



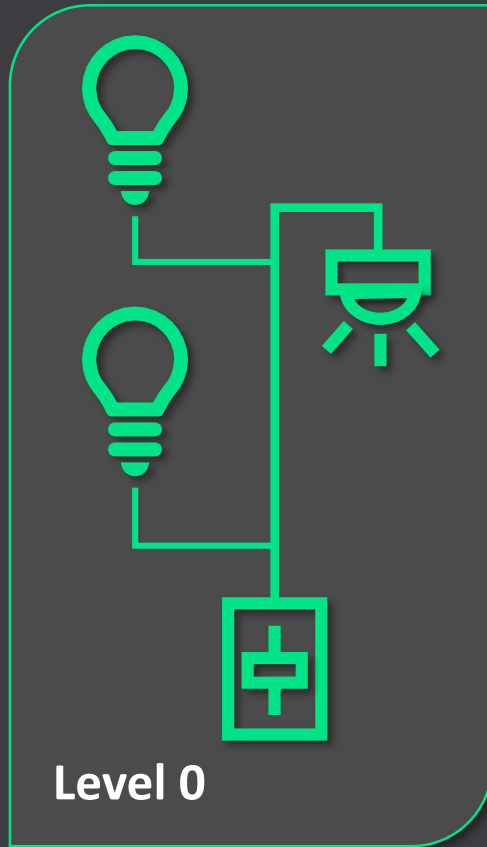
**Reliability Factors In Multi-Channel,
Connected Lighting Systems**
DoE Lighting Conference, 2020

Ben Sweet-Block, System Architect

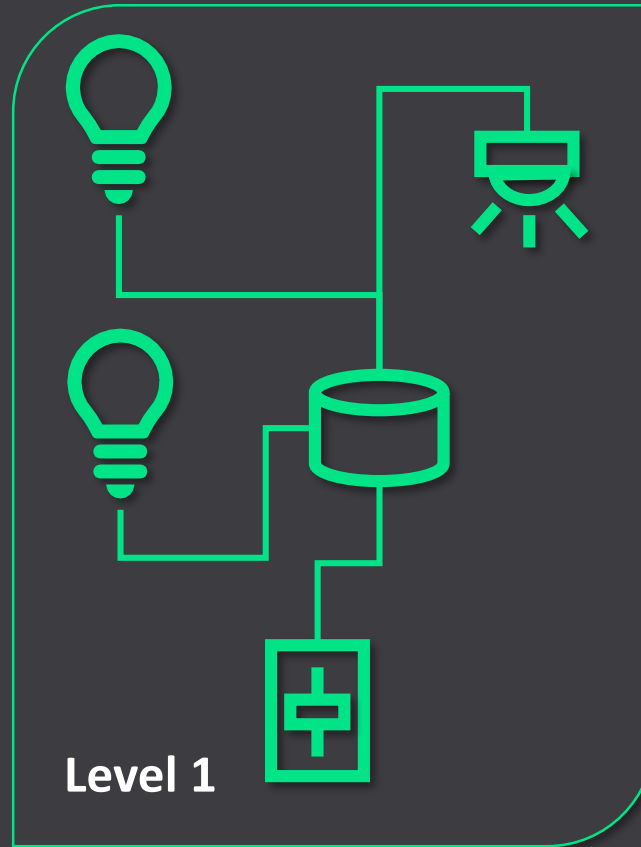


Background

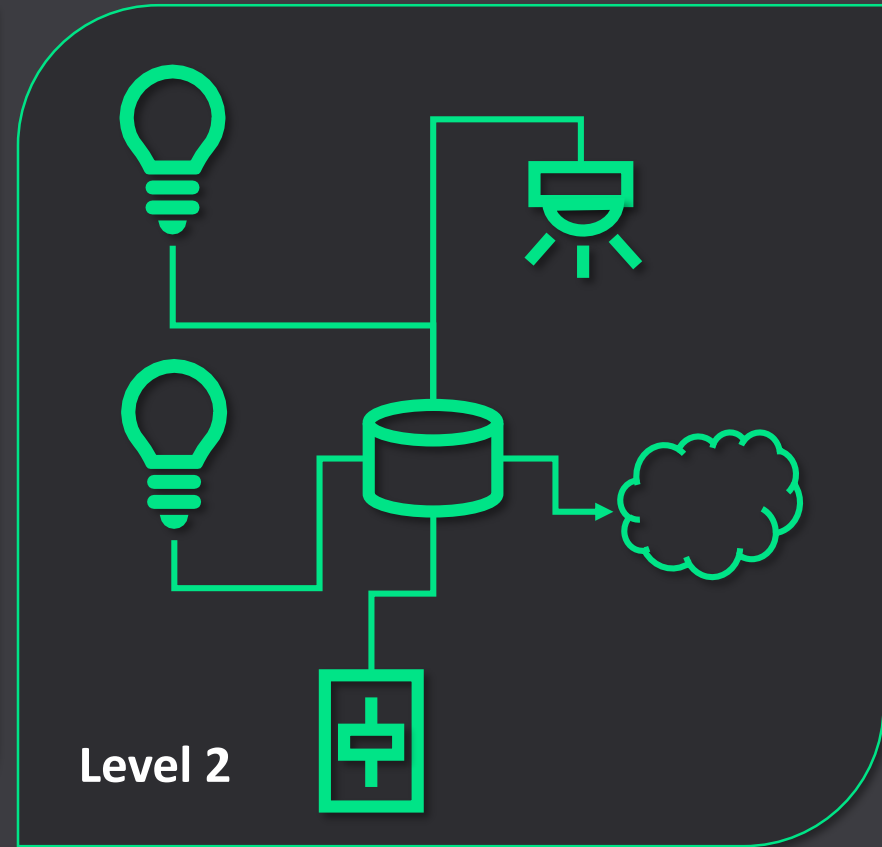
Systems



Direct connection



Scalable, but closed system

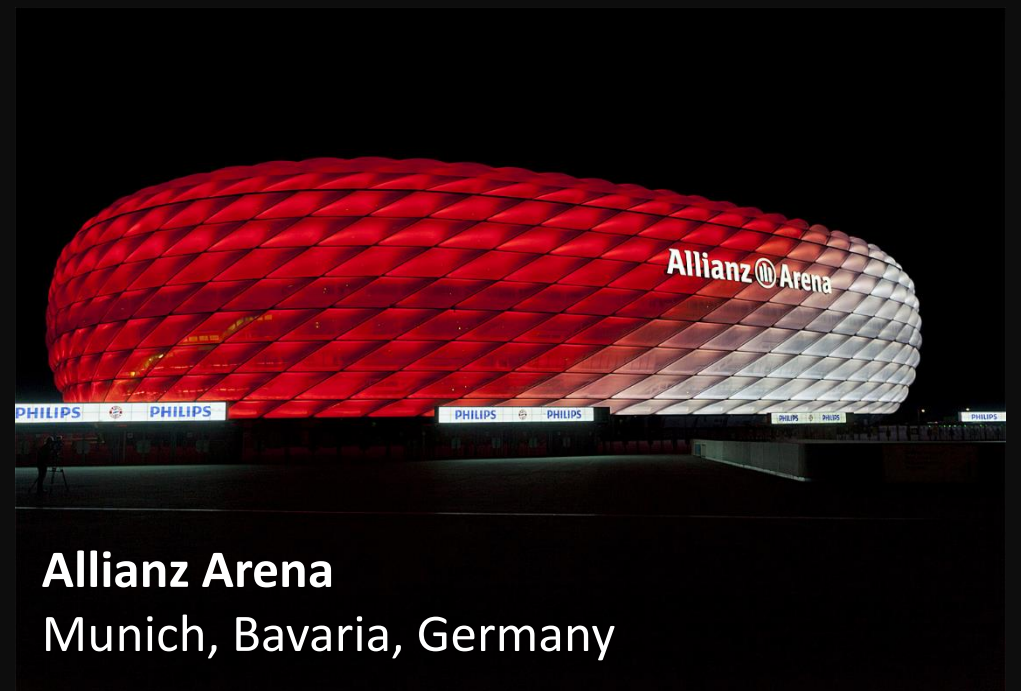


Outward-connected system

Application Context



Pearl River
Guangzhou, China



Allianz Arena
Munich, Bavaria, Germany



**Galeries Royales
Saint-Hubert**
Brussels, Belgium



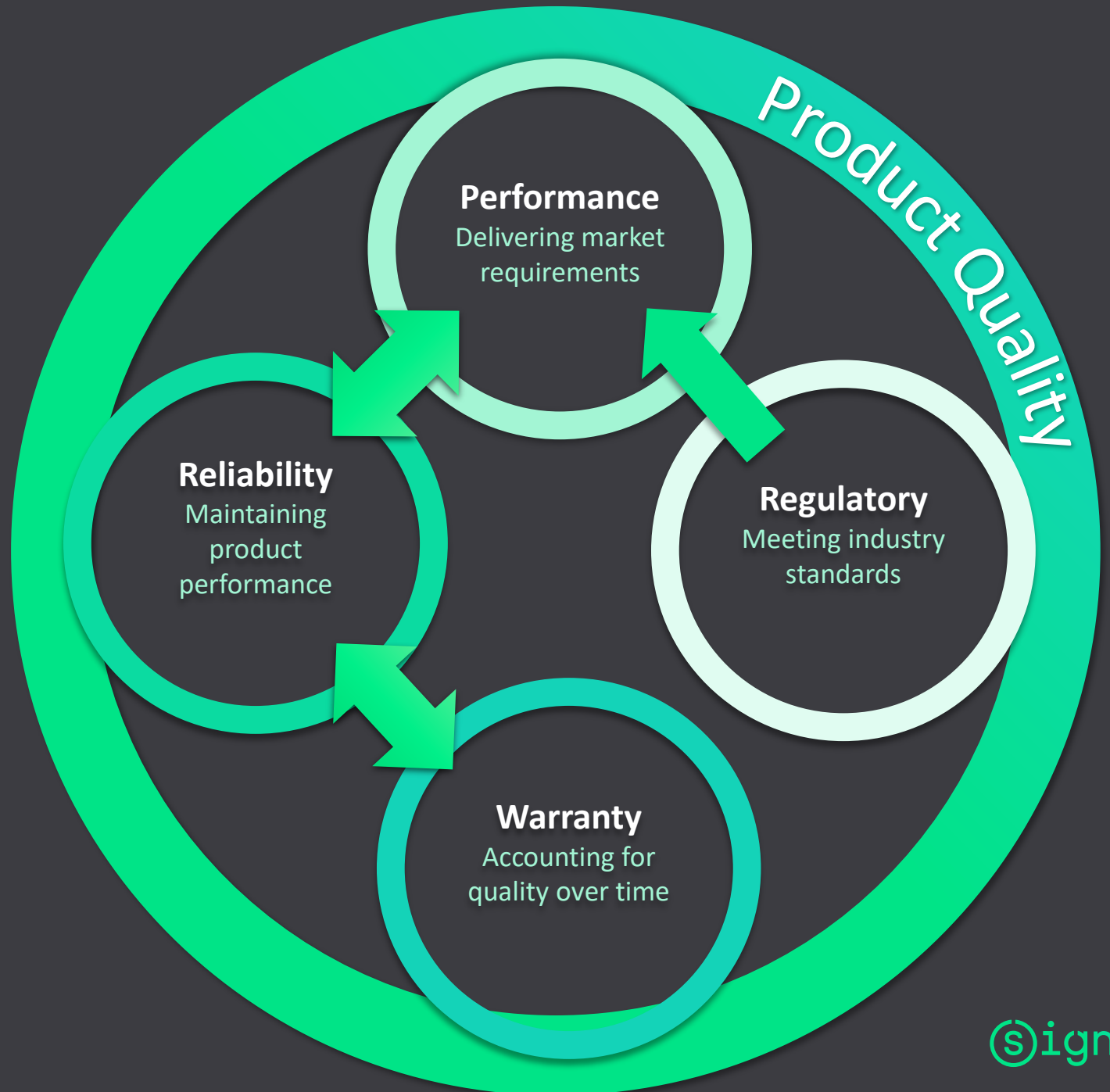
Inputs To Product Quality

Product is defined by its **PERFORMANCE**

REGULATIONS and **STANDARDS** influence market requirements, thus influence **PERFORMANCE**

RELIABILITY is maintaining performance over time

WARRANTY can drive or be driven by market requirements



Product Reliability

Factors of Reliability

Product features and functions...

1

Color Precision

Color Accuracy

Spectral Consistency

Color Over Angle

Dimming Performance

Color Saturation

Optical Control

Surge Immunity

Efficacy @ x,y

Scalability

Luminous Flux

Durability

Data Integrity

Standby Power

Communication Protocol

Power Factor

Mis-wire Protection



Events

2

Natural Environment

Installation Conditions

System Interactions

Time

3

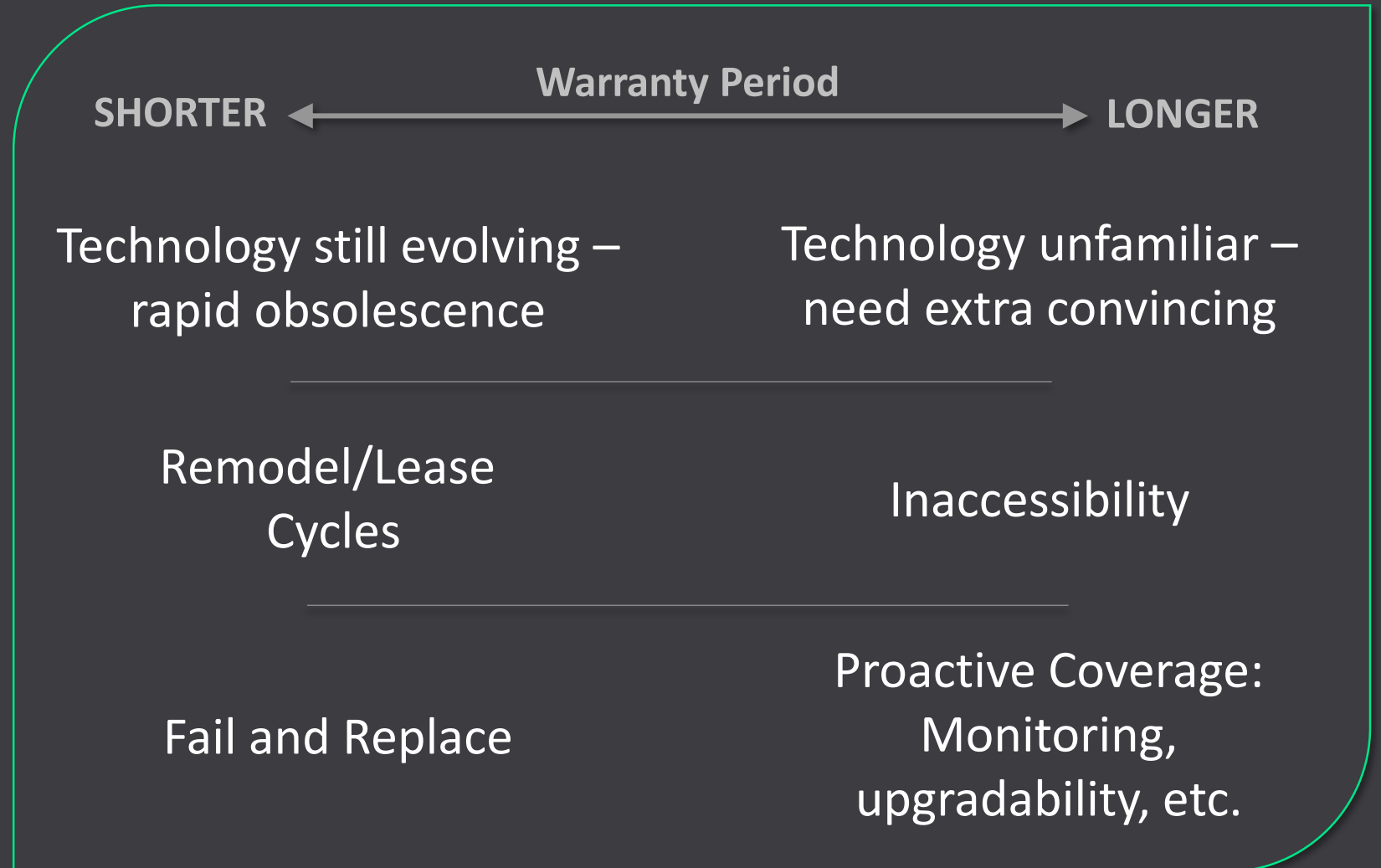
Reliability
Maintaining product performance

Time Factor on Warranty

Expectations shift in opposite directions with new technologies

External factors have big influence

Design for Warranty strategy



Sensitivity and Awareness

Sensitivity: multi-channel systems are more complex (more data, more components, more drivers, more interdependence with installation conditions...) which generates more opportunities for failure

Awareness: multi-channel systems can generate more failure effects

- System level failures (e.g., data/communications) can generate widespread effects
- Color differences more visible than brightness differences
- Connected systems enable Monitoring; monitoring generates more data for better diagnostics, but also generates more “failures”



How Is Reliability Different In a Multi-Channel System?

Product features and functions...

Color Precision	Scalability
Color Accuracy	Luminous Flux
Spectral Consistency	Durability
Color Over Angle	Data Integrity
Dimming Performance	Standby Power
Color Saturation	Communication Protocol
Optical Control	Power Factor
Surge Immunity	Mis-wire Protection
Efficacy @ x,y	

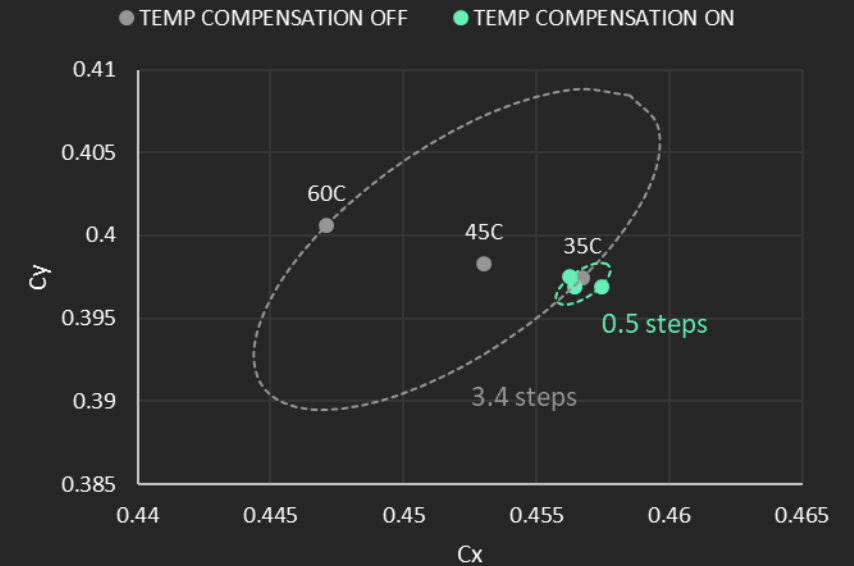
Starts with the product **PERFORMANCE**

- To meet color performance targets, design must account for:
 - Control resolution to provide color over dimming range
 - Current variation and impact on flux and chromaticity
 - Thermal management
 - Chromaticity and flux of primaries (calibration)
 - Control system
 - Output and efficacy impact @ calculated metamer
 - Spectral impact of color point calculation algorithm
 - LED selection

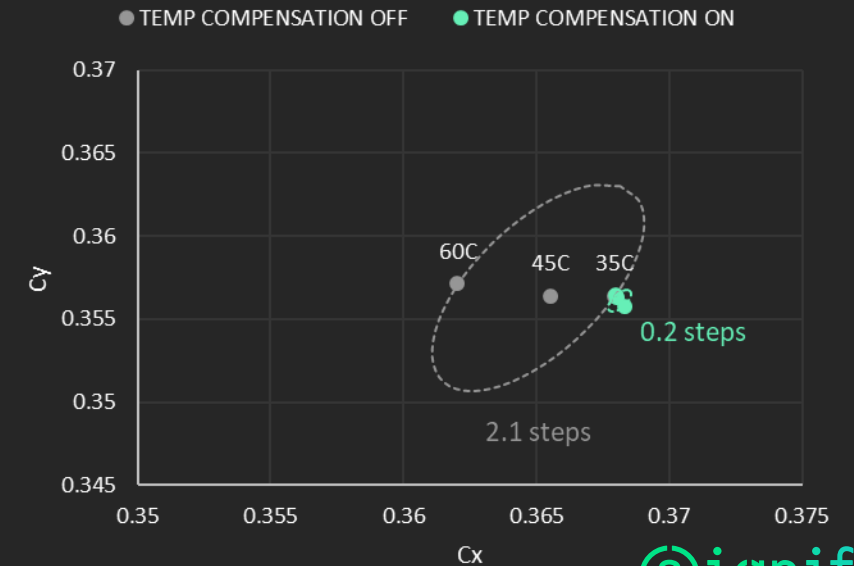
How Is Reliability Different In a Multi-Channel System?

- Over temperature –
 - Flux can change due to conversion efficiency in LED
 - Chromaticity shift of primaries
 - Flux can change due to inconsistent drive current with temperature

~2700K with 4ch: 30C Temperature Variability



~4000K with 4ch: 30C Temperature Variability



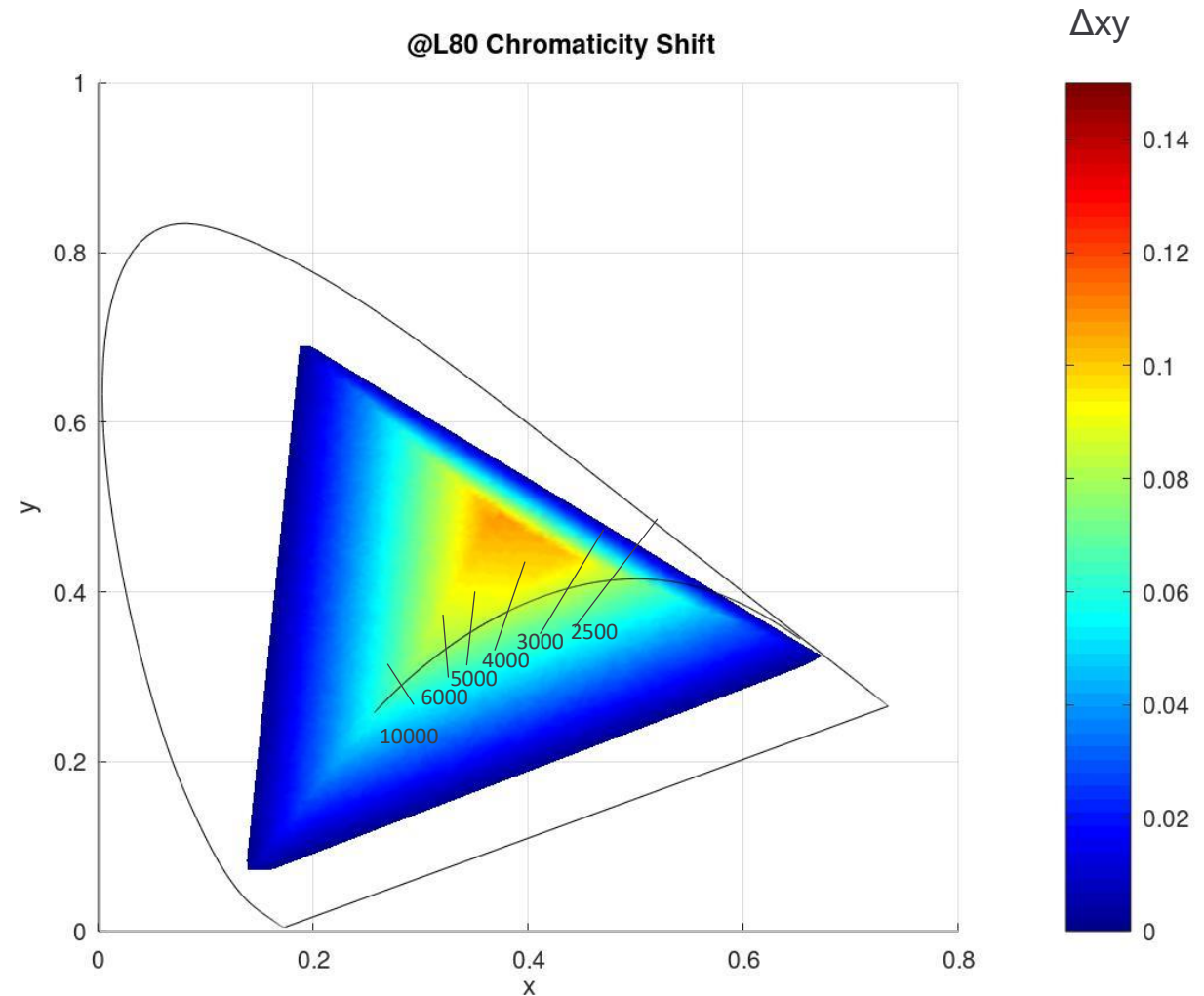
How Is Reliability Different In a Multi-Channel System?

- Over time –
 - Chromaticity shift of primaries
 - Small for direct colors (typical $<0.001 \Delta u'v'$)
 - Larger for PC colors (e.g. PC Amber typical $>0.001 \Delta u'v'$)
 - Net result – small impact

How Is Reliability Different In a Multi-Channel System?

- Over time –
 - Lumen depreciation
 - Lumen depreciation of phosphor converted LEDs is greatest contributor to color shift.
 - Sensitivity is greater – L90 is significant in multi-channel system.
 - Phosphor converted component *may* see meaningful depreciation within lifetime, but depends on use case.

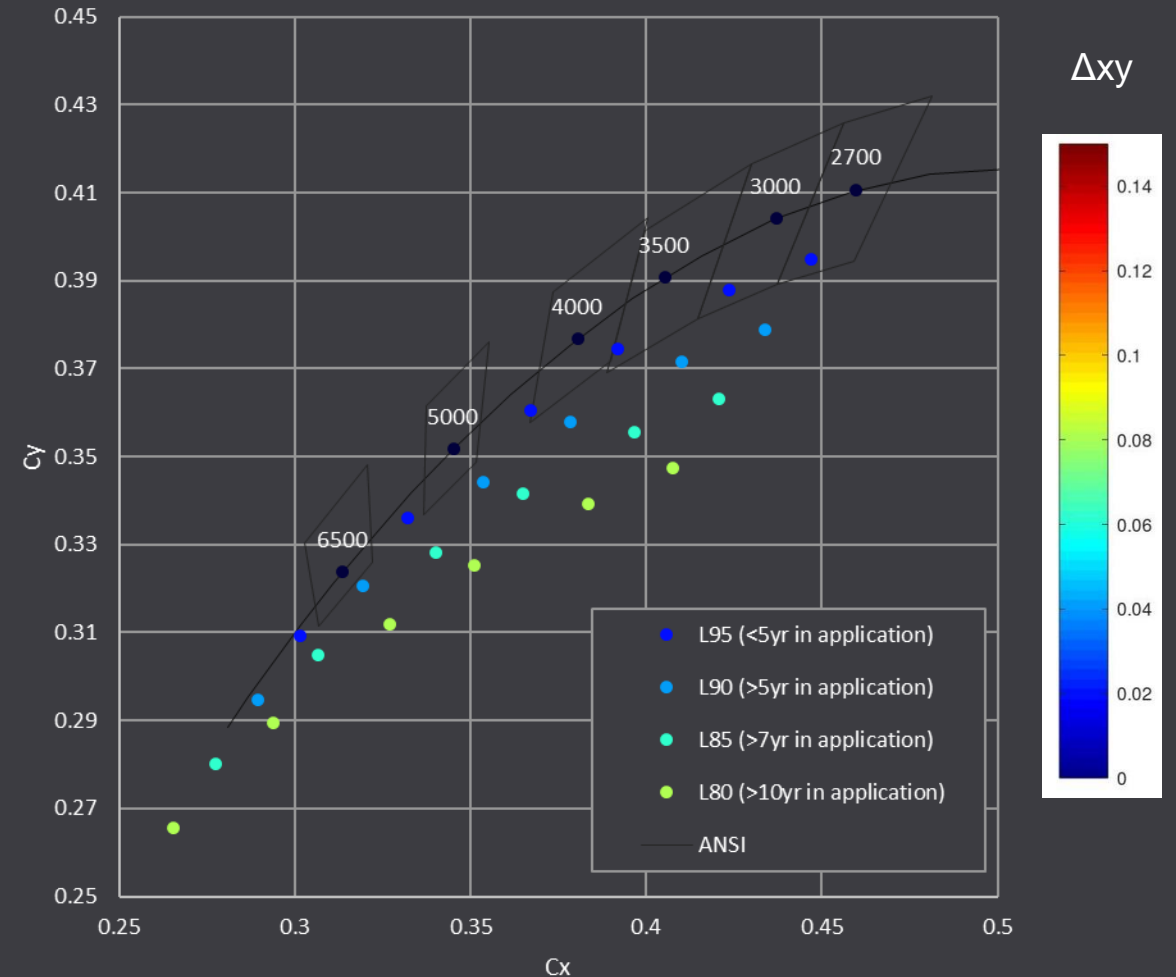
~50k hours : >10yr typical



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Uncompensated Chromaticity Shift From Flux Loss In PC LED In "RGBW" Color System



Conclusions

1. Multi-channel lighting systems have more opportunity for failure (sensitivity) and often greater visibility (awareness).
2. Multi-channel lighting systems enable installations and usage that may demand longer life-time and/or expected warranty periods.
3. Product performance must be separated from product reliability.
4. Design for multi-channel product performance imposes greater challenges for reliability.

Signify