

# Proposal for a Certificate Program in Geographic Information Science

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## 1. Justification

The Department of Geography proposes to offer a certificate program in Geographic Information Science (GIS) with initial enrollment in the Fall Semester of 2009. The program is designed to accommodate increasing demands both for workforce development and for training to enhance the research skills of students in our graduate programs. Because the University of Delaware does not currently offer any degree programs in GIS, we lag behind many of our regional peer institutions in that respect.

University-wide there are at least a dozen specialized courses either in generalized GIS or in GIS applied to a particular area of research or technology. This certificate program will make use of the existing faculty and courses, and complement the education of students in all allied disciplines, without replacing or duplicating any degree program on campus. Although many of the students matriculating in the program will be graduate students that are currently attached to other degree programs, we expect this program to be popular with workforce professionals and continuing students, whose tuition is expected to cover development of the program as it expands.

## 2. Introduction

Geographic Information Science (GIS) is the academic theory behind the development, use, and application of geographic information systems. The technological methodology labeled as the “systems” part of GIS involves the collection, processing, analysis and mapping of spatial information. The fundamental technique of GIS, that of overlaying maps to make analytical comparisons among different geographic datasets, has been carried out by geographers (at least conceptually) since classical Greek civilization. Modern GIS technology increases the scope and scale of problems that can be analyzed to a degree that is revolutionary, enabling a wide range of new geographic questions to be addressed.

In 2004, the U.S. Department of Labor identified *geotechnology*, another name for the technological side of GIS, as one of the three most important emerging and evolving fields, along with nanotechnology and biotechnology. The evolution of GIS over the last ten years has changed the nature of many fields that utilize spatial data. These diverse fields collect spatial data, often with advanced technologies from space-borne, airborne, and terrestrial systems (e.g., multi- and hyperspectral satellite sensors, light detection and ranging (LIDAR), kinematic GPS). They organize their information into mapable databases, bring specialized spatial and area-weighted analyses to bear on the data, and make use of the unique insights that can be gained from the ability to easily compare map layers. The output of such analyses range from static maps or statistics for a single research question to a web site that incorporates the latest available data into specialized software that provides spatial analysis capabilities. GIS encompasses this entire range of hardware and software functions.

The model for GIS education that we are developing for the University of Delaware, attempts to provide students with a toolkit of intellectual concepts and practical skills that can be applied to any level of research or study that makes sophisticated use of geographic data. GIS is no longer an optional high-end means of analysis, it is the norm, and graduates in many fields may need to show at least basic familiarity with GIS to be considered professionally trained. Geography graduates who seek an academic career are nearly universally expected to have sufficient skills to teach basic GIS principles and to mentor students on the use of GIS in their field of study. Likewise, many departments require GIS use in advanced degree programs and need to ensure that their students are getting adequate professional training for today’s competitive job market. Thus, the demand for graduate GIS training has spread beyond the usual purview of our allied

disciplines (e.g., programs in the College of Marine and Earth Studies) attracting, for example, a large number of students from various social sciences and engineering disciplines.

The same global, multi-disciplinary perspective that inspired the Geography Department to propose and nurture the University's Environmental Science program nearly 20 years ago has kept us in the forefront of interdisciplinary research and education activities. GIS is providing a similar impetus, as engineers, agriculturalists, social scientists, and environmental researchers find spatial variations in their research that are best understood via GIS. To the broader University of Delaware community, we have been evangelical rather than proprietary in offering GIS courses needed by other departments, and the new program is proposed to serve the interests of the broader UD community.

### **3. Benefits**

Graduates of this certificate program will be able to convey to potential employers the comprehensiveness of their training and readiness to implement their GIS knowledge in research projects and in the classroom, which is often not self-evident in the application and interview process. For many Ph.D. candidates intent on research and academic careers, obtaining a level of GIS skill commensurate with the certification is necessary to their research anyway. The existence of the certificate program provides guidance and coherence to their training. The certificate program also provides an avenue for workforce training, whether initiated by the individual or the employer, to pursue advanced skills while working in professional settings (i.e., government agencies, consulting and engineering firms). Very importantly, this program will count as part of the educational achievement requirements needed to obtain a Geographic Information Science Professional (GISP) certification from the GIS Certificate Institute (<http://www.gisci.org/index.aspx>), which employers are looking very favorable towards to assure a GIS professional has met the minimum standards for ethical conduct and professional practice.

### **4. Eligibility and Admission Requirements**

This program is intended to function as means for graduate certification, so the minimum requirements for admission are a bachelor's degree. Some of the structure of the program is designed with the idea that future undergraduates of the University will be able to include courses for certification as part of their bachelor's degrees in Geography or closely related fields, subsequently completing the remainder after graduation. At present, this program serves as an advising track for such undergraduate students.

It is anticipated that many applicants to this program will begin their education via continuing education or using courses taken as part of an earlier degree program. Students interested in this program must apply for certification before completing more than 9 credits. Some courses in the program may be available only to students who are matriculated into the program.

For students not currently enrolled in a UD graduate program, a regular graduate application form is required. Applicants must include a brief statement of purpose and arrange for two letters of recommendation to be sent, along with transcripts from previous universities. Applicants whose previous degrees included no evidence of instruction in English should also include TOEFL scores. No GRE scores are required. Applications will be reviewed on an ongoing basis for admission in any semester. No specific numerical criteria for admission exist, but applicants will be evaluated in terms of likelihood of success and availability of seats in our courses.

Students currently enrolled in a UD graduate program should complete a “Change of Classification Form” to seek approval to add the certificate program. This should be accompanied by a letter of support from the student’s advisor.

Students are required to choose an appropriate advisor associated with the certificate program, or have an appropriate advisor appointed by the Director of the Certificate Program, who will be the primary contact for questions. The Director of the Certificate Program will verify that the student has completed the requirements for the certificate and will approve the application for the certificate upon successful completion of the requirements.

## **5. Curriculum and Course Structure**

The proposed Certificate Program consists of 12 credits with the core course (Section A) and practical and applied skills courses in Section B through D. Three tracks – *Technician*, *Analyst*, and *Developer* – are available for a student to select and are summarized below in sections 5.2 through 5.4. Several 1-credit courses that will be offered to develop specialized skills will be taught in sub-semester increments, so that more than one can be completed in any semester allowing a single faculty member to do multiple courses in a semester.

The certificate curriculum involves choosing combinations from a palette of 21 courses. Several online courses are available to students living and working anywhere, enabling working professionals to complete course work off site. The frequency with which the curriculum is offered allows for students to proceed at their own pace, but allowing a full-time student to complete the program in two semesters. The program is designed such that students can complete the certification with online and evening classes, but students who can *only* take online and evening classes may reduce their options within the program.

### **5.1 Curriculum Section A: Fundamentals of Geographic Data Analysis**

The introduction to GIS course is required for all students. Note that *GEOG271 Geographic Data Analysis* (4 credits) is a prerequisite for this course. However, students may be allowed to substitute any undergraduate or graduate course that shows completion of computational, statistical, and graphical techniques used in scientific data analysis where there is a particular emphasis on the special nature of geographic and spatial data.

*GEOG670 Introduction to GIS* (3 credits)

Introduces the principles, concepts, and technical issues of geographic information systems and science.

### **5.2 Curriculum Section B: Practical Skills**

These courses provide fundamental technical skills that are typical of understanding the framework of GIS. They will initially be offered as a Seminar in Geographic Information Systems (GEOG672) and as courses in Special Problems (GEOG666) that will be implemented as part of the online ESRI “virtual classroom” (ESRI, Inc., originally Environmental Systems Research Institute, Inc., is the largest software vendor in GIS, and it offers training courses, both classroom and online, in GIS, albeit centered on using its own products. ESRI software is sufficiently widespread that experience with it is often considered as an essential job skill by employers.). It is expected that the 1-credit curriculum will expand over time so that courses that clearly fill a niche can be formalized.

The current series of GEOG672 courses that will be offered include the following:

GEOG672      *Using ArcGIS and Open Source GIS* (1 credit)  
                 *Computer Cartography* (1 credit)  
                 *SQL and Querying in GIS* (1 credit)  
                 *Developing Geoprocessing Models* (1 credit)  
                 *Feature Creation and Editing in the ArcGIS Model* (1 credit)

GEOG666 *Special Problems*: approved online ESRI courses (1 credit / limit of 2 credits)

### 5.3 Curriculum Section C: Application Development

Students should be aware that this section refers to courses that may require a background and/or additional course work in computer science. Because programming environments utilized in a GIS framework are constantly evolving, experience relevant to the specific needs of a student may be substituted for courses in this section pending approval of the program director.

We recommend the following two undergraduate courses, or similar courses from other institutions, as background for students entering the Application Development track of this certificate program.

*CISC103 Introduction to Computer Science with Web Applications* (3 credits)

Principles of computer science illustrated through programming in scripting languages such as JavaScript and VBScript. Topics include control structures, arrays, functions, and procedures. Programming projects illustrate web-based applications.

*CISC370 Object Oriented Programming Using Java* (3 credits)

Object oriented programming through use of the Java programming language, which includes the use of Java's extensive library of API's (application programming interfaces). Study of the design issues of large program systems.

For the Application Development track, students need to acquire at least 5 credits from the following list.

*CIEG675 Matlab for Engineering* (1 credit)

The course is based on the description and usage of the commercial Matrix Laboratory (Matlab) software for analyzing multi-dimensional data sets and formulating numerical models of engineering processes.

GEOG605      *Computer Programming For Environmental Research* (1 credit)

GEOG672      *Using Python in a GIS Framework* (1 credit)  
                 *Introductions to Scripting and Visual Basic in ArcGIS* (1 credit)  
                 *Developing Geoprocessing Scripts* (1 credit)  
                 *Developing Applications with GIS Web Servers* (1 credit)

GEOG666 *Special Problems*: approved online ESRI courses (1 credit each)

## 5.4 Curriculum Section D: Applied GIS

This section is focused on developing research skills within a GIS framework and requires that students pursuing an Analyst track take two courses; other tracks take any one course.

*GEOG604 GIS for Environmental Sciences (3 credits).*

Applied course in the use of Geographic Information Systems (GIS) in the context of interpreting unique environmental data specifically focused on climate and land-surface changes. Emphasis on practical experience in developing research methodologies employing GIS techniques.

*GEOG671 Advanced Geographic Information Systems (4 credits).*

Commercial geographical information systems are introduced and used to analyze a wide variety of spatial databases.

*GEOG677 Spatial Data Analysis (3 credits)*

Special approaches to analysis of data associated with points, lines and areas on the Earth's surface.

*UAPP652 GIS in Public Policy (1 credit)*

Hands-on introduction to GIS and their uses in public policy areas. Content varies. Exercises focus on using geographic data in fields such as environmental analysis, land use planning, and socio-economic analysis.

*UAPP655 GIS in the Public & Nonprofit Sector (3 credits)*

Introduction to the use of GIS in urban planning and water-resources fields. Emphasis on practical experience in developing research methodologies employing GIS techniques. Topics include data/metadata creation, remote sensing as it relates to GIS, cartographic representation of spatial data, and vector/raster spatial modeling.

*FREC680 GIS in Natural Resource Management (4 credits)*

Introductory hands-on training in GIS for environmental and natural resources.

*FREC682 Spatial Analysis (3 credits)*

Advanced hands-on training in geographic information systems and spatial statistics for environmental and resource management.

*MAST/GEOG681 Remote Sensing of the Environment (3 credits)*

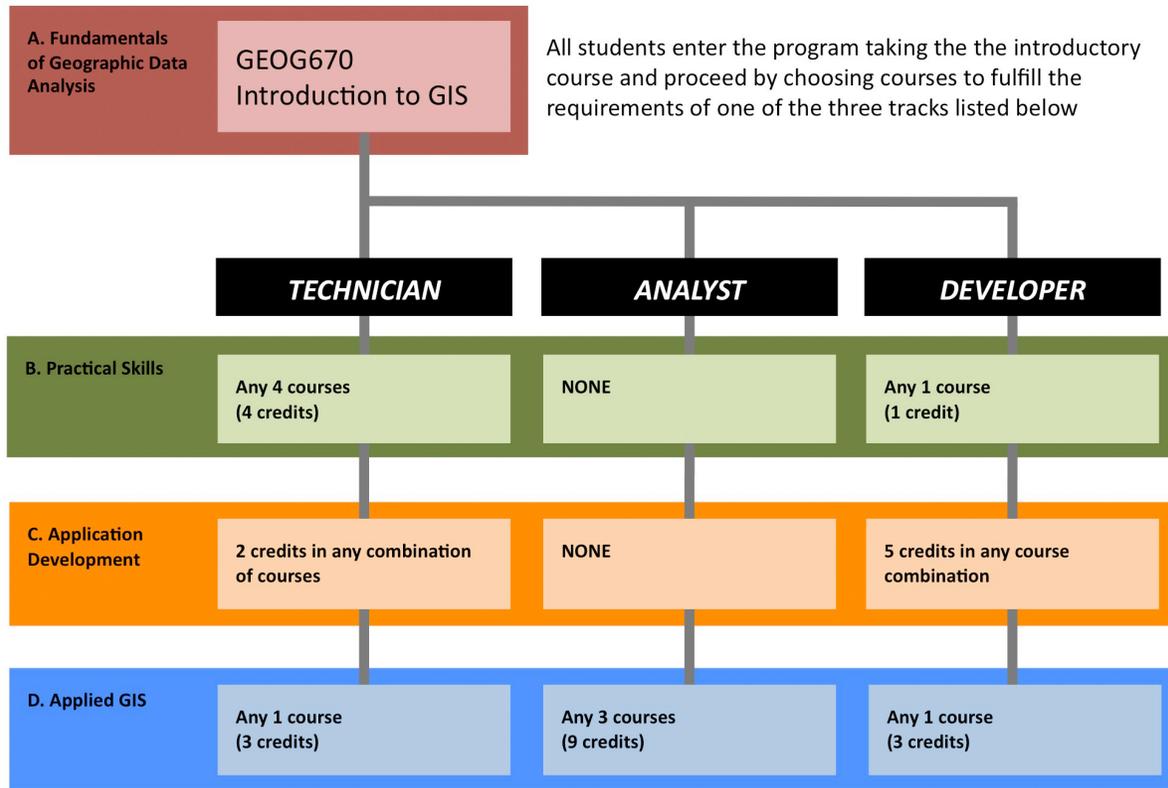
Detection and mapping of atmosphere, land, and ocean resources with optical, infrared, and microwave sensors. Digital analysis of satellite images using multispectral and spatial analysis techniques and correlation with ground/ship data. Application to oceanography, coastal processes, geology, land use, geography, agriculture, climate and pollution studies.

*STAT657 Statistics for Earth Sciences (3 credits)*

Spatial distributions; directional data; statistical graphics, regression and time series analysis; model validation; sampling; principal components; cluster analysis; discriminant analysis; and statistical software routines.

## 5.5 Curriculum: Summary of Tracks

The Core Requirement for all tracks is GEOG670 (3 credits). The following defines the requirements for each Track.



## 6. Resources

The implementation of the proposed program hinges on the fact that UD currently offers nearly all of the courses that are required to complete the program in a timely manner. Therefore, the teaching load is mostly within the domain of the current faculty.

The current single-purpose GIS teaching facility on campus is a classroom in Pearson Hall, with space provided by the Geography Department and equipment by the College of Arts and Sciences. The facility makes an excellent teaching lab, sufficient for our program and for the introductory courses needed by graduate students. However, this teaching lab is overbooked due to its popularity with instructors from other Colleges (Agriculture and Natural Resources; Human Services, Education and Public Policy; Marine and Earth Studies). Consequently, research time slots in the lab may be limited and discontinuous – more suitable for shorter undergraduate projects than for long-term continuous use for a graduate research project. As the program evolves, there will be a need for more specialized, continuous, high-speed access to data, secure storage for periods of at least one year, long periods of continuous access to quality workstations, and the flexibility to modify software and install related specialized packages that may not be site licensable by the University.

Geography has a professional staff position whose primary role is to provide GIS technical support. The job description for this professional position is being revised around the needs of the GIS certificate program. The staff member would be expected to: 1) provide direct communication, leadership, and interpersonal assistance to the programs' students, 2) solve and implement research and technical problems, 3) present complex GIS technical demonstrations to all levels of faculty, students, and staff in diverse range of departments and programs, and 4) maintain the level of expertise necessary to teach some of the 1-credit technical classes offered in the program.

One of the key selling points of the proposed program is that it will attract external students on nontraditional tracks, in addition to serving those in conventional graduate programs. While future budgeting models of the University remain more a matter of speculation than understanding at this point, we are led to believe that tuition revenue from such students will be available to hire additional staff to service their special needs.

## **7. Administration**

The certificate program will be administrated by the Department of Geography. The Chair will appoint the director for a term of two years. It is anticipated that the directorship will rotate to different tenure-track faculty members teaching GIS curriculum. Semiannual meetings between Geography and faculty / staff contributing to the program will provide a forum for assessing the successful implementation of the program, including issues of staffing courses, workload, and assessment of outcomes.

## **8. Completion of the Program**

Upon successful completion of the certificate requirements, each student will receive a printed certificate. The certificate itself is printed by the Office of the Assistant Provost for Graduate and Professional Education. It will be signed by the Office of Graduate and Professional Education, the Provost and the Director of the Certificate in Geographic Information Science Program at the time of completion. The certificate will be noted on the student's transcript.

## **9. Draft Catalog Entry**

*(This text is expected to go in the section of catalog entitled "ACADEMIC REGULATIONS FOR GRADUATE STUDENTS," which begins on p. 129 of the current catalog)*

The Certificate of Geographic Information Science (GIS) is designed for working professionals aspiring to leadership positions in the field and wishing to obtain a certificate of GIS specialization. The Program first requires two core courses that provide a student the theoretical underpinnings of GIS to make informed use of geographic technologies, followed by the selection of one of three tracks – *Technician*, *Analyst* and *Developer* – to gain the technical skills needed to construct and solve problems in the physical and social realms.

The GIS Certificate Program is designed to meet the education needs of both traditional and non-traditional students. For traditional students, the GIS Certificate program prepares them to utilize GIS in their major areas of studies, while non-traditional students can take advantage of the GIS Certificate program to learn and/or upgrade their GIS knowledge and skills that are applicable and important to their professions.

The GIS Certificate program can be completed in one academic year. To receive the GIS Certificate, students must complete 12 credits of GIS coursework that includes:

**CERTIFICATE REQUIREMENTS**

GEOG670 Geographic Information Systems and Science .....3

Choose one Track to follow to complete 9 additional credits.

**Technician**

4 courses from Practical Skills .....4  
 2 credits from Application Development .....2  
 1 course from Applied GIS .....3

**Analyst**

3 courses from Applied GIS .....9

**Developer**

1 course from Practical Skills .....1  
 5 credits from Application Development .....5  
 1 course from Applied GIS .....3

**Practical Skills**

GEOG672 Using ArcGIS and Open Source GIS .....1  
     Computer Cartography .....1  
     SQL and Querying in GIS .....1  
     Developing Geoprocessing Models .....1  
     Feature Creation and Editing in the ArcGIS Model .....1  
 GEOG666 Special Problems: approved online ESRI courses .....1

**Application Development**

CIEG675 Matlab for Engineering .....1  
 GEOG605 Computer Programming for Environmental Research .....3  
 GEOG672 Using Python in a GIS Framework .....1  
     Introductions to Scripting and Visual Basic in ArcGIS .....1  
     Developing Geoprocessing Scripts .....1  
     Developing Applications with GIS Web Servers .....1  
 GEOG666 Special Problems: approved online ESRI courses .....1

**Applied GIS**

FREC680 GIS in Natural Resource Management .....4  
 FREC682 Spatial Analysis .....3  
 GEOG604 GIS for Environmental Sciences .....3  
 GEOG671 Advanced Geographic Information Systems .....4  
 GEOG677 Spatial Data Analysis .....3  
 MAST/GEOG681 Remote Sensing of the Environment .....3  
 STAT657 Statistics for Earth Sciences .....3  
 UAPP652 GIS in Public Policy .....1  
 UAPP655 GIS in the Public & Nonprofit Sector .....3

## **Appendix A: Letters of Participation and Support**

Over the last two years, Drs. O'Neal and DeLiberty have discussed the framework of this proposal with the administration of Arts and Sciences and the GIS community at UD to ensure their support of the proposed program. We have gained written or verbal support from the following programs:

SOPP (UAPP courses), FREC, CISC, DGS (John Talley and professional GIS staff), Geological Sciences, CMES (Nancy Target), Civil & Environmental Engineering (Jack Puleo, MatLab course support), and Dick Sacher (Instructional Technology).