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

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for



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Pacific Science & Engineering

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- 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

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 is a scientific discipline concerned with the interactions of

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.

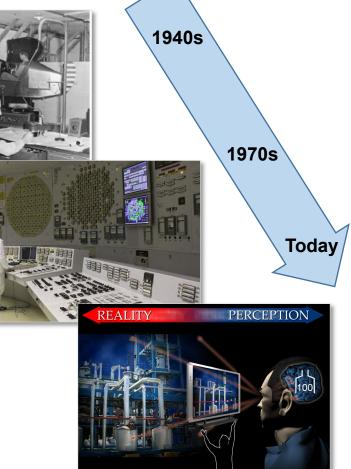
Human Machine Interfaces (HMIs) are the critical bridges between human users and the systems they oversee, control, and make decisions about. **HMI design** is a key area where Human Factors Engineering can be applied to improve user and system performance.

Systems must be engineered for human capabilities in order to perform well and safely

What is Human Factors? Human Machine Interfaces?

Applied science field started in WWII

WORLD





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





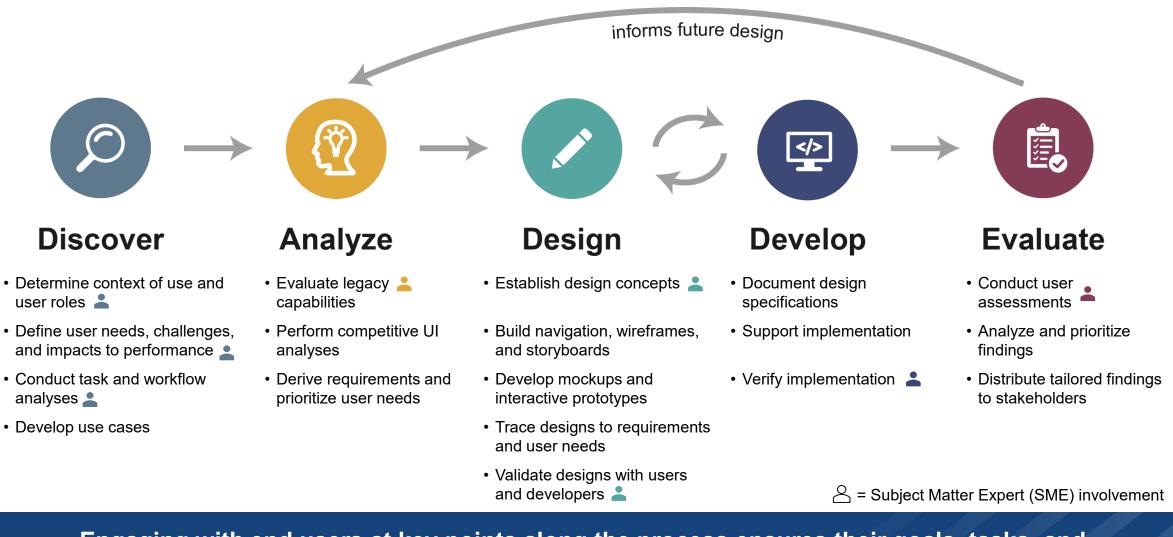






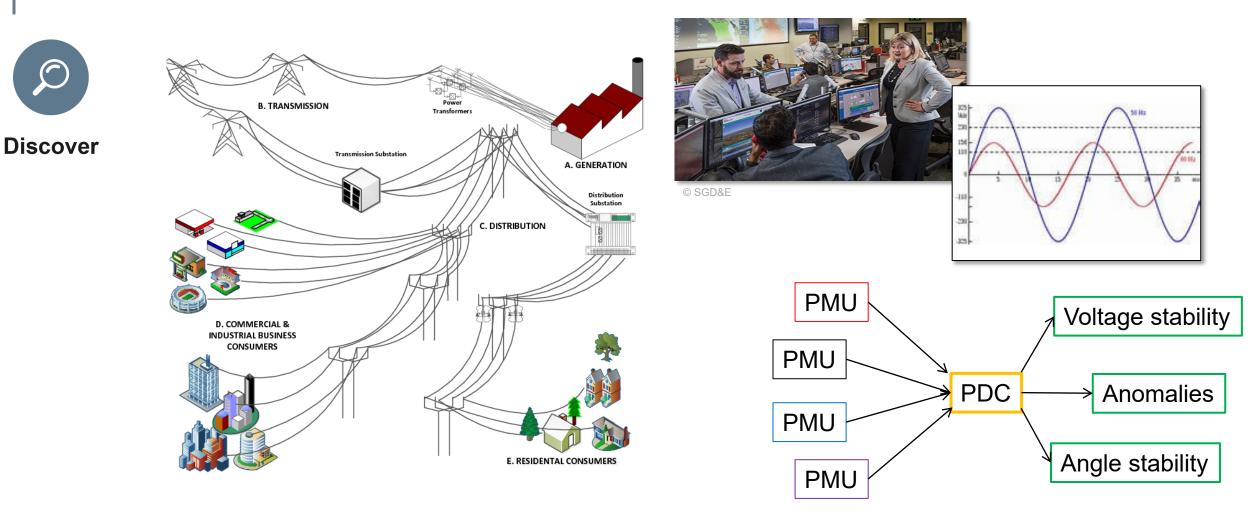
PSE's User-Centered Design (UCD) approach





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





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

Phasor Magnitudes



Analyze

Time (x20 mili Seconds Phasor Angles 1 2 3 4 PMU 5 Worst Case PMU 5 Averag 0 1 2 3 time (s) 2 3 4 time (s)

Real-time plotting metaphors and raw data visualizations

Overwhelming, unusable Data rich, information poor

 \uparrow

The system shall...

The HMI should...

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





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



Develop

quiren cot #	Priority -	Functional Requirement	Impacted NMS Container(c)		Additional Description/Details	Link to mockup
	High	MMS chall exoble users to add PDPS haddoff forme to device that have backwill be de-avergioud "to protect public calvey" from the Work Agenda view.	Work Agenda	MHS shill display a "Inteddiff Form" column in the Vork Agenda view. MMS shall mash urars to right-click in a Modelf Form coll to access rail-bl-click mass with the option to "Add/Edif Form." This Huddelf Form coll shall aren as the haddeff status indicator social device viewed from the Vork Agenda. Alternatively, IMMS shall enable users to select the appropriate Huddeff Form coll, colore the Actions dropdown in the Vork Agenda toolbar, and then access the option to "Add/Edif Form."	Adding a kandolf form from Work Agunda opens up the digital handolf form modul.	41
	High	1890 divid indicate bundset form minter in the Vorit Agorda.	Work Aganda	under der carrie handelf fem mit nicht er och dieter. The Finne centen abeid besoch ich für fich sochen die apprech ab Schröden könne jeden die die soch ab Kin für können sochender ab Kinne können abeid apprech auf die sochen ab Kinnen ab Kinnen ab Kinnen Kontegen Apprech Schröder fem zur besinder ab possible at texes 1. Onges, Apprech die Apprech Apprech die Apprech Apprech B. Richtigung Apprech B. Richtigung Apprech B. Richtigung Richtigung B. Richtigung Richtigung B. Richtigung Richtigung	Instant in merusis based a slope balan bas the risks of degla based from. The risks of using a part of the strong particle and from ranks the relations of the desla states of risks of the risks of t	
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	High	NIMS shall indicate handoff form statue in the Switching Plan List.	Switching Plan List	From the Switching Plan List, NMS shall display a "Handoff Ferm" column that contains a readout of carron handoff from ratura for each device. This Handoff Form column choid be asso of the first first columns that spopar is the Switching Plan List view by default. For a whiching plane that do not yot have any forma associated with them, the Form column should appear sample.		л
	High	NMS chall enable users to add PSPS handoff forms to dovices that have been/will be de-energised "to protect public safety" from the NMS Viewer.	NMS Viewer	NMS shall display the option to "Add/Edit Form" in the Control Tool for such device that can be accessed from the NMS Viewer.	Adding a handolf form from the NMS Viseur opens up the digital handoff form modal.	424
	High	NIMS shall submatically add a handoff form tag to the colocted derice in the NIMS Viewer communants with handoff form status.	NIMS Viewer	NMS shall display a tog that contains a rusdout of current handoff form status attacked to the relevant drives in the NMS Visure. The handoff form tag shall cares as the leadedf status indicator for each drives insued for the NMS Visure. If no knodoff form has been added to a drivies, no handoff form tag shall appear attacked to the drivies.		A24
	High	NMS chall indicate handoff form status in the NMS Viewer.	NMS Viewer	From the NIMS Viewer, NIMS shall display handoff form tags that contain a readout of current handoff form status attached to relevant devices. If no handoff form has been added to a device, no handoff form tag shall appear attached to the		A24
	High	NMS chall enable users to add PSPS handoff forme to device that have been/will be de-easegized "to protect public safety" from the Steps tab of a selected switching plan.	Stops tab	NMS shall enable users to right-click on a row in a device's evitching plan to access a right-click mean with the option to "Add/Edit Form" as a stop in the evitching plan. Upon selections of the "Add/Edit Form" stop, a new row for a handoff form top shall be added below the selected row.	Adding a kundoff form from the Steps tab opens up the digital kundoff form modul and adds a row to the device's switch plan.	A59
	High	NMS chall automatically add a handoff form step to a de-energized device's switching plan commensurate with handoff form status.	Steps tab	NMS shall display a readout of current handoff form status in the sutomotically added handoff form stop of a device's switching plan.		ASS
	High	NMS shall indicate handoff form status in the Steps tab.	Steps tab	From the Stops tab inside a switching plus, NMS shall display rows for handoff form stops that contain readout of current handoff form status where		A59
	High	NMS shall provide usure with access to current and historical PSPS handoff forms.	Safety Documento tab Handoff form	form stops that costain readoute of current handoff form statue where NMS shall enable users to access current handoff forms by double-clicking on any handoff statue indicator.		ALU
				Alternatively, NMS shall enable users to access current handoff forms by right- clicking on any handoff status indicator. Upon right-clicking of a handoff status		



Work directly with IT team to ensure designs are implemented as intended

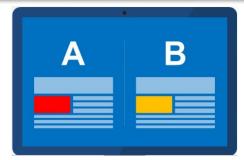


Evaluate

- 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



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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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