



A proposal for the

Doctor of Philosophy Degree  
in  
Electrical Engineering with Dissertation in  
Cyber Electronic Systems

at the  
New Mexico Institute of Mining and Technology

2016

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## Executive Summary

The Electrical Engineering Department at New Mexico Institute of Mining and Technology (NMIMT) proposes a **Ph.D. in Electrical Engineering with Dissertation in Cyber Electronic Systems. Cyber electronic systems provide reliable position, navigation and timing information to distributed, tightly-integrated, smart infrastructure supporting its operation, protection, defense and flexibility.** The primary purpose of the program is to prepare students with necessary education to advance the state-of-the-art in cyber electronic systems which is the building block of our future. This is accomplished by rigorous Ph.D. level education in the unique, and highly needed area of cyber electronic systems. Students completing the program will become leaders in a highly needed concentration that is required to meet today's and tomorrow's evolving challenges.

The reliance on position, navigation, and timing as well as embedded controls and cognitive radios has been increasing rapidly. Applications that depend on these technologies range from personal devices, health care, smart homes, structural health monitoring, transportation, and energy to unmanned aerial vehicles, first responders, and military. This reliance makes critical infrastructure vulnerable to malicious attacks or conditions imposed by challenging environments. As an example, if GPS is jammed, which is extremely easy, many systems will be crippled. Through the proposed Ph.D. level research oriented program, students will have unique education that prepares them for the challenges of the future.

There is an immediate and pressing need for highly qualified Ph.D. level engineers in the area of cyber electronic systems. The proposed program will graduate students that are highly sought after in the academia, research laboratories, e.g., Sandia National Laboratories, Los Alamos National Laboratory and Air Force Research Laboratory, and government agencies, e.g., Department of Defense (DoD), Department of Energy (DoE), National Security Agency (NSA) and Department of Homeland Security (DHS), as well as supporting industries.

NMIMT has the advantage of having the Energetic Materials Research and Testing Center (EMRTC) and the Institute for Complex Additive Systems Analysis (ICASA) with which further collaborations will be formed and new research venues will be sought. Furthermore, the existence of EMRTC and ICASA provides a unique opportunity to attract research projects that may be protected by U.S. Government International Traffic in Arms Regulation (ITAR) policies, or national security classification, which other universities may not be able to work on.

This highly needed and unique program requires highly specialized facilities beyond traditional laboratory environments. These facilities, e.g., EMRTC, ICASA, Playas Testing and Research, are unique and exist at NMIMT. ICASA is currently conducting research with the focus of cyber security and cyber electronic systems for infrastructure protection. The EMRTC facilities include over 10,000 square feet of office and traditional laboratory space in addition to over 40 square miles of field laboratory testing space. NMIMT's Playas Training and Research Center provides an area in which relevant environment, e.g., warfare- and navwar-like, that will be leveraged for educating the students and for conducting research in the area of cyber electronic systems. Playas is a 640 acre town site with over 300 buildings with capabilities such as irregular warfare, unconventional warfare, counter insurgency operations and urban operations training support, unmanned aerial systems flight and test activity, unmanned aerial systems flight and test activity, micro-grid and distributed energy production, and critical infrastructure protection research.

The Electrical Engineering Department at NMIMT is already offering unique courses with the focus area of cyber electronic systems as well as conducting research relevant research, hence, no additional resources are required to establish the newly proposed program.

## A. Program Description and Purpose

The proposed program must have a clear purpose that is consistent with the mission of the proposing institution.

### 1. What is the primary purpose of the proposed program?

In pursuit of a smart and connected world, we become heavily dependent on electronic systems that are interconnected over large distances. These systems require accurate location and timing, and communication to function. Basic applications such as monitoring the health of patients or physical structures as well as the entire operation of the United States military all depend on electronic systems with the requirements of wireless connectivity, accurate positioning, navigation and timing. This dependency of our basic infrastructure results in huge vulnerability. As an example, if GPS is jammed, basic functions and ability to navigate will be crippled, in the case of the US military that is catastrophic. Focus area in electronic cyber systems investigates and addresses these vulnerabilities.

The primary purpose of the program is to prepare students with necessary education to enter the workforce in the field of cyber electronic systems to meet current and future needs. This is accomplished by rigorous Ph.D. level education in the unique, and highly needed area of cyber electronic systems. The program is structured such that students could complete their degree in three years. Students completing the program will become leaders in advancing the state-of-the-art in a highly needed area that is required to meet today's and tomorrow's evolving challenges. Cyber electronic systems are essential for the future of a smart and connected world. It is also of utmost importance to our national security.

### 2. What are its secondary purposes, if any?

The secondary purposes of the proposed program are

- a) To generate highly sought after workforce highly needed by Sandia National Laboratories (SNL), Los Alamos National Laboratory (LANL) and Air Force Laboratory (AFRL) and New Mexico small businesses with the much needed workforce with expertise in cyber electronic systems.
- b) To improve collaboration with other Ph.D.-level graduate programs in the state and the region by encouraging exchange programs whereby students can spend time learning new techniques and carrying out research at another university and through cross campus course offerings. NMT and UNM have conducted a few such courses in the past, e.g., a manipulator based robotics, and inertial navigation. In addition, faculty from NMIMT has served on several Ph.D. committees at UNM.
- c) To connect and take advantage of the existing NMIMT-specific and STEM-focused expertise in the various fields of science and engineering and to create multidisciplinary opportunities in the emerging fields of structural health monitoring, and smart cities as well as enhance research in position, navigation, timing, and first responder capabilities.
- d) To increase the number of doctoral-level members in the New Mexico science, technology, and engineering communities from under-represented groups.
- e) To attract highly qualified applicants for faculty positions in the Electrical Engineering Department.
- f) To support undergraduate laboratory teaching by employing graduate teaching assistants who are Ph.D. degree-seeking students and thus more highly trained than typical students pursuing a M.S. degree.
- g) To enhance graduate research by employing Ph.D.-degree-seeking students, who are typically more highly trained than M.S. degree seekers. Related advances will be seen in the quantity and quality of scientific publications and patentable inventions, leading to institutional financial gains in the form of increased funding and more patent licenses which will help support future students.

- h) To support NMIMT’s Energetic Materials Research and Testing Center (EMRTC) and the Institute for Complex Additive Systems Analysis (ICASA) in Socorro, as well as research laboratories such as Los Alamos National Laboratory, Sandia National Laboratories, Air Force Research Laboratory’s Space Vehicles and Directed Energy directorates within the state of New Mexico with highly trained workforce to support current research as well as create new venues for funding.

### 3. Is the proposed program consistent with the role and scope of the institution as set forth in its mission statement and interpreted by its governing board?

The Doctor of Philosophy program in Electrical Engineering with Dissertation in Cyber Electronic Systems is consistent with NMIMT’s mission and strategic plan. The NMIMT’s mission indicates the following central aspects pertaining to the role and scope of the institute:

*“New Mexico Tech serves the state and beyond through education, research, and service, focused in science, technology, engineering, and mathematics. Involved faculty educate a diverse student body in rigorous and collaborative programs, preparing scientists and engineers for the future. Our innovative and interdisciplinary research expands the reach of humanity’s knowledge and capabilities. Researchers, faculty, and students work together to solve real-world problems. Our economic development and technology transfer benefit the economy of the state and create opportunities for success. We serve the public through applied research, professional development, and teacher education, benefitting the people of New Mexico.”*

The proposed program is also naturally consistent with the Mission of the Electrical Engineering Department –

*“The mission of the New Mexico Tech Electrical Engineering Department is two-fold: (1) to develop and maintain a program of excellence in teaching which ensures that our graduates have technical knowledge and professional skills they need to become effective engineers in the rapidly-changing technical environment of today’s society, so that these graduates will contribute to the growth and development of New Mexico and our nation, and (2) to develop and maintain state-of-the-art research programs which are responsive to the needs of industry and government, which provide excellent educational opportunities for students, and which provide an environment for intellectual growth and excitement.”*

### 4. What is the institution’s priority for the proposed program, as indicated in its most recent plans, funding requests or other institutional documents?

The proposed Ph.D. in Electrical Engineering with Dissertation in Cyber Electronics Systems is consistent with NMIMT’s priorities as listed in its strategic plan:

*“New Mexico Tech aspires to be a preeminent community of scholars dedicated to research, education, and innovation – advancing science, technology, engineering, and mathematics – to meet the challenges of tomorrow. We will drive innovation and education through transdisciplinary collaborations.”*

[http://www.nmt.edu/images/stories/presidentsofficepages/NMT\\_Strategic\\_Plan\\_2015-2020\\_final.pdf](http://www.nmt.edu/images/stories/presidentsofficepages/NMT_Strategic_Plan_2015-2020_final.pdf)

New Mexico Institute of Mining and Technology’s 2015---2020 Strategic Plan further specifically identifies:

*Strategic Priority #4: Ensure Intentional and Planned Quality Growth*

*Goal 2: Grow graduate enrollment to become PhD-granting institution in 7 to 10 years.*  
*Goal 3: Strengthen / Grow research components*

**5. What is the curriculum for the proposed program? What types of courses and other degree requirements are needed for degree completion? What types of skills or competencies will students develop as a result of completing the degree program?**

**Course Requirements**

All course work must be approved by the student's graduate committee, the Electrical Engineering Department Chair, and the Dean of Graduate Studies.

**Direct to Ph.D. (Students with Bachelor of Science Degree)**

A student must complete a minimum of 72 credit hours beyond the Bachelor of Science degree in related area with:

- a minimum of 24 credit hours of electrical engineering courses 500-level or above including required core courses (8 credits)
  - EE 5xx Electronic Warfare
  - EE 5xx Position, Navigation and Timing
- a minimum of 6 credit hours outside of the Electrical Engineering department;
- 24 credit hours of dissertation; and,
- no more than 6 credit hours of 300- or 400-level courses.

**Students with Master of Science Degree**

A student must complete a minimum of 48 credit hours beyond the Master of Science degree in related area with:

- a minimum of 12 credit hours of electrical engineering courses 500-level or above including required core courses (8 credits)
  - EE 5xx Electronic Warfare
  - EE 5xx Position, Navigation and Timing
- a minimum of 6 credit hours outside of the Electrical Engineering department unless satisfied by the Master of Science degree;
- 24 credit hours of dissertation; and,
- no more than 3 credit hours of 300- or 400-level courses.

**Core Courses**

**EE 5xx Electronic Warfare** (already being offered)

Explores the various aspects of Electronic Warfare (EW) from the standpoint of both the user and the attacker. The course begins with a definition of terms such as Electronic Support (ES), Electronic Protection (EP), Electronic Attack (EA), and Electronic Counter-Counter Measures (ECCM). The primary emphasis is on the impact of EW techniques on radar and communication systems.

**EE 5xx Position, Navigation and Timing** (already being offered)

Covers the fundamentals of timing, terrestrial location and navigation with an emphasis on practical exposure to the technology. Key components include: GPS fundamentals; an overview of inertial navigation technology; principles of strapdown inertial navigation systems including coordinate frames, attitude representation, and mechanization in various coordinate frames; sensor technology covering a wide range of accelerometers and gyroscopes; sensor specifications and characterization; testing and calibration approaches; effects of inertial sensor error and compensation methods; introduction to unmanned systems; analysis of real sensor data and simulation and modeling using MATLAB/Simulink.

## New Courses

The following three 500-level courses, in addition to existing fourteen 500-level courses:

- EE 5xx Directed Energy
- EE 5xx Electronic Counter Measures
- EE 5xx Space Vehicles

## Qualifying Exam

The graduate committee, in consultation with the student, will select a technical paper. The student must perform an in-depth study of the paper through analysis and modeling, and/or simulation. The student will present the analysis and critique of the paper in a written report and an oral presentation. The exam is designed to test the student's ability to be successful in the Ph.D. program by demonstrating his/her ability to analyze, critique, solve technical problems, grasp fundamental concepts, solve open problems, and communicate effectively. The graduate student can only take the qualifying exam once. In case the student did not pass, he/she may appeal the decision to the Electrical Engineering Department Chair.

## Candidacy Exam

The student must present a detailed review of his/her research area and hypothesis under investigation to the members of his/her graduate committee. The presentation will be open to the public.

## Ph.D. Research Defense and Dissertation

- a) Written dissertation
- b) Oral presentation open to the public followed by a closed discussion with the student's graduate committee

## Learning Outcomes

- a) an ability to apply methods of advanced analysis appropriate for professionals to use when solving problems;
- b) an ability to apply in-depth knowledge in the area of cyber electronic systems that supports the use of innovative techniques to solve problems;
- c) an ability to demonstrate skills pertinent to the research process, including the ability to formulate problems, synthesize and integrate information, work collaboratively, communicate effectively, and publish results.

## Catalog Draft Copy

### **Doctor of Philosophy in Electrical Engineering with Dissertation in Cyber Electronic Systems**

The prospective doctoral candidate will develop a high level of competence in the specialized area of cyber electronic systems. Candidates will also develop the ability to integrate aspects of this area and apply them in cutting-edge research. The program is arranged by the prospective student and the student's graduate committee. Upon completion of the program, students shall exhibit:

- a) an ability to apply methods of advanced analysis appropriate for professionals to use when solving problems;
- b) an ability to apply in-depth knowledge in the area of cyber electronic systems that supports the use of innovative techniques to solve problems;
- c) an ability to demonstrate skills pertinent to the research process, including the ability to formulate problems, synthesize and integrate information, work collaboratively, communicate effectively, and publish results.

The Ph.D. requirements include the following:

1. Select a graduate committee that shall consist of a minimum of four members: (a) an academic advisor from the Electrical Engineering department, and (b) at least three other members, one of which must be from outside the department assigned or approved by the Dean of Graduate Studies. The research advisor may be the academic advisor or another member of the committee.

2. Students with only a Bachelor of Science degree in related area must complete a minimum of 72 credit hours:
  - a minimum of 24 credit hours of electrical engineering courses 500-level or above including required core courses (8 credits)
    - EE 5xx Electronic Warfare
    - EE 5xx Position, Navigation and Timing
  - a minimum of 6 credit hours outside electrical engineering;
  - 24 credit hours of dissertation; and,
  - no more than 6 credit hours of 300- or 400- level courses.
3. Students with a Master of Science degree in related area must complete a minimum of 48 credit hours:
  - a minimum of 12 credit hours of electrical engineering courses of 500-level or above including required core courses (8 credits)
    - EE 5xx Electronic Warfare
    - EE 5xx Position, Navigation and Timing
  - a minimum of 6 credit hours outside of the Electrical Engineering department unless satisfied by the Master of Science degree;
  - 24 credit hours of dissertation; and,
  - no more than 3 credit hours of 300- or 400-level courses.
4. All course work must be approved by the student's graduate committee, the Electrical Engineering Department Chair, and the Dean of Graduate Studies.
5. The graduate committee, in consultation with the student, will select a technical paper. The student must perform an in-depth study of the paper through analysis and modeling, and/or simulation. The student will present the analysis and critique of the paper in a written report and an oral presentation. The written report and the oral presentation constitute the qualifying examination. The exam is designed to test the student's ability to be successful in the Ph.D. program by demonstrating his/her ability to analyze, critique, solve technical problems, grasp fundamental concepts, solve open problems, and communicate effectively. The graduate student may only take the qualifying exam once. In case the student did not pass, he/she may appeal the decision to the Electrical Engineering Department Chair.
6. Successfully pass the candidacy examination. The student must present a detailed review of his/her research area and hypothesis under investigation to the members of his/her graduate committee. The presentation will be open to the public. This examination may only be taken after a student has passed the qualifying examination.
7. The admission to candidacy to the Ph.D. degree requires that the qualifying and candidacy examinations be passed and approved by the graduate committee; after which the student may enroll in EE 5xx: Dissertation.
8. The student must write a final dissertation and defend it in an oral public defense before the student's graduate committee.

Additional requirements include the New Mexico Institute of Mining and Technology Graduate Program requirements.

## B. Justification for the Program

The proposed program must meet one or more specified needs within the state or region; must not duplicate existing programs unnecessarily or inappropriately; and, to the extent feasible and appropriate, should benefit from cooperative arrangements with other institutions.

### 1. Evidence of Need

The proposed program must meet one or more specified needs within the state or region. Clear and convincing evidence must be provided of the reality and extent of such need.



- a. Why is the program needed? Will graduates of the program help meet some specified state or regional workforce need? Have specific potential employers requested or expressed interest in the program? What, if any, internal institutional needs will also be met by the program?

Within New Mexico, SNL, LANL and AFRL and New Mexico small businesses need workforce with expertise in cyber electronic systems. Furthermore, there is a national demand for Ph.D. level engineers with expertise in the area of position, navigation and timing, electronic warfare, and navwar.

Innovations in tightly coupled cyber and physical systems have led to a new era of applications ranging from health systems and smart cities to emergency response and homeland security. Electronic systems are in the heart of those applications due to the requirements for communication, controls, analog and digital sensors and devices, and hardware reconfigurability with a central element being positioning, navigation and timing. Cyber systems based applications have created a new level of challenges and threats. Intentional or unintentional electromagnetic interference could cause hardware and/or communication failures. In a system of systems world that relies heavily on tight control of several devices at a time, this could prove catastrophic. Consequently, the need for a new generation of electrical engineers capable of combating those challenges and threats will continue to increase.

There is an immediate and pressing need for highly qualified Ph.D. level engineers in the area of cyber electronic systems. The proposed program will graduate students that are highly sought after in the academia, research laboratories, e.g., SNL, LANL and AFRL, and government agencies, e.g., Department of Defense (DoD), Department of Energy (DoE), National Security Agency (NSA) and Department of Homeland Security (DHS), as well as supporting industries. NMIMT has the advantage of having the Energetic Materials Research and Testing Center and the Institute for Complex Additive Systems Analysis with which further collaborations will be formed and new research venues will be sought. Furthermore, the existence of EMRTC and ICASA provide a unique opportunity to attract research projects that require restricted access, i.e., ITAR or clearance, which other universities are not able to work on. The program is structured to allow for rapid workforce development within a three year period.

### National Security Need

In an article by Kevin McCaney in *Defense Systems*, Feb. 09, 2015, he cites the DoD's emphasis on navigation warfare:

<https://defensesystems.com/articles/2015/02/09/dod-directive-navigation-warfare-pnt-tools.aspx>

*“For starters, the instruction from DOD Acting CIO Terry Halvorsen directs all of the military services and other DOD components to employ Navwar, in a move that emphasizes the ever-growing importance of the electromagnetic spectrum. The Pentagon last year updated its electronic warfare policy, calling for EW to be incorporated into the full range of military capabilities, including navigation warfare.”*

In the *National Interest Magazine* the article *The American Military's Greatest Vulnerability: No GPS in a War*, October 18, 2016, Mames Hasik, quotes Doug Loverro, the deputy assistant secretary of defense for space policy:

<http://nationalinterest.org/blog/the-buzz/the-american-militarys-greatest-weakness-no-gps-war-18085>

*“If we lost GPS worldwide, most of our warfighters—in fact, all of our warfighters—would lose the ability to navigate and tell time and drop the precision munitions and do everything we do with GPS. If we lose GPS tomorrow, none of our warfighters can fight, but your iPhone can still tell you where you are and get you down the street.”*

The Resilient Navigation and Timing Foundation highlights the vulnerabilities of our infrastructure <http://rntfnd.org/what-we-do/>

*“The U.S. Department of Homeland Security identifies 16 critical infrastructure, and has stated that 11 of those rely upon satellite timing signals as an essential part of their operation. And all 16 sectors use satellite navigation and timing to some degree. This is*

*true across the globe. Any system that depends upon a single source for anything is fragile and subject to rapid and unanticipated disruption or failure.”*

### National Need

The National Science Foundation (NSF) emphasizes ([https://www.nsf.gov/news/special\\_reports/cyber-physical/](https://www.nsf.gov/news/special_reports/cyber-physical/)) that the future will be that of a smart and connected world, and has identified areas such as: **transportation and energy** with driverless cars, smart road, automated damage checking of infrastructure damage, delivery of Wi-Fi to disaster zones and smart grids; **health care and medicine** with smart medical treatments and services, and smart homes; and **environment and sustainability** by helping in early fire detections and environment monitoring. All of which increase the need for qualified workforce to ensure that the integrity of the future infrastructure.

### State Level Need

AFRL Space Vehicles Directorate’s primary mission area thrusts includes position, navigation and timing, defensive space control and space based intelligence. In addition, AFRL Directed Energy Directorate’s primary mission thrusts includes laser systems and directed energy and electro-optics for space superiority. All of these areas are within the focus of the proposed Ph.D. in Electrical Engineering with dissertation in Cyber Electronic Systems. Furthermore, SNL and LANL and small businesses in New Mexico that are in close ties with AFRL would benefit from the proposed program that will meet their workforce needs as well as provide a venue for their employees to seek advanced degree to help advance their career.

*“The demand for the research skills this new degree program would support has been clear to us for some time.”* Support letter (attached) from Applied Technology Associates

### Educational Need:

In meeting all the above needs, a rigorous and focused Ph.D. level education in the area of cyber electronic systems coupled with extensive research is essential. The unique focus of the proposed Ph.D. in Electrical Engineering with Dissertation in Cyber Electronic Systems requires unique facilities such EMRTC and ICASA not available at any university in the region, therefore, NMIMT is the perfect institution to provide Ph.D. level education in the area of cyber electronic systems.

- b. Evidence of need might include results of employer surveys, current labor market analyses and projections, or long-term need projections prepared by a relevant professional organization. Summaries of student interest also are appropriate but will not by themselves be considered sufficient evidence of need.

A brief national search for jobs requiring advanced degree in cyber electronic systems demonstrates high demand with an average of 200 jobs currently open.

- c. Although academic and research interests of institutional faculty may be met through implementation of the proposed program, such interests by themselves are unlikely to persuade NMHED of need for the program. However, institutions of higher education may build programs around their areas of excellence. A clear demonstration of such excellence is expected in the proposal.

There is a wealth of expertise in the area of cyber electronic systems in the department of Electrical Engineering based on their current research and courses they teach. In addition, there are other departments with relevant expertise that are highly interested in collaborating with the Electrical Engineering department on multidisciplinary research requiring the area of cyber electronic systems. These include

- ICASA is currently conducting research with the focus of **cyber security and cyber electronic systems for infrastructure protection**. Several faculty members from the Electrical Engineering Department have already been participating in that research, providing their expertise in cyber electronic systems.

- **EMRTC host thousands of first responders for training.** Providing reliable and resilient communication and navigation systems is of extreme importance. Access to EMRTC and first responders is highly valuable and is unique to NMIMT, and hence, to the proposed program. The EMRTC facilities include over 10,000 square feet of office and traditional laboratory space in addition to **over 40 square miles of field laboratory testing space.**
- NMIMT's Playas Training and Research Center provides an area in which **relevant environment, e.g., warfare- and navwar-like,** that will be leveraged for educating the students and for conducting research in the area of cyber electronic systems. **Playas is a 640 acre town site with over 300 buildings with the following capabilities: irregular warfare, unconventional warfare, counter insurgency operations and urban operations training support, unmanned aerial systems flight and test activity, unmanned aerial systems flight and test activity, , micro-grid and distributed energy production and critical infrastructure protection research.**
- The Computer Science and Engineering department has a center of excellence in cyber security and the proposed program will result in a natural complementarity.
- The Civil Engineering Department has recently hired a faculty member with close ties to the Electrical Engineering department that works on structural health monitoring.
- NMIMT has recently started a Ph.D. in Mechanical Engineering with Dissertation in Intelligent Energetic Systems. Research in this area is another example of the need for cyber electronic systems to ensure required electronic systems and wireless connectivity is resilient to attacks.
- NMIMT's Petroleum Recovery Research Center is highly interested in navigation and positioning for horizontal drilling.

## 2. Duplication

The proposed program must not duplicate existing programs unnecessarily or inappropriately. A proposal for a program similar to one (or more) that already exists within the state must present clear and convincing evidence that need for the program cannot be met by the existing program(s).

- a. Is the program, or are similar programs, offered at any other public or private institutions within New Mexico?

The proposed Ph.D. in Electrical Engineering with Dissertation in Cyber Electronic Systems is unique in focus and is not currently offered at other institutions in New Mexico or the region. In the State of New Mexico, both University of New Mexico (UNM) and New Mexico State University (NMSU) offer high quality degrees of Doctor of Philosophy in Engineering with a variety of concentrations. These degree programs are similar in that they are based in the fundamental discipline of engineering. None of the New Mexico universities offer a graduate program with Dissertation in Cyber Electronic Systems. Faculty at UNM and NMSU are not conducting research in this focus area or offer courses in the area of electronic warfare, or navigation, position and timing. Furthermore, none of the new courses that will be offered under the proposed program overlap. With the proposed Ph.D. program, NMIMT extends its established expertise and educational services into the Ph.D. level. It is the specialized nature and associated areas of study that differentiate the proposed Ph.D. program from other Engineering Ph.D. programs in the state.

Given the fact that

- the Electrical Engineering Department at NMIMT is already offering courses in the focus area of cyber electronic systems,
- the faculty has also been conducting research in that area for the past 10 years, and
- the current NMIMT infrastructure has highly specialized research facilities,

offering such program at NMIMT is a logical choice. For other institutions to offer a similar program, they will have to divert existing resources from their current focus areas and duplicate existing facilities already available at NMIMT, not to mention the need for additional resources.

*“NMIMT also brings some very important institutional support that matters to us as well as the research content of the proposed new PhD program. It is very important to us to be able to conduct research on specific technologies which may be protected by U.S. Government International Traffic in Arms Regulations (ITAR) policies, or national security classification. The isolated outdoor test ranges and infrastructure NMIMT supports (Institute for Complex Additive Systems Analysis (ICASA) and Energetic Materials Research and Training Center (EMRTC) in particular) are important to us and provide the kind of protection our clients demand for sensitive test activities.” -- Support letter (attached) from Applied Technology Associates.*

*“The EE Department at NMTech is a unique position to offer such a curriculum given the strong interaction that the department has with both the DoD and DHS via other programs at EMRTC. Such position allows a much more in depth understanding of the specific needs in the area of cyber security directly related to these departments.” – Support letter (attached) from Naval Research Laboratory.*

*“NMIMT is uniquely positioned to offer such a program, already offering classes in electronic warfare, position navigation and timing, embedded controls, and communications. NMIMT further already intends to offer additional courses in the area of electronic counter measures, smart grids, space vehicles and directed energy. Existing NMIMT programs such as the Energetic Materials Research and Testing Center (EMRTC) and the Institute for Complex Additive Systems Analysis (ICASA) provide a collaborative base and synergy to enhance the proposed cybersecurity program, including facilities and capabilities for ITAR and classified projects.” – Support letter (attached) from Sandia National Laboratories.*

- b.** If so, what is the remaining capacity of the program(s)? How many students could the existing program(s) accommodate without additional resources for faculty, equipment, facilities and other needs?

Current programs in the State of New Mexico don't have a focus in the area of cyber electronic systems.

- c.** In light of the above information, why should the proposed program also be approved? What programmatic, geographic or other factors warrant approval of the program as an addition to the existing educational resources in the state?

Since there is no duplication in the Ph.D. in Electrical Engineering with Dissertation in Cyber Electronic Systems, there is no duplication of resources in the state.

- d.** Do New Mexico students have access to a comparable program in another state through either the WICHE professional student exchange or the WICHE regional graduate program?

The Western Interstate Commission for Higher Education (WICHE) seeks to leverage educational resources located in the western region to provide residents with opportunities that extend beyond the borders of their home state. We have examined existing programs in neighboring states that participate in WICHE for duplication.

There are Ph.D. programs available in Electrical Engineering from Colorado School of Mines, Colorado State University, the University of Colorado at Boulder, the University of Utah, Utah State University, and Arizona State University. These programs are structured with emphasis in the typical areas of the discipline: electromagnetics, communications, signal processing, and controls. However, none of these programs have an emphasis (or even courses available) on electronic warfare or inertial navigation.

- e.** As evidence, the proposing institution must assemble and display data listing each similar program offered by regionally accredited public and private universities in New Mexico; the numbers of students admitted to each of those programs during each of three recent, consecutive

years; the numbers of degrees/certificates awarded during each of those years; and each university's estimated remaining capacity of its program(s).

Current programs in the State of New Mexico don't have the focus in the area of cyber electronic systems.

- f. To the extent feasible and appropriate, statements from representatives of the existing programs should be attached to the proposal, articulating their positions with regard to the proposed program.

Support letters attached.

- g. The purpose of this requirement is twofold: (1) to assure that communication has taken place with existing programs, as an element in planning the proposed program, and (2) to aid reviewers in assuring that there is need for the program that cannot be met through existing programs.

Faculty at NMIMT Electrical Engineering Department have been collaborating with their colleagues other institutions within the state for years. There is constant discussions, collaborations, proposals, etc. Through these interactions, there is a solid understanding of NMIMT's focus and agreement that there is no duplication or competition, but rather complementarity and collaboration.

### 3. Inter-institutional Collaboration and Cooperation

The New Mexico Higher Education Department strongly encourages collaborative relationships with other programs within New Mexico, so that state investments can be shared and students can benefit from expanded opportunities across institutional boundaries.

- a. Are there programs at other institutions, and particularly programs already supported by the state, through which shared instruction, collaboration with faculty or other means of broadening student options and experiences can be arranged as part of the proposed program?
- b. If the proposed program is related to other programs operating at public institutions in the state, the proposal should document how collaboration will be achieved with those programs. For example, if it is feasible and productive to share faculty, instruction or other assets with an existing program at another institution, the proposal should outline how that collaboration will take place. If other arrangements for expanding students' experiences can be made with other institutions, those arrangements should be summarized.

There is no program at any of the institutions in the state with the focus on cyber electronic systems but due to its nature many multidisciplinary projects that require it, faculty from the Electrical Engineering Department at NMIMT have a history of collaborations with other institutions in the state of New Mexico, ranging from course exchanges, to seminars, to advising graduate students, to collaboration on proposals.

As an example, the University of New Mexico, New Mexico State University, New Mexico Institute of Mining and Technology, Santa Fe Community College, Dona Ana Community College, Northern New Mexico College, Sandia National Laboratories and Los Alamos National Laboratory are collaborating on a proposal entitled "Towards a SMART Grid Center: Sustainable, Modular, Adaptive, Resilient, Transactive". This proposal was selected by New Mexico's EPSCoR Committee as New Mexico's focus for the national EPSCoR Research Infrastructure Improvement Program Track-1 proposal to be submitted in 2017. The proposal leverages existing infrastructure, research and educational programs across New Mexico to develop a framework for resilient and sustainable smart grids. Aspects of the smart grid to be considered include the physical infrastructure (grid and hardware), the communications infrastructure (hardware, software, protocols) and the decision-making components. The goal is to further build research and educational capacity in New Mexico capable of addressing energy-related challenges at the state, national and international levels.

## C. Clientele and Projected Enrollment

The proposal must clearly describe the population of students who will be recruited for the proposed program and must include a detailed projection of enrollment and credit hours anticipated during the first five years.

### 1. Clientele

- a. Who are the students to be served by the proposed program? Will the program concentrate its recruitment upon students representing some particular geographic area, students from some special employment sector or some other identified group?

The students to be served by the proposed Ph.D. in Electrical Engineering with Dissertation in Cyber Electronic Systems program are primarily:

1. Recent Bachelor or Master degree graduates, who obtained their degrees in science, engineering, technology, or another closely related discipline and who are interested in advancing their education, training, and expertise to compete for high level employment positions in industry, academia, and governmental entities.
2. Qualified working professionals who have encountered a need to strengthen their professional capabilities.
3. Qualified staff members of national laboratories and other governmental entities who wish to continue their professional education.

- b. What academic or experiential qualifications will be set for admission?

The following guidelines are proposed for admission of students into the Ph.D. program in Electrical Engineering with Dissertation in Cyber Electronic Systems:

1. Consistent with general admission requirements set by the NMIMT graduate school. These requirements, among others, include GRE (domestic and international students) and TOEFL or IELTS (international students) tests.
  2. A minimal grade point average (GPA) of 3.0 on a 4.0 scale or other proof of satisfactory academic standing if the GPA is not available candidates for admission into the proposed Ph.D. program. In addition, three letters of recommendation for admission into the program are required.
  3. Candidates for admission into the program must possess a Bachelor or Master degree in science, engineering, technology, or other closely related discipline from an accredited institution of higher learning.
  4. Depending on the candidate's background, additional course work may be required to ensure meeting the pre-requisite courses and competency requirements.
- c. Will the proposed program be consistent with state goals for equitable representation of all students? How will the program assure equal access and success of students from groups historically underrepresented in graduate education or in the fields of employment for which the program is intended to prepare its graduates?
    - At a minimum, the proposal also should include information about representation of diversity in ethnic and sex/gender groups of (a) undergraduate students and (b) graduate students at the proposing institution and should articulate the methods that will be used to assure equity in access and success in the proposed program.
    - To the extent possible, the proposal also should include information about representation in the fields of employment for which the program is intended to prepare students and other information relevant to assessing the capacity of the program to help redress underrepresentation.



The New Mexico Institute of Mining and Technology is qualified as a Hispanic- Serving Institution by the U.S. Department of Education (see the attached letter). For Fall 2016 semester, New Mexico Institute of Mining and Technology: 30.8% of undergraduate students are Hispanic with Male-to-Female Ratio: 73.1% male, 26.9% female, and for graduate students 11.2% are Hispanic with Male-to-Female Ratio students: 67.1 % male 32.9 % female.

The following NMIMT services are available that are aimed at increasing the higher educational opportunities for the underrepresented groups:

- Academic Referral Program – An early intervention program designed to identify and help students when they show signs of academic difficulty. The teaching faculty is asked to refer students to the Graduate Dean for assistance during the third week of the semester.
- Academic Counseling – Individual and group counseling is offered to help students identify their learning style and develop academic success skills such as time and stress management, study skills, and adaptive choice-making.
- Counseling and Disability Services, which mission is to support the emotional, intellectual and social development of students at NMIMT. This service helps individuals resolve existing problems, prevent potential problems, and develop new skills that will enrich their lives. NMIMT provides accessible programs, services, and reasonable accommodations for any student with a documented, qualifying disability as defined by Section 504 of the Rehabilitation Act of 1973, as amended, and by the Americans with Disabilities Act of 1990.
- Advising Resources for Faculty – A seminar for new faculty members on utilizing the theory and techniques of developmental advising, mentoring, as well as orientation to academic policies, services and resources on campus and in the community.
- Instructional Training – Teaching training is provided to all new faculty and teaching assistants. This training is provided by the Center for Graduate Studies and addresses all aspects of teaching practice.
- STEM Communication Fellows – Partial TA-ships intended to improve communication within academic departments and to assist in written and oral communication tutoring at the graduate level through the Writing and Oral Presentation Center.
- Writing and Oral Presentation Center – Provides writing and presentation assistance to students of all levels and from all disciplines. Multiple resources are available for students to consult or borrow. Technology in this center includes recording of presentations that students can view via web link.
- Thesis and Dissertation Bootcamp: Students attend bootcamp focused on thesis and dissertation writing as well as best practices to present their work.
- Student Research Symposium a (SRS) is a campus-wide co-curricular event open to all New Mexico Tech students and organized by faculty, students, administrators, and staff. The mission of the Student Research Symposium is to provide a forum for students to voluntarily share knowledge with their peers, faculty, community, guests, and reviewers through oral or poster presentations and extended abstracts of their research/design projects. Students are encouraged to develop professional oral presentation, writing, and document design skills to communicate their research/design to a multidisciplinary audience.
- Research @ Tech Day – New Mexico Tech invites prospective students and their families to explore cutting-edge research on campus.

## 2. Projected Enrollment

- a. The proposal must display, in clear tabular form, the projected enrollment in the proposed program during its first five years. This presentation must distinguish the number of new students (headcount) expected to enroll each year, the number of returning students expected to re-enroll in each year, and the methodology used to arrive at those projections.

- b. The proposal should indicate the number of students expected to enroll full-time and the number expected to enroll on a part-time basis and must display the total number of student credit hours expected to be generated in each of the first five years.

Table 1: Projected enrollment for the Ph.D. in Electrical Engineering with Dissertation in Cyber Electronic Systems Program

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
New Students (Full-time)	2	1	1	1	1	1	1
New Students (Part-time)	1	1	1	1	1	1	1
Total Students (Full-time)	2	3	4	4	4	4	4
Total Students (Part-time)	1	2	3	4	5	6	6
Program Graduates	0	0	1	1	1	2	2
Total Credit Hours Generated*	75	120	165	180	195	210	210

\* 12 credit hours per semester is assumed per full-time student during Fall and Spring semesters and 6 credit hours during summer semester for a total of 30 credits per year. Part-time students are assumed to take 15 credits per year.

## D. Institutional Readiness for the Program

The institution should have nearly all of the resources needed to initiate the program. The proposal should include a clear statement of the extent to which the institution is ready to initiate the program, citing the remaining needs and recognizing each of those needs in the cost analysis developed pursuant to Subsection E of 5.5.2.9 NMAC.

- a. Is the teaching faculty adequate in number and qualifications to initiate the program? If not, what additional faculty are needed? To what extent will the program rely upon graduate assistants to free faculty time for graduate instruction in the proposed program?

Faculty of the Electrical Engineering Department at New Mexico Tech have the required expertise to offer the proposed program. All courses proposed as the core for the program have already been offered in previous years. Faculty are conducting research in the area and have the required laboratories, hence, the department will not require any additional resources to offer the program. The new program will be the first of its kind in the state and will attract students that otherwise pursue Ph.D. degrees with similar focus out of state. Sandia National Laboratories, Los Alamos National Laboratories and NMIMT's ICASA and EMRTC have demand for Ph.D. level electrical engineers with focus in cyber electronic systems to support new research and development directions.

- b. Are the library and other academic support resources sufficient to initiate the program? If not, what additional resources are needed?

NMIMT Skeen Library has a rich offering of science and engineering resources to support the proposed Ph.D. in Cyber Electronic Systems program. The library maintains subscriptions to electronic journals and research databases that are available to NMIMT faculty, staff and students. The library currently subscribes to many prominent electronic research collections including: IEEE/IET Electronic Library, VDE Verlag Conference Proceedings, ACM Digital Library, ASME, Elsevier's ScienceDirect, Springer, IOP, AIP and ACS. Related research databases include Compendex, Web of Science, Computer Database, Computers & Applied Sciences Complete and CSA Materials Research Database. The library's book collection is substantial with 93,000 printed books and over 350,000 eBooks available for immediate download 24/7. Some articles from non-subscribed journals and books not available in the NMIMT library can be obtained via Interlibrary Loan.

- c. Are the physical facilities of the institution adequate for the first five years of the program? Will additional space or modifications of existing space be required within the first five years of program operation?



Electrical Engineering faculty have research laboratories. These laboratories, described below will provide the required space and equipment required to support the new program.

*Hyperspectral Imaging Laboratory:* This laboratory is operated by Prof. Erives. Focus area of Prof. Erives is the use of spectroscopy sensors and spectral image analysis for a wide range of remote sensing and close range non-contact inspection applications. Related areas to this topic are the integration and calibration of 3-D hyperspectral instrumentation, *i.e.*, an instrument capable of providing hyperspectral imagery (hypercubes) and range measurements (3-D information), non-rigid image registration (a current research topic is the implementation of an active optics-based real-time registration method), image calibration and analysis, and intelligent multi-wavelength inspection systems. Equipment housed in this laboratory includes Spectralon calibration panel (99% reflectance), color chart, Edmund high precision motorized stage, Physik Instrumente (PI) tunable mirror.

*Instrument Development Laboratory:* Instrumentation development by Prof. Jorgensen includes astronomical instrumentation, spacecraft instrumentation, and software-defined-radio-based RF instrumentation. Research also include space plasma physics and RF propagation, space weather, sensor networks, machine learning, and data assimilation for space situational awareness. Equipment in the Instrument Development Laboratory includes computing servers, RAID storage arrays, clean area, electronics workstation, PCB mill and test equipment.

*Modeling and Simulation Laboratory:* This laboratory is operated by Prof. El-Osery. The focus of the research conducted in this laboratory is the development of new approaches for navigation, guidance and control (GNC) for unmanned vehicles. A key component of the research is the use of signals of opportunity to aid the navigation algorithms. This research is interested in providing viable GNC in harsh environments where GPS signals may be degraded or denied. Equipment available in this laboratory includes Xilinx Field Programmable Gate Arrays (FPGAs), software defined radios, high-speed cameras, and inertial navigation units.

*Optics and Photonics Applications Laboratory:* This active laboratory is operated by Prof. Scott Teare and is a combined optics and electronics facility equipped to support studies related to adaptive optics, telescope systems, ballistics, energetic materials, drone technologies, telescopes, smart instrumentation and interferometry. The laboratory currently houses a number of specialized instruments including: telescopes; spectrometers; optical components; 3D printers; quadcopter; electronic test equipment; optical test equipment; and several computer and data logging instruments.

*Robotics Laboratory:* This laboratory is operated by Prof. Wedeward. Robotics-related research focuses on mobile robots and robotic arms. Mobile robots are capable of navigating through rugged, unstructured environments out of an operator's line-of-sight. Applications of interest include surveillance, and land-mine detection and remediation. Low-cost, single-board computer based-control is the focus of work in robotic manipulators. The Laboratory currently houses two Mesa Robotics Matilda outdoor robotic platforms, one CRS Robotics A255 five axis robotic arm, and one Rhino Robotics SCARA four axis robotic arm.

*Signal Processing Laboratory:* This laboratory is operated by Prof. Arechiga. Research focuses on on acoustical monitoring and analysis of thunder due to lightning in the infrasound, audible and higher frequency ranges. Equipment housed in the Signal Processing Laboratory includes: high resolution dataloggers, custom made audio dataloggers, mixed signal oscilloscope, arbitrary, function generator.

*Smart-Grid Laboratory:* This laboratory is operated by Prof. Wedeward. Research focuses on modeling power systems to study the effects of increasing the amount of distributed generation. Characterize alternative energy sources and assess their impact as a larger number of them are integrated into the power system. Effects at both the distribution- and transmission-level are of interest as are techniques for coordinating and controlling their behavior.

*System Identification and Communications Laboratory:* This laboratory is operated by Prof. Senay. Research conducted in this laboratory includes developing signal processing algorithms using time frequency analysis, wavelets and nonuniform sampling for the areas of system identification and

communication systems. The current interest is in the use of software defined radios for implementing and developing signal processing algorithms for an OFDM communication system. Equipment includes arbitrary waveform generator, software-defined radios, spectrum analyzer, and computational platforms and software.

- d. Are the institution's equipment and technological resources adequate for the first five years of the program? What if any, additional equipment will be needed?

Current equipment in Department of Electrical Engineering is adequate to start and maintain the Ph.D. program and no additional institution equipment or resources are required.

- e. Are other operating resources adequate to initiate the program? For example will additional clerical or specialized personnel be needed?

Current operating resources are adequate for the program. Departmental administrative assistant and lab manager, in the Electrical Engineering Department, should be able to handle the modest increase in graduate student-related administrative duties.

- f. Are there existing external facilities that will be used? Have agreements been established to ensure use of those facilities? For example, if you are offering a nursing or allied health program have you established a partnership with local hospital(s) and other clinical settings?

No external facilities are needed for the program.

## E. Projected Cost of the Program

The proposal must include a clear analysis of the projected cost of the proposed program and the sources of funding that will support it.

- a. New costs for program start-up. The proposal should provide a clear indication of new costs that must be met in order to begin the program and to sustain it during its first five years. The analysis must address at least the following cost categories:

- 1) Additional faculty needed for the program, full-time and part-time.

The program is designed in such a way that it does not require any additional resources other than what is already available to the Electrical Engineering Department. Core courses required for the program are already being offered and additional courses will be offered in concert with other requirements for the already existing Master's program. By offering courses on well-studied cycle, no additional resources will be needed.

- 2) Additional library resources needed for the program. The proposal should include a statement from the university librarian, indicating the cost of these new resources and the schedule on which the resources will be provided.

No additional library resources are needed for the program.

- 3) Additional facilities, equipment and technological resources needed for the program.

Current research laboratories supervised by the faculty in the Electrical Engineering Department can absorb the increase in the number of graduate students and has the necessary equipment to conduct the required research.

- 4) New graduate assistantships needed to support the program, including the dollar value of the assistantships during each of the first five years of the program.

New graduate assistantships will be added and supported through the research funding obtained by the faculty. Currently, in the Electrical Engineering Department the faculty combined research funding is on the order of \$1M. Additionally, offering the new program will attract more research funding from research laboratories and government agencies.

- b. **State Support.** An analysis must be presented showing the approximate amount of state operational formula funding that will flow to the program for each of the first five years, based upon the projected student credit hours and current formula funding factors, and recognizing the delay and averaging characteristic of the formula.

*Table 2: Projected formula funding to be generated by the Ph.D. in Electrical Engineering with Dissertation in Cyber Electronic Systems Program*

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
	<b>Full Time</b>						
Students Enrolled	2	3	4	4	4	4	4
Graduate Student - Credit/Year	30	30	30	30	30	30	30
	<b>Part Time</b>						
Students Enrolled	1	2	3	4	5	6	6
Graduate Students - Credit/Year	15	15	15	15	15	15	15
	<b>Totals</b>						
Graduates	0	0	1	1	1	2	2
SCH Formula Total Funding <sup>1</sup>	\$39,966	\$63,946	\$87,925	\$95,918	\$103,912	\$111,905	\$111,905
Award Formula Funding <sup>2</sup>	\$0	\$0	\$860	\$860	\$860	\$1,720	\$1,720
Total Revenue	\$39,966	\$63,946	\$88,785	\$96,779	\$104,772	\$113,625	\$113,625

<sup>1</sup> Funding per credit = \$532.88

<sup>2</sup> Funding per graduate = \$860.20

- c. **Other Support.** If the proposed program will benefit from other sources of operational support, the proposal should describe those. For example, if particular cost categories such as new equipment or additional graduate assistantships are expected to be supported by research grants, contracts or other sources, the proposal should clearly describe those sources and levels of support and should indicate that advantage to the state of receiving such support.

Faculty members conducting cyber electronic systems research are constantly seeking funding from, e.g., from the National Science Foundation (NSF), New Mexico EPSCoR (through an NSF grant), and other agencies. All proposals include funding for graduate research assistantships.

## F. Quality of the Program

The proposed program must be designed to meet high standards of academic quality, considering its instructional curriculum, faculty, student admission standards, opportunities for experiential learning and academic support, and provisions for continual review and improvement of the program.

- a. All programs supported by state funds are expected to comply with principles of academic quality delineated as part of NMHED's regulation on instructional funding, 5.3.12 NMAC.
- b. Among the questions that will be considered in evaluating proposals for new graduate programs are the following:
- 1) Is the curriculum adequately structured to meet the stated purposes of the program?

The curriculum is structured so as to insure that students gain a breadth of knowledge in cyber electronic systems via core courses and also a depth of knowledge in specialized topics via upper level elective courses and dissertation research.

2) Is the faculty adequate in number, experience and availability to offer a high quality program?

The faculty of the Electrical Engineering Department have a wide range of expertise directly related to cyber electronic systems. This expertise covers satellite communication and instrumentation, controls, inertial navigation, signal processing, analog and digital electronics, optics, and directed energy.

3) How do the proposed academic admission standards for students entering the program compare with standards for other programs at the institution and with admission standards for comparable programs at other institutions in New Mexico or other states?

The standards for admission are comparable to Ph.D. programs at the other New Mexico research universities.

4) How will the proposed program utilize current technologies to support program quality and delivery?

NMIMT is up to date in pedagogical technologies, including those supporting graduate studies. DegreeWorks is in development for graduate student tracking. NMIMT also maintains state-of-the-art research equipment and adequate computational capabilities.

5) What opportunities will be available to students to gain experiences relevant to work settings for which the program will prepare them?

In addition to the hands-on research performed at NMIMT's Electrical Engineering Department, students will have opportunities to gain extra training and to perform research at NMIMT's research centers such as EMRTC and ICASA, other research universities in New Mexico, Los Alamos National Laboratory, Sandia National Laboratories, Air Force Research Laboratory, or other collaborating institutions.

6) What academic support services are available to students, to assist them in succeeding in the program?

NMIMT prides itself not only for the rigor of its academic programs but also for the support provided to students to meet the high expectations. Academic support services available to graduate students include the annual Graduate Student Orientation, Teaching Training for all new graduate teaching assistants, the Writing and Oral Presentation Center, communications assistance from STEM Communication Fellows, tutoring in the Office of Student Learning, annual Thesis and Dissertation Boot Camp, and Counseling and Disability Services.

7) What final integrating experiences or other features will be used to assure that graduate have acquired the knowledge and skills expected for the degree or certificate awarded?

The curriculum and the specific degree requirements have several built-in milestones. Completion of each of these milestones involves evaluation by faculty members. These milestones include:

- qualifying exam
- research proposal
- dissertation defense

Standards for completion of each of these milestones will be in keeping with those of other doctoral programs at NMIMT and with related programs at other New Mexico research universities.

8) Has the proposed program been evaluated by any external reviewers or is there other external evidence or opinion regarding the quality of the program?

See attached letters of support.

9) When will the new program be proposed for accreditation by the Higher Learning Commission of the North Central Association?

We will seek accreditation as soon as the program has been approved by the State of New Mexico.

**10) Will specialized accreditation be sought for the program? If so, when?**

ABET, the accrediting agency for engineering programs, will accredit either the undergraduate or graduate program, not both. All of NMIMT's engineering departments participate in the ABET accreditation process for their undergraduate programs, therefore only HLC accreditation of Ph.D. in Electrical Engineering with Dissertation in Cyber Electronic Systems program will be sought.

## G. Assessment of Operations and Impact

The proposal must include a plan by which the proposed program will be assessed for its operation and impact over at least a five-year period.

- a. At a minimum, the plan must indicate methods that will be used to monitor program operations, progress of students and program completion rates.

Procedures already implemented for assessment of existing M.S. program in Electrical Engineering will be used to evaluate operation and impact of the Ph.D. program. The program will be assessed annually to ensure the following learning outcomes are demonstrated by electrical engineering graduate students

- a) an ability to apply methods of advanced analysis appropriate for professionals to use when solving problems;
- b) an ability to apply in-depth knowledge in cyber electronic systems that supports the use of innovative techniques to solve problems;
- c) an ability to demonstrate skills pertinent to the research process, including the ability to formulate problems, synthesize and integrate information, work collaboratively, communicate effectively, and publish results.

The Electrical Engineering Department has a standing Graduate Committee that is responsible for reviewing the graduate program, assessing its quality and recommending changes towards its continuous improvement. Updates and/or recommendations from the graduate committee are discussed during the department's monthly meetings.

- b. The plan also must include methods for obtaining evaluations from students, graduates or other appropriate sources and feeding that information into future operation of the program.

The proposed program will comply with the assessment process implemented by the NMIMT Graduate School. In particular, operation and impact of the program will be assessed by collecting and analyzing data on:

- a) Quality of candidates entering the program, retention rates, program completion time, and graduation rates.
- b) Student academic and professional achievements including GPA, internships, awards, and scholarships.
- c) Dissemination of candidates' research results in peer-reviewed publications and presentations at professional meetings.
- d) Recommendations of candidates' graduate study committee.

## H. Administrative Responsibility for the Program and Institutional Commitment

There must be a clear indication in the proposal that the institution is committed to the success of the proposed program.

- a. The proposal should indicate where in the structure of the institution the program will be administered. For example, which department will have primary responsibility and which additional departments, if any will contribute to operation of the program?

The Electrical Engineering Department assume responsibility of the Ph.D. in Electrical Engineering with Dissertation in Cyber Electronic Systems.

- b. The proposal should include a clear statement of administrative support for the program, sufficient to assure that resources will be provided during the first five years of the program. The proposal should also verify that all within-institution approvals needed for the program have been granted, including approval by the institution's governing board.

At the departmental level, the Electrical Engineering Department's Graduate Program Committee will be facilitate administration of departmental graduate programs. Responsibilities of the committee will include developing guidelines for the graduate study, approving policies and procedures for departmental graduate programs, and serving as an arbiter in resolving academic disputes and complains. To maintain a sharp focus on recruiting needs of regional employers, the Graduate Study Committee will regularly consult the Department of Electrical Engineering external Advisory Board consisting of representative of regional business and national laboratories. Finally, the Dean of Graduate Studies oversees all graduate programs at NMIMT.

## Appendix A – Support Letters



IN REPLY REFER TO:

18 November 2016

MEMORANDUM

FROM: Chief Engineer, China Lake Ranges

SUBJ: SUPPORT FOR ESTABLISHMENT OF ELECTRICAL ENGINEERING Ph.D. PROGRAM

New Mexico Institute of Mining & Technology's proposal to establish a Ph.D. program in Electrical Engineering with dissertation in cyber electronic systems targets an important niche in our current and future national defense requirements. In particular, the proposed program's emphasis on *electronic warfare* and *positioning, navigation, and timing* addresses core skill shortfalls seen across the national defense community associated with the widespread retirement of senior technical staff. When coupled with the rapidly advancing electronic warfare environment and high degree of system integration leveraging positioning, navigation & timing technologies seen across the world's stage, New Mexico Institute of Mining & Technology's proposal is very timely.

In many ways, the proposed Ph.D. program complements a long lineage of New Mexico Institute of Mining & Technology's programs, starting with its Research & Economic Development activities during World War 2 that focused on the development of the revolutionary proximity fuze and quantifying its associated terminal effects. In the seven decades since, New Mexico Institute of Mining & Technology has built on this foundation, and produced generations of the nation's key experts in critical defense technologies, ranging from energetic materials to electromagnetics to instrumentation and effects analysis. These are specialties that are uniquely found in the academic and research environment found at New Mexico Institute of Mining & Technology and often nowhere else. Establishing an Electrical Engineering Ph.D. program focusing on cyber electronic systems that emphasizes electronic warfare and positioning, navigation and timing builds on this core area of expertise and heritage in support of our national defense.

Naval Air Warfare Center Weapons Division (the Navy's largest research, development, test & evaluation organization) enjoys a unique relationship with New Mexico Institute of Mining & Technology that goes back to the early defense work of World War 2. This relationship has culminated in collaboration on research projects, involvement in the academic programs, and ultimately, extensive recruitment from New Mexico Institute of Mining & Technology's student body to become a part of our technical staff. Many of these alumni hold key roles in our organization that are borne by the unique foundation that they received at New Mexico Institute of Mining & Technology. This long standing relationship between the two organizations is formally captured by a longstanding Educational Partnership Agreement that serves to provide a

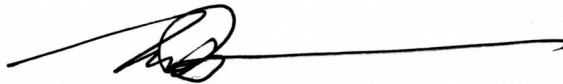


SUBJ: SUPPORT FOR ESTABLISHMENT OF ELECTRICAL ENGINEERING Ph.D.  
PROGRAM

framework for our continued support of education in engineering and the sciences at New Mexico Institute of Mining & Technology.

I am very supportive of New Mexico Institute of Mining & Technology's proposal to establish a Ph.D. program in Electrical Engineering with dissertation in cyber electronic systems. The focus of this proposed program directly aligns with Naval Air Warfare Center Weapon Division's current and future core mission. As such, I look forward to the Naval Air Warfare Center Weapon Division's relationship with New Mexico Institute of Mining & Technology in this endeavor, with the objective to participate in the curriculum, recruit graduates and even provide staff members as candidates for this program.

Feel free to contact me for further discussion. I may be reached at 760-939-4404, or [matthew.boggs@navy.mil](mailto:matthew.boggs@navy.mil).

A handwritten signature in black ink, consisting of a stylized 'M' and 'B' followed by a long horizontal line extending to the right.

M.L. Boggs



# ATA

*Applied Technology Associates*

1300 Britt St SE, Albuquerque, NM 87123  
(505) 767-1200, Fax (505) 768-1379

[www.atacorp.com](http://www.atacorp.com)

December 6, 2016

New Mexico Institute of Mining and Technology  
Electrical Engineering Department  
801 Leroy Place  
Socorro, NM 87801

Dear Professor El-Osery,

This letter conveys our support for creating a new PhD program in cyber electronic systems at New Mexico Institute of Mining and Technology (NMIMT).

The demand for the research skills this new degree program would support has been clear to us for some time. We supply advanced engineering and scientific talent to the Air Force Research Laboratory (AFRL) on Kirtland Air Force Base. That client has, within the past year, identified research to attack risks of cyber security of U.S. military space systems and the overall resiliency of space systems to operate through hostile actions as their top priority. AFRL is also focusing new attention and investments in reducing the electronic warfare vulnerabilities of GPS in specific. We, as a New Mexico small business and employer active in developing embedded controls for air and space systems, have a vital interest and immediate need for a supply of top-level research talent in these areas.

NMIMT also brings some very important institutional support that matters to us as well as the research content of the proposed new PhD program. It is very important to us to be able to conduct research on specific technologies which may be protected by U.S. Government International Traffic in Arms Regulations (ITAR) policies, or national security classification. The isolated outdoor test ranges and infrastructure NMIMT supports (Institute for Complex Additive Systems Analysis (ICASA) and Energetic Materials Research and Training Center (EMRTC) in particular) are important to us and provide the kind of protection our clients demand for sensitive test activities.

Last, and perhaps most important, we have a long history of collaboration with NMIMT and the alumni who have joined our company have earned a record of becoming among our most valued and productive staff.

For all the reasons outlined; our need for the research talent, NMIMT's infrastructure for supporting sensitive test and research, and the outstanding contributions your alumni have made with us, we encourage the establishment of a new PhD program in cyber electronic systems.



William N. McCasland, PhD  
Director of Technology

**Armin W. Doerry, Ph.D.**  
Distinguished Member of Technical Staff

22 November 2016

Subject: ***NMIMT Cyber Electronic Systems Program***

To Whom it may concern:

Please accept this letter as endorsement and recommendation for a new Ph.D. in Electrical Engineering with Dissertation in Cyber Electronic Systems at New Mexico Institute of Mining and Technology (NMIMT).

As the United States' civilian, industrial, government, and military infrastructures increasingly drive to a network-connected (indeed network-centric) environment, the need for securing both the network and the components that are connected therewith is increasing exponentially. In my own area, this includes Global Positioning System (GPS), command and control (C2), as well as radio-frequency (RF) sensor systems such as radar, etc. Without the assured integrity of these systems, their reliability and utility becomes problematic, rendering our decision-makers blind, or worse yet, subject to nefarious manipulation.

Currently, even as the need is increasing, no dedicated program exists to prepare scientists and engineers to meet these specific threats and innovate new and needed protections. Were such a program to exist, graduates will no doubt be eminently employable and highly sought-after across a broad spectrum of technical organizations, including industry and government/military national laboratories. In addition, the new program will strengthen existing collaborations with, and open much needed new venues for collaboration between Sandia National Laboratories and NMIMT.

NMIMT is uniquely positioned to offer such a program, already offering classes in electronic warfare, position navigation and timing, embedded controls, and communications. NMIMT further already intends to offer additional courses in the areas of electronic counter measures, smart grids, space vehicles and directed energy. Existing NMIMT programs such as the Energetic Materials Research and Testing Center (EMRTC) and the Institute for Complex Additive Systems Analysis (ICASA) provide a collaborative base and synergy to enhance the proposed cybersecurity program, including facilities and capabilities for ITAR and classified projects.

I have no doubt that NMIMT graduates of such a program will become esteemed leaders in this field, and credits to NMIMT as well as the state of New Mexico.

Sincerely,



Armin W. Doerry



To Whom It May Concern,

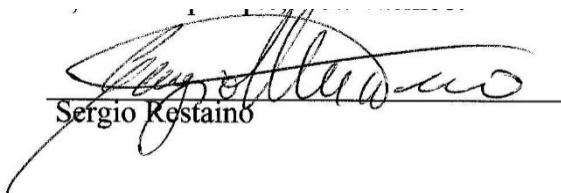
This letter is in support of the proposed Ph.D. program at the EE department at the New Mexico Institute of Mining and Technology (NMTech). The proposed graduate degree in Cyber Electronic Systems is sorely needed since it is in an area of dramatically increasing concern for National Security and for Homeland Security applications. It is, of course, an area of general concern but given my vantage point as a civilian member of the Department of Defense my emphasis is more on the national security side.

The EE department at NMTech is a unique position to offer such a curriculum given the strong interaction that the department has with both the DoD and DHS via other programs at EMRTC, for example. Such position allows a much more in depth understanding of the specific needs in the area of cyber security directly related to these departments. As aforementioned, in my capacity of Branch Head in a renowned DoD laboratory, I have firsthand experience of the shortage of personnel with this type of training, especially at the PhD level. Also, from my vantage point I strongly believe that this is indeed an area of growth with excellent employment opportunities.

Because of my direct experience with NMTech graduates in the past, I have hired two EE graduate students and I'm very familiar with other graduates that have found employment with the US Air Force Research Laboratory and Sandia National Laboratories, I have no doubt the future graduates from this program will find fast and easy employment with the national laboratories in New Mexico and elsewhere in the nation.

In light of all these considerations I feel that such a program would be extremely beneficial and I'm looking forward for first batch of graduates from this curriculum.

Sincerely,



Sergio Restaino

Branch Head  
Radio/IR/Optical Sensor Branch  
Remote Sensing Division  
Naval Research Laboratory



# ALTAMIRA

05 January 2017,  
Altamira Technologies Corporation  
8201 Greensboro Dr. McLean, VA

Electrical Engineering Department  
New Mexico Institute of Mining and Technology  
Socorro, NM

Prof. El-Osery,

I am writing in support of the proposed new program Ph.D. in Electrical Engineering with Dissertation in Cyber Electronic Systems at NM Tech.

The new proposed area is of vital importance to national security, as well as the corporate and industrial sectors. Altamira provides analysis, technology and cyber solutions to the US Intelligence Community and Department of Defense. Our current work in the cyber and electronic warfare areas is continuing to grow as is the awareness of our customers for which we provide other services. These customers are investing in cyber electronic systems and the demand for these skills will continue to grow in the mid-term.

NM Tech has a track record of successfully addressing specialized research. The infrastructure at NMIMT such as ICASA and EMRTC is necessary to successfully provide the cyber focus area. Additionally, the Electrical Engineering Department at NMIMT is already offering key courses to the program such as position navigation and timing and electronic warfare.

We are interested in the new program and it would increase the likelihood of Altamira and our customers' chances of collaborating with NMIMT, or hiring graduates of the program.

Sincerely

Ryan Christopher

Principal Engineering Scientist  
Altamira Technologies Corporation



MZA Associates Corporation  
2021 Girard Blvd. SE, Suite 150  
Albuquerque, NM 87106  
(505) 245-9970

November 20, 2016

Aly El-Osery  
Associate Professor and Chair  
New Mexico Tech  
Socorro, NM 87801, USA  
Office: Workman Center, Room 207  
Phone : 575-835-6432  
Email : aly.elosery@nmt.edu

Subject: Endorsement of the Development of a Ph.D. Program in Cyber Electronic Systems

Dear Dr. El-Osery,

This letter is to voice my support for the development of a Ph.D. program in Electrical Engineering (EE) with dissertation in cyber electronic systems at New Mexico Tech (NMT). To put my comments in context, I received my doctorate in Electrical Engineering from Stanford University in 2002 for developing deformable mirrors for high power lasers. I had the privilege of being taught by faculty that were and are world-class and pioneers in their field. I have subsequently been employed since graduation developing military systems for defense of our nation.

I have served on the advisory committee for the EE department at NMT for several years now and have seen first-hand the talent and passion that the EE professors at NMT have for teaching and motivating students to learn and grow. When I have seen their students present their Capstone projects at the end of their senior year, I have always been impressed with their capabilities and their depth of knowledge and readiness to join the work force. I also watched the EE department prepare for their ABET accreditation with great drive and professionalism. Based on these experiences, I believe that the EE faculty at NMT are ready to tackle the challenge of developing a new Ph.D. program.

The area of Cyber Electronic Systems is not one that I'm well versed in, but I have seen information on the threat that cyber-security poses to our national and corporate secrets. As a nation, we need more talented students to help secure our secrets and protect our competitive edge. The focus area of this proposed Ph.D. program addresses a need expressed by both our country and by its corporations, which will likely be one that will garner external financial support. NMT is in a unique position to offer the Ph.D. in Electrical Engineering with Dissertation in Cyber Electronic systems due to courses they have already developed, current research interest of the faculty as well as the unique facilities such as the Energetic Materials Research and Testing Center (EMRTC), the Institute for Complex Additive Systems Analysis (ICASA) and Playas training research center that are not matched at other institutions.

In summary, I believe that this new Ph.D. program will address a need not being adequately addressed by the existing educational community at large and that the EE faculty at NMT are ready and able to address this challenge.

Sincerely,

A handwritten signature in black ink that reads "Justin D. Mansell". The signature is written in a cursive, flowing style.

Justin D. Mansell, Ph.D.  
Vice-President & Chief Technology Officer  
(505) 245-9970, ext. 121  
Justin.Mansell@mza.com





**Institute for Complex Additive Systems Analysis**

801 Leroy Place, Socorro, NM 87801

Fax: 575-835-5980 • <http://www.icasa.nmt.edu>

**Michael Smith**

Associate Director, ICASA

575-835-5231

email: [msmith@icasa.nmt.edu](mailto:msmith@icasa.nmt.edu)

**Date:** 05 December 2016  
**To:** Aly El-Osery, Chair, Electrical Engineering Department  
**Fr:** Michael Smith, Associate Director, ICASA  
**Subject:** Ph.D. in Electrical Engineering with dissertation in cyber electronic systems

Dear Prof. El-Osery:

It is my pleasure to support your new Ph.D. program in Electrical Engineering with Dissertation in Cyber Electronic Systems. This program is in high demand and is of critical importance to our national security and will directly support and complement on going work at the Institute for Complex Additive Systems Analysis (ICASA).

ICASA is a research branch of New Mexico Institute of Mining and Technology (NMT) focused on leveraging advancements in math, engineering and science to design novel approaches to big data problems, especially for cyber electronics, critical infrastructure protection and national security. Today ICASA fosters undergraduate and graduate internships from the NMT community, and would take pleasure in integrating Ph.D. level engineers focused on cyber electronics to the program. If eligible interns are submitted through a high-level DoD security clearance process to support ICASA with solving national security problems through innovative approaches. This provides a means for student interns to gain real world experience working on cyber problems so that graduates can then either stay in New Mexico as technically trained scientists or transition into the government or industry sectors. This facility is unique within the state and the region. ICASA facilities are well situated to house classified or ITAR work. NMT is also recognized by the National Security Agency and Department of Homeland Security as a "Center of Academic Excellence in Information Assurance Education" expanded to include being a "Center of Academic Excellence in Information Assurance Research.

Established in 2001 by an act of the New Mexico State Legislature, ICASA has consistently delivered high quality research and development (R&D) products to the Federal government and other customers. Past team members have transitioned to positions in the State and Federal government as well as high-tech industry entities. ICASA's suite of analytic capabilities has been iteratively developed over the last 15 years for various customers including DoD, DoE, DoJ and industry partners. Many of these analytics are highly adaptable for a variety of environments, missions and classified applications. ICASA's specific expertise in cyber analytics will become increasingly relevant in a rapidly expanding data-driven world.





**Institute for Complex Additive Systems Analysis**

801 Leroy Place, Socorro, NM 87801

Fax: 575-835-5980 • <http://www.icasa.nmt.edu>

**Michael Smith**

Associate Director, ICASA

575-835-5231

email: [msmith@icasa.nmt.edu](mailto:msmith@icasa.nmt.edu)

ICASA agrees there is an immediate and pressing need for highly qualified Ph.D. level engineers in the area of cyber electronic systems and fully supports NMT's Electrical Engineering Department. The new program will expand the ongoing collaboration with your department and will allow for the pursuit of new funding opportunities. These opportunities typically require facilities capable of handling ITAR or classified research, for which ICASA is perfectly suited. Such a program will also provide much needed Ph.D. level education in which several of our employees are very much interested to further their careers.

Very Respectfully,

Michael Smith

Associate Director, ICASA







Office of the Vice President  
Research & Economic Development

December 21, 2016

To Whom It May Concern:

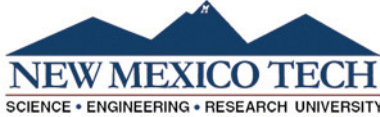
The Electrical Engineering Department at New Mexico Tech (NMT) is proposing a new Ph.D. program. This new program will focus on cyber electronic systems, and will serve to prepare students with the necessary education to advance the state-of-the-art in cyber electronic systems, which are the core of most every modern device. Students completing the program will become leaders in a much-needed concentration that is required to meet the challenges of today and tomorrow.

The reliance on position, navigation, and timing as well as embedded controls and cognitive radios have been increasing rapidly. Applications that depend on these technologies range from personal devices, health care, smart homes, structural monitoring, unmanned aerial vehicles, first responders and military. This reliance makes critical infrastructure vulnerable to malicious attacks as well as conditions imposed from challenging environments. To address this vulnerability two of NMT's research centers, the Energetic Materials Research and Testing Center (EMRTC) and the Institute for Complex Systems Analysis (iCASA), have joined forces to create the Kinetic Cyber Test Bed. This facility will provide both a virtual and real-world research environment to develop solutions to protect modern infrastructure. Customers of this facility will include, the Department of Defense, the Department of Energy, the National Security Agency, the Department of Homeland Security, as well as the private sector. Students in the Electrical Engineering program will have direct access to this one-of-a-kind facility. This will allow for students to work on real-world problems as part of their dissertation. Additionally the facility will benefit from the students that have not been influenced by traditional solutions that may not fully address future threats.

In conclusion, it is paramount that this program be initiated as soon as possible to not only meet the needs of our students but to address critical issues in both the public and private sector.

Regards,

Van Romero  
Chief Operating Officer  
Vice President of R&ED  
Professor of Physics



DEPARTMENT OF  
COMPUTER SCIENCE & ENGINEERING **Dongwan Shin, PhD**

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January 12, 2017

Aly El-Osery, Ph.D.  
Chair and Associate Professor  
Department of Electrical Engineering  
New Mexico Tech  
Socorro, NM 87801

*Chair and Associate Professor  
Cramer 230D  
801 Leroy Place  
Socorro, NM 87801  
Phone: (575) 835-6459  
E-mail: doshin@nmt.edu  
URL: <http://scl.cs.nmt.edu>*

Dear Dr. El-Osery

I am writing to express my strong support for your proposed PhD program in Electrical Engineering with Dissertation in Cyber Electronic Systems.

The proposed program aims at preparing students with necessary education to advance the state-of-the-art in cyber electronic systems, especially in the application areas of personal devices, health care, smart homes, structural health monitoring, transportation, and energy to unmanned aerial vehicles, first responders, and military. Considering the complexity, connectivity, and security of systems in these application areas, there is a strong need for a PhD level program in cyber electronic systems for both statewide and national interests. Hence, it is my firm belief that students completing the proposed program will be in high demand in academia, industries, and government agencies.

The Computer Science and Engineering department is very interested in advancing current research and education opportunities with your department on cyber electronic systems, particularly in the area of cybersecurity. Our department has been a national leader in educating cybersecurity professionals, since National Security Agency (NSA) and Department of Homeland Security (DHS) designated it as a national Center of Academic Excellence in Information Assurance Education (CAE/IAE) and Research (CAE-R) in 2002 and 2009, respectively; and its current and past research focuses, in support from national laboratories such as Sandia and Los Alamos Lab and from government agencies such as NSA, DoD, and NSF, have distinguished itself with high impact research in many areas of cybersecurity, including: access control, intrusion detection and prevention, malware and vulnerability analysis, software security, and digital forensics. With your proposed program's focus on electronic warfare, I strongly believe that the two departments will be able to develop a synergistic and collaborative opportunity to build a powerhouse for better educating cybersecurity professionals in the state of New Mexico as well as our nation.

I look forward to collaborating with you and your department for the proposed PhD program.

Sincerely,

Dongwan Shin, PhD



January 15, 2017

To Whom It May Concern:

I am writing to express my support for the proposed Ph.D. program in Electrical Engineering with Dissertation in Cyber Electronic Systems. Design and development of advanced products and systems often involve interdisciplinary interaction and collaborations between mechanical, electrical, and computer engineers. Examples include robotics, smart homes, unmanned vehicles, just to name a few. Functionality and effectiveness of such systems may be put to risk by compromising cyber electronic elements such as communication, navigation and controls. It is apparent that any modern mechanical, aeronautical, space and other systems include cyber electronic functionality. Mechanical engineers understand criticality of cyber electronics and consider its impact on systems development. This provides a collaborative opportunity between electrical and mechanical engineering disciplines. The proposed Ph.D. program addresses many important elements in system development (e.g. electronic warfare, timing, navigation, communications, embedded controls) and I enthusiastically support it.

I believe that availability of Ph.D. program in Electrical Engineering with Dissertation in Cyber Electronic Systems will increase number of professionals in an important emerging field. The academic preparation offered by the proposed Ph.D. program matches well with the needs of local employers such as a number of national laboratories and private companies. I view the establishment of this program as a significant contribution to New Mexico Tech interdisciplinary science and engineering efforts and I foresee its considerable collaborative potential with Mechanical Engineering programs.

Please do not hesitate to contact me if additional information is needed.

Respectfully,

Andrei Zagrai, PhD  
Associate Professor and Mechanical Engineering Department Chair  
Voice: 575-835-5636 Email: [andrei.zagrai@nmt.edu](mailto:andrei.zagrai@nmt.edu)