



**VILLANOVA**  
**UNIVERSITY**  
IGNITE CHANGE. GO NOVA.

The Center for  
**Energy-Smart  
Electronic Systems**  
at Villanova University

A National Science Foundation  
Industry/University Cooperative  
Research Center



[www.villanova.edu/ES2](http://www.villanova.edu/ES2)

**ES2**

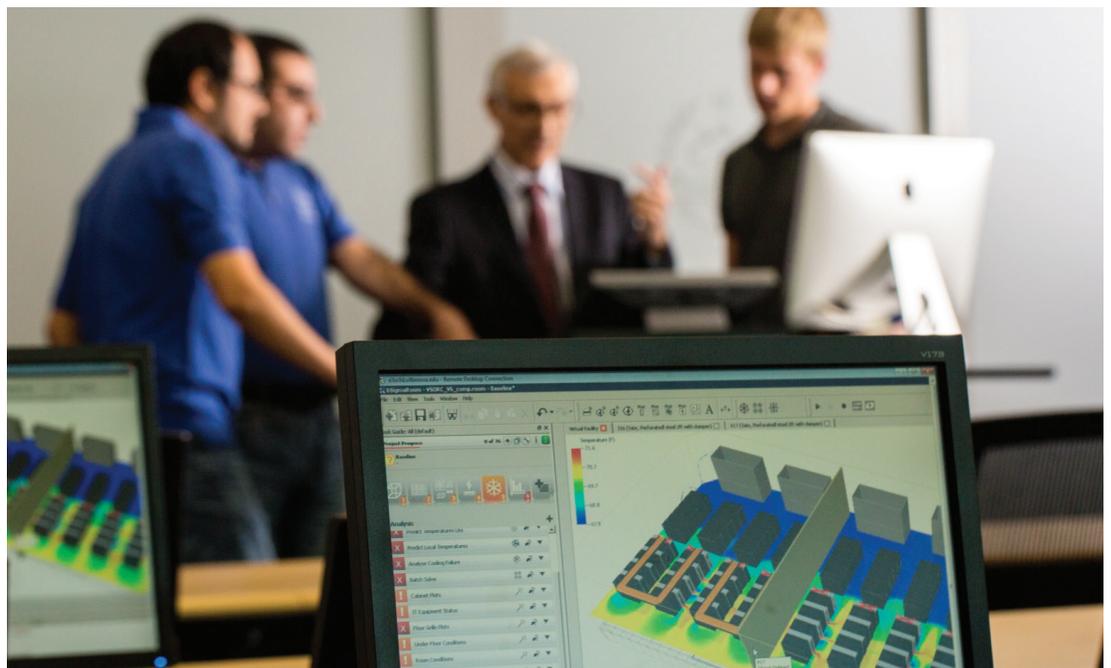
Center for Energy-Smart  
Electronic Systems



## THE CENTER FOR ENERGY-SMART ELECTRONIC SYSTEMS (ES2)

is a National Science Foundation Industry/University Cooperative Research Center (I/UCRC) established to develop methodologies for efficient operation of electronic systems, including data centers, by controlling resources and managing workloads to achieve optimal energy consumption.

ES2 is the first research center of its kind funded by the NSF. The Center works in partnership with industry and academia to develop systematic methodologies for operating electronic systems and cooling equipment synergistically, as dynamic, self-sensing and self-regulating systems that are predictable, stable and verified in real-time. By bringing together computer scientists and mechanical and electrical engineers, and linking the fields of information technology, dynamic systems control, thermodynamics, electronic systems and electronics cooling, the Center integrates research in all aspects of energy efficiency in electronic systems and data centers, “from the chip to the cooling tower.” This holistic approach to the development and design of energy-smart electronic systems could translate into millions of dollars in savings and a “greener” industry, touching everything from personal handheld devices to the massive data centers behind Internet enabled services such as search engines, e-commerce and social media.



Center for Energy-Smart  
Electronic Systems



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## ES2 UNIVERSITY PARTNERS

Binghamton University is the lead university working with Georgia Tech, University of Texas at Arlington and Villanova University



UNIVERSITY OF  
**TEXAS**  
ARLINGTON



**VILLANOVA**  
UNIVERSITY





## MEMBER BENEFITS

The opportunity to share in the Center's strategic planning through representation on the Industrial Advisory Board (IAB).

Access to a shared research pool from Villanova and the other member universities.

The opportunity to conduct exclusive and confidential research through one-on-one partnering.

Early access to research publications, short courses and electronic systems databases.

Access to non-exclusive, royalty-free licenses to use or incorporate any research product or invention developed within the Center.

Access to Villanova University's PhD-level graduate students for internships and permanent positions.

Access to laboratories, research equipment, infrastructure and expertise at Villanova University and all of the ES2 partner campuses.

Opportunities to develop research partnerships across the I/UCRC network.





## STEPS TO FOLLOW FOR PROSPECTIVE MEMBERS JOINING THROUGH THE VILLANOVA UNIVERSITY SITE

- Visit the ES2 website [www.villanova.edu/ES2](http://www.villanova.edu/ES2) to learn more about the Center.
- Contact Site Director, Dr. Al Ortega (aortega@villanova.edu), for further details about the Center and to discuss your areas of interest.
- Your company's interest will then be discussed with the ES2 site directors and the Industrial Advisory Board (IAB) at the earliest opportunity.
- If your company's interests are consistent with the mission and goals of ES2, you will be invited to attend the next biannual ES2 IAB meeting where you can meet the IAB members, university site directors and researchers. You will be asked to sign a confidential non-disclosure agreement prior to the meeting. The IAB meets twice per year, at the conclusion of Q2 and Q4.
- If your company elects to join the center, the Villanova University team will guide you through the membership process. Formal membership requires that you sign a membership agreement with Villanova University (acting on behalf of the ES2), detailing the terms and conditions of membership. All companies sign a common agreement—the agreement may not be customized.
- Your company can begin active participation in the Center immediately upon signing the membership agreement.
- Your annual membership fee is \$50,000 and entitles you as a member to full privileges including a nonexclusive royalty-free license to ES2-funded university inventions and a role in the selection of research projects. Generally, the annual fee is paid in one annual payment but the member company may arrange for semi-annual or quarterly payments.
- Member companies are encouraged to guide the projects by actively mentoring those which are of interest to the company. Company mentors meet with the university research teams via a monthly Web conference and attend two yearly meetings of the IAB hosted by the university sites.



## INDUSTRY PARTNERS

Bloomberg  
Comcast  
CommScope  
Corning  
Degree Controls  
DVL Group  
Endicott Interconnect  
Technologies  
Facebook  
Future Facilities  
IBM  
Internap  
Mestex  
Microsoft  
NYSERDA  
Panduit  
Quanta Cool  
Rambus  
Sealco/Bick Group  
Steel ORCA  
Triad Tiles  
Verizon  
Wolverine/MicroCool



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“Through our partnership with ES2, we see an opportunity to test the limits of technology in a lab environment while developing and leveraging the talents of future leaders in this very important and highly competitive field.”

**Richard Craig**  
**Director of Engineering and**  
**Operations Support**  
**Verizon Wireless**

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# VILLANOVA UNIVERSITY

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## MEMBERSHIP MAP



National Science Foundation  
WHERE DISCOVERIES BEGIN



Rambus

Microsoft



nyszerda  
Energy. Innovation. Solutions.

PANDUIT



BINGHAMTON UNIVERSITY  
STATE UNIVERSITY OF NEW YORK

CORNING



Bloomberg



VILLANOVA UNIVERSITY



verizon wireless

Comcast



facebook



MESTEX  
A Division of Mestek Inc.  
4830 Transport Drive | Dallas TX 75247

INTERNAP



WOLVERINE  
MICROCOOL  
ENGINEERING THERMAL INNOVATION



UNIVERSITY OF TEXAS  
ARLINGTON

# ES2

Center for Energy-Smart  
Electronic Systems



## CURRENT ES2 FUNDED PROJECTS

Thermodynamic Tools for Holistic Analysis  
and Optimization of Energy Efficient Data Centers

Energy-Aware Scheduling of Linux Servers and  
Synergistic Management of Workload, IT Equipment and Cooling System

Compact Models for Rapid Thermal Modeling  
of Data Centers: Phase 2

Maximizing Use of Efficient Air-Side Economization in Modular,  
Large Data Centers and Datacom Housing Units

Computational and Experimental Models in Design of Dynamic,  
Energy-Efficient Cooling Solutions for Very High Power Data Centers

Models and Metrics for Dynamic Air and Hybrid Liquid Cooled Data Centers  
Based on Computational and Experimental Approaches

Energy-Aware Virtualization for Data Centers

High Bandwidth Integrated Parallel Optical Communication Links  
for Power Efficient, Cost Effective Data Center Interconnects

Impacts of Particulate and Gaseous Contamination on  
IT Equipment Where Air-Side Economizers are Implemented

Waste Heat Recovery and Reuse from Data Centers

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“Our goal as an ES2 partner is to provide a dual platform for researchers to use our digital utility center labs to innovate, test and prove theory. We are also pleased to provide a production theatre for commercial applications consequent to the work done in the lab.”

**Dave Crocker, CEO, Steel ORCA**

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Center for Energy-Smart  
Electronic Systems



## VILLANOVA UNIVERSITY

With one of the most respected Thermal and Fluid Sciences research groups in the country, Villanova University College of Engineering brings a number of areas of expertise to the ES2 team:

- Thermal management
- Electronics cooling
- Fluid mechanics
- Convective heat transfer
- Sustainable energy technology
- Multiscale systems
- Computational fluid dynamics
- Modeling

Villanova's outstanding thermal-fluids laboratories contribute to the mission of the NSF ES2 Center:

- Laboratory for Advanced Thermal and Fluid Systems
- NovaTherm—Villanova's Thermal Management Laboratory

- Thermal and Flow Management of Multiscale Systems Laboratory
- Multiscale System Analysis Laboratory

Augmenting the breadth of Villanova ES2 team's approach to data center energy management is the collective expertise found in the Villanova Center for the Advancement of Sustainability in Engineering (VCASE). VCASE is one of the first national research centers devoted to sustainable engineering practice and is comprised of an interdisciplinary group of researchers who are addressing these related topics:

- Alternative and renewable energy
- Biorenewable resources and conversion technologies

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## VILLANOVA UNIVERSITY

### *Continued*

- Environmental sustainability
- Sustainable infrastructure and materials
- Stormwater management

As one of the top 15 undergraduate engineering schools in the country (US News & World Report), Villanova's College of Engineering is nationally recognized for its academic excellence. That excellence extends to a robust

and growing graduate studies program, which offers nine Master of Science degrees and a PhD in engineering. Villanova's ES2 team integrates world class research within the goal of developing outstanding scholars, innovators and leaders who will put that research into practice within partner companies. The Center also provides opportunities for inter-university student and faculty exchange.



Center for Energy-Smart  
Electronic Systems



## VILLANOVA'S ES2 TEAM



**Dr. Alfonso Ortega**  
James R. Birle Professor of Energy Technology  
Associate Vice President for Research  
and Graduate Programs,  
and Site Director, NSF I/UCRC in Energy-Smart  
Electronic Systems, Villanova University

Dr. Alfonso Ortega is the James R. Birle Professor of Energy Technology and Associate Vice President for Research and Graduate Programs at Villanova University. He is the Director of the Laboratory for Advanced Thermal and Fluid Systems, which he founded in 2005.

Dr. Ortega received his BS from The University of Texas-El Paso and his MS and PhD from Stanford University, all in Mechanical Engineering. His career has included:

- Six years on the technical staff at Sandia National Laboratories where he worked on solar and geothermal energy research
- Director of the Experimental and Computational Heat Transfer Laboratory and a faculty member in the Department of Aerospace and

Mechanical Engineering at The University of Arizona in Tucson, where he spent 18 years

- Program director for Thermal Transport and Thermal Processing in the Chemical and Transport Systems Division of the National Science Foundation in Arlington, Virginia, where he managed the NSF's primary program funding heat transfer and thermal technology research in US universities

At Villanova University, Dr. Ortega teaches the science and design of thermal systems. His areas of research include:

- Thermal management in electronic systems
- Convective and conjugate heat transfer in complex flows

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## VILLANOVA'S ES2 TEAM

### *Continued*

- Experimental measurements in the thermal sciences
- Thermal management in energy systems

Dr. Ortega has supervised more than 40 MS and PhD candidates to degree completion, five postdoctoral researchers, and more than 70 undergraduate research students. In 2012, he was named to Villanova's newly created position of Associate Vice President for Research and Graduate Programs. In this role, he leads the University's Office for Research and Graduate Programs, which oversees Villanova's internally and externally funded research activities, the Office of Research Administration, the Center for Undergraduate Research and Fellowships, and coordination of campus-wide graduate programs.

The author of more than 300 journal and symposia papers, book chapters and monographs, Dr. Ortega is currently an associate editor of the ASME Journal of Heat Transfer, a former associate editor of the ASME

Journal of Electronic Packaging and guest associate editor of the IEEE Transactions on Components, Packaging, and Manufacturing Technology.

Dr. Ortega is a Fellow of the American Society of Mechanical Engineers (ASME), a former chair of the ASME K16 Committee on Heat Transfer in Electronic Equipment and the ASME Electronic and Photonic Packaging Division. He was the general chair of the ASME/IEEE IThERM Symposium, the IEEE SEMITHERM Symposium, and the 2005 ASME International Electronic and Photonic Packaging Conference. He is the recipient of the National Science Foundation Presidential Young Investigator Award, the ASME Electronic Packaging Division Thermal Management Award, and the SEMITHERM Significant Contributor Award.





## VILLANOVA'S ES2 TEAM



**Dr. Gerard F. 'Jerry' Jones**  
**Professor of Mechanical Engineering and Senior Associate Dean for Graduate Studies and Research**

After gaining industry experience at Mobil Oil Corporation and Los Alamos National Laboratory, Dr. Gerard F. 'Jerry' Jones joined the College of Engineering in 1987. Today, he oversees research and graduate studies for the College of Engineering and has taught in the areas of heat transfer, fluid mechanics, thermodynamics, analysis and design, and gravity-driven water networks. He also regularly travels with students to conduct international service-engineering projects. At the graduate level, he teaches:

- Heat conduction
- Convection
- Computational fluid dynamics
- Advanced fluid dynamics
- Solar thermal energy conversion

Dr. Jones directs the Thermal and Flow Management of Multiscale

Systems Laboratory, where he investigates heat transfer in composite materials, high-performance heat exchangers, and thermal management of power production and dissipation systems. He is a Fellow and active member of the American Society of Mechanical Engineers (ASME) and serves on the ASME K-20 Committee on Computational Heat Transfer. He also serves on the Committee on Science and the Arts for the Franklin Institute of Philadelphia and was recently published as the author of the book *Gravity-Driven Water Flow in Networks: Theory and Design*.

Dr. Jones earned his Bachelor of Science in Mechanical Engineering from Villanova University. His Master of Science and PhD in Mechanical Engineering and Applied Mechanics are from the University of Pennsylvania.



## VILLANOVA'S ES2 TEAM



**Dr. Amy Fleischer**  
**Professor of Mechanical Engineering and**  
**Director of NovaTherm—The Villanova Thermal**  
**Management Laboratory**

Internationally recognized for her expertise in thermal fluid systems design, Dr. Amy Fleischer's research interests include sustainable energy systems design and thermal management of electronic systems. Recent investigations have included:

- Energy storage in phase change materials
- Development of nano-enhanced materials
- Jet impingement
- Porous heat sinks
- Boiling heat transfer

She currently teaches thermal fluid systems design, thermal management of electronics and conduction heat transfer.

Dr. Fleischer has served as chair of the ASME Heat Transfer K-16 Technical Committee on Electronics Thermal Management and on the Executive Committee of the ASME's Electronics and Photonics Packaging Division (EPPD), which named her the 2010 Woman Engineer of the Year. She also received the 2011 ASME K-16/EPPD Clock Award in recognition of outstanding contributions to the field of heat transfer in electronics.

Dr. Fleischer earned her Bachelor of Science and Master of Science degrees in Mechanical Engineering from Villanova University and her PhD from the University of Minnesota.



## VILLANOVA'S ES2 TEAM



**Dr. Aaron P. Wemhoff**

**Assistant Professor of Mechanical Engineering and  
Director of the Multiscale System Analysis Laboratory**

Prior to joining Villanova University, Dr. Aaron P. Wemhoff spent three years as a staff engineer at Lawrence Livermore National Laboratory. Today, he teaches courses in the areas of thermodynamics, heat transfer and fluid mechanics at the undergraduate and graduate levels. He also directs the Multiscale System Analysis Laboratory, where he pursues research in the areas of computational and microscale heat transfer. Recent projects have involved nanoscale energy conversion and storage applications, development of new methods in computational heat and mass transfer, and energy conservation in HVAC systems using advanced control schemes.

Dr. Wemhoff currently serves on the board of directors for the Philadelphia section of the ASME and on the ASME K-20 Committee for Computational Heat Transfer. He is also a member of the editorial board for the International Journal of Transport Phenomena.

Dr. Wemhoff earned his Bachelor of Science in Mechanical Engineering at the University of Virginia and his Master of Science and PhD in Mechanical Engineering at the University of California, Berkeley.



## VILLANOVA'S ES2 TEAM



**Dr. Kamran Fouladi**  
**Adjunct Professor of Mechanical Engineering**

Dr. Kamran Fouladi oversees InfoMec Solutions, the computational fluid dynamics (CFD) consulting firm he founded in 2000. With more than 25 years of experience in the fields of mechanical and aerospace engineering, Dr. Fouladi currently focuses on research pertaining to thermal management and state-of-the-art airflow simulation tools for modeling data centers and other mission-critical applications. He also teaches computational fluid dynamics courses at both the undergraduate and graduate levels.

Dr. Fouladi earned his Bachelor of Science in Mechanical Engineering from Florida International University and his Master of Engineering and PhD in Mechanical Engineering from Old Dominion University. Dr. Fouladi began his professional career at

NASA's Langley Research Center conducting research involving CFD code development and analysis focused on sonic boom minimization of high-speed civil transports. Other industry experience includes aero-acoustic research at Pratt and Whitney Company. He continues to support NASA and commercial aerospace initiatives through his work at InfoMec.

Dr. Fouladi is a licensed Professional Engineer in Pennsylvania, Florida and Virginia and maintains active involvement with the American Society of Mechanical Engineers; American Society of Heating, Refrigerating and Air-Conditioning Engineers; American Institute of Aeronautics and Astronautics; the Delaware Valley Green Building Council and the 7x24 Exchange.



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## FOR FURTHER INFORMATION

Contact:

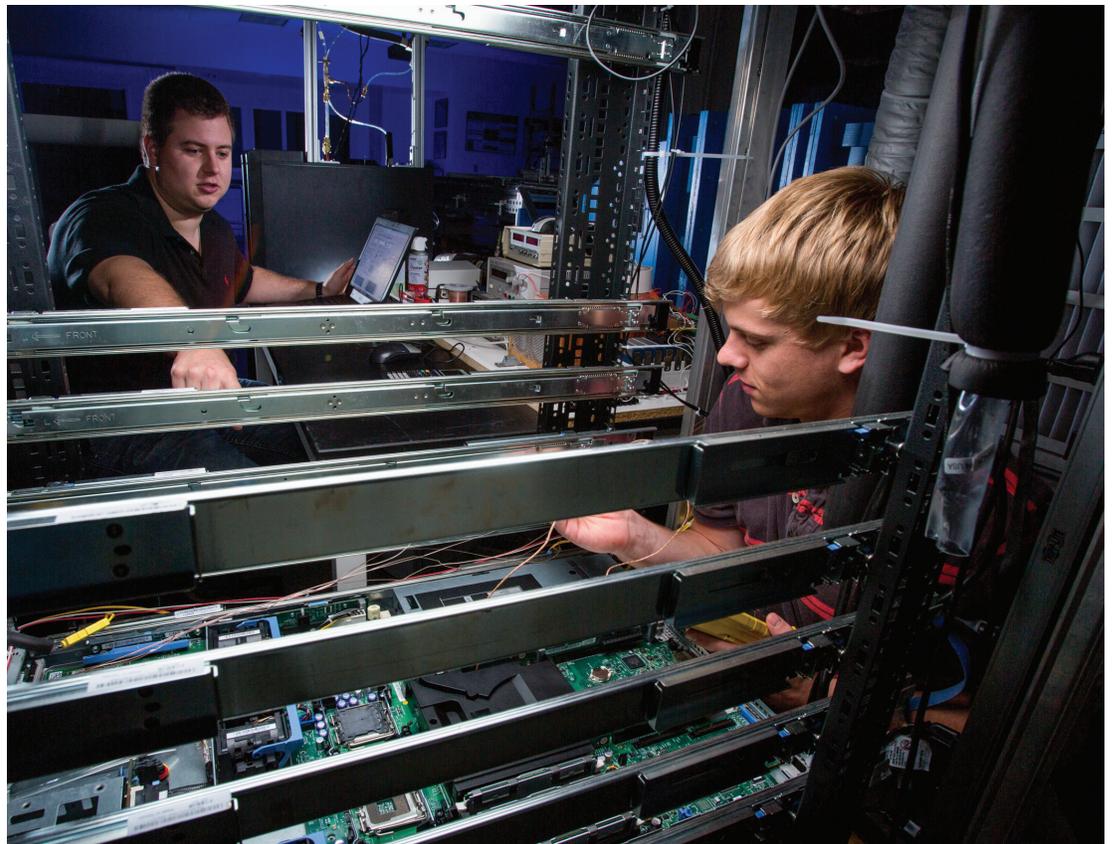
Alfonso Ortega, PhD

alfonso.ortega@villanova.edu

610.519.7440

Or visit our website:

[www.villanova.edu/ES2](http://www.villanova.edu/ES2)



**ES2**

Center for Energy-Smart  
Electronic Systems

**The Industry/University Cooperative Research Center  
for Energy-Smart Electronic Systems**

**MEMBERSHIP AGREEMENT**

**THIS AGREEMENT** is made this 1st day of September, 20\_\_ by **Villanova University**, with its primary location at Villanova University (Mailing address: Office of Research Administration, 800 Lancaster Avenue, Villanova, Pennsylvania, 19085-1699), hereinafter called **UNIVERSITY** on behalf of the Industry/University Cooperative Research Center for Energy-Smart Electronic Systems (ES2) which is defined as all ES2 Research Sites funded by the Industry/University Cooperative Research Center Program of the National Science Foundation and \_\_\_\_\_, a corporation organized under the laws of the State of \_\_\_\_\_, with offices located at \_\_\_\_\_, hereinafter called “**COMPANY.**”

**WHEREAS**, the parties to this Agreement intend to join together in a cooperative effort to support an Industry/University Cooperative Research Center in Energy-Smart Electronic Systems (hereinafter called "CENTER") at the UNIVERSITY to maintain a mechanism whereby the UNIVERSITY environment can be used to perform research to optimize energy efficiencies and thermal management of electronic systems and data centers, and

**WHEREAS**, the Industry/University Cooperative Research Center in Energy-Smart Electronic Systems is a cooperative effort between multiple universities (Binghamton University, University of Texas at Arlington, Georgia Institute of Technology and Villanova University, and any future universities as determined), and

**WHEREAS**, industrial membership in CENTER is between the member COMPANY and the specific UNIVERSITY identified above.

**NOW THEREFORE**, for the mutual benefit, each to the other, the parties hereto agree to the following terms and conditions:

- A. CENTER will be operated by certain faculty, staff and students at the UNIVERSITY. For the first five years, the CENTER will be supported jointly by industrial firms, Federal laboratories, the National Science Foundation (NSF), the State, and the UNIVERSITY. It is possible that the UNIVERSITY may receive support from NSF for an additional five years and then for a third additional five years at reduced levels.
- B. Any COMPANY, Federal Research and Development organization, or any Government-owned Contractor Operated laboratory may become a sponsor of the CENTER, consistent with applicable state and federal laws and statutes.
- C. COMPANY agrees to contribute (Alternative 1: \$50,000 in support of the CENTER and thereby becomes a Full Member (Alternative 2: \$25,000 in support of the CENTER and thereby becomes an Associate Member (Alternative 3: \$50,000 in In-Kind equipment and services and thereby becomes a full In-Kind member for one year). Benefits accrue to members according to the schedule found at <http://www2.binghamton.edu/ES2/>.

The term of this Agreement is September 1, 20\_\_ - August 31, 20\_\_. Payment of these membership fees shall be made to **Villanova University, IUCRC**, as a lump sum effective September 1, 20\_\_; or in four equal quarterly installments on September 1, December 1, March 1, and June 1, of each year of membership. Checks from COMPANY should be made payable to **Office of Research Administration (ORA), Villanova University, Middleton Hall, 800 Lancaster Avenue, Villanova, PA 19085-1699**.

Because research of the type to be done by the CENTER takes time and research results may not be obvious immediately, COMPANY should join CENTER with the intention of remaining a fee paying member for at least two years. However, COMPANY may terminate this Agreement by giving UNIVERSITY 90 days written notice prior to the termination date.

- D. There will be an Industrial Advisory Board composed of one representative from each member. This board makes recommendations on (a) the research projects to be carried out by CENTER (b) the apportionment of resources to these research projects, and (c) the formulation of and subsequent changes to CENTER Bylaws. Such Bylaws will be adopted at the first Advisory Board meeting and will become part of this Agreement as Exhibit A.
- E. UNIVERSITY reserves the right to publish in scientific or engineering journals the results of any research performed by CENTER. COMPANY, however, shall have the opportunity to review any paper or presentation containing results of the research program of CENTER prior to publication of the paper. If COMPANY determines that the proposed publication contains patentable subject matter and the COMPANY desires to have such subject matter protected by a patent application, UNIVERSITY agrees, at its choosing, to either delay publication or disclosure for up to ninety (90) days until a patent application has been filed or to remove the description of patentable subject matter. UNIVERSITY shall have the final authority to determine the scope and content of any publications, provided that such authority shall be exercised with reasonable regard not to publish confidential or proprietary information except as allowed by this Agreement and any separate Confidentiality Agreement in accordance with Clause F below.
- F. It is understood that in the course of carrying out this Agreement, COMPANY and UNIVERSITY may wish to share proprietary information. If so, the exchange of Proprietary Information will be handled via a separate Confidentiality Agreement.
- G. All inventions conceived or first reduced to practice in the course of research funded by the CENTER solely by investigators from LEAD or PARTNER UNIVERSITY will be owned solely by the investigator's home institution, pursuant to chapter 18 of title 35 of the United States Code, commonly called the Bayh-Dole Act. UNIVERSITY will have ownership of all patents developed from this work, subject to "march-in" rights as set forth in the Bayh-Dole Act.
- H. UNIVERSITY agrees that Full Member COMPANIES of the CENTER are entitled to a nonexclusive royalty-free license to CENTER-funded UNIVERSITY inventions. COMPANY will have the right to sublicense to its subsidiaries and affiliates. Full

Member COMPANIES that wish to exercise rights to a royalty-free license agree to pay for the costs of patent application.

- I. If only one COMPANY seeks a license, that COMPANY may negotiate an exclusive fee-bearing license. COMPANY has the right to sublicense to its subsidiaries and affiliates.
- J. Copyright registration may be obtained for software developed by CENTER. Full Member COMPANIES shall be entitled to a nonexclusive, royalty-free license to all software developed by CENTER, exercisable within six (6) months from disclosure of any software. COMPANY will have the right to enhance and to re-market enhanced or unenhanced software with royalties due to CENTER to be negotiated, based on the worth of the software.
- K. Any royalties and fees received by UNIVERSITY under this Agreement will be handled in accordance with relevant UNIVERSITY policies and regulations.
- L. UNIVERSITY shall not assume any liability for the actions or omissions of COMPANY. COMPANY shall indemnify and hold the UNIVERSITY harmless against all claims, liability, injury, damage or cost based upon injury or death to person, or loss of, damage to, or loss of use of property, which arises out of the performance of this agreement to the extent that such claims, liability, damage, cost or expense results from the negligence of a party's agents or employees.
- M. UNIVERSITY DISCLAIMS ANY AND ALL WARRANTIES BOTH EXPRESS AND IMPLIED WITH RESPECT TO THE SERVICES TO BE PERFORMED HEREUNDER AND ANY DELIVERABLES RESULTING THEREFROM, INCLUDING THEIR CONDITION, CONFORMITY TO ANY REPRESENTATION OR DESCRIPTION, THE EXISTENCE OF ANY LATENT OR PATENT DEFECTS THEREIN, AND THEIR MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE OR PURPOSE. FURTHER, THE UNIVERSITY DISCLAIMS ANY WARRANTY THAT THE USE OF ANY OF THE INVENTIONS OR IP WILL NOT INFRINGE ANY RIGHTS OF THIRD PARTIES.
- N. UNIVERSITY, CENTER, and COMPANY shall be and act as independent contractors, and under no circumstances shall this Agreement be construed as one of agency, partnership, joint venture, or employment between the parties. UNIVERSITY, CENTER and COMPANY shall each be solely responsible for the conduct of their respective employees, agents and contractors in connection with the performance of their obligations hereunder.
- O. Neither UNIVERSITY, on behalf of the CENTER, nor COMPANY shall have any right to assign this Agreement without the prior written consent of the other party. This Agreement and all of the terms and provisions hereof will be binding upon, and will inure to the benefit of, the parties hereto and their respective successors and permitted assigns.
- P. This Agreement shall be governed by the laws of the Commonwealth of Pennsylvania without reference to any conflicts of laws provisions that would apply under the laws of another state.

Q. It is understood that this Agreement may be modified only under terms mutually agreed upon in a duly executed amendment to this Agreement.

**IN WITNESS WHEREOF**, the parties hereto have caused this Agreement to be duly executed by their duly authorized representatives, all intending to be legally bound hereby.

**UNIVERSITY**

**(insert Member Name here)**

By \_\_\_\_\_

By \_\_\_\_\_

Name: Dr. Milton Cole

Name \_\_\_\_\_

Title: Assistant Vice President  
Office of Research Administration

Title \_\_\_\_\_

Date \_\_\_\_\_

Date \_\_\_\_\_