NC State Engineering in the 21st Century

Louis A. Martin-Vega, Ph.D., P.E.
Dean of Engineering, NC State University

NC State Board of Trustees
September 21, 2007
Academic Departments

- Biomedical Engineering (BME)
- Chemical and Biomolecular Engineering (CBE)
- Civil, Construction, and Environmental Engineering (CCEE)
- Computer Science (CSC)
- Electrical and Computer Engineering (ECE)
- Industrial and Systems Engineering (ISE)
- Materials Science and Engineering (MSE)
- Mechanical and Aerospace Engineering (MAE)
- Nuclear Engineering (NE)

Engineering Departments in Other Colleges

- Biological and Agricultural Engineering (BAE)
- Wood and Paper Science (WPS)
- Textile Engineering (TE)
ND State Engineering

Students

- Enrollments Fall 2007
  - Undergraduate 5,738
  - Graduate 2,086

- Degrees awarded (2006-07)
  - Undergraduate 1,103
  - Graduate 585

- Among all U.S. engineering colleges*:
  - 5th in undergraduate enrollment
  - 12th in graduate enrollment
  - 9th in total degrees awarded
  - 8th in BS degrees awarded
  - 17th in MS degrees awarded
  - 19th in PhD degrees awarded

* ASEE figures for 2005-06
NC State Engineering

Diversity Profile

- 14th in BS degrees awarded to women
- 7th in BS degrees awarded to African Americans
- Top 10 in MS degrees awarded to African Americans
- NC State ranks in the Top Five among Non-HBCUs in the number of African-American faculty members
NC State Engineering

Faculty

- 910 faculty and staff, including 249 tenured and tenure-track faculty members
- 11 members of the National Academy of Engineering
- 1 National Medal of Technology
- 1 Emmy Award
- 77 Presidential and NSF recognitions, including
  - 52 NSF Career Awards
  - 3 Presidential Mentoring Awards
Mission: To significantly increase the number and success of underrepresented minority engineering and science faculty through partnerships

Director Christine Grant, Professor of Chemical and Biomolecular Engineering, NC State University
NC State Engineering

Research Expenditures*

- 17th in total research expenditures ($103M)
- 14th in industry sponsored research

*All US colleges of engineering for 2005-06
Engineering in the 21st Century

Forecasting the profession, NAE, 2004

NY Times columnist on globalization, 2004

30K-foot-view, plus proposals, National Academies, 2005

White House launches new initiative, 2006

Challenges and Opportunities
Enabling the Nation’s future through: Discovery, Learning, and Innovation

Strategic Goals

**PEOPLE**
Diverse, internationally competitive and globally engaged science and engineering workforce

**IDEAS**
Discovery across the frontiers of science and engineering, connected to learning, innovation, and service to society

**TOOLS**
Accessible, state-of-the-art, shared and networked research and education tools
Implementing the NSF Vision

Assure we are invested in vital areas of research growth and educational need

Make strategic investments in faculty and facilities
Interdisciplinary Thrust Areas

Emphasis on the integration of research and education

Engineering the Service Sector
Bioengineering
Nanotechnology
Robotics & Sensor Technology
Information & Communications Technology
Critical Infrastructure
Advanced Materials & Manufacturing
Energy & Environmental Systems
Transportation & Logistics
University Thrust Areas

- Faculty Research in Health and Well Being
  - Dr. Ruben Carbonell (Bioengineering)
  - Dr. Annie Antón (Information Privacy and Security)
- Undergraduate Research in Energy and the Environment
  - Casey Holder and Matthew King
- Innovation and Outreach in K-12 Education
  - Dr. Laura Bottomley
- Economic Impact
  - Secretary of Commerce Jim Fain
Dr. Ruben Carbonell
Frank Hawkins Kenan Distinguished Professor of Chemical and Biomolecular Engineering

Dr. Annie I. Antón
Associate Professor of Computer Science
Founder of ThePrivacyPlace.org
Separation and Purification of Proteins

• Human Protein Therapeutics
  – Antibodies, anticancer,…
  – Genetically engineered
    • Bacteria, mammalian cells
  – Human plasma sources

• High Value Products
  – ($25,000 - $500,000/lb)

• Biomanufacturing Industry Challenge
  – Rising costs of therapeutic products
    • Downstream processing 50-80% of manufacturing costs
Column Affinity Chromatography

- Find **small** molecules that bind **specifically** to a desired target protein
- Attach small molecules to porous particles
- Put particles in a column
- Pass the fluid through column to adsorb protein
- Remove the protein at high level of purity

**Step 1** Adsorb

**Step 2** Elute

- Combinatorial libraries
- Robust
- Inexpensive
- Made pure in large quantities

Feed → **Step 1** Adsorb → **Step 2** Elute → Product
New Process for Purifying Human Antibodies

- Current industrial process using expensive protein ligand from bacteria (Protein A)
  - Resin costs $15,000/L
  - Columns cost ~ $5,000,000
- New ligand:
  - Less expensive
  - Can withstand sterilization conditions
  - Mimics the binding of Protein A
  - Yields > 90%
  - Purity > 90%

H. Yang, P. Gurgel, R.G. Carbonell
Start-Up Co.: Blood Safety Applications

- Transmission of Mad Cow Disease (Prion Protein) by Blood Transfusion
- Removal of Prions from Plasma Biotherapeutics
- Removal of Viruses (HIV, Hepatitis, B19)

Pathogen Removal and Diagnostic Technologies, Inc (PRDT)

NC State University

University of Maryland

MacoPharma

NC STATE UNIVERSITY
Breakthrough in Prion Removal from Blood Products

- First-ever demonstrated removal of *endogeneous* prion infectivity from blood
- First-ever demonstrated removal of *spiked* prion infectivity from blood
MacoPharma P-Capt™ Filter

- Prion capture filter with affinity resin packed between nonwoven membranes
- Manufactured by MacoPharma Lille, FR
- Manufacturing process developed in collaboration with NCRC (NC State)
- Currently in medical trials
- Use in UK, Ireland, Scotland, Japan, France, Spain
- Building up resin production capacity
Other Applications

• Resin captures prion from plasma biotherapeutics (3 biomanufacturers)
• Pre-mortem prion diagnostics (mad cow diasease)
• Hepatitis A, Parvoviruses
• Homeland security, food safety
  – Salmonella, Anthrax, Staphylococcal Enterotoxin B (SEB), Ricin B Chain
  Lee Ann Jaykus (Food Science)
Bioengineering Faculty in CBE

- Dave Ollis
  - Bailey & Ollis, Biochemical Engineering Principles
- Bob Kelly
- Carol Hall
- Jan Genzer
- Orlin Velev
- Steve Peretti
- Jason Haugh
- Bala Rao
- Henry Lamb
- Michael Flickinger (Microbiology, BTEC)
- Peter Kilpatrick (BTEC)

International Society of Pharmaceutical Engineers (ISPE) Student Chapter
Biomolecular Concentration
Biomanufacturing Science Concentration
Golden Leaf Biomanufacturing Training and Education Center (BTEC)
Bioseparations and Bioprocessing Development Center (BBDC)

• **Vision**
  – Supports research needs of the biomanufacturing industry
  – Complements the educational and training mission of BTEC
  – A “virtual center” that utilizes existing infrastructure
  – Collaborative, multi-disciplinary, multi-institutional
  – Facilitate advancements in production of biologicals
  – Helps attract biotechnology companies to NC

Symposium
NCBC
Oct. 25-26, 2006
150 Participants
16 Corporations
Research Collaborations with BBDC

- Use of supercritical fluids for extraction of nutraceuticals from plants (Avoca)
- Purification of antibodies from mammalian cell culture (Biogen Idec)
- Separation of enzymes from fermentation broths (Novozymes)
- Removal of prion protein from blood products (Prometic BioSciences, American Red Cross)
Information Privacy & Security

Annie I. Antón

Department of Computer Science
College of Engineering
North Carolina State University

NCSU Board of Trustees
September, 2007
Context: Compliance & Privacy

- Properly protecting information is in all our best interests.

- Compliance with regulations was the primary driver of information security policy from 2004-2007 [Ernst & Young].

- Companies are increasingly being held accountable for their privacy practices.

- Information systems must be designed holistically within broader regulatory and legal compliance context.

  Machine-readable and machine-enforceable policies are needed to consistently apply privacy practices and prevent breaches.
The Legal Compliance Landscape

HIPAA/PIPEDA/EU/OECD: Regulatory Compliance
Stiff criminal and civil penalties may be imposed for non-compliance. Our software fully complies with all current HIPAA regulations, as well as the Common...

www.sona-systems.com/compliance.asp - 14k - Cached - Similar pages

HIPAA.ORG - EDI Practice Management System Directory
There is no such thing as "HIPAA compliant" software. The responsibility to be compliant rests with the practice. However, the software can be "HIPAA ready"...

www.hipaa.org/pmsdirectory/help_physicians.php - 18k - Cached - Similar pages
Support & Collaboration

- **National Science Foundation**
  - *Medium ITR Grant (2003-2008)*
    Antón, Earp, Baumer, Aiman-Smith @ NCSU
    Potts @ Georgia Tech
  - *Cyber Trust Grant (2004-2008)*
    Antón, Yu, Baumer, Rappa @ NCSU
    Bertino, Li @ Purdue University
    Antón, Baumer @ NCSU
    Spafford @ Purdue University

- **Computing Research Association DMP**
  ('04,'05,'07)

- **IBM**

- **Purdue University CERIAS**
THE BEST THING ABOUT
THE INTERNET IS THEY
DON'T KNOW YOU'RE A DOG.

You're a four-year-old German Shepherd-Schnauzer mix, likes to shop for
rawhide chews, 213 visits to Lassie website, chatroom conversation
8-29-99 said third Lassie was the hottest, downloaded photos of third
Lassie 10-12-99, e-mailed them to five other dogs whose identities are...

D ID YO U
M AR K
A LL T H A T?
Investigating Data Breaches
JetBlue Airways & ChoicePoint


- Understanding privacy breaches in real information systems is complex...
Impact on NCSU
Research & Education

- $2.6M from NSF for our compliance research projects since 2003.
- Addressing the critical shortage of information security & privacy professionals in the U.S. [PITAC’05 & NRC’07]
- Interesting synergy:
  - First J.D. / Ph.D. will graduate in 2010.
  - Second J.D. / Ph.D. is studying for the LSAT.
- National recognition for our privacy students:
  - 4 Cisco National Information Assurance Scholarships
  - 1 two-time IBM Ph.D. Fellowship
  - 1 $10,000 Google Anita Borg Undergraduate Scholarship
  - 1 NSF PhD Fellowship (pursuing PhD at CMU)
- CSC faculty have graduated 9 security PhDs in past three years & 23 more are in progress!
Helping Shape National Policy

- NSF Distinguished Lecture & CISE AC
- CRA Board of Directors
  - A leading org for science & education policy
- IDA/DARPA Defense Science Study Group
  - Enhanced information sharing
- U.S. DHS Data Privacy and Integrity Advisory Committee
- US ACM Public Policy Executive Committee
  - Privacy Design Principles
  - eVoting
- Congressional Testimony
  - House Ways & Means Social Security Subcommittee, June 2007
Examples of Current Research in the College

- Process for turning fats into jet fuel and biodiesel fuel
- New plastics recycling for food-grade containers
- Reduction of nuclear waste hazards
- Modeling of vehicle emissions and improved emissions data
- Cost-effective alternative fuels
Matthew King
Graduate student in Materials Science and Engineering

Casey Holder
Senior in Materials Science and Engineering
The Institute for Maintenance Science and Technology (IMST)

Graduate Student Mentors
Christopher Oldham
Patrick Davis
Brian Allen
Myles Connor
Brad Hartman
Brendon Bass
Kelly Ervin

Undergraduate Students
Lindsay Berk
Raphael Clearfield
Steven Disseler
Angie Felker
Michael Hallock
Joseph Heil
Casey Holder
Matthew King
Kristina Marshall
Beth Paisley
Mary Rebovich
Matthew Ross
Margaret Schilling
Jessica Sievers
Steven Weuster
Jeremy Wooock

Faculty/Staff Mentors
Dr. Jerry Cuomo
Dr. Roger Sanwald
Dr. John Strenkowski
Dr. Richard Guarnieri
Robert Roth
Darren Thomas
Tom Hunter
James Mullin
Undergraduate Research in Energy and the Environment

Converting Hog Waste to Methanol

**Undergraduate Researchers**
Casey Holder, Kristina Marshall

**Graduate Mentors**
Patrick Davis, Christopher Oldham

- Developed process with Orbit Energy Inc. to convert hog waste (methane) and greenhouse gas (carbon dioxide) to a renewable energy source (methanol) with a novel reactor.

- Found that atmospheric plasma can be used to generate methanol, ethanol and other high-value carbon compounds.

\[ \text{CH}_3\text{-OH} \] (methanol)
Undergraduate Research in Energy and the Environment

Converting Wood Chips to Ethanol

Undergraduate Researchers
Matthew King, Steven Disseler, Mary Rebovich

- Atmospheric plasma breaks down biomass (wood) into glucose and xylose (sugars) that can be fermented to make ethanol.
- Demonstrated 50% increase at low power, low temperature and atmospheric pressure.
- A patent application has been filed for this process.

Graduate Mentor
Christopher Oldham

Fermentable Sugars

$\text{CH}_3\text{-CH}_2\text{-OH}$ (ethanol)
Impacts of Undergraduate Research

• **Academic**
  - Posters, presentations, papers and patents!
  - Graduate school

• **Collaboration**
  - Interdepartmental: BAE, CBE, WPS, ISE, ECE, Food Science, Textiles
  - Interdisciplinary: Engineering, Physical Sciences, Energy Science

• **Career**
  - Job offers: US Army Contractor, Nucor
  - Internships: Micron Technology, Nucor, Progress Energy
These students are the engineers of 2020
Community and Campus Goals

• National Impact
  – Networking with universities to incorporate engineering in the K-12 curriculum, encourage underrepresented groups in engineering and aide engineering professionals in outreach

• North Carolina Impact
  – Encouraging NC Public Schools to teach technology and incorporate engineering in NC Standard Course of Study and encouraging teachers to teach STEM courses with depth

• Local Impact
  – Improving recruiting and retention of engineering students at NC State, especially women and underrepresented minorities, and establishing links between teachers and the university
We continually strive to make a difference

- Data show that outreach can have a significant effect on:
  - Students (5,000)
  - K-12 teachers (200)
  - Parents (500)
  - Engineering professionals (100)
  - Undergraduate students (200)
  - Graduate students (10)
  - How the University and the College are viewed by the public
Off Campus

- NSF/GE Foundation program, partnering with Shaw University
- Engineering on the Road
- Teacher workshops
- Freshman K-12 outreach projects
On Campus

- Summer camps for elementary - high school students
- Campus visits for elementary - high school students
- Participation of middle and high schools in Freshman Design Day
- Open house presentations for middle school students
Research Based Efforts

- Involve all student groups
- Special programs for ESL and hearing impaired classes
- Emphasis on active/visual learning
- Cooperative relationships with tribal schools

Classroom Science Gets a Makeover: NSF GK-12 Fellows Bring Hands-on Lessons to Young Students

Students and teachers in Wake County, North Carolina learn to enjoy a hands-on approach to elementary school science education.
Collaborative Contributions

- Boston Museum of Science
- Science, engineering and math nights and science fairs
- Central regional science fair
- Science Olympiad
- National engineering standards for K-12 curriculum
- Reform science and math in county public schools
- Reform for STEM education in NC
- Expanding Your Horizons
- Q&A website
Selected Sponsors

- GE Foundation
- NSF GK-12 Program
- Burroughs Wellcome Fund
- Alcoa
- Boeing
- Duke Energy
- Caterpillar
- Lucent
- NASA
Economic Impact: Private Sector

- Educate engineers and computer scientists for high-tech industries
- Conduct innovative research for next-generation of technology
- Create new jobs through tech transfer and entrepreneurship
- Examples of start-up companies:
  - Cree
  - Nitronex
  - HexaTech
  - Stingray Software
  - ChannelAdvisor
  - Da Vinci Systems
  - MiCEL
  - TransLoc
# Economic Impact: Public Sector

## NSF Bioreactor Partnership*

<table>
<thead>
<tr>
<th>Private Owners</th>
<th>Engineering Firms</th>
<th>Industry Associations</th>
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<tr>
<td>Allied Waste Industries</td>
<td>GeoSyntec Consultants</td>
<td>National Solid Waste Management Association</td>
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<tr>
<td>Onyx Waste Systems</td>
<td>CH2M Hill</td>
<td>Solid Waste Association of North America</td>
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<td>Republic Services</td>
<td>CDM</td>
<td>Environmental Research and Education Foundation</td>
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<td>Waste Connections</td>
<td>SCS Engineers</td>
<td>National Council for Air and Stream Improvement</td>
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<td>Waste Management</td>
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### Public Owners

- Buncombe County, NC
- Delaware Solid Waste Authority
- Yolo County, CA

### Regulatory Agencies

- US EPA
- NY Dept. of Environmental Conservation
- Wisconsin Dept. of Natural Resources

* Dr. Mort Barlaz, NC State, and Dr. Craig Benson, U of Wisconsin
The College of Engineering’s Industrial Extension Service (IES) is the first industrial extension service established in the nation (1955).

Over the past five years, companies assisted by IES reported $500 million in direct economic impact from IES’ services, and in 2005-06 alone, IES helped retain or create 1,237 jobs across the state.

IES director Terri Helmlinger Ratcliff is the first woman to serve as president of the National Society of Professional Engineers.
Mr. Jim Fain
Secretary of Commerce
North Carolina
Our Place in the Rankings
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<td>NC State</td>
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<td>Virginia</td>
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<tr>
<td>Clemson</td>
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<tr>
<td>ARWU*</td>
<td>2007 Rank</td>
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<td>MARYLAND</td>
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<td>&gt;100</td>
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- **Academic Ranking of World Universities**
- Developed by the Institute of Higher Education of the Shanghai Jiao Tong University
- Rankings used by the *Wall Street Journal* and *The Economist*
What should the goal be?

“To become and be perceived as the leading public college of engineering in the country and one of the leading colleges of engineering in the world”

Our College is well positioned and ready to make this happen...
Alumni Opportunity: Leverage and enhance state, university commitments

State’s Commitment: Increased $$$ for New Facilities and Infrastructure

University’s Commitment: Increased $$$ for Growth, New Faculty
Investments in New Faculty

2007-08

• 24 new faculty
• 6 new women faculty members
• Significant critical mass in interdisciplinary areas

Bioengineering & Health Systems
Kemafor Anyanwu, CSC
Paul Dayton, BME
Brian Denton, ISE
Julie Ivy, ISE
Michael Gamcsik, BME
Nagiza Samatova, CSC
Reha Uzsoy, ISE
Yaroslava Yingling, MSE

Energy & Environment
Jacob Eapen, NE
Tiegang Fang, MAE
Wesley Henderson, CBE
Hany Abdel Khalik, NE
Steven Shannon, NE
Jie Yu, CCEE

Nanotechnology
Paul Cohen, ISE
Joseph Tracy, MSE
Yong Zhu, MAE
Yuntian Zhu, MSE

Other Thrust Areas
Kirill Efimenko, CBE
Xiaohui Gu, CSC
Min Liu, CCEE
Hong Luo, MAE
David Schurig, ECE
James Tuck, ECE
Investments in Infrastructure

State budget includes $34M to expand Engineering Building III, which will house the departments of Biomedical Engineering and Mechanical and Aerospace Engineering.
Meet the Dean

2007
Meet the Dean Hosts

**Nov. 30, 2006 - Raleigh**
Dr. & Mrs. Joseph Archie, Jr. ’68
Sepi & Farzia Asefnia ’93
Dr. & Mrs. Calvin Carter, Jr. ’77
Mr. & Mrs. Thomas Church, Jr. ’64
Mr. Wayne Clark
Mr. & Mrs. Joseph Colson, Jr. ’68
Mr. & Mrs. Michael Creed ’73
Mr. & Mrs. Justus Evrette ’76
Mr. & Mrs. Glenn Futrell ’63
Mr. & Mrs. Ramey Kemp, Jr. ’65
Gayle & Dwain Lanier ’82
Dr. & Mrs. Charles Manning, Jr. ’67
Mr. & Mrs. James Williamson ’86

**Jan. 11, 2007 - Wilmington**
Mr. Ron Brown ’74
Mr. Paul Burton ’61
Mr. Ken Dull ’85
Mr. Jack Erdody ’67
Ms. Nicole Holmes ’94

**Jan. 18, 2007 - Winston-Salem**
Mr. Marcus Crotts ’53
Mr. Richard Harrington ’77
Mr. Don Lamonds ’78
Mr. Ed Scott ’65
Mr. Tim Scronce ’87
Mr. Edwin Welch, Jr. ’99
Mr. Ron Morgan ’78

**Feb. 8, 2007 - Washington, DC**
Mr. Ray Sparrow ’78
Mr. Wayne Day ’65
Mr. Bill Dean ’88
Mr. Tom McPherson ’76

**Feb. 21/22, 2007 - Houston and Dallas, TX**
Mr. John Chambard ’97
Mr. Frank Culberson ’60
Mr. Ned Hill ’90
Mr. Clyde Moore ’50

Mr. Roger Owens ’69
Mr. Gilbert W. Smith ’49
Mr. Carl Stutts ’68
Mrs. Theresa Snyder ’85
Mr. Greg Schwartz ’87
Mr. Frank Culberson ’60

**March 14, 2007 - San Jose, CA**
Mr. Christopher Crump ’78
Mr. Bobby Johnson ’77
Mr. William Parks ’49
Mr. Ken Watkins ’71

**April 5, 2007 - Greensboro**
Mr. Quint Barefoot ’85
Mr. Willie Bullock ’74
Mr. Jimmy Clark ’74
Mr. E.O. Ferrell ’66
Mr. Rob Kennerly ’76
Mr. Phil Kennett ’62
Mr. Bob Mackey ’72
Mr. David Parker ’68
Mr. Bob Rhodes ’60
Mr. Norm Samet ’59
Mr. Tim Scronce ’87
Mr. Ken Stevens ’72

**April 12, 2007 - Atlanta, GA**
Mr. Jeff Buffo ’86
Mr. Bill Bullock ’57
Mr. Richard Little ’65
Mr. Roger Scovil ’51

**April 24, 2007 - Charlotte, NC**
Mr. Penn Cassels ’60
Mr. Kim L. Craven ’77
Mr. Otis Crowder ’70
Mr. Ed Ernst ’75
Mr. Jesse Fearrington ’73
Mr. Tom Forshaw ’66
Mr. Tim Holleman ’71
Dr. Charles R. Manning Jr. ’78

Mr. Ron Pendred ’76
Mr. Larry Petty ’54
Mr. Chris Rolfe ’72
Mr. Ron Sherrill ’70
Mr. J. Philip Sweet ’76
Mr. Bill Vernon ’74
Mr. Craig Wardlaw (friend)
Mr. & Mrs. H.G. Warren Jr. ’84
Mr. Ed Weisiger Jr. ’82
Mr. Mark Wyatt ’80

**May 1, 2007 - Raleigh, NC**
Mr. Scot Wingo ’92
Mr. Tim Clancy (friend)
Mr. Joe Doman ’87
Dr. Allen Eberhardt ’72
Mr. Donnie Goins ’85
Mr. Steven Kuekes ’81
Mrs. Suzanne Gordon ’75
Mr. Ralph Gordon ’72
Mr. Henry Liles ’74
Mr. Smedes York ’63
Mr. Jack McDonald (friend)
Mr. Robert Meares ’74
Dr. Francis P. O’Dell ’75
Mr. Dan Perry ’77
Mr. Stuart Phoenix ’76
Mr. John Simmons ’65
Mr. Ross Lampe Jr. ’77
Mr. Willy Stewart ’81
Mr. Tim Scronce ’87
Dr. Robert E. Troxler ’83
Mr. Ed Vick ’56
Mr. Ed White ’78
Mr. Chuck Wilson ’65
Mr. Marc Reese ’84
Mr. Bob Wright ’68
Our ultimate goal is to assure that the "E" in Engineering truly stands for Excitement.