HU Aquaponics Monitoring and Control System
: European Annual EduNet Conference 2020



Rachel Fogle, Josh Krug, Glenn Williams

Tuesday, 10/13/20 : 10.00 am – 10.30 am

Harrisburg, PA, USA

HU Aquaponics Monitoring and Control System

: HU AqMCS (Glenn Williams)

- Harrisburg University **Presidential Research Grant 2019 / 2020**

"The functional purpose of the HU Aquaponics Monitoring and Control System Project is to develop an environmental and plant monitoring and control system for the HU Aquaponics Lab, located in the Student Union. The project involves the design and implementation of technology that will regularly take measurements from the environment (e.g., air temperature, water temperature, pH, dissolved oxygen, etc). PLCnext Technology will systematically collect, store, and web-publish the measurement data for HU researchers and the public to use for scientific research."

Accepted and **Approved** :

Dr. Eric Darr, Ph.D.
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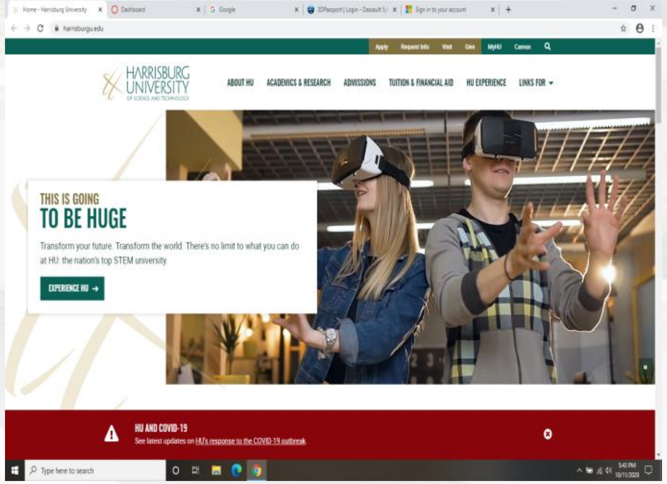
www.harrisburgu.edu



welcome and introductions (Glenn Williams)

Rachel L. Fogle, Ph.D.

Associate Professor of Biological Sciences

EDUCATION: B.S. Chemistry / Mathematics, York College; Ph.D. Physiology, Pennsylvania State University College of Medicine.

Joshua R. Krug

Solutions Engineer
Phoenix Contact USA

EDUCATION: The Pennsylvania State University Bachelor of Science, Electro-Mechanical Engineering Technology

Glenn P. Williams, P.E.

Lecturer in Advanced Manufacturing, AR & Robotics

EDUCATION: BSME from the University of Vermont, EIT from Louisiana and PE from Ohio. However, everyone that knows Glenn knows — he is a computer guy.

hu su aquaponics lab tour
(Rachel and Joseph)

- **Rachel Fogle** speaking, **Joseph Tetreault** HD Camera operator (and HU Aquaponics Technician))
- --
- Even though it has existed for centuries, **aquaponics**, or the **combination** of **raising fish** and **growing plants together** in **water**, has only in recent years grown in popularity as society continues to move toward more locally produced food and vegetation.
- In aquaponics, fish waste provides an **organic food source** for plants, and plants naturally filter water for fish.
- Many people today view aquaponics as a more **sustainable** and **environmentally** conscious form of raising food and plants.




presentation 1 (Rachel Fogle - science)

- **OPENING STATEMENT :** learning doesn't stop, even in a pandemic.

- slide 1 - Emerging Aquaponics Market - **CEA** (controlled environment agriculture)
- slide 2 - Emerging Aquaponics Market - **Expanding CEA**
- slide 3 - Expanding Aquaponics at Harrisburg University - **HU AqMCS**
- slide 4 - Expanding Aquaponics at Harrisburg University - **Automation Research Goals**
- slide 5 - Interdisciplinary Collaboration Opportunities with HU - **Collaboration**
- slide 6 - Interdisciplinary Collaboration Opportunities with HU - **Commercial-scaled Research**

presentation 1 (Rachel's point of view)

- slide 1 of 6 - Emerging Aquaponics Market - **CEA**

- Aquaponics is an emerging controlled environment agriculture (CEA) technology
  - Combines established practices of recirculating aquaculture and hydroponic plant production
  - Current research to combine two separate agricultural systems
  - Benefits include water conservation, year-round fresh food production, elimination of food deserts

presentation 1 (Rachel’s point of view)

- slide 2 of 6 - Emerging Aquaponics Market - **Expanding CEA**

- Expanding CEA market
  - Increased urbanization and loss of arable land
  - Recirculating aquaculture up 5.8% over past decade per FAO 2018 Report
  - Food security concerns resulting from pandemic

presentation 1 (Rachel's point of view)

- slide 3 of 6 - Expanding Aquaponics at Harrisburg University - **HU AqMCS**

- Current lab-scaled system with on-going construction for commercial-scaled system
  - STEM education for students
  - Experiential learning opportunities for CEA careers
  - Research with industry partners

presentation 1 (Rachel's point of view)

- slide 4 of 6 - Expanding Aquaponics at Harrisburg University – **Automation Research Goals**

- Automation research goals
  - Sensor applications to manage water quality, maintain plant and animal health, and control environmental conditions
  - Allow for improved growth rates for increased revenue

presentation 1 (Rachel's point of view)

- slide 5 of 6 - Interdisciplinary Collaboration Opportunities with HU - **Collaboration**

- Combination of Advanced Manufacturing and CEA faculty and scientist
  - Experts in the automation and agricultural sciences
- Foundation of lab-scaled research
  - Completed and on-going research to develop new technologies

presentation 1 (Rachel’s point of view)

- slide 6 of 6 - Interdisciplinary Collaboration Opportunities with HU - **Commercial-scaled Research**

- Expanding to commercial-scaled research for industry impact
  - Opportunity to beta test developed technologies and research in “real world” scenarios
  - Ensure success before approaching the open market

presentation 2 (Josh Krug - automation)

- **OPENING STATEMENT :** Discussion on technical details about the system monitoring the aquaponics lab.

- slide 1 - Technical Details - **Overview**
- slide 2 - Technical Details - **Hardware**
- slide 3 - Technical Details - **Software**
- slide 4 - Technical Next Steps - **HU AqMCS**
- slide 5 - Comments / Observations / Thoughts - **Reflections**

presentation 2 (Josh’s point of view)

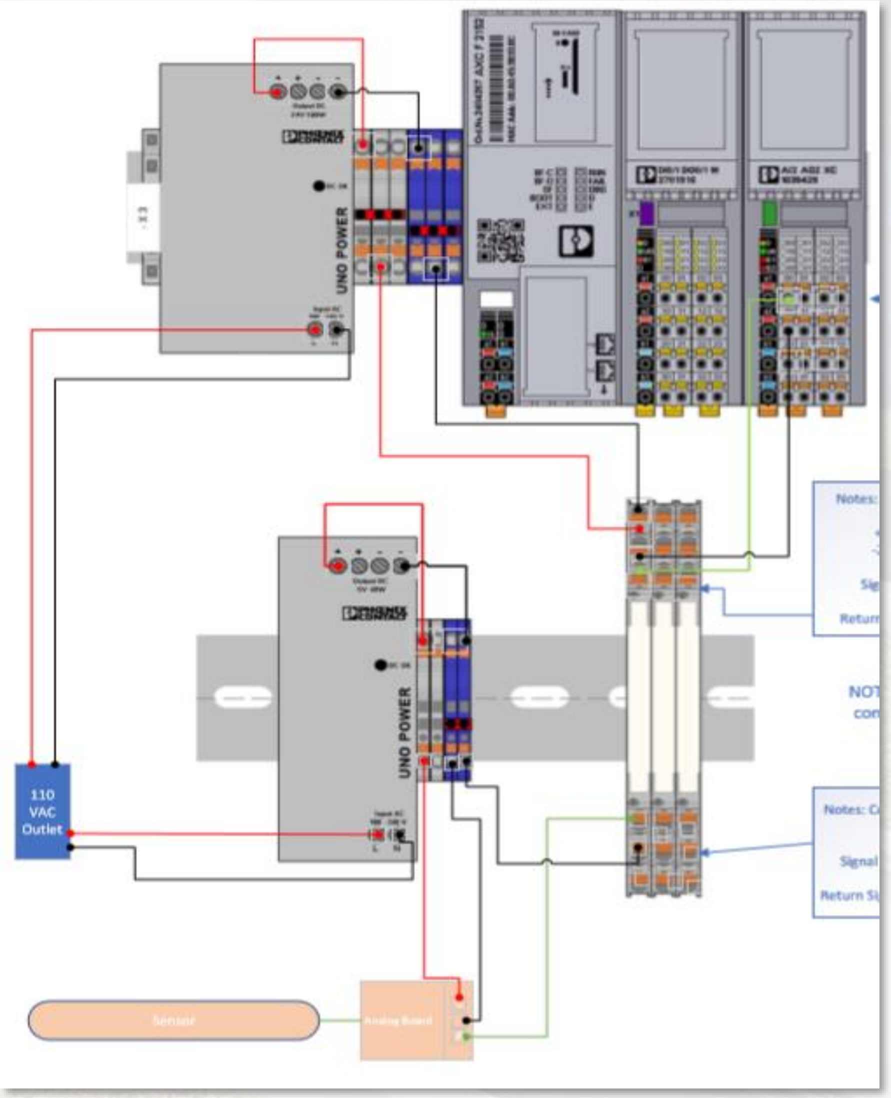
- slide 1 of 5 - Technical Details - **Overview**

- Training
  - In-person
  - Online
- Support
  - Hardware specification
  - Programming
  - Debugging
- Examples
  - Programming
  - Visualization (HMI) development

presentation 2 (Josh’s point of view)

- slide 2 of 5 - Technical Details - **Hardware**

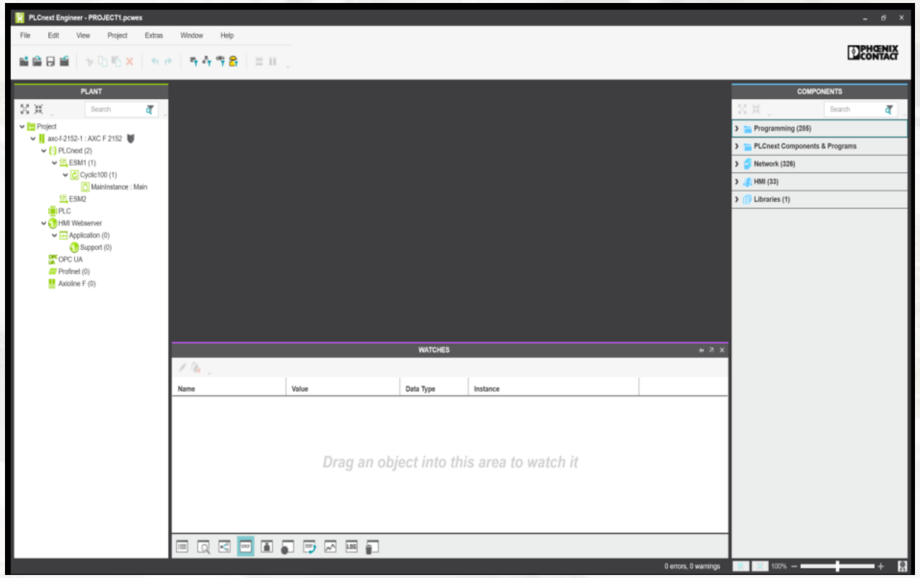
- Main Components
  - PLCnext Controller - AXC F 2152
- AXL F I/O modules
  - Analog Inputs
  - Digital Inputs/Outputs
  - Thermocouple Inputs
- Signal conditioners
  - Convert 0-3V analog signal to PLC readable signal
- Sensors
  - Ph, Temperature, Dissolved Oxygen and more
- Power
  - 5 VDC – Powers sensor hardware
  - 24 VDC – Powers control system hardware



presentation 2 (Josh’s point of view)

- slide 3 of 5 - Technical Details - **Software**

- PLCnext Engineer
  - Programming Language Used : IEC611-31
  - HMI Development
- Linux
  - Openness allowed for installation of a Domain Name Server client for remote access to a webpage.
  - Accessed controller remotely using: https://aquaponicsnext.ddns.net/ehmi/hmiapp.html
  - No VPN required
- Database
  - Using the native mySQL database on the controller allows for simple data collection.
  - The database can offer local access for other services to use the data for analytics



presentation 2 (Josh's point of view)

- slide 4 of 5 - Technical Next Steps

- Continue testing and setting up new sensors
- Finalize the visualization (HMI)
- Gather complete Bill of Materials (BOM)
- Design the control cabinet for hardware
  - Allow for expansion to add control functionality
  - in the future
- Build out the cabinet
- Install the system
- Test the system

presentation 2
(Josh’s point of view)

- slide 5 of 5 - **Reflections**

- Harrisburg University continues to stay engaged with the technology used for the monitoring system. They take great initiative in setting up meetings to ensure the project continues to move forward.
- Technical challenges:
  - Finding sensors to work with industrial hardware.
  - Figuring out how to design a solution to be both educational and functional.
  - Busy schedules create challenges for exchanging ideas and knowledge

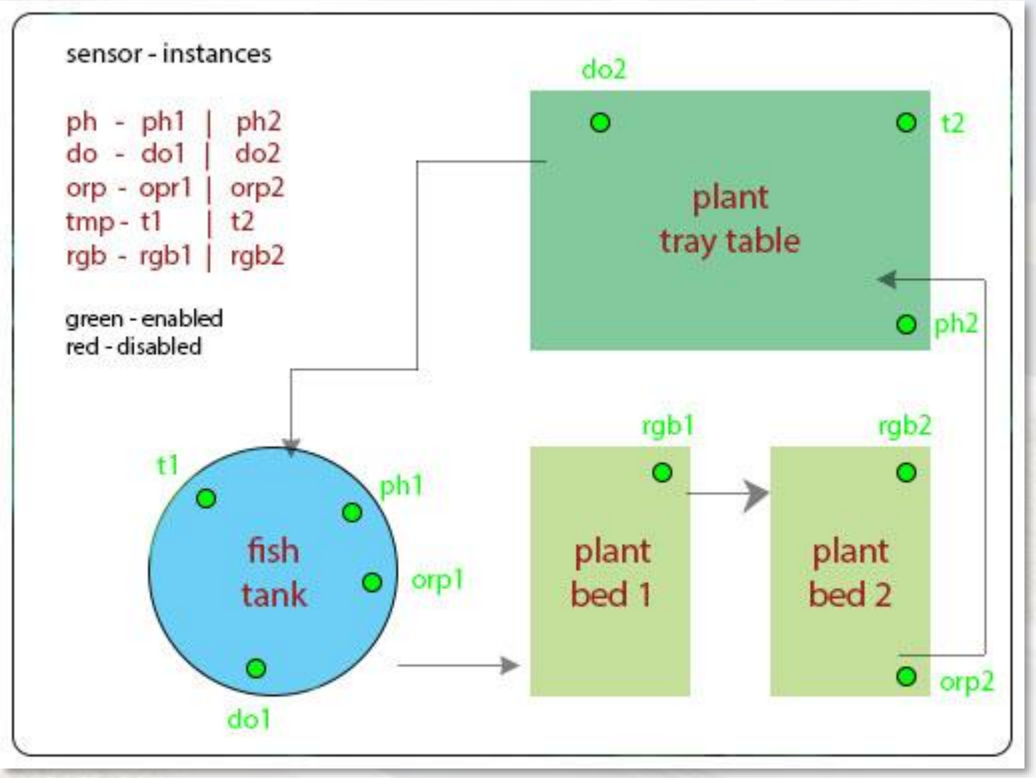
presentation 3 (Glenn Williams - education)

- **OPENING STATEMENT :** teaching doesn’t stop, even in a pandemic.

- slide 1 - HU student lab layout (beta 2 - placement of 10 sensors)
- slide 2 - dashboard design (beta 2 - monitoring 10 sensors)
- slide 3 - sensor naming convention (5 types; 10 instances - 2 per type)
- slide 4 - plcNext Main Program variable list (based on Josh code example)
- slide 5 - plcNext Application Navigation (plcNext controller "website" Josh code example)
- slide 6 - remote access (Rachel computer to Josh plcNext controller "website")

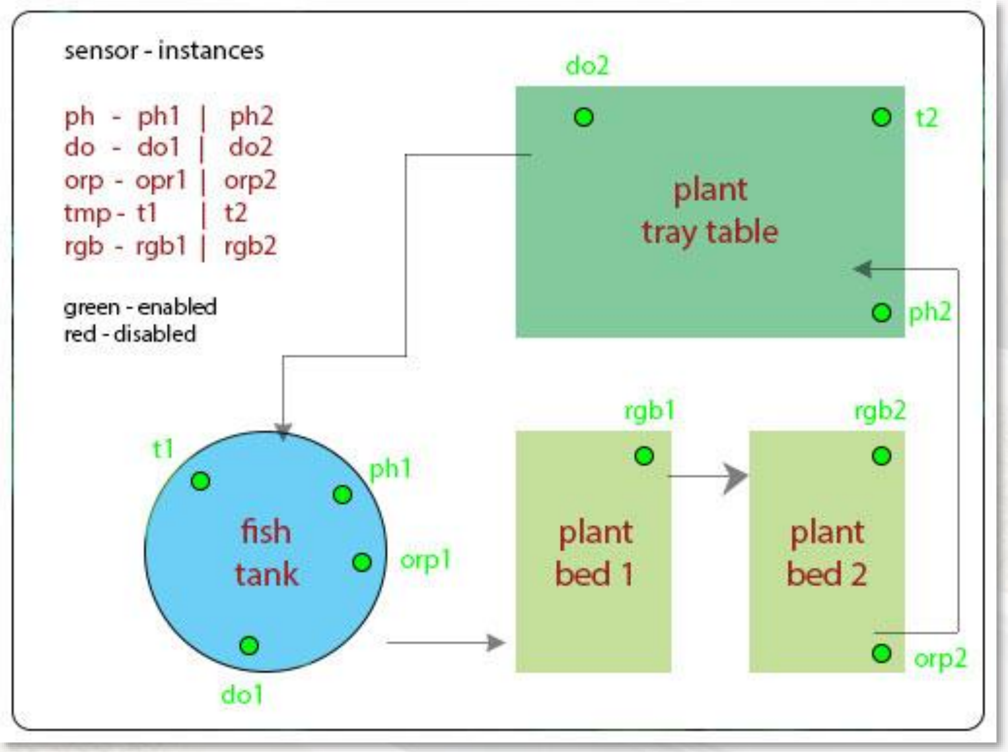
presentation 3 (Glenn's point of view)

- slide 1 of 6 - HU student lab layout (beta 2 - placement of 10 sensors)



presentation 3 (Glenn's point of view)

- slide 2 of 6 – dashboard design (beta 2 - monitoring 10 sensors)



presentation 3 (Glenn's point of view)

- slide 3 of 6 – sensor naming convention (5 types; 10 instances - 2 per type)

Naming Convention: by Sensor Type

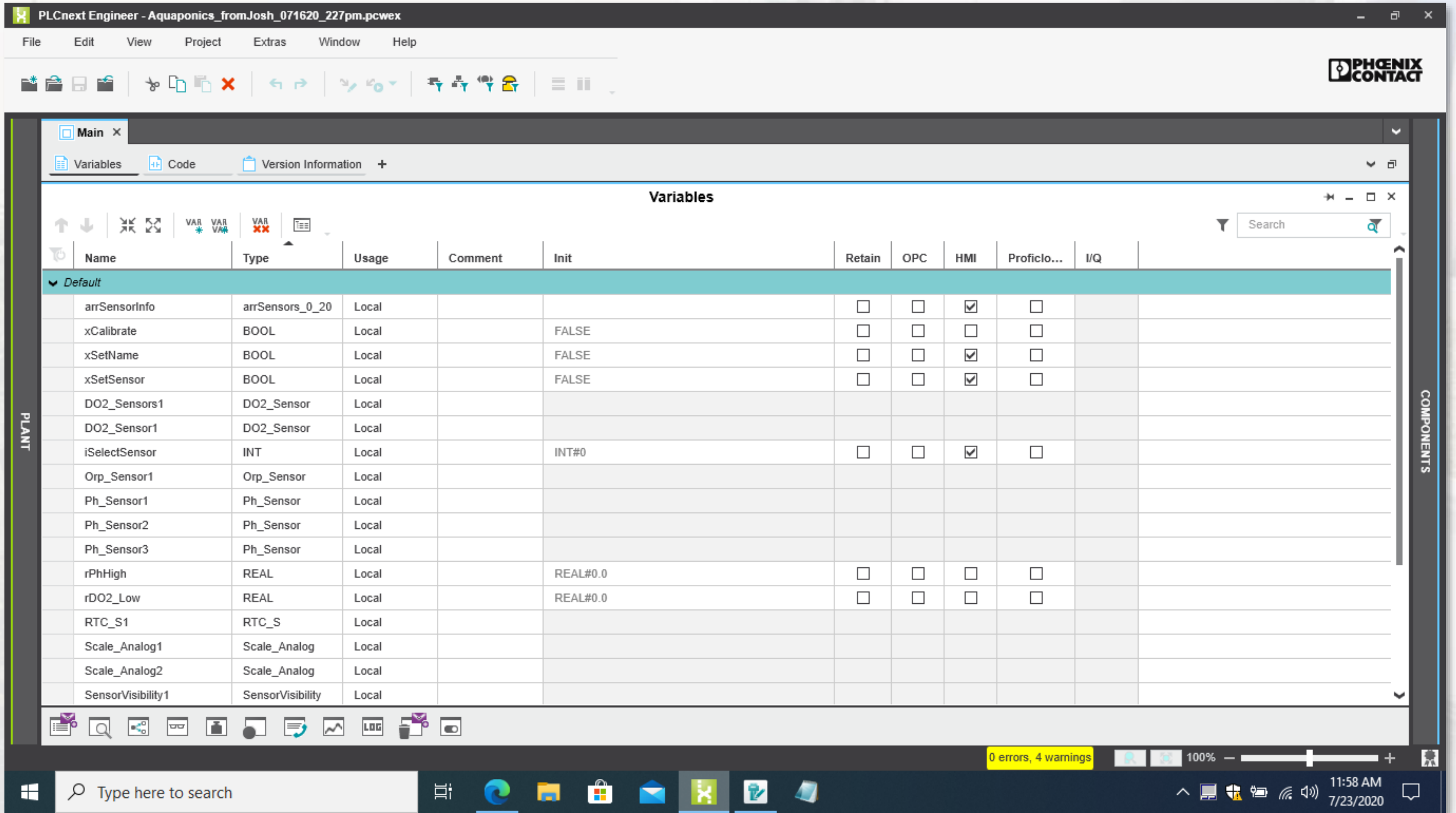
index:	sensor Type (actual):	Sensor ID (instance):	Sensor Location (hu su lab):
01	pH (Analog pH Sensor / Meter)	ph1	fish tank
02	pH (Analog pH Sensor / Meter)	ph2	plant tray table
03	DO (Analog Dissolved Oxygen Meter)	do1	fish tank
04	DO (Analog Dissolved Oxygen Meter)	do2	plant tray table

Naming Convention: by Sensor Location

index:	sensor Type (actual):	Sensor ID (instance):	Sensor Location (hu su lab):
01	T (Temperature Kit)	t1	fish tank
02	pH (Analog pH Sensor / Meter)	ph1	fish tank
03	ORP (Analog ORP Sensor / Meter)	orp1	fish tank
04	DO (Analog Dissolved Oxygen Meter)	do1	fish tank

presentation 3 (Glenn's point of view)

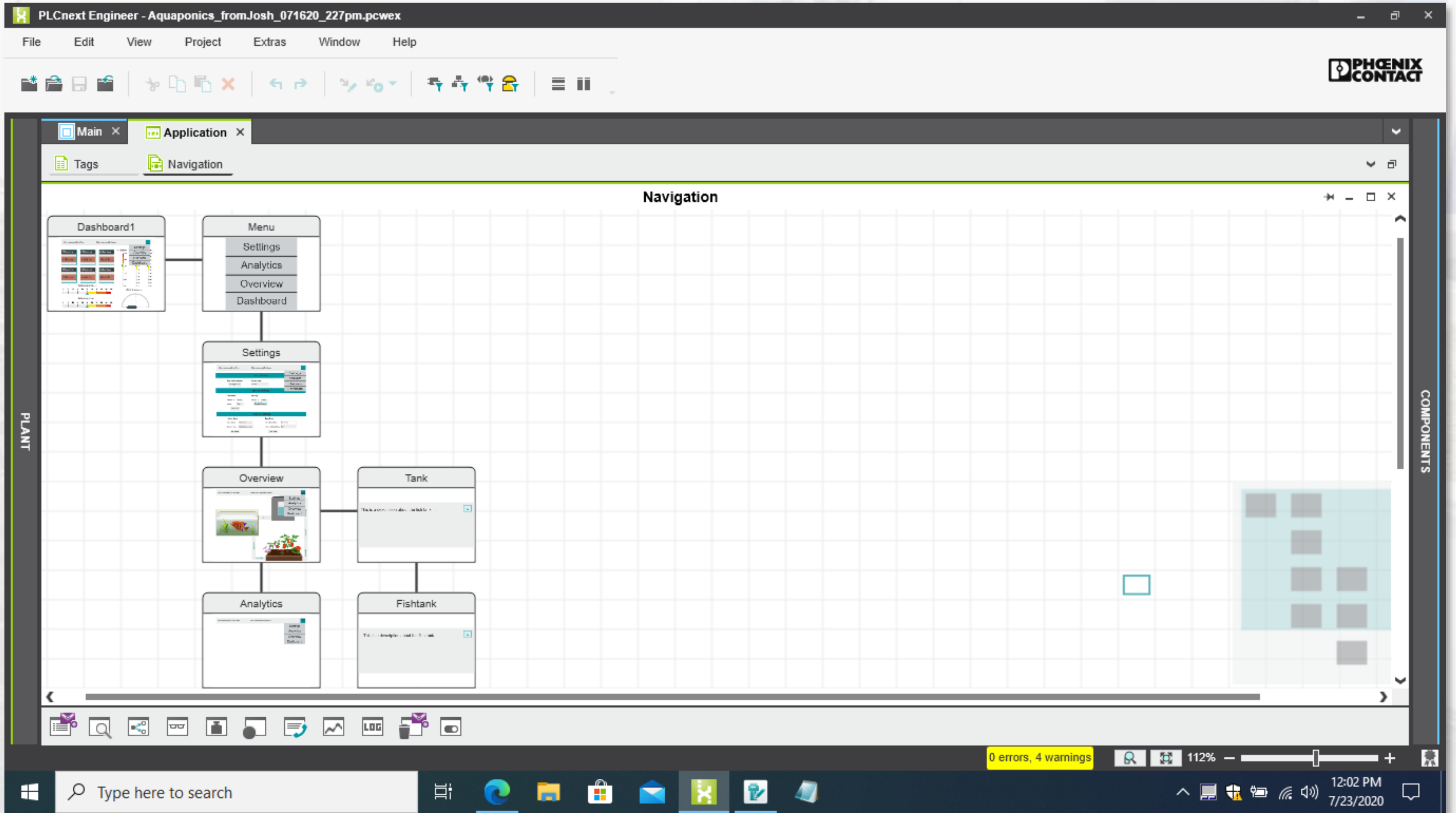
- slide 4 of 6 – plcNext Main Program variable list (based on Josh code example)



Name	Type	Usage	Comment	Init	Retain	OPC	HMI	Proficlo...	I/Q
Default									
arrSensorInfo	arrSensors_0_20	Local			☐	☐	☑	☐	
xCalibrate	BOOL	Local		FALSE	☐	☐	☐	☐	
xSetName	BOOL	Local		FALSE	☐	☐	☑	☐	
xSetSensor	BOOL	Local		FALSE	☐	☐	☑	☐	
DO2_Sensors1	DO2_Sensor	Local							
DO2_Sensor1	DO2_Sensor	Local							
iSelectSensor	INT	Local		INT#0	☐	☐	☑	☐	
Orp_Sensor1	Orp_Sensor	Local							
Ph_Sensor1	Ph_Sensor	Local							
Ph_Sensor2	Ph_Sensor	Local							
Ph_Sensor3	Ph_Sensor	Local							
rPhHigh	REAL	Local		REAL#0.0	☐	☐	☐	☐	
rDO2_Low	REAL	Local		REAL#0.0	☐	☐	☐	☐	
RTC_S1	RTC_S	Local							
Scale_Analog1	Scale_Analog	Local							
Scale_Analog2	Scale_Analog	Local							
SensorVisibility1	SensorVisibility	Local							

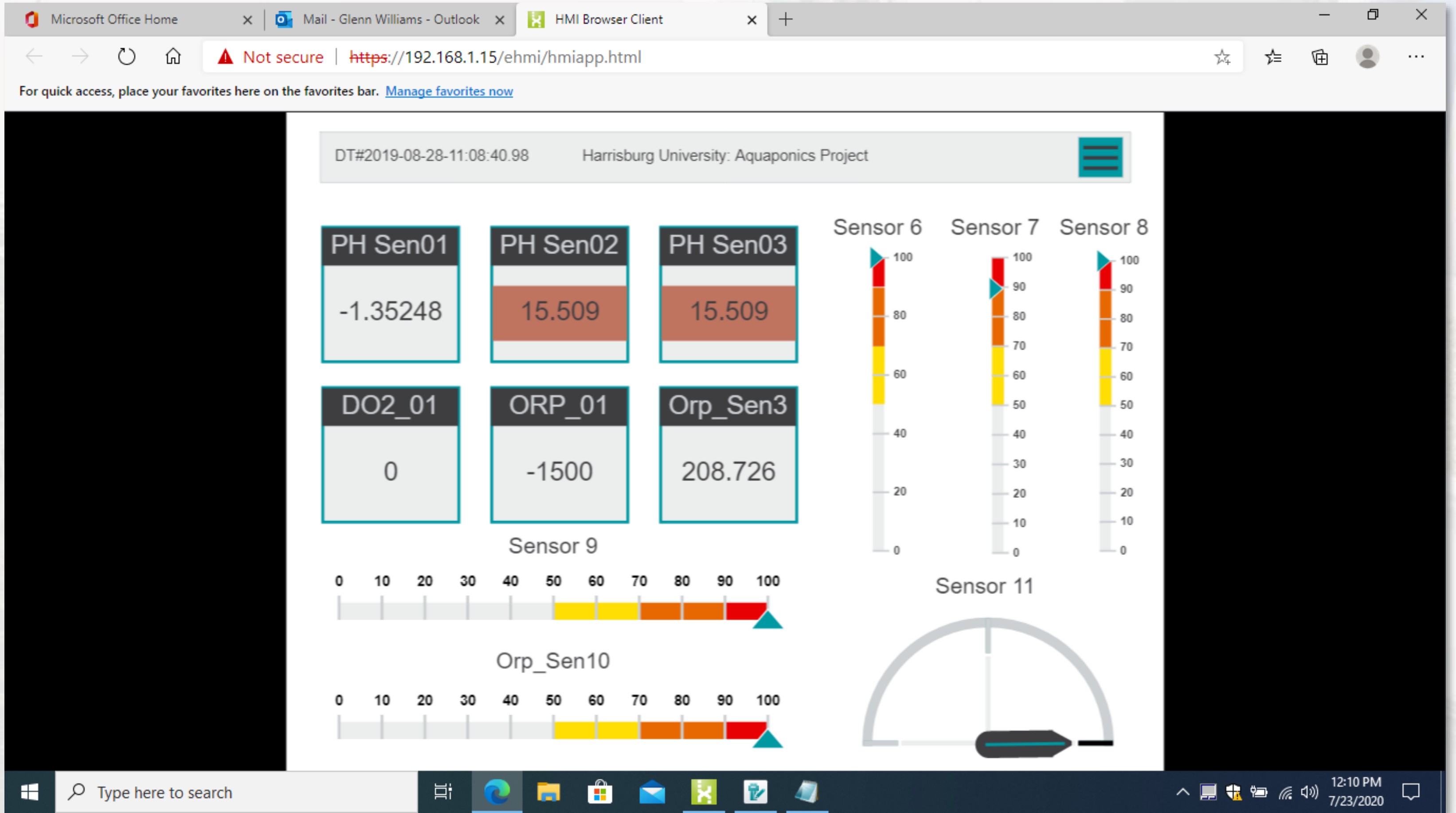
presentation 3 (Glenn's point of view)

- slide 5 of 6 – plcNext Application Navigation (plcNext controller "website" Josh code example)



presentation 3 (Glenn's point of view)

- slide 6 of 6 – remote access (Rachel computer to Josh plcNext controller "website")



thank you (Rachel, Josh and Glenn)

- FYI everyone - on the horizon: “ HU - PxC Cool Control Cabinet “

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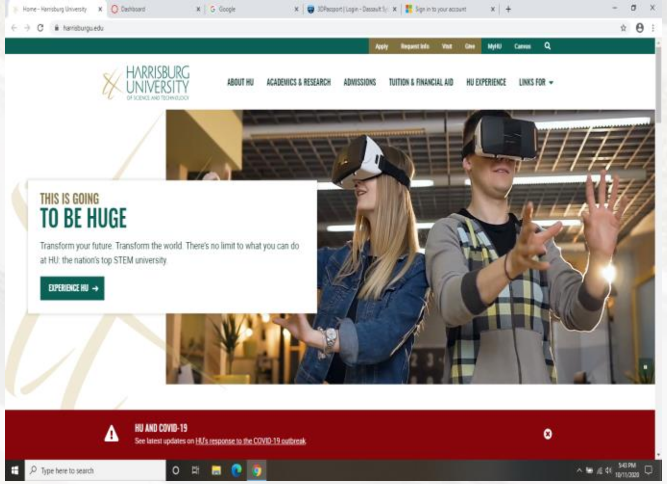
we are at a point where we can describe the plcNext Control Platform: controller, IO modules, signal conditioners, buttons, switches, sensors.

I think once we have all the components identified and working in the two "home aquaponics lab setups", we should be able to describe the technical and functional requirements for the PLCnext Control Cabinet.

On the horizon: ”HU - PxC Cool Control Cabinet”



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