Lighting and CONTROL
Opportunity and Incentives for Innovation
Michael Poplawski

Now:
Pacific Northwest National Laboratory
Data-driven lighting: using data for digital validation and verification, energy management, maintenance, and grid-interaction

Previous:
Semiconductor Industry
Multiple jobs: ON Semiconductor, Magnachip, Motorola
Multiple roles: R&D, Design, Reliability

Michigan
MSE Electrical Engineering, Solid-State Physics
Now:
Starting something new

Previous:
**WeWork**
Global Head of Lighting

**Arup**
Project Manager + Lighting Consultant

**Carpenter Norris**
Daylighting Designer

**Wharton**  EMBA candidate (current)

**Parsons**  MFA Architectural Lighting

**Duke**  BSE Structural + Architectural Engineering
Now:
Pacific Northwest National Lab
Lighting Research Engineer
New tech evaluations, simulations, digital design

Previous:
Lighting Designer

Parsons  MFA Architectural Lighting
RPI  Architecture

Jessica Collier
(Many) Lessons Learned
A Typical Project Organization...

- **Owner**
  - **Project Mgmt Owner Rep.**
  - **Real Estate:** Sourcing, Finance + Legal
  - **Design:** Architect, Interior Design Engineer + Lighting
  - **Construction**
  - **End User**
  - **Operations + Maintenance**
  - **Construction**
  - **Sourcing + Procurement**
Real Estate Developer Org

Owner

Real Estate: Sourcing, Finance + Legal

Project Mgmt Owner Rep.

Design Architect, Interior Design Engineer + Lighting

Construction

Sourcing + Procurement

Operations + Maintenance

End User
Institutional Organization...

- **Owner**
  - **Project Mgmt Owner Rep.**
    - **Design**
      - Architect, Interior Design Engineer + Lighting
    - **Construction**
    - **Sourcing + Procurement**
  - **Real Estate: Sourcing Finance + Legal**
  - **End User**
    - **Operations + Maintenance**
A Typical Project Organization...
Vertically Integrated Organization...

- Owner
- Real Estate: Sourcing, Finance, + Legal
- Project Mgmt: Design Architect, Interior Design Engineer, + Lighting
- Sourcing + Procurement
- Construction
- Operations + Maintenance
- End User
Process: Parallel + Aligned
WeWork is unique vs. a typical design-build firm in that we are not only designing and building, but also sourcing our spaces and operating them after construction is complete.
Vertically Integrated Feedback Loop . . .
Evolve Sustainably

Experiences → Data → Insights → Iterate + Improve

Reinvent
Vertical Integration Efficiencies

1. Reduce repetitive workflows
2. Reduce errors as the same base model moves from phase to phase
3. True Collaboration with Trust (!) less CYA
4. Automation: from document production to commissioning
5. Automate error checking, code compliance and standard verification
6. Operations feedback into design evolution
1. Reduce Repetitive Workflows
2. Reduce Errors through Data Continuity
3. True Collaboration with Trust

Design

Construct

Operate

Q?

A!

NO

CYA
# 4. Automation Efficiencies

Starts with standards (not with computers)

<table>
<thead>
<tr>
<th>01</th>
<th>02</th>
<th>03</th>
<th>04</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define: the extents of “standard” solutions (80/20)</td>
<td>Design: Think systemically, simple, modular.</td>
<td>Automate Listen, Adapt, + Evolve</td>
<td>Let go. Use the new space and time to be creative again!</td>
</tr>
<tr>
<td>Set clear, achievable targets</td>
<td>LIMIT YOUR TOOLBOX</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Standards are Boring excellent.

Favorite Solutions systematized for implementation
80% 20%
Standard  Unique

Automate what you can ...
Focus on the FUN!

Decisions
Identify all the key decisions that need to take place
- fixture type
- fixture performance
- fixture spacing

Variables
Automate Standards
Identify all the key variables that those decisions are dependent on
- ceiling height
- program type
- materials

Image courtesy of WeWork
6. Operations feedback into design
Buildings = Data
 Wouldn’t it be nice?

Save time ... Save money

Prevent Errors

Allow for Progress?
We’ve come a long way

Ancient History: Hand Drawing
Past: 2D CAD
Now: - BIM
- BIM Integrated Tools
- Automation
Future: ...

…
**Level of Detail:**
The way a model looks. The level of detail refers to *the input* of the model.

Example: Specific shapes and measurable location of steel pipes in a model.

**Level of Development:**
The depth of thinking applied to the model. The level of development refers to *the reliability* of the model.

Example: Whether the pipes in a model have been engineered and the permanence of their placement.

Implemented + in Progress
BIM Integrations

ElumTools
(by LightingAnalysts)
More Opportunities

- Automate Pre-Cx of control systems
- Semi-automate commissioning
- Reduce time and labor
- Allow for more complexity in the solution without adding risk of failure
- Reduce energy demand
- Verify performance
- Bring operations into the loop early + hand over completely.
Q: Why are we stuck right now?
A: No incentive.

Advanced controls cost more, take more time and have low return for the owner.
RISK?

Legal/Contract Realities.

The Model: A platform allowing for integration + automation (through shared data)
Can be resolved!
Accountability for Errors

*Feedback is a gift!*
The greatest learning comes from mistakes!
5: Align Incentives for Change

This is not a technology barrier – it’s been done!
This is a people/industry behavior problem

- Automate Install and Labor
- Reduce Errors/Checking
- Support Ops Handover
- Verify Performance
- Communicate with Facilities

SAVE costs upfront & long term!
**How do we get there - what’s next?**

<table>
<thead>
<tr>
<th>Contribution of Architect/Engineer/Designer</th>
<th>The anchors are here</th>
<th>The industry is here</th>
<th>The leaders are mainly here</th>
<th>The evangelists are here</th>
<th>Some enlightened companies are here</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Design Intent only. Paper based deliverables.</td>
<td>Design Intent with some discussion. Introducing an independent digital approach.</td>
<td>Design Intent with increasing digital collaboration. May now be part of GC team.</td>
<td>Design incorporating catalog parts and DfMA approach.</td>
<td>Design by assembling catalog parts</td>
<td></td>
</tr>
</tbody>
</table>
Digital Communication & Collaboration

Identify workflow weaknesses and develop tools to fill gaps in traditional project communication and collaboration.
Where are the gaps and needs?

- Vertical integration and software can deliver significant improvements

- Independent disciplines (e.g., architects, designers, contractors) can evolve too, but will need to rely on software and data even more

- Workflows need to be discovered and demonstrated, software gaps need to be identified and resolved, standards need to be targeted for the critical paths
Connecting the dots

High-Fidelity Model Development

Automation & Data Export

Validation & Verification Measures

FUTURE
High-Fidelity Model Development

Medium Office Prototype Building

- **PNNL Modifications:**
  - Interior Architecture
  - Furniture (Occupancy)
  - Lighting and Control System

- **Modeled in Autodesk Revit**
  - Explore capabilities and limitations
  - Understand dataflows and associations behind building information modeling
High-Fidelity Model Development

Medium Office Prototype Building

- 53,000 sq ft.
- 286 Occupants
- 12 Space types (e.g., enclosed/open office, conference, storage, dining/food prep)
- 12 luminaire types
Automation & Data Export

- How can you intentionally automate and standardize your workflows?

- Just because you have reached the limitations of one piece of software doesn’t mean it is impossible.

- Patchwork solutions are here to stay, but will lead to standardization and development of best practices.
Dynamo

A visual programming plug-in for Autodesk Revit.

- Automate repetitive processes
  - Associations
  - Sheet creation
- Minimize human error
  - Coordinating tags and notes
- Export data
  - 2-way data flow with excel
- Generative design analysis
  - Explore design options
  - Verify design performance
  - Automate standard designs
Dynamo

A visual programming plug-in for Autodesk Revit.

Project Parameters:
- X, Y, and Z coordinates
- Unique identification number
- Associated room number
ODBC Export

A database management protocol that organizes all the Revit BIM data in a set of structured and coordinated tables.

**PROS**
- Contains detailed component tables and relational tables
- Repeatable and predictable
- Searchable and queryable
- Link to other software
- Platform for real-world building system or occupant data

**CONS**
- Additional work required to associate components between tables
- Lots of data! Can be difficult to decode and find what you need
ODBC Export

A database management protocol that organizes all the Revit BIM data in a set of structured and coordinated tables.

| Lighting Fixtures |

<table>
<thead>
<tr>
<th>Standard Component Parameters</th>
<th>User Defined Component Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Id</td>
<td>TypeId</td>
</tr>
<tr>
<td>----</td>
<td>--------</td>
</tr>
<tr>
<td>862573</td>
<td>862665</td>
</tr>
<tr>
<td>862767</td>
<td>869652</td>
</tr>
<tr>
<td>862835</td>
<td>869652</td>
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<tr>
<td>871042</td>
<td>845374</td>
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<td>872232</td>
<td>845981</td>
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</tbody>
</table>
ODBC Export

A database management protocol that organizes all the Revit BIM data in a set of structured and coordinated tables.

### Standard Component Parameters

<table>
<thead>
<tr>
<th>Id</th>
<th>Typeld</th>
<th>PhaseCreated</th>
<th>Dimming</th>
<th>Emergency Luminaire</th>
<th>COORD_X</th>
<th>COORD_Y</th>
<th>COORD_Z</th>
<th>Room-luminaire Association</th>
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</thead>
<tbody>
<tr>
<td>862573</td>
<td>862665</td>
<td>118390</td>
<td>0.8</td>
<td>0</td>
<td>130.1</td>
<td>49.7</td>
<td>9.6</td>
<td>125</td>
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</table>

### Lighting Fixture Types

<table>
<thead>
<tr>
<th>Id</th>
<th>Type</th>
<th>Description</th>
<th>Mounting</th>
<th>Efficacy</th>
<th>Wattage</th>
<th>Color Temperature</th>
<th>Photometric Web File</th>
<th>Luminous Flux</th>
</tr>
</thead>
<tbody>
<tr>
<td>862665</td>
<td>G</td>
<td>Perimeter slot linear LED wall grazer</td>
<td>Recessed in ceiling</td>
<td>73</td>
<td>28</td>
<td>3500</td>
<td>Type G WG.ies</td>
<td>2044</td>
</tr>
</tbody>
</table>
Design and Information Models

Design Model

Highly Structured Information Model

<table>
<thead>
<tr>
<th>Id</th>
<th>Occupancy</th>
<th>Area</th>
<th>Number</th>
<th>Name</th>
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</thead>
<tbody>
<tr>
<td>698132</td>
<td>4</td>
<td>25</td>
<td>120</td>
<td>Private Office</td>
</tr>
<tr>
<td>698133</td>
<td>1</td>
<td>19</td>
<td>116</td>
<td>Private Office</td>
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<tr>
<td>698134</td>
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<td>Private Office</td>
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<tr>
<td>698154</td>
<td>43</td>
<td>109</td>
<td>Storage</td>
<td></td>
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<tr>
<td>698155</td>
<td>24</td>
<td>107</td>
<td>Mechanical</td>
<td></td>
</tr>
<tr>
<td>698156</td>
<td>25</td>
<td>137</td>
<td>Restroom</td>
<td></td>
</tr>
<tr>
<td>698158</td>
<td>33</td>
<td>103</td>
<td>Lobby</td>
<td></td>
</tr>
<tr>
<td>698159</td>
<td>6</td>
<td>33</td>
<td>114</td>
<td>Private Office</td>
</tr>
<tr>
<td>698160</td>
<td>4</td>
<td>27</td>
<td>113</td>
<td>Private Office</td>
</tr>
<tr>
<td>698161</td>
<td>12</td>
<td>37</td>
<td>112</td>
<td>Conference Room</td>
</tr>
<tr>
<td>698162</td>
<td>12</td>
<td>37</td>
<td>135</td>
<td>Conference Room</td>
</tr>
</tbody>
</table>
Verification & Validation

Part 1: Define
Part 2: Data
Part 3: Document
Design Validation
Design data > design intent

● Validation and verification procedures can support specifications and reduce assumptions

● Verification can be as simple as evidence of meeting a specification or project goal

● Avoid room for interpretation

● Not just about filling BIM with data - validation measures raise flags that enforce boundaries when they are passed along project channels
Link simulation outcomes to design model

Highly Structured Data Model

Workstation Locations

Simulation Results

Demonstrated and documented specification value

Design Model

Simulation Model

ODBC Export

Dynamo

AUTODESK REVIT

ALFA

Rhinoceros

Adaptive Lighting for Alertness
Opportunities for Validation and Verification

REPLACE PATCHWORK SOLUTIONS WITH A REIMAGINED STANDARD PRACTICE

Near-Term

PNNL research activities

LPD Verification
- Automated in real-time, including control strategies

Control Narrative Errors/Omissions
- Define expected performance, verify sufficient data to accomplish commissioning

Long-Term

Industry standardization activities

Control Narrative Templates
- Greater standardization would pave the path for automated configuration

System Performance
- Data-producing building systems monitor and verify over time
What’s Next?

- Be the change - ask for more!
- Be open to the possibilities, but don’t expect an easy experience
- Consider developing and implementing near-term, low-hanging fruit solutions
- Imagine (and plan for!) long term wants and goals
- Recognize your strengths - and outsource when you need to

Reconsider your current practice and contract terms regarding BIM and LOD: Design data > design intent

Final deliverables will include the contract drawings, not the BIM file. If the general contractor would like to use the BIM file for their purposes, a standard release form will need to be signed.

- If you want to work at a more mature level, find others with the same vision and look to the future!
- If you want to help define, develop, demonstrate, and standardize new digital tools and workflows, contact us!