

## **GENERATING RICH TRIP DATA USING SMARTPHONE APPLICATIONS TO FACILITATE FEASIBILITY STUDIES FOR BICYCLE SHARING SCHEMES**

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### **Abstract**

Limerick was designated as Ireland's National Smarter Travel demonstration area in 2012. Limerick Smarter Travel, which aims to promote sustainable travel in the City and suburbs, is a partnership between the Limerick Councils and the University of Limerick (UL).

Within UL, final-year projects and other research is on-going in the smarter travel subject area.

This paper is based on Limerick City's Bike Sharing Scheme and a final-year project thesis which is a study of the feasibility of a stand-alone bike sharing scheme in the suburb of Castletroy adjacent to the University of Limerick. This paper also focused on discovering if it would be feasible to merge a Castletroy scheme with the existing Limerick city scheme or extend the existing city scheme to the Castletroy area.

The paper details the use of a smartphone application to collect rich trip and mode share data and proposes this methodology as a significant improvement on current feasibility study methods for bike sharing scheme feasibility studies. The smartphone application is capable of collecting numerous persons travel data for the entire period of the day. Data such as distance travelled, mode of travel, time taken to travel and trip destination and origin are all collected within the application. From this data, heat maps were produced for each of the survey participants. An example of a heat map for one candidate can be seen in Figure 3.6. In these heat maps, dark purple lines highlight routes of low activity, where bright orange lines highlight routes of high activity for that user for the specified study period.

A number of precedent studies were also investigated as well as generating, collecting, analysing and investigating a number of quantitative datasets. The quantitative datasets explored include: travel survey results for University of Limerick students and staff; Places of Work – Census of Anonymised Records data for Castletroy residents; secondary data gathered through an online survey and primary data gathered using the implementation of the GPS smartphone application to monitor the travel patterns of eighteen candidates.

Recommendations for further research are also outlined in the paper.

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## **1. Introduction**

### **Limerick Smarter Travel (LST)**

The Department of Transport set out aims in February 2009 to achieve a sustainable transport community in Ireland by 2020. With this aim in mind, a number of study locations were chosen, with Limerick City being chosen as the study "City". The appointment of Limerick as Ireland's smarter travel demonstration city led to the formation of Limerick Smarter Travel (LST) in 2012. LST is a government funded organisation which is now fully dedicated to developing sustainable transport within Limerick City.

The University of Limerick was involved in the original bid to make Limerick, Ireland's demonstration city. As a result of this involvement, the University of Limerick has been awarded funding to develop sustainable modes of transport to and around the campus. Due to this investment, a Smarter Travel Co-Ordinator for the University was appointed in 2014.

Limerick, Castletroy and the University of Limerick are in the focus as a smarter travel demonstration community. This paper provides a detailed insight into a scheme which may help this community to achieve the figures set out by the Department of Transport in 2009 in the National Spatial Strategy.

The paper describes the processes involved in gathering quantifiable travel data for residents of the Castletroy community as well as University of Limerick students and staff. This formed the primary research. Information was also gathered from a number of precedent studies which included Lancaster University, University College Cork – Campus Bike scheme, Dublin bikes and the Coca-Cola Zero bikes Limerick feasibility study. By using both qualitative and quantitative data and a set of criteria which are outlined below, a conclusion was made as to the feasibility of a bike sharing scheme for the Castletroy community and to the feasibility of extending the existing Limerick City scheme to the Castletroy area.

### **Feasibility Criteria**

Based on facts discovered in the literature review and precedent studies, a number of criteria have been identified in order to determine the feasibility of a BSS for the Castletroy area. These feasibility criteria include;

- Relatively short travelling distances of between 1km – 8km are found to be most favourable;
- Low cycling modal share within the study area is favourable for the implementation of a BSS. Low cycling modal share will result in higher usage figures;
- Good cycling infrastructure is important for promoting scheme use and improving cyclist safety;
- A relatively flat topography of the study area increases natural re-distribution of the rented bicycles;
- High traffic congestion encourages commuters to consider alternative forms of commuting, therefore high traffic congestion is favourable for scheme implementation in terms of achieving usage figures;
- High population densities see larger usage figures and therefore this would be favourable;
- A variety of varying daily timetables of scheme users is beneficial for a BSS as the natural re-distribution of rented bicycles would be enhanced;

- Varying travel destinations is favourable (i.e. there is not a large percentage of the population travelling to one general area) and
- Students are the most likely users of a BSS. Therefore having a large student population is favourable [1].

### Coca-Cola Zero Bikes, Limerick City

A bike sharing scheme for Limerick city centre was launched in December 2014. The scheme is named “Coca-Cola Zero bikes” and consists of 200 bicycles spread over 23 stations. A layout of the scheme is shown in Figure 1.1. LST staff claim that their expertise and knowledge of the local area were not utilised in the design of the scheme [2]. It is important to note, that the inclusion of all stakeholders, with an interest in such a scheme, should be, in some way, involved in the design of the scheme in order for the project to reach its optimum fulfilment, much like the “community led design” as used by LST.

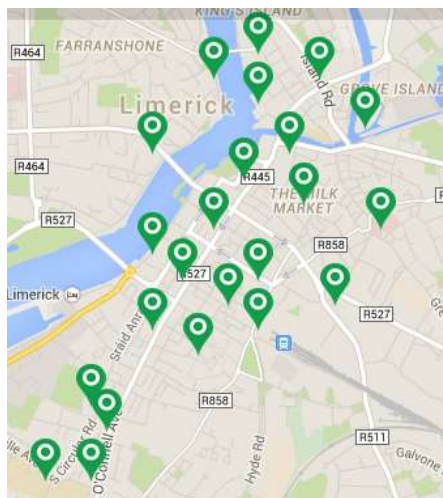


Figure 1.1: Bike Share Station Map – Limerick City

## 2. Methodology

The purpose of gathering quantitative data is to develop a robust approach of determining the feasibility of a bike sharing scheme for the Castletroy study area. To do this, a new type of transport trip data was generated, collected, collated and analysed as well as investigating various other existing travel data. This new type of data was generated using the smartphone health and fitness application, *Strava* coupled with the use of heat map generating software. The overarching aims of this section are to:

- A. Determine distances and mode of travel of commuters to the University of Limerick;
- B. Gather “leisure trip” (Non-commuting) travel data (i.e. trips made outside of the normal commuting route and normal commuting time);
- C. Using “A” & “B” a full analysis of University of Limerick students and staff 5-7 day travel patterns was developed;
- D. Analyse existing data available from the Central Statistics Office (CSO) and
- E. Analyse existing data available from the University of Limerick about student and staff travel patterns.

In order to gather this data, the following resources were utilised:

- UL Students and Staff Travel Survey, 2014 [3].

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- A travel pattern questionnaire issued to students and staff of the University of Limerick using SurveyMonkey
  - The GPS smartphone application called “Strava”
  - Places of Work – Census of Anonymised Records (POWCAR) data, available from the CSO [4].

By accumulating the data from the many available resources a conclusion may be drawn as to the quantitative feasibility of a bike sharing scheme. This data was used to determine the feasibility of such a scheme joining the existing Coca-Cola Zero bikes in Limerick city centre and the possibility of the Coca-Cola Zero scheme extending towards the Castletroy area.

### **3. Results**

The primary data research focused on the use of a GPS smartphone application to monitor and record the travel patterns of University of Limerick students and staff. The test period for this research consisted of 5-7 days depending on whether or not the student or staff candidate would be present in the Castletroy study area (Figure 3.1) at the weekend. The initial e-mail sent to all students and staff of the University of Limerick returned 59 respondents, of which 47 downloaded the application and followed the relevant set-up instructions provided. Of these 47 participants, 18 successfully used the application for the specified test period and provided sufficient interpretable data. Data was deemed to be sufficient if the user logged at least one round trip for at least five days.

The Jonathan O’Keefe website (<http://www.jonathanokeeffe.com/strava/map.php>) was used to create a heat map for each of the 18 candidates’ travel patterns. A heat map is a map produced for each individual candidate that highlights areas where the application user travels. Bright orange lines on a heat map describe an area of high activity for that user, while dark purple lines highlight areas in which the user rarely ventures. An example of a heat map can be seen in Figure 3.6.

In order to analyse the data, a number of data points were specified within the study area (Figure 3.1 & Figure 3.2). The data points were chosen based on assumed high travel activity areas and in specific locations whereby travel activity entering and leaving the chosen study area could be determined. The data points were also arranged so that quantitative movement within the study area may be determined.

A total of thirteen data point locations were chosen. These include:

1. UL SU courtyard;
  2. UL main entrance;
  3. UL east gate entrance;
  4. The Glucksman Library;
  5. UL North campus;
  6. UL sport arena;
  7. To/from the city/ Parkway;
  8. Groody roundabout;
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9. Killmurray roundabout;
10. Milford road –R445 intersection;
11. Plassey park road – L118 intersection;
12. Castletroy Park hotel and
13. UL college court entrance / Kemmy business school.

The results for each candidate and each data point are tabulated in Table 3.1 & Table 3.2.

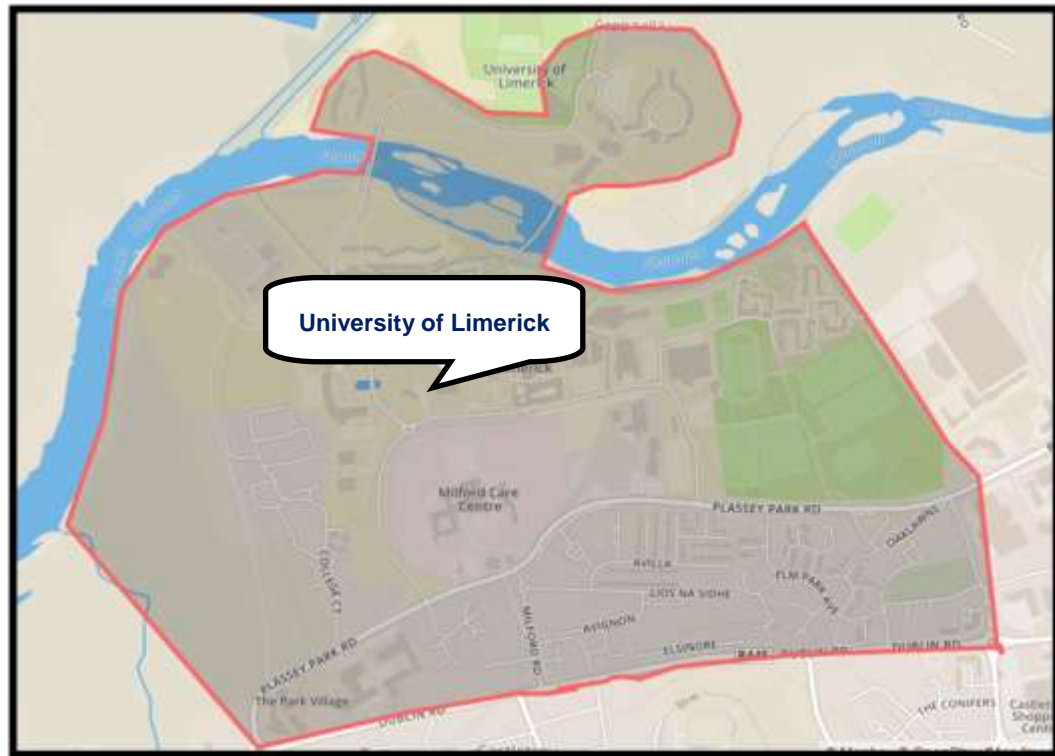


Figure 3.1: The Study Area



Figure 3.2: Chosen Data Point Locations within Castle Troy

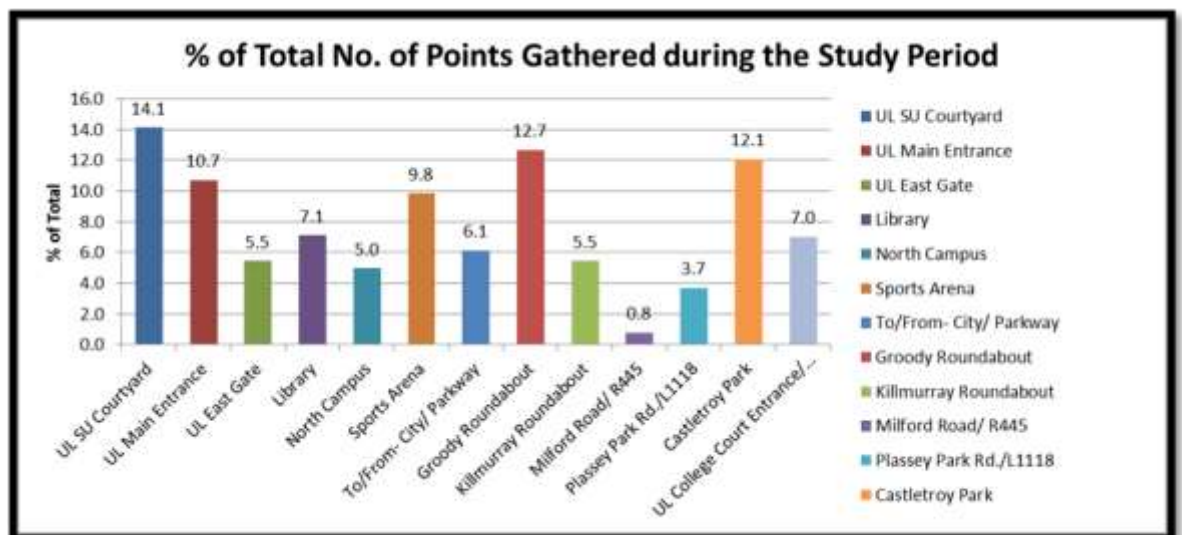
Table 3.1: No. of times candidates passed specific locations during the test period – Part A

Candidate No.:	No. of times candidates passed specified locations during the test period						
	Location						
	UL SU Courtyard	UL Main Entrance	UL East Gate	Library	North Campus	Sports Arena	To/From- City/ Parkway
1	8	6	0	4	1	3	3
2	5	2	2	2	1	6	2
3	4	0	10	2	2	10	2
4	6	4	6	0	1	6	4
5	6	4	0	7	0	2	0
6	4	0	0	2	10	0	0
7	10	0	10	0	0	10	0
8	2	8	0	10	0	2	0
9	10	12	0	5	12	8	0
10	8	10	0	2	0	12	10
11	10	10	0	0	0	0	0
12	8	8	0	8	0	10	0
13	16	10	6	12	2	6	14
14	14	2	12	8	8	12	0
15	4	10	0	2	10	0	10
16	10	12	0	5	4	2	12
17	10	0	10	0	0	12	0
18	10	12	0	4	0	0	6
<b>Total:</b>	<b>145</b>	<b>110</b>	<b>56</b>	<b>73</b>	<b>51</b>	<b>101</b>	<b>63</b>
<b>Total Trips:</b>	<b>1027</b>						
<b>% of Total Trips:</b>	<b>14.1</b>	<b>10.7</b>	<b>5.5</b>	<b>7.1</b>	<b>5.0</b>	<b>9.8</b>	<b>6.1</b>

**Table 3.2: No. of times candidates passed specific locations during the test period – Part B**

Candidate No.:	No. of times candidates passed specified locations during the test period					
	Location					
	Groody Roundabout	Killmurray Roundabout	Milford Road/ R445	Plassey Park Rd./L1118	Castletroy Park	UL College Court Entrance/ Kemmy
1	12	0	0	0	12	8
2	4	4	2	2	12	14
3	2	14	0	10	0	4
4	6	8	0	8	4	10
5	10	0	0	0	0	0
6	0	0	0	0	0	0
7	0	6	0	0	0	2
8	0	0	0	0	8	4
9	8	6	4	0	8	12
10	10	0	0	0	10	2
11	10	0	0	0	10	2
12	12	0	0	0	10	0
13	16	0	2	0	14	6
14	0	4	0	6	2	4
15	14	0	0	0	10	4
16	12	0	0	0	12	0
17	0	14	0	12	0	0
18	14	0	0	0	12	0
Total:	130	56	8	38	124	72
Total Trips:	1027					
% of Total Trips:	12.7	5.5	0.8	3.7	12.1	7.0

The combined results, for the percentage of total travel paths passing the specified data points is described in Figure 3.3. Travel paths were created by a user every time they moved in a given direction when the application was active. A single line or travel path was thus created in the heat map.



**Figure 3.3: % of Total No. of Points Gathered during the Study Period**

The four highest activity areas as seen in Figure 3.3 are that of Groody roundabout (13%), Castletroy Park (12%), UL main entrance (11%) and the UL SU Courtyard (14%). These results highlight a very specific route to and from the University as being the busiest route



used by University of Limerick students and staff (Figure 3.4). This particular route facilitates the three modes of cycling, walking and driving as used by the survey participants.

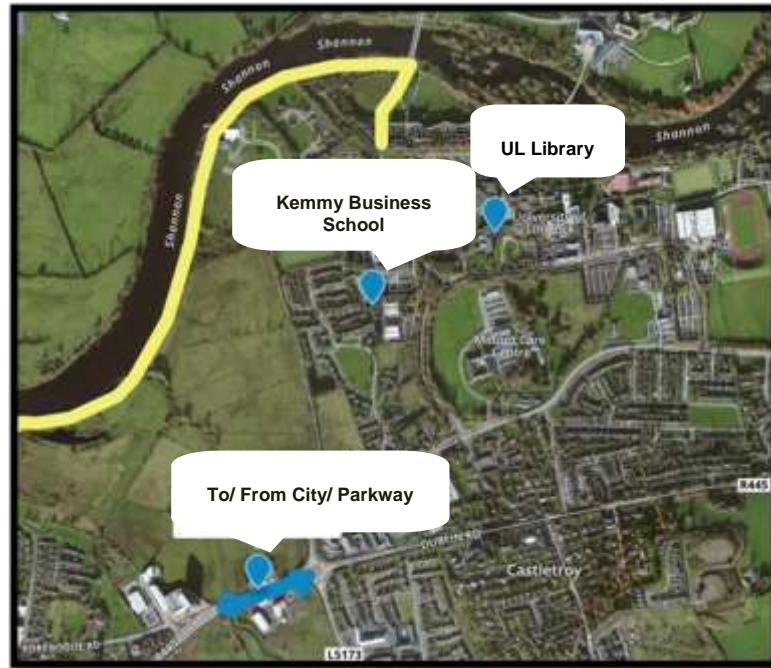


**Figure 3.4: Busiest Route Utilised by Survey Participants**

The second group of high activity areas was found to be the Glucksman Library (7%), UL College Court entrance/ Kemmy business school (7%) and to/ from the city centre/ Parkway (6%) (Figure 3.5).

Of importance also is the variety of destinations and intermediate destinations of those trips passing the “to/ from city centre/ Parkway” data point. Participants passing this data point were found to make intermediate or “by-pass” trips to areas such as the Parkway Retail Park/ Shopping Centre, Childers Road Retail Park, services such as Aldi and the Maxol forecourt and various residences along the R445 connecting Castletroy to the city centre. Participants’ trips were also found to terminate at a number of these locations. This highlights the need to incorporate more detailed information of the travel patterns of the various area users in the design of a bike sharing scheme instead of solely focusing on trip attractor and generator locations. This information also highlights the possibility of a Castletroy scheme linking with the existing Coca-Cola Zero bikes scheme located in Limerick city centre, as trips between the two locations appear to be non-linear.





**Figure 3.5: Second Highest Group of High Activity Areas**

The results from the GPS application study period describe a large variety of different individual timetables. Trips outside of the traditional commuting periods of 08:00am – 09:00am and 05:00pm – 06:00pm [5], are seen to take place at a large variety of periods throughout the day. This describes a community of people who are not associated with the traditional daily generator - attractor trips and therefore base their daily trips, whether commuter or non-commuter based, on their own individual timetables. A bike sharing scheme implemented in such a community would see a more sporadic usage pattern as compared to a traditional bike sharing scheme which experiences peak periods during the specified commuter times and at lunch time periods. An example of how erratic this particular groups travel patterns may be over the course of 5 days is described in Figure 3.6, where one candidates daily commuting route is outlined in blue. This figure describes a heat map for a particular candidate. Bright orange indicates the path most regularly used and dark purple describes paths which are least used.

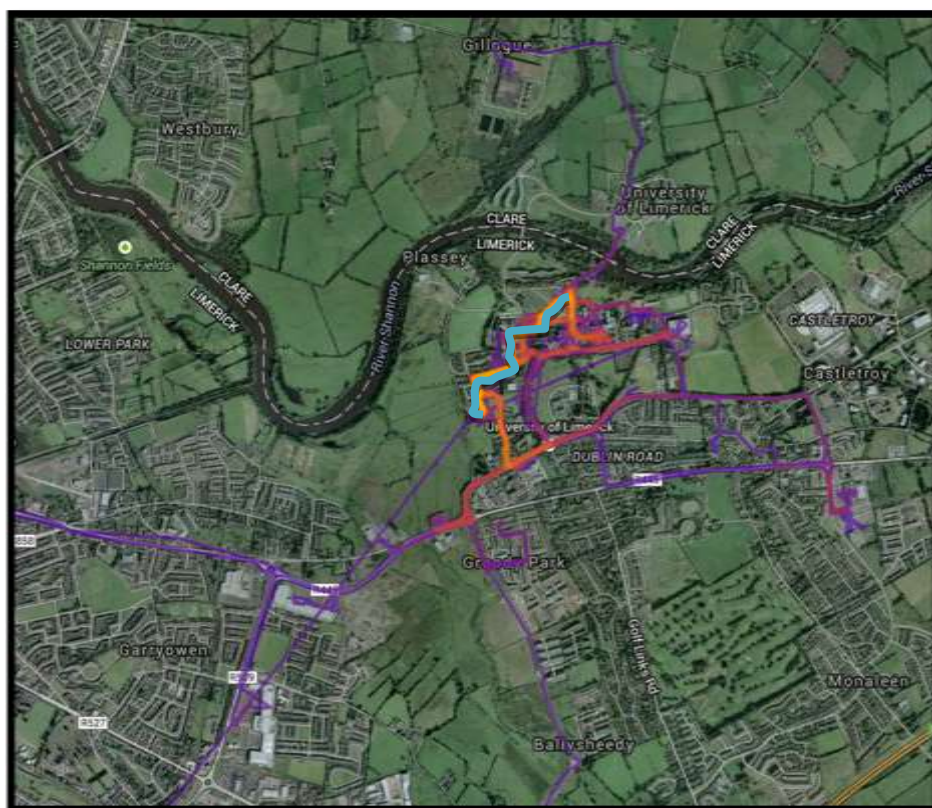


Figure 3.6: “Erratic” Travel Patterns of Candidate Over 5 Days

#### 4. Conclusions

Castletroy is within the ideal commuting distance by rented bike of 8km from Coca-Cola Zero scheme base in Limerick city centre. This distance is based on a feasibility research carried out for the London bikes scheme which found that the ideal distance for a bike sharing scheme trip was 1-8kms [1]. A high percentage of University of Limerick staff members are also found to live in close proximity to the existing bike rental station locations [3]. This data initially highlights the possibility of a Castletroy and Coca-Cola Zero bike scheme link.

Non-linear trips (i.e. a variety of trip destinations instead of one common destination) between the city centre and the University of Limerick/ Castletroy further highlights the possibility of connecting this area to the existing Coca-Cola Zero bikes scheme. The main concern of connecting Castletroy to the existing scheme is that trips produced would be linear which would therefore result in the expensive re-distribution of bicycles. However, the results from the smartphone application show this not to be the case, as participants are seen to make a number of intermediate stops on the way to and from the city centre.

Bike sharing scheme implementation in the Castletroy area would see a more sporadic usage pattern compared to a traditional bike sharing scheme which experiences morning and evening peaks [6]. This is largely due to the fact that a University population operates on a large variety of schedules.

From the results, it would be advised to provide access to bike sharing stations at greater distances from attraction hubs as well as within the attraction hubs as people who live further from that trip attractor are more likely to drive to the destination. People living within 2km of an attractor are more likely to walk to that destination and therefore the provision of a bike sharing station at this location would not be as beneficial to the wider modal split for the area. This conclusion is drawn from analysing the GPS data, survey questionnaire and UL travel pattern study results.

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The type of detailed information gathered during the smartphone application implementation provides an analysis whereby bike sharing scheme designers may confidently decide on rental station locations. These decisions should be based on a high percentage of people passing a given location and intermediate locations as well as incorporating other qualitative factors, such as those listed in Section 1 under "Feasibility Criteria". This data also provides detailed travel information such as the inclusion of "non-commuting trips", exact trip length and exact trip time, which is currently not available to local authorities.

Interestingly, from the results it is found that the majority of candidates travel to more than 3 locations within the campus and around Castletroy during any given day. This would be of benefit to a bike sharing scheme as hire bicycles would be used at various periods throughout the day, including commuter times. Of importance also is the distances travelled by candidates during the day. Once a candidate has arrived at their main commuting destination, they can be seen to travel up to 1.5km during any given day before commuting back to their original trip generator location. Sporadic movements in the period between the morning commute and evening commute and outside of the morning to evening commute period are also observed. This would aid in the natural redistribution of rented bicycles if they were to be used for these trips.

The type of data provided by the implementation of the GPS smartphone application allows for a more robust design approach to bike sharing schemes. This can be compared to the approach used for designing the Coca-Cola Zero bikes scheme for Cork, Galway, Limerick and Waterford whose designs are "based largely on a review of equivalent data in other European schemes" [1]. The type of travel pattern analysis utilised here may provide BSS designers with quantifiable data which will aid in the decision making process for determining station locations.

The extensive and detailed data provided by this analysis is currently unavailable to local and government authorities. This is a data source which should be exploited by planners, as the level of detail provided is well in excess of the current attractor and generator datasets.

## 5. Recommendations for Further Research

Due to time constraints, not all work was carried out to the extent which was desired.

Therefore a number of recommendations are made on which further work on the subject area of using heat maps to record a community's travel patterns may be carried out. These recommendations are as follows:

- Extend the study period of the smartphone application implementation in order to gather a larger variety of trips and trip types;
- Increase the sample size in order to gather a more representative sample for the study population;
- Achieve a larger variation of the sample composition to include both staff and students of UL as well as residents of the Castletroy area and
- Develop a computerised process whereby, if the heat map results were to be aggregated into one master map for all survey participants, then a truly robust approach to analysing a community's travel patterns may be developed;

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