Teaching & Catalyzing Innovation in the Vertically-Integrated Projects Program

Ed Coyle, Director    Randal Abler, Co-Director    Julia Melkers & Gordon Kingsley, Evaluators    Julia Sonnenberg-Klein, Program Manager
What is Innovation?

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

“Inspiration plus Execution”
(Works in all Disciplines!)

Why is it Important?
Provide People and Society with New Opportunities
Processes and Ideals Worth Preserving
Vertically-Integrated Projects Program

The Role of Universities in Innovation?
- Research: Exploration, Idea Generation
- Education: Knowledge, Skills
- Service: Partnerships

for Innovation

What is Missing?
- Integration!
- Everyone can Participate
- New Pathways
- A Pervasive Culture of Innovation
Vertically-Integrated Projects Program

The VIP Goal: Foster Innovative Thinking & Entrepreneurial Behavior by Involving Students in Challenging Projects Embedded in Research.

Ensure Success by Providing the Necessary:

- Time
- Context
- Mentoring
Vertically-Integrated Projects Program

Innovation in an R&D Context

Students need Real Projects in which they Learn the Innovation Process

Research and Development Efforts Need Help at all Levels of Innovation
VIP Program Architecture

- Long-term, Large-scale Projects:
  - Large teams: 10-20 undergraduates; 1-4 grad students
  - Long-term participation – up to 3 years per student
  - Sophomores through seniors on each team
  - New students replace those who graduate
  - Teams continue for years, decades
  - Academic credit each semester
  - Capstone-design credit option

- Challenging, Real-World Projects
Example: The eStadium Project

- 14-year old project:
  - Partnership with GaTech Athletics
- R&D in wireless networks
  - Wireless sensor network research, design & deployment
  - WiFi, 3G, 4G network design and optimization
  - Spectrum-sensing, cognitive radio
  - Infotainment, user studies and application development
- Industry Partners: AT&T, TI, NI, BIT Systems, ..
- 15 conf. papers; 12 journal articles
- Deployed Systems!
Vertically-Integrated Projects Program

The eStadium VIP Team at Georgia Tech (F’10)
eStadium Web-Apps: **AT&T + Falcons**

Video clips, stats, tracker on your phone during a game: [http://estadium.gatech.edu](http://estadium.gatech.edu)
Additional Web-Apps Projects

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

- WiFi–Mesh for ease of installation in old stadiums
- 802.11a Backbone; b,g,n for Fan Access
Vertically-Integrated Projects Program

eStadium Wireless Sub-Project

A WiFi Mesh Node: 3 APs per node
Vertically-Integrated Projects Program

Sensor Net Sub-Project:
- Few wired gateways
- Many sensor motes
- Multi-hop architecture
- 6-month football season
- Supports many applications

Sensing Tasks:
- Vibration, Audio, Images
- Sensors vary node-to-node
- Processing tasks differ
- Energy varies node-to-node
Sensor Net Architecture

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

500 MHz TV-White Space Backhaul Link

SensorNets Server
Vertically-Integrated Projects Program

Structural Vibration Monitoring at Stadium
Vertically-Integrated Projects Program

eStadium Sensor Net - BIT Systems

Accelerometer and Signal Conditioning Board

Vibration Sensor Connected to Wireless Sensor Node

Accelerometers

TI Sensor Mote

Signal Conditioning Board

7/22/2014
Structural Vibrations $\Leftrightarrow$ Events in a Football Game

- Touchdown by Miami
- Advertisement on the big screen
- Half-time break
- Introducing 1990 national champion team + half time show
- Touchdown by GT
- Touchdown by Miami
- "Make some Noise"
- Introducing GT fans
New eStadium Industry Partners

- **AT&T and Qualcomm**
  - Multicast and Broadcast of Video/Video-Clips/Images
  - 4G LTE CoW for the Fall 2014 Season + DAS in Stadium
  - eStadium in the AT&T Foundry in Tech Square

- **Falcons**
  - NFL Focus on Communication in Stadiums
  - New Falcons stadium to be built in Atlanta
  - Discussions about eStadium/VIP participating

- **BIT Systems**
  - Spectrum Sensing, Cognitive-Radio, Sensor Nets
2014 Georgia Tech VIP Teams: 23

<table>
<thead>
<tr>
<th>Project</th>
<th>Teams</th>
<th>Focus Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>eStadium</strong></td>
<td>CEE, CS, CM, CEE, ECE, MGMT, Law</td>
<td>Wireless, Multimedia, Sensor Nets, etc</td>
</tr>
<tr>
<td><strong>eDemocracy</strong></td>
<td>CS, ECE, ISyE, INTA</td>
<td>Election Monitoring System, Redistricting, Policy, etc</td>
</tr>
<tr>
<td><strong>Airborne Measurement of Atmospheric Electricity</strong></td>
<td>EE, CmpE, CS</td>
<td>Create sensing systems for atmospheric E&amp;M fields</td>
</tr>
<tr>
<td><strong>Intelligent Tutoring Systems</strong></td>
<td>CS, ECE, ISyE</td>
<td>Learning Theory, Databases, GUIs, Ontologies, etc</td>
</tr>
</tbody>
</table>
Vertically-Integrated Projects Program

Georgia Tech VIP Teams

• GTRI Robotics Team
  – CS, ECE, ME
  – Design and develop robot/unmanned systems

• Technology for Healthy Aging
  – ID, CS, HCI, DM, ECE
  – Design tech. for older adults in retirement communities

• Constructacons
  – 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
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

• **I-Natural**
  – CS, ECE, ME
  – Design of robots that interact with people

• **Brain Beats**
  – BME, CS, ECE, ME
  – Neural basis of human ability to maintain “rhythmic time”
Vertically-Integrated Projects Program

Georgia Tech VIP Teams

• **AquaBots**
  – CEE, CS, ECE, ME
  – Underwater/surface vehicles, map/explore underwater

• **Open Academic Environment**
  – CS, ECE, IC, CM
  – Web tools supporting learning & research collaborations

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

• **Physics MOOCs**
  – Physics, ECE, CS, MGMT
  – Create tools for inquiry-based intro physics courses.
Vertically-Integrated Projects Program

Georgia Tech VIP Teams

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

- **Energy Geotechnology**
  - 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

- **Design Space Construction**
  - Arch, ID, ME, CS, Mgmt, HCI, AI
  - Develop & test building design space exploration systems

- **Predictive Health**
  - CS, ISyE, BME, MGMT
  - Develop, evaluate and deploy health analytics applications
Growth and Dissemination

Disciplines of Faculty + Students in VIP at GT:
- Engineering: AE, BME, CEE, ChBE, ECE, ISyE, ME
- Computing: CS, CSE, CM
- Architecture: ID, Music, ConE
- Science: Biology, Math, Physics
- IAC: CM, INTA, Public Policy
- MGMT+Law: via TI:GER Program

Other Universities with VIP Programs:
- Purdue University: 15 VIP Teams
- Univ. of Strathclyde, Glasgow, UK: 8 VIP Teams
  - Joint project
- National Ilan Univ., Taiwan: 6 VIP Teams
Vertically-Integrated Projects Program

VIP: Benefits to 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 the Work Environment
- Learn and Practice Many Skills
- Understanding of the Innovation Process
Vertically-Integrated Projects Program

VIP: Benefits to Georgia Tech

- Enhances Student Learning
- Compelling Reason to be on Campus
- **Everyone** Benefits, Including Faculty
- Enables Major Projects that Make a Difference
- Enables New Partnerships for Innovation
- Opens Up Multidisciplinary Opportunities
- Deepens/Broadens the University Community
  - Everyone can work together
Current Status of VIP at GT

- S-14: 196 Students Enrolled in 18 Teams
- F-14 Advisers: CETL, CoA, CoC, CoE, CoS, GTRI, IAC; Every team is Multi-Disciplinary
- “Counts” for Design in CoC, ECE, ISyE
- Teaching Credit for Faculty in ECE
- Support from CoE
  - Dr. Randal Abler, Co-Director of VIP
  - Julie Sonnenberg-Klein, VIP Program Manager
  - Infrastructure Support
VIP Program Growth
Course Enrollment over Time
Vertically-Integrated Projects Program

VIP Program Growth
Number of Teams over Time

<table>
<thead>
<tr>
<th>Year</th>
<th>Spring 2009</th>
<th>Fall 2009</th>
<th>Spring 2010</th>
<th>Fall 2011</th>
<th>Spring 2012</th>
<th>Fall 2012</th>
<th>Spring 2013</th>
<th>Fall 2013</th>
<th>Spring 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>13</td>
<td>17</td>
<td>19</td>
</tr>
</tbody>
</table>

Year 0  Year 1  Year 2  Year 3  Year 4
VIP Enrollment by Major
Spring 2014

Number of Students

<table>
<thead>
<tr>
<th>College of Engineering</th>
<th>College of Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Science</td>
<td>39</td>
</tr>
<tr>
<td>Aerospace Engineering</td>
<td>10</td>
</tr>
<tr>
<td>Biomedical Engineering</td>
<td>12</td>
</tr>
<tr>
<td>Chemical &amp; Biomolecular Engineering</td>
<td>1</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>3</td>
</tr>
<tr>
<td>Computer Engineering</td>
<td>40</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>56</td>
</tr>
<tr>
<td>Industrial Engineering</td>
<td>14</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>18</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>1</td>
</tr>
<tr>
<td>Biology</td>
<td>1</td>
</tr>
<tr>
<td>Psychology</td>
<td>1</td>
</tr>
</tbody>
</table>
The VIP Consortium ....17 so far

- Georgia Tech
- Univ of Michigan
- Purdue Univ
- Morehouse College
- National Ilan Univ
- Univ of Strathclyde
- Univ of Washington
- Howard Univ
- Florida Int’l Univ

- VA Commonwealth Univ
- Colorado State
- Univ of Hawaii
- Boise State
- Rice Univ
- Univ of Delaware
- UC Davis
- IU School of Law
VIP Plans – 1

• Create University-wide VIP Courses
• Make VIP available to All Disciplines
  – Maximize the variety of projects
  – Credit towards degrees ensuring 2+ years participation
• Scale-up within Disciplines
  – Goal: 100+ teams by 2020
  – How large/fast can it grow?
• Create Multi-Disciplinary Advisory Board
• Faculty Development Resources
VIP Plans – 2

• Enable Partnerships
  — Both on an off campus; Carter Center, CDC, AT&T, …

• Integrate VIP with other Campus Efforts
  — Create a Pathway to Innovation
  — Entrepreneurship: IP, Commercialization Efforts
  — First-year active learning experiences ➔ VIP

• Approach ABET & other Accrediting Bodies
  — VIP Recognized for Design Experience, Studio Experience, etc
Vertically-Integrated Projects Program

VIP Plans – 3

- Help Form and Grow the VIP Consortium
  - Determine Architecture of the Consortium
- Systemic Reform of Higher Education
  - Overcome Disciplinary Boundaries
  - Over Come Time-Barriers
  - Create a More Unified University Community
  - Enable New Ways to Work with Partners
What could you do if you had a VIP team?