



THE
UNIVERSITY OF
NORTH CAROLINA
SYSTEM

Letter of Intent to Develop New Academic Degree Program

The following approvals must be obtained prior to sending the Letter of Intent to Develop a New Academic Degree Program to the UNC System Office.

Institution The University of North Carolina at Charlotte

Degree Program Title (e.g. M.A. in Biology) M.S. in Computer Engineering

Reviewed and Approved By (Name and title only. No signature required in this section.)

Check box to indicate participation in review. (Provost is required.)

- Provost:** Joan F. Lorden, Provost and Vice Chancellor for Academic Affairs
- Faculty Senate Chair (as appropriate):** Rich Leeman, Faculty Council President
- Graduate Council (as appropriate):** Christine Haynes, Chair of Graduate Council
- Undergraduate or Graduate Dean (as appropriate):** Dr. Thomas Reynolds, The Dean of the Graduate School
- Academic College Dean:** Dr. Robert E. Johnson, Dean of The William States Lee College of Engineering
- Department Chair:** Dr. Asis Nasipuri, Chair of the Electrical & Computer Engineering Department
- Program Director/Coordinator:** Dr. Aba Ebong, Grad Program Director, Electrical & Computer Engineering

New Academic Proposal Process

New academic programs are initiated and developed by the faculty members. Approval of the Letter of Intent to Develop a New Academic Degree Program must be obtained from department chairs and college deans or equivalent administrators before submission to the UNC System Office review.

Directions: Please provide a succinct, yet thorough response to each section. Obtain the Provost's signature and submit the proposal via the PREP system to the UNC System Vice President for Academic Programs, Faculty, and Research, for review and approval by the UNC System Office. Once the Letter of Intent to Develop is approved, the institution can begin work on the formal Request to Establish a New Degree Program.

Letter of Intent to Develop a New Academic Degree Program

| | |
|--|---|
| Institution | University of North Carolina at Charlotte |
| Joint Degree Program (Yes or No)? If so, list partner campus. | No |
| Degree Program Title (e.g. M.A. in Biology) | M.S. in Computer Engineering |
| CIP Code and CIP Title (May be found at National Center for Education Statistics) | 14.0901 - Computer Engineering, General |
| Require UNC Teacher Licensure Specialty Area Code (Yes or No). If yes, list suggested UNC Specialty Area Code(s). | No |
| Proposed Delivery Mode (campus, online, or site-based distance education). Add maximum % online, if applicable. | Campus |
| Proposed Term to Enroll First Students (e.g. Spring 2019) | Fall 2019 |
| List other programs in the UNC System (may be found at UNC System website) | MS in Computer Engineering |

SACSCOC Liaison Statement: *(Provide a brief statement from the University SACSCOC liaison regarding whether the new program is or is not a substantive change.)*

The new degree is not a substantive change, as it uses existing, approved courses from the M.S. in Electrical Engineering and a limited number of approved courses from other Master's programs at UNC Charlotte, and it does not require new equipment, facilities, financial resources, faculty, and library/learning resources. Therefore, neither SACSCOC notification nor approval is required.

Program Summary: *(Briefly describe the proposed program and summarize the overall rationale.)*
Maximum of 1,000 words.

Include the following in your narrative:

- Ways in which the proposed program is distinct from others already offered in the UNC System (use the 4-digit CIP as a guide). Information on other programs may be found on the UNC System [website](#).
- How this program supports specific university and UNC System [missions](#).
- Collaborative opportunities with other UNC institutions as appropriate.

The proposed Master of Science in Computer Engineering (MSCPE) program is designed to impart advanced knowledge on current and future generation computer hardware and software technologies. Specifically, the proposed program is structured to emphasize the broad areas of (1) Computer Architecture and Hardware Design, (2) Computer Systems and Applications Software, and (3) Distributed and Real-time Computer Systems. The proposed program requires successful completion of at least 30 approved graduate credits, which may be completed under the thesis, project, or the coursework options. Students enrolled in the MSCPE program will be required to take a set of three core courses (9 credits), at least two depth courses from any one of three focus areas (6 credits), and remaining courses as electives from other areas, as approved by the student's advisor. All courses included in the focus areas are currently available and are already offered on a regular basis by the Electrical and Computer Engineering (ECE) Department or related departments at UNC Charlotte. The MSCPE program will be offered in day, evening, and hybrid (online/in-person) instructional formats. Full-time students will be able to complete the program within two years. The evening and online courses will allow professionals in the workplace to pursue a part-time MS degree in Computer Engineering.

The MSCPE program will complement the Master of Science in Electrical Engineering (MSEE) program that is offered by the ECE Department at the William States Lee College of Engineering (COE). Currently, the MSEE program serves four broad areas within ECE: (1) Communications, Controls, and Signal Processing; (2) Computer Systems; (3) Devices, Circuits, and Systems; and (4) Power Systems. Rapid advancements in the field of computer engineering over the past few decades has led to an increasing demand for computer engineers. This in turn generated increasing interest of graduate students to specialize in this sub-discipline within the existing MSEE program. The proposed MSCPE program will include core, depth, and elective courses specific to computer engineering that will serve this growing need in the Computer Systems sub-discipline more effectively – both in terms of curriculum specialization and in meeting industry workforce demands. In effect, establishing this new degree program will lead to two distinct Master's programs in the ECE Department. This will foster growth in graduate enrollment without requiring additional resources, enable more efficient course and curriculum development, streamlined student advising, and lead to more effective workforce development.

As detailed below, the proposed degree program is closely aligned with the goals described in "Higher Expectations: The Strategic Plan for the University of North Carolina (2017-2022)"¹

- **Critical Workforce:** The proposed MSCPE program will attract graduate students in a high-demand STEM field, contributing to regional workforce needs in the Charlotte region and beyond.
- **Research Productivity:** Computer engineering is still a fast-evolving field, and faculty and students in this area are continuously engaging in new research directions. The MSCPE program will support the growing interest of graduate students to be involved with research projects and scholarship in computer engineering.
- **Human Capital:** Computer Engineering is currently a very active area within ECE, which comprises a large portion of its graduate students. The trend is also noticed at the undergraduate level and students are increasingly following their undergraduate degrees with a Master's degree. The ECE Department has hired several new faculty members in computer engineering recently to cope with this increase in student enrollment. The proposed MSCPE program will help in faculty as well as student retention in this area.
- **Affordability:** The proposed program will not require new resources as the corresponding courses and faculty are already being taught on a regular basis. However, the development of a new program that enables students to concentrate in the rapidly growing area of computer engineering will provide a higher value of their efforts and financial investments.

Currently, the only institution in the UNC System that offers an MS in Computer Engineering is North Carolina

¹ <https://www.northcarolina.edu/strategic-planning>

State University (NCSU). NCSU’s MS in Computer Engineering includes specializations in Computer Architecture, Networking, Software, and VLSI Systems. North Carolina A&T offers an MSEE degree with a concentration in Computer Engineering. However, these institutions are located far from the Charlotte region. Further, the emphasis on integrated hardware-software systems is a unique feature of UNC Charlotte’s proposed MSCPE program.

The proposed MSCPE program at UNC Charlotte and the existing Computer Engineering program at NCSU have the potential for being mutually benefited by enabling UNC Charlotte students to take a limited number of online courses from NCSU in areas such as VLSI Design, while NCSU students could take the systems-oriented courses offered at UNC Charlotte. In addition, MSCPE graduates from UNC Charlotte can add to the pool of potential Ph.D. applicants to NCSU focusing on Computer Engineering. Additionally, Computer Engineering faculty in these two institutions could also collaborate on jointly developing curriculum material.

The proposed MSCPE program also leverages strengths of the existing MS in Computer Science offered by the College of Computing and Informatics (CCI) at UNC Charlotte. Specifically, currently offered courses in Cybersecurity, Artificial Intelligence, Algorithms and Data Structures will be appropriate electives in the proposed MSCPE degree program. In turn, CCI students could take the computer hardware-oriented courses offered by the proposed program.

Student Demand: *(Provide evidence of student demand. Discuss the extent to which students will be drawn from a pool of students not previously served by the institution. Maximum length 1,000 words.)*

Enrollments in ECE’s graduate programs have increased markedly over recent years, although the Master’s student enrollment has experienced a drop since 2016. The recent drop in enrollment is primarily due to declining numbers of international applicants to the Master’s program, which has been experienced by institutions of higher education nationwide². Specifically, between Fall 2010 to 2015, the total graduate enrollment in ECE increased by 78%, of which the enrollment in the MSEE program increased by more than 115%, as demonstrated in Figure 1. The MSEE enrollment dropped by nearly 25% over the next two years, with the Ph.D. enrollment remaining relatively unchanged. However, the total graduate enrollment in 2017 is still over 43% higher than that in 2010, which includes a 70% increase in the MSEE program enrollment over this time. Moreover, the number of MSEE

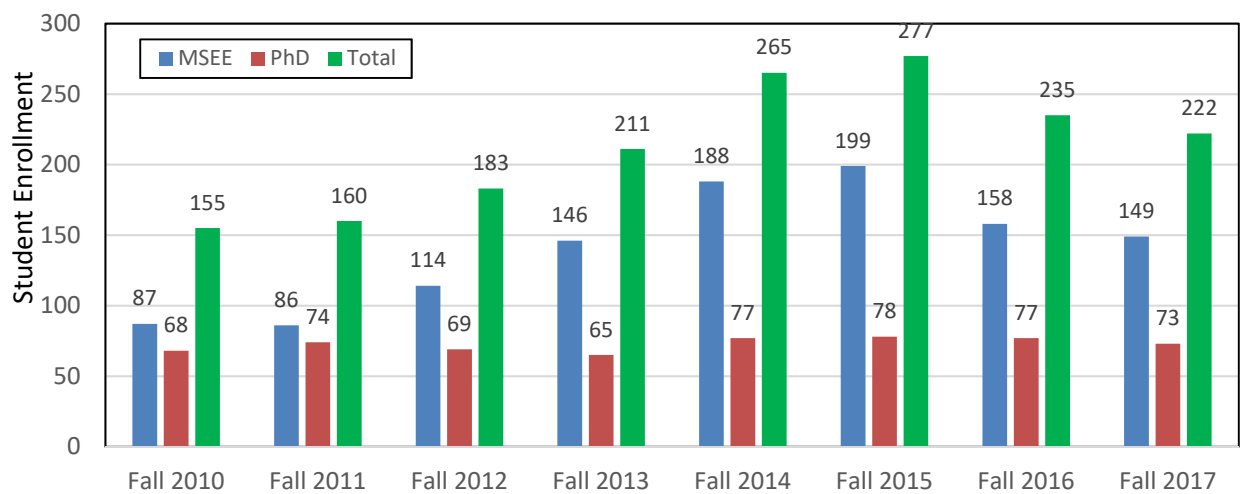


Figure 1: Graduate program enrollments in ECE at UNC Charlotte.

² “International Student Numbers Decline”, by Elizabeth Redden, Inside Higher Ed, January 22, 2018.

students with a focus in computer engineering continued to grow at a rate that is higher than the national average over this period, as indicated in Figure 2.

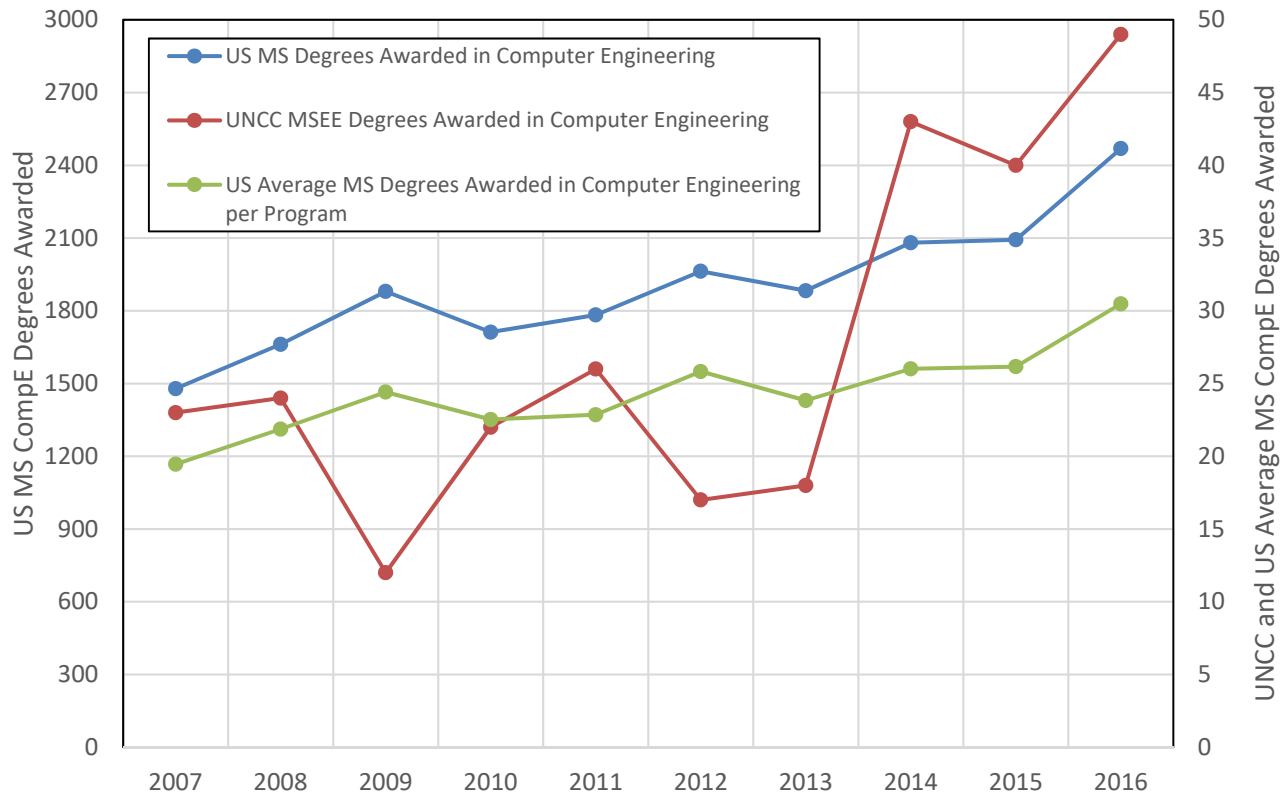


Figure 2: Annual Masters' degrees awarded in computer engineering courses. (Source: ASEE)

A similar trend of growing interest in computer engineering is also observed at the undergraduate level in the ECE Department, as indicated in Figure 3. The ECE Department has an Early Entry program that allows exceptional undergraduate students to take advantage of faster completion of the MSEE degree immediately following the BSEE or BSCPE program. It is envisioned that the increasing interest of undergraduate students in computer engineering will also reflect on the proposed MSCPE enrollments.

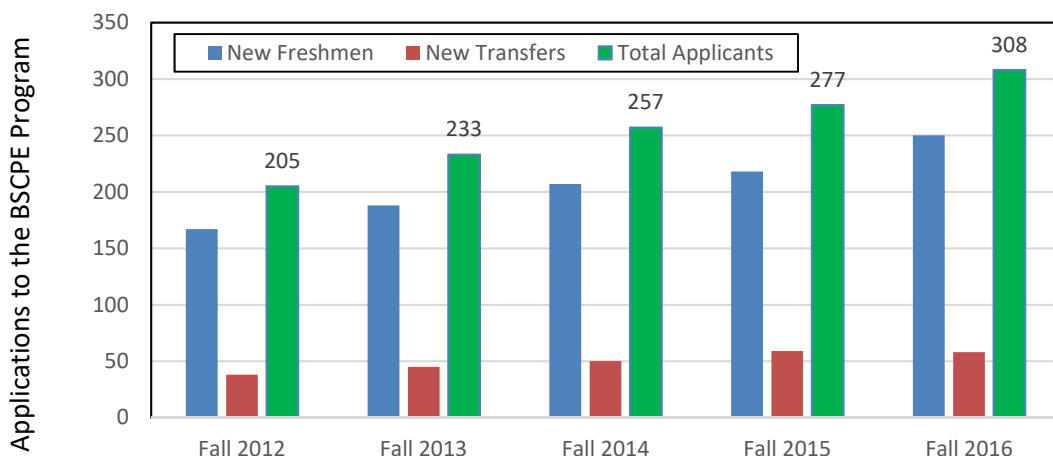


Figure 3: Number of applicants to the Bachelor of Science in Computer Engineering (BSCPE) program at UNC Charlotte.

To assess the level of interest of graduate students currently enrolled in the MSEE program in an MS in Computer Engineering, a limited student survey was conducted in fall 2017 in one of the graduate courses in the ECE Department (ECGR-6181: Embedded Operating Systems). The survey included the question “Would you prefer that your M.S. degree be titled M.S. in Computer Engineering, instead of M.S. in Electrical Engineering as it is now?”. Of the 37 respondents, 76% responded “yes”, 14% said that they would prefer MSEE, and another 5% said that it did not make any difference. The survey also included the option to provide the reason for their answers. Significant responses in favor of adding an MSCPE program include: “degree title should match the student’s interest in computer engineering”, “better job opportunities”, “more appropriate professional title for students interested in robotics”, and “embedded systems interest is best described by computer engineering and not electrical”.

Based on the above, it is clear that the proposed MSCPE program will draw students from the increasing pool of applicants who are interested in the growing computer hardware and software industry, such as microcontroller design and programming, advanced computer systems architecture, robotics, real time systems, mobile devices, hardware security, the Internet of Things, and others. The demand for graduates trained in these advanced topics is expected to grow in future. While the applicants to the proposed MSCPE program may draw away some applicants who would otherwise consider the MSEE program, the MSCPE program will have a much higher appeal to those interested in a career in computer engineering, and hence help increase the total number of Master’s applications in both programs.

Societal Demand: *(Provide evidence of societal demand and employability of graduates from each of the following source types. Maximum length 1,000 words)*

- Labor market information (projections, job posting analyses, and wages)
 - Specific to North Carolina (such as ncworks.gov, nctower.com, or outside vendors such as [Burning Glass](http://BurningGlass.com))
 - Available from national occupational and industry projections (such as the [U.S. Bureau of Labor Statistics](http://U.S.BureauofLaborStatistics.gov))
- Projections from professional associations or industry reports
- Other (alumni surveys, insights from existing programs, etc.)
 - Labor market information (projections, job posting analyses, and wages)
 - specific to North Carolina (such as ncworks.gov, nctower.com, outside vendors such as [Burning Glass](http://BurningGlass.com))
 - available from national occupational and industry projections (such as BLS).

Specific to North Carolina

Charlotte is most often associated with banking rather than technology. However, from 2006 to 2016, technology-based employment in Charlotte increased by 62%. From 2014 to 2016, Charlotte was recognized as one of the fastest growing cities in terms of technology in the nation with an 18% increase in jobs. This 10-year growth in technology employment in the metro area includes a 23% increase in the number of workers in STEM occupations that are heavily populated by computer engineering professionals nationwide.

This rapid job growth and strong recent momentum, driven partly by health care and environmental technology, ranks Charlotte as the second fastest growing technology area in the country after Silicon Valley, and ahead of Raleigh and Denver. In the past ten years, the region has added 7,400 jobs in two key high-tech business services sectors: custom programming and systems design services, along with nearly 700% growth in software publishing employment.

According to the Charlotte Chamber of Commerce, more than 44,000 people work in technology occupations in the Charlotte region. These core technology occupations draw heavily from the education objectives of the proposed MSCPE program, and include software publishers, data processing and hosting, computer systems design, computer networking and communications, cloud computing, financial technologies, and other related services (Table 1).

Table 1: Computer Engineering Related Jobs and Employment Numbers in Charlotte

| Job Title | Number Employed |
|---|-----------------|
| Computer Systems Analyst | 8500 |
| Application Developers | 7500 |
| Computer Support Specialists | 5400 |
| Hardware Engineers | 4600 |
| Systems Software Developers | 4400 |
| Network and System Administrators | 3100 |
| Network Support Specialists | 1900 |
| Computer Programmers | 2700 |
| Information Security Analysts | 1800 |
| Computer Network Architects | 1600 |
| Database Administrators | 1000 |
| Computer and Information Systems Managers | 130 |
| Others | 600 |

(Source: Bureau of Labor Statistics 2015)

Table 2 shows the jobs in computer engineering related fields currently in North Carolina according to nworks.gov. The occupations listed in the table are specific to those that require skill sets covered by the educational objectives of the proposed MSCPE program. The last column of the table is a direct metric of the demand of MSCPE graduates in this state. Note that a value of less than 1 always implies a high demand for graduates in a specific occupation, and an overwhelming majority of the rows have fewer potential candidates than job opening.

Available from national occupational and industry projections (such as BLS)

Employment of software developers is projected to grow 24% from 2016 to 2026, much faster than the average for all occupations. Employment of applications developers is projected to grow 30%, and employment of systems developers is projected to grow 11%. Employment of computer hardware engineers is projected to grow 5% from 2016 to 2026, about as fast as the average for all occupations.

The need for new applications on smart phones and tablets, cloud-based computing, and the emerging areas of edge and fog computing and autonomous vehicles will help increase the demand for applications software developers. As the number of people who use digital platforms increases over time, demand for systems developers will grow (see Table 3). For example, more embedded computer systems are being built into consumer electronics such as cell phones, autonomous vehicles, smart appliances, and smart edge sensors/actuators. Concerns over threats to computer security could result in more investment in security software and hardware to protect computer networks and electronic devices. Job prospects will be best for applicants with knowledge of

the most up-to-date programming tools, for those who are proficient in one or more programming languages, and for those who have a “whole-system” approach (hardware and software) who can solve business needs. The educational objectives of the proposed MSCPE program is tailored for the needs of today’s technological growth.

Table 2: Computer Engineering Job Detail in NC

| Occupation Title | 2016 Estimated Median Annual Wage | Potential Candidates | Job Openings | Potential Candidates per Job Openings |
|--|-----------------------------------|----------------------|--------------|---------------------------------------|
| Computer Programmers | \$85,550 | 217 | 1223 | 0.18 |
| Computer Systems Analysts | \$89,220 | 470 | 687 | 0.68 |
| Software Developers, Applications | \$95,100 | 341 | 455 | 0.75 |
| Computer Systems Engineers/Architects | \$80,570 | 112 | 333 | 0.34 |
| Database Administrators | \$87,470 | 144 | 226 | 0.64 |
| Electrical Engineers | \$96,940 | 148 | 202 | 0.73 |
| Operations Research Analysts | \$67,670 | 74 | 148 | 0.5 |
| Software Developer, Systems Software | \$98,300 | 96 | 142 | 0.68 |
| Computer Network Architects | \$105,690 | 49 | 108 | 0.45 |
| Computer and Information Research Scientists | \$105,870 | 40 | 23 | 1.74 |

(Source: ncworks.gov)

Table 3: Employment Projections Data for Software Developers, 2016-26

| Occupational Title | SOC Code | Employment, 2016 | Projected Employment, 2026 | Change, 2016-26 | |
|--|----------|------------------|----------------------------|-----------------|---------|
| | | | | Percent | Numeric |
| Software developers | — | 1,256,200 | 1,555,700 | 24 | 299,500 |
| Software developers, applications | 15-1132 | 831,300 | 1,084,600 | 30 | 253,400 |
| Software developers, systems software | 15-1133 | 425,000 | 471,000 | 11 | 46,100 |

(Source: U.S. Bureau of Labor Statistics, Employment Projections Program)

Projections from professional associations or industry reports

According to an industry report spearheaded by Wells Fargo in 2017, North Carolina’s technology sector has played a key role in the state’s economic recovery. From 2010 to 2016, jobs requiring specific educational objectives of our proposed MSCPE program such as software publishing, data processing, computer systems

design and internet search firms increased the North Carolina population by 60%. Job growth in these industries has remained robust, with North Carolina posting the fifth largest job gain in these sectors among all states in 2016. Charlotte's professional and technology services sector added 5,600 jobs over the past year, an increase of 8.2%. Raleigh posted the seventh strongest growth in the information sector, which includes software publishing, internet search and data processing.

The Research Triangle has long been the center for technology employment in North Carolina with a tech workforce of 34,500 workers. The strongest growth over the past six years has been in computer systems design and software, where firms added 6,900 jobs and 4,000 jobs from 2010 to 2016, respectively. While the Triangle is served by programs at NC State, the demand is sufficiently large and growing that additional graduates would benefit the State. Charlotte Metro Area's current pool of tech workers stands at about 47,150 and is rapidly growing (Charlotte Observer, January 2018). With the rapid growth in tech employment, more tech education programs will be needed, especially at the graduate level.

For Doctoral Programs Only:

Describe the following (maximum length 2,000 words):

- The research and scholarly infrastructure in place (including faculty) to support the proposed program.
- 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.
- State the number, amount, and source of proposed graduate student stipends and related tuition benefits that will be required to initiate the program.

N/A

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

| Position Title | Name | E-mail Address | Telephone |
|--|----------------|--|--------------|
| Professor and Chair, ECE | Asis Nasipuri | anasipur@uncc.edu | 704-687-8418 |
| Professor, Associate Chair of Computer Engineering | James Conrad | jmconrad@uncc.edu | 704-687-8597 |
| Professor | Ron Sass | rsass@uncc.edu | 704-687-8196 |
| Associate Professor | Arun Ravindran | aravindr@uncc.edu | 704-687-8427 |

This Letter of Intent to Plan a New Program has been reviewed and approved by the appropriate campus authorities.

| Position Title | Signature | Date |
|--------------------------------|-----------|------|
| Provost | | |
| Provost (Joint Partner Campus) | | |