**UNIVERSITY SENATE** | **LEGISLATION APPROVAL | #18-19-26**

**Approved by the Senate on February 5, 2019**

# PCC Proposal to Establish a Master of Science in Geospatial Information Sciences (Senate Document #18-19-26)

**TO** **Wallace D. Loh | President**

**FROM** **Christopher Walsh | Chair, University Senate**

I am pleased to forward the accompanying legislation for your consideration and approval. Janna Bianchini, Chair of the Programs, Curricula, & Courses Committee, presented the PCC Proposal to Establish a Master of Science in Geospatial Information Sciences (Senate Document #18-19-26), which the University Senate approved at its meeting on February 5, 2019. Please inform the Senate of your decision and any administrative action related to your conclusion.

**Approved:**  **Date:** **02-12-2019**

**Wallace D. Loh**
**President**

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

**Mary Ann Rankin**, Senior Vice President and Provost
**Reka Montfort**, Executive Secretary and Director, University Senate
**Michael Poterala**, Vice President and General Counsel
**Cynthia Hale**, Associate Vice President for Finance and Personnel
**John Bertot**, Associate Provost for Faculty Affairs
**Elizabeth Beise**, Associate Provost for Academic Planning & Programs
**Sylvia B. Andrews**, Academic Affairs
**Gregory Ball**, Dean, College of Behavioral and Social Sciences
**Jack Ma**, Director of MPS Program, Center for Geospatial Information Science
**Janna Bianchini**, Chair of the Programs, Curricula, & Courses Committee
**Michael Colson**, Senior Coordinator for Academic Programs

# Establish a Master of Science in Geospatial Information Sciences (PCC 18050)

| | |
|---|---|
| **PRESENTED BY** | **Janna Bianchini, Chair, Senate Programs, Curricula, and Courses Committee** |
| **REVIEW DATES** | **SEC – January 28, 2019 \| SENATE – February 5, 2019** |
| **VOTING METHOD** | **In a single vote** |
| **RELEVANT POLICY/DOCUMENT** | **N/A** |
| **NECESSARY APPROVALS** | **Senate, President, University System of Maryland Board of Regents, and Maryland Higher Education Commission** |

## ISSUE

The Department of Geographical Sciences within the College of Behavioral and Social Sciences (BSOS) proposes to establish a Master of Science degree program in Geospatial Information Sciences. This program exists currently as an iteration of the Master of Professional Studies (MPS) program. The 31-credit program has been in operation since 2007. The Master of Professional Studies program was approved in 2005 by the University System of Maryland Board of Regents and Maryland Higher Education Commission to allow for the expedited approval of curricula that respond to changing market needs of working professionals. Once a new iteration of the MPS is approved through campus PCC review, it only needs approval by the USM Chancellor to become official.

A limitation of offering the program as an MPS iteration is that all Professional Studies programs must use the same generic Federal Classification of Instructional Programs (CIP) code rather than a CIP code that accurately describes the program content. Searches that use CIP codes to find program offerings will not find the discipline-specific iteration, which reduces market visibility. Moreover, some CIP codes are designated as “STEM” eligible by the Department of Homeland Security, and international students with F1 visas who graduate from STEM designated programs may continue to work in the United States for two years longer than students in non-STEM designated programs. The generic CIP code for Professional Studies programs does not qualify as STEM-designated, even if the academic content of the Professional Studies program is STEM-related.

Consequently, the Geographical Sciences Department proposes to transition the program from a Master of Professional Studies program to a stand-alone Master of Science program in order to be classified more accurately. No changes are proposed to the program curriculum or administration. In a separate proposal, Geographical Sciences is proposing to convert its Professional Studies program in Geospatial Intelligence to a stand-alone program. The Economics Department is also proposing to convert its Master of Professional Studies program in Applied Economics to a stand-alone program in a separate proposal.

The Geospatial Information Sciences program provides advanced education in geospatial technology, theory and applications. The courses cover spatial analysis, spatial statistics, remote

sensing, computer programming, spatial databases, geographic information systems (GIS) modeling, Web GIS, mobile GIS, big data analytics, and open source GIS.

The curriculum consists of 22 credits of core courses and 9 credits from a list of eligible GEOG courses. The core courses are as follows:

- GEOG651 Spatial Statistics (3 credits)
- GEOG652 Digital Image Processing and Analysis (3 credits)
- GEOG653 Spatial Analysis (3 credits)
- GEOG655 Spatial Database System (3 credits)
- GEOG656 Programming and Scripting for GIS (3 credits)
- GEOG657 Web Programming (3 credits)
- GEOG795 Professional Practices Seminar (1 credit)
- GEOG797 Professional Project (3 credits)

The elective course list is as follows:

- GEOG650 Mobile GIS (3 credits)
- GEOG654 GIS and Spatial Modeling (3 credits)
- GEOG660 Advanced Remote Sensing using Lidar (3 credits)
- GEOG661 Fundamentals of Geospatial Intelligence (3 credits)
- GEOG663 Big Data Analytics (3 credits)
- GEOG670 Open Source GIS (3 credits)
- GEOG677 Internet GIS (3 credits)
- GEOG796 GIS Project Management (3 credits)

Through the program, students develop a proficiency in the collection, processing, analysis, modeling and visualization of spatial data. Students develop spatial databases, process digital images, design web and mobile applications, and use high performance computing for analysis of large sets of spatial data.

The program has been successful since its inception in 2008. Graduates have been able to find job placements in a variety of institutions including federal government agencies, local government, non-profit organizations, and private sectors.

This proposal was approved by the Senate Programs, Curricula, and Courses committee on December 7, 2018.

## RECOMMENDATION(S)

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

## COMMITTEE WORK

The committee considered this proposal at its meeting on December 7, 2018. Jack Ma, Director of the Master of Professional Studies Program in Geospatial Information Sciences, presented the proposal. The proposal was approved by the committee.

## ALTERNATIVES

The Senate could decline to approve this new degree program.

## RISKS

If the Senate declines to approve this degree program, the university will lose an opportunity to take an existing program and make it more attractive to international students by simply classifying the program more accurately.

## FINANCIAL IMPLICATIONS

There are no significant financial implications with this proposal as the program already exists as a Master of Professional Studies program.

**University of Maryland PCC**
**Program/Curriculum/Unit Proposal**

***PCC Log No:*** 18050

**Program:** Master of Science in Geospatial Information Sciences

**Department/Unit:** Geographical Sciences

**College/School:** BSOS

**Proposal Contact Person (with email):** Jianguo Ma, jma3@umd.edu

**Type of Action (check one):**

- ☐ Curriculum change (includes modifying minors, concentrations/specializations and creating informal specializations)
  - ☐ Curriculum change is for an LEP Program
- ☐ *Rename a program or formal Area of Concentration*
- ☐ *Establish/Discontinue a formal Area of Concentration*
- ☐ Other:
- ☒ *Establish a new academic degree/certificate program*
- ☐ Create an online version of an existing program
- ☐ Establish a new minor
- ☐ *Suspend/Discontinue a degree/certificate program*
- ☐ Establish a new Master or Certificate of Professional Studies program
  - ☐ New Professional Studies program will be administered by Office of Extended Studies

*Italics indicate that the proposal must be presented to the full University Senate for consideration.*

**Approval Signatures** - *Please print name, sign, and date. For proposals requiring multiple unit approvals, please use additional cover sheet(s).*

1. Department Committee Chair JULIE SHEVA 10/10/18
2. Department Chair Chris Justice 10/11/18
3. College/School PCC Chair for Karol Salton 11/9/18
4. Dean Wayne Mackay 11/9/18
5. Dean of the Graduate School (if required)
6. Chair, Senate PCC Janna Bianchini 12-7-18
7. University Senate Chair (if required)
8. Senior Vice President and Provost

**Instructions:**
When approved by the dean of the college or school, please send the proposal and signed form to the Office of the Associate Provost for Academic Planning and Programs, 1119 Main Administration Building, Campus-5031, **and** email the proposal document as an MSWord attachment to pcc-submissions@umd.edu.

**Summary of Proposed Action (use additional sheet if necessary):**
The proposed Master of Science in Geospatial Information Sciences (MSGIS) will replace the current Master of Professional Studies in Geospatial Information Sciences (MPSGIS) program, and continue to provide advanced education in the field of geospatial information sciences. This new MSGIS will have an appropriate STEM designation which 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 will benefit their job search. The success of these students will in turn strengthen the academic reputation of the MSGIS program and the University.

**Unit Code(s)** (to be entered by the Office of Academic Planning and Programs):

**Program: Master of Science in Geospatial Information Sciences**

**Date of Proposal: September 21, 2018**

**Start Term for New Program: Fall, 2019**

A new degree program proposal will need to be approved not just by campus but also by the University System of Maryland (USM) Board of Regents and the Maryland Higher Education Commission (MHEC). New certificate programs need to be approved by the USM Chancellor and MHEC. The following prompts are based on academic policies for programs and reflect campus requirements and MHEC requirements. The prompts also include questions frequently asked by review committees. See http://mhec.maryland.gov/institutions_training/Pages/acadaff/AcadProgInstitApprovals/NewAcademicProgramProposals.aspx for more information about MHEC requirements. Please feel free to add additional information at the end of this document or in a separate appendix.

## Mission and Purpose

**1. Describe the program and explain how it fits the institutional mission statement and planning priorities. The University Mission Statement and Strategic Plan can be found on this site: https://www.umd.edu/history-and-mission.**

The University of Maryland is committed to providing educational programs that meet the needs of a variety of audiences. The Department of Geographical Sciences proposes to establish a **Master of Science in Geospatial Information Sciences (MS GIS)** to provide advanced education and training in geospatial technology, theory and applications. The program aims to help students from nationwide learn the most up-to-date knowledge and skills of geographical information systems, remote sensing, and computing in general. A **Master of Professional Studies in Geospatial Information Sciences (MPS GIS)** program was established in 2007 to fulfill this very responsibility. In past 10 years, it has grown into one of the largest and also the best GIS programs in the US. This program is recognized as one of the Esri Development Centers (http://www.esri.com).

The proposed **MS GIS** program will replace the current **MPS GIS** program, and continue to provide advanced education in the field of geospatial information sciences. This new MS GIS will have an appropriate STEM designation which 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 will benefit their job search. The success of these students will in turn strengthen the academic reputation of the program and the University.

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, the University of Maryland has the responsibility of playing an important role and providing quality education and training to such work force in Maryland and the greater Washington D.C. metropolitan area.

## Program Characteristics

**2. 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 **MS GIS** program is designed to provide advanced education and training of the most up-to-date knowledge and skills of geospatial technology including GIS, remote sensing, and computing. The concentration of the program is on GIS application development and integration of GIS and remote sensing. This is very different from traditional GIS which is focused on desktop software application and typically does not require computer programming and development.

**3. What are the educational objectives of the program?**

The goal is to help students become GIS developers, instead of GIS users. Therefore, the MS GIS curriculum is beyond GIS and includes remote sensing, statistics, and computing as well. The topics cover spatial analysis, spatial statistics, programming and scripting, spatial databases, GIS modeling, remote sensing, Internet GIS, Mobile GIS, Big Data, and Open Source GIS.

Specifically the education objectives of the MS GIS program include but are not limited to:

1. Comprehend and apply concepts and practices of geographic information systems (GIS)
2. Comprehend and apply concepts and practices of remote sensing
3. Comprehend and apply concepts and issues related to modeling and simulation in the GIS context
4. Comprehend and apply concepts and practices of GIS application development on Web and mobile platforms
5. Comprehend and apply scripting and object-oriented programming with Python

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

The **MS GIS** program admission policies are based on that of the Graduate School of the University of Maryland. In addition, the Program has a set of specific admission criteria.

The admission criteria of the Graduate School include:

- The applicants should have earned a four-year baccalaureate degree or equivalent from an accredited institution.
- The applicants should have a minimum cumulative 3.0 GPA (on a 4.0 scale). Official transcripts of a post-secondary degree and a résumé are required along with the application.
- International applications must meet all requirements for international admissions, which have specific standards for academic credentials, language proficiency, financial support, visa requirements, etc. Refer to http://www.gradschool.umd.edu/admissions/international-admissions for process and requirements for international applications.

In addition to the admission criteria from the Graduate School, the MS GIS program also requires that applicants will have completed prerequisite courses in Geographic Information Systems and Remote Sensing

before their official enrollment. Students without this academic background may substitute with relevant professional experience in GIS field.

As required by the Graduate School, all application materials are to be submitted electronically:

- Graduate Application
- College or University Transcripts
- Statement of Purpose
- Letters of Recommendation
- Program/Department Supporting Documents
- Non-refundable application fee ($75) for each program to which an applicant applies

Completed applications are reviewed by an admissions committee in each graduate degree program. The recommendations of the committees are submitted to the Dean of the Graduate School, who will make the final admission decision. Students seeking to complete graduate work at the University of Maryland for degree purposes must be formally admitted to the Graduate School by the Dean. To ensure the integrity of the application process, the University of Maryland authenticates submitted materials through **iThenticate for Admissions**.

**5. Indicate the course requirements with course numbers, titles and credits. If applicable, indicate if any course will also count for a general education requirement. In an appendix, provide the course catalog information (credits, description, prerequisites, etc.) for all of the courses. Note that suffixed "selected" or "special" topics courses should be avoided. If suffixed-selected or special topics courses are offered regularly in the new program, you should make the courses permanent. Also, please review the basic requirements of degree programs or certificate programs to ensure that they meet the minimum policy requirements.**

**Please note: new courses or modifications to courses need to be submitted through the Testudo Curriculum Management system and will need to follow the normal VPAC course proposal review process. You may submit individual course changes to VPAC concurrently with the PCC proposal; however, the course changes may be held depending on the outcome of the PCC proposal.**

The proposed MS GIS program requires 31 credits to complete and offers **eight core courses** and **eight elective courses**.

| Course Type | Course # | Course Title | Credit |
|---|---|---|---|
| *Core* | 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 Programming | 3 |
| | GEOG795 | Professional Practice Seminars | 1 |
| | GEOG797 | Capstone Project | 3 |
| *Electiv e* | 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 |

Course Catalog Information is provided in Appendix A.

**6. 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 existing MPS GIS program has been operating successfully since 2008. We are proposing this MS GIS curriculum to continue the previous one based on:

- Geospatial technology trends
- Demand for GIS professionals
- Growth of teaching and research in the Department of Geographical Sciences
- Success of our current MPS GIS program

According to the U.S. Department of Labor, the geospatial technology industry can be defined as an information technology field of practice that acquires, manages, interprets, integrates, displays, analyzes, or otherwise uses data focusing on geographic, temporal, or spatial contexts. It incorporates tools such as aerial and satellite remote sensing imagery, global positioning systems (GPS), and computerized geographic information systems (GIS). The growth of Geospatial Information Sciences has underpinned the rejuvenation of the geography discipline, in the U.S. and internationally, over the last three decades.

The department of Geographical Sciences at the University of Maryland 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. The department of Geographical Sciences uses its accumulated experience to provide a cutting-edge master's degree for professionals; exploiting its unique academic profile within the Washington, D.C. region.

This new **MS GIS** program will replace the current MPS GIS program, with the same curriculum. The curriculum focuses on advanced geospatial information sciences and their related technologies such as remote sensing and computing.

The success of our current **MPS GIS** program has demonstrated that the demand for GIS professionals is indeed robust. The graduates from this program have been able to find job placements in a variety of institutions including federal government agencies, local government, non-profit organizations, and private sectors. Our program has been recognized as one of 33 Esri Development Centers worldwide.

**7. 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*.**

The **MS GIS** will be offered according to the newly established official 12-week calendar system. This allows working professionals or part-time students to concentrate on one or two courses at a time, which contributes to a better learning outcome. Students have the options to study full-time or part-time. A full-time student will mostly take two courses per term, while part-time students take one course per term.

The tables below provide different sample study plans.

**Master Degree Track (Fall Enrollment, Full Time)**

| Year | Fall | Winter | Spring | Summer |
|---|---|---|---|---|
| 1 | GEOG652 (Digital Image Processing and Analysis)<br><br>GEOG653 (Spatial Analysis) | GEOG656 (Programming and Scripting for GIS)<br><br>GEOG651 (Spatial Statistics) | GEOG657 (Web Programming)<br><br>GEOG655 (Spatial Database Systems) | GEOG795 (Professional Practice Seminars)<br><br>**Select one from the following:**<br>GEOG796 (GIS Project Management)<br>GEOG670 (Open Source GIS)<br>GEOG663 (Big Data Analytics) |
| 2 | **Select one from the following:**<br>GEOG654 (GIS and Spatial Modeling)<br>GEOG650 (Mobile GIS)<br>GEOG661 (Fundamentals of Geospatial Intelligence) | **Select one from the following:**<br>GEOG677 (Internet GIS)<br>GEOG660 (Advanced Remote Sensing) | GEOG797 (Capstone Project) | |

**Master Degree Track (Fall Enrollment, Part Time)**

| Year | Fall | Winter | Spring | Summer |
|---|---|---|---|---|
| 1 | GEOG653 (Spatial Analysis) | GEOG656 (Programming and Scripting for GIS | GEOG657 (Web Programming) | **Select one from the following:**<br>GEOG796 (GIS Project Management)<br>GEOG670 (Open Source GIS)<br>GEOG663 (Big Data Analytics) |
| 2 | GEOG652 (Digital Image Processing and Analysis) | GEOG651 (Spatial Statistics) | GEOG655 (Spatial Database Systems) | GEOG795 (Professional Practice Seminars) |

| | | | | |
|---|---|---|---|---|
| 3 | **Select one from the following:**<br>GEOG654 (GIS and Spatial Modeling)<br>GEOG650 (Mobile GIS)<br>GEOG661 (Fundamentals of Geospatial Intelligence) | **Select one from the following:**<br>GEOG677 (Internet GIS)<br>GEOG660 (Advanced Remote Sensing) | GEOG797 (Capstone Project) | |

**Graduate Certificate Track (Fall Enrollment)**

| Year | Fall | Winter | Spring | Summer |
|---|---|---|---|---|
| 1 | GEOG653 (Spatial Analysis) | GEOG656 (Programming and Scripting for GIS) | **Select one from the following:**<br>GEOG657 (Web Programming)<br><br>GEOG655 (Spatial Database Systems)<br><br>GEOG661 (Fundamentals of Geospatial Intelligence) | GEOG651 (Spatial Statistics) |

**8. Indicate whether the program will be offered either online or off-campus. Please note that MHEC requires a separate proposal for off-campus delivery. If the program will be offered exclusively online or will have both a face-to-face and online version of the program, please complete this additional form and add as an appendix:**
**https://docs.google.com/document/d/1ojpUBt4mAWlNPCiQNzZ48UH68zGPYj31TPgEOfW3q1E/**

While the **MS GIS** program is a face-to-face offering, provisions will be available for students to participate remotely due to their location or work schedule. All class material is presented in classrooms and then broadcast through streaming video using WebEx. Similarly, laboratory sessions may be attended physically, or students may access instruction remotely using video conferencing and virtual machine access to our software and data at UMD. Courses are scheduled in evenings (e.g. 5:30 pm - 8 pm) to accommodate working professionals. International students are required to attend physically in classrooms on the College Park campus. This is based on the F-1 student visa regulations by the United States Citizenship and Immigration Services (USCIS).

**9. If the program will be offered in a non-semester format, identify the term structure that will be used for the program:**

- **Approved Campus 12-Week Term (see Academic Calendars)**
- ***Non-Standard Term**

***If you are using a non-standard term structure, indicate whether relevant offices, such as the Registrar's Office and International Scholar & Student Services, have been notified and support the program. Non-standard terms need to fit within the university's scheduling system calendar, and non-standard terms need to work with international student visa requirements.**

**Term structure:**

The proposed **MS GIS** will be based on the approved campus 12-week term calendar. An academic year is composed of four terms (fall, winter, spring, and summer).

The following schedule outlines the 12-week terms for the academic year 2018-2019:

- fall term 8/26/2019 - 11/15/2019
- winter term 11/25/2019 - 2/19/2020
- spring term 2/27/2020 - 5/20/2020
- summer term 6/1/2020 - 8/21/2020

The detailed academic calendar is available at https://www.provost.umd.edu/calendar/index.html#.

**10. For Master's degree programs, describe the thesis requirement and/or the non-thesis requirement.**

The proposed **MS GIS** program requires the students complete a capstone project. Before taking the capstone project class, students must have completed all other 10 classes including core courses and electives. Students are required to apply the knowledge and skills they have learned in other classes to their capstone projects, which are comprehensive and in-depth research on the selected topics. The capstone project, a faculty-advised independent research project, is the culmination of the students' entire body of work, and is essential to determining whether the student has met a sufficient number of the required competencies. In addition to demonstrating problem-solving and critical thinking in one or more of the technical areas within the GIS domain, students must also take the initiative in planning and organizing this project and demonstrate that they can communicate effectively in writing and through the capstone project presentation.

**11. List the intended student learning outcomes. In an appendix, provide the plan for assessing these outcomes.**

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

1. Understand the big picture of geospatial technology as a disciplinary field, with a good understanding of its history, current state, and future development trend.
2. Grasp of the comections between different geospatial technology components such as GIS, remote sensing, computing, and emerging software aud 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.
7. Comprehend and apply ethical issues in geospatial practice and research, including ethical standards to protect data privacy, security, and copyright, among others

The plan for assessing these outcomes is provided in Appendix C.

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

Our 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.

Specifically, we use a variety of ways to recruit and retain students:

- Attend conferences that are related to geospatial technology. We have an exhibitor booth or present in the following conferences:
    - Esri Federal User Conference (It is annually held in Washington DC. Considering that a large portion of our students come from federal government agencies, this conference is particularly important and effective for us to recruit students.)
    - Esri International User Conference (It is annually held in San Diego, California. It is the largest and also most influential GIS conference in the world.)
    - Towson University GIS Conference (It is annually held at Towson University. We are able to reach out to the local GIS professionals in this conference.)
    - American Association of Geographers (AAG) Annual Meeting. (It is the largest conference in the

field of Geography.)

- The **MS GIS** program director or other faculty members give presentations to graduating seniors in the department of Geographical Sciences and other departments. This way, we are able to reach out those students who are facing the decision whether they want to continue their education in graduate school.
- We actively advertise our program through Google to increase the profile on the Internet.
- We advertise our program on the UMD university shuttles.
- Another effective way of reaching out to prospective students is through our increasing number of alumni. We regular feature some MPS GIS alumni and their testimony of the program quality through our web site. The success of our graduates have definitely played a more and more important role in helping recruit students.

In terms of retaining students, we have been implementing a variety of ways:

- We actively update and upgrade the curriculum. Geospatial technology is a field which changes rapidly. Students expect to learn the most up-to-date knowledge and skills. Therefore, it is important to offer a curriculum that can reflect the technology trends and offer some of the latest technical practices. We have been trying to offer a new course every two years, along with continual revision of the content of existing courses.
- Some students are interested in participating real-world research or internships while they are studying in the program. We have tried to make connections between our students and the faculty in the department of Geographical Sciences as well as other academic units on campus. Some faculty need students' assistance in their research while students look for research opportunities to enhance their educational experiences. This has worked out well.
- We also have tried to make connections between our students with some government agencies as well as private companies. For example, internships have been designed to help students gain real-world problem solving experiences.

## Relationship to Other Units or Institutions

**13. 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, add supporting correspondence as an appendix.**

Not applicable.

**14. 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.**

While the program is not subject to specialized accreditation or licensure, UMD is a founding member of University Consortium of Geographic Information Science (UCGIS) - https://www.ucgis.org/ .
The current **MPS GIS** program is recognized as an Esri Development Centers (EDCs) since 2008.

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

Not applicable.

## Faculty and Organization

**16. Faculty and organization. Who will provide academic direction and oversight for the program? As an appendix, please indicate the faculty involved in the program. Include their titles, credentials, and courses they may teach for the program.**

The MS GIS will be housed in the Department of Geographical Sciences. Continuing academic and program direction will be provided by the Program Oversight Committee. Members of the Program Oversight Committee include:

- Graduate School Representative
  - Steve Fetter, Dean, Graduate School, University of Maryland
- Graduate Director
  - Laixiang Sun, Professor, department of Geographical Sciences, College of Behavioral and Social Sciences, University of Maryland
- CGIS Director
  - Kathleen Stewart, Professor, department of Geographical Sciences, College of Behavioral and Social Sciences, University of Maryland

The program will be administrated and managed by the University of Maryland Center for Geospatial Information Science (CGIS). The program will also form an "MS GIS Advisory Committee". The role of the Advisory Committee will be to provide term-to-term guidance on the running of the program, as well as strategic advice regarding future opportunities for the program.

The administrative and teaching team will be led by:

- Jianguo (Jack) Ma — Director, department of Geographical Sciences, College of Behavioral and Social Sciences, University of Maryland

The complete faculty list is provided in Appendix D.

## Resource Needs and Sources

**17. 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. Please contact your departmental/programmatic library liaison or Daniel Mack at dmack@umd.edu, Associate Dean of Collections, to request a library assessment that will be added as an appendix.**

A library assessment report is provided in Appendix E.

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

The **MS GIS** Program will have access to a variety of physical facilities, hardware and software resources:

- GIS Labs
    - The MS GIS students have access to two 25-seat GIS labs equipped with dual-monitor high-end workstations and connected to remote storage facilities. 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. Students can study in these labs anytime as long as there are no classes in session.
- High-Performance Computing
    - The CGIS has 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 Department maintains a Linux-based HPC cluster). The CGIS and department of Geographical Sciences also link to high-performance computing in the College of Behavioral and Social Sciences (the "BSWIFT" cluster), as well as to the University of Maryland Institute for Advanced Computer Studies (UMIACS), which operates several clusters. In partnership with the Mid-Atlantic Crossroads (MAX), we also have high-performance networking access to other high-performance computing sites around the country, as well as nimble access to commercial computing resources (Amazon AWS).
- GIS/Web/Data Servers
    - Two servers have been purchased specifically use in instruction. Students will have access to these servers when they take classes such as Web Programming, Spatial Database, Internet GIS, etc.
- VMWare Servers
    - VMWare servers provide a virtual environment so that students can access to the software installed on the server anywhere anytime as long as they have an Internet connection. It is essentially a cloud-based service that gives students free access to software needed for teaching and learning.
- ELMS
    - The University of Maryland 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 MS GIS program will use ELMS to organize all of its teaching.
- WebEx
    - The University of Maryland provides the faculty with access to a Cisco WebEx Online course delivery platform. WebEx is used to create virtual classrooms to broadcast all lectures in real time so that some students (domestic only) can have the option to attend online while the others attend physically in real classrooms.
- ArcGIS Software Suite
    - The existing MPS GIS program is one of the Esri Development Centers (EDCs). Based on the agreement, the students in our program have free license to most ArcGIS software products including desktop ArcGIS, ArcGIS Server, ArcGIS Pro, and ArcGIS Online. They can install the software on their own computer as long as they are enrolled in the program. Our students will also have free technical support from Esri.

**19. 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.**

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. The proposed **MS GIS** program will continue to have these teaching resources. In addition, the **MS GIS** program will have four Teaching Assistants (TA). They are instrumental to improve students' learning experiences and outcomes. Tuition revenue is sufficient to cover all instructional needs.

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

The MS GIS Program Director and a Senior Faculty Specialist will play the major management roles for the program. The director and lecturers in the program will serve as academic advisors for students. Tuition revenue will cover the cost of these resources.

**21. Use the Maryland Higher Education Commission (MHEC) commission financial tables to describe the program's financial plan for the next five years: https://docs.google.com/spreadsheets/d/1V6iSZG05edMitWP6CAOXjCoGO58Gf6VXxPaacKfrhZ4/edit#gid=0. Add these tables as attachments. Use the space below for any additional comments on program funding.**

The program's five-year financial plan is provided in Appendix F.

**Implications for the State (Additional Information Required by MHEC and the Board of Regents)**
If the proposed program is for a Post-Baccalaureate Certificate that is derived entirely from existing courses within an existing Master's degree program, then you **only** need to respond to prompts 22 (on market demand) and 25 (curriculum of current master's degree program).

**22. 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.**

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.

A market research firm, Adeo Strategy Partners, conducted a market analysis for the Office of Extended Studies at the University of Maryland about a potential Master's level degree and/or graduate certificate program in the field of Geospatial Information Sciences prior to establishment of the existing MPS GIS program. Adeo's

research concluded that Geospatial Information Sciences is a field that is 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 MPS GIS 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.

The University of Maryland is an equal opportunity institution with respect to both education and employment. The University does not discriminate on the basis of race, color, national origin, sex, age, or handicap in admission or access to, or treatment or employment in, its programs and activities as required by federal (Title VI, Title IX, Section 504) and state laws and regulations.

The students enrolled in the MPS GIS Program have diverse social-economic background. About 50% of students are female and more than 25% are minorities.

**23. 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, or Maryland state Occupational and Industry Projections 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 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.**

GIS is essentially an information technology and thus, often classified as a computer related subject.

According to Maryland State Occupational and Industry Projections, the projections for general Computer Occupations are 117,471 in 2016 and 125,310 in 2026 with an increase rate of 6.67%.

Based on USBLS Occupational Outlook Handbook, it is estimated that the number of jobs for database administrators and computer programmers were 119,500 and 294,900 respectively in 2016. These two positions are the closest job categories that the MS GIS program graduates would possibly fill. It is projected that there will be an 11% increase from 2016 to 2026 for database administrators.

The existing **MPS GIS** program can provide much more accurate and specific insight about the demand and supply for GIS graduates. The current enrollment size has been stable since 2013, which indicates that it might have reached a balance of demand and supply.

Based on our existing **MPS GIS** program, we have high confidence to estimate the enrollment of the proposed **MS GIS** program to be about 40-50 students per year. It is also possible that we can grow slightly by reaching out more to international students. However, we do not plan to grow the program much beyond current enrollments (>60 students per year), in order to maintain a high quality experience for matriculated students.

**24. 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.**

Currently there are two universities have similar programs in the State of Maryland.

- Master of Science in Geographic Information Systems at Johns Hopkins University, Baltimore, Maryland - http://advanced.jhu.edu/academics/graduate-degree-programs/geographic-information-systems/
- Master of Professional Studies in GIS and a Post-Baccalaureate Certificate in GIS at UMBC-Shady Grove, Rockville, Maryland - http://shadygrove.umbc.edu/gis/

Both of these programs are relatively small with no more than 30 students per year. Our MPS in GIS was established prior to these two programs.

Our MS GIS program will not result in an unreasonable duplication of these two programs based on the following factors:

- Our curriculum is focused on Enterprise GIS which is different from traditional GIS. The topics covered include GIS, remote sensing, computing, and statistics, a broader range than a traditional program.
- The goal of our program is to help students become GIS developers rather than GIS users. Therefore, computer programing and development is greatly emphasized. Many of our classes involve computer programming.
- Johns Hopkins University's MS GIS program is a fully online program. On the other hand, the GIS program at UMBC is on-site at the Universities at Shady Grove. Our teaching format offers both on-site teaching and remote participation and thus will allow us to attract both in-state and out-of-state students.

**25. 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?**

Not applicable. None of the Maryland HBIs currently offer a GIS program.

**26. For new Post-Baccalaureate Certificates derived from existing master's programs only, include the complete curriculum of the existing master's program.**

Not applicable.

## Appendix A: Course Catalog

**GEOG650: Mobile GIS**
The emergence of highly-capable mobile devices and applications has opened a new opportunity for location-based services. Mobile apps enable us to collect, view, and analyze location-based data wherever and whenever we are. Mobile apps are generally classified into web apps, hybrid apps, and native apps. Nowadays, hybrid mobile app development makes developers easier to develop mobile apps running on different mobile platforms such as Android, iOS, Windows Phone, etc. as they write once and build mobile apps with no extra effort. Hybrid mobile apps are like native apps and run on the mobile device. However, hybrid apps are written with web standards and wrap into native apps using PhoneGap, Cordova, or other hybrid app development frameworks. Also, the application running on Android and iOS can be reused for progressive web applications and even desktop applications. In this course, advanced HTMP5, JavaScript, TypeScript and AngularJS web programming are covered, which can be used to develop both web applications and hybrid mobile applications. In addition, this course teaches how to develop, test, and publish mobile applications using PhoneGap/Cordova and Ionic frameworks. The capabilities of mobile devices such as Camera, Geolocation, Notification, etc. are added to the apps through Apache Cordova and Ionic APIs and map functionality is added to the mobile apps using Google Maps.
(3 credits; Prerequisite: GEOG657)

**GEOG651: Spatial Statistics**
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 application of spatial statistics to a variety of social and environmental problems using 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.
(3 credits; Prerequisite: none)

**GEOG652: Digital Image Processing and Analysis**
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.
(3 credits; Prerequisite: Introduction to Remote Sensing)

**GEOG653: Spatial Analysis**
This course is designed to help students develop a comprehensive and systematic understanding of spatial analysis methods and learn practical skills in using GIS and spatial analysis to discover features of spatial distribution. The class covers the 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. Spatial statistics, geospatial processing, and modeling will be used for analyzing the data. In terms of the software used in this class, besides the ArcGIS Desktop suite, we will be migrating to ArcGIS Pro, which is a new platform that represents the current trend in GIS field.
(3 credits; Prerequisite: Introduction to GIS)

**GEOG654: GIS and Spatial Modeling**
This course introduces advanced techniques in GIS data manipulation, geostatistics, and geospatial modeling. The fundamental theories behind analytical and modeling techniques are covered in detail, including model design, construction, evaluation, and application. The theoretical knowledge will be enforced by a series of intensive computer exercises using real data sets. The course covers descriptive and predictive GIS modeling

techniques, including regression modeling, suitability modeling, hydrological modeling, and agent-based modeling.
(3 credits; Prerequisite: GEOG653)

**GEOG655: Spatial Database System**
This course is designed to help students understand, analyze, design, and implement spatial databases. Topics covered include: spatial data models, spatial query languages, database architecture, data storage and indexing, SQL, data mining, etc. Oracle and ArcSDE are used to design database in GIS context.
(3 credits; Prerequisite: none)

**GEOG656: Programming and Scripting for GIS**
This course teaches programming and scripting for GIS users. The concepts of scripting and object-oriented programming using the Python programming language are reviewed. This course teaches students to design clearly structured programs and introduces ArcPy, a library providing access to ArcGIS geoprocessing tools. ArcPy includes a series of modules such as data access, mapping, spatial analysis, and network analysis. Students will develop geoprocessing programs to edit, query, manipulate, and analyze spatial data (both vector and raster data) with Python, ArcPy, and other modules like NumPy.
(3 credits; Prerequisite: none)

**GEOG657: Web Programming**
Component-based web server design and efficient session and secure access management have become challenges to provide fast, robust, and flexible GIS services on the Internet. This course is designed to teach fundamental techniques required in developing both client-side and server-side web application for not only GIS but also non-GIS applications. This course covers web design and static web generation using HTML5 and CSS, client-side programming with JavaScript, and dynamic web development using PHP and MySQL. Basic web design using HTML, XHTML, CSS, etc. is helpful, but not required.
(3 credits; Prerequisite: GEOG656)

**GEOG660: Advanced Remote Sensing using Lidar**
This course will expand on remote sensing concepts with a focus on light detection and ranging (lidar) technology. Lidar, also known as laser scanning, is an active remote sensing tool that can produce high resolution point clouds. This course will cover the fundamentals of lidar, explore current developments in lidar technology, and discuss different applications where it is being used. Students will get hands-on learning about lidar data management, processing, and analysis. It is recommended that students have a some background in spatial modeling and computer programming.
(3 credits; Prerequisite: GEOG652)

**GEOG670: Open Source GIS**
Students will learn to use Free and Open Source Software for GIS (FOSS4g) to conduct GIS analysis and articulate the strengths and weaknesses of FOSS4g compared to commercial offerings. Students will be introduced to advanced concepts and techniques including enterprise GIS, spatial SQL, parallel processing, and displaying the results of GIS analysis over the Internet - something very few professional know how to do. Students will learn how to use the FOSS4g products QGIS, PostGRES/PostGIS, and Geoserver into their technology stack and will become familiar with using spatial SQL for solving GIS and database related tasks.
(3 credits; Prerequisite: none)

**GEOG677: Internet GIS**
This course is designed to: (1) introduce the concepts and theories that are related to an increasingly important technology – Internet/Web GIS; (2) introduce various technologies or techniques for creating, analyzing, and disseminating GIS data and services via the Internet. The topics covered include the hardware/software structure of the Internet (e.g. server-client model, TCP/IP protocol), the evolution of Web GIS, and most

importantly, different technology options. Students will be required to practice almost all of the Web GIS tools including Google Map API, ArcGIS Server, JavaScript API, GeoJSON, Mapbox, and Leaflet. Students will also be exposed to the experience of working with the cloud environment such as AWS EC2 and ArcGIS Online
(3 credits; Prerequisite: GEOG653)

**GEOG795: Professional Practices Seminars**
This course will provide a preparation for students who are embarking upon professional careers with government agencies, companies, and other institutions who utilize geographic information science and technologies. The topics covered in this class include but not limited to: expectations and requirements of GIS professionals in government agencies from a manager perspective, understanding about Enterprise GIS, GIS data and services in DC, Maryland and Virginia, how to develop Resume and portfolio as a GIS professional, review of latest developments in the GIS field, research seminars in GIS and remote sensing, etc. Alumni from the MPSGIS program are also invited to talk about their GIS career in real world. The content of the class may vary in different years.
(1 credits; Prerequisite: none)

**GEOG796: GIS Project Management**
This course covers project management methodology emphasizing implementing geographic information systems and integrating geospatial information sciences into broader projects. Topics include project initiation, planning, scope, scheduling, budgeting and risk management.
(3 credits; Prerequisite: none)

**GEOG797: Capstone - Professional Project**
Each student must undertake a project as a demonstration of his/her competence in geospatial science and technologies. The data and materials for this project can originate from an internship, or from relevant work experience at the student's current employer. The Department of Geographical Sciences will work with each student individually to determine the best mechanism for obtaining the necessary data and experience. Under the direction of a faculty advisor, the student will prepare a project report which shall contain an explanation of the requirements for the work, a technical account of the activities undertaken, including a literature review, a description of the methods and approaches taken, a critical discussion of the results obtained, along with conclusions and recommendations developed from the project. The final project will consist of a full-fledged GIS application that is up and running and can be tested. This will enable the student to present potential employers with a portfolio containing an example of their ability to manage and develop a GIS application project and will show that they understand how to apply the technology to real world situations.
(3 credits; Prerequisite: GEOG653, 651, 652, 655, 656)

**GEOG 661: Fundamentals of Geospatial Intelligence**
This course introduces the fundamental knowledge required to become a successful GIS practitioner, including the history of the GIS discipline, the intelligence applications of remote sensing and Geographic Information Systems (GIS) technologies, and how GIS 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 GIS products that provide context for decision makers.
(3 credits; Prerequisite: none)

**GEOG 663: Big Data Analytics**
This course is 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.
(3 credits; Prerequisite: GEOG653)

## Appendix B: Online Program Offering Supplemental Information

According to the Maryland Higher Education Commission, a new offering of "more than 50 percent" of an existing program in an online format requires MHEC approval. The following prompts are based on academic policies for online programs as well as questions frequently asked by review committees.

**Discuss the role of faculty in the development, oversight, and teaching of this online program. Note that MHEC 13B.02.03.11(F) requires that "at least 50 percent of the total semester credit hours within the proposed program shall be taught by full-time faculty." Indicate any other unit or vendor that will be used to administer or deliver the program.**

The MS GIS will be housed in the Department of Geographical Sciences. The "Program Oversight Committee" is responsible for directing the program, while the program will be administrated and managed by the University of Maryland Center for Geospatial Information Science (CGIS). The program will also form an "MS GIS Advisory Committee".

Members of the Program Oversight Committee include:

- CGIS Director— Kathleen Stewart, Professor, Department of Geographical Science, College of Behavioral and Social Sciences, University of Maryland
- Graduate Director— Laixiang Sun, Professor, Department of Geographical Sciences, College of Behavioral and Social Sciences, University of Maryland
- Graduate School Representative— Steve Fetter, Dean, Graduate School, University of Maryland

The "MS GIS Advisory Committee" will be formed internally from faculty in the MS GIS program, with two elected student representatives. The role of the Advisory Committee will be to provide term-to-term guidance on the running of the program, as well as strategic advice regarding future opportunities for the program.

Totally there are sixteen courses (core and elective) offered in the MS GIS Program. Thirteen (81%) of these classes are taught by full-time faculty in the Department of Geographical Sciences, while the other three classes are taught by GIS experts from industry. Thus, it is ensured that at least 50% of our classes are taught by full-time faculty.

**Discuss the resources available for training and supporting faculty in regard to course development and instructional technology.**

GIScience is a field that changes very fast due to software and hardware advancements. Therefore, it is critical for the faculty to receive continuous training. The faculty are encouraged to attend academic conferences and also conduct research to update their knowledge and skills so that they can develop new courses or upgrade existing courses.

In addition, use of instructional technology is important to help improve teaching efficiency and learning effectiveness. The Teaching and Learning Transformation Center (TLTC) 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. TLTC Teaching

consultants work one-on-one with teachers based on their own goals. The requesting teacher determines the issues to be explored, and the consultant provides an outside perspective, peer support for a plan of action, and suggestions for additional resources.

**Discuss how courses will be taught using online technologies. Will courses be synchronous, asynchronous, or a combination of both? What technologies will be used to present material and evaluate the quality and authenticity of student work? How will these technologies be assessed?**

For all classes in the MS GIS program, instructors present lectures and lead discussions in physical classrooms and at the same time, the lectures are broadcast online through streaming videos. Students have the options to choose whether they want to attend in person or online. In either case, students can see the slides, see and hear instructors speaking, and also ask questions. Therefore, in both scenarios, lectures are presented in real time dynamically and interactively. All courses will be delivered synchronously.

In addition, all the lectures and lab sessions are video archived. Students can review them anytime. It is also make it easy for some students to catch up on the course materials if they have to miss lectures because of medical issues or business travel.

International students are required to attend the lectures in person, due to visa requirements.

The University of Maryland 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 MS GIS 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. WebEx is a Web conferencing application that can be used to host classes, office hours, and other meetings, in an online environment. 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. These interactions can also allow the instructors to identify and authenticate the students and their involvement in the teaching and learning processes.

The existing MPS GIS Program has been using the same or similar technologies and strategies since 2009. They have proved to be effective in teaching and learning as well as evaluating students.

**Discuss how the online program will be comparable to the existing program in terms of academic rigor. What are the learning outcomes for the online offering? Do they differ from the existing on-site program? How will the program be evaluated?**

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.

**Describe the admissions criteria and procedures for the online program.**

The admission criteria are the same for all MS GIS applicants regardless of whether they will attend classes in person or at a distance. The admission criteria and procedures are listed in section 4 of this proposal.

**Discuss how students will have reasonable and adequate access to the range of student support services (library materials, teacher interaction, advising, counseling, accessibility, disability support, and financial aid) needed to support their learning activities.**

All students in the MS GIS program will have equal access to resources on-campus just other regular graduate students. These resources are listed on our program website (https://geog.umd.edu/graduate/mps-student-resources ).

**Discuss how the program will provide students with clear, complete, and timely information on the curriculum, technological competence and equipment needed for the program, admissions criteria, financial aid resources, complaint procedures, and cost and payment policies.**

The MS GIS program's website - http://mpsgis.umd.edu serves as the portal to provide clear, complete, and updated information on curriculum, requirement, course plan, admission procedure, financial aid information, resources, etc.

The MS GIS Program Coordinator is dedicated to providing information service and help to students on questions regarding to application, admission, registration, curriculum, course schedule, tuition and fees, complaint procedures, etc.

New student orientation sessions are held before every spring and fall term starts and when there is a new cohort of students. At the orientation sessions, students are introduced to the faculty and also provided with all the information needed to succeed in the program. Particularly, exemplar projects completed by MS GIS graduates in the past will be demonstrated to the new students so that they will have an understanding of program goals and the curriculum.

**Intellectual Property Policy. Units developing online programs should be familiar with the university's intellectual property policy. See https://www.president.umd.edu/iv-320a. Please indicate that the unit will comply with the university's intellectual property policy.**

The department will comply with the university's intellectual property policy to deliver the proposed MS GIS program.

**Discuss the instructional and administrative resources (faculty, staff, and teaching assistants) that will be needed to cover the cost of the program. Indicate the source of resources for covering these costs. These formatted tables can be used to indicate the resources and expenditures for the program: https://docs.google.com/spreadsheets/d/1V6iSZG05edMitWP6CAOXjCoGO58Gf6VXxPaacKfrhZ4/edit#gid=0.**

Program resources are the same for face-to-face and for distance delivery.

**Describe the market demand for the program. Evidence may be research from industry or the discipline, and should also consider state and federal employment projections. Indicate the job opportunities available to those who would graduate from this program.**

Both market research and the success of our existing MPS GIS program since 2008 have both indicated there is a strong demand for GIS professionals.

A market research firm - Adeo Strategy Partners once conducted a market analysis for the Office of Professional Studies at the University of Maryland about a potential Master's level degree and/or graduate certificate program in the field of Geospatial Information Sciences. Adeo's research concluded that Geospatial Information Sciences is a field that is experiencing rapid growth. GIS is used heavily in the federal government, and is growing quickly in state, county, and local government.

The U.S. Department of Labor has also identified geospatial technologies as one of the three most important emerging and evolving fields, along with nanotechnology and biotechnology. Introduction of a Master of Professional Studies in Geospatial Information Sciences is part of a larger trend nationally and internationally.

More importantly, the success of our existing MPS GIS program has provided perfect research as well. Since 2008, the MPS GIS program has grown from only 10 students a year into a program with about 40-50 students a year. This enrollment size increase is an evidence that the GIS job market is promising and growing. Since 2008, the graduates from the MPS GIS program have secured a wide range of career opportunities including:

- Federal governmental agencies such as NASA, NOAA, FEMA, Census Bureau, EPA, NGA, DOT, USGS, Veteran's Affairs, National Park Service, etc.
- State and local governmental GIS Offices
- Private companies that are specialized or involved geospatial technology, for example Esri, MDA, Dewberry, etc.
- Non-profit organizations such as the World Bank, WWF, etc.

It is also worth to mention that there have been about 15 MPS GIS graduates who have continued to pursue PhD programs at the University of Maryland and also some other institutions.

## Appendix C: Plan for Assessment of Learning Outcomes

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 D: Program Faculty

### Dr. Kathleen Stewart

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

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 (Capstone Project)

### Dr. Jonathan Resop

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**

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**

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 Intelligence (MS GEOINT)

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

*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

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

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

## Budget Analysis: Master of Science in Geospatial Information Sciences

| **Program Revenue** | AY 2019/20 | AY 2020/21 | AY 2021/22 | AY 2022/23 | AY 2023/24 |
|---|---|---|---|---|---|
| **I. Total Tuition Revenue** | **$1,015,560** | **$1,035,871** | **$1,173,987** | **$1,197,467** | **$1,221,416** |
| A. Total Professional Students (annually) | 45 | 45 | 50 | 50 | 50 |
| 1. Fall Cohort Enrollment 1st Year of matriculation | 30 | 30 | 35 | 35 | 35 |
| 2.Spring Cohort Enrollment 2nd Year of matriculation | 15 | 15 | 15 | 15 | 15 |
| B. Total Credits (annually) | 31.0 | 31.0 | 31.0 | 31.0 | 31.0 |
| 1. Cohort Courses 1st Year of matriculation | 15.5 | 15.5 | 15.5 | 15.5 | 15.5 |
| 2. Cohort Courses 2nd Year of matriculation | 15.5 | 15.5 | 15.5 | 15.5 | 15.5 |
| C. Per course rate; Assumes 2% increase | $728 | $743 | $757 | $773 | $788 |
| **Estimated Expenses** | AY 2019/20 | AY 2020/21 | AY 2021/22 | AY 2022/23 | AY 2023/24 |
| **I. Total Instructional and Administration** | **$729,600** | **$751,488** | **$774,033** | **$797,254** | **$821,171** |
| **A. Instructional Totals** | **$331,500** | **$341,445** | **$351,688** | **$362,239** | **$373,106** |
| 1.Total Faculty Salaries [a x b] | **$255,000** | **$262,650** | **$270,530** | **$278,645** | **$287,005** |
| a. Total paid instructors per year | 3 | 3 | 3 | 3 | 3 |
| b. Instructor salary; assumes a 3% annual increase | 85,000 | 87,550 | 90,177 | 92,882 | 95,668 |
| 2. Fringe Benefits (30%) | 76,500 | 78,795 | 81,159 | 83,594 | 86,101 |
| **B. Academic Administration Totals** | **$398,100** | **$410,043** | **$422,344** | **$435,015** | **$448,065** |
| 1. Program Director (also teaches 3 course per year) (assumes 3% annual increase) | 100,000 | 103,000 | 106,090 | 109,273 | 112,551 |
| 2. Fringe Benefits (30%) | 30,000 | 30,900 | 31,827 | 32,782 | 33,765 |
| 3. Full-time Coordinator (assumes 3% annual increase) | 67,000 | 69,010 | 71,080 | 73,213 | 75,409 |
| 4. Fringe Benefits (30%) | 20,100 | 20,703 | 21,324 | 21,964 | 22,623 |
| 5. Admin Asst (assumes 3% annual increase) | 21,000 | 21,630 | 22,279 | 22,947 | 23,636 |
| 6. Teaching Assistants ( 4 per year) (tuition remission + stipend; assumes 3% annual increase) | 160,000 | 164,800 | 169,744 | 174,836 | 180,081 |
| **C. Equipment, Materials and Supplies Totals** | **$12,000** | **$12,360** | **$12,000** | **$12,000** | **$12,000** |
| Estimated equipment | 10,000 | 10,300 | 10,000 | 10,000 | 10,000 |
| Materials & Supplies | 2,000 | 2,060 | 2,000 | 2,000 | 2,000 |
| **II. Marketing** | **$15,000** | **$15,000** | **$15,000** | **$15,000** | **$15,000** |
| Estimated Marketing (by academic unit) | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 |
| **SUBTOTAL: DIRECT PROGRAM EXPENSES** | **744,600** | **766,488** | **789,033** | **812,254** | **836,171** |
| **III. Campus Administrative Fee** | **$152,334** | **$103,587** | **$176,098** | **$179,620** | **$183,212** |
| 15% of tuition revenue for OES administrative costs | 152,334 | 103,587 | 176,098 | 179,620 | 183,212 |
| **Total Estimated Expenses** | **$896,934.00** | **$870,075.12** | **$965,130.74** | **$991,873.69** | **$1,019,383.70** |
| **Total Estimated Program Revenue** | **$1,015,560** | **$1,035,871** | **$1,173,987** | **$1,197,467** | **$1,221,416** |
| **Net Revenue** | **$118,626** | **$165,796** | **$208,857** | **$205,593** | **$202,033** |