Elizabethtown College

Robotics & Machine Intelligence Lab, and Architecture Studio

(founded in1999)

Original talk at 2017 Vienna Austria **EduNet** Conference
to over 100 University representatives from 19 countries and 29 Universities
Talk updated in 2019

Joseph T Wunderlich PhD

- *Lab Director*
- *Associate Professor of Engineering and Computer Science*
  - *Computer Engineering Program Coordinator*
  - *Architecture Program Coordinator*

JT Wunderlich PhD prior to 1999

Purdue University Assistant Professor
of Electrical Engineering Technology

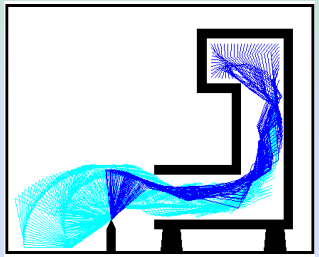
IBM S/390 Supercomputer Research & Development

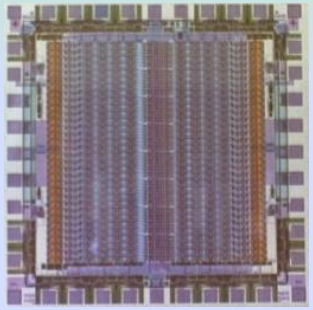
PhD Electrical & Computer Engineering

- Rehabilitation Robotics *(AI Dupont Children's Hospital)*
- Robotic-arm design
- Neural Network chips

M Eng Engineering Science

- Neural Network chip design





Coordinated *(and participated in)* all Architecture, Engineering, and Development of $100,000,000 of Hi-Tech office parks in Texas and California

39 credits of Urban Design (2nd Degree program)

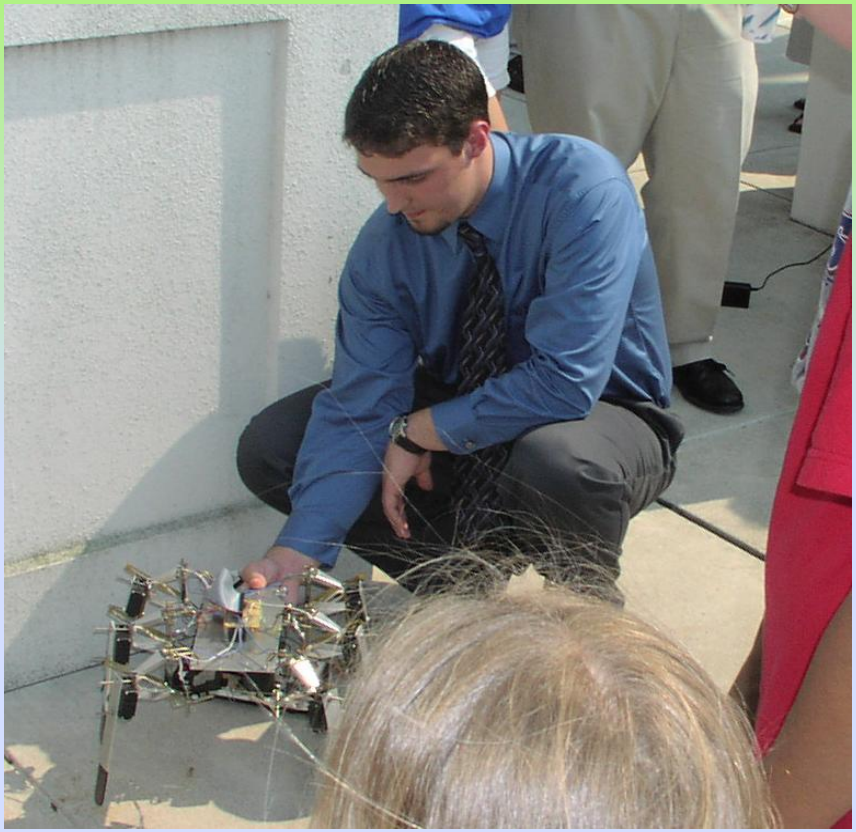
BS Architectural Engineering

Over 200 student projects since 1999

Some early projects:

- Neural Net Voice Recognizer (2000)
- Neural Net Character Recognizer (2002)
- “MultEbot I” (2002)
- Search and Rescue Robots (2002)
- Neural Net Chord Recognizer (2002)
- “Gollum” Mobile Robot (2002)
- Neural Net Vision System (2002)
- Neural Net Language Translator (2002)
- Scalable Neural Net Simulator (2003)
- A.I. Psychological Analyzer (2003)
- Neural Net Music Harmonizer (2004)
- “Nervous Net” Robot (2005)
- Submarine (2005)

“Nervous Net” Robot (2005)



Submarine (2005)

In 2000, created a symposium of student research that helped lead to **Annual Scholarship and Ceative Arts Day (SCAD)** for all students

11 Robotics and Machine Intelligence Symposiums

- Spring 2000
- Spring 2001
- Spring 2002
- Spring 2003
- Spring 2004
- Spring 2005
- Spring 2006
- Spring 2007
- Spring 2008
- Spring 2009
- Spring 2011

5 Sustainability Symposiums

- Spring 2012
- Spring 2013
- Spring 2014
- Spring 2015
- Spring 2016

5 Architecture Design Studio Defenses

Judged by Senior Faculty & Staff, Professional Architects & Engineers, Industry leaders &Trustees

- Spring 2015
- Spring 2016
- Spring 2017
- Spring 2018
- Spring 2019

Select student Computer Engineering researchers from the first decade of the Lab

Mathew Lister, CompE 02, organized students for first large robot, then went on to design UAV's for ~20 years

Brian Holton, CompE 02, First Wunderot with Machine Intelligence

- MS CompE, Rensselaer Polytechnic Institute
- Now upper management at Hershey

Diego Campos, CompE 02, Presented in Japan Search & Rescue robot swarm, simulated & built

- MS Engineering, Drexel

Dax Kephire, CompE 04, Raised $100,000 for first Wunderbot entered in international competition

- MS and PhD Engineering Sciences, Dartmouth
- Raised $12,000,000 in venture capital to Found SustainX; 200 employees; Now exec for Siemens in DC

Mathew Barley, CompE 05, One of the founders of Wunderbots for international competition

- Senior Management at GEA USA & Germany; hired 5 other Etown CompE's, and many others

Steve Sanko, CompE 05, First Wunderbot complex vision, NCAA All-american Track & Field

- Partial completion of PhD EE at Notre Dame, US Naval Officer (almost completed Navy Seal training)
- MBA U. Pittsburg, and now upper Management for Ford in Florida

James Painter, CompE 08, presented paper on Wunderot vision in Florida, in session with NASA researchers

- MS in Electrical Engineering from Stanford University after working at Google and Intel
- Now at Sortvision in silicon valley

David Coleman, CompE 08, Presented complex Wunderbot path-planning at Italy conference

- MS Electrical Engineering U. of Arkansas, PhD Computer Science, U. of Maryland
- Now leads research group at Johns Hopkins

Tom Yeager CompE 06 MBA U Maryland, and **Dan Fenton CompE 11**, have advanced positions at Phoenix Contact USA where many other CompE, CS, and other students have gained employment and internships.

Over a dozen other CompE grads work for Lockheed, Boeing, Raytheon, NSA, and other DOD related positions

- Several top students not listed because of the confidentiality of their work

Significant changes in the mid-2000's

1) New Lab in $22,000,000 Science, Technology, Engineering, & Mathematics Center

2) Relationship with Phoenix Contact began

- Initially for our large autonomous mobile robots

3) Growing International Activities

New Lab in the Mid-2000's

New Lab in the Mid-2000's

New Lab in the Mid-2000's

New Relationship in Mid-2000's

A "WunderBot" at Phoenix Contact USA Headquarters

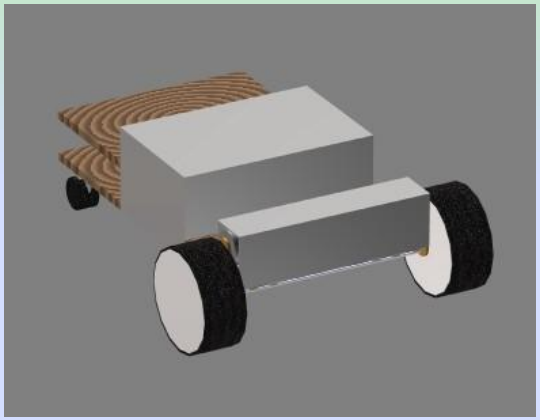
New Relationship in the Mid-2000's

A "WunderBot" at Phoenix Contact USA Headquarters (with President **Jack Nehlig**)

Wunderbots originally a test-bed for education

- With variable performance goals

MultEbot 1,
2000/2001
"Wunderbot" 0



http://users.etown.edu/w/wunderjt/home_wunderbot0.html

Wunderbot 1
"MultEbot 2"

http://users.etown.edu/w/wunderjt/StudentProjects/Wunderbot%202003/Wunderbot%20Webpage2003/Robot%20webfiles/index.htm

NOTE: Students announced renaming MultEbot 2 to "Wunderbot" at 2001 annual symposium (All their idea, not Dr W's)

Wunderbots 2, 3, and 4 entered into international competitions

http://www2.etown.edu/wunderbot/

Wunderbot 2 prototype

Wunderbot 3

Wunderbot 4

IGVC

(Intelligent Ground Vehicle Competition)

- Etown competed in 2004, 2006, and 2008

- 50 to 60 Universities from U.S., Canada, and Japan (mostly R1 grad school programs) compete on a U.S. military base in Michigan

  - Wet/dry obstacle courses with white lines boundaries painted on grass
  - Also a GPS course

  - ALL ROBOTS MUST BE FULLY AUTONOMOUS !

Wunderbot 4

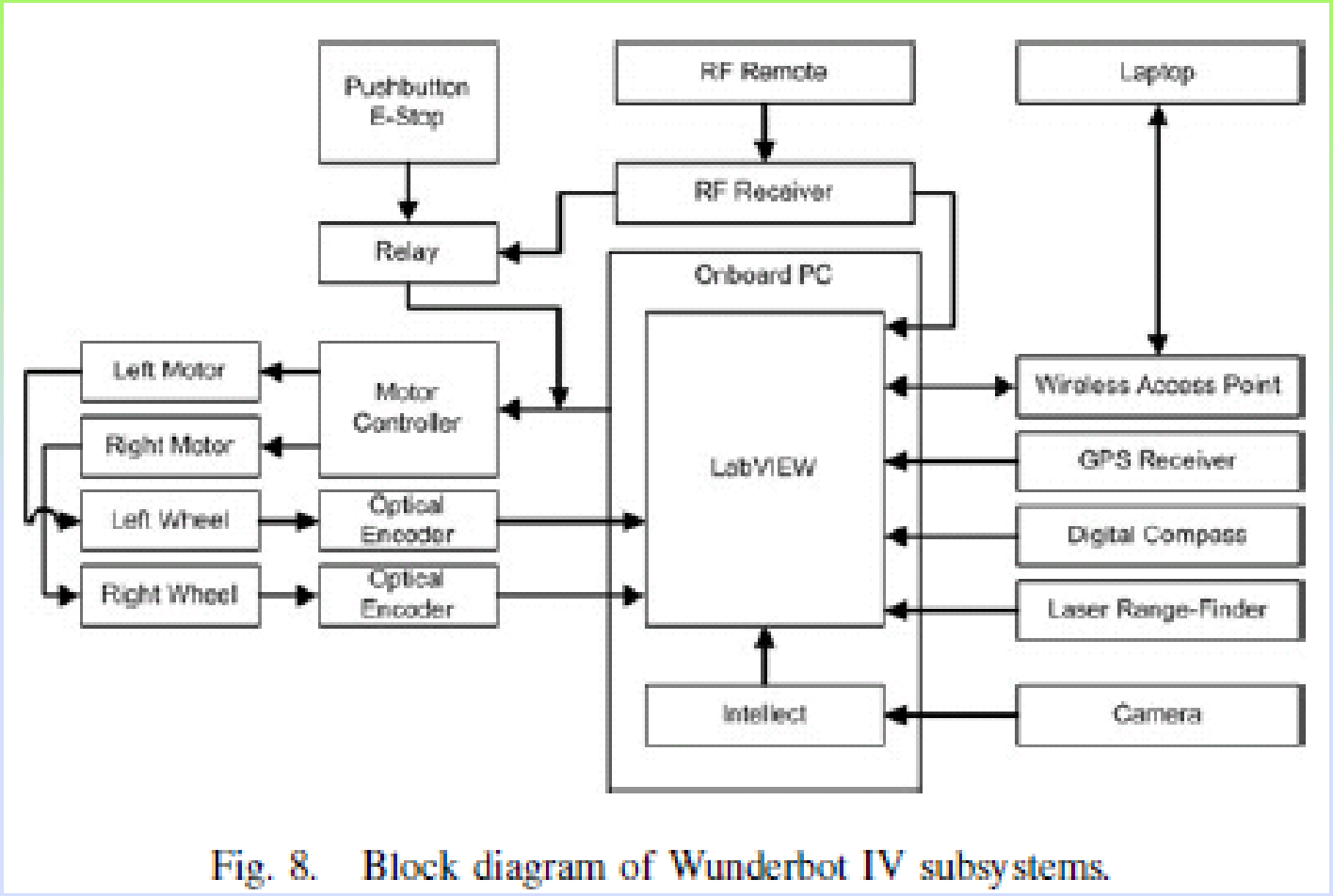


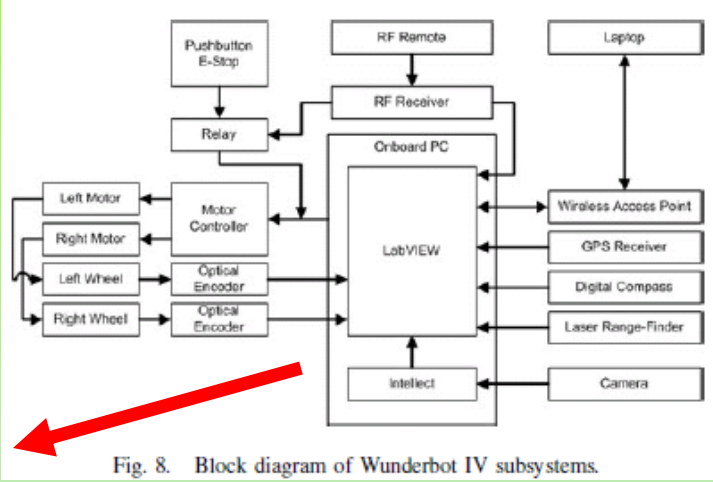
Fig. 8. Block diagram of Wunderbot IV subsystems.

Painter, J. and Wunderlich, J.T. (2008). **Wunderbot IV: autonomous robot for international competition.** In *Proceedings of the 12th World Multi-Conference on Systemics, Cybernetics and Informatics: WMSCI 2008, Orlando, FL*: (pp. 62-67). Also HERE

Wunderbot 4

Phoenix Contact Industrial PC

Fig. 2. Phoenix Contact IPC5500 Industrial PC, fully connected.



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Wunderbot 4

Phoenix Contact connectivity blocks, fuses, relays, and wireless access point

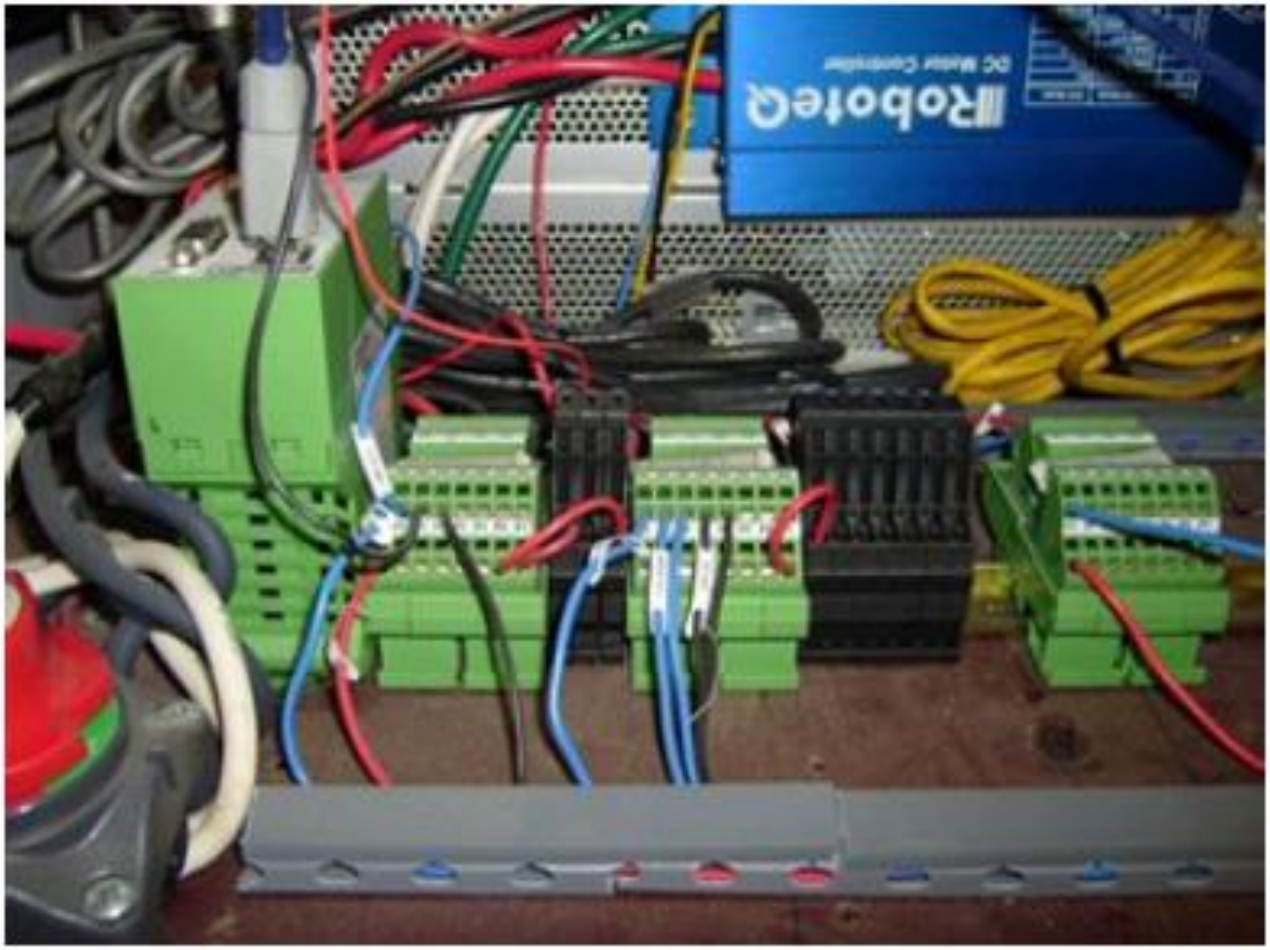
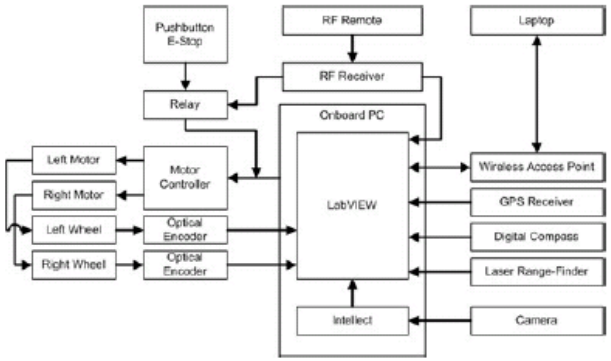


Fig. 3. Power wires running at the heart of the electrical system, from connectivity blocks (green) and fuses (black) mounted on a DIN rail, and then neatly tucked away in mounted plastic conduits. Phoenix Contact RAD-80211-XD wireless access point mounted on far left of rail.



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Wunderbot 4

Laser Range Finders and high-performance camera donated by **Phoenix Contact** affiliates

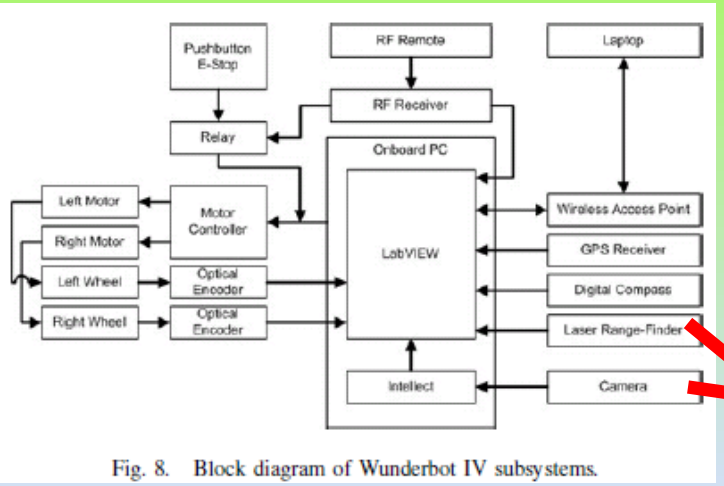


Fig. 8. Block diagram of Wunderbot IV subsystems.

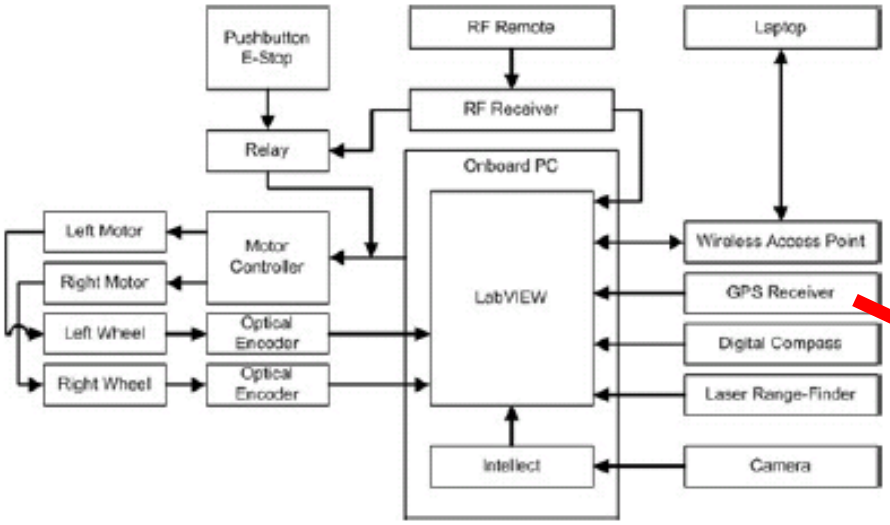
(a) (b)

Fig. 5. (a) One of two SICK LMS 200 laser range-finders. (b) Cognex DVT Legend 554C XE camera.

Painter, J. and Wunderlich, J.T. (2008). **Wunderbot IV: autonomous robot for international competition.** In *Proceedings of the 12th World Multi-Conference on Systemics, Cybernetics and Informatics: WMSCI 2008, Orlando, FL*: (pp. 62-67). Also HERE

Wunderbot 4

- **Phoenix Contact** five-point switch
- GPS donated by **Phoenix Contact** affiliate



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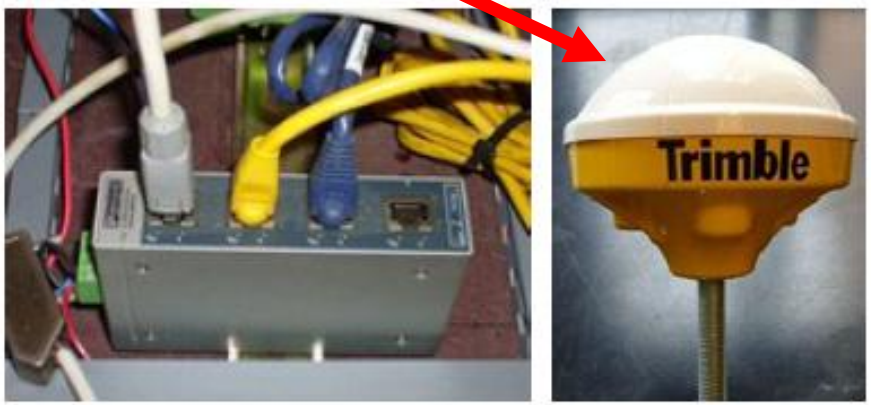


(a) (b)

Fig. 7. (a) Phoenix Contact SFN 5TX five-port switch, to which is connected, from left to right: camera, PC, wireless access point. (b) Trimble AgGPS 114.

Painter, J. and Wunderlich, J.T. (2008). **Wunderbot IV: autonomous robot for international competition.** In *Proceedings of the 12th World Multi-Conference on Systemics, Cybernetics and Informatics: WMSCI 2008, Orlando, FL*: (pp. 62-67). Also HERE

Wunderbot 4
- Motor Controller

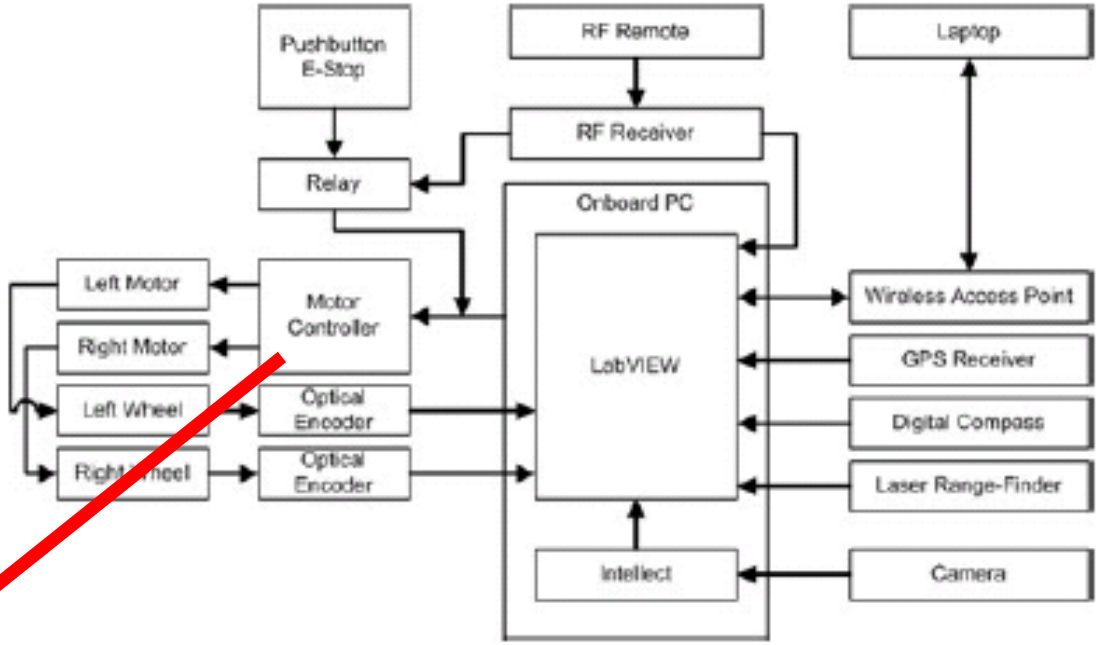


Fig. 8. Block diagram of Wunderbot IV subsystems.

(a)

(b)

Fig. 6. (a) Roboteq AX2550 motor controller. (b) One of two Hamilton Series 5000 pneumatic casters.

Painter, J. and Wunderlich, J.T. (2008). **Wunderbot IV: autonomous robot for international competition.** In *Proceedings of the 12th World Multi-Conference on Systemics, Cybernetics and Informatics: WMSCI 2008, Orlando, FL*: (pp. 62-67). And HERE

Wunderbot 4

Won an IGVC award for one of a few schools able to implement "JAUS" (Joint Architecture for Unmanned Systems) Wireless Communication

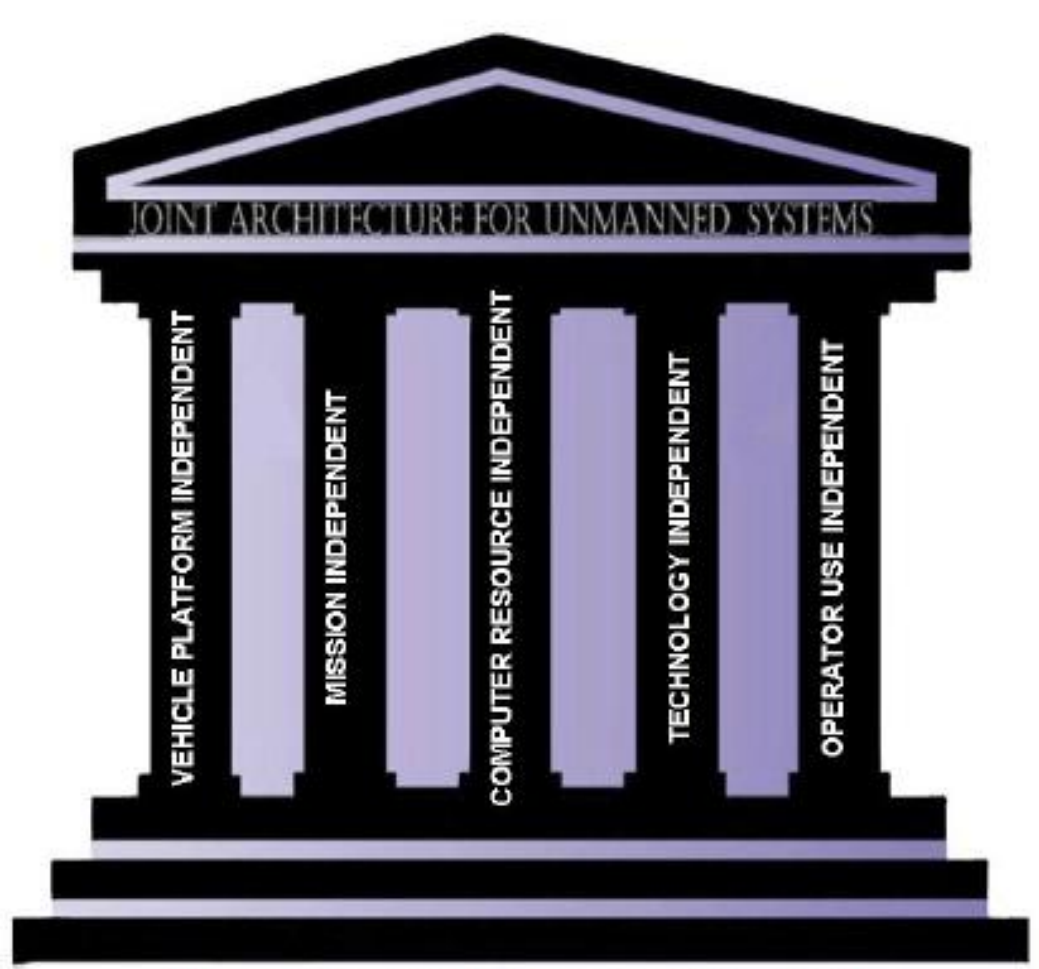


Figure 1: JAUS Independence requirements [3]

Crouse, J. (2008) **The joint architecture for unmanned systems: a subsystem of the wunderbot 4**.

Wunderbot 4 Wireless Communication

Although Wunderbots are fully autonomous, the IGVC awarded those who could respond to “JAUS,” a U.S. Department of Defense protocol.

(Competitions partially funded by DARPA, and held on a U.S. military base)

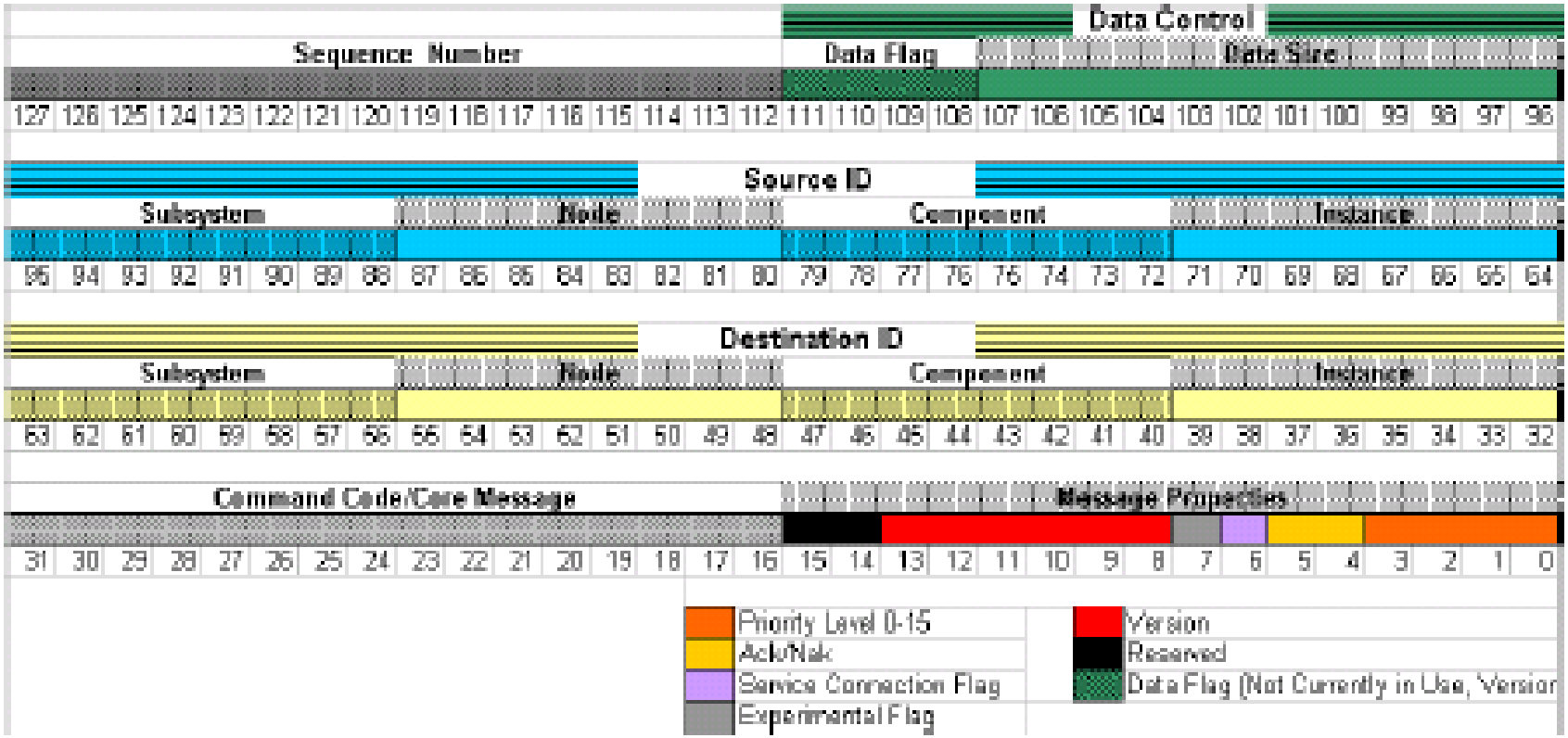


Figure 7: JAUS message header detailed structure [6]

Crouse, J. (2008). **The joint architecture for unmanned systems: a subsystem of the wunderbot 4**.

Online tutorials created for future generations of students

Wunderbot - Main VI Labview Tutorial
Wunderbot - GPS Subsystem Labview Tutorial
Wunderbot - LADAR Subsystem Labview Tutorial
Wunderbot - JAUS Subsystem Labview Tutorial
Wunderbot - Vision Subsystem Labview Tutorial
Wunderbot - Motor Control Subsystem Labview Tutorial
Wunderbot - Digital Compass Subsystem Labview Tutorial
Wunderbot - MCglobal08 Subsystem Labview Tutorial
nanoLC Robot Simulation

Theory and design decisions here:

[1] Painter, J. and Wunderlich, J.T. (2008). **Wunderbot IV: autonomous robot for international competition.** In *Proceedings of the 12th World Multi-Conference on Systemics, Cybernetics and Informatics: WMSCI 2008, Orlando, FL*: (pp. 62-67). Session for mostly NASA researchers. And HERE

[2] Coleman, D. and Wunderlich, J.T. (2008). **O^3: an optimal and opportunistic path planner (with obstacle avoidance) using voronoi polygons.** In *Proceedings of IEEE the 10th international Workshop on Advanced Motion Control, Trento, Italy.* vol. 1, (pp. 371-376). IEEE Press.

[3] **JAUS wireless packetized communication by Jeremy Crouse**

Wunderbot 4

Significant changes in the mid-2000's

1) New Lab in $22,000,000 Science, Technology, Engineering, & Mathematics Center

2) **Relationship with Phoenix Contact** began

- Initially for large mobile robots

3) Growing International Activities

Conference publications in Japan, Jamaica, England, and Italy *(and across the US)*

Taught "*Advanced Robotics with Applications to Space Robotics*"

- Visiting Professor of Engineering at The University of Trento in Italy
- For PhD students, engineering faculty, and robotics researchers

- http://users.etown.edu/w/wunderjt/syllabi/EGRXXX%20Wunderlich,%20Joseph%20TRENTO.htm

Developed relationship with six Universities in Italy:

1. University of Trento (Visiting Professor)
2. Pantheon Institute in Rome (to help create our Architecture programs)
3. University of Genoa (to help organize a conference)
4. Italian Institute of Technology (sent student to conduct robotics research)

Also began relationship with:

Sapienza University in Rome, and University of Padua

See more here: http://users.etown.edu/w/wunderjt/BCA%20Report%20on%20Italian%20Schools%20by%20Dr%20Wunderlich%202011%20SUBMITTAL.pdf

And here: http://users.etown.edu/w/wunderjt/home_personal_ITALY_ALL.html

Japan

1. Sent student to Hiroshima to present our research on Search & Rescue Robots

2. Key-note Speaker in Osaka on research using on-line “Crowd-sourced Architecture” games to rapidly prototype Architectures, followed by use of professional architectural renderings and animations.
    - Follow-up work presented in London.

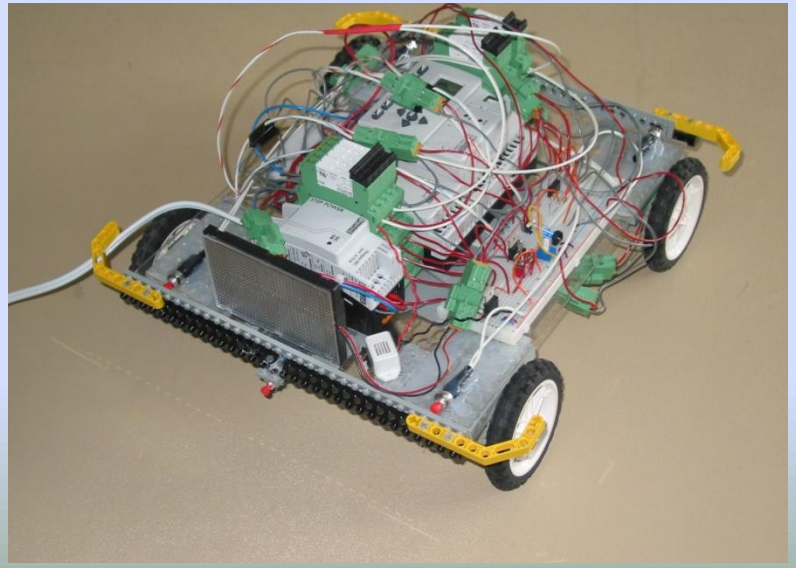
more: http://users.etown.edu/w/wunderjt/TSOJIN_ranks.pdf

Phoenix Contact NanoLC Hi-Tech competitions

- - East Coast Regional's hosted and judged at Etown College
- - Nationals judged at USA headquarters in Pennsylvania

Phoenix Contact NanoLC’s

Elizabethtown College students experimented with some of the very first NanoLC’s in the early 2000’s

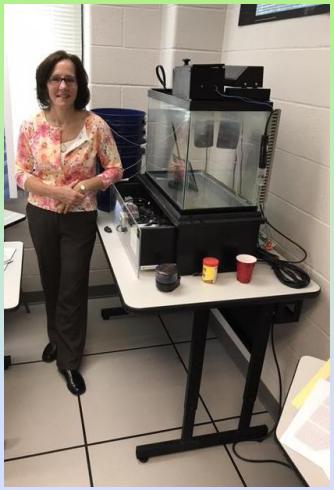


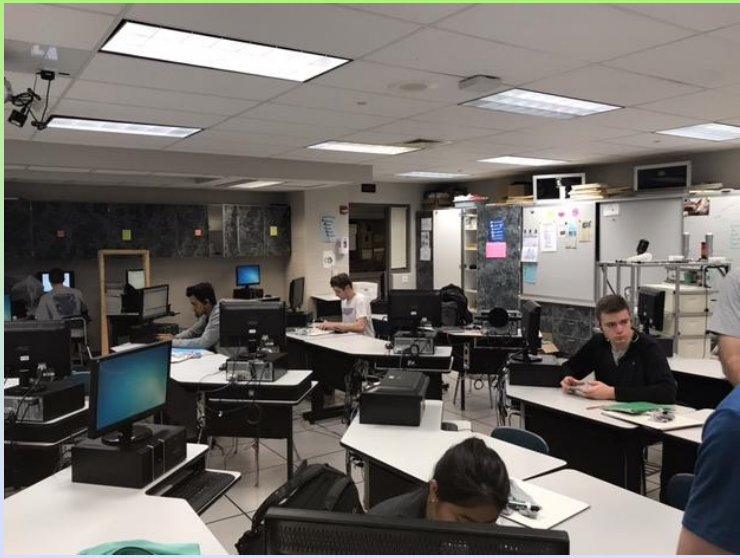
Now helping host and judge regional and national **Phoenix Contact NanoLC** competitions

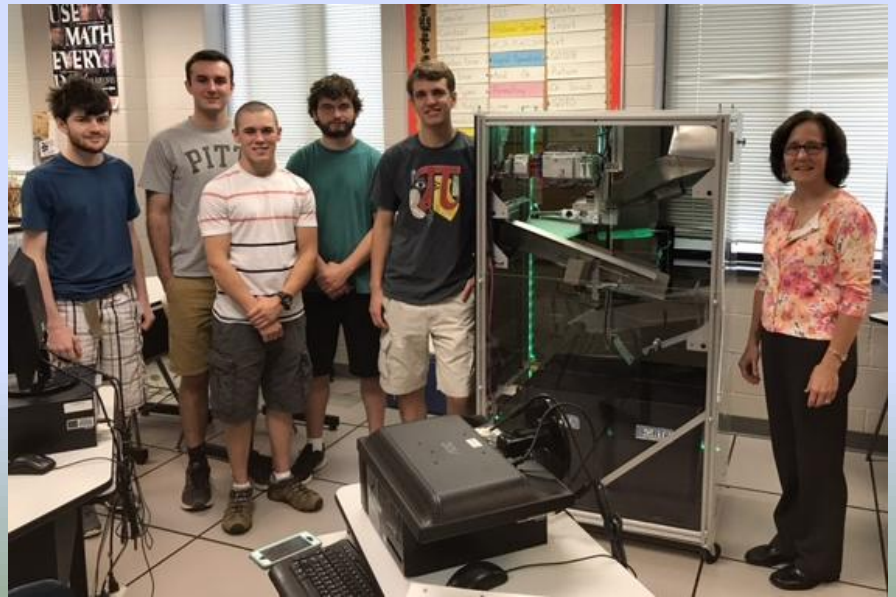
Now helping host and judge regional and national **Phoenix Contact NanoLC** competitions

Phoenix Contact NanoLC competitions

EXAMPLE: Lower Dauphin High School in Pennsylvania has consistently competed for past six years, with only mentoring from their Computer Science & Math teacher; and projects built in her garage after school





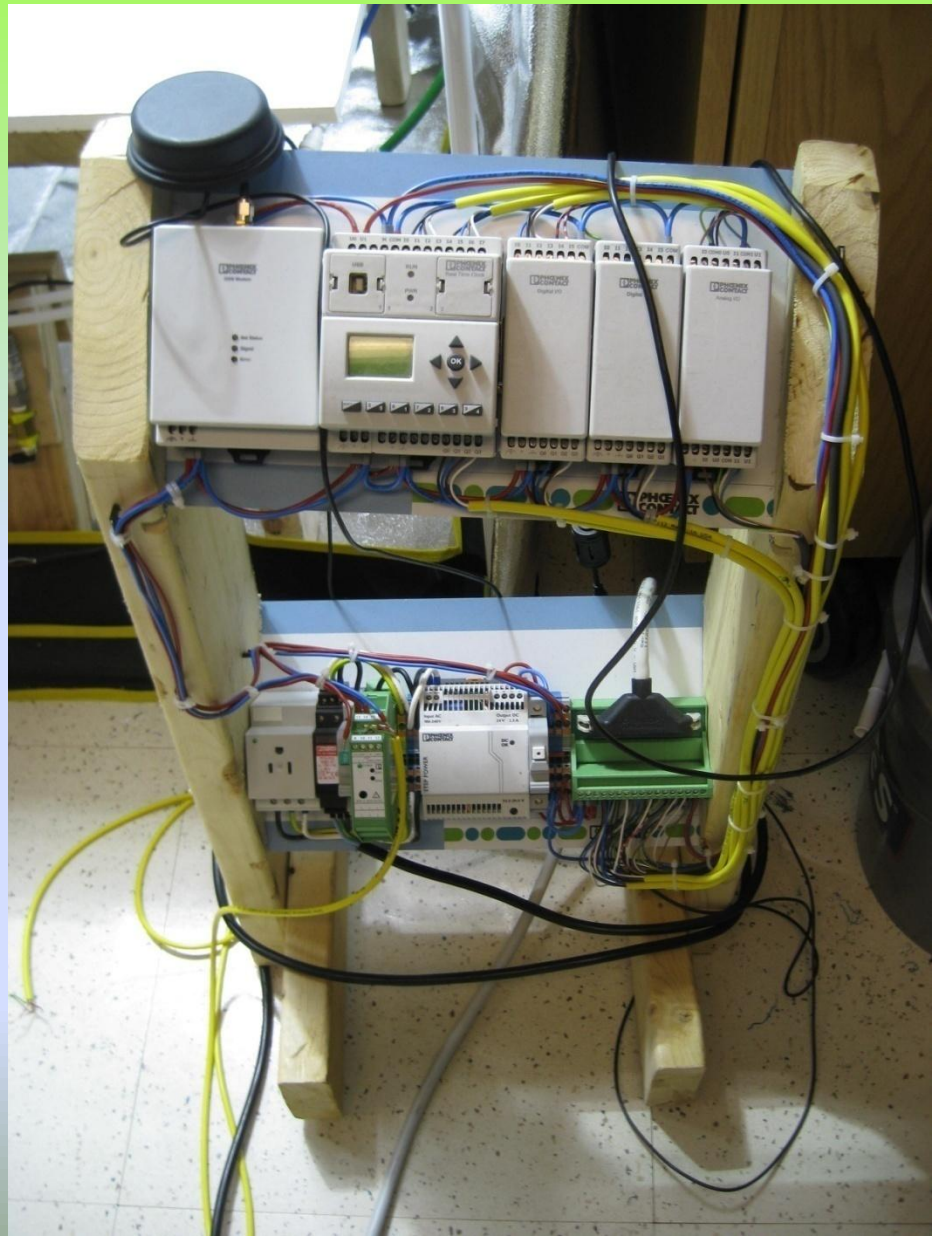


Phoenix Contact and Elizabethtown College
Eastern Regional NanoLC Programmable Logic Controller (PLC) Contest
Saturday, February 2,2019

Time	Room	Team Assigned	Teacher/Mentor	
8:00 am – 9:30 am		Team 1 may start set up		
8:30 am – 9:00 am		Judges arrive (Light breakfast/review)		
9:00 am – 9:20 am	TBD	Elizabethtown Middle School	**Mr. Terry Bupp-Petersheim**	PA
9:25 am – 9:45 am	TBD	Lower Dauphin High School	**Mrs. Nancy Kiscadden**	PA
9:50 am – 10:10 am	TBD	Elizabethtown High School	**Mr. Terry Bupp-Petersheim**	PA
10:15 am – 10:35 am	TBD	Cumberland Valley High School	**Ms. Anne Miller**	PA
10:40 am – 11:00 am	TBD	Dauphin County Technical School	**Mr. Stephan Miller**	PA
11:05 am – 11:25 pm	TBD	Le Roy High School	**Mr. William Hunt**	NY
11:30 am – 11:50 am	TBD	York County School of Technology	**Mr. Robert Bierman**	PA
12:00 pm – 1:00 pm	Judges' Lunch (teams have lunch on their own at any time that works)			
1:00 pm – 1:20 pm	ZOOM	Salamanca High School	**Ms. Kim Dry**	NY
1:25 pm – 1:45 pm	ZOOM	Academic Magnet High School	**Ms. Maria Desbrow**	SC
1:45 pm – 2:45 pm		Team networking – family and friends welcome View team projects in assigned rooms Judges Deliberation Time		
2:45 pm – 3:15 pm	Gibble Hall	Welcome & Remarks Jerry Wise – Phoenix Contact Dr. Wunderlich - Elizabethtown College		
3:15 pm – 3:45 pm	Gibble Hall	Awards recognition – family and friends welcome Jerry Wise		
3:45 pm – 3:55 pm	Gibble Hall	Photos with teams Team meeting for national contest qualifiers		
3:45 pm – 4:30 pm	Team rooms	Project dismantling		

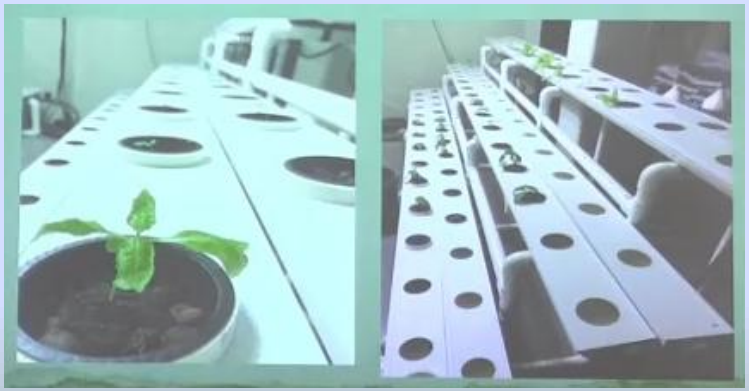
Phoenix Contact equipment used for Hydroponics
in EGR/CS 333 "***Digital Design II, Interfacing, and Assembly Language***"

Hydroponic Gardens



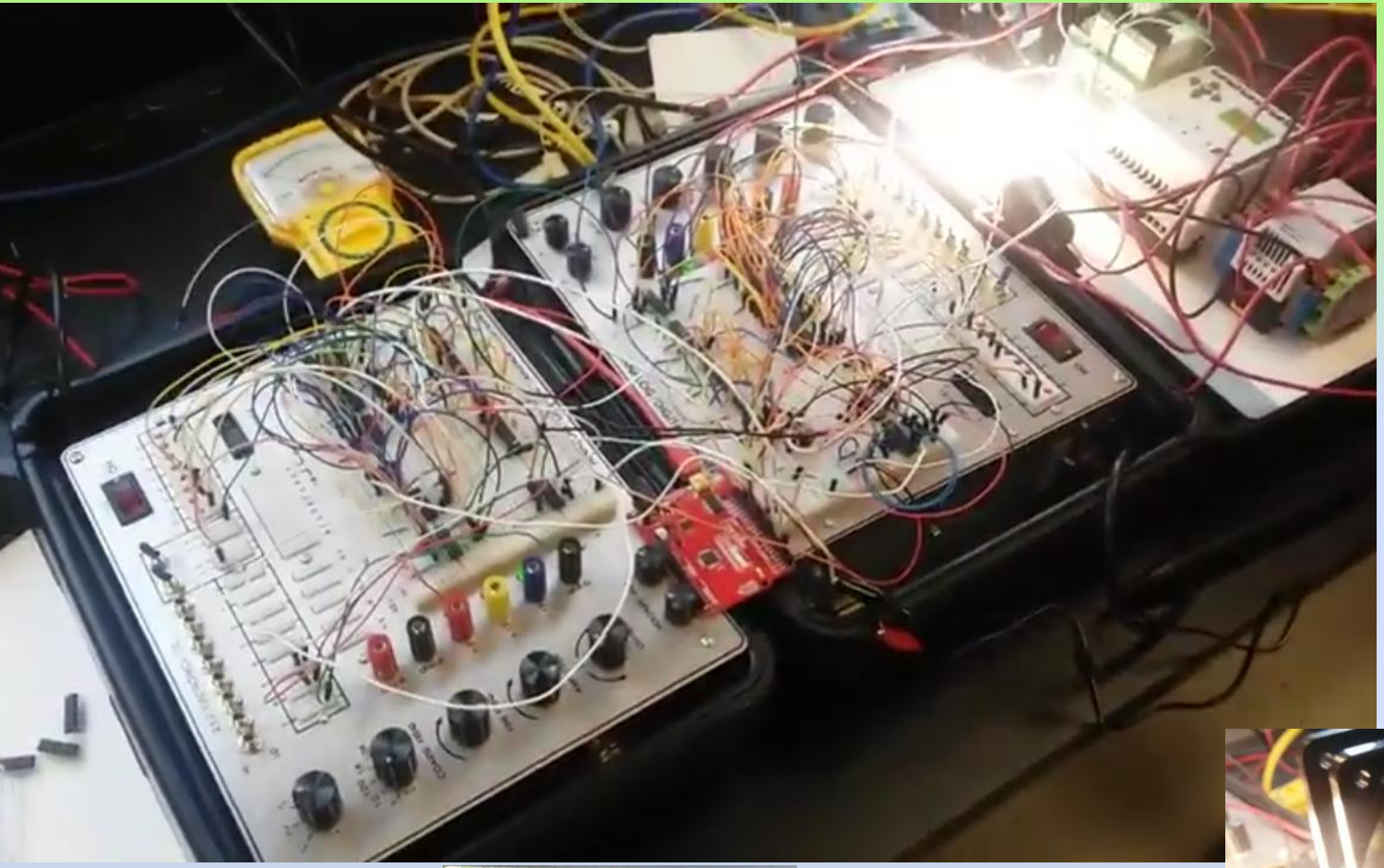
Hydroponic Gardens

Hydroponic Gardens now
scaled up for Elizabethtown College food services



Phoenix Contact 2016 equipment donations

EGR/CS333: 2017 Serial Packetized Bus Communication between systems, with parity checks: (1) Programmable Logic Controller; (2&3) Two combinational & sequential SSI TTL Synchronous Digital Circuits *(including tri-state buffers)*; (4) Raspberry PI *(small single-board computer;* (5) **E**mergency override system; (6) Arduino for Bus Control, and I^2C protocol for an LCD

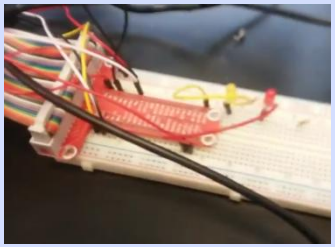


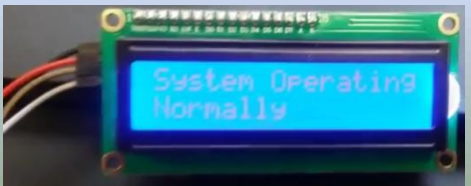
Assignment:

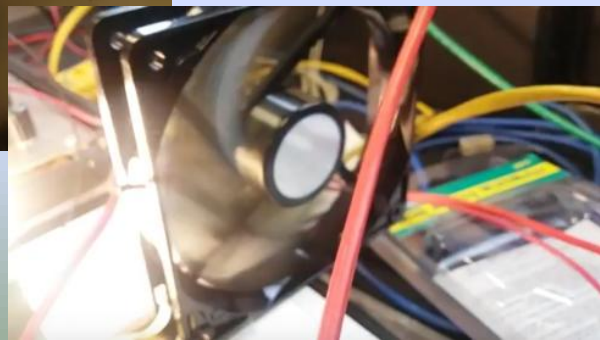
http://users.etown.edu/w/wunderjt/333_Lab_5_2017_Revised_and_MIDTERM.pdf

VIDEO:

https://www.youtube.com/watch?v=d_tGoalH0F8&feature=youtu.be





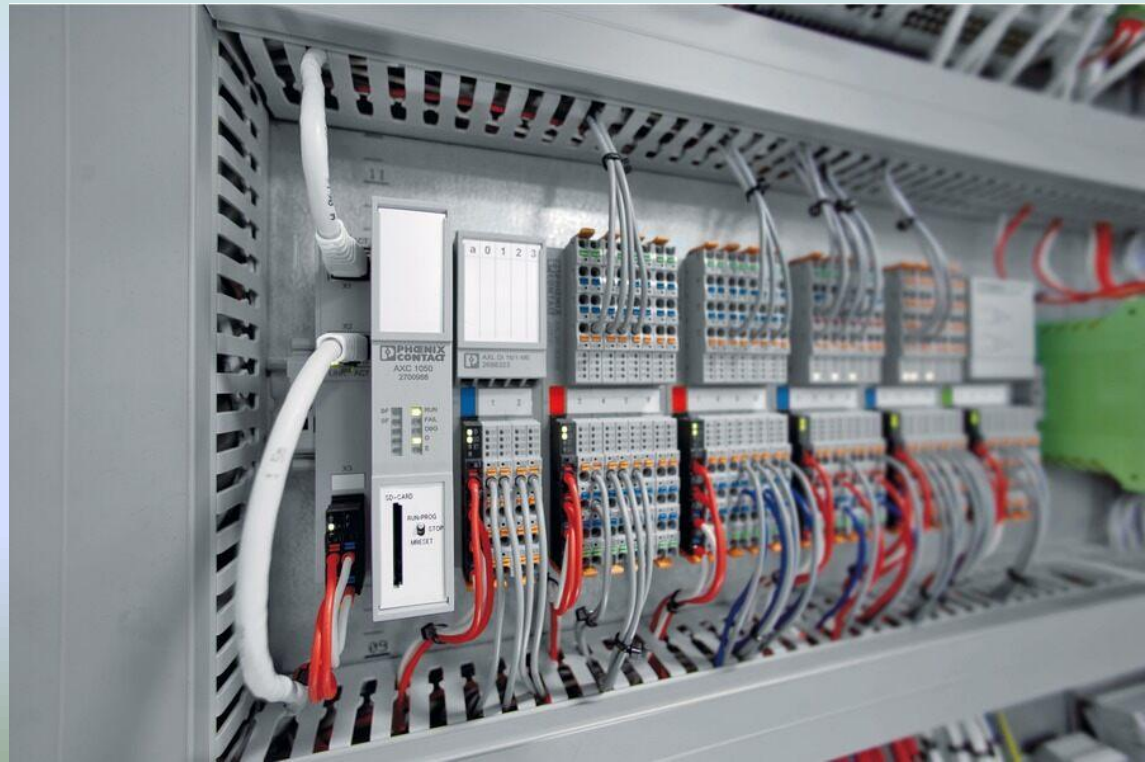


Advanced Axioline controllers in:

EGR/CS 333 "***Digital Design II, Interfacing, and Assembly Language***"
(prereq: "***Digital Design I***")

EGR/CS 433 "***Advanced Computer Engineering***"
(prereq: "***Digital Design I***")

EGR/CS 434 "***Green Robotics & Machine Intelligence***"

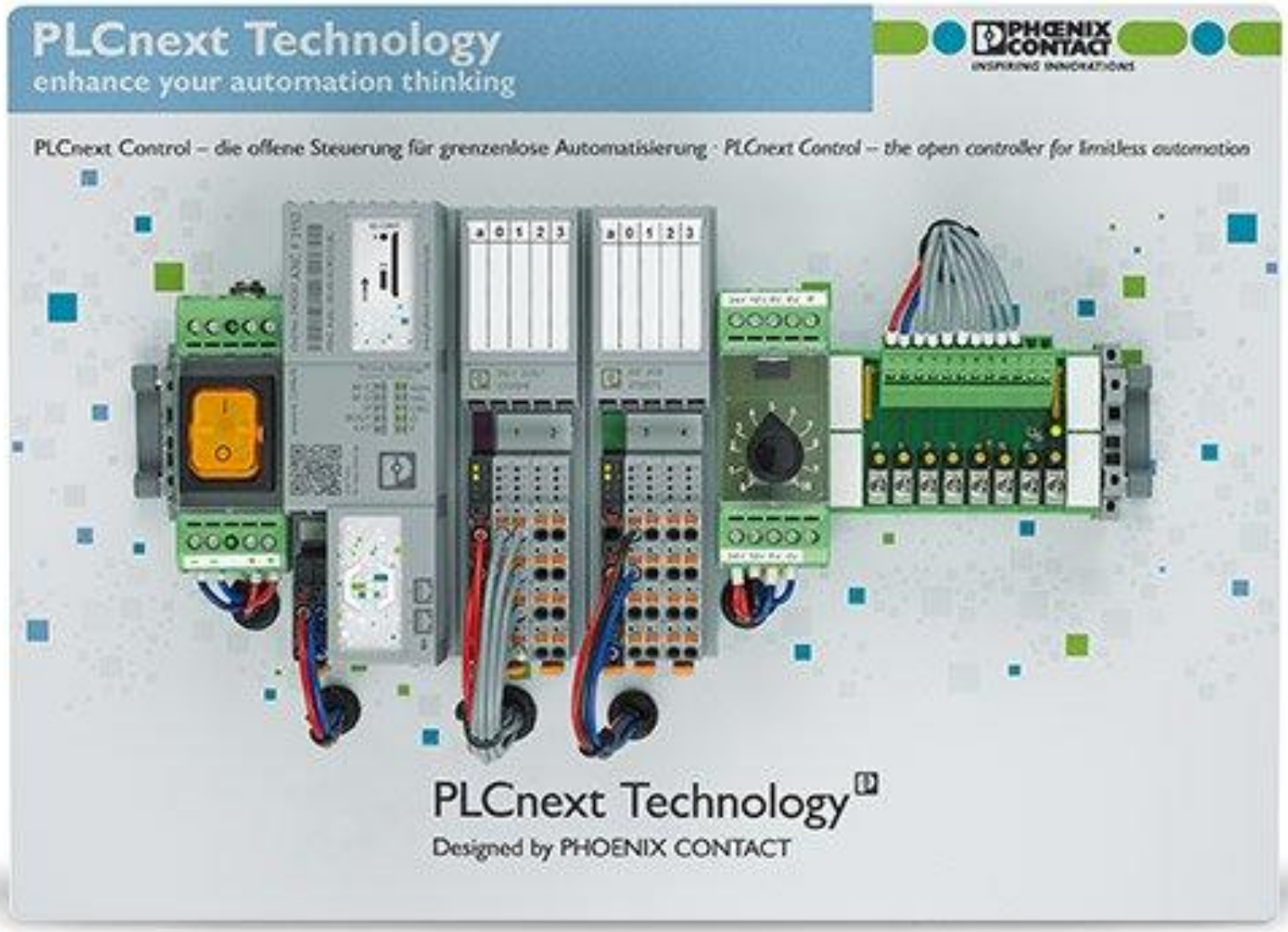


We customize our own User Manuals

and upload them to the Edunet
for use by ~100 Universities Worldwide

2018 IC's, Circuit Trainer, and Power Supply
2019 FPGA (2018B, 2018A, 2013, pre-2013)
2019 Relays
2019 NanoLC
2019 Advanced Axioline PLC
2019 Intel 8051 Microcontroller (2015, 2014, Pre-2013)
2019 Rasberry Pi and ARM Microcontroller

New Advanced PLC's in 2020



Lab now includes Architecture

Courses in:

1. *Green Architectural Engineering*
2. *Architecture Design Theory*
3. *Architectural Materials & Methods*
4. *Conceptual Architecture*

5&6. *Architecture Studios I&II*

taught to **LEED** *(Leadership in Energy & Environmental Design)* standards

New academic programs:

1. Major in **BS Engineering, Sustainable Design** Option

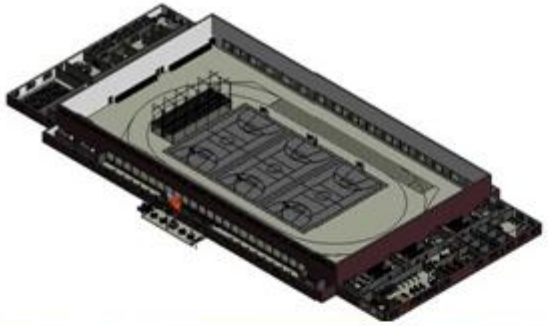
   (renamed "Environmental Engineering")

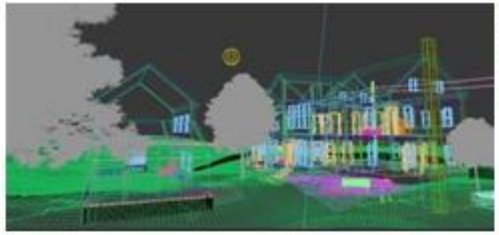
2. **Minor in Architectural Studies**
3. Individualized Major: **BA in Architecture**

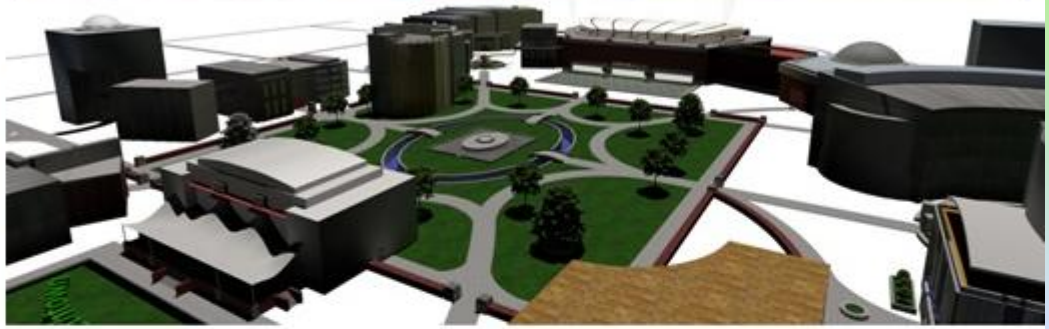
   - Recently proposed for all students

Student Architecture

using advanced computer modeling & animation software's







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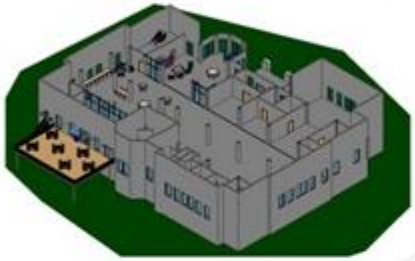
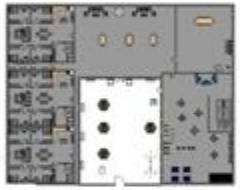
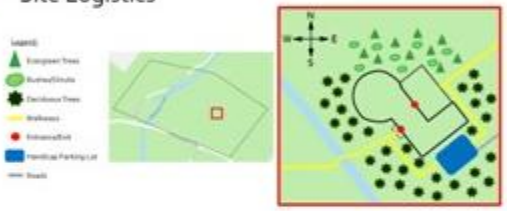
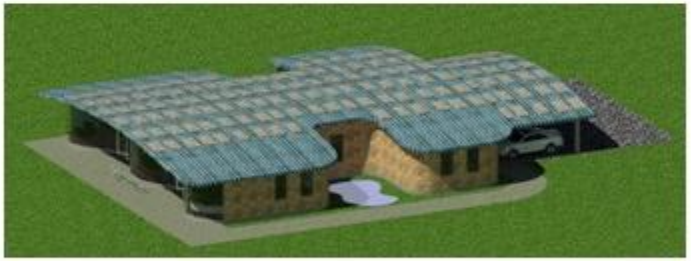


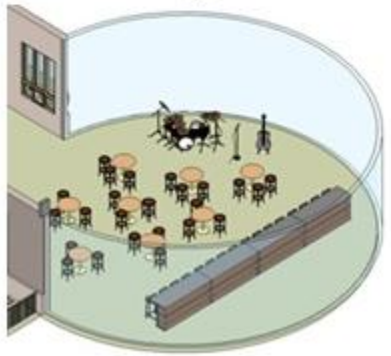


Site Logistics





The Music Lounge



Bar

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Proposed Etown Cedar Hill housing

See more on my website:
http://users.etown.edu/w/wunderjt/

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