UNIVERSITY OF
MARYLAND
OFFICE OF THE PRESIDENT

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February 4, 2019

James D. Fielder, Jr.
Secretary of Higher Education
Maryland Higher Education Commission
6 N. Liberty Street
Baltimore, MD 21201

Dear Secretary Fielder:

I am writing to request approval for a new Master of Science program in Geospatial Information Sciences. The proposal for the new program is attached. I am also submitting this proposal to the University System of Maryland for approval.

The proposal was endorsed by the appropriate faculty and administrative committees. I also endorse this proposal and am pleased to submit it for your approval.

Sincerely,

Wallace D. Loh
President

MDC
cc: Antoinette Coleman, Associate Vice Chancellor for Academic Affairs
Mary Ann Rankin, Senior Vice President and Provost
Gregory Ball, Dean, College of Behavioral and Social Sciences

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MHEC
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Cover Sheet for In-State Institutions
New Program or Substantial Modification to Existing Program

Institution Submitting Proposal	University of Maryland, College Park

Each action below requires a separate proposal and cover sheet.

- (●) New Academic Program
- ( ) New Area of Concentration
- ( ) New Degree Level Approval
- ( ) New Stand-Alone Certificate
- ( ) Off Campus Program
- ( ) Substantial Change to a Degree Program
- ( ) Substantial Change to an Area of Concentration
- ( ) Substantial Change to a Certificate Program
- ( ) Cooperative Degree Program
- ( ) Offer Program at Regional Higher Education Center

Payment Submitted: ( ) Yes (●) No	Payment Type: ( ) R*STARS (●) Check	Payment Amount: 850	Date Submitted:

Department Proposing Program	Geographical Sciences	
Degree Level and Degree Type	Master of Science	
Title of Proposed Program	Geospatial Information Sciences	
Total Number of Credits	31	
Suggested Codes	HEGIS: 220601.00	CIP: 45.0702
Program Modality	(●) On-campus ( ) Distance Education (*fully online*) ( ) Both	
Program Resources	(●) Using Existing Resources ( ) Requiring New Resources	
Projected Implementation Date	(●) Fall ( ) Spring ( ) Summer	Year: 2019
Provide Link to Most Recent Academic Catalog	URL: https://academiccatalog.umd.edu/	
Preferred Contact for this Proposal	Name: Michael Colson	
	Title: Senior Coordinator for Academic Programs	
	Phone: (301) 405-5626	
	Email: mcolson@umd.edu	
President/Chief Executive	Type Name: Wallace D. Loh	
	Signature: [signature]	Date: 02/04/2019
	Date of Approval/Endorsement by Governing Board:	

Revised 12/2018

A. Centrality to the University's Mission and Planning Priorities

Description.
For the last decade, the University of Maryland has been offering an iteration of its Master of Professional Studies (MPS) in Geospatial Information Sciences (GIS). The MPS is an approved "umbrella" degree program created in 2005 to allow for nimble changes in graduate level training for working professionals. The purpose of this proposal is to move the existing curriculum out from under the Master of Professional Studies umbrella and to create a standalone Master of Science degree program, allowing it to be classified as a STEM program through a more appropriate federal CIP ("classification of instructional programs") designation. Giving a proper CIP classification to the curriculum will help attract more highly skilled domestic and international students. For domestic students, the STEM designation will enhance their application for scholarships and career improvement. For international students, the extra optional practical training (OPT) term, allowed by the Department of Homeland Security for specific STEM-designated programs, will benefit their future job searches.

GIS is a software application system that has a wide range of application areas such as transportation logistics, network analysis, emergency management, urban planning, environmental research, etc. Demand for well-trained GIS professionals is growing much faster than supply. Trained individuals are needed at multiple levels – from certified entry-level technicians to Ph.D. research scientists. In the Washington DC metropolitan area, there is a high concentration of government agencies and various organizations which have high demand for skilled GIS professionals. Because of its unique location, UMD has a responsibility to provide this kind of quality education and training in Maryland and the greater Washington D.C. metropolitan area.

Relation to Strategic Goals. The GIS curriculum relates to UMD's strategic goals by adding to its STEM program offerings, particularly in an area in which the campus already has significant strength. UMD's department of Geographical Sciences has a research program that is recognized nationally and internationally for its leadership in land remote sensing and allied GIS applications. The department's undergraduate program has more than doubled in size since the introduction of our Geographic Information Systems and Automated Cartography focus in the early 1990's. This professional master's program takes advantage of the department's expertise and facilities.

Funding. Resources for the program are drawn from tuition revenue and are adequate to support program needs.

Institutional Commitment. The program will be administered (as it currently is now) by the Department of Geographical Sciences within the College of Behavioral and Social Sciences. Since the program already exists as Professional Studies iteration, the department has the administrative, instructional, advising, and facilities infrastructure in place to operate the program. In the event that the program is discontinued, the courses will be offered for a reasonable time period so that enrolled students can finish the program. The faculty and administrative infrastructure will still be in place to work with students who have not finished the program.

B. Critical and Compelling Regional or Statewide Need as Identified in the State Plan

Need. The U.S. Department of Labor has identified geospatial technologies as one of the three most important emerging and evolving fields, along with nanotechnology and biotechnology. Introduction of a Master of Science in Geospatial Information Sciences (MS GIS) is part of a larger trend nationally and internationally. Prior to the initial launch of the curriculum in 2008, a market analysis concluded that Geospatial Information Sciences as a field has been experiencing rapid growth. It is used heavily in the federal government, and is growing quickly in state, county, and local government. More importantly, the success of the existing GIS curriculum within the MPS umbrella program has demonstrated market demand. Since 2008, the MPS GIS program has grown from 10 students a year into a current enrollment of about 40-50 students a year.

State Plan. The proposed program aligns with the *Maryland State Plan for Postsecondary Education's* emphasis on success and innovation by connecting students with the innovative technologies needed for careers in geospatial information sciences. Students have access to two 25-seat GIS labs equipped with dual-monitor high-end workstations and connected to remote storage facilities. Students are also able to work from virtual desktops and servers supported by a VMware environment. 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. For high-performance computing (HPC), the department's Center for Geospatial Information Science maintains two high-performance Hadoop-based computing clusters that have been purchased for research and student teaching. These clusters are networked to other HPC resources in the Geographical Sciences department, the College of Behavioral and Social Sciences (the "BSWIFT" cluster), and the University of Maryland Institute for Advanced Computer Studies (UMIACS), which operates several clusters. In partnership with the Mid-Atlantic Crossroads (MAX), the department also has high-performance networking access to other HPC sites around the country, as well as nimble access to commercial computing resources (Amazon AWS).

C. Quantifiable and Reliable Evidence and Documentation of Market Supply and Demand in the Region and 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, as growing "much faster than average" between 2016-2026.[1] 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.[2]

[1] US Bureau of Labor Statistics. (September 6, 2018). Occupational Outlook Handbook: Cartographers and Photogrammetrists. Retrieved from: https://www.bls.gov/ooh/architecture-and-engineering/cartographers-and-photogrammetrists.htm.

[2] US Bureau of Labor Statistics. (March 30, 2018). Occupational Employment and Wages, May 2017 - 19-3092 Geographers. Retrieved from: https://www.bls.gov/oes/current/oes193092.htm#nat.

As the program currently exists as a Professional Studies iteration, its current enrollment provides of evidence of market demand. For the past three fall terms, enrollment has been more than 50 students. The program has high confidence that the enrollment of the proposed MS GIS program will be about 40-50 students per year. The STEM CIP designation will make the program more attractive to international students and it is therefore possible that the program may grow. However, the program does not intend to grow much beyond current enrollments (to no more than 60 students per year), in order to maintain a high quality experience for matriculated students.

D. Reasonableness of Program Duplication

Currently, three universities have similar programs in the State of Maryland. Johns Hopkins offers a Master of Science in GIS (http://advanced.jhu.edu/academics/graduate-degree-programs/geographic-information-systems). UMBC offers a 30-credit Master of Professional Studies and a 15-credit post-baccalaureate certificate in GIS at the Universities at Shady Grove (http://shadygrove.umbc.edu/gis). Salisbury University offers a Geographic Information Systems Management MS (https://www.salisbury.edu/explore-academics/programs/graduate-degree-programs/geo-info-sys-masters/index.aspx).

Our curriculum differs from these others programs in that it is focused on enterprise-level GIS, including topics such as remote sensing, computing, and statistics, with a broader spectrum than a traditional program. The goal of our program is to help students become GIS developers rather than GIS users.

Salisbury's program focuses on GIS management and is fully online. Johns Hopkins University's MS GIS program is also a fully online program. UMBC's GIS program is offered on-site at the Universities at Shady Grove with hybrid and in-person classes. UMD's existing program is face-to-face in College Park, with remote streaming of lecture material that allows participation by those for whom coming to the College Park campus is not convenient. Some laboratory instruction is required, and international students on F-1 visas are required to participate in person in order to comply with regulations by the United States Citizenship and Immigration Services (USCIS). The program is also offered on a 12-week term calendar, which is more attractive to working professionals.

Ultimately, the proposed program will not alter the market demand for these other programs, other than some international students, as our current MPS program has been recruiting and enrolling students since 2008.

E . Relevance to Historically Black Institutions (HBIs)

No such program currently exists at any of Maryland's Historically Black Institutions (HBIs).

F. Relevance to the identity of Historically Black Institutions (HBIs)

UMD has already established itself in the field of Geographical Sciences with its established undergraduate and graduate programs in geographical sciences. Accordingly, the proposed program would not have an impact on the uniqueness or institutional identity of any Maryland HBI.

G. Adequacy of Curriculum Design, Program Modality, and Related Learning Outcomes

Curricular Development. The existing MPS program has been operating successfully since 2008. The program's curriculum, which is not changing, was developed based on geospatial technology trends, demand for GIS professionals, and the growth of teaching and research areas within the department.

Faculty Oversight. The MS GIS program is overseen 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.

Educational Objectives and Learning Outcomes. Students who graduate from the **MS GIS** program will:

1. Understand the big picture of geospatial technology as a disciplinary field, including its history, current state, and trends in future developments;
2. Grasp 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 geospatial technology is applied to real-world problems;
4. Develop proficiency in the following specific knowledge and skills:
    a. collection, processing, analysis, modeling and visualization of spatial data;
    b. interpretation, analysis, design and implementation of spatial databases;
    c. processing and analysis of digital images;
    d. development of mobile GIS and native apps across mobile platforms (Android, iOS, etc.);
    e. interpretation and design of clearly structured programs using Python;
    f. development of client-side and server-side Web applications for non-GIS applications
    g. creation, analysis, and dissemination of GIS data and services via the Web using various technologies;
    h. spatial analysis, including enterprise GIS, spatial SQL, parallel processing, and display of GIS results on Internet, through open use of open-source software;
    i. development of applications of experimental semivariograms, semivariogram models,

kriging, cross validation, spatial sampling, and spatiotemporal pattern analysis;

j. analysis of big data with high performance computing, especially spatial data in large volume and high velocity;

5. Develop analytic thinking and real-world problem solving for future success in the workforce. Skills include but are not limited to interpersonal communications and teamwork, creative and critical thinking, occupational planning and organizing, problem-solving and decision making;
6. Design and develop a comprehensive and in-depth GIS project; and
7. Comprehend and apply ethical issues in geospatial practice and research, including ethical standards to protect data privacy, security, and copyright, among others.

See Appendix A for more information on learning outcomes assessment.

Institutional assessment and documentation of learning outcomes. Student learning outcomes assessment in graduate programs is directed by the Graduate Outcomes Assessment Committee. Established in 2011, this committee is comprised of representatives from each college and school. Graduate Outcomes Assessment reports for doctoral and master's programs are due every other year, with approximately half of the campus graduate programs reporting each year.

Course requirements. The curriculum will consist of 31 credits organized into the following categories:

- 22 credits of core courses
- 9 credits of elective courses

Geospatial Information Sciences Core Courses (22 credits)		
Course	Title	Credits
GEOG651	Spatial Statistics	3
GEOG652	Digital Image Processing and Analysis	3
GEOG653	Spatial Analysis	3
GEOG655	Spatial Database System	3
GEOG656	Programming and Scripting for GIS	3
GEOG657	Web Programing	3
GEOG795	Professional Practices Seminar	1
GEOG797	Professional Project (Capstone)	3

Geospatial Information Sciences Elective Courses (9 credits)		
Course	Title	Credits
GEOG650	Mobile GIS	3
GEOG654	GIS and Spatial Modeling	3
GEOG660	Advanced Remote Sensing Using Lidar	3
GEOG661	Fundamentals of Geospatial Intelligence	3
GEOG663	Big Data Analytics	3
GEOG670	Open Source GIS	3

GEOG677	Internet GIS	3
GEOG796	GIS Project Management	3

See Appendix B for course descriptions.

General Education. Not applicable as this is as a master's program.

Accreditation or Certification Requirements. There are no specialized accreditation or certification requirements for this program.

Other Institutions or Organizations. The department will not contract with another institution or non-collegiate organization for this program.

Student Support. As the program already exists as an iteration of the professional studies program, student support mechanisms are already in place. The Center for Geospatial Information Science provides a comprehensive and detailed webpage of resources for understanding curriculum, advising, technological needs (including the learning management system), relevant Graduate School policies, financial aid and cost and payment information. See https://geospatial.umd.edu/education/resources for more details.

Marketing and Admissions Information. The professional studies program iteration is clearly and accurately described in the university website: https://geog.umd.edu/graduate/mpsgis-0. This website will be updated for the Master of Science program upon approval.

H. Adequacy of Articulation

As a graduate program, articulation is not applicable.

I. Adequacy of Faculty Resources

Program faculty. As the program is already offered as an iteration of the professional studies program, faculty resources are already in place. The current MPS GIS program has three 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.

See faculty biographies in Appendix C for those currently expected to teach in the program.

Faculty training. The Teaching and Learning Transformation Center at the University of Maryland inspires and supports effective, engaging, efficient, and equitable teaching innovations among the university's instructors and assistants. This team provides faculty with training, resources, professional development activities, and individualized consultation to transform their classrooms and careers.

For the learning management system, faculty teaching in this program will have access to teacher development opportunities available across campus, including those offered as part of the Teaching

and Learning Transformation Center. For online elements of the coursework, instructors will work with the learning design specialists on campus to incorporate best practices when teaching in the online environment. Since all courses are delivered synchronously, the learning outcomes, assessments, and expected student participation are the same whether students are participating remotely or are physically present in the classroom. The existing MPS GIS Program has been using ELMS and video conferencing technologies to provide dynamic and interactive online teaching component since 2009. Program evaluation is the same for distance delivery and face-to-face delivery.

J. Adequacy of Library Resources

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

K. Adequacy of Physical Facilities, Infrastructure, and Instructional Resources

The program exists already as an iteration of the professional studies program, and currently 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. As noted in Section B of the proposal, the program also has access to multiple high-performance computing resources.

For online components of the program, UMD maintains an Enterprise Learning Management System (ELMS) for coursework. ELMS is a Web-based platform for sharing course content, tracking assignments and grades, and enabling virtual collaboration and interaction. The Geospatial Information Sciences program will use ELMS for all its courses. The Department of Geographical Sciences also maintains a Cisco WebEx Online course delivery platform, by which lectures and discussions can be streamed virtually. Faculty, staff, and students can communicate in real-time using chat, voice (microphone and speakers), and video (webcam) with WebEx. WebEx allows for the ability to display presentations, annotate overtop slides, perform live editing of documents and even conduct a poll within the software. The Department maintains two dedicated servers and shared storage for server-side delivery of GIS software. All students have access to the UMD email system.

L. Adequacy of Financial Resources

Tables 1 and 2 contain the details of resources and expenditures. Tuition revenue, with some modest investment from the Center for Geospatial Information Science, is sufficient to cover the cost of offering the program.

M. Adequacy of Program Evaluation

Formal program review is carried out according to the University of Maryland's policy for Periodic Review of Academic Units, which includes a review of the academic programs offered by, and the research and administration of, the academic unit (http://www.president.umd.edu/policies/2014-i-600a.html). Program Review is also monitored following the guidelines of the campus-wide cycle of Learning Outcomes Assessment (https://www.irpa.umd.edu/Assessment/LOA.html). Faculty within the department are reviewed according to the University's Policy on Periodic Evaluation of Faculty Performance (http://www.president.umd.edu/policies/2014-ii-120a.html). Since 2005, the University has used an online course evaluation instrument that standardizes course evaluations across campus. The course evaluation has standard, university-wide questions and also allows for supplemental, specialized questions from the academic unit offering the course.

N. Consistency with Minority Student Achievement goals

The current MPS GIS program has been very successful in recruiting and retaining a diverse student body since 2008. This new MS GIS program will draw on the previous experiences and with continued exploration of new opportunities for further improvement. The program recruits in person at professional conferences and by visiting undergraduate courses. The program also advertises online. Since many students are working professionals, the program networks with governmental agencies and private companies. 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. UMD has stated goals for recruiting and graduating a diverse population of graduate students in its strategic plan for diversity. The Graduate School works with programs on recruiting and graduating diverse populations. Furthermore, "the provost and Graduate School will consider the success of its programs in recruiting and graduating a diverse population of graduate students when allocating institutional financial support to programs, departments, and colleges and schools."[3]

O. Relationship to Low Productivity Programs Identified by the Commission

N/A

P. Adequacy of Distance Education Programs

N/A

[3] University of Maryland, College Park. (September 16, 2010). *Transforming Maryland: Expectations for Diversity and Inclusion.* (p. 20). Retrieved January 28, 2019 from: http://www.provost.umd.edu/Documents/Strategic_Plan_for_Diversity.pdf.

Appendix A: Learning Outcomes Assessment

The learning outcomes of students graduated from the MS GIS program include:

1. Can see the big picture of geospatial technology as a discipline field with a good understanding of its history, current state, and future development trend.
2. Grasp of the connections among different geospatial technology components such as GIS, remote sensing, computing, and emerging software and hardware options, e.g. drones and artificial intelligence.
3. A good understanding of how geospatial technology is applied in solving real-world problems.
4. Proficient in the following specific knowledge and skills:
    a. Collect, process, analyze, model and visualize spatial data
    b. Interpret, analyze, design and implement spatial databases
    c. Process and analyze digital images
    d. Develop mobile GIS and native apps across mobile platforms (Android, iOS, etc.)
    e. Interpret and design clearly structured programs using Python
    f. Develop client-side and server-side Web applications for non-GIS applications
    g. Create, analyze, and disseminate GIS data and services via the Web using [various technologies]
    h. Conduct spatial analysis, including enterprise GIS, spatial SQL, parallel processing, and display of GIS results on Internet, through open use of open-source software
    i. Develop applications of experimental semivariograms, semivariogram models, kriging, cross validation, spatial sampling, and spatiotemporal pattern analysis
    j. Analyze big data with high performance computing, especially spatial data in big volume and velocity
5. Training of analytic thinking and real-world problem solving for future success in the workforce. Skills include but are not limited to interpersonal communications and teamwork, creative and critical thinking, occupational planning and organizing, problem-solving and decision making.
6. Design and develop a comprehensive and in-depth GIS project.
7. Comprehend and apply ethical issues in geospatial practice and research, including ethical standards to protect data privacy, security, and copyright, among others

To help students achieve these outcomes, the MS GIS program will make great efforts in the following three areas:

1. Curriculum
    a. The curriculum must be cutting-edge and provide the most updated information to the students. The MS GIS course materials will be frequently upgraded to keep up with the advancement of geospatial technology in terms of both software and hardware.
    b. The curriculum must be more than just GIS and should be broad enough to encompass topics such as remote sensing, and increasingly computing. We will try to add new topics such as data science and drones.
    c. More elective courses will be developed and offered in the MS GIS Program. This will help meet specific interest or needs of students, which in turn will improve learning satisfaction.

2. Teaching format
    a. We will provide teaching in both on-site and online format. This will ensure the students to attend the real lectures in real time no matter which option they will choose. This dynamic and interactive teaching environment will definitely improve their learning experiences and effectiveness.
    b. All the lectures and lab session are video archived. This will allow students to review these materials repeatedly when needed until they fully understand the course materials. These video archives can also be saved for later reference. Therefore, this teaching technology can help improve students' learning and also retain the knowledge.
3. Resources for teaching and learning
    a. We will help students improve their learning experiences by providing a variety of resources. Besides, instructors, Teaching Assistants are available to help students in each class.
    b. Instructors are encouraged to attend academic conferences and also conduct research. This will help instructors to gain the updated knowledge and skills in the field, which in turn will benefit the students during the teaching process.
    c. Beyond the MS GIS Program, students will have access to all the teaching and research resources in the Department of Geographical Sciences. We encourage MS GIS students to participate in faculty's research projects whenever possible.

To assess the learning outcomes, we will evaluate students in a variety of ways:

1. Capstone project
    - The capstone project is one of the main culminating course experiences for the MS GIS program. Each capstone project will be evaluated in a dedicated review session and evidence of learning outcomes as they present in the projects will be assessed.
2. Exit interview
    - An exit interview will be conducted annually with a random sample of graduates (80%) to assess their overall satisfaction with the Program. Some of the interview questions can be designed specifically to help evaluate students' learning effectiveness and outcomes.
3. In-class observation
    - This assessment will be conducted through informal observations by instructors in the MS GIS program, as well as by faculty in the Department of Geographical Sciences. Unstructured (quick chats and check-ins) and structured (survey questions) data will be collected to support these observations.
4. Course Evaluation

The course evaluation report for each MS GIS class will be carefully analyzed to identify issues and also evaluate students' satisfaction to teaching and learning. Very often in their comments, students will describe their learning outcomes.

Appendix B: Course Descriptions

Core Courses

GEOG651 Spatial Statistics (3 Credits)
This course is about quantitative analysis of spatial data. It is intended to provide a broad survey of various spatial statistic methods. The course is geared towards helping students: (1) develop an understanding of the important theoretical concepts in spatial data analysis; and (2) gain practical experience in the application of spatial statistics to a variety of social and environmental problems using the advanced statistical software. This course covers five broad topical areas: (1) point pattern analysis; (2) area data analysis; (3) continuous data analysis; (4) spatial sampling; and (5) multivariate spatial and temporal analysis.

GEOG652 Digital Image Processing and Analysis (3 Credits)
Digital image processing and analysis applied to satellite and aircraft land remote sensing data. Consideration is given to preprocessing steps including calibration and georegistration. Analysis methods include digital image exploration, feature extraction thematic classification, change detection, and biophysical characterization. Example applications will be reviewed.

GEOG653 Spatial Analysis (3 Credits)
Methods of spatial analysis including measuring aspects of geometric features and identifying spatial patterns of geospatial objects that are represented as point, line, network, areal data, and 3-D surfaces.

GEOG655 Spatial Database (3 Credits)
This course is designed to help students understand, analyze, design, and implement spatial databases. While the basic concepts and theories of database will be introduced, the focus of this course will be on providing students with hands-on experiences to practice the technical skills used in spatial database design and implementation. SQL, Oracle, and ArcSDE are the key topics.

GEOG656 Programming and Scripting for GIS (3 Credits)
An introduction to programming and scripting for intermediate GIS users. The fundamental concepts of computer programming will be introduced within the Geoprocessing framework in ArcGIS primarily using Python. Basic concepts of object-oriented programming and scripting will be presented. Students will develop skills in programming techniques to explore, manipulate and model spatial data using the Geoprocessor methods.

GEOG657 Web Programming (3 Credits)
Intermediate course designed to teach students the techniques for Web development, particularly creating dynamic and data-driven Web applications. Introduces a high-level, object-oriented programming language such as VB.Net and the designing, coding, debugging, testing, and documenting for the development of Web-based applications. Other popular Web development tools such as DHTML, CSS and PHP are also covered.

GEOG795 Professional Practices Seminar (1 Credit)
Development and preparation of a resume, selecting and helping reference writers, conducting successful interviews, negotiating an employment package, giving professional presentations, proposal prepartion,

writing reports, codes of ethics and responsibilities. Presentations from practitioners in GIS field. Basic project management skills and strategies in preparation for professional project.

GEOG797 Professional Project (3 Credits)
Data and materials can originate from an internship (internal or external) or from relevant work experience with current employer. Under direction of faculty advisor, students will prepare a project report containing explanation of the requirements for the work, technical account of the activities undertaken, including literature review, description of methods and approaches taken, a critical discussion of results, along with conclusions and recommendations developed from the project. Final project will consist of a full-fledged GIS application that is up and running and can be tested, providing potential employers with a portfolio demonstrating student's ability to manage and develop a GIS application in real world situations.

Elective Courses

GEOG650 Mobile GIS (3 Credits)
This course covers how to create, test, and publish mobile GIS applications that work across multiple platforms (Android, iOS, and Black Berry Tablet OS) and adapt to a smartphone or tablet display.

GEOG654 GIS and Spatial Modeling (3 Credits)
Provide foundations and understanding on various issues related to modeling and simulation in GIS context. It will addresses the concepts, tools, and techniques of GIS modeling, and presents modeling concepts and theory as well as provides opportunities for hands-on model design, construction, and application. The focus will be on raster-based modeling. This course is also application-orientated, particularly in these fields such as terrain modeling, LULC modeling, hydrological modeling, suitability modeling, etc.

GEOG660 Advanced Remote Sensing using Lidar (3 Credits)
Lidar, also known as laser scanning, is an active remote sensing tool that can produce high-resolution point clouds. Lidar is being applied to problems such as terrain modeling, biomass estimation, change detection, feature extraction, and measuring tree canopy. Topics covered are fundamentals of lidar, current developments in lidar technology, and different applications where lidar is being used. Students will get hands-on learning about lidar data management, processing, and analysis.

GEOG661 Fundamentals of GEOINT (3 Credits)
Geospatial Intelligence (GEOINT) is the collection, analysis, visualization and dissemination of geospatial information to support decision-making. This course introduces the fundamental knowledge required to become a successful GEOINT practitioner, including the history of the GEOINT discipline, the intelligence applications of remote sensing and Geographic Information Systems (GIS) technologies, and how GEOINT products are used to support national security and humanitarian missions. Upon completion of this course you will understand the roles that technology, policy, doctrine, government, and industry play in shaping the Geospatial Intelligence discipline, and develop the technical knowledge and domain expertise to create basic GEOINT products that provide context for decision makers.

GEOG663 Big Data Analytics (3 Credits)

Designed to introduce statistical analysis over big data sets (and tackling big data problems), primarily in geography and spatial sciences, but with broader appeal throughout the socio-behavioral sciences. Students will be introduced to a range of methods that can be applied to the exploration, modeling, and visualization of big quantitative data. This course explores data fusion, statistical analysis, and data-mining for geospatial and non-geospatial data in structured and unstructured form, with an emphasis on large silos of data across diverse sources and assumptions. Topics will include open sourcing, metadata schemes, data standards and models, data-access, data-mining, clustering methods, classifiers, data reduction, machine learning, filtering schemes, real-time and streaming data, archiving and preservation, and handling uncertainty.

GEOG670 Open Source GIS (3 Credits)
An exploration of techniques for using Free and Open Source Software for GIS (FOSS4g) from conception to final presentation of results. Advanced concepts and techniques including enterprise GIS, spatial SQL, parallel processing, and displaying the results of GIS analysis over the Internet will also be covered.

GEOG677 Internet GIS (3 Credits)
Online course delivers information on the use of GIS applications on the Internet. Covers hardware/software structure of the Internet, the means for communicaton between Internet-connected devices, applications that provide GIS program and data, and performance and security concerns.

GEOG796 GIS Project Management (3 Credits)
Project management methodology is covered, emphasizing implementing and integrating GIS into broader projects. Topics include project initiation, planning, scope, scheduling, budgeting and risk management.

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. 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)

Table 1: Resources

Resources Categories	Year 1	Year 2	Year 3	Year 4	Year 5
1.Reallocated Funds	$0	$0	$0	$0	$0
2. Tuition/Fee Revenue (c+g below)	$902,720	$920,774	$939,190	$957,974	$977,133
a. #FT Students	0	0	0	0	0
b. Annual Tuition/Fee Rate	$17,208	$17,724	$18,256	$18,804	$19,368
c. Annual FT Revenue (a x b)	$0	$0	$0	$0	$0
d. # PT Students	40	40	40	40	40
e. Credit Hour Rate	$728	$743	$757	$773	$788
f. Annual Credit Hours	31	31	31	31	31
g. Total Part Time Revenue (d x e x f)	$902,720	$920,774	$939,190	$957,974	$977,133
3. Grants, Contracts, & Other External Sources	$0	$0	$0	$0	$0
4. Other Sources	$0	$0	$0	$0	$0
TOTAL (Add 1 - 4)	**$902,720**	**$920,774**	**$939,190**	**$957,974**	**$977,133**

Student enrollments are a mix of full-time and part-time, but for ease of computation, enrollments are identified as part time and tuition revenue is computed on a per credit-hour basis.

Table 2: Estimated expenditures

Expenditure Categories	Year 1	Year 2	Year 3	Year 4	Year 5
1. Faculty (b+c below)	$339,150	$349,325	$359,804	$370,598	$381,716
a. #FTE	3.0	3.0	3.0	3.0	3.0
b. Total Salary	$255,000	$262,650	$270,530	$278,645	$287,005
c. Total Benefits	$84,150	$86,675	$89,275	$91,953	$94,712
2. Admin. Staff (b+c below)	$133,000	$136,990	$141,100	$145,333	$149,693
a. #FTE	1.0	1.0	1.0	1.0	1.0
b. Total Salary	$100,000	$103,000	$106,090	$109,273	$112,551
c. Total Benefits	$33,000	$33,990	$35,010	$36,060	$37,142
3. Total Support Staff (b+c below)	$89,110	$91,783	$94,537	$97,373	$100,294
a. #FTE	1.0	1.0	1.0	1.0	1.0
b. Total Salary	$67,000	$69,010	$71,080	$73,213	$75,409
c. Total Benefits	$22,110	$22,773	$23,456	$24,160	$24,885
4. Graduate Assistants (b+c)	$148,832	$153,297	$157,896	$162,633	$167,512
a. #FTE	4.0	4.0	4.0	4.0	4.0
b. Stipend	$80,000	$82,400	$84,872	$87,418	$90,041
c. Tuition Remission	$68,832	$70,897	$73,024	$75,215	$77,471
5. Equipment	$10,000	$10,300	$10,000	$10,000	$10,000
6. Library	$0	$0	$0	$0	$0
7. New or Renovated Space	$0	$0	$0	$0	$0
8. Other Expenses: Operational Expenses	$152,408	$155,116	$157,878	$160,696	$163,570
TOTAL (Add 1 - 8)	**$872,500**	**$896,811**	**$921,215**	**$946,633**	**$972,785**

The Program director, who also teaches in the program, is included as Administrative Staff. Support staff includes a program coordinator. Equipment includes periodic turnover of computing equipment used in the instructional laboratories. Other expenses include marketing, materials and supplies, and centrally provided administrative expenses computed at 15% of tuition revenue.