Systemic Reform of Higher Education: The Vertically Integrated Projects (VIP) Program and Consortium

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Evaluation Co-Director – Julia Melkers
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Primary Goal of the VIP Program: Involve Everyone on Campus in Innovation

What is Innovation?

“The development of novel products, services, and processes for the benefit of society”
(Too Narrow)

“Inspiration plus Execution”
(Works in all Disciplines)
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The Barriers: 3 Forms of Fragmentation

– By Mission
  • *Research*: Exploration, Idea Generation
  • *Education*: Knowledge, Skills
  • *Service*: Partnerships, Economic Development

– By Time
  • Semesters, Academic Years

– By Discipline
  • Budget Lines, Culture

Must Overcome These

– So Everyone can Participate
The VIP Approach: Foster Innovation by Involving Students in Challenging Projects Embedded in Faculty Research

Ensure Success by Providing the Necessary:

**TIME**  **CONTEXT**  **MENTORING**
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Bringing People Together

Students need Real Projects in which they Experience the Innovation Process

Faculty can Benefit from Help at all Levels of The Innovation Process
VIP Program Architecture

- **Long-term, Large-scale Projects:**
  - Projects led by professors; Embedded in their research
  - Large teams: 10-20 undergraduates; 1-4 grad students
  - 2nd year through 4th year students on every team
  - Long-term participation – up to 3 years per student
  - New students replace those who graduate
  - Teams continue for years, decades
  - Academic credit each semester

- **Challenging, Real-World Projects**
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Large Teams: The Stadium-IoT VIP Team (F’10)
Football Game at our *Internet of Things Testbed*:
Georgia Tech’s Bobby Dodd Stadium
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People + Information: In-Stadium Web-Apps:

Video clips, stats, tracker on your phone during a game:

http://estadium.gatech.edu
Addendum: New Web-Applications Projects

- SuiteTV: Infrastructure Challenges
- Friend Finder: Social Networking in the Stadium
- 4G LTE Multi- and Broadcast with AT&T:
  - Test in the stadium after development in the AT&T Foundry in Tech Square
  - Enables SuiteTV and other applications
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eStadium Wireless: **Baseball Stadium**

- WiFi–Mesh for easy installation in old stadiums
- 802.11a Backbone; b,g,n for Fan Access

![Diagram of eStadium Wireless network architecture](Diagram.png)
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eStadium Wireless Sub-Project

A WiFi Mesh Node: 3 APs per node
One 802.11a Backhaul; Two 802.11b,g,n for Fans
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Sensor Net Sub-Project:
- Few wired gateways
- Many sensor motes
- 6-month football season
- Supports many applications

Sensing Tasks:
- Vibration, Audio, Spectrum
- Sensors vary node-to-node
- Processing tasks differ
- Energy varies node-to-node
RF Sensor Node and Vibration-Net Clusterhead on top of Concessions Area in North Stands
Sensor Net Architecture

- 40~50 Sensor Motes
- 10~12 ClusterHeads
- Cognitive Radio Backhaul
- <125μsec Synchronization

500 MHz TV-White Space Backhaul Link
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Structural Vibration Monitoring at Stadium
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Structural Vibrations ⇔ Events in a Football Game
Georgia Tech VIP Teams: Fall 2016

- **Stadium – Internet of Things and People**
  - CEE, CS, CM, CEE, ECE, MGMT, Law
  - Wireless, Multimedia, Sensor Nets, etc

- **Active Safety for Semi/Fully-Autonomous Vehicles**
  - CS, All Engineering, Psych
  - Develop system to drive like an expert human driver

- **Lightning from the Edge of Space**
  - EAS, EE, CmpE, CS, Physics
  - Create sensing systems for atmospheric E&M fields

- **Intelligent Tutoring Systems**
  - CS, ECE, ISyE
  - Learning Theory, Databases, GUIs, Ontologies, etc
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Georgia Tech VIP Teams

- **Engineering for Social Innovation**
  - CmpE, CS, EE, ME, ISyE, Policy
  - Engineering design/development for social needs

- **TerraBots**
  - EE, CmpE, CS, CEE
  - Apply robotic technology to large-scale bldg. construction

- **BioBots**
  - BIO, BME, ChBE, ECE, ME, Physics
  - Create microrobots that can traverse biological barriers

- **EcoCAR**
  - ChBE, CoC, ECE, ME, MGMT
  - Advanced vehicles that reduce environmental impact.
Georgia Tech VIP Teams

- **USLI Rocket Team**
  - AE, ECE
  - Rocket design, instrumentation, construction and flight

- **Intelligent Transportation Systems**
  - CS, ISyE
  - Optimal control of transportation fleets; Tech Trolley

- **Smart City Infrastructure**
  - CEE, CmpE, CS, EE, ISyE, ME
  - Apply emerging tech. to develop smart infrastructure

- **Active Safety for Autonomous Vehicles**
  - AE, CmpE, CS, EE, ISyE, ME, Psych
  - Develop systems that can drive like a human
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Georgia Tech VIP Teams

• **AquaBots**
  – AE, CS, ECE, Marine Sciences, ME
  – Underwater/surface vehicles, map/explore underwater

• **Academic Resilience**
  – All Disciplines
  – Identifying patterns of student success

• **RoboSense**
  – ECE, ME, CS, MGMT
  – Design of autonomous coordinated fleets of ships

• **Data Driven Education**
  – CS, ECE, CM, ISyE, Physics
  – Create tools for inquiry-based study of education practice
Georgia Tech VIP Teams

- **Humor Genome**
  - CoC, CmpE, Math, IAH, Psych
  - Characterize and build repository of humor for analysis

- **Rock Damage Modeling and Energy Geostorage**
  - CEE, CmpE, CS, ME
  - Predict rock behavior during heat/fluid injection/extraction

- **Intelligent Digital Communications**
  - EE, CmpE, CS
  - Design of cognitive radio nets; Spectrum sensing

- **Secure Hardware**
  - EE, CmpE, CS
  - Design of secure embedded systems for the IoT.
Georgia Tech VIP Teams

- **Robotic Musicianship**
  - HCI, CS, ME, BME, DM, AP, CmpE, ECE
  - Develop robots that can listen to, play and improvise music

- **Bee Snap**
  - Arch, Bio, CE, CM, CmpE, CS EnvE, Math
  - Collect and analyze big data about bee-flower interactions

- **Health Informatics on FHIR**
  - CS, ISyE, BME, MGMT
  - Develop, evaluate and deploy health analytics applications

- **Augmented Reality Experiences**
  - Arch, CEE, CM, CmpE, CS, EE, ID, INTA
  - Create augmented-reality experiences
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Georgia Tech VIP Teams

- **STEMcomm**
  - All STEM disciplines, Liberal Arts, Business
  - Improve societal understanding of & enthusiasm for STEM

- **Concussion Connect**
  - AP, BME, CM, CmpE, CS, EE, HTS, HCI, ME, Psy, PP, etc
  - Develop multidisc. approach to problem of concussions

- **Hands-On Learning**
  - AE, CmpE, CS, EE, ME
  - Create small, portable experimental platforms for teaching

- **Configurable Computing and Embedded Systems**
  - CmpE, CS, EE
  - Create tools/methods for designing configurable systems
Georgia Tech VIP Teams

- **Brain Trauma Assessment Protocols**
  - BME, BA, CmpE, CS, EE
  - Use touch, audio and video to assess brain trauma

- **EnerCage**
  - AP, BME, BA, CM, CmpE, CS, EE, Psych
  - Smart, wireless control’d arena for animal behavior studies

- **Bio Big Data**
  - BME, CM, CmpE, CS, MGMT
  - Recapture published biomed data for “big data” analysis

- **GTRI Agricultural Robotics**
  - AW, Bio, Biomed, ECE, CS, ECE, ME, Physics
  - Revolutionize inspection and harvesting in agriculture
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Georgia Tech VIP Teams

• **21st Century Security Challenges**
  – INTA, PubPol, HTS, LMS, ECON, MGMT, …, Sci + Engr
  – How science and technology affect global security

• **Collaborative Air, Sea, and Underwater Vehicles**
  – ME+AE, ECE, CS, EAS, Science
  – Collaborative teams of robots for underwater applications

• **eDeliberations**
  – Philosophy, Cognitive Science, Digital Media, CS, ECE
  – On-line deliberation platforms to facilitate engagement

• **M.A.R.S**
  – AE, BIO, Architecture, Materials, ME
  – Martian advanced renewable systems for Mars habitats
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Georgia Tech VIP Teams

• Big Data Analytics for Public & Private Enterprises
  – CSE, CmpE, ISyE, Mgmy, Econ, Math, PubPol
  – Build platforms to enhance economic decision-making

37 Teams for Fall 2016
Expected Enrollment of ~540 Undergraduates
Univ. of Strathclyde’s VIP Teams

• **Systems Biology of Polarized Growth**
  – BIO, ECE, Math
  – Automated eval of genetically manipulated antibiotics

• **TextLab**
  – English, CS
  – Computational Analysis of English literary works

• **Enterprise VIP**
  – MGMT
  – Match MGMT students with new enterprises

• **Sustainable Energy for Development**
  – ECE (initially)
  – Long-term energy system evolution for dev. countries
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Univ. of Strathclyde’s VIP Teams

• Water and Sanitation Hygiene (WASH)
  – EEE, MAE
  – Water and sanitation engineering in Malawi

• Mobileland
  – Architecture, Humanities
  – Community-revitalization focused landscape architecture

• Robotic Vehicles for Education and Research
  – MAE, EEE, Mechatronics
  – Autonomous robotic vehicles for smart cities

• VIP in Developing Competitive SMEs
  – MGMT
  – Developing competitive small and medium enterprises
Univ. of Strathclyde’s VIP Teams

- **Performance VIP**
  - Humanities, Science, Engineering
  - Using theatre to widen access to STEM fields

- **STEM Education and Public Engagement**
  - Education, Science, Engineering
  - Improving STEM literacy by developing STEM Clinics
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VIP Enrollment by Semester at Georgia Tech

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<th>Semester</th>
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<td>Spring 2009</td>
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VIP Enrollment by Major & Year, Spring 2016
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VIP (91%) vs STEM (84%) 6-Year Graduation Rate
Note: First students enrolled in VIP in Fall 2009
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VIP Course Structure

VIP-X81Y

X = Year: 2=Soph; 3=Junior; 4=Senior
Y = Credits: 1, 2, or 3

Each course can be taken multiple times
Currently: 2811 -- 3811, 3812 -- 4811, 4812, 4813
4813 for Senior Design, Project, Thesis, …

Each team is one section of every course

Available to all Disciplines
Model for How VIP Credits Count

Incentive to Participate Multiple Years

- Take 5 or fewer credits:
  - All are Approved-Elective (Free-Elective) Credits

- Take 6+ credits:
  - 3 to 6 Become Technical Elective Credits
  - Rest are Approved-Elective (Free-Elective) Credits

- VIP + VIP Senior Design: 8+ Credits
  - 3+ Credits as a Junior
  - 2 Credits (4811) 1st-Semester Senior Year
  - 3 Credits of VIP Senior Design (4813)
VIP: Benefits to all Students

- Realistic Team Experience
- Opportunity to Learn/Master different Roles/Skills
- In-Depth Experience in their Field
- Authentic Multi-Disciplinary Experience
- Knowledge Exchange across many Boundaries
- Provide a Compelling Reason to be on Campus
- Preparation for Work / Grad School
- Understanding of the Innovation Process
- Fun and Interesting!
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VIP: ABET 2K Outcomes for Engr. Students

• Long-Term, Large-Scale Team Experience (d,f,i)
• Opportunity to Learn/Apply/Master different Roles/ Skills (a-i,k)
• In-Depth Experience in their Field (a,b,c,e,f,k)
• Authentic Multi-Disciplinary Experience (a-e,g,h,k)
• Knowledge Exchange across many Boundaries, including Grad-UG, Acad Yr, Fac-Student, etc. (c-h,l,j)
• Preparation for Work / Grad School (a-k)
• Understanding of the Innovation Process (a-e,h-k)
• Fun and Interesting! (h-k)
VIP: Pending ABET Outcomes for Engr. Students

- Long-Term, Large-Scale Team Experience (4,5,7)
- Opportunity to Learn/Apply/Master different Roles/Skills (1-7)
- In-Depth Experience in their Field (1-3,5,6)
- Authentic Multi-Disciplinary Experience (1-4,5-7)
- Knowledge Exchange across many Boundaries, including Grad-UG, Acad Yr, Fac-Student, etc. (1-7)
- Preparation for Work / Grad School (1-7)
- Understanding of the Innovation Process (1-7)
- Fun and Interesting! (1,6,7)
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VIP: Benefits to Companies

• Work with Teams in Your Areas of Interest
  – Partner with Teams in Your Area
  – Research and Design Activities

• Build long-term Relationships with Students
  – UGs: Internships after sophomore and junior years
  – Grads: Research collaboration

• Basic VIP Partnership has Zero Overhead
  – Students own IP like other design programs
  – Companies receive updates on project progress

• Research Contract per Master Agreement
• Partnership with VIP Program
VIP: Benefits to Universities

- Enhances Student Learning
- Enhances Faculty Research
- Enables New Partnerships
- Creates Multidisciplinary Opportunities
- Compelling Reason to have a Campus
- Everyone Participates in Innovation
- Deepens/Broadens the University Community
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The VIP Consortium .... So Far:

- Arizona State Univ.
- Boise State
- Colorado State
- Florida International
- Georgia Tech
- Howard Univ.
- Inha Univ.
- Morehouse College
- National Ilan Univ.
- New York Univ.
- Purdue Univ.
- Rice Univ.
- Riga Technical Univ.
- Texas A&M Univ.
- Univ. del Norte
- Univ. of California, Davis
- Univ. of Delaware
- Univ. of Hawaii
- Univ. of Michigan
- Univ. of Strathclyde
- Univ. of Washington
- VA Commonwealth Univ.
Consortium Membership:

- **1st Wave**: Georgia Tech, Michigan, Purdue, Strathclyde, Texas A&M
- **2nd Wave**: Boise State, Colorado State, Florida Int’l, Howard, Morehouse, National Ilan, Rice, Hawaii, Washington, VA Commonwealth
- **3rd Wave**: Arizona State, Delaware, Inha, NYU, Riga Technical Univ., UC Davis, Univ Del Norte
- **Pending**: UT Austin, Univ of South Florida, Tuskegee, Univ. of Sheffield, Univ. of Miami, Peking Univ., National Dong Hwa Univ, Univ. of Georgia
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VIP Consortium Meeting – May 2015:
Essential Characteristics of VIP

- VIP Program Led by Professors
- Each Project in a Professor’s Research Effort
- Large-Scale Projects Lasting Years/Decades
- Multidisciplinary Teams Possible/Encouraged
- Program is Curricular; All Students Graded
- Incentives for Students to Participate for 2+ Years
- Classroom and Meeting Space Supporting Teams
- Learning Outcomes Include Development of both Disciplinary and Professional Skills
VIP Consortium Characteristics

- All Institutions Field a Professor-Led VIP Program
- Program Must Have Essential Elements of VIP but Adapt to Local Conditions
- Share Resources/Tools/Processes/etc.
- Everyone Contributes What They Can
- Participation in Evaluation and Dissemination
- Publish Papers and Write Proposals Together
Consortium Status:

- **The Numbers as of Dec 2015:**
  - 20 Institutions have VIP or are starting it this year.
  - 1172 Undergraduates Registered for Fall 2015
  - 123 VIP Teams in Fall 2015
  - 148 Advisers in Fall 2015
  - 60 Depts with VIP Teams
  - 42 Depts with VIP Credit Policies
  - 24 Depts developing Credit Policies
  - VIP Teams in almost all Disciplines

- **Next Update in June 2016**
What could you do if you had a VIP team?

http://vip.gatech.edu
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+1-609-751-1781
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ABET Reference Slide

**CURRENT**

The program must have documented student outcomes that prepare graduates to attain the program educational objectives.

Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.

(a) An ability to apply knowledge of mathematics, science, and engineering
(b) An ability to design and conduct experiments, as well as to analyze and interpret data
(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) An ability to function on multidisciplinary teams
(e) An ability to identify, formulate, and solve engineering problems
(f) An understanding of professional and ethical responsibility
(g) An ability to communicate effectively
(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) A recognition of the need for, and an ability to engage in lifelong learning
(j) A knowledge of contemporary issues
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

**PROPOSED**

The program must have documented student outcomes. Attainment of these outcomes prepares graduates to enter the professional practice of engineering.

Student outcomes are outcomes (1) through (7) plus any additional outcomes that may be articulated by the program.

1. An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs.
3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
4. An ability to communicate effectively with a range of audiences.
5. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
6. An ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately.
7. An ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty.