New AP® Course Proposal

Geographic Information Science and Technology

AAG
AMERICAN ASSOCIATION of GEOGRAPHERS

BACKGROUND AND JUSTIFICATION

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INTRODUCTION

Advanced Placement® Geographic Information Science & Technology (AP GIS&T) is an opportunity for high school students to experience one of the most dynamic, innovative, and transformative scientific fields of the 21st Century.

Since ancient times, the geographic practices of observation, mapping, and spatial visualization have been essential for understanding the world. Today, these practices are supported by modern geospatial technologies such as Geographic Information Systems (GIS), the Global Positioning System (GPS), satellite remote sensing, and virtual globes. From smartphone apps that enable parents to track the movements of their children to the most sophisticated climate models; from real-time spatial decision support systems for emergency responders to spatial analytics for political campaigns and supply chain management, geospatial technologies have become indispensible for life, work, and citizenship.

The creation of an AP GIS&T course would dramatically raise the capacity of U.S. high schools to provide students with geographic knowledge, skills, and abilities that will enable them to make sense of a rapidly changing planet. As tools for spatial analysis, geospatial technologies are widely used to address scientific problems of local, national, and global significance. Consider the following three examples as illustrations of the far-reaching scientific capabilities of geospatial technology:

1. Development of a Global Ecological Land Units Map

GIS makes possible the compilation and computation of datasets from different disciplines to generate new information for research and analysis. A recent monumental achievement of GIS data creation is the Global Ecological Land Units map, a project by the United States Geological Survey and Esri (Figure 1). Using GIS to input and combine data for land forms, bioclimates, geology, and land cover, researchers developed the highest spatial resolution, data-derived global ecosystem map of the world ever produced, providing systematic classification of ecological and physiographic information about land surface features. Land managers, scientists, conservationists, planners, and the public can use the data to support conservation efforts and monitor environmental change. Potential research applications of the data include: assessing carbon storage and soil formation; investigating climate change impacts on biodiversity; addressing issues of habitat protection; conserving rare and endangered species; and economic and non-economic valuation of ecosystem services. Click here for a full report on the methodology of this project, or browse a Story Map about the project here.

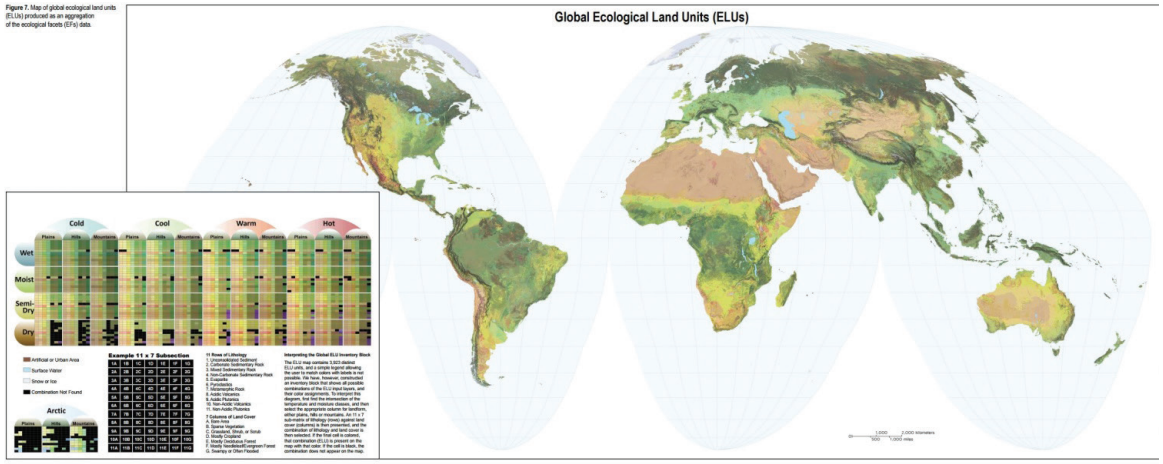


Figure 1: *Global Ecological Land Units.*

2. Mapping Risk Areas for Zika Virus Emergence in the U.S.

GIS is an important interdisciplinary tool for the monitoring and modeling of vector-borne diseases. A recent emerging risk to global health is the Zika virus. With the proximity of current Zika outbreaks to North America, researchers have used geospatial technology to identify high-risk areas for contracting the virus in the U.S. (Figure 2). These spatial models incorporate climate conditions (to identify the potential range of the disease vector, the *Aedes aegypti* mosquito), travel patterns (to identify potential exposure to existing outbreak areas), and poverty levels (higher poverty levels are related to increased exposure to the outdoor environment, for example spending more time outdoors because individuals do not have air conditioning in their dwellings). The National Center for Atmospheric Research and NASA'S Marshall Space Flight Center conducted this disease emergence work to help limit the impact of Zika in the U.S. by anticipating the location and timing of the disease vector. This information helped local authorities to focus their public health outreach and mosquito control initiatives. The published study can be found here.

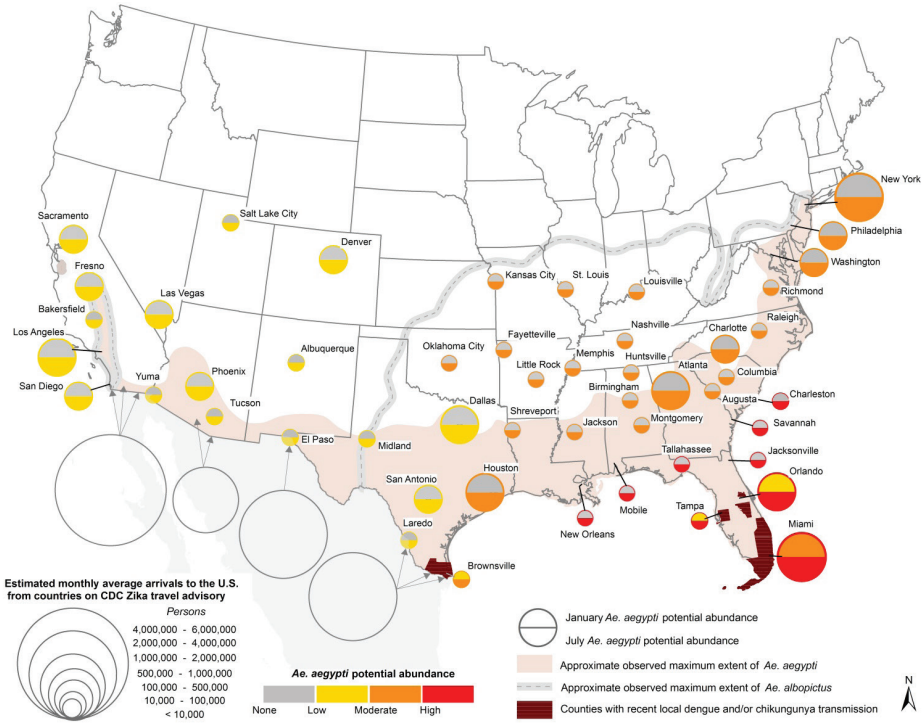


Figure 2: *Mapping potential risk of exposure to the Zika virus.*

3. Monitoring urban development in Miami, Florida

GIS is an important tool for urban planners, developers, and city officials. With downtown condo development on the rise in Miami, the Downtown Development Authority is using geospatial technology to map and model current and future building developments that will impact their community in a variety of ways, including population density, service and amenity needs, infrastructure, traffic flow, and viewsheds. This 3D interactive map of Miami shows proposed, planned, under construction, and recently constructed buildings on top of the existing skyline, including information on the developer and intended use of the new structures (Figure 3). The map also shows metro routes and zoning regulations. This tool, which will be updated on a quarterly basis, provides information to a broad audience, from investors to residents, allowing them a new perspective for understanding the location and rate of structural change in downtown Miami.

Figure 3: *CyberCity 3D Miami.*

These three examples of geospatial technology applications demonstrate the integrative and interdisciplinary theories and conceptual frameworks of geography and GIS&T. From its origins in quantitative spatial methods in the early 1960s, GIS&T stands today as a major field of academic research and industry with rapidly evolving and expanding services (Figure 4). A recent study commissioned by Google estimates the value of the geospatial technology industry's global services at $150-270 billion annually (Oxera, 2013). More than 500,000 people work in geospatial technology-related occupations, exceeding employment levels in the airline industry, and on par with the number of jobs in residential construction (Henttu, Izaret, & Potere, 2012).

A 2013 report by the National Research Council (NRC) attributes the ongoing innovation and growth of GIS&T to several factors:

> *The creation of Google Earth and similar services, the ready availability of technology to support location-based services and analysis, and the use of the Internet as cyberinfrastructure … [all of] these technological changes challenge the traditional model of an industry dominated by the products of a small number of vendors.* (NRC 2013, 32).

NRC's report also mentions the open source sector of the geospatial technology industry, a development that is especially significant for the long-term prospect of AP GIS&T in schools:

> *Increasingly, GIS is offered as a web service and credible open source competitors to the commercial platforms are appearing, supported by open standards developed by organizations such as the Open Geospatial Consortium. This development has significantly democratized access to geographic information, which relies increasingly on a web browser to query, analyze, and visualize spatial data. Crowdsourcing is becoming more important, changing the role of traditional data providers. Research in geospatial analysis is embracing the study of space-time dynamics pertaining to both human and physical phenomena, increasingly supported by massive quantities of data. This new direction requires new conceptual frameworks, methods, and computational techniques, and is driving a rapidly evolving state of the art.* (NRC 2013, 32).

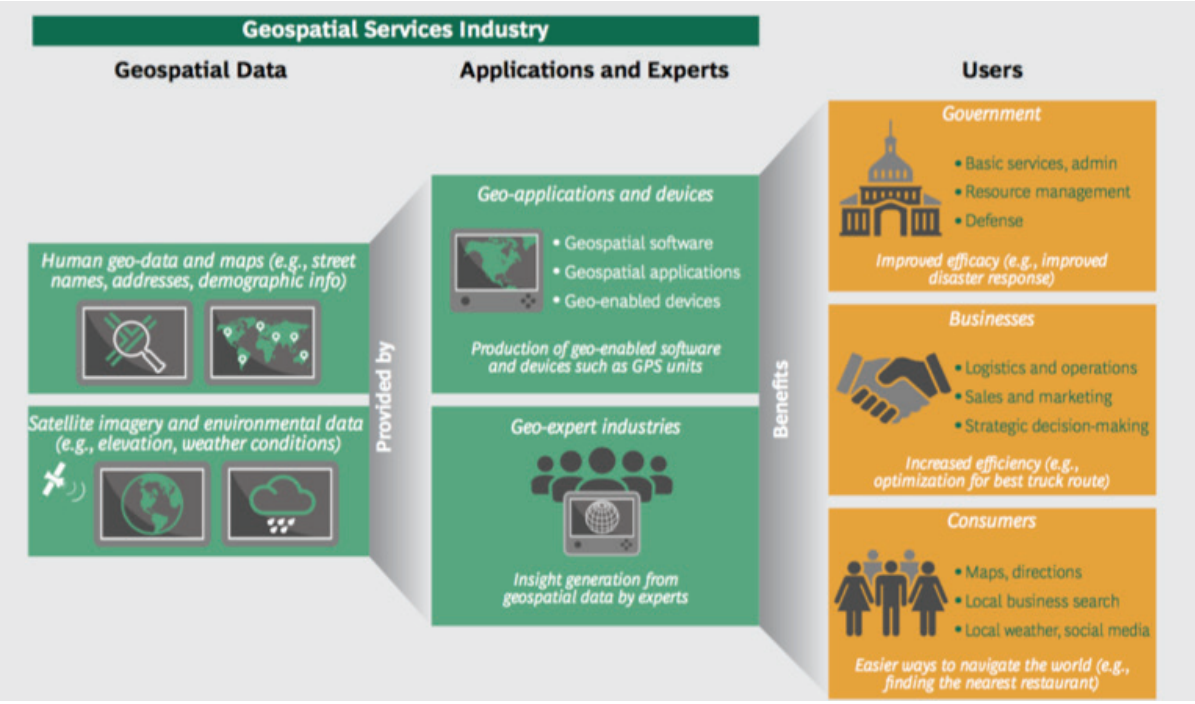


Figure 4: *Geospatial Technology and Services Landscape (Henttu, Izaret, & Potere, 2012).*

CAREER OPPORTUNITIES IN GEOSPATIAL TECHNOLOGY

For students, the "geospatial revolution" offers many exciting career opportunities (Downs, 2014). According to the U.S. Department of Labor (2015), the employment of geographic information scientists, technicians, and analysts will continue to grow rapidly over the coming decade, with upwards of 15,000 additional employees needed annually through 2022 and beyond. Because high school is a crucial time for encouraging and inspiring young people to think about future careers (Leggon, 2003; Xie & Reider, 2013), the opportunity that AP GIS&T offers for employment at multiple pathways — from technical positions with a GIS certificate or associate's degree, to professional occupations for holders of bachelor's and graduate degrees — will almost certainly make the AP GIS&T course an attractive choice for students (Davis, 2015; Mirzoev et al., 2014).

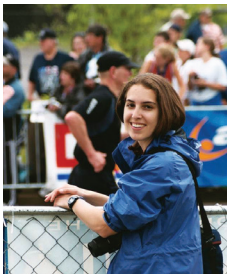
BUSINESS AND INDUSTRY

The private sector features many dynamic and exciting employment settings where applications of geospatial technologies are pervasive. From small businesses to the largest multinational corporations, private sector employers place high value on skills related to geospatial technology, spatial analysis, and cartography. For example, the emerging Unmanned Aerial Systems (UAS) industry requires individuals skilled in geospatial analysis. Early commercial applications of UAS developed in the fields of precision agriculture, emergency response, utilities, real estate, and law enforcement among others (Canis, 2015). Other examples of private sector industries hiring GIS&T-skilled graduates include (Blatt & Ziolkowski, 2013):

- Environmental consulting (e.g., as a geologist, ecologist, sustainability manager, or geographic information systems specialist).
- Software development and database management (as many information technologies now have a geographical or spatial component, such as Google, MapQuest, and Oracle).
- Real estate and retail markets (such as energy companies and grocery store chains, which require location analysis capabilities).
- Map publishers and companies (e.g., the American Automobile Association, Rand-McNally, the National Geographic Society, Waze, Garmin).
- Transportation and logistics departments of major corporations (including Ingram Micro, Cisco, Hewlett-Packard, and Intuit) and companies like Uber and Lyft.

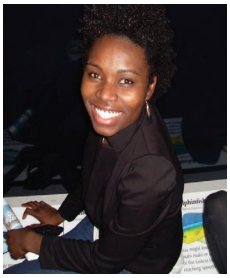
Meet some of the professionals who are applying geospatial technologies in the private sector:

Carmen Tedesco — *Senior Spatial Planning and Development Specialist, Development Alternatives, Inc. (DAI)*



As Senior Spatial Planning and Development Specialist in DAI's Environment and Energy Division, Carmen helps integrate GIS and geospatial planning into the company's international development consulting strategies. Much of her work involves devising and applying geospatial solutions to mitigate the effects of climate change in developing countries.

Esther Ofori — *Marketing Analyst, Macy's Inc.*



Esther Ofori joined the Marketing Analytics Team at Macy's, Inc. in 2011. "We are essentially the resident Area Research Team here but with a focus on the customer," she explains. "We do all kinds of analytical work, but a big part of our job is to predict customer behavior by measuring their response to a marketing event or promotion. We use various tools for our analysis and having a GIS and statistics background is a huge plus."

Examples of GIS&T-related occupations in Business and Industry

Geographical Information Systems (GIS) Analyst, Digital Cartographer, CAD (Computer Aided Design) Technician, Marketing Analyst, Mapping Editor, Real Estate Market Research Director, International Research Coordinator, Environmental Consultant, Urban Design Consultant, Location Intelligence Specialist, Environmental Affairs Director, Sustainability Manager, Global Transportation Manager, Freight Coordinator, Business Analytics/ Intelligence Specialist, Land Use Consultant, Data Scientist, Software Developer.

GOVERNMENT

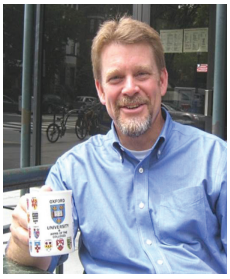
Geospatial technologies are also in high demand in the public sector (Williams, Brown, Moriarty, & Wertman, 2013). At the state and local levels of government, GIS and other geospatial tools have become essential in the work of emergency responders, public health workers, urban planners, law enforcement, and transit agencies. The federal government is also expanding job opportunities for geographic information scientists, GIS technicians, and geospatial analysts in major agencies, including the U.S. Census Bureau, National Geospatial-Intelligence Agency, U.S. Geological Survey, National Oceanic and Atmospheric Administration, and the Departments of State, Defense, Transportation, and Housing and Urban Development. With the call for more evidence-based policy, accountability, and transparency in the public sector, geospatial technologies are becoming central to informing efforts by agencies at all levels of government.

Meet some of the professionals who are applying geospatial technologies in state and federal government:

Dr. Sonia Arbona — *Medical Geographer, Texas Department of Health*

Sonia has worked as an epidemiologist with the Texas Department of Health, HIV/STD Epidemiology Division in Austin since 1998. She uses GIS for geographical analysis and epidemiological investigations of HIV/AIDS and other Sexually Transmitted Diseases.

Mike Ratcliffe — *Assistant Division Chief, U.S. Census Bureau*



Since joining the Census Bureau in 1990, Mike has worked his way up to his current position as Assistant Division Chief for Geocartographic Products and Criteria. These products include TIGER files, thematic and reference maps, and general boundary files available for public use on the Census Bureau's American FactFinder website. Mike believes opportunities for geographers will be sustained by the need to continually update and maintain geospatial data: "Geography will always have a central role in everything the Census does."

Examples of GIS&T-related occupations in Government

Geospatial Intelligence Subject Matter Expert, Remote Sensing Scientist, Aerial Photo Lab Manager, Geographical Information Systems (GIS) Analyst, Photogrammetrist, Remote Sensing Technician, Digital Cartographic Technician, Earth Observations Scientist, Environmental Science Technician, Geophysical Data Technician, Medical Geographer, City Planner, School Demography/Enrollment Forecaster, Transportation Planner, Tax Map Technician, Environmental Field Technician, Land Surveyor, Geodesist, Emergency Management Coordinator, Hydrographic Surveyor, Aerotriangulation Specialist, Agricultural Global Positioning System (GPS) Mapper, Zoning Technician, Socioeconomic Modeling Specialist, Sustainability Metrics Coordinator

NONPROFIT/NONGOVERNMENTAL ORGANIZATIONS

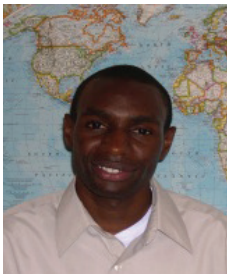
Geospatial technologies are supporting the activities of many nonprofit and non-governmental organizations (Shimada & Tasch, 2013). The analytical and management capabilities of geospatial technologies are being applied to revolutionize approaches to environmental stewardship, children's advocacy and welfare, domestic and international development, education and health, culture and the arts, historic preservation, heritage conservation, and many other issues. There are also many examples of how geospatial technologies are making nonprofit management more efficient, resulting in much lower operating costs.

Meet some of the professionals who are applying geospatial technologies in the nonprofit sector:

Serge Dedina — *Executive Director, WiLDCOAST/COSTASALVAjE*

Serge Dedina found himself drawn to applied geography and decided that a nonprofit career would be a great fit for him. He co-founded WiLDCOAST/COSTASALVAjE, a binational organization that works to conserve coastal and marine ecosystems and wildlife. Serge believes his exposure to geographic tools and perspectives is one of the main reasons WiLDCOAST has been successful. "Take advantage of every opportunity," he advises. "It's more important than ever that geographers get out there and use their skills and training to make a difference."

Peter Ndunda — *Geoinformation Consultant, World Bank*



After graduating from the University of Redlands, Peter Ndunda took a position in Washington, D.C. at the World Bank as a geo-information consultant. There he worked to establish a GIS supporting African sustainable development efforts a "Green Belt Movement" by helping to analyze historical land cover changes, map reforestation efforts, provide information required to monitor and manage forests, and support decision making for land use planning and regulatory requirements.

Examples of GIS&T-related occupations in the nonprofit and NGO sector:

Environmental Education Specialist, Community Development Planner, Housing Grant Analyst, Historic Presevation Specialist, Policy Analyst, Museum Guide, Science Interpreter, Advocacy Director, Program Director, Economic Development Manager, Environmental Health Specialist, Land Records Analyst, Geographical Information Systems (GIS) Analyst, Lobbyist, Socioeconomic Modeling Specialist

BUILDING CAPACITY FOR GIS&T EDUCATION IN SCHOOLS

Despite the considerable evidence of the importance of Geography and GIS&T for the U.S. economy, environment, and society, the U.S. government has invested very little in K-12 geography and GIS&T education. Serious concerns exist among educators and policymakers about the nation's capacity to address critical workforce needs in geospatial technology. A study published in October 2015 by the Government Accountability Office notes that "…throughout the country, K-12 students may not be acquiring adequate skills in and exposure to geography, which are needed to meet workforce needs in geospatial and other geography-related industries" (GAO, 2015). This situation contrasts with the experience of over a dozen European and Asian countries, where governments are investing heavily in academic-industry partnerships for geospatial technology training, and are even making courses in geospatial technology a compulsory part of the school curriculum (Kerski, Demirci, & Milson 2013).

In the U.S., inconsistent curricular requirements across the U.S. currently limit opportunities for students of all demographic backgrounds to study geography and learn with geospatial technology in K-12 schools. 50% of eighth grade teachers spend 3-5 hours per week on social studies instruction, of which only 18-30 minutes are devoted to geography (GAO, 2015). Given this inadequate classroom time it is unsurprising that U.S. students repeatedly fare poorly on the National Assessment of Educational Progress (NAEP) exam for Geography, with average test scores showing 8th-graders overall falling far short of "Proficient" (i.e., adequate mastery of subject matter). Hispanic and African American 8th-grader performance on the NAEP Geography exam has trended upward, yet in the most recent exam Hispanics overall barely scored above Basic (defined as only partial mastery), with African American students as a whole never reaching the Basic level. The reasons for this underperformance are well-documented: a lack of qualified teachers with the content knowledge to be effective geography teachers; testing-driven pressures to emphasize other subjects; poor public understanding of geography and its significance as a science and career field; and schools without access to geospatial technology, high-quality geography textbooks, and other classroom materials (Schell, Roth, & Mohan, 2013).

As challenging as the K-12 situation may seem, examples of remarkable educational innovation, the presence of a robust national infrastructure for teacher professional development, and recent public policy developments all indicate the timing is right for introducing an AP GIS&T course. Consider:

- All 50 states, the District of Columbia, and Puerto Rico have a Geographic Alliance funded by the National Geographic Society (and endowments in some states). The Geographic Alliance Network offers professional development to approximately 200,000 teachers nationwide.
- Since 2015, the $1 billion Esri-ConnectED initiative has supplied free organizational accounts for GIS software to U.S. schools; to date nearly 3,000 schools have signed up for this program while curricular resources based on the software are attracting 30-40,000 views and downloads per month. The AAG is supporting the Esri-ConnectED initiative through a GeoMentors network, whose 1,000 (and growing) members (including college students, educators, and industry professionals) provide critical mentoring, technical, and pedagogical support to schools.
- In 2016 approximately 180,000 students took the AP Human Geography exam (compared to 3,272 students in 2001).
- In 1994, the Elementary and Secondary Education Act (ESEA) recognized geography as a core academic subject; all 50 states now have K–12 standards for geography. Although Geography suffered from having no federal funding support under ESEA (No Child Left Behind) since 2001, the reauthorized law (known as the Every Student Succeeds Act) restores dedicated programs for geography education.
- The National Center for Research in Geography Education, established in 2013 and co-headquartered at the AAG and Texas State University, is leading an NSF-funded research coordination network capable of designing and coordinating research with significant potential to inform broad-scale improvement and change.

The AAG developed this course proposal for AP GIS&T as a direct and constructive response to all of these challenges and opportunities. It is based on extensive original research and consultation with key geography organizations and stakeholders, including academic geographers, high school teachers, and public and private sector GIS professionals. The proposal has been endorsed by a diverse coalition of leading scientific, environmental, and trade organizations, and is fully consistent with the AAG's longstanding mission to advance geographic knowledge, theory, and education.

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