The User Experience of Lighting Control

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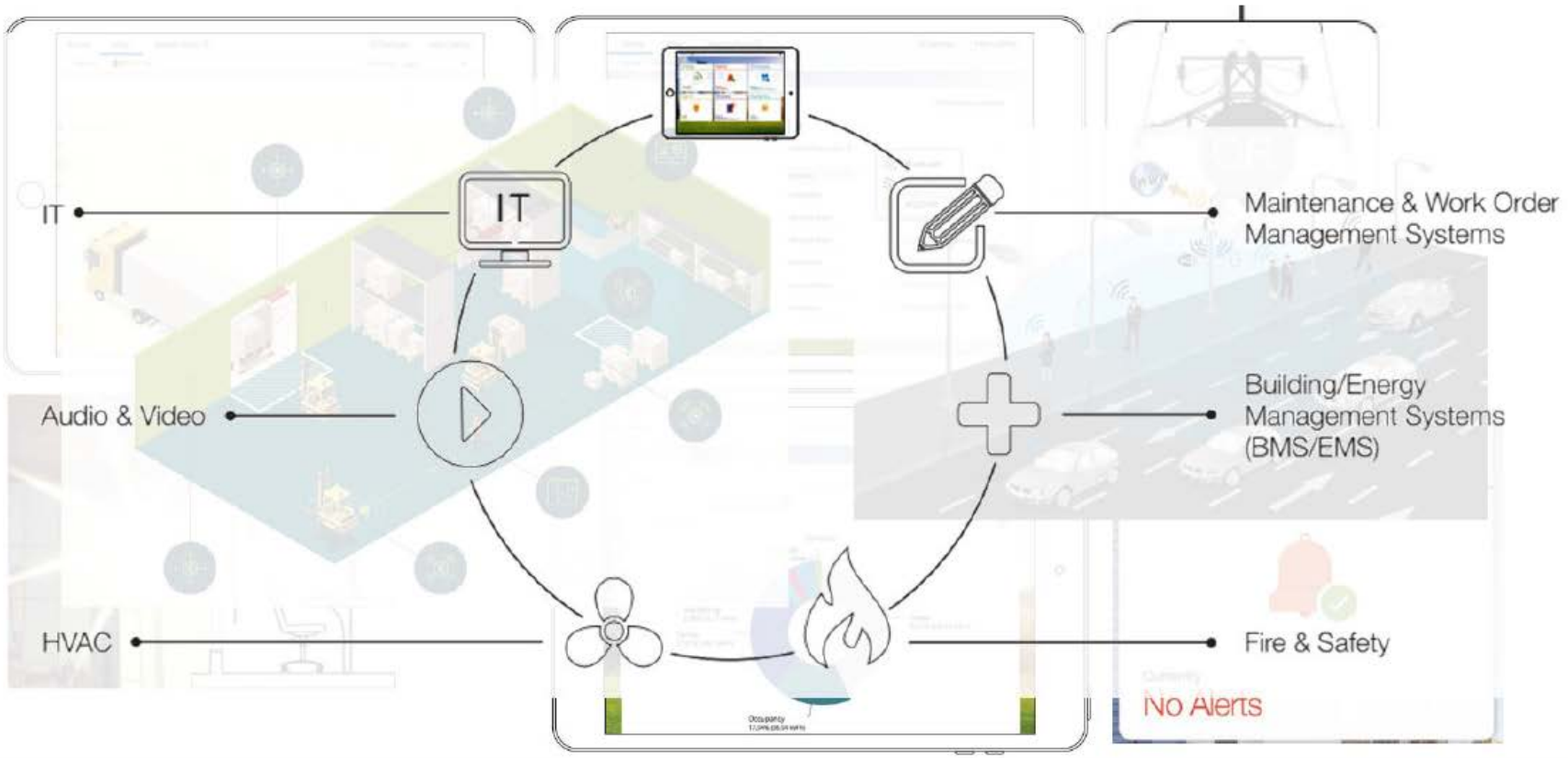
Learning Objectives

At the end of this course, participants will be able to:

1. Understand the uncanny valley of smart lighting and its impact on occupants when systems are not customized to the end user.
2. Implement the process for customizing smart lighting systems based on lighting narratives and documenting the sequence of operations.
3. Apply example control sequences to new projects that meet the needs of the end user and are documented to minimize implementation errors.
4. Recommend system features that meet the user experience requirements while future-proofing the design.

Smart lighting brings great opportunities at a risk to occupant comfort and productivity



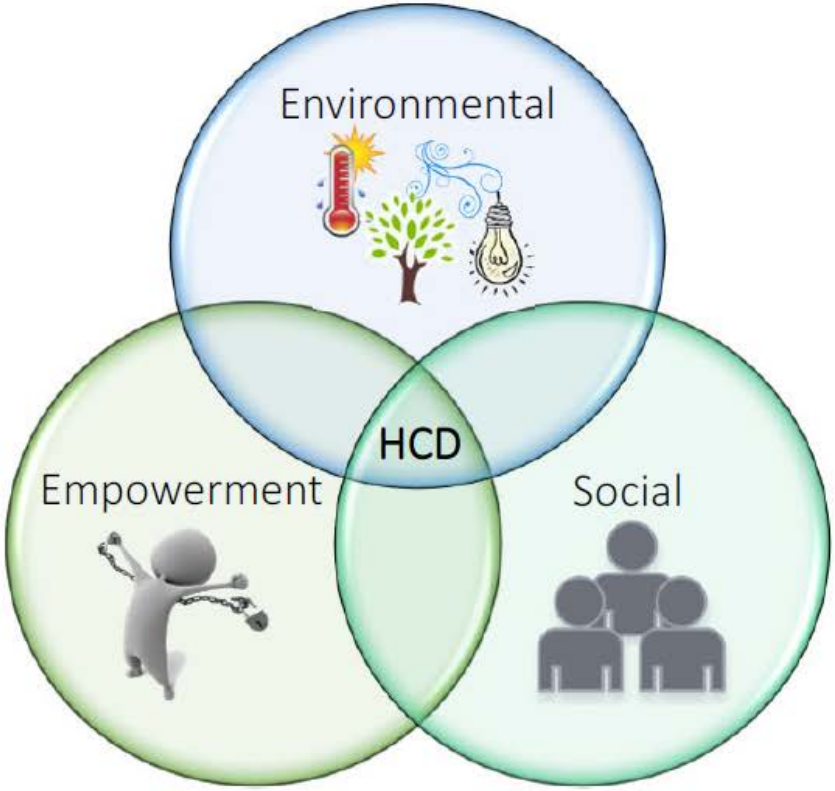
The value of occupant performance greatly outweighs the cost of operations and energy usage

Annual Costs for Commercial Buildings

- **Energy: $3/ft²** ($30/m²)
- **Operations/Rent: $30/ft²** ($300/m²)
- **Salaries: $300/ft²** ($3000/m²)

Source: Rocky Mountain Institute. 2012. Guide to Building the Case for Deep Energy Retrofits.

Optimized design for students and faculty can improve well-being and performance, particularly when customized.



Access to views and daylight is particularly beneficial for learning and office work performance

OFFICE WORKER Tests	Improved Performance
Short & Long Term Memory	16%
Short Term Memory	10%
Visual Acuity & Mental Function	8%

STUDENT Tests	Vegetation in View	Activity in View
Mathematics	40%	30%
Reading		6%

Source: California Energy Commission (Prepared by Heschong Mahone Group). 2003. Taken from 2 studies: Windows and Offices; Windows and Classrooms.

Smart lighting control systems not designed for the occupants can have detrimental effects

COMPLICATED

- Controls not intuitive
- Too many options

DISRUPTIVE

- System reacts too often
- System reacts too fast or slow

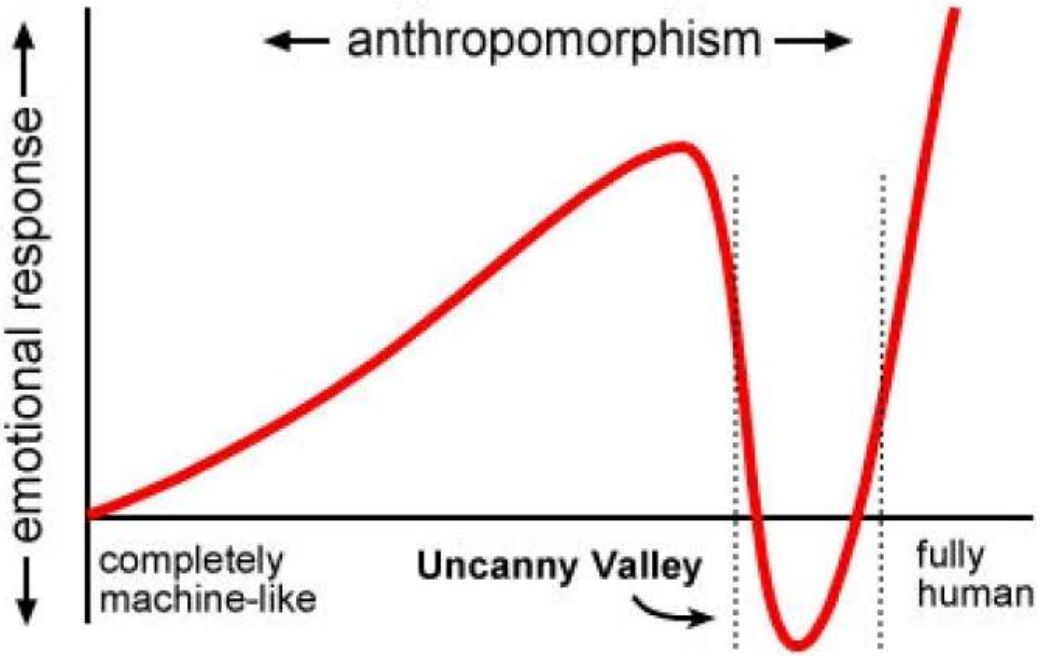
COGNITIVE DISSONANCE

- Not customized to application
- Not sensing correctly
- Product failure

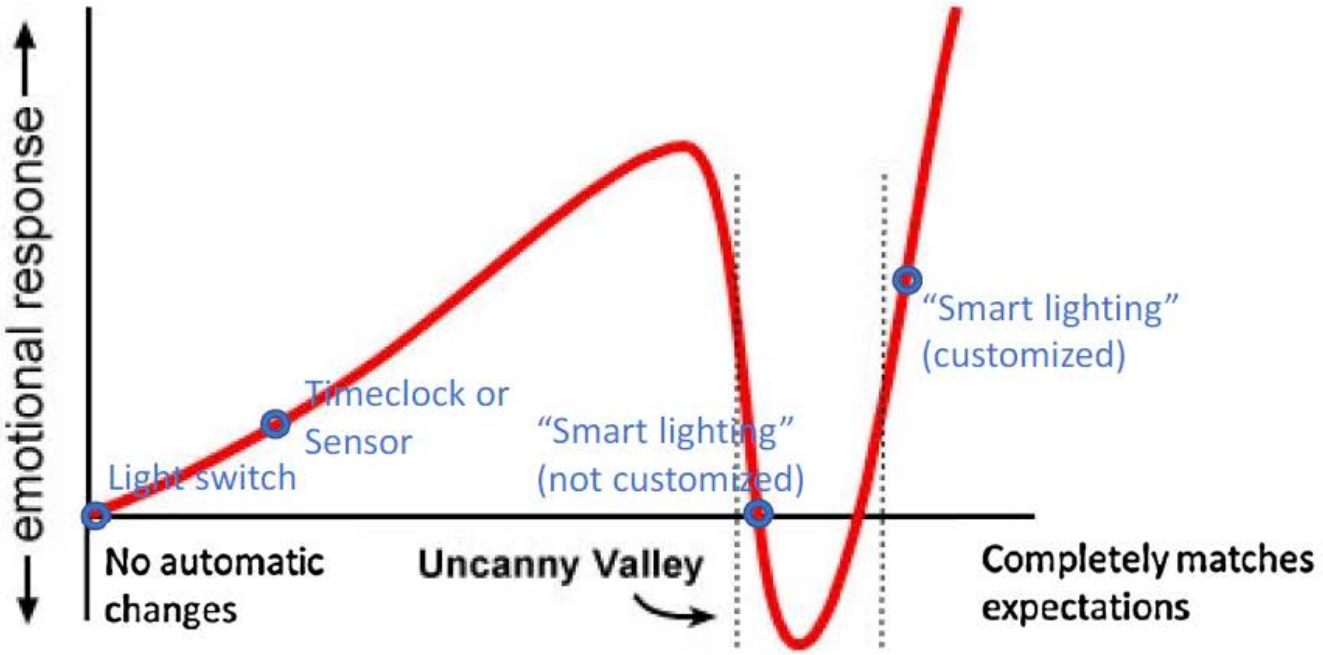
POOR AESTHETICS

- Detracts from architectural beauty
- Cluttered and disorganized

There is a negative dip in acceptance when non-human objects or images appear nearly human



A similar negative dip in acceptance when "smart" control systems don't quite meet user expectations



Setting the right environment requires multiple user experience considerations

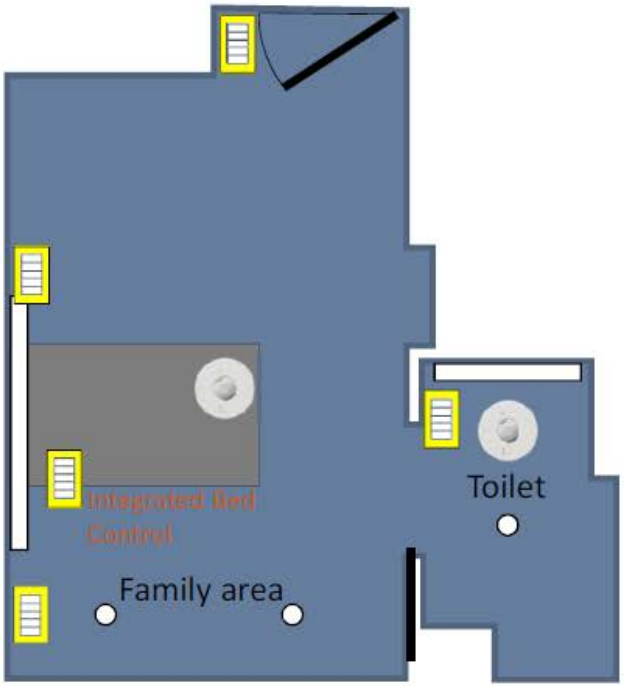
Sequence of Operations (SoO)

How to customize a lighting control system to create the right user experience

A sequence of operations (SoO) defines how the system operates, setting the user experience

Even spaces with only a few lighting control strategies require an SoO

Spaces with complicated control functionality require deep consideration and detailed documentation



Lighting zones and control locations

Setting	Output
Full On	100%
High	60%
Medium	35%
Low	5%
Off	0%

Engraving and scene settings

Time	Illuminance (FC)	CCT (K)
6AM	0	2400
6:30AM	20	4000
7AM	40	6000
11AM	40	6000
1PM	25	3500
4PM	25	3500
9PM	20	3500
10PM	20	2400

Lighting CCT/Intensity schedule

So you want to design a dynamic lighting system for a patient room, let's get back to design basics.

- Interview end users
- Understand tasks and usage for each space
- Develop scenarios that define experiences
- Should the scenarios change based on time-of-day

- Consider both user personas and key individual users
- Consider transitions

- Review with end users

- Include detailed narrative of each scenario
- Keypad Labeling

Critical Note: Customized user experience (also known as SoO) must be space and user dependent!

There are many tools in the controls toolbox to define the right user experience

- Dimming light levels
- Color temperature (white tuning)
- Scene control
- Control zones
- Daylight zones
- Timeclock scheduling
- Manual ON vs Auto ON
- Partial OFF (when vacant)
- Fade rates for dimming
- Fade rates for white tuning
- Fade rates upon occupancy/vacancy
- Visual communication (e.g. blink warn)
- Modify control based on occupancy
- Modify control based on time of day
- Modify control based on occupancy and time of day

Don’t forget these!

Getting the system you need

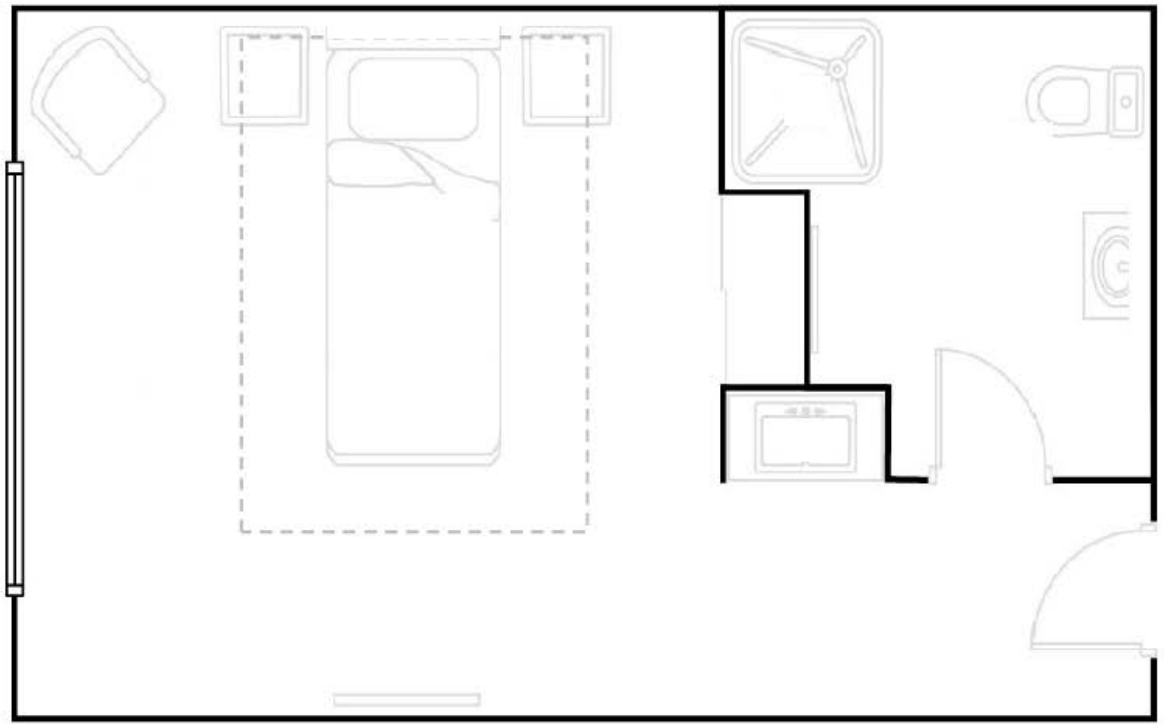
Using a patient room as an example for designing a dynamic lighting system

Photos © Halkin Mason Photography

Brief background on the “project”

Desired Features:

- Tunable white to mimic daylight
- Color changing light for patients



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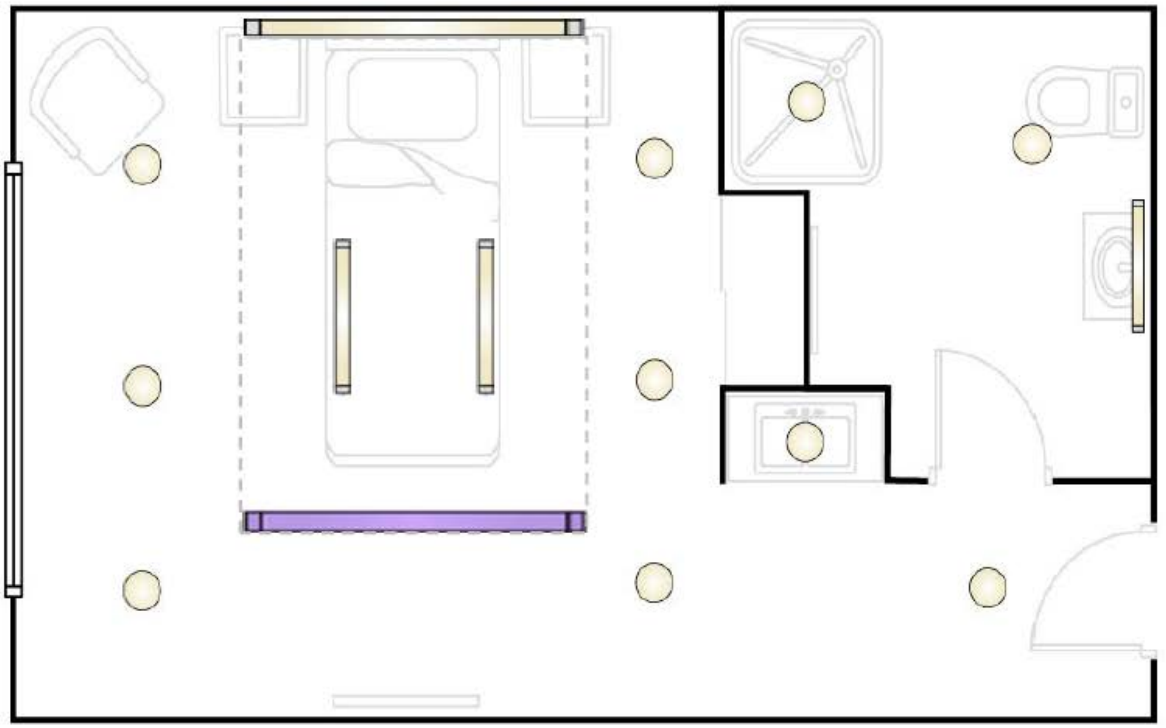
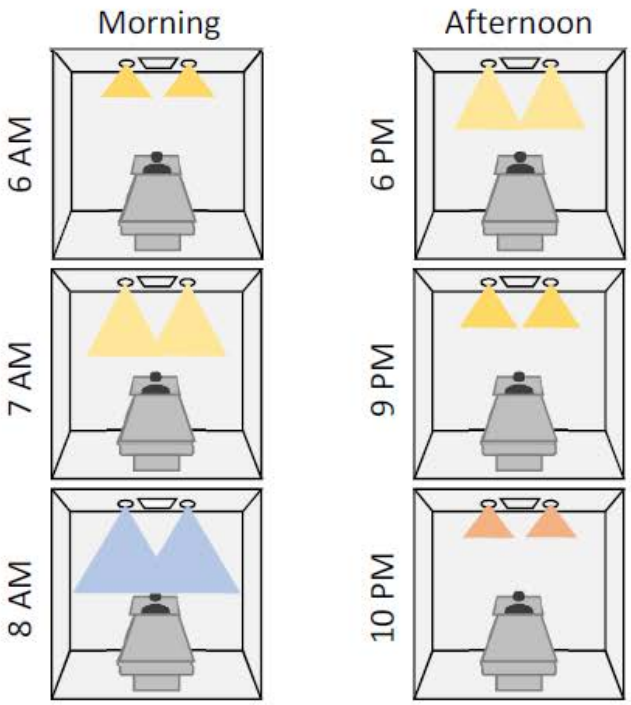


Evaluate all of the use case scenarios and document into a detailed controls narrative.

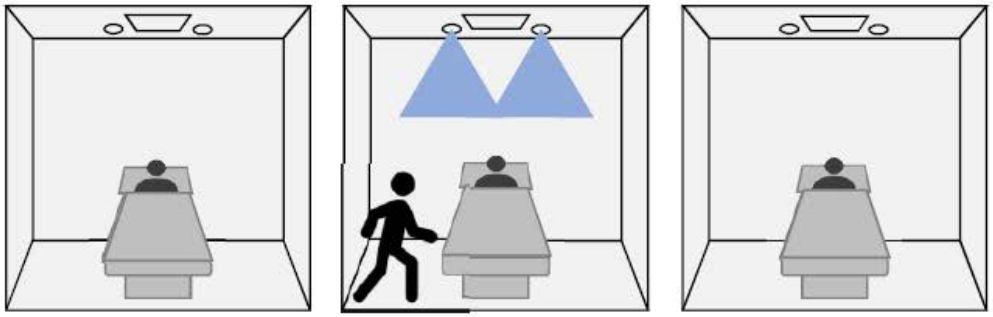


DAILY CYCLE:
Automatic changes that occur without user interaction

- Color temperature and intensity of lights (except color changing luminaire) change in an attempt to mimic intensity and color of daylight.
- When changing, the fade time will be set to minimize distractions.
- Lights fade when returning to the daily schedule from an override.

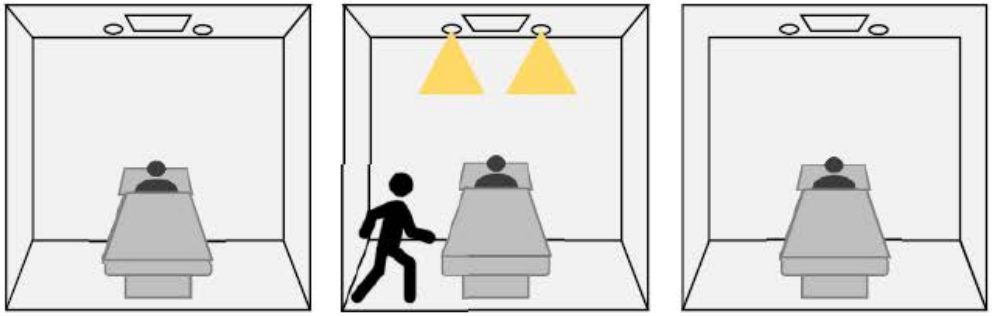
Evaluate all of the use case scenarios and document into a detailed controls narrative.

6 AM - 10 PM



15 minutes later

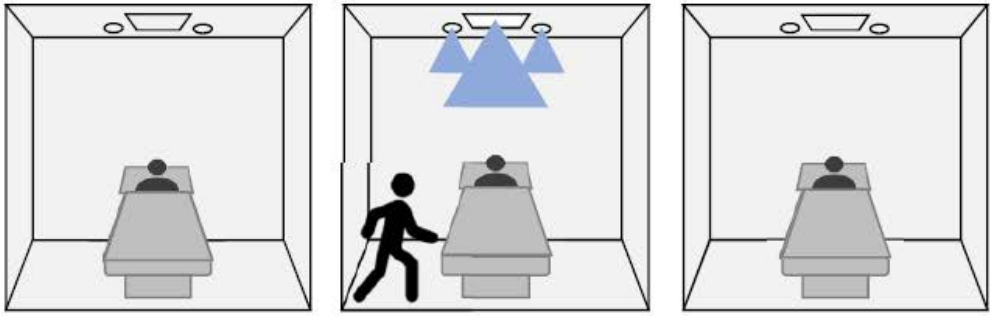
10 PM – 6 AM



CHECK ON PATIENT:
Quick check with minimal disruption

- 6am – 10pm: Patient room downlights are set to “medium” and CCT follows the daily schedule.
- 10pm – 6am: Patient room downlights are set to “low” and CCT follows the daily schedule.
- Override lasts 15min.

Evaluate all of the use case scenarios and document into a detailed controls narrative.



1 hour later

PATIENT EXAM:
Longer, more thorough exam

- Patient room downlights are set to “medium”. Lights over the patient bed are set to “Bright”. CCT follows the daily schedule.
- Patient keypad is disabled.
- Override lasts 1hour.

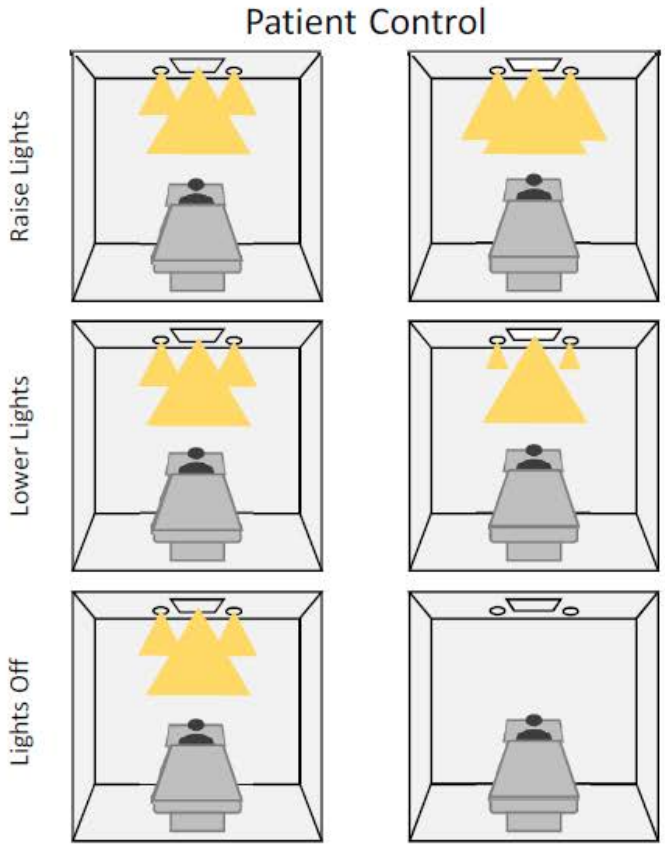
Evaluate all of the use case scenarios and document into a detailed controls narrative.

Not until staff release override

PATIENT EMERGENCY:
Bright, consistent emergency light

- All patient room and restroom lights (except color changing luminaire) are set to “Bright” at a constant 5000K CCT.
- All other keypads disabled.
- Override lasts until another button is pressed on that keypad.

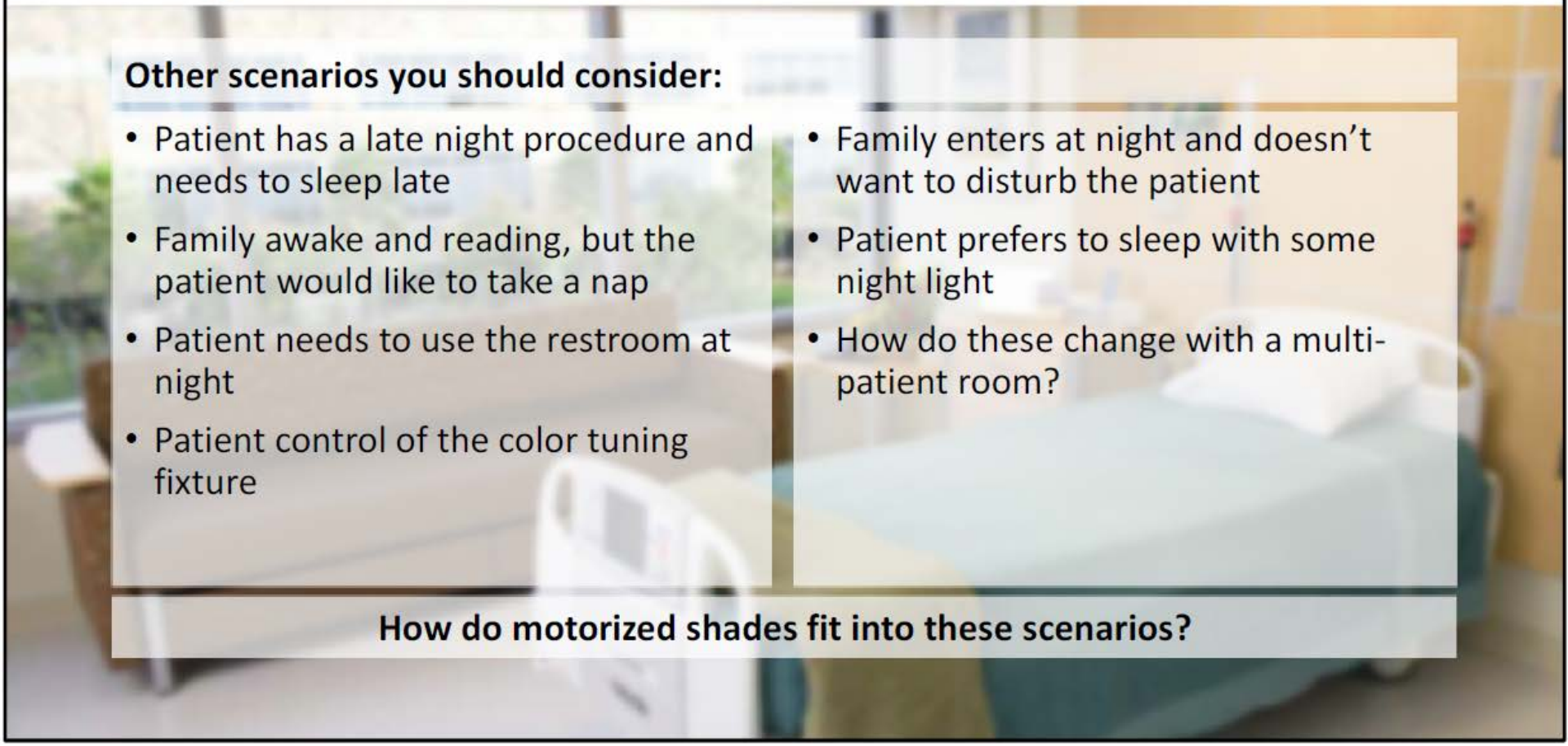
Evaluate all of the use case scenarios and document into a detailed controls narrative.



PATIENT OVERRIDES (e.g. nap):
Temporary change in level and color

- Patient keypad 1 turns ON, raises, and lowers the headboard light.
- Patient keypad 1 turns OFF all of the lights in the room.
- Patient keypad 2 turns ON, turns OFF and changes the hue of the color changing luminaire.

Evaluate all of the use case scenarios and document into a detailed controls narrative.

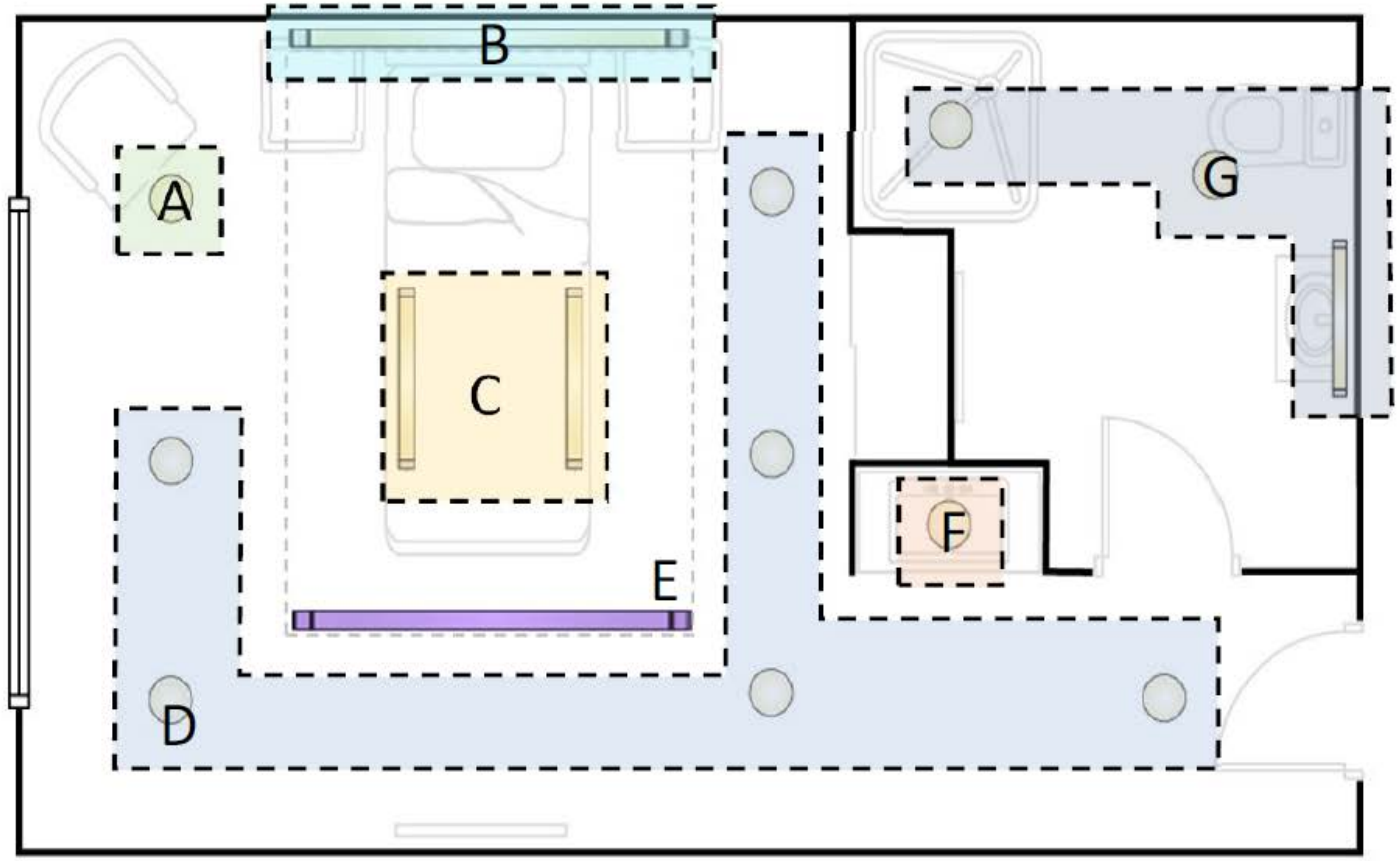


Other scenarios you should consider:

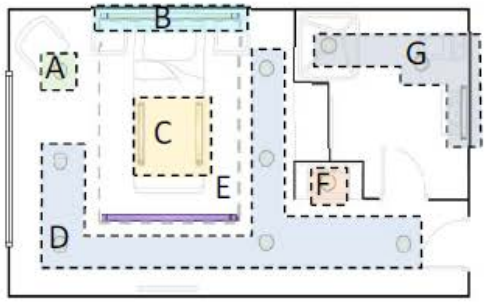
- Patient has a late night procedure and needs to sleep late
- Family awake and reading, but the patient would like to take a nap
- Patient needs to use the restroom at night
- Patient control of the color tuning fixture
- Family enters at night and doesn't want to disturb the patient
- Patient prefers to sleep with some night light
- How do these change with a multi-patient room?

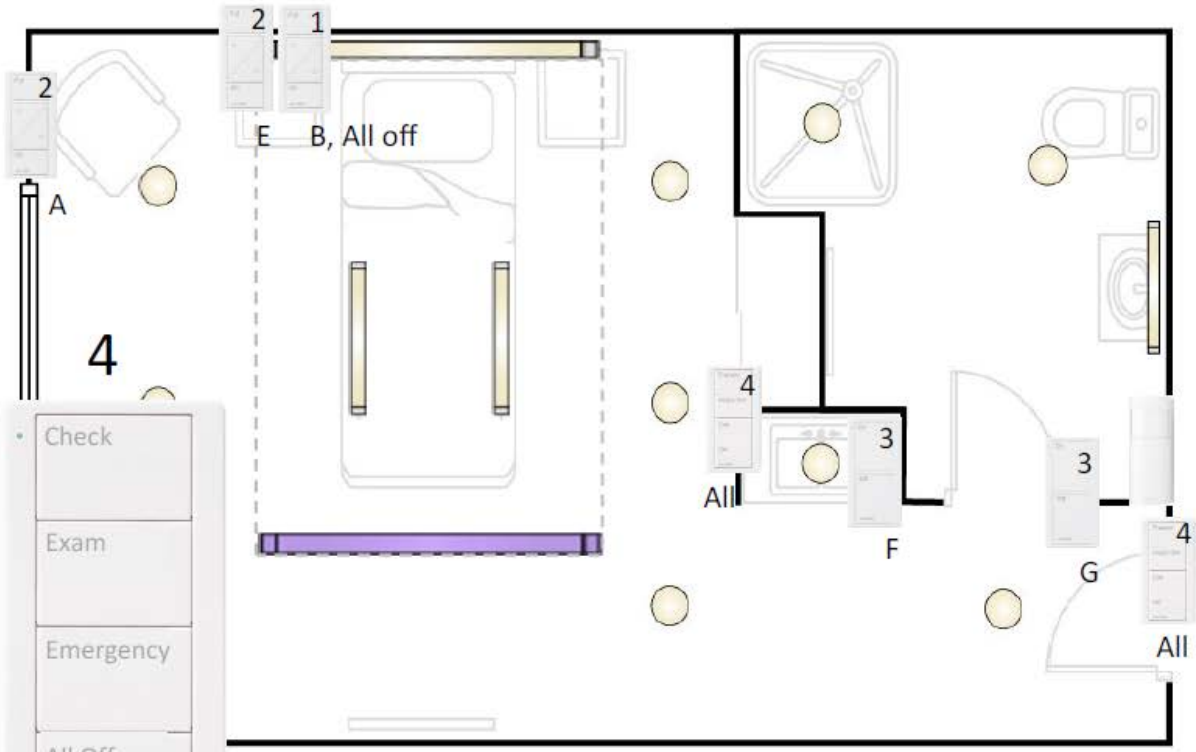
How do motorized shades fit into these scenarios?

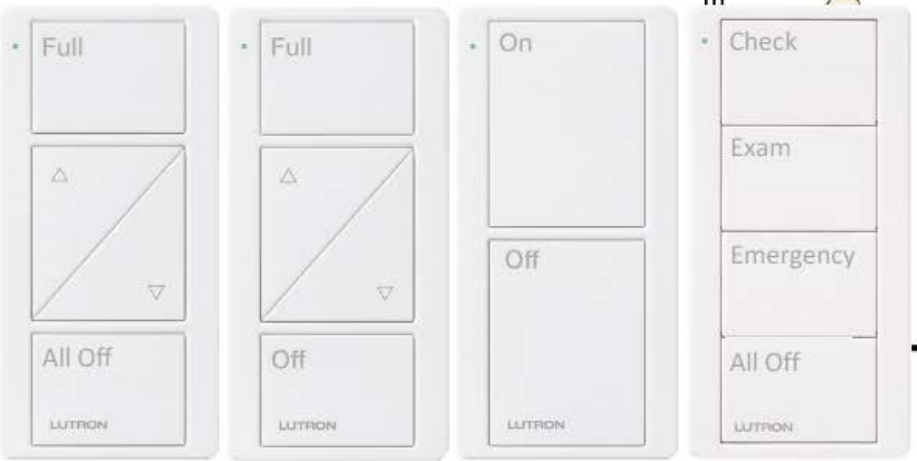
After visualizing all of the scenarios, the fixtures can be separated into their control zones.



Proper controls layout and intuitive labeling are critical to a positive user experience.







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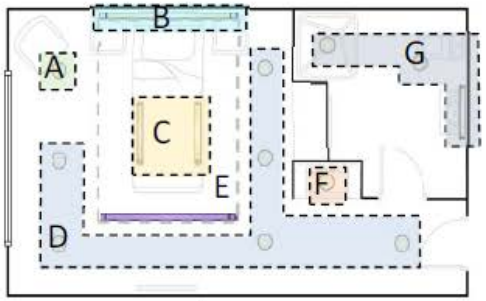


Keypad	6AM-10PM*	10PM-6AM
Check	Zone D is set to 50% intensity. CCT follows the daily schedule. Override lasts 15 minutes.	Zone D is set to 10% intensity. CCT follows the daily schedule. Override lasts 15 minutes.
Exam	…	
Emergency	…	
All Off	…	
General Note: When override is over, lights shall fade back to daily cycle over 90 second fade.		

*Keypad buttons that are not affected by time of day based control shall follow the sequence of operations written all day.

CHECK ON PATIENT:
Quick check with minimal disruption

- 6am – 10pm: Patient room downlights are set to “medium” and CCT follows the daily schedule.
- 10pm – 6am: Patient room downlights are set to “low” and CCT follows the daily schedule.
- Override lasts 15min.

CLASSROOM EXAMPLE: Documenting the SoO

Daylight & Shade Control:

- Motorized shades automatically modulate position based on sun position and daylight levels at the window to minimize glare while maximizing views.
- The shade control allows manual override to fully open, fully close, raise, or lower the shades.
- All lights automatically increase, decrease, and shut off according to daylight availability. There are two independent daylight zones.
- Manual control of lights does not set the lights above the current level set by daylight.

Entry/Exit:

- Upon entry: lights are not automatically turned on, they must be manually turned on by the occupant according to the light scene they select.
- Upon exit: all lights are automatically shut off within 30minutes of all occupants leaving the room.

"Relax" Scene:

- White board lights are set to 80%.
- Ambient lights are set to 50%.
- Shades modulate based on daylight conditions.

"Instruction" Scene:

- White board lights are set to 100%.
- Ambient lights are set to 100%.
- Shades modulate based on daylight conditions.

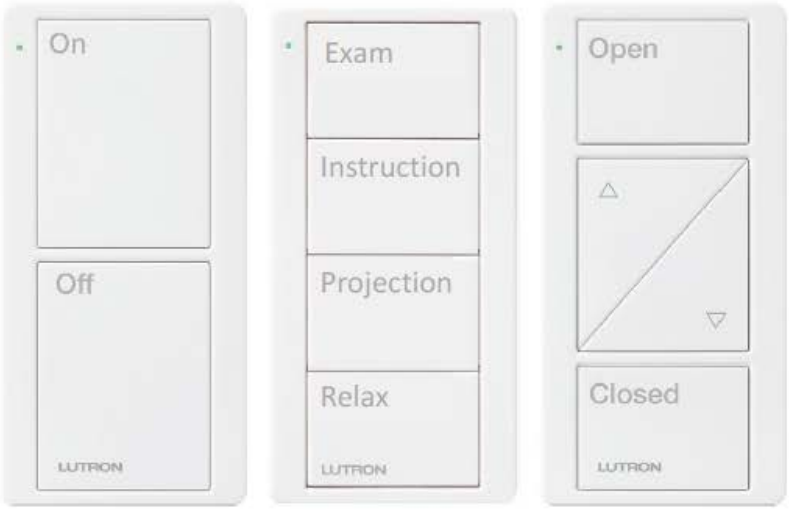
"Projection" Scene:

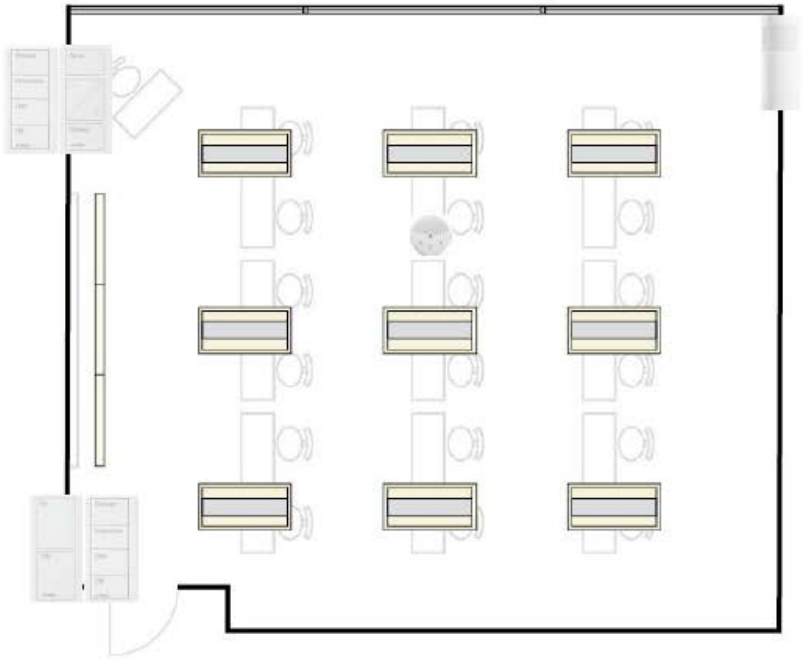
- White board lights are set to full off.
- Ambient lights are set to 40%.
- Shades are lowered to be fully closed.

"Exam" Scene:

- White board lights are set to 50%.
- Ambient lights are set to 100%.
- Shades are lowered to be fully closed.

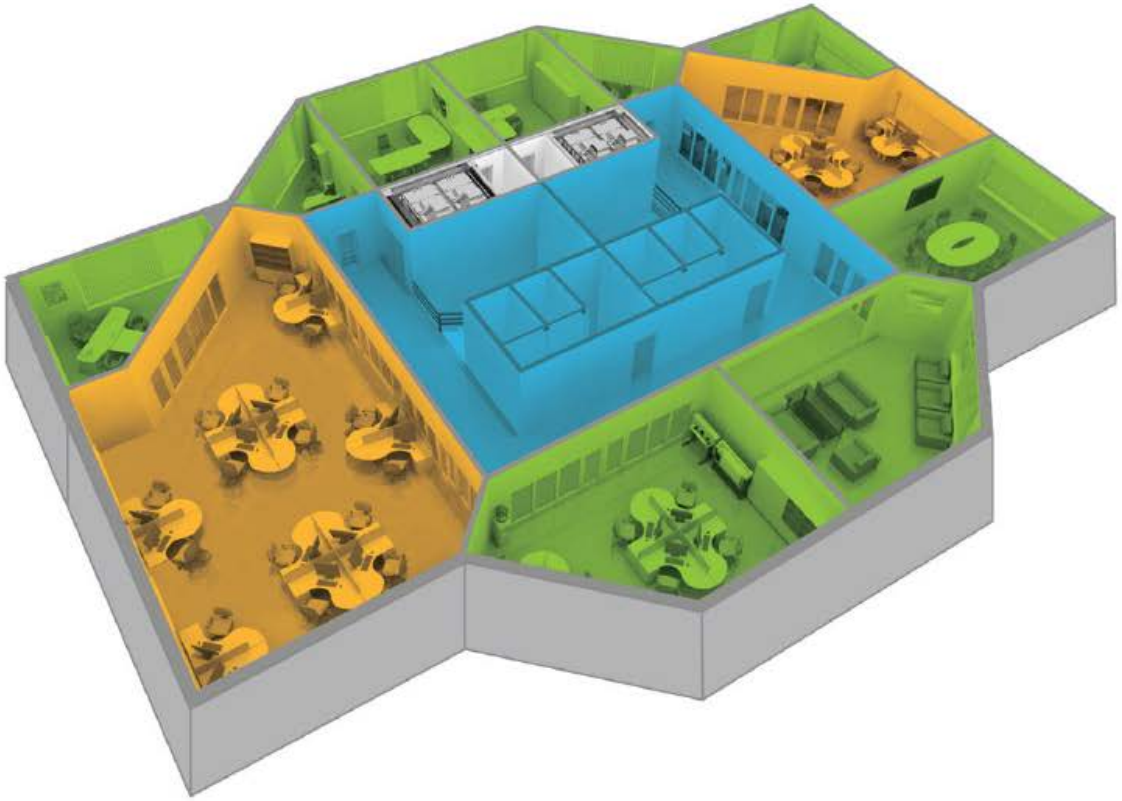
CLASSROOM: Documenting the SoO





LIBRARY: Documenting the SoO

FLOORPLAN: Documenting the SoO



SoO Key:

- Core Area
- Office Area A
- Office Area B
- Restroom

Future Proofing

Systems and technologies that adapt to building evolution

SCALABLE: Campus buildings are usually remodeled in sections or even room by room.

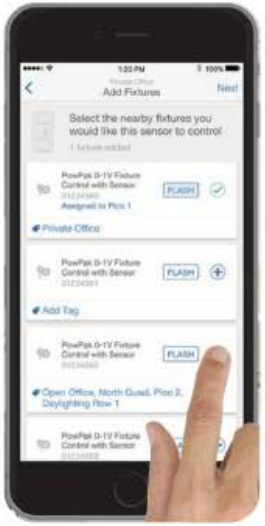
WIRELESS DEVICES

ROOM SOLUTIONS

SYSTEM UPGRADES

FLEXIBILE: Spaces change, the usage changes, and the system should be easy to adapt.

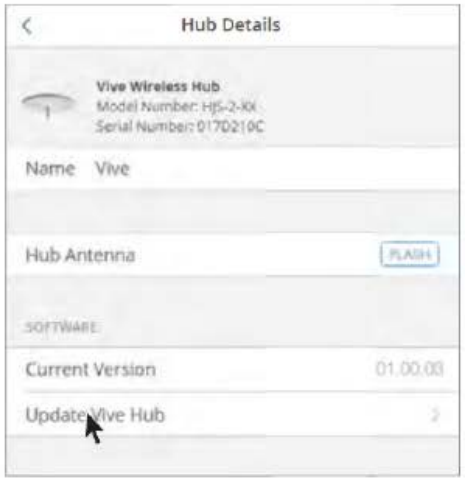
WIRELESS DEVICES



SIMPLE INTERFACE

ACTIONABLE DATA

UPGRADABLE: New features, data, analytics, and learning algorithms will be here before you know it.



SOFTWARE UPGRADES

- **Energy Dashboards and Analytics Packages**
- **Audio & Video**
- **Building/Energy Management Systems (BMS/EMS)**
- **HVAC**
- **IT**

BMS INTEGRATION

DESIGN

INSTALL

MAINTAIN

TRUSTED PARTNER

Learning can improve system performance based on data from the users

User defined

- Survey applications
- Helper wizards

Automated

- User overrides
- Changes to system settings

When the user doesn't directly define the problem, there is much greater likelihood of cognitive dissonance.

Presentation Summary

If you remember nothing else…

User experience is critical in smart lighting systems

Key Takeaways:

1. Smart lighting systems add value, but require greater consideration for user experience.
2. User experience is more important than operational and energy efficiency combined.
3. A customized SoO dramatically increases user acceptance.
4. Future proof with wireless, digital, simple user interfaces, and remote software upgrades from a trusted partner.
5. Lighting systems of the future will provide personalized lighting that reacts to task, mood, and social situation.

Questions?