Use the QR Code below to respond to two quick questions before we start!

Researching like an engineer

Dan Burleson, PhD

Instructional Associate Professor

CULLEN COLLEGE OF ENGINEERING UNIVERSITY of HOUSTON | ESIDE Engineering Student Innovation and Design Experience

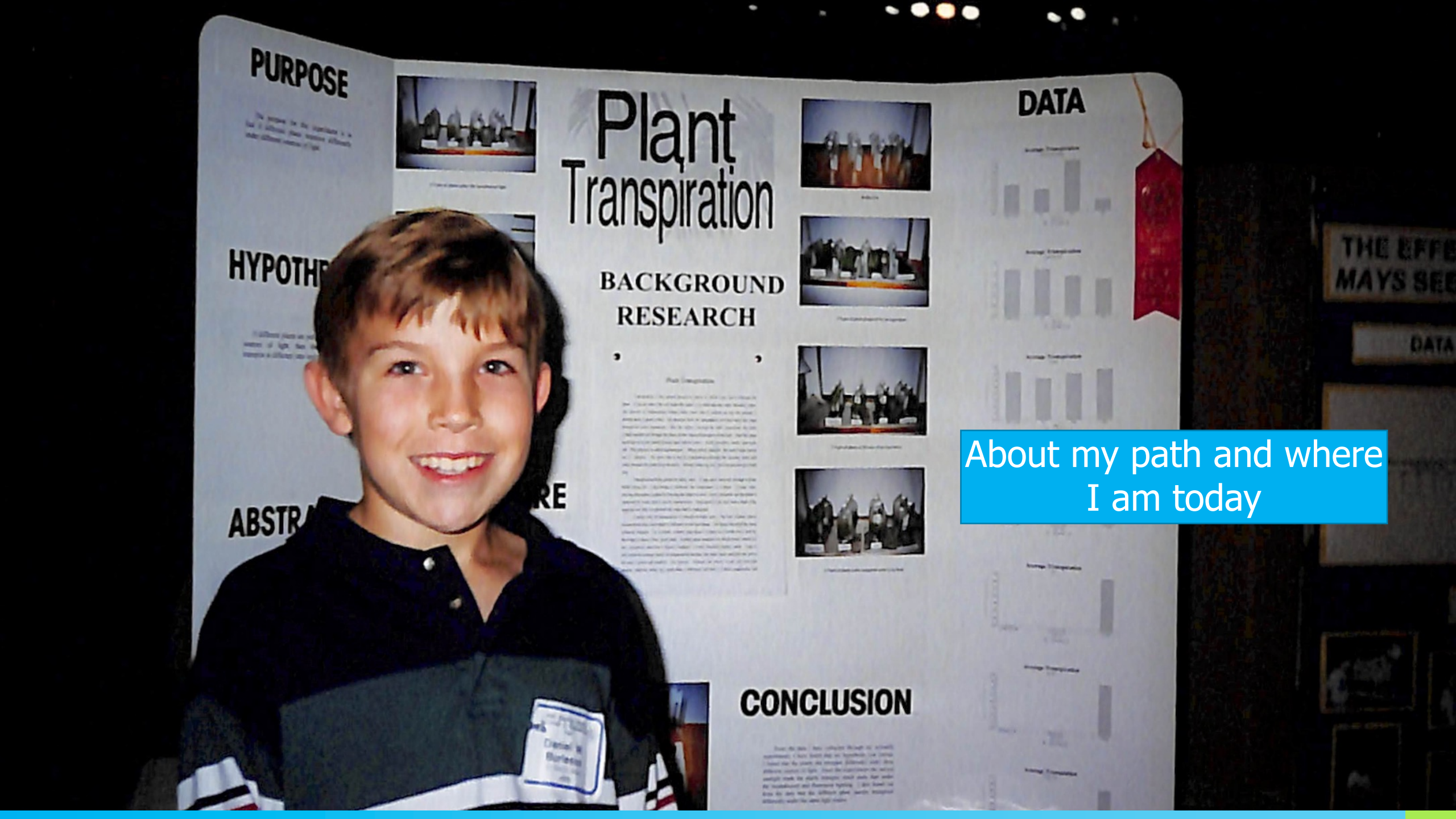
SEFH Seminar 2022

The purpose of this session is to explore the engineering research process

How does that fit in the context and research scientific process?

What motivates students to choose engineering problems?

How do we leverage that motivation for solutions (projects)?



About my path and where I am today

My Education

- Elementary School – Homeschooled
  - Career Goal = Professional athlete
- Catholic Middle School
  - Career Goal = Meteorologist
- Public High School
  - Career Goal = Computer engineering

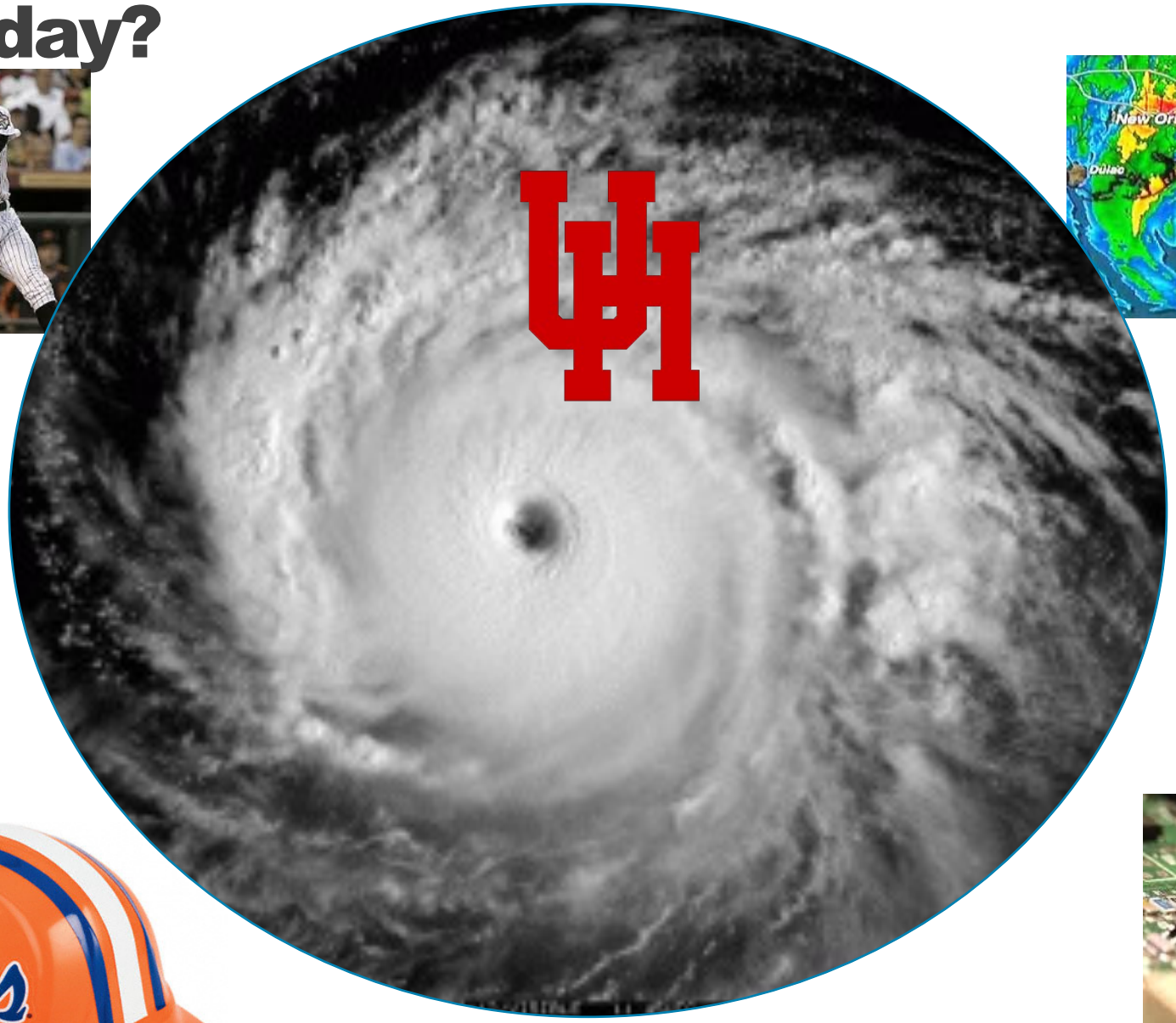
College (undergraduate)

- Graduated from

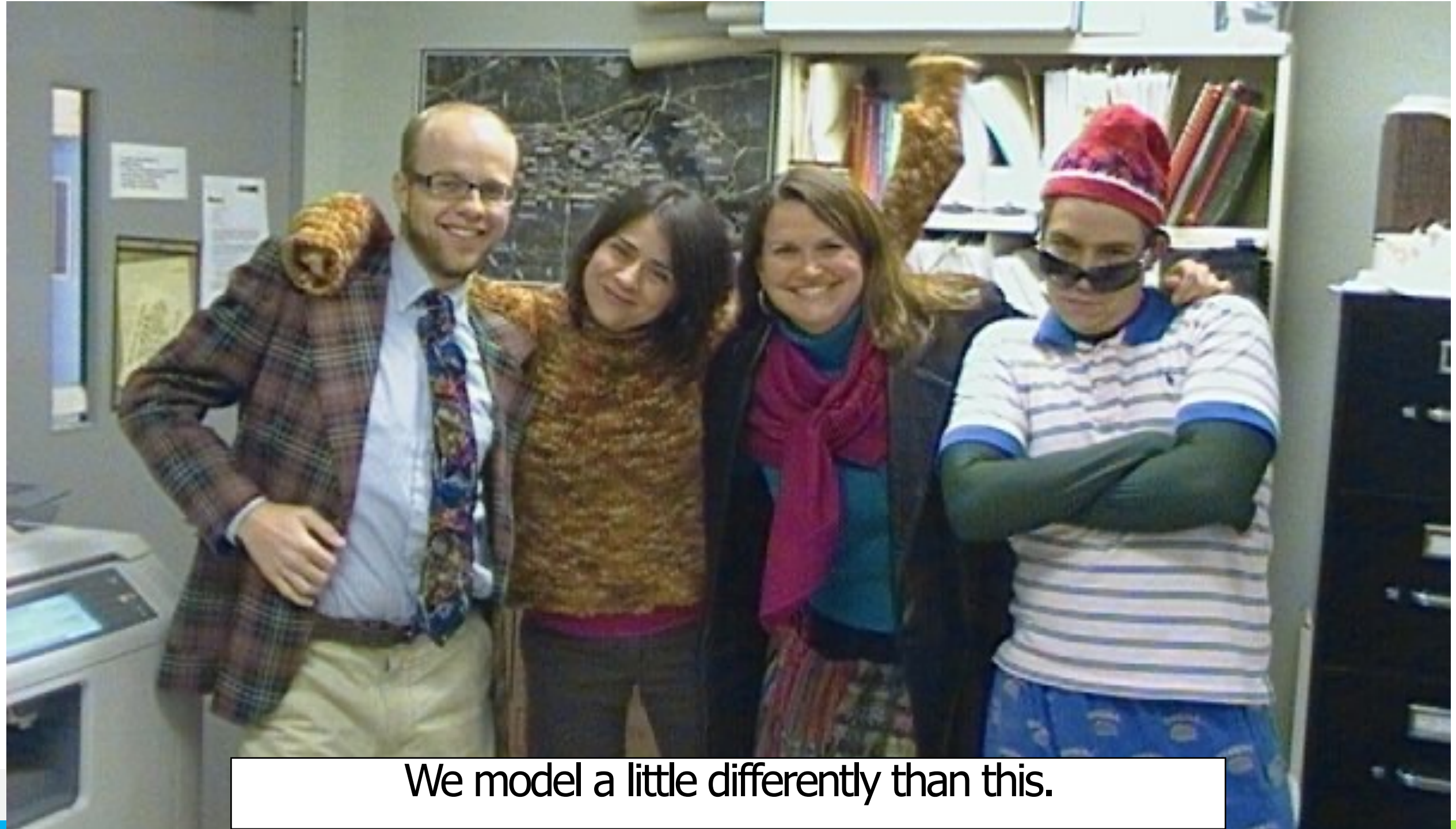
  University of Florida in 2009

- Studied Civil Engineering
  - Focus on hydrology and water resources
  - Design, construction, and maintenance of the physical and naturally built environment such as buildings, roads, and waterways

What has all of this made me into today?

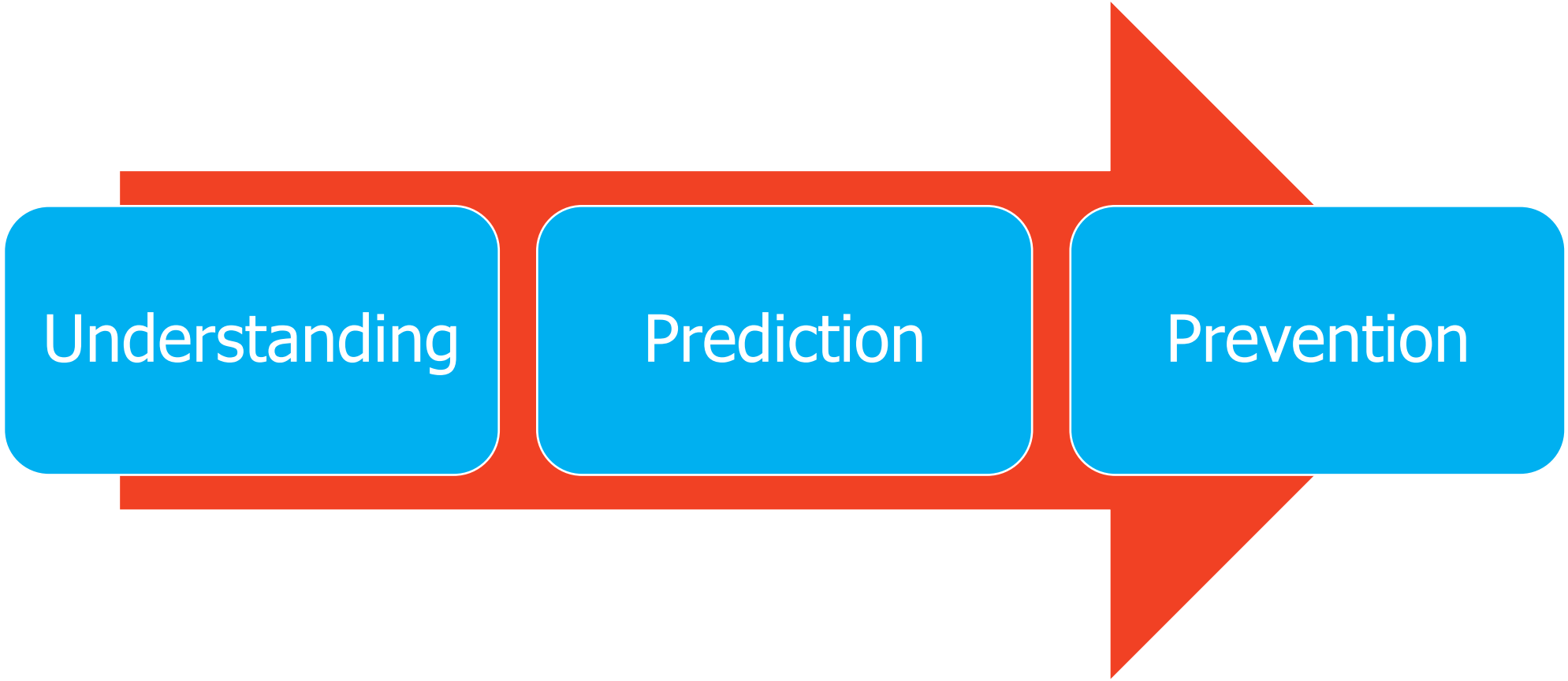


What is Environmental Engineering?



We model a little differently than this.

Why is it important to model [research]?

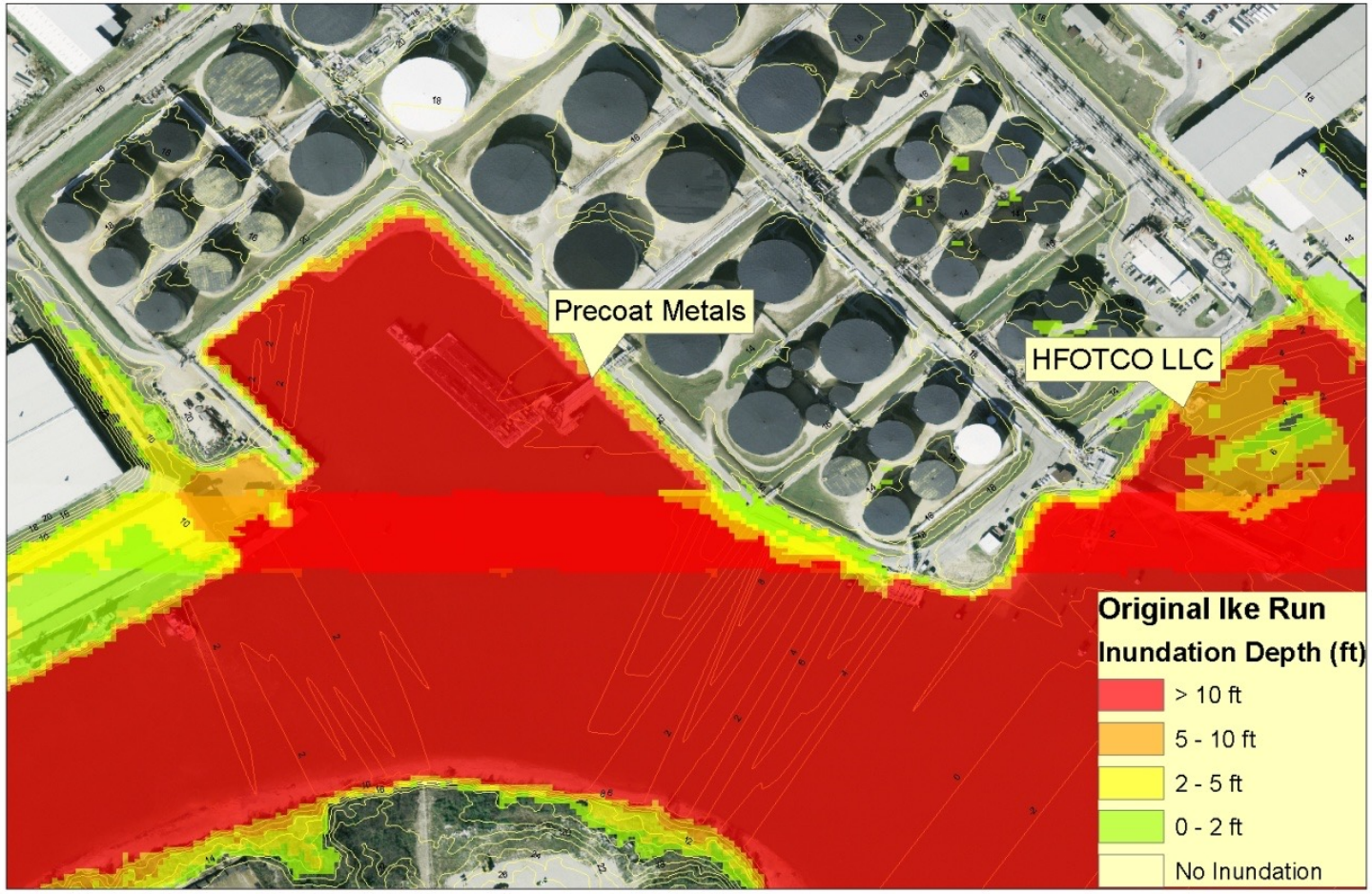


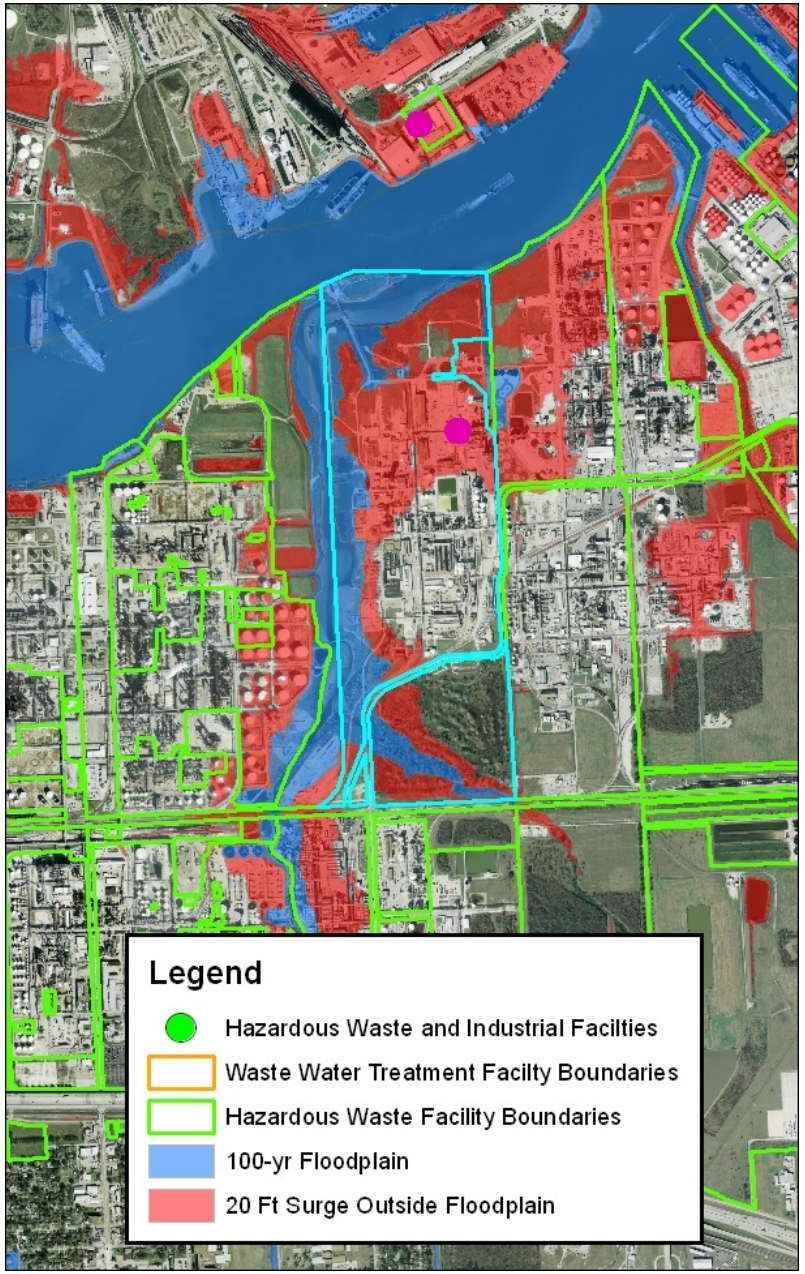

SMILEY N./GETTY IMAGES

Hurricane Katrina

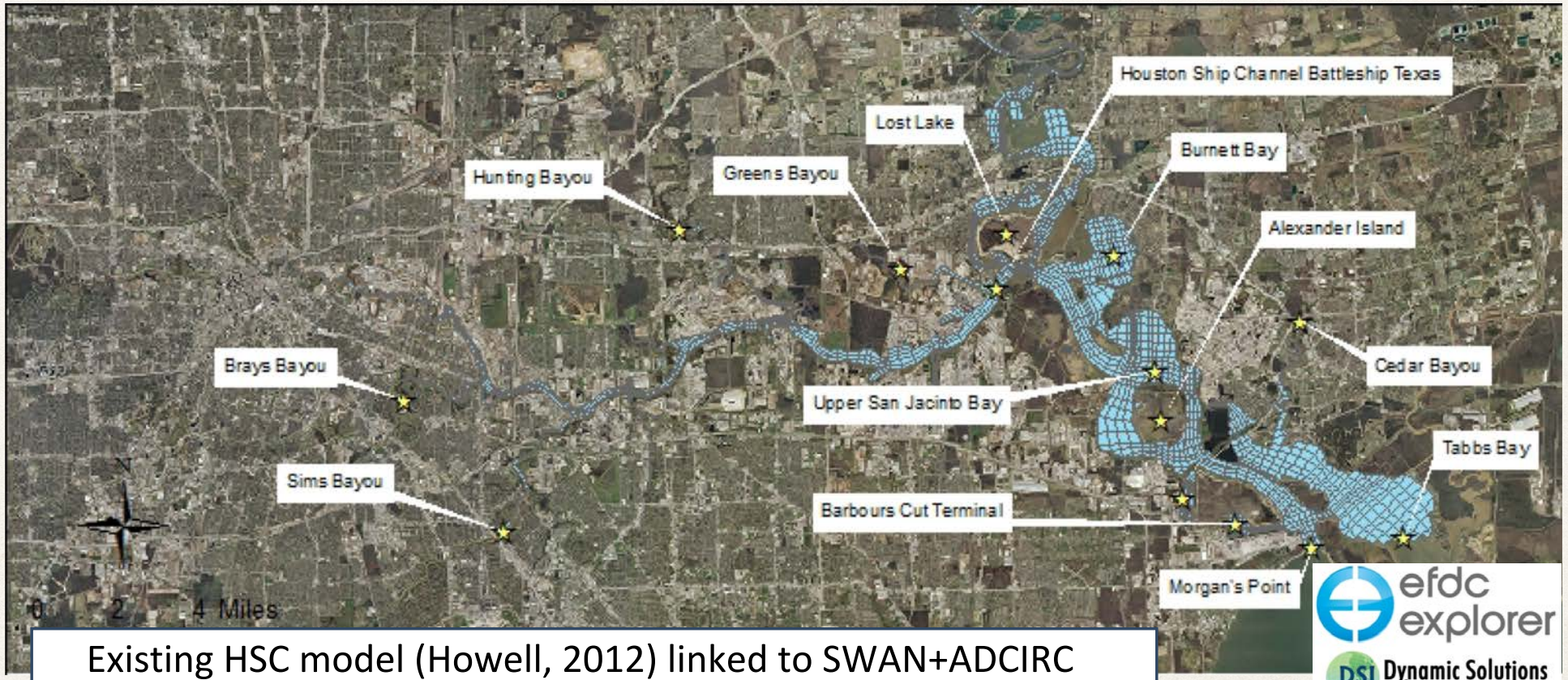
Pilot Town, LA

Where are we vulnerable?





Understanding the complexity of spill scenarios in the HSC



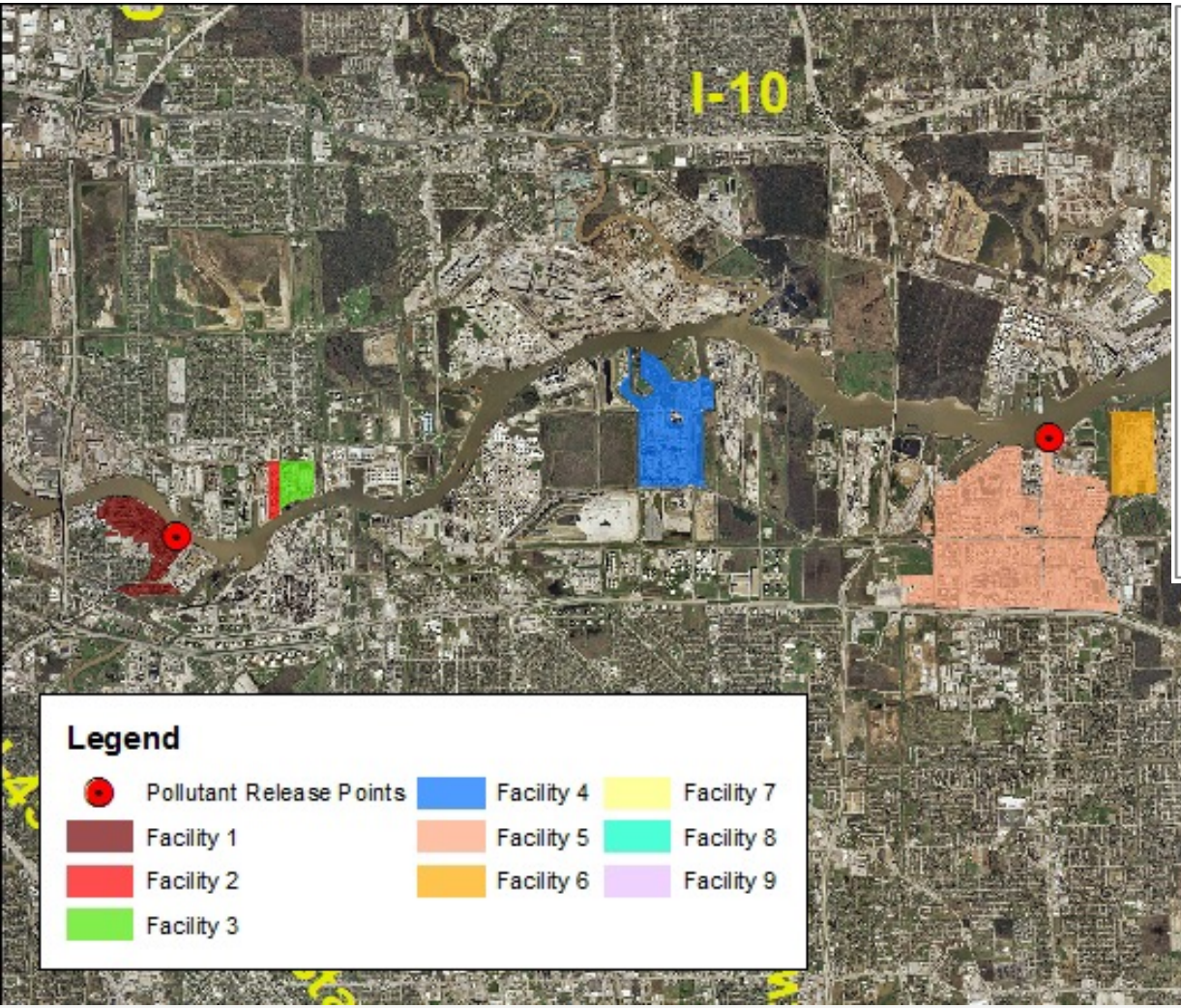
Existing HSC model (Howell, 2012) linked to SWAN+ADCIRC using a surge boundary condition

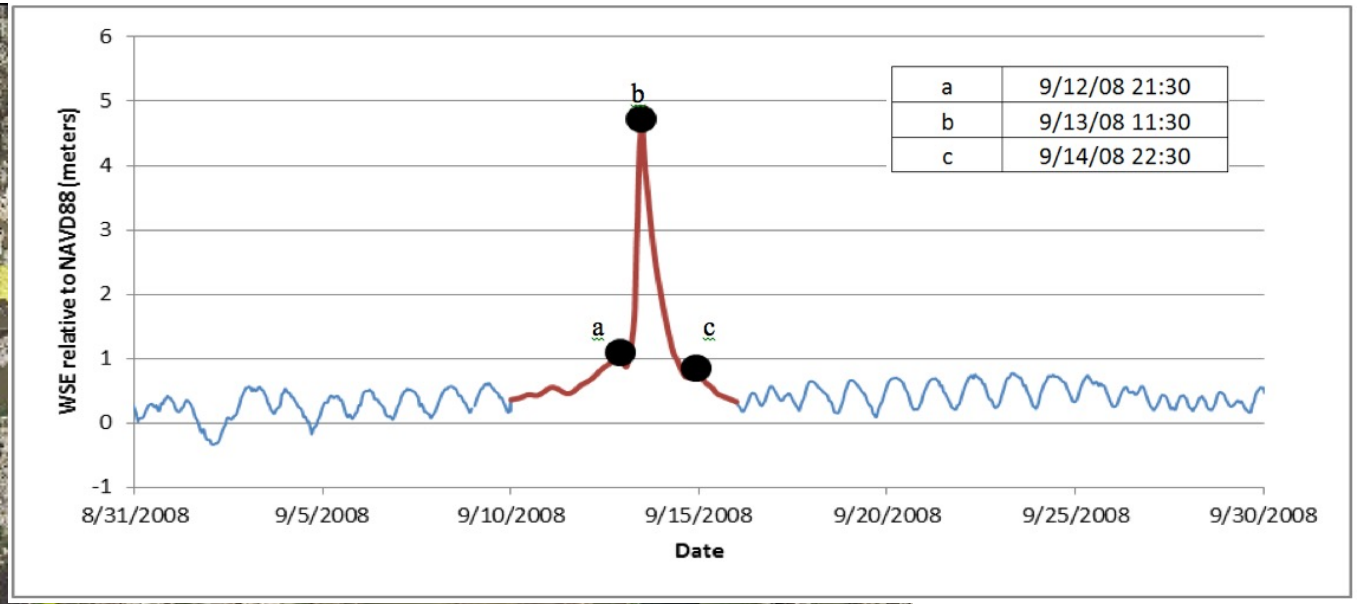
efdc explorer

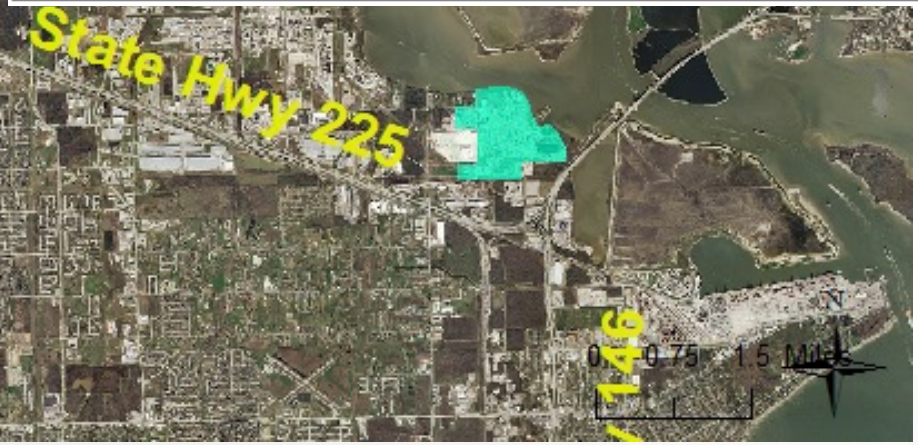
DSI Dynamic Solutions International LLC

EPA United States Environmental Protection Agency

Pollutant Spill Setup: Conservative dye tracer







Burleson

Pollutant Spill Scenarios

3 Spill Locations:
(1) Facility 1
(2) Facility 5
(3) Facility 9

3 Spill Timing:
(1) Before peak
(2) At peak
(3) After peak

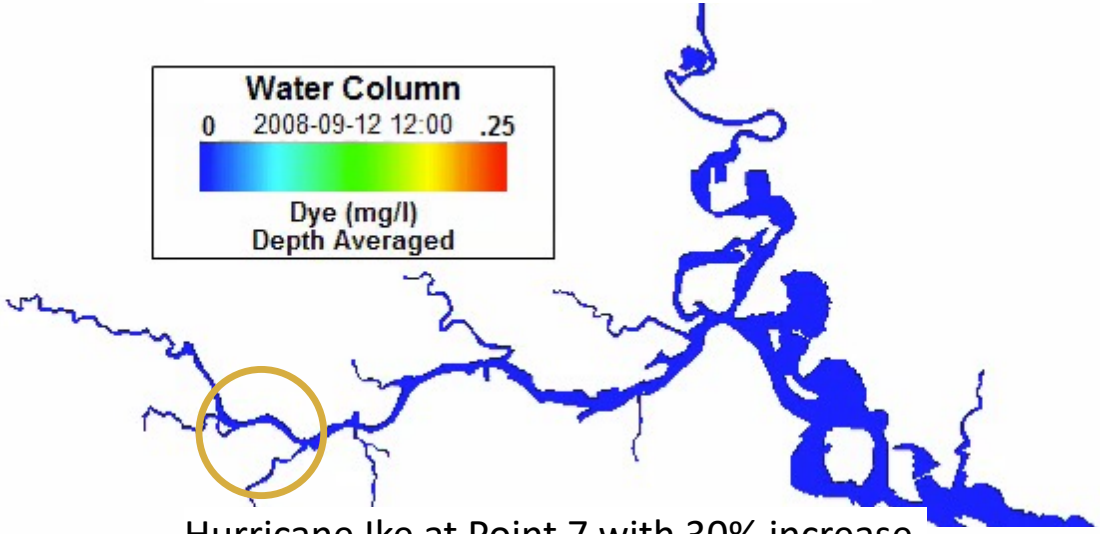
27 modeled spill scenarios

3 Hurricane Scenarios
(1) Hurricane Ike
(2) Hurricane Ike at Point 7
(3) Hurricane Ike at point 7 with 30% increase in winds

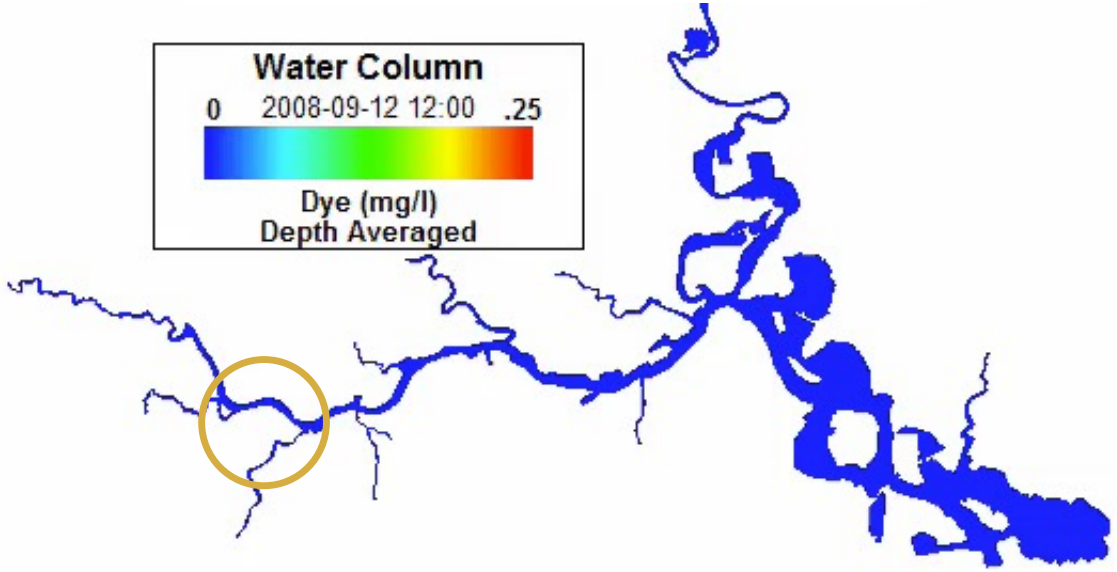
Effect of Hurricane Intensity:

Spill from Facility 1 at peak storm surge

Hurricane Ike at Point 7



Hurricane Ike at Point 7 with 30% increase in winds



Instructional Associate Professor

2015 – Present

University of Houston

Founding Faculty

First Year Experience

Director for Engineering Student Innovation and Design Experience

Director, UH Grand Challenge Scholars Program

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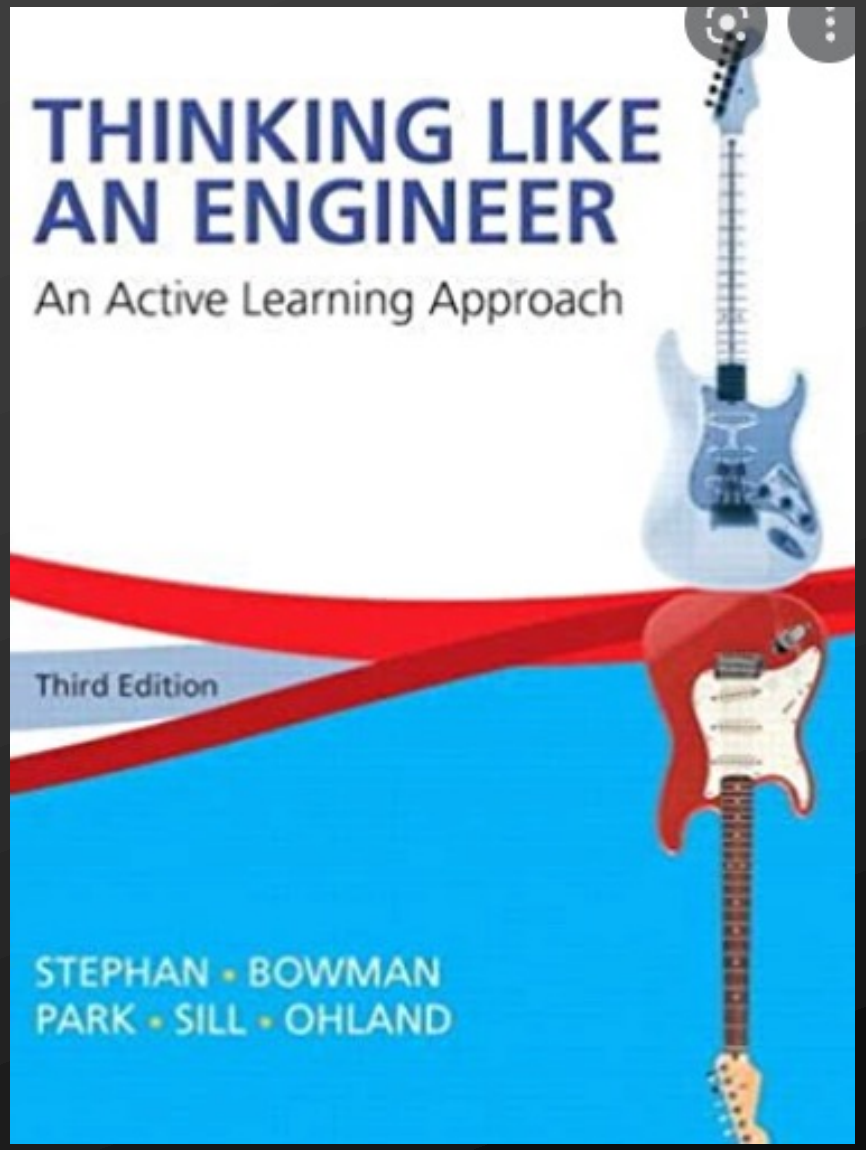
In my classes, we talk about thinking like an engineer.

Today we are going to connect that with how to

<u>RESEARCH</u> like an engineer.



Typical Scientific Process

1. **Purpose:** Ask a question about a topic that can be tested.
2. **Research:** Plan your investigation.
3. **Hypothesis:** Make a prediction about what you think will happen.
4. **Experiment:** Conduct the investigation and collect data about what occurred.
5. **Analysis:** Review your data and think about why.
6. **Conclusion:** Explain what you figured out by exploring the topic.

Engineering Design Challenge using the scientific process

Paper airplanes

[10 minutes]

Complete the scientific process for creating a paper airplane.

This is intentional vague. You define the purpose, hypothesis, experiment, and analysis.

Materials include:

- Paper (different types of paper)

Use the paper provided to test it out!

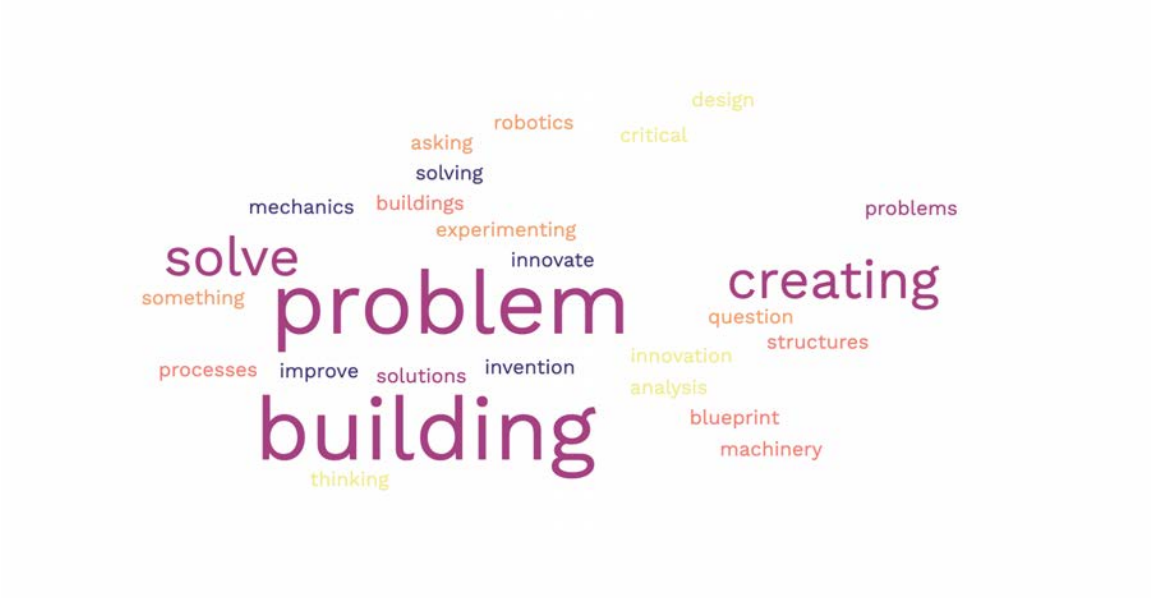
Questions to consider:

What was hard to fit?

What did you feel like was missing?

What you said

Engineering



Research

Design

*Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often **iterative**), in which the basic science and mathematics and engineering sciences are **applied** to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing and evaluation. The engineering design component of a curriculum must include most of the following features: development of student **creativity**, use of **open-ended problems**, development and use of **modern design theory and methodology**, formulation of design problem statements and specification, consideration of alternative solutions, **feasibility** considerations, production processes, concurrent engineering design, and detailed system description. Further it is essential to include a variety of **realistic constraints**, such as economic factors, safety, reliability, aesthetics, ethics and social impact."*

Elsewhere in the ABET criteria for accreditation, they stress the use of teams in solving problems and performing designs.

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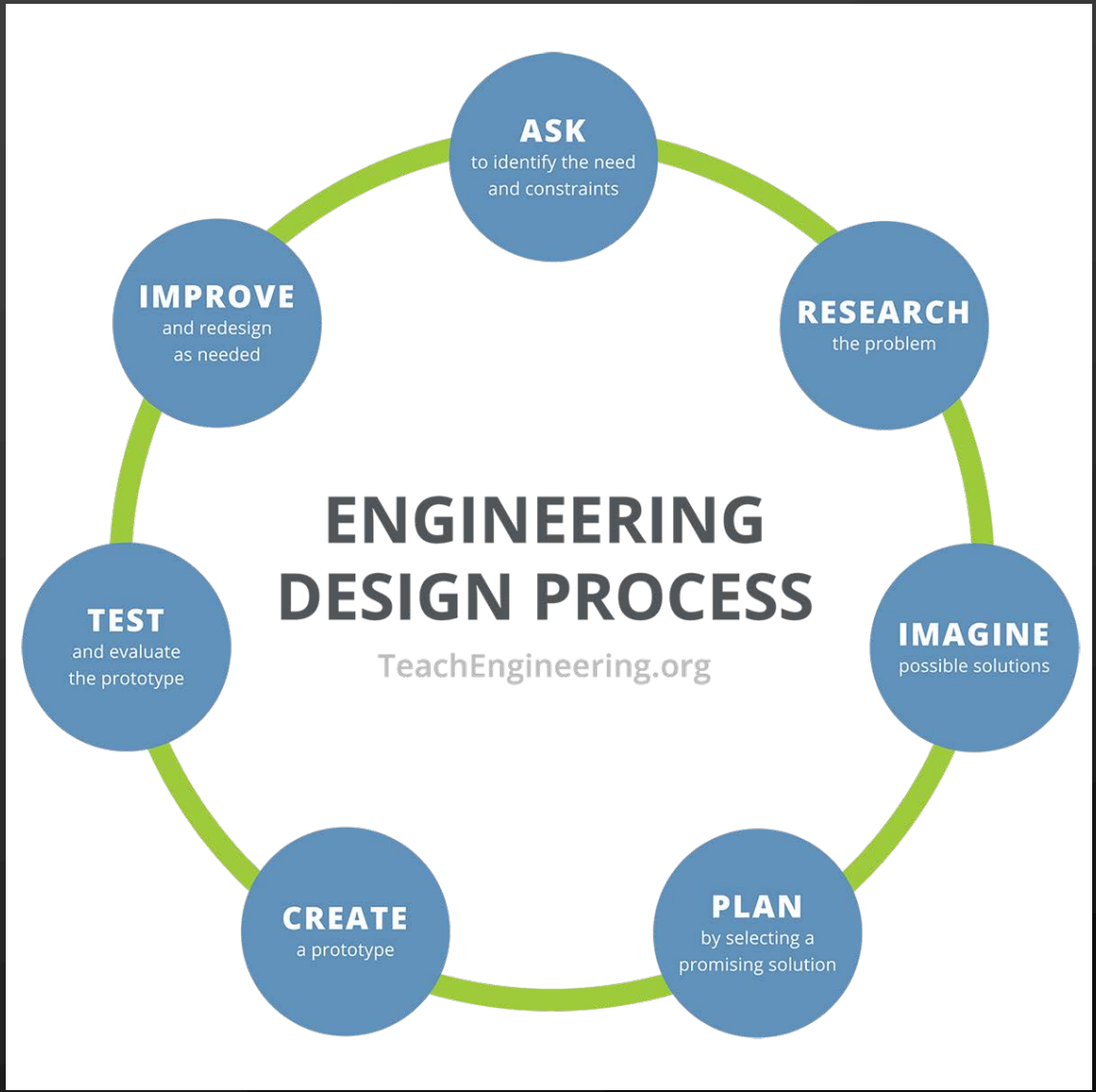


Difference in Scientific Method and Engineering Process leads to engineering research!

The Scientific Method	The Engineering Process
State your question	Define a need
Do background research	Do background research
Formulate your hypothesis, identify variables	Establish design criteria
Design experiment, establish procedure	Prepare preliminary designs
Test your hypothesis by doing an experiment	Build and test a prototype
Analyze your results & draw conclusions	Test & redesign as necessary
Present results	Present results

Engineering Research

- Research that produces fundamental knowledge (understanding what is happening)
- Research to creates an invention (using understanding in a unique way)

The Scientific Method	The Engineering Process
State your question	Define a need

problem to question

How do we get there?

HERE

HOUSTON EARLY RESEARCH EXPERIENCE

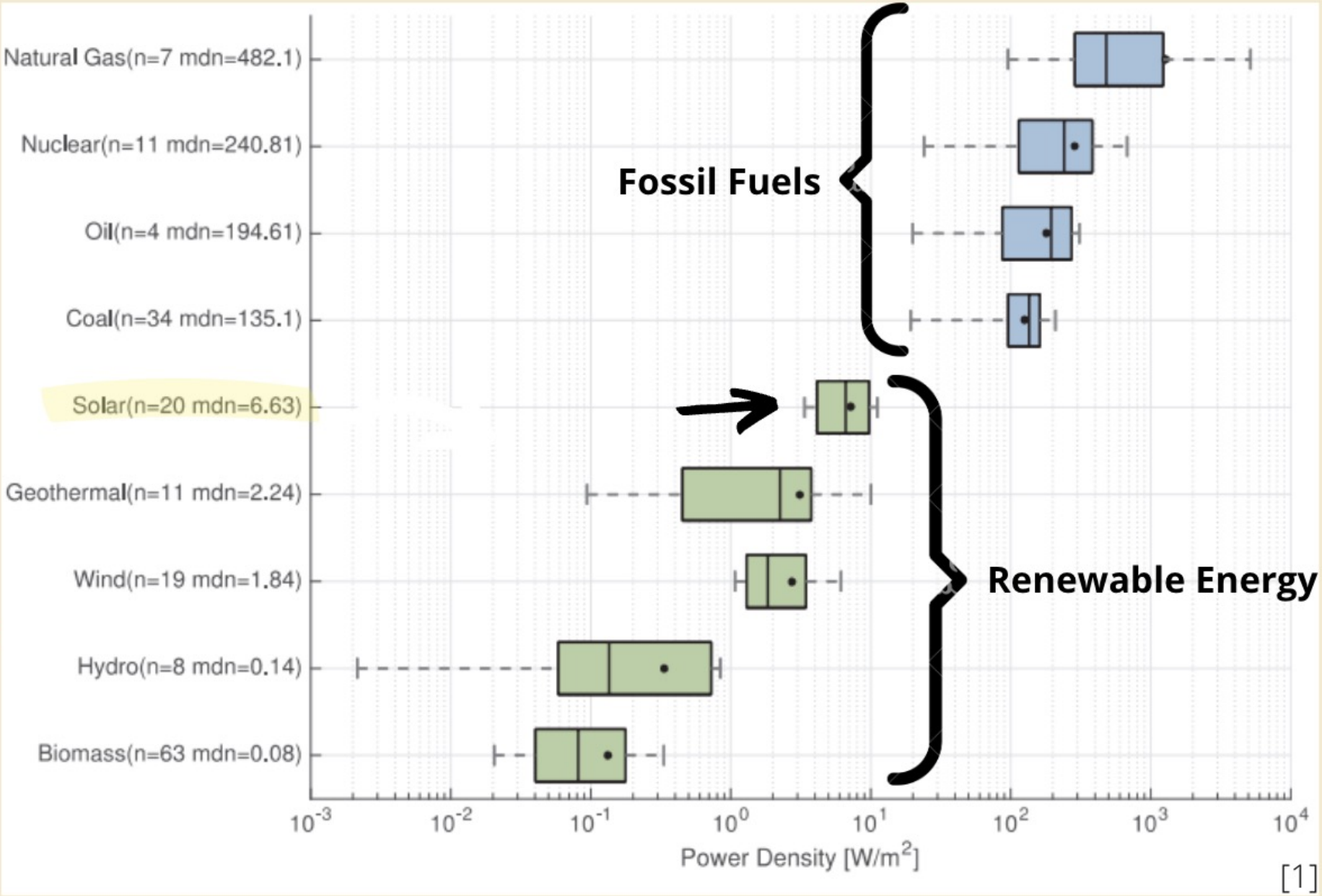
HERE 2022: ENERGY IN HOUSTON

RENEWABLE ENERGY IN HOUSTON

Abby Dobney, Karina Montero, Adri Taing

The problem with renewable energy

- **power density:** the amount of power per unit area.
- renewable energy tends to be **less efficient** than fossil fuels
- **solar energy** outputs the **greatest power density**



[1]

SOLAR ENERGY

THE APPEAL

Of all the renewable energy sources, **why solar**?

Solar panels can be **space efficient** due to its ability to be placed on buildings.

the sun has enough power to fuel **all** commercial energy **10,000 times over**

On average, standard photovoltaic panels are **10%-20% efficient**. How can this be improved?

PHOTOVOLTAIC - THERMAL PANELS

Heat and light energy naturally coexist. PVT can utilize them both.

1 What is a PVT panel?

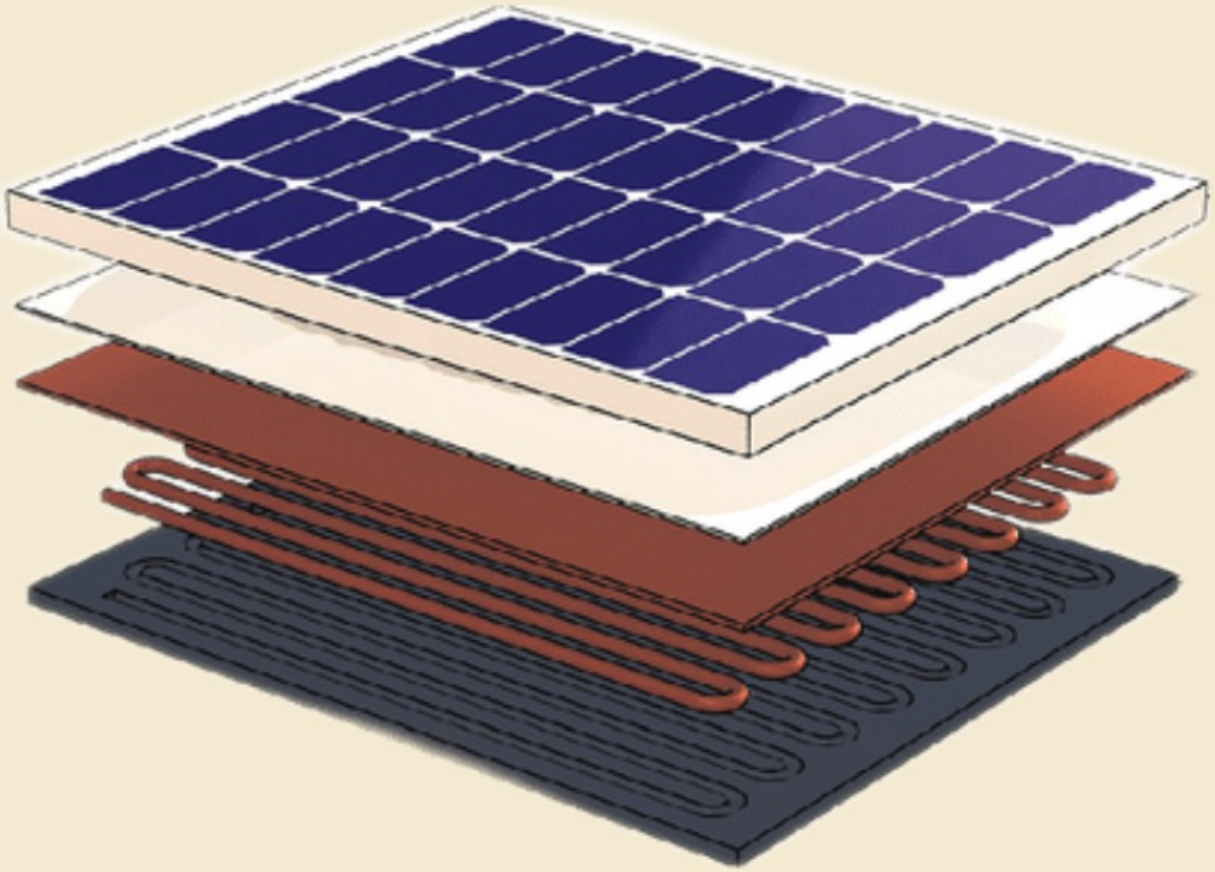
Photovoltaic- Thermal (PVT) panels harvest both light and heat energy

2 Photovoltaic (PV) vs PVT

One study found that is can even generate 82.3% of the electrical demand of a university sports centre that requires 814 MWh annually. [3]

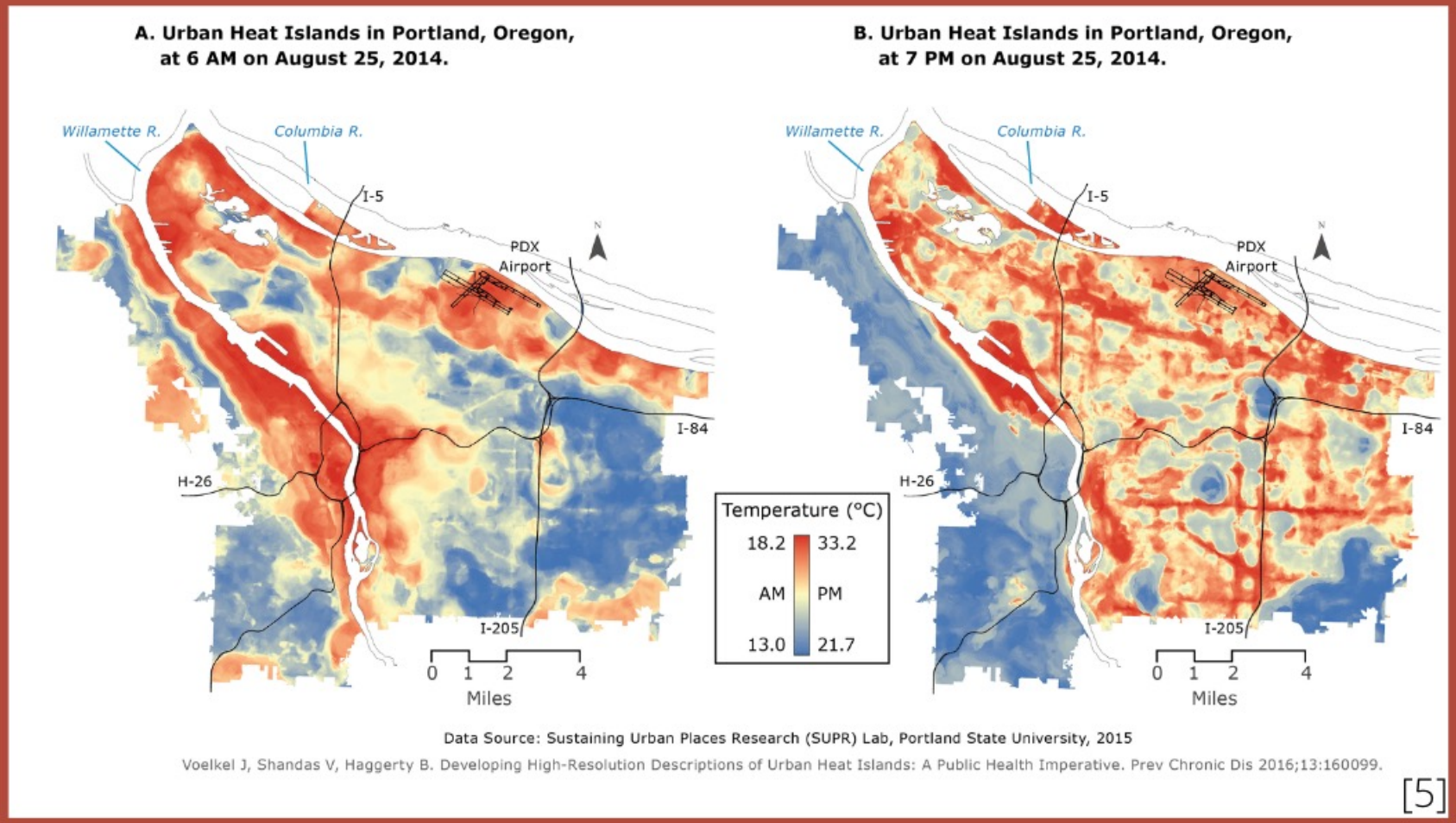
? Key Questions:

Where can it be applied and how can that application be maximized



Urban Heat Islands

A phenomenon associated with **large cities** where temperatures are **warmer** than in surrounding suburban/ rural areas due to its **high traffic** and **low greenspace** environment.



[5]

Urban environment causes heat increase

Heat increase causes increase in energy demand

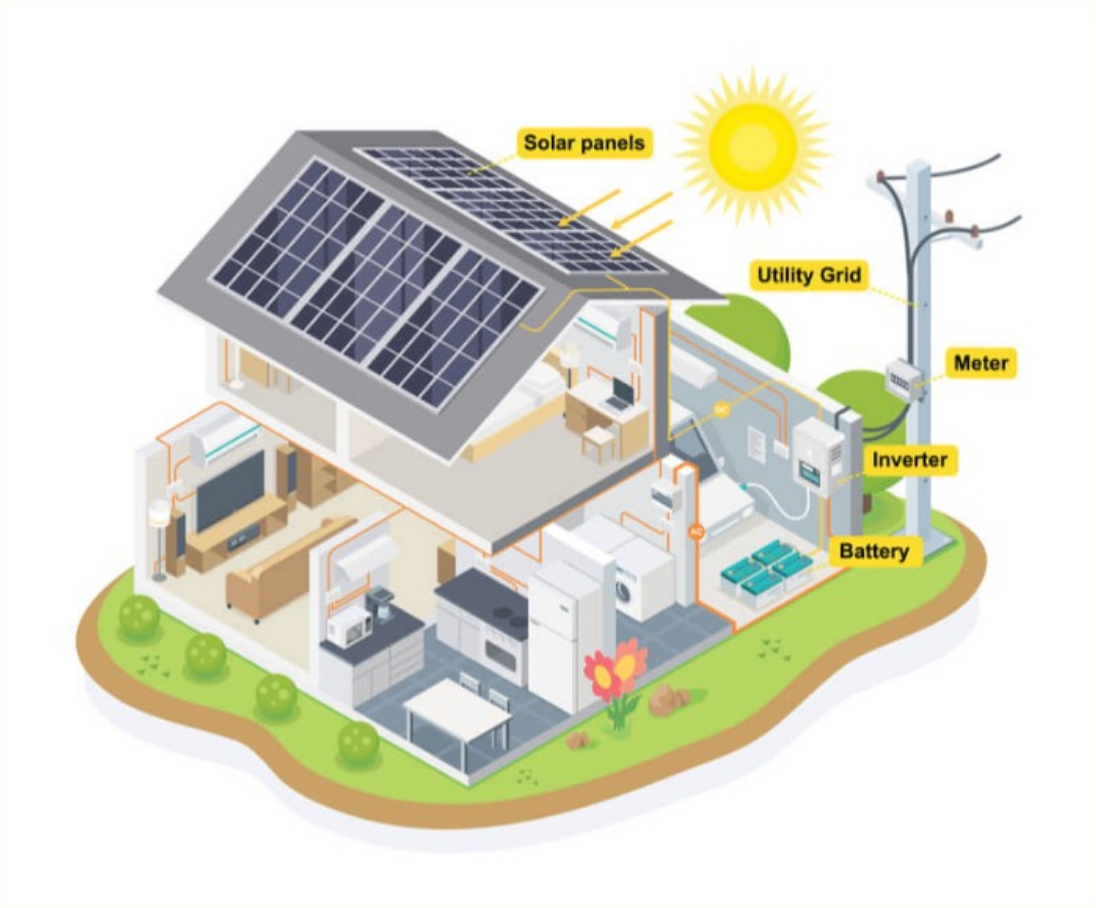
The emissions from energy source(s) cause further heat increase

How does photovoltaic-thermal (PVT) solar panel placement on structures affect energy capture?

Design Criteria as Variables and Hypothesis

The Scientific Method	The Engineering Process
Formulate your hypothesis, identify variables	Establish design criteria

Critical Failures in Past Solar Grids



Solar Panel components (Iscrupe 2022)

Failure Area	% of Tickets	% of kWh lost
Inverter	43%	36%
AC Subsystem	14%	20%
External	12%	20%
Other	9%	7%
Support Structure	6%	3%
DC Subsystem	6%	4%
Planned Outage	5%	8%
Module	2%	1%
Weather Station	2%	0%
Meter	1%	0%

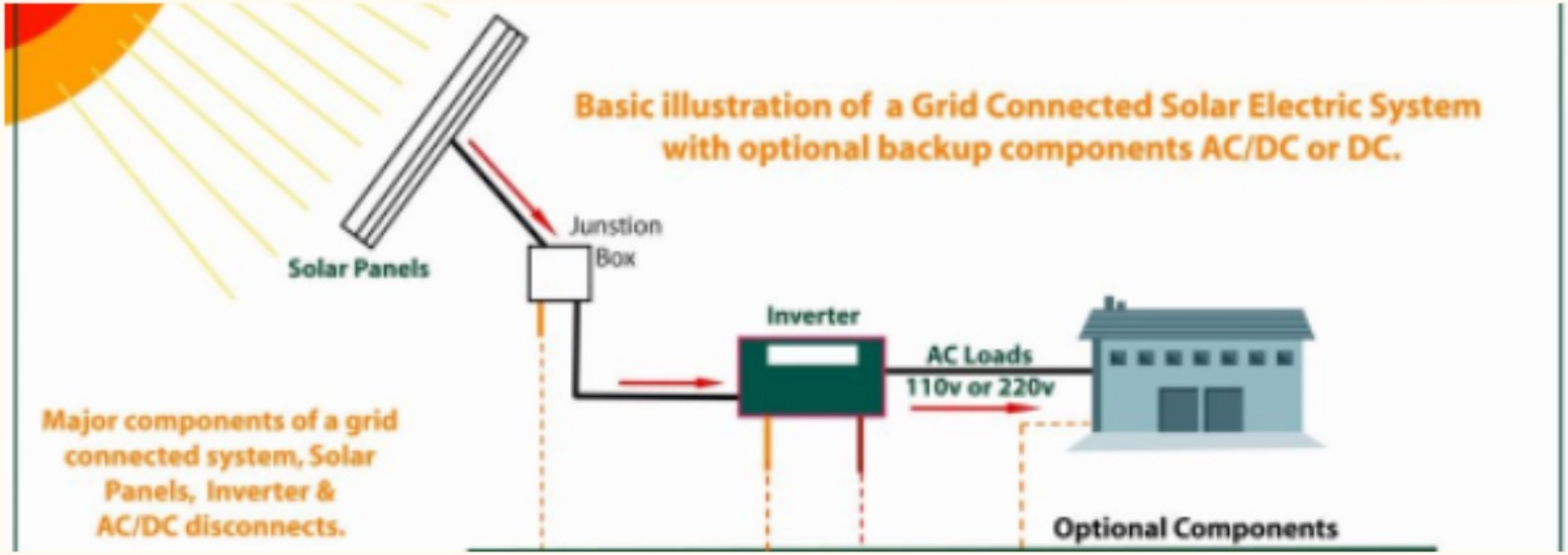
Failure Rate Chart (Formica 2017).

Our Research Question

How do material improvements in inverters and batteries in solar microgrids affect energy reliability for rural American communities?

Previous Experimental Results

Changes to the Inverter	Changes to the Battery
Si (standard) vs Si-C (proposed).	Pb (standard) vs Zn/MnO_2 (proposed).



Designs & Results

The Scientific Method	The Engineering Process
Design experiment, establish procedure	Prepare preliminary designs
Test your hypothesis by doing an experiment	Build and test a prototype
Analyze your results & draw conclusions	Test & redesign as necessary

Redesign & Retest is in your Data Analysis & Graph

Effect of Hurricane Intensity:

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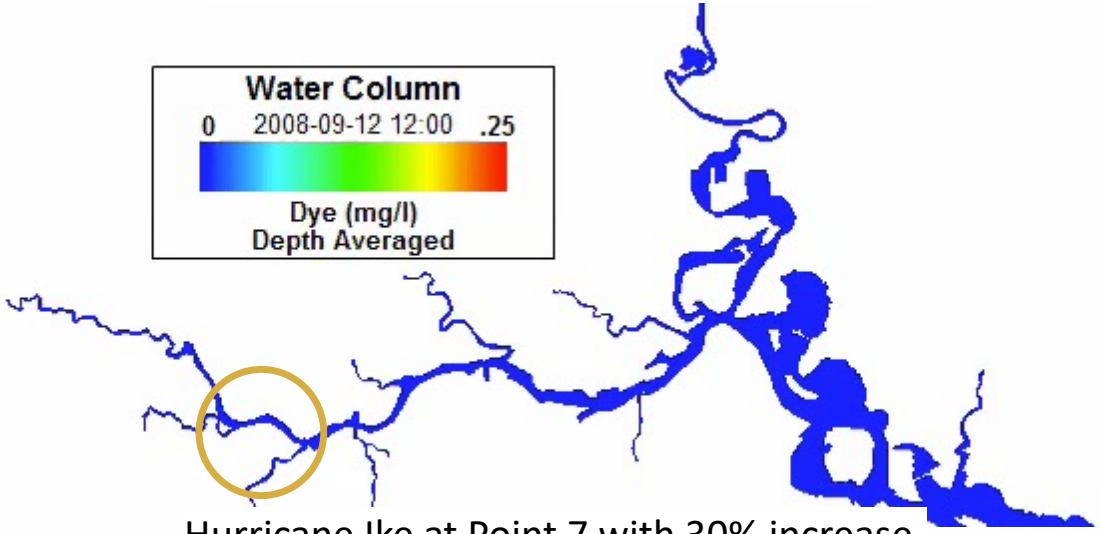
Hurricane Ike at Point 7



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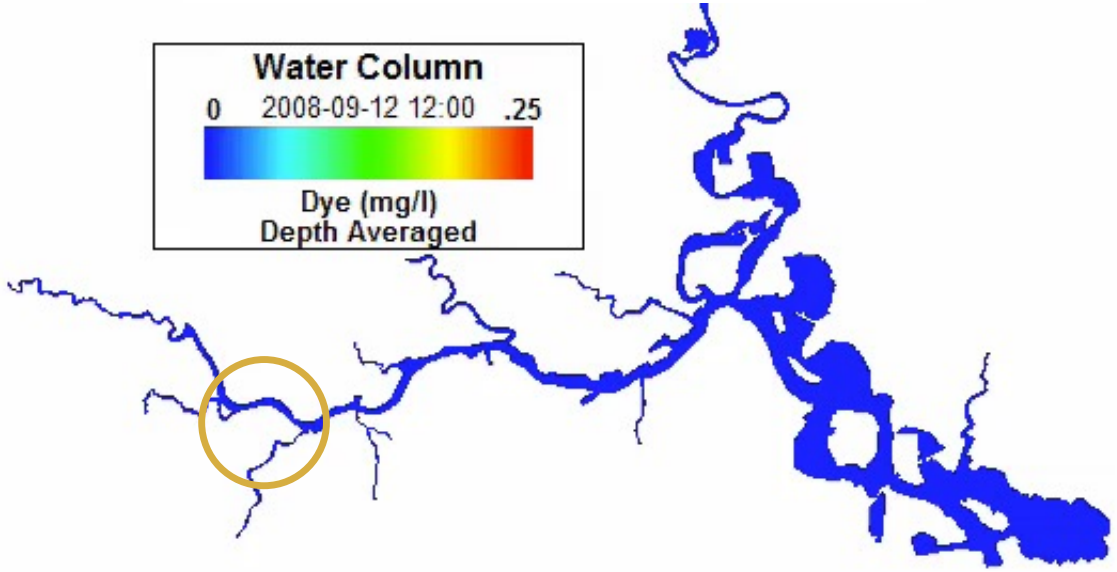
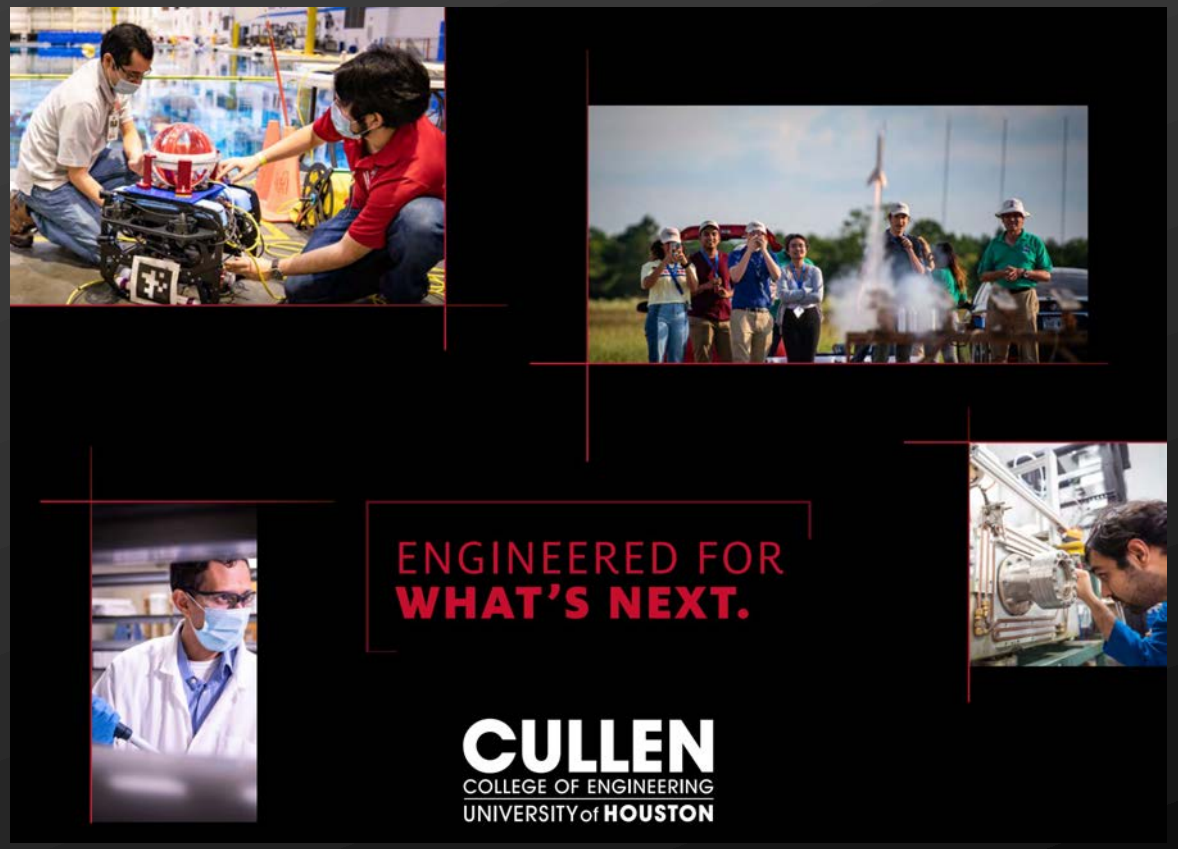


What do your engineering research steps look like?

My proposed engineering research process

1. Problem
2. Background
3. Critical Factors
4. Fundamental Question: Do you want to understand the factors or use the factors to create?
5. Define different designs.
6. What are you measuring/recording/comparing?
7. Perform tests
8. Analyze results
9. Conclusion & **FUTURE WORK**



What does other research look like in engineering?

I am working with a research team that investigates High Voltage Direct Current systems (HVDC), mainly for power transmission. My job is mainly to do simulations on a software called COMSOL in order to investigate the behavior on the materials of transmission cables at high voltages.

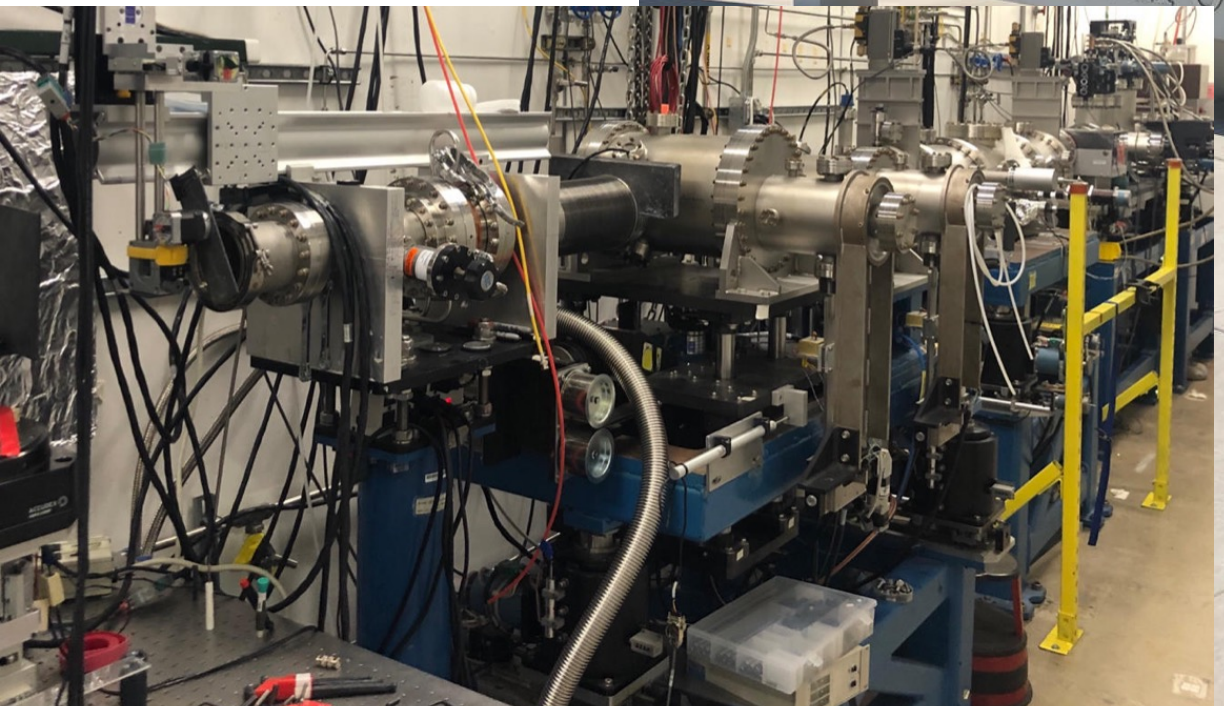
Jesus Silva Rodriguez

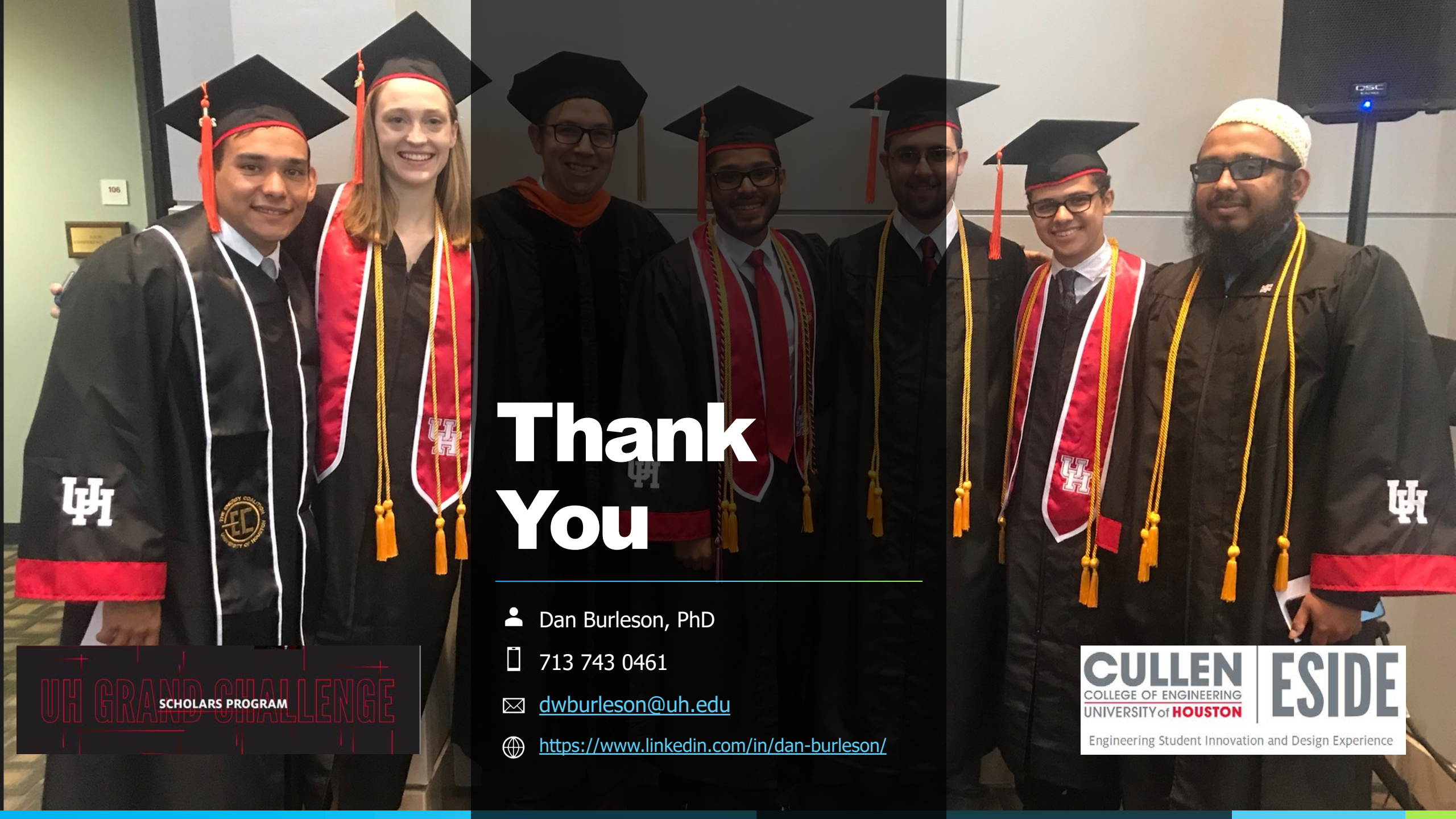
Technical University Dortmund, in Dortmund, Germany


HONDA

"This is the last day of the trip to Argonne National Lab. Incredibly busy, but got some great data / results! This is a picture of the gigantic setup that brings electrons from the particle accelerator to our specimen to produce our tomography images."

Javi Solano





Thank You

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