2022 THE STATE OF GIS & THE GEOSPATIAL:

Contemplating concepts, methods, technologies, and trends

By Shane Clement
October 23, 2022

Clement Geospatial

WHAT IS GIS?

The art and science of using technology to collect, store, manage, analyze, and visualize data to explain spatial interactions on the Earth's surface.

Most photographed places in the world

GIS AS DEFINED BY ESRI…

"A geographic information system (GIS) is a system that creates, manages, analyzes, and maps all types of data. GIS connects data to a map, integrating location data (where things are) with all types of descriptive information (what things are like there). This provides a foundation for mapping and analysis that is used in science and almost every industry. GIS helps users understand patterns, relationships, and geographic context. The benefits include improved communication and efficiency as well as better management and decision making."

WHY GIS?
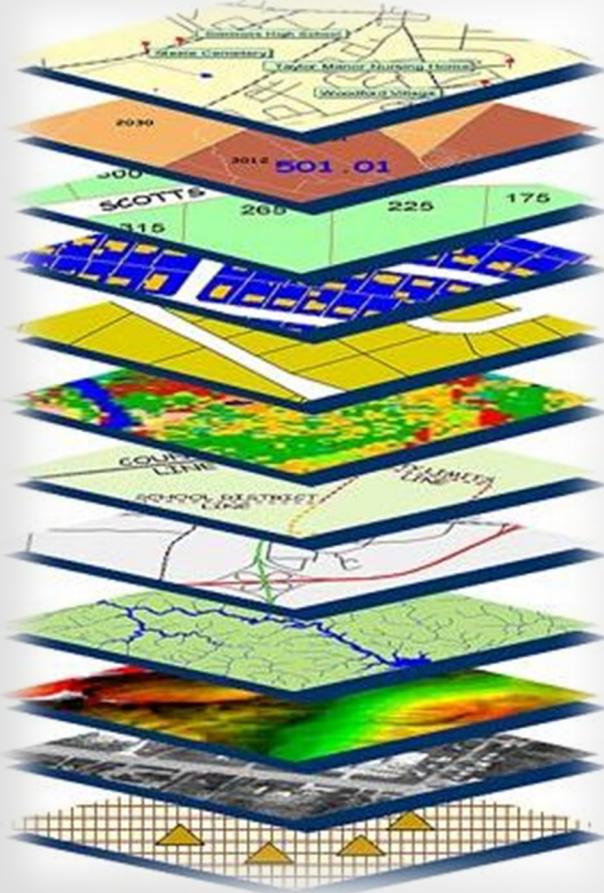
- Used to identify problems

- Monitor changes

- Manage and respond to events

- Perform forecasting

- Set priorities

- Understand trends

WHAT IS GEOSPATIAL?

- Understanding spatial interactions through data

  - Geodata – addresses, city/state/zip codes, parcels, geographic coordinates

    - Vector – points, lines, and polygons to represent features like cities, rivers, and political boundaries

    - Raster – digital images of the physical and man-made features including aerial photos and satellite imagery

  - Examples of Data Providers
    - USGS
    - U.S. Census Bureau
    - NASA

Source: Geospatial - A Complete Introduction | HEAVY.AI

TOOLS & TECHNOLOGIES

GIS Workflows
- Cartography
- Remote Sensing & Imagery Analysis
- 3D Visualization
- Machine Learning
- Data Storage
- Scripting & Development
- Data Collection
- Spatial Analysis
- Data Management

Platforms
- ArcGIS
- Timble
- Google Earth
- GeoDa
- AWS
- Jupyter
- Azure
- R Studio
- Mapbox
- QGIS
- Google Colab
- Carto

Hardware
- Tablets & Smartphones
- Personal Computers
- Cloud Servers
- Satellites
- GPS Units
- Digitizers
- LIDAR

Tools
- Postgres
- GDAL
- Pandas
- R
- Python
- SQL
- JavaScript

EXPERIENCE WITHIN THE GIS WORKFORCE: TOOL, TOOLMAKER, AND SCIENTIST

Figure 1
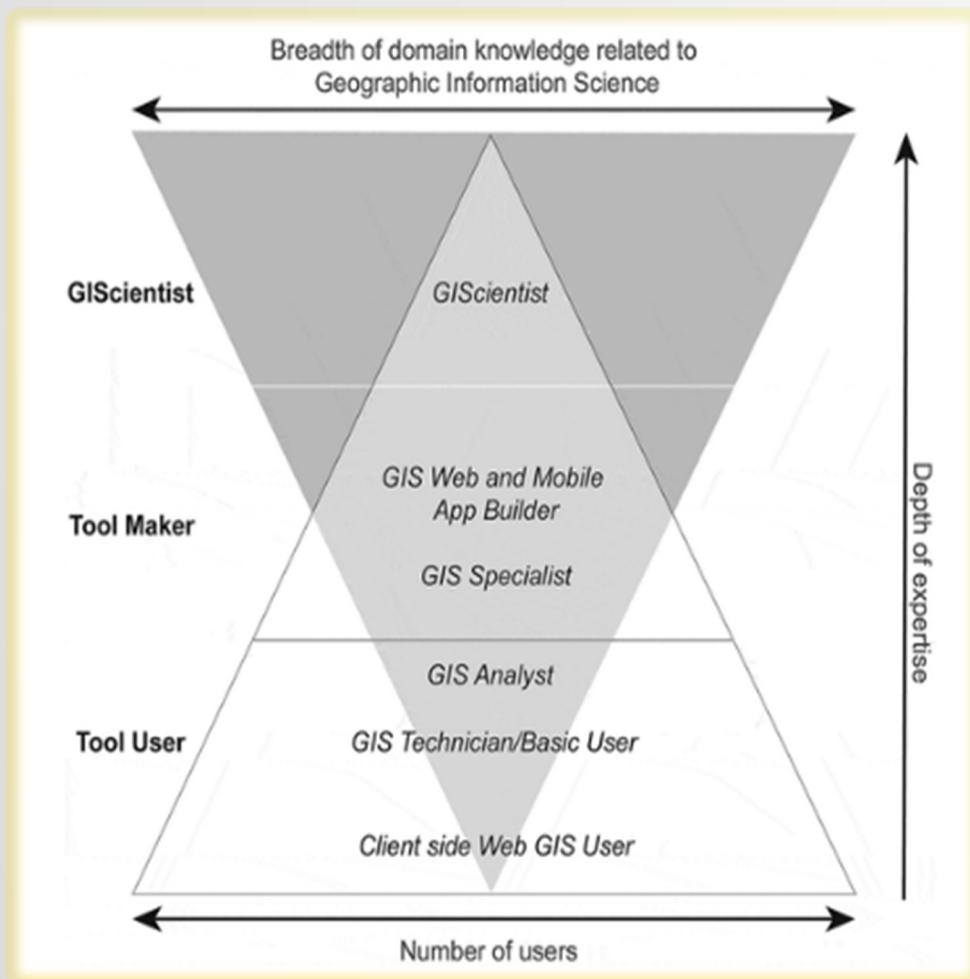
Rickers et al. published an article in 2020 titled "Tool, toolmaker, and scientist: case study experiences using GIS in interdisciplinary research," suggesting that GIS is a tool with defined different classes of GIS experts, as shown in Figure 1.

- Tool User: GIS Technicians and Analyst performing from basic task to data analyses, integration and conversions, manage products and systems, and coordinating work task and activates.

- Tool Maker: Includes GIS Specialists who design, develop, customize, and maintain discipline specific GIS. They have more knowledge that Technicians and Analysts.

- GIScientist: Able to perform most of the elements from the above-mentioned roles in addition to understanding the conceptual and theoretical implications of the work to be undertaken.

CAREER PATHS

On December 14, 2021, Indeed.com published "26 Types of Jobs You Can Get with a Degree in GIS". Below are a few of the suggested job positions.

Job Title	Description
Geospatial Engineer	Gathers, evaluates and maps geospatial data, meaning information related to a designated area's land, bodies of water, natural resources and man-made features.
GIS Developer	Creates the software that runs and supports various GIS systems. They develop, test and alter software code for various hardware systems that use GIS technology, such as mobile phones, laptops, and remote sensing platforms.
GIS Manager	Oversees all operations and staff related to GIS products or plans. Handle responsibilities such as developing long-term strategies or goals, monitoring project budgets, hiring or training GIS professionals and giving presentations or progress reports to key stakeholders. Some GIS managers may share a few job duties with GIS analysts, such as evaluating different types of geospatial data or creating digitized maps.
GIS Analyst	Evaluates and translates the raw data provided by GIS tools, such as satellites and remote sensors, into maps and databases. Most GIS analysts begin their careers as GIS technicians and then advance into an analyst role after two or three years. They often oversee and help GIS technicians or interns, such as by developing and monitoring their workflows or internal quality standards

THE FUTURE OF GIS AND GEOSPATIAL

The global GIS market is expected to reach

$17.5 BILLION
by 2023

This growth stems partly from investments in homeland security plus an uptick in capital funding for urban development in developing countries.

Other contributors to GIS growth are light detection and ranging (LIDAR) technology and the increasing availability of spatial data and cloud technology.

- Government
- Water & wastewater
- Telecommunications
- Engineering & business services
- Aerospace & defense
- Oil & gas refining
- Oil & gas exploration
- Transportation & logistics
- Healthcare
- Others

- Fastest-growing career path in modern GIS
  - Spatial Data Science

- Technological Advancements
  - Miniature lidar
  - 3D data modeling
  - Digital Twin

- Emerging Trends
  - Climate Resiliency
  - Location intelligence

Source: The Many Applications of GIS - USC GIS Online
Go Bruins!

SPATIAL DATA SCIENCE

In April 2022, Carto's VP of Solutions Engineering, Matt Forrest, published "Top Modern GIS Skills for Spatial Data Science in 2022", stating that with the proliferation and popularity of Python and the boom in data science, Spatial Data Science continues to the fastest-growing career path in Modern GIS.

Desired skills include:

- ✓ Spatial SQL
- ✓ Communication
- ✓ Geospatial Python
- ✓ Spatial Data Science
- ✓ Data Processing/ETL
- ✓ Visualization
- ✓ Dashboards
- ✓ Application Development

MINIATURE LIDAR

LiDAR is frequently used to create a three-dimensional model of the world around the LiDAR sensor.

- In 2020, Apple introduced the iPhone 12 Pro with a lidar sensor
  - Used by surveyors and field technicians

- Samsung, Dreamtech, Narwal, and iRobot adding miniature lidar to their products
  - Advancing manufacturing
  - Reducing costs

Source: Abdullah, Qassim. "Top Geospatial Trends to Watch in 2022." Photogrammetric Engineering &Amp; Remote Sensing, vol. 88, no. 2, American Society for Photogrammetry and Remote Sensing, Feb. 2022, pp. 77–82. https://doi.org/10.14358/pers.88.2.77.

What Is LiDAR and How Does It Work? | Synopsys.
www.synopsys.com/glossary/what-is-lidar.html. Accessed 23 Oct. 2022.

3D MODELING

Advancements in Virtual Reality (VR) and Augmented Reality (AR) platforms provided new means of data modeling and interpretation

- Applied to GIS 3D modeling for engineering and environmental projects

- Bentley released Synchro XR designed for visualizing 4D in 2019

- In 2021, NVIDIA Omniverse is a real-time reference development platform for 3D simulation and design collaboration

Abdullah, Qassim. "Top Geospatial Trends to Watch in 2022." Photogrammetric Engineering &Amp; Remote Sensing, vol. 88, no. 2, American Society for Photogrammetry and Remote Sensing, Feb. 2022, pp. 77–82. https://doi.org/10.14358/pers.88.2.77.
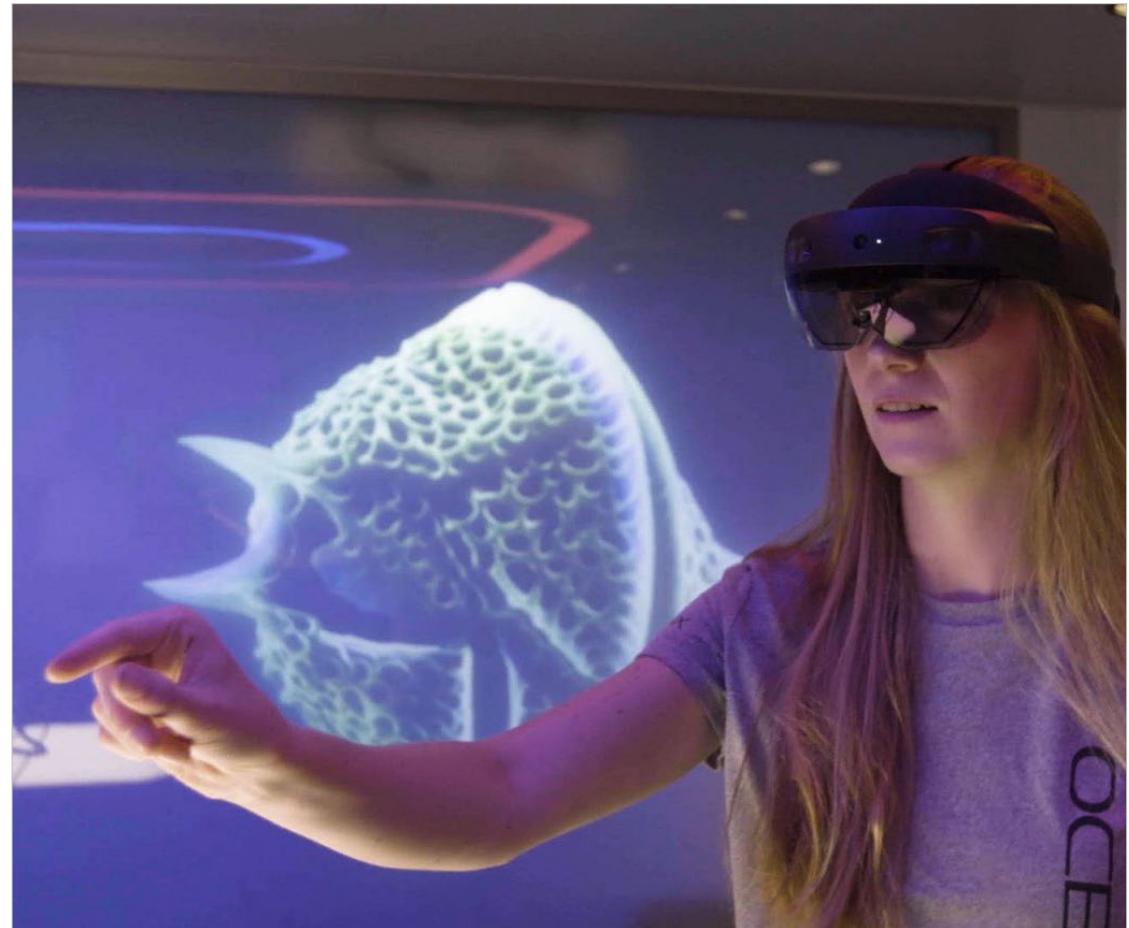
DIGITAL TWIN

Synonymous with "metaverse", Digital Twin is more complex than 3D modeling.

- Encompasses scan-to-BIM, 3D modeling, and GIS

- Is a dynamic, up-to-date replica of a physical object, with complete collection of data

- Evolves with the flow of real-time input from sensors and other sources

- Is not a static 3D model or simulation; continues to evolve with added data and information
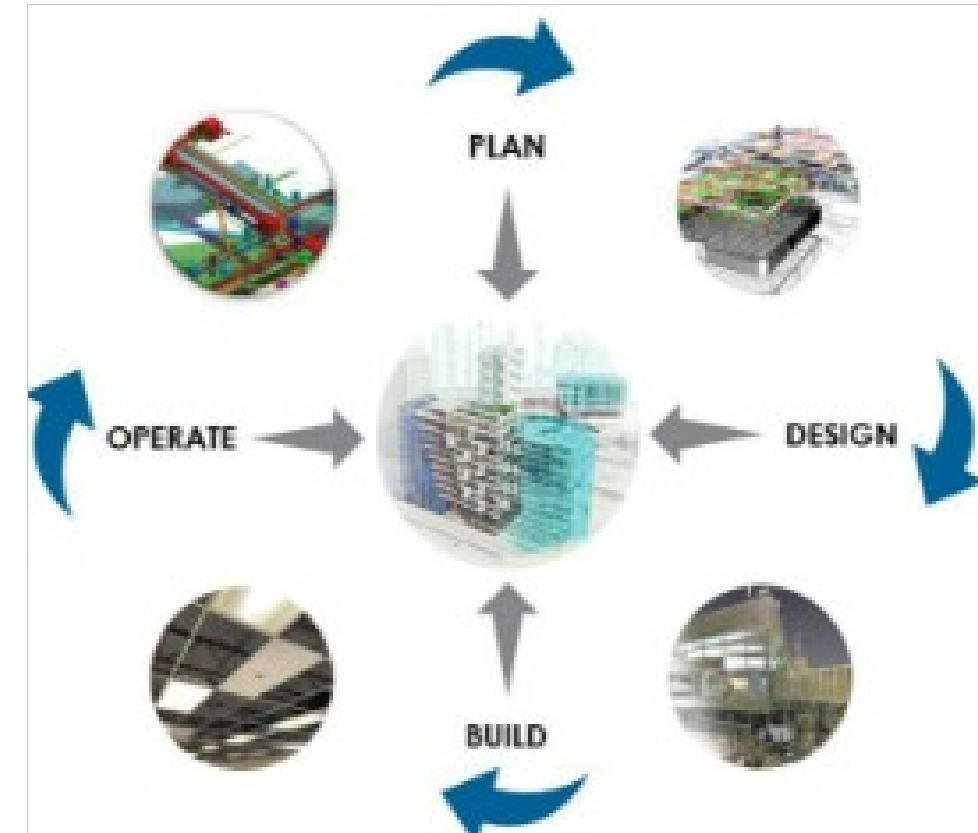
Source Abdullah, Qassim. "Top Geospatial Trends to Watch in 2022." Photogrammetric Engineering &Amp; Remote Sensing, vol. 88, no. 2, American Society for Photogrammetry and Remote Sensing, Feb. 2022, pp. 77–82. https://doi.org/10.14358/pers.88.2.77.

CLIMATE RESILIENCY

According to Esri, climate change is one of the most pressing issues for GIS professionals today. Esri president Jack Dangermond stated that effective action would require scaling up the geographic approach.

- Bathymetric survey and data collection made industry news in 2021 due to the global economy's growing support for the blue economy, increasing the demand for coastal and deep ocean mapping.

  - Mainstream lidar manufacturers are continuing to make advancements in bathymetric lidar.

- Coastal wind energy is expected to flourish. In 2021, the U.S. first large-scale offshore wind farm was approved about 12 nautical miles off Martha's Vineyard, Mass.

- Robert Cheetham, CEO & President of Azavea, states that the number of climate-specific Earth observation satellites will continue to increase.
  - Carbon Mapper project launched in 2022: Methane, CO2 Detection Satellite I Greenhouse Gas I Carbon Mapper
  - The project will provide "comprehensive, accurate, and timely measurement of methane, carbon dioxide, and 25+ other environment indicators to closely monitor the health of planet."

Sources: Cheetham, Robert "2022 Trends in Geospatial." Azavea, Feb. 2022, www.azavea.com/blog/2022/02/02/2022-trends-in-geospatial.
Created Sustainable Future (esri.com)'
Abdullah, Qassim. "Top Geospatial Trends to Watch in 2022." Photogrammetric Engineering &Amp; Remote Sensing, vol. 88, no. 2, American Society for Photogrammetry and Remote Sensing, Feb. 2022, pp. 77–82. https://doi.org/10.14358/pers.88.2.77.

LOCATION INTELLIGENCE

Boston Consulting Group (BCG) describes location intelligence as "the use of mapping and geospatial data, in combination with a company's internal data, to improve the customer and underlying business processes."

- In 2021, BCG surveyed more than 500 executives in the US, UK, Singapore, and India, in five sectors: financial services, retail and e-commerce, logistics and delivery, real estate, and travel and tourism.
  - Areas of use:
    - Customer-facing: geomarketing, digital customer experience enhancement, on-premises customer experience enhancement, and zone-based pricing.
    - Operations-oriented: route planning and optimization, workforce coverage optimization, and support function optimization.

- Location Intelligence leaders reported improvements 1.3 to 2.0 times greater than followers in three key metric areas: customer experience, sales performance, and operational efficiency.

Source: Unlocking Value with Location Intelligence | BCG

REFERENCES

What is GIS? | Geographic Information System Mapping Technology (esri.com)

Geospatial - A Complete Introduction | HEAVY.AI

Unlocking Value with Location Intelligence | BCG

26 Types of Jobs You Can Get With a Degree in GIS | Indeed.com

Created Sustainable Future (esri.com)

B. A. Ricker, P. R. Rickles, G. A. Fagg & M. E. Haklay (2020) Tool, toolmaker, and scientist: case study experiences using GIS in interdisciplinary research, Cartography and Geographic Information Science, 47:4, 350-366, DOI: 10.1080/15230406.2020.1748113

Forrest, Matt. "Top Modern Skills for Spatial Data Science in 2022.", 26 Apr. 2022, forrest.nyc/top-modern-gis-skills-for-spatial-data-science-in-2022.

What Is LiDAR and How Does It Work? | Synopsys. www.synopsys.com/glossary/what-is-lidar.html. Accessed 23 Oct. 2022.

Abdullah, Qassim. "Top Geospatial Trends to Watch in 2022." Photogrammetric Engineering &Amp; Remote Sensing, vol. 88, no. 2, American Society for Photogrammetry and Remote Sensing, Feb. 2022, pp. 77–82. https://doi.org/10.14358/pers.88.2.77.

Cheetham, Robert "2022 Trends in Geospatial." *Azavea*, Feb. 2022, www.azavea.com/blog/2022/02/02/2022-trends-in-geospatial.

From Location Based Data to Location Intelligence. 2020, www.korem.com

State of Spatial Data Science in Enterprise 2020 | CARTO