UNIVERSITY AFFAIRS COMMITTEE
NORTH CAROLINA STATE UNIVERSITY
September 12, 2019

BOARD OF TRUSTEES
NORTH CAROLINA STATE UNIVERSITY
AGENDA

University Affairs Committee
1:15 p.m. – 3:00 p.m.  September 12, 2019
Winslow Hall Conference Room

Stan Kelly, Chair
Members: Emma Carter, Jimmy Clark, Jim Harrell, Ven Poole, Ron Prestage

CALL TO ORDER
Stan Kelly, Chair

ROLL CALL
Stan Kelly, Chair

READING OF STATE GOVERNMENT ETHICS ACT CONFLICT OF INTEREST STATEMENT
Stan Kelly, Chair

1. RESPONSIBILITIES OF THE COMMITTEE

A. Review Committee Responsibilities as established in Bylaws
   Presenter: Warwick Arden, Executive Vice Chancellor and Provost
   7.1A

B. Review Draft Plan of Work for the 2019-2020 Year
   Presenters: Stan Kelly, Committee Chair
   Warwick Arden, Executive Vice Chancellor and Provost
   7.1B

2. CONSENT AGENDA

A. Approval of July 10, 2019 Minutes (open & closed session)
   7.2A

B. Requests to Continue Centers/Institutes
   a. Future Renewable Electric Energy Delivery and Management Systems Center (FREEDM)
   7.2B

C. Designation of Time Limited Option for Distinguished Professorships
   7.2C

3. REPORTS

A. Fall Enrollment Report
   Presenter: Louis Hunt, Senior Vice Provost, Enrollment Management & Services
   7.3A

B. Student Body President Report
   Presenter: Emma Carter, Student Body President
   7.3B

C. Faculty Senate Report
   Presenter: Hans Kellner, Chair of the Faculty
   7.3C

✓ Denotes full Board approval required
D. December 2019 Commencement Speaker (no materials)
   Presenter: Chancellor W. Randolph Woodson

E. Provost Update (no materials)
   Presenter: Warwick Arden, Executive Vice Chancellor and Provost
   a. 2019-2020 Academic Year Initiatives

4. CLOSED SESSION

5. RECONVENE OPEN SESSION

6. ADJOURN

Denotes full Board approval required
Board of Trustees - University Affairs Committee

Delegated Authority and Assignments
Based on Board of Trustees Bylaws - POL 01.05.01, Appendix 1, Section V

Academic Programs
Review and recommend academic degree proposals requiring BOG approval*
Receive notification of other academic program proposals (ex. certificates)

Student Affairs
Review and recommend campus initiated tuition increases and student fees

EHRA Personnel (Exempt from the State Human Resources Act)
Conferral of permanent tenure*
- New faculty hires tenured at a previous institution
- Faculty candidates reviewed through annual reappointment, promotion, and tenure process

Salary matters
- Establish salary ranges for SAAO employees that are not otherwise established by UNC-SO
- Recommend any salary increase for an EHRA employee, other than for Vice Chancellors, that requires approval by the Board of Governors

Non-salary compensation
- Approve non-salary compensation for all EHRA employees other than Vice Chancellors

Designation of particular Distinguished Professorships as time limited*

Conferral of Emeritus status to SAAO Tier I employees

Appoint or extend the contract of the Athletic Director and Head Coaches

Appointment of Deans
Review and recommend petitions relating to employees seeking political candidacy and/or public office holding

Administrative separation and retreat rights
- “Retreat rights” are those conditions of employment that would apply should the administrator leave his/her administrative position.
- Review and approve any administrative separation or retreat rights subject to BOT approval under UNC and NC State policies.

* These items go through comprehensive evaluation processes on campus prior to being brought to the board and are typically included on the committee’s consent agenda.
**Employee Appeals**

Hear appeals of discharged or suspended employees

Hear and render a decision on appeals from the disposition of grievances

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**Honorary Degrees, Awards and Distinctions**

**Honorary Degrees and Holladay Medals**
- Receive and review nominations
- Recommend nominees to Board of Trustees for approval

Provide advice in Chancellor’s selection of a commencement speaker

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**Planning**

Review and recommend changes in the university’s mission statement

Advise chancellor on development of plans to carry out the university’s mission

Review and approve establishment, continuation and discontinuation of Centers and Institutes*

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**Policy Development**

Recommend to Board policies related to:
- Personnel
- Collection of tuition, fees and other monies from students
- Administration of scholarships and other financial aid to students
- Provision of student services activities, including government and intercollegiate athletics
- Research, Centers and Institutes

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**Reports**

Hear reports from the Chair of Faculty, Chair of Staff Senate, and Student Body President

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<thead>
<tr>
<th>Chair, Faculty</th>
<th>Chair, Staff Senate</th>
<th>Student Body President</th>
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<tr>
<td>Hans Kellner</td>
<td>Janice Sitzes</td>
<td>Emma Carter</td>
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Other reports include:
- Enrollment
- Faculty retention
- Graduation statistics
- Intercollegiate athletics
- Residency for full scholarship undergraduate students
- Students requiring special consideration
- Strategic Plan

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* These items go through comprehensive evaluation processes on campus prior to being brought to the board and are typically included on the committee’s consent agenda.
NC STATE BOARD OF TRUSTEES
UNIVERSITY AFFAIRS COMMITTEE
2019-2020 PLAN OF WORK (DRAFT)

September

- Centers and Institutes Requests (UNC Pol. 400.5 (R) (NC State Pol. 01.05.01 App. 1, V.f.iii) (as needed)
  Review and approve the establishment, continuation and discontinuation of Centers and Institutes.
- Committee Responsibilities and Plan of Work (Annually)
  Review committee's delegated authority and assignments and develop plan of work for the year.
- Degree Program Proposals (NC State Pol. 01.05.01, App.1, V.c.i.) (as needed)
  Review and recommend approval to the BOT.
- Fall Enrollment Report / Progress Toward Enrollment Planning (NC State Pol. 01.05.01, App 1, V.f.ii)
  Receive report and comment as warranted.
- Honorary Degree Recommendations (UNC Pol. Ch. 100.1, Appendix 1 (IV) (NC State Pol 01.05.01, App.1, V.e.i)
  Receive and review nominations as needed. Recommend nominees for approval to the BOT.
- Personnel Requests (NC State Pol. 01.05.01, App 1.V.a.i.ii.iii.iv.v.vi.vii.viii.ix.b.i.ii)) (as needed)
  Approve or recommend approval to the BOG.
- Salary Ranges for Faculty (Annually) [If not shared at July meeting.]
  The Chancellor has delegated authority for faculty salary ranges. Upon the Chancellor’s approval, these ranges are
  shared with the committee.
- Student Body President Report (NC State Pol. 01.05.01 App.1, V.h.i.)
  Receive report and comment as warranted.

November

- Campus Initiated Tuition Increase and Student Fees (UNC Pol. 1000.11, II, 3.A. iii) (NC State Pol. 11.00.01 and 01.05.01,
  App. 1, V.d.i)  Review and recommend approval to the BOT.
- Centers and Institutes Requests (UNC Pol. 400.5 (R) (NC State Pol. 01.05.01 App. 1, V.f.iii) (as needed)
  Review and approve the establishment, continuation and discontinuation of Centers and Institutes.
- Commencement Speaker – December (NC State Pol. 01.05.01 App. 1, V.e.ii)
  Provide advice in Chancellor's selection of Commencement Speaker.
- Degree Program Proposals (NC State Pol. 01.05.01, App.1, V.c.i) (as needed)
  Review and recommend approval to the BOT.
- Faculty Retention Report
  Receive report and comment as warranted.
NC STATE BOARD OF TRUSTEES  
UNIVERSITY AFFAIRS COMMITTEE  
2019-2020 PLAN OF WORK (DRAFT)

- Faculty Senate Report (NC State Pol. 01.05.01 App.1, V.h.i.)  
  Receive report and comment as warranted.
- Honorary Degree Recommendations (UNC Pol. Ch. 100.1, Appendix 1 (IV) (NC State Pol. 01.05.01, App.1, V.e.i)  
  Receive and review nominations as needed. Recommend nominees for approval to the BOT.
- Personnel Requests (NC State Pol. 01.05.01, App.1.V.a.i.ii.iii.iv.v.vi.vii.viii.ix.b.i.ii) (as needed)  
  Approve or recommend approval to the BOG.
- Staff Senate Report (NC State Pol. 01.05.01 App.1, V.h.i.)  
  Receive report and comment as warranted.

February
- Centers and Institutes Overview (Informational report provided every 2 years.)  
  Receive report and comment as warranted.
- Centers and Institutes Requests (UNC Pol. 400.5 (R) (NC State Pol. 01.05.01 App. 1, V.f.iii)) (as needed)  
  Review and approve the establishment, continuation and discontinuation of Centers and Institutes.
- Degree Program Proposals (NC State Pol. 01.05.01, App.1, v.c.i) (as needed)  
  Review and recommend approval to the BOT.
- Graduation Report  
  Receive report and comment as warranted.
- Holladay Medal Recommendations (NC State Pol. 01.05.01, App.1, V.e.i) (Annually)  
  Receive and review nominations. Recommend nominees for approval to the BOT.
- Honorary Degree Recommendations (UNC Pol. Ch. 100.1, Appendix 1 (IV) (NC State Pol. 01.05.01, App.1, V.e.i)  
  Receive and review nominations as needed. Recommend nominees for approval to the BOT.
- Personnel Requests (NC State Pol. 01.05.01, App 1.V.a.i.ii.iii.iv.v.vi.vii.viii.ix.b.i.ii) (as needed)  
  Approve or recommend approval to the BOG.
- Reappointment, Promotion and Tenure Process  
  Receive report and comment as warranted.
- Student Body President Report (NC State Pol. 01.05.01 App.1, V.h.i.)  
  Receive report and comment as warranted.
- UNC Report on Intercollegiate Athletics (UNC Pol. 1100.1) (Annually)  
  Receive and review report prior to submission to UNC System Office.
April

- Annual Human Resources Compliance Report (UNC Pol. 600.3.4.)
  
  Review report prior to submission to UNC System Office.

- Centers and Institutes Requests (UNC Pol. 400.5 (R) (NC State Pol 01.05.01 App. 1, V.f.iii) (as needed)
  
  Review and approve the establishment, continuation and discontinuation of Centers and Institutes.

- Commencement Speaker – May (NC State Pol. 01.05.01 App. 1, v.e.ii)
  
  Provide advice in Chancellor’s selection of Commencement Speaker.

- Degree Program Proposals (NC State Pol. 01.05.01, APP1, v.c.i.i)(as needed)
  
  Review and recommend approval to the BOT.

- Distinguished Professorship Update
  
  Receive information about recently awarded professorships of distinction as applicable.

- Faculty Senate Report (NC State Pol. 01.05.01 App.1, V.h.i.)
  
  Review and comment as warranted.

- Honorary Degree Recommendations (UNC Pol. Ch. 100.1, Appendix 1 (IV) (NC State Pol 01.05.01, App.1, V.e.i)
  
  Receive and review nominations as needed. Recommend nominees for approval to the BOT.

- Nepotism Report (UNC Pol. 300.4.2) (Annually)
  
  Receive annual report on university’s compliance with UNC Policy 300.4.2.

- Personnel Requests (NC State Pol. 01.05.01, App 1.V.a.i.ii.iii.iv.v.vi.vii.viii.ix.b.i.ii) (as needed)
  
  Approval or recommend approval to the BOG.

- Residency for Full Scholarship Undergraduate Students (§ 116-143.6) (UNC Pol. 900.4 [G])(NC State Reg 02.70.03)
  
  Receive report and comment as warranted.

- Staff Senate Report (NC State Pol. 01.05.01 App.1, V.h.i.)
  
  Receive report and comment as warranted.

- Students Requiring Special Consideration (UNC Pol. 700.1.1.1[R] and UNC Pol. 1100.1)(NC State Reg 02.10.04)
  
  Receive report and comment as warranted.

Salary Ranges for Senior Academic and Administrative Officers (SAAO) (UNC Pol. 600.3.4) (NC State Pol. 01.05.01, App. 1, V.a.ii)

Review and approve recommended ranges.
Special Meetings (called as needed)
- There may be items that need the committee’s consideration in between the regularly scheduled meetings. In these cases, a special meeting of the committee will be held.

Additional Topics for Discussion
- Topics associated with implementation of the strategic plan/other topics of interest
- Updates from the Provost

Desired Outcomes
- To comply with delegated authority and assignments as prescribed by N.C. General Statutes, UNC Board of Governors Policies and NC State University Policies.
- To keep the Board fully informed of major issues and policies associated with the governance of the university.
- To solicit the Board’s input on policy, strategy and goal-setting for the university.
CONSENT
AGENDA
ITEMS
The University Affairs Committee of the Board of Trustees of North Carolina State University met July 10, 2019 in the Winslow Hall Conference Room.

Members Present:   Tom Cabaniss, Acting Committee Chair  
                  Emma Carter  
                  Jimmy Clark, Board Chair  
                  Ron Prestage  

Mr. Tom Cabaniss chaired the meeting in Mrs. Ann Goodnight’s absence. Mr. Cabaniss called the meeting to order at 3:51 p.m. He called roll and noted that with the addition of Chairman Clark, a quorum was present.

All members of the Committee were reminded of their duty to avoid conflicts of interest and appearances of conflicts of interest under the State Government Ethics Act. It was inquired as to whether there were any known conflicts of interest or appearances of conflict with respect to any matters coming before the Committee at this meeting. There being none, the meeting continued.

Consent Agenda
A motion was made by Mr. Clark to approve the consent agenda which included approval of the June 10, 2019 open and closed session meeting minutes; four academic program requests (Change in Delivery Mode for the Master of Management, Change in Degree Program Title to the Bachelor of Science in Crop and Soil Science, and Discontinuation of two degree programs - the Bachelor of Science in Soil and Land Development and the Bachelor of Science in Extension Education); designation of a time limited option for a distinguished professorship; and conferral of tenure to three new faculty members joining the university in the fall. Dr. Prestage seconded the motion. The motion carried.

Requested Action
Ms. Sheri Schwab, Interim Vice Provost for Institutional Equity and Diversity, presented revisions to Policy 04.25.05 – Equal Opportunity, Non-Discrimination and Affirmative Action. She explained the most substantive revisions occur in section 4 of the policy and include the definition of sexual harassment. The other revisions are to provide overall clarity throughout the policy. A motion was made by Dr. Prestage and seconded by Mr. Clark to recommend the policy revisions to the full board for approval. The motion carried.

Vice Chancellor and General Counsel Allison Newhart reviewed revisions to Policy 04.20.02 – Alcohol Policy. She noted that the revisions reflect changes to State law authorizing the sale of alcoholic beverages in athletic facilities and at certain special events. The policy changes would allow sales in athletic facilities, but there would be further internal discussion to decide the specific facilities in which the alcohol would be sold. Mr. Clark moved to recommend the policy revisions to the full board for approval. Dr. Prestage seconded the motion. The motion carried.

Informational Report
Provost Arden provided an update on six new certificate programs and discussed the 2019-2020 faculty salary ranges that have been approved by the Chancellor.

Closed Session
At 4:02 p.m. a motion was made by Chair Cabaniss, and seconded by Dr. Prestage, to go into closed session to prevent the premature disclosure of an honorary degree or award; to establish the amount of compensation and other materials terms of an employment contract or proposed employment contract; and to consider the qualifications, competence, performance, character, fitness, conditions of appointment or conditions of initial employment of an employee or prospective employee. The motion carried.
Reconvene in Open Session
After coming out of closed session, Chair Cabaniss announced the meeting in open session.

Dr. Prestage moved to approve the personnel item discussed in Closed Session related to the appointment and initial salary of a Dean. Mr. Clark seconded the motion. The motion carried.

With no further business, Chair Cabaniss announced the meeting adjourned at 4:09 p.m.

__________________________
Tom Cabaniss, Acting Committee Chair
MEMORANDUM

TO: W. Randolph Woodson
Chancellor
NC State University

FROM: Mladen A. Vouk
Vice Chancellor for Research and Innovation
NC State University

SUBJECT: Recommendation to continue Future Renewable Electric Energy Delivery and Management Systems Center (FREEDM) under Regulation 10.10.04

DATE: July 29, 2019

The Future Renewable Electric Energy Delivery and Management Systems Center (FREEDM) began its tenure as a National Science Foundation (NSF)-funded Engineering Research Center (ERC) in September 2008, and was established simultaneously as a UNC System-sanctioned membership Center by the NC State Board of Trustees. Over the 10-year funding lifespan of NSF’s ERC program, FREEDM research and education programs received more than $36 million in federal support to pioneer technologies that will help create the modern electric power grid. FREEDM will “graduate” from the NSF’s ERC program in August 2019 and plans to continue its important work for NC and the nation with support from its industrial partners as well as follow-on funding from extramural grants and contracts.

FREEDM provides reports of its activities annually to the NSF and NC State, and participates in formal five-year periodic reviews conducted by NSF. NC State takes advantage of these annual and periodic federal reviews to satisfy University oversight requirements specified in Reg. 10.10.04. The most recent periodic review delivered by NSF spanned ten years of Center accomplishments, as well as prospects for the future. The consensus review provided by NSF concludes that the Center has (i) largely achieved its initial vision, (ii) developed a strong brand and leadership in the field, (iii) deployed three testbeds that will serve well into the future, and (iv) nurtured productive relationships with key industrial partners. The NSF reviewers also concluded that much work remains to be accomplished to provide confidence that the Center will operate sustainably into the future.

Given the effectiveness of ongoing operations within the Center and plans that will enable the Center to achieve its research goals in a sustainable manner, the NC State College of Engineering requests continuance of FREEDM as a University Center as sanctioned by the Board of Trustees. The Office of Research and Innovation and the Provost endorse the request by the College to continue FREEDM, and I request your approval of this recommendation.

MAV/mh

cc: Louis Martin-Vega, Dean, College of Engineering
John Gilligan, Executive Associate Dean
Iqbal Hussein, Executive Director, FREEDM
Jonathan Horowitz, Associate Vice Chancellor for Research
Larisa Slark, Centers and Institutes Specialist
MEMORANDUM

TO: Mladen Vouk  
Vice Chancellor for Research and Innovation

FROM: W. Randolph Woodson  
Chancellor

SUBJECT: Recommendation to continue the Future Renewable Electric Energy Delivery and Management Systems Center (FREEDM) under Regulation 10.10.04

DATE: July 30, 2019

In response to your Memorandum dated, July 29, 2019, authorization is hereby granted to forward the request to continue the Future Renewable Electric Energy Delivery and Management Systems Center (FREEDM) to the Board of Trustees for approval.

WRW/mh

cc: Louis Martin-Vega, Dean, College of Engineering  
John Gilligan, Executive Associate Dean  
Iqbal Hussein, Executive Director, FREEDM  
Jonathan Horowitz, Associate Vice Chancellor for Research  
Larisa Slark, Centers and Institutes Specialist
July 22, 2019

Dr. Jonathan Horowitz  
Associate Vice Chancellor for  
Research Infrastructure and Development  
Office of Research and Innovation  
Poulton Innovation Center 212  
Campus Box 7018  
Raleigh, NC 27695-7018

Dear Jon:

The College of Engineering (CoE) has reviewed the progress and performance of The Future Renewable Electric Energy Delivery and Management Systems Center (FREEDM), sponsored by the National Science Foundation (NSF). The review is based on the extensive Tenth Year Reverse Site Visit and Review (attached). A self-study report covering the 10th year accomplishments and journey into the future was submitted by the FREEDM center. A Reverse Site Visit Team (RSVT) spent two days at NSF on October 25-26, 2018, with presentations by RSVT and the RSVT answering questions, both orally and in written form.

A summary report (attached) was generated by the RSVT based on the site review and self-study. The FREEDM Center [RSVT] responded to comments and questions. We agree with the report that, FREEDM has performed admirably in its mission as a research center. Budget and sources of funding are adequate and a sustainability plan is in place. Moreover, faculty and student interactions among colleges are strong and service provided to NC industry and government is highly valued. We agree with many of the suggestions to help strengthen FREEDM and to diversify the funding base.

At this time, we recommend that FREEDM be continued as a Board of Governors Center in the UNC System. The CoE feels that the goals and important services of the Center cannot be provided by any other organization in the College or UNC system. FREEDM is an essential part of the national research program to implement renewable energy in the US. In addition, FREEDM provides the fundamental research platform for the Power America Manufacturing Institute at NCSU.

Sincerely,

Louis Martin-Vega, Ph.D., P.E.  
Professor and Dean

Attachments [2]

cc: Mladen Vouk, Vice-Chancellor for Research  
Larisa Slark, Centers and Institutes Specialist, Office of Research and Innovation  
John Gilligan, Executive Associate Dean, College of Engineering  
Iqbal Hussein, Executive Director of FREEDM  
Dan Stancill, Department Head, Electrical Computer Engineering

An Equal Opportunity/Affirmative Action Employer
**FREEDM 10th Year ERC Reverse Site Visit Agenda**  
**Location: NSF**

**DAY 1:** October 25, 2018 —Room E3430

8:00 AM  Reverse Site Visit Team Briefing  C. Londoño/E. Misawa

9:00 AM  Break (15 min)

9:15 AM  Welcome and Introductions  C. Londoño/E. Misawa

9:30 AM  FREEDM – An ERC Success Story  Iqbal Husain

10:10 AM  Accomplishments & Future Plans

   1. HIL Testbed and FID and FSU partnership – Bruce McMillin (15 min)
   2. GEH TestBed - David Lubkeman (15 min)
   3. LSSS Testbed and ASU Partnership – Raja Ayyanar (15 min)
   4. DGI, Cybersecurity and MS&T partnership - Bruce McMillin (15 min)

11:10 AM  Break (15 min)

11:25 AM  Accomplishments and Future Plans (continued)

   1. Advanced Storage and FAMU partnership - Jim Zheng (15 min)
   2. DESD, SST and Future Plans - Srdjan Lukic (20 min)

12:00 PM  Lunch

1:15 PM  Workforce Development

   1. College Education – Pam Carpenter (10 min)
   2. Undergraduate, Pre-college and k-12 Programs – Pam Carpenter (30 min)

1:55 PM  Students Perspective – Thomas Dotson (10 min)

2:05 PM  Culture of Inclusion – Roy Charles (10 min)

2:15 PM  Innovation Ecosystem – Ken Dulaney (30 min)

2:45 PM  C2C Collaboration Update – Joe DeCarolis (20 min)

3:05 PM  Break (15 min)

3:20 PM  Sustainability and Future Plans for the Center – Srdjan Lukic or Iqbal Husain (30 min)

3:50 PM  Reverse SVT Private Discussion

4:30 PM  Questions and Answers

5:30 PM  Adjourn FREEDM Team

5:45-6:30  SVT Discussion and Prepare for Next Day

**DAY 2:** October 26, 2018 —Room E3430

9:00 AM  Summary Report Writing Session - Reverse SVT

4:00 PM  Adjourn  Reverse SVT
SITE VISIT REPORT TEMPLATE & ERC REVIEW CRITERIA
PANEL ID: V190341

National Science Foundation
Division of Engineering Education and Centers

Future Renewable Electric Energy Delivery and Management
(FREEDM) Systems Center (FREEDM) - Response

North Carolina State University, Arizona State University
Florida State University, Florida A&M University
Missouri University of Science and Technology

October 25-26, 2018

Summative Merit Review Criteria and Site Visit Report Outline
Performance Years One through Ten
(September 1, 2008 to August 31, 2018)

The FREEDM Systems Center Leadership is pleased to have the opportunity to respond to feedback provided by the NSF Reverse Site Visit Team and is also thankful for the encouraging comments on our successes. The Center Leadership views the opportunity to present feedback to Industry as a means to continue the innovations and research and education methodologies as the center moves beyond NSF support. The feedback also establishes the value proposition to the University Administration for continuation of institutional commitments for sustaining the Center in the years beyond NSF support.

The FREEDM Systems Center is thankful to the National Science Foundation and the Management of the Directorate of Engineering for granting the funds for the FREEDM Center to the College of Engineering at the NC State University and its partner institutions. We acknowledge the commitment and support of Lynn Preston and the Program Directors from the NSF, Barbara Kenny, Eduardo Misawa, and Carmiña Londoño during the 10 years and the many site visit reviewers whose critiques, valuable comments, and feedback continued to improve the performance and output of the FREEDM Center.

Responses to Weaknesses, Opportunities and select individual program feedback are presented in red preceded by "Response: " in the following document.
Site Visit Team Members

**Eyard Abed**  
Professor  
University of Maryland  

**Aniruddha Gole**  
Distinguished Professor  
University of Manitoba Engineering  
15 Gillson St, Winnipeg, MB  
Canada, R3T 5V6  

**Timothy Johnson**  
Systems Engineer  
GE Global Research, Retired  

**Rajesh Kavasseri**  
Associate Professor and Graduate Coordinator  
North Dakota State University  
Electrical Engineering 101H  
Dept. 2480, PO Box 6050  
Fargo, ND 58108-6050North  

**Barbara Kenny**  
Former NSF Program Director  

National Science Foundation Staff  

**Jennifer Beierlein**  
AAAS Science and Technology Policy Fellow, EEC/ENG  
National Science Foundation  
2415 Eisenhower Avenue  
Alexandria, VA 22314  

**Carmiña Londoño**  
National Science Foundation  
Division of Electrical, Communications & Cyber Systems  
2415 Eisenhower Ave  
Alexandria, VA 22314  

**Eduardo Misawa**  
National Science Foundation  
Division of Engineering Education and Centers  
2415 Eisenhower Ave  
Alexandria, VA 22314
A. Executive Summary

Intellectual Merit:

The FREEDM Center had a transformative approach to creating the next generation of electric power distribution systems, with a structure very different from present-day systems that tend to include bulky and inefficient transformers which are severely affected by network faults and voltage distortions. The FREEDM vision proposed new energy cells based on power electronic components and improved energy storage systems to enable power delivery with higher efficiency and power quality. Using advanced distributed automated control concepts, this was expected to lead to a resilient grid with high efficiency and high-power quality, that could enable easier harnessing of distributed renewable energy resources such as wind and solar energy. To achieve this goal, the Center needed to overcome major barriers. The required precision power handling components, and semiconductor devices with sufficient voltage and power ratings and low losses did not exist at the time FREEDM started. The FREEDM Center’s vision was to overcome these critical barriers.

The central enabling technology for the FREEDM system was energy cells that would be interfaced using the solid state transformer (SST), which is a power electronics based energy transformation device that can precisely control the power flow as well as provide regulation of voltage and power factor. Another key component was a solid-state fault isolation device (FID) that would quickly isolate a faulted section of the network in a matter of milliseconds.

To achieve its vision, the Center has followed the approach required by NSF involving the ERC 3-Plane Strategic Planning Chart. At the fundamental research plane, FREEDM researchers focused on new Post-Silicon Devices (PSD) that have low losses and can withstand high voltages. It also planned to develop new advanced control, stability analysis, and modelling methods. These fundamental science thrusts were to contribute to the enabling technology plane components, i.e., the SST and FID. Another key enabling technology is the “distributed grid intelligence” (DGI) which would reside within every FREEDM component and enable ‘plug-and-play’ functionality with the other components. The components constructed in the enabling technologies plane would then migrate to the top-most plane, which was to consist of three testbeds. The Hardware in the Loop (HIL) testbed uses a real time simulator which is interfaced to control and power hardware. This is used to test, refine, and validate the FREEDM control algorithms as well as the FREEDM power-electronic hardware. Stability and control of larger systems is investigated using the Large Scale System Simulation (LSSS) testbed. Finally, a fully functional but limited size FREEDM grid is implemented on the Green Energy Hub (GEH).

Response: We thank the NSF and Reverse-SVT for recognizing FREEDM efforts in involving the ERC 3-Plane Strategic Planning Chart in its approach to achieve the vision. The testbeds in FREEDM drove the vision and mission of the Center. The testbeds are essentially the platform for the development of the enabling technologies which lead to systems development. Viewing in reverse, the interplay of activities in the fundamental research plane contributed to the enabling technology plane and the components constructed in that plane that migrated to the testbed plane. The research agenda of FREEDM came to completion with the help of the testbeds, and in parallel, the Center-conceived innovations move towards maturity. The testbeds also play an important role in attracting relevant industries to become members of the Center and provide appropriate mechanisms to train and educate undergraduate and graduate students. Testbeds further enhance the capabilities
of the postdocs and other faculty members. Additionally, the development of the testbeds significantly facilitated the transfer of technology from the Center to the Industries.

Overall, the Center has largely achieved its vision. The testbeds clearly demonstrated the viability of its essential vision. Particularly impressive is the HIL testbed on which many of the real-time FREEDM controls as well as FREEDM power-electronic hardware were validated. The LSSS testbed allows modelling of large networks and shows the scalability of the FREEDM concept. The GEH combines multiple SST interfaced energy cells to create a small but real FREEDM microgrid. The GEH and the HIL testbeds are now being recommended as test facilities for testing microgrid innovations from parties outside the ERC. This is in part due to the Center’s involvement in IEEE and other Standards and Guides (such as P2004 - Recommended Practice for HIL).

There was considerable cross-thrust integration with close collaboration. This contributed significantly to the implementation of the Center’s vision. Discussions between the enabling technology thrusts and the fundamental thrust dictated how the enabling technology components, i.e., the SST and DGI were implemented. The enabling technologies fed back the properties of their developed components to the fundamental science thrusts to define performance requirements for the PSD elements and the controls. The successful development of the SST and DGI eventually led to the success of the three testbeds. The Generation-3 SST was successful in exceeding the targeted 97% efficiency figure in the original vision.

Nevertheless, certain original objectives remained unfulfilled. The PSD initiatives have yielded a wealth of information on the characterization of SiC and GaN devices. One particular achievement was the development of a 10kV SiC MPS diode which uses a novel geometry that results in lower switching and conduction losses. However, fabrication challenges remain a barrier to constructing and testing larger devices. Consequently, one of the original objectives of the Center—that of using such higher rating devices in the enabling technology layer are yet to be fulfilled. Nevertheless, a workaround was found where commercial post-silicon device samples were acquired and used for the Generation-3 SST. Likewise, as of year 10, the Center has not been able to create an FID with the required current rating.

**Response:** We appreciate the SVT comment on the PSD initiatives. We acknowledge the appropriate comments regarding the achievements and the issue of moving the PSD outcome from the fundamental plane to the next level.

After a late start, the ERC was able to implement a new approach to distributed grid intelligence (DGI). The DGI was capable of hosting advanced control algorithms developed in the system theory and control sub-thrust and was also able to detect physical grid faults as well as cyber attacks in an integrated framework. Resiliency is achieved by automatic reconfiguration following a fault or attack. Using the DGI, key functionalities such as energy management and volt-var control can be readily implemented.

**Response:** The FREEDM team would like to clarify that the DGI/RSC efforts didn’t have a late start and that the type of DGI/RSC efforts can be broadly categorized into two phases. The DGI infrastructure development started in year one and was completed by year six of the Center. The DGI/RSC efforts concentrated on applications development and implementation within the DGI infrastructure in the last four years of the Center.
A true measure of the success of the ERC's vision would be how well it is accepted by the wider power community, known to be highly conservative. The ERC is now recognized internationally as the center of expertise in its field. Its collaboration with other research centers such as CREDEANCE, and collaboration with institutions in Ireland and Spain go a long way in supporting this view. The ERC spawned 10 startup companies. One, Gridbridge that built distribution SSTs was recently acquired by ERMCO, a major transformer manufacturer. This is a potentially major first step in the wider dissemination of the FREEDM concept. Twenty companies are members of the Center, with Duke Energy, NYPA, ABB, TOTAL and Gilbarco Veeder-Root being full members. Duke Energy in particular is working closely with the Center in testing FREEDM components in their network.

**Response:** The FREEDM Center appreciates the acknowledgement by the NSF that the Center is recognized internationally as the Center of excellence in its field. In addition to the 10 startup companies already reported, there is potential for additional startups under FREEDM with the intellectual property filed and awarded in the later years of the program. Some of the member companies such as Duke Energy, ABB, NYPA, and Gilbarco Veeder-Root continue to show significant and committed partnership with the FREEDM Center. In addition, the FREEDM IAB has expressed interest in seeing more startups in the future and the Center will continue to work towards that goal.

The education efforts of the Center have also matured with comprehensive undergraduate and graduate student research participation as well as the mentoring of K-12 students through various outreach initiatives. Specialized MS courses and streams based on the Center’s research activities have been established at all partner institutions. These efforts have led to the production of a record number of Ph.D. and MS students. These students have been welcomed as a necessary asset by industry. Several new courses have been implemented at all member universities. Eight new courses were introduced at all partner universities. Three partner schools, NCSU, ASU and MST are being recognized among the leading institutions offering comprehensive power programs.

The FREEDM research team consists of world-class researchers with the right mix to deliver on the objectives. The team evolved, responding effectively to changing requirements that emerged over the lifetime of the Center. Although it largely consists of electrical engineers, their skill sets are very diverse ranging across semiconductor physics, controls, and power system analysis. In addition, computer scientists are involved in the DGI thrust. Later, appropriate faculty members were added to bring in additional expertise. An example of this was the creation of a sustainable energy technology and policy cluster at NCSU that includes energy economists, policy analysts, and life cycle analysts. A key factor in the success of the Center is the Center’s present Director, Dr. Iqbal Husain. He had a clear vision and took difficult decisions when needed. Similarly, the Industry Advisory Board was properly constituted and contributed to the success of the Center. The Center took diversity seriously and tried hard to create a diverse academic and research community. One commendable factor was the hiring of Diversity Director Dr. Roy Charles, who strived to create a culture of inclusion.

The resources available to the Center in terms of research funding, laboratory facilities, and student support have been extensive and have enabled it to carry out its vision. One shortcoming has been the NCSU's PSD fabrication facility which was unable to deliver the post-silicon devices required for implementation on the testbeds. Also, the resources required for education and outreach evaluation and assessment were limited.
During its tenure as an NSF ERC, the Center’s funding has come from the NSF as well as from industry memberships and associated government and industry projects. However, for continued existence beyond graduation, it will be necessary to seek alternate funding avenues. The Center will need to remain vigilant in its efforts to maintain its leadership in Smart Grid technology and reinvent itself over time as appropriate. The Center needs to establish mechanisms and incentives for all member universities to remain engaged in the Center and continue pursuing significant team efforts in the future. Collaboration between the Center and PowerAmerica at NCSU could be a valuable asset to improve the facilities available to the PSD effort and to help in future commercialization of its research.

**Broader Impacts:**
Emissions from burning fossil fuels for the generation of electric power are contributing to global climate change. Alternate forms of energy, e.g., renewable sources such as wind and solar, have been proposed and are being deployed, but are intermittent and not immediately dispatchable. This requires careful consideration when integrating these sources into legacy power grids. The FREEDM ERC has offered a vision of a controllable power distribution grid that can integrate and coordinate the various renewables and newer loads such as electric vehicles. The vision has a significant societal benefit by offering a methodology and various technologies that will enable a distribution system of the future that can integrate the necessary renewables and accommodate the increasing number of electric vehicles. In addition to notable technological innovations, described elsewhere in this report, the Center has made a lasting and significant impact on the development of a workforce with the skill set necessary to address challenges associated with the development and deployment of renewable energy resources. Since inception of the Center, the partner universities have developed several new courses and degree/certificate programs, both at the undergraduate and graduate levels. In particular, through research efforts and development of three state-of-the-art testbeds, the education of ERC students has included access to unique testing facilities along with exposure to the current best ideas in the integration of renewable energy resources into a distribution grid. This educational experience makes the ERC students ideal candidates to enter the industry workforce and begin to contribute in substantial ways. Industry members often cite the high talent the Center graduates acquire as one of the reasons for joining the Center, and approximately 30% of Center graduates are hired by Center members.

The Center has also worked to increase the diversity of the participants in the energy sector through attention to creating a "culture of inclusion" environment while also recruiting for new participants from various targeted efforts such as visits and virtual presentations to minority serving institutions as well as exhibiting at STEM conferences (i.e. American Indian Science and Engineering Society (AISES), National Society of Black Engineers (NSBE), Society of Hispanic Professional Engineers (SHPE), Society of Women Engineers (SWE)) The Center has noted the relative lack of women in the electrical engineering discipline overall as a challenge to increasing numbers in a specific sub-field of electrical engineering graduate education, but some successes have also been noted. In particular, one woman originally on the leadership team is now Vice Provost for Research at MST. In another case, a female faculty participant in the Center has gone on to establish her own Engineering Research Center and became its Center Director. In addition, the Center has consistently offered research experiences for undergraduates (REU) programs at all of the institutions of the Center, with special attention to the recruitment of women and under-represented minorities to these programs. For
example, in Year 10, 29% of REU participants were women, 14% were African-American, and 21% were Hispanic.

The Center also offered an Undergraduate Research Scholars program that provides undergraduates an opportunity to be in a research environment during a year-long academic program where they experience research, learn technical and professional development skills, and have opportunities to network with industry. Over 100 undergraduates have had this experience through the FREEDM ERC.

The Center’s work has also had an impact on industry. There are twenty members, and three key industry players, ABB, Duke Energy and NY Power Authority, have been Full Members (the highest level of involvement) for several years. Duke Energy in particular is working closely with the Center in testing FREEDM components in their network.

The Center has also had significant success with technology transfer. Innovations related to the signature technology area, the solid state transformer (SST), were licensed early on in the Center’s history by a start-up company, GridBridge, which worked closely with the Center and hired some of its graduates. GridBridge went on to develop a low voltage version of the SST which found a market in rural electrical distribution systems. This company was acquired in 2017 by ERMCO (Electric Research and Manufacturing Cooperative), a wholly owned subsidiary of Arkansas Electric Cooperatives based in Tennessee. This rapid timeline of start-up to acquisition is particularly commendable given the conservative nature of the power industry in adopting new technology.

SWOT Analysis

STRENGTHS

1. The Center has established strong intellectual leadership and strong branding in the Center’s core technology areas.

2. The Center researchers were early innovators in Solid State Transformers (SST) and have now demonstrated the generation 3 version with an efficiency exceeding 97% which meets the goals of the original proposal.

3. The three testbeds are a strength for both research and education programs.

4. Students are well organized and are proactive in professional development and outreach activities which enrich the Center.

5. The leadership team has been responsive and flexible in addressing site visit team recommendations over the course of the Center.
6. The Center has secured significant institutional support including funding from NCSU for facilities (two years support with possibility of extension) and administration, including education and diversity directors.

7. The Center makes use of its extensive simulation capabilities to derive and refine component requirements and investigate overall system interactions. The hardware in the loop (HIL) simulation capability also enables device design validation.

8. The Center has cultivated significant relationships with industry resulting in a core group of committed partners including Duke Energy, NYPA, and ABB.

9. The Center has spawned several startups included GridBridge, which has been acquired.

10. The Center to Center (C2C) collaboration shows significant interest and buy in from international community and offers FREEDM an opportunity to focus on an extensive real-world system.

11. Center has embraced the concept of Culture of Inclusion, which moves them beyond simple diversity counts.

WEAKNESSES

1. There are limited resources for education and outreach evaluation and assessment.

**Response:** The FREEDM education program resources have been maintained through year 10 and beyond with funds from NSF and other sources. As we entered the ramp-down phase, additional funds from other programs such as PowerAmerica and Duke Energy Foundation were leveraged to maintain the education program with consistent large number of activities. We acknowledge that the perception of the Reverse-SVT is due to our own lack of adequate reporting on evaluation and assessment in the year 10 annual report. We have attempted to rectify the situation by augmenting the report with additional information in the Education Section of this document.

2. Controls methodology developments are not as comprehensive as needed for the envisioned system.

**Response:** The systems controls methodology has evolved over the past four years and we are gradually integrating the four different levels of controls into the FREEDM system, viz., PWM controls, primary controls, secondary controls, and tertiary controls. The center had a late start with the development of primary level control algorithms which caused a delay for implementing a comprehensive systems controls. However, we quickly overcame the challenges, developing several primary level controllers from fundamental principles for the FREEDM system. The SMC thrust developed controllers for energy management (secondary and tertiary level controls) and power management (primary level controls) have been validated in the LSSS, HIL, and GEH testbeds. Several of the primary controls have been integrated into the systems demonstration projects, and more are being integrated for a comprehensive and diverse set of controllers. The work on controls
methodology continues in FREEDM with new generation of PhD students and post-doc scholars who are returning to FREEDM during the summer to continue with the work.

3. The Fault Isolation Device (FID) is not sufficiently mature to meet current market requirements.

**Response:** FREEDM focused on developing the FID with the hybrid technology of an ETO-based solid state component and a piezoelectric actuator-based fast mechanical switch component. While the fast mechanical switch achieved its targets, the ETO device and solid state component didn’t reach expected levels which remained an obstacle for the FID to meet market requirements. FREEDM continues its efforts to further develop the FID with alternative technologies and other sources of funding at both NC State and Florida State University.

4. There is no clear strategic plan for staying together as the FREEDM Center.

**Response:** The center PIs continue to work together to secure research funding to advance the FREEDM vision in an organic way although not through a planned approach. These teams are formed based on the topic of funding, the expertise required, and the relationships established through the FREEDM Center. Several proposals to NSF and DOE from teams within the FREEDM Center have been funded and many more are currently under review. Various challenges prevented the partner institutions from committing resources to the FREEDM Center that would help develop a strategic plan for staying together for research activities. The infrastructure developed through the ERC program will attract researchers to use one another’s facilities as unique capabilities were established over the past 10 years. On the education side, course curriculum agreements have been executed which will help course-sharing among the partner institutions.

5. The Center has not integrated their developed post Silicon devices into the enabling technology devices.

**Response:** It is correct that the devices developed in the PSD sub-thrust are not used due to the low TRL level. However, the device development work has significantly contributed towards improved device design and design methodology by the device manufacturers who can make reliable and robust devices for use in enabling technologies. Nevertheless, the present evolutions of SSTs and FIDs are all using Wide Bandgap (WBG) power devices. It was the analysis of SiC power devices in Year one in the PSD thrust that resulted in procurement of 10 kV SiC power MOSFETs from CREE (now Wolfspeed) that were successfully used to make Gen-II and Gen-III SSTs. The selection of MOSFET vs. other devices was an outcome of Year one and Year two study. The Center is continuing to utilize SiC devices from Wolfspeed for the Gen.-IV SST development

**OPPORTUNITIES**

1. The Center should seriously consider identifying and developing services (e.g., studies, testbed use, access to staff and students) and other tangible benefits that would be of value to industry, which would attract new members and funding.

**Response:** We thank the Reverse-SVT for identifying the opportunity. We have been using the Center testbeds for executing testing services agreement with our industry partners and, in fact, some of our
partners have utilized the benefit. We have also used our testbed facilities for demonstrations in short courses presently being offered. We will continue to explore other tangible benefits that would be of value to the industry.

2. The Center needs to establish mechanisms and incentives for all member universities to remain engaged in the Center and continue pursuing significant team efforts in the future.

**Response:** We appreciate the opportunity identified by the Reverse-SVT. We will continue to explore potential mechanisms and incentives for all member universities to remain engaged in the Center. In one of our attempts to establish a mechanism, we are planning an annual conference in March 2019 with engagement and participation of partner Universities. We are also exploring with our Industry Members on mechanisms of how we can engage partner University PIs to remain engaged in Industry seed funded projects.

3. The Center needs to remain vigilant in its efforts to remain a leader in Smart Grid technology and reinvent itself over time as appropriate.

**Threats**

None identified
B. Summary Analysis of Performance in the ERC’s Key Features over Ten Years and the Strength of its Future Plans for Self Sufficiency

(1) Vision and Impact

The FREEDM Engineering Research Center’s vision is based on the concept of an “Energy Internet” - wherein generation, distribution, control, and end-use of electric power and energy can be achieved seamlessly. The vision is transformative in that it moves away from centralized and monolithic systems towards one that is highly distributed, yet secure, carbon-minimal, reliable, and resilient.

The Center’s efforts towards this vision, as guided by the three planes: fundamental science, technology, and demonstration are as follows. In the fundamental science plane, the emphasis is on high performance post-silicon (Silicon Carbide (SiC) and Gallium Nitride (GaN)) switching devices with appropriate system modeling and controls. In the technology plane, the Center has developed and refined a set of enabling technologies which include: the Solid State Transformer (SST), a Fault Isolation Device (FID), Distributed Energy Storage Devices (DESD), and a platform called Distributed Grid Intelligence (DGI). In the demonstration plane, the Center has developed three testbeds: Large Scale System Simulation (LSSS), Hardware-in-the-Loop (HIL), and the Green Energy Hub (GEH).

Over a decade, the Center’s strengths emerge through several noteworthy accomplishments which support its vision. The SST has progressed from a Gen-I, Silicon (Si)-based 6.5 kV Insulated-Gate Bipolar Transistor (IGBT) to a Gen-II, Silicon Carbide (SiC) based (15kV metal-oxide-semiconductor field-effect transistor (MOSFET)), to a Gen-III (SiC and Gallium Nitride (GaN)) based device boasting efficiencies over 97% as originally envisioned in the ERC proposal. The Center’s leadership in SST technologies has helped it achieve brand recognition in the broader power engineering community. The three testbeds are now sufficiently mature and have over the years, helped the Center validate and demonstrate several key functionalities and use cases. The 1 MW Green Energy Hub (GEH) testbed in fact, provides a credible architecture and a platform to demonstrate how FREEDM technologies can transition from laboratory-scale concepts to actual field deployments. The testbeds also serve as a natural focal point for industry collaboration and engagement. These achievements demonstrate that the Center has a clear understanding of key technology areas. The Center’s research has led to well over 800 distinct high-quality publications, while its education and workforce development efforts have conferred around 220 doctoral degrees, 183 Masters’ degrees, and 30 undergraduate degrees while creating 25 new courses and 10 new full-degree programs. Graduates from the Center are well-placed, mostly in industry, and a few in academia. The Center’s impact is also being felt through its involvement in workshops, short courses, and synergistic international collaborations, especially with Ireland. On the technology transfer front, the Center has had good impact, filing over 100 invention disclosures resulting in 27 patent awards, 9 licenses, and 11 spin-off companies with 1 company (GridBridge) that was acquired.

The Center’s weaknesses emerge in a few areas within the three planes and its efforts towards cohesively sustaining its activities. Post-silicon device research, though exceptional, has still remained on the fundamental science-plane and has not fully matured its way into FREEDM’s enabling technology plane. The thrust on systems modeling and control (though appropriate to support part of the vision) is not as comprehensive to support the overall vision. The FID, though an important component, has not matured enough to meet current market requirements. 
In summary, the Center's accomplishments over a decade are commendable and overall, its technical leadership and contributions have helped bring the vision of an internet-like energy delivery system, which is necessary for society to have the full benefit of renewable energy resources, closer to fruition.

(2) Strategic Plan

The FREEDM Systems Center has developed several generations of devices and software over its 10 years of existence as an NSF Engineering Research Center. The Center's research has followed the ERC's 3-Plane Strategic Planning Chart, and the Center has maintained leadership in fundamental science and technology for future smart distribution grid components and architectures. During Year 10, the Center's progress continued in the fundamental science, enabling technology, and system demonstration planes, guided by the Center's core research vision. All FREEDM system components have been developed to useful degrees of functionality, with continued developments in progress in order to meet further functionality requirements in the next generation of component designs.

The SST technology is now in its fourth generation of development and remains at the core of the envisioned FREEDM system architecture. The completed third generation SST achieved a 97.5% efficiency level, thus meeting an original goal of the Center. For the fourth generation SST, the aim is to maintain this efficiency level while also achieving several functionalities that are not in the Gen-3 SST, including reaching the rated input voltage 7.2 kV level with full controllability of the Medium Voltage (MV) AC power factor, 400 V DC voltage and 240 V AC voltage regulation. In Year 10, the FREEDM Center team has focused on integration of a multi-SST hardware platform into the Green Energy Hub testbed, and on using the expanded testbed for validating the Center's developed autonomous control and the distributed intelligence systems. The Center has also begun new related research projects, including one on medium voltage fast chargers for plug-in electric vehicles that utilize Center-developed Silicon Carbide (SiC) solid state transformer technology.

The Systems Theory, Modeling and Control (SMC) research thrust remains key for understanding performance and stability issues associated with distribution grids containing SSTs coupled through the developed control and communications architecture. The Center's research in the SMC area has continued to employ the invariants concept along with passivity-based control ideas, and effectiveness of developed control schemes is being verified through simulations. Guarantees of performance through fundamental analysis would be desirable, supported by extensive simulations, which can perhaps be automated to some extent and cover many possible contingencies.

At the enabling technology plane, progress continues in all four thrusts. The SST thrust is a key strength of the Center, followed by the DGI and DESD thrusts. The DGI thrust, including the work of the FREEDM Architecture Working Group (FAWG), serves as the glue that automatically controls all the hardware components, using distributed communications and decision making. The FID thrust has produced innovative fault isolation devices, which are demonstrated on the GEH.

The Center has been consistently migrating the research outcomes of projects under these thrusts to the upper plane through demonstrations in the three testbeds, all of which are operational and mature. As new generations of components with greater functionality are developed, they will be integrated
into the testbeds and their performance within an overall FREEDM distribution system will be validated.

Even upon having highly mature components meeting real-world requirements verified through extensive simulations, the Center will need to convince a conservative utility industry to deploy FREEDM-developed technologies. Moreover, in recent years competing technology developments have begun to appear, and further such developments are to be expected in the future. Thus, the Center needs to remain vigilant in its efforts to remain a leader in Smart Grid technology and reinvent itself over time as appropriate.

The Center has strong partners in industry and overseas institutions. These collaborations should continue, as they provide the FREEDM Center leadership and faculty with excellent research and development partners, as well as opportunities for growth for students.

(3) Research Thrusts

**Thrust 1: Solid State Transformers**

This research thrust includes the following three projects in Year 10:

- Gen-4 SST Design
- Multi-SST Medium Voltage Testbed (in GEH)
- SST Residential Demonstration (in GEH)
- MV SST Development leveraging PowerAmerica funding
- SiC Power Devices for SST Applications

The solid-state transformer (SST) achievements during the last year build on the completed Gen-3 design from Year 9 in several directions. One is work toward the design and development of the Gen-4 SST. The target for the Gen-4 SST design is to maintain the 97.5% efficiency level achieved in the Gen-3 design while also achieving several new functionalities that will be important for deployment, namely: reaching the rated input voltage 7.2 kV level with full controllability of the MV AC power factor, 400 V DC voltage and 240 V AC voltage regulation. Also, in Year 10, the FREEDM Center team has been integrating a multi-SST hardware platform into the Green Energy Hub testbed and using this expanded testbed for further validation of FREEDM's autonomous control and distributed intelligence systems. The Center has also started work on medium voltage fast chargers for plug-in electric vehicles that utilize its Silicon Carbide SST technology.

FREEDM was an early innovator in SST technology and its work led to the creation of several start-up companies, including GridBridge, which was subsequently acquired by another US firm. With the continued positive developments summarized above, it is anticipated that FREEDM will continue to play a leading role in SST advances in the coming years and should make progress in integrating post-silicon devices into future SST designs.

**Thrust 2: Fault Isolation Devices**

The objective of the Fault Isolation Device (FID) is to support the Center's vision to control transients during turn-on and turn-off in medium voltage circuits. The Center has successfully developed and tested Gen-1 and Gen-2 versions of the device for 15 kV class applications with continuous currents
of 50 A and fault currents up to 400 A. It is interesting to note that these devices are silicon based. A hybrid device combining a vacuum switching chamber with a piezo-electric actuator - called the fast-mechanical switch, was also developed and patented as a Gen-2 offering. Testing and demonstration projects were conducted on the Green Energy Hub.

The group also explored the industry value for this application through an NSF I-Corps project and concluded that the ratings of the Gen-3 FID do not meet current market requirements. While the switching times are in the sub-cycle range (2 ms), the current handling capabilities were not sufficient to meet the needs of electric utilities. Reflecting on the findings from the I-Corps project, a new NSF project, headed by Georgia Institute of Technology is now focusing on the design of building viable prototypes for utility-scale deployment.

The appealing aspects (strengths) of the research include the device’s ability for ultra-fast fault isolation, intelligent communication and compatibility with other FREEDM technologies, possibility for supervisory control, and quick system voltage restoration during continuous operation. A significant weakness that the device is currently not viable for utility-grade applications because of its current handling abilities. However, it should be noted that this weakness does not undermine the Center’s overall vision. Additionally, the publications from this group are very limited.

**Thrust 3: Distributed Energy Storage Devices**

The Distributed Energy Storage Devices (DESD) thrust area resides in the technology plane, enabling several applications envisioned by the Center. The core functionalities and construction of DESD are based on the Solid State Transformer (SST), augmented by insights and findings in energy storage technologies. Therefore, DESD devices inherit the features, merits, and limitations of SSTs. The primary objectives are to develop modular, efficient, and scalable units that interface with the SST based distributed energy cells across the FREEDM grid. Having the ability to store and rapidly access energy is an important requirement for harnessing renewables and energy management in the grid. The DESDs include capabilities for online battery capacity estimation, real-time dispatch and control and utilize optimized and safe Li-ion chemistries. A key application for these devices is fast charging, especially for electric vehicles.

The Center has successfully leveraged SST research achieving efficiency levels over 97.5%. The Gen-4 SST-based fast electric vehicle (EV) charger has advanced the state-of-the-art (referenced by the classical transformer) by halving the power losses and cost, while shrinking the volume by 30x. Laboratory scale demonstrations have been conducted for a 50kW EV charging application for Nissan Leaf. These innovations have also been benchmarked with Tesla’s supercharger station. In comparison, the Center’s solution can serve 40 charging stalls while halving the losses for the same footprint. Besides EV charging, the efforts are being integrated for applications for Department of Energy led projects on Solid State Power Substations - where high voltage power electronic converters are used to provide enhanced capabilities for the power grid. The proposed solutions are also integrated with other research subareas of the Center - for example, the Distributed Grid Intelligence (DGI) module for real-time dispatch and decision making and incorporating insights (such as degradation models) from battery-based storage into the SST models. Several prototypes (AC and DC) have been developed and tested in the Green Energy Hub multi-SST testbed. A unique aspect is the Center’s ability to use off-the-shelf components (for example, Toshiba’s Lithium Titanium Oxide (LTO) batteries) while integrating them into Center-developed innovations, followed
by testing. The Center’s research activities in this area appear in prominent journals and conferences with core intellectual property developments protected by patents.

Overall, the work is highly applied, collaborative, ripe for emerging commercial and industry applications, and strongly aligned with the Center’s vision.

**Thrust 4: System Theory Modeling and Controls**

The incorporation of System Theory, Modeling and Controls (SMC) in the FREEDM ERC research, as described in the Year 10 report and final presentation, is representative of the state of the art in all three of these disciplines but is beyond the normal practice in Power Systems and Power Device Engineering. In Power Systems engineering it is common practice to work with large system simulations – but not typical to evaluate specific device-level innovations. In Power Device Engineering, it is common practice to work with device-level hardware simulations, but not typical to incorporate control system analysis or system-level effects.

The FREEDM ERC has used three levels of simulation to achieve the desired goals that include detailed device-level testing while at the same time evaluating the requirements and limitations of such devices in the context of their role in the larger system context. The LSSS is a high level power system simulation, the HIL is a hardware-in-the-loop simulator that incorporates actual hardware into a more focused simulation environment that represents the Low Voltage level system architecture (to design and evaluate DGI controls, fault isolation devices, and solid state transformers), the GEH (Green Energy Hub) is another HIL simulator that is used to evaluate the effect of larger disturbances due to distributed generation (e.g. wind power or large solar array, DRER, volt-var compensation) at the Medium Voltage level. These simulators allow some devices and concepts to be viewed or used at multiple levels (DGI, SST). This approach has enabled the FREEDM researchers to evaluate system effects such as islanding, voltage sag, and standards in a more complete way, and to gain a more complete understanding of device requirements.

This system level approach evolved in the course of the research at this ERC, based on annual reviewer suggestions, when Use Cases were developed in order to refine system level objectives, and to evaluate their impact on lower levels of the Power System. It ties together different simulation types (static, dynamic) that have been used in power system analysis and design.

This research does not advance the state of the art in control theory, but the program does effectively apply known results in control. In particular, the system/control theory result that a passive interconnection of passive circuits remains passive is used to deduce system level passivity from passive components in the DGI devices. In addition, there is another use of related results for hierarchical systems, where a hierarchical interconnection of stable systems can be determined to be stable. Lyapunov methods are also employed to deduce stability of nonlinear power management controls for intelligent power management (IPM), as described in Section 2.11.4 of the Year 10 report. These applications suggest further applications of control theory that might be applied to other system level stability issues, e.g., for application to the GEH.

These power system applications are innovative and have been described both in publications (Section 2.11.5) and intellectual property (Section 2.11.5) in the Year 10 report. They are considered to be a result of the synergy of disciplines within the ERC. The publications reporting these results
are in leading journals and conferences that are familiar to Power System researchers (e.g., IEEE Trans. Power Systems, IEEE Trans. on Power Electronics, IEEE Trans. on Industry Applications), and involve ERC members at NCSU, Missouri, ASU and FSU-FAMU. Several of the publications have attracted large numbers of citations (cf. publications 4, 7, 8 and 2 in the list of SMC publications, where other battery estimation and management related publications have also won awards).

**Thrust 5: Distributed Grid Intelligence / Reliable & Secure Communications**

The purpose of the Distributed Grid Intelligence (DGI) / Reliable & Secure Communications (RSC) thrust is to deliver an integrated plug-and-play software and functionality interface to all FREEDM system components so they can work together resiliently to achieve the FREEDM objective. This goal has largely been accomplished. The DGI is included in every FREEDM energy node. The DGI implemented in a completely distributed manner and is self-organizing and self-governing; and does not require a centralized coordinator. Rather than rely on cloud-based computing, which could have high communication latency, the DGI uses a “Fog” based architecture which relies on local communication between the nodes.

The ERC team developed a combined cyber-physical security approach that is able to detect and react to cyber-attacks, electrical system faults and hardware/software failures in a coherent manner. The approach uses “static and dynamic invariants” which are computed at each node. Sets of Lyapunov functions are computed and the operating philosophy is that any system action should act to reduce the Lyapunov function. This is taken as evidence that the system remains passive, thereby ensuring the stability of the overall system.

Iterative control algorithms are also being implemented using this approach. For example, static invariants enforce rating constraints, such as line flow limits, as well as other operating range restrictions, and are also used to identify erroneous information via attestation. A cyber-physical attack might also be identified using this approach, as it may lead to a lack of feasible solutions.

Using the DGI, the team implemented the necessary algorithms required to run a FREEDM grid. Examples include a load balancing algorithm which is able to modify the energy dispatch in the network following an electrical fault. A volt-var control (VVC) algorithm was also implemented. The VVC dynamically changes the var supply setting to regulate network-wide voltage and thereby excessive operation of tap-changing voltage regulators and switched capacitors is avoided.

The DGI/RSC thrust was largely developed in the last four years of the program. Although it worked effectively, control approaches other than those based on invariants were not sufficiently investigated. All work under the SMC thrust now seems to be concentrated at NCSU.

**Response:** The FREEDM team would like to clarify that the DGI/RSC efforts can be broadly categorized into two phases. The DGI infrastructure development started in year one and was completed by year six of the Center. The DGI/RSC efforts concentrated on applications development and implementation within the DGI infrastructure in the last four years of the Center.

**Thrust 6: Post-Silicon Devices**
The aim of this thrust was to create advanced low loss, high efficiency switching semiconductor devices for the FREEDM system components such as the Solid State Transformer (SST) and the Fault Isolation Device (FID).

A major achievement was a combination 10 kV MPS rectifier that combines cross sections of Schottky and Junction Barrier Schottky (JBS) devices to obtain a device with low ohmic resistance and low turn-on voltage. This research was driven by the need to improve the poor efficiency of the Generation I SST, which was attributed to losses in the 10 kV P-i-N flyback diodes. A breakthrough was achieved with innovations in edge terminations which resulted in a device with a high blocking voltage while still maintaining small leakage current. The performance of this device is significantly superior to that of the previously used 10 kV P-i-N device. The FREEDM 10 kV SiC MPS diode is a new component which is ready for industry commercialization for utility scale applications.

The PSD team also developed 10 kV 4H-SiC Junction Field Effect transistors (JFETs) and a new device called Field Control Diodes (FCDs) capable of bi-directional voltage blocking capability. As part of this effort, was the development of a new orthogonal bevel edged termination. This is the first and only method reported for bi-directional blocking.

The PSD team interacted with the SST developers and recommended the development of a 10 kV SiC MOSFET device, although they did not produce this themselves. This was later fabricated by CREE and used in the Generation 2 and Generation 3 SSTs.

The PSD team developed several new devices and promising semiconductor design methods. They have also conducted world class research on improving the characteristics of these devices. However, fabrication facilities available to the ERC continue to remain a challenge, and the Center has not yet been able to produce devices with sufficient voltage and/or current ratings required for the SST or the FID. However, the PSD investigators are also involved with the PowerAmerica Center at NCSU, and this collaboration is likely to rectify the situation.
Cross Cutting Themes

Systems Architecture

The FREEDM Architecture Working Group (FAWG) was established in year five of the ERC to coordinate with the thrust teams with the aim to facilitate the overall development and documentation of the hardware, software, and networking of the FREEDM components. In year six, the FAWG identified four levels for each physical layer to ensure robust and secure interactions within each layer. FAWG has established a methodical procedure applicable across all thrusts to create documentation using a common semantic basis. Later, the team developed a document of the functional system architecture with distinguished hardware/software components that have multiple levels of detail and a hierarchical structure. This has been helpful in establishing close and effective integration between the various thrusts.

A shared web portal was developed for FAWG documentation, starting in year 9. The team created Git Repositories for GEH implementation, and also developed web-based simulations that included several use cases for demonstrating the FREEDM Grid functionalities. The web portal continues to be populated with new information as the research activities continue. The information is presented at a high level and includes references to detailed team reports and publications at a lower level. It is expected that the portal will continue to be highly relevant after the ERC has graduated from under the NSF umbrella.

The web-based simulation portal is a key component that facilitates the education of power electronics. It contains simulation models and application examples for the major power electronics device in FREEDM systems - the SST, DESD, and DRER. These are accessible to students and researchers at any time via the web and are highly effective in clarifying operating and application principles of the FREEDM grid.

System Cost/Benefit Analysis

Cost-Benefit Analysis (CBA) was originally proposed by the FREEDM ERC team as a means of estimating the commercial value and relative utility of new Grid technologies and has subsequently been used to evaluate several innovations. The approach, which approximates existing practice, involved an analysis of each innovation by a sequence of three teams who produced: (1) a system analysis to determine the system benefits, (2) an economic analysis to estimate the monetary benefit corresponding to the system benefit, and (3) an analysis to estimate the statistics associated with the estimated benefit. A working group from industry provided data and information for this analysis process. This activity occurred primarily in Years 8-10, after the key technology component developments were sufficiently well defined. The detailed methodology for three FREEDM innovations is outlined in Section 2.5.4 of the Year 10 report.

Case 1: Distributed Energy Resources (DER) may become an issue for conventional grids when new commercial or residential grown has a much higher penetration of renewable energy than historical developments, and this might be addressed by adding new feeders (using solid state transformers, SST) based on smart grid technology. The costs are dominated by the SST subsystem costs, whereas the benefits may include system savings (not dispatching new generating capacity), avoiding widespread grid upgrades using conventional technology. The net present value (NPV) method was used
to estimate annualized benefits of using SST, and these were used to estimate the discounted payback period (DPBP), which turned out to be 2.9 yr., 1.6 yr., and 4 yr. respectively.

Case 2: Alternate technologies were evaluated for the situation of Case 1 above, to show that SST was potentially better than other existing technology solutions. An in-line power regulator (IPR) as an “edge-of-grid” device, and a smart inverter (STI) were evaluated. In summary, the discounted payback period for SST was 3.2 yr., for IPR was 3.4 yr, and for SMI was 4.4 years, suggesting that the SST would be attractive.

Case 3: DC Service for Residential Customers. The SST is capable of generating DC as well as AC outputs, and in this scenario the relative benefits of going to DC instead of AC for residential power were evaluated. This analysis has been described in a publication (Sun, Lubkeman, and Baran, 2018, Yr 10 report ref. [4], p. 76).

Fast-charging of electric vehicles using DC power (EV) was also evaluated on the basis of a similar analysis. Most of these cases were evaluated using spreadsheets, with all resulting in discounted payback periods. In this case, the ownership of the fast chargers (utility vs. customer, vs. gas stations) was also evaluated. The payback appeared very favorable to Fast Charger application, attracting more attention to this “spin-off” application.

While the actual technical evaluation approaches used in each case were different, since they required assumptions about what the costs of the existing systems would be, and how they would respond to a need for innovation, the strategy was similar in each case, and payback estimates could be done by one team. These analyses did confirm the economic attractiveness of the SST in different applications. These results represent crude estimates, and other factors such as vendor viability, reliability, availability of alternate suppliers, and accuracy of cost estimates, would need to be evaluated in more realistic circumstances.

For the purposes of this research, the CBA work represents a realistic approximation to methods used by industry (and sometimes by venture capitalists) for initial evaluation of new technologies. The CBA strategy has been shown to apply to multiple situations. In later years, the team involved an economist to assist with the broader issues in evaluating technology alternatives to formulate and resolve new technology alternatives. It also extended the methodology to include a probabilistic cost benefit analysis (cf. Year 10 report, Section 2.5.8) based on the Kaldor-Hicks criterion for choice in the presence of uncertainty. This begins to address multidisciplinary (economic, psychological) research issues, even though these were not the primary focus of this ERC.

The cost benefit analyses carried out for the FREEDM ERC has provided a very good starting point for new research in tradeoff studies to prioritize and monetize estimates of the value of new Smart Grid Technologies. They have suggested means by which the value of certain technologies, such as SST, may considerably exceed initial estimates as new uses for the technology are discovered. Even the initial studies have given rise to a reassessment of a new product introduction strategy.

The area of CBA for new Smart Grid devices seems worthy of further development in its own right. Seven publications are given in the Year 10 report (Section 2.5.9). It is indeed a cross-cutting technology.
(4) Research Thrust (Testbeds)

Testbed 1: Large Scale Simulation

The large-scale system simulation (LSSS) testbed is aimed at providing a simulation platform to test and validate Center-developed concepts on large-scale power systems with high penetration of renewable resources. Though a formal definition of scale is missing, a large-scale system is understood to consist of hundreds of buses, sources, and loads. The activities thus far have developed control and optimization methods, both at the local (device) level and at a system level aimed at assessing control performance, understanding component interactions, system dynamics, and protection. The activities complement the other testbeds (HIL and GEH) while supporting the Center’s vision to validate concepts at the large scale.

The research had enabled the Center to study the behavior of distribution power systems with a large number of SSTs. An interesting feature in emerging power systems is that the inclusion of a large number of power electronic- devices with fast switching dynamics can adversely impact stability and control in ways that are not clearly understood. The LSSS testbed precisely allows the study and mitigation of such phenomena. For example, harmonic resonance could induce the potential for instability when SSTs are energized in distribution systems. The group’s activities have helped remediate this issue by designing a suitable input filter. This is a good example of how jointly advancing the scope of research from other groups within the Center. Another example is the demonstration of online Volt/VAR control for distribution systems with SSTs. This is a core operational component used routinely by several utilities. The testbed clearly helps demonstrate how these functions can be achieved when Center-developed components are integrated into future power systems. Besides these routine applications, the group has also examined how dynamic simulations could be conducted when a multiple SSTs are hosted in the grid. This task is non-trivial as power electronics-based simulations are often in the time domain. Research from this thrust area has proposed an interesting alternative - by developing dynamic phasor-based models for SSTs implemented by Dynamic Linked Libraries (DLL). The proposed approach has been validated with commercial solvers and tools such as OpenDSS and ElectroMagnetic Transients (EMT)-type simulations in PLECS. This project is a good example of synergy between power systems and power electronics researchers. The group has also stretched the application to larger systems - the IEEE 8500 bus feeder system, though the case study only covers a fault simulation. The extensions and applicability, especially dynamic simulations in (truly) large systems is a challenging problem and the testbed might help the Center catalyze research in this area post-graduation. Research findings from this thrust area are aptly interdisciplinary and appear in high quality publications.

The quality of the work thus far, the researchers involved, and the contributions towards the overall vision are real strengths while fundamental theoretical challenges (true dynamic simulations with several thousands of state variables) stemming from a multitude of SST-type devices, limiting the scope of studies only to smaller systems might project as awreckness.

Testbed 2: Hardware in the Loop

Hardware in the Loop (HIL) testbeds have frequently been used within the power industry to validate and verify components that must operate in real-time. Such test beds may take two forms: (a) where
a large real-time system is used to test a simulated component, and (b) where a real-time system simulation is used to test a new hardware component. In either case, the simulated portion of the system must be made to run in real time (a real-time simulator) in order to provide accurate reflection of dynamic (and feedback) effects within the overall testbed. Within the ERC, the HIL Testbed uses primarily type (b) configuration, where a real-time simulation of the power system is used with to verify the correct operation of prototype Smart Grid hardware.

The FREEDM HIL Simulator uses state-of-the-art simulation technology, including embedded real-time processors and software (RTDS– Real-Time Digital Power System Simulator, OPAL-RT Real-Time Solutions), and has been used to verify, validate, and in some cases develop several Smart Grid component technologies such as the Digital Grid Interconnect (DGI), and Medium Voltage AC and DC devices (MVAC, MVDS). The evolution of the HIL and its uses over the course of the FREEDM research efforts is described in Section 2.3.2 of the Year 10 report. The FREEDM HIL Simulator differs from many other HIL Simulators in that it has been developed and used over a long period of time (10 years), that it has been used and modified to validate several Smart Grid component technologies, and that its network architecture has also been modified to include a larger number of signals passed between components as it has evolved (for example as of year 8, there were up to 240 real-time signals at a 240 Hz update rate). In this regard some of its capabilities are relatively unique, even within the power industry.

Although it has primarily been an enabler for the development of new Smart Grid component technologies, this system has been an important research aid – for refining component requirements, for improving algorithms (DGI, Volt-Var), for component design verification (including multiple interacting components or subsystems), and for quantifying and displaying results of simulated performance of new technologies. The difficulty of developing, maintaining, and validating accurate real-time system simulations should not be under-estimated, particularly where feedback interactions occur between the simulated subsystem and components, and within a network of components. The HIL Testbed has several unique capabilities and has also attracted attention from industry as a possible means for early development or verification of new product ideas.

In the context of the FREEDM ERC the HIL Simulator has also been a vehicle for multiple groups, including student teams at both NCSU and FSU-FAMU, to collaborate. In earlier years, multiple students participated in hardware and software development of the HIL itself. Remote access capability was added in Year 7. Real-time embedded system programming skills have developed within the student body and have been a mentoring interest among high school and undergraduate student groups. Thus, the HIL has played a significant role, in its own right, in the evolution of Smart Grid concepts within the FREEDM team.

Testbeds such as the HIL testbed are often incidental to publications, but 5 publications based on the testbed design are noted in Section 2.3.6 of the Year 10 report. The HIL should be cited as a strength of the FREEDM ERC, and it can continue to be of use to undergraduate and graduate students, as well as industrial partners, for several years to come. Development of the HIL testbed can continue and its functions can be further expanded, e.g., for evaluating cyber-physical system security.

**Testbed 3: Green Energy Hub**
At the start of Year 4 the Green Energy Hub (GEH) test bed was one of three that were defined based on feedback from the site visit team and a better understanding of the needs to demonstrate the functionality of the overall FREEDM system. The objective was for the GEH to provide a clear architecture and experimental validation platform of how the FREEDM distribution system can transition from the laboratory setup to field deployment. Along with the other two defined test beds, the GEH was up and running by year 5 under the very capable direction of Dr. David Lubkeman.

During the first few years of operation, the focus of the Green Energy Hub test bed was on the testing and demonstration of the FREEDM component building blocks. In later years the focus was expanded to include projects with a broader systems focus such as multi-SST applications with an emphasis on energy management. Year 10 activities included projects involving a multi-SST testbed, single-SST residential demonstration, integration of integrated power management (IPM) and integrated energy management (IEM) applications and a demonstration of multi-SST islanding and black start operation. All of these projects have shown an integration between research efforts and results across the center. The Center’s prior attention over the years to systems engineering, the development of use cases, and the formation of the FREEDM Architecture Working Group has contributed directly to the ability to successfully integrate hardware components and control algorithms from research results across the center. While there is more work to be done to fully implement and demonstrate all of the envisioned features of the FREEDM system, and to fully integrate the results from all of the fundamental research work (particularly the post-silicon devices), the work to date on the GEH is excellent. The capability of the GEH to provide a unique learning environment for students to demonstrate principles associated with the development of a grid system that will support renewable energy sources is also significant. In addition, the students are exposed to systems engineering concepts that enable the overall operation.

In addition, the GEH testbed has drawn industry interest over the years. An ABB fast charger was installed as part of the GEH to study the impact of fast vehicle charging on the grid. Another center member company, Eaton Corp., has used the GEH to test one of their high power uninterruptible power systems (UPS) systems that they have donated to the center. Schneider Electric, a large electrical equipment manufacturer and a FREEDM member, used the GEH as a flexible testing space that included medium voltage power, solar PV, battery storage, and inductive and resistive loads to test a new microgrid management system. This microgrid management system is now branded as EcoStruxure and is a leading product line within the company.

The GEH offers an opportunity to continue to closely engage with industry as a useful test bed to test new smart grid concepts and potentially generate revenue as a test facility.
(5) Education/Educational Outreach

University Education Program

The Center provides strong and dedicated educational programs at both the undergraduate and graduate levels, as well as significant educational programs for pre-college students. Students continue to fare well in terms of job placement. Many courses have been developed in the Center, and there is a healthy culture of sharing of courses among the partner institutions. In addition to courses, the Center provides various research opportunities for undergraduates including a Research Experiences for Undergraduates (REU) program at each institution and an Undergraduate Research Scholars program for academic year research experiences. Students are proactively involved in advancing their education through special programs that are led through the Student Leadership Council (SLC), and students share best practices in these and other activities across member institutions. The SLC is also represented in regularly held leadership team meetings. The Center recognizes that the desired ratio of 2:1 graduate to undergraduate is not yet met and is working toward reducing the current ratio of 4:1 toward this target. The ERC engages in significant educational outreach efforts, with some 460 students and 260 teachers attending such activities in 2017, and only three quarters through 2018 already 500 students and 150 teachers attending such activities so far this year. Although some information was presented on assessment of education and outreach efforts, the Center still has limited resources for preparing detailed assessments.

Pre-College Education Program

The pre-college education program includes several components: a Research Experiences for Teachers (RET) program, a Young Scholars program, the Sustainable Transportation Education Program (STEP), and the Kenan Fellows program. In the early years of the Center, all five sites offered the pre-college educational programs. However, starting in Year 7, the pre-college activities were limited to NCSU and ASU due to budget limitations. The pre-college program in year 10 included three Research Experiences for Teachers participants, two Young Scholars at NCSU and seven at ASU, and a Kenan Fellow who is a high school teacher in engineering education.

The Center integrates university education and pre-college activities where possible. REU students often work closely with teachers and Young Scholars, and Ph.D. students often serve as mentors. In year 10, the Center started a Friday afternoon program taught by a Center PhD student that provided modules and labs for REUs and pre-college participants on topics such as simple circuits, wide bandgap power electronics, electric vehicles, Matlab, and Solidworks, to enhance participants' capability to contribute to Center research projects.

The Sustainable Transportation Education Program (STEP) is a rather unique activity hosted at NCSU (but offered to all FREEDM participating universities) that aims to educate middle and high school students about sustainable transportation and the shift toward the electrification of transportation. Teachers learn about wide bandgap devices and their applications. The program includes a hands-on component using radio control electric vehicles, with students learning about battery technologies, power train, chassis design, and other related topics. A teachers' workshop and a competition is held annually. In Year 10, there were 12 schools and 125 participants in the competition.

The Center Education Director also serves on two high school business advisory boards, which provides an additional opportunity to reach the pre-college community about FREEDM research.
The year 10 annual report provides a limited amount of information on assessment techniques and outcomes of the Center’s educational programs. However, the report did note that feedback from year 9 resulted in adding additional training in year 10 on conducting literature reviews, as well as in a Friday afternoon lab that taught basic skills.

**Response:** We apologize for the omission of the assessment details on FREEDM education program. The following is reported to augment the year 10 annual report on education:

The Education program revamped FREEDM’s assessment program in 2016 as recommended by the NSF Site Visit team. In addition to using indirect assessment for pre-college, REU, UGRS, and graduate programs, we developed a direct assessment for courses and programs. There is funding to support the Education Director’s position and a Graduate Assistant for the Education program so they will continue to collect, analyze, and interpret the data along with writing reports. The assessment will continue to be used to review and enhance programs along with individual students and teachers to ensure impact and success.

The FREEDM System Center’s assessment program is a strategy to meet the ERC Gen-3 education requirement. Systematic planning and effective implementation strategies are required to be effective. The Center has had an indirect assessment plan in place for eight years that involves students’ self-reporting and in Year seven the NSF Site Visit recommended that the Center develop a direct assessment program for measuring students’ desired skillsets to ensure our students are meeting the critical workforce needs to prepare them to have the skills of a global engineer.

Two pilot programs were implemented in 2015 and 2016 which included direct assessment with the REUs during the summer program and a graduate research laboratory cohort training program for new students entering the Center.

The objectives for graduate students in the Center developing skillsets in the following areas:

1. Define, formulate, and solve problems related to power and energy systems.
2. Design a power energy system or some of its components.
3. Demonstrate an understanding of professional and ethical responsibility.
4. Strengthen understanding of innovation, professionalism, and ethical standards.
5. Develop the needed knowledge, skills and experiences in the areas of renewable energy, energy storage, and power semiconductors.
6. Increase global preparedness and innovation/creativity.
7. Problem solving skills
8. Communication skills
9. Design skills
10. Modeling skills

**Graduate College Education**

**Background:** The assessment program is a strategy to meet the ERC Gen-3 education requirement. Systematic planning and effective implementation strategies are required to be effective. The proposed skill-sets are based on NSF requirements, the National Academy of Engineering’s Engineer of 2020 recommendations, and discussion with industry members.

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Methodology: The strategic plan includes both direct and indirect assessment, artifacts collected from project-based learning and experiences, professional skills training, and self-reporting through surveys based on the NAE Global Engineer of 2020. Artifacts from project-based learning courses will be collected from the student’s faculty adviser to further demonstrate the student’s competency in the technical area(s).

To implement the assessment program effectively and train students to be creative and innovative, FREEDM integrates industry and research seminars, webinars, meetings, and workshops into its graduate education programs. These activities provide students with industrial practice knowledge that assists their career development. FREEDM offers a series of seminars related to intellectual property law and entrepreneurship and innovation. Additional industrial practice puts students in contact with practicing engineers who have worked in the industry in the U.S., Asia, and Europe and exposes them to interdisciplinary approaches to energy policy and regulations.

Impact/benefits: The purpose of this program is to augment graduate students’ technical education and research with training to be successful in a global environment. It will benefit the industry and society as a whole by training students to be creative, adaptive, and innovative before entering the workplace. In other words, participating in the program will develop students who have professional and technical skills prepared to enter the workforce.

Undergraduate Research Scholars’ Program

Methodology: The strategic plan includes both direct and indirect assessment through meetings, rubrics, focus groups, and self-reporting. All UGRS students participating in the FREEDM program receive a plan with detailed components to be completed and are expected to meet with the education director monthly. Students are expected to gain experience working in a team-based research environment, be exposed to professional development opportunities and industry networking, and complete an engineering ethics course. A rubric will be developed to evaluate each student’s progress. Faculty and graduate mentors will develop learning objectives for the UGRS’s projects and conduct assessment through observation and/or test(s).

Impact/benefits: The purpose of this program is to provide a research experience along with the professional skills for undergraduates pursuing a degree in Electrical and Computer Engineering. The students in this program are introduced to graduate school opportunities. UGRS students participating in the program will assist in the development of their professional and technical skills.

Research Experience for Undergraduates

Methodology: The strategic plan includes both direct and indirect assessment through meetings, rubrics, and self-reporting. All UGRS students participating in the FREEDM program receive a plan with detailed components to be completed and are expected to meet with the education director monthly. Students are expected to gain experience working in a team-based research environment, be exposed to professional development opportunities and industry networking, and complete an engineering ethics course. A rubric will be developed to evaluate each student’s progress. Faculty and graduate mentors will develop learning objectives for the UGRS’s projects and conduct assessment through observation and/or test(s).

Impact/benefits: The purpose of this program is to provide a research experience along with the
professional skills for undergraduates pursuing a degree in Electrical and Computer Engineering. The students in this program are introduced to graduate school opportunities. UGRS students participating in the program will assist in the development of their professional and technical skills.

**Pre-College Programs**

**Methodology:** The strategic plan includes both direct and indirect assessment through rubrics, artifacts, and pre and post surveys of the students’ learning experience and knowledge as a participant in the program. The Young Scholar’s program is a six-week program for selected high school students to provide an immersive experience working in lab, learning about engineering concepts, design, working on a research project, and poster. Students will develop one project to present after their four-week experience and are encouraged to present at one event at their school or community. The Research Experience for Teachers is also a six-week program where selected middle and high school teachers who will work in lab setting to learn about engineering education, working on a selected project, presenting their research findings, and developing curriculum, a presentation, and assessment to deliver to their students and other teachers.

**Impact/benefits:** The purpose of this program is to create awareness about STEM and develop skills through curriculum and engineering activities for the pre-college participants. Students and teachers will be involved in learning about engineering concepts, hands-on activities, attending webinars, and going on industry visits to ensure that they are exposed to multiple opportunities to learn about the field of engineering, skills, and careers.

(6) **Innovation Ecosystem**

The Innovation Ecosystem, in the context of an ERC, refers to the collection of stakeholders who will participate in bringing an initial innovation (e.g., as expressed in the form of a patent) into the market as a new product. These might include the end user, a venture capitalist, a large business with related products, a small start-up company, suppliers of materials, or those with other potential uses for the innovation. One goal of the ERC is to interact with these stakeholders at an early stage, to continue to seek their inputs in developing the innovation, with the hope that ultimately these stakeholders will invest in bringing the innovation to market. It has been estimated that an innovation must clear about 20 critical hurdles to get to market, so this is a long and complicated process that is successfully completed only for a small percentage of innovations. Experience has shown that early involvement of stakeholders in the innovation process greatly improves the chances of success (say, from 1% to 5%).

The FREEDM ERC made an effective effort to build a strong Innovation Ecosystem and has had many successes. At a very early stage the Center started with an Industrial Advisory Board (IAB) and began to solicit members of an industrial partner group, now also affiliated with PowerAmerica. The partner group included many small companies at the beginning, some of whom were interested in patent rights. By the middle years of the ERC, it became apparent that many publications, patents, and graduates were being produced. As time passed, more and larger “partner” members, including Duke Energy, ABB, and the New York Power Authority joined the collaboration: these members have more interest in hiring students and in sponsoring FREEDM projects. This evolution, over a 10-year period, seems likely to occur in other Innovation Ecosystems that affiliate with other ERC efforts. Continued management attention will be required to extend the adaptive agility that has led to the success achieved to date forward into the years beyond the initial years with NSF support. This
might include re-approaching earlier member candidates, inviting new groups from within the ecosystem (e.g., standards or testing organizations), or cooperative work-study arrangements with students and prospective employers.

This ERC has attracted a robust group of members from industry and academic affiliates who have been actively engaged in many aspects of the Center’s research. Financial support from these members has been respectable, but it must grow in order to at least partially compensate for the ending of NSF ERC program funding. The FREEDM management team has worked to develop a strategy for increasing this support, but it is not yet fully in place – though some short-term commitments are in hand, as described elsewhere in the report.

With over 100 inventions, 50 patents, and over 20 licenses, several successful technology transfers have occurred in the course of the FREEDM initiative, including 10 start-up companies, the Gridbridge SST system, and Bing Energy. This is an excellent track record. With a relatively large innovation ecosystem and a huge and utility industry to engage with, there is every reason to believe that this team can remain to be successful in the future.
(7) Infrastructure

(a) Configuration & Leadership

While several of the original members of the leadership team have moved on to other positions, the Center graduates with a very capable team in charge. The leadership team recognizes the challenges in remaining as a multi-institutional Center post-NSF support, but is committed to pursuing opportunities as they arise. They will continue to work together on projects related to CREDENCE and to integrating the Gen-IV version of the SSTs into the GEH during the no-cost extension period.

Due to other large grants at the Center, the positions of Education Director and Diversity Director have support from additional sources beyond the Center. In particular, the Education Director position will work for the PowerAmerica program along with continuing her work with the FREEDM Center. The Diversity Director will work with the ASSIST ERC as well as the FREEDM ERC. The sharing of these positions provides a synergistic opportunity to leverage lessons learned from all the programs and share best practices while sharing resources. The REU program will be shared between the ASSIST and FREEDM ERCs and this offers the students the opportunity to explore power device concepts at the nano-watt scale (ASSIST) to the mega-watt scale (FREEDM).

The Student Leadership Council (SLC) seems well-organized and positioned to continue post-graduation. They have applied to be recognized as a student organization on the NCSU campus, and this will result in a modest amount of funding for the SLC. Notably, they recognized a need for additional training in the area of Digital Signal Processing (DSP) programming and organized a workshop with an instructor around that topic to help the students. This was an excellent example of how the SLC can support the needs of the Center and the SLC is planning additional workshops to meet needs as identified by students in the future.

(b) Diversity Strategy and Impact

The ERC set forth three objectives for its diversity strategy:

Objective # 1: Recruit and retain a graduate student population that is richly diverse and exceeds the national average demographic composition of comparable engineering-based programs.

Objective # 2: Attain faculty and staff representation that better reflects the diversity of the general population.

Objective # 3: Maintain an environment that makes FREEDM an attractive place for all people to work and grow professionally.

The ERC also adopted the “culture of inclusion” ideals that were developed in the NSF strategic plan after the inception of the Center. The Center Diversity Director, Dr. Roy Charles, also serves as the Diversity Director for the ASSIST ERC, which is also head-quartered at NCSU. This dual role allows Dr. Charles to pass best-practices between the Centers, and also to leverage recruitment efforts to encompass both centers.

The Center is working to increase connections to various campuses with a high number of traditionally underrepresented minority student populations with campus visits and recruitment
efforts. The Center is also engaging with national organizations such as National Society of Black Engineers, Society of Hispanic Professional Engineers, Society of Women Engineers, and the American Indian Science and Engineering Society in order to create a more diverse pipeline of students for the ERC. In addition to recruitment activities, the Center offered training on accessibility for persons with disabilities, and on Non-Discrimination and Title X issues.

The percentage of women students participating in the ERC is generally less than national or ERC averages. FREEDM reports 16% of its graduate population and 35% of its undergraduate population as female but the average ERC reports 33% and 44% respectively, and national averages are 27% and 23% respectively. However, it should be noted that electrical engineering is a traditionally underrepresented field of study for women and the ERC has generally increased its participation by women, particularly in the last three years of the Center.

For Hispanics, the participation numbers for both graduate and undergraduate students exceed the national and ERC averages. FREEDM reports 12% of its graduate population and 21% of its undergraduate population as Hispanic while the average ERC reports 11% and 15% respectively, and national averages are 10% and 15% respectively.

For underrepresented racial minorities, the results are mixed, with the FREEDM center exceeding ERC and national averages for graduate students but coming in slightly below ERC averages for undergraduates (although still exceeding national averages). FREEDM reports 12% of its graduate population and 14% of its undergraduate population as Hispanic while the average ERC reports 9% and 17% respectively, and national averages are 6% and 6% respectively.

(c) Management Effort

The Center has a strong management team that has deep involvement in all aspects of the Center’s work, including its efforts in research, education and outreach. The Center management is prudent in financial management, in securing institutional support, and in helping to guide the research of the faculty and students in directions that are likely to maintain strength and visibility into the future. The Center Director in particular is to be commended for flexibility and responsiveness to the Site Visit Team’s requests aimed at achieving a balance in the Center’s research between component and systems level research. The central management of the ERC has coordinated well with management at the member institutions, and this has led to a strong and complementary working relationship among the partner institutions, allowing for shared resources including laboratories and educational materials.

(d) Sustainability

At this post-graduation juncture, a main issue is sustainability of the FREEDM Center in its current form without NSF funding as an ERC. The Center has obtained commitments of support for some aspects of its activities, including a two-year commitment from NCSU to support the Center facilities. Also, the member universities have over the past decade provided additional faculty lines in the power area. The Center brings in significant research funding besides the original NSF Center grant that totals three times the previous NSF base funding. Other sources of support include an endowment and industry membership fees. The Center management has put together a plan for sustainability. The SVT feels that to succeed in sustaining the Center in its present form with its current spectrum of
activities, the Center management team needs to take further major and creative pro-active steps. The FREEDM Center has many significant and rather unique capabilities and strengths which could be leveraged to achieve sustained external sources of support. This could include providing a services center for industry that could engage students and faculty in project work on a contract basis with member companies, providing for visiting opportunities for member company engineers and scientists, short courses, access to students, access to software, and so on. The Center’s management is also encouraged to seek mechanisms and incentives for all member universities to remain engaged in the Center and continue pursuing significant team efforts in the future.

(e) Resources & University Commitment

The FREEDM Center has enjoyed strong support and commitment from all partner university administrations, including provision of space, hiring of faculty and other financial support for Center activities. Both NCSU and ASU saw their faculty numbers approximately double in the power area since 2008. NCSU is providing excellent facilities to house the Center’s activities. FAMU-FSU has hired 5 new faculty in Fall 2018 in cyber physical systems and controls, as well as a distinguished senior faculty member in power electronics from Michigan State University, Prof. Fang Peng. FAMU-FSU has also confirmed plans for building a 12,000 square foot laboratory for Center-related activities. At Missouri S&T, a 1,750 square foot addition to the Power Systems Laboratory occurred as a result of the university’s involvement in the FREEDM Center.

The Center has a strong group of partner companies. This contributes important discretionary funds to the Center. As mentioned elsewhere in the report, the SVT believes that the industry support base for FREEDM can be strengthened through creative development of additional services and opportunities for a larger group of potential member companies.
Designation of Time Limited Option for Distinguished Professorships

Background: Donors who endow a distinguished professorship at NC State University may elect to pursue matching funds available through the state’s Distinguished Professors Endowment Trust Fund (DPETF). In accordance with state statutes, as well as University of North Carolina system and NC State University policies, the NC State University Board of Trustees (BoT) is authorized to designate that endowed distinguished professorships seeking DPETF matching funds may be time limited.

We request this designation from the BoT when a donor agreement indicates intent that a distinguished professorship be awarded, or potentially awarded, at a rank other than professor (i.e. assistant, associate professor) and/or for a period other than an individual’s full career.

This designation provides the university with the maximum flexibility in awarding the distinguished professorship over time. Still, the overwhelming majority of NC State’s distinguished professorships are offered to professors for the duration of their career at NC State.

Recommended Action: We request designation of the following distinguished professorships which may be time limited:

1. Blanton J. Whitmire Distinguished Professorship, College of Agriculture and Life Sciences, $1.5M endowment
2. Charles G. Wright Distinguished Professorship, College of Agriculture and Life Sciences, $1.5M endowment

Policy References:
UNC Policy 600.2.3 - Distinguished Professors Endowment Trust Fund
NCSU Policy 01.05.01 – Board of Trustees Bylaws
NCSU Regulation 05.20.17 – Professorships of Distinction
REPORTS
ENROLLMENT 2025

Board of Trustees Enrollment Update

Presented by Louis Hunt
2025 Enrollment Plan Goals

Enrollment History 1885 - 2025
2025 Enrollment Plan Goals

☑ Enhance student success
☑ Enhance diversity
☑ Establish manageable growth pattern by improving planning process to reduce “volatility” in enrollment growth
☑ Ensure access for North Carolinians to unique programs in UNC system, while emphasizing competitive excellence
☑ Increase global engagement
# 2025 Enrollment Plan Goals

<table>
<thead>
<tr>
<th></th>
<th>NEW</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshmen</td>
<td>+ 8.00%</td>
<td>+ 11.7%</td>
</tr>
<tr>
<td>Transfers</td>
<td>+ 51.8%</td>
<td>+ 141.3%</td>
</tr>
<tr>
<td>Master's</td>
<td>+ 30.4%</td>
<td>+ 25.2%</td>
</tr>
<tr>
<td>Doctoral</td>
<td>+ 51.8%</td>
<td>+ 28.4%</td>
</tr>
<tr>
<td>DVM</td>
<td>0%</td>
<td>+ 1.00%</td>
</tr>
</tbody>
</table>

+13.8% Total Enrollment Growth
2025 Enrollment Plan Goals

Fall Enrollment History 2009-2019

Total Enrollment by Career

- AGI
- GRAD
- NDS
- UGRD
- VETM

Total 2025 Enrollment Target: 38,700
Fall 2019 Enrollment: 36,290

Source: data.emas.ncsu.edu
Undergraduate Enrollment Trend

Source: data.emas.ncsu.edu as of August 19, 2019

Source: data.emas.ncsu.edu as of August 19, 2019
Graduate Enrollment Trend

Graduate Enrollment

- Masters
- PhD

Source: data.emas.ncsu.edu as of August 19, 2019
Undergraduate Enrollment Funnel

Applications - Freshmen

Freshmen Applications

Source: data.emas.ncsu.edu as of August 19, 2019
Undergraduate Enrollment Funnel
*Admitted - Freshmen*

Enrollment Management and Services

Source: data.emas.ncsu.edu as of August 19, 2019
Undergraduate Enrollment Funnel

Enrolled/Will Enter - Freshmen

Source: data.emas.ncsu.edu as of August 19, 2019
# Academic Profile

## Enrolled - Freshmen

<table>
<thead>
<tr>
<th>Measure</th>
<th>2019 Mid 50% Range</th>
<th>2019 Average</th>
<th>2013 Mid 50% Range</th>
<th>2013 Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SAT Evidence-Based Reading &amp; Writing and Math</strong></td>
<td>1270 – 1410</td>
<td>1337</td>
<td>1180 – 1310</td>
<td>1240</td>
</tr>
<tr>
<td><strong>SAT Composite</strong></td>
<td>27 – 32</td>
<td>29.3</td>
<td>26 – 30</td>
<td>28</td>
</tr>
<tr>
<td><strong>Unweighted GPA</strong></td>
<td>3.69 – 3.96</td>
<td>3.80</td>
<td>3.5 – 3.88</td>
<td>3.68</td>
</tr>
<tr>
<td><strong>Weighted GPA</strong></td>
<td>4.15 – 4.47</td>
<td>4.29</td>
<td>4.22 – 4.67</td>
<td>4.44</td>
</tr>
<tr>
<td><strong>Rank in class</strong></td>
<td>4.7% – 18.8%</td>
<td>13.2%</td>
<td>4.7% – 17.6%</td>
<td>12.7%</td>
</tr>
<tr>
<td><strong>Average GPA</strong> (weighted)</td>
<td>4.29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average GPA</strong> (unweighted)</td>
<td>3.80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average ACT</strong></td>
<td>29.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Top 20% of HS Class</strong></td>
<td>77%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Top 10% of HS Class</strong></td>
<td>49.7%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Demographic Trends
Enrolled - Freshmen

- **50.3%** Female
- **31.3%** Non-White students

- **654** Students from outside North Carolina
- **258** Black or African American
- **29** Native American
- **1136** Different high schools represented
- **292** Hispanic
- **2** Hawaiian / Pacific Islander
- **1470** Students from rural North Carolina counties
- **392** Asian
- **148** Non-Resident Alien
- **518** First generation college-bound students
- **188** Multiracial
- **189** Unreported

Source: data.emas.ncsu.edu as of August 19, 2019
Efforts to Shape the Class and Enhance Student Success

2020 Spring Connect

- 157 Students from rural North Carolina counties
- 122 males
- 200 females

2020 Spring Connect by College

- UC: 20.0%
- TEX: 3.4%
- MGMT: 14.2%
- COS: 14.5%
- CNR: 4.3%
- CHASS: 22.2%
- CED: 4.0%
- CALS: 17.5%

2020 Spring Connect by Race

- Two or more races: 5.85%
- White: 67.69%
- Black or African American: 8.31%
- Asian: 4.92%
- American Indian or Alaskan Native: 0.31%
- Hispanic: 9.85%
- Race and Ethnicity Unknown: 3.08%

Source: data.emas.ncsu.edu as of August 19, 2019
Undergraduate Enrollment Funnel

Applications - Transfer

Source: data.emas.ncsu.edu as of August 19, 2019
Undergraduate Enrollment Funnel
Admitted - Transfer

Transfer

Admit Rate

34.3% 33.5% 39.0% 38.7% 45.2% 35.3% 42.0% 42.9% 42.7% 43.8%

Total Admitted


Source: data.emas.ncsu.edu as of August 19, 2019
Undergraduate Enrollment Funnel
Enrolled/Will Enter - Transfer

Transfer Enrolled

Source: data.emas.ncsu.edu as of August 19, 2019
Academic Profile

Enrolled - Transfer

3.43 average GPA

Average GPA by College

<table>
<thead>
<tr>
<th>GPA</th>
<th>College</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.30</td>
<td>Agriculture &amp; Life Sciences</td>
</tr>
<tr>
<td>3.33</td>
<td>Design</td>
</tr>
<tr>
<td>3.37</td>
<td>Education</td>
</tr>
<tr>
<td>3.59</td>
<td>Engineering</td>
</tr>
<tr>
<td>3.33</td>
<td>Humanities &amp; Social Sciences</td>
</tr>
<tr>
<td>3.60</td>
<td>Management</td>
</tr>
<tr>
<td>3.29</td>
<td>Natural Resources</td>
</tr>
<tr>
<td>3.42</td>
<td>Sciences</td>
</tr>
<tr>
<td>3.34</td>
<td>Textiles</td>
</tr>
</tbody>
</table>

Top 10 Programs

- Business Administration
- Psychology
- Mechanical Engineering
- Communication
- Biological Sciences
- Animal Science
- Computer Science
- Political Science
- Electrical Engineering
- Sport Management

Source: data.emas.ncsu.edu as of August 19, 2019
## Demographic Trends

### Enrolled - Transfer

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students from outside North Carolina</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>Different transfer schools represented</td>
<td>253</td>
<td></td>
</tr>
<tr>
<td>Students from rural North Carolina counties</td>
<td>354</td>
<td></td>
</tr>
<tr>
<td>First generation college-bound students</td>
<td>186</td>
<td></td>
</tr>
<tr>
<td>Students from NC Community Colleges</td>
<td>56%</td>
<td></td>
</tr>
<tr>
<td>Non-White</td>
<td>36%</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>43%</td>
<td></td>
</tr>
<tr>
<td>Black or African American</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>Multiracial</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Native American</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Hawaiian / Pacific Islander</td>
<td>0</td>
<td></td>
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<tr>
<td>Non-Resident Alien</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>Unreported</td>
<td>72</td>
<td></td>
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<tr>
<td>Served in the Military</td>
<td>50</td>
<td></td>
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<tr>
<td>Active Duty</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Dependents</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

Source: data.emas.ncsu.edu as of August 19, 2019
Efforts to Shape the Class and Enhance Student Success

Community College Collaboration (C3)
One, Two and Three-Year Retention Rates

*Estimated Current Year Rates
Student Success

Graduation

Four, Five and Six-Year Graduation Rates

*Estimated Current Year Rates

Source: data.emas.ncsu.edu as of August 19, 2019
QUESTIONS?
ROTC Student Needs

Recognizing the need for improved parking for ROTC Students, we met with the ROTC Cadre from each branch and discussed the idea of extending the parking window for students who are required to be at Physical Training and ROTC class before 8am. We then met with Dr. Lisa Zapata, Interim Vice Chancellor, about this idea and were able to collaborate with parking to bring this to fruition. All branches of the ROTC now have a $10 parking pass available for the hours they are there when parking is enforced but their pass is not applicable. We also worked with Wellness and Recreation to open Miller Fields earlier for ROTC students to ensure they can complete their Physical Training and course on time.

Cultural Competency Training

We met with OIED to discuss the most impactful ways an online diversity competency training could be implemented at NC State. Working with OIED we decided that high impact practices would be the most effective way to implement a cultural competency training. Research led us to the University of Illinois at Urbana Champaign where we discovered their I-Connect series. This series is an interactive discussion required of incoming freshmen and transfer students, offered in the spring of each academic year where students can talk about shared experiences. We are currently reaching out to University of Illinois’ Diversity Department to do further research.

Respect the Pack

An annual event, Respect the Pack has been planned this year by our Director of Diversity Outreach, Zakiya Covington, and is set to occur on August 20, 2019 at 6pm. This year Director Covington has worked tirelessly to create a more welcoming and community environment by working with our Community Centers, including the GLBT Center, Women’s Center, African American Community Center, and Multicultural Student Affairs.

Prayer Space

Identifying a change in space, we worked with Campus Enterprises to move the Interfaith Prayer Space solely to Talley Student Union. Campus Enterprises will be monitoring traffic to
the space and we will be evaluating the need for a second space at the end of the Academic year.

Executive Officers 2019-2020
Emma Carter, Student Body President; Nicole Teague, Student Body Vice President; Mitchell Moravec, Student Senate President; Garrison Seitz, Student Body Treasurer; Kiera Jonson, Student Body Chief Justice

What have our members been up to?
Over the summer, our members have had internships, been able to travel and have gotten to build relationships with countless individuals from tech companies to political figures. Here are a few students who have been working hard this summer!

- Nicole Teague, Student Body Vice President
  - Nicole interned with JPMorgan Chase & Co. as a Technology & Reporting Intern where she able to create projects and present to senior leadership including the CEO of Consumer Banking, Thasunda Brown Duckett. At the end of her internship she also earned a full-time offer for after she graduates

- Daniel Mock- Director of Athletics
  - Daniel had an internship in Silicon Valley with Samsung. He served as a Software Engineering Intern.

- Jordan Clayborn- ASG Delegate
  - Jordan worked at a summer camp in Florida as a camp counselor, ropes course instructor, and CIT Program Director. He also went on a solo trip to New York.

Executive Branch Goals
As a branch with 10 Directors, we want to work together this year to build community and relationships here at NC State. Our directors have been working this summer to create and curate ideas and programs that relate to We promise to serve as allies to all students, connect the Student Body to Student Government, collaborate with students, administration, faculty, and staff through inclusive, sustainable efforts that can be continued beyond just this year.
Board of Trustees Report
August 20, 2019

The Faculty Senate report at the start of the academic year is always a bit unique, especially with a new Board of Trustees and a new Chair of the Faculty. The actions of the Senate since the last Trustees meeting were presided over by the Past Chair Carolyn Bird and this is being written before the Senate has begun its year. Nevertheless, the activity has been remarkable.

I am Hans Kellner, Chair for the 2019-2021 term. I was Chair once before, from 2011-2013, and I am the first to repeat in this position at NCState. Although I was a reluctant candidate, I hope to attack the job with what I have and to get some things accomplished. I believe in shared governance and have devoted a lot of time to it at several universities. What I have gotten from this service is a deep and broad picture of how a university works, both at levels above the faculty and below. The Faculty Senate is the ideal spot to see things whole. Even more gratifying -- and the best reason -- for running for the Senate -- are the relationships that grow from mixing people from many disciplines and regions of the campus. I'm happy to say, as I could say eight years ago, that we have in our chamber folks from 6 different continents -- as long as the Provost is in attendance.

That said, my principal goals at this point are to improve the Senate's physical condition and to attract more candidates for the body, especially for the top job. We have been in the same rooms in D.H. Hill Jr. Library since 1954 and we treasure them as historic and vital to the traditions of the faculty. But they need work. And we need to pay more attention to the history of our institution; it is remarkable and fascinating. Once the academic year begins, a torrent of issues can wash away goals and plans, but I intend to be persistent about bringing the Senate up to where it ought to be.
Because there are a number of new trustees, I shall recount the basics of the Faculty Senate, the one body representing all of the NCSU faculty, tenure-track and professional and emeritus. We are elected by colleges, weighted by size. The Senate is relatively small at 37 members, and we meet rather frequently -- every other Tuesday during the academic year, with committee meetings on alternate Tuesdays. (Compare that to Chapel Hill, with 90-odd members and monthly meetings.) Like the Board of Trustees, much Senate business is done in the four Senate standing committees, and the Senate is represented on all of the University Standing Committees and Advisory Committees that have such a major role in the development of university policy.

The Chair of the Faculty was for 45 years called the Chair of the Faculty Senate, elected by that body and serving for one year, until about 20 years ago it was decided that a longer term was necessary for the learning process and the growing job. Now the Chair signs up for a four-year commitment -- as Chair-elect, then two as Chair, then one more as Immediate Past Chair. And the Chair is elected by the General Faculty, no longer by the Senate -- hence the change of title. (By the way, the job of Chair, here and elsewhere, is also growing year by year. In Chapel Hill, the Chair of the Faculty Council recently stepped down with a year left in her term.)

The Chair of the Faculty represents the faculty in almost everything -- many committees, search committees, athletic and ceremonial events. At graduation, you Trustees will follow me as I carry the university mace (for your protection). As I write this in mid-August, the activity is in full swing. Since Chair Bird's last report to the Board, the Senate continued its inquiry into NCSU-sponsored child care, a perennial issue that becomes more important to faculty and staff every year. Interim Vice Chancellor Peloquin-Dodd and Human Resources head Marie Williams gave encouraging news about fresh arrangements and the future. The results of election for the Senate were announced, and Chair Bird earned praise for her successful effort at recruitment. We have a full Senate, and adequate membership for the important 603/607 pools that handle grievances and tenure hearing case (and are hard to fill).
The penultimate meeting in April was devoted mainly to athletics and academics, an important topic for the faculty. Joel Pawlak, the Faculty Athletic Representative, described the work of verifying eligibility for all student-athletes and maintaining relationships with coaches and staff.

Finally, the Senate presented a Resolution of Commendation to departing Athletic Director for upholding academic standards and supporting the teams of all the students as shown by our standing in the Director's Cup. This is what the faculty cares about. At the second meeting of my first term as Chair in 2011, the new AD Yow said she would do these two things, and, on the whole, she has.

This meeting and the last one were also devoted to elections -- Athletics Council, Faculty Assembly, Senate Executive Committee -- all of them important to the university and the System. The Alumni Association presented the outgoing Chair with an NCState rocking chair, a valuable tradition.

Facing the first meeting of the 67th session of the Faculty Senate, we have already received seven Issues of Concern, most of which will be referred to one or another of the standing committees. It will be a busy and demanding year.