors.

The project has gained a lot of interest and it has significant potential for expansion and development in the future. The following recommendations were drawn:

- Include missing features that were identified during the survey.
- Transform 2D interface to 3D and include insights of the buildings.
- Develop downloadable mobile application.
- Build a commercial case.

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APPENDICES

Appendix A – GPS mapping with Trimble



Figure 4: GPS mapping process of the parking lot with GeoExplorer device

Appendix B – Attribute tables for Cranfield Interactive Campus App

Table 2: Fields in attribute tables of the shapefiles

shapefile name	shapefile type	fields
academic	point	type, name, open, tel, email, url, info
airports	point	type, name, air_link, bus_name, bus_tel, bus_link, taxi_name, taxi_tel, taxi_link, taxi_price
atm	point	type, name
base_layer	polygon	type
bike_parking	point	type
buildings	polygon	type, bld_name, bld_no, departments, rooms, description, picture, credit
bus_routes	polyline	route

bus_stops	point	type, name, tel, direction, timetable, s_price, ad_price
campus_outline	polygon	name, tel, email, url, address
campus_point	point	name, tel, email, url, address
car_parking	point	type
disabled_parking	point	type
food_drink	point	type, name, opening, tel, email, url, pay, info
kids	point	type, name, open, tel, email, url, info
laundry	point	type, name, opening, link, url, prices, picture, credit
library	point	type, name, open, tel, email, url, info
medical	point	type, name, open, tel, url, info
more	point	type, name, open, tel, url, info
other	point	type
paths	polyline	type
rail	point	type, name, rail_times, rail_tel, bus_name, bus_tel, bus_link, taxi1, taxi1_tel, taxi1_link, taxi2, taxi2_tel, taxi2_link
rd_names	polyline	name
reception	point	type, name, open, tel, email, info
shop	point	type, name, opening, tel, email, url, pay, info
sport	point	type, name, opening, tel, email, url, info
worship	point	type, name, email, url, info

Appendix C – Zip archives for Cranfield Interactive Campus App

Table 3: Contents of zip files

file	contents
academic.zip	academic.shp
base.zip	base_layer.shp, other.shp, paths.shp
buildings.zip	buildings.shp
campus_location.zip	campus_outline.shp, campus_point.shp
directions.zip	airports.shp, bus_routes.shp, bus_stops.shp, rail.shp
food_drink.zip	food_drink.shp
library.zip	library.shp
medical.zip	medical.shp
parking.zip	bike_parking.shp, car_parking.shp, disabled_parking.shp
reception.zip	reception.shp
road_names.zip	rd_names.shp
services.zip	atm.shp, kids.shp, laundry.shp, more.shp, shop.shp
sport.zip	sport.shp
worship.zip	worship.shp

Appendix D – Icons for Cranfield Interactive Campus App



Figure 5: Set of produced custom icons

Appendix E – Attribute tables for Cranfield Students App

Table 4: Fields in attribute table of student structure by continent shapefiles

Shapefile	Fields
Age	20-25, 26-35, 36-45, 45plus, total
Gender	male, female, total
Mode	full_time, part_time, total
School	SOM, SWEE, SATM, total
Theme	leadership, agrifood, energy, env_tech, aerospace, manufactor, transport, total

Appendix F – Survey for Cranfield Interactive Campus App (Qualtrics)

Welcome to Cranfield University Interactive Campus App Survey!

Please, preview the app here: <https://cranfield-uni.maps.arcgis.com/apps/webappviewer/index.html?id=28457e6453de4ad19c4fe1c32022fa5a>

Your participation is very much appreciated. The survey itself will take you only 2 minutes.
Your response is anonymous and will be only used as aggregate values.

I like the design of the campus app.

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The campus app is user friendly and easy to use.

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The campus app is good at providing information.

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

It is easy to find the information I need.

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The organization of the information is clear. The symbols used are self explanatory.

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The existing static map of the campus is sufficient.



Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

I would prefer to use the app rather than searching for information on the Cranfield website/intranet.

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

I find it useful that the campus app is available on a mobile phone.

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

I am overall satisfied with the campus app.

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

There is nothing missing in the campus app.

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

If you disagree, please specify what you think is missing:

I think the campus app would be useful for: (select all that apply)

- Prospective students
- Existing students
- Alumni
- Visitors

I searched for information about the university campus prior to my arrival:

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

The app would help me as a prospective student with arrival and orientation around the campus.

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

As a prospective student I would be interested in having the campus app connected to another app that shows students structure and destinations of alumni students.

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

Appendix G – Screenshots from Cranfield Interactive Campus App

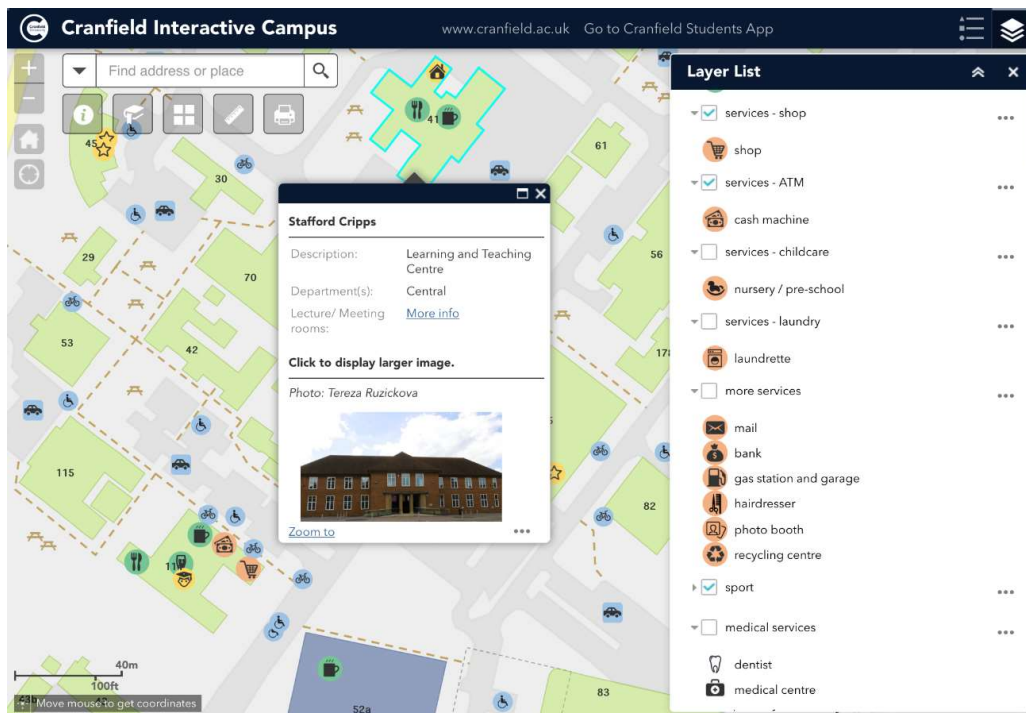


Figure 6: Cranfield Interactive Campus App - selectable layers

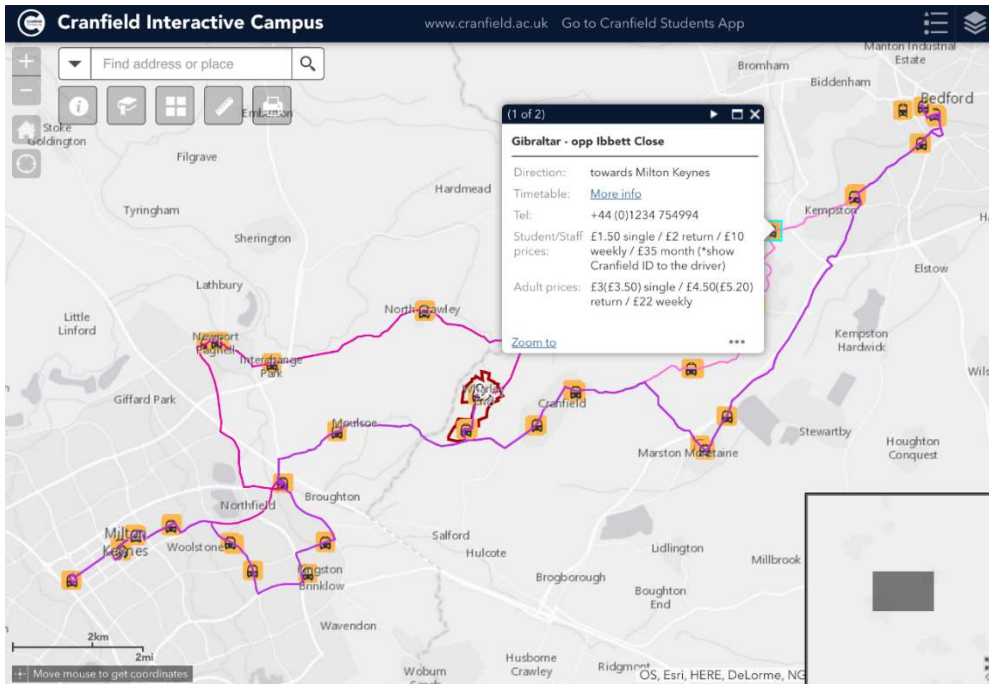


Figure 7: Cranfield Interactive Campus App - directions layer (bus routes and bus stops, railway stations)

Appendix H – Screenshots from Cranfield Students App

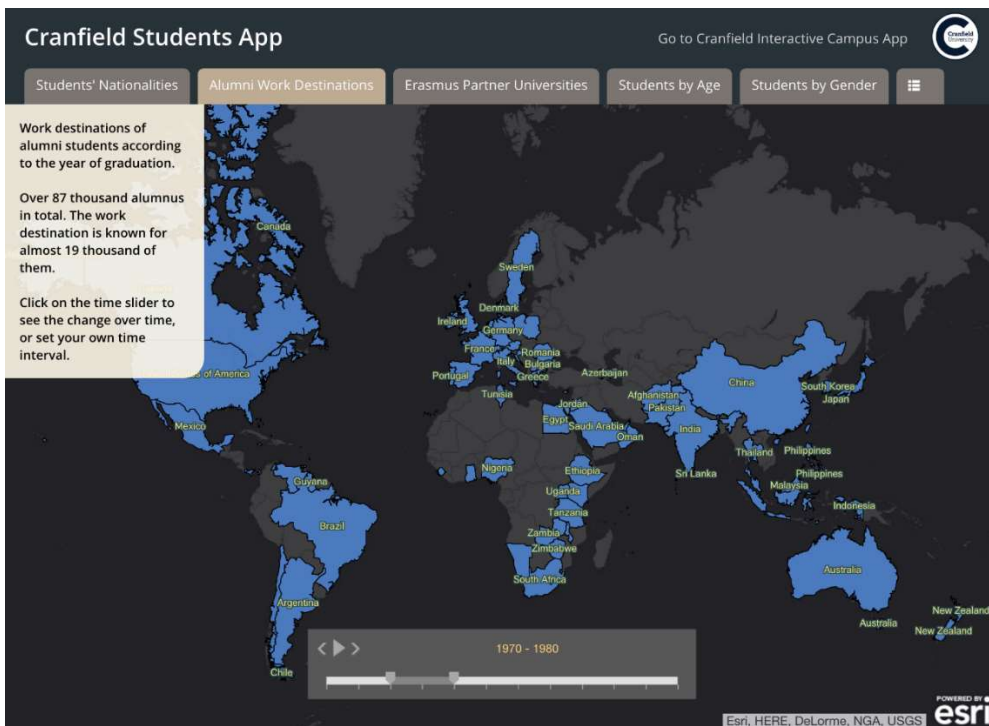


Figure 8: Cranfield Students App - Alumni Work Destinations

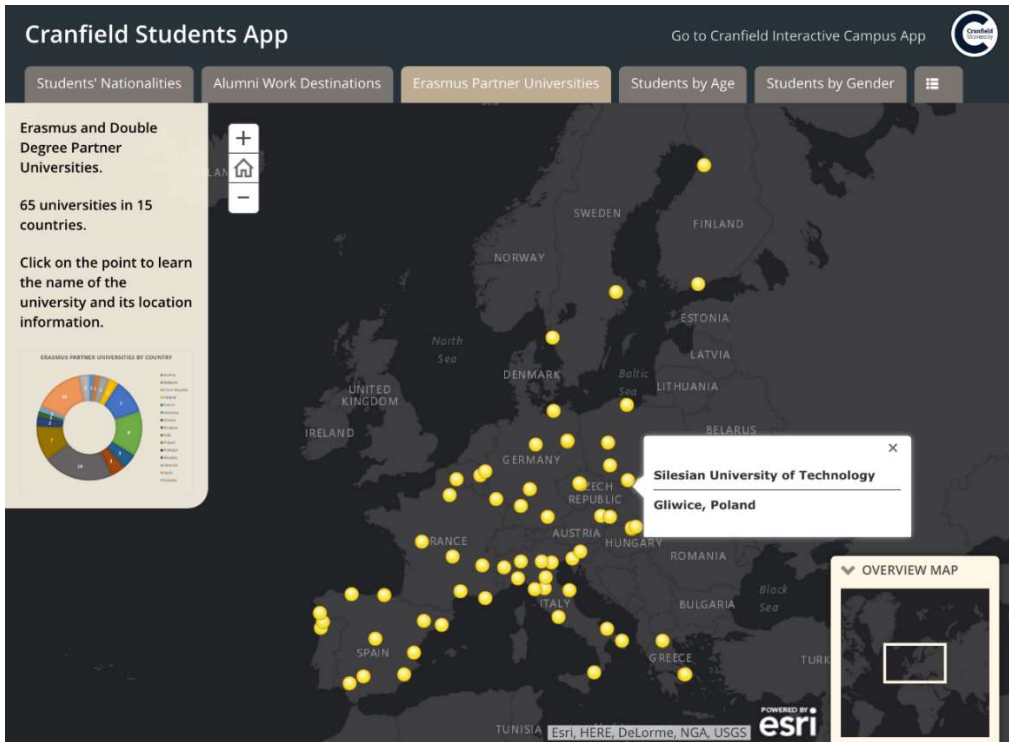


Figure 9: Cranfield Students App - Erasmus Partner Universities