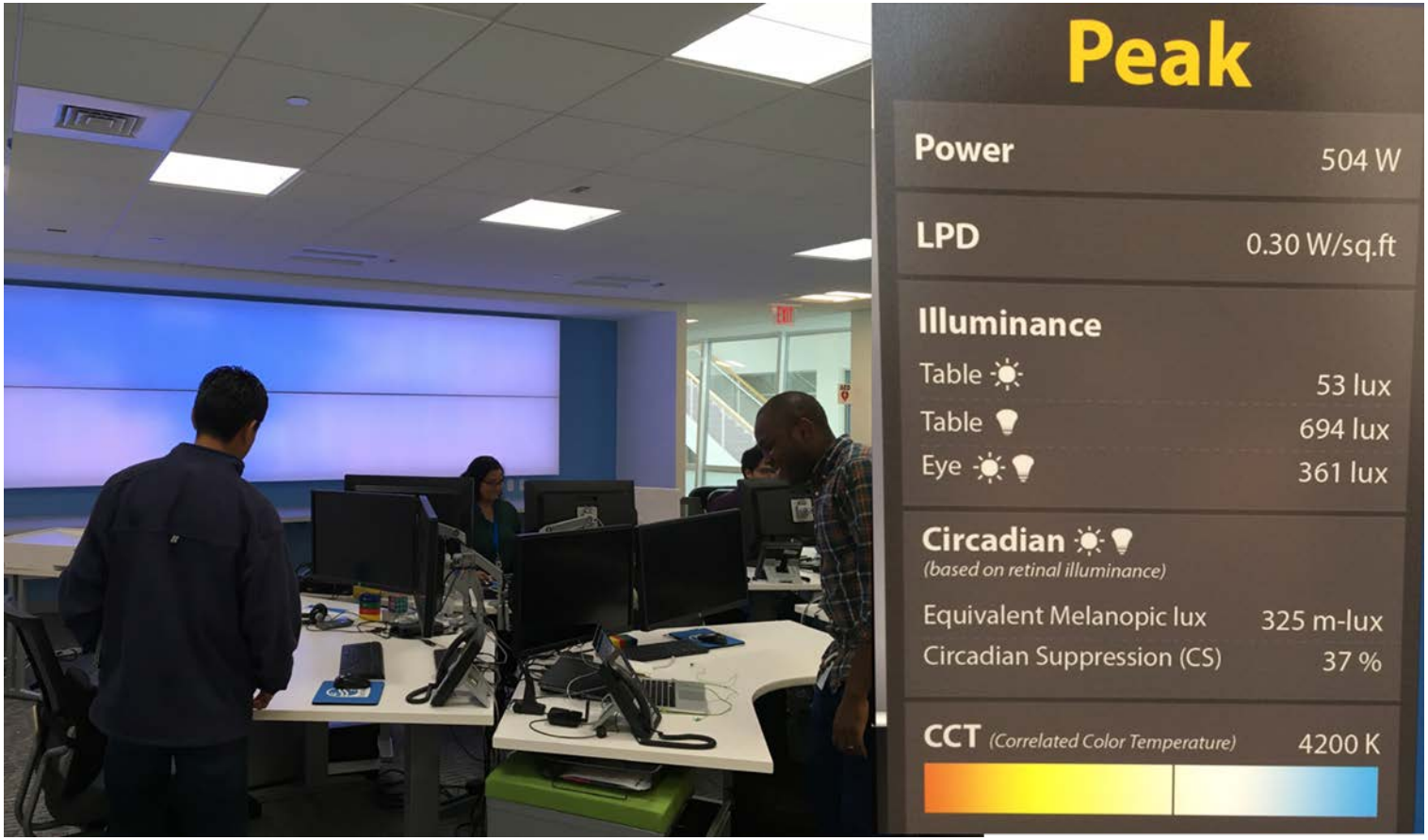
Innovative Office Lighting System with Integrated Spectrally Adaptive Control

2017 Building Technologies Office Peer Review



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Meg Smith, meg.smith@Philips.com
Philips Lighting Research, NA

Project Summary

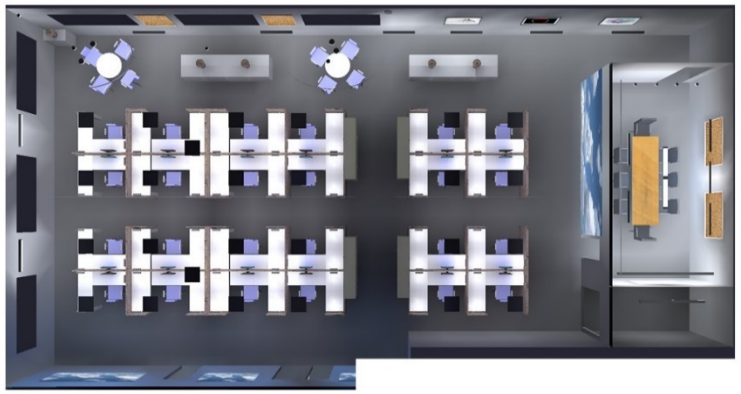
Timeline:

Start date: October 1, 2015

Planned end date: June, 30 2017

Key Milestones

1. Budget Year Review, September; 28 2016
2. Validation & Reporting Complete; June 30, 2017



Budget:

Total Project $ to Date: 602,543.16

- DOE: $451,907.37
- Cost Share: $150,635.79

Total Project $:650,508

- DOE: $499,131.00
- Cost Share: $166,377.00

Project Outcome:

Provide an energy aggressive system capable modulating lighting intensity, distribution and spectrum in order to support the diverse image forming and non-image forming requirements to insure effectiveness and well-being in the workplace.

Purpose and Objectives

Problem Statement: *The office requires* an illuminated environment capable of meeting the range of visual and non-visual needs required to accommodate the generational, task, lifestyle and cultural diversity of the workplace, while continuing to deliver deep energy saving (40% more energy efficient than existing)

Target Market and Audience: The commercial office space represents 18% of commercial buildings and floor space. Lighting consumes 16% of the energy in offices, approximately 23kBt^2. We are estimating effective lighting power density of this system to be .45w/ft^2, reducing lighting power density by 45% compared code baseline ASHRAE 90.1 2010, resulting energy savings and reduced EUI's. Managers and owners of commercial offices value the facility efficiency and organizational effectiveness delivered by these systems.

Impact of Project: Demonstrating the implementation of an aggressive energy savings system capable of accommodating the diverse image forming and non-imaging forming needs of the activity based workplace, removes an obstacle of adoption, the perceived need to choose between comfort and efficiency. Additionally, we hope to increase confidence in system adoption by simplifying the deployment of these systems.

The outcomes of this project will be:

1. A low glare, low lumen output ambient/task lighting resulting in comfort and 40% energy savings

2. A protocol and communication agnostic software platform enabling cloud communication and consistent delivery of lighting application behaviors for both existing building and new construction , allowing specifiers and end users to be confident to adopt advance lighting systems.

3. We plan to complete the validation of this system and report the results by July 2017. After project completion, we will pilot the system in a variety of workplace environments to extend our understanding and match of development roadmaps to support market adoption. Long term outcomes will be measured by the success in the marketplace.

Approach

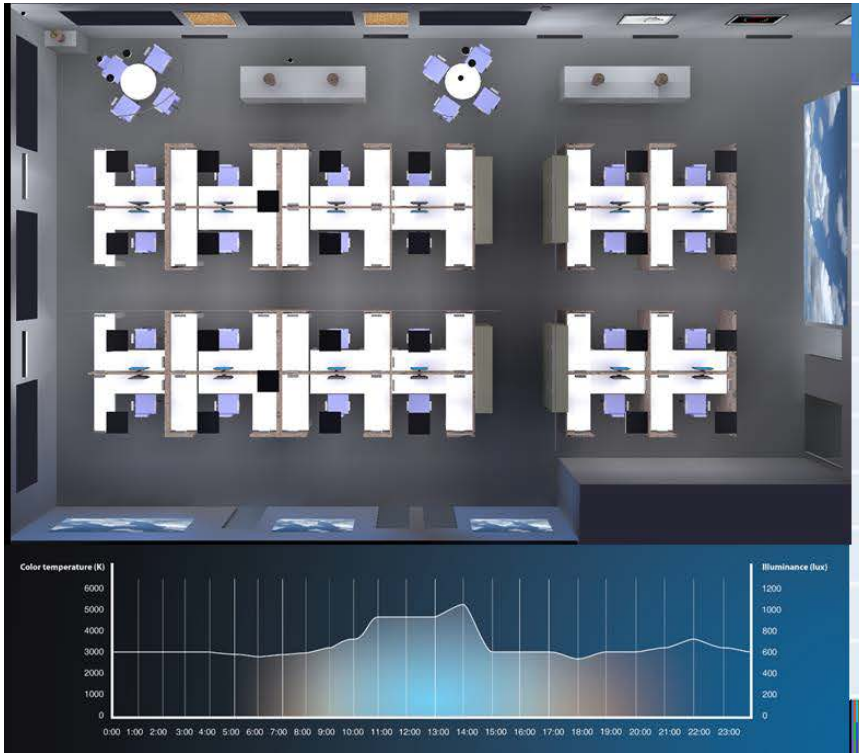
Approach: This project is one of two Application based projects awarded by the DoE SSL Research and Development Program in 2015. It was offered as Topic Area 3: LED Product Development – Novel LED Luminaire Systems for Option B: Innovative Office Lighting System. The stated goal *"to dramatically change the way light is delivered to people." in order to deliver the desired quality and quantity of light where and when it is needed and to realize the potential of SSL to reduce lighting energy*. We are following the path of stakeholder engagement from concept design through validation, pilots and commercialization in order to achieve this goal and accelerate market adoption.

Key Issues:

- Energy and Comfort (Reduced Glare and Balanced Brightness)
- Mitigation of the circadian "light- during- day -deficit" and the consequences of light at night
- Employee Effectiveness
- Personalization
- Open Protocols

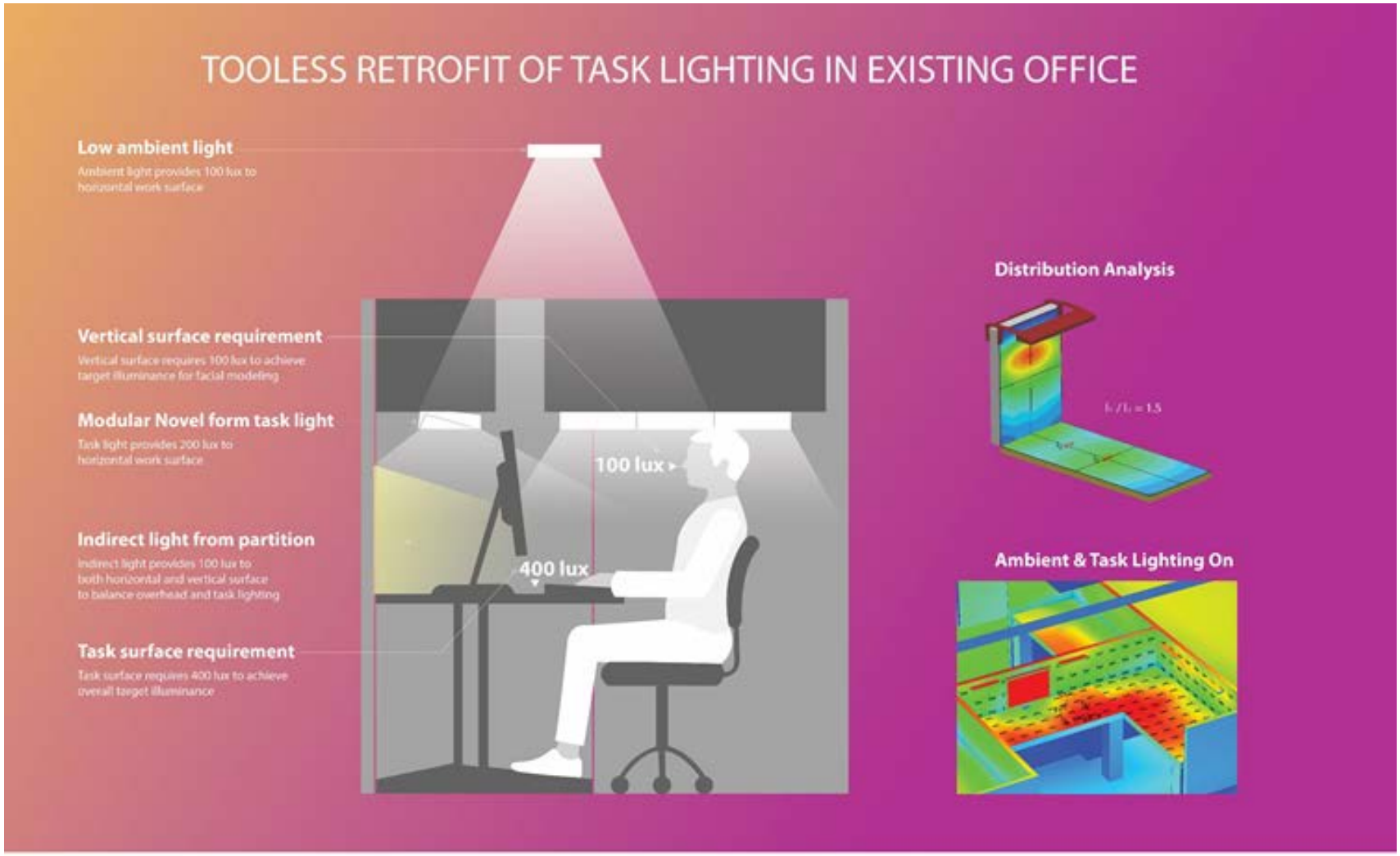
Distinctive Characteristics: A 3 level control hierarchy which organizes the delivery of illumination and is capable of variable modulation of intensity, distribution and correlated color temperatures.

Sensor Driven Dynamic CCT, Intensity and Distribution



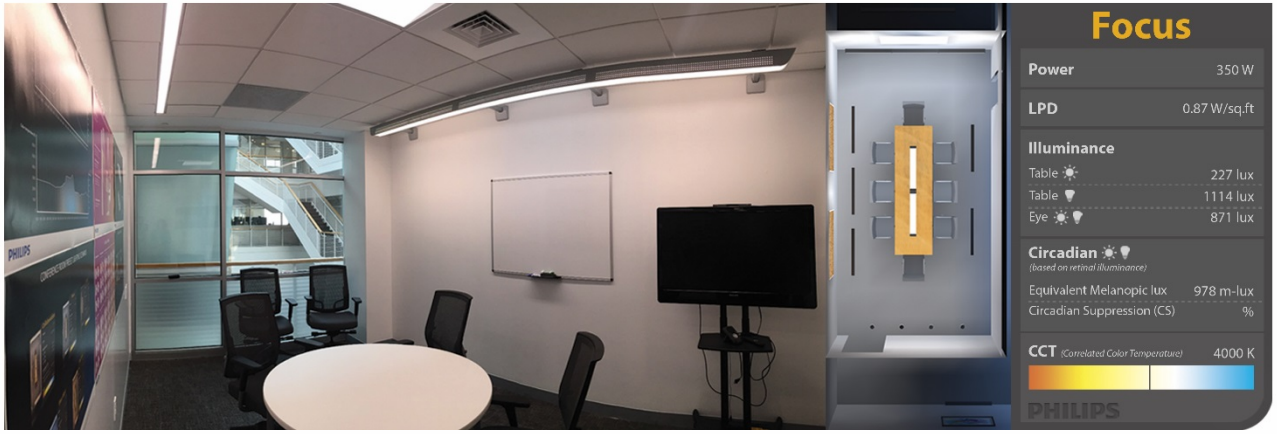
Open Office Silk Space 2x2 1700lm **only**			
CCT	Watts	LPD (Silk Space only)	Total Duration
2700K	21.41	0.325	4 hours
3000K	24	0.364	6 hours
3500K	23.26	0.353	1 hours
4100K	23.43	0.356	3 hours
5000K	22.77	0.346	1 hours
6500K	20.52		0 hours
		Average .35	Over 15 day

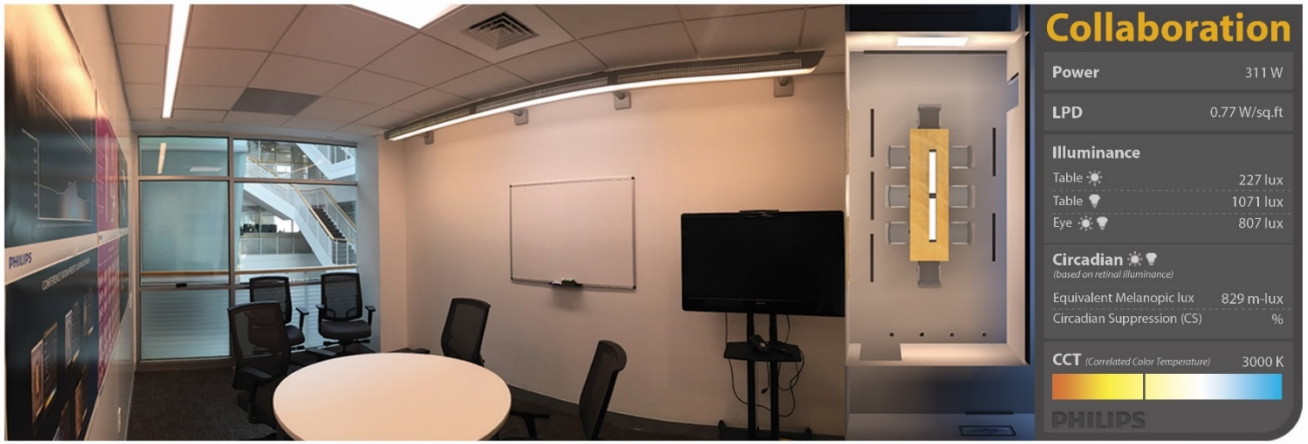
Low Ambient/Task System and Novel optical design



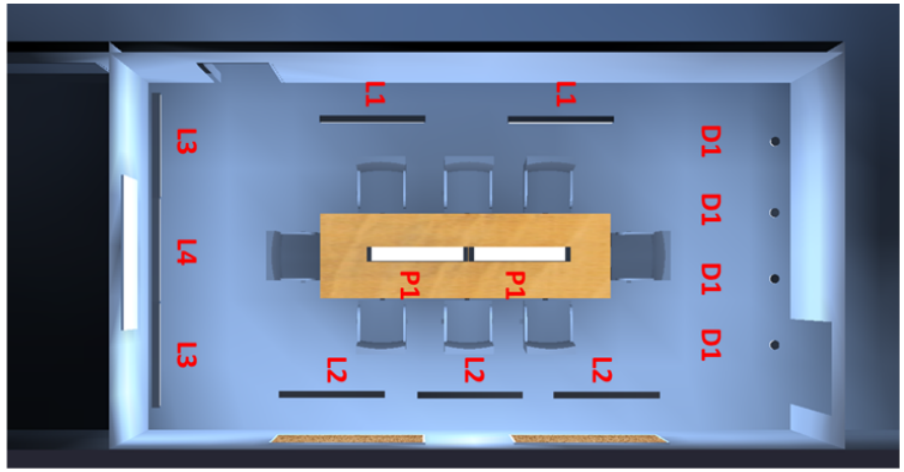
Low Ambient/Task Novel optical design

Selectable Pre-Sets to Support Tasks





Selectable Task Pre-Sets: Calculated Energy Use



		Blue Alert			Red Alert			A/V			Focus			Collaboration		
ID	Description	CCT	Output	Power	CCT	Output	Power	CCT	Output	Power	CCT	Output	Power	CCT	Output	Power
L1	Linear West Wall	6500	1.0	37.3	2700	1.0	39.2	4000	0.5	19.7	4000	0.5	19.7	3000	0.5	21
L1	Linear West Wall	6500	1.0	37.3	2700	1.0	39.2	4000	0.5	19.7	4000	0.5	19.7	3000	0.5	21
L2	Linear East Wall	6500	1.0	37.3	2700	1.0	39.2	4000	0.5	19.7	4000	0.5	19.7	3000	0.5	21
L2	Linear East Wall	6500	1.0	37.3	2700	1.0	39.2	4000	0.5	19.7	4000	0.5	19.7	3000	0.5	21
L2	Linear East Wall	6500	1.0	37.3	2700	1.0	39.2	4000	0.5	19.7	4000	0.5	19.7	3000	0.5	21
L3	Linear South Wall	6500	1.0	37.3	2700	1.0	39.2	-	0.0	0.0	4000	0.7	27.6	3000	0.5	21
L3	Linear South Wall	6500	1.0	37.3	2700	1.0	39.2	-	0.0	0.0	4000	0.7	27.6	3000	0.5	21
L4	Linear (White board)	6500	1.0	37.3	2700	1.0	39.2	-	0.0	0.0	5000	1.0	38.5	4000	1.0	39
D1	Downlight North Wall	6500	1.0	19.6	2700	1.0	22.1	4000	0.5	9.7	4000	0.5	19.7	3000	0.5	11.1
D1	Downlight North Wall	6500	1.0	19.6	2700	1.0	22.1	4000	0.5	9.7	4000	0.5	19.7	3000	0.5	11.1
D1	Downlight North Wall	6500	1.0	19.6	2700	1.0	22.1	4000	0.5	9.7	4000	0.5	19.7	3000	0.5	11.1
D1	Downlight North Wall	6500	1.0	19.6	2700	1.0	22.1	4000	0.5	9.7	4000	0.5	19.7	3000	0.5	11.1
P1	Pendant	6500	1.0	37.3	2700	1.0	39.2	4000	1.0	39.4	4000	1.0	39.4	3000	1.0	41
P1	Pendant	6500	1.0	37.3	2700	1.0	39.2	4000	1.0	39.4	4000	1.0	39.4	3000	1.0	41
			Total:	451		Total:	481		Total:	216		Total:	350		Total:	311
			Area:	404		Area:	404		Area:	404		Area:	404		Area:	404
			LPD:	1.12		LPD	1.19		LPD	0.54		LPD	0.87		LPD	0.77

ASHRAE 90.1=
LPD 1.24

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System Architecture: Open data and Cloud-enabled

System Architecture

Visualization
Cloud based graphs and plots to show sensor/luminaire related data.

User Interaction
Web UI for commissioning and advanced control.

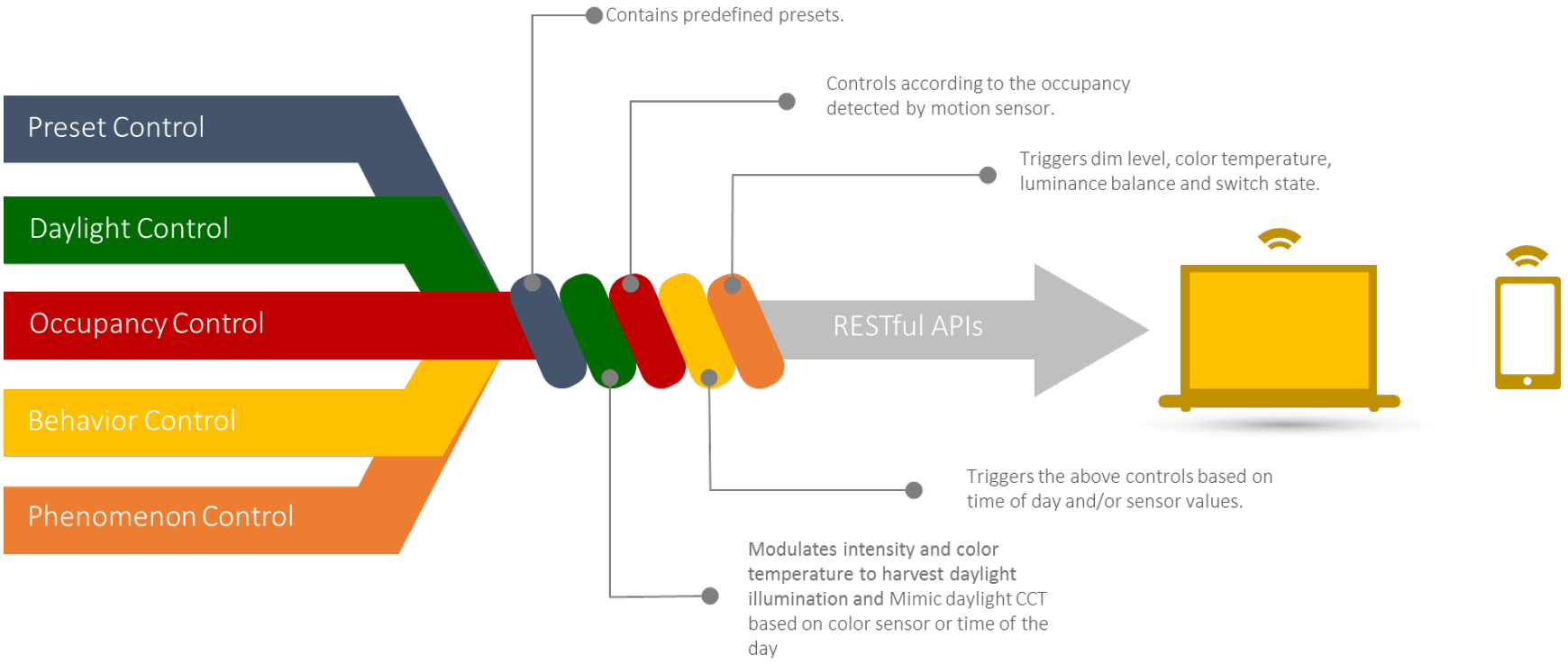
Cloud Services
Real-time sensor data pushed to Cloud for Analysis and BM

Physical Layer
Consisting of all the devices like controllers, drivers et al.

Network Layer
Interaction between devices using various protocols

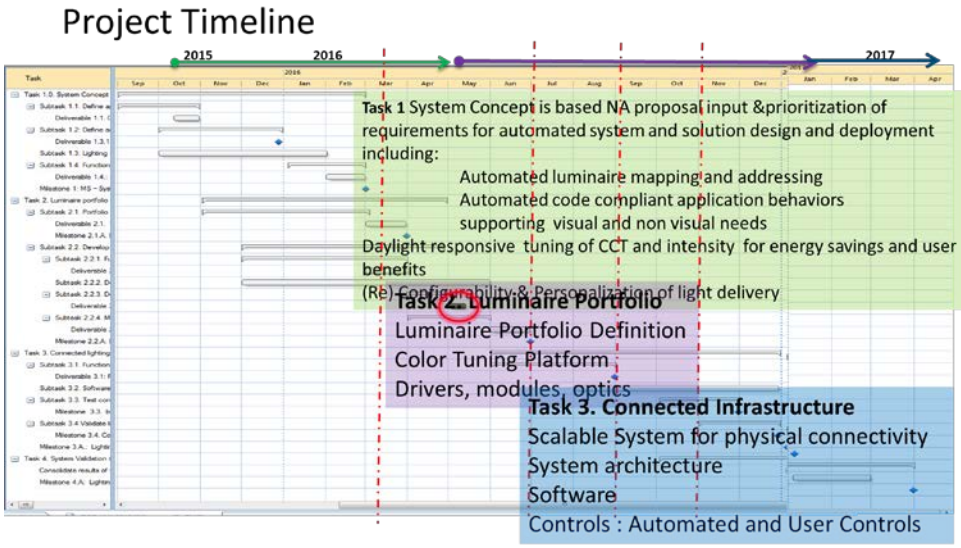
Software Platform
Core Platform which acts as a middleware.

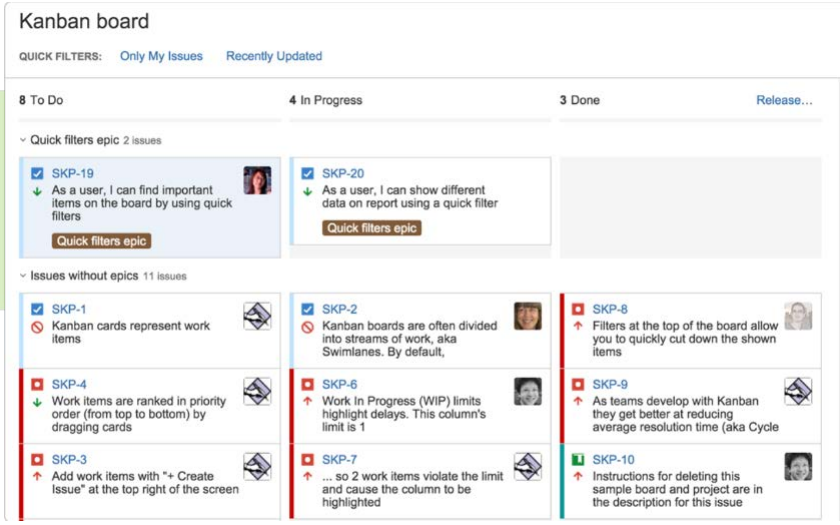
Core Software Platform and Embedded behaviors



Progress and Accomplishments

Accomplishments: Completed value proposition development, design concept, wrote system architecture requirements, benchtop working demonstration including software component and integrated system testing. We plan to file a patent regarding the control of the automatic behaviors, and write additional ID's.





Lessons Learned: Applications research is time consuming and challenging at the current pace of change in scientific understanding, technology, metrics and markets. Cross functional teams need to be prepared to abandon the waterfall project management approach embrace managing resources dynamically.

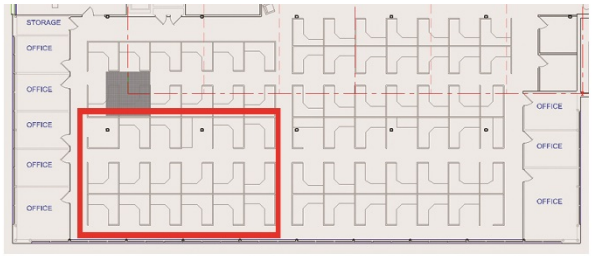
Project Integration and Collaboration

Project Integration: Pacific Northwest National Labs has provided consultative support, and we anticipate collaborating further with the labs to assist in pilot planning.

Communications: 2016 and 2017 Department of Energy SSL R&D Workshop Poster Sessions.

Next Steps and Future Plans

Next Steps and Future Plans:



Philips Lighting System Pilot Installation

You are invited to participate in a validation of a Department of Energy co-funded lighting research project. The project goal is to provide a low glare, energy aggressive system, which follows the change of color and intensity similar to the daylight coming in to the space. Individuals can control the brightness and appearance of their personal task lighting.

This validation is a critical step to project completion and commercialization by Philips Lighting North America.

We will be installing a new lighting system in the area highlighted above.

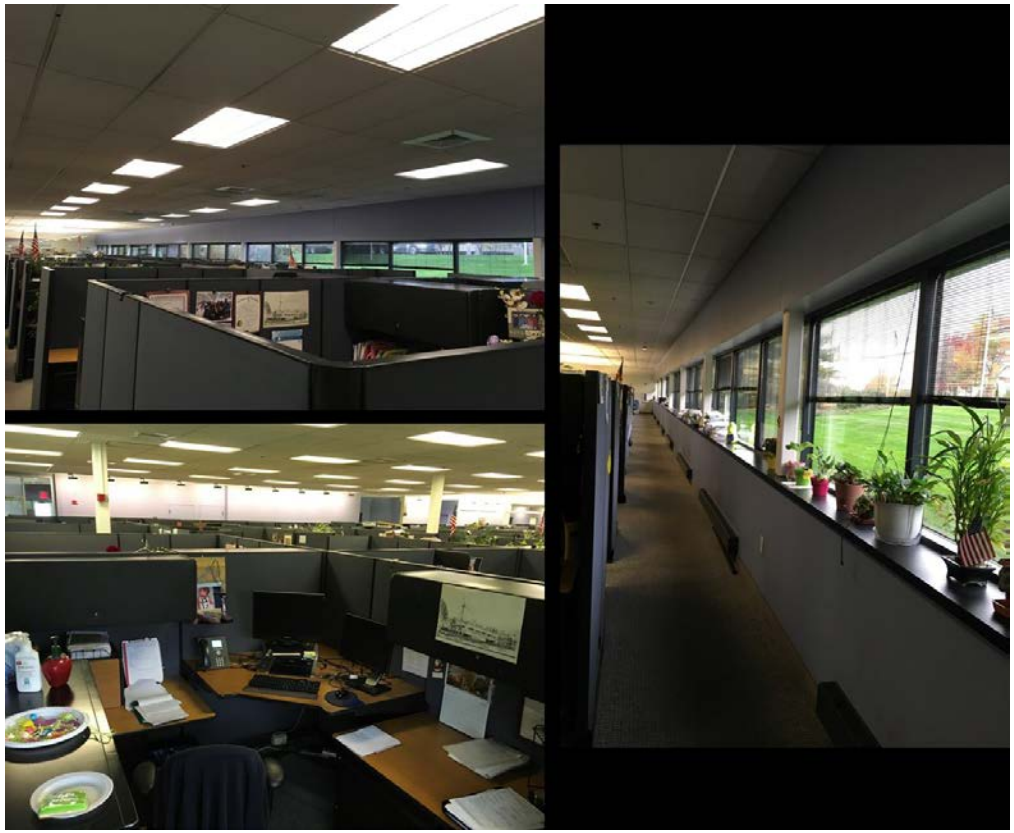
If you work in these areas you will want to know:

Starting the week of February 2017 through early March. We will be installing new lighting above your head as well as providing a prototype task lighting in your workspace. Every effort will be made during the installation and validation to minimize any disruption to your work.

You will be asked to respond to a brief online survey before and after the installation in order to document existing conditions and capture your experience of the re lighted space.

You may volunteer to participate in brief interview/conversations about the your experience as the project progresses.

Pilots like these are important to Philips Lighting for industry recognition and opportunity to fast forward system development. Thank you for your participation in these lighting system evaluations.



Next Steps and Future Plans

Next Steps and Future Plans:

Additional pilots to:

Quantify the human light interaction through both physiological and behavioral measures.

Develop more behaviors to optimize facility efficiencies and employee effectiveness.

Explore the possibilities of adaptive systems to create inclusive environments supporting increased workplace diversity, reducing stress and increasing well-being.

Roadmaps system portfolios for existing building and new construction system offerings.

References

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P. Khademagha , M.B.C. Aries , A.L.P. Rosemann .J. van Loenen

The Impact of Light Including Non-Image Forming Effects on
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Apiparn Borisuit

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Schulte-Markworth,M., Barkmann,C. & Wessolowski,N. Effect of Light in Schools. CIE x035:2010: Proceedings of CIE 2010 "Lighting Quality and Energy Efficiency" 14-17 March 2010, Vienna, Austria. 2010. ISBN 978 3 901906 83 1.]

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Rahman SA; Flynn-Evans EE; Aeschbach D; Brainard GC; Czeisler CA; Lockley SW. Diurnal spectral sensitivity of the acute alerting effects of light. *SLEEP* 2014; 37(2):271-281.

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Project Budget

Project Budget: Total budget: $658,508. Award of $499,131. for an 18 month co-funded project with 25% of $166,377. Project start October 1, 2015

Variances: A no cost extension was granted extending the validation and reporting period from March 30 to June 30 2017.

Cost to Date: **Total Project $ to Date**: **602,543.16**

Budget History

October 1,2015 – FY 2015 (past)		FY 2017 (current)		FY 2017 – June 30,2017 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$287,153.99	$95,717.98	$451,907.37	$150,635.79	$499,131.00	$166,377.00

Project Plan and Schedule

- Planned project duration October 1, 2015 – March 2017 with reporting completed by June 30, 2017
- Pilot installation delayed, however we expect to complete validation and reporting by June 30,2017.

Milestone Summary Table							
Project Title:	Innovative Office Lighting System with Integrated Adaptive Control						
Task Number	Task or Subtask (if applicable) Title	Milestone Type (Milestone or Go/No-Go Decision Point)	Milestone Number* (Go/No-Go Decision Point Number)	Milestone Description (Go/No-Go Decision Criteria)	Milestone Verification Process (What, How, Who, Where)	Anticipated Date (Months from Start of the Project)	Anticipated Quarter (Quarters from Start of the Project)
1.0.	Value Proposition Summary	MS	M 1.	Complete System Functional Performance Requirements	Report submitted to DOE.	Month 6	Q2
2.1.	Portfolio definition	MS	M 2.1.	Complete Luminaire portfolio definition	Report submitted to DOE	Month 6	Q2
2.2.4	Luminaire system platform validated in mockup.	Go/No Go MS	M 2.2	Validate System platform and luminaire performance	Report submitted to DOE	Month 9	Q3
3.1	Functional system architecture definition	MS	M 3.1.	Functional system architecture definition complete.	Report submitted to DOE.	Month 12	Q4
3.2	Bench top functional testing and validation completed.	MS	M3.2	System Architecture Specification complete	Report submitted to DOE	Month 15	Q5
3.3	Validate lighting system platform functionality	MS	M3.3	Lighting system connectivity platform validated.	Report submitted to DOE	Month 15	Q5
4.0	System Validation	MS	M 4.	Lighting system performance validated	Document validation	Month 18	Q6
4.0	System Validation	MS	M 4.	Lighting system performance validated	Report submitted to DOE	Month 21	Q7