

Geospatial Engineering Briefing Sheet: *Geographic Information Systems (GIS)*

ICE's Geospatial Engineering Panel has published a series of reports concerned with various subjects such as A Civil Engineers Guide to GPS and GNSS and many others. Designed to be both informative and contemporary, the reports are updated regularly and are intended to provide accurate information to a varied audience. The present report focuses on Geographic Information Systems (GIS) for Graduates & Students (G&S)

Why should I be interested in Geographic Information Systems (GIS)?

Civil engineering happens in the real world, therefore understanding the geography in which we work, the inter-relationships between what we do, different assets, the environment and society is important. GIS can help ensure that we plan, design, construct and operate civil engineering assets or infrastructure in a sustainable, economical and environmentally friendly manner.

In many cases the only relationship which exists between two things will be the spatial relationship. GIS will assist us in identifying and accommodating these relationships appropriately.

Many organisations will integrate GIS into their overall Information Systems Strategy in order to maximise the benefits of the systems and to make more data available for spatial analysis.

How can GIS help in civil engineering?

GIS can be used throughout the asset and infrastructure lifecycle, from planning, capital projects and operations to visualise and analyse spatial data. GIS software can produce a variety of maps to communicate your visualisation and analysis in a more accessible way.

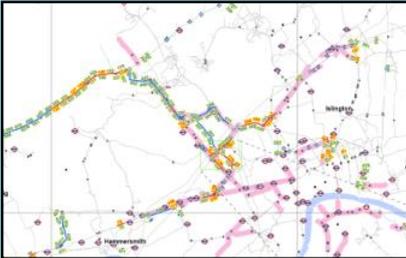
Use through the asset and infrastructure lifecycle

Phase	Examples
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Strategy Development	<ul style="list-style-type: none"> Identification of new requirements Solution selection Master planning
Planning	<ul style="list-style-type: none"> Topography - Land use Site selection Customer and demand distribution Economic analysis - transport impact Environmental analysis - constraints (e.g. SSSIs), impact assessment Geotechnical data - ground conditions, hydrology Project planning
Design	<ul style="list-style-type: none"> Road or rail alignments, utility networks, drainage plan Distribution of buildings (customer's premises), parking, green space Cut and fill specification Environmental mitigation
Construction	<ul style="list-style-type: none"> Earth movement Logistics such as material tracking Traffic management and Traffic Management Act notifications Monitoring impact on neighbours / customers
Operations	<ul style="list-style-type: none"> Asset management Work reporting and scheduling Condition reporting and monitoring

Types of map

GIS can be used to carry out all kinds of spatial analysis, but the results can be output in either tabular form or as a map. The types of map used or created will depend on the purpose. Some common types of map are included in the table below.

Type	Use	Examples	Sample image
Basemaps	Foundational data provides context and reference detail	Aerial imagery Topographical, e.g. spot heights or contours Ordnance Survey maps e.g. MasterMap	
Thematic maps	Display location and distribution of data	Environmental, social or economic statistics Hydrological or geological data Customer data	
Network maps	Infrastructure connectivity Manage assets	Infrastructure could be roads, railways or utilities Line or node relates to detailed properties such as: <ul style="list-style-type: none"> • Pipe material, material and depth, pipe history • Road classification, speed limit, material 	
Incident mapping	Show geographic patterns of incidents	Health and safety Maintenance work Pipe leaks or bursts	http://upload.wikimedia.org/wikipedia/commons/2/27/Snow-cholera-map-1.jpg

What are the key things should I know?

GIS data consists of two broad categories of data, 'raster' and 'vector'.

- A raster is grid of cells that have each have a value, for example an aerial image is made up of cells with a colour value, which viewed at an appropriate resolution we can see urban and rural areas. Rasters can also be used for elevation data, geological maps etc. Rasters are particularly useful when displaying data across very large areas, however if a raster is 'zoomed in' too much then it becomes pixelated. The analysis capabilities of raster data are limited but it can be invaluable when no vector data is available.

- Vector data is coordinate based and represents objects with points, lines or polygons. Vectors are often used in defining utility networks, where network connectivity is also defined, or in detailed topography such as property boundaries. Objects can also have attributes that can represent properties of the physical asset they represent, for example name, size, material, colour, ownership, service regime, age, maintenance history, condition, level above datum, or more specific properties such as address, road speed limit, asset 'subtype' (A property could be detached, semi-detached, terraced, etc.).

These attributes can all be used in a geographic analysis, so we could create a report giving details of all pipes material in a given polygon. The analysis could result in a map showing pipes of different materials depicting each in a different colour, for example. In addition, there could be an associated report giving the total lengths of each pipe material in the polygon.'

One of the key attributes of each object will be its unique identifier. This identifier ensures that we can refer to each object uniquely and unambiguously, like each person has their own passport number. In many organisations the identifier will also be used by other systems and enables them to link data in different systems. A link to the work management system will enable engineers to map jobs to assets, which could be used to identify areas that have more problems than others. It is essential that an organisation has processes for creating, allocating and managing these identifiers. The GIS will have a key role to play in these processes.

Most modern GIS make extensive use of relational databases to store all the information including all the spatial data, the information about the objects and any raster drawings. All the major commercial databases have structures available for storing spatial data. However, GIS applications often present this to the user as 'layers' of separate data, and the potential of GIS is unleashed when these 'layers' are brought together to visualise the inter-relationships of the data. This may be done either by viewing the data or by carrying out a spatial analysis. GIS software will have a number of analysis tools to complete complex or time-consuming tasks, for example:

- Identify utilities that cross motorways or railways – [Intersect]
- List all residential addresses within 100m of a proposed construction site [buffer]
- Brownfield sites within a local authority boundary
- Areas of residential land at risk from flooding

GIS is not CAD or BIM and it is very important to be careful to use each of these systems appropriately. At the same time it is essential to ensure that data may be passed from one system and another when necessary and that at all stages up to date data is used. Within the GIS it is important to add new data either as new attributes or annotations to existing objects or as new objects (layers). In this way the data may be made available to other systems and used in future analysis.

Where can I get more information? Who can I ask some questions about Geospatial Engineering?

Try the [Geospatial Engineering Panel](#) pages

[Association for Geographic Information \(AGI\)](#) – Membership body representing the interests of the UK's GI industry and members who use, or benefit from geographical information.

[Ordnance Survey](#) – Britain's Mapping Agency

System Suppliers

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