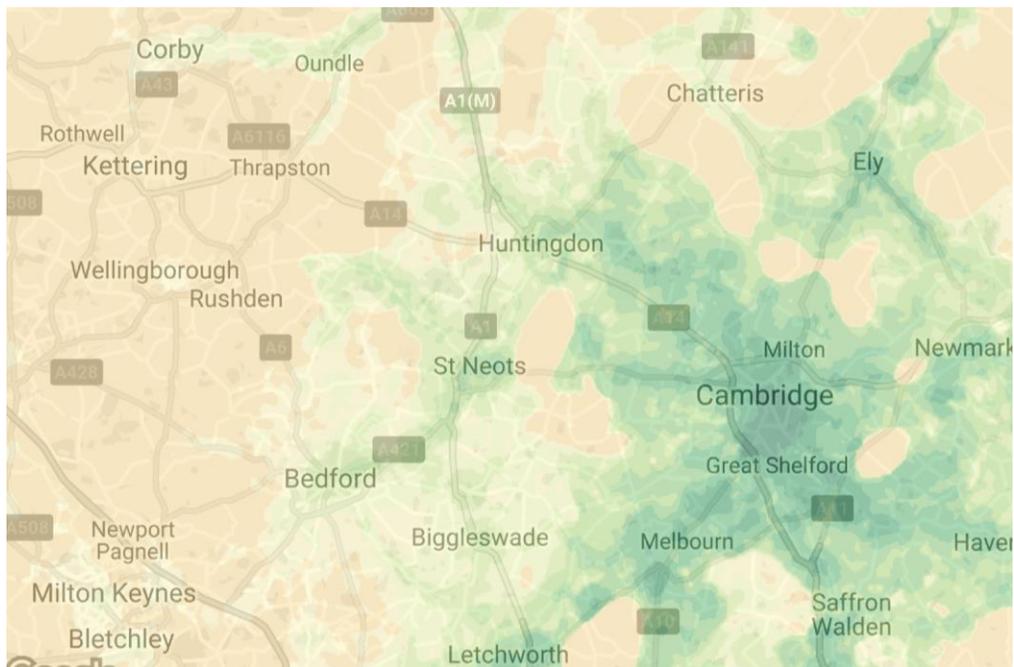


# Accessibility and Criticality in Cambridgeshire

*Using Google data*



## Study conducted for Cambridgeshire County Council

Adrià Salvador Palau & Jon Roozenbeek<sup>1</sup>  
Centre for Digital Built Britain  
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<sup>1</sup> Email: [as2636@cam.ac.uk](mailto:as2636@cam.ac.uk) (Adrià) and [jjr51@cam.ac.uk](mailto:jjr51@cam.ac.uk) (Jon).

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## INTRODUCTION

In this report, we study the accessibility of some of Cambridgeshire's points of interest by public transport by creating heat maps of the area. We conduct two practical case studies. First, we look at the accessibility by public transportation of the Cambridge Biomedical Research Centre and the Babraham Research Campus. Second, we conduct a criticality analysis of infrastructure assets around Addenbrooke's Hospital.

## WHAT ARE HEAT MAPS?

A heat map is the visual representation of data on a geographical map using colours [1]. They are used in a wide variety of contexts ranging from visualising weather and climate models to understanding house foreclosures and consumer demand for certain products. This makes heat maps an useful tool for optimising problems relevant to citizens' everyday lives. When it comes to infrastructure asset management, particularly for public administrations, heat maps also have myriad potential applications as they can be used to visualise the effect of particular assets within the geographical landscape of a country. They also have potential as a tool for criticality analysis, as they present an intuitive way to visualise the importance of certain assets [2].

## METHOD OF ANALYSIS

We make use of data obtained through the Google Maps API [3]. An API, or "Application Programming Interface", is a set of protocols and tools that developers can use to build software based on existing software [4]. The Google Maps API can be used by developers for a wide range of implementations and applications. Google encourages developers to create their own tools and solutions by making use of their API.

Google has a wide set of APIs that can be accessed online, each with a different purpose. For this project we are particularly interested in the Directions API and the Static Maps API. The Directions API can be used to obtain directions between two geographical points, and the Static Maps API provides high-quality maps for practically any region of the planet.

## The Directions API

The Directions API gives access to an online data generator that responds to individual calls [5]. These calls have the following inputs:

- Position of origin and position of destination: by coordinates, address or name of point of interest.
- Mode of travel: driving, walking, cycling or public transit. Here, “transit” includes combinations of public transportation (bus, subway, train or tram) and walking.
- Time of departure, or time of arrival.
- Additional specifications: for example, requiring the API to provide alternative routes and not only the fastest option from A to B.

The Directions API then returns the following outputs (summarised):

- Detailed directions from the origin to the destination. This includes the roads to be travelled, public transportation lines to be used, detailed directions for walking or cycling, warnings (for example with regards to dangerous traffic), and a geometrical polyline of the trajectory between the two points.
- Information about transportation time, and the total distance.

## The Static Maps API

The Static Maps API provides high resolution maps of the earth’s surface tailored to the user’s demand [6]. Here, the input to Google and subsequent output are much simpler. The user inputs the centre of the map, its extension and style, and Google generates it from its dataset of geographical data. The style, content and scope of such maps is broad, as Google allows users to generate their own map-generating instructions.

## Python as a plotting and data manipulation tool

We use a Python framework previously scripted by Jon Roozenbeek and Adrià Salvador Palau. The main libraries of reference are matplotlib [7] and googlemaps [8], the latter being an official library supported by Google that gives online access to its API services.

# CASE STUDY 1: ACCESSIBILITY OF BIOMEDICAL RESEARCH CENTRE AND BABRAHAM RESEARCH CAMPUS

Smart Cambridge, which provides “a ‘digital’ platform to support the transport infrastructure investments taking place in [Cambridgeshire]” [9], asked us to look at the accessibility of the Cambridge Biomedical Research Centre (also called the Cambridge Biomedical Campus) and the Babraham Research Campus, specifically when it comes to bus schedules and travel times. We have calculated the accessibility to both sites using public transportation at 8am and 5pm of a typical working day.

## Cambridge Biomedical Campus

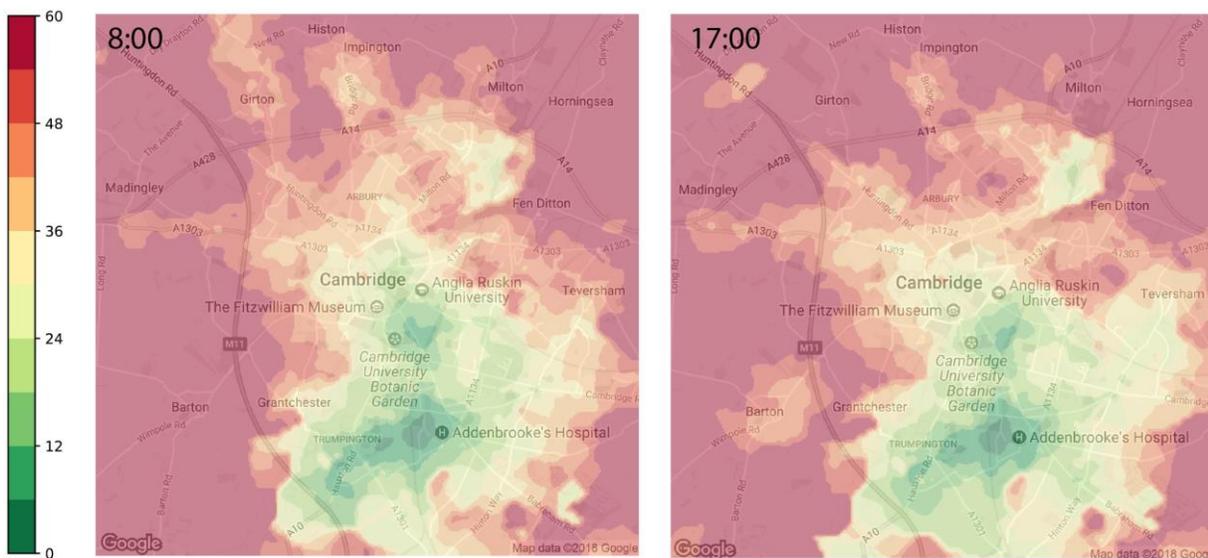


Fig. 1: Transportation times by public transport to the Cambridge Biomedical Campus / Cambridge Biomedical Centre (close to Addenbrooke’s Hospital on the map), city level, at 08:00 and 17:00.

The Biomedical Research Campus is located near Addenbrooke’s Hospital, just to the south-east of Cambridge. Figure 1 shows the accessibility of the Biomedical Research Campus, in the morning and late afternoon. The scale on the left indicates the number of minutes of travel time by public transportation.

As we can see, the area roughly between Trumpington and Hills Road/Babraham Road has the best accessibility to the campus. Here, the average travel time is approximately 5-10 minutes. Trumpington is especially well-connected through the A1134. Most of the city centre is roughly 20-30 minutes away from the campus.

A number of areas are rather less well-served than one might expect. First, the area around Mill Road (south-east of Anglia Ruskin University on the map) is on average almost 30 minutes away from the campuses, despite the fact that the A1134 provides a direct route between these two places. Right now,

bus lines do not use the A1134 directly to go between the Mill Road area and the Addenbrooke's area. Considering that a substantial number of Mill Road area residents working in and around Addenbrooke's, it could be worthwhile thinking about how to improve travel times here.

Furthermore, smaller residential areas around Cambridge experience difficulty reaching the campus by bus. In figure 1, places like Barton, Madingley, Girton, Milton, Fen Ditton and the area around Huntingdon Road in the north-east are more than 40 minutes away from the Addenbrooke's/Biomedical Research Campus area. It is, however, unclear if there are employee shuttle buses running between these villages and the campus, which might substantially improve travel times.



Fig. 2: Transportation times by public transport to the Cambridge Biomedical Campus, county level at 08:00 in the morning.

Figure 2 shows the transportation times for Cambridgeshire County. At the county level, we can see that it is especially the areas to the south-east of Cambridge that are well-connected to the campus. Haverhill, Letchworth Garden City, Saffron Walden, Newmarket and Milton are all within 100 minutes away. Huntingdon is also relatively well-connected through the A14. The A10 to Downham Market and King's Lynn also provides decent accessibility.

Areas to the north and especially north-west of Cambridge are much less well-connected. Parts of the

area around Kettering, Wellingborough, Thrapston and Rushden are more than 200 minutes away from the campus by public transportation. This is despite the fact that these areas have good access to important infrastructure assets such as the A6.

### Babraham Research Campus

The Babraham Research Campus is located to the south of Cambridge, near the village of Babraham. Figure 3 shows the transportation times for the morning and late afternoon.

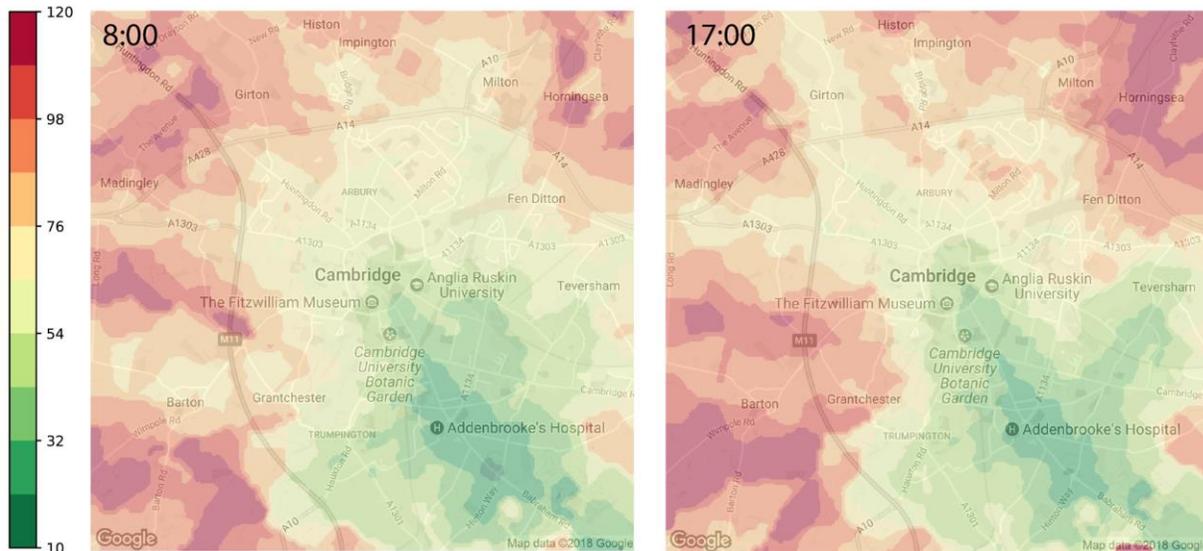


Figure 3. Transportation times by public transport to the Babraham Research Campus at 08:00 and 17:00.

In figure 3, Babraham can be found just south-east of Addenbrooke's Hospital. The scale on the left (as before) indicates the number of minutes of travel time.

We observe that the entirety of Babraham Road, between Babraham and Cambridge city centre, is well-connected to the campus. Travel times generally do not exceed 40 minutes in most areas around this road. Hinton Way, which leads towards Great Shelford (not visible on the map) is also well-connected, as is Cherry Hinton Road, which leads towards Teversham.

As with the Biomedical Research Campus, some areas in the centre of Cambridge are less well-connected than one may expect from such a central location. Once again, the area around Mill Road (close to Anglia Ruskin University on the map) is underserved based on its location and importance as a residential area. Furthermore, the areas around Barton, Grantchester and Trumpington, in the south-east of the map, are especially poorly serviced. The same goes for the area around Madingley. From here, travel times to Babraham can run up to about 2 hours. This might be mitigated by installing a bus

route that goes along the M11 and connects to Addenbrooke's and Babraham.

Finally, there is a huge gap in travel times between Teversham (in the north-east of the map) and Fen Ditton and Ditton Lane, which are geographically very close to each other. This suggests a lack of efficient bus routes. A closer inspection of the Google Maps route between these two places reveals that the bus travel time between them is approximately 40 minutes. Depending on customer demand, it might be worthwhile installing a bus route between Ditton Lane and Teversham along the A1303 and Airport Way.

## CASE STUDY 2: CRITICAL INFRASTRUCTURE AROUND ADDENBROOKE'S HOSPITAL

In our second case study, we analyse the criticality of public transportation assets for Addenbrooke's Hospital, in order to find out which assets are critical to its accessibility, and in which order. This can help administrators determine, for example, when and where to conduct road maintenance in the public transportation system.

Criticality is calculated by weighting the appearance of different routes in the transportation recommendations from the Google API. Concretely, we perform a random sample of destinations of origin and count how many times each route appears in the recommendations. These routes are then overlaid on the map with a colour scale proportional to the times that they have appeared in Google's recommendations. This weighting is then ideally done in proportion to the population density of each point on the map. However, for this analysis data no high-resolution population density was provided and thus this step was skipped. In the presented analysis, only public transportation is considered, but the analysis could be potentially extended to private transportation, or a combination of both.

Figure 4 shows the results of our analysis. The purple routes are considered critical. The higher the criticality, the larger the influence of these roads on travel times to the hospital. The more intense the colour is, the more critical they are.

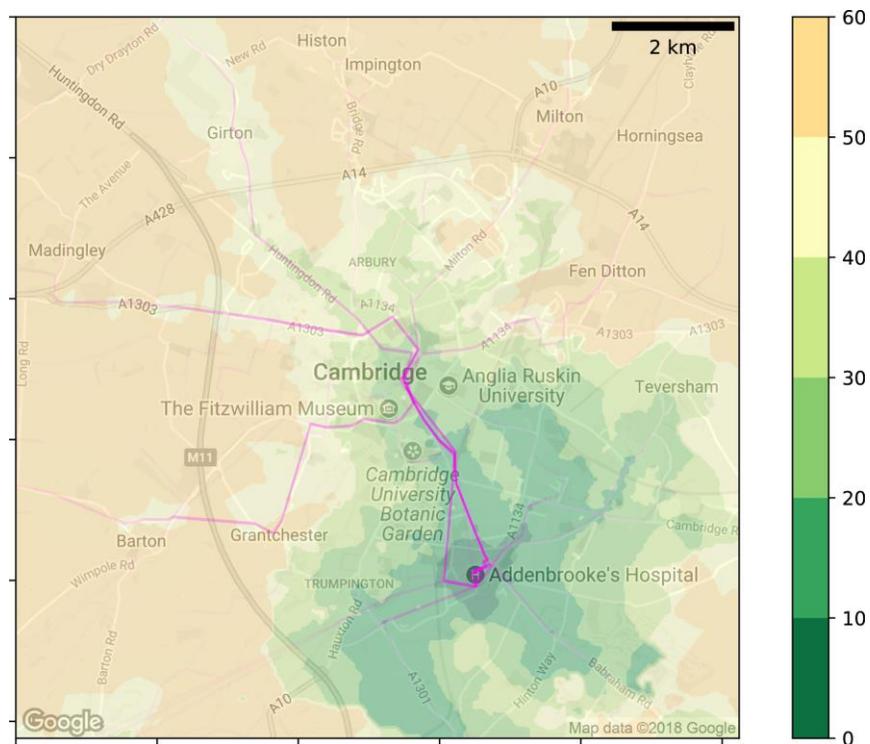


Figure 4. Transportation times and most critical public transportation routes servicing Addenbrooke's Hospital.

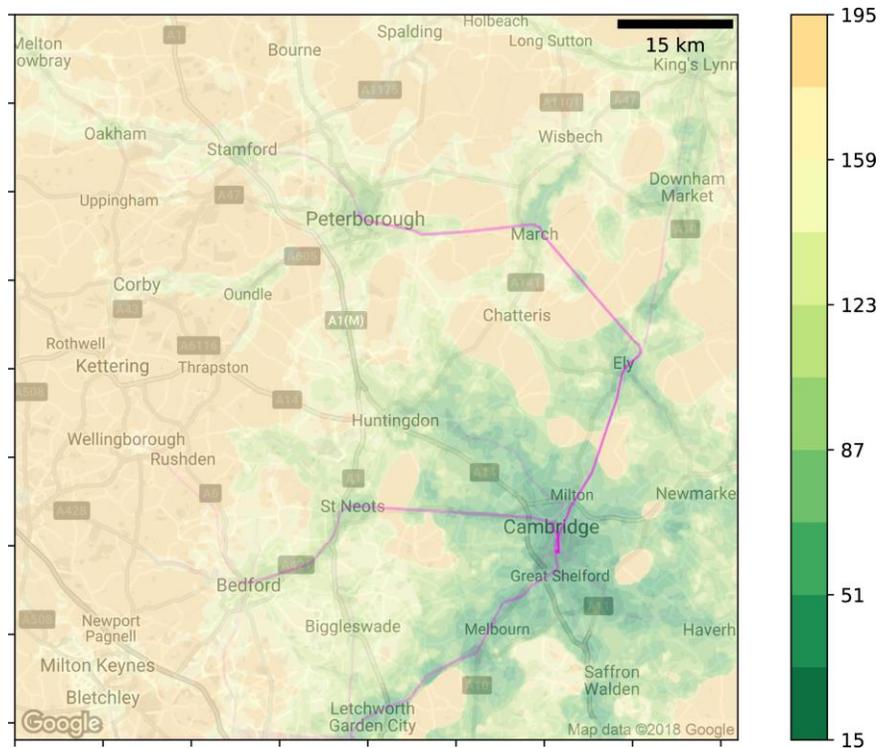


Figure 5. Transportation times and most critical public transportation routes servicing Addenbrooke’s Hospital (County level).

Figure 4 shows that the Busway Route (routes A and U) between the Cambridge Railway Station and Addenbrooke’s Hospital is by far the most critical infrastructure asset. Robinson Way, which curls around the hospital, is also highly critical. Other critical assets are the bus routes along the A1307 between the station and the city centre, Babraham Road and Hills Road (but only up until Hinton Way), and the A603 between the centre and the M11, which also connects Grantchester and Barton.

In Figure 5, we zoom out to the county level. The most important assets in Cambridgeshire appear to be the CrossCounty bus route along the A10 between Cambridge and Ely, and the railway between Peterborough, March and Ely. The X5 bus route on the A428 towards St. Neots, the X5 along the A4280/A427 between St. Neots and Bedford and the Great Northern railway between Cambridge and Letchworth Garden City are also critical assets.

Surprisingly, the East Midlands train line between Kettering and Bedford and the railway between Bedford and Luton (the latter doesn’t show on the map) are more critical than may be expected based on how far it is from Addenbrooke’s. This indicates that the results of a criticality analysis are not necessarily trivial or intuitive; sometimes, unexpected roads can turn out to be critical.

## CONCLUSIONS

In this report, we have sought to do two things:

1. Assess the accessibility by public transportation of the Biomedical Research Campus and the Babraham Research Campus at the city and county level.
2. Assess the criticality of infrastructure assets around Addenbrooke's Hospital.

Regarding point number 1, we conclude that the Biomedical Research Campus can be reached by public transport within 30 minutes from most of Cambridge. Babraham is less than approximately 40 minutes away for most locations along Babraham Road and the city centre. Many villages around Cambridge, however, are much more poorly serviced. The areas around Barton, Grantchester and Trumpington are especially badly connected. This might be mitigated by installing a bus route that connects the areas around the M11 to Addenbrooke's and Babraham. In addition, the area around Mill Road is less well-serviced than can be expected when looking at the existing infrastructure. This suggests that some improvements may be made in this regard. For example, it could be worthwhile to investigate the possibility of creating or re-routing a bus route along the A1134 between the Mill Road area and Addenbrooke's. We also recommend looking into the possibility of a bus route between Ditton Lane and Teversham.

Regarding point number 2, the Busway Routes between Cambridge Station and Addenbrooke's and the railway between Cambridge, Ely, March and Peterborough are the most immediately critical infrastructure assets. Other important routes are bus routes along the A10, the A428 and the A10/A505. Surprisingly, the railway lines between Luton and Kettering (through Bedford) are also more critical than expected based on their location and proximity to the hospital. This is likely because these routes incorporate a big fraction of the public transportation routes originating in the westernmost area of the region.

## ABOUT US

This report was written as part of a project for the Centre for Digital Built Britain (CDBB)<sup>2</sup>. The CDBB is a partnership between the Department of Business, Energy & Industrial Strategy and the University of Cambridge. Its mission is to “deliver a smart digital economy for infrastructure and construction for the future and transform the UK construction industry’s approach to the way we plan, build, maintain and use our social and economic infrastructure.”

Each year, the CDBB runs a number of mini projects, funded from the University of Cambridge network, which look at how digital technologies impact the built environment, and how society might be affected by the changes which may follow from the employment of these technologies. These mini projects usually run for a period of two months.

Our CDBB mini project is called “Exploiting traffic data to improve asset management and citizen quality of life”<sup>3</sup>. The project’s goal is to demonstrate how data sources such as the Google Maps API service can be used to generate insights that are visualised using colour-coded maps, for use as an effective decision-support tool.

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