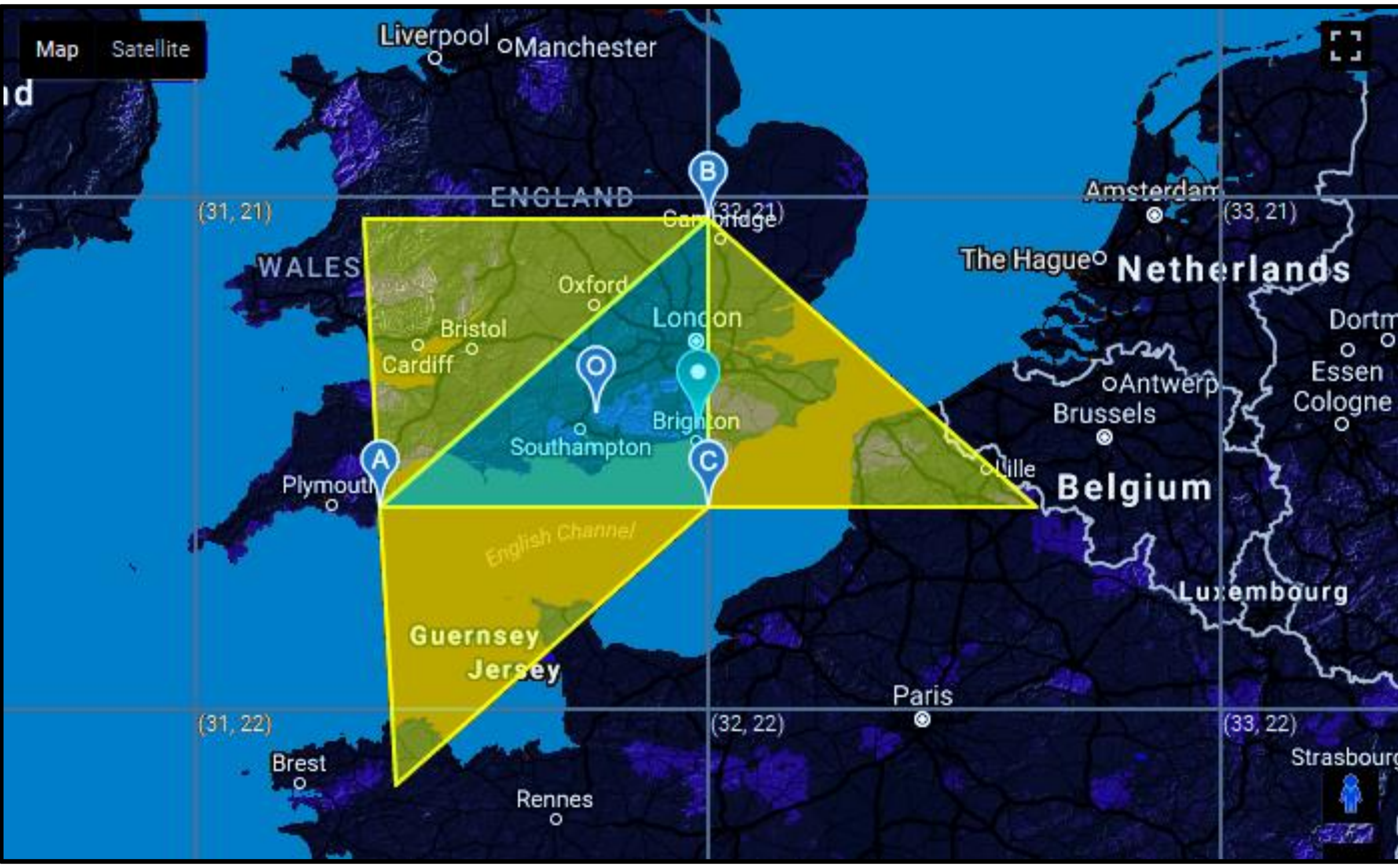
# Smart Ledger Geostamping

## Steps Towards Interoperability & Standards



# Foreword

We are pleased to have sponsored this report about geostamping and geocoding for Smart Ledgers. With the increasing number of applications needing to record not just transactions (timestamping) but also geolocation information, we see the rise of ‘geostamping’. Geostamping = timestamping + geolocation information. Much work has gone into recording geolocations over millennia. This report provides guidance on three practical ways Smart Ledgers can geostamp.

The project from which this report emerges is GeoGnomo, an open-source project exploring various forms of geocoding for use in Smart Ledgers (aka blockchains with embedded computer code). The GeoGnomo project focuses on memorable systems that provide easy ways to aggregate areas together, as well as giving users some clues to location and distance and scale.

This report gives an overview of work so far resulting in a Quaternary Rectangular System, a Quaternary Triangular System, and a Variable Rectangular System for geostamping. Each can be used to record geographic areas into a blockchain. We have provided the source code online along with an online API translating from latitude & longitude areas to geocodes and back. Thus, blockchain applications can have instant ‘global post code’ or ‘global zip code’ systems. By using consistent geocoding, data retrieval is easier. Users can share information easily – for example, “tell the drone to come to F49PUR9B7-20”, a resolution of 7.6 metres, or “tell the drone to come to F49PUR9B78A-25”, a resolution of 0.25 metres.

We look forward to further output from the GeoGnomo project as part of our wider exploration of Smart Ledgers in Long Finance’s Distributed Futures research programme.

**Michael Parsons, FCA**
**Chairman, Cardano Foundation**

# Contents



# Introduction

Smart Ledgers (aka blockchains) provide a facility for recording immutable transactions. This takes the form of a 'timestamp', a permanent record of computer-based transactions. A natural extension is to add other information, in particular geolocation information, thus a 'geostamp'.

However, there is a multitude of ways to encode geolocation information. This guide provides executives with an overview of Smart Ledger geostamping, clarifies terminology, explains the concept, gives a taste of the technology and applications, and looks to longer-term developments.

# 1. What Is Geostamping?

A geostamp is a digital record of the geographic location of a transaction or, in other words, a timestamp with a geographic location attached. As the use of Smart Ledgers becomes more widespread, people will have a wider variety of reasons to need to understand where events occurred.

Geocoding or georeferencing is the assignment of a unique identification to a place on the earth represented by a point, line, or area. We are already familiar with some forms of geocoding, such as latitude and longitude, or post and zip codes. For example, an address at 41 Lothbury in the City of London, is in the post code area EC2R 7HG, while New York 55 West 17th Street, New York City is in zip code 10011-5513.

The adoption of a limited number of consistent geocoding structures that have global applicability could increase interoperability of Smart Ledgers.

We believe the principal qualities of a good geocode can be encapsulated in the 'MAPS' Acronym:

| | | |
|---|---|---|
| **M** | Memorability | A geocode should be compact and memorable |
| **A** | Aggregation | A coding system should be able to describe comparably a variety of area sizes and structures, both natural and human, such as forests, beaches, buildings, sports grounds, country borders, etc. |
| **P** | Proximity | Similar codes should represent similar locations, so that people exchanging codes can roughly understand the distance and relationship between them |
| **S** | Scale | Users should have control over the precision |

Distributed Futures has an open source resource project, **GeoGnomo,** to research and share methods for Geostamping.

## 2. Geostamping Formats

GeoGnomo has developed three methods for geocoding, two use rectangular areas, one triangular areas. GeoGnomo examples are shown throughout the report and detailed in section 4.

| Method | Memorability | Aggregation | Proximity | Scale |
|---|---|---|---|---|
| Latitude/Longitude Coordinates | Poor | Average | Very Good | Poor |
| Quaternary Rectangular System (QRS) | Good | Average | Good | Good |
| Quaternary Triangular System (QTS) | Good | Average | Good | Good |
| Variable Rectangular System (VRS) | Average | Good | Average | Very Good |

GeoGnomo provides codes using the following syntax:

**Method ":" Code "-" Level**

**Method** = "QRS", "QTS", or "VRS",
**Code** = is a combination of letters and numbers (QRS/QTS: all letters A to X inclusive and all numbers 2 to 9 inclusive; VRS: all letters except I, O, Z and all numbers 0 to 9 inclusive)
**Level** = (QRS and QTS only) a number from 1 to 40 (inclusive) to any length, though typically less than 30 which is a tiny area of 0.000022121 metres.

For example,

"QRS:HFK-5" is an offshore area south of Ghana and Togo,
"QTS:F49OM6A-13" is London Zoo,
"VRS:RUYR3XXHDH" is Hyde Park.

| Location | QRS | QTS | VRS |
|---|---|---|---|
| 41 Lothbury<br>City of London<br>EC2R 7HG | QRS:G5V4UWB-13 | QTS:F49PURB-13 | VRS:BTWHF0NP039A |
| 55 West 17th Street<br>New York<br>10011-5513 | QRS:F8IMBRA-13 | QTS:E8VQLLB-13 | VRS:BRCTRXTUEGBT |

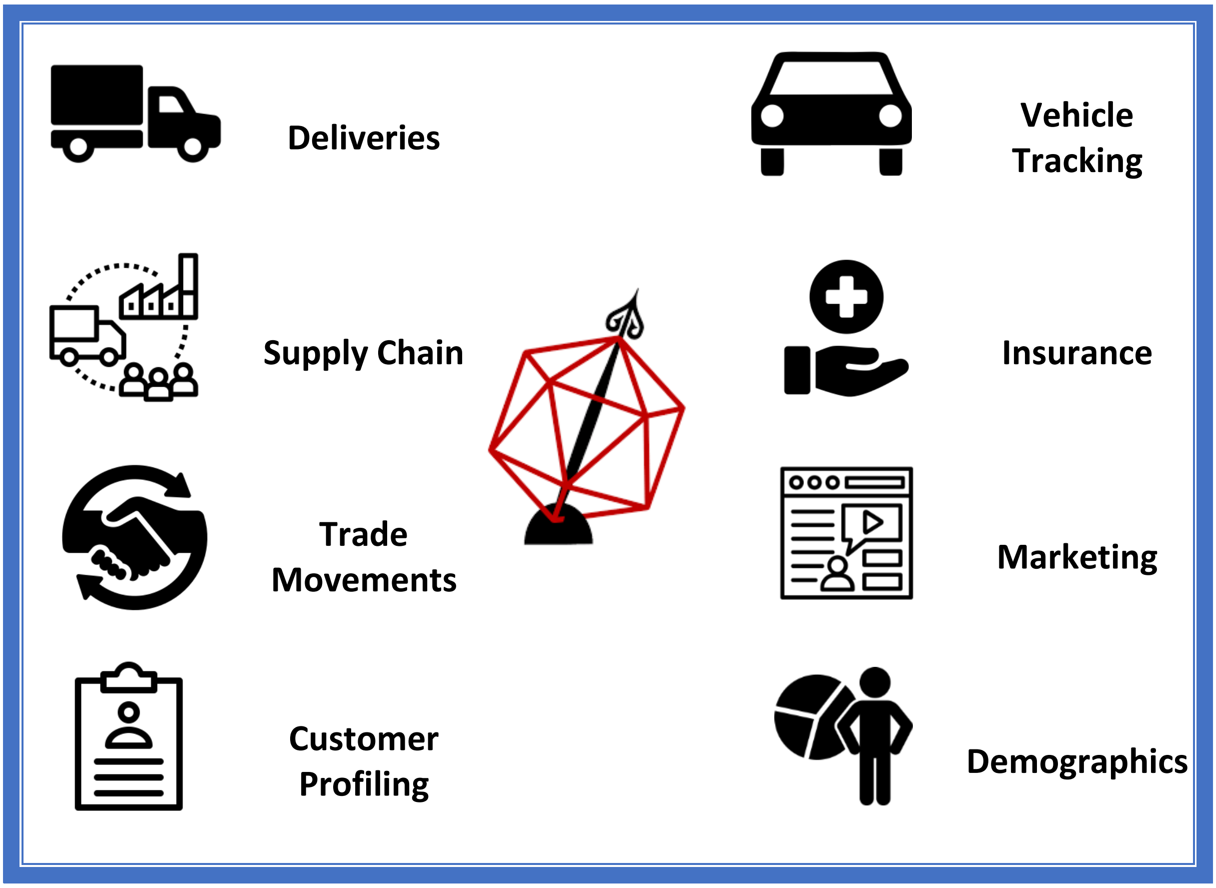
# 3. Smart Ledger Examples of Geostamping

Smart Ledgers are mutual distributed ledgers (MDLs, aka blockchains) with embedded, executable code. Smart Ledgers are able to specify rules about the use of data within the MDL, for example, "release this ship's location four hours after it has been recorded on the MDL".

While global positioning systems and associated technologies allow devices to record and timestamp their own positions, people will want to record specific information of transactions and events that occur within a specific area. Latitude and longitude provide good point data, but areas are more difficult because many latitude and longitude points are needed.

Geostamping triangular and rectangular areas can often approximate polygons as well as more complex latitude and longitude vectors. Geostamping is typically constructed from letters and numbers and can be accessed at different levels, depending on the detail required.




Let's explore four examples of practical use:

## i) The exact destination for a parcel delivery.

| | | |
|---|---|---|
| **M** | Memorability | A geocode should be compact and memorable |

We could specify an area using latitude and longitude map references, which would involve several long (and not very memorable) numbers.

Using geostamping tools such as GeoGnomo we can zoom in on a specific area in a single code. Depending on the area in question, this could be as short as three or four digits. If more detail is required, then the code can be extended.

Figure 1 shows an area of the City of London, along with the corresponding latitude and longitude references and the GeoGnomo references that define it.

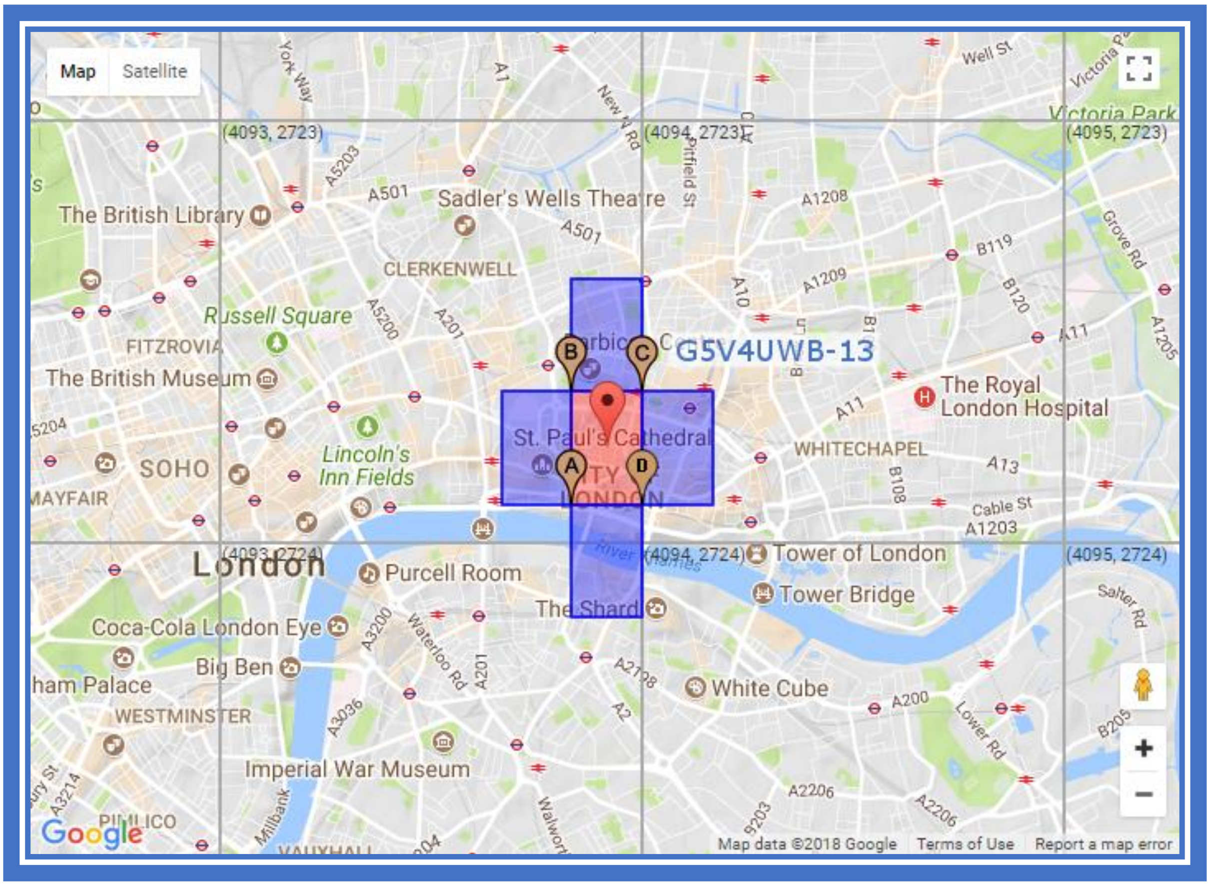



**Figure 1 The City of London at access level 13**

The latitude and longitude references for the red highlighted area are a lot to remember:

Point A (51.51123046875, -0.09521484375), Point B (51.5185546875, -0.09521484375), Point C (51.5185546875, -0.087890625), Point D (51.51123046875, -0.087890625)

Whereas the GeoGnomo alphabetic codes are **QRS:G5V4UWB-13**, QTS:F49PURB-13, and VRS:TWHF0NP039A, when we zoom in to level 20, we see the details of a more specific address as shown in Figure 2.

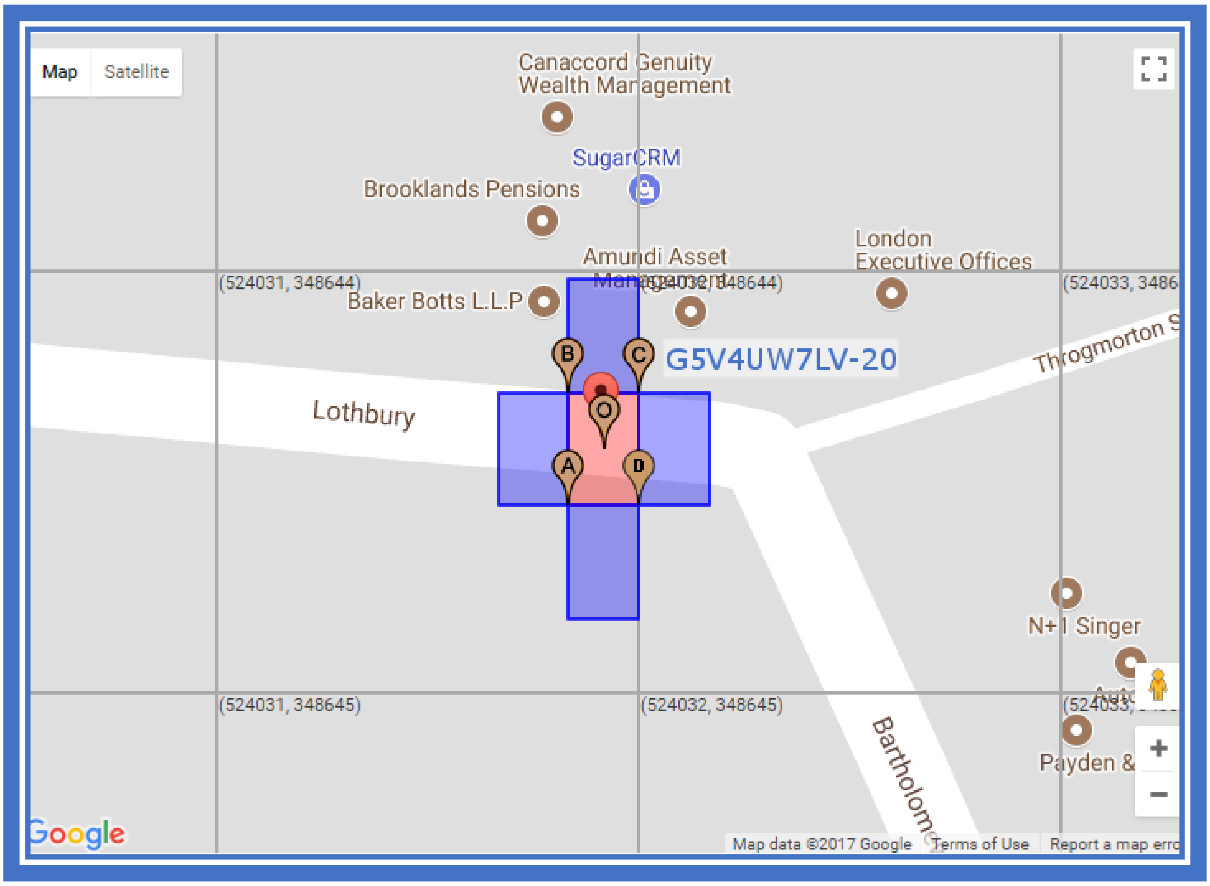



**Figure 2 The City of London at access level 20**

Point A (51.51460647583008, -0.08794784545898438), Point B (51.51466369628906, -0.08794784545898438), Point C (51.51466369628906, -0.087890625), Point D (51.51460647583008, -0.087890625)

The GeoGnomo alphabetic codes are **QRS:G5V4UW7LV-20**, QTS:F49PUT92V-20, and VRS:Q4W1WGJ2L6JAAA.

## ii) An organisation wants to know what happened within a small, specified location over the last year.

| | | |
|---|---|---|
| **A** | Aggregation | A coding system should be able to describe comparably a variety of area sizes and structures, both natural and human, such as forests, beaches, buildings, sports grounds, country borders, etc. |

Perhaps, in a particular location, a tax authority wants to identify relevant transactions. An insurer may want to know that 237 aircraft flew overhead; 10,014 mobile phone numbers were recorded; 3 robberies were reported; a care worker attended six addresses. At level 20, referencing 64 different GeoGnomo codes (4 x 4 x 4) would be too unwieldy, so the user could go up to level 17 as required (figure 3).

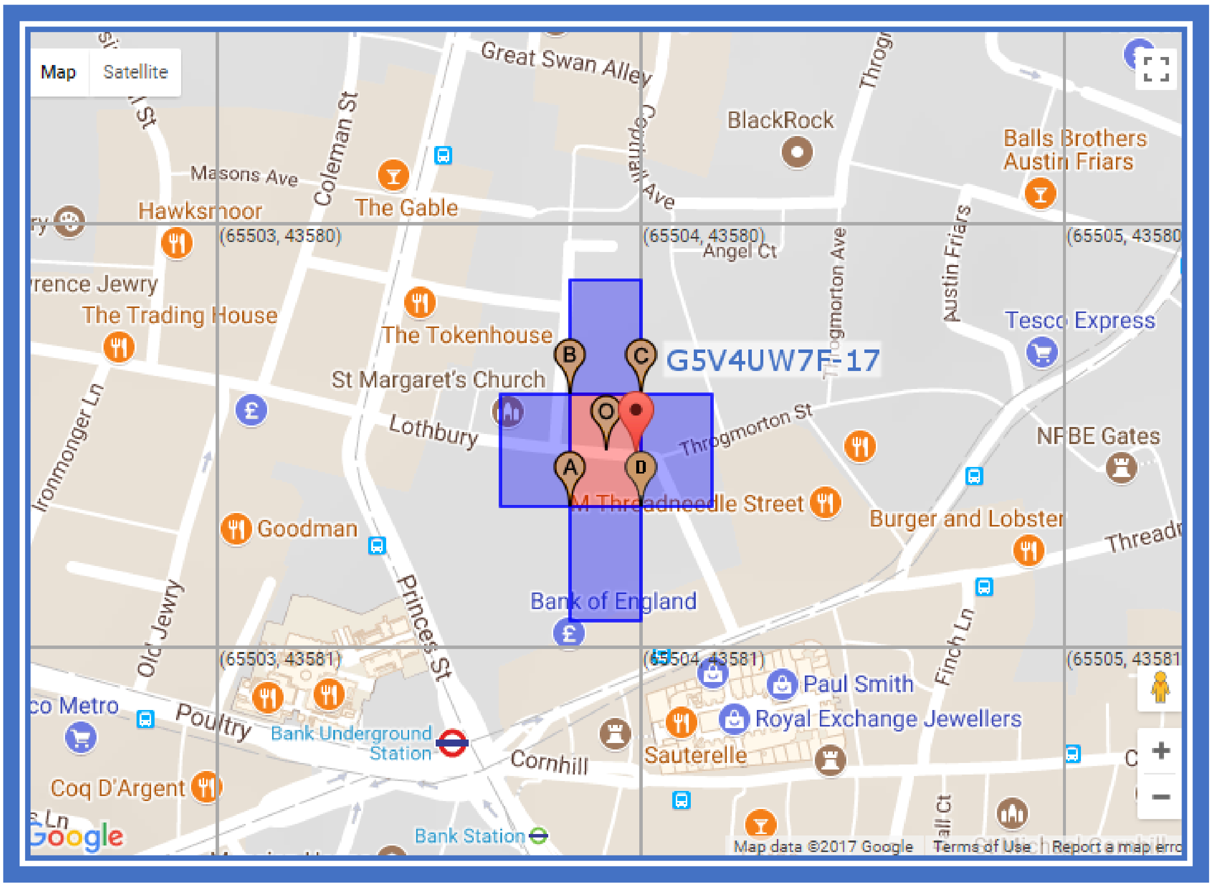



**Figure 3 A small, specified area within the City of London at access Level 17**

Point A (51.514434814453125, -0.088348388671875), Point B (51. 514892578125, -0.088348388671875), Point C (51.514892578125, -0. 087890625), Point D (51.514434814453125, -0.087890625)

The GeoGnomo alphabetic codes are **QRS:G5V4UW7F-17**, QTS: F49PUT9O-17, and VRS:E16CP4LNA5TAA.

### iii) People exchanging codes want to understand the distance and proximity between them.

| | | |
|---|---|---|
| **P** | Proximity | Similar codes should represent similar locations, so that people exchanging codes can roughly understand the distance and relationship between them |

Adopting this protocol, neighbouring shapes will share similar geocodes, so when faced with multiple geocodes, one can tell roughly how far away they are from each other.  Figure 4 highlights an area of central London and gives an idea of the geocodes applied to each neighbouring area.

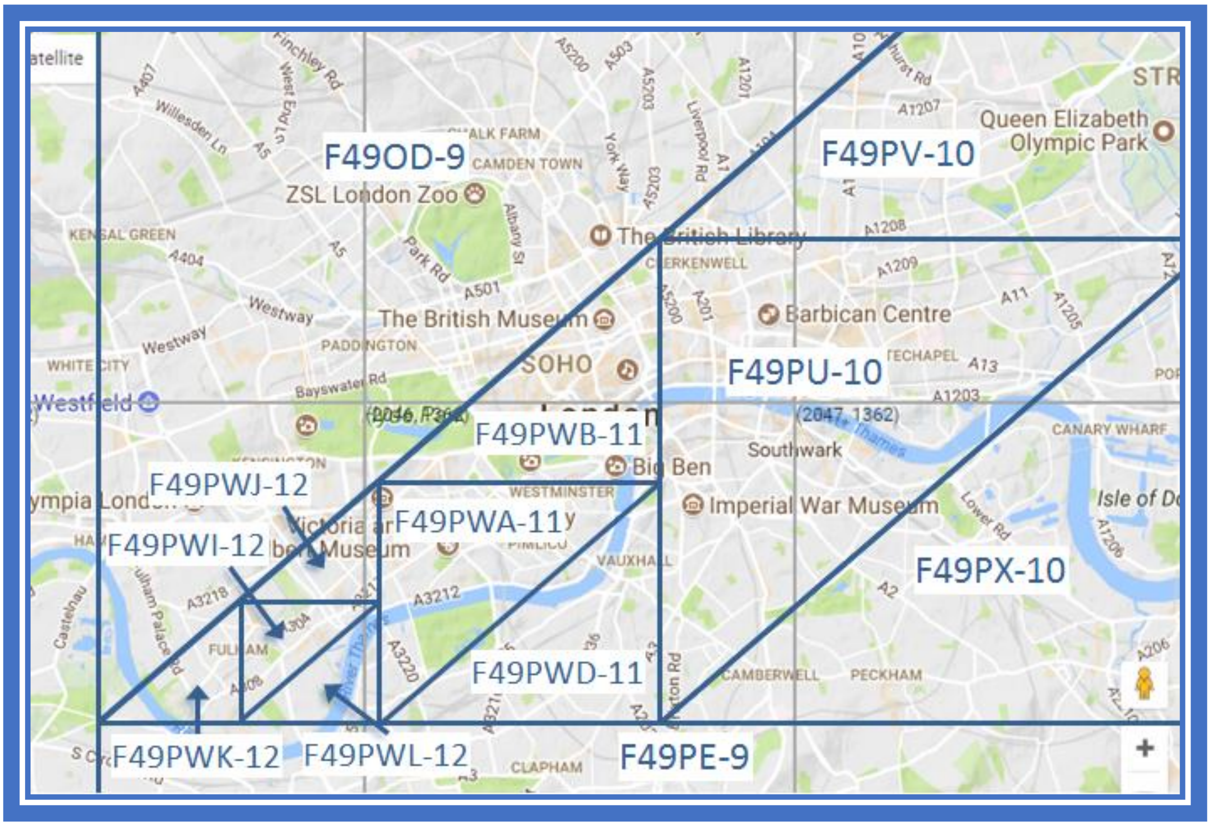



**Figure 4 Neighbouring areas and proximity codes in London (QTS)**

Someone living in area QTS:F49PU-10 will know they are <u>fairly</u> close to someone living in area QTS:F49PX-10, whereas someone living in area QTS:F49PWI-12 will know they are <u>very</u> close to someone living in area QTS:F49PWJ-12.

Conversely, someone living in Jakarta, Indonesia will have an entirely different GeoGnomo code (figure 5).

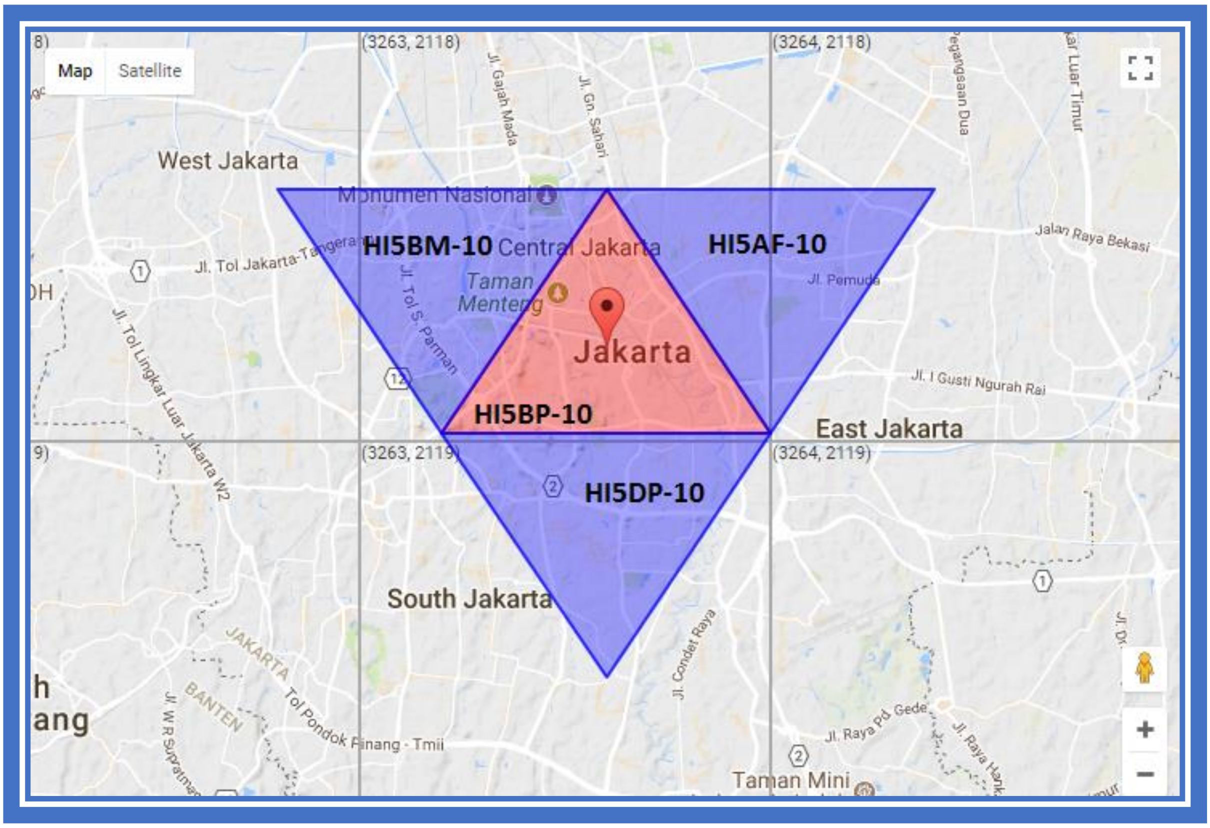



Figure 5 Neighbouring areas and proximity codes in Jakarta (QTS)

## iv) Allowing the size of the areas to vary increases flexibility.

| | | |
|---|---|---|
| **S** | Scale | Users should have control over the precision |

We can use small area geocodes to keep track of the location of a computer at level 19 (figure 6) and larger area geocodes to keep track of the area of land that a farmer owns at level 15 (figure 7).

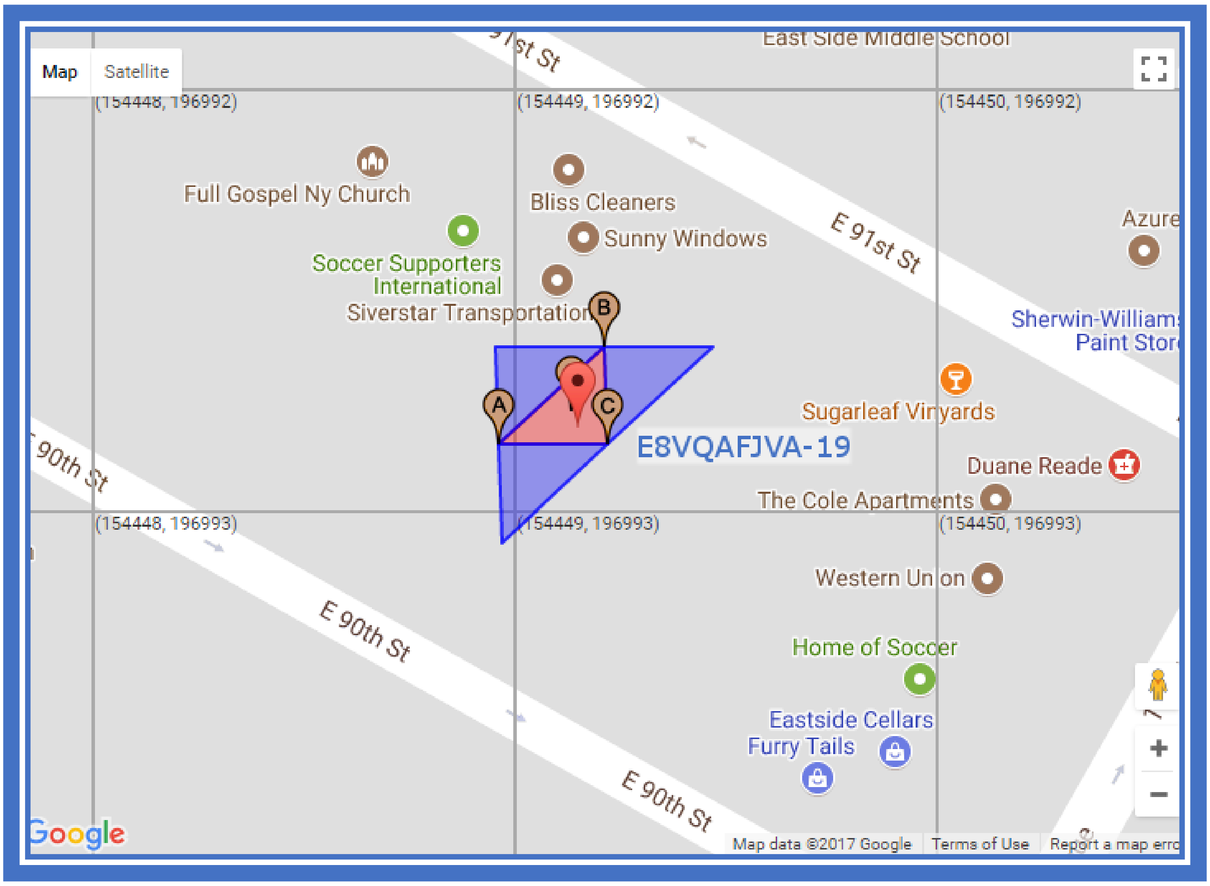



**Figure 6 Computer Location QTS:E8VQAFJVA-19**

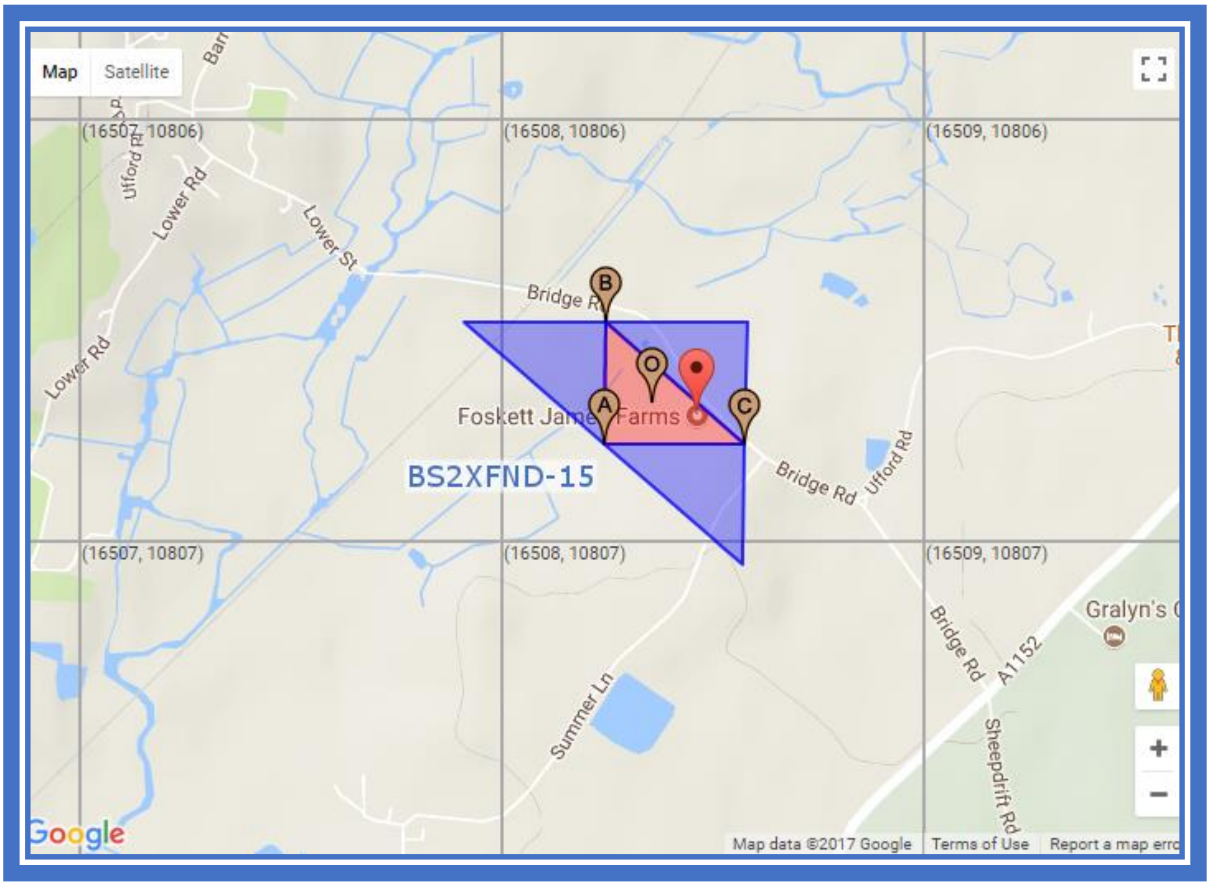



**Figure 7 Farm Area QTS:BS2XFND-15**

# 4. The GeoGnomo Project

GeoGnomo has developed three methods for geocoding.

### A. Method 1: Quaternary Rectangular System (QRS)

The Quaternary Rectangular System defines the level 0 grid by dividing latitude into 3 bands and longitude into 6 bands, resulting in eighteen 60 by 60 degree squares that can be subdivided with no exceptions.

**QRS Example:** Figure 8 shows the QRS grid over central London. The proximity and memorability are comparable to QTS.

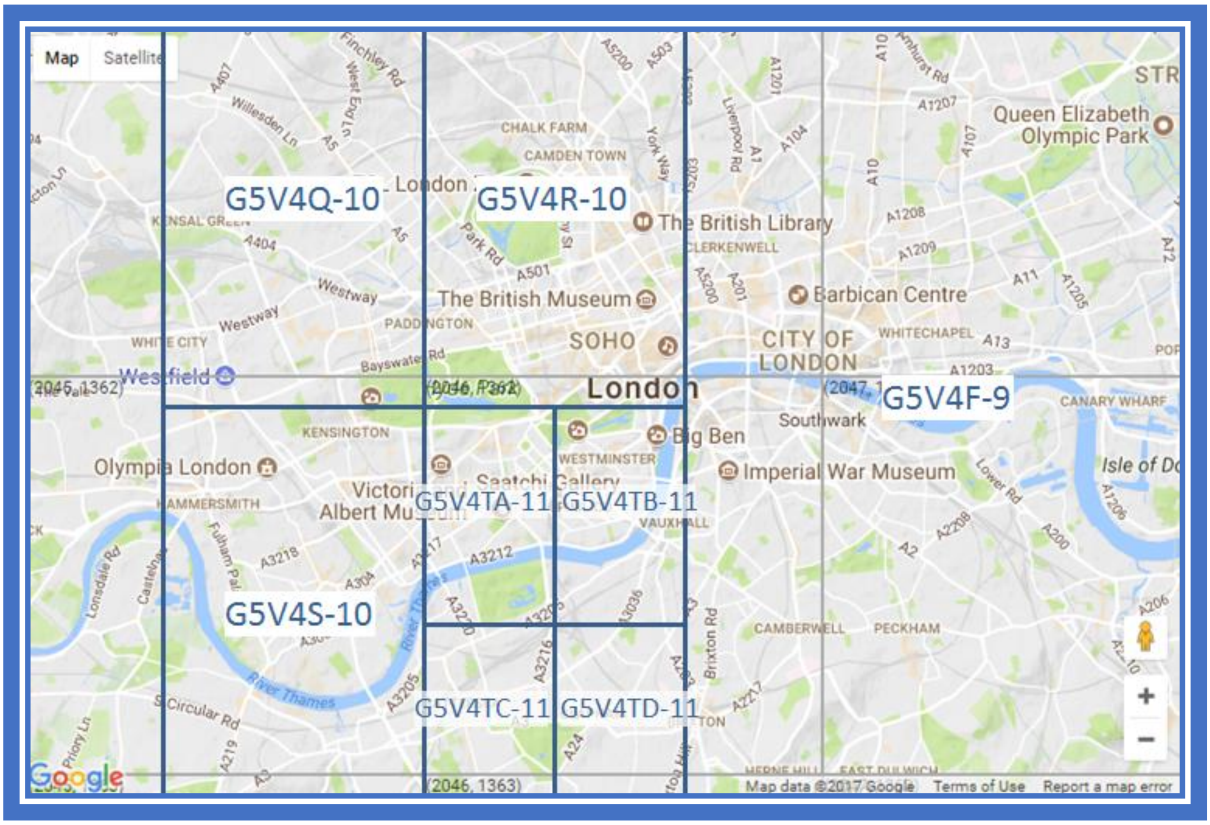



**Figure 8 The QRS grid over central London**

## B. Method 2: Quarternary Triangular System (QTS)

The Quaternary Triangle System divides the globe into a fixed grid of triangles and assigns a unique geocode to each triangle. Codes are generated from a latitude and longitude coordinate pair and a specified level *n*, which determines the scale of the grid. The code generated describes an area that contains the specified point.


**Figure 9 The Quaternary Triangular Mesh (QTM) Grid with one level of subdivision, alongside the classic Geographic Grid**

The grid system starts with an inscribed icosahedron in a sphere. The icosahedron is one of five platonic solids, meaning that each face is regular and identical. As a result, each face covers an equal area of the globe. This is an important advantage over any rectangular grid where the poles become lines.

We orient the icosahedron so that vertices are at the North and South poles. Instead of directly using a radial projection onto the icosahedron, we instead project the globe onto the two-dimensional faces of the icosahedron. Our projection is a hybrid of two methods, an equirectangular projection for latitudes near the equator and a variation of the Collignon projection for latitudes nearer the poles, which helps to reduce distortion. We then start a recursive division process, where each triangle face of the icosahedron is decomposed into four equilateral triangles, then each of the four triangles of each face is further decomposed in four equilateral triangles, and so on and so forth. At each level, the resulting four triangles of the decomposition of a triangle are referred to as the triangle's children. Figure 9 shows how this divides the globe at the first level of decomposition.

**QTS Example:** A map view of central London, with an approximation of the QTS grid showing codes at multiple levels. Figure 10 shows the map for QTS. This illustrates the relationship among geocodes that are close together.

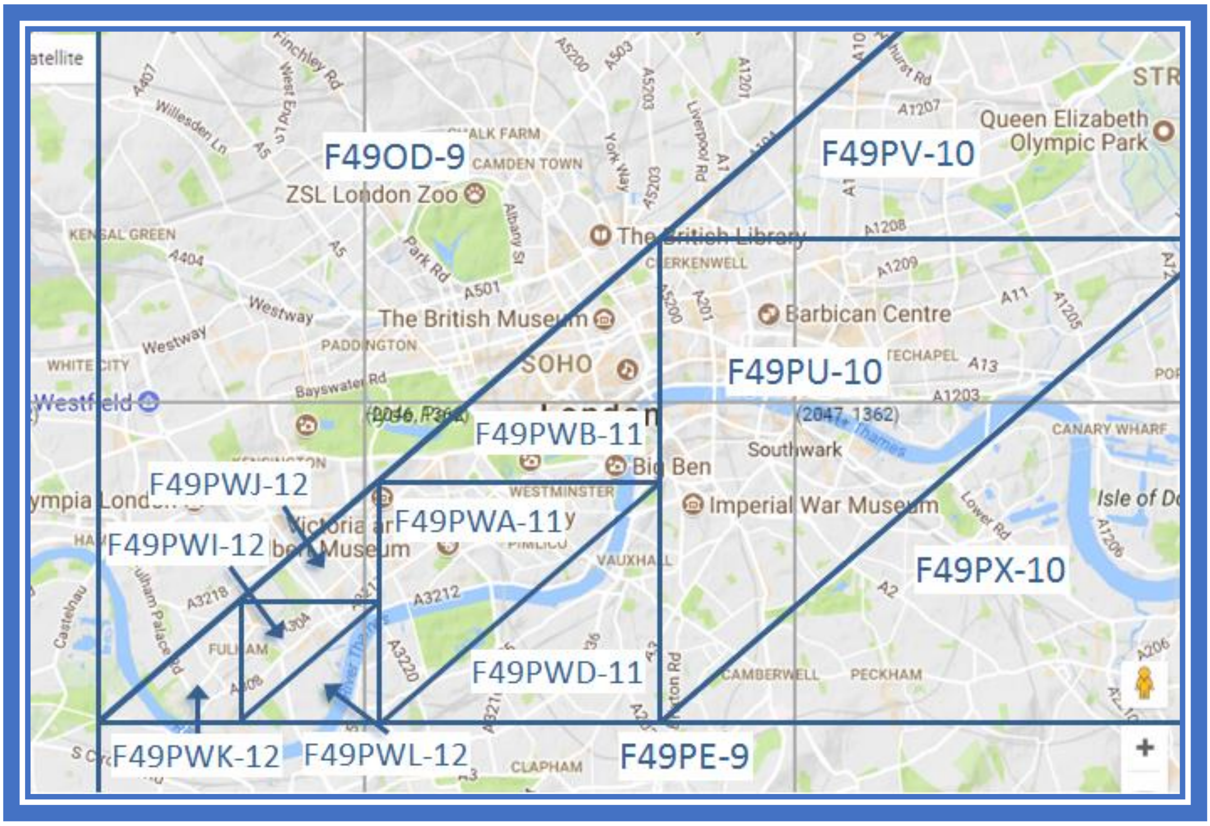



**Figure 10 The QTS grid over central London**

## C. Method 3: Variable Rectangular System (VRS)

The Variable Rectangular System generates codes from a rectangular area, specified through a 'click and drag' selection to represent the selected area. Once the area has been selected, the approach is to round the coordinate values, so that the information can be stored in a code of memorable length. 'Rounding' is chosen so that the area retains a relatively close approximation to the selection. Once rounded values have been chosen, they are organised in a predetermined way into a numerical code that reproduces the rectangle.

The selected area is defined by the latitude and longitude coordinates of the bottom-left and top-right corners. The latitude and longitude differences, i.e., the side lengths in degrees are then rounded to 2 significant figures. This ensures that rounding error is restricted to a small percentage of the size of the rectangle. The coordinates of the bottom-left corner are then rounded to the same number of decimal places as the rounded difference. The numerical digits of the corner position and the 2 digits of difference for latitude and longitude are joined together to form a numerical code.

**VRS Example:** This example illustrates the improvement in aggregation this system makes over the quaternary systems. One potential drawback of using any grid-based system is the chance that a single code does not describe a particular area very well; the area in question may cover the corners of several regions, thus overlapping them all, but filling none of them to a significant extent.

Figure 11 shows Battersea Park in London at (latitude 51.479472, longitude -0.157194) using QTS at level 13; the corresponding code is QTS:F49PWDB-13.

Figure 12 shows how Battersea Park can be selected, the blue line shows an initial selection and the shaded area shows the 'snapped' area that generates the code.

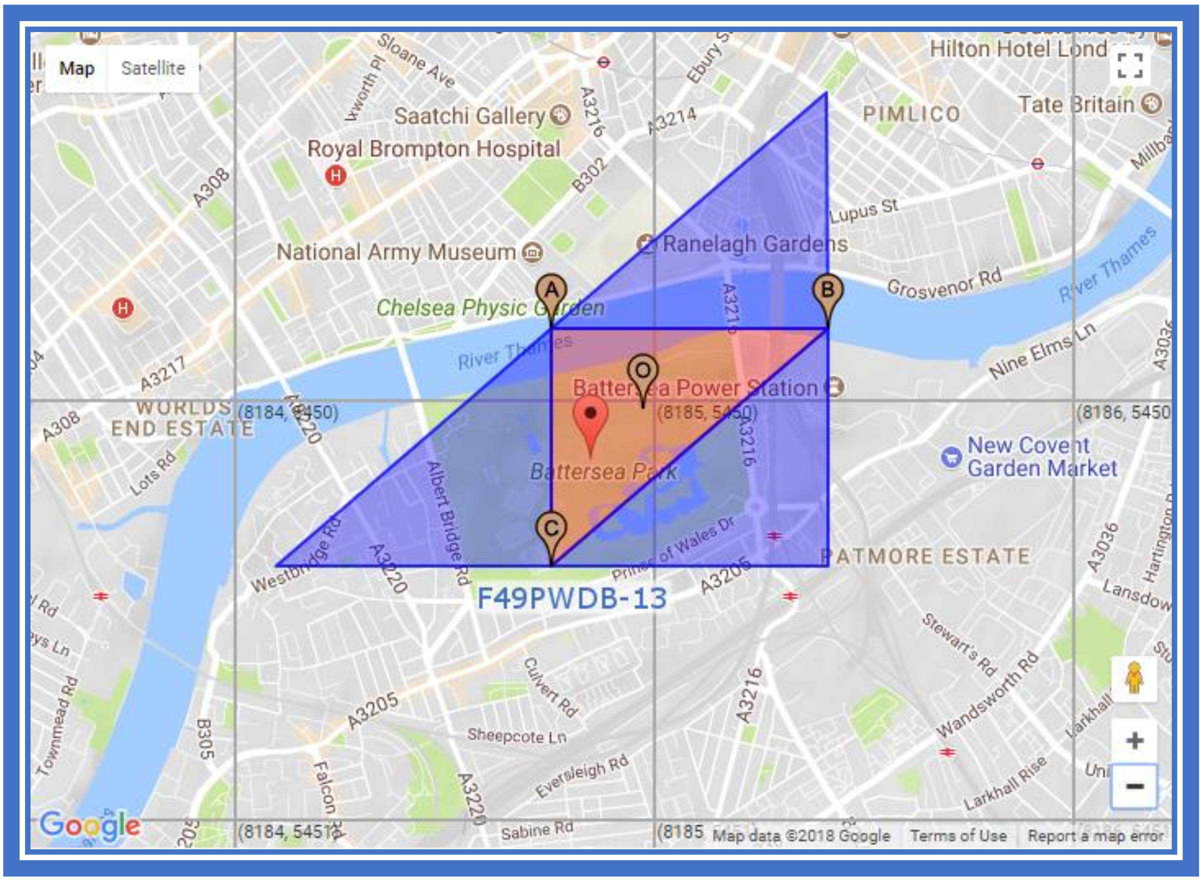



**Figure 11 Battersea Park as seen using the QTS at level 13**

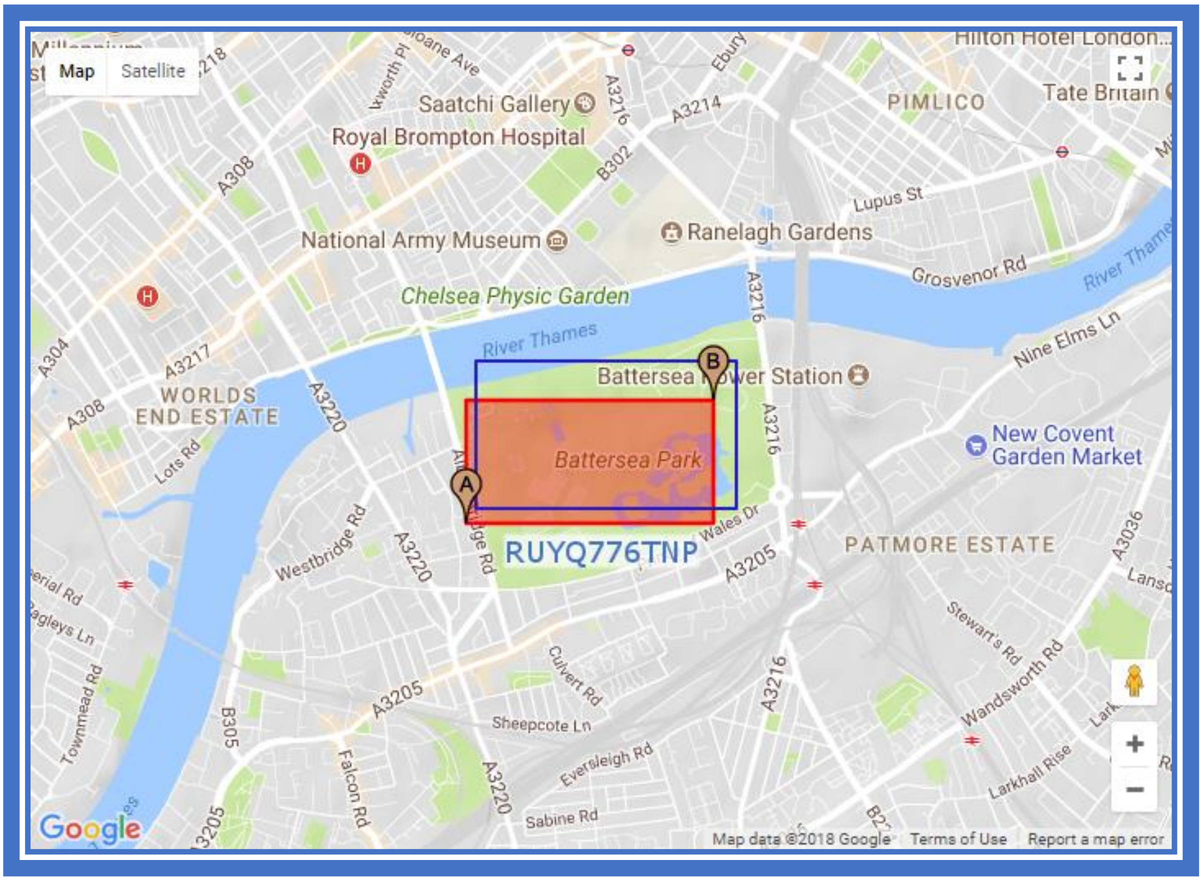



**Figure 12 Battersea Park as seen using a VRS selection**

The VRS code is VRS:RUYQ776TNP, which is only one digit longer than the QTS code but greatly improves the control over the specified area. The snap distance is noticeable, but small relative to the size of the selection.

Figure 13 shows how Battersea Park can then be selected to capture a larger area. The VRS code is VRS:RUYQ785HM8.

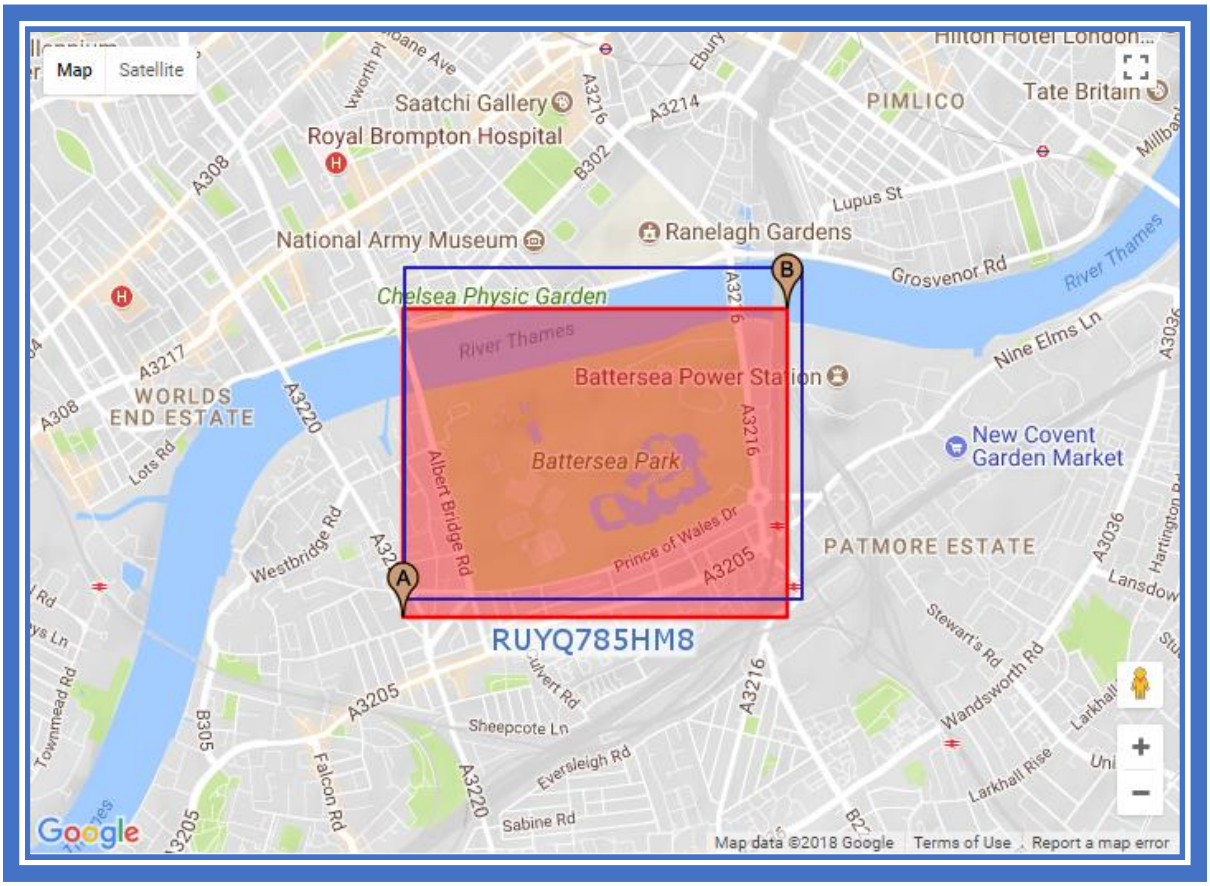



**Figure 13 Battersea Park as seen using a larger VRS selection**

## 5. Future Research Directions For GeoGnomo

So far, we have explored triangles and rectangles as geocoding shapes, but there are other methods for consideration.

**Shapes:** Hexagons, for example, are a popular choice for area division (and common in nature), especially on a 2-dimensional plane, due to their mathematical properties. Hexagons would be more complicated than current systems in GeoGnomo as hexagonal tiling of a sphere would also be based on an icosahedron. Because hexagons do not subdivide into further hexagons, a

new 'level' system would need to be devised. Furthermore, hexagons would need to overlap the edges of the icosahedron and there would also need to be separate equations for 12 pentagons to be introduced at each vertex of the icosahedron.
**Thought:** More complex to develop, but stronger 'MAPS' adherence?

**Words:** Can also be used as codes for small geographical areas. There have been ongoing attempts to encapsulate specific areas with memorable words or groups of words. We will continue to look into this. GeoGnomo could be developed to assign a word or words, perhaps even short sentences, to pre-selected areas. The words or phrases could then be as specific and relevant as the user required.
**Thought:** Complex to standardise, and variable 'MAPS' adherence?

**Altitude:** Next generation geocoding applications might include 3-dimensional virtual globes that will allow a broad spectrum of users, including scientists, businesses, and individuals, to interactively visualize, analyse, model, manipulate, and generate geospatial big data. For example, it will allow insurers to do a broader range of analysis with regards to how their business relates to a location in 3-dimensional view. We have incorporated an '@' symbol into QRS and QTS to facilitate this going forward,
**Thought:** Is a building better modelled as a set of blocks in 3 dimensions rather than a planar map of portions of the Earth's surface?

A potential addition to the quaternary systems would be a feature that uses the neighbours to encode a path, or more generally a list of geocodes that specify an irregular area. The encoded list would have to be given in addition to the first code, so the list part would have to be efficiently encoded in order to avoid making the overall geocode too long. To specify an area using only direct neighbour, it will be necessary to minimise backtracking in cases where a continuous path does not exist. A possible approach to this problem would be to model the grid's underlying graph structure.

# 6. What Can Smart Ledger Developers Do From Here?

As Smart Ledgers proliferate, there will be an increasing amount of geolocation information that needs to be incorporated into them, 'geostamped'. The GeoGnomo project provides a Quaternary Rectangular System, a Quaternary Triangular System, and a Variable Rectangular System for geostamping.

Developers and users of Smart Ledgers, and other recording systems, may find that the addition of geocodes from the GeoGnomo project help to simplify human-system interaction. The use of geocodes reduces human error and eases human data retrieval. So which system might best be used where? Our suggestions:

- map scale reasonably standard and significant human interaction – the Quaternary Rectangular System seems best suited;
- map scale reasonably standard and low human interaction – the Quaternary Triangular System or the Quaternary Rectangular System;
- map use at various scales and significant human interaction – the Variable Rectangular System.

GeoGnomo is an ongoing research project and there may well be further geocoding approaches. Meanwhile, the project provides some online resources:

### Website

To experience geostamping using GeoGnomo, visit the GeoGnomo Website and follow the on-screen instructions:

https://www.geognomo.com/

### Open Source Code

For detailed technical options and instructions, visit the github site:

https://github.com/ZYenGroupLimited/Geognomo

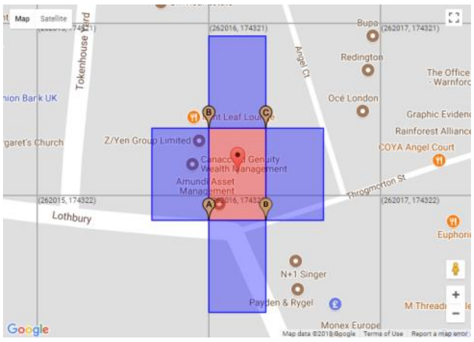
## Share Geocodes

To share Geocodes with Z/Yen, you can access Geognomo

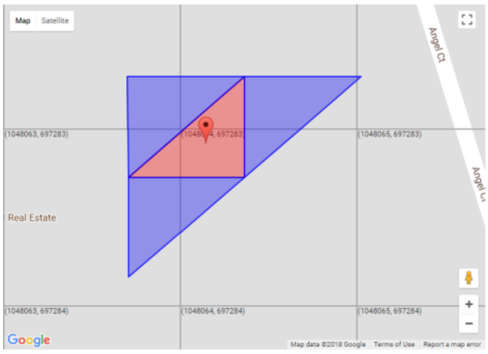
**https://www.geognomo.com/**

and enter any of the following codes for the Z/Yen office:

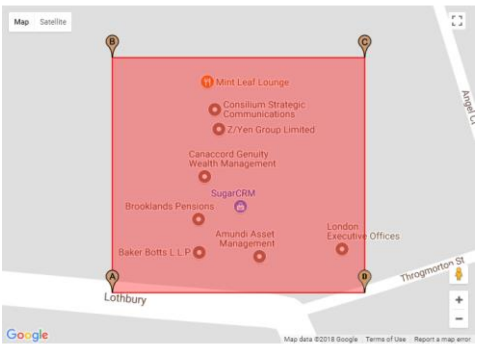
- QRS:G5V4U6IAA-18 or use hyperlink
  www.geognomo.com/geognomo/shareQRS/QRS:G5V4U6IAA-18/18




- QTS:F49PUR9B7-20
  www.geognomo.com/geognomo/shareQTS/QTS:F49PURRM9-20/20




- VRS:E16CP4LNVG3AA or use hyperlink
  www.geognomo.com/geognomo/shareVRS/VRS:E16CP4LNWC2AA



## Principal Authors

This report was written by Professor Michael Mainelli and James Pitcher of Z/Yen Group.

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Distributed Futures is a significant part of the Long Finance research programme managed by Z/Yen Group. The programme includes a wide variety of activities ranging from developing new technologies, proofs-of-concept demonstrators and pilots, through research papers and commissioned reports, events, seminars, lectures and online fora.

Distributed Futures topics include smart ledgers, artificial intelligence, cryptocurrencies, blockchains, FinTech, RegTech, and the internet-of-things. www.distributedfutures.net

Cardano Foundation is a blockchain and cryptocurrency organisation based in Zug, Switzerland. The Foundation is dedicated to act as an objective, supervisory and educational body for the Cardano Protocol and its associated ecosystem and serve the Cardano community by creating an environment where advocates can aggregate and collaborate.

The Foundation aims to influence and progress the emerging commercial and legislative landscape for blockchain technology and cryptocurrencies. Its strategy is to pro-actively approach government and regulatory bodies and to form strategic partnerships with businesses, enterprises and other open-source projects. The Foundation's core mission is to "standardise, protect and promote" the Cardano Protocol. www.cardanofoundation.org

"When would we know our financial system is working?" is the question underlying Long Finance's goal to improve society's understanding and use of finance over the long term. Long Finance aims to:

- expand frontiers - developing methodologies to solve financial system problems;
- change systems - provide evidence-based examples of how financing methods work and don't work;
- deliver services - including conferences and training using collaborative tools;
- build communities - through meetings, networking and events.

www.longfinance.net

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