



The structure is a design in light.

- Louis Kahn

# 216 Networked Lighting Controls For Healthcare Environments

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**Presented by**  
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**Senior Lighting Specialist**  
**April 20, 2021**



**l i g h t i n g   d e s i g n   l a b**

# Before we begin...

## During the Class

- Attendees will be muted
- Please use the chat feature in the control panel to submit questions to LDL staff
- The presenter will pause to address questions every ~10 minutes
- Please participate in the online polls.

## Following the Class

- Please take the short survey
- A recording and the slide deck will be posted on LDL's webpage
- Reach out to [LightingDesignLab@seattle.gov](mailto:LightingDesignLab@seattle.gov) with comments or questions.



*Powered by*

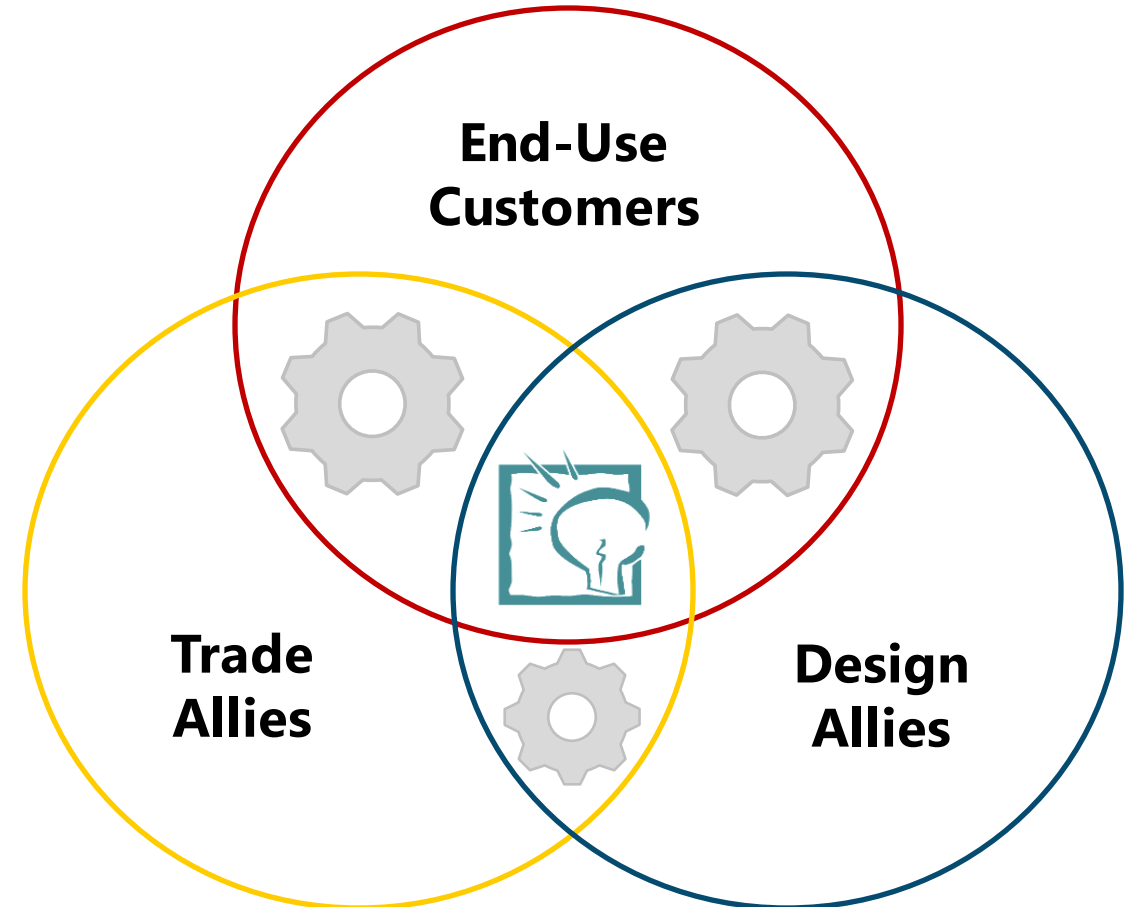
**Seattle City Light**



# Who We Work With



*It takes a village...*

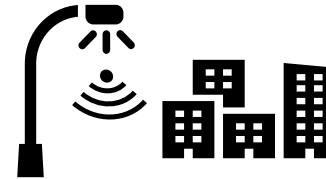


# LDL's Four Core Service Areas

## EDUCATION & TRAINING



## TECHNOLOGY EVALUATION



## TOOLS & RESOURCES



## INFORMATION AGGREGATION





Shaun.Darragh@seattle.gov

## Selected Projects

- King Abdullah University of Science and Technology
- Masdar Headquarters
- Pearl River Tower
- Canyon Ranch Spa Club
- Amgen Helix Campus
- Reebok World Headquarters
- Reno Sparks Convention Center
- Pacific Place Retail Center
- Ala Moana Retail Center
- REI Denver Flagship Store
- Boeing Commercial Airplanes Offices
- Real Networks Headquarters
- Tommy Bahama Headquarters
- Microsoft B16/17
- San Francisco PUC Headquarters

## Selected Awards

- Amgen Helix Campus
- Amgen Helix Pedestrian Bridge
- Canyon Ranch Spa Club
- Harvard University 60 Oxford
- King Street Station
- Lighting Design Lab
- Methodist Hospital Research Institute
- Microsoft B16/17
- One Cambridge Center
- Pacific Place Retail Center
- Reebok World Headquarters
- Reno Sparks Convention Center
- Real Networks Headquarters
- SFPUC Headquarters
- Tommy Bahama Headquarters

## AIA COTE Top 10

- REI Flagship Store Denver
- King Abdullah University of Science and Technology
- San Francisco PUC Headquarters
- Manitoba Hydro Place

- More than 30 years in the lighting industry as an architectural lighting designer, instructor, daylighting and sustainability specialist, lighting control system consultant, and theatrical designer.
- Has taught and consulted on sustainability issues, lighting, and daylighting for the Lighting Design Lab and University of Washington Architecture Department

# Brief Survey

- Please tell me a little bit about yourselves....



# Learning Objectives

- Understand common lighting control strategies
- Review the fundamental concepts of Networked Lighting Controls
- Review how lighting controls may relate to current light and health research
- Review practical application opportunities for a variety of healthcare specific spaces.



# Healthcare Spaces

- Private Practice Offices
- Small Clinics
- Multi-Care Clinics
- Specialty Clinics
- Hospitals
- Hospital Systems
- Research Institutions
- Long Term Care
- Other?



UW Medical Center

# Common Areas

- Offices
- Conference rooms
- Corridors
- Check in / Out
- Exam Rooms
- Procedure Rooms
- Labs



lighting design lab

Polyclinic Madison



# More Specialized

- Patient Rooms
- Patient Corridors
- Imaging Centers
- Infusion Therapy
- LDRP
- Pharmacy
- Surgery



# Trends

- Traditional Healthcare Environment
- More Holistic Approach
- Hospitality Environments
- Patient Centered
- Wellness
- Outcomes Based Care



River's Edge Hospital and Clinic



# Trends



## High Value Healthcare

### Data

Outcomes data, utilization and costs of care essential

### Collaboration

Collaboration and communication between members of the care team

### Patient Care

Patients are healthier when pathologists are part of the care team

### Coordination of Care

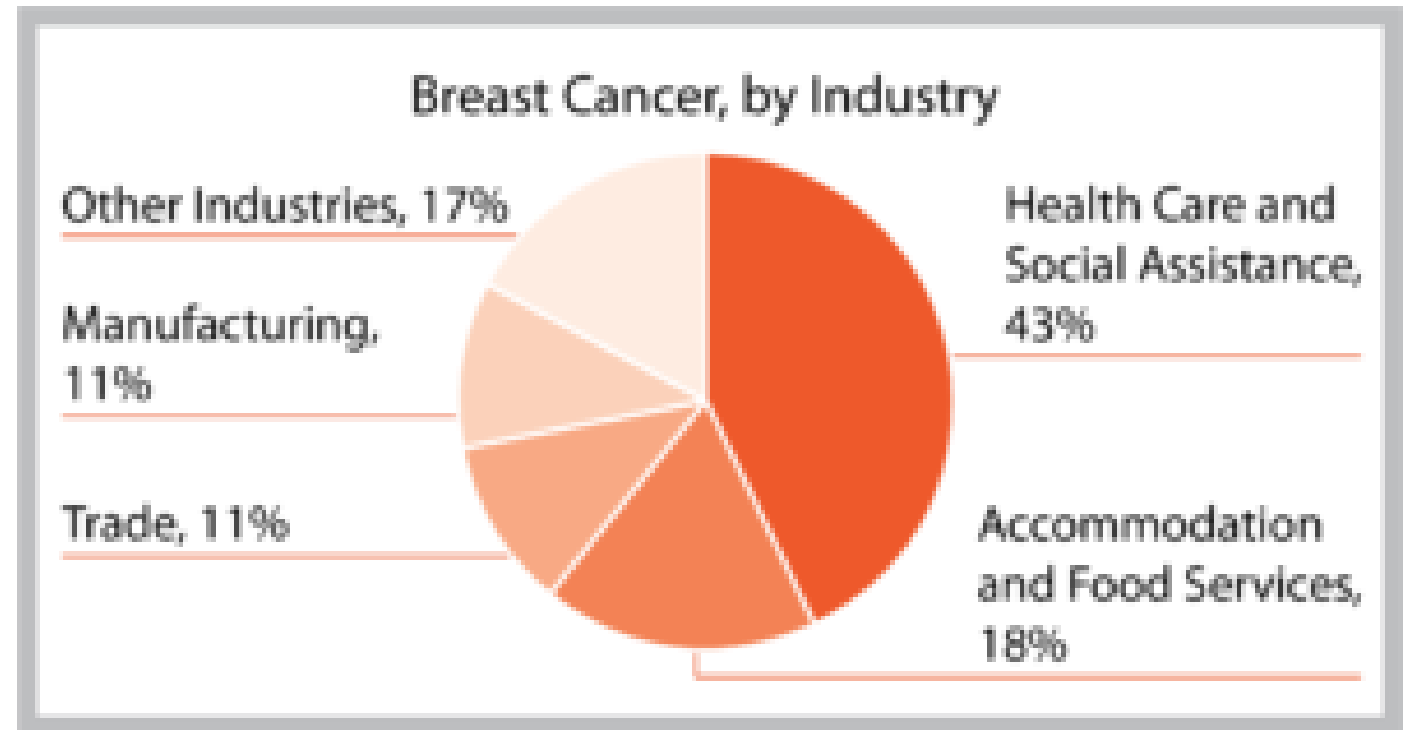
High value, accountable care depends upon close coordination of services

### Patient Engagement

Empowering patients to be their own advocates

# Specific Concerns

- Wellness
- Circadian Systems
- Shift Workers
- Infection Control
- Others?



# Controls Class

This class is specific to controls....

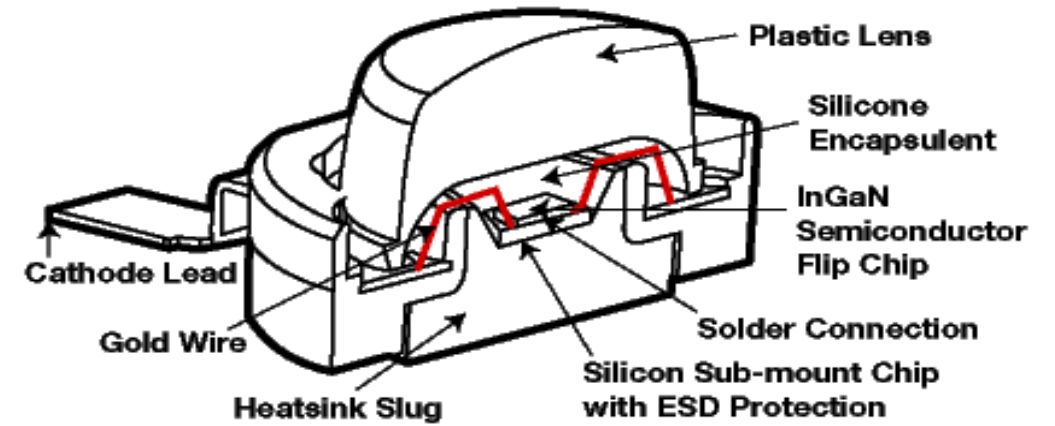
We could be talking about  
Healthcare Lighting all week and  
still not cover it all...

Let's review briefly.....



# LED – the defacto light source du jour....

- Solid state light source
- Extremely flexible
- Potentially long lamp life
- Dynamic color opportunities
- White light
- Poor to excellent color rendering



Courtesy: Philips



# Architectural Impacts of LED

- Smaller fixtures
- Better efficacy
- Possibly better color
- **More flexibility in control**
- Longer lamp life
- Reduced maintenance
- Better optics
- **Back to dimming**
- Better integration
- **Potential confusion**
- **Tunable Color**



Nemours Children's Hospital  
Perkins + Will



SmartCast™ Technology Handheld Configuration Tool

SmartCast™ Technology Ambient/Motion Sensor for 0-10v Interface

SmartCast™ Technology Single Gang Dimmer and Switch

SmartCast™ Technology Ambient/Motion Sensor

SmartCast™ Technology RF Module and Driver

SmartCast™ Technology Ambient/Motion Sensor



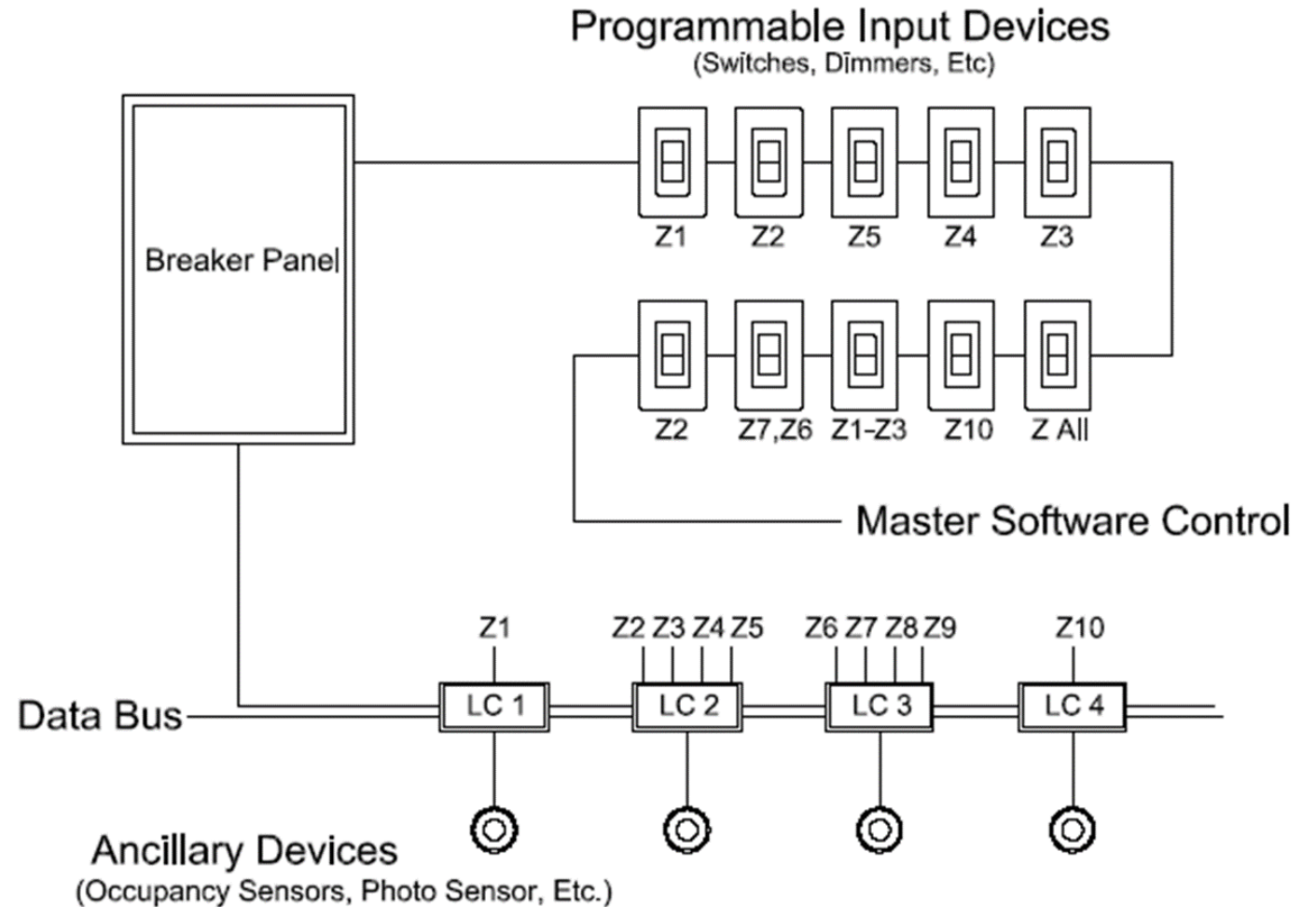
# Distributed Systems

## Characteristics:

- May be stand alone or integrated.
- Will be a scalable digital system
- May incorporate scheduling capability
- Will accept input from devices including occupancy sensors and photo-controllers
- Inherently Flexible

## Considerations:

- Coordinate digital protocol - LON, BacNet, etc



# Luminaire Level Lighting Controls

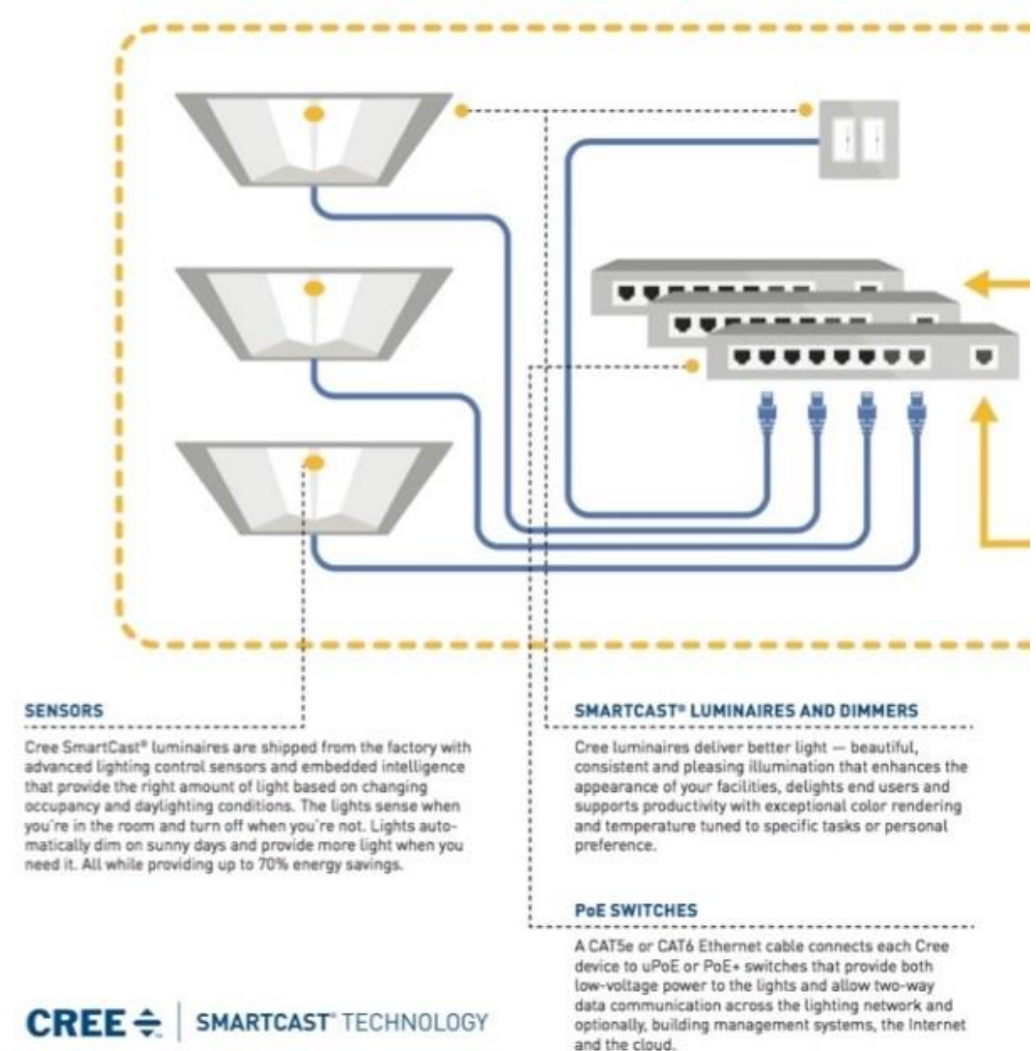
- Wrap all of the sensors and most of the logic into the luminaire itself
- Simple to specify and install
- Will require commissioning to function most effectively.
- May be capable of all control strategies
- May be capable of only OS/VS and Daylight harvesting
- Smarter systems will be more capable



Courtesy: Acuity, Cree

# POE – Power over Ethernet

- Open Source Standard?
- Each device has a unique address
- Maximum flexibility
- Maximum commissioning
- All controls strategies possible
- Energy management software
- Lumen Maintenance
- Scheduling
- Data Logging



Courtesy: Cree

# Control Systems

We work with many different control systems manufacturers for this class.

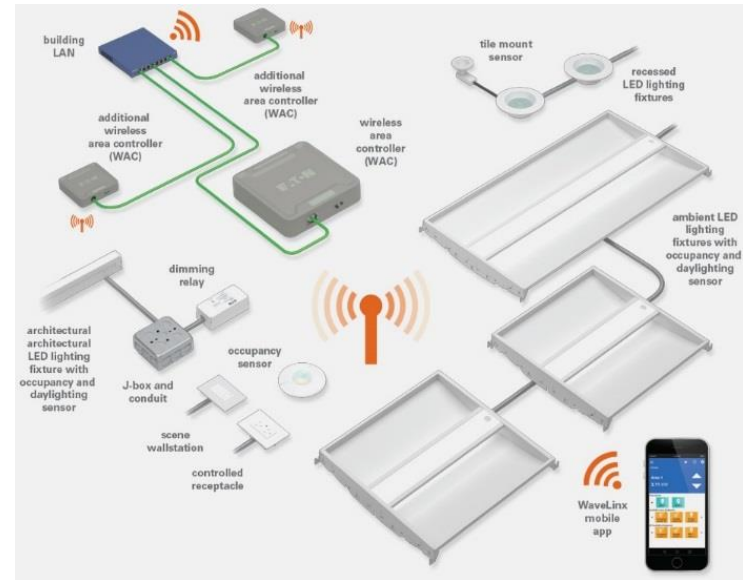
- Acuity nLight Air
- Audacy by Ideal
- Cooper Wavelinx
- Cree Smartcast
- Crestron Zum
- Encellium Edge
- ETC Echoflex
- Lutron Vive





# Networked Lighting Controls Today

- Distributed
- Wireless
- More Capable
- More Complex
- Less Complicated
- Less Costly
- Easier to Install / Commission
- Compatible
- Integrated
- Better!



Courtesy: Lutron, Eaton

# Pop Quiz

- What are some of the benefits of LLLC Systems?

# Typical Control Strategies

Methodist Hospital Research Institute  
KPF / WHR

- Manual Switching
- Manual Dimming
- Scene / Preset Control
- Occupancy Sensing
- Vacancy Sensing
- Daylight Harvesting
- Task Tuning
- Time Scheduling
- Astronomic Scheduling



# Manual Switching

- Line voltage
- Low voltage with relays
- Zones or groups
- Simple to design
- Easy to understand
- May not meet codes

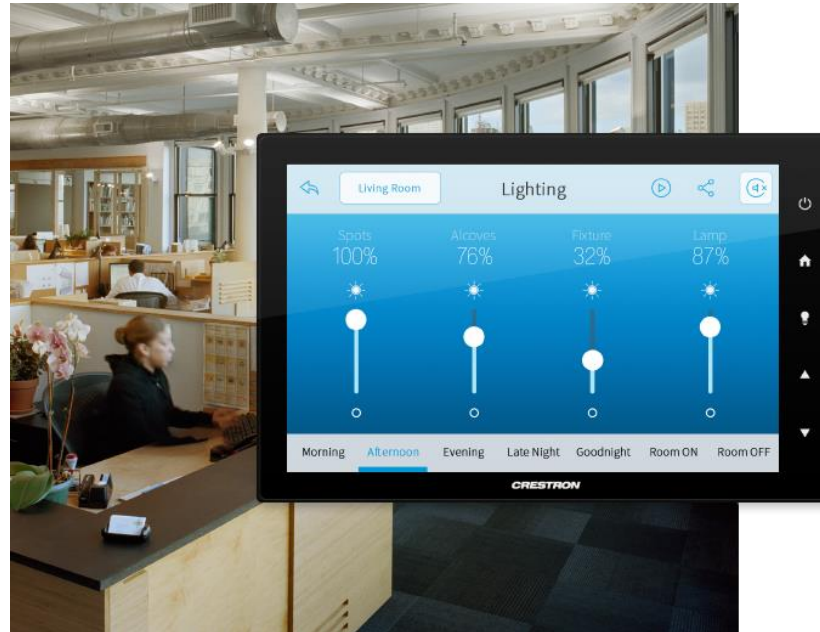


Courtesy: GE, Leviton



# Manual Dimming

- Line voltage
- Low voltage remote dimming
- Networked System
- Zones or groups
- Simple to design
- Easy to understand
- Users like personal control



Courtesy: Lutron, Leviton, Crestron



# Scene / Preset

- Grouping of zones at specific levels
- More complicated
- Simply Repeatable
- May be confusing
- Consider engraving



# Switching...Dimming.....Scene Control



# Occupancy Sensing

- Automatically turn lights on or off depending on occupancy
  - May have some residual angst over older systems
  - Supplanted by vacancy sensors in many cases.
- 
- Public spaces
  - Corridors / Stairwells
  - Toilet rooms
  - Warehouses
  - Parking garages
  - Site lighting



Courtesy: Leviton



# Vacancy Sensing

- Automatically turn lights off when no occupants are present
- Requires manual touch to turn on.
- May have some residual angst over older systems.
- Users may require some training.
  - Almost all enclosed commercial spaces
  - Offices
  - Classrooms
  - Storage



Courtesy: Leviton

# Daylight Harvesting

- Luminaires are governed by photo-sensors determining real time daylight availability
  - Continuous range dimming is preferable to threshold based switching.
- 
- Offices
  - Education
  - Public Spaces
  - Circulation
  - Warehouse / Industrial



Cleveland Clinic Taussig Cancer Center



# Task Tuning / High Trim

- Setting a high trim tuned to deliver the target illuminance level.
  - Can reduce glare
  - Can balance brightness
  - Can save as much as 20-30% of the energy in a typical system.
- 
- Offices
  - Education
  - Public Spaces
  - Circulation
  - Warehouse / Industrial



Asklepios Clinic

# Time Scheduling

- Lighting is governed by time of day events rather than occupancy or vacancy sensing.
  - Multiple calendars required for effective use.
- 
- Public Spaces
  - Circulation
  - Retail
  - Areas in which OS/VS would pose difficulty



Courtesy: Stantec

# Newer Controls Strategies

- Color selection
- Tunable White
- Circadian Lighting
- Generally based on LED capabilities



Children's Hospital  
ZGF



# Color Selection



CS Mott Children's Hospital



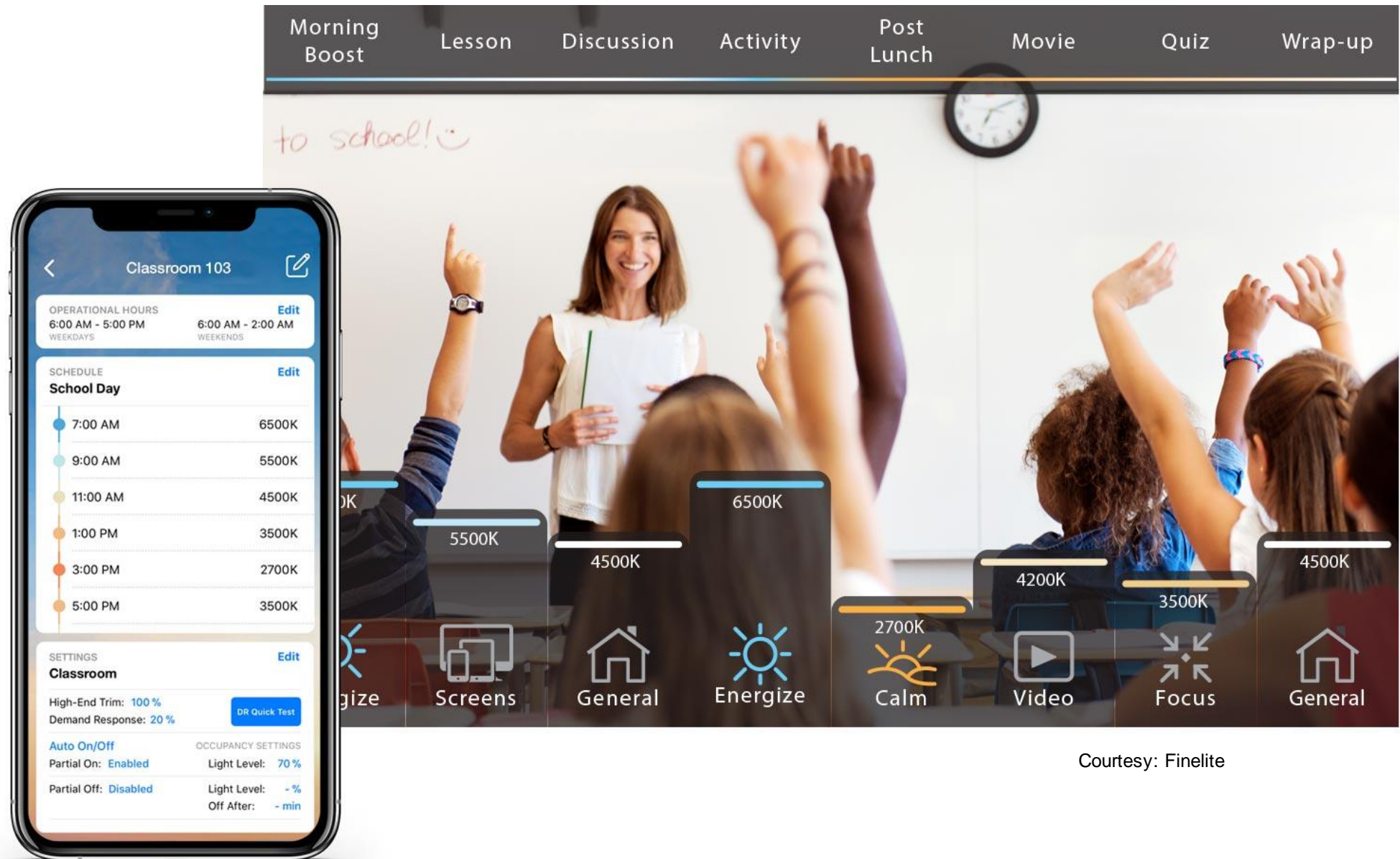
# Tunable White

- Specific color tuning adjusting the correlated color temperature / SPD along the black body radiator curve.
- Meant to affect mood or alertness.
- Circadian lighting.
- Aesthetic reasons.



Courtesy: Fagerhult

# Tunable White



Courtesy: Finelite

# Circadian Controls



ACC Care Center

U.S. DEPARTMENT OF  
**ENERGY**

Office of  
ENERGY EFFICIENCY &  
RENEWABLE ENERGY

## Measuring Light Exposure and its Effects on Sleep and Behavior in Care Center Residents

ACC Care Center – Sacramento, CA

November 2019



# Hardware Evolution

- Line voltage switch
- Three way switch
- Contactor
- Low voltage hardwired relay
- Strap and wallbox dimmers
- Preset control dimming
- Luminaire addressable hardwired
- Zone control wireless
- Luminaire addressable wireless
- POE (Power Over Ethernet)
- IOT (Internet of Things)





# Pop Quiz

- Are color tuning and tunable white the same thing?

# Why use advanced lighting controls?

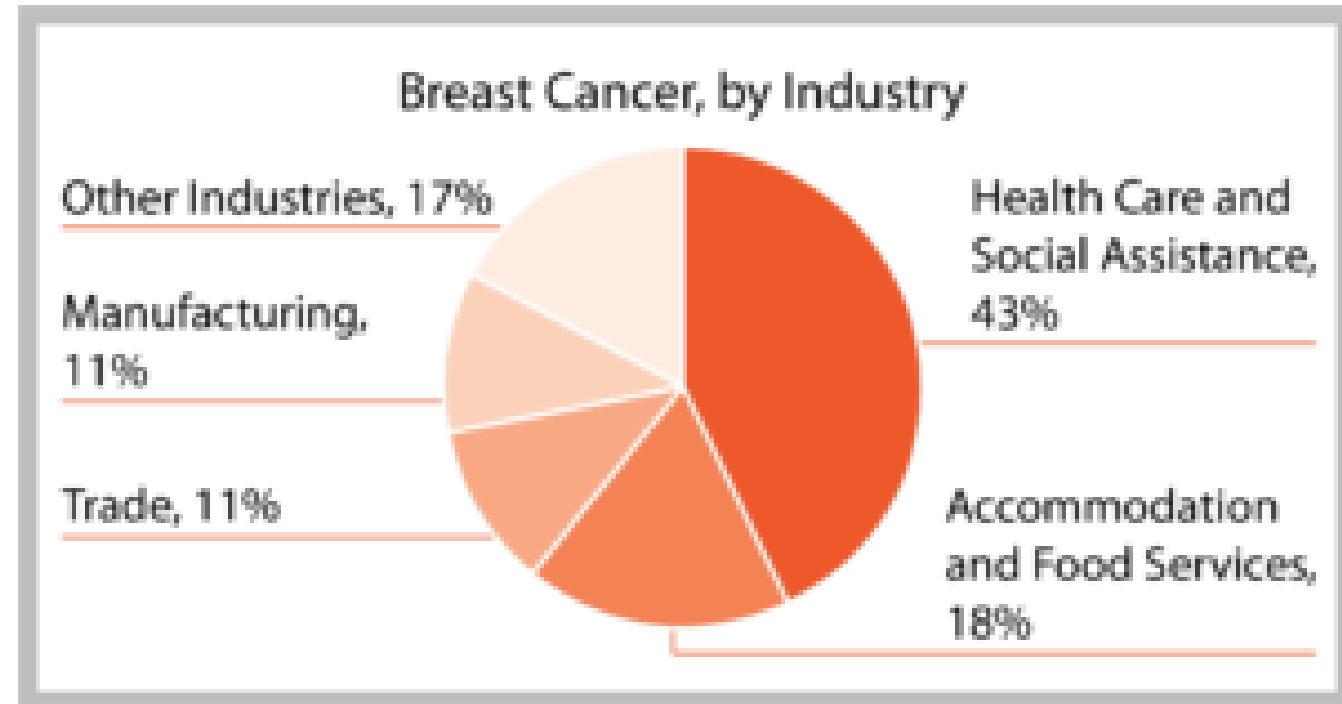
Tommy Bahama Headquarters  
SkB

- Flexibility
- Productivity
- User Satisfaction
- Aesthetics
- Maintenance
- LEED / WELL / LBC
- Energy Savings
- Energy Codes
- Staff Wellness
- Patient Outcomes



# Specific Concerns

- Wellness
- Circadian Systems
- Shift Workers
  - Poor sleep quality
  - Mood
  - Metabolism
  - Cardiovascular disease
  - Obesity
  - Cancer



# Light and Health

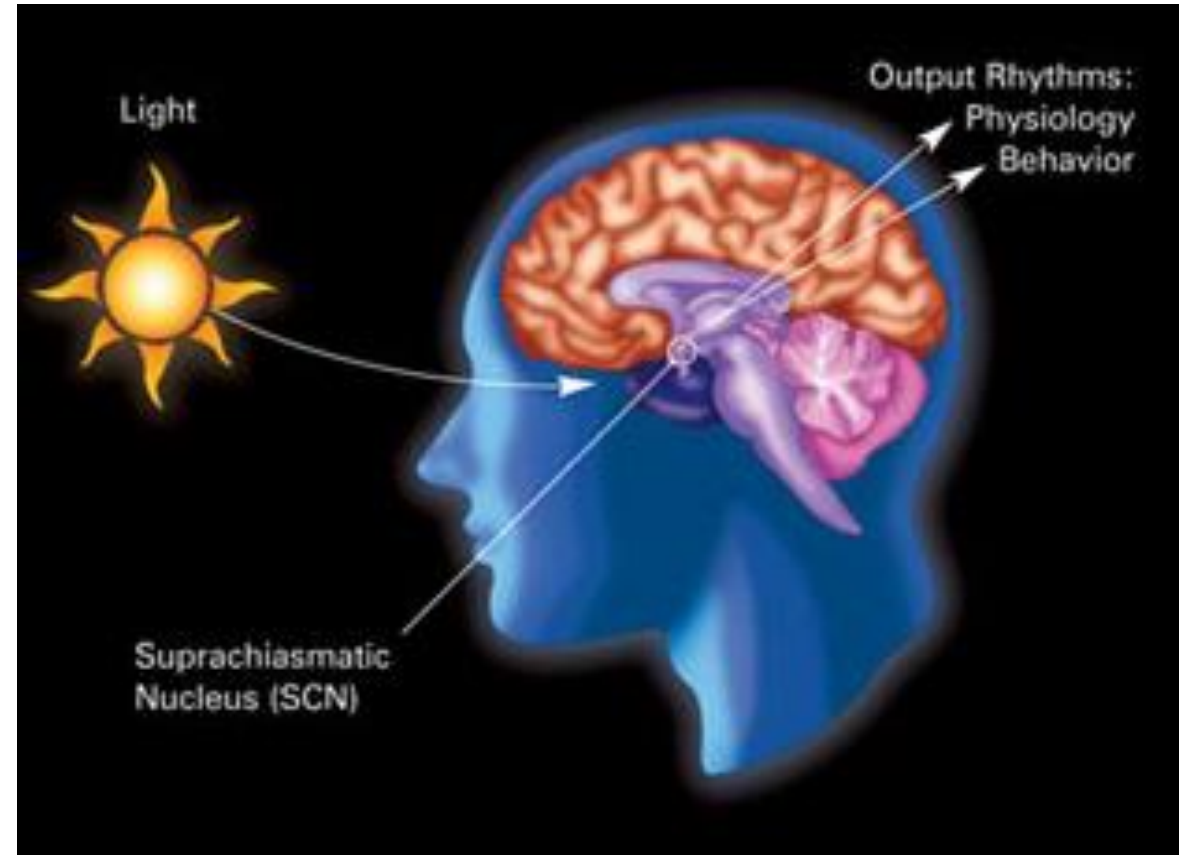
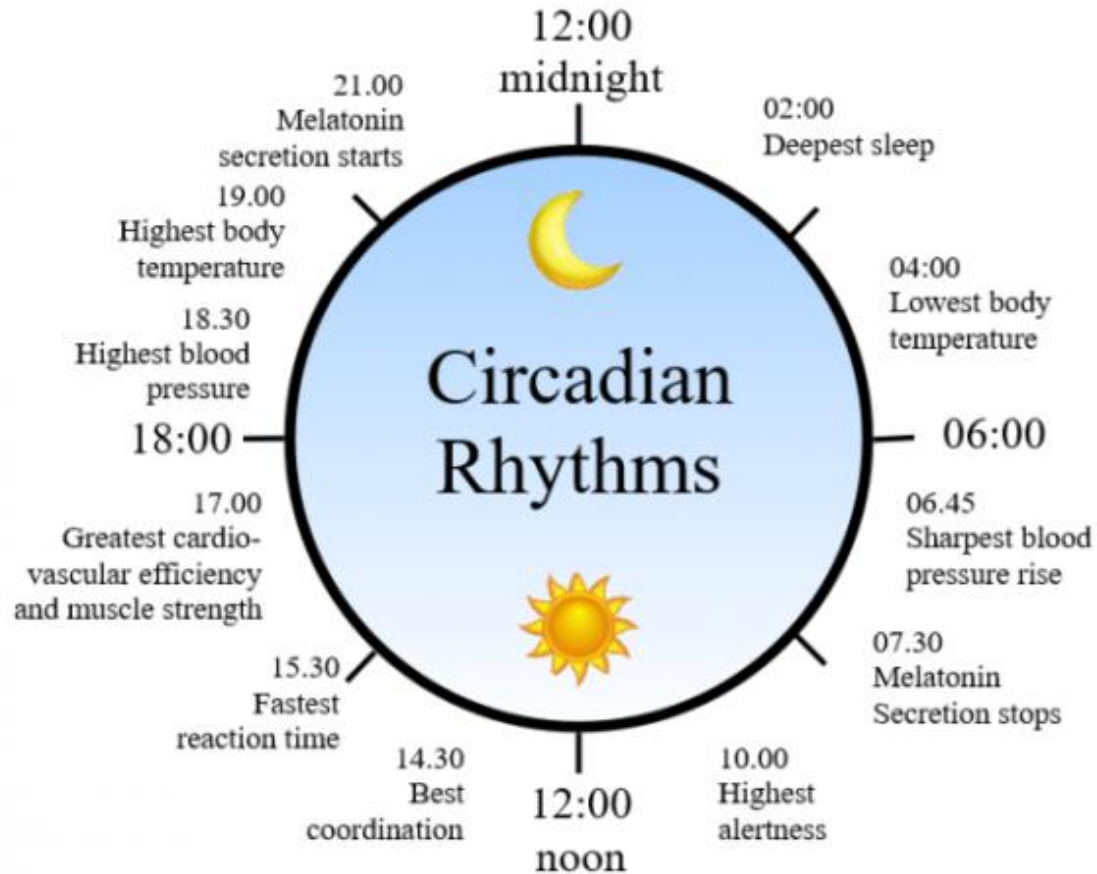
There is a huge amount of research going on today with respect to light and human physiology / non visual effects of light.

- Circadian systems
- Sleep impacts
- Aging Populations
- Dementia
- Behavior Modification
- Alerting Functions
- Blue Light Hazard
- Flicker



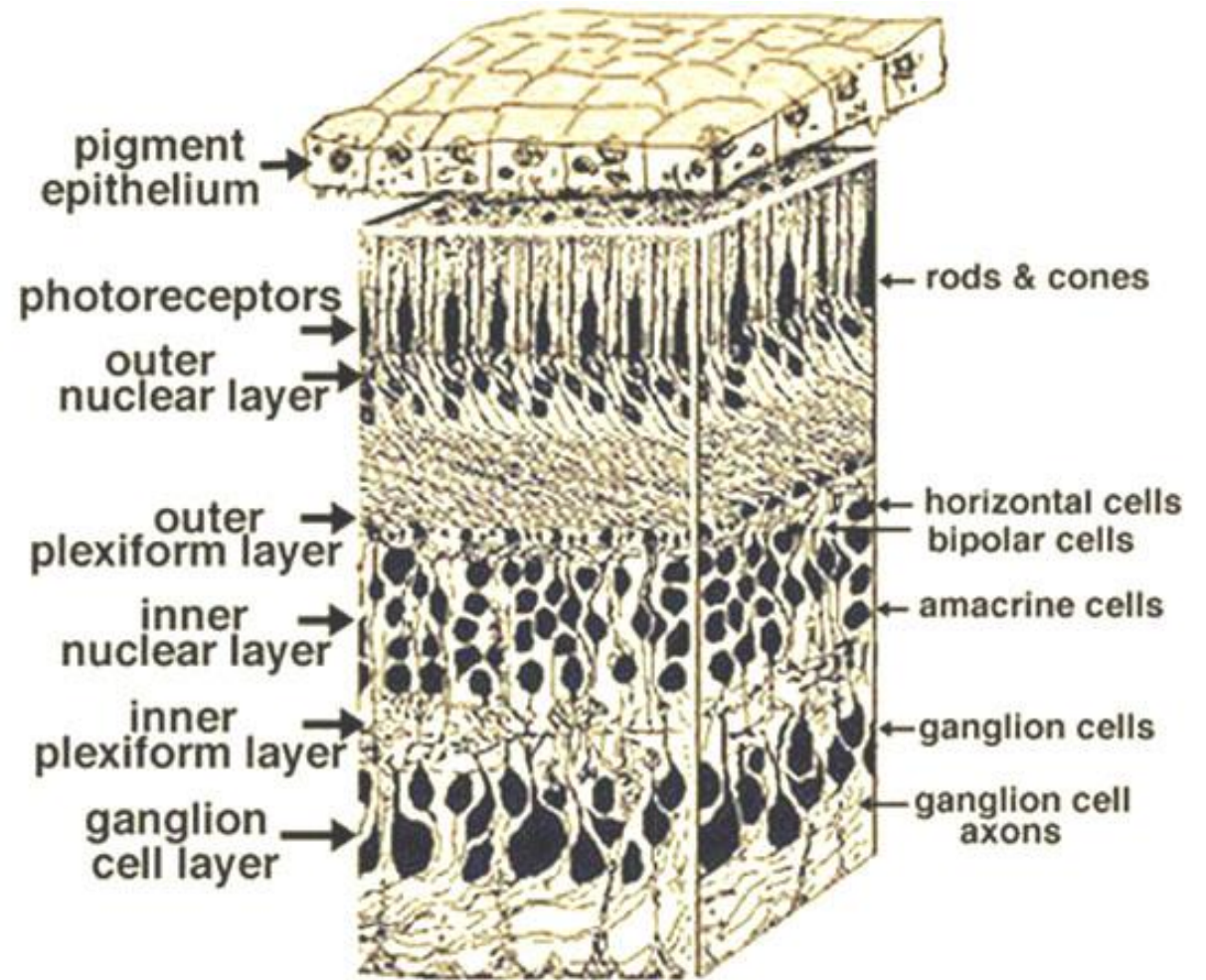


# Light has a role in circadian rhythm?



# What about non-visual light stimulus?

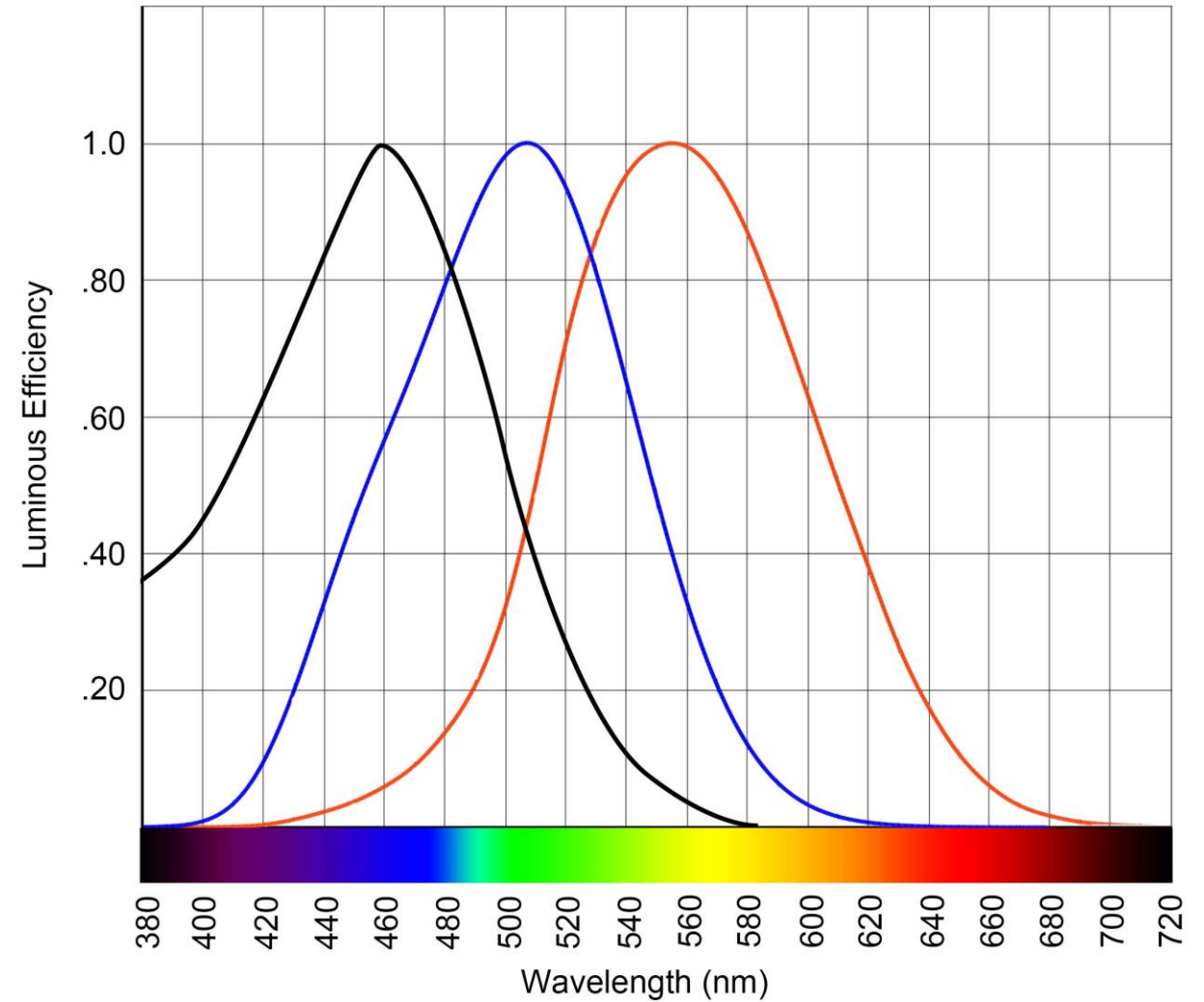
- A new photo-receptor was identified in 2002 in humans.
- Melanopsin-expressing, Intrinsically Photosensitive Retinal Ganglion Cells ipRGC
- Studies suggested that existing visual structures – rods and cones – were unrelated to light response and the circadian timing cycle.



# ipRGC

## Intrinsically Photosensitive Retinal Ganglion Cells

- Non vision forming light receptors
- Slow response
- Melanopsin
- Circadian Rhythm
- Pupil Size
- Melatonin suppression





# Circadian Rhythm and Light Spectrum





# What Do We Know?

- Well.....
  - The research is ongoing...
  - Consensus standards are slowly being developed...
  - There are limited practical application research examples.
- 
- There's a lot of interest in the public press and the with the public.



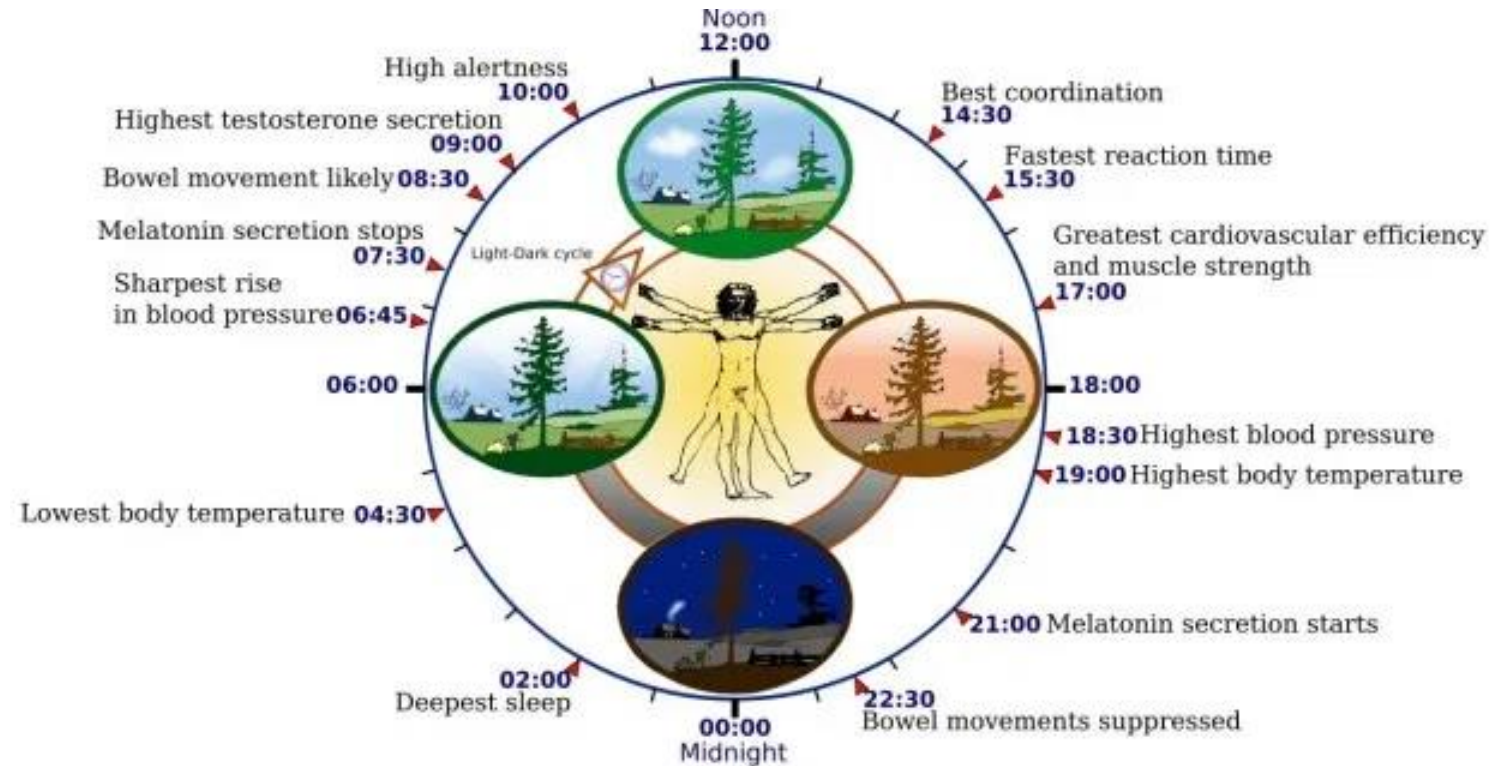
# Lighting Hippocratic Oath



# Circadian Entrainment

What do we know about the circadian system in humans?

- Needs to be reset
- Suprachiasmatic nucleus
- Regulated in part by the endocrine system
- Affected by light exposure
- Melatonin suppression
- Chronotypes





# Key Light Stimulus Variables

- Intensity
- Distribution
- Spectral Power Distribution
- Duration – Dose
- Timing
- Photobiological History





# Intensity

- How much light is incident on the eye
- Lux
- Typically measure at seated eye height for most environments



St John's Hospital

# Distribution

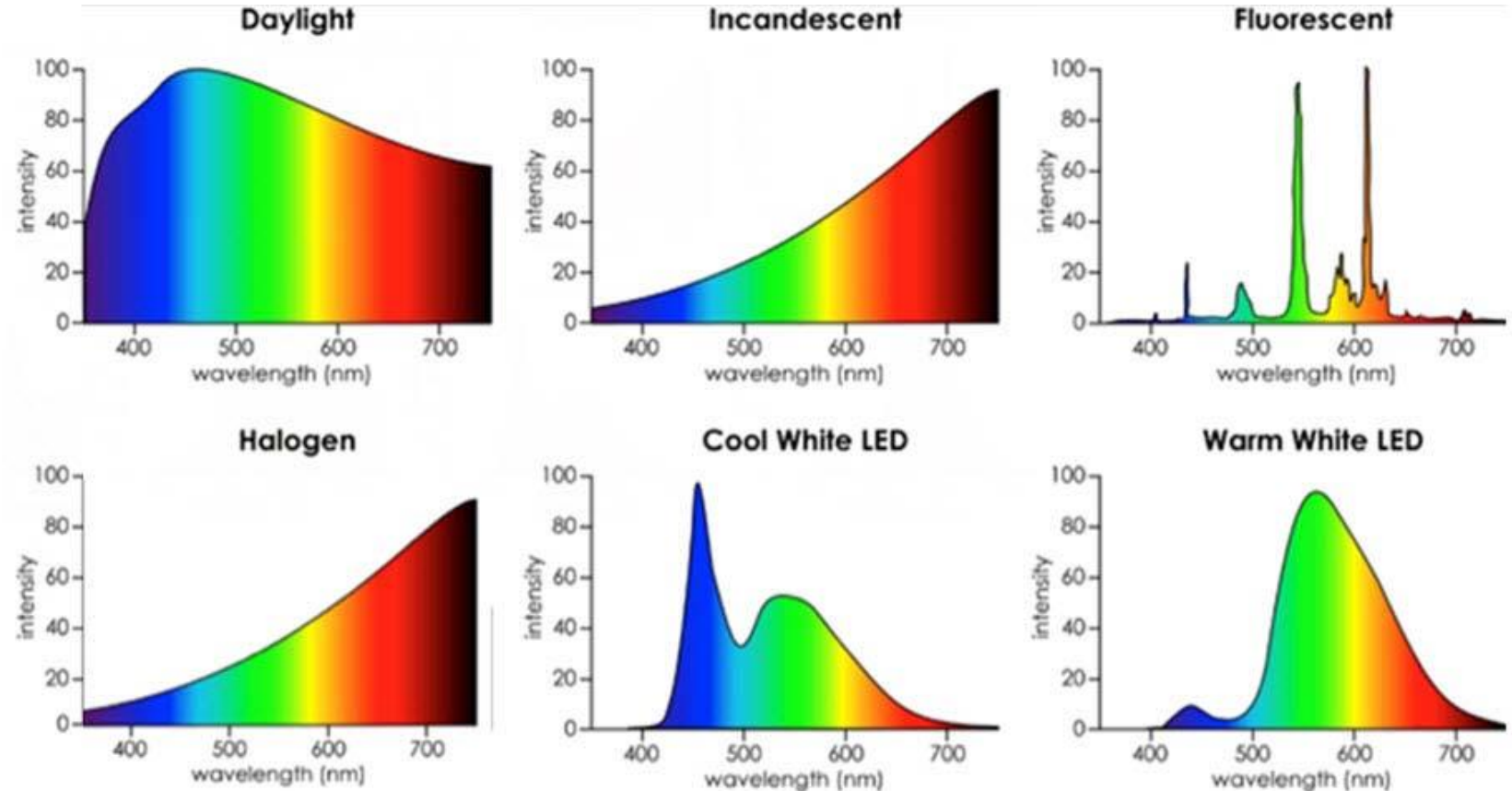
- Direction of light matters
- 90 degrees from nadir and higher
- Think about blues sky light



Cook Hospital

# Spectral Power Distribution

- What wavelengths are present in the light source
- Heavy reliance on blue wavelengths
- Research is showing this may not be as important as thought





# Duration - Dose

- How long are you subjected to the light stimulus?
- At what intensity was the light stimulus?





# Timing

- What time are you subjected to the stimulus?
- Resetting the circadian clock at 5:30 pm may not be the best choice for day active workers.
- What about for patients?



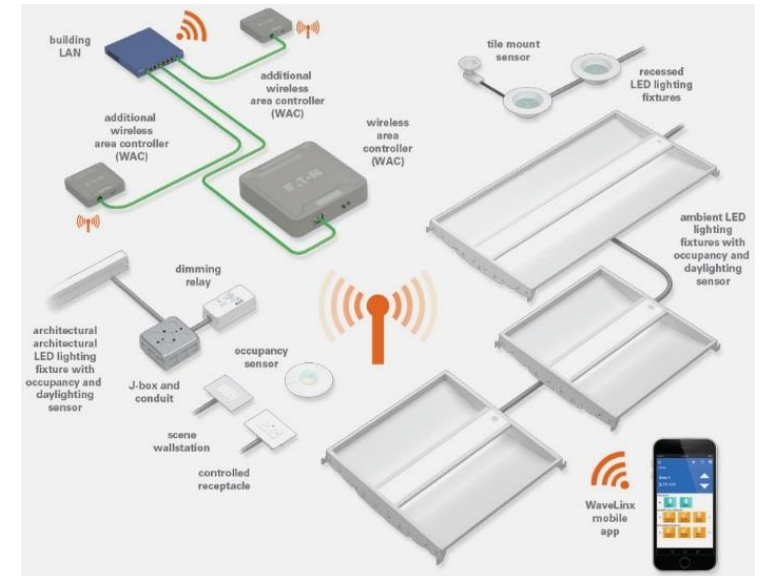
# Photobiological History

- The patterns of light exposure during the day and over time matter
- Intensity ranges may be critical over time
- How does this effect shift workers?



# Lighting Controls to the Rescue

- Intensity
- Distribution
- Spectral Power Distribution
- Duration – Dose
- Timing
- Photobiological History
- If only we had a convenient means of manipulating most of these variables....

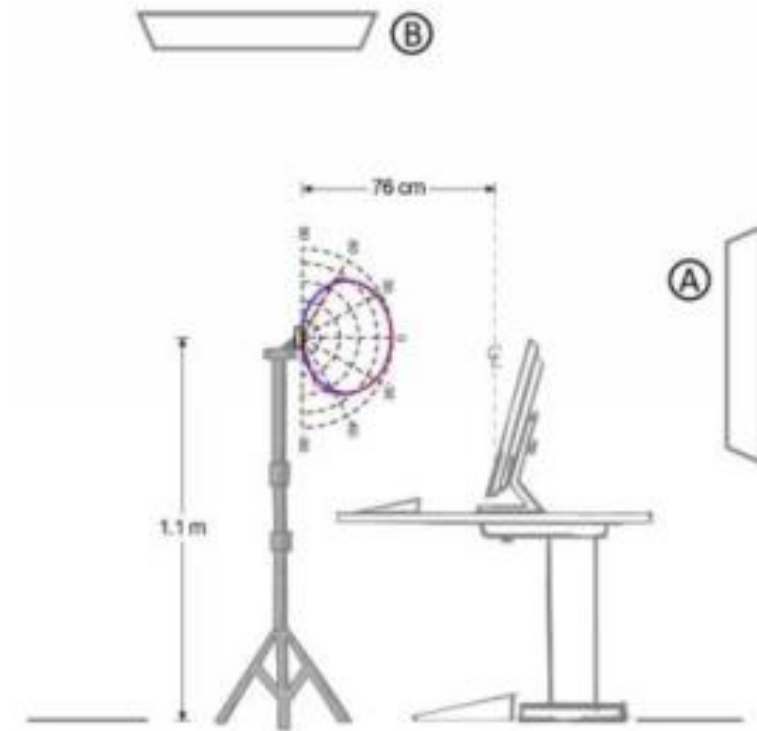


Courtesy: Lutron, Eaton

## Recommended Practice and Guideline for Promoting Circadian Entrainment with Light for Day Active People

- Currently in final review
- 77 pages long currently
- Largely adopts LRC CS system
- Considers EML
- Many examples
- Not a consensus document like IES / ANSI standards

Figure 4.1  
Measuring photopic illuminance





# Pop Quiz

- Does timing of high light exposure seem to affect circadian entrainment?

# Lobby / Waiting / Patient Intake

Soin Medical Center

- Scheduling
- Daylight Controls
- Task Tuning / High Trim
- Tunable White?
- Scene Based
- Zone based load controllers
- Decorative equipment
- 



# Typical Exam

St Luke's Cancer Institute  
Outpatient Clinic

- Manual Dimming
- Scene Control / Raise Lower
- Occupancy Sensor
- Task Tuning / High Trim
- Tunable White?
- LLLC Opportunity



# Procedure

- Manual Dimming
  - Scene Control / Raise Lower
  - Task Tuning / High Trim
  - Tunable White?
  - Low end dimming
- 
- LLLC Opportunity





# Operatory

- Manual Dimming
- Scene Control / Raise Lower
- Color Tuning?
- Low end dimming
- They're all different
- Load Controllers



# Imaging

Carver College of Medicine

- Manual Dimming
  - Scene Control / Raise Lower
  - Task Tuning / High Trim
  - Low end dimming
- 
- LLC Opportunity?



# Imaging

Massachusetts General Hospital

- Manual Dimming
  - Scene Control / Raise Lower
  - Task Tuning / High Trim
  - Tunable White?
  - Low end dimming
  - Active imagery?
- 
- Zoned Load controllers



# Corridors

- Scheduled
  - Occupancy Sensor to Dimmed Level
  - Task Tuning / High Trim
  - Tunable White?
- 
- Excellent LLLC Opportunity





# Patient Corridors

- Scheduled
- Occupancy Sensor to Dimmed Level
- Task Tuning / High Trim
- Tunable White
- Manual dimming at charting and nurse stations
- Excellent LLLC Opportunity



Robert Packer Hospital



# Patient Room

- Manual Dimming
  - Integrated patient controller
  - Task Tuning / High Trim
  - Tunable White
  - Manual dimming at charting stations
  - Color Tuning?
  - Night Light
- 
- Zoned Load Controllers



Seattle Children's Hospital  
ZGF

# Pop Quiz

- Is manual dimming potentially beneficial to staff and patients in most healthcare settings?

# Considerations

- Simplicity
- Ease of Operations
- Ease of Maintenance
- Ease of Installation
- Patient Outcomes
- Patient Preferences
- Staff Well Being
- Energy Savings





# Commissioning

Preby's Cardiovascular Institute

- One of the most often overlooked Commissioning elements....

Commission the occupants....

- Let them know what to expect from the system and how it operates....and why....



# Sequence of Operations

Whoever winds up doing it....a sequence of operations is required to tell the contractor, startup technician, and commissioning agent how the system is supposed to function.

- What are the time and astronomic schedules
- Which sensors are vacancy and which are occupancy?
- What is the vacancy timeout?
- What are the target light levels for task tuning?
- What switches or dimmers are tied to which zones?
- What zones are included in each preset and at what levels?
- What are the daylight zone dimming thresholds?
- Are there any specialty programming tasks like partition controls?

# Wireless Communications

- Zigbee
- Bluetooth
- BLE
- EnOcean
- Zwave
- WiFi
- IEEE 802 Networks
- Proprietary
- Others

**WIRED VS. WIRELESS COSTS**

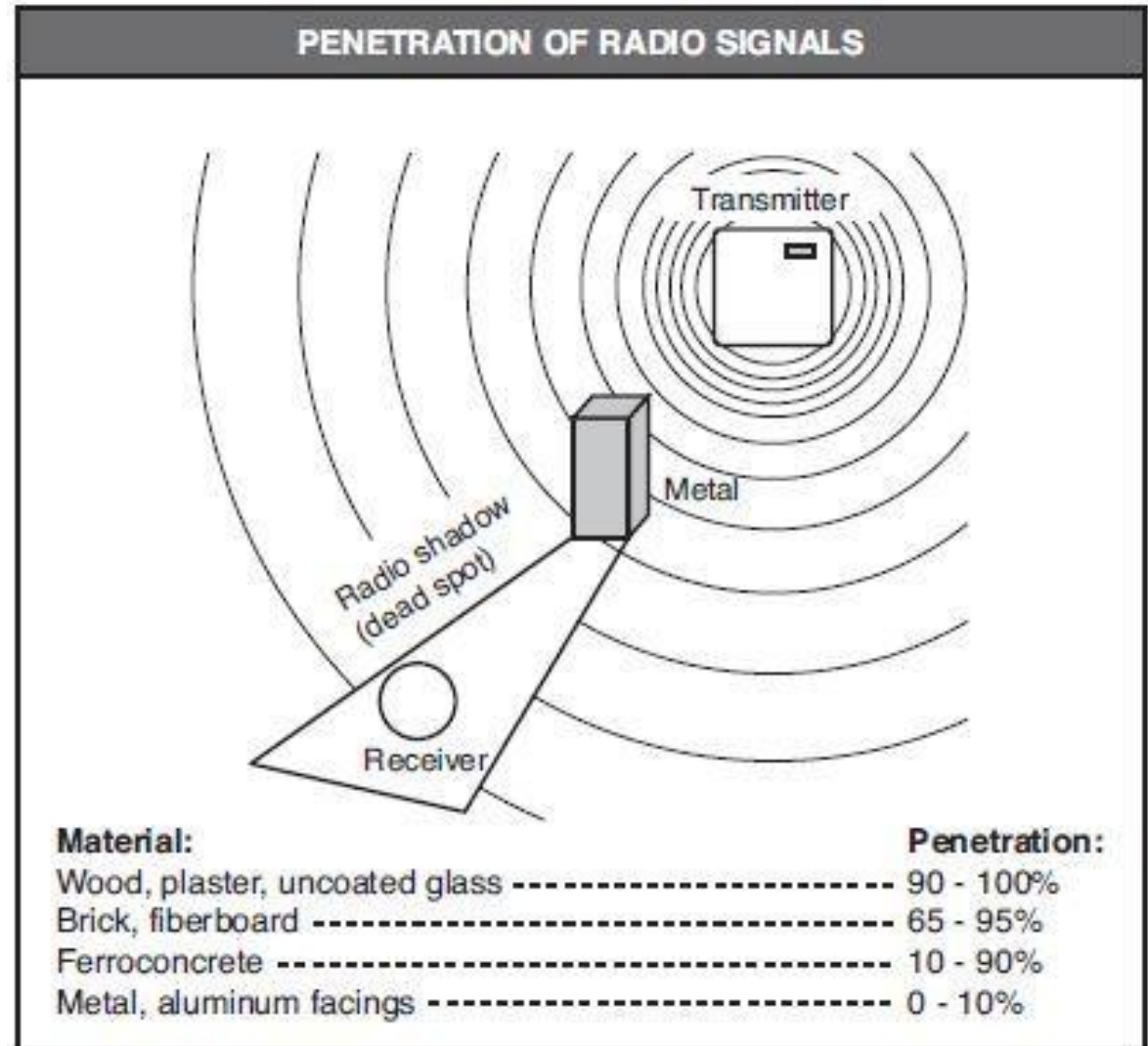


Courtesy: Leviton

# Wireless Communications Considerations

Wireless communications is robust, but there are some considerations:

- Physical obstacles and mass
- Distance between devices
- Number of devices per node or hub
- Other systems on similar frequencies
- E-mag interference
- IOT



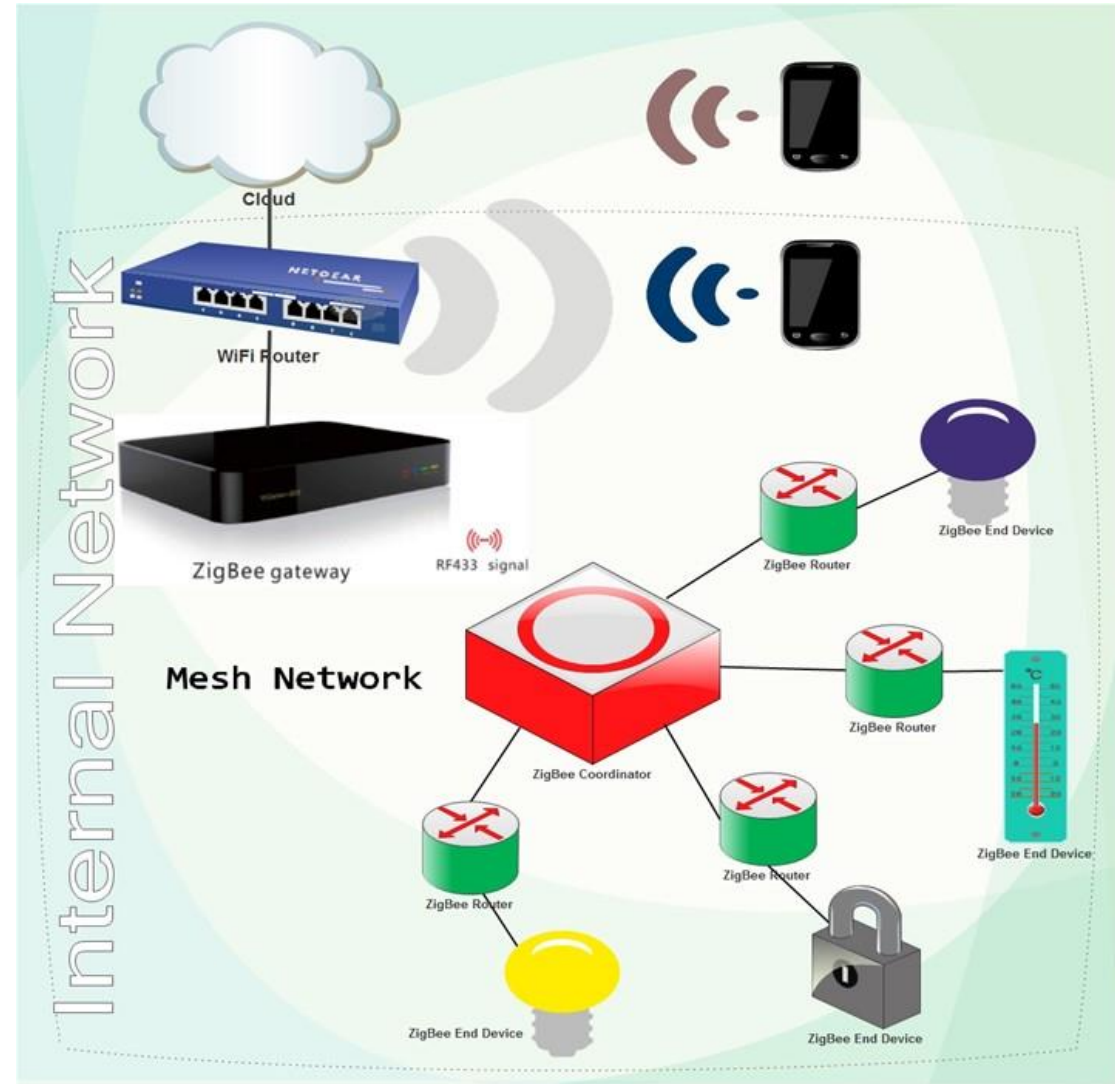
Courtesy: Leviton



# Wireless Communications Considerations

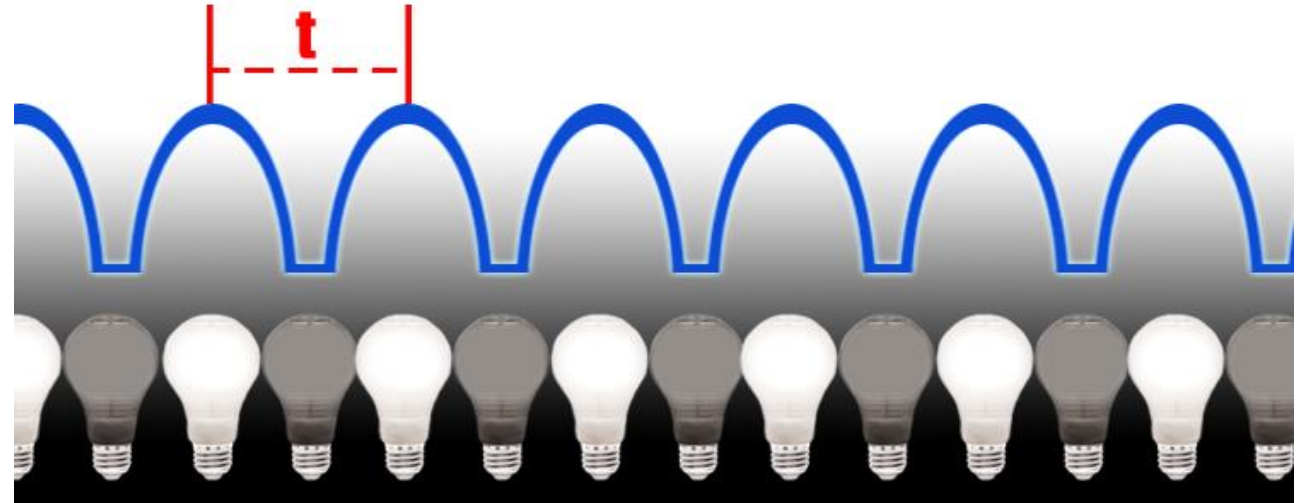
## Cybersecurity:

- In an increasingly connected digital realm, lighting may be a gateway to attack just like other building systems.
- Expect this to become a greater issue over time.
- Lighting controls and building automation may be precluded from corporate networks.



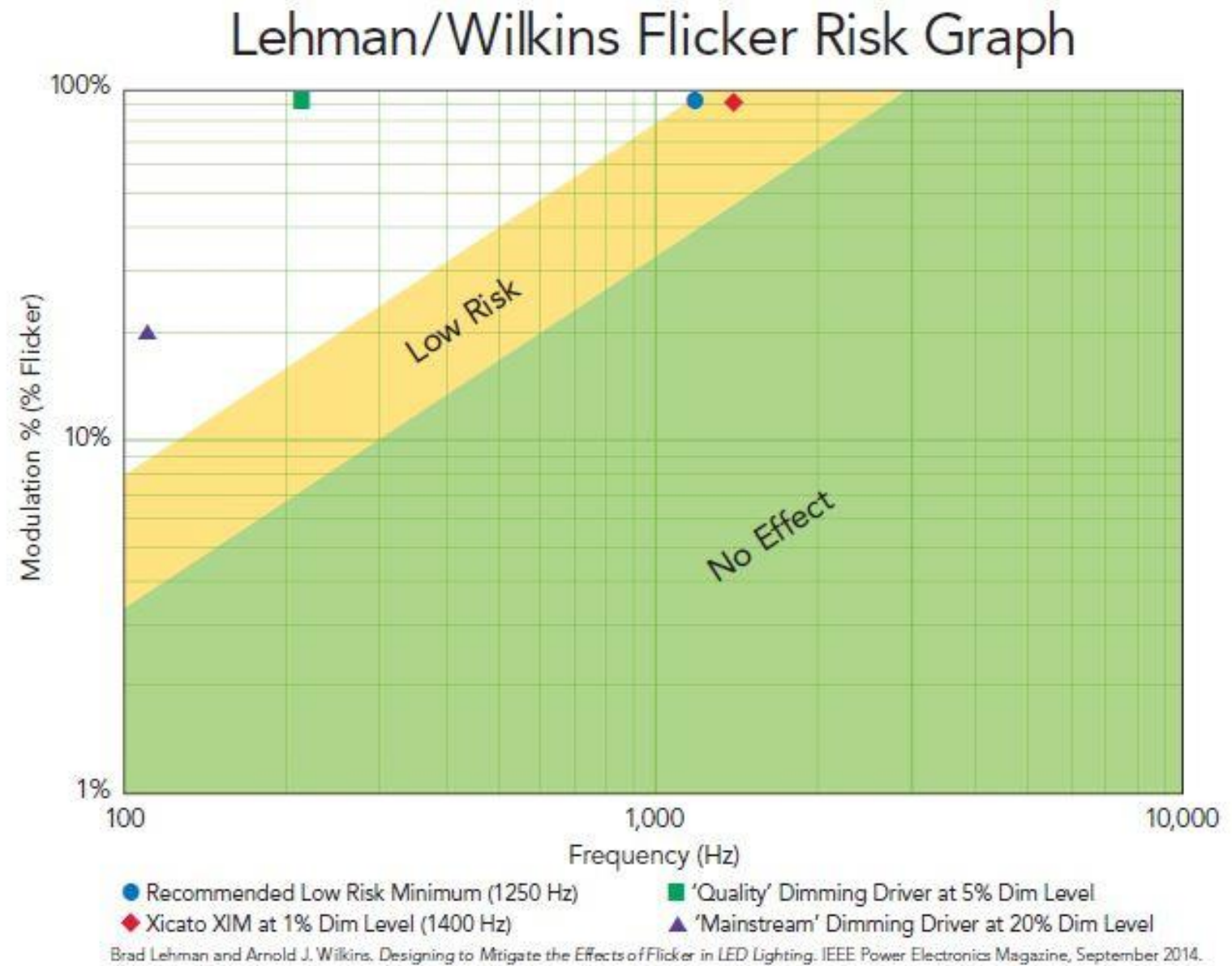
# Flicker

- All light sources can flicker under the right circumstances
- LED sources may be particularly susceptible with low quality drivers or in specific cases.
- This may be ok, mildly annoying, hugely annoying, or disastrous.
- In some cases (think LiFi) very high frequency flicker is desirable)



# Flicker

- Is it flicker, flutter, shimmer, or other?
- % flicker = amplitude
- Amplitude and frequency both matter.
- Check at multiple dimmed light levels.
- Do the research upfront to ensure compatibility
- When in doubt ask for samples and test



# Future of Lighting Controls

Where do we go from here?

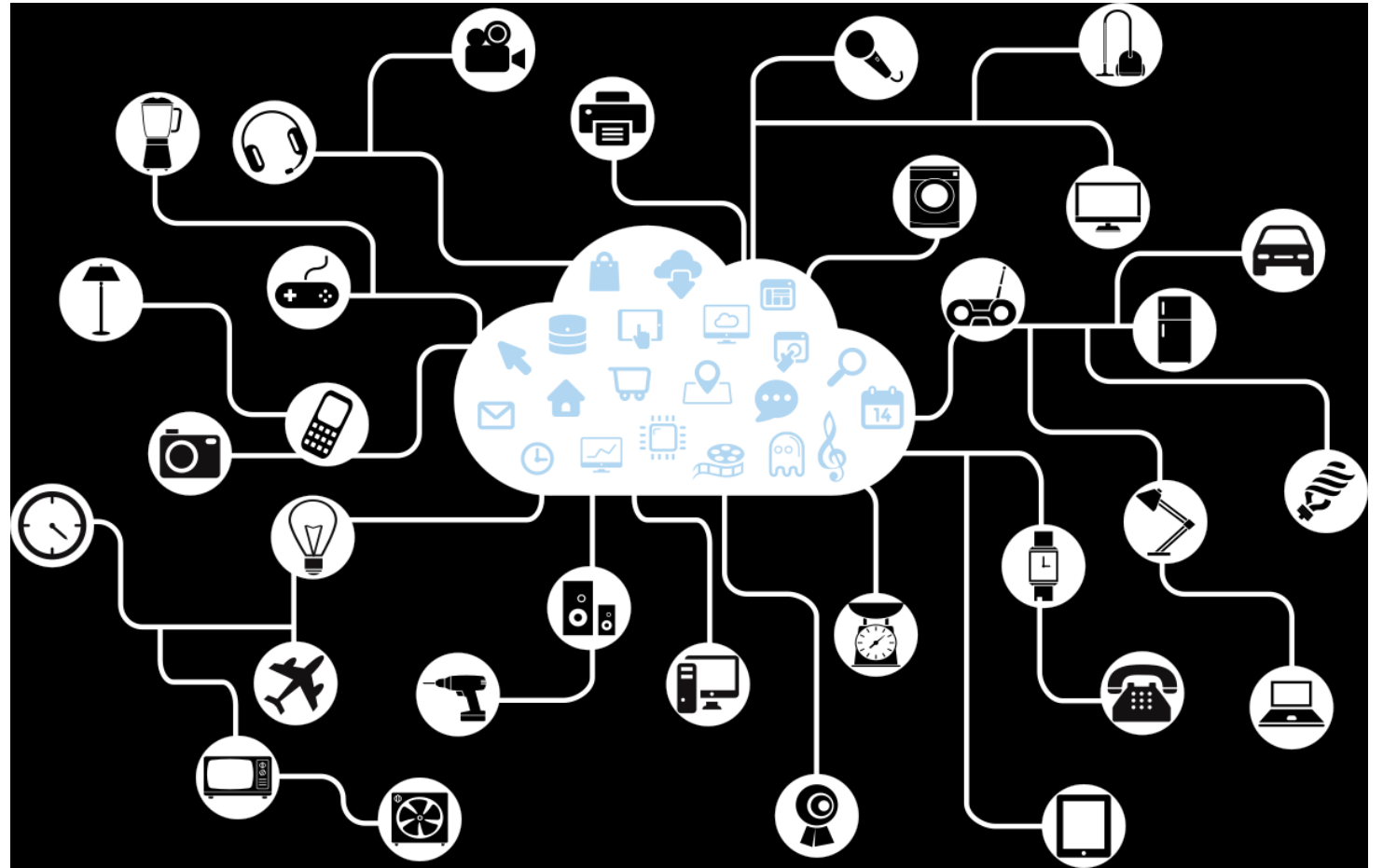
What do YOU think?





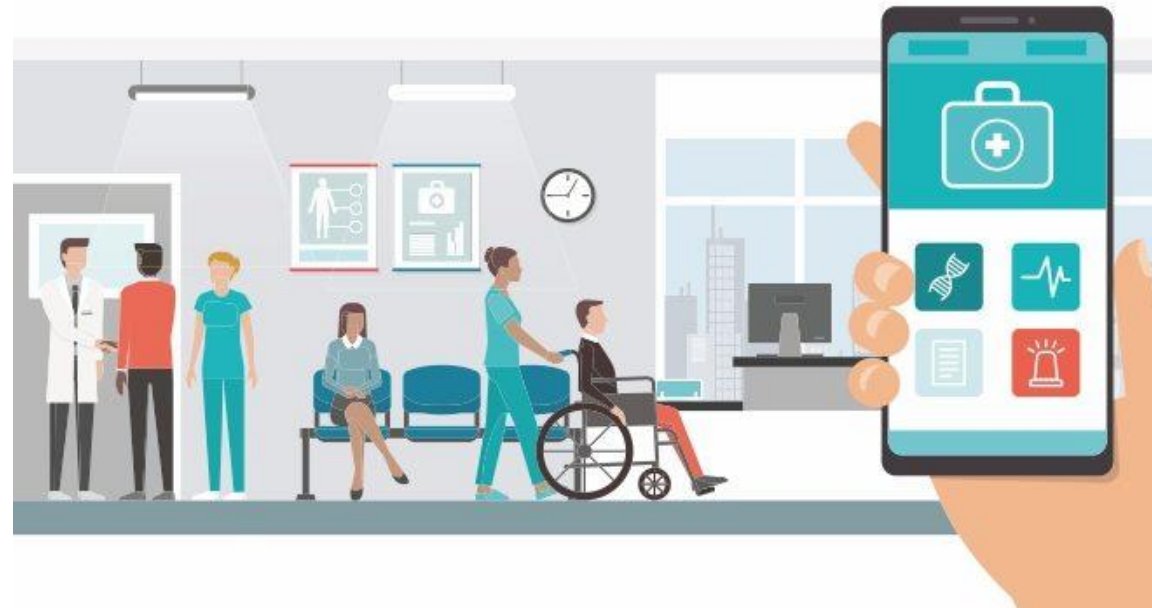
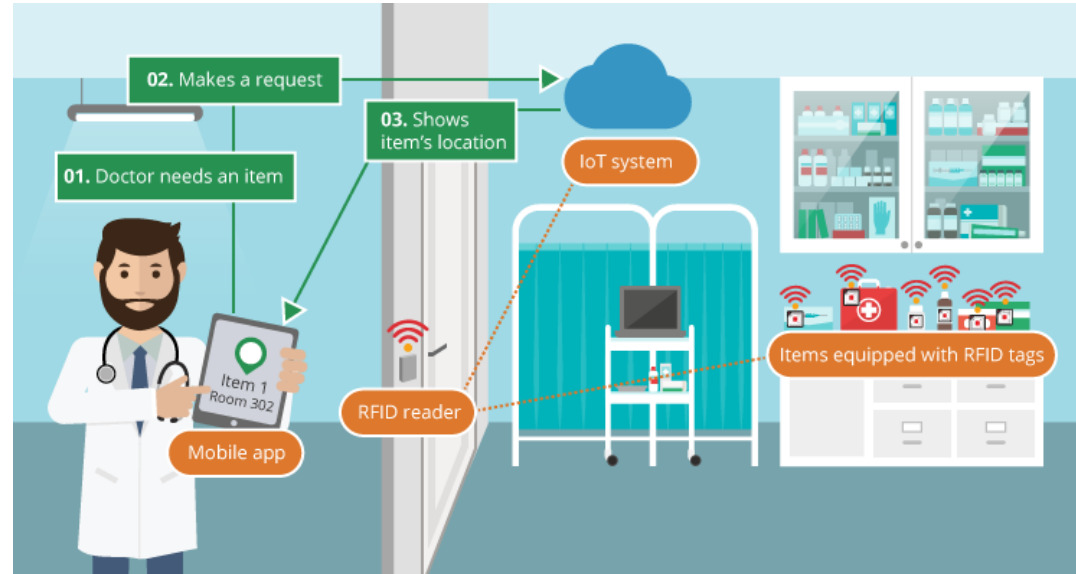
# IOT

- HVAC
- Room Scheduling
- Communications
- Tracking
- Security
- Audio
- Video
- Your Toaster
- What else?



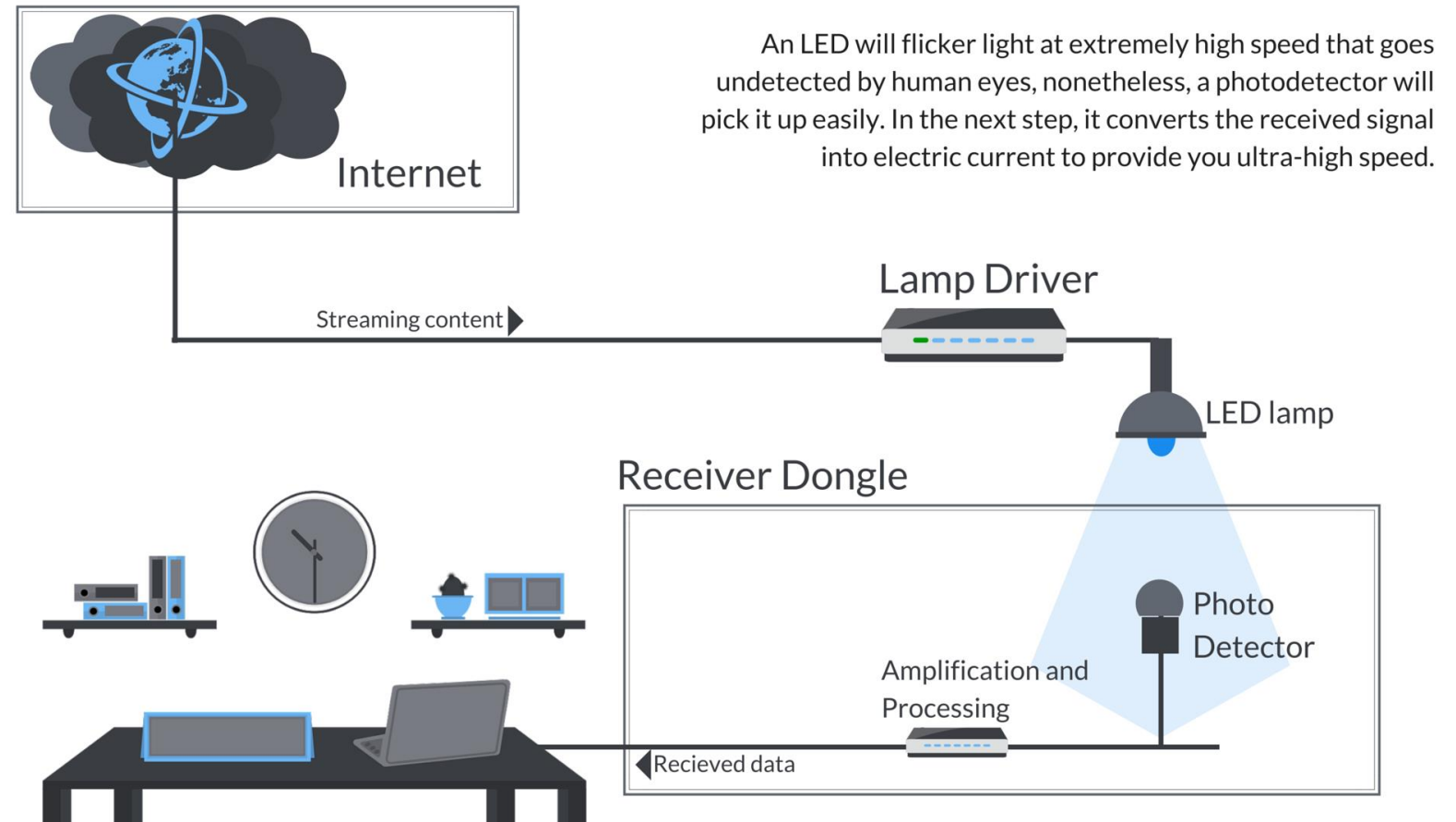
# Asset Tracking

- How might lighting / lighting controls be used for asset tracking?
- Other functions?



# LiFi

- Requires line of sight
- More bandwidth
- Infrared or Visible
- Security
- Health Care
- Schools
- Public Realm



Courtesy: GrayB

# Implementation

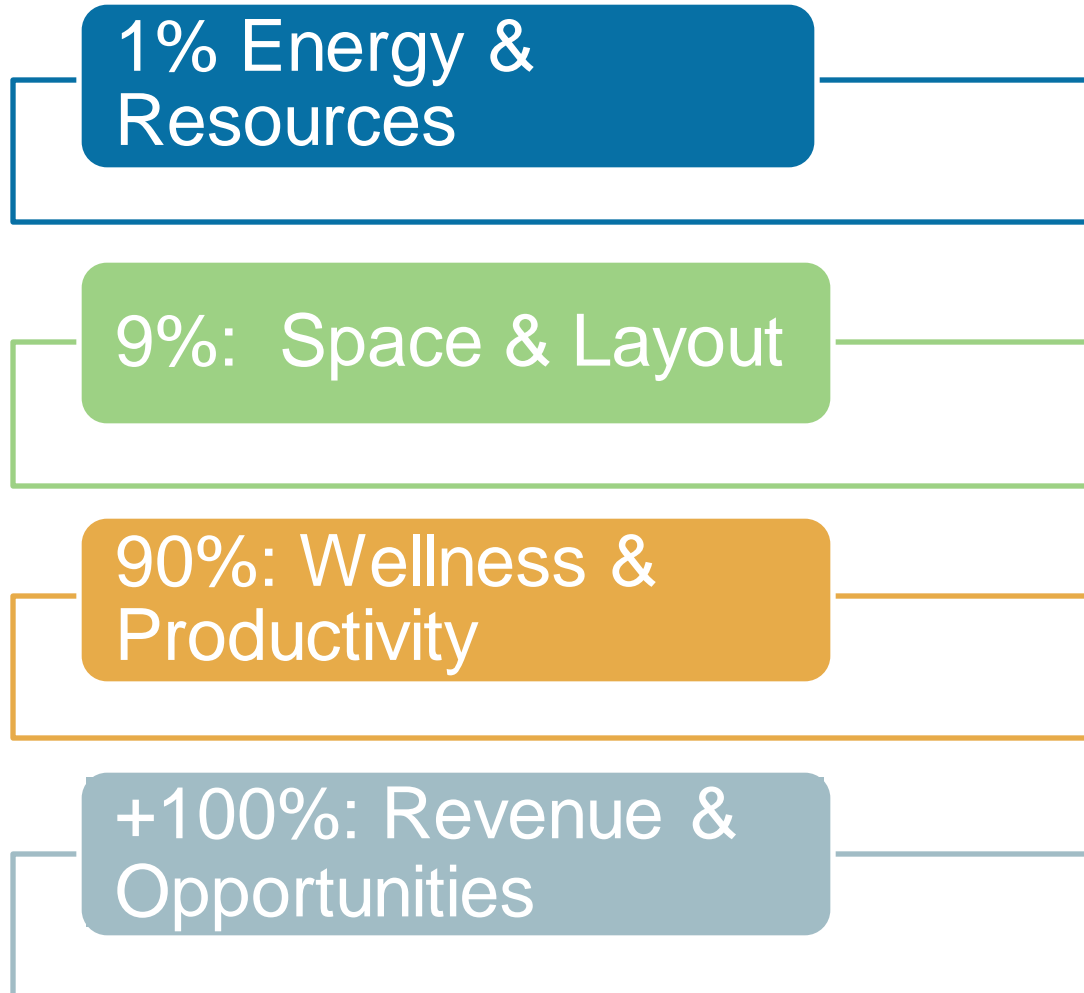
- The kind of NLC / LLLC systems we've been discussing are an excellent fit for both new construction and existing building retrofit.
- LLLC in particular – replace existing luminaires one for one with 3 connection points to existing wiring.
- No additional controls wiring or sensors to install.





# Connected Lighting Prospectus for Buildings

## The 1-9-90 Rule



# Benefits of plugging in to your Territory Utility

- Investment on innovation and energy efficiency
- Customer and technical support on specific projects
  - Or access to resources for these
- Access to tools and resources
- Access to encyclopedia of implementation knowledge
- Access to impactful programming



# Program Design Considerations: Savings & Incentives

## Example of prescriptive savings in City Light's lighting program

Space Use Type	Networked Lighting Controls	Luminaire Level Lighting Controls
Break Room	40%	50%
Classroom	25%	25%
Hallway	40%	50%
Lobby	40%	50%
The Loo	40%	50%
Warehouse	40%	50%

*And so on and so forth...*

### Regional Technical Forums: Non-Residential Lighting Retrofits protocol

Dictionary

Search for a word



pro·vi·sion·al  
/prəˈvɪʒənəl/

1. Arranged or existing for the present, *possible to be changed later*

### **Simplify Approach:**

- prescriptive savings
- prescriptive incentives



### **Right-Sized Incentive**

- \$50-75 incentive bonus –  
*In addition to performance savings!*



# NLC / LLLC Best Practice Guides



- LLLC Videos
  - Demonstrate simple primary control strategies
  - Simulates tenant improvement to highlight system flexibility
- <https://www.lightingdesignlab.com/resources>



# Late Breaking News



- Report commissioned by NEEA on replacement vs redesign with LLLC
- Included in the downloadable handouts
- Also available from NEEA:
- <https://neea.org/resources/lllc-replacement-vs-redesign-comparison-study>

September 3, 2020

REPORT #E20-315

Luminaire Level Lighting  
Controls Replacement vs  
Redesign Comparison Study

Prepared For NEEA:  
Chris Wolgamott, Sr. Product Manager,

Prepared by:  
Alan Mahić  
Jeff Kline  
Dale Northcutt  
Kevin Van Den Wymelenberg

University of Oregon Energy Studies in  
Buildings Laboratory  
105A White Stag Building  
70 Northwest Couch Street  
University of Oregon  
Portland, OR 97209

Northwest Energy Efficiency Alliance PHONE  
503-688-5400  
EMAIL  
info@neea.org

# Additional Resources

Night Shift Work – A Risk Factor for Breast Cancer, 2020

*Marta Szkiela, Kusidel, Makoiec-Dabrowska, Durota Kaleta*

Disruption of Circadian Rhythms by Light During Day and Night, 2017

*Mariana G. Figueiro, PhD*

Measuring Light at Night and Melatonin Levels in Shift Workers: A Review of the Literature, 2017

Claudia M. Hunter PhD, Mariana Figueiro PhD

The NICU Lighted Environment, 2016

*Mark S Rea PhD, Mariana G Figueiro PhD*

Bright Light Improves Sleep and Psychological Health in Shift Working Nurses 2013

*Bjorn Bjorvatn MD, PhD, Siri Waage PhD*

ANY  
QUESTIONS  
?

*And now – a few words from LDL*



# Upcoming LDL Online Events

LDL Course	Delivery Date	Time
Lighting & Homes for Tomorrow 2020 Competition Winners	April 27	10:00 – 11:30
NLC for Schools	May 4	10:00 - Noon

Today's slide deck and previous online courses  
can be found on our [website](#)

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