

# Improving Operating Rooms' Visual Comfort for Surgeons and Nurses

*Through the Deployment of Customizable Lighting Strategies*



1

## Speaker Introductions



**Alexandra Andrei,  
RA, EDAC**

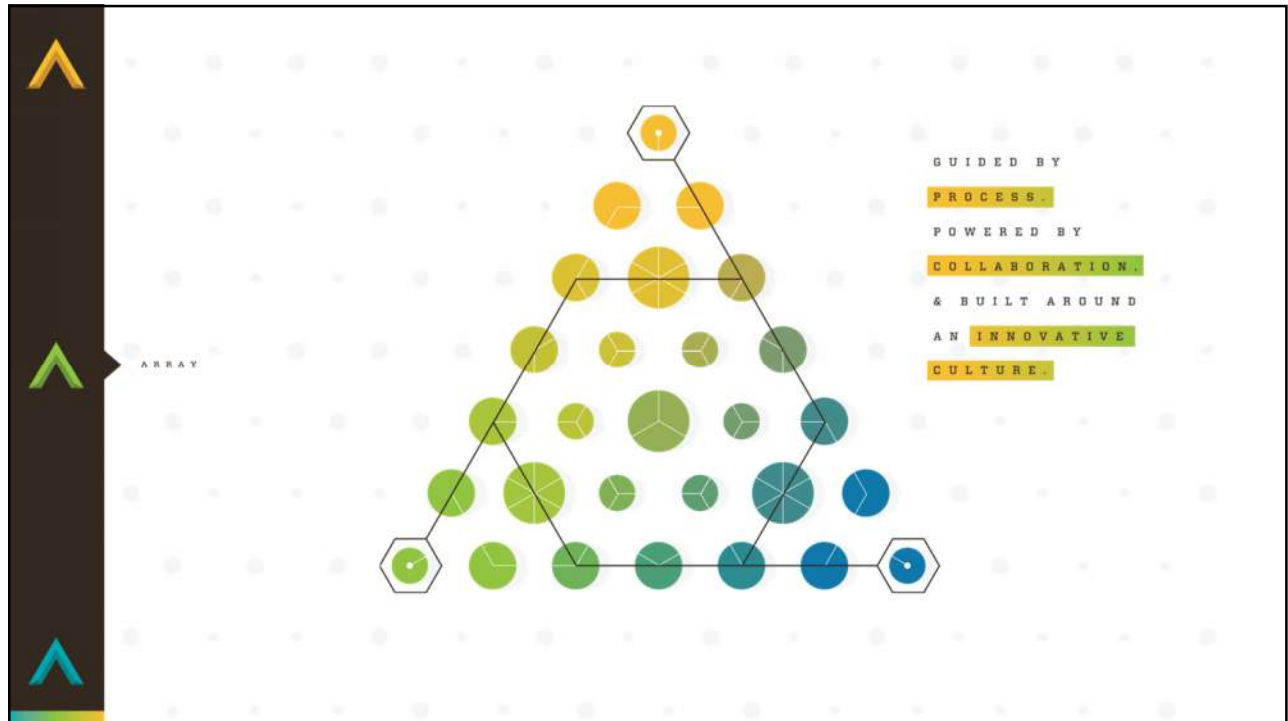
*Associate Principal,  
Array Architects*



**Michael Steward,  
PE, CxA, LEED AP**

*Principal,  
TLC Engineering Solutions*

2



3

**ARRAY**  
OUR LOCATIONS

- BOSTON
- NEW YORK CITY
- PHILADELPHIA
- WASHINGTON D.C.
- CHARLESTON
- SOUTH FLORIDA

We are not architects who do healthcare.  
We are **healthcare architects.**

**100%**  
Dedicated to Healthcare

**1,000+**  
Beds over last 5 years

**10M+ SF**  
Completed Projects in the Last Five Years

**2K+**  
Projects Awarded in the Last Five Years

**90%+**  
of Array Staff Trained in Lean Practices

4



## Healthcare Expertise



Healthcare  
accounts for

# 45%

of TLC's  
business



*Baptist Health South Florida  
Baptist Hospital of Miami Hope Tower  
Image Courtesy of Miami In Focus*

### 68

Years of Experience

### 450+

Employees

### 95%

First-Time AHCA  
Approval Record

### #1

ENR Top Southeast  
Design Firm  
Healthcare (2022)

5

## Learning Objectives

- 1
 Understand the lighting needs and concerns of Operating Room occupants
- 2
 Review current lighting technologies and the flexibility they offer
- 3
 Review ways to integrate daylighting for provider well-being within the operating room environment.
- 4
 Understand and address the balance between contrast and glare
- 5
 Take into account considerations for infection control/  
infection prevention

### 39th Annual FPC Seminar + Expo

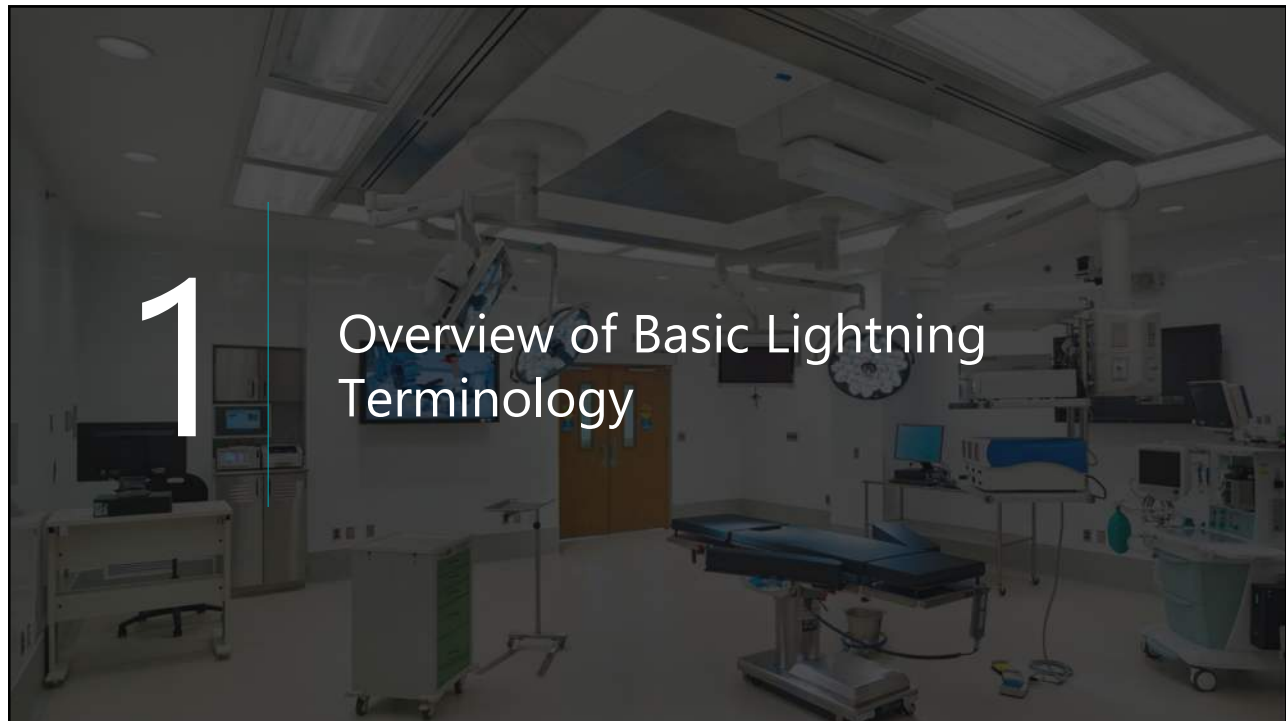
6

## Our Agenda

1. Overview of Basic Lighting Terminology
2. Planning Considerations in Lighting the OR Environment
3. A Review of Occupant Needs
4. Applicable Code and Standards
5. Illustrative Examples

39th Annual FPC Seminar + Expo

7



8

## Candela (cd)



### Unit of Luminous Intensity

One of 7 base units of SI system of measurement

Measures how bright light is in a particular direction

Origins are based on the brightness from a 'standard candle'

May also be colloquially be referred to as Candlepower

#### Official SI Definition:

The candela is defined by taking the fixed numerical value of the luminous efficacy of monochromatic radiation of frequency  $540 \times 10^{12}$  Hz,  $K_{cd}$ , to be 683 when expressed in the unit  $\text{lm W}^{-1}$ , which is equal to  $\text{cd sr W}^{-1}$ , or  $\text{cd sr kg}^{-1} \text{m}^{-2} \text{s}^3$ , where the kilogram, metre and second are defined in terms of h, c and  $\Delta\nu_{Cs}$ .

39th Annual FPC Seminar + Expo

9

## Lumens (lm)



### The Unit of Luminous Flux

Measurement of the total amount of visible light from some source

How much light we get from a light fixture

Higher Lumens = Brighter Source



40-50lm



800-900lm

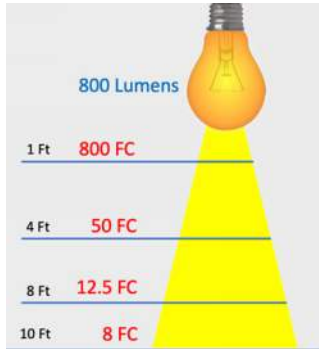


60,000lm+

39th Annual FPC Seminar + Expo

10

## Foot Candles (fc)



### A Unit of Illuminance

Amount of luminous flux (lumens) incident on a surface

Defined as one Lumen per Square Foot ( $\text{lm}/\text{ft}^2$ )

Lower Foot Candles = Darker Area

Non-SI cousin to Lux ( $\text{lm}/\text{m}^2$ )     $1 \text{ fc} = 10.764 \text{ Lux}$



Sunny Day  
1,000 fc



Overcast  
100 fc

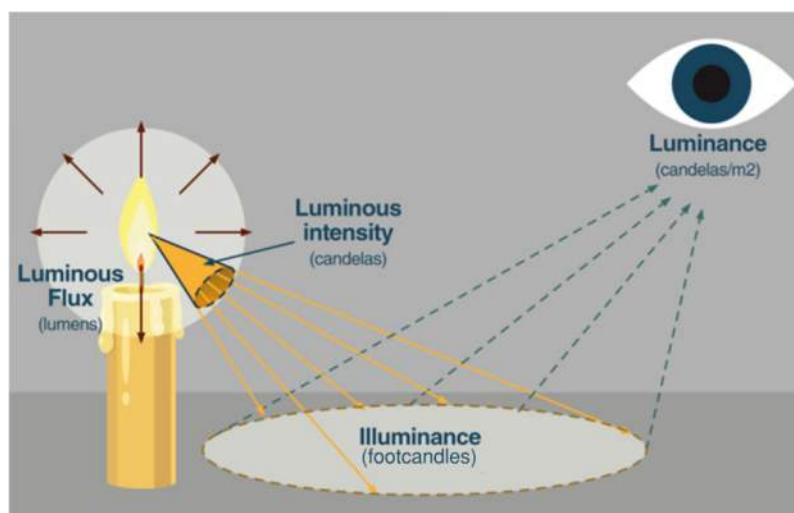


Full Moon  
0.1 fc

39th Annual FPC Seminar + Expo

11

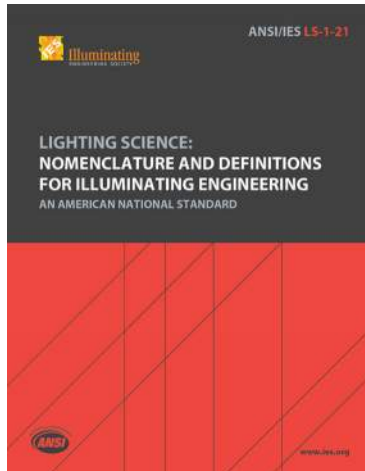
## Summary of Lighting Measurements



39th Annual FPC Seminar + Expo

12

## Summary of Lighting Measurements



<https://www.ies.org/standards/definitions/>

39th Annual FPC Seminar + Expo

13

## CCT: Correlated Color Temperature

IES Definition:

The absolute temperature of a blackbody whose chromaticity most nearly resembles that of the light source.

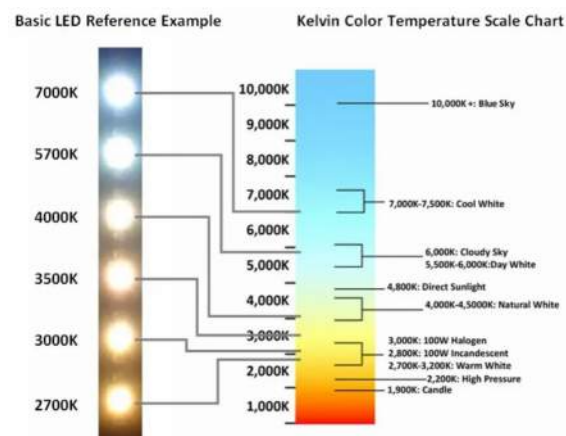
Measured/described in Kelvins (K)

The relative color appearance of a white light source:

from yellowish or "warm" (2700K-3000K)  
 to bluish white or "cool" (5000+K)

Sunny Midday ~ 5000-5500K

Sunrise/Sunset ~ 2000-3000K



39th Annual FPC Seminar + Expo

14



## CCT: Correlated Color Temperature

Lighting Facts Per Bulb	
<b>Brightness</b>	820 lumens
<b>Estimated Yearly Energy Cost</b>	\$7.23
Based on 3 hrs/day, 11¢/kWh Cost depends on rates and use	
<b>Life</b>	1.4 years
Based on 3 hrs/day	
<b>Light Appearance</b>	
<b>Energy Used</b>	60 watts

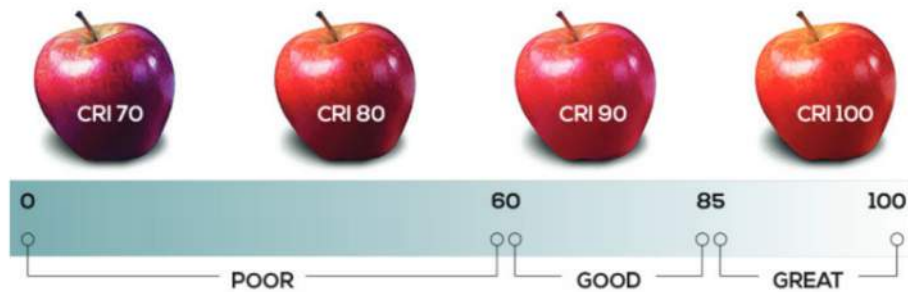


39th Annual FPC Seminar + Expo

15

## CRI: Color Rendering Index

- Measures a light's ability to accurately show an object's colors when compared to natural light
- Measured on a scale of 0 to 100, with 100 being the best (closest to natural light)



39th Annual FPC Seminar + Expo

16



## CRI Examples



100



~100



70-80-90



90+

39th Annual FPC Seminar + Expo

17

## Importance of CRI



- IES (RP-29-22) Recommends >90 CRI for lighting within ORs
- General overhead lighting and task lighting should closely match in chromaticity (ideally CRI and CCT should be similar)
- VA Lighting Design Manual PG-19-10 requires light fixtures within ORs to have min CRI **R9** of 90

39th Annual FPC Seminar + Expo

18



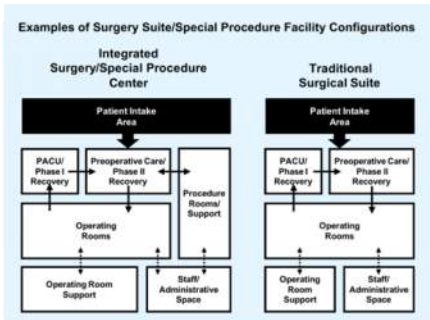
19

## 2 Planning Considerations for Lighting the OR Environment

## Planning Considerations within the Campus

### Existing Campus Planning

Traditionally OR dept located deep within the campus and Pacu areas along the perimeter.

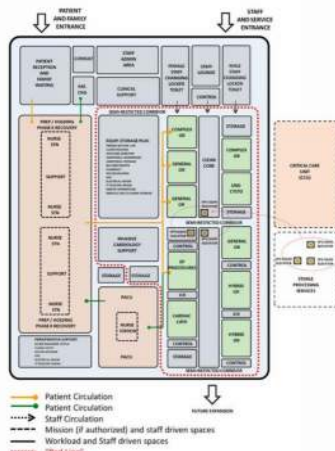


Resource: Space Med, 3<sup>rd</sup> Ed.

VS

### New Trends in Campus Planning

- With the advent of more advanced technologies/ equipment, we're seeing a shift towards more minimally invasive procedures and therefore a move of those procedures to ASC and outpatient settings and away from hospital-based procedures.
- Renovation opportunities to locate ORs on the perimeter of the building and the Pacu areas moving inside the facility.



Resource: VA resources, 2021 *Surgical and Endovascular Service Design Guide*

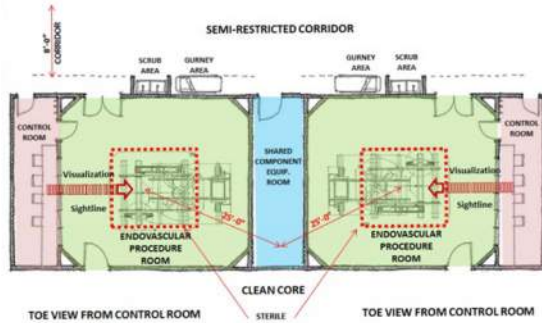
39th Annual FPC Seminar + Expo

20

## Planning Considerations within the Campus

### Competing Priorities

- "Form follows Function"
- Prioritizing functions and support spaces to complement the OR environment leaves little room for opportunities to address wellbeing and staff burn-out.



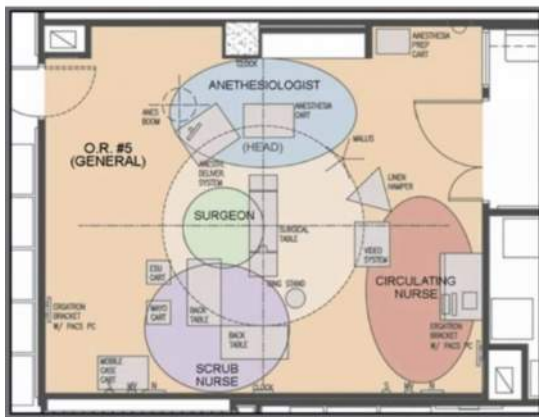
Resource: VA resources, 2021 [Surgical and Endovascular Service Design Guide](#)

## 39th Annual FPC Seminar + Expo

21

## Staff Well-Being / A Review of the Research & Gaps

### Operating Room Work Zones



Resource: Golvani et al. *BMC Nursing* (2021) 20:227  
<https://doi.org/10.1186/s12912-021-00751-8>

A 2021 study from Biomed Central Nursing journal revealed that OR nursing staff benefit from exposure to natural light. Two conclusions were drawn:

- Daylight could lead to a sensation of joy but also increased awareness and energy which seemed to improve the ability to perform at work.
- The limited access to daylight contributed to fatigue and led to an internal stress that affected the nurses even after work.

## 39th Annual FPC Seminar + Expo

22

## Staff Well-Being / A Review of the Research & Gaps

- Operating room nurses rarely leave the operating room before the surgery is done. This situation can result in the **absence of daylight for a significant portion of the workday** for the operating room nurse.
- In order to minimize traffic in and out of an operating room, the operating room nurse may have to remain in the room for extended periods of time without the option of leaving. Absence of daylight has proven to affect a person's performance negatively. **Lack of daylight can also affect the circadian rhythm** resulting in cognitive effects.
- **Low exposure to daylight** on surgical and/ or intensive care wards have been **associated with stress** and decreased contentment at work and have the opposite effect at exposure to daylight.



Resource: Galvani et al. BMC Nursing (2021) 20:227  
<https://doi.org/10.1186/s12912-021-00751-8>

39th Annual FPC Seminar + Expo

23

## Staff Well-Being / A Review of the Research & Gaps

- The advancement of surgical techniques has resulted in more procedures performed where every-thing is seen on screens. This requires **darkness in the operating room to enhance visual sight, often during long periods of time**. To work in darkness was perceived as stressful on the body and demanded mental preparedness before the surgery started.



- Lighting technology and approach are shifting to a new paradigm by **focusing not only on vision but also human psychophysical wellbeing in interior spaces**.



Resource: Galvani et al. BMC Nursing (2021) 20:227  
<https://doi.org/10.1186/s12912-021-00751-8>  
Resource: Journal of Advanced Research in Fluid Mechanics and Thermal Sciences  
Volume 82, Issue 2 (2021) 47-60 . <https://doi.org/10.37934/arfmis.82.2.4760>

39th Annual FPC Seminar + Expo

24

## Natural Lighting Integration Consideration

YES

**Figure 15.** Comparative study of ceiling conformation and furniture arrangement according to natural light distribution. Option (A): Furniture centrally located between the two beds; no suspended ceiling. Requirements are not met. Option (B): Furniture placed centrally between the two beds; suspended ceiling on only one side of the room. Requirements are not all met. Option (C): Furniture placed centrally between the two beds; suspended ceiling on a both sides of the room. Requirements are not all met. Option (D): Furniture placed between each bed and adjacent wall; no suspended ceiling. Requirements are not all met. Option (E): Furniture placed between each bed and adjacent wall; false ceiling on only one side of the room. Requirements are not all met. Option (F): Furniture placed between each bed and adjacent wall; suspended ceiling on a both sides of the room. All requirements are met.



Resource: MDPI Buildings 2022, Ferrante, 12,2145. <https://doi.org/10.3390/buildings12122145>

39th Annual FPC Seminar + Expo

25

## Natural Lighting Integration Consideration

NO

A room with four walls and a few doors and windows provided a feeling of **“being in a bunker”**. The so-called light courts located throughout a campus may not provide much relief, considering the ability to access them involves a process where the staff have to change clothes before and after going outside. This leads to staff staying indoors.

39th Annual FPC Seminar + Expo

26



## Surgical Team Lighting Needs



### [IES Learning: Well-Lit for Well-Being in Hospitals: The Connection Between Quality Light and Enhanced Health Care Environments](#)

As the hospital experience transforms from primarily “sterile” patient environments to more comfortable, curative spaces focused on well-being and support, ongoing research continues into the connection between light and health. This research is impacting the way designers and technologies enhance the hospital experience.

39th Annual FPC Seminar + Expo

27



28

## Surgical Team

### Core Personnel

- Surgeon
- Anesthesiologist (CRNA)
- OR (Circulating) Nurse

### Additional Personnel

- Surgical Assistant
- OR/Surgical Technician
- Medical Students
- Perfusionist
- Medical Device Representatives

39th Annual FPC Seminar + Expo

29

## Procedural Lighting Needs

*Different Cases Need Different Lighting*



### Open Surgery

These procedures typically need a lot of lighting. Emphasizing the reduction of shadows is crucial for open surgery. **Good light quality (color temperature and CRI)** is important to accurately distinguish tissues and organs.



### Minimally Invasive Surgery

Procedures using laparoscopic instruments rely on the visual acuity of video displays. Eliminating glare and **maintaining a high contrast on the display** is essential. Ambient overhead lighting is typically turned off during these procedures.

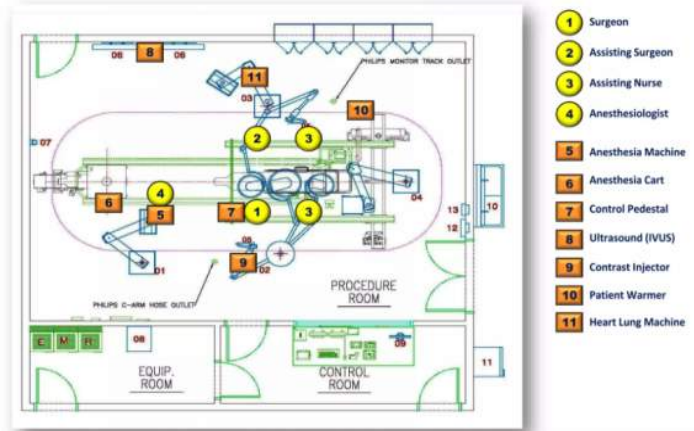
39th Annual FPC Seminar + Expo

30



## Surgical Team Lighting Considerations

- OR lights are frequently adjusted, notably every 7.5 minutes, and 50% of previously sterile light handles have been shown to foster bacterial growth.
- In 97% of the cases, the performing surgeon paused his/her task to complete the lighting adjustment.
- Such distractions have a marked effect on surgeon performance, with experts citing that a 1-minute distraction may result in a 23-minute delay in cognitive processing and focus. Distractions could lead to negative outcomes with respect to patient safety and quality of care.



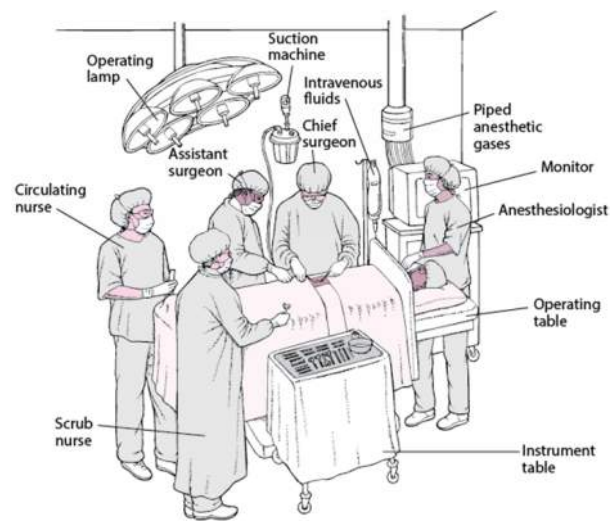
Resource: The Surgery Journal Vol. 6 No. 2/2020

## 39th Annual FPC Seminar + Expo

31

## Surgical Team Lighting Considerations

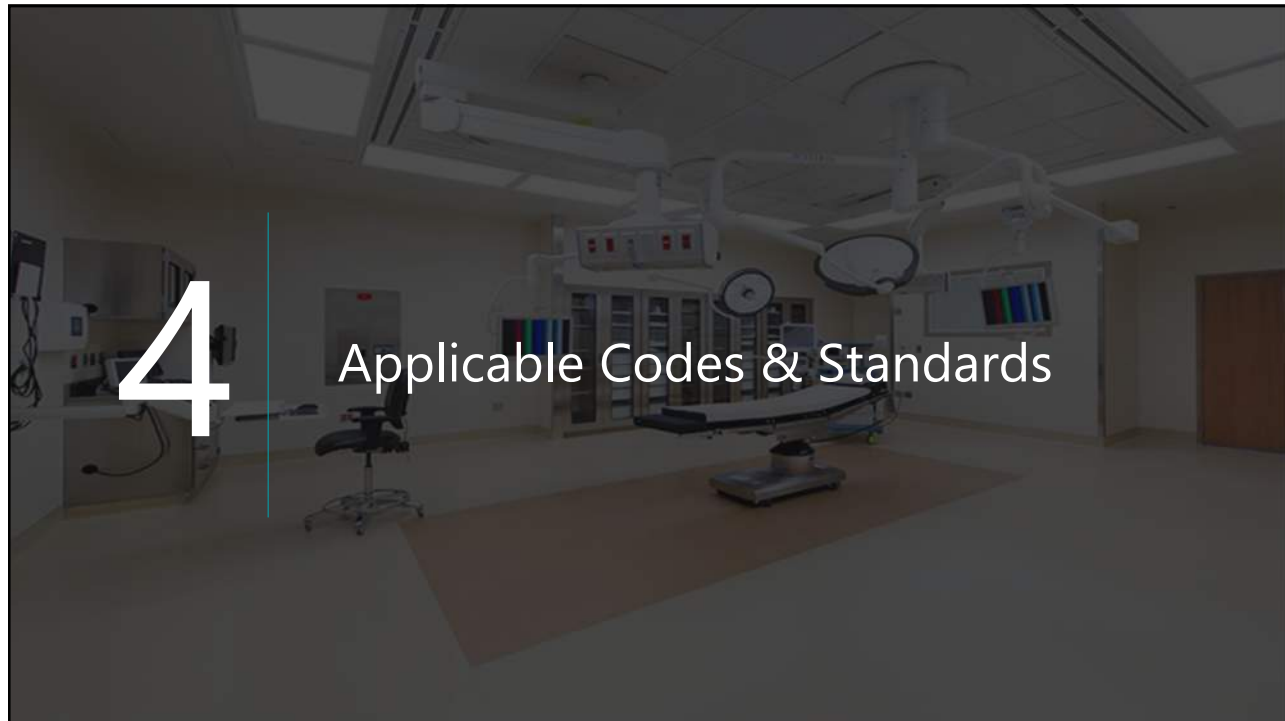
The average cost per minute in the OR can be up to \$100 per minute, not including the surgeon's cost, so efficiency and time savings can result in an increase in facility profitability. (2020 article)



Resource: The Surgery Journal Vol. 6 No. 2/2020

## 39th Annual FPC Seminar + Expo

32



33

## What Do the Codes Say



### 2.1-7.2.3.3 Ceilings

#### 2.1-7.2.3.3(3) Restricted Areas

*These include area such as operating rooms, Class 3 imaging rooms, PE rooms, and sterile compounding and hazardous drug compounding pharmacies.*

- (a) Ceilings in restricted areas shall be of monolithic construction.
- (b) ...
- (c) Ceiling finishes shall be scrubbable and capable of withstanding cleaning and/or disinfecting chemicals.
- (d) All access openings in these ceilings shall be gasketed.

39th Annual FPC Seminar + Expo

34

## What Do the Codes Say



### 2.1-8.3.4 Lighting

#### 2.1-8.3.4.1

Luminaires in patient areas shall have smooth, cleanable, impact-resistant lenses concealing the light source

#### 2.1-8.3.4.2

(4) Operating and delivery rooms

- (a) Operating and delivery rooms shall have general lighting in addition to special lighting units provided at surgical and obstetrical tables.
- (b) General lighting and special lighting shall be on separate circuits.

39th Annual FPC Seminar + Expo

35

## What Do the Codes Say



### 7.4.1 Operating Rooms

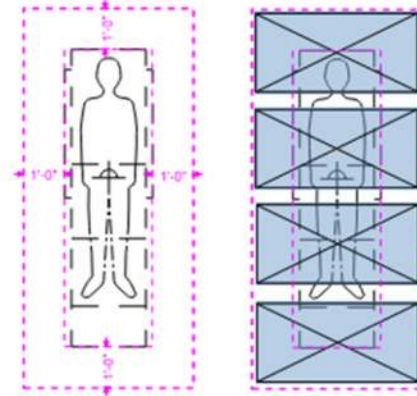
...These rooms shall be provided with a primary supply diffuser array this is designed as follows:

- (b) The coverage area of the primary supply diffuser array shall extend a minimum of 12 in. beyond the footprint of the surgical table on each side. Within the portion of the primary supply diffuser array that consists of an area encompassing 12 inch on each side of the footprint of the surgical table, no more than 30% of this portion of the primary supply diffuser array shall be used for nondiffuser uses such as lights, gas columns, equipment booms, access panels, sprinklers, etc.

39th Annual FPC Seminar + Expo

36

## What Do the Codes Say



39th Annual FPC Seminar + Expo

37

## What Do the Codes Say



### 6.3.2.6 Battery – Powered Lighting Units

6.3.2.6.1 One or more battery-powered lighting units shall be provided within locations where deep sedation and general anesthesia is administered.

6.3.2.6.2 The lighting level of each unit shall be sufficient to terminate procedures intended to be performed within the operating room

6.3.2.6.3 The sensor for units shall be wired to the unswitched portion of branch circuit(s) serving general lighting within the room.

6.3.2.6.7 Units shall be capable of providing lighting for 1-½ hours.

6.3.2.6.8 Units shall be tested monthly for 30 seconds, and annually for 30 minutes.

39th Annual FPC Seminar + Expo

38

## What Do the Codes Say



### Chapter 3 Definitions

**3.3.15 Battery-Powered Lighting Units.** Individual unit equipment for backup illumination consisting for a rechargeable battery, battery-charging means, provisions for one or more lamps mounted on the equipment, or with terminals for remote lamps, or both, and relaying devices arranged to energize the lamps automatically upon failure of the supply to the unit equipment. [70, 2020] (ELS)



UL 924

39th Annual FPC Seminar + Expo

39

## What Do the Codes Say



### 449.3.11.8

Operating and delivery rooms shall have general lighting for the room in addition to local high intensity, specialized lighting provided by special fixtures at the surgical and obstetrical tables. Each special lighting unit for local lighting at the tables shall be connected to an independent circuit and shall be powered from the critical branch. A minimum of one general purpose lighting fixture shall be powered from a normal circuit in an operating room, delivery or similar room.

39th Annual FPC Seminar + Expo

40

## What Do the Codes Say



### FGI

**A2.1-8.3.4** Required levels for illumination in health care facilities should comply with the horizontal illuminance targets for visual observers where at least half the patient population is between the ages of 25 and 65, as found in Table 2 of Illuminating Engineering Society (IES) publication ANSI/IES RP-29: *Lighting Hospitals and Healthcare Facilities*. Design should consider light quality as well as quantity for effectiveness and efficiency. While light levels in the IES publications are referenced herein, those publications include other useful guidance and recommendations which the designer is encouraged to follow.

### ANSI/IES RP-29-22

#### RECOMMENDED PRACTICE: LIGHTING HOSPITAL AND HEALTHCARE FACILITIES

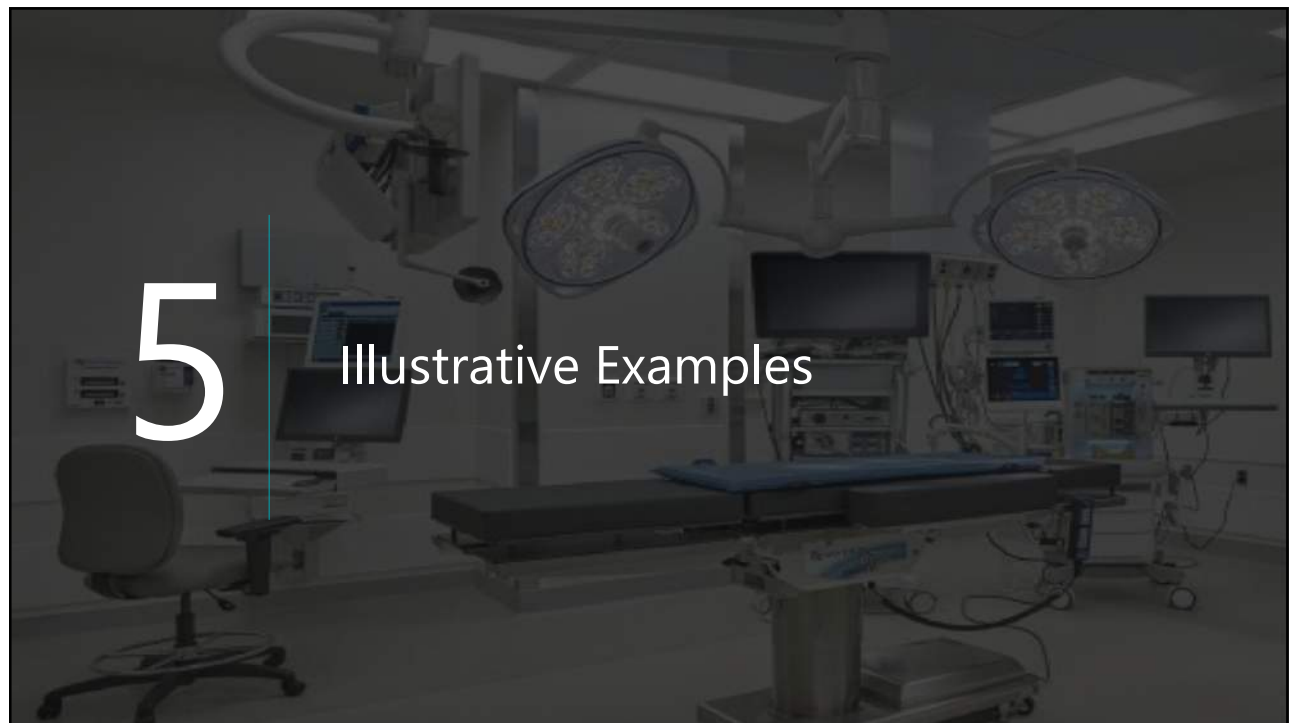
OR Cleanup/Setup: 100fc

OR General: 200fc

OR: Table: 300fc

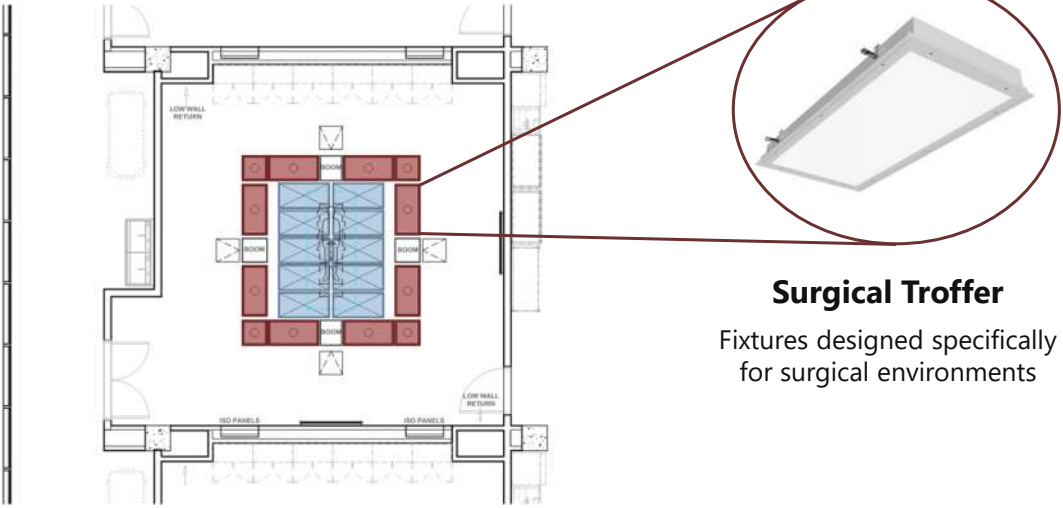
39th Annual FPC Seminar + Expo

41



42

## Lighting the OR: The Classic



**Surgical Troffer**  
Fixtures designed specifically for surgical environments


**39th Annual FPC Seminar + Expo**

43

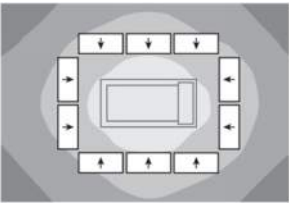
## Lighting the OR: The Classic

### Features

- CRI 90 (or better)
- 4000K – 5000K CCT (match the Surgical Task/ Boom light)
- Dimmable to at least 1%
- Lensed; sealed and gasketed
- IP65 rating (or better)
- MIL-STD-461G (for EMI protection)
- Asymmetric distribution if installing in ring pattern



**Surgical Troffer**

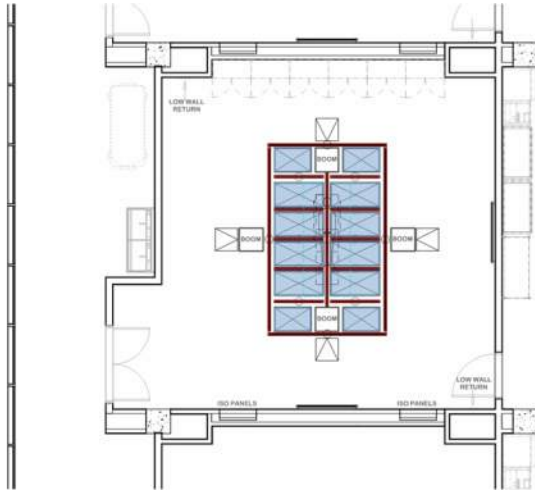


**39th Annual FPC Seminar + Expo**

44



## Lighting the OR: The New



**Modular/Prefab Ceiling Systems**

39th Annual FPC Seminar + Expo

45

## What Do the Codes Say



### 2.1-7.2.3.3(3) Restricted Areas

- (b) Use of a modular or prefabricated laminar (or controlled) flow ceiling systems shall be permitted in operating rooms and Class 3 imaging rooms/hybrid operating rooms in place of monolithic ceiling construction where the following conditions are met:
  - (i) Seams and access doors shall be continuously gasketed.
  - (ii) The assembly shall be constructed with a structural frame engineered and rated for the system supported and equipped with seismic bracing, as required.
  - (iii) Accommodations shall be made to provide access for testing, maintenance, and replacement of items.
  - (iv) Diffuser arrangement and airflow design shall be compliant with ANSI/ASHRAE/ASHE Standard 170.
  - (v) Devices and related controls shall be UL/ETL labeled, as applicable

39th Annual FPC Seminar + Expo

46

## What Do the Codes Say



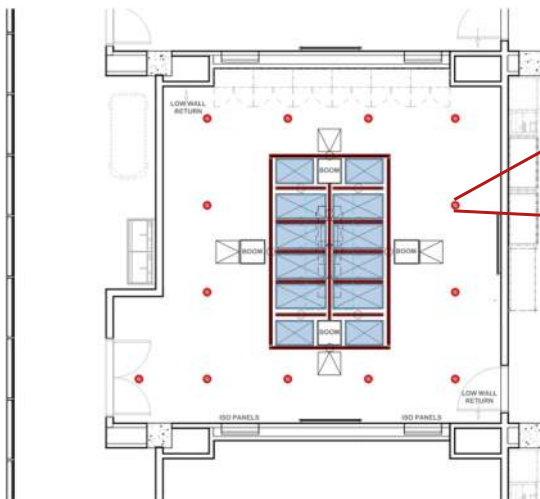
### Appendix commentary:

Modular laminar flow ceiling systems. These complex assemblies are built in a factory setting, which provides a higher level of quality control than on-site construction. Systems and equipment such as ductwork and other air delivery systems, sprinklers, lighting, boom mounts, and ceilings are engineered and fabricated off-site, minimizing late changes (and related design inadequacies) due to field conditions and miscoordination. Benefits include concurrent construction, less risk, less waste, faster installation, control of quality and a support structure that is integral to the design of the assembly.

39th Annual FPC Seminar + Expo

47

## Lighting the OR: Ambient/Task



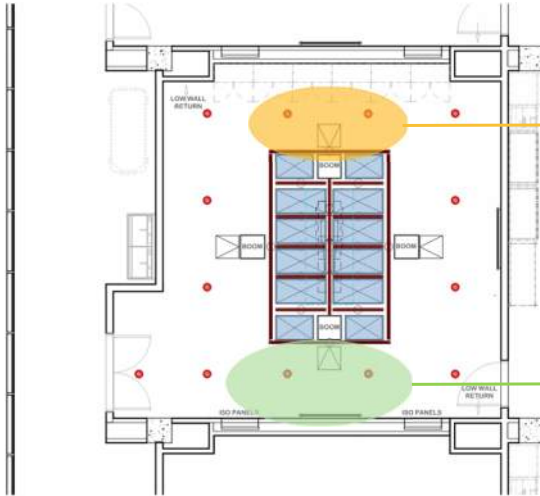
### Surgical Downlight

- Locate fixtures around the perimeter and in areas of circulation
- Same selection criteria as troffers

39th Annual FPC Seminar + Expo

48

## Lighting the OR: Ambient/Task



Anesthesia Work Area

Consider placing lights for specific areas/functions on separate switches/dimmers

Circulating Nurse Area

39th Annual FPC Seminar + Expo

49

## Lighting the OR: Ambient/Task



*Falls, slips and trips represented the second most common nonfatal occupational injury event to registered nurses and accounted for 25% of all injuries and illnesses occurring to nurses. (1)*



*Of the 379 facility managers we recently surveyed, 60% say a staff member or a surgeon has sustained an injury from slipping or falling in their ORs. (2)*



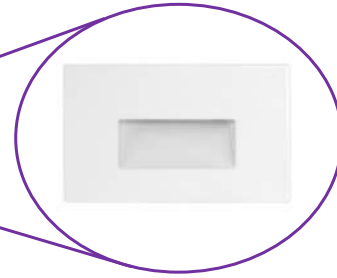
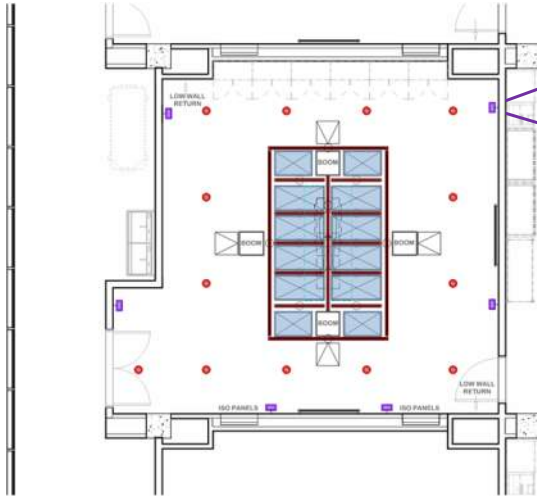
(1) <https://www.bls.gov/opub/mlr/2018/article/occupational-injuries-and-illnesses-among-registered-nurses.htm>

(2) <https://www.aorn.org/outpatient-surgery/article/2017-October-prevent-slips-trips-falls-in-the-or#:~:text=From%20cables%20and%20cords%20to,cords%20or%20slip%20on%20fluid.>

39th Annual FPC Seminar + Expo

50

## Lighting the OR: Ambient/Task



### Perimeter Low Level Lighting

A.K.A. Step Light; similar to Patient Room night lights

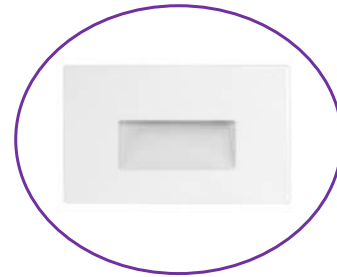
39th Annual FPC Seminar + Expo

51

## Lighting the OR: Ambient/Task

### Features

- Consider fixtures that are flush with the wall to avoid damage from movable equipment.
- Select fixtures without grooves/ledges to facilitate cleaning
- Consider fixtures with integral photocells to turn off lights automatically when there is sufficient ambient light.
- Provide wall switch for use as an override in case lighting causes a distraction



### Perimeter Low Level Lighting

39th Annual FPC Seminar + Expo

52

## Lighting the OR: Ambient/Task



39th Annual FPC Seminar + Expo

53

## Lighting the OR: The Natural

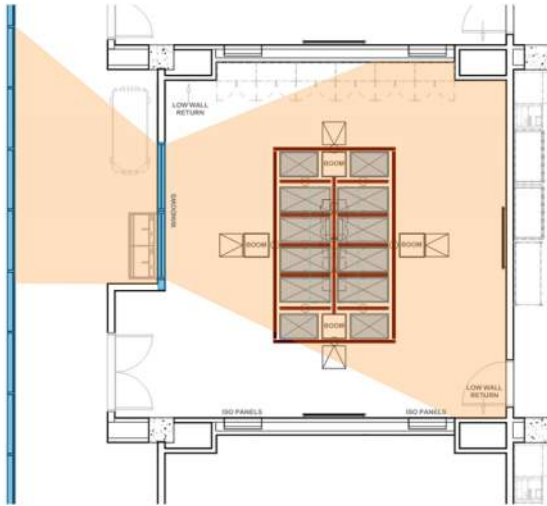


39th Annual FPC Seminar + Expo

54



## Lighting the OR: The Natural



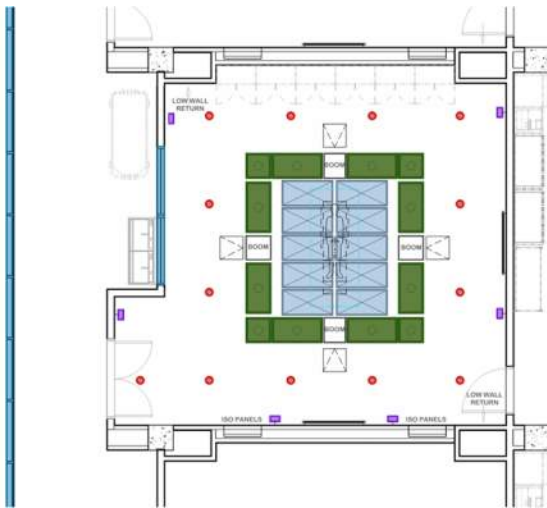
Windows should be flush with wall or have sloped sills to prevent accumulation of dust

Integral type blinds should be provided to provide visual privacy and shade when needed.

39th Annual FPC Seminar + Expo

55

## Lighting the OR: Going Green



39th Annual FPC Seminar + Expo

56

## Lighting the OR: Going Green



**What:** 520-540nm wavelength 'green' spectrum

**When:** Minimally Invasive Surgery

**Why:** Reduces reflected glare  
 Reduces washout of monitors  
 Reduces eye fatigue  
 Reduces afterimage affect  
 Provides ambient lighting for support staff

39th Annual FPC Seminar + Expo

57

## Lighting the OR: Going Green

Operating rooms often are too bright. The two ORs where the trial was held had nine fluorescent fixtures. The light meter reading with the white lights on was nearly 1,800 lux; with the lights off, it was 3.44 lux. (A typical living room, by contrast, is about 50 lux, Dr. Goldman said.) Ryan Forde, an engineer at MGH who helped lead the project, said most ORs have two or three switches and no dimmers, probably because of limitations with the ballast.

Monitors have improved dramatically over the years to cut the glare, but more was needed. The human eye is most sensitive to the color green, said Dr. Goldman, a member of the editorial board of *Anesthesiology News*. So Mr. Forde rewired some switches and slipped green sleeves over just four bulbs (as opposed to 42 under "white" conditions). Under these conditions, the average light reading was 86 lux, just 5% of that under white lights.



### Seeing the (Green) Light In the OR

*Researchers take on poor visibility during surgery*

Operating rooms that are too dark should go green, according to a new study that purposely sheds little light on a safety issue.

The research, presented at the 2011 annual meeting of the American Society of Anesthesiologists (abstract 1660), found that rather than shutting off the overhead fixtures in the OR—a common practice that gives surgeons the clearest view of monitors—bathing the room in a dim green light accomplishes the same goal more safely and without forcing others to feel as if they are working in a tomb.

see **green** page 16

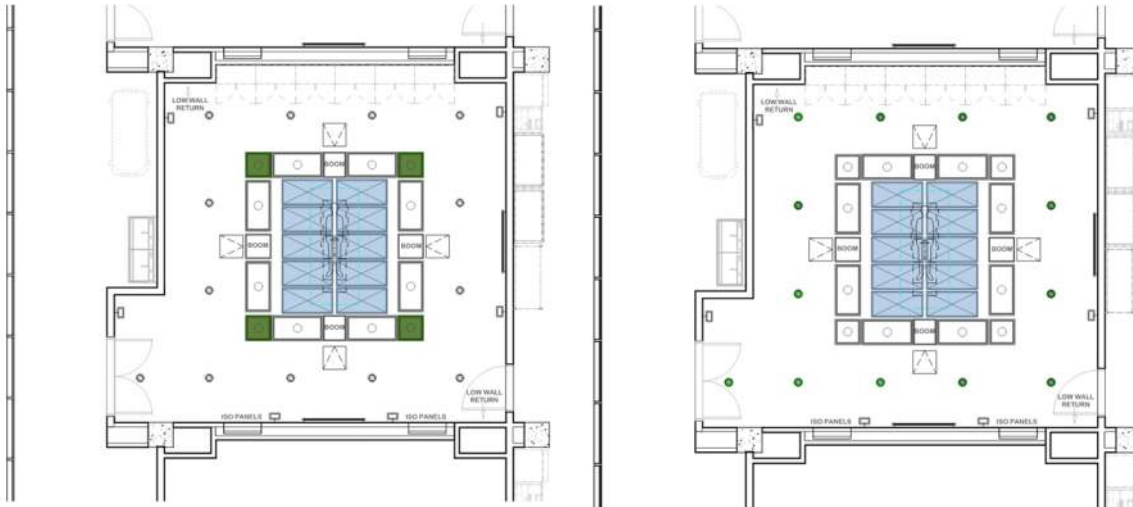


39th Annual FPC Seminar + Expo

58



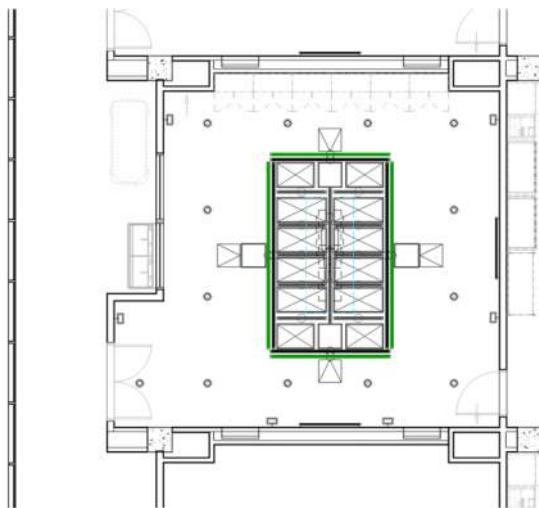
## Lighting the OR: Going Green



39th Annual FPC Seminar + Expo

59

## Lighting the OR: Going Green



Most modular ceiling manufacturers can also offer green lighting options

39th Annual FPC Seminar + Expo

60

## Lighting the OR: Tuning the Light



39th Annual FPC Seminar + Expo

61

## Lighting the OR: Tuning the Light

- Available from multiple manufacturers for troffers and downlights
- Typically an option from most modular ceiling manufacturers as well
- Typically uses 0-10V control similar to the industry standard commercial dimmers
- Can also be setup for pre-programmed scenes



0-10V

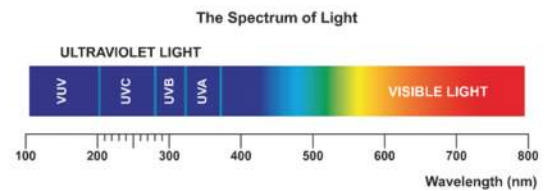
39th Annual FPC Seminar + Expo

62

## Lighting the OR: Light for Disinfection



- UVC
- Near UV
- Continuous Disinfection



39th Annual FPC Seminar + Expo

63

## Lighting the OR: Light for Disinfection

- Traditional germicidal UV operates at 254nm wavelength
- Unfiltered UVC is harmful to humans
- UVC Robots include integral motion detectors as a safety shutoff
- Permanently mounted ceiling UVC fixtures require similar motion safety and engineering controls

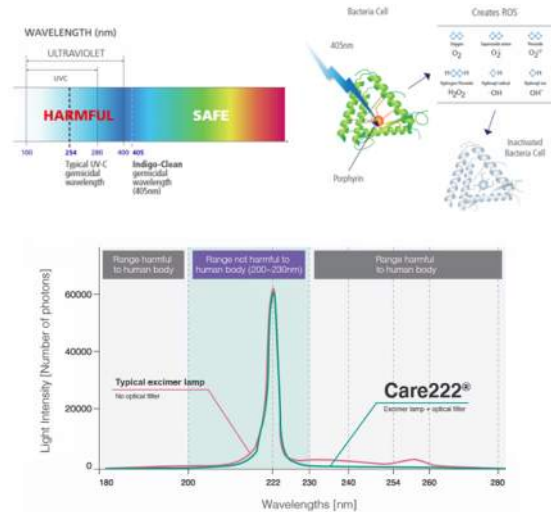


39th Annual FPC Seminar + Expo

64

## Lighting the OR: Light for Disinfection

- Several manufacturers offer lights for continuous disinfection using near UV or filter UV technology
- These products are UL listed and found safe to operate in occupied areas
- Meant to supplement other disinfection/sterilization protocols (not as a replacement to standard terminal cleaning)



39th Annual FPC Seminar + Expo

65

## Key Takeaways

- 1 An understanding of basic lighting terminology in the OR environment
- 2 Various types of procedures and their lighting requirements
- 3 Remember the 2022 FGI lighting code requirements
- 4 Design with flexibility in mind
- 5 In your next project look to integrating natural light into previously dark spaces to promote well-being and staff satisfaction.

39th Annual FPC Seminar + Expo

66

## ▶ Thank you!

*Alexandra Andrei:* [aandrei@array-architects.com](mailto:aandrei@array-architects.com)  
561.287.9595

*Michael Steward:* [michael.steward@tlc-eng.com](mailto:michael.steward@tlc-eng.com)  
407.487.1264

Improving Operating Rooms Visual Comfort for Surgeons and Nurses