

Routing for On-Campus Approval of Degree Program Actions

Type of Action: Enter "X" for Action Type(s) and list Title and Prefix(s) as indicated

___ X ___ New Degree Program	Proposed Program Title <u>PhD in Geospatial Analytics</u>
___ New Certificate Program	Proposed Certificate Program Title _____
___ New Minor Program	Proposed Minor Program Title _____
___ Change in Degree Program Title	Current Degree Program Title _____
___ Change in Certificate Program Title	Current Certificate Program Title _____
	Proposed Certificate Program Title _____
___ Change in Minor Program Title	Current Minor Program Title _____
	Proposed Minor Program Title _____
___ Change in Course Prefix	Current Course Prefix _____ Proposed Course Prefix _____
___ Program Discontinuation	

Proposed Effective Date Fall, 2017 Program Contact: Dr. Ross Meentemeyer (rkmeente@ncsu.edu)

Proposed CIP Code (see <https://nces.ed.gov/ipeds/cipcode/default.aspx?y=55>): 30.0601

Routing of Action: Indicate date when the following occurs

Completed Appendix A and 1-page Concept Paper

08/05/15 Council of Dean's- Approval to Plan

Completed Proposal

01/26/16 Department Head endorses*

01/27/16 College Curriculum Committee (undergraduate or graduate) recommends*

01/28/16 College Dean endorses*

Proposal moves to Undergraduate or Graduate office for routing

___ **NA** ___ Recommended by Vice Provost, DELTA, if applies*

___ Substantive Change Review Team (SCRT) informed

___ If SACS notification is required, SCRT prepares letter for Chancellor to send to SACS

___ University Courses & Curriculum Committee **or** Administrative Board of the Graduate School recommends

___ Associate Deans Council **or** Graduate Operations Council informed

___ Dean (Graduate School or DASA) approves*

Proposal move to the Provost's office for routing

___ Vice-Provosts informed

___ Deans' Council recommends*

___ Provost approves*

___ Chancellor's Executive Officer's (EOM) recommend

___ University Council informed

___ Board of Trustees subcommittees recommend

___ Chancellor approves*

___ Accreditation Liaison notifies SACS, if applicable

___ Submitted to UNC-General Administration by Provost's Office

* Signature is required on the signature page for the action

PhD in Geospatial Analytics
North Carolina State University

This request has been reviewed and approved by the appropriate campus committees and authorities.

Endorsed By:

Ron K. W. H. 1-30-2016
Head, Department/Director of Graduate Program (Printed Name and Signature) Date

Recommended By:

ILONA PESZLEN Ilona Peshlen 1/27/2016
Chair, College Graduate Studies Committee (Printed Name and Signature) Date

Endorsed By:

Adrianna G. Kirkman Adrianna G. Kirkman 1/28/2016
College Dean (Printed Name and Signature) Date

Recommended By:

NA
Vice Provost, DELTA (if DE degree) (Printed Name and Signature) Date

Approved By:

Dean of the Graduate School (Printed Name and Signature) Date

Recommended By:

Dean's Council (Printed Name and Signature) Date

Approved By:

Provost (Printed Name and Signature) Date

Approved By:

Chancellor (Printed Name and Signature) Date

PhD in Geospatial Analytics

Executive Summary

The integrative PhD in Geospatial Analytics will bring together departments from across NC State to produce a new generation of interdisciplinary data scientists skilled in developing novel understanding of spatial phenomena and applying the new knowledge to address pressing societal needs. Two strategic goals drive the vision for the new PhD program:

- > **Education and Training:** Prepare students to integrate knowledge from the natural and social sciences with advanced technical training in geospatial data collection, computational processing, modeling and analytics for scientific discovery and decision-making.
- > **Sustainable Solutions:** Implement novel open-source geospatial technologies to better understand and communicate the key roles that place, spatial interaction, and multi-scale processes play in solutions to complex environmental and societal challenges. The program recognizes that no single “technical solution” will provide sustainable futures; we need integrated approaches with new tools for envisioning the future and evaluating the tradeoffs that arise from multiple social, economic, and environmental drivers.

The program will connect students with mentors and peers across multiple disciplines at NC State and will provide scientific and professional knowledge practicing Geospatial Analytics in academia, industry and government agencies. Our approach to education and training will include:

- > **Multidisciplinary Advising:** Students will belong to a participating department and will have a primary advisor in their home department who is recognized by the Graduate School as a full member of the Geospatial Information Science and Technology (GIST) faculty (currently composed of 40+ members). In addition, a multidisciplinary advising committee of four faculty members in a complementary field will provide direction in the methods, models, and problem-driven motivation for Geospatial Analytics. One committee member will be declared the domain expert of the problem being studied.
- > **Core Curriculum:** During the first year, students will cover a sequence of integrated courses that covers advanced theory in the geospatial sciences along with specialized technical training in the quantitative, algorithmic, and systems aspects of Geospatial computing, information technology, applications, and Analytics (15-18 credit hours). The second through fourth year of study will include individualized plans of work that focus on a combination of technical and domain coursework and research hours approved by a student’s advising committee.
- > **Dissertation:** Students will be required to complete an innovative research dissertation in accordance with guidelines of NC State Graduate School. The program will expect all students to make publishable, peer-reviewed contributions to the advancement of Geospatial Analytics, with a focus on developing tools that could be used to help understand and communicate the roles space and place play in sustainable solutions to grand challenges. Approaches to participatory research that engage stakeholders in spatial thinking and decision-making will be encouraged.
- > **Professional Experience:** Students will complete a 6-8 week internship, gaining applied geospatial experience in industry or government. The program is envisioned as a win-

win-win: students expand their professional network and gain experience, industry makes connections to new talent, and NC State builds industry partnerships for future research and education initiatives.

The Center for Geospatial Analytics (geospatial.ncsu.edu) will direct the PhD program (administered through the College of Natural Resources), including overseeing admissions, managing enrollment, reporting, and graduation.

Geospatial Analytics enables interdisciplinary discovery and communication of meaningful patterns of geospatial data and complex processes for innovative solutions to grand challenges. This one-of-a-kind PhD program will strategically build on the education success of the Professional Science Masters degree in Geospatial Information Science and Technology (geospatial.ncsu.edu/mgist) and the 40+ GIST Graduate Faculty who are collectively delivering NC State's popular Graduate Certificate in GIS across several colleges. The PhD will also leverage interdisciplinary momentum of the Chancellor's Faculty Excellence Program cluster in Geospatial Analytics, which has recently added several faculty members at the top of this emerging field. Finally, the Center for Geospatial Analytics provides the interdisciplinary hub that is well equipped with the computational, physical, and intellectual infrastructure needed to catalyze and sustain this cross-college initiative.

APPENDIX C

UNIVERSITY OF NORTH CAROLINA REQUEST FOR AUTHORIZATION TO ESTABLISH A NEW DEGREE PROGRAM

***INSTRUCTIONS:** Each proposal should include a 2-3 page executive summary. The signature of the Chancellor is required. Please submit one hard copy and an electronic copy of the proposal to the Office of the Senior Vice President of Academic Affairs at UNC General Administration.*

Date: **March 3, 2016**

Constituent Institution: *North Carolina State University*

CIP Discipline Specialty Title: **Systems Science and Theory**

CIP Discipline Specialty Number: 30.0601 Level: B ____ M ____ Res. Doc. **X** Prof. Doc. ____

Exact Title of the Proposed Degree: **Geospatial Analytics**

Exact Degree Abbreviation: **PhD**

Does the proposed program constitute a substantive change as defined by SACS? **YES**

The current SACS Substantive Change Policy Statement may be viewed at:
<http://www.sacscoc.org/pdf/081705/Substantive%20Change%20policy.pdf>

If yes, please briefly explain.

This proposed new degree represents the next evolutionary step in the maturation of interdisciplinary Geospatial Sciences. It is one of the first such programs in the United States and is the culmination of several decades of theory development, the extension of spatial analysis applied to related disciplines, and the opportunity to significantly advance scientific understanding of spatial phenomena.

Proposed date to enroll first students in degree program: Month: **August** Year: **2017**

Are there plans to offer 50% or more of program credit hours to students off-campus or online? **NO**

Note: If a degree program has not been approved by the Board of Governors, its approval for alternative, online, or distance delivery must wait until BOG program approval is received. (400.1.1[R], page 3)

Provide a summary of the status of this proposal in your campus review processes.

Campus Body	Determination (votes)	Areas of Concern	Resulting Revisions
Head/DGP, Dept. of Parks, Recreation and Tourism Management	Approved	None	Minor grammatical revisions
Head/DGP, Dept. of Forestry and Environmental Resources	Approved	None	None
College of Natural Resources Graduate Studies Committee	Unanimous approval	Brief comments on the need for a new course prefix versus using our current 'GIS ' prefix; Better highlight differences between a Geography degree and this degree	Adjusted the language in the proposal to identify a possible new prefix based on feedback from the Graduate School; We added additional language to the Executive Summary and program description to highlight these important differences
Dean, College of Natural Resources	Approved	Making sure resource needs are appropriately highlighted; Budget modifications to reflect enrollment increase funds;	Language was adjusted to better describe resource needs at the onset and 10 years into the program; Budget was adjusted to better reflect possible Purpose 101 funds.
Administrative Board of the Graduate School			
Associate Deans Council			
Dean, Graduate School			
Deans Council			
Provost			
Board of Trustees			
Chancellor			

I. DESCRIPTION OF THE PROGRAM

A. Describe the proposed degree program

The PhD in Geospatial Analytics will be an integrative program bringing together the Center for Geospatial Analytics (CGA) with departments from across NC State to produce a new generation of interdisciplinary data scientists skilled in developing novel understanding of spatial phenomena. The program will connect students with mentors and peers across multiple disciplines and will provide scientific and professional knowledge through practicing geospatial analytics in academia, industry, and government agencies. The program will consist of (1) multidisciplinary advising, (2) an intense core curriculum that covers advanced theory in the geospatial sciences along with specialized training in the quantitative, algorithmic, and systems aspect of geospatial computing, information technology, applications, and analytics, in combination with domain research and coursework, (3) an internship experience, and (4) a complete dissertation that advances the field of geospatial science, GIS, and geospatial analytics.

B. List the educational objectives of the program.

This is a unique degree focused on preparing outstanding geospatial scientists skilled in developing novel, trans-disciplinary understanding of spatial phenomena and relationships and applying this new knowledge to societies' grand challenges. The specific educational objectives are designed such that students will:

- 1) Learn to integrate spatial theory, advanced analytics, and sophisticated computational methods for solving place-based societal challenges
- 2) Gain the knowledge and experience needed to conduct outstanding scholarly research on the application of geospatial analytics to complex problems
- 3) Engage in multiple trans-disciplinary research experiences and leveraging the collaborative atmosphere established by the Chancellor's Faculty Excellence initiatives in areas such as Geospatial Analytics, Digital Transformation of Education, Global Environmental Change, Leadership in Public Science, and Global Food Security.

C. Describe the relationship of the program to other programs currently offered at the proposing institution, including the common use of courses, faculty, facilities, and other resources:

This program extends the educational success of NC State's Professional Master of Geospatial Information Science & Technology (MGIST) degree and Graduate Certificate in GIS, which currently have over 240 students enrolled. Furthermore, it is the logical extension of the Chancellor's Faculty Excellence Program (CFEP) cluster in Geospatial Analytics. The addition of Geospatial Analytics also enhances the existing research scope of both the Laboratory for Analytic Sciences and the Data Driven Sciences CFEP initiative.

Courses that currently serve as part of the MGIST curriculum may serve as pre-requisites or skill-building courses for students entering the new PhD program. Some of the more advanced courses may also serve as electives in the PhD program.

Likewise, Faculty Fellows within the Center for Geospatial Analytics will serve as instructors for many of the core courses proposed for the new PhD program. Some of these faculty currently teach in the Master of Geospatial Information Science & Technology (MGIST) program as well.

Students and Faculty involved in the PhD program will have access to many shared *facilities*, including CGA's state-of-the-art Geovisualization Laboratory, Hunt Library visualization studios, Jordan Hall computer labs, and the Center's collaborative spaces, including seminar rooms and advanced classrooms.

Common *resources*, including NC State library resources, software and equipment, as well as specialized software and hardware within CGA and the College of Natural Resources will be readily available for PhD students.

II. JUSTIFICATION FOR THE PROGRAM – NARRATIVE STATEMENT

A. Describe the proposed program as it relates to:

Institutional mission: This degree is fully aligned with the science and technology mission of the University and is designed to markedly enhance both the basic and applied research portfolios of the University. In addition, it addresses a national need for geospatial analytic scientists.

Strategic plan: The new degree directly enhances progress on several of the University's strategic goals including: 1) enhancing interdisciplinary scholarship through the combination of geospatial science with our program in computational science and analytics, 2) enhancing student success by addressing a national workforce need for geospatial scientists, 3) enhancing faculty scholarship and research by adding geospatial analytics to the suite of expert strengths available to our CFEP initiatives, and 4) enhancing the University's strategic partnerships.

Student demand: No additional updates from the information provided in Appendix A.

Societal demand and employability of graduates: No additional updates from the information provided in Appendix A

B. Provide any update to the discussion of similar degree programs and opportunities for collaboration presented in Appendix A. Discuss here the feasibility of a joint or collaborative degree program with one or more UNC institutions.

No other public or private institutions of higher education offer a degree like this proposed degree. In the UNC system, the closest other degree programs are framed within the context of the broader discipline of Geography. Three universities (UNCG, UNCC, and UNC-CH) offer doctoral level degrees in Geography, with the option to concentrate on theory and application of GIScience; seven offer Masters level degrees, and eleven offer undergraduate degrees, primarily focused around Geography, with a few emphasizing the use of GIS. None of these programs solely focus on the scientific and technological advancement of geospatial analytics across disciplines, as we are proposing here.

We have contacted other cognate programs at UNC Chapel Hill (e.g., Geography and City and Regional Planning), Duke (e.g., Geology), UNC Charlotte, and UNC Greensboro, and will use these relationships to explore other possible collaborations. We will also contact other universities in the UNC system, such as East Carolina University, Appalachian State University, Fayetteville State University, NC Central and UNC Wilmington that are

preparing students for PhD level work. Graduates of the undergraduate and master's programs at these institutions might be recruited into this PhD program. Students who do matriculate in this new degree program will also be encouraged to explore opportunities to work with faculty at these other institutions through appropriate research collaborations and by inviting these faculty members to serve on graduate committees.

C. Enrollment

Please indicate the anticipated first year and fourth year steady-state enrollment (head count) for the proposed program.

Year 1: Full Time **12** Part-time **0** Total **12**

Year 4: Full-time **48** Part-time **0** Total **48**

III. PROGRAM REQUIREMENTS AND CURRICULUM

A. Program Planning

Institutions considered with similar high quality offerings:

While the content and approach of the proposed program is unique among peer institutions, there are a number of quality geography programs and some GIScience programs that have related content that was useful in informing the development of this program.

UNC Chapel Hill, University of Maine, UC Santa Barbara, University of Maryland, SUNY Buffalo, George Mason University, The Ohio State University, Arizona State University, and University of South Carolina have well respected programs in geography, with some also including GIScience as part of the curriculum. Other fledgling programs, such as Virginia Tech, South Dakota State University, and UT Dallas have offerings in GIScience as well that were reviewed in developing this program.

Institutions visited or consulted in developing this proposal and consultant reports:

CGA Director, Dr. Ross Meentemeyer held numerous discussion on the proposed program with several institutions, including UNC Chapel Hill, UNC Charlotte, East Carolina University, University of South Carolina, University of Illinois, and Arizona State University.

B. Admissions

Requirements: Admissions to the PhD program will follow all NC State Graduate School criteria for admissions including:

- Minimum undergraduate GPA of 3.0
- GRE Scores
- IBT TOEFL Score of at least 80 overall (18 in each section) (International Applicants)

In addition to program specific requirements including:

- Graduate GPA of at least 3.0 (if entering with a Master's degree)
- Identification of advisor(s)

Required Documents: All applicants will be required to submit the following documents before review of their application will take place

- Official transcripts from all colleges/universities attended
- Personal statement
- 3 Letters of Recommendation
- Official NC State Graduate School application
- CV
- GRE Scores (within last 5 years)
- Writing Sample

C. **Degree requirements**

Total hours required: 72

Other requirements: The PhD program will consist of 72 credit hours beyond the Bachelor's degree. The core required courses comprise 21 credit hours (18 core courses + 3 credit professional experience; listed below). The remaining 51 credit hours are devoted to an individually tailored selection of electives and research.

In the summer following their first year in the program, students will be required to participate in an experiential learning activity in the form of an off-campus professional experience within government (local, state, federal), industry, private and academic research institutions, or other organizations in the geospatial arena. Students will consult with their advisors to identify specific opportunities that will enhance their doctoral program.

A written preliminary exam will be required by the end of the 4th semester, followed by an oral exam consisting of the dissertation proposal defense, typically before the start of the 5th semester. A written dissertation and final dissertation oral defense will be required to complete the degree.

Proportion of courses open only to graduate students to be required in program: 100%

Grades required: Students are expected to maintain a 'B' average or above in all coursework. Any courses with a grade below a 'C' will not count towards the degree credit hour requirements.

Amount of transfer credit accepted: Rules for transfer credit will follow the posted Graduate School rules. A total of 18 hours may be transferred from a previous Master's degree from another university upon approval by the student's advisory committee. Up to 36 hours may be transferred from an NC State Master's degree if there is no break between the Master's degree and PhD degree (If there is a break, only 18 hours can transfer). A maximum of 12 credit hours can be transferred from PBS status for courses with a grade of 'B' or better. All transfer allowances will be determined by the student's graduate advisory committee and DGP, with final approval from the Graduate School.

Language and/or research requirements: There is no specific language requirement. A total of 51 hours in the degree will be devoted to individually tailored selection of electives (technical and domain relevant) and research credit hours approved by the student's advising committee.

Any time limits for completion: Students are expected to reach candidacy by the end of their 6th year and the program will recommend completion of the entire degree within 6 years, excluding approved Leaves of Absences. The Graduate School allows a maximum of 10 years to complete the doctoral degree.

- D. For all programs, list existing courses by title and number and indicate (*) those that are required. Include an explanation of numbering system. List (under a heading marked "new") and describe new courses proposed.**

Existing Courses:

Our existing GIS courses are primarily a part of the Professional Master's program, but some courses may be relevant to a PhD student's work or as technical and analytical skill builders for students entering the program. None of these courses are required but may serve as electives.

GIS 512: Introduction to Environmental Remote Sensing
GIS 515: Computer Cartography
GIS 520: Advanced Geospatial Analytics
GIS 530: Principles of Geographic Information Science
GIS 540: Geospatial Programming Fundamentals
GIS 550: Geospatial Data Structures and Web Services
GIS 582: Geospatial Modeling and Analysis
GIS 595: UAS/Lidar Data Analytics
GIS 609: Geospatial Forum
ST 733: Applied Spatial Statistics
ECE 558: Digital Imaging Systems
ECE 759: Pattern Recognition
ISE 754: Logistics Engineering
FOR 510: Intro to GPS
CSC 540: Database Management and Analysis

New Courses (required core courses):

We propose a possible new prefix (GA) for courses specific to the PhD program, while the GIS prefix would still be used for undergraduate and 500/600 level courses. The following new courses will be developed as part of the program. All courses are 3 credit unless otherwise specified with GA/GIS 710/711/712 being offered in the Fall and GA/GIS 713/714/715 being offered in the Spring semesters each year. All students will take GA/GIS 710 in their first semester and will have a choice from the additional required courses and electives during their first 2 years to include the remaining GA courses.

GA/GIS 710: Geospatial Analytics for Grand Challenges

Demonstrates why sustainable solutions to grand challenges require geospatial analytics. Emphasis is given to the roles that place, spatial interaction, and multi-scale processes play in scientific understanding and communication. Grand challenges such as global environmental change and biological invasions, climate change and disaster management, urbanization and sustainable development, and interactions in the food-energy-water nexus are explored as case studies that benefit from spatial thinking and geospatial analytics

GA/GIS 711: Geospatial Data Management

Applied experience in the architecture of geospatial data management including open source options. The course introduces students to: (i) spatial and temporal data types (OGC specification, GPS and accelerometer matching), (ii) spatial predicates, (iii) spatial indices, and (iv) spatial query processing. In addition, students will be exposed to modern spatial data

management systems like NoSQL and graph databases, and data integration principles including protected health information (PHI/HIPAA)

GA/GIS 712: Environmental Earth Observation and Remote Sensing

Advanced understanding of physical principles of remote sensing, image processing, and applications from earth observations. Awareness of tradeoffs between earth observing sensors, platforms and analysis techniques will help prepare the students to critically assess remote sensing products and devise solutions to environmental problems. Students will be able to communicate the complexities of image analysis and will be better prepared to integrate earth observations into their areas of expertise. Topics include electromagnetic energy and radiative transfer; US and international orbital and suborbital data acquisition platforms; passive and active imaging and scanning sensors; spatial, spectral, radiometric, and temporal resolutions; geometric corrections and radiometric calibrations; preprocessing of digital remotely sensed data; advanced image analysis including enhancement, enhancement, classification, geophysical variable retrieval, error and sensitivity analysis; data fusion; data assimilation; and integration of remotely sensed data with other data types in a geospatial modeling context.

GA/GIS 713: Geospatial Data Mining and Analysis

Spatial data mining is the process of discovering interesting and previously unknown, but potentially useful patterns from the spatial and spatiotemporal data. However, explosive growth in the spatial and spatiotemporal data (~70% of all digital data), and the emergence of geosocial media and location sensing technologies has transformed the field in recent years. This course reviews the current state of the art in spatial, temporal, and spatiotemporal data mining and looks at real-world applications ranging from geosocial networks to climate change impacts. Course introduces various spatial and temporal pattern families and teaches how to incorporate spatial relationships and constraints into data mining approaches like clustering, classification, anomalies, and colocations

GA/GIS 714: Geospatial Computation and Simulation

Methods, algorithms, and tools for geospatial modeling and predicting spatio-temporal dimensions of environmental systems. The course covers the physical, biological, and social processes that drive dynamics of landscape change. Deterministic, stochastic, and multi-agent simulations are explained, with emphasis on coupling empirical and process based models, techniques for model calibration and validation, and sensitivity analysis. Applications to real-world problems are explored, such as modeling multi-scale flow and mass transport, spread of wildfire, biological invasions, and urbanization.

GA/GIS 715: Geovisualization

Principles of visualization design and scripting for geospatial visualization. This course provides a systematic framework of visualization design

principles based on the human visual system and explores open-source geospatial data visualization tools. Topics include challenges and techniques for visualizing large multivariate dataset, spatio-temporal data, and landscape changes over time. Students have the opportunity to work with broad range of visualization technologies, including frontiers in immersive visualization, tangible interaction with geospatial data and eye tracking.

GA/GIS 850: Professional Experience

Experiential learning activity in the form of an off-campus professional experience within government (local, state, federal), industry, private, and academic research institutions, or other organizations in the geospatial arena. Students consult with their advisors to identify specific opportunities that will enhance their doctoral program.

GA/GIS 893: Doctoral Supervised Research

GA/GIS 895: Doctoral Thesis Research

GA/GIS 899: Doctoral Thesis Preparation

IV. FACULTY

A. Faculty List (For undergraduate and master's programs)

NA for doctoral programs

B. Faculty List (For doctoral programs)

Names, Rank, and Tenure Home of the SACS approved faculty are listed below. These faculty have been identified for their ability to teach, advise, and/or mentor within the proposed program, it is not an exhaustive list.

Faculty Name	Rank	Tenure Home	College
Ross Meentemeyer	Professor	CGA/Forestry and Environmental Resources	Natural Resources
Raju Vatsavai	Associate Professor	Computer Science/CGA	Engineering
Helena Mitsova	Professor	Marine, Earth, Atmospheric Sciences/CGA	Sciences
Laura Tateosian	Research Assistant Professor	CGA/Parks, Recreation, Tourism Management	Natural Resources
Perver Baran	Teaching Assistant Professor	CGA/Parks, Recreation, Tourism Management/Design	Design/Natural Resources
Aaron Hipp	Associate Professor	Parks, Recreation, Tourism Management/CGA	Natural Resources

Siamak Khorram	Professor	Forestry and Environmental Resources	Natural Resources
Benjamin Watson	Associate Professor	Computer Science	Engineering
Ryan Emanuel	Assistant Professor	Forestry and Environmental Resources	Natural Resources
Erin Hestir	Assistant Professor	Marine, Earth, Atmospheric Science/CGA	Sciences
Karl Wegman	Associate Professor	Marine, Earth, Atmospheric Science	Sciences
Roland Keys	Research Associate Professor	Forestry and Environmental Resources	Natural Resources
Alyson Wilson	Professor	Statistics	Sciences
Montserrat Fuentes	Professor	Statistics	Sciences
Eric Money	Teaching Assistant Professor	CGA/Forestry and Environmental Resources	Natural Resources
Jeff White	Associate Professor	Soil Science	Ag and Life Sciences
Yu-Fai Leung	Professor	Parks, Recreation, and Tourism Management	Natural Resources
Dan Obenhour	Assistant Professor	Civil Engineering	Engineering
Tom Gower	Professor	Forestry and Environmental Resources	Natural Resources
Stacy Nelson	Professor	Forestry and Environmental Resources/CGA	Natural Resources
Del Bohnenstiehl	Associate Professor	Marine, Earth, Atmospheric Science	Sciences
Melissa McHale	Assistant Professor	Forestry and Environmental Resources	Natural Resources

- C. **Estimate the need for new faculty for the proposed program over the first four years. If the teaching responsibilities for the proposed program will be absorbed in part or in whole by the present faculty, explain how this will be done without weakening existing programs.**

With the addition of faculty from the CFEP cluster hires in geospatial analytics, with expertise in Geospatial Modelling, Computational Geospatial Analytics, and Large System Remote Sensing, the need for additional faculty is minimal at this time. All of the core courses in the new program will be taught by existing faculty.

D. Explain how the program will affect faculty activity, including course load, public service activity, and scholarly research.

Core faculty teaching course load will not change since new and upcoming faculty hires as part of several Chancellors Faculty Excellence Program cluster hires have expectations to support this new program. In addition, faculty involved in this program will have the opportunity to increase their collaborative scholarly research by working with students and other faculty within the program on publications, research projects, and grants as appropriate.

V. LIBRARY

A. Provide a statement as to the adequacy of present library holdings for the proposed program to support the instructional and research needs of this program.

The expansive Visualization and Geospatial staff, facilities, literature and data collections of the Hunt and Hill Libraries and the Natural Resources Library, in combination, provide an unparalleled environment for research and study in this field.

B. State how the library will be improved to meet new program requirements for the next four years. What additional library support must be added to areas supporting the proposed program?

The existing library infrastructure is comprehensive and will be able to provide us with the necessary resources for the foreseeable future. A few additional periodicals in areas such as computing and remote sensing may be acquired to supplement the expansive periodicals already available. With the existence of a GIS librarian, visualization spaces, expansive network of regional, state, national, and international libraries, the University library system is well-positioned to support this new program.

C. Discuss the use of other institutional libraries.

Through existing relationships and agreements with other university libraries UNC system-wide, as well as with private institutions, such as Duke, inter-institutional library resources are readily available on a local, regional, state, national, and international level and will be leveraged in coursework and research throughout the program.

VI. FACILITIES AND EQUIPMENT

A. Describe facilities available for the proposed program.

There are a number of facilities available to provide extensive support for the new program. The Center for Geospatial Analytics, as part of both the College of Natural Resources' Strategic Plan and the CFEP, has created an outstanding new graduate teaching and research facility in Jordan Hall to support the proposed program, this facility includes:

- State-of-the-art Geovisualization Laboratory with computing equipment, modeling technologies, workstations, and collaborative spaces. Completed in May 2013, the Geovisualization Laboratory (Jordan Hall 5111) is the Center's flagship, research and teaching environment designed to visualize real-world geospatial data through abstracted mediums, including, including 3D imagery, collaborative touch-screen displays, immersive virtual environments, and interactive decision-making systems. This outstanding facility enables the Center and the College of Natural Resources to attract internationally acclaimed faculty, postdoctoral and visiting scholars, and talented graduate students. The Geovisualization Laboratory houses a variety of tools and instruments dedicated to representing and interacting with geospatial data collected through projects dedicated to research, extension, and teaching. Specifically, these advanced tools and instruments include:
 - An Immersive Virtual Reality System includes a 360° high-resolution camera designed to collect full-motion image sequences of research settings such as natural landscapes or urban environments. The immersive virtual reality system also includes virtual simulation stations, which allow researchers to simulate external environments within the lab setting via the use of head-mounted displays synched to the previously collected image sequences.
 - A Tangible Geospatial Modeling Workstation allows researchers to build a physical 3D-scale model of a landscape, scan it with a laser that feeds data back to a geographic information modeling system where it can be analyzed. Subsequently, the researcher can alter the physical, scale model and rapidly reanalyze the altered landscape, thus allowing rapid development and analysis of alternative scenarios.
 - An Ocular Tracking System with specialized hardware and software enables researchers to measure eye movement over digital maps and other media in order to increase the efficiency of visual communications.
 - A 3D-4k Projection System provides researchers the capability of presenting data and research findings via large-screen, extremely high definition, 3D images and special 3D goggles. Potential applications include not only visualizing complex data in a large format at resolutions exceeding standard HD monitors, but also developing and sharing high-quality visualizations of research findings, such as fly-throughs of remotely sensed data, among industry and government representatives and other stakeholders.
 - A SimTable Modeling Environment combines existing geospatial data with agent-based modeling and ambient computing to transform traditional sand table exercises into interactive digital maps and simulations projected onto any surface. SimTable provides a straightforward and interactive approach to displaying research results to fellow researchers, management, stakeholders, and the public alike. (Image credit: Stephen Guerin)
 - Several 3D GIS Workstations allow researchers to display and navigate through complex geospatial data such as high-resolution satellite imagery and LiDAR data. These stations also have the capability of allowing researchers to manipulate these data via motion sensing devices that capture hand gestures and movements.
 - An Interactive Multitouch Tabletop Display functions as a workspace where groups can collaborate on problem-solving that requires a geographic information system. The displays enable groups of researchers and collaborators to share ideas and visualize existing data in a digitally-integrated and socially-interactive setting. Within the

laboratory are numerous technologies available for teaching and research including:

- Interactive seminar room
- Advanced Teaching Classroom with movable computer pods for individualized and group instruction
- Graduate Student Workspace and Collaboration Facility with individual and group work spaces

In addition, the University has joined with the NC Museum of Natural Resources in establishing the Earth Observation and Biodiversity Lab in the new Nature Research Center, which will provide both facilities and outreach for the new degree program.

D.H. Hill and Hunt Libraries on campus also provide multiple workstations, collaborative spaces, and visualization studios for teaching and research.

B. Describe the effect of this new program on existing facilities and indicate whether they will be adequate, both at the commencement of the program and during the next decade.

The existing CGA facilities as described above were designed to be adaptable for some amount of growth, and it is expected that these current facilities will be adequate to meet the needs of the first cohort of PhD students. During the first year we will work to increase the efficiency of existing space; however, if the popularity of our other educational program offerings is any indication, there will be a need for additional space at full buildout of the program, including additional common lab space and workstations for graduate students. We look forward to working with the Dean of the College and the Graduate School to make this a reality. We have already begun identifying space to explore for future development and rehabilitation in the Jordan Building complex.

C. Describe information technology and services available for the proposed Program

The College of Natural Resources has an outstanding Information Technology group that provides personalized support related to computing and IT within the College. In combination with the University OIT, the IT infrastructure is well prepared to support the new program. CNR IT provides services such as computer and equipment set-up, troubleshooting, classroom technology upgrades and maintenance, along with University services related to software acquisition and other general IT support.

Within the Center for Geospatial Analytics, Dr. Raju Vatsavai has been appointed as the Associate Director of Spatial Computing and Technology charged with maintaining and expanding the technology infrastructure needed for teaching and research within the Center.

D. Describe the effect of this new program on existing information technology and services and indicate whether they will be adequate, both at the commencement of the program and during the next decade.

We do not expect this program to have a significant impact on the existing IT infrastructure and services during the first year of implementation; however, at full buildout of the program, additional resources may be warranted in order to fully support the influx of students with computing and technology needs. This includes server

development and enhancements for big data computing, analysis, and storage needs as well as additional Virtual Computing Lab support. With the computing and IT resources currently within CGA, the College of Natural Resources, and the University, we are able to absorb the demands of the new program at the onset; however, over the next decade additional resources will need to be considered.

VII. ADMINISTRATION

A. Administration Overview

The PhD program will be administered by the Center for Geospatial Analytics and College of Natural Resources. It is expected the CGA Director, Dr. Ross Meentemeyer will serve as the Director of Graduate Programs and will be responsible for overseeing the matriculation and progress of students in the program. The DGP will be assisted by a part-time Graduate Coordinator who will serve as the liaison between students, academic affairs, and the graduate school concerning admissions, progress, graduation and other student related issues.

The DGP will coordinate with the faculty, departments and college deans as necessary when admitting students into the PhD who have selected advisors with a unit outside of CGA and the College of Natural Resources. Due to the interdisciplinary nature of this degree, it is expected that some PhD students will select advisors in other departments and agreements between the faculty's home department/college will be formalized before any student matriculates into the program.

B. Responsibilities (by Dept/Div/College)

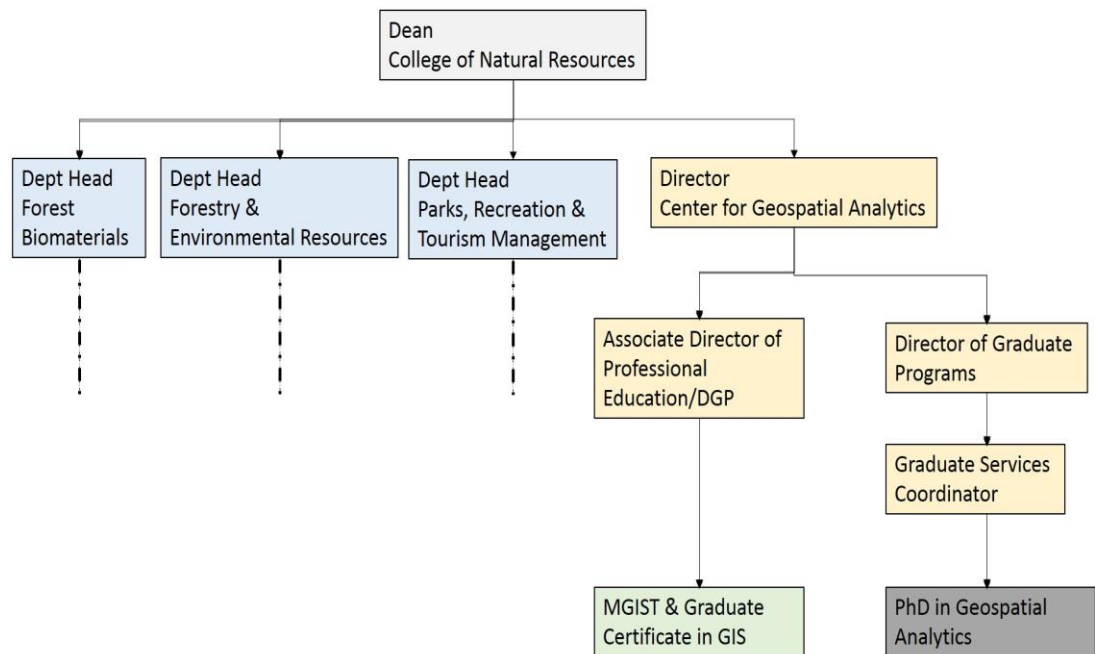
The College of Natural Resources and Center for Geospatial Analytics will be responsible for matriculation, reporting, student progress, graduation, and other activities for students enrolled in the PhD program. Faculty in participating departments may serve as advisors, chairs or co-chairs and/or committee members for students in the program.

C. Inter-departmental/Inter-unit Plans

The PhD in Geospatial Analytics is designed to be an interdisciplinary degree. Students will matriculate into the program through the CGA and College of Natural Resources, with the expectation of multidisciplinary advising. Students will belong to a participating department and will have a primary advisor in that home department who is recognized by the Graduate School as a member of the Geospatial Information Science and Technology (GIST) faculty. In addition, the advising committee will consist of four additional faculty members in a complementary field. One committee member will be declared a domain expert for the problem being studied.

D. Organizational Chart showing location of new program

The organizational chart below shows the general location of the proposed program within the College of Natural Resources. Administratively the program will be directed by the Center for Geospatial Analytics, which is also the administrative home of the MGIST and Graduate Certificate in GIS programs. There will be a DGP and coordinator assigned specifically to the PhD program.



VIII. ACCREDITATION AND LICENSURE

- A. **Where appropriate, describe how all licensure or professional accreditation standards will be met, including required practica, internships, and supervised clinical experiences.**

Not applicable to this program

- B. **Indicate the names of all accrediting agencies normally concerned with programs similar to the one proposed. Describe plans to request professional accreditation.**

Not applicable to this program

- C. **If the new degree program meets the SACS definition for a substantive change, what campus actions need to be completed by what date in order to ensure that the substantive change is reported to SACS on time?**

All required information would be submitted to SACS more than six months prior to the first student being enrolled in the program. This proposal recommends fall 2017 as the date of first student enrollment. It is anticipated that given this time frame all reporting requirements can be met.

- D. **If recipients of the proposed degree will require licensure to practice, explain how program curricula and title are aligned with requirements to “sit” for the licensure exam.**

Not applicable to this program

IX. SUPPORTING FIELDS

Discuss the number and quality of lower-level and cognate programs for supporting the proposed degree program. Are other subject-matter fields at the proposing institution necessary or valuable in support of the proposed program? Is there needed improvement or expansion of these fields? To what extent will such improvement or expansion be necessary for the proposed program?

There are no lower-level programs supporting this program. Other subject-matter fields, including Computer Science, Engineering, Statistics, Marine, Earth and Atmospheric Science, Forestry and Environmental Resources, Parks, Recreation and Tourism Management, other natural science and social science disciplines will be valuable in supporting this program in terms of faculty serving on interdisciplinary advising committees and serving as advisors. We do not anticipate any need for significant expansion or improvement in these fields.

X. ADDITIONAL INFORMATION

XI. BUDGET

A 4 year budget is presented on the following 4 pages, followed by a brief narrative describing the proposed funds.

A. 4 Year Budget

SUMMARY OF ESTIMATED ADDITIONAL COSTS FOR PROPOSED PROGRAM					
INSTITUTION	NC State University			Date:	14-Jan-16
Program (CIP, Name Level)	30.0601, PhD Geospatial Analytics				
Degree(s) to be Granted	PhD		Program Year	Year 1 (2017-2018)	
Projected annual FTE students	12				
Differential tuition requested per student per academic yr	\$0				
Projected annual differential tuition	\$0				
Projected annual differential tuition for financial aid	\$0				
Differential tuition remainder	\$0				

Cost Description	Number	Source of Funds				Total
		Reallocation from College	Enrollment Increase *	Contracts & Grants	Other (DELTA)	
12XX SPA salary						
Graduate Services Coordinator	0.500	5,000	20,000			25,000
TOTAL 12XX	0.500	5,000	20,000	-	-	25,000
13XX EPA salaries						
Director of Graduate Programs	0.200	5,260	21,040		-	26,300
Position 2 title	0.000				-	-
Position 3 title	0.000				-	-
Graduate Student Assistants @ \$25K	6.000	30,000	120,000	-	-	150,000
TOTAL 13XX	6.200	35,260	141,040	-	-	176,300
18XX Fringes						
Faculty/Staff @ 27%	0.750	2,770	11,081		-	13,851
Graduate Student Assistants @ 9.5%	12.000	2,850	11,400	-	-	14,250
						-
						-
TOTAL 18XX		5,620	22,481	-	-	28,101
2-5XX Operating						
Copying/Postage/Office Supplies		1,000	1,000		-	2,000
Travel		1,500	2,500		-	4,000
Equipment		1,000	7,500			8,500
Other		1,000	4,000			5,000
TOTAL 2-5XX		4,500	15,000	-	-	19,500
6XX Graduate Student Support Plan (GSSP)						
RA/TA Health Insurance	6	2,325	9,301	-	-	11,626
In-State Tuition	6	12,268	49,070	-	-	61,338
Tuition Remission	2	2,738	10,950	27,376	-	41,064
Tuition Remission Matching @ 25%						
TOTAL 6XX		17,330	69,321	27,376	-	114,028
TOTAL COSTS		\$ 67,711	\$ 267,842	\$ 27,376	\$ -	\$ 362,929

SUMMARY OF ESTIMATED ADDITIONAL COSTS FOR PROPOSED PROGRAM					
INSTITUTION	NC State University			Date:	14-Jan-16
Program (CIP, Name Level)	30.0601, PhD Geospatial Analytics				
Degree(s) to be Granted	PhD		Program Year	Year 2 (2018-2019)	
Projected annual FTE students	24				
Differential tuition requested per student per academic yr	\$0				
Projected annual differential tuition	\$0				
Projected annual differential tuition for financial aid	\$0				
Differential tuition remainder	\$0				

Cost Description	Number	Reallocation from College	Enrollment Increase *	Source of Funds			Total	Total New This Year
				Contracts Grants	& Other (DELTA)			
12XX SPA salary								
Graduate Services Coordinator	0.500	5,000	20,000				25,000	
TOTAL 12XX	0.500	5,000	20,000	-	-	-	25,000	-
13XX EPA salaries								
Director of Graduate Programs	0.250	5,260	21,040			-	26,300	
Position 2 title	0.000					-	-	
Position 3 title	0.000					-	-	
Graduate Student Assistants @ 25K	12.000	70,000	230,000		-	-	300,000	
TOTAL 13XX	12.250	75,260	251,040	-	-	-	326,300	150,000
18XX Fringes								
Faculty/Staff @ 27%	0.750	2,770	11,081			-	13,851	
Graduate Student Assistants @ 9.5%	24.000	6,650	21,850		-	-	28,500	
							-	
							-	
TOTAL 18XX		9,420	32,931	-	-	-	42,351	14,250
2-5XXX Operating								
Copying/Postage/Office Supplies		1,000	500			-	1,500	
Travel		1,500	2,000				3,500	
Equipment		1,000	2,000				3,000	
Other		1,000	2,000				3,000	
TOTAL 2-5XX		4,500	6,500	-	-	-	11,000	(8,500)
6XX Graduate Student Support Plan (GSSP)								
RA/TA Health Insurance	12	4,650	18,601		-	-	23,252	
In-State Tuition	12	24,535	98,141		-	-	122,676	
Tuition Remission	1	2,738	10,950			-	13,688	
Tuition Remission Matching @ 25%								
TOTAL 6XX		31,923	127,693	-	-	-	159,616	45,588
TOTAL COSTS		126,103	438,163	-	-	-	564,267	201,338

SUMMARY OF ESTIMATED ADDITIONAL COSTS FOR PROPOSED PROGRAM					
INSTITUTION	NC State University			Date:	14-Jan-16
Program (CIP, Name Level)	30.061, PhD Geospatial Analytics				
Degree(s) to be Granted			Program Year	Year 3 (2019-2020)	
Projected annual FTE students	36				
Differential tuition requested per student per academic yr	\$0				
Projected annual differential tuition	\$0				
Projected annual differential tuition for financial aid	\$0				
Differential tuition remainder	\$0				

Cost Description	Number	Source of Funds					Total New This Year
		Reallocation from College	Enrollment Increase *	Contracts & Grants	Other (DELTA)	Total	
12XX SPA salary							
Graduate Services Coordinator	0.500	5,000	20,000			25,000	
TOTAL 12XX	0.500	5,000	20,000	-	-	25,000	-
13XX EPA salaries							
Director of Graduate Programs	0.250	5,260	21,040			26,300	
Position 2 title	0.000					-	
Position 3 title	0.000					-	
Graduate Student Assistants @ \$25K	18.000	90,000	360,000			450,000	
TOTAL 13XX	18.250	95,260	381,040	-	-	476,300	150,000
18XX Fringes							
Faculty/Staff @ 27%	0.750	2,770	11,081			13,851	
Graduate Student Assistants @ 9.5%	36.000	8,550	34,200			42,750	
						-	
						-	
						-	
TOTAL 18XX		11,320	45,281	-	-	56,601	14,250
2-5XXX Operating							
Copying/Postage/Office Supplies		1,000	1,000			2,000	
Travel		1,500	2,500			4,000	
Equipment		1,000	2,500			3,500	
Other		1,000	4,000			5,000	
TOTAL 2-5XX		4,500	10,000	-	-	14,500	3,500
6XX Graduate Student Support Plan (GSSP)							
RA/TA Health Insurance	18	6,976	27,902			34,878	
In-State Tuition	18	36,803	147,211			184,014	
Tuition Remission	1	2,738	10,950			13,688	
Tuition Remission Matching @ 25%							
TOTAL 6XX		46,516	186,064	-	-	232,580	72,964
TOTAL COSTS		162,596	642,384	-	-	804,981	240,714

SUMMARY OF ESTIMATED ADDITIONAL COSTS FOR PROPOSED PROGRAM					
INSTITUTION	NC State University			Date:	4-Jan-16
Program (CIP, Name Level)	30.061, PhD Geospatial Analytics				
Degree(s) to be Granted	PhD		Program Year	Year 4 (2020-2021)	
Projected annual FTE students	48				
Differential tuition requested per student per academic yr	\$0				
Projected annual differential tuition	\$0				
Projected annual differential tuition for financial aid	\$0				
Differential tuition remainder	\$0				

Cost Description	Number	Source of Funds				Total	Total New This Year
		Reallocation from College	Enrollment Increase *	Contracts Grants	& Other (DELTA)		
12XX SPA salary							
Graduate Services Coordinator	0.500	5,000	20,000			25,000	
TOTAL 12XX	0.500	5,000	20,000	-	-	25,000	-
13XX EPA salaries							
Director of Graduate Programs	0.250	5,260	21,040			26,300	
Position 2 title	0.000					-	
Position 3 title	0.000					-	
Graduate Student Assistants @ \$25K	24.000	120,000	480,000			600,000	
TOTAL 13XX	24.250	125,260	501,040	-	-	626,300	150,000
18XX Fringes							
Faculty/Staff @ 27%	0.750	2,770	11,081		-	13,851	
Graduate Student Assistants @ 9.5%	48.000	11,400	45,600	-		57,000	
						-	
						-	
TOTAL 18XX		14,170	56,681	-	-	70,851	14,250
2-5XXX Operating							
Copying/Postage/Office Supplies		1,000	1,000			2,000	
Travel		1,500	2,500			4,000	
Equipment		1,000	2,500			3,500	
Other		1,000	4,000			5,000	
TOTAL 2-5XX		4,500	10,000	-	-	14,500	-
6XX Graduate Student Support Plan (GSSP)							
RA/TA Health Insurance	24	9,301	37,203		-	46,503	
In-State Tuition	24	49,070	196,282		-	245,352	
Tuition Remission	1	2,738	10,950		-	13,688	
Tuition Remission Matching @ 25%							
TOTAL 6XX		61,109	244,435	-	-	305,543	72,964
TOTAL COSTS		210,039	832,155	-	-	1,042,194	237,214

B. Budget Narrative

SPA Salary: We anticipate utilizing a half-time (0.5 FTE) graduate services coordinator at an annualized salary of \$50,000 to aid in the day to day operations of the program including assisting students and the DGP through admissions, student progress, reporting, assessment, and graduation.

EPA Salary: One-fifth faculty time will be allotted for Director of Graduate Program duties. It is anticipated the CGA Director will be the DGP for the PhD program, with the budgeted amount equal to 0.20 of annual salary.

Graduate Student Stipends: The program will offer \$25,000 12-month assistantships to students entering the program. With a first cohort of 12 students, we propose full TAs for 6 of the students, with the source of funds divided between College funds and enrollment increase funds, with the other 6 FTE students being supported on faculty contracts and grants. In subsequent years we propose to maintain support for half of all incoming students through teaching assistantships with funds coming from the College (~20%) and the remainder (~80%) from enrollment increase funds. The remaining students would be supported through faculty contracts and grants. By year 4 of the program we expect to be supporting half of the students (24) through TA support funds and half of the students on RA (contract and grant) funds.

Tuition Support: Up to a third of students may enter from out-of-state and require tuition remission support either through TAs or RA's from contracts and grants as outlined above during their first year. It is expected that out-of-state students will transition to in-state for tuition purposes by the end of the first year/beginning of their second year at latest, resulting in approximately 1-3 FTE students (out of 48) needing tuition remission support each year by year 4 of the program. Again, we propose dividing the source of these funds among the College and enrollment increase funds.

Office Supplies: Additional funds are requested each year to support office and administrative operations, including developing and printing materials for recruitment, admissions, and orientation programs.

Travel: Funds are requested to help support both faculty and student travel to professional conferences, both for scholarly research and presentation, but also for program advertising and recruitment.

Equipment: Funds will be used to help with the procurement of computer equipment for new students, and support IT infrastructure improvements for data storage and analysis.

Other: Additional funds are requested to assist the library in obtaining additional journals relevant to the PhD program focusing on remote sensing, geospatial analytics, and other topics that may not currently be in the library's collection. Additionally, these funds will go to support the CGA forum series that is an integral part of the PhD program and will allow us to host numerous invited speakers from across the country and internationally.

C. Based on the campus' estimate of available existing resources or expected non-state financial resources that will support the proposed program (e.g., federal support, private sources, tuition revenue, etc), will the campus:

1. *Seek enrollment increase funds or other additional state appropriations (both one-time and recurring) to implement and sustain the proposed program? If so, please elaborate.*

We have proposed to use enrollment increase funds to help support recurring teaching assistantships for first year students as well as some operational expenses as outlined in the budget. We are working closely with the Dean of the College of Natural Resources to acquire some additional reallocations funds to support additional expenses. Approximately half of our overall costs will come from faculty contracts and grants for supporting students, with the remaining costs split among College funds and enrollment increase funds. We propose approximately 80% of the remainder will come from enrollment increase funds.

We are also proposing a one-time appropriation for 2016/2017 to help with the final stages of course and curriculum development before the first students matriculate into the program in Fall 2017.

2. *Require differential tuition supplements or program-specific fees? If so, please elaborate.*

Not applicable

D. If enrollment increase funding, differential tuition, or other state appropriations noted in the budget templates are not forthcoming, can the program still be implemented and sustained and, if so, how will that be accomplished? Please elaborate and provide documentation of campus commitments where appropriate.

Enrollment increase funds are desirable to help recruit and retain the highest caliber students into the program with competitive stipends and teaching assistantships during their first year. We are working closely with the College to provide supplemental support, but it will be difficult to meet the goals of this program without the appropriate funds as outlined in the proposed budget.

XII. EVALUATION PLANS

All new degree program proposals must include an evaluation plan which includes:

A. Criteria to be used to evaluate the quality and effectiveness of the program, including academic program student learning outcomes.

The PhD in Geospatial Analytics will be evaluated using the following criteria:

- Number, quality, and diversity of students who apply, are admitted, and who enroll
- Faculty serving as advisors, instructors, and mentors
- Peer reviewed papers and presentations at professional meetings
- Research and training grants earned in Geospatial Analytics and related fields
- Time to degree

- Evaluation of Professional Experience requirement by student and partner
- Information from exit interviews
- Career paths and placement
- Employer surveys
- Periodic program review

B. Measures (metrics) to be used to evaluate the program (include enrollments, number of graduates, and student success).

The Director of Graduate Programs and Graduate Services Coordinator will track various metrics to use when evaluating the program through the use of exit interviews, as well as consultation with advisory panels (employers) and students pre- and post-graduation. These include:

- Tracking recruitment and retention numbers (contacted, applied, admitted, enrolled, graduated)
- Faculty involvement through number of committees served, number of advisor roles
- Scholarly productivity through the number and frequency of student publications and presentations
- Grants earned
- Time to degree
- Assessment of career paths and time to placement post-graduation

C. The plan and schedule to evaluate the proposed new degree program prior to the completion of its fourth year of operation.

The program will initially be assessed after year 1 of the program by consulting with the initial cohort of students, as well as faculty involved. The program will again be assessed at years 2, 3, and 4 to examine student progress of the first cohort and assess the effect any modifications may have had after the year 1 review. At the end of year 4 we expect to be able to evaluate our first graduates from the program and at that point will have a continuous assessment plan in place to coincide with the Graduate School assessment schedule for programs to assess the program objectives and student outcomes on a rotating basis as required by the Graduate School.

XIII. REPORTING REQUIREMENTS

Institutions will be expected to report on new program productivity as a part of the biennial low productivity program review process.

XIV. ATTACHMENTS

Attachment 1: Approved Appendix A

Attachment 2: (separate document) Faculty CVs

This proposal to establish a new degree program has been reviewed and approved by the appropriate campus committees and authorities.

Chancellor:

Date: _____

Attachment 1: Final Approved Appendix A

APPENDIX A
UNIVERSITY OF NORTH CAROLINA
REQUEST FOR AUTHORIZATION TO PLAN
A NEW DEGREE PROGRAM

THE PURPOSE OF ACADEMIC PROGRAM PLANNING: Planning a new academic degree program provides an opportunity for an institution to make the case for need and demand and for its ability to offer a quality program. The notification and planning activity to follow do not guarantee that authorization to establish will be granted.

Date: **June 13, 2014**

Constituent Institution: *North Carolina State University*

CIP Discipline Specialty Title: ***Systems Science and Theory***

CIP Discipline Specialty Number: **30.0601** Level: B ____ M ____ Res.Doc. **X** Prof. Doc. ____

Exact Title of the Proposed Program: ***Geospatial Analytics***

Exact Degree Abbreviation (e.g. B.S., B.A., M.A., M.S., Ed.D., Ph.D.): ***Ph.D.***

Does the proposed program constitute a substantive change as defined by SACS? **Yes**

The current SACS Substantive Change Policy Statement may be viewed at:

<http://www.sacscoc.org/pdf/081705/Substantive%20Change%20policy.pdf>

If yes, please briefly explain.

This proposed new degree represents the next evolutionary step in the maturation of interdisciplinary Geospatial Sciences. It is one of the first such programs in the United States and is the culmination of several decades of theory development, the extension of spatial analysis applied to related disciplines, and the opportunity to significantly advance scientific understanding of spatial phenomena.

Proposed date to enroll first students in degree program: Month **August** Year **2016**

1. Provide a summary of the status of this proposal in your campus review processes.
 - a. List the campus bodies that reviewed and commented on this Appendix A proposal before submission to UNC General Administration. What were their determinations? Include any votes, if applicable.

This proposal was reviewed and endorsed, recommended, or approved by:

Graduate GIS Faculty

Head, Department of Parks, Recreation and Tourism Management

Head, Department of Forestry and Environmental Resources

College of Natural Resources Graduate Studies Committee (unanimous approval)

Dean, College of Natural Resources

Council of Deans (unanimous approval)

Administrative Board of the Graduate School

Dean of the Graduate School
Provost
Chancellor

- b. Summarize any issues, concerns or opposition raised throughout the campus process and comment periods. Describe revisions made to address areas of concern.

All reviews of this Appendix A proposal were favorable. The Deans of the Colleges of Natural Resources and Sciences recommended expanding the role of the Statistics department in the planning process. In response, we met with the Statistics department head and selected faculty and subsequently added several additional members of the Statistics faculty to the curriculum planning team.

2. Describe the proposed new degree program. The description should include:

- a. A brief description of the program and a statement of educational objectives

This is a unique degree focused on preparing outstanding geospatial scientists skilled in developing novel, trans-disciplinary understanding of spatial phenomena and relationships and applying this new knowledge to societies' grand challenges. The specific educational objectives are designed such that students will:

- 4) *Learn to integrate spatial theory, advanced analytics, and sophisticated computational methods for solving place-based societal challenges*
- 5) *Gain the knowledge and experience needed to conduct outstanding scholarly research on the application of geospatial analytics to complex problems*
- 6) *Engage in multiple trans-disciplinary research experiences, particularly those linked to other Chancellor's Faculty Excellence initiatives (e.g., data driven science, bioinformatics, forensic sciences, public health, etc.)*

The curriculum will consist of an intense first year of theory and modeling in geospatial science, development of advanced computational skills, and spatial research design methods. These initial courses will be a combination of existing courses in Advanced GIS, Statistics, Computer Science, and Advanced Analytics plus three new courses developed by our lead Geospatial faculty. The second through fourth years would focus on advanced study and research frontiers in one of the core science areas of the faculty. Frontiers include Environmental Remote Sensing, Geospatial Intelligence and Data Mining, Spatial-Temporal Modelling, Geovisualization, and advanced applications in one of the 15+ disciplines represented in the program.

- b. The relationship of the proposed new program to the institutional mission

This degree is fully aligned with the science and technology mission of the University and is designed to markedly enhance both the basic and applied research portfolios of the University. In addition, it addresses a national need for geospatial analytic scientists.

- c. The relationship of the proposed new program to existing programs at the institution and to the institution's strategic plan

This program extends the educational success of our two Professional Science Masters' degrees in Geospatial Information Science and Technology and Advanced Analytics. It is the logical extension of the Chancellor's Faculty Excellence Program (CFEP) cluster in Geospatial Analytics. In addition, it enhances the existing research scope of both the Laboratory for Analytic Sciences and the Data Driven Sciences CFEP initiative with the addition of geospatial analytics.

The new degree directly enhances progress on several of the University's strategic goals including: 1) enhancing interdisciplinary scholarship through the combination of geospatial science with our program in computational science and analytics, 2) enhancing student success by addressing a national workforce need for geospatial scientists, 3) enhancing faculty scholarship and research by adding geospatial analytics to the suite of expert strengths available to our CFEP initiatives, and 4) enhancing the University's strategic partnerships.

- d. Special features or conditions that make the institution a desirable, unique, or cost effective place to initiate such a degree program

NC State has assumed a leadership role in the region with the establishment of the very successful Professional Science Master of Geospatial Science and Technology (MGIST) degree, the Graduate Certificate in Geographic Information Systems, and the graduate minors in Geographic Information Systems and Remote Sensing. The success of these programs, both in enrollment and student placement (e.g., 95%+ for the MGIST students), and the related success of the research program (e.g., 4 million dollars in active grants in 2013 in the Center for Geospatial Analytics alone) illustrate the great potential for international impact by NC State in this area. In addition, NC State already has in place a recognized and active Graduate Geographic Information Science Faculty that connects over 35 faculty spanning 16 different departments and 7 colleges.

Perhaps most importantly, the Chancellor's Faculty Excellence Program in Geospatial Analytics created three new faculty lines (all hired), and the College of Natural Resources is currently conducting an open search for two additional tenure-track faculty positions focused on Geospatial Analytics. These new faculty lines along with the corresponding expansion of students and staff in the Center for Geospatial Analytics immediately makes NC State a premier institution for research and scholarship in computational geospatial analytics.

The proposed program aligns exactly with NC State's strategic goal to enhance interdisciplinary scholarship that addresses the grand challenges of society.

3. Provide documentation of student demand. Discuss the extent to which students will be drawn from a pool of students not previously served by the institution. Evidence of student demand should reflect likely applicant pools (local, regional, statewide, national, or global) and could include:
 - a. Surveys of potential enrollees (such as students or alumni of feeder programs, community college enrollees, etc.).

Formal surveys of potential enrollees have not been conducted. However faculty and staff of the Center for Geospatial Analytics receive an average of five to eight inquiries per month from individuals interested in obtaining a doctoral degree in geospatial science at NC State. These inquiries come from current NC State students as well as from students and professionals in North Carolina, in other states, and throughout the world.

Due to the interdisciplinary nature of Geospatial Analytics, we expect applicant pools to include students from a variety of baccalaureate and Master's degree programs in related disciplines (e.g. GIS, computer science, geography and the geosciences) as well professionals seeking to develop or expand their research credentials in geospatial science. The creation of this program is not expected to draw many, if any, students away from existing doctoral programs in the College of Natural Resources or other departments at NC State. While some students currently enrolled in those doctoral programs apply geospatial tools in parts

of their scholarly work, these students are not focused on solutions to complex geospatial challenges, but rather developing knowledge in particular areas (e.g., forestry, fisheries and wildlife, earth science, and parks, recreation and tourism management). Students enrolled in the Geospatial Analytics PhD would be seeking advanced education and technical training on measuring, analyzing, and visualizing large, complex geospatial data sets and developing novel analytics for place-based societal challenges.

- b. Enrollment data from existing minor, concentration or certificate programs on your campus.

Demand for the proposed PhD degree is evidenced by very high levels of student enrollment and graduation in our Professional Science Master of Geospatial Information Science and Technology (MGIST) and related graduate certificate program. Since launching the MGIST program in 2010, 44 students have graduated and enrollment continues to be high (126 students currently enrolled). A total of 147 students have completed our Graduate Certificate in Geographic Information Systems, with 135 students currently in process. For the last few years, our entry graduate-level GIS course has been fully subscribed with over 100 students per semester.

- c. Enrollment data from similar programs in UNC, the state, or country.

No other institutions of higher education in North Carolina offer a program similar to the proposed degree program. The website for George Mason University's Ph.D. degree in Earth Systems and GeoInformation Sciences lists 49 currently active students. The University of California at Santa Barbara reports 26 students currently enrolled in their Geography Ph.D. program in which Modeling Measurement and Computation (including spatial statistics, remote sensing, GIS, and visualization) is one of three areas of focus. Since 2011, the University of Texas at Dallas has graduated two students per year from their Geospatial Information Sciences Ph.D. program. These programs are representative of the burgeoning importance of doctoral education in geospatial science but none of them are at the scope and scale we envision for this program. NC State's PhD in Geospatial Analytics will take this rapidly growing data science field to another level through advanced training in dynamic space-time modeling, full immersion geo-visualization, advanced remote sensing and the development of new sensor networks, spatial decision support systems, and novel open source solutions, making this PhD unique among peer institutions.

- 4. Provide evidence of societal demand and employability of graduates from as many of the following sources as feasible unless a good reason exists why such evidence cannot be obtained and similar evidence is presented from sources not listed here.
 - a. Labor market information (www.ncworks.gov) – Current and projected industry and occupational data by region and statewide from the NC Department of Commerce. Available data include (but are not limited to):
 - 1) Area, occupation, and industry profiles.

Occupational Profile information available from the NC Department of Commerce (www.ncworks.gov) indicates a “bright outlook nationally” for Geospatial Information Scientists and Technologists and reports that the 2013 estimated median annual wage for Geospatial Information Scientists and Technologists in North Carolina was \$80,230.
 - 2) NC occupational and employment projections.

The NC Department of Commerce (www.ncworks.gov) projects an average of 360 openings per year for Geospatial Information Scientists and Technologists and closely related occupations in North Carolina for the period 2010-2020. (Closely related occupations include Geographic Information Systems Technicians, Geoscientists, Remote Sensing Scientists and Technologists, and Transportation Planners.)

Occupation information for Geospatial Information Scientists and Technologists posted on the U.S. Department of Labor, Employment and Training Administration sponsored web site mySkills myFuture (www.myskillsmyfuture.org) shows current employment in North Carolina of 3,618, 100 projected job openings per year, with a typical annual salary of \$59,800 - \$95,500.

3) Job postings.

The following job search web sites were accessed on 05/23/2014:

NCWorks Online (www.ncworks.gov) listed 239 “GIS” job openings, 141 “Geospatial” job openings, and 7,907 job openings for the related occupational group Computer and Mathematical Occupations.

A search of the U.S. Department of Labor, Employment and Training Administration sponsored web site mySkills myFuture (www.myskillsmyfuture.org) found 500 job listings for Geospatial Information Scientists and Technologists in North Carolina.

GeoSearch Inc. (www.geosearch.com) listed 152 full time GIS, GPS, and Geospatial jobs in North Carolina, 84 of which are classified as senior level positions.

Additional searches were performed using several possible keywords and job listings on 02/15/2015. Numbers presented here will be conservative estimates due to the wide variety of possible search terms in the emerging field of Geospatial Analytics (i.e., ‘GIS’, ‘Geographic Information Systems’, ‘Geographic Information Science’, ‘Geospatial Information Science’, ‘Geospatial Science’, ‘Remote Sensing’, ‘Geoprocessing’, ‘Spatial Analysis’, to name a few).

It is expected that many PhD students will pursue academic careers:

The University Consortium for Geographic Information Science (ucgis.org/job-postings) provides one of the most up to date listings of academic positions in the field. During the most recent hiring cycle (Fall 2014-present), from this site alone there are 25 active openings at various academic levels.

Outside of academia, many government agencies hire PhD level graduates:

A simple search through USAjobs.org using ‘Geospatial’ and ‘GIS’ keywords yielded 14 active PhD-level positions, with nearly 50 percent of the positions at a pay scale greater than \$75,000. These positions occurred across a wide variety of agencies including the Department of Interior, Department of Commerce, Department of Agriculture, the US Army, and Department of Defense.

In addition, the need for highly trained geospatial analysts in the private sector is growing rapidly. The number of PhD-Level Geospatial Scientists is increasing:

A gisjobs.com recent salary survey showed that 10% of North Carolina respondents with a job in the GIS field held a PhD

As stated previously, these statistics represent only a small portion and a conservative estimate of potential jobs currently active in this growing field. Additional outlooks are summarized below.

4) Economic and demographic indicators.

In December 2012, the National Geospatial Advisory Committee issued a paper addressing the role of geospatial information technology in supporting cost-effective government and stimulating economic growth through job creation. The authors pointed out that:

“U.S.-based geospatial companies, which generate technical, high-paying jobs in the United States, help drive the American economy by providing goods and services that are sold worldwide. A recent study by the Center for Strategic and International Studies estimated that geospatial-related companies generate \$30 billion annually. The geospatial sector has grown steadily, with the commercial side growing at an accelerated rate. The U.S. Department of Labor has predicted that the geospatial industry will be one of the technology areas that will create the most jobs in the coming decade. Yet this industry faces a serious shortage of qualified and skilled workers to meet the demands of the fast growing field, potentially providing an opportunity for trained American workers.”
([www.fgdc.gov/ngac/meetings/december-2012/NGAC Geospatial Strategy Paper.pdf](http://www.fgdc.gov/ngac/meetings/december-2012/NGAC_Geospatial_Strategy_Paper.pdf))

Moreover, according to the 2014-2016 National Spatial Data Infrastructure Strategic Plan:

“In recent years, the availability and usage of geospatial information and products have dramatically expanded as software has matured and high-quality data became available....The geospatial technology and services industry is a growing and important factor in the United States and world economies, driving significant benefits and providing high-wage jobs. A 2012 study by the Boston Consulting Group (BCG) estimated that the U.S. geospatial industry generated approximately \$73 billion in revenues in 2011 and comprises at least 500,000 high-wage jobs....In addition, the U.S. Department of Labor recently identified the geospatial technology sector as one of the three technology areas that would create the greatest number of new jobs over the next decade.” (www.fgdc.gov/nsdi-plan/nsdi-strategic-plan-2014-2016-FINAL.pdf)

- b. National occupational and industry projections (<http://www.bls.gov/data>) – National, regional and state outlook for occupations, also including wage data.

In 2006, the National Research Council Mapping Science Committee observed that “geographic information systems have become central to the ways thousands of government agencies, private companies, and not-for-profit organizations do business. However, the supply of GIS/GIScience professionals has not kept pace with the demand generated by growing needs for more and improved geographic information systems and for more robust geographic data.” (The Mapping Science Committee, National Research Council, *Beyond Mapping: Meeting National Needs Through Enhanced Geographic Information Science*, www.nap.edu/catalog/11687.html)

In its High Growth Industry Profile for Geospatial Technology (updated March 2010), the Employment and Training Administration of the U.S. Department of Labor noted that: “Because the uses for geospatial technology are so widespread and diverse, the market is growing at an annual rate of almost 35 percent, with the commercial subsection of the market expanding at the rate of 100 percent each year.”
(www.doleta.gov/brq/indprof/geospatial_profile.cfm)

In 2010, the U.S. Bureau of Labor Statistics estimated that nearly 425,000 geospatial professionals were employed in the United States and that almost 150,000 additional positions would be created by 2020.
(www.esri.com/news/arcnews/summer12/articles/strengthening-the-gis-profession.html)

Reporting that employment of geographers is expected to grow 29 percent from 2012 to 2022, the Occupational Outlook Handbook, 2014-15 edition (U.S. Department of Labor, Bureau of Labor Statistics), states and that “those with advanced degrees...and experience working with geographic technologies, such as GIS, should have the best job prospects.” (www.bls.gov/ooh/life-physical-and-social-science/geographers.htm#tab-6)

Following are state and national employment projections and wage data from a sampling of public agencies and private organizations:

- *The U.S. Department of Labor, Employment and Training Administration sponsored web site mySkills myFuture (www.myskillsmyfuture.org) shows current employment in North Carolina of 3,618 Geospatial Information Scientists and Technologists, 100 projected job openings per year in the state, and typical annual salary of \$59,800 - \$95,500. (Web site accessed 04/07/2014)*
 - *The summary report for Geospatial Information Scientists and Technologists accessed at O*NET OnLine (www.onetonline.org) sponsored by the U.S. Department of Labor projects 40,200 job openings, nationally, for the 2012-2020 time period and reports a 2013 median annual wage of \$82,340. (Web site accessed 04/07/2014)*
 - *Indeed (www.indeed.com), a worldwide job search site reports average annual salaries of \$85,000 for Geospatial Analysts in the U.S. and \$83,000 for GIS Data Analysts in the U.S. (Web site accessed 05/22/2014)*
- c. Wages and employment of graduates in NC – Percentage of graduates of UNC programs employed in North Carolina and wages paid to graduates of UNC programs employed in North Carolina.

The proposed degree is not currently offered in North Carolina.

- d. Wages and employment of graduates nationally when these data become available (see http://www.doleta.gov/performance/pfdocs/wris2_status_state_optin.pdf) – Wages paid to graduates of UNC programs employed nationally (North Carolina partnership in WRIS2 forthcoming).

The proposed degree is not currently offered in North Carolina.

- e. Job posting analyses.

A brief overview of the numbers of jobs posted on a sample of job search web sites (accessed 05/23/2014):

- *NCWorks Online (www.ncworks.gov): in North Carolina, 239 “GIS” job openings, 141 “Geospatial” job openings, and 7,907 job openings for the related occupational group Computer and Mathematical Occupations.*
- *mySkills myFuture (www.myskillsmyfuture.org) sponsored by the U.S. Department of Labor, Employment and Training Administration: in North Carolina, 500 job listings for Geospatial Information Scientists and Technologists.*
- *GeoSearch Inc. (www.geosearch.com): in North Carolina, 152 full time GIS, GPS, and Geospatial jobs; 84 classified as senior level positions.*

- Indeed (www.indeed.com): in the United States, 5,123 full time GIS jobs and 918 full time Geospatial Analyst positions.
- Geojobs.biz (www.geojobs.biz): in the United States, nearly 1,800 GIS Information Technology jobs.
- GIS Careers (www.giscareers.com): in the United States, over 180 full time positions.
- The GIS Jobs Clearinghouse (www.gjc.org): 192 job postings.

f. Projections from professional associations or industry reports.

In the January 2012 Geospatial Workforce Development White Paper, the National Geospatial Advisory Committee reported that:

“The United States is a world leader in geospatial technology and research, an area that represents a multi-billion [dollar] sector of the US economy....This vital industry faces a serious workforce development challenge. A shortage of qualified and skilled workers exists to meet the demands of this fast growing industry. Efforts must be undertaken across all levels of government, private sector, academic community, and professional associations to prepare workers to take advantage of new geospatial job opportunities in high demand and economically vital sectors of the American economy.”
 (www.fgdc.gov/ngac/ngac-geospatial-workforce-development-paper-final.pdf)

g. Data concerning employment and wages for graduates of a particular program area from the UNC alumni survey when this survey and data become available.

Although no UNC alumni survey data are available, student placement of our MGIST graduates has exceeded 95% since the inception of the program in 2010. Graduates of the MGIST program are employed throughout the state and nation in GIS firms (some of which they own); banks; federal, state and local government agencies; environmental engineering companies; NGO's; planning firms; development companies; academic institutions; and more. Their positions include CEO's, department managers, customer service managers, educational consultants, GIS analysts, environmental engineers, city planners, software engineers, environmental modelers, information technology specialists, cartographers, research analysts, and university faculty. A sample of firms that currently employ our graduates include:

*American Forest Management, Inc.
 Battelle
 Bechtel Corporation
 City of Charlotte, North Carolina
 City of Raleigh, North Carolina
 City of Rock Hill, North Carolina
 City of Southport, North Carolina
 DeKalb County, Georgia
 Duke Progress Energy
 East Carolina University
 Esri
 Federal Bureau of Investigation
 Federal Emergency Management
 Agency
 Fort Bragg, North Carolina
 General Dynamics
 Geographic Technologies Group*

*Greenhorne and O'Mara
 Hazen and Sawyer
 Hyundai
 IBM
 Johnston County, North Carolina
 Jones Edmunds
 NC Center for Geographic
 Information and Analysis
 NC Department of Agriculture
 NC Division of Parks and Recreation
 NC General Assembly
 NC State University
 SAS
 Seymour Johnson Air Force Base
 SunGard HTE, Inc.
 Technicolor
 Town of Cary, North Carolina*

University of Tennessee
US Environmental Protection Agency
US Fish and Wildlife Service
US Department of Agriculture
USDA Animal and Plant Health
Inspection Service
USDA Forest Service
USDI National Park Service
US Geological Survey
Wachovia Bank
Wake County, North Carolina
Wake Technical Community College
Walt Disney World
Wisconsin State Parks

5. List all other public and private institutions of higher education in North Carolina currently operating programs similar to the proposed new degree program, including their mode of delivery.

No other public or private institutions of higher education in North Carolina offer a program similar to the proposed degree program.

- a. Show a four-year history of enrollments and degrees awarded in similar programs offered at other UNC institutions (using the format below for each institution with a similar program); describe what was learned in consultation with each program regarding their experience with student demand and job placement. Indicate how their experiences influenced your enrollment projections.

Not Applicable - No other UNC institutions offer a similar program.

- b. Identify opportunities for collaboration with institutions offering related degrees and discuss what steps have been or will be taken to actively pursue those opportunities where appropriate and advantageous.

With the addition of the three new CFEP faculty members (currently in place), and the two additional open faculty lines in the College of Natural Resources, all of whom will teach in the new program, and the intended replacement of three additional core faculty members in the next few years due to retirement, we will have a nationally competitive core curriculum. We have initiated contact with other cognate programs at UNC Chapel Hill (e.g., Geography and City and Regional Planning) and Duke (e.g., Geology) and will direct individual students to courses at those institutions as appropriate to their research areas.

The major NC State cognate programs, with which we will continue to collaborate closely, are the programs in Advanced Analytics, Statistics, Marine Earth and Atmospheric Science and Computer Science as well as the multiple CFEP Initiatives in "big data" research areas.

- c. Present evidence that establishment of this program would not create unnecessary program duplication.

Given that no similar degree program is offered by any UNC institution, establishment of the proposed program would not create any program duplication.

6. Are there plans to offer all or a portion of this program to students off-campus or online? **No**
7. Estimate the total number of students that would be enrolled in the program during the first year of operation: *Full-Time: 5 Part-Time: 0*

Estimate the total number of students that would be enrolled in the program during the fourth year of operation: *Full-Time: 25 Part-Time: 0*

8. Will the proposed program require development of any new courses: **Yes**
If yes, briefly explain.

The new faculty hired through the CFEP will bring additional areas of expertise. New courses will be developed around these topics. For example, numerical geospatial modeling, geospatial data mining, and geovisualization courses will be developed as part of the core curriculum.

Numerous existing graduate courses would provide depth in a variety of disciplines (e.g., civil engineering, computer science, electrical engineering, Earth science, environmental sciences, forestry, landscape architecture, soil science, and statistics).

9. Will any of the resources listed below be required to deliver this program? (If yes, please briefly explain in the space below each item, state the estimated new dollars required at steady state after four years, and state the source of the new funding and resources required.)

a. New Faculty:

No

The new graduate faculty hires in Geospatial Modelling, Computational Geospatial Analytics, and Large System Remote Sensing made under the Geospatial Analytics Initiative in the CFEP, when added to the existing Graduate Geographic Information Science Faculty (35+), will provide an extensive research and teaching base faculty for the new degree.

b. Additional Library Resources:

No

The expansive Visualization and Geospatial staff, facilities, literature and data collections of the Hunt and Hill Libraries, in combination, provide an unparalleled environment for research and study in this field.

c. Additional Facilities and Equipment:

No

The Center for Geospatial Analytics, as part of both the College of Natural Resources' Strategic Plan and the CFEP, has created an outstanding new graduate teaching and research facility in Jordan Hall to support the proposed program. In addition, the University has joined with the NC Museum of Natural Resources in establishing the Earth Observation and Biodiversity Lab in the new Nature Research Center, which will provide both facilities and outreach for the new degree program.

d. Additional Other Program Support:
(for example, additional administrative staff, new graduate student assistantships, etc.)

Yes

An additional 1/2 time graduate administrative support position will be required to manage student applications and other administrative support functions for the program. Funding for this position will come from reallocation of College or University funds. It is anticipated that the majority of students will be funded through external grants particularly as the new faculty arrive (e.g., Dr. Meentemeyer brought six new fully funded graduate students with him). In addition, some students will be funded through teaching assistantships supported by the MGIST program. However, for the program to reach its potential, base support of eight research assistantships will be required over the first three from reallocation of College or University funds. This number of additional assistantships will allow the immediate establishment of the program as a pre-eminent institution, will create a very competitive application pool, and will provide initial support for our new Faculty Excellence hires as they establish their individual research prominence. These assistantships will be rolled over quickly to grant sponsored positions and will likely be phased out as the program reaches a steady state of 25 students by year five.

In an effort to take full advantage of NC State's extensive expertise in Analytics and to coordinate the Geospatial research with these programs, first year students will have the option to take additional courses in the MS program in the Advanced Analytics Institute. The Center for Geospatial Analytics has already established a collaborative teaching relationship with the Institute for Advanced Analytics to provide geospatial content to one or more of their instructional modules. With the addition of the PhD program in Geospatial Analytics, a similar arrangement can be established for instructing our students and/or providing opportunities for our students to participate in Advanced Analytics modules. The Institute Director has assured that enrollment slots will be reserved for Geospatial Analytics PhD students.

10. Does the program require enrollment growth funding in order to be implemented and sustained? If so, can the campus implement and sustain the program should growth funding be unavailable? Letters of commitment should be provided.

While enrollment growth funding is desirable, the program could be established via reallocation of College and University funds.

11. For graduate programs only:

Does the program require a tuition differential or program specific fee in order to be implemented and sustained?

No

- a. If yes, state the amount of tuition differential or fee being considered and give a brief justification.

Not Applicable

- b. Can the campus implement and sustain the program if the tuition differential or program fee is not approved? Letters of commitment should be provided.

Not Applicable

12. For doctoral Programs only:

- a. Describe the research and scholarly infrastructure in place (including faculty) to support the proposed program.

The Center for Geospatial Analytics will be the core unit supporting the new degree program. This interdisciplinary research and teaching facility connects faculty from across the campus in a network of geospatial research investigations and graduate course and degree programs. Currently the Center supports over 25 in-residence graduate students. The students and research projects are spread among multiple departments and colleges but linked by combinations of faculty co-investigators, shared facilities, and graduate advisors. It is anticipated that in addition to the Geospatial Analytics students, the existence of advanced geospatial courses, outstanding new faculty, and excellent research facilities will attract additional exceptional PhD students to NC State's existing research and doctoral programs. This will yield even stronger interdisciplinary teams of faculty and students working on vital research relevant to societal needs.

The Center is the home of the new CFEP in Geospatial Analytics and correspondingly has added three new graduate faculty positions.

The Center's core research strengths include:

- Environmental remote sensing: This involves designing and evaluating airborne and space borne remote sensing instruments as well as techniques for analyzing the data they collect. These results are applied to a wide variety of fields ranging from the Earth sciences, physical geography, and oceanography to engineering, archeology, and the social sciences and humanities. Center faculty are currently engaged in remote sensing studies aimed at developing new classification algorithms and data fusion techniques with applications in natural resource inventories, environmental management and monitoring, and climate change. The faculty are also participating in the University's new initiative in Unmanned Aerial Vehicles (UAV) research, specifically, in developing algorithms to process and interpret UAV-collected data.
- Geospatial intelligence and data mining: NC State is the home of the newly created Department of Defense Laboratory for Analytic Sciences, a multimillion dollar research facility focused on developing the basic science that supports the U.S. National Security Agency. Center faculty are partnered with this group to connect geospatial data to these efforts. In addition, faculty and students are engaged with the very successful Institute for Advanced Analytics, the Intuitive Information Fusion and Visualization Project, the Unmanned Aerial Vehicle Initiative, and the CFEP in Data Driven Science, all of which are engaged in research and education in "Big Data" management and intelligence derivation.
- Geovisualization: Geovisualizations are graphical representations and interaction tools for complex and dynamic multidimensional geospatial data. The Center's geovisualization research program currently includes: 1) Tangible Geospatial Modeling Systems that allow users to manually alter physical terrain models of natural and built environments and dynamically visualize the consequences (e.g., potential flooding impacts of homes, roads, and hydrologic flow, 2) Immersive Virtual Geovisualization Systems that deploy high resolution panoramic imagery to investigate behavioral questions involving spatial cognition and perception, landscape preferences, and contingent responses to alternative environmental stimuli, and 3) Physical Geospatial Perception Measurement and Analysis, a research initiative using eye tracking

technology to evaluate the effectiveness of various display and immersion technologies on human visual perception. These studies are focused on representing geospatial phenomena and large spatial-temporal datasets.

- **Spatial-temporal modeling:** Center faculty are developing new and complex simulation models to understand spatial temporal phenomena that involve dynamic social and environmental processes across multiple scales. Current research projects include analyses of urban sprawl and landscape fragmentation related to the provision of ecosystem services; spatial patterns and dynamics of erosion, sediment transport and deposition; the geographic spread of infectious diseases; and an extensive program developing new models of eastern wildfire behavior and occurrence. Of particular note, one of the new models (FUTURES) is being used by the State of North Carolina to evaluate new urban growth management policies.
- **Open source solutions:** NC State's Center for Geospatial Analytics was recently designated as the initial North American Research and Educational Laboratory for the International Open Source Geospatial Sciences Program. Center faculty and students are actively involved in developing software, applications, and educational material for open source GIS with special focus on environmental modeling, geovisualization, spatial-temporal simulations, and multi-temporal LiDAR data analysis.

In addition, the Center is the administrative home of the Graduate Geographic Information Science Faculty. Active members, listed below, include faculty from 16 different departments and 7 different colleges.

College of Agriculture and Life Sciences:

David Crouse	(Soil Science)
Ron Heiniger	(Crop Science)
Gary Roberson	(Biological and Agricultural Engineering)
Jeffrey White	(Soil Science)

College of Design:

Eugene Bressler	(Landscape Architecture)
Arthur Rice	(Landscape Architecture)

College of Engineering:

Christopher Healey	(Computer Science-Engineering)
Hamid Krim	(Electrical & Computer Engineering)
Margery Overton	(Civil, Construction and Environmental Engineering)
William Rasdorf	(Civil, Construction and Environmental Engineering)
Robert St. Amant	(Computer Science-Engineering)
Henry Trussell	(Electrical & Computer Engineering)
Benjamin Watson	(Computer Science-Engineering)
Raju Vatsavai*	(Computer Science-Engineering)

College of Humanities and Social Sciences:

David Garson	(Public & International Affairs)
William Smith	(Sociology & Anthropology)
Michael Vasu	(Public & International Affairs)
Stephen Wiley	(Communication)

College of Natural Resources:

Perver Baran	(Parks Recreation and Tourism Management)
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Bronson Bullock	(Forestry and Environmental Resources)
Glenn Catts	(Forestry and Environmental Resources)
Heather Cheshire	(Forestry and Environmental Resources)
John Coulston	(Forestry and Environmental Resources)
Hugh Devine	(Parks Recreation and Tourism Management)
George Hess	(Forestry and Environmental Resources)
Roland Kays	(Forestry and Environmental Resources)
Siamak Khorram	(Forestry and Environmental Resources)
Frank Koch	(Forestry and Environmental Resources)
Yu-Fai Leung	(Parks Recreation and Tourism Management)
Ross Meentemeyer*	(Forestry and Environmental Resources)
Eric Money	(Center for Geospatial Analytics)
Stacy Nelson	(Forestry and Environmental Resources)
Jordan Smith	(Parks Recreation and Tourism Management)
Laura Tateosian	(Center for Geospatial Analytics)

College of Sciences:

Del Bohnenstiehl	(Marine Earth and Atmospheric Sciences)
Helena Mitasova	(Marine Earth and Atmospheric Sciences)
Karl Wegmann	(Marine Earth and Atmospheric Sciences)
Sandra Yuter	(Marine Earth and Atmospheric Sciences)
Erin Hestir*	(Marine Earth and Atmospheric Sciences)

College of Veterinary Medicine:

Jay Levine	(Population Health and Pathobiology)
Mike Loomis	(Clinical Sciences)

*Chancellor's Faculty Excellence Program Initial Hires. Two additional hires, one in Parks, Recreation, and Tourism Management and one in Forestry and Environmental Research are currently underway. These new faculty members will work closely with the initial CFEP hires to expand the educational and research mission of the Center for Geospatial Analytics.

- b. Describe the method of financing the proposed new program (including extramural research funding and other sources) and indicate the extent to which additional state funding may be required.

The Center for Geospatial Analytics faculty have a long record of securing external research funding to support graduate students (currently over 25). This is expected to continue particularly as the degree program matures. In addition, program faculty have been augmented by three new positions all of which have graduate student grant support as part of their assignment.

A minimum a three teaching assistantships will be generated by MGIST funds and will be used to support Ph.D. students as they assist with teaching in that program.

Operational support will be primarily generated by the core faculty via their grants and from resource allocations from their respective colleges. In addition, required teaching facilities and administrative costs will be shared with the MGIST program.

However, in order to initiate the Ph.D. program and to allow for anticipated program growth into new research initiatives, support for additional Ph.D. students will be needed incrementally over the first three years.

In addition support for a ½ time administrative position will be required.

To sustain the program, some program generated enrollment growth funds (e.g., 40-60%) will be required for operational expenditures and student support.

- c. State the number, amount, and source of proposed graduate student stipends and related tuition benefits that will be required to initiate the program.

As noted above, the majority of students in the program will be funded with external research dollars generated by the core faculty. However, we request eight assistantship stipends (\$30,000/year) with full tuition and health insurance. Some funding to support these students could be generated through College and University reallocations, however, additional resources from program associated enrollment growth funds or other state sources will be required.

13. List the names, titles, e-mail addresses and telephone numbers of the person(s) responsible for planning the proposed program.

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*Mary Watzin
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This request for authorization to plan a new program has been reviewed and approved by the appropriate campus committees and authorities.

Chancellor _____ **Date** _____