Visualizing PMU Data for the End-User: A Human Factors Approach

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Agenda

- Review what Human Factors is and its value in Energy
- Review PSE's unique user-centered design (UCD) process
- Explore application of HF and UCD to support PMU data visualization
- Discuss anticipated impacts of UCD PMU data visualization

What is Human Factors? Human Machine Interfaces?

Applied science field started in WWII

Human Factors is a scientific discipline concerned with the interactions of humans with systems. It addresses human capabilities and limitations in system design, development, and use.

History: Originating to address aviation training accidents in WWII, and then nuclear power control room design after the Three Mile Island accident in the 1970s, Human Factors is now a large field with multiple subdisciplines and specialties, from physical to cognitive ergonomics.

Human factors engineering applies this science to the design of tools, displays and processes to improve overall system performance by enhancing user task performance and reducing error.

Human Machine Interfaces (HMIs) are the critical bridges between human users and the systems they oversee, control, and make decisions about.
HMI design is a key area where Human Factors Engineering can be applied to improve user and system performance.

1940s

1970s

Today

REALITY | PERCEPTION

WORLD | DISPLAY DESIGNER | USER
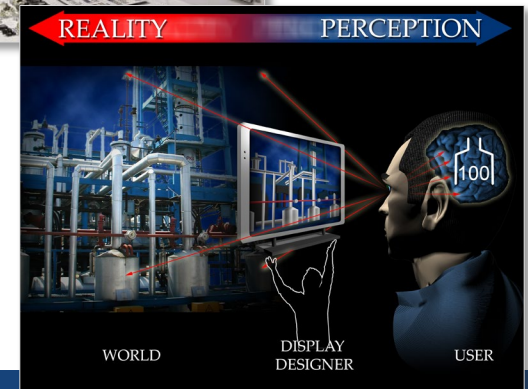
Systems must be engineered for human capabilities in order to perform well and safely

Why is Human Factors relevant to the Energy domain?

Utilities have multiple complex systems involving humans…

- Grid Operations, Cyber Security, Emergency Risk Management, Repair services, Customer Support, Aviation Services, and many more…

…in different contexts

- Inside: Control rooms, individual offices
- Outside: Pole laying, line repair, remote sensing
- Large Scale: Extended co-located or distributed teams
- Small Scale: Individual or small teams

…performing different tasks

- Monitoring, supervisory control, decision making, forecasting, training, maintenance, software development, installation, and repair

Human Factors issues are ubiquitous across utility operations

Human Factors Design Principles

- Physical ergonomics
- Consistency
- Familiarity
- Sense of control
- Efficiency
- Error management
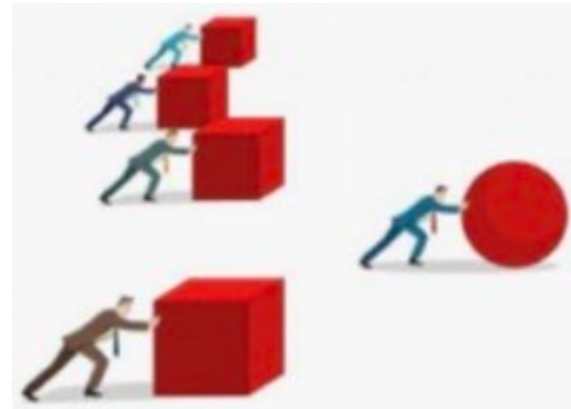
PSE's User-Centered Design (UCD) approach

informs future design

Discover

- Determine context of use and user roles
- Define user needs, challenges, and impacts to performance
- Conduct task and workflow analyses
- Develop use cases

Analyze

- Evaluate legacy capabilities
- Perform competitive UI analyses
- Derive requirements and prioritize user needs

Design

- Establish design concepts
- Build navigation, wireframes, and storyboards
- Develop mockups and interactive prototypes
- Trace designs to requirements and user needs
- Validate designs with users and developers

Develop

- Document design specifications
- Support implementation
- Verify implementation

Evaluate

- Conduct user assessments
- Analyze and prioritize findings
- Distribute tailored findings to stakeholders

= Subject Matter Expert (SME) involvement

Engaging with end users at key points along the process ensures their goals, tasks, and information needs are met

Applying the UCD process to PMU HMIs

Discover
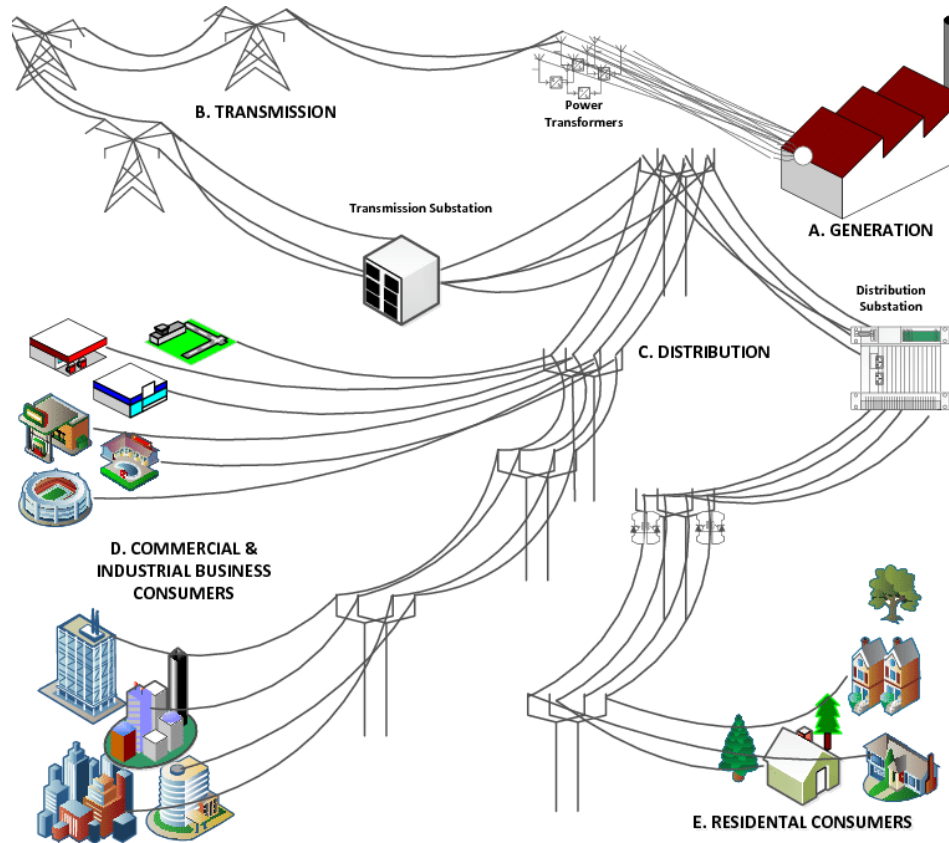
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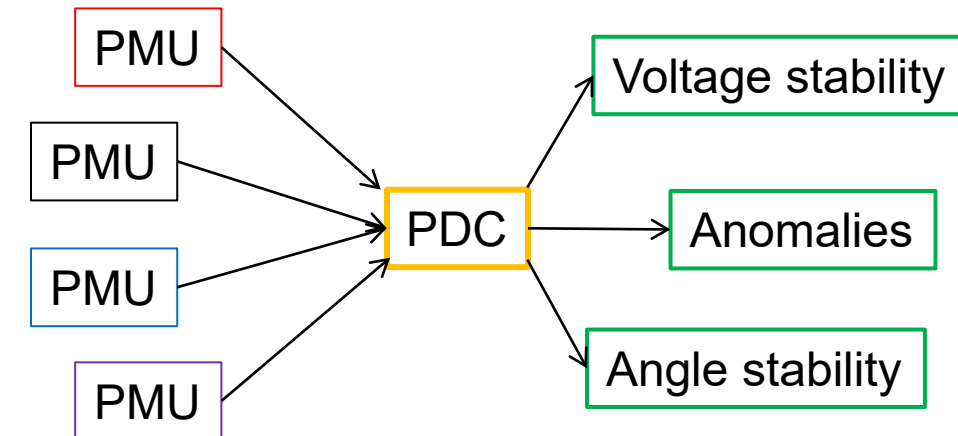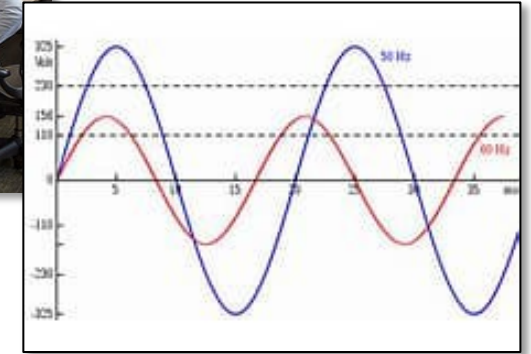
Who are the users, how are they using the data, in what situational context?

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Applying the UCD process to PMU HMIs

Analyze
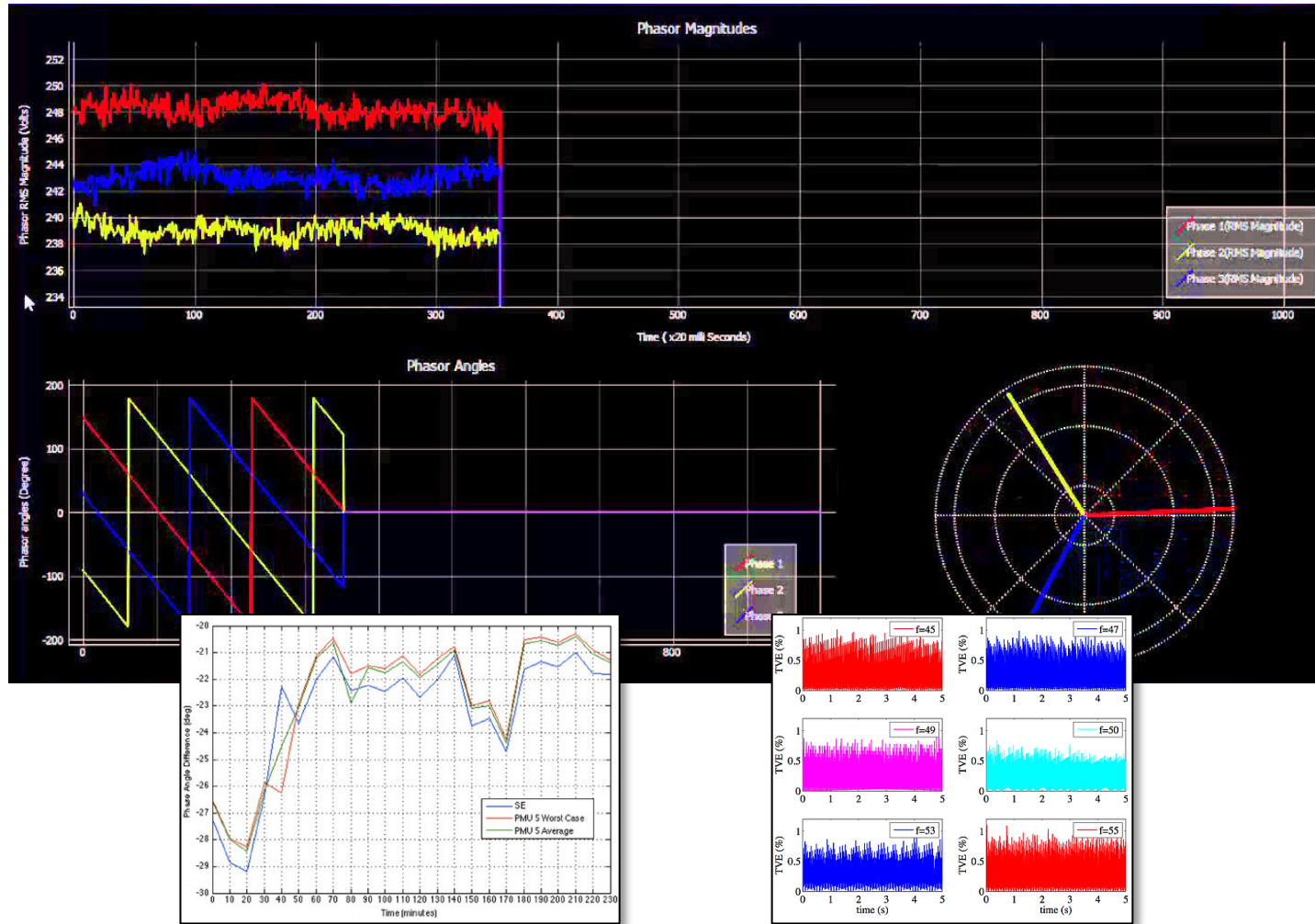
Real-time plotting metaphors and raw data visualizations

Overwhelming, unusable Data rich, information poor

The system shall…

The HMI should…

How are these data currently represented? What do users need to make better use of the data?

Applying the UCD process to PMU HMIs

Design
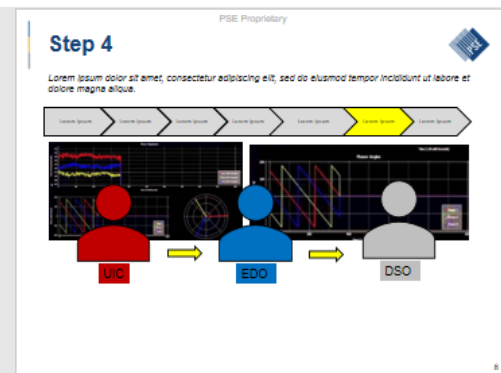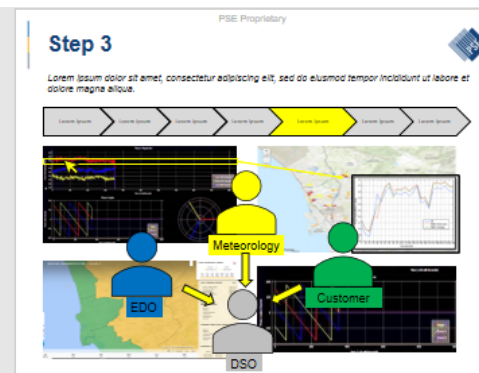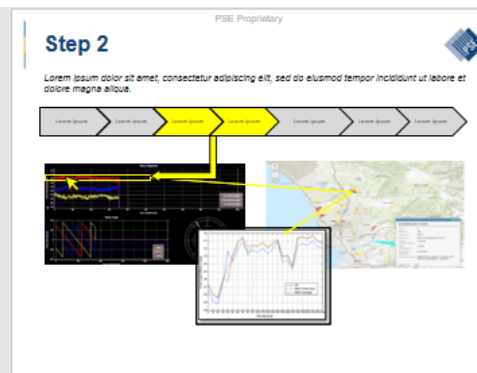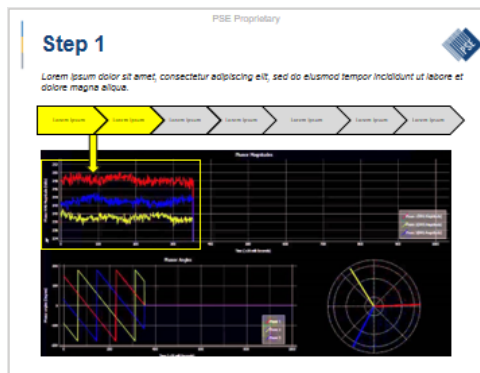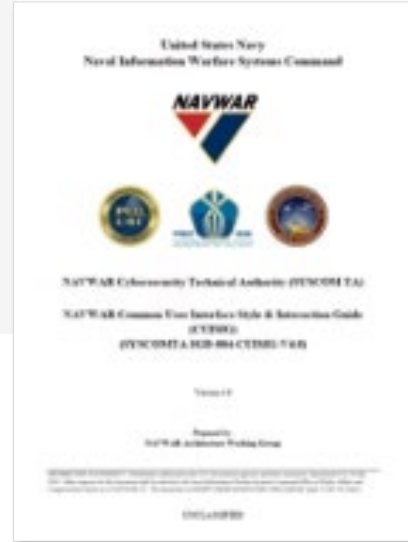
Apply standards and best practices from HF, cognitive science, and UX/UI, while working within domain constraints to iterate on designs to meet user needs

Applying the UCD process to PMU HMIs
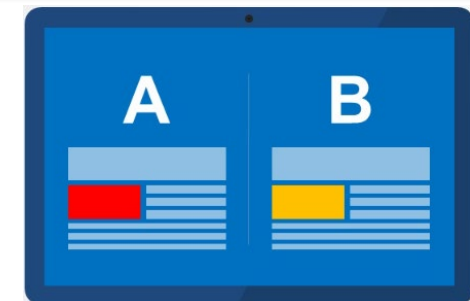
Develop

Applying the UCD process to PMU HMIs

Evaluate

- Computational models simulate human visual/attention
  - Clutter models produces a "feature congestion" score that tracks time needed to find info on display (i.e., more congested, longer to find information) (Rosenholtz and Nakano, 2006)
  - Salience models indicates which area(s) would pull visual attention (i.e., brighter areas) (Harel, Koch, and Perona, 2007)
- Human information processor models capture interactions with HMIs
- Human performance experiments validate anticipated outcomes

Benefits of HMI concepts can be explored before and after implementation

Anticipated impacts

- UCD HMIs address critical issue of PMU data adoption
- Utilities see ROI on PMU investments and experience more reliable energy transmission & distribution through reduced outages
- Scientific community gains topical, relevant visualizations to empirically validate research on PMUs
- Operators make use of PMU data and experience improved, proactive monitoring, data management, and faster, more reliable anomaly detection

Thank you!

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