Systemic Reform of STEM Education:
The Vertically Integrated Projects (VIP) Consortium

Director – Ed Coyle
Technology Co-Director – Randal Abler
Diversity Co-Director – Eve Riskin
Minority Serving Institutions Co-Director – Amos Johnson
Evaluation Co-Director – Julia Melkers
Consortium Manager – Julie Sonnenberg-Klein
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)
Vertically-Integrated Projects Program

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

Must Overcome These

– So Everyone can Participate
– To Create a True “University-Deep” Community
The VIP Approach: Foster Innovation by Involving Students in Challenging Projects Embedded in Faculty Research

Ensure Success by Providing the Necessary:

TIME  CONTEXT  MENTORING
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:**
  - Faculty Led Projects
  - Large teams: 10-20 undergraduates; 1-4 grad students
  - Sophomores through seniors on each 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**
Large Teams: The eStadium VIP Team (F’10)
Vertically-Integrated Projects Program

eStadium Web-Apps: **AT&T + Falcons**

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

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

WSN NODE

SENSOR

MSP-430,
CC-2520, BATTERIES
RF Sensor Node and Vibration Net Clusterhead
On top of Concession Stand 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
Vertically-Integrated Projects Program

Structural Vibration Monitoring at Stadium
Structural Vibrations $\Leftrightarrow$ Events in a Football Game

- Touchdown by Miami
- Advertisement on the big screen
- Introducing GT fans
- Introducing 1990 national champion team + half time show
- Touchdown by Miami
- “Make some Noise”
- Half-time break
Vertically-Integrated Projects Program

Fall 2015 Georgia Tech VIP Teams: 31

• **eStadium**
  - CEE, CS, CM, CEE, ECE, MGMT, Law
  - Wireless, Multimedia, Sensor Nets, etc

• **eDemocracy**
  - CS, ECE, ISyE, INTA
  - Election Monitoring System, Redistricting, Policy, etc

• **Airborne Measurement of Atmospheric Electricity**
  - 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
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.
Vertically-Integrated Projects Program

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**
  - BME, CS, ECE, LMC, ME
  - Design of robots that interact with people

- **Brain Beats**
  - BIOL, BME, CS, ECE, Math, ME, Psych
  - Neural basis of human ability to maintain “rhythmic time”
Georgia Tech VIP Teams

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

- **Open Academic Environment**
  - CS, ECE, CM, ID, HCI
  - Web tools supporting learning & research collaborations

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

- **MOOC Analytics**
  - CS, ECE, CM, ISyE
  - Create tools for inquiry-based intro physics courses.
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

• **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
Georgia Tech VIP Teams

- **CDC Organ Match-Maker**
  - BME, CmpE, CS, ISyE
  - Improve matching of wait-listed recipients with organs

- **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 controlled arena for animal behavior studies

- **Bio Big Data**
  - BME, CM, CmpE, CS, MGMT
  - Recapture published biomedical data for “big data” analysis
### Univ. of Strathclyde’s VIP Teams

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<thead>
<tr>
<th>Project Name</th>
<th>Departments</th>
<th>Description</th>
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<td><strong>Systems Biology of Polarized Growth</strong></td>
<td>BIO, ECE, Math</td>
<td>Automated eval of genetically manipulated antibiotics</td>
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<td><strong>TextLab</strong></td>
<td>English, CS</td>
<td>Computational Analysis of English literary works</td>
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<td><strong>Enterprise VIP</strong></td>
<td>MGMT</td>
<td>Match MGMT students with new enterprises</td>
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<td><strong>Sustainable Energy for Development</strong></td>
<td>ECE (initially)</td>
<td>Long-term energy system evolution for dev. countries</td>
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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
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Univ. of Strathclyde’s VIP Teams

- **Performance VIP**
  - Humanities, Science, Engineering
  - Using theatre to widen access to STEM fields
VIP Program Growth:
Course Enrollment over Time

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<th>Year</th>
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Vertically-Integrated Projects Program

Multidisciplinary: Enrollment by Team/Major
VIP Course Structure

VIP-X00Y

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, or Equivalent
Each team is one section of every course

Available to all Disciplines
Vertically-Integrated Projects Program

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 Technical Elective Credits
  - Rest are Approved-Elective (Free-Elective) Credits

- VIP + VIP Senior Design: 8+ Credits
  - 3+ Credits as a Junior
  - 2 Credits (4812) 1st-Semester Senior Year
  - 3 Credits of VIP Senior Design (4813)
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 Work / Grad School
- Understanding of the Innovation Process
- Fun!
Vertically-Integrated Projects 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 the Innovation
- Deepens/Broadens the University Community
The VIP Consortium .... So Far:

- Boise State
- Colorado State
- Florida International
- Georgia Tech
- Howard Univ
- Morehouse College
- National Ilan Univ
- Purdue Univ
- Rice Univ
- Texas A&M Univ
- Univ of Hawaii
- Univ of Michigan
- Univ of Strathclyde
- Univ of Washington
- VA Commonwealth
The VIP Consortium …. Additions?

- HBCU ECE Network
- Northeastern Univ
- NYU-Polytechnic
- Ohio State
- Univ. of Delaware
- UC Berkeley
- UC Davis
- ??

How to Join

- Application Process for Remaining Funded Slot
- Anyone Else Can Join
- We Can All Work on Funding
- Institutionalization is the Goal
Vertically-Integrated Projects Program

Essential Characteristics of VIP

- VIP Program Led by Faculty
- Projects Homed in Faculty Research Efforts
- Large-Scale Projects Lasting Years/Decades
- Multidisciplinary Teams Encouraged
- Program is Curricular – Identifiable VIP Courses
- 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 Faculty-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
- Participate in Evaluation and Dissemination
- **Publish Papers** and **Write Proposals** Together
What could you do if you had a VIP team?

http://vip.gatech.edu
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