



**PCC Proposal to Establish a Post-Baccalaureate Certificate in Remote Sensing
(Senate Document #21-22-07)**

TO Darryll J. Pines | President

FROM Ellen D. Williams | Chair, University Senate

I am pleased to forward the accompanying legislation for your consideration and approval. Betsy Beise, Member of the PCC Committee, presented PCC Proposal to Establish a Post-Baccalaureate Certificate in Remote Sensing (Senate Document #21-22-07), which the University Senate approved at its meeting on September 8, 2021. Please inform the Senate of your decision and any administrative action related to your conclusion.

Approved:

**Darryll J. Pines
President**

Date:

09-10-2021

Copies of this approval and the accompanying legislation will be forwarded to:

Jennifer King Rice, Senior Vice President and Provost
Reka Montfort, Executive Secretary and Director, University Senate
Michael Poterala, Vice President and General Counsel
Dylan Baker, Interim Associate Vice President for Finance and Personnel
John Bertot, Associate Provost for Faculty Affairs
Elizabeth Beise, Associate Provost for Academic Planning & Programs
Rhonda Smith, Acting Director, Division of Academic Affairs
Gregory Ball, Dean, College of Behavioral & Social Sciences
Jean McGloin, Associate Dean for Research and Graduate Education, College of Behavioral & Social Sciences
Jack (Jianguo) Ma, MPS Program Director, Department of Geographical Sciences
Kristen Bergery, Assistant Director, Master of Science Programs, Department of Geographical Sciences
Valerie Orlando, Chair, PCC Committee



Establish a Post-Baccalaureate Certificate in Remote Sensing (PCC 20101)

PRESENTED BY Valérie Orlando, Chair, Senate Programs, Curricula, and Courses Committee

REVIEW DATES SEC – August 26, 2021 | SENATE – September 8, 2021

VOTING METHOD In a single vote

**RELEVANT
POLICY/DOCUMENT** N/A

**NECESSARY
APPROVALS** Senate, President, University System of Maryland Chancellor, and Maryland Higher Education Commission

ISSUE

The College of Behavioral and Social Sciences' Department of Geographical Sciences proposes to establish a Post-Baccalaureate Certificate in Remote Sensing. The purpose of this certificate is to provide advanced education and training in collecting, processing, analyzing, and visualizing geospatial data through remote-sensing platforms, such as satellite images, aerial photos, and drone images. Students in this program will take courses that cover all major aspects of remote sensing, including digital image processing and analysis, working with Lidar, drones for data collection, and also computer programming that is critical for data processing and analysis. Students will develop a good understanding of how remote sensing is applied to real-world problems, and graduates will have the necessary knowledge and skills to work as remote sensing professionals and specialists.

The program is 12 credits, including a core set of courses consisting of 9 credits, and 3 credits from a list of electives:

- GEOG652 Digital Image Processing and Analysis (3 Credits)
- GEOG660 Advanced Remote Sensing Using Lidar (3 Credits)
- GEOG666 Drones for Data Collection (3 Credits)
- One of the following 3-credit courses:
 - GEOG646 Programming for GIS
 - GEOG656 Advanced Programming for GIS
 - GEOG653 Spatial Analysis
 - GEOG654 GIS and Spatial Modeling
 - GEOG663 Big Data Analytics

The Department of Geographical Sciences already offers a Master of Science in Geospatial Information Sciences. All of the courses for the proposed certificate program are currently offered through the master's program. Consequently, the instructional and administrative resources for this program already exist. This certificate program will allow students who may not want to enroll in a master's program to earn a graduate credential in remote sensing. Some students may already have a master's degree, but lack this specific training. Given the high concentration of governmental, non-profit, and private organizations that work with geospatial information sciences in

the Baltimore-Washington region, it is expected that demand will be high for this program. The program will be supported by tuition revenue.

This proposal was approved by the Graduate School Programs, Curricula, and Courses committee on May 3, 2021, and the Senate Programs, Curricula, and Courses committee on May 7, 2021.

RECOMMENDATION

The Senate Committee on Programs, Curricula, and Courses recommends that the Senate approve this new certificate program.

COMMITTEE WORK

The committee considered this proposal at its meeting on May 7, 2021. Jack Ma and Kristen Bergery from the Department of Geographical Sciences presented the proposal and answered questions from the committee. The proposal was approved by the committee.

ALTERNATIVES

The Senate could decline to approve this new certificate program.

RISKS

If the Senate declines to approve this certificate program, the university will lose an opportunity to establish a desired certificate program from courses that already exist within an active master's program.

FINANCIAL IMPLICATIONS

Because this program is self-supported, there are no significant financial implications for this proposal.

767: GRADUATE CERTIFICATE IN REMOTE SENSING

In Workflow

1. D-GEOG Curriculum Manager (bmarroqu@umd.edu; kbergery@umd.edu; rberndts@umd.edu)
2. D-GEOG PCC Chair (loboda@umd.edu; sineadf@umd.edu; ddwang@umd.edu)
3. D-GEOG Chair (loboda@umd.edu; rberndts@umd.edu)
4. BSOS Curriculum Manager (khall@umd.edu; gdenbow@umd.edu)
5. BSOS PCC Chair (khall@umd.edu)
6. BSOS Dean (khall@umd.edu; krussell@umd.edu; jmcgloin@umd.edu)
7. Academic Affairs Curriculum Manager (mcolson@umd.edu)
8. Graduate School Curriculum Manager (aambrosi@umd.edu)
9. Graduate PCC Chair (aambrosi@umd.edu)
10. Dean of the Graduate School (sfetter@umd.edu; aambrosi@umd.edu)
11. Senate PCC Chair (mcolson@umd.edu; vorlando@umd.edu)
12. University Senate Chair (mcolson@umd.edu)
13. President (mcolson@umd.edu)
14. Chancellor (mcolson@umd.edu)
15. MHEC (mcolson@umd.edu)
16. Provost Office (mcolson@umd.edu)
17. Graduate Catalog Manager (aambrosi@umd.edu)

Approval Path

1. Thu, 04 Feb 2021 14:19:17 GMT
Byron Marroquin (bmarroqu): Approved for D-GEOG Curriculum Manager
2. Thu, 04 Feb 2021 14:52:41 GMT
Tatiana Loboda (loboda): Approved for D-GEOG PCC Chair
3. Mon, 08 Feb 2021 22:36:41 GMT
Tatiana Loboda (loboda): Approved for D-GEOG Chair
4. Tue, 09 Feb 2021 19:43:19 GMT
Kristi Hall (khall): Approved for BSOS Curriculum Manager
5. Tue, 23 Feb 2021 17:21:04 GMT
Kristi Hall (khall): Approved for BSOS PCC Chair
6. Tue, 23 Feb 2021 17:56:58 GMT
Jean McGloin (jmcgloin): Approved for BSOS Dean
7. Tue, 27 Apr 2021 18:07:36 GMT
Michael Colson (mcolson): Approved for Academic Affairs Curriculum Manager
8. Mon, 03 May 2021 20:47:34 GMT
Angela Ambrosi (aambrosi): Approved for Graduate School Curriculum Manager
9. Mon, 03 May 2021 20:48:34 GMT
Angela Ambrosi (aambrosi): Approved for Graduate PCC Chair
10. Fri, 07 May 2021 20:22:20 GMT
Steve Fetter (sfetter): Approved for Dean of the Graduate School
11. Sat, 08 May 2021 16:40:26 GMT
Valerie Orlando (vorlando): Approved for Senate PCC Chair

New Program Proposal

Date Submitted: Thu, 04 Feb 2021 01:20:18 GMT

Viewing: 767 : Graduate Certificate in Remote Sensing

Last edit: Wed, 14 Apr 2021 14:09:34 GMT

Changes proposed by: Jianguo Ma (jma3)

Program Name

Graduate Certificate in Remote Sensing

Program Status

Proposed

Effective Term

Fall 2021

Catalog Year

2021-2022

Program Level

Graduate Program

Program Type

Post-Baccalaureate Certificate

Delivery Method

On Campus

Departments**Department**

Geography

Colleges**College**

Behavioral and Social Sciences

Degree(s) Awarded**Degree Awarded**

Certificate, Post-Baccalaureate

Proposal Contact

Jianguo Ma

Proposal Summary

The MS in Geospatial Information Sciences (MSGIS) program has been one of the biggest graduate level GIS programs in the country since 2008 and offers both a MS degree and also a Graduate Certificate in GIS. We are proposing to add a Graduate Certificate in Remote Sensing track in this exiting program to reflect both the needs by potential students and the demand by employers.

(PCC Log Number 20101)

Program and Catalog Information

Provide the catalog description of the proposed program. As part of the description, please indicate any areas of concentration or specializations that will be offered.

The MSGIS program is designed to provide advanced education and training using the most up-to-date knowledge and skills from the field of geospatial sciences including GIS, remote sensing, and computing. The MSGIS curriculum is beyond GIS and includes remote sensing, statistics, and computing as well. The topics cover spatial analysis, spatial statistics, computer programming and scripting, spatial databases, GIS modeling, remote sensing, Web GIS, mobile GIS, big data analytics, drones for data collection, open source GIS, etc.

This specific Graduate Certificate in Remote Sensing program will concentrate on teaching of science and technology for collecting, processing, analyzing, and visualizing geospatial data through remote sensing platforms such as satellite images, aerial photos, and drone images. The students in this certificate program will learn both the concepts and technical skills to be able to work as a Remote Sensing specialist. Totally four courses (12 credits) related to topics of Remote Sensing are required to complete this graduate certificate.

Catalog Program Requirements:

Course	Title	Credits
Core Courses		
GEOG652	Digital Image Processing and Analysis	3

GEOG660	Advanced Remote Sensing Using Lidar	3
GEOG666	Drones for Data Collection	3
Elective Courses (choose one of the following):		3
GEOG646	Programming for GIS	
GEOG656	Advanced Programming for GIS	
GEOG653	Spatial Analysis	
GEOG654	GIS and Spatial Modeling	
GEOG663	Big Data Analytics	

Total Credits **12**

The material below is for the proposal review and will not appear in requirements section of the Graduate Catalog*

The four courses required to complete this graduate certificate are as follows:

Core courses:

GEOG652 - Digital Image Processing and Analysis (3 credits)

GEOG660 - Advanced Remote Sensing using Lidar (3 credits)

GEOG666 - Drones and Data Collection (3 credits)

Elective course (choose one from the list below):

GEOG646 - Intro to Programming for GIS (3 credits)

GEOG646 - Advanced Programming for GIS (3 credits)

GEOG653 - Spatial Analysis (3 credits)

GEOG654 - GIS and Spatial Modeling (3 credits)

GEOG663 - Big Data Analytics (3 credits)

Sample plan. Provide a term by term sample plan that shows how a hypothetical student would progress through the program to completion. It should be clear the length of time it will take for a typical student to graduate. For undergraduate programs, this should be the four-year plan.

A student in this graduate certificate program can study part time and take one course per term. This will take the student to complete the program in 12 months. A sample study plan is as follows:

Fall 2021: GEOG652

Winter 2021-2022: GEOG660

Spring 2022: GEOG646

Summer 2022: GEOG666

List the intended student learning outcomes. In an attachment, provide the plan for assessing these outcomes.

Learning Outcomes

The learning outcomes of students in the Graduate Certificate in Remote Sensing program:

1. Understand the big picture of remote sensing as a disciplinary field, with a good understanding of its history, current state, and future development trend.
2. Grasp of the connections between different geospatial technology components such as GIS, remote sensing, computing, and emerging software and hardware options, e.g. drones and artificial intelligence.
3. Develop a good understanding of how remote sensing is applied to real-world problems.
4. Develop proficiency in the following specific knowledge and skills:
 - a. Collecting spatial data through various remote sensing platforms
 - b. Processing remote sensing data using software such as ENVI
 - c. Be able to interpret remote sensing data
 - d. Be able to analyze remote sensing data
 - e. Be able to automate the data processing and analyzing through computer programming and scripting with languages such as Python
 - f. Have a good understanding about analysis of big data with high performance computing, especially spatial data in large volume and high velocity

New Program Information

Mission and Purpose

Describe the program and explain how it fits the institutional mission statement and planning priorities.

The University of Maryland (UMD), College Park is a flagship public institution that is centrally located in the Baltimore-Washington corridor. There are more GIS and Remote Sensing related activities and needs in this region than anywhere else in the country because of the high concentration of federal agencies, NGOs, and private sectors in geospatial field. UMD is particularly well positioned to play a strong role in geospatial research and

education given the long heritage of innovating in the development and application of geographic information systems for public, government, and commercial uses.

Adding to our existing MS in Geospatial Information Science program, this new graduate certificate in Remote Sensing track will help provide much needed education and training to prospective students and meet the demand by the local employers.

Program Characteristics

What are the educational objectives of the program?

The students in this certificate program will take courses that cover all major aspects of remote sensing including digital image processing and analysis; working with Lidar, drones for data collection, and also computer programming that is critical for data processing and analysis. The graduates will have necessary knowledge and skills to work as a Remote Sensing professional and specialist.

Describe any selective admissions policy or special criteria for students interested in this program.

General application documents:

- (1) Transcript(s)
- (2) Statement of Purpose

Program-specific application documents:

- (1) Letters of Recommendation (2)
- (2) CV/Resume
- (3) Prerequisite requirement. To gain admission, applicants are not required to have any GIS or remote sensing background. However, before a student can start the program, he/she needs to meet the prerequisite requirement: an introductory course in GIS or professional experiences working with GIS.

Summarize the factors that were considered in developing the proposed curriculum (such as recommendations of advisory or other groups, articulated workforce needs, standards set by disciplinary associations or specialized-accrediting groups, etc.).

The MSGIS program has been offering advanced education and training in geospatial technology since 2008. The curriculum covers GIS, remote sensing and computer programming. There are a few factors that contribute to this proposal of adding a Graduate Certificate in Remote Sensing.

- (1) There have always had some inquiries from prospective students who are specifically interested in graduate studies in remote sensing. While it is easier to find graduate programs in GIS, it is not the case for similar programs in remote sensing.
- (2) There also have been consistent demand for professionals who have knowledge and skills in remote sensing. More importantly, a lot of such demand by employers are in DC area because of the high concentration of federal government agencies and NGOs.
- (3) Our department is one of the top ones in the field of remote sensing research. In one of the rankings, we are the #2 worldwide. Therefore, it is important to take advantage of this academic strength.

In summary, we would like to create this graduate certificate program to meet the needs and demand by prospective students and also employers. In addition, we want to further expand on our existing strength in remote sensing research in our department and on campus.

Select the academic calendar type for this program (calendar types with dates can be found on the Academic Calendar (<https://www.provost.umd.edu/calendar/>) page)

Approved 12-Week Term

Identify specific actions and strategies that will be utilized to recruit and retain a diverse student body.

UMD has stated goals for recruiting and graduating a diverse population of graduate students in its strategic plan for diversity.

- (1) We advertise and promote our programs through a variety of platforms including Google Ads, LinkedIn, etc. This will ensure we reach to prospective students of all background.
- (2) We also participate in and present at various conferences to reach a wider audience.
- (3) We particularly encourage students from underrepresented groups to apply.
- (4) The program also works with alumni to help recruit for the program.

Retention efforts has focused on developing experiential learning opportunities for students as well as ensuring that the curriculum is up-to-date given the evolution of this technical field.

Relationship to Other Units or Institutions

If a required or recommended course is offered by another department, discuss how the additional students will not unduly burden that department's faculty and resources. Discuss any other potential impacts on another department, such as academic content that may significantly overlap with existing programs. Use space below for any comments. Otherwise, attach supporting correspondence.

N/A

Accreditation and Licensure. Will the program need to be accredited? If so, indicate the accrediting agency. Also, indicate if students will expect to be licensed or certified in order to engage in or be successful in the program's target occupation.

Our university is a member of University Consortium for Geographic Information Science (UCGIS), but this program will not need accreditation.

Describe any cooperative arrangements with other institutions or organizations that will be important for the success of this program.

N/A

Faculty and Organization

Who will provide academic direction and oversight for the program? In an attachment, please indicate the faculty involved in the program. Include their titles, credentials, and courses they may teach for the program.

The MS GIS program including this proposed certificate program is oversight by the faculty in the department of Geographical Sciences, along with a Program Oversight Committee. Administration and day-to-day management are provided through the University of Maryland Center for Geospatial Information Science (CGIS). Members of the Program Oversight Committee include the Graduate Director (Prof. Laixiang Sun), and the CGIS director (Prof. Kathleen Stewart). The administrative and teaching team is led by program director Dr. Jianguo (“Jack”) Ma. The program will also form an “MS GIS Advisory Committee”, comprised of about six faculty members, whose role will be to provide term-to-term guidance on the running of the program, strategic advice regarding future opportunities and curricular modifications, and oversight of the annual learning outcomes assessment evaluation.

See the attachment for more details on the faculty involved.

Indicate who will provide the administrative coordination for the program

Kristen Bergery
 Assistant Director, Master of Science Programs
 2108 LeFrak Hall
 Department of Geographical Sciences
 College Park, MD 20742
 301.314.1883
 Kbergery@umd.edu

Resource Needs and Sources

Each new program is required to have a library assessment prepared by the University Libraries in order to determine any new library resources that may be required. This assessment must be done by the University Libraries. Add as an attachment.

The University of Maryland Libraries has conducted an assessment of library resources required for the MSGIS program. The assessment concluded that the University Libraries are able to meet, with its current resources, the curricular and research needs of the program including this new Graduate Certificate program. See the attachment.

Discuss the adequacy of physical facilities, infrastructure and instructional equipment.

The current MSGIS program has facilities, infrastructure, and instructional resources in place. The Center for Geospatial Information Science has access to two 25-seat GIS labs with specialized software and hardware that allows students to engage in GIS training. The labs run a wide variety of commercial and open source software for GIS, remote sensing, statistical analysis, data access, image processing, mathematical analyses, graphics and 3D modeling, and software development. The program also has access to multiple high-performance computing resources.

Discuss the instructional resources (faculty, staff, and teaching assistants) that will be needed to cover new courses or needed additional sections of existing courses to be taught. Indicate the source of resources for covering these costs.

As the MSGIS program has been offered since 2008, faculty resources are already in place. The current MS GIS program has four full-time lecturers who are dedicated to teaching most of the classes offered in the curriculum. Part-time lecturers are used for some classes, especially during summer and winter terms. Adding this new graduate certificate program will not require new teaching resources or costs.

Discuss the administrative and advising resources that will be needed for the program. Indicate the source of resources for covering these costs.

As the MSGIS program has been offered since 2008, there are adequate administrative resources to cover the new graduate certificate program because it is a simple expansion. The expansion is also very moderate (about 5 students per year at the most). Therefore, adding this new graduate certificate program will not result in additional administrative costs.

Use the Maryland Higher Education Commission (MHEC) commission financial tables to describe the program's financial plan for the next five years. See help bubble for financial table template. Use space below for any additional comments on program funding.

The proposed Graduate Certificate program will be a part of the existing MSGIS program. The students will take courses currently being offered. Therefore, there will be almost no additional cost in terms of teaching and administration. It is equivalent to recruiting about 5 more students each year.

Tables 1 contains the details of resources and expenditures.

Implications for the State (Additional Information Required by MHEC and the Board of Regents)

Explain how there is a compelling regional or statewide need for the program. Argument for need may be based on the need for the advancement of knowledge and/or societal needs, including the need for “expanding educational opportunities and choices for minority and educationally disadvantaged students at institutions of higher education.” Also, explain how need is consistent with the Maryland State Plan for Postsecondary Education (<https://mhec.state.md.us/About/Documents/2017.2021%20Maryland%20State%20Plan%20for%20Higher%20Education.pdf>).

The University of Maryland (UMD), College Park is in a unique geographical location because it is centrally placed in the Baltimore-Washington corridor. There are more GIS and Remote Sensing related activities and needs in this region than anywhere else in the country because of the high concentration of federal agencies, NGOs, and private sectors in geospatial field. For example, NASA and NOAA are two of the most important users of remote sensing data from various sources such as satellite images, aerial photos, etc. UMD is particularly well positioned to play a strong role in geospatial research and education. Our Department of Geographical Sciences is well known for research in remote sensing and recognized as a leader worldwide. Therefore, UMD has all the resources to take the charge and play an important role in this field both in the State of Maryland and nationwide.

Adding to our existing MS in Geospatial Information Science program, this new graduate certificate in Remote Sensing track will help provide much needed education and training to prospective students and meet the demand by the local employers.

Is the proposed Post-Baccalaureate Certificate derived entirely from the core requirements of an existing master’s degree program?

No

Present data and analysis projecting market demand and the availability of openings in a job market to be served by the new program. Possible sources of information include industry or disciplinary studies on job market, the USBLS Occupational Outlook Handbook (<https://www.bls.gov/ooh/>), or Maryland state Occupational and Industry Projections (<http://www.dlir.state.md.us/lmi/iandoproj/>) over the next five years. Also, provide information on the existing supply of graduates in similar programs in the state (use MHEC’s Office of Research and Policy Analysis webpage (<http://mhec.maryland.gov/publications/Pages/research/>) for Annual Reports on Enrollment by Program) and discuss how future demand for graduates will exceed the existing supply. As part of this analysis, indicate the anticipated number of students your program will graduate per year at steady state.

The need for a well-trained and nimble workforce in geospatial information sciences is growing, markedly. The US Bureau of Labor Statistics Occupational Outlook Handbook does not list geospatial information scientist as an occupation, but does project that jobs in a related category, cartographers and photogrammetrists, is growing “much faster than average” between 2016-2026. The Bureau lists the state of Maryland as one of the strongest states in the nation for jobs in the geographical sciences, mainly because of the prevalence of federal agencies.

Our current MS GIS program recruits about 50 students in total annually. We have high confidence that the enrollment of the proposed Graduate Certificate program will be about 5 students or more per year. This projection is based on inquiries from prospective students and also feedback from past students. This will be a positive addition to our existing MSGIS program.

Identify similar programs in the state. Discuss any differences between the proposed program and existing programs. Explain how your program will not result in an unreasonable duplication of an existing program (you can base this argument on program differences or market demand for graduates). The MHEC website can be used to find academic programs operating in the state: http://mhec.maryland.gov/institutions_training/pages/HEPrograms.aspx

There are geographic information system (GIS) certificate programs in institutions in the state of Maryland (see attachment Remote Sensing Market Analysis V2), but remote sensing is the study of objects (mainly earth surface objects such as water bodies and vegetation for civil engineers), without being in contact with those objects, using imagery captured with help of electromagnetic radiation. A geographic information system is a computer-based tool for mapping and analyzing features and events on earth. GIS technology integrates common database operations, such as query and statistical analysis, with maps. A GIS program may or may not include components of remote sensing.

Discuss the possible impact on Historically Black Institutions (HBIs) in the state. Will the program affect any existing programs at Maryland HBIs? Will the program impact the uniqueness or identity of a Maryland HBI?

This proposed Graduate Certificate program will not impact Historically Black Institutions (HBIs) in the state. The reason is that this program is focused on Remote Sensing and there are no similar post-baccalaureate programs of Remote Sensing offered in those institutions. See attachment Remote Sensing Market Analysis V2.

Supporting Documents

Attachments

MSGIS Faculty.docx
 Library Resource Assessment for MSGIS.docx
 MSGIS Graduate Certificate in RS 5-Year Budget Analysis.xlsx
 MSGIS_Assessment Plan - 2021.docx
 Remote Sensing_Market_Research V2.xlsx
 Remote Sensing_Employment_Projections.xlsx

Key: 767

MS in Geospatial Information Sciences (MSGIS) Program Graduate Certificate in Remote Sensing

Appendix C: Faculty

Dr. Kathleen Stewart, Full-Time, Tenure Track

Kathleen Stewart is Director of the Center for Geospatial Information Science and works in the area of geographic information science with a particular focus on geospatial dynamics. This includes topics such as moving objects research (e.g., space-time trajectories, space-time scheduling) and event modeling for dynamic GIS. She is interested in mobility, spatial accessibility, big geospatial data, and currently investigates movement and mobility for a number of different application domains, for example, health and transportation. She is also interested in modeling geospatial semantics including geospatial ontologies and their role for geographic information system design, and spatiotemporal information retrieval. At the University of Maryland, Dr. Stewart is a member of the Program in Oncology at the University of Maryland Marlene and Stewart Greenebaum Comprehensive Cancer Center and also collaborates with researchers at the Institute for Global Health, the Center for Substance Abuse Research, the National Transportation Center, the School of Public Health, and among others. Her research is currently supported in part by grants from the National Institutes of Health, NASA, and the Federal Highway Administration, among other organizations, and she has also received support from IARPA, NGA and NSA. Dr. Stewart serves as a member of the Mapping Science Committee of the National Academies of Sciences, Engineering and Medicine and the Board of Directors for the University Consortium of Geographic Information Science. She is a member of the steering committee for the Maryland Transportation Institute. She also serves as a member of the editorial boards for The International Journal of Geographical Information Science (IJGIS), Computers, Environment, and Urban Systems, Transactions in GIS, Geographical Analysis, and the open-access Journal of Spatial Information Science (JOSIS).

Dr. Jianguo Ma, Full-Time, Professional Track

Dr. Ma is the Director and a Lecturer in the Department of Geographical Sciences at the University of Maryland, College Park. His teaching and research interest are focused on the application of Spatial Analysis, GIS modeling and Web GIS in the field of renewable energy and sustainable development as well as marketing analysis. His educational background includes PhD in Biological and Environmental Engineering from Cornell University (2005) and MS (2003) from Cornell University, MA from Peking University, BS in Geological Engineering from Beijing University of Science and Technology.

The courses that Dr. Ma teaches in the MS GIS program:

GEOG653 (Spatial Analysis), GEOG654 (GIS and Spatial Modeling), GEOG677 (Internet GIS), GEOG795 (GIS Professional Seminars), GEOG797 (Professional Project)

Dr. Jonathan Resop, Full-Time, Professional Track

Dr. Resop is a Senior Lecturer in the Department of Geographical Sciences at the University of Maryland. Jonathan earned his Ph.D. at Virginia Tech in Biological Systems Engineering. During

his time at Virginia Tech, he worked on multiple projects related to spatial modeling and remote sensing, in particular problems that involve agricultural and environmental systems. His dissertation involved applying ground-based lidar to various ecological applications. After completing his Ph.D. he worked as a post-doc for the USDA-ARS in Beltsville in the Crop Systems and Global Change Lab, doing research related to simulating the potential production capacity of crops within regional food systems using a geospatial crop model. Jonathan received his undergraduate degrees at the University of Maryland, College Park in Biological Resources Engineering and Computer Science.

The courses that Dr. Resop teaches in the MS GIS program:

GEOG654 (GIS and Spatial Modeling), GEOG656 (Programming and Scripting for GIS), GEOG660 (Advanced Remote Sensing with Lidar), GEOG797 (Capstone Project)

Dr. Eunjung Lim, Full-Time, Professional Track

Dr. Lim earned a Ph.D degree in Geography (GIS specialty) from the State University of New York at Buffalo. Her specialty is geographic information sciences. In the realm of GIS, she has developed special interest and knowledge in GIS modeling, programming, network analysis, and spatial statistics. She has about 12 years of experience developing software using Java, C, C++, Visual Basic and relational databases.

The courses that Dr. Lim teaches in the MS GIS program:

GEOG650 (Mobile GIS), GEOG651 (Spatial Statistics), GEOG656 (Programming and Scripting for GIS), GEOG657 (Web Programming), GEOG797 (Capstone Project)

Dr. Rejanne Le Bivic, Full-Time, Professional Track

Dr. Le Bivic is a Lecturer in the Department of Geographical Sciences at the University of Maryland. She earned her Ph.D. University of Western Brittany. During the PhD she focused on using Remote Sensing data to quantify the erosion processes in a volcanic tropical island: La Reunion, in the Indian Ocean. This led her to use a very broad range of data, from Terrestrial LiDAR, to aerial imagery, drone imagery and DGPS in a very remote area.

The courses that Dr. Le Bivic teaches in the MS GIS program:

GEOG652 (GIS and Spatial Modeling), GEOG646 (Introduction to Computer Programming for GIS), GEOG660 (Advanced Remote Sensing with Lidar), GEOG797 (Capstone Project)

Dr. Naijun Zhou, Full-Time, Professional Track

Dr. Zhou is a Senior Lecturer in the Department of Geographical Sciences at the University of Maryland. His teaching and research are focused on Web GIS, Databases, Geospatial semantics and ontology. His educational background includes BS in Photogrammetry and Remote Sensing, MS in GIS, Remote Sensing & Cartography, MS in Computer Science, and PhD in GIScience from the University of Wisconsin.

The courses that Dr. Zhou teaches in the MS GIS program:

GEOG652 (Digital Image Processing and Analysis), GEOG655 (Spatial Databases)

DATE: September 18, 2018

TO: Dr. Kathleen Stewart
Director of the Center for Geospatial Information Sciences
Department of Geographical Sciences

Dr. Jianguo Ma
MPS Program Director, Center for Geospatial Information Sciences
Department of Geographical Sciences

CC: Daniel Mack, Associate Dean of Collections, UMD Libraries
Maggie Saponaro, Head, Collection Development, UMD Libraries

FROM: Kelley O’Neal, GIS and Spatial Data Librarian, UMD Libraries

RE: Library Resources to Support New Program – a Master of Science in Geospatial Information Sciences (MS GIS)

We are providing this assessment in response to a proposal by the Department of Geographical Sciences in the college of Behavioral and Social Sciences to create a Master of Science in Geospatial Information Sciences (MS GIS). The MS GIS program requested a collections resources assessment from the University of Maryland Libraries to determine how well the Libraries support the curriculum of this proposed program.

Serial Publications

The University of Maryland Libraries subscribe to a large number of scholarly journals, almost all in online format, focusing on Geospatial Information Science and related topics including:

Remote Sensing and Image Processing

Remote Sensing of Environment
ISPRS Journal of Photogrammetry and Remote Sensing
IEEE Transactions on Geoscience and Remote Sensing
International Journal of Applied Earth Observation and Geoinformation
IEEE Applied Earth Observations and Remote Sensing
IEEE Geoscience and Remote Sensing Letters
International Journal of Remote Sensing

Geographic Information Science (GISc)

International Journal of Geographical Information Science
Journal of Geographical Sciences
Transactions in GIS

Computers & Geosciences
Journal of Spatial Science
International Journal of Digital Earth
GeoInformatica
Computers, Environment and Urban Systems
The Cartographic Journal
Geographical Analysis
Cartographica: The International Journal for Geographic Information and Geovisualization

Big Data Analytics and Computation

Big Data and Society
Computational Intelligence: An International Journal
Advances in Artificial Intelligence
Data Mining and Knowledge Discovery
Neural Networks
IEEE Transactions on Neural Networks

In cases in which the Libraries do not subscribe to a particular journal of interest, articles within that journal likely will be available through Interlibrary Loan.

In addition to subscriptions, the following open access journals are another valuable resource to the Master of Science in Geospatial Information Science program:

Remote Sensing
Public Library of Science One (PLOS One)
Journal of Spatial Information Science
International Journal of Spatial Data Infrastructures Research
Applied Computational Intelligence and Soft Computing

Databases

The Libraries' *Database Finder* (<http://www.lib.umd.edu/dbfinder>) resource offers online access to databases that provide indexing and access to scholarly journal articles, geospatial datasets, and other information sources. Databases relevant to the Master of Science in Geospatial Information Science program include:

Policy Map - Policy Map is a cloud-based GIS and geospatial data tool that provides access to over 15,000 indicators related to housing, crime mortgages, health, jobs, demographics, and education from more than 150 authoritative public and proprietary sources. Data is cleaned and standardized and updated regularly. The database includes basic GIS tools to create reports and maps.

Social Explorer - Social Explorer is a cloud-based GIS and geospatial data tool that provides access to demographic information about the United States from 1790 to present. Available data includes Census, Public Use Microdata Sample (PUMS), and American Community Survey (ACS). The database includes basic GIS tools to create reports, maps, and slide shows.

SimplyAnalytics – SimplyAnalytics is a cloud-based GIS and geospatial data tool that contains extensive data including demographic, historic census, business, health, real estate, housing, employment, consumer spending, and marketing (over 70,000 variables total). Users can create customized maps and reports. Data is available at the State, County, City, ZIP Code, Census Tract, and Block Group levels for custom trade areas and the entire United States.

LandScan Global Population Dataset - LandScan is a global population database that shows geographical distribution of population at one-kilometer resolution over an average 24 hour period. LandScan datasets are compiled annually using different information sources and analytical techniques and should ideally not be compared across years.

IEEE Xplore - Provides full-text access to IEEE transactions, journals, magazines and conference proceedings published since 1988 and all current IEEE Standards. Includes access to Bell Labs Technical Journal Archive (BLTJA) 1922-2015.

Encyclopedia of Statistical Sciences (Wiley) - Covers topics in statistics, biostatistics, quality control, economics, sociology, engineering, probability theory, computer science, biomedicine, psychology, survey methodology, and many other areas. Includes the full text of the first and second print editions, plus the supplemental volumes. The entries are self-contained and easily understood by readers with a limited statistical background.

Also four multi-disciplinary databases, *Academic Search Ultimate*, *Nexis Uni*, *ScienceDirect*, and *Web of Science*, are good sources of articles relevant to this topic.

In most cases, these indexes offer full text copies of the relevant journal articles. In those instances in which the journal articles are available only in print format, the Libraries can make copies available to graduate students through either the Libraries' Scan & Deliver Program or via Interlibrary Loan.

Monographs

The Libraries acquire scholarly monographs regularly in geographical sciences and geospatial science and technology along with allied subject disciplines. Monographs not already part of the collection can usually be added upon request.

Even though most library research for this course/program likely will rely upon online journal articles, students may wish to supplement this research with monographs. Fortunately, more and

more monographs are available as e-books. Even in instances when the books are only available in print, graduate students will be able to request specific chapters for online delivery through the Libraries' Scan & Deliver program (Note: see below).

A search of the University of Maryland Libraries' WorldCat UMD catalog (<http://www.lib.umd.edu>) was conducted, using a variety of relevant subject terms. This investigation yielded sizable lists of citations of books that we own. I provide here some example subjects within the field of geospatial information sciences, title counts for those subjects, and some example monographs available within our holdings.

Geographic Information Systems (GIS) = 1,666

- Imagery and GIS: best practices for extracting information from imagery (e-book) 2017
- Geographic information science & systems (print) 2015
- Geographic information systems in action (e-book) 2017
- Geographic information systems (GIS): techniques, applications and technologies (e-book) 2014
- Geographic information systems (GIS) for disaster management (e-book) 2015

Mobile GIS = 22

- Information fusion and geographic information systems (IF & GIS' 2015): deep virtualization for mobile GIS (e-book) 2015
- Building web and mobile ArcGIS Server applications with JavaScript: master the ArcGIS API for Java Script, and build exciting, custom web and mobile GIS applications with the ArcGIS Server (e-book) 2014
- Geospatial computing in mobile devices (print) 2014

Web GIS = 26

- Mastering ArcGIS Enterprise Administration (e-book) 2017
- Getting to know web GIS (print) 2016
- ArcGIS for JavaScript Developers by Example (e-book) 2016
- Tile-based geospatial information systems: principles and practices (e-book) 2010

Remote Sensing = 4,590

- Earth observation open science and innovation (e-book) 2018
- Urban remote sensing (e-book) 2018
- Satellite Earth observations and their impact on society and policy (e-book) 2017
- Remote Sensing of Aerosols, Clouds, and Precipitation (e-book) 2017
- Remote sensing image fusion: a practical guide (e-book) 2017

Image Processing = 4,851

Digital image processing (print) 2018
Automatic Target Recognition (e-book) 2018
Digital Image Processing and Analysis with MATLAB and CVIPtools, Third Edition (e-book) 2017
Multisensor Image Fusion and Data Mining for Environmental Remote Sensing (e-book) 2017

Spatial Statistics = 112

Spatial Analytics with ArcGIS (e-book) 2017
Spatial econometrics (e-book) 2017
Computational and statistical methods for analysing big data with applications (e-book) 2016
Stochastic geometry, spatial statistics and random fields: models and algorithms (print) 2015

Network Analysis = 1,113

Environment, Politics and Society (e-book) 2018
Networks of international trade and investment: understanding globalization through the lens of network analysis (print) 2018
GIS and the social sciences: theory and applications (e-book) 2018
Sociometrics and human relationships: analyzing social networks to manage brands, predict trends, and improve organizational performance (e-book) 2017

Big Data Analytics = 121

Practical big data analytics: hands-on techniques to implement enterprise analytics and machine learning using Hadoop, Spark, NoSQL and R (e-book) 2018
Big data analytics: tools and technology for effective planning (print) 2018
Earth observation open science and innovation (e-book) 2018
Big Data Analytics with Hadoop 3 Build highly effective analytics solutions to gain valuable insight into your big data (e-book) 2018

Python = 812

Beginning Data Analysis with Python And Jupyter Use powerful industry-standard tools to unlock new, actionable insight from your existing data (e-book) 2018
Hands-On Data Analysis with NumPy and Pandas Implement Python Packages from Data Manipulation to Processing (e-book) 2018
Hands-On Automated Machine Learning A beginner's guide to building automated machine learning systems using AutoML and Python (e-book) 2018

Mastering Geospatial Analysis with Python Explore GIS processing and learn to work with GeoDjango, CARTOframes and MapboxGL-Jupyter (e-book) 2018

ArcPy = 10

ArcPy and ArcGIS - Second Edition (e-book) 2017

Introduction to GIS programming and fundamentals with Python and ArcGIS (print) 2017

ArcPy and ArcGIS, geospatial analysis with python: use the ArcPy module to automate the analysis and mapping of geospatial data in ArcGIS (e-book) 2015

Python for ArcGIS (print) 2015

Programming ArcGIS with Python cookbook: over 85 hands-on recipes to teach you how to automate your ArcGIS for Desktop geoprocessing tasks using Python (e-book) 2015

A further search revealed that the Libraries' membership in the Big Ten Academic Alliance (BTAA) dramatically increases these holdings and citations. As with our own materials, graduate students can request that chapters be copied from these BTAA books if the books are not available electronically.

Geographic Information Systems (GIS) = 4,954

Mobile GIS = 44

Web GIS = 60

Remote Sensing = 12,287

Image Processing = 10,767

Spatial Statistics = 4,181

Network Analysis = 3,239

Big Data Analytics = 1,427

Python = 2,127

ArcPy = 11

Access Services: Scan & Deliver and Interlibrary Loan

These services offer online delivery of bibliographic materials that otherwise would not be available online. As a result, remote users who take online courses may find these services to be helpful. Scan & Deliver and Interlibrary Loan are available free of charge.

A special amenity for graduate students and faculty, the Scan & Deliver service scans and delivers journal articles and book chapters within three business days of the request--provided that the items are available in print on the UM Libraries' shelves or in microform. In the event that the requested article or chapter is not available on campus, Scan & Deliver will automatically refer the request to Interlibrary Loan (ILL). Interlibrary Loan is a service that enables borrowers to obtain online articles and book chapters from materials not held in the University System of Maryland.

Please note that one limitation of these services that might create some challenges for the online student is that the Libraries are not allowed to make online copies of entire books. The only way that a student can get access to a print copy of an entire book is to physically come to the Libraries and check out that book.

Additional Materials and Resources

In addition to serials, monographs and databases available through the University Libraries, students in the Master of Science in Geospatial Information Sciences will have access to a wide range of media, datasets, software, and technology. Library Media Services (<http://www.lib.umd.edu/lms>) houses media in a variety of formats that can be utilized both on-site and via ELMS course media. GIS datasets are available through the GIS and Spatial Data Center website (<http://www.lib.umd.edu/gis>) which includes the BTAA Geoportal (<https://geo.btaa.org/>). Statistical consulting and additional research support is available through the Research Commons (<http://www.lib.umd.edu/rc>) while technology support and services are available through the Terrapin Learning Commons (<http://www.lib.umd.edu/tlc>).

The subject specialist librarian for geographic information systems (GIS) and spatial data, Dr. Kelley O'Neal (kelleyo@umd.edu), also serves as an important resource to Geographical Sciences and the upcoming Master of Science in Geospatial Information Sciences program.

Other Research Collections

Because of the University's unique physical location near Washington D.C., Baltimore and Annapolis, University of Maryland students and faculty have access to some of the finest libraries, archives and research centers in the country vitally important for researchers in geospatial intelligence. These include the Library of Congress, the National Archives, National Agricultural Library, and the Smithsonian, to name just few.

Conclusion

With our substantial journals holdings and index databases, as well as additional support services and resources, the University of Maryland Libraries have resources to support teaching and learning in Geospatial Information Sciences. These materials are supplemented by a strong

monograph collection. Additionally, the Libraries' Scan & Deliver and Interlibrary Loan services make materials that otherwise would not be available online, accessible to remote users in online courses. As a result, our assessment is that the University of Maryland Libraries are able to meet the curricular and research needs of the proposed Master of Science in Geospatial Information Sciences program.

Budget Analysis: Graduate Certificate in Remote Sensing, MS GIS Program					
Program Revenue	AY 2021/22	AY 2022/23	AY 2023/24	AY 2024/25	AY 2025/26
I. Total Tuition Revenue	\$48,000	\$48,960	\$49,939	\$50,938	\$51,957
A. Total Professional Students (annually)	5	5	5	5	5
1. Fall Cohort Enrollment 1st Year of matriculation	5	5	5	5	5
B. Total Credits (annually)	12.0	12.0	12.0	12.0	12.0
1. Cohort Courses 1st Year of matriculation	12.0	12.0	12.0	12.0	12.0
C. Per course rate; Assumes 2% increase	\$800	\$816	\$832	\$849	\$866
Estimated Expenses	AY 2021/22	AY 2022/23	AY 2023/24	AY 2024/25	AY 2025/26
I. Total Instructional and Administration	\$3,500	\$3,585	\$5,142	\$5,215	\$5,290
A. Instructional Totals	\$0	\$0	\$0	\$0	\$0
1.Total Faculty Salaries [a x b]	\$0	\$0	\$0	\$0	\$0
a. Total paid instructors per year	0.0	0.0	0.0	0.0	0.0
b. Instructor salary; assumes a 3% annual increase	85,000	87,550	90,177	92,882	95,668
2. Fringe Benefits (30%)	0	0	0	0	0
B. Academic Administration Totals	\$2,000	\$2,040	\$2,081	\$2,122	\$2,165
C. Equipment, Materials and Supplies Totals	\$1,500	\$1,545	\$3,061	\$3,093	\$3,126
Estimated equipment	1,000	1,030	1,061	1,093	1,126
Materials & Supplies	500	515	2,000	2,000	2,000
II. Marketing	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000
Estimated Marketing (by academic unit)	2,000	2,000	2,000	2,000	2,000
SUBTOTAL: DIRECT PROGRAM EXPENSES	5,500	5,585	7,142	7,215	7,290
III. Campus Administrative Fee	\$7,200	\$4,896	\$7,491	\$7,641	\$7,794
15% of tuition revenue for OES administrative costs	7,200	4,896	7,491	7,641	7,794
Total Estimated Expenses	\$12,700.00	\$10,481.00	\$14,632.58	\$14,855.84	\$15,083.88
Total Estimated Program Revenue	\$48,000	\$48,960	\$49,939	\$50,938	\$51,957
Net Revenue	\$35,300	\$38,479	\$35,307	\$36,082	\$36,873

Note: The proposed Graduate Certificate program will be a part of the existing MSGIS program. The students will take courses currently being offered. Therefore, there will be almost no additional cost in terms of teaching and administration. It is equivalent to recruiting about 5 more students each

MS in Geospatial Information Sciences (MSGIS) Program
 Graduate Certificate in Remote Sensing

Assessment Plan

Student Learning Outcomes	Assessment Measures and Criteria	Assessment Schedule
1. Demonstrate continued retention of students and progress towards the graduate certificate completion.	Measure: Registrar’s Enrollment Records Criteria: The majority (>80%) of existing students will be enrolled for courses each academic year.	2022 and then on a yearly basis
2. Students will demonstrate comprehension of knowledge and skills related to remote sensing	Measure: Successful completion of required courses Criteria: The majority (> 80%) of students will achieve a cumulative GPA of 3.0 or above	2022 and then on a yearly basis
3. Demonstrate completion of the certificate program.	Measure: Registrar’s Graduation Records Criteria: The majority of students (>80%) will graduate within the five-year limit for graduate students.	2025 and then on a yearly basis
4. Students will assess the relevance of program content as it applies to their professional and educational needs. (The survey is web-based and students can submit their responses anonymously to encourage participation. The survey seeks to assess a student’s experiences in the MSGIS Program regarding the quality of	Measure: An exit interview will be conducted with graduates to assess their overall satisfaction with the program.	2025 and then on a yearly basis

courses, the general program, faculty, and staff. The survey also collects information on employment at graduation.)

Criteria: The majority (80%) of students will correlate academic program offerings to their needs.

Five-Year Enrollment Trends		
Year	Bowie State University	Hood College
	Geographical Information Systems and Image Processing, GC	Geographic Information Systems, GC
2014	Students admitted for the certificate program are also automatically admitted to the master's degree program; certificate program enrollment not included on MHEC report.	5
2015		3
2016		7
2017		7
2018		6
2019		3
Projected		
Five-Year Degree Recaps		
Year	Bowie State University	Hood College
	Geographical Information Systems and Image Processing, GC	Geographic Information Systems, GC
2014	Students admitted for the certificate program are also automatically admitted to the master's degree program; MHEC report has no data for degrees.	5
2015		3
2016		7
2017		7
2018		6
2019		3

OES In-House Market Research

Program Name = Remote Sensing, GC

Occupation	# of Jobs in the Field	Professional Salary Information	Projected Job Growth
Information from U.S. Bureau of Labor Statistics' Occupational Outlook Handbook			
Remote Sensing Scientists and Technologists	22,800 (2019)	\$109,910/year \$52.84 hourly	-2% (2019-2029)
Operational Research Analysts	105,100	\$84,810/year \$40.78/hour	25% (much faster than average)
Information from State of Maryland's Occupational and Industry Projections			
Remote Sensing Scientists and Technologists	2,290 (2018)	\$126,800/year	4% (2018-2028)
Operational Research Analysts	4,710 (2018)	\$98,760/year	27% (2018-2028)

<https://www.onetonline.org/link/summary/19-2099.01>

<https://www.bls.gov/ooh/math/operations-research-analysts.htm>