**Evolution of GIS- The Past and Near Future**

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# Abstract

Geographical Information system or GIS is a system for capturing, storing, checking, manipulating, analyzing, and displaying data that are spatially referenced to, but not limited to, Earth. Before the introduction of GIS, the management of different aspects of geography, economy, society, and other sciences were done manually with limited reference to spatial data. The natural and human resource management and detailed analysis were done with the help of physical maps and non-digital methods. In the early 1960s, the world was introduced to the digitalization of mapping systems and the relation of different attributes of the world to the spatial influence. The rise and development of GIS was divided into 6 phases, namely: ‘The pioneer period’, ‘The government-supported/ experimental period’, ‘The commercial period’, ‘The user dominance era’ ,’ The rise of GIScience and open data/software’, ‘The era of volunteered GIS, webGIS, mobile GIS, cloud computing, and bigdata’.

The application of GIS, even after 60 years of introduction, is on an exponential rise. Integration and collaboration of GIS with different technologies are resulting in significant outcomes. With the new era of data, the limits of GIS applications widen up to a great extent and are expected to increase further in the upcoming decade.

# Evolution of GIS in Past

## The First GIS- CGIS

Canada Geographic Information System (CGIS), developed in 1960-66, was an initiative by the Canadian government to create a computerized resource management system. Due to the large landmass of Canada, the data related to natural and other resources was significantly large. The large data size was causing several data-related problems such as storage, measurement, computation speed of data for conventional methodologies. The decision-making process for any resource management was highly time-consuming. Reading and summarizing the surveyed data was manual, and the number of human resources required for the operation was enormous. The computation process of resource-related data involves interrelating different resources, geospatial information and significant use of maps. Reading, drawing and analysis of maps manually was highly time-consuming process due to difference in parameters and features of maps, the whole process had high financial demand.

To tackle all the problems, the Canadian government initiated CGIS and laid a foundation to use computers for spatial data handling. The development of CGIS and outcomes of the project set a motivational ground for other countries and organizations to invest in computer-based geographical information systems.

Post-CGIS, US Census Bureau adopted GIS methodology and digitized different social features like the census. Ordnance Survey, a Great Britain-based mapping agency, began to use computers to develop topographical maps at a large scale.

## The Harvard Laboratory

Howard T. Fisher, in 1965, established a laboratory for Computer Graphics and Spatial Analysis at Harvard University. Howard developed a mapping package to produce proximal, choropleth, and isoline maps called Synergistic Mapping (SYMAP). The package was famous among various universities due to its ease of usage. Following SYMAP, Harvard Laboratory or HLCGSA developed Odyssey project for spatial analysis within a single system and different 15 programs for spatial data analysis. Among the programs developed, 8 of them were for commercial purposes, while seven programs were part of Odysses. Due to lack in commercial work, reduced budgets and full focus on research leads to dispersal of team members and closure of laboratory in 1991.

Odysses program by Harvard laboratory became an inspiration for various GIS software. The Harvard Laboratory itself had a significant influence on the foundation of ESRI as the Founder of ESRI, Jack Dangermond, worked at the laboratory as a research assistant. There were many examples other than Dangermond, who acquired remarkable achievements in the field of GIS and were part of the lab at some point of career.

## Esri foundation

Jack Dangermond founded the Environmental Systems Research Institute (Esri) in 1969. Esri first started as a non-profit organization, acted as an environmental consultancy, and provided services related to computer graphics. During earlier operations, Esri used and worked on the GRID package, which was a vector-based system. Due to lack of financial sources, Esri changed the funding status from a non-profit to a with-profit organization. By the early 1980s, Esri acquired minicomputers and got involved in several town planning in USA, Australia, Canada, and many more countries. Esri started undertaking projects related to various GIS uses such as wastewater management, floodplain management and other fields. The increasing number of projects undertaken by Ersi with commercial benefits maked 1980-1990 (Phase 3) as ‘The Commercial Period’ of GIS.

The constant involvement of Esri staff in project to overcome flaws in system and financial approach of Esri prevented it’s downfall which was a fact about Harvard Laboratory.

In 2021, Esri dominates the current GIS market and holds nearly 40% of global market share in GIS operations. By developing products like ArcGIS, MobileGIS, ArcGIS online and ServerGIS, Esri had a major contribution to the growth of GIS and related domains.

## Launch of GPS12/ Development of Global Positioning System

Global Positioning System (GPS) was developed by a combined effort of the US Navy and the US Airforce. During the 1970s, US Navy and US Airforce had their individual satellite-based navigation systems,’ Transit’ and ‘Timation’ for Navy and ‘System 621B’ for Airforce. The development of artificial satellites, line of sight radio navigation and limitations of existing systems led to the development of GPS in the 1980s. Initially, the GPS system was designed with 24 satellites, but it was cut to 18 satellites due to lack of funds. The launch of satellites was carried out in two Blocks (initial stage), It was planned to launch 11 satellites in Block 1 but one satellite launch was failed due to unfortunate circumstances. It was followed by the launch of 9,19 satellites were launched in Block II and Block IIA respectively. The satellite system is known as the Global Navigation Satellite System (GNSS). GPS satellites broadcast signals that any device receives at a particular time and GPS satellites carry an atomic clock for time determination. The computation of time difference between transmission and reception of signal gives a distance of the device from all signal broadcasting satellites. By analyzing distance from more than 3 satellites, the position of the receiver is determined.

Currently, there are 31 operational GPS satellites are orbiting Earth. The development of GPS was a revolution in the world of GIS, as it provides highly accurate spatial data in terms of Longitude, Latitude, and Altitude. All three geospatial attributes are used as reference points to relate GIS data and analysis the dataset. The use of GPS is increasing exponentially with the development of new technologies and the demand for data.

## LandSat program

In 1972, under the name of the LandSat program first-ever remote sensing satellite ‘the Earth Resource Technology Satellite’ was launched. It was renamed as Landsat 1. Since then series of Landsat satellites were launched. The latest Landsat satellite was Landsat 9, with the ability to map surface temperature and surface water quality.

After the launch of Landsat 1, It covered approximately 75% of landmass within 2 years. From the data obtained by Landsat 1 a new island was discovered, which was named after the program i.e. Landsat. Dataset from the satellite helped the government introduce new indexes for research and global resource management, such as the Vegetation index.

With an increase in number of satellites under LandSat program, the application of the dataset from the program is massive. It provides an efficient check on environmental resources as well as socio-environmental interaction.

Timeline

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Figure 1 Landsat Program, Source: <https://svs.gsfc.nasa.gov/11433>

# Expected Evolution of GIS in Near Future

## Traffic Automation and management

In late 2010s, the development of embedded systems and automation was exponential. A number of automated vehicles were introduced for military and civil purposes. With an increment in number of civilian automated vehicles the demand of inter-vehicle communication is increasing day by day.

In the next decade, if the number of self-driving vehicles dominate the market, traffic management using satellites will be the efficient way to maximize the smooth flow of traffic. There are high chances and full of the visionary idea that transportation will be completely automated with in next two or three decades. GIS layers with real-time traffic related data will be required along with other surrounding data. So, GIS will play a huge role in optimum management of future traffic and will act as medium for inter-layer interaction.

## Hydrological stabilization

In the late 2010s and early 2020s, Climate change is the major issue of sinking small islands (due to increase in sea water level) and the whole world. The polarisation of hydrological attributes is occurring worldwide, which includes too heavy rainfall or increment in drought conditions. Different organizations are trying to fight the condition by various environment-friendly actions such as planting trees, reducing the emission of greenhouse gasses, and enforcing sustainable development projects. The primary outcome of global warming is hydrological destabilization and shift in weather conditions.

The majority of nations are planning to enforce sustainable development projects for the stabilization and restoration of hydrological balance. GIS plays an essential part in planning the development and achieving sustainability. GIS provides a platform to simulate and analyze the interaction of different changes for optimized sustainable development. The simulation and analysis will consider factors like the amount of area for infiltration, tree plantation area, building structures, areas currently suffering water-related natural hazards, etc.

## Energy Demand and supply management

In the late decade, there was a slight shift in Energy extraction from non-renewable energy to renewable energy. It is forecasted that the use of renewable resources for energy will increase in next decade. The management of energy transducer, from determining the correct type according to environmental condition to determination of efficient location, will be computed by GIS as it can create a socio-environment linkage for optimization of Energy delivery system.

## IoT and networking layer management

With the introduction to sixth-generation communication, the new information age will be based upon IoT and high-speed communication. All the devices and parts of IoT will be connected by high-speed intercommunication protocol and will individually act as transmitter for device connectivity. This transmission and reception medium embedded within IoT devices will provide better connectivity to the user at places where high-frequency waves can’t reach efficiently. With the significant increase in number of users and IoT devices, the management of the network will be a huge issue.

For efficient management, all the communication protocol-related data will be related to spatial data, which will provide better insight into network coverage and the location of communication device for security purposes. Whole network management will probably use GIS as a base of reference for computation and management of all attributes.

## Atmospheric and Planetary simulation

The current era could be considered as an early stage of the Spacefaring era. Most of technical giants are talking about space travel and interplanetary colonization. For all the Spacefaring era-related ideas, the initial step would be to create a simulation of the planet of Interest and all atmospheric and geographic components. Currently, developers are working on software for GIS-related to Mars. Data related to mars allowed NASA to create a 3D map of the terrain with maximum details. In the next decade, GIS application for space exploration will rise, as the number of spacecraft satellites is increasing to provide data related to different planets and heavenly bodies.

Graphical user interface, application

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Figure 2 Screenshot of JMARS, Source: https://www.gislounge.com/using-gis-space-exploration/

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