

# *Creating a Learning Lab to Improve the Engineering of Cyber Physical Social Systems*

---

*December 3, 2022*

John Wood, PhD  
[john.n.wood.civ@us.navy.mil](mailto:john.n.wood.civ@us.navy.mil)

Jon Wade, PhD  
[jpwade@eng.ucsd.edu](mailto:jpwade@eng.ucsd.edu)

Rick Gessner  
[rgessner@eng.ucsd.edu](mailto:rgessner@eng.ucsd.edu)

# The Situation

Decision superiority is one of the top four Office of Naval Research (ONR) priorities.

“As the cyber and the physical domains become increasingly intertwined, it is clear that the advantage will go to the competitor who can utilize digital tools, to include analytics and artificial intelligence, to distill information and data into actionable decisions that are richer and faster than the adversary.”

# The Situation

Decision superiority is one of the top four Office of Naval Research (ONR) priorities.

“As the cyber and the physical domains become increasingly intertwined, it is clear that the advantage will go to the competitor who can utilize digital tools, to include analytics and artificial intelligence, to distill information and data into actionable decisions that are richer and faster than the adversary.”

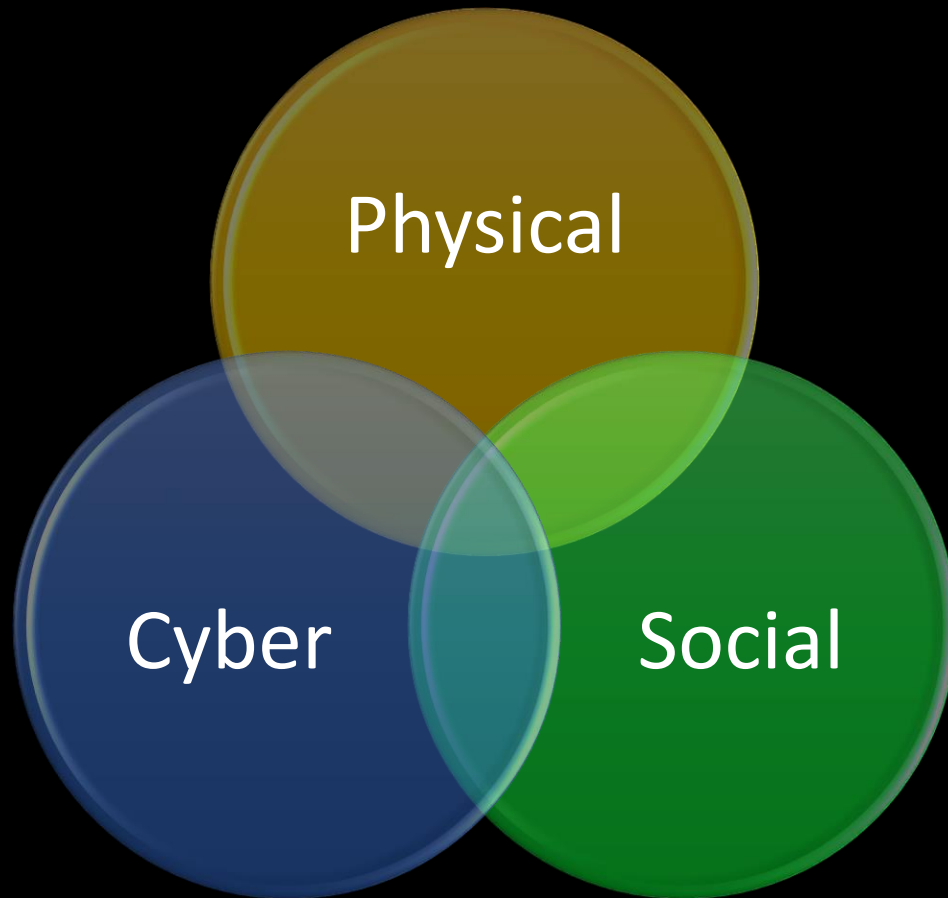
# The Situation

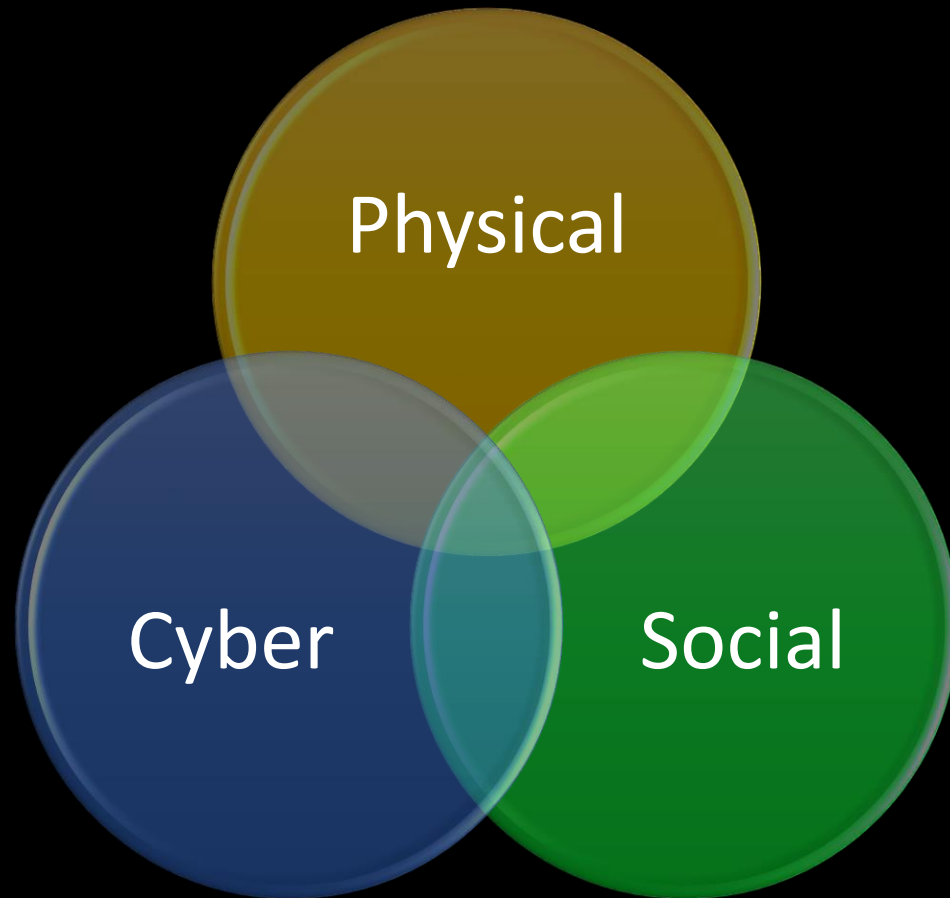
Decision superiority is one of the top four Office of Naval Research (ONR) priorities.

“As the cyber and the physical domains become increasingly intertwined, it is clear that the advantage will go to the competitor who can utilize digital tools, to include analytics and artificial intelligence, to distill information and data into actionable decisions that are richer and faster than the adversary.”

*The decision agent (competitor)  
is a critical component in this system!*

# The Domains

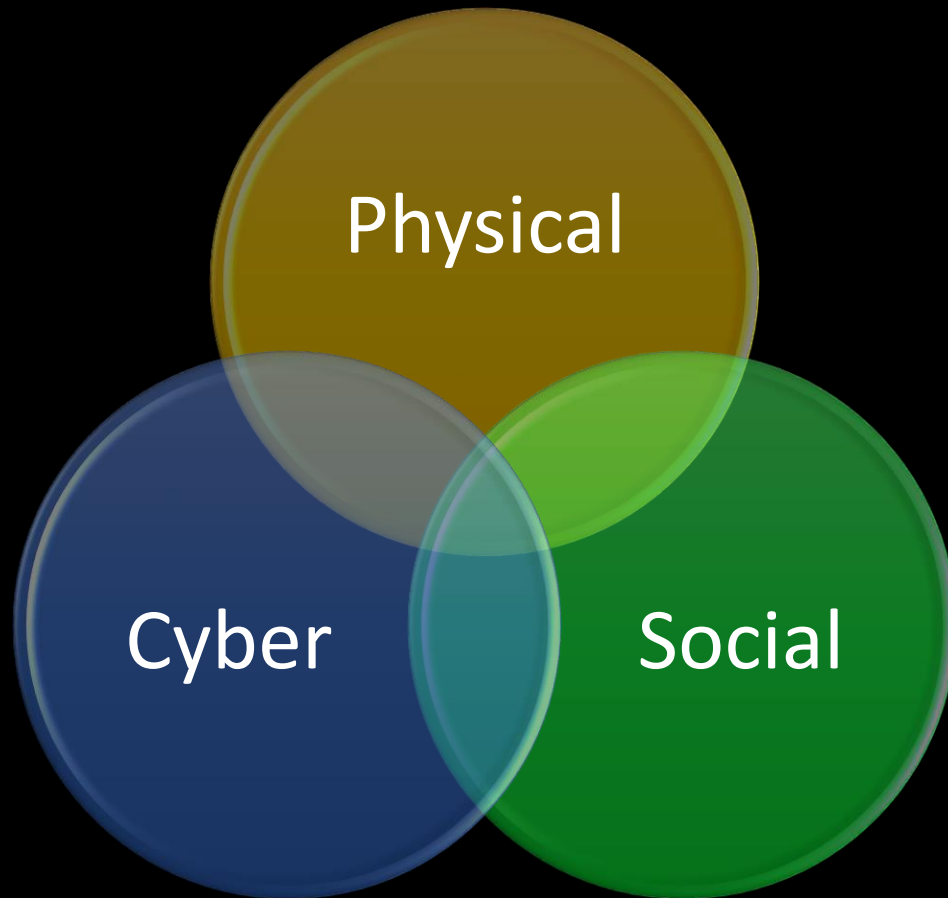




=

Cyber Physical  
Social Systems

# The Domains



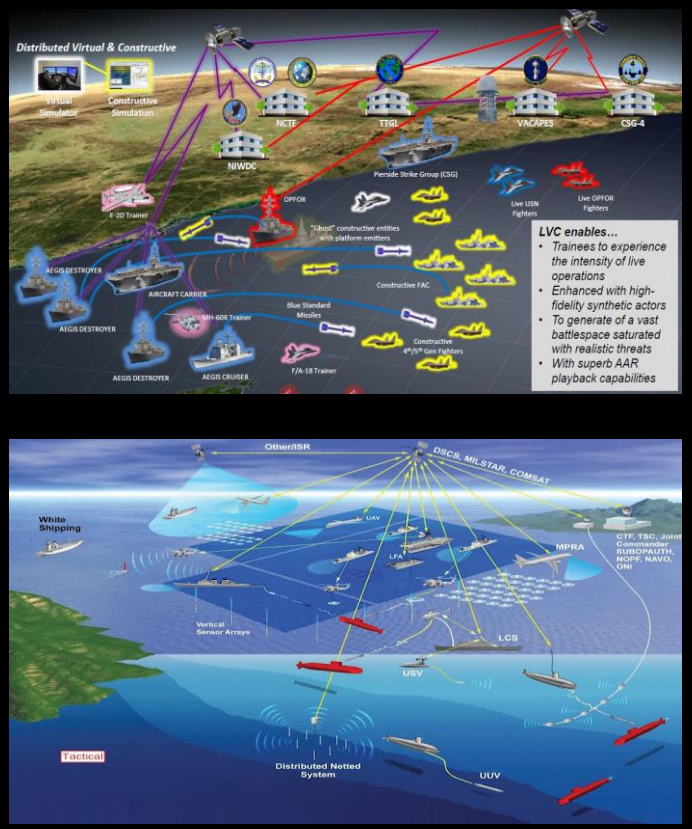
=

Cyber Physical  
Social Systems

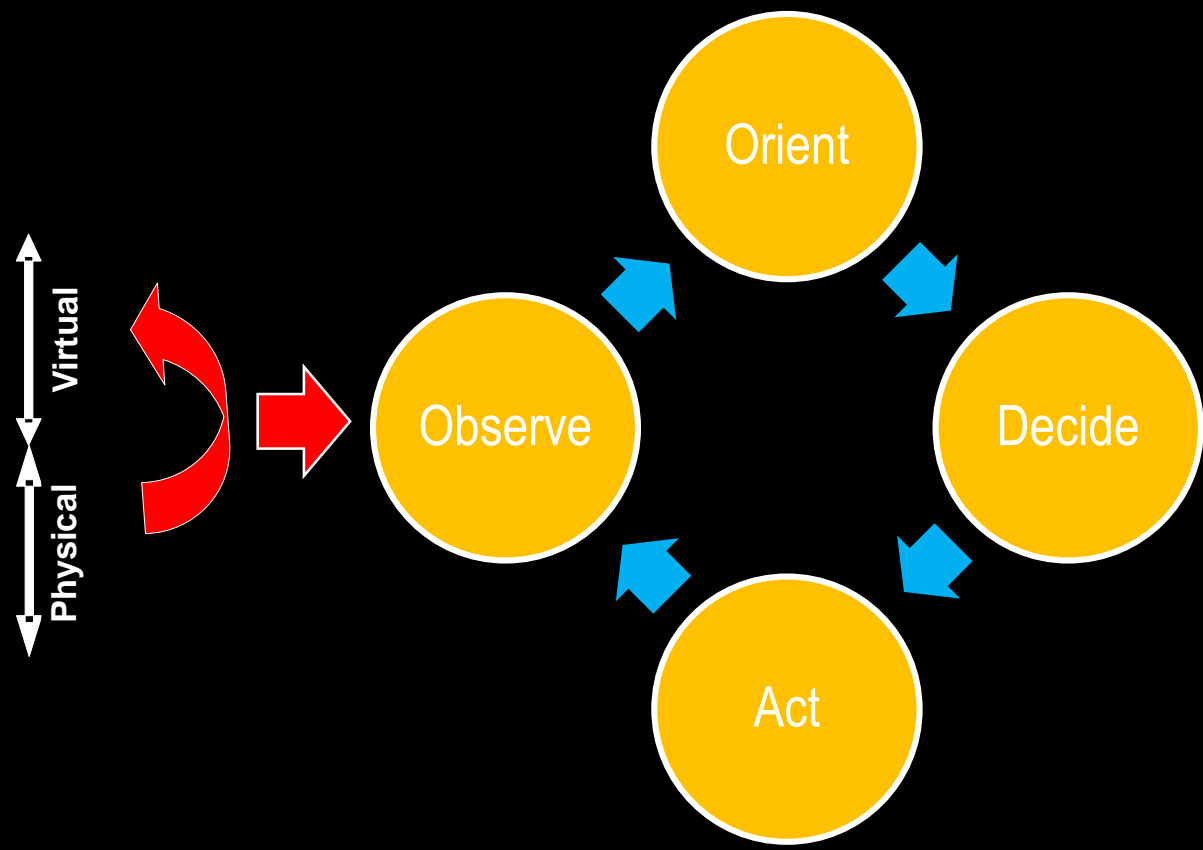
For more on CPSS, see: Yilma, Bereket Abera, Hervé Panetto, and Yannick Naudet. "Systemic formalisation of Cyber-Physical-Social System (CPSS): A systematic literature review." *Computers in Industry* 129 (2021): 103458.



# Cyber Physical Social Systems: Exploiting Digital Power



- Simulated world
- Experimental data
- Observed world



Using computation, AI/ML, visualization, and communication to take better, faster actions.



# The Challenge

- ▼ How can we best engineer cyber physical social systems?
  - Which tools and techniques provide the highest quality systems?
  - Which tools and techniques accelerate engineering activities?
- ▼ How can we keep learning?
- ▼ How can we accelerate the learning?
- ▼ How can we share what we learn?

# The Partnership

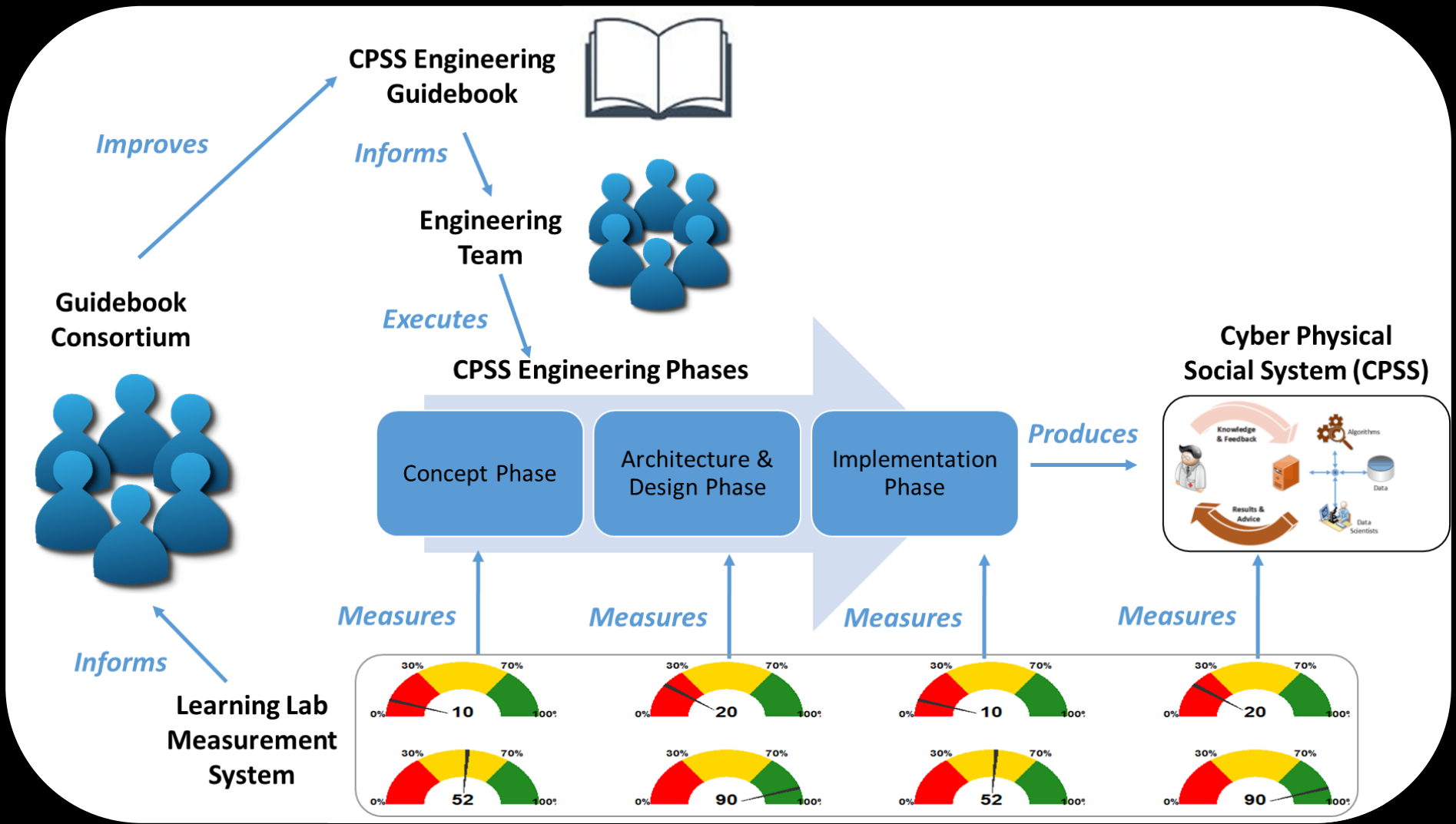
## NIWC Pacific

- ▼ Develops cyber physical social systems in support of national defense initiatives
- ▼ Understands real world use cases
- ▼ Amassing experiences, challenges, lessons learned, and best practices related to the systems engineering of cyber physical social systems

## UCSD Jacobs School of Engineering

- ▼ Creates and delivers educational curricula for engineering cyber physical social systems
- ▼ Needs use cases and associated artifacts for research initiatives and student projects
- ▼ Cycles student teams through the entire systems engineering life cycle each semester

# The Vision

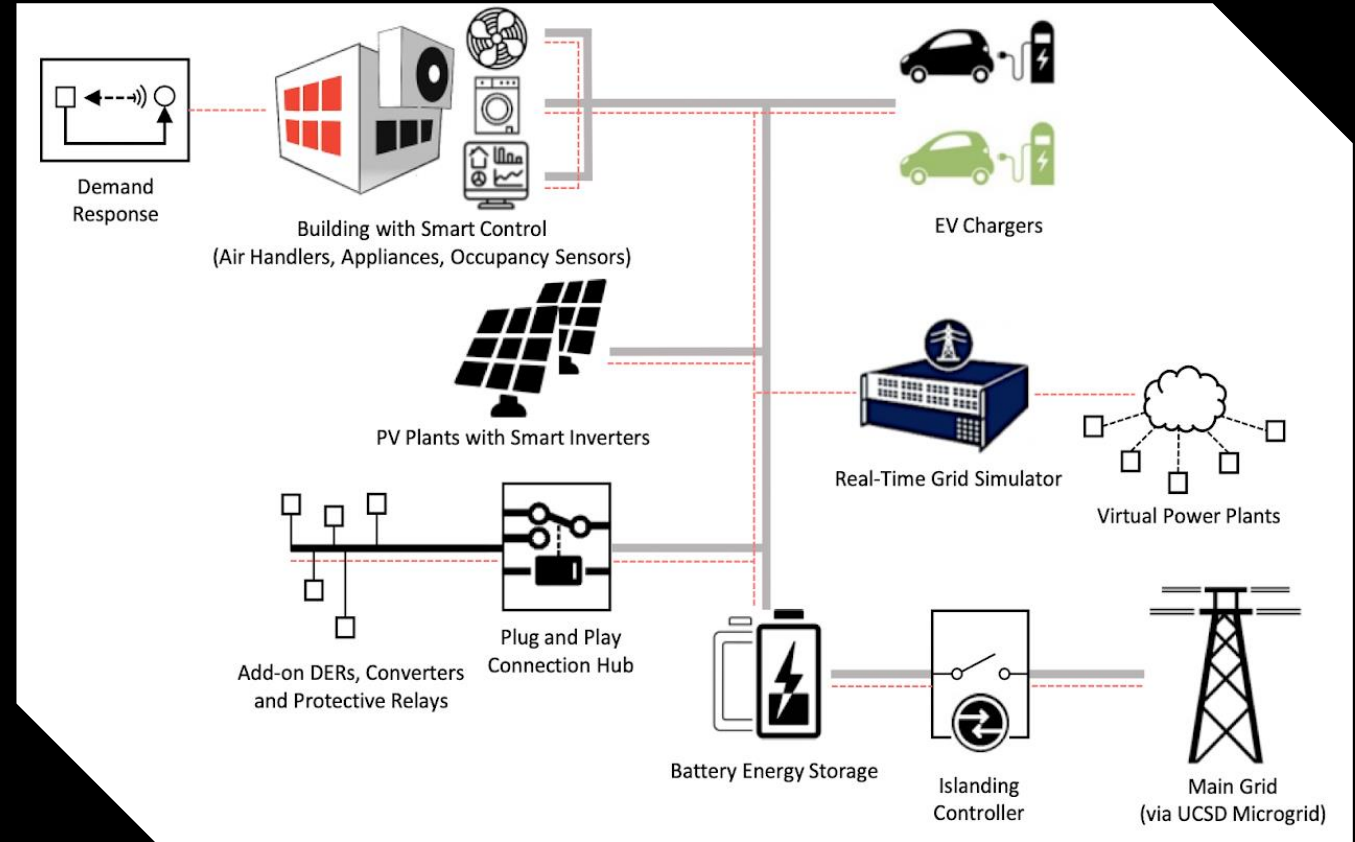


# The Approach

- ▼ Select a basis for student projects that is analogous to real world Navy efforts
- ▼ Develop cyber physical social system engineering curricula
- ▼ Cycle student teams through the curricula, experiment with different tools and techniques, and measure results
- ▼ Draft a guidebook documenting best practices as well as antipatterns
- ▼ Pilot the guidebook with NIWC Pacific engineers supporting real world efforts
- ▼ Update, publish, and promote first edition of the guidebook
- ▼ Continually update the guidebook based on measured results of its user community

# Analogous System DERConnect

- ▼ Generally analogous to DoD command and control systems
- ▼ Specifically analogous to Navy and Marine Corps microgrid initiatives
- ▼ Learn more at:  
<https://sites.google.com/ucsd.edu/derconnect/home>



# Courses/Phases

- ▼ Concept
- ▼ Architecture and Design
- ▼ Implementation
- ▼ Evolution

# Courses/Phases

## ▼ Concept

Practitioners explore entre/intrapreneurial approaches to innovation and perform contextual analysis to ensure social, environmental, and economic sustainability. Practitioners transform the definition of a problem in a technical social context to a system concept, use-case scenarios, and technical requirements using a model-based approach.

## ▼ Architecture and Design

## ▼ Implementation

## ▼ Evolution



# Courses/Phases

- ▼ Concept
- ▼ **Architecture and Design**

Practitioners develop potential architectures and then evaluate their strengths and weaknesses. Practitioners are aided by the guidebook's case studies of successful and unsuccessful examples, architectural patterns, and methodologies.

- ▼ Implementation
- ▼ Evolution

# Courses/Phases

- ▼ Concept
- ▼ Architecture and Design
- ▼ **Implementation**

Practitioners evaluate systems for correctness, efficiency, performance, scalability, and reliability. Additionally, practitioners execute inspection, unit-level testing, integration activities, and, ultimately, product acceptance testing via customer requirements oriented verification and validation.

- ▼ Evolution

# Courses/Phases

- ▼ Concept
- ▼ Architecture and Design
- ▼ Implementation
- ▼ **Evolution**

Practitioners manage the evolution of a system after its initial release via a three level framework. Level 1 includes policies, processes, and infrastructure required to maintain the system and respond to quality issues. Level 2 evolves system capabilities and characteristics based on emerging needs and technologies. Level 3 proactively disrupts the market by reframing the opportunity and reinventing the system based on internal innovation or external disruptions.

# Next Steps

- ▼ Define metrics per phase
  - Quality
  - Velocity
- ▼ Create guidebook outline
- ▼ Create course material
- ▼ Execute courses
- ▼ Complete initial draft guidebook

# BRINGING THE POWER OF INFORMATION TO THE FIGHT!

*Naval Information  
Warfare Center*



***PACIFIC***

**JACOBS  
SCHOOL  
OF ENGINEERING**  

---

**UC SAN DIEGO**