Designers Lighting Forum

What if We Thought of a Lighting System
as a Teammate?

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives

1. Attendees will be able to explain human-machine teaming.

2. Attendees will understand how human-machine teaming can influence the lighting industry.

3. Attendees will be able to explore new ways of thinking about how we interact with technology and lighting systems.

4. Attendees will be able to apply action uncertainty principles when designing adaptive lighting systems.
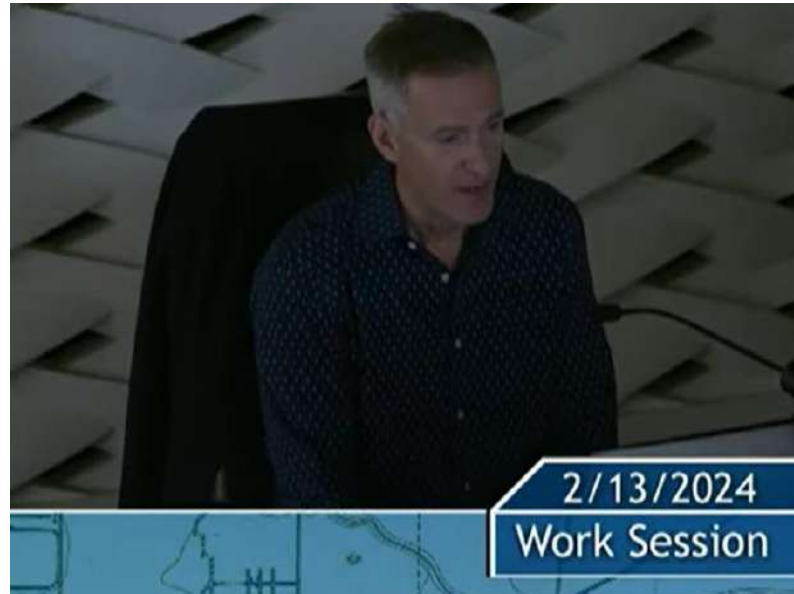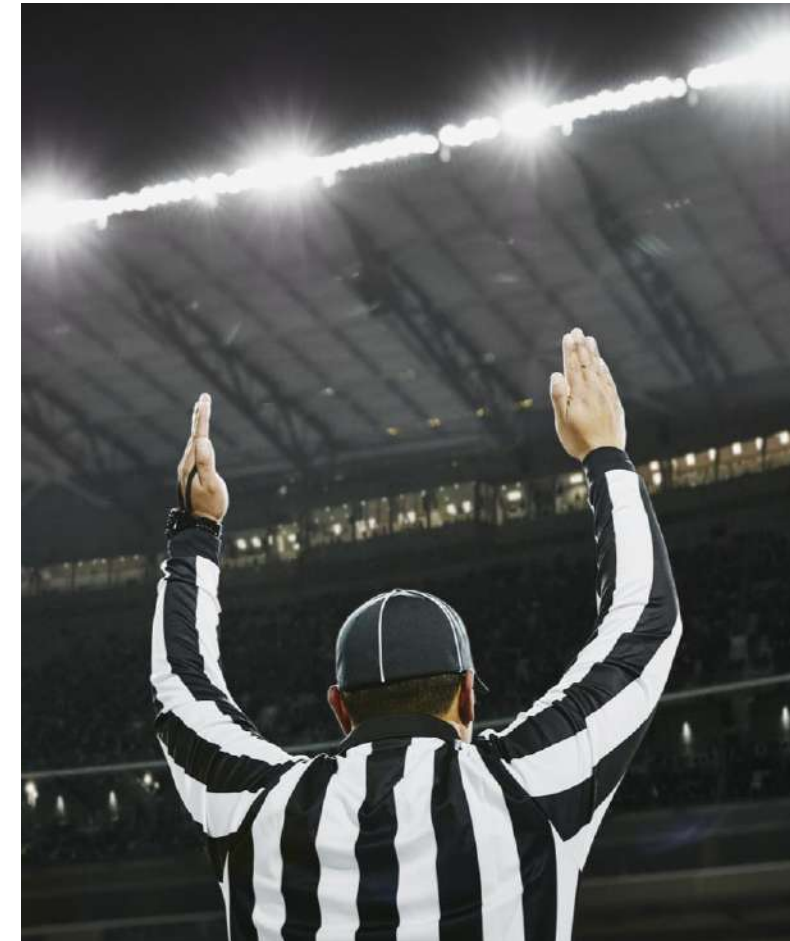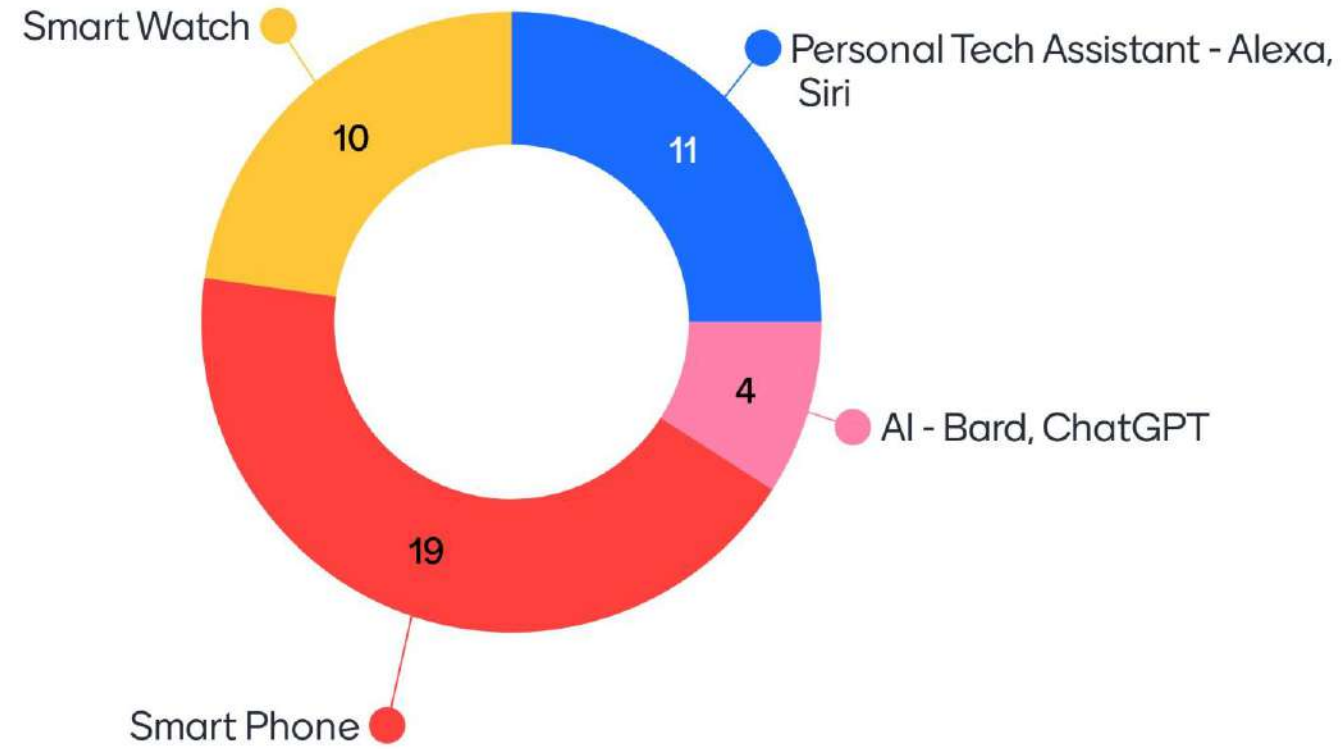
LEDucation.org

Frustrating Foe?

Teammate?

Mayor Wheeler expresses frustrations as lights go out during budget meeting

by: John Ross Ferrara
Posted: Feb 13, 2024 / 05:53 PM PST
Updated: Feb 13, 2024 / 05:53 PM PST

What Tech do You Use Day to Day

Smart Watch — 10

Personal Tech Assistant - Alexa, Siri — 11

AI - Bard, ChatGPT — 4

Smart Phone — 19

What App do You Use the Most?

46 responses

DESIGN HEURISTICS

Design Heuristics

Definition: Rules of thumb for design based on best practice

Visibility of System Status — 1

Match Between System & Real World — 2

User Control And Freedom — 3

Consistency And Standards — 4

Error Prevention — 5

Recognition Rather Than Recall — 6

Flexibility And Efficiency of Use — 7

Aesthetic And Minimalististic Design — 8

Help Users With Errors — 9

Help And Documentation — 10

https://adamfard.com/ux-design-process
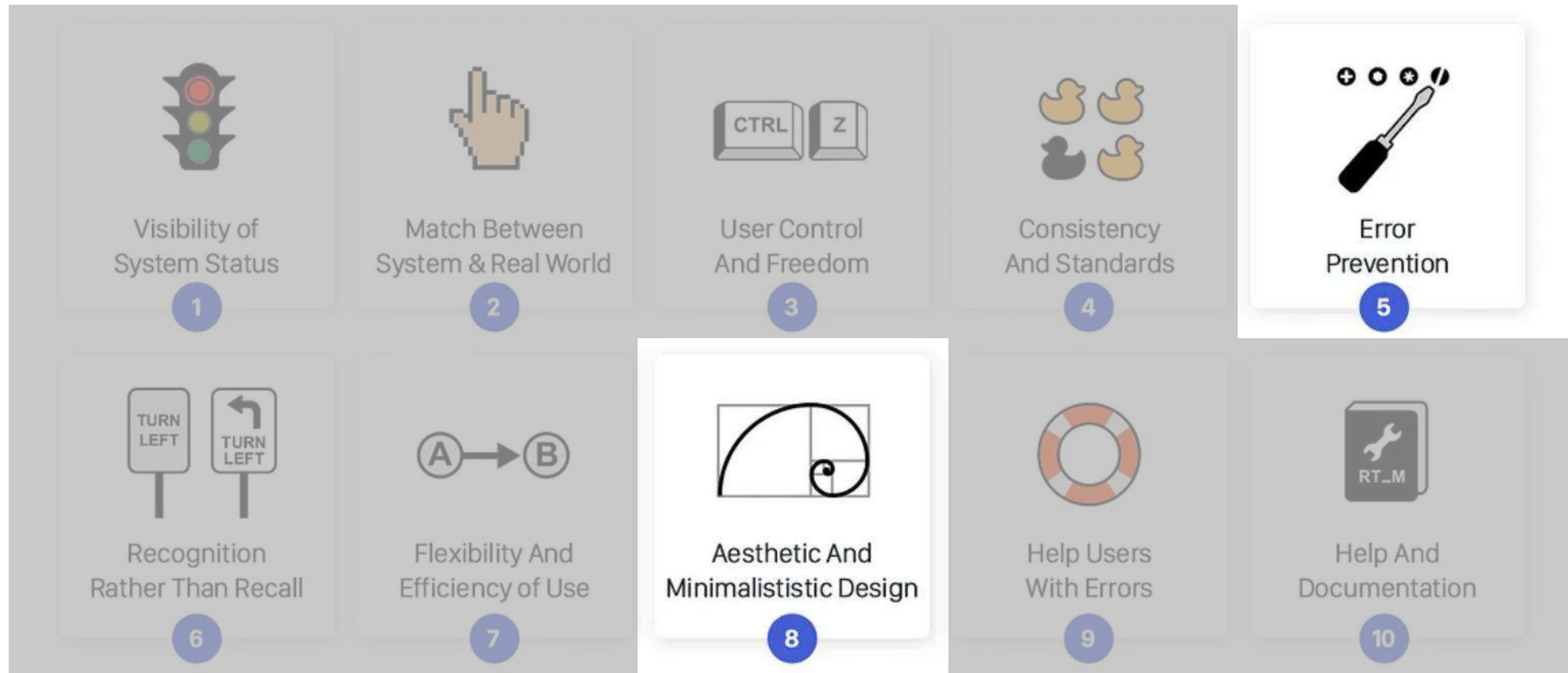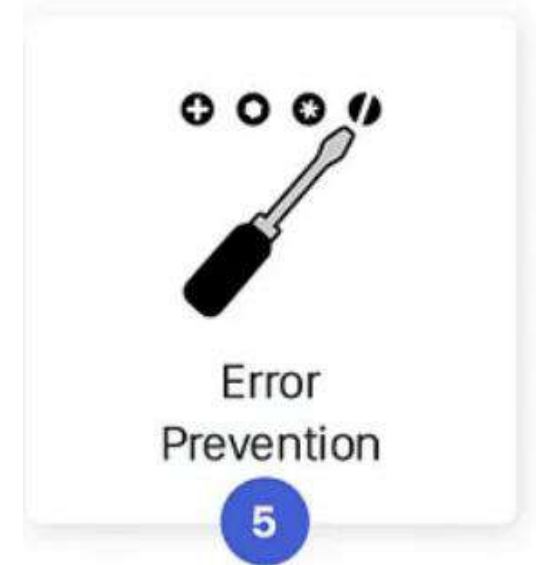
Design Heuristics: Error Prevention

- Design systems to . . .
  - Avoid risky conditions that could lead to error
  - Warn users of risky actions

Error
Prevention
5
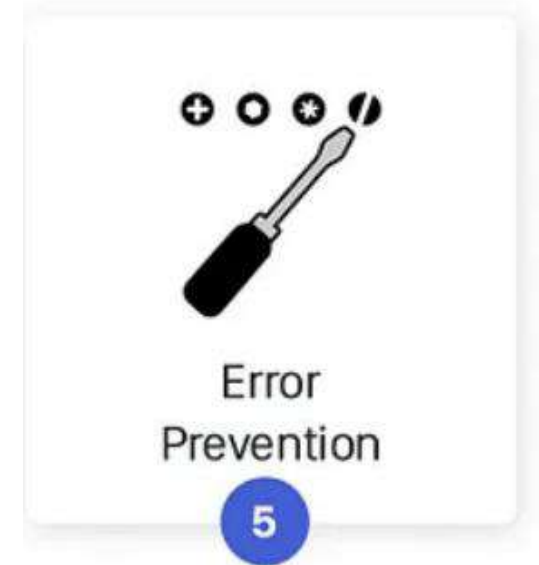
Design Heuristics: Applied to Lighting

Design Heuristics: Design Aesthetic

Aesthetic And
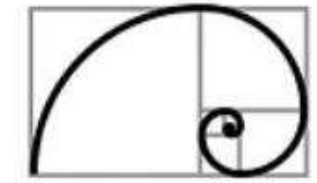Minimalististic Design

8

- Design systems that . . .
    - Have low clutter
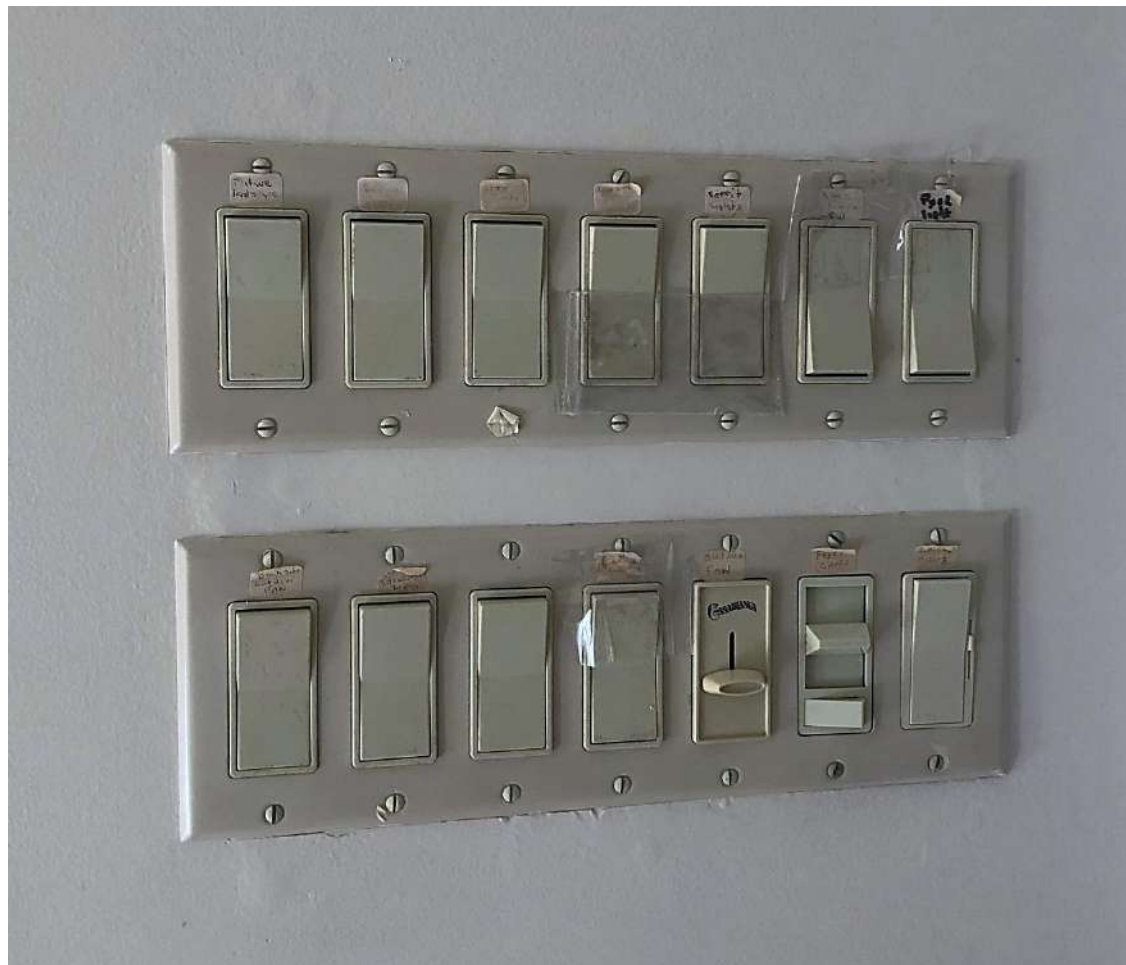   - Highlight only relevant information for current task

Design Heuristics: Applied to Lighting
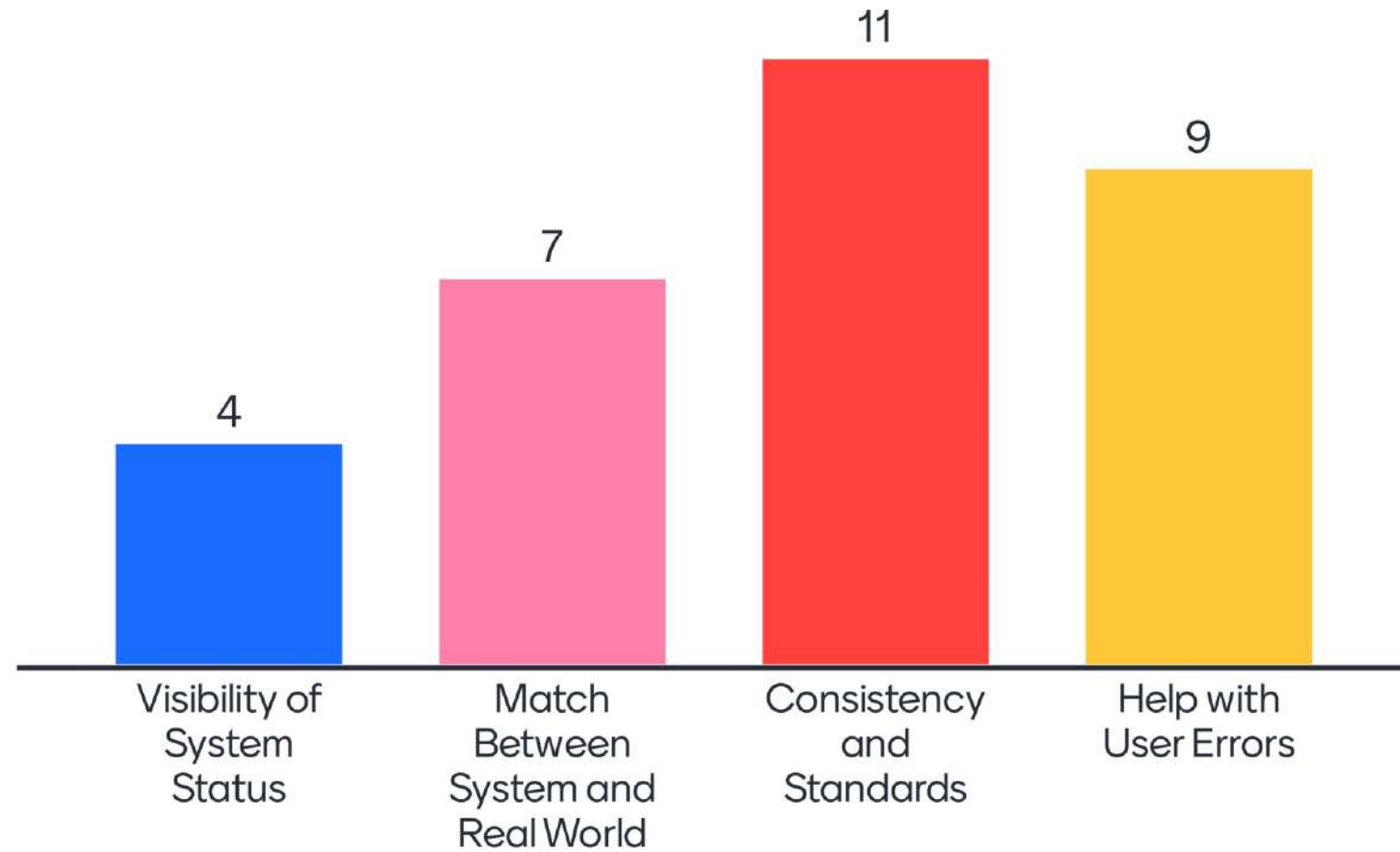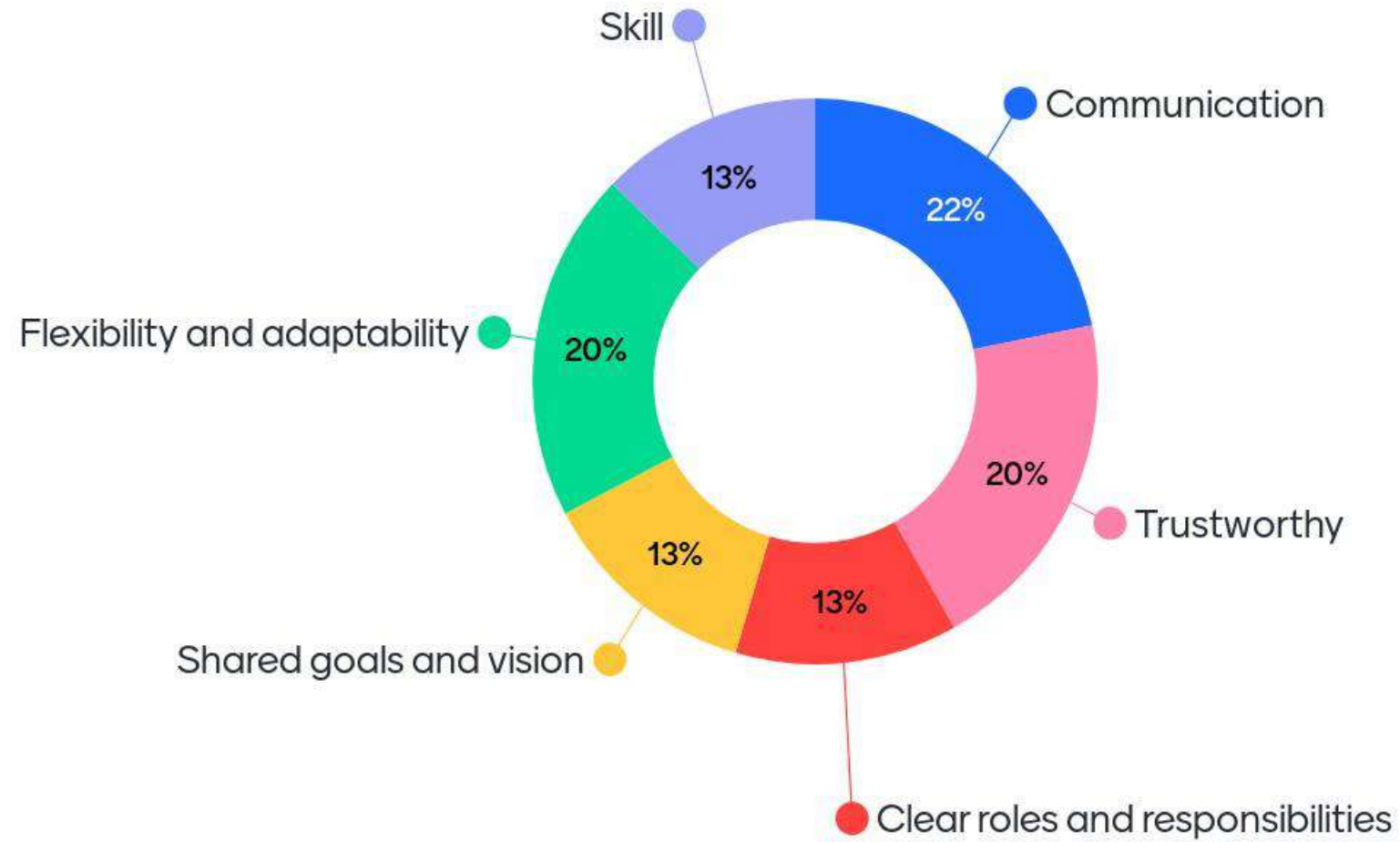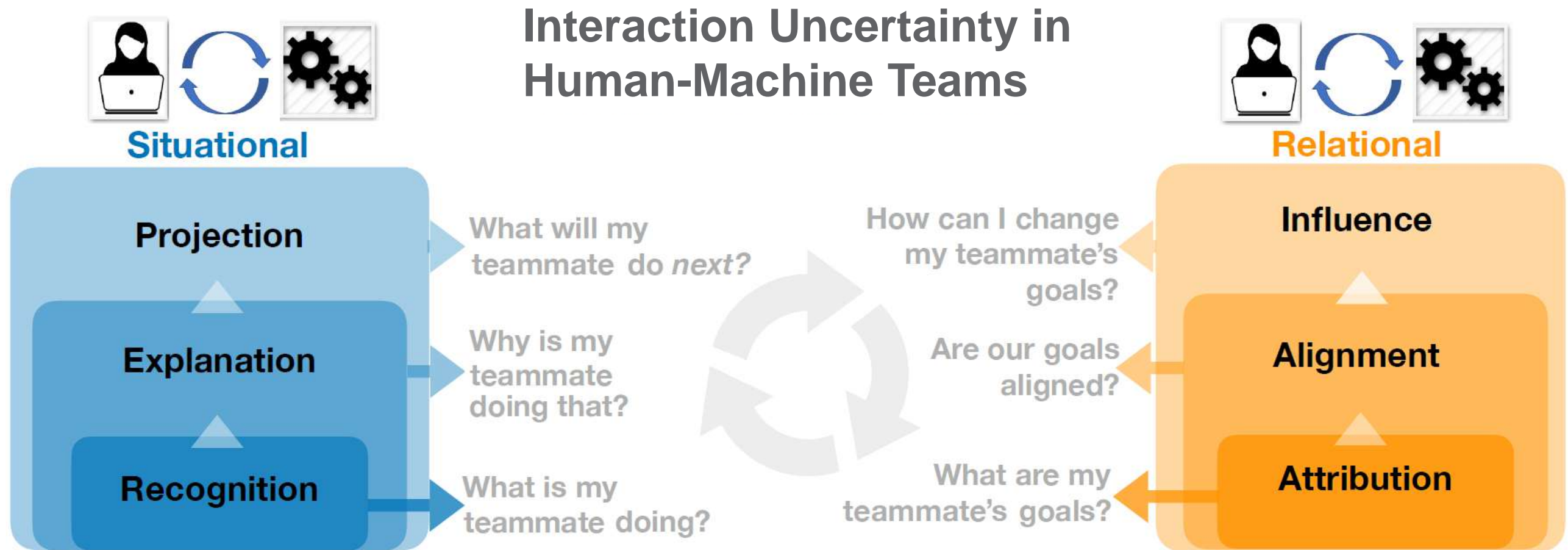
TECHNOLOGY AS A TEAMMATE

Integrated Systems

- 5000K – 2700K Dynamic CCT
- w/ Sensor Controlled Indicator

Adaptive Learning

Interaction Uncertainty

Interaction Uncertainty in Human-Machine Teams

Situational
- **Projection** — What will my teammate do *next*?
- **Explanation** — Why is my teammate doing that?
- **Recognition** — What is my teammate doing?

Relational
- **Influence** — How can I change my teammate's goals?
- **Alignment** — Are our goals aligned?
- **Attribution** — What are my teammate's goals?

Wenskovitch et al. (in press). Characterizing Interaction Uncertainty in Human-Machine Teams. IEEE International Conference on Human-Machine Systems 2024.

Interaction Uncertainty

High Uncertainty Examples for working with an Adaptive Lighting system

- Recognition: What are the lights doing?
- Explanation: Why have the lights dimmed?
- Projection: When will the lights readjust to full brightness?

- Attribution: What have the lights been programed to do?
- Alignment: How well does this program align with my own goals?
- Influence: Can I modify this program to better align with my own goals?

Goal (mis)Alignment

Are Trust and Uncertainty in a Machine Teammate Different from Traditional Automation?

Moving to a more relational approach to Machines

- Antecedents of Trust in Machines for simple Automation
    - Reliability
    - Accuracy
    - Understandability
    - Familiarity

- Additional factors may be relevant for Machine Teammates
    - **Automation responsivity** - ability to adjust to sudden altered conditions
    - **Coordinative** – Automation times its contributions well

What makes a Good Machine Teammate?

What characteristics of smart technology are perceived as important for being a good teammate?

Anthropomorphism?

Ability to Communicate?

Robustness?

Ability to Learn?

Agency?

Research Background and Approach

- Amazon's MTurk, $n = 1{,}174$

- Teammate Task Prompt
  - Describe recent task involving working with a smart device

- Teammate Questionnaire
  - For described task, rate importance of each statement
    - 116 items derived from literature survey
    - Likert scale, 1 ("Not at all important") to 7 ("Extremely important")

- Tool/Teammate Rating
  - For described task, use 8-pt scale (0, Tool; 7, Teammate) to rate perception of smart device
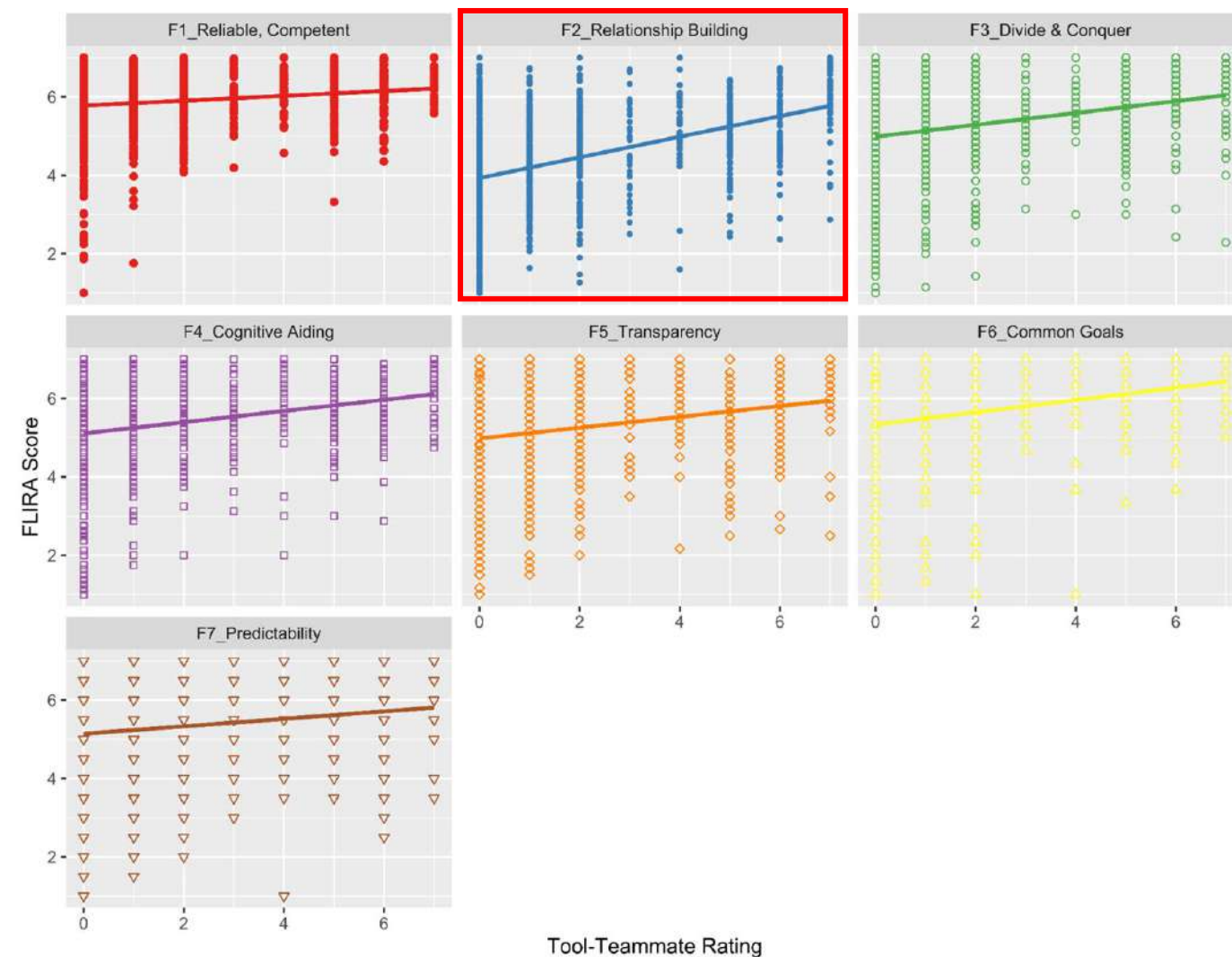
Average Importance Ratings of Each Factor

- Highest importance: Reliable, Competent Factor
- Least importance: Relationship Building

Device Condition FLIRAs
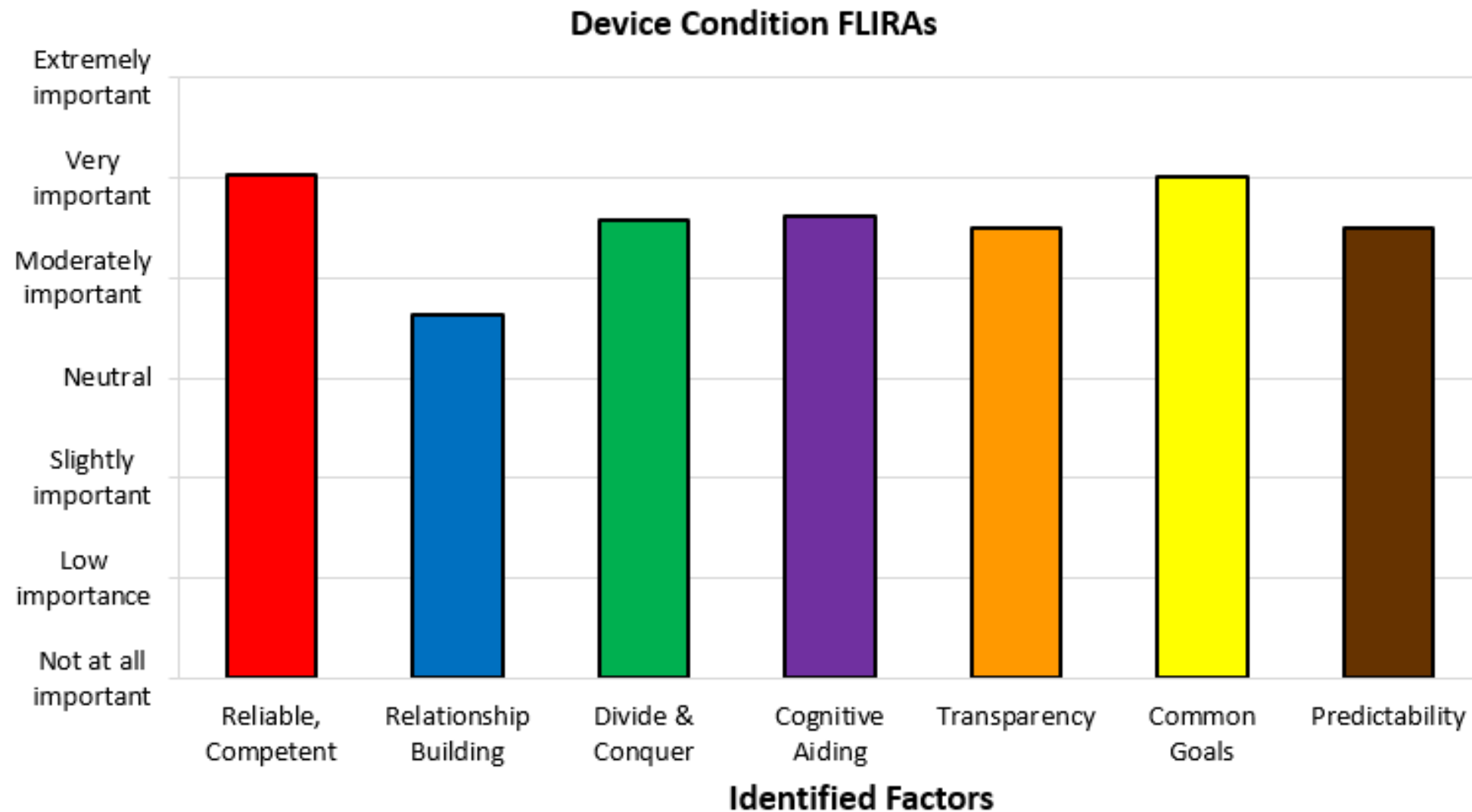
Relationship Building Increases in Importance the More Technology is Seen as a Teammate

Importance rating correlated positively with Tool/Teammate Rating

Strongest for *Relationship Building*

- Importance of Relationship Building was positively correlated with Tool/Teammate Rating

- Participants who view their smart device as a teammate perceived Relationship Building as more important

- May suggest prior device experience impacts what users think is important for being a good teammate

Which users would value a lighting system teammate?
24 responses

art exhibition director
restaurant owner
surgeon
nurses
nicu
facilities staff
patients
residents
restaurant owners
teachers
presenters
passengers
nature
facilities manager
models
memory care
customers
homeowner
theater performers

What is your biggest fear when specifying lighting controls?

34 responses

MACHINE TEAMMATE DESIGN HEURISTICS

What is Human-Machine Teaming?

Human-machine teaming is about elevating technology to the role of a Teammate
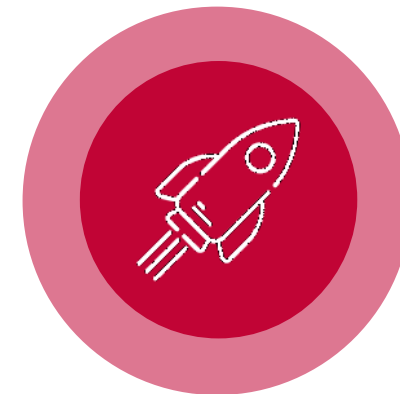
- The machine is more than a tool designed to execute a task
- The machine has capabilities consistent with human teammates
  - ✓ Capable of understanding larger task goals
  - ✓ Proactive in executing tasks communicating with their human teammate
  - ✓ Can learn from their human teammate and environment

Observe   Communicate   Act

Machine Teammate Design Heuristics

- Guidelines that designers can apply when attempting to develop technology that functions like a teammate

- Informed by the Human-Machine Teaming literature

- Example
  - Control Cost: The cost in time and energy required for the human to communicate with the machine teammate should be minimal.

Does the human need to learn code?

Can the human use natural language?

PNNL's Machine Teammate Design Heuristics

Observe includes:
- Monitor → The machine should be able to monitor its own performance, changes in the operational environment, progress toward task goals and resources available to complete the tasks.
- Learn
- Predict

Communicate includes:
- Practice Etiquette
- Cost Control
- Be Observable → The machine should be able to communicate its rationale for its actions and recommendations as well as its status, to the human teammate in multiple modalities.
- Adapt Consistently

Act includes:
- Take Initiative
- Be Directable
- Direct → The machine should be able to direct the human when appropriate, including directing the human's attention to important developments.

Machine Teammate Design Heuristics

Observe

|	
Monitor	The machine should be able to monitor its own performance, **changes in the operational environment**, the **team's progress toward task goals and resources available** to complete the tasks.
Learn	The machine teammate should have the ability **to learn task goals**, new ways of performing a task and **human's work preferences** both **implicitly** through interaction with the human and through **explicit instructions** from the human.
Predict	The machine should be able to **anticipate** the human's actions, needs and upcoming events based on what it monitors and learns about the **human's preferences and the task environment**.

Monitor:

The machine should be able to monitor its own performance, changes in the operational environment, the team's progress toward task goals and resources available to complete the tasks.

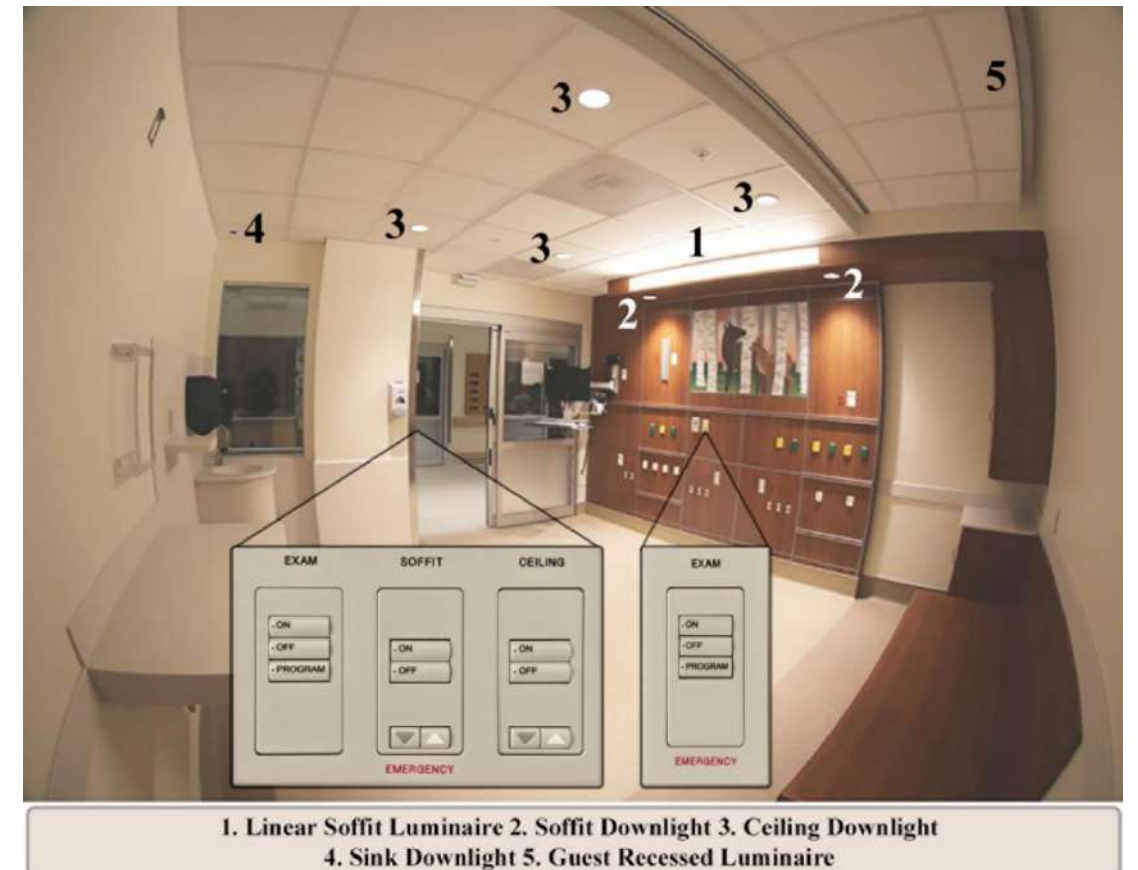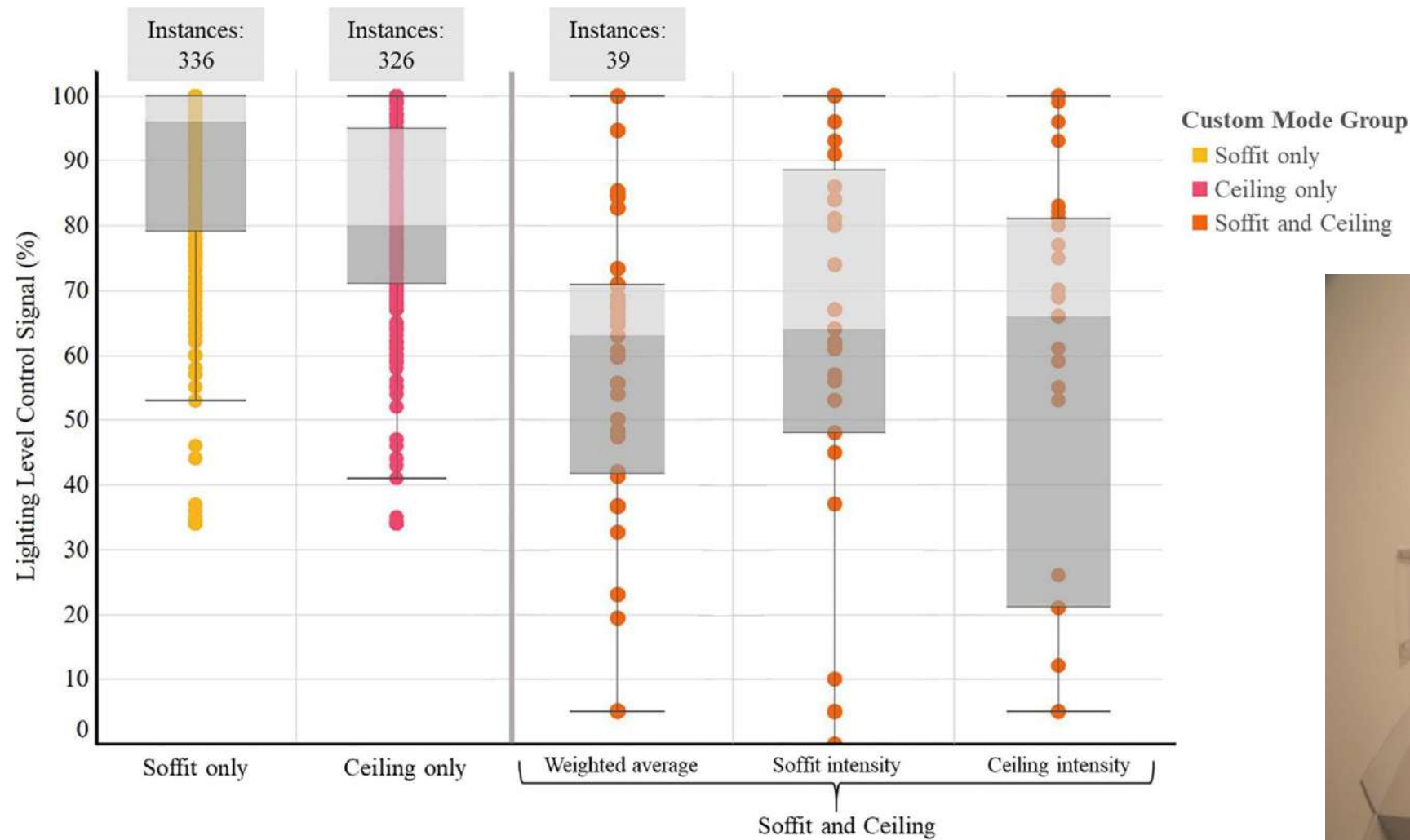| timestamp	W8 Warm (%)	W8 Cool (%)	Ceiling Color (%)	Ceiling Intensity (%)	Soffit Color (%)	Soffit Intensity (%)	Lighting Level (%)	Lighting Power Used (W)	Lighting Scene	Lighting State	Dev Not Responding	Lamp Fail	Lamp Near EOL
28-Jun-19 5:55:00 AM EDT	0	0	0	0	0	0	0	0	6	FALSE	0	0	0
28-Jun-19 6:00:00 AM EDT	0	0	34	0	80	0	80	80	8	TRUE	0	0	0
28-Jun-19 6:05:00 AM EDT	0	0	34	0	80	0	80	80	8	TRUE	0	0	0
28-Jun-19 6:10:00 AM EDT	0	0	34	0	80	0	80	80	8	TRUE	0	0	0
28-Jun-19 6:15:00 AM EDT	0	0	34	0	80	0	80	80	8	TRUE	0	0	0
28-Jun-19 6:20:00 AM EDT	0	0	34	0	80	0	80	80	8	TRUE	0	0	0
28-Jun-19 6:25:00 AM EDT	0	0	0	0	0	0	0	0	6	FALSE	0	0	0
28-Jun-19 6:30:00 AM EDT	0	0	0	0	0	0	0	0	6	FALSE	0	0	0
28-Jun-19 6:35:00 AM EDT	0	0	0	0	0	0	0	0	6	FALSE	0	0	0
28-Jun-19 6:40:00 AM EDT	0	0	0	0	0	0	0	0	6	FALSE	0	0	0
28-Jun-19 6:45:00 AM EDT	0	0	0	0	0	0	0	0	6	FALSE	0	0	0
28-Jun-19 6:50:00 AM EDT	0	0	0	0	0	0	0	0	6	FALSE	0	0	0
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28-Jun-19 7:05:00 AM EDT	100	1	0	0	0	0	100	100	7	TRUE	0	0	0
28-Jun-19 7:10:00 AM EDT	100	1	0	0	0	0	100	100	7	TRUE	0	0	0
28-Jun-19 7:15:00 AM EDT	100	1	0	0	0	0	100	100	7	TRUE	0	0	0
28-Jun-19 7:20:00 AM EDT	100	1	0	0	0	0	100	100	7	TRUE	0	0	0
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28-Jun-19 7:30:00 AM EDT	100	1	0	0	0	0	100	100	7	TRUE	0	0	0
28-Jun-19 7:35:00 AM EDT	32	100	0	0	0	0	100	100	2	TRUE	0	0	0
28-Jun-19 7:40:00 AM EDT	32	100	0	0	0	0	100	100	2	TRUE	0	0	0
28-Jun-19 7:45:00 AM EDT	32	100	0	0	0	0	100	100	2	TRUE	0	0	0
28-Jun-19 7:50:00 AM EDT	32	100	0	0	0	0	100	100	2	TRUE	0	0	0
28-Jun-19 7:55:00 AM EDT	32	100	0	0	0	0	100	100	2	TRUE	0	0	0
28-Jun-19 8:00:00 AM EDT	32	100	0	0	0	0	100	100	2	TRUE	0	0	0
28-Jun-19 8:05:00 AM EDT	32	100	0	0	0	0	100	100	2	TRUE	0	0	0
28-Jun-19 8:10:00 AM EDT	32	100	0	0	0	0	100	100	2	TRUE	0	0	0
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28-Jun-19 8:30:00 AM EDT	32	100	0	0	0	0	100	100	2	TRUE	0	0	0
28-Jun-19 8:35:00 AM EDT	32	100	0	0	0	0	100	100	2	TRUE	0	0	0
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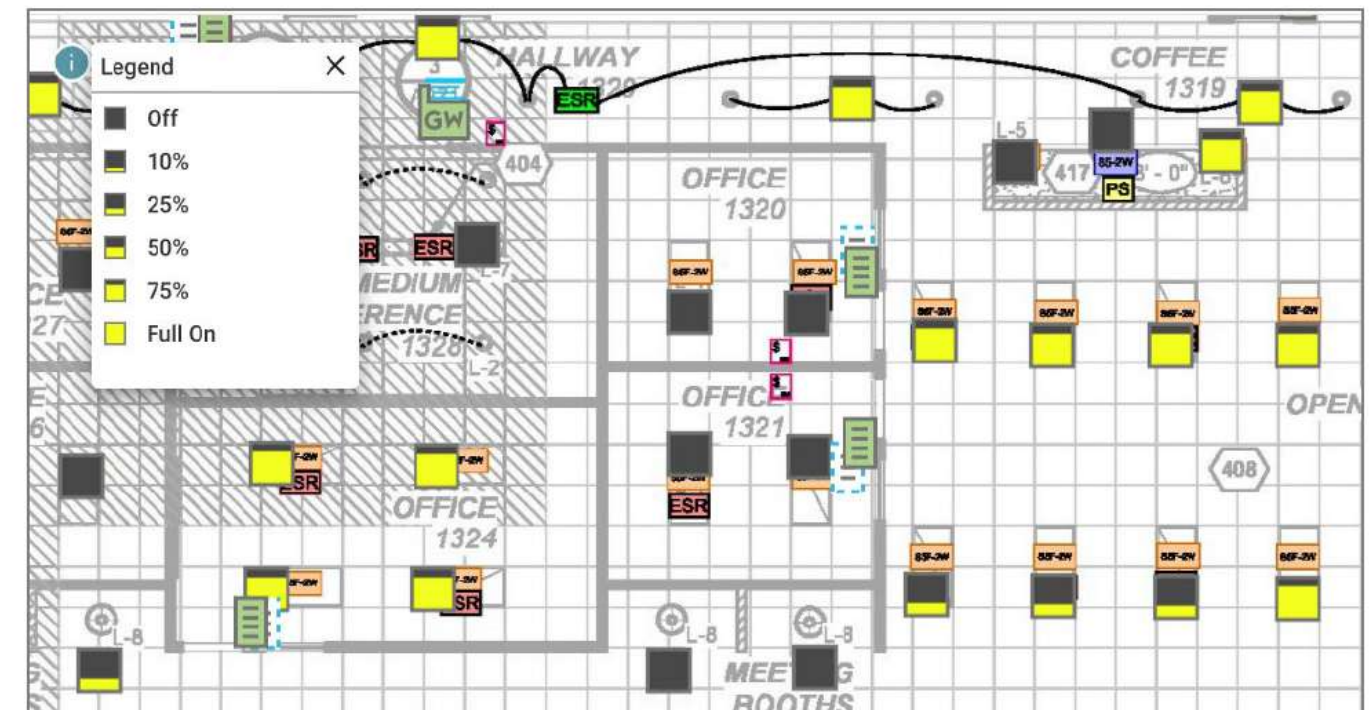
Legend
- Off
- 10%
- 25%
- 50%
- 75%
- Full On

Learn:

The machine teammate should have the ability to learn task goals, new ways of performing a task and human's work preferences both implicitly through interaction with the human and through explicit instructions from the human.
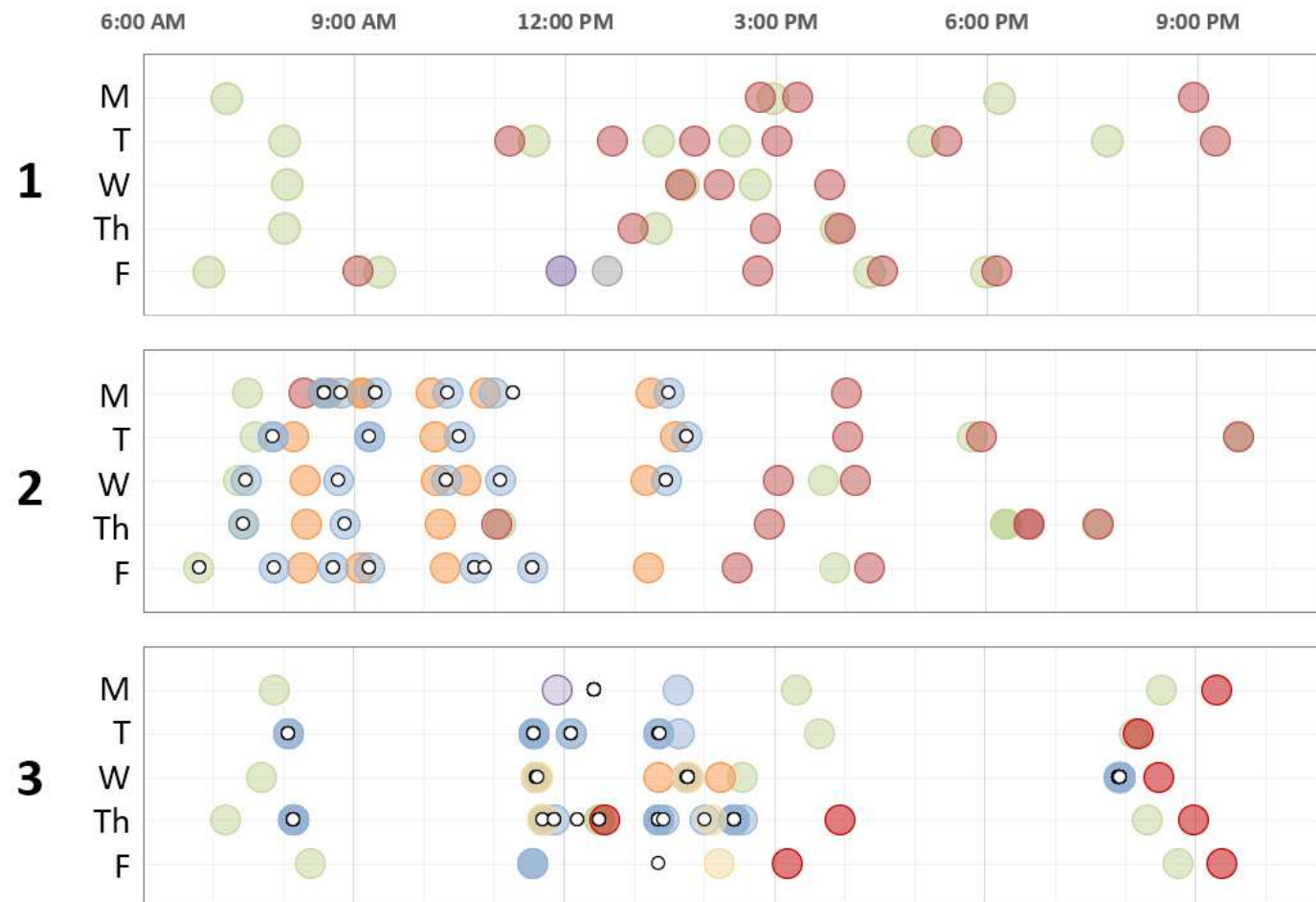
Predict:

The machine should be able to anticipate the human's actions, needs and upcoming events based on what it monitors and learns about the human's preferences and the task environment.

Machine Teammate Design Heuristics

Communicate

Practice Etiquette	The machine's **communication** with the human should be **consistent** with the **norms, expectations and terminology** used by the human.
Control Cost	The **cost in time and energy required for the human to communicate** with the machine teammate should be minimal.
Be Observable	The machine should be able to **communicate its rationale for its actions** and recommendations as well as its status, knowledge of the team, task and environment to the human teammate in multiple modalities.
Adapt Consistently	When the machine must adapt to new events or challenges in the task environment, it should **communicate** its **change in a predictable way**.

Practice Etiquette:

The machine's communication with the human should be consistent with the norms, expectations and terminology used by the human.
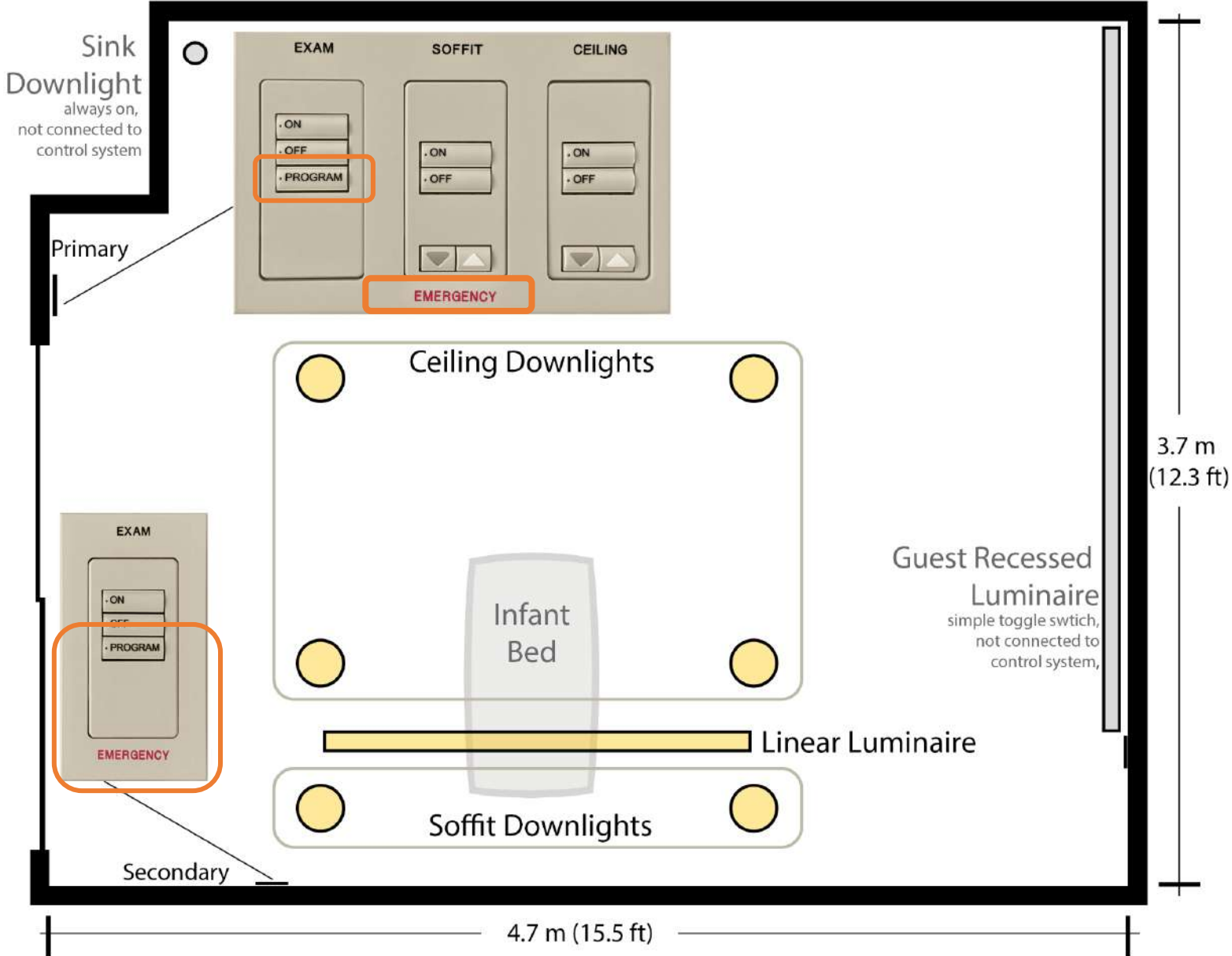
Control Cost:

The cost in time and energy required for the human to communicate with the machine teammate should be minimal.

Lighting problem

Trying to figure out who can help

Still have a lighting problem

Be Observable:

The machine should be able to communicate its rationale for its actions and recommendations as well as its status, knowledge of the team, task and environment to the human teammate in multiple modalities.

Adapt Consistently:

When the machine must adapt to new events or challenges in the task environment, it should communicate its change in a predictable way.
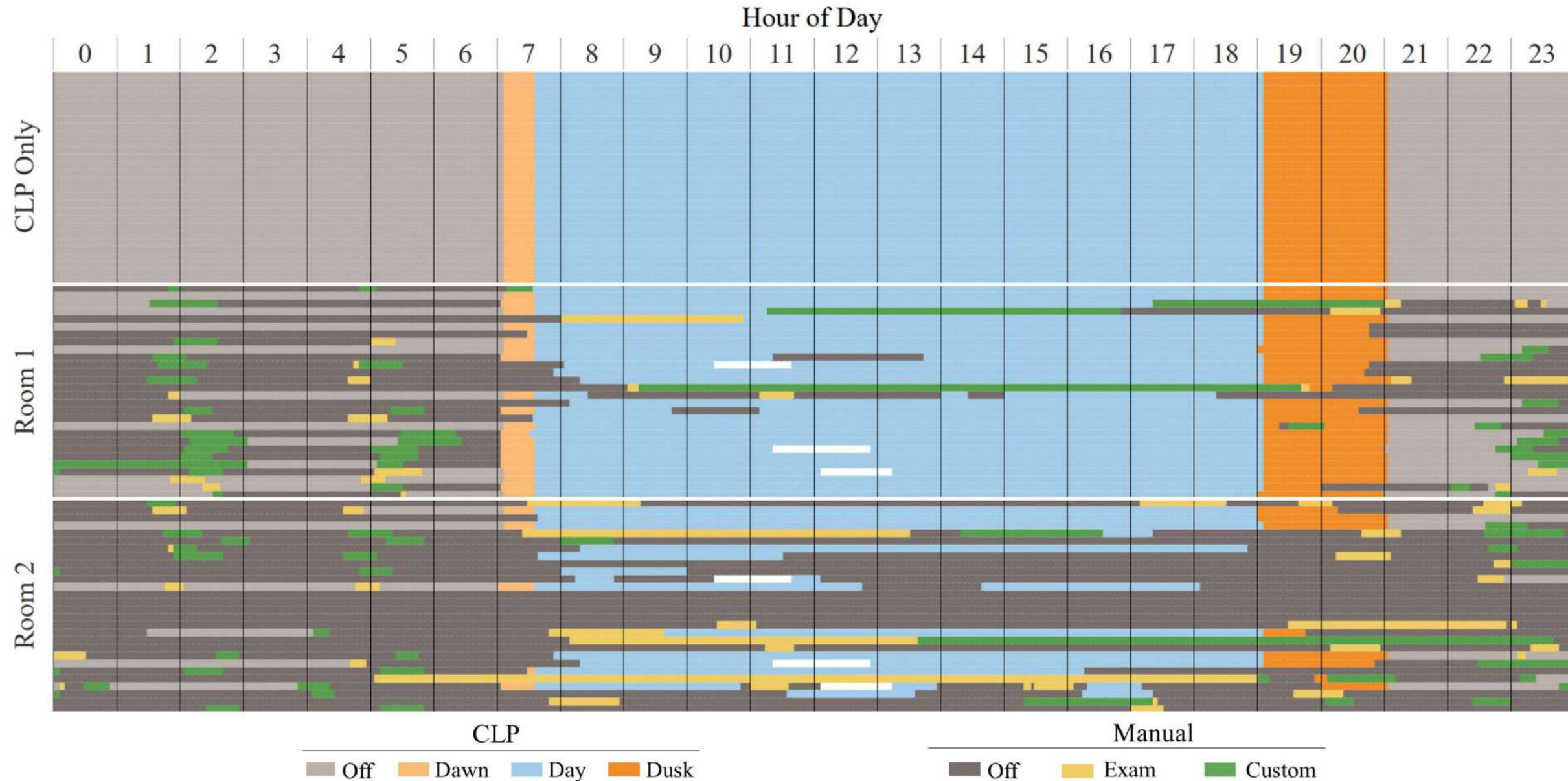
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Machine Teammate Design Heuristics

Act

Direct	The machine should be able to direct the human when appropriate, including directing the human's attention to important developments.
Be Directable	The machine should be able to **flexibly take direction from the human** such as responding to new goals and task assignments administered by the human.
Take Initiative	**The machine should be given autonomy to offer support and act without specific, explicit instructions** and oversight from the human when task demands require the machine's unique strengths.

Direct

The machine should be able to direct the human when appropriate, including directing the human's attention to important developments.

Be Directable

The machine should be able to flexibly take direction from the human such as responding to new goals and task assignments administered by the human.

Mayor Wheeler expresses frustrations as lights go out during budget meeting

by: John Ross Ferrara
Posted: Feb 13, 2024 / 05:53 PM PST
Updated: Feb 13, 2024 / 05:53 PM PST

"Can we please get that switch fixed," Wheeler said. "Can we just hire an electrician please and have an on and off switch put over there on the wall so that guy doesn't have to sit here all meeting holding the button. Thank you for doing that."

Take Initiative

The machine should be given autonomy to offer support and act without specific, explicit instructions and oversight from the human when task demands require the machine's unique strengths.
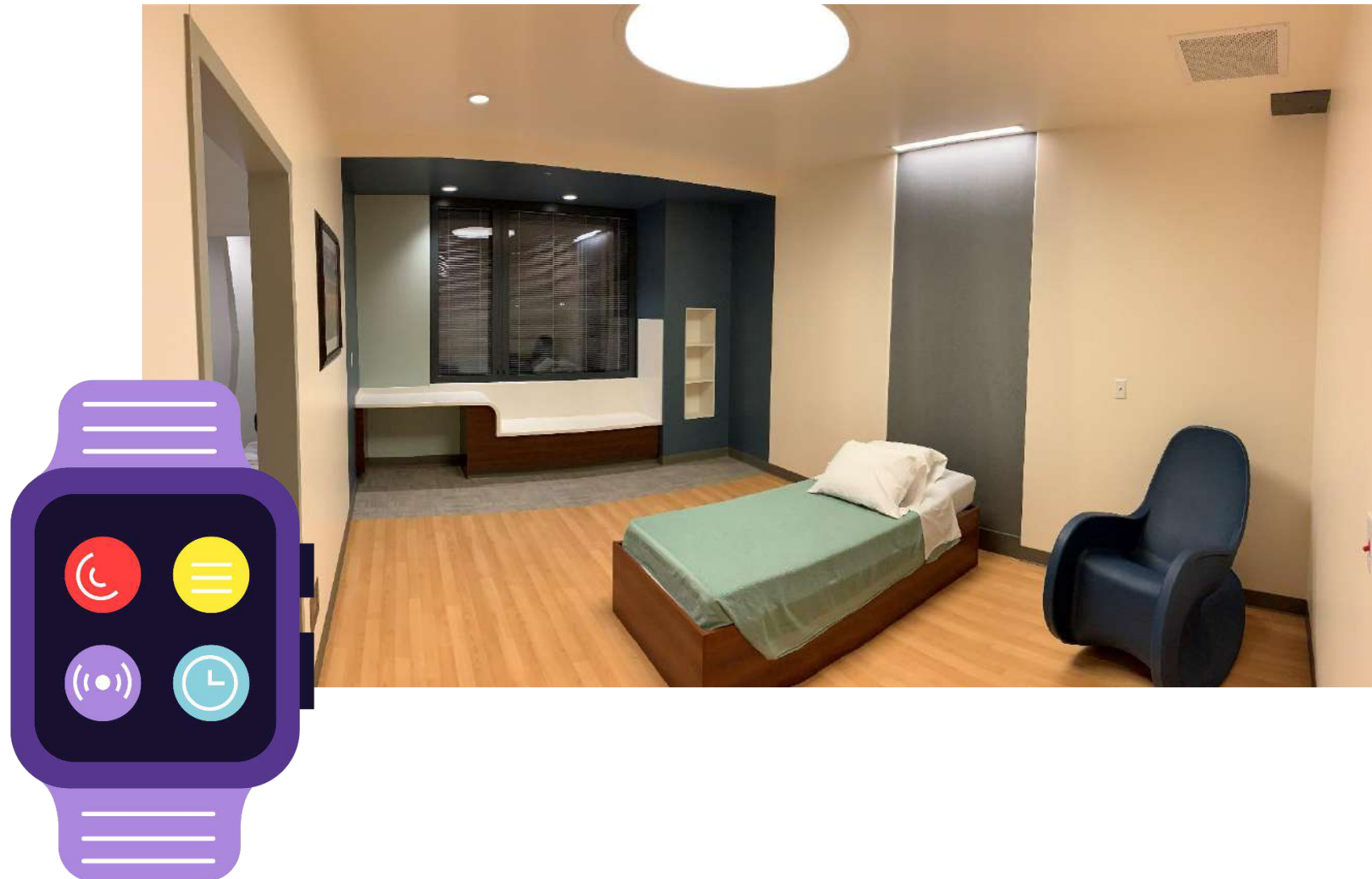
During your recent shifts, indicate how often these attributes **hindered** your ability to perform your professional duties.

Legend: Always | Usually | Sometimes | Rarely | Never

Old Unit (Nov. 2018)

Categories (top to bottom):
- Control of Lights
- Light Level in Work Area
- Color of Light
- Flicker from Light Fixtures
- Pattern of Light and Dark Areas
- Shadows from People and Objects
- Glare from Light Fixtures

New Unit (Jun. 2020)

Categories (top to bottom):
- Control of Lights — ← ~30% "Usually"
- Light Level in Work Area
- Color of Light
- Flicker from Light Fixtures
- Pattern of Light and Dark Areas
- Shadows from People and Objects
- Glare from Light Fixtures
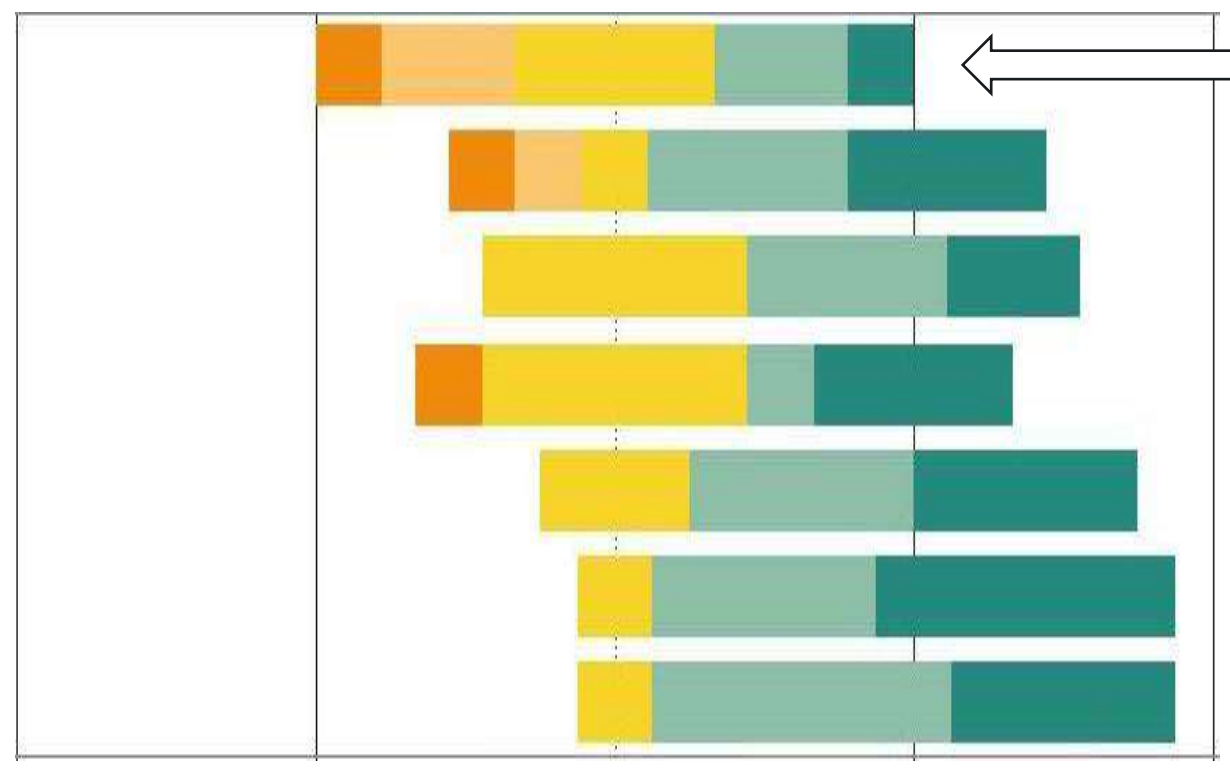
Axis: 100% — 50% — 0% — 50% — 100%

During your recent shifts, indicate how often these attributes **hindered** your ability to perform your professional duties.

Old Unit
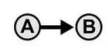
New Unit

FINAL THOUGHTS
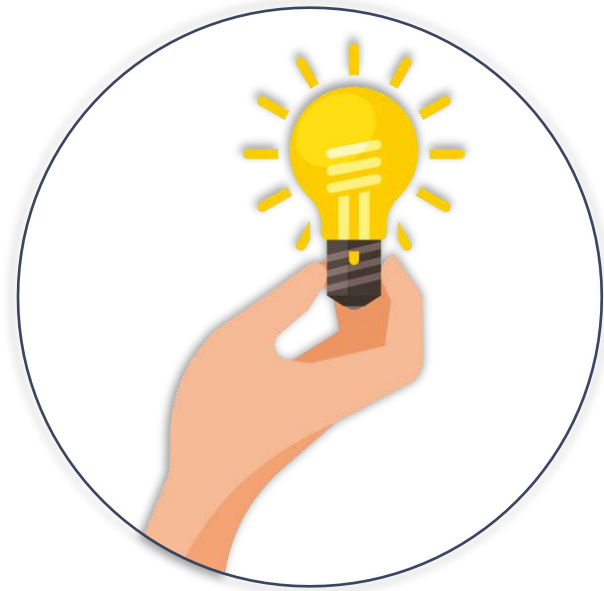
SUMMARY

Design Heuristics

Technology as a Teammate

Machine Teammate
Design Heuristics

This concludes The American Institute of Architects Continuing Education Systems Course