GIS (Geographical Information System)

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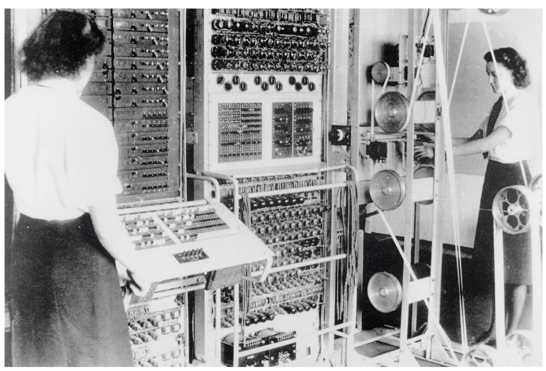
1 (not so) Brief history of GIS

The history of Geographic Information Systems (GIS) is largely tied to the evolution of digital computers used to manage and analyze mapped data. Initially, computers were designed for number crunching and not for handling complex map information. It was only after the first electronic computers, like the British Colossus of the 1940s, that the potential for map handling emerged.



British Colossus

By the 1950s, computers were being used for tasks like weather mapping and geographical analysis of agricultural data. Despite the recognized potential of computer mapping, early technological limitations made automation impossible.

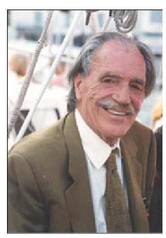
The first substantial GIS-based research was likely conducted by Terry Coppock. In Canada, Roger Tomlinson, often credited as the father of the first real GIS, the Canada Geographic Information System (CGIS), recognized the need for computers in performing labor-intensive tasks related to land inventory. Tomlinson's work highlighted the ease of measuring basic map elements if the map could be digitally represented.

1.1 GIS in map making

A separate aspect of GIS history is tied to the advantages of automating map production. Once data is digitized, it becomes easier to manipulate, duplicate, modify, and share. David Bickmore, a key innovator in this field, along with Ray Boyle, invented the 'free pencil' digitizer and established the Oxford system for high-quality digital cartography by 1964. Around this time, major mapping agencies, including U.S. and other military bodies, started the long and challenging process of automation. The complexity of this task is evident in the fact that even today, many map-producing agencies use a mix of manual and automated techniques. The widespread benefits of automated cartography had to wait for the development of suitable mechanisms for map data input, display, and output. By the early to mid-1970s, necessary devices like map digitizers, interactive graphic display devices, and plotters became reasonably priced, leading to more organizations converting their maps into digital form.

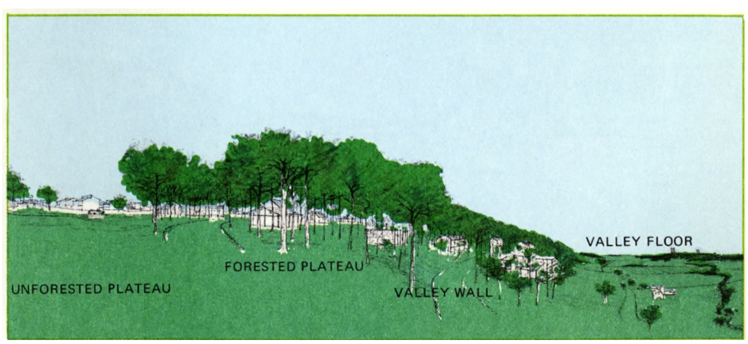
1.2 Ian L. McHarg

Ian L. McHarg was a scottish geographer born in the first half of the 20th century, he moved to the United States of America (USA) to get a master's degree after World War II. In 1954 he took a position as the Professor of Landscape Architecture and Regional Planning, Ian became famous for introducing ecological concerns into land planning. He is credited with being the father of map overlays, which had a major impact on Geographical Information Systems.



Ian L. McHarg

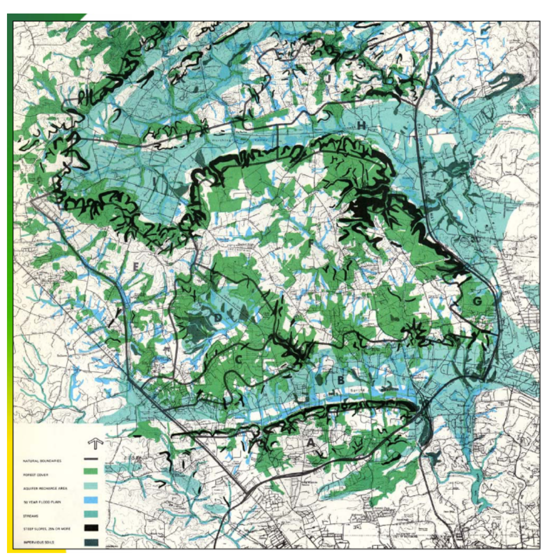
Through the ecological lens that he had, he made several contributions to geography, many of which impacted GIS development. His starting point was usually a physiographic section. Just like the one below



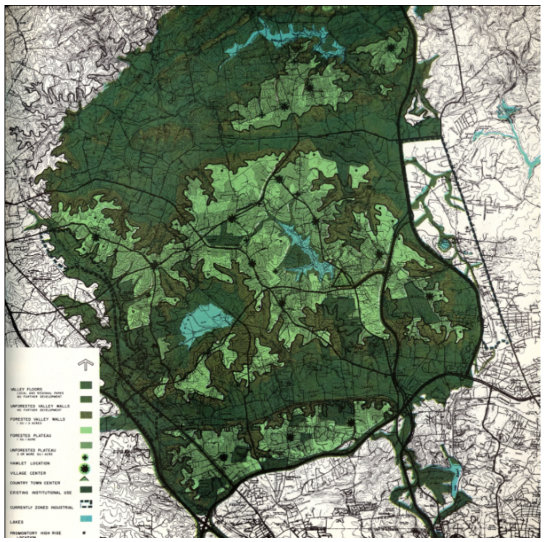
McHarg's Basic **Amenity Map** depicted slopes with forest cover as a significant resource, comparable to an urban park. Structures sheltered by the earth could be built on these slopes, provided they were integrated into the rock, causing minimal tree loss. This concept is referred to as “urban camouflage” or “designing in harmony with nature”.

Ian’s Basica Amenity Map

McCarg typically initiated his work with a map of Physiographic Features. This particular instance compared various elements such as forest cover, aquifer recharge, 50-year flood plains, streams, slopes greater than 25%, and impervious soils in a comprehensive overlay. In the initial years, these composite maps were created using acetate overlays on a cadastral base map.



McCarg's **Optimal Land Use Map** integrated physiographic features with existing infrastructure, development, and zoning restrictions. These elements were weighted according to the preferences of local residents and regulatory boards.



Optimal Land Use Map

McHarg also showed that a wide range of societal characteristics could be depicted on maps and overlaid in a similar manner to composite physiographic obstructions. These often tended to reflect property values.

2 What is GIS?

Geographical information refers to data related to specific locations on the Earth's surface, including adjacent zones such as the subsurface, oceans, and atmosphere. The term 'spatial' is often used interchangeably with 'geographical', although it could theoretically refer to information tied to other frames, like the human body in medical imaging or a building in architectural drawings. Due to this ambiguity, the term 'geospatial' has gained popularity, especially in the context of the US National Spatial Data Infrastructure, the Canadian National Geospatial Infrastructure, and the UK National Geospatial Data Framework. In this context, 'geographical' and 'geospatial' are used synonymously.

The concept of Geographic Information Systems (GIS) has evolved over time, but it has always involved processing geographical data within an integrated setting. While it's argued that this environment doesn't necessarily have to be digital, the increasing digitization of today's world means GIS is typically associated with digital computing. Some argue that the definition of GIS should extend beyond the digital realm to include the people who interact with it. GIS has also been defined by its objectives, such as Cowen's definition of GIS as a spatial decision-support system.

Today, the term GIS is used whenever geographical data in digital form is manipulated, regardless of the purpose. This could involve using a computer to create a map or to analyze geographical data and make future predictions using complex geographical models. However, there are exceptions. For instance, while images of the Earth collected by remote-sensing satellites are geographical data, the systems processing them aren't typically referred to as GIS unless they integrate this data with other types or process already cleaned and transformed data.

Professionals like atmospheric scientists or oceanographers often associate 'GIS' with systems used for multidisciplinary work and policy studies, using other software environments for modelling and analysis within their specific discipline. In essence, because GIS implies a generalized software environment exclusive to geographical information, it's often most strongly associated with multidisciplinary, integrative work and applications. In more narrowly-defined environments, less general solutions may suffice.

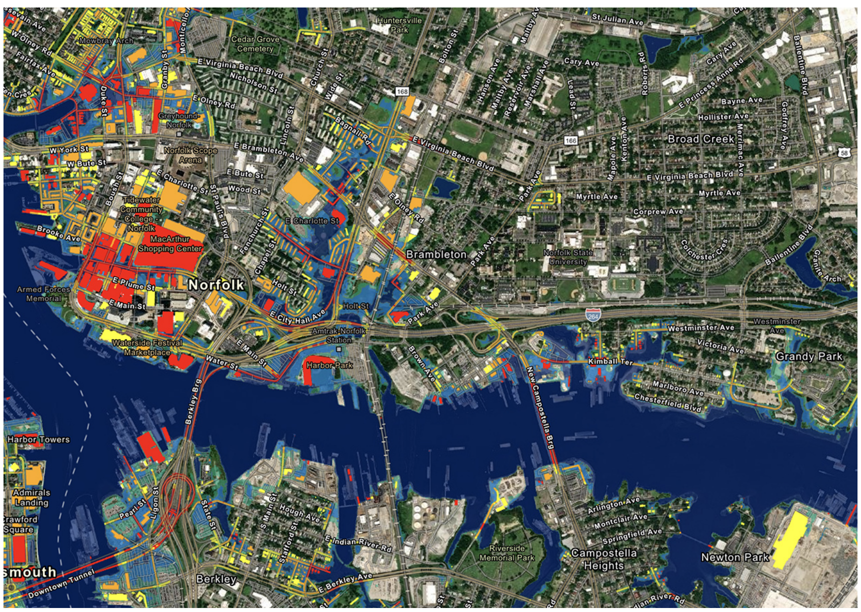
There's a persistent, albeit misleading, tendency to associate 'GIS' primarily with the digital representation of geographical information traditionally displayed on paper maps, rather than with geographical information in a broader sense. While maps may seem to impose few restrictions on their creators and users, they can actually be quite limiting in how they represent the Earth's surface.

Traditionally, information on paper maps has typically been:

- Static, favoring the depiction of fixed aspects of the Earth's surface, as once created, a paper map cannot be altered.
- Two-dimensional, unable to represent many diverse attributes of three-dimensional socio-economic systems like cities, or physical environments

such as the subsurface, oceans, or atmosphere.

- Flat, as the curved surface of the Earth must be projected to be displayed on a flat sheet of paper or a regular solid like a globe.
- Seemingly exact, as there have been few applications of cartographic techniques for displaying uncertainty in mapped information.
- Unconnected to other information that may be available about the same set of places but cannot be displayed on the same map (and possibly cannot even be physically stored in the same place)



GIS, rooted in traditional cartography, has often been limited by the constraints of paper maps. 'Doing GIS' can mean different things, from using specific software to gain insights or support decision-making, to applying GIS principles, advancing GIS technology, or studying fundamental issues related to digital information technology for examining the Earth's surface.

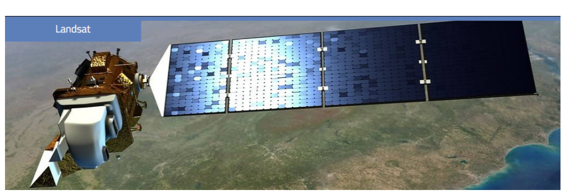
The term 'GIS' has evolved to include broader activities, leading to new terms like 'geographical information science' (GISc), reflected in the establishment of organizations like the University Consortium for Geographic Information Science (UCGIS). Other terms like 'geomatics' and 'geocomputation' have also gained popularity. The term 'GIS' can be decoded differently depending on the context: 'GISy' for the systems, 'GISc' for the science, and 'GISt' for studies of GIS, especially in societal and institutional contexts.

The ongoing relevance of GIS hinges on the belief that there is unique value in treating geographical information as a distinct category - that there's 'something unique about spatial'. While there's no perfect English term to encapsulate ‘something. . . about geographical’, the importance of GIS has been justified on several grounds:

- The complexity of geographical queries, which may blend topological, geometric, and attribute elements, all with inherent ambiguity.
- The need for unique data structures, indexing systems, and algorithms for efficient processing of geographical information.
- The multi-dimensional character of geographical information (x,y,z,n. . .).
- The large volume of much geographical information.
- The inherent challenge in creating a perfect representation of the Earth’s surface, compelling GIS users to grapple with issues of data quality, accuracy, and uncertainty.
- The isolated nature of traditional production methods for geographical data, including the presence of public sector mapping agencies in most countries.
- The requirement for special standards for geographical information.
- The interplay of unique legal and economic contexts of geographical information, including copyright laws, liability, privacy protection, freedom of information laws, and acquisition costs, which can vary significantly from one country to another.

3 GIS today

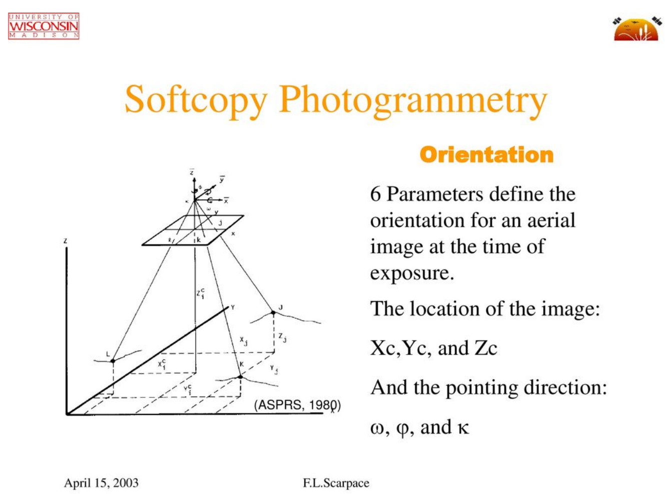
In recent times, the distinct boundaries of GIS have blurred. The specialized structures required for handling geographical data are now largely hidden in modern software environments. The size of a single remotely-sensed image, such as those from Landsat, is no longer daunting given the storage capacities of personal computers. Debates about the legal and economic contexts of GIS are now part of broader discussions on information policy and practice.



These technologies separate the handling of an information container from the nature of its contents, treating all information as ‘bags of bits’. Query languages like SQL have been extended to handle geographical information and queries. Extensions like Oracle’s SDO allow geographical information to be managed within mainstream database management systems. This evolution reflects the increasing integration and versatility of GIS in today's digital world.

Significant changes in data usage and dissemination have influenced GIS applications. Spatial referencing is crucial for any GIS application, but thematic layers specific to an application often don't provide a recognizable view of the world. Developments in digital 'framework data' for GIS are ongoing. This data provides information about the location of key features in the natural, built, or cultural landscape, and can be used alongside application-specific thematic data.

These data sources have become increasingly commercialized. National mapping and census agencies are developing commercial datasets to meet cost recovery targets, and the breakup of the former Soviet Union and the launch of new commercial satellites have increased the number of remote sensing imagery sources. These developments have become more important to GIS due to recent technical advancements in softcopy photogrammetry and pattern recognition, leading to the creation of new products like digital orthophoto maps and elevation models (DEMs) at a much lower cost.



With the proliferation of digital datasets, it's becoming harder for GIS users to know what datasets exist, their quality, and how to obtain them. An important current development is the creation of online metadata services, many of which use geographical location as a primary search criterion. The development of digital libraries of geographical information is becoming feasible, with growing interest in using the library metaphor to support geographical information management and data sharing.

It's also becoming easier for GIS users to collect their own digital data. Despite the bottlenecks of digitizing data from old hardcopy sources, much new data is now collected using Global Positioning System (GPS) technology. Low-cost handheld or mounted GPS receivers are suitable for many field data collection purposes and record geographical location routinely to high levels of precision. This technology has revolutionized data collection for a wide range of applications.

As early as 1991, it was evident that information, especially geographical information, was becoming a tradable commodity and a strategic resource. This trend is most noticeable in the business applications of GIS, where a large value-added reseller (VAR) and consultancy industry has emerged to meet business client needs.

Data for most business applications have primarily been derived by merging census variables into composite 'geodemographic' indicators, which have shown a recognizable correlation with observed consumer behavior.

More recently, the growth of digital customer records, coupled with data from new customer loyalty programs, is leading to the creation of an increasing number of 'lifestyles' databases. While these databases are not as geographically comprehensive as traditional geodemographics, they are updated more frequently and contain data that may be more relevant for predicting customer behavior than conventional census data.