U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Stationary Concentrator Daylighting System

Glint Photonics Inc.

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Project Summary

Timeline:

Start date: 10/1/2016

Planned end date: 3/31/2020

Key Milestones

1. Panels & Mechanics Survive Testing; 12/31/17
2. Field Installation Site Secured; 3/31/18
3. Panels Achieve >75% of Theoretical Performance 9/30/18
4. Field Installation Complete; 3/31/2019

Budget:

Total Project $ to Date:

- DOE: $719,558
- Cost Share: $150,289

Total Project $:

- DOE: $1,080,000
- Cost Share: $270,000

Key Partners: N/A

Project Outcome:

The goal of this program is to scale the Glint Daylight Concentrator into a full-size integrated prototype and evaluate its performance in a field installation.

In this program Glint will develop a full prototype including internal actuation mechanism, light delivery system, and building interface.

Glint will install systems in a field installation in order to evaluate real-world performance, validate the expected >50% energy savings over a pre-installation baseline, meeting MYPP daylighting goals, attracting potential customers, and further investment in the technology.

Team

- Leading development of innovative optical devices
  - Advanced materials and device designs
  - Unique IP in self-tracking solar concentrators, tunable IR optical devices, and advanced luminaires
- Technical leadership:
  Over 60 years combined experience in materials and device technologies, product development, startup companies
- Expertise:
  Engineering staff from a variety of technical fields.
  Expertise in optical device design, optoelectronics, process development, simulation, optical test
- Facilities:
  Large mixed lab, office, light manufacturing and warehouse space. Located in Burlingame, CA.
- History:
  Founded in October 2010. Over $7 million in government funding.

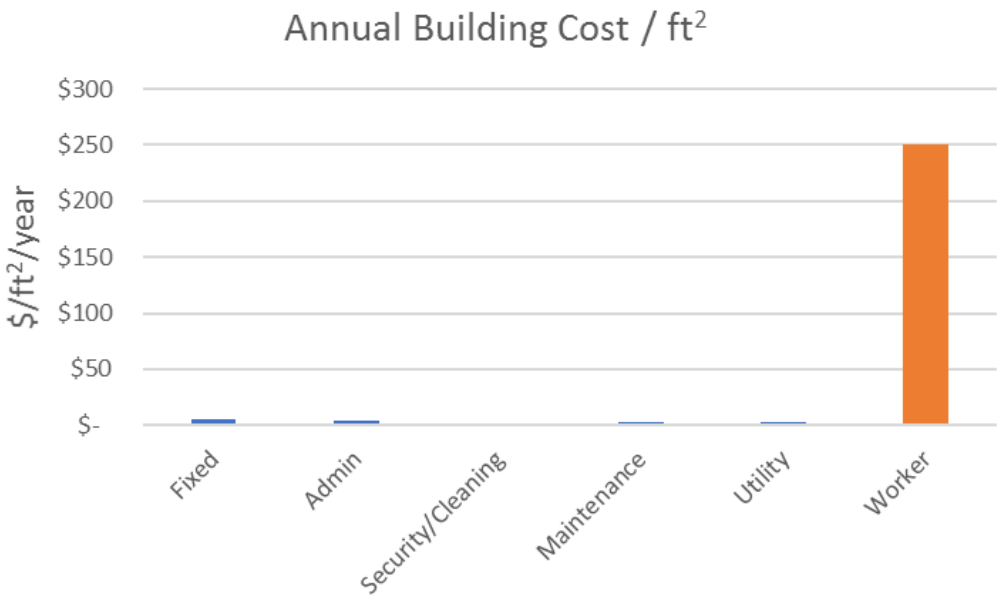
Dr. Peter Kozodoy
Founder & CEO

Dr. Chris Gladden
Director of Engineering

Challenge

Human Costs Dominate Building Expenses

- Human factors offer the biggest cost saving opportunity in buildings
- Total O&M + fixed costs:
  < $15/ft^2
- Typical office worker:
  >$250/ft^2
- Average office utility costs are ~$2.35/ft^2



Increasing worker productivity by 10% could save 10 times more that the total cumulative utility costs.

Challenge

Many building interiors have insufficient daylight

Studies suggest that by adding high quality daylight to buildings:

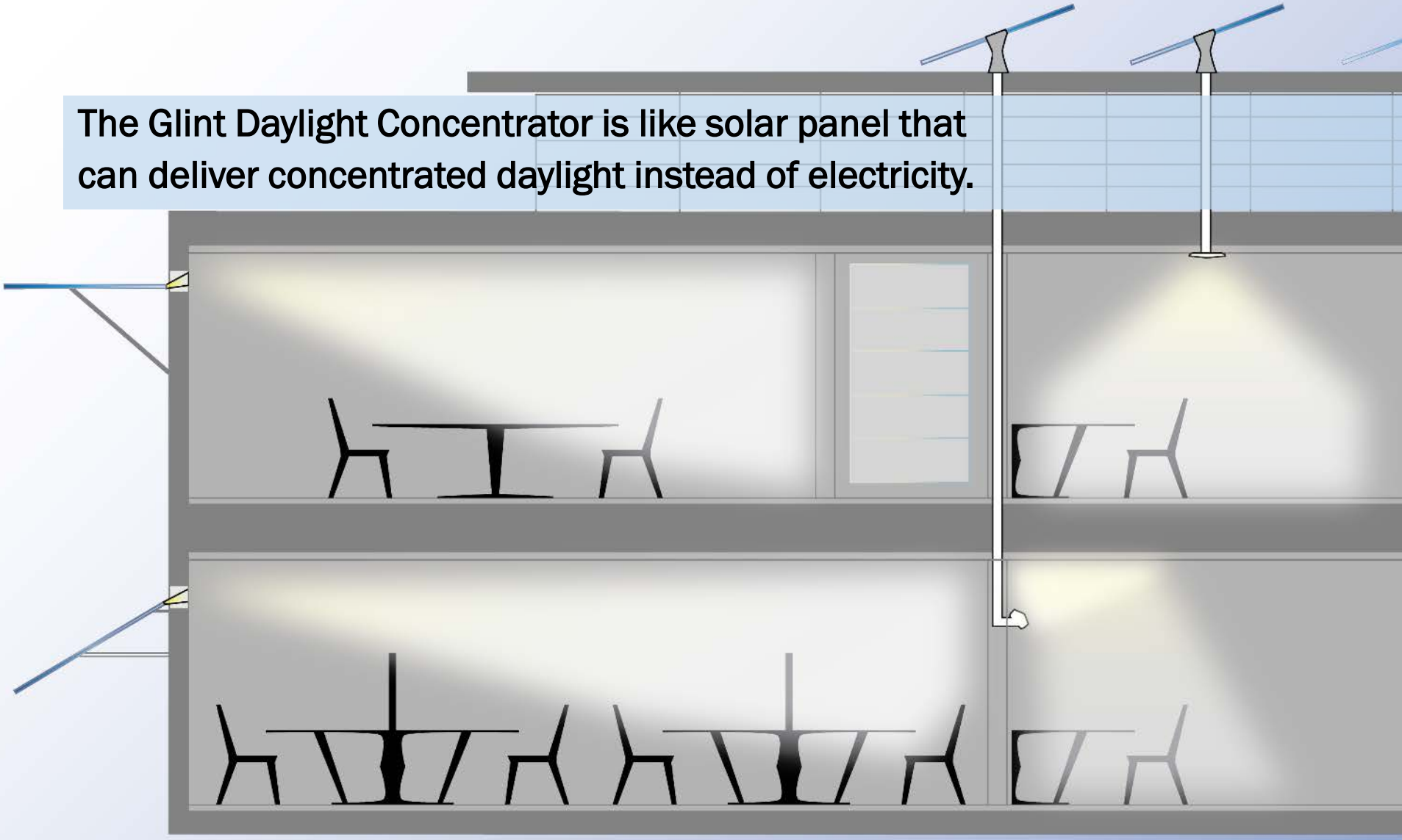
- Retail sales increase 31%-49% [1]
- Students progress 20%-26% faster in reading and math [2]
- Office worker productivity increases by 13% [3]
- Occupants can maintain healthy circadian rhythm, have increased cognitive performance, and decreased stress levels [4,5]

The Glint Daylight Concentrator is a revolutionary new product that can bring natural daylight deep into the interior of buildings

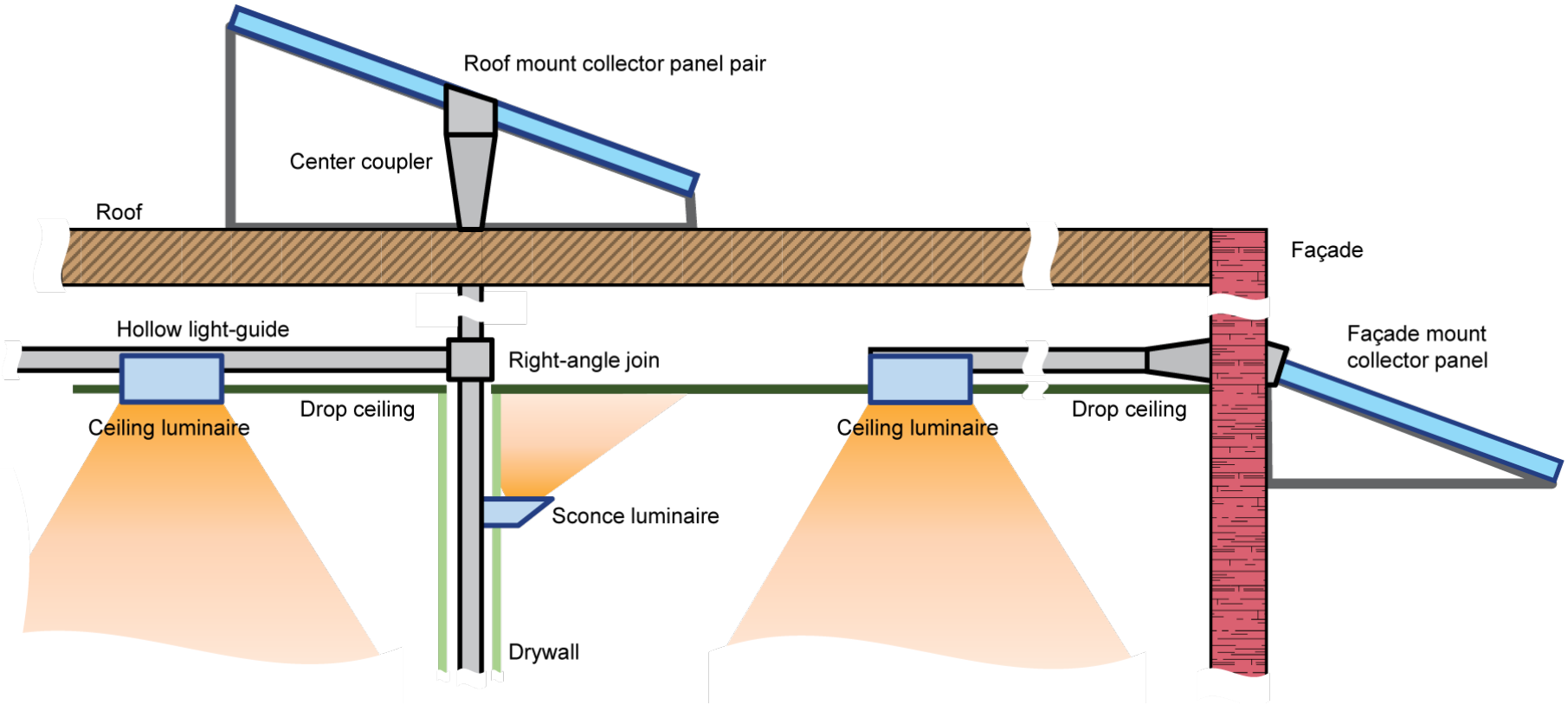
1. Heschong Mahone Group (1999). *Skylighting and Retail Sales: An Investigation into the Relationship Between Daylighting and Human Performance*
2. Heschong Mahone Group (1999). *Daylighting in Schools An Investigation into the Relationship Between Daylighting and Human Performance*
3. Heschong Mahone Group, I. (2003). Windows and Offices: A Study of Office Worker Performance and the Indoor Environment.
4. *Lucas, R.J., et al. (1999) Regulation of the mammalian pineal by non-rod, non-cone, ocular photoreceptors. Science Vol. 284, Issue 5413, pp. 505–507*
5. *Gabal V, et al. (2013) Effects of artificial dawn and morning blue light on daytime cognitive performance, well-being, cortisol and melatonin levels. Chronobiology International 30(8) 988-97*

Approach

The Glint Daylight Concentrator is like solar panel that can deliver concentrated daylight instead of electricity.



Approach

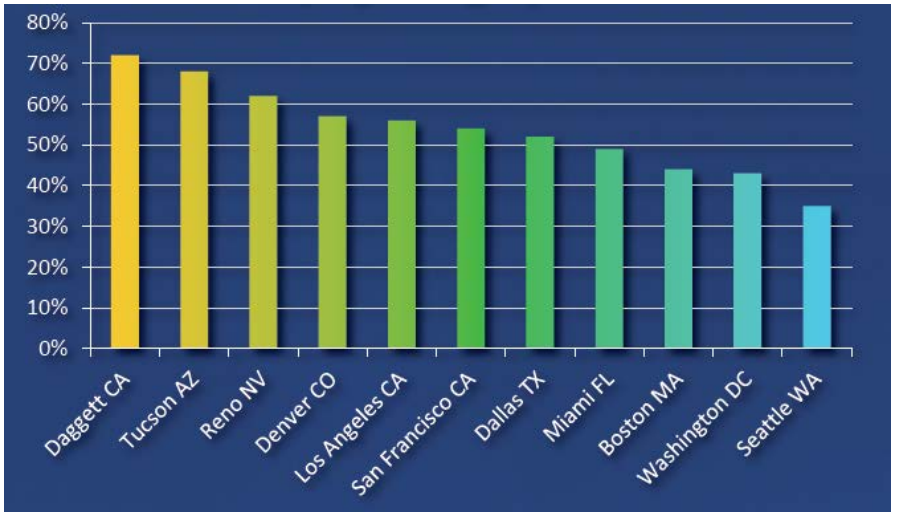


- Thin, flat, stationary collector panel mounted on roof or building façade
- Highly concentrated sunlight is delivered into hollow reflective light pipes, 2” x 12” in cross section
- Hollow light-guides can be routed through walls and plenums as desired, up to 30 meters from collector
- Gathers sunlight at angles >60°, providing >8 hours of daylight delivery per day

Approach

Market Opportunity

- 93% of the $6B daylighting market is currently skylights for commercial and institutional buildings
- California commercial buildings
  - 600,000 buildings with 6 billion square feet
  - 120,000 buildings per year perform alterations to improve energy efficiency
- Initial market: Commercial buildings in CA performing window glazing replacement or new construction (~12,000 buildings)



predicted annual lighting energy savings for US locations

Approach

Key Risks & Mitigation

Risk 1 - Mechanical Actuation System Accuracy

- Develop actuation system with mechanical advantage
- Characterize performance with motion capture

Risk 2 - Solar Position Algorithm

- Deploy photodiode based sun tracker
- Long term algorithm testing

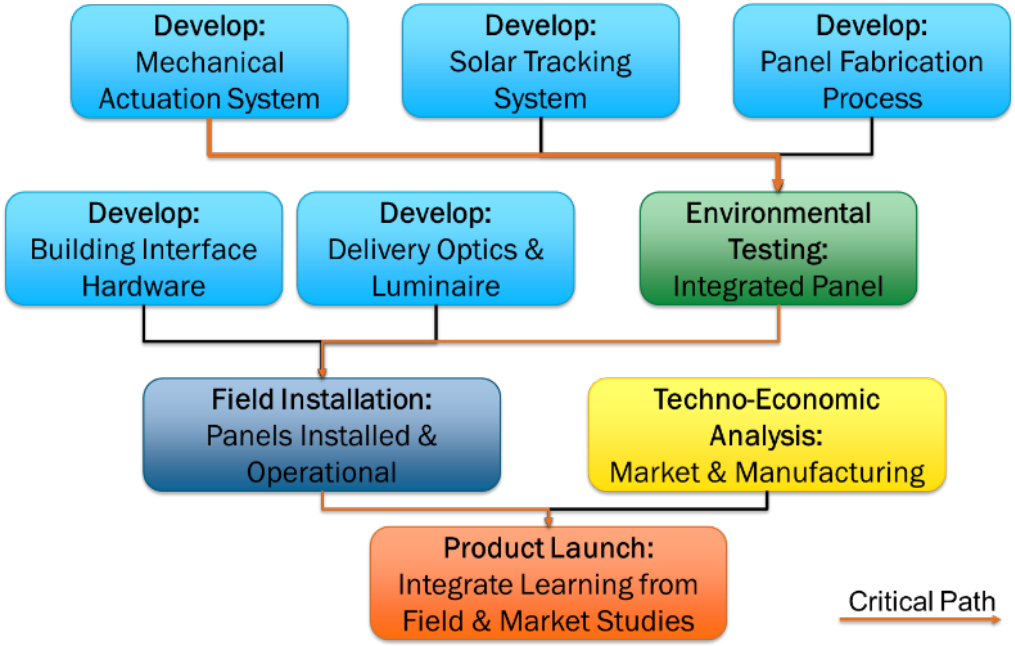
Risk 3 - Panel Sealing and Environmental Durability

- Redesign panel sealing interface
- Extended environmental testing

Risk 4 – Building Interface System

- Down-select to roof or façade
- Develop mounting hardware w/ input from field installation

Project Plan Overview



Risk 5 – Market Acceptance

- Stakeholder outreach
- Field Installation
- Techno-Economic Analysis

Impact

Multi-Year Program Plan Alignment

Project aligns with MYPP window light redirection and daylighting goals to reduce cost, improve aesthetics, reduce glare, and improve energy offset with higher efficiency and deeper redirection.

Daylighting Technologies	Lighting energy use (% reduction) 50 ft. floor plate;	16%	35%	50%
	Installed cost prem. incl. sensors & controls ($/sq. ft.)	$9	$13	$5

MYPP (pg. 83)

"Window light redirection technology reduces the amount of energy consumed for interior lighting, but the reach of the technological benefits is currently limited due to high cost of installations and aesthetic issues. The Sub-Program's focus is on reducing the high cost of daylighting and improving deep light redirection technologies at a low cost and without glare. Demonstrations related to appearance, the energy savings impact based on season and time of day, and appropriate integration with building controls and operation in coordination with R&D will help drive the technologies to the market." (MYPP pg. 82)

Field Installation

- Field installation planned at offices of Loisos + Ubbelohde
- New building construction will allow for easy integration
- George Loisos is an architect/lighting designer and early adopter of novel daylighting technologies
- System will be monitored and studied once installed
- Energy and human impacts will be quantified

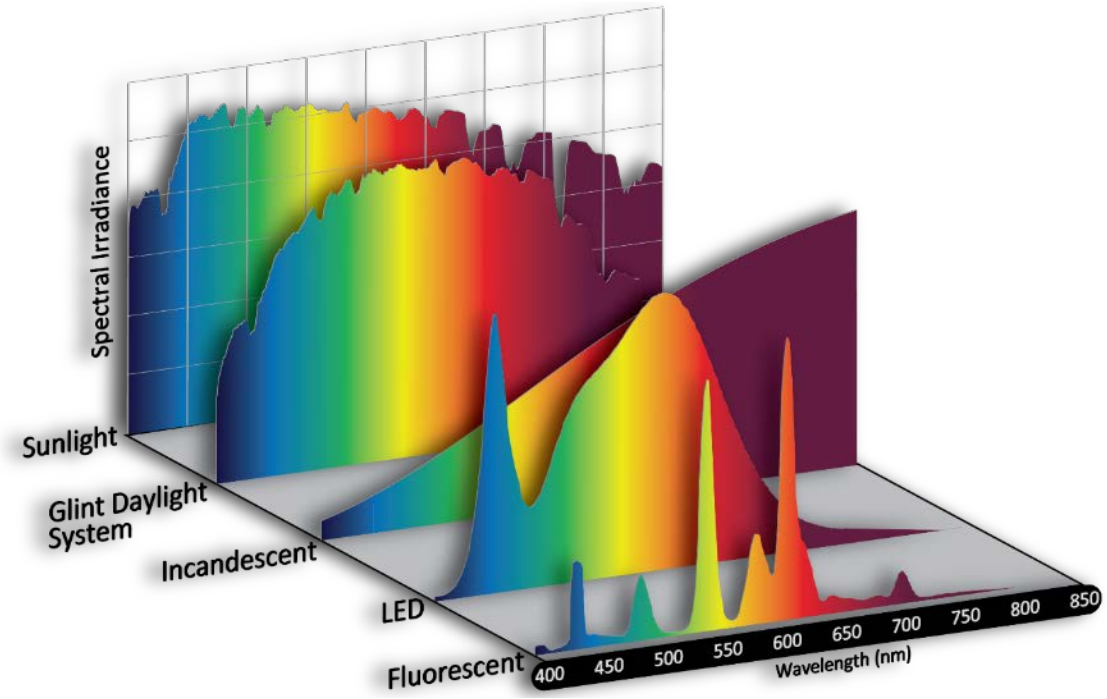
Impact

Cost and Performance Advantage

Daylighting system	Routing capability	Roof penetration area (sq ft)	Peak lumens	Cost
Skylight in drywall shaft	None	8.00	30,000	$2,500
Tubular daylighting device	Limited	1.10	8,000	$300
Concentrator with fiber optics	Flexible	0.05	4,000	$10,000
Glint daylighting device	**Flexible**	**0.17**	**13,000**	**$400**

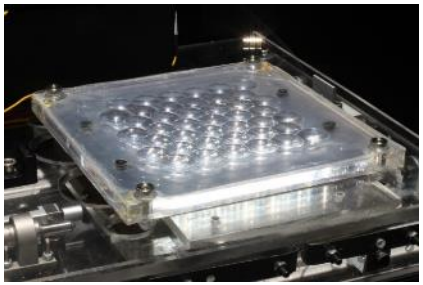
The Glint Daylight Concentrator provides significant cost and performance advantages over incumbent technology.

- More light delivered through a smaller roof penetration
- Reduced installation cost
- Increased routing flexibility
- Greater annual energy savings
- Excellent spectral quality

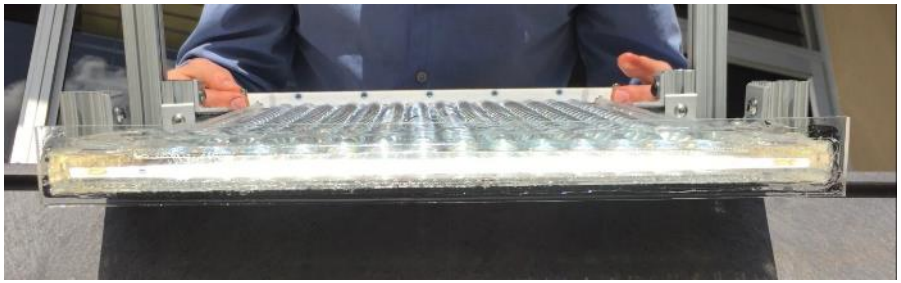


Progress

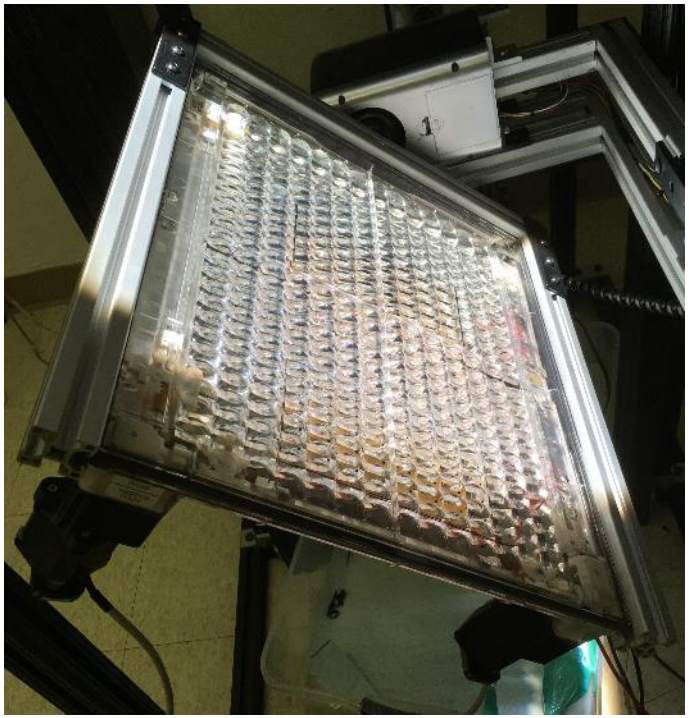
- Project is currently at mid-point
- Extended vendor delays and quality issues have delayed project by 2 quarters
- BTO BENEFIT funding will support development from 2016-2020



2016 – 20 in^2



2017 –Manually Actuated 170 in^2



2018 – Fully Automated 170 in^2

Technology featured in Scientific American, MIT Tech Review, CleanTechnica, TechSpot, Gizmodo and more.

Progress

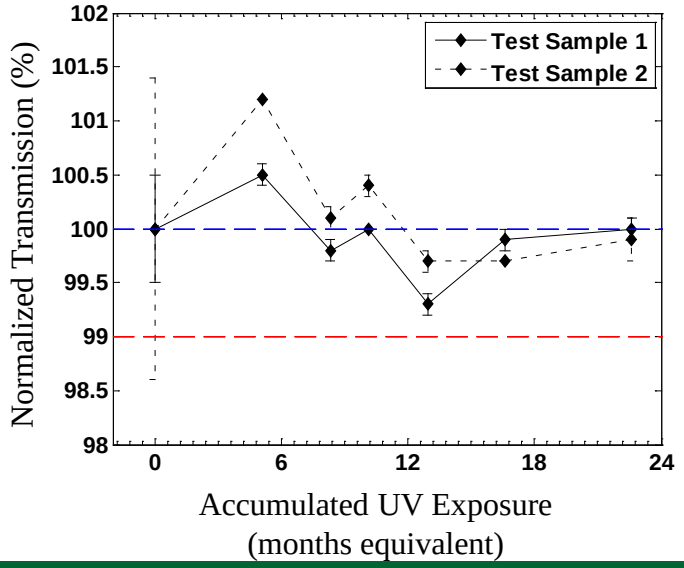
Major Accomplishments

- Actuation system developed and tested for durability
- Solar tracking hardware developed and tested
- Worked with molded optics vendor to develop improved molding process
- Significant market interaction with lighting designers and daylighting experts has validated the value proposition
- Secured high profile field installation opportunity
- Program budget on target

Optical Molding

Mechanical Actuation

Environmental Testing



Stakeholder Engagement

- **Project currently at mid-point**
- **Extensive interaction with lighting designers and industry experts:**
  - George Loisos, Principal at Loisos + Ubbelohde, an Oakland-based architectural design firm. Offered offices for field installation site.
  - Eight Inc., a San Francisco-based "experience design" firm that designs high-profile retail, hospitality, and commercial spaces. Met with a group of 10 designers.
  - Jeremy Steinmeir, a leading lighting designer at the San Francisco office of the architectural design firm Gensler.
  - Dane Sanders, Principal at Clanton & Associates, a Boulder-based lighting design and engineering firm.
  - Earl Armstrong, a builder and developer in the Santa Barbara area active in the construction of schools, museums, and office space.
  - Konstantinos Papamichael, Co-director at California Lighting Technology Center, UC Davis.

Stakeholder Engagement

- **Industry engagement has directed several key decisions:**
  - Targeting façade mounted applications for initial field installation
  - Free space optical transmission for initial field installation
  - Target new construction or buildings with planned window replacement/retrofit
  - Emphasize aesthetic appeal of product to improve adoption by lighting designers and architects
  - Develop attractive/unique internal luminaires to distinguish product
  - Design optical system to eliminate glare as much as possible (downfall of many previous daylighting system)
  - Solar tracking / mechanical actuation system must be automated, robust, and self correcting (many previous daylighting trackers eventually stop tracking the sun)

Remaining Project Work

Key Risks Remaining

Risk 1 - Mechanical Actuation System Accuracy (COMPLETE)

Risk 2 - Solar Position Algorithm (COMPLETE)

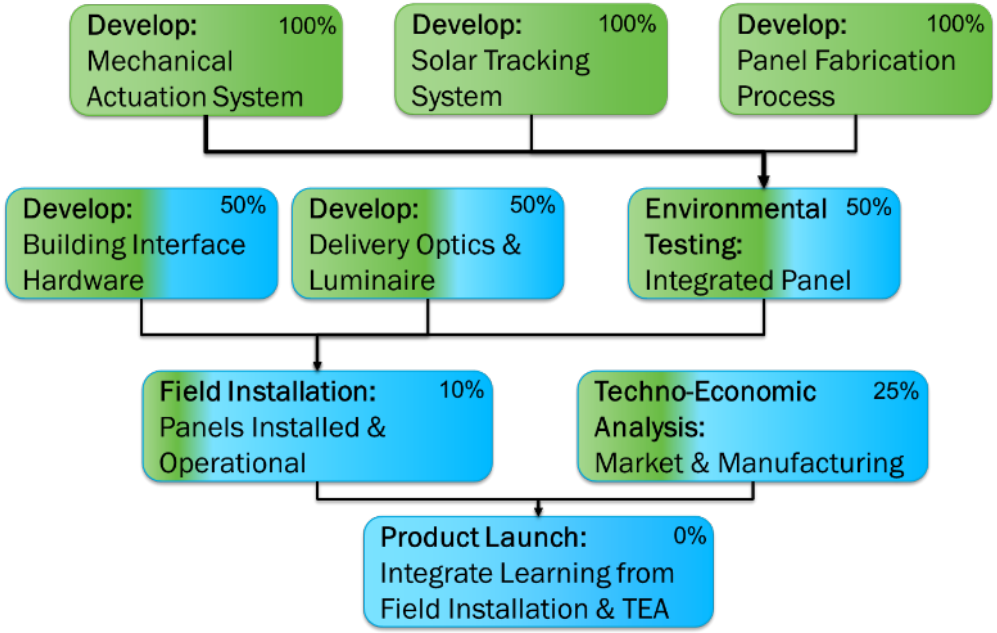
Risk 3 - Panel Sealing and Environmental Durability (IN PROGRESS)

- Redesign panel sealing interface (COMPLETE)
- Verification of component durability (COMPLETE)
- Extended environmental testing (IN PROGRESS)

Risk 4 – Building Interface System

- Down-select to roof or façade (COMPLETE)
- Develop mounting hardware w/ input from field installation (IN PROGRESS)

Project Plan Progress



Risk 5 – Market Acceptance

- Stakeholder outreach (COMPLETE)
- Field Installation (IN PROGRESS)
- Techno-Economic Analysis (IN PROGRESS)

Thank You

Glint Photonics Inc.
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REFERENCE SLIDES

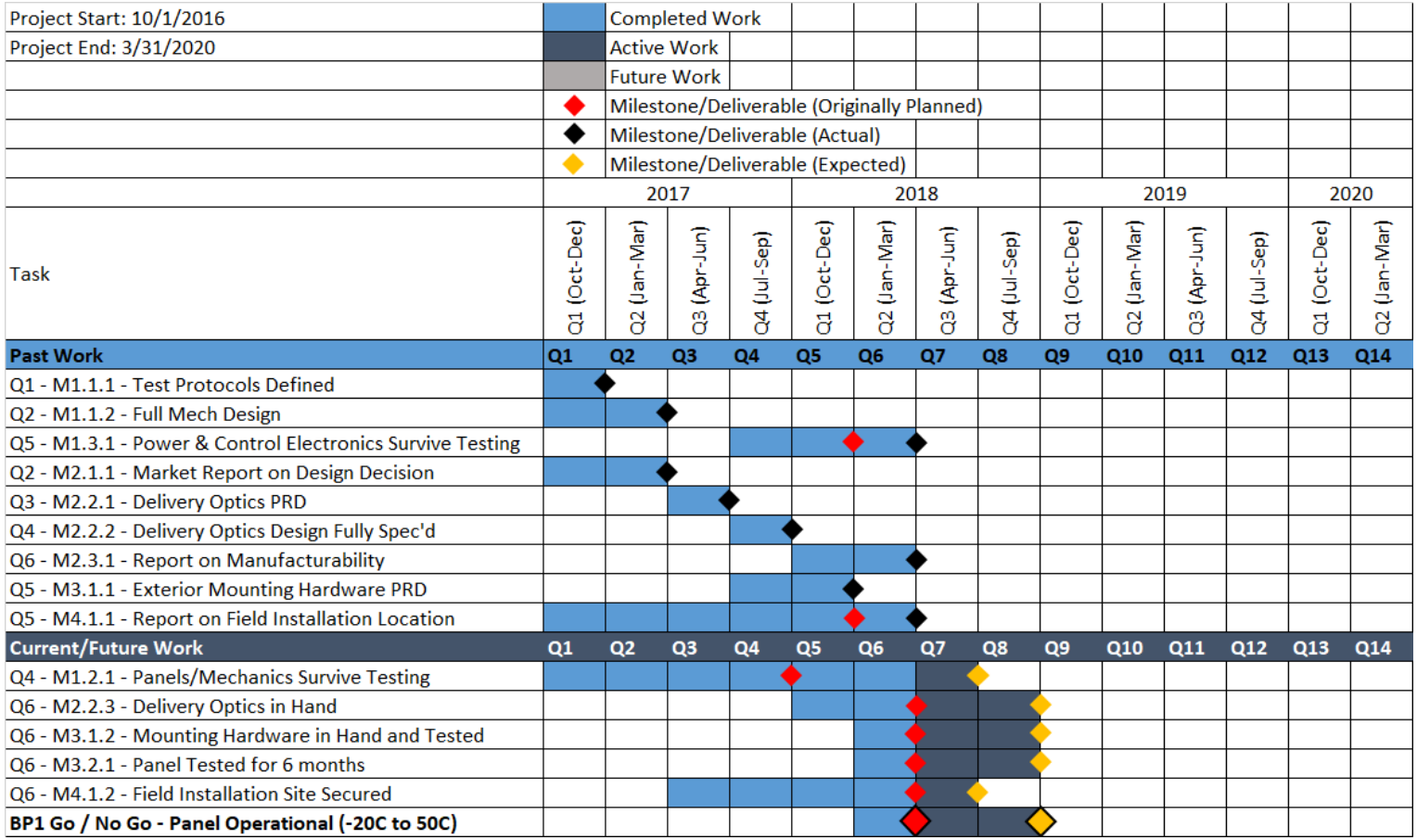
Project Budget

Project Budget: $1.08M DOE, $270K cost-share (CEC)
Variances: No major variances aside from NCE
Cost to Date: 66.6% of 1,080,000 DOE Spent, 55.7% of Cost Share
Additional Funding: ARPA-E MOSAIC DE-AR0000644, CEC EPC-14-040

Budget History					
10/1/2016 – FY 2017 (past)		FY 2018 (current)		FY 2019 – 3/31/2020 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$461,791	$77,828	$319,640	$122,172	$298,569	$70,000

Project Plan and Schedule

- Vendor delays for molded optical panels resulted in program wide delays
  - Mechanical system changes required mold revision
  - Vendor had 3 month delay in completing mold revisions
  - Molded part planarity issues required additional 3 months of work
- Six-month no cost extension was used to re-align project schedule
- All slipped milestones are a result of these delays



Project Plan and Schedule

- Budget Period 2 delayed by six months due to NCE
- All BP2 milestones have been moved 2 quarters
- No further program delays are expected now that vendor issues have been resolved

Project Start: 10/1/2016		Completed Work													
Project End: 3/31/2020		Active Work													
		Future Work													
	◆	Milestone/Deliverable (Originally Planned)													
	◆	Milestone/Deliverable (Actual)													
	◆	Milestone/Deliverable (Expected)													
		2017				2018				2019				2020	
Task		Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)
Budget Period 2		**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**
Q9 - M5.1.1 - Interior Mounting Hardware PRD										◆					
Q10 - M5.1.2 - Interior Mounting Hardware Tested											◆				
Q10 - M5.2.1 - Full System Tested for 6 months											◆				
Q11 - M5.3.1 - New Panel Design Finalized												◆			
Q12 - M5.3.2 - New Hardware and Delivery System Design													◆		
Q9 - M6.1.1 - Field Installation Panels Assembled										◆					
Q10 - M6.1.2 - Mounting Hardware and Optics Assembled											◆				
Q10 - M6.2.1 - Baseline Data Collection Complete											◆				
Q11 - M6.2.2 - System Installed and Operational												◆			
Q12 - M6.2.3 - Performance and Energy Savings Analysis													◆		
Q14 - M6.2.4 - Revised design and documentation															◆
Q9 - M6.3.1 - Key Partner Engagement										◆					
Q11 - M6.3.2 - Beachhead / First Market Analysis												◆			
Q12 - M6.3.3 - Business Model Complete													◆		
Q13 - M6.3.4 - Tranistion Plan Complete														◆	
Q14 - M6.3.5 - Path to Market Report															◆