

A GUIDE TO RESOURCES FOR GEOSPATIAL ACADEMIC RESEARCH

NGA RESEARCH DIRECTORATE | NOVEMBER 2019



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Acknowledgments

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We also thank the cadets, midshipmen, and instructors of the U.S. Military, Naval, Air Force, and Coast Guard Academies who participated in our 2019 Service Academy Day — “Know the Earth Day.” Their feedback on research project challenges to obtain suitable imagery and geospatial data provided the impetus for this guide.

Internet Security

While we attempt to ensure hyperlinks contained in this publication are trustworthy, we encourage users of this guide to follow Internet security best practices by copying and pasting hyperlink addresses directly into their browsers, rather than clicking on hyperlinks directly.

Introduction

NGA's Research Directorate is pleased to provide this publication, "A Guide to Resources for Geospatial Academic Research." It is primarily intended to help professionals and students at the high school, undergraduate, and graduate levels focus their research projects on issues that will further the geospatial intelligence (GEOINT) body of knowledge; and to provide publicly available GEOINT imagery and data sources that will enhance their project execution.

NGA is both an intelligence agency and a combat support agency, which delivers world-class GEOINT to policymakers, warfighters, and intelligence professionals; and assists humanitarian and disaster relief efforts by working directly with the lead federal agencies. In addition, NGA is the functional manager for the National System for Geospatial Intelligence (NSG), which provides strategic thinking, guidance, and direction concerning all aspects of GEOINT across the GEOINT Enterprise which it defines as — "the combination of technology, data, people, policies, capabilities, doctrine, activities, and organizations necessary to produce GEOINT in any government, academic, or commercial environment in the U.S. and partner countries."

Successful GEOINT is comprised of many disciplines, including remote sensing, photogrammetry, cartography, geodesy, earth sciences, and imagery analysis. Other closely aligned disciplines include computer or data sciences, artificial intelligence, machine learning, cyber security, space systems, unmanned aircraft systems, environmental or agricultural studies, infrastructure, and logistics. Since almost every discipline has a place and/or time component, there is often a GEOINT application or equity that would greatly benefit from your research interest.

To help achieve its mission, NGA maintains a multidisciplinary program with academia that supports basic and applied research in GEOINT topics, including the award of [NGA Academic Research Program \(NARP\)](#) grants to leading U.S. investigators, research universities, and colleges. We also sponsor research projects with the U.S. military service academies, which engage many cadets and midshipmen. NGA has Cooperative Research and Development Agreements with several universities and works with the U.S. Air Force to support the Applied Research Laboratory for Intelligence and Security (ARLIS) University Affiliated Research Center (UARC) at the University of Maryland. Further, NGA has a strong [undergraduate internship program](#), [recruits from universities](#), and engages numerous [visiting scientists](#) with recent master's or doctorate degrees in challenging research efforts.

We hope that your successful research project will encourage you to continue your geospatial studies and consider a career in geospatial services. If the latter, we look forward to welcoming you as a GEOINT colleague very soon!



Cindy Daniell, Ph.D.
Director of Research
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Purpose

The [NGA's](#) Research Directorate developed this publication — “A Guide to Resources for Geospatial Academic Research” — to uniformly provide researchers a better starting point for their geospatial projects.

Our intent is to point you to information resources that will help narrow down the focus of your research and jump start your work, help align your research project to address actual government and commercial GEOINT challenges, better acquaint you with GEOINT state-of-the-art technology, and provide publicly available sources of geospatial products and data that may be useful to your project.

Our secondary purpose in developing this guide is to provide a collection of scholastic, professional, and employment references for researchers and practitioners, as well as individuals that might advise them (e.g., instructors, guidance counselors, career counselors, internship coordinators, placement counselors, thesis advisors).

Background

NGA is the lead federal agency for GEOINT and manages a global consortium of more than 400 commercial and government relationships. NGA:

- Delivers the strategic intelligence that allows the president and national policymakers to make crucial decisions on counterterrorism, weapons of mass destruction, global political crises and more;
- Enables the warfighter to plan missions, gain battlefield superiority, precisely target the adversary, and protect our military forces;
- Provides timely warnings to the warfighter and national decision-makers by monitoring, analyzing, and reporting imminent threats — often, NGA has the only “eyes” focused on global hot spots and can give unique insight into these critical areas;
- Protects the homeland by supporting counterterrorism, counternarcotics, and border and transportation security
- Supports security planning for special events, such as presidential inaugurations, state visits by foreign leaders, international conferences, and major public events (Olympics, Super Bowl, satellite launches, etc.);
- Ensures safety of navigation in the air and on the seas by maintaining the most current information and highest quality services for U.S. military forces and global transport networks’
- Defends the nation against cyber threats by supporting other intelligence agencies with in-depth analysis of cyber networks;
- Creates and maintains the geospatial foundation data, knowledge, and analysis that enable all other missions; and
- Assists humanitarian and disaster relief efforts by working directly with the lead federal agencies responding to fires, floods, earthquakes, landslides, hurricanes, or other natural or manmade disasters.

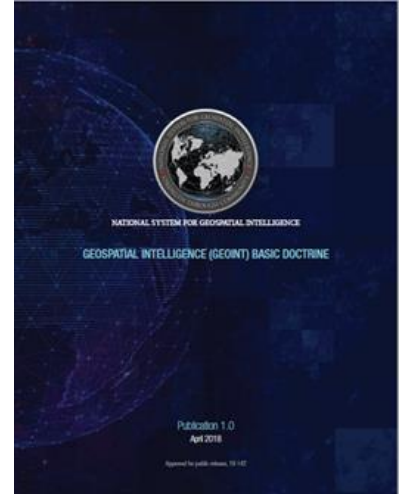


Beyond ongoing relationships with our intelligence community (IC) partners, Department of Defense (DOD) agencies, and allies, NGA maintains close operational and research connections with other federal agencies, such as the [Department of Agriculture \(USDA\)](#), [Department of Commerce \(DOC\)](#), [Department of Health and Human Services \(HHS\)](#), [Department of Interior \(DOI\)](#), [Department of Transportation \(DOT\)](#), [Environmental Protection Agency \(EPA\)](#), [Federal Emergency Management Agency \(FEMA\)](#), [National Science Foundation \(NSF\)](#), and the [National Aeronautics and Space Administration \(NASA\)](#). NGA also maintains close research liaisons with the [Defense Advanced Research Project Agency \(DARPA\)](#) and the [Intelligence Advanced Research Projects Activity \(IARPA\)](#).

In addition to our day-to-day contractual relationships with the commercial sector, NGA and many of our employees participate in industry professional associations, such as the [U.S. Geospatial Intelligence Foundation \(USGIF\)](#), the [Armed Forces Communications-Electronics Association \(AFCEA\) International](#), the [American Society for Photogrammetry and Remote Sensing \(ASPRS\)](#), the [National Military Intelligence Association \(NMIA\)](#), and the [Institute of Electrical and Electronics Engineers \(IEEE\)](#). Related NGA senior leadership public engagements and public statements are detailed in the [NGA Newsroom](#).

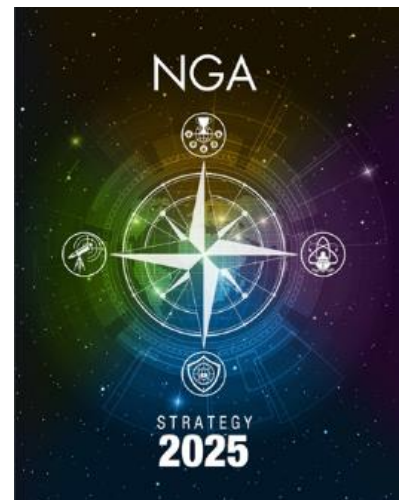
Scoping Your Geospatial Research Project

Your institution, instructor, and advisor will provide invaluable guidance on how to determine your research topic. To get a glimpse of the breadth of geospatial subjects, consult the NSG's "[Geospatial Intelligence \(GEOINT\) Basic Doctrine](#)," Pub 1.0, early in your review. This publication describes **GEOINT concepts and functions**, establishes **common references and terminology**, and provides reference charts for **sensor platforms** (including advantages and disadvantages of each) and characteristics of the various **geospatial phenomenologies**. Consult the "Tradecraft" chapter to gauge **how your interests align with the GEOINT professional tradecraft areas**.



GEOINT Enterprise-Wide References

Next, acquaint yourself with where the GEOINT Enterprise is headed as relates to emerging needs, technologies, methods, services, education, and research. Since 2015, USGIF has published an annual "[State and Future of GEOINT Report](#)" to illuminate **forward-looking trends**. In addition, consult NGA's strategic planning documents: NGA's [Strategic Vision 2025](#) statement, [Strategy 2025](#), [GEOINT CONOPS 2020](#), and [Commercial GEOINT Strategy](#). These documents will also be inclined towards the GEOINT Enterprise, as NGA is the functional manager for the NSG.



NGA's research priorities are as follows:

- *Foundational GEOINT* — accurate, high-resolution, continually updated representations of the Earth's properties that are available on demand; automated feature extraction, physical models, activity models, and precision, navigation, and timing (PNT) resilience are key concerns
- *Collection Technologies* — novel collection methods and efficient collection strategies to deliver spatiotemporal data from an increasing number of traditional and nontraditional sources
- *Analytic Technologies* — accurate, timely, reliable, and scalable methods for data exploitation and analysis driven by new data sources and types and emerging threats; sensor data analytics, patterns of life, and secure GEOINT are key concerns

Other Government and Commercial Strategic References

Other government agencies' and commercial entities' strategic planning documents will likely have a narrower focus. The Background section of this guide lists several key federal organizations that NGA has close ties with, but there are many others that use geospatial information. There are also a multitude of international, state, and local governments with similar responsibilities and geospatial needs.

Other References

Knowing which geospatial products and services federal agencies are acquiring may also provide ideas for potential research projects. The [Federal Business Opportunities \(FBO\)](#) and [Grants.gov](#) websites are the federal government's primary locations for advertising contractual and academic grant opportunities for the commercial and academic sectors, respectively.

To see NGA research opportunities listed on the FBO website: from the FBO web site "Agency" search option, enter "Other Defense Agencies/National Geospatial-Intelligence Agency" and click on the Search button. From the results, perform an on-page search for "BAA" (Broad Agency Announcement).

To see NGA research opportunities listed on the Grants.gov website: select the "Search Grants" tab. Then in the keyword search section, enter "NGA" or "NARP."

You may also want to search FBO and Grants.gov for other agency opportunities or by keywords such as those appearing in NSG's "[Geospatial Intelligence \(GEOINT\) Basic Doctrine](#)," Pub 1.0.

NGA also participates in DOD's Small Business Independent Research/Small Business Technology Transfer (SBIR/STTR) Program and frequently lists research opportunities at its website. Visit its [Current Announcements](#) section for ideas on your research project.

NGA often conducts joint research projects with [DARPA](#) and [IARPA](#); visit their opportunities pages.

Though far from exhaustive, businesses providing geospatial products and services can often be found in professional associations' membership lists, as well as their lists of conference sponsors, exhibitors, speakers, and panel members. In addition, NGA co-sponsors the [Innovative GEOINT Application Provider Program \(IGAPP\)](#), which maintains a vendors list. NGA has also worked with the General Services Administration (GSA) to establish an [Earth Observation Solutions](#) provider list.

Lastly, NGA and other federal agencies often sponsor geospatial crowd-sourced prize challenges on the [Challenge.gov](#) website. In addition, the [Citizen Scientist](#) site is a good source of current crowdsourcing initiatives and how to plan your project. You might even consider designing your research to compete in a prize challenge!

Publicly Available Geospatial Imagery and Data

Appendix 1 provides a short list of publicly available geospatial imagery and data sources which may be useful to your research project.

For those you find helpful that have an associated cost or that require subscriptions, contact your instructor or advisor to see if your academic institution might sponsor their expenses.

Continuing Your Geospatial Education and Career

Though this guide is primarily intended to assist in your geospatial research project, our hope is that your successful work will encourage you to continue your geospatial studies and consider a career in geospatial services.

Internships, Scholarships, and Academic Grants

Review the information we've already presented in the context of possible internship, scholarship, and academic grant sources. NGA's [Student Programs](#) and [Academic Research Program](#) links will guide you to NGA opportunities.

Don't overlook the U.S. military service academies and Reserve Officers Training Corps (ROTC) opportunities. Academy websites are: [U.S. Military Academy \(West Point\)](#), [U.S. Naval Academy \(Annapolis\)](#), [U.S. Air Force Academy](#), and [U.S. Coast Guard Academy](#). The [U.S. Merchant Marine Academy](#) is also an officer commissioning source. ROTC websites are: [U.S. Army ROTC](#), [U.S. Navy ROTC](#), [U.S. Navy ROTC \(Marine Corps option\)](#), and [U.S. Air Force ROTC](#).



Geospatial Careers

If you are considering a career in geospatial services, review GEOINT tradecraft areas in Chapter 4 of NSG’s [“Geospatial Intelligence \(GEOINT\) Basic Doctrine,”](#) Pub 1.0; if you are considering a geospatial career in the federal civil service or U.S. military, review that publication’s “GEOINT Tradecraft Work Role/Designation Chart,” which provides position designations that will help you search the government’s jobs boards.

Read USGIF’s [“Geospatial Intelligence Essential Body of Knowledge”](#) for additional information on technical, cross-functional, and emerging competencies needed in the discipline. ASPRS’ [“Career Brochure”](#) also provides useful information.

The Introduction of this guide lists supporting disciplines GEOINT comprises.

Federal Civil Service Careers

Federal agencies use [USAJOBS](#) to facilitate their hiring processes and match qualified applicants to job openings. USAJOBS serves as the central location to find job openings within hundreds of federal agencies and organizations.

Visit NGA’s [Careers](#) website, which includes our schedule of recruiting events. NGA and several other IC agencies also use the [Intelligence Careers](#) website to advertise opportunities.

U.S. Military Careers

Each of the active duty uniformed services has its own recruiting website: [U.S. Army](#), [U.S. Navy](#), [U.S. Air Force](#), [U.S. Marines](#), and [U.S. Coast Guard](#).

National Guard and Reserve opportunities can be found at: [U.S. Army National Guard](#), [U.S. Air National Guard](#), [U.S. Army Reserve](#), [U.S. Navy Reserve](#), [U.S. Air Force Reserve](#), U.S. Marine Corps Reserve, and [U.S. Coast Guard Reserve](#).

Questions

Appendix 2 provides answers to some of the most recurring inquiries we receive. If you require additional information, please email the [NGA Academic Research Program staff](#) using “The Guide” in the subject line.

Feedback

We’d like to hear your thoughts on “A Guide to Resources for Geospatial Academic Research.” Was it a hit or miss? How did you use it to guide your research project, continuing studies, and/or career direction? How we might improve future versions. Please include broken hyperlinks you experienced.

Email your kudos, comments, suggestions, and fixes to [NGA Research](#) using “The Guide” in the subject line.

Conclusion

By providing you links to key information resources, we hope to help you focus your geospatial research project on issues that will further the GEOINT body of knowledge and provide you publicly available GEOINT imagery and data sources that will enhance your project execution.

Should you choose to pursue a career in geospatial services, NGA looks forward to welcoming you as a GEOINT colleague very soon!

Appendix 1 – Publicly Available Geospatial Product and Data Sources

Name	Description
Alaska Satellite Facility	Synthetic Aperture Radar (SAR) data from more than a dozen satellite platforms, most available via its Vertex database
ArcticDEM	ArcticDEM is an NGA-NSF public-private initiative to automatically produce a high-resolution, high quality, digital surface model (DSM) of the Arctic using optical stereo imagery, high performance computing, and open source photogrammetry software.
Central Intelligence Agency	Maps and publications available to the general public
Common Object in Context (COCO)	Large-scale object detection, segmentation, and captioning dataset
Data.gov	Data.gov includes over 225,000 datasets, tools, and resources from federal agencies, states, counties, and cities to conduct research, develop web and mobile applications, design data visualizations, etc. Topics include agriculture, climate, consumer, ecosystems, education, energy, finance, health, local government, manufacturing, maritime, ocean, public safety, science and technology.
Defence Science and Technology Laboratory (Dstl) - Kaggle	3-band and 16-band imagery from the United Kingdom's Defence Science and Technology Laboratory's 2017 Kaggle prize competition
Directory of Open Source Journals	An online directory that indexes and provides access to numerous quality, open-access and peer-reviewed journals
Functional Map of the World (fMoW)	2017 object identification and classification prize challenge to classify facility, building, and land use from satellite imagery; provides links to numerous data sources
GEOnet Names Server (GNS)	GNS is the official repository of standard spellings of all foreign geographic names, sanctioned by the United States Board on Geographic Names (US BGN). The database also contains variant spellings (cross-references), which are useful for finding purposes, as well as non-Roman script spellings of many of these names. All the geographic features in the database contain information about location, administrative division, and quality. The database can be used for a variety of purposes, including establishing official spellings of foreign place names, cartography, Geographic Information System (GIS), GEOINT, and finding places.
GEOINT Content Extraction Specification (GCES)	GCES is a specialized website for GEOINT professionals to extract items of interest. The GCES provides guidelines for a logical approach to entity extraction used to populate a product-neutral digital database. The NSG Application Schema provides the GEOINT standards and content information that formulates the guidelines throughout the GCES website.
GeoNames WMS Viewer	Provides access to Web Map Services (WMS) interface and a high-level graphical search
GeoRef	Bibliographic records of worldwide geoscience literature
Geospatial Repository and Data	3D spatial database and data warehouse of high-resolution multi-dimensional geospatial datasets (principally LiDAR — light detection and

Name	Description
Management System (GRiD)	ranging), as well as related and derived 2D geospatial products, such as imagery and digital elevation models
GitHub	An open-source development platform to host and review code, manage projects, and build software; lists over 3,000 geospatial capabilities
Government Printing Office	World Fact Book (printed after 1980) in hardcover or CD-ROM.
GPS and Earth Orientation Products	GPS Division which ensures the targeting and navigation grid (WGS84) is constantly realized in GPS for all users and that it meets National, DOD, and IC requirements; provides timely, accurate, leading-edge GPS content, technical support, and situational awareness to the DOD, IC, and scientific community to support precise positioning, navigation, and targeting.
ImageNet	Large-scale visual object recognition research database; organized according to WorldNet hierarchy; consists of image thumbnails and URLs to source providers
Library of Congress	Historical maps and charts
Maritime Safety Products and Services	<p>The Maritime Safety Office collects, evaluates, and compiles worldwide marine navigation products and databases. It is responsible for maritime safety and hydrographic activities, including support to the worldwide portfolio of NGA and National Oceanic and Atmospheric Administration standard nautical charts and hard-copy and digital publications.</p> <p>Publications are available in digital format and include the U.S. Notice to Mariners, Sailing Directions, NGA List of Lights, U.S. Coast Guard Light Lists, American Practical Navigator (Bowditch), and other navigation science publications. The office coordinates the worldwide Navigational Warning Service's NAVAREA IV and NAVAREA XII safety messages, an essential part of the Global Maritime Distress and Safety System.</p>
MATLAB SAR Toolbox	The MATLAB SAR Toolbox is a basic MATLAB library to read, write, display, and do simple processing of complex SAR data using the NGA SICD format. It has been released by NGA to encourage the use of SAR data standards throughout the international SAR community. The MATLAB SAR Toolbox complements the SIX library (C++) and SarPy (Python), which are implemented in other languages but have similar goals.
National Archives Cartographic and Architectural Branch	Historical maps and charts
National Technical Information Service	Maps and publications in print after January 1, 1980
NGA SIX Library	The SIX library is a cross-platform C++ API for reading and writing NGA's complex phase history (CPHD), complex (SICD), and derived (SIDD) sensor independent radar formats; Python bindings are gradually being added as well. Additionally it is the official reference implementation library for the SIDD format. The library also provides a sensor model implementation of many equations in the SICD and SIDD document. This sensor model implementation provides the foundations for the SICD and SIDD CSM (Community Sensor Model) implementation.

Name	Description
NSG Standards Registry	Search for SICD and SIDD here to find the standards that the National System for Geospatial Intelligence (NSG) uses. Developing NITF SIDD products enables utilization of MSP SIDD sensor model within ELT tools such as RemoteView and SOCET GXP.
NOAA National Center for Environmental Information (NCEI)	Hosts and provides public access to one of the most significant archives for environmental data on Earth. Through the Center for Weather and Climate and the Center for Coasts, Oceans, and Geophysics, we provide over 25 petabytes of comprehensive atmospheric, coastal, oceanic, and geophysical data.
Open Source Enterprise Databases	Provides access to many foreign and domestic databases, newspapers, periodicals, blogs, etc.
Pacific Earthquake Engineering Research (PEER)	Provides earthquake ground motion data, models, and software tools to support a formalized performance-based earthquake engineering methodology
Purdue University GIS Data Guide	Provides sources of geospatial information by U.S. state, numerous themes, software, and learning resources
SarPy	SarPy is a basic Python library to read, write, display, and do simple processing of complex SAR data using the NGA SICD format. It has been released by NGA to encourage the use of SAR data standards throughout the international SAR community. SarPy complements the SIX library (C++) and the MATLAB SAR Toolbox, which are implemented in other languages but have similar goals.
Sentinel – 1	European Space Agency (ESA) satellite data products from polar-orbiting satellites performing C-band SAR imaging
SpaceNet Open Data Satellite Imagery	Commercial satellite imagery and labelled training data to use for machine learning research
Statistical Abstracts of the World	Aggregates statistical abstracts of nearly 50 countries, and makes content available through a single-search interface
STM Source	A multidisciplinary resource that provides a wealth of content encompassing all areas and facets of research-and-development activity
U.S. Geological Survey (USGS) Data and Tools	Features a science data catalog, science datasets, web applications, developer Application Programming Interfaces (APIs), and some real-time data
USGS Earth Resources Observation and Science Center (EROS)	Resources include The National Map, Earth Explorer, GloVIS, LandsatLook; real-time data available on earthquakes, water conditions, floods, geomagnetism, remote land sensing, Landsat, landslides, volcanoes, droughts, and wildfires.
U.S. Government Printing Office	Nautical publications
World Magnetic Model (WMM) 2015	The WMM is the standard model used by DOD, NATO, and IHO for a wide range of positional and navigation systems. (Updated in 2018)
xView	One of the largest publicly available datasets of overhead imagery; contains images from complex scenes from around the world, annotated using bounding boxes; developed for the Defense Innovation Unit Experimental (DIUx)/NGA 2017 Detection Challenge.

Appendix 2 – Frequently Asked Questions (FAQ)

How will I know which are the best geospatial products and data sources to help with my project?

Unfortunately, we are unable to endorse any particular geospatial product, service, or data source due to government procurement conflict of interest rules. We highly recommend you consult the instructors and advisors most familiar with your project objectives and examine product reviews and blogs for insight into what will best meet your needs.

How can I have my geospatial product or data source listed in “A Guide to Resources for Geospatial Academic Research”?

Product and data source listings in this guide are principally free general purpose government and open-source offerings that would benefit students in their geospatial academic research projects.

Commercial offerings of potential interest to academic institutions and geospatial academic programs themselves are indirectly referenced via citations of lists maintained by NGA’s [IGAPP](#), GSA’s [Earth Observation Solutions](#) program, professional or academic associations, or trade publications.

Please inform us of other government and open-source offerings, as well as other government, professional, or academic association or trade publication geospatial product/data source lists, via email to [NGA Research](#) using “The Guide” in the subject line. Be sure to include hyperlinks to that information.

How often will “A Guide to Resources for Geospatial Academic Research” be updated?

We anticipate updating the guide annually in the July–August timeframe, so it is ready for the upcoming academic year. Additional updates may occur as warranted.



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