Adrian J. Soble
BPRC Summer Seminars
June 27th 2019

NSERC CRSNG
CREATE Heritage Engineering Program

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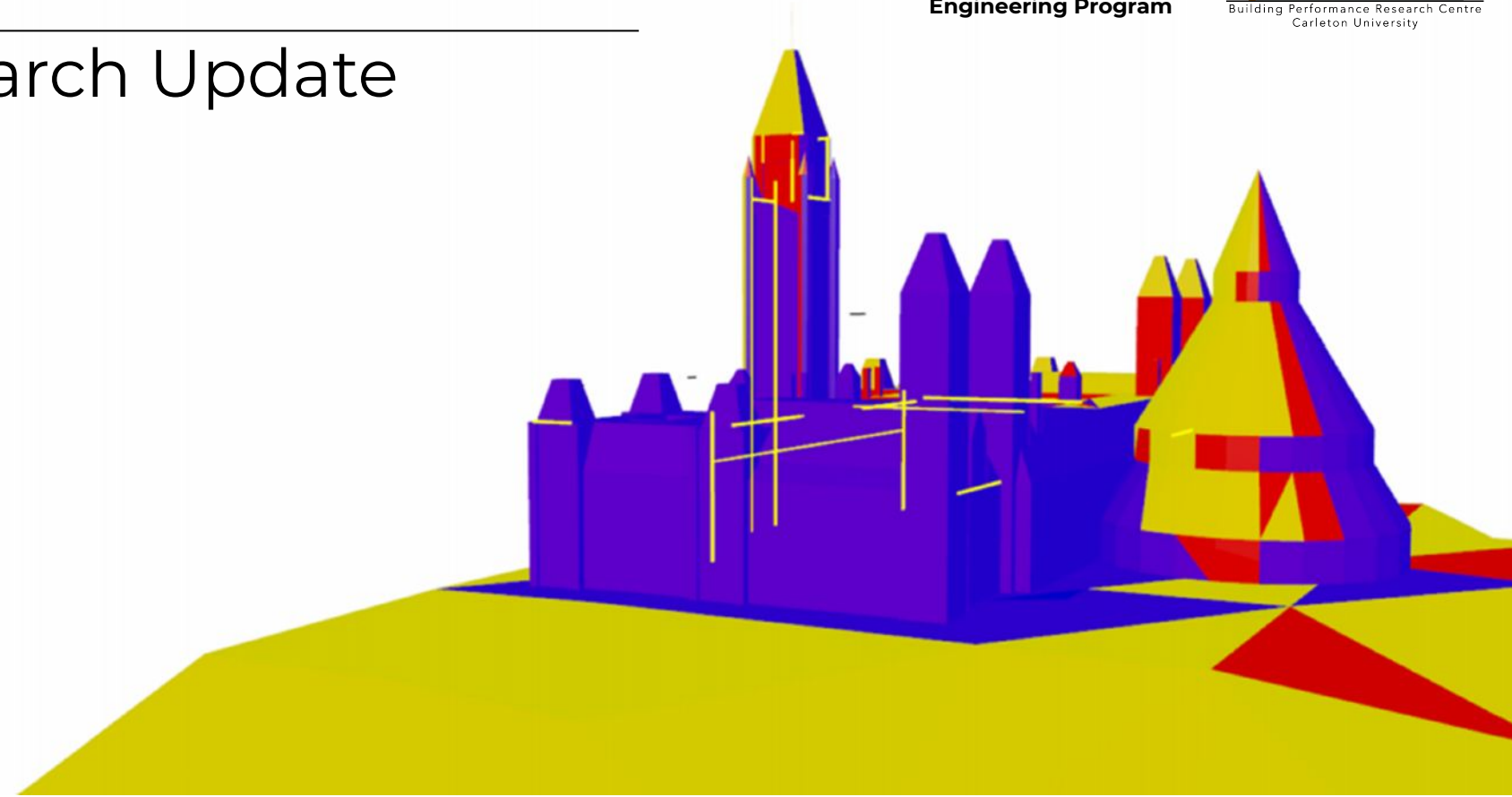
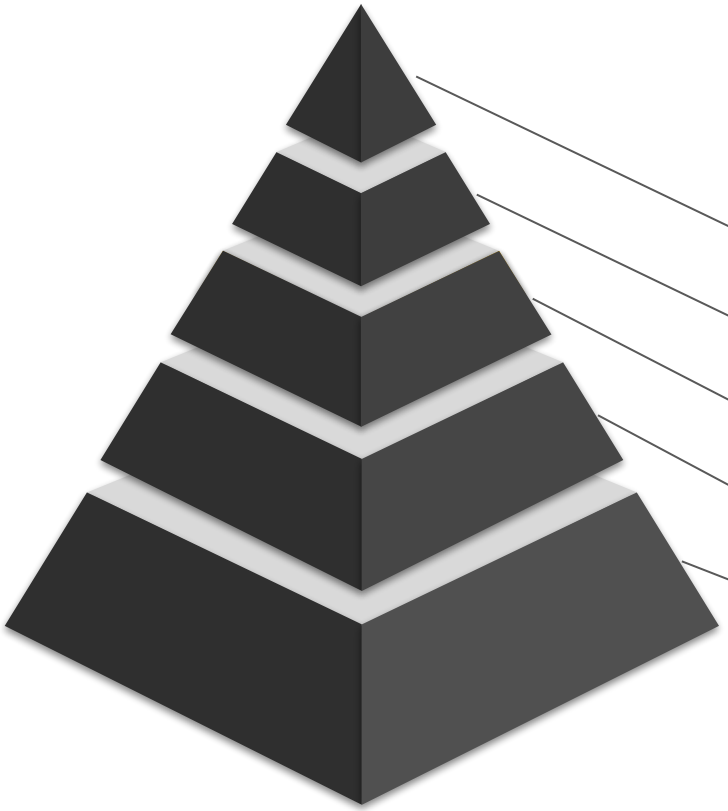
Research Update



Overview



1. Hello!
2. Looking Back
3. Recent Lessons Learned
4. Intro to Grasshopper
5. Work Looking Forward

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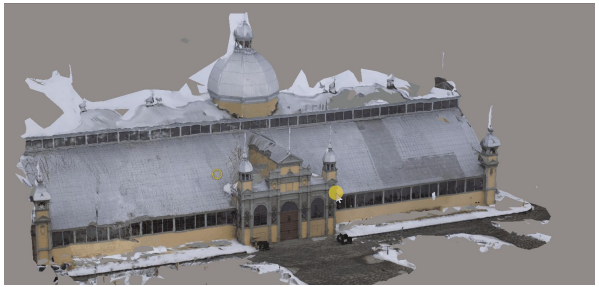
What Have I been Up To?

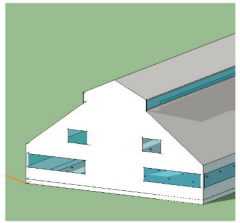
Carleton Heritage Conservation Symposium
April 27th 2019

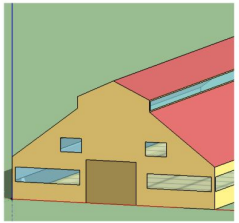


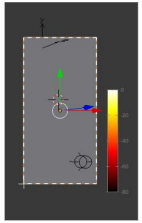
Google SketchUp
Version 7.0.11018

SketchUp Make
Version 17.2.2555 64-bit

Blender 2.76.



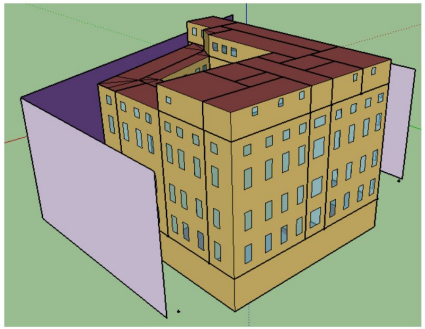


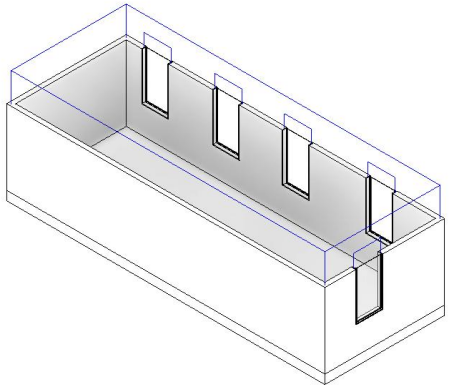


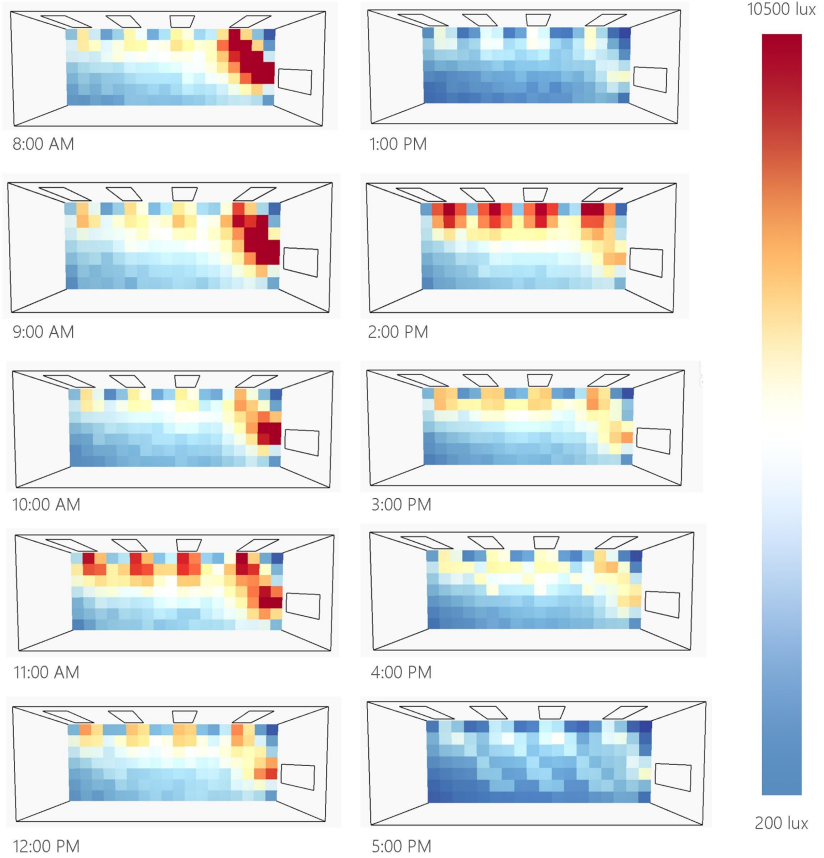
OpenPSTD

What Have I been Up To?

IBPSA Rome 2019 Student Modeling Competition







What Have I been Up To?

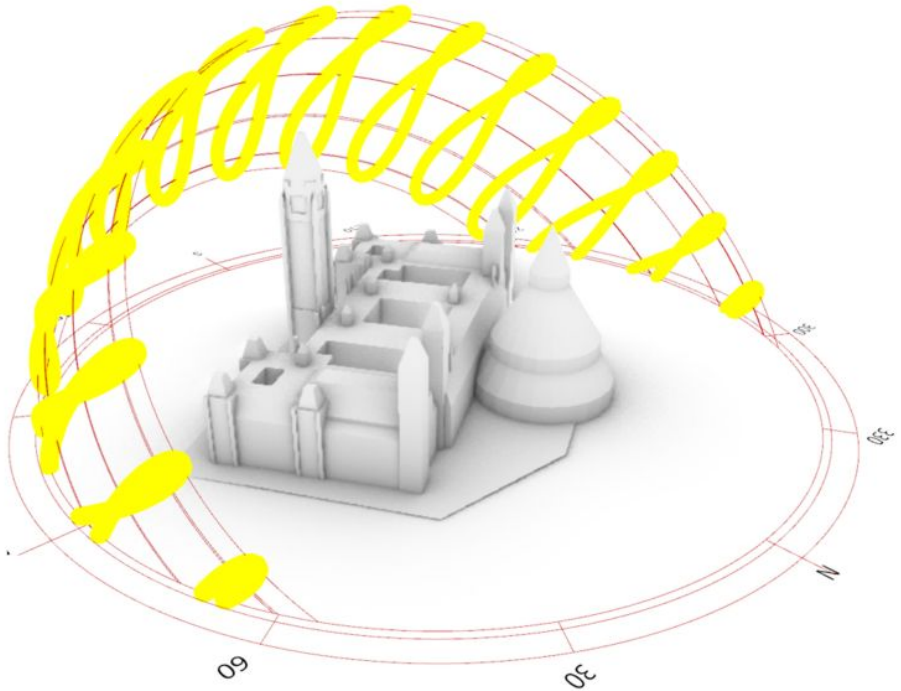
Mexico DSA 2019

What Have I been Up To?

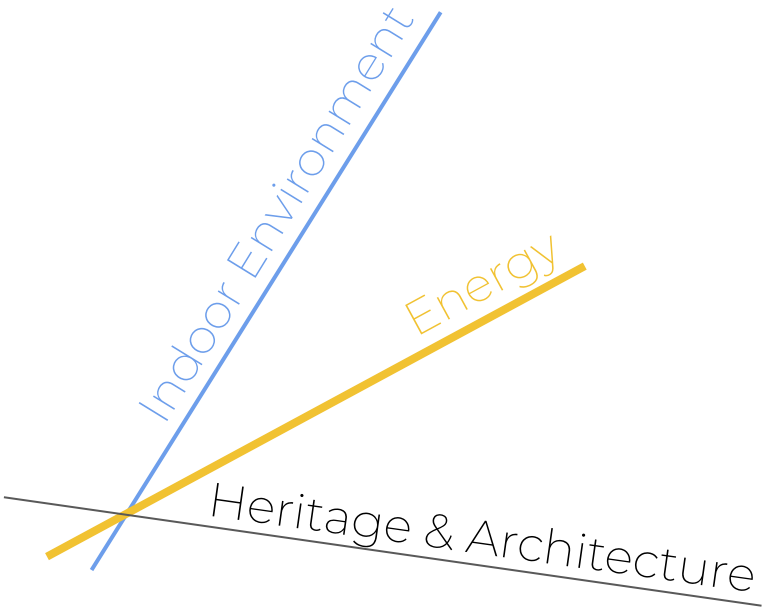
CENTRE BLOCK REHABILITATION PROGRAM | ÉDIFICE DU CENTRE PROGRAMME DE RÉHABILITATION

CENTRUS

wsp



Looking Back : Research Objectives



Develop tools and methodology to better incorporate existing/historical building **performance** aspects into the decision making process for retrofits by means of **generative design**

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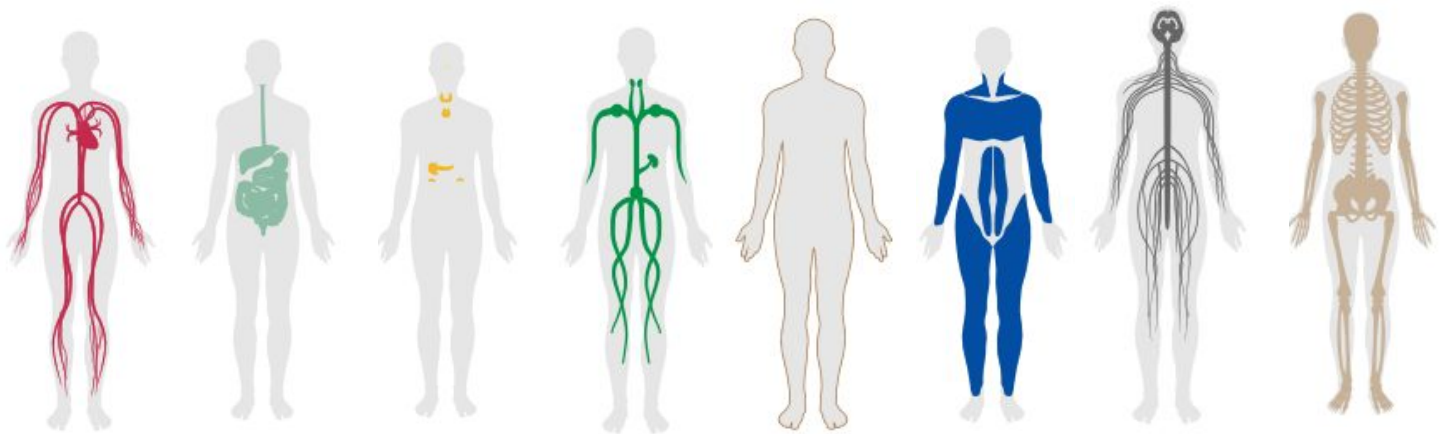
Looking Back : Indoor Environmental Quality

People spend up to 95% of their time indoors

Designers should keep the best interest of the public in mind



 International WELL Building Institute, "The Well Building Standard," vol. V1, no. May, 2016.

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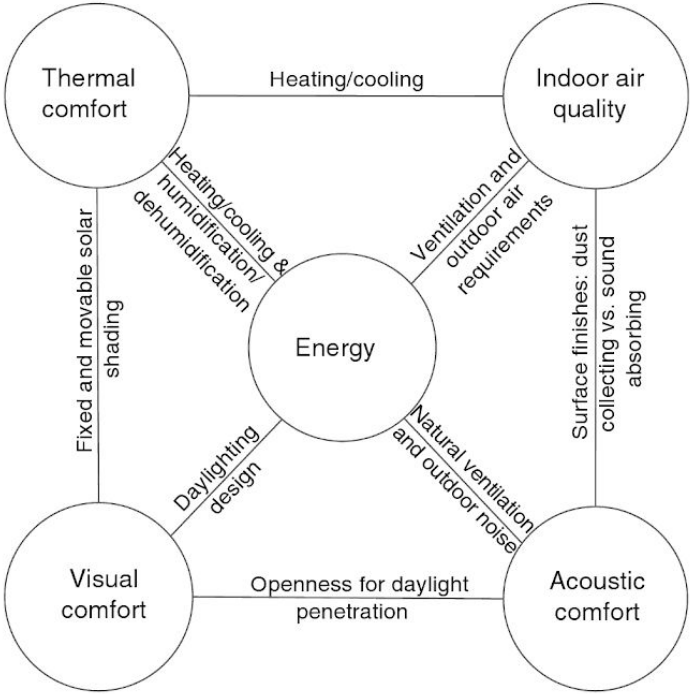
Looking Back : Building Energy



Buildings are responsible for 30 - 45% of the global energy usage via systems that support:

- Heating
- Ventilation
- Lighting
- Appliances
- Electronics
- Hot Water

W. O'Brien, A. Athienitis. Modeling, design, and optimization of net-zero energy buildings. Erns & Sohn, 2015.

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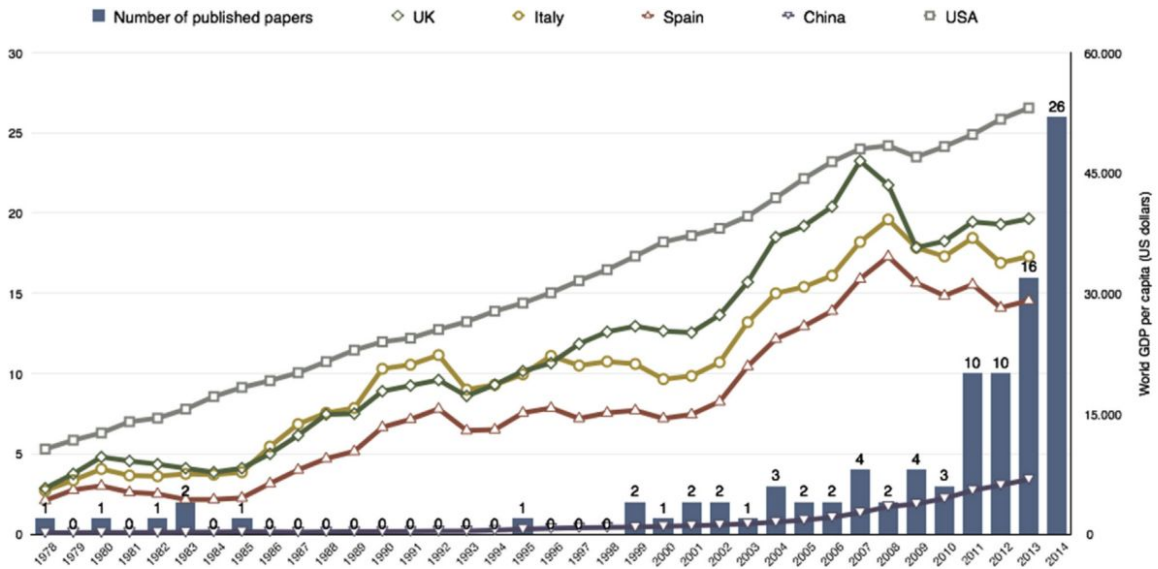
Looking Back : Heritage and Existing Buildings

Heritage buildings comprise of 10 - 15% of the building stock

The rate of replacement for existing buildings is only 1 – 3% annually



A. Martínez-Molina, I. Tort-Ausina, S. Cho, and J. L. Vivancos, "Energy efficiency and thermal comfort in historic buildings: A review," Renew. Sustain. Energy Rev., vol. 61, pp. 70–85, 2016.

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IEQ Category	Metric Name
LIGHT	· Average light intensity · Work surface lighting intensity · View access distance · Spatial daylight autonomy · Annual sunlight exposure · Useful Daylight Illuminance
Acoustic COMFORT	· Exterior Noise Intrusion · Perceived Noise Criteria · Reverberation Time · Sound Transmission Class · Speech Transmission Index
AIR	· Formaldehyde · TVOC · CO · $PM_{2.5}$ · PM_{10} · Ozone · Radon · CO_2 · RH · Odor
COMFORT	· Predicted Mean Vote · Predicted Percent Satisfied

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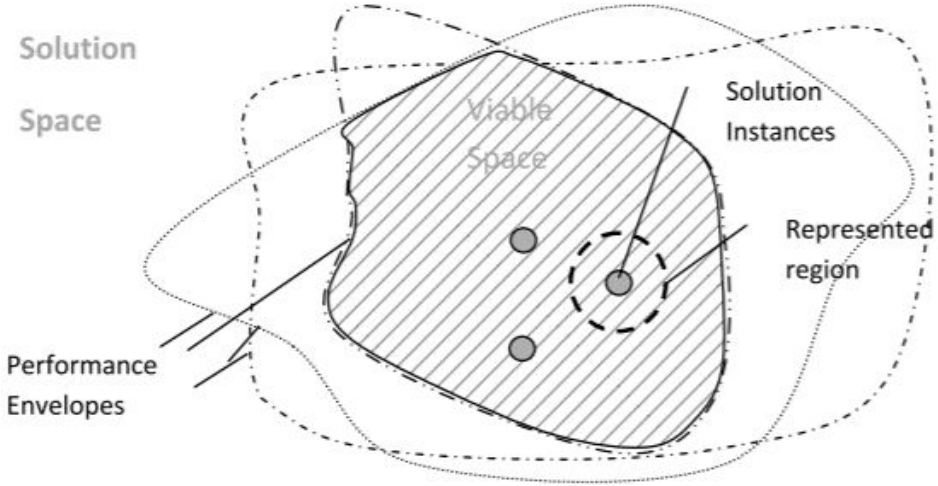
Looking Back : What is Generative Design?

- More than parametric analysis
- Uses evolutionary optimization algorithms
- Compromise Oriented
  - Not intended to find single “Most Optimal” solution
- **Design options must be formatted for stakeholder evaluation**



Krish, S. (2011). A practical generative design method. CAD Computer Aided Design, 43(1), 88–100. https://doi.org/10.1016/j.cad.2010.09.009

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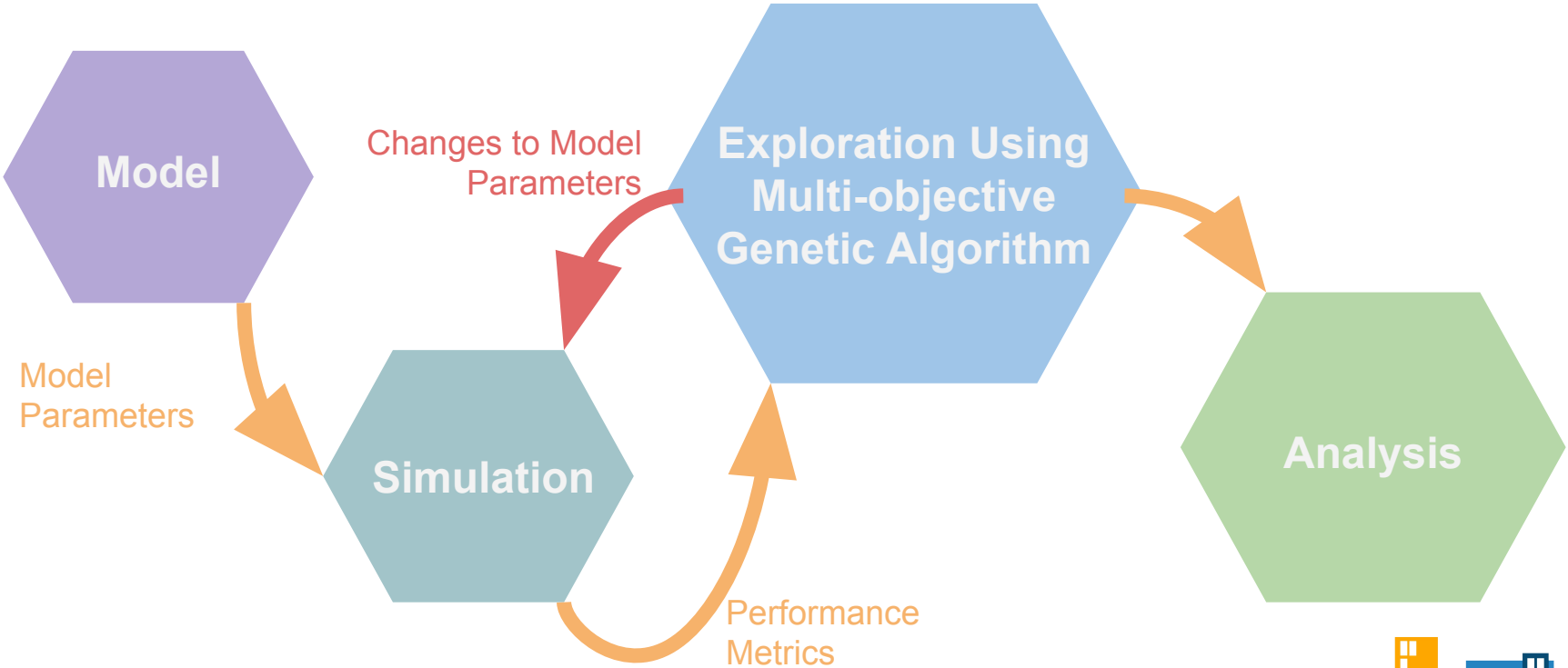
Looking Back : GD Methodology



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Be the chef, not the farmer*

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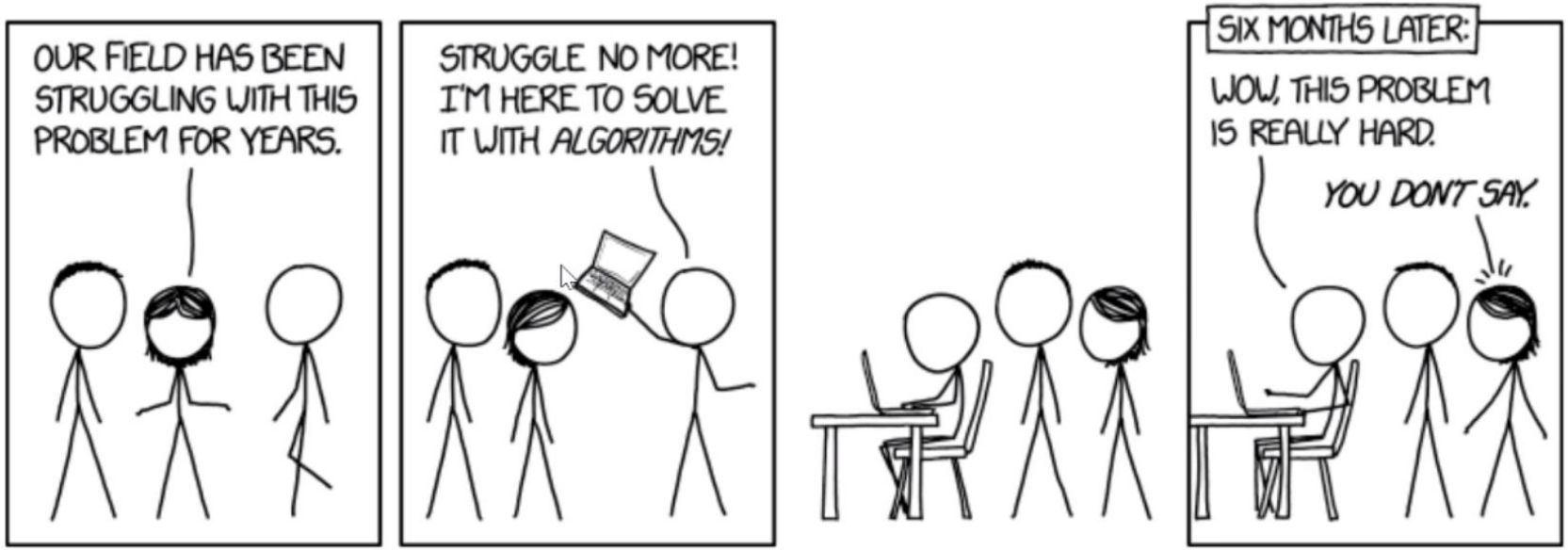

https://www.youtube.com/watch?v=RB9ly1sRxtc&t=5403s

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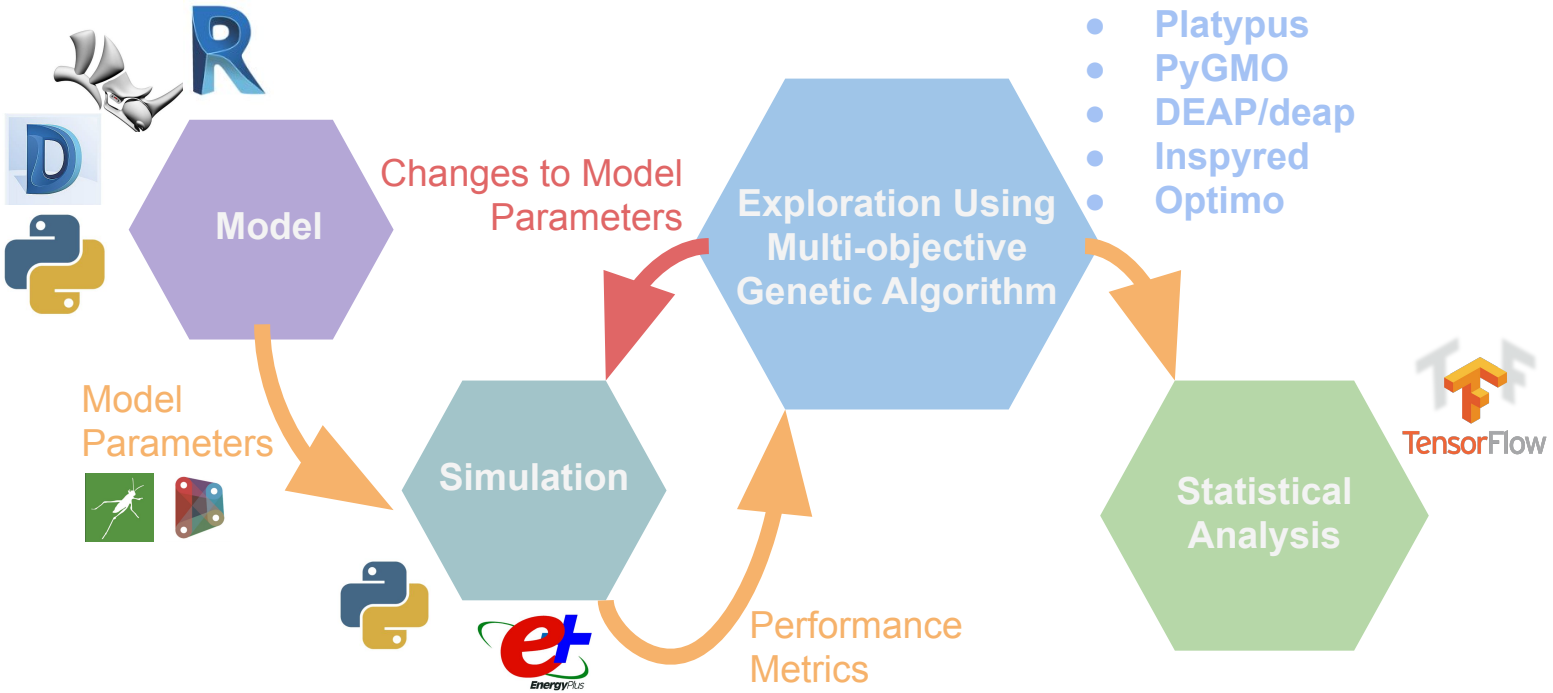
Looking Back : Tool Review



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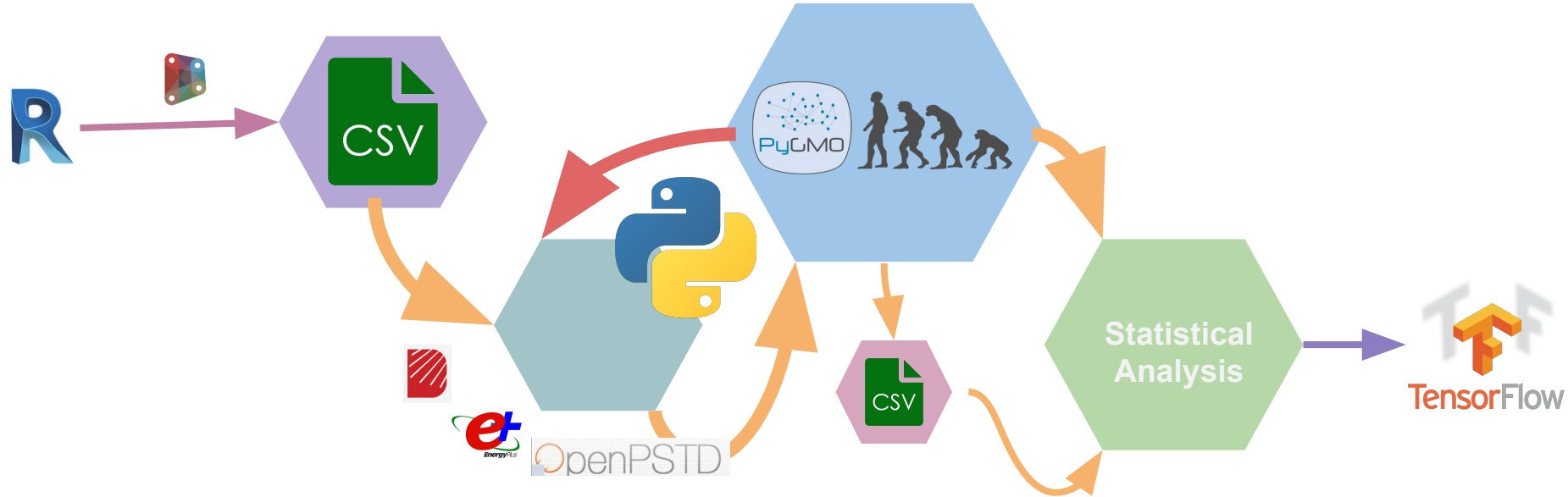
First Idea



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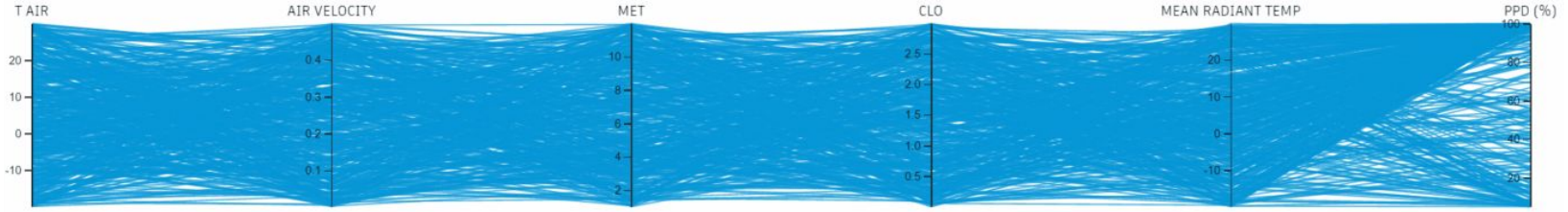
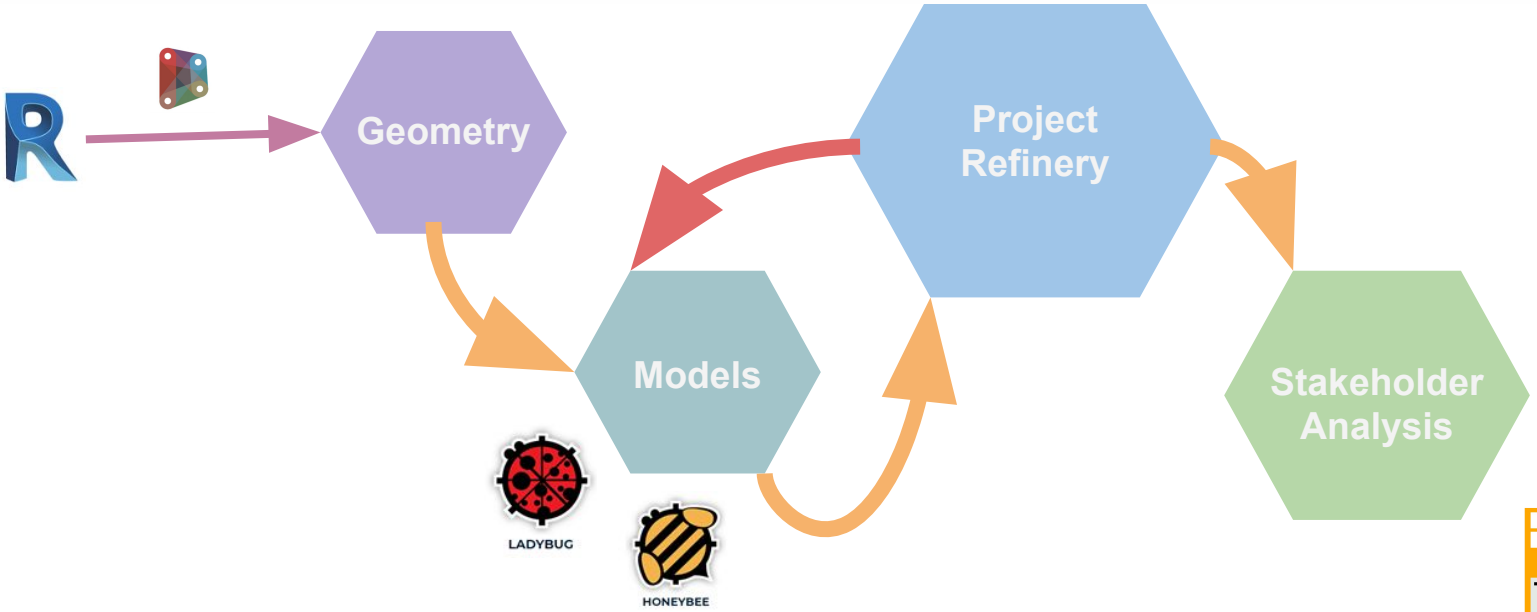
Second Idea





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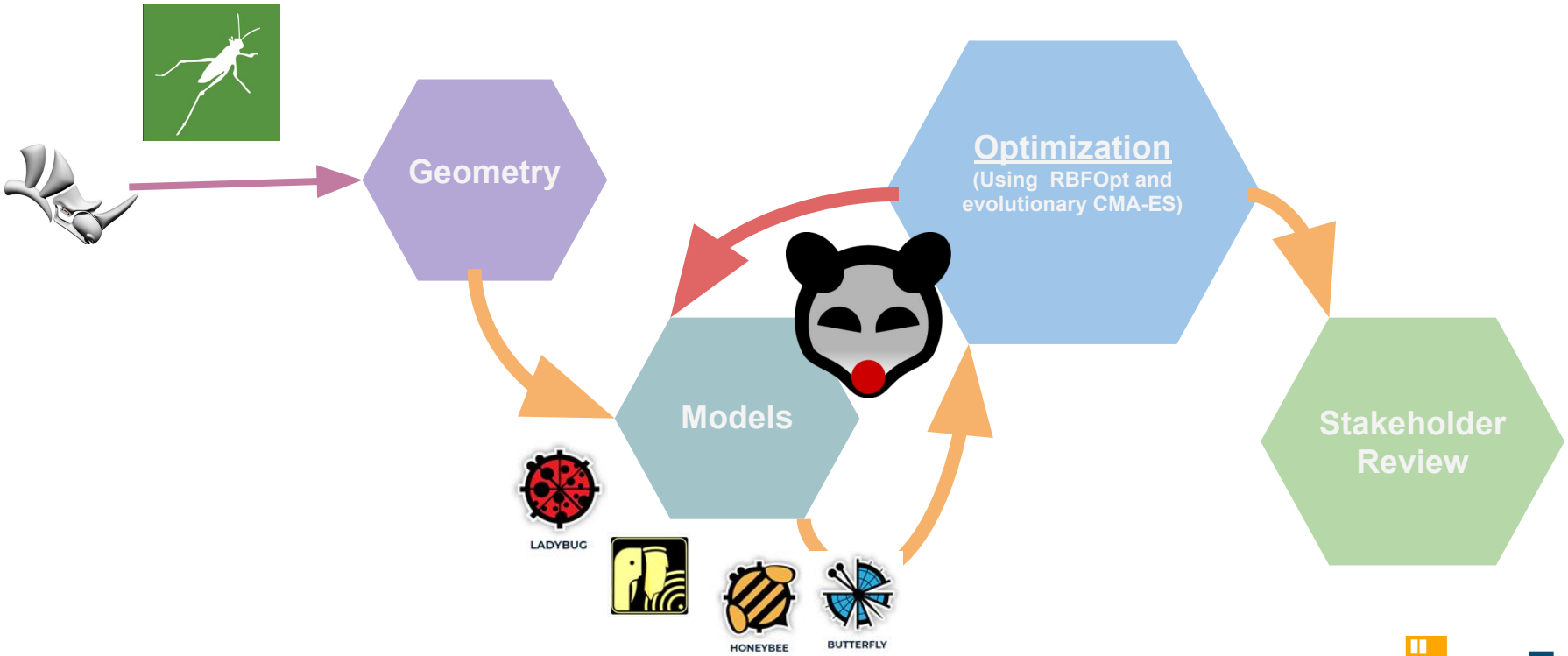
Current Idea



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Why did I move away from Dynamo?

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Visual Programming Comparison

Interfaces with		
First Released	2013	2007
Open Source Back End	Yes	Yes
Python Interface	Yes	Yes, More Stable
Imports Geometry	Yes	Yes
Imports BIM Features	Yes	No
Apps / Plugins	1176	728, Tighter Control

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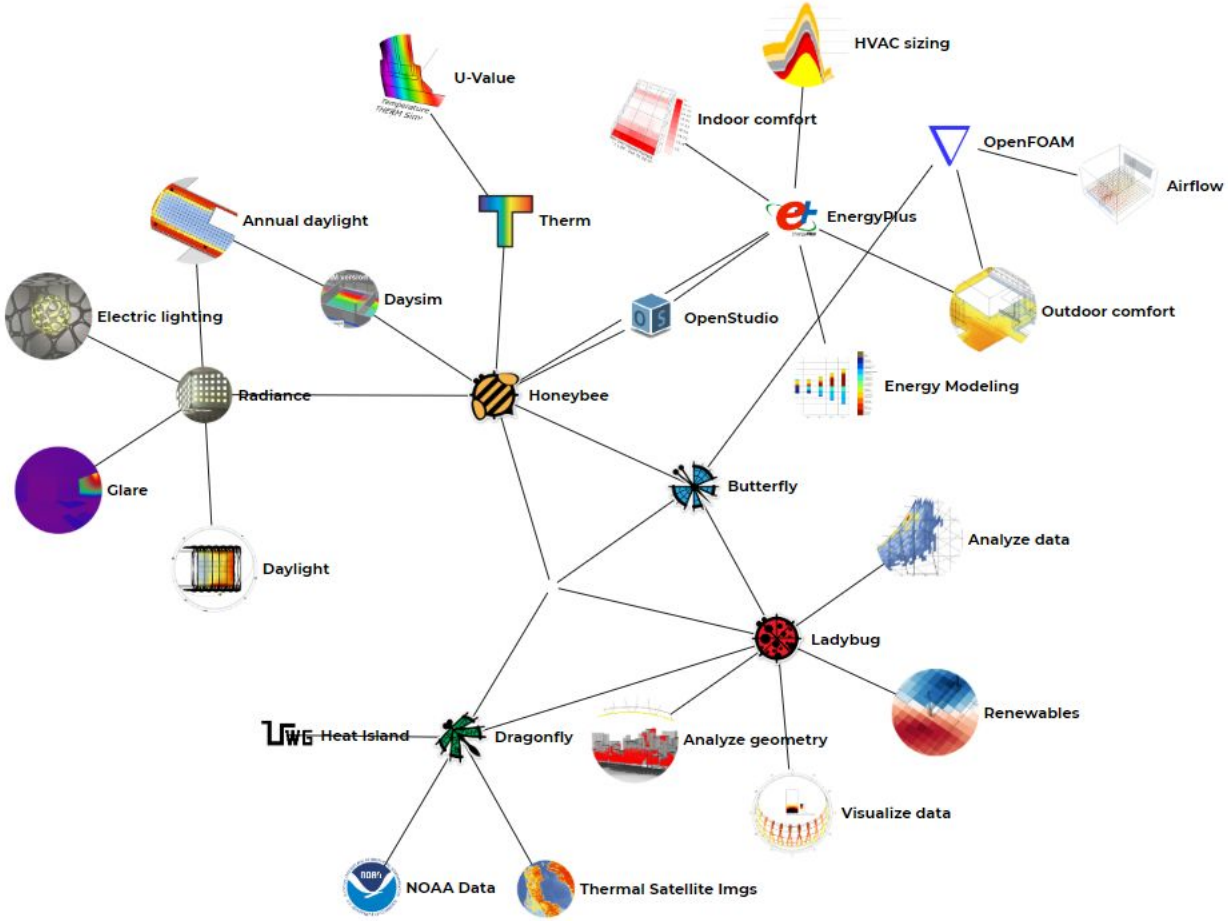
LADYBUG

HONEYBEE

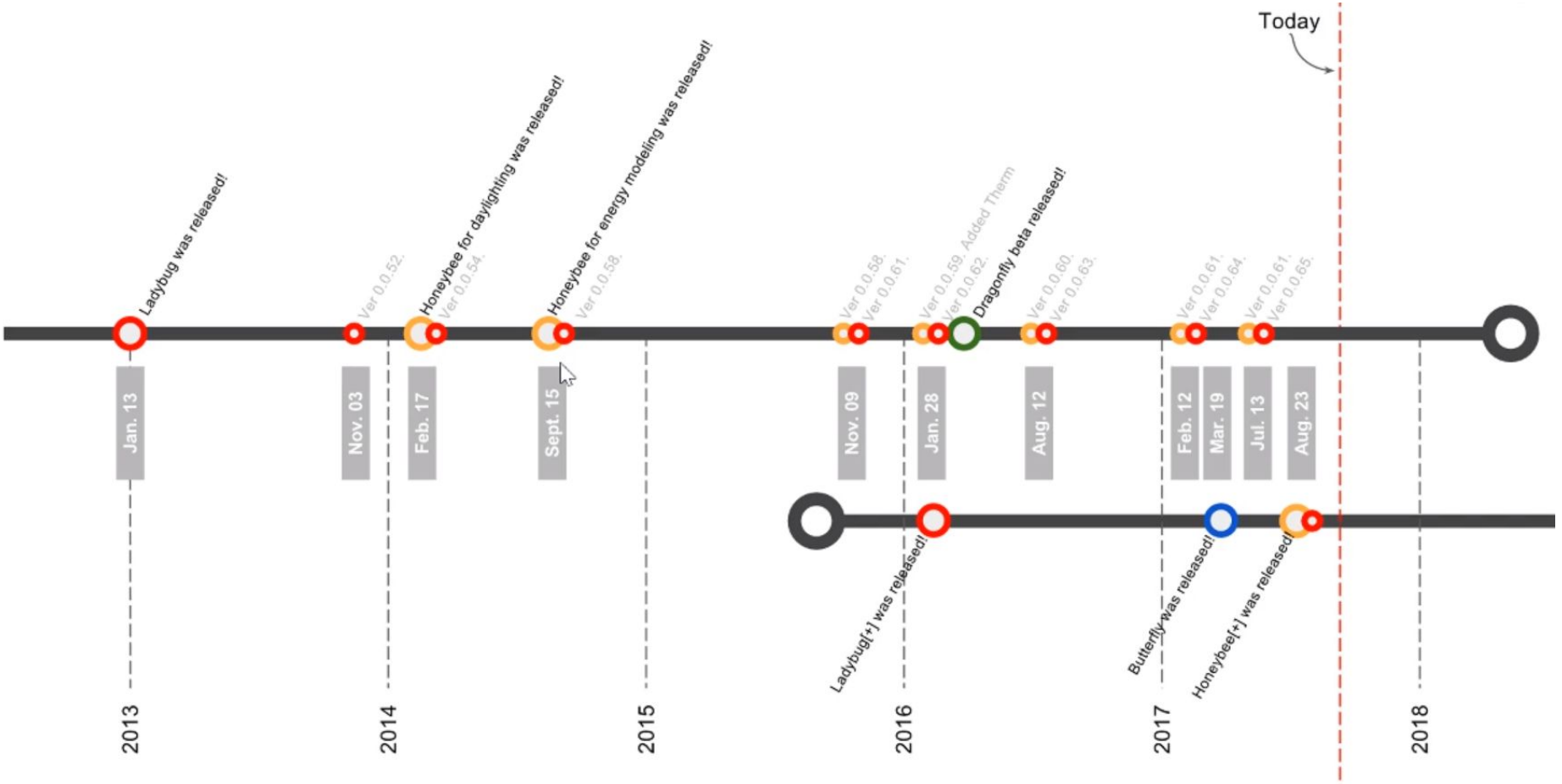
BUTTERFLY

DRAGONFLY

LINK



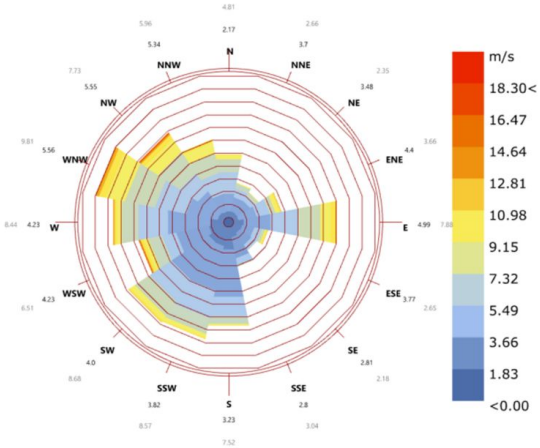
https://www.ladybug.tools/

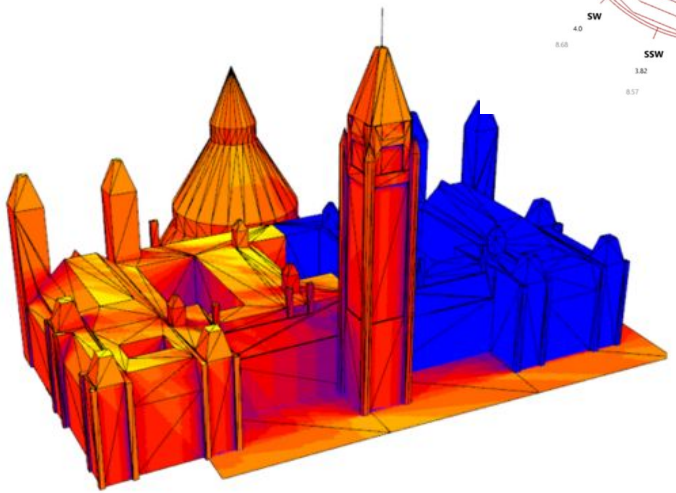


 https://www.youtube.com/watch?v=RB9ly1sRxtc&t=5403s

We should all be using / teaching grasshopper?

- Comfortable and interactive front end to **already verified simulation engines**
- Open source and developed in Python
- Robust data visualization capabilities
- Very flexible
- Extensive documentation
- Industry is using it!





Let's Dive into Grasshopper!

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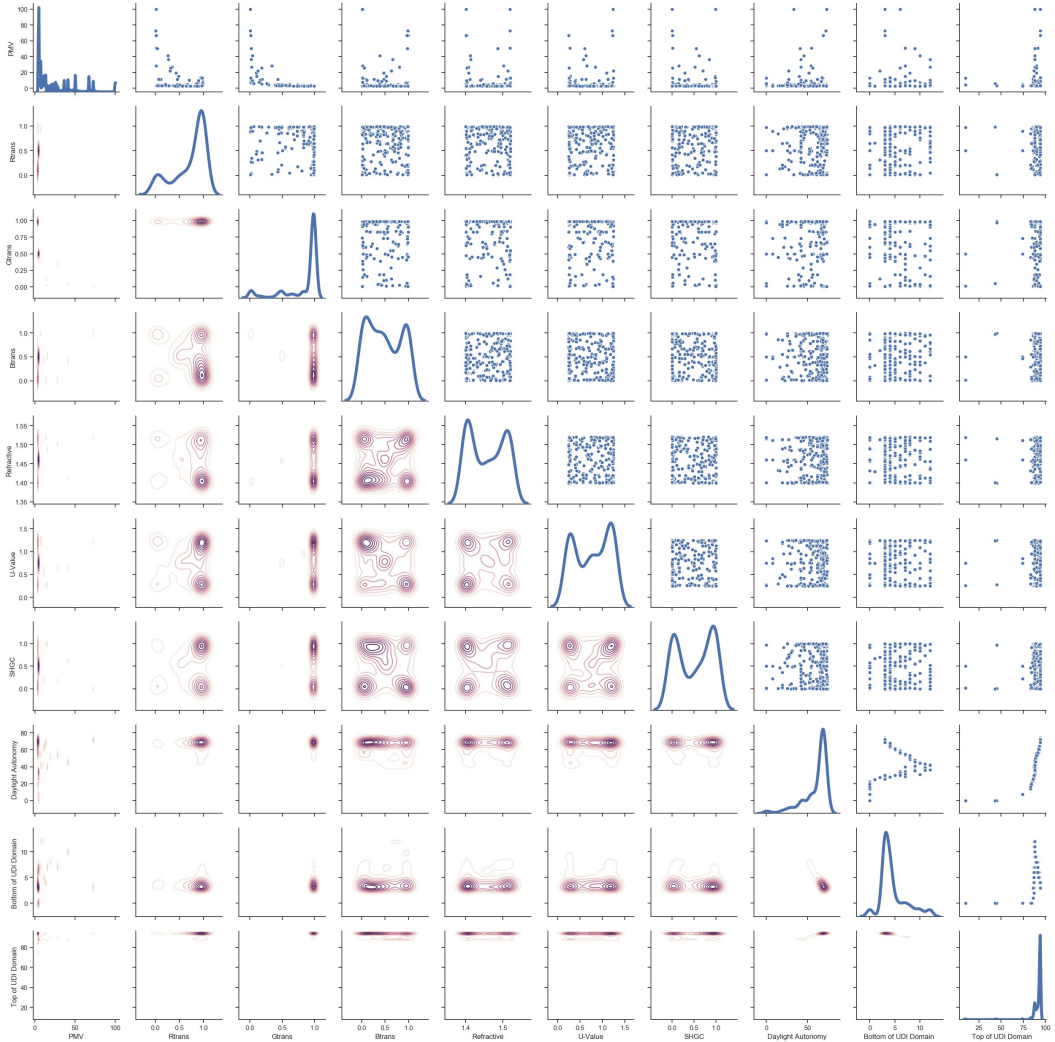

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Looking Forward

- More optimization runs
- Develop balanced cost function for:
  - Light Comfort
  - Energy Efficiency
  - Thermal Comfort
  - Air Quality
- Figure out how to speed up run times
- Explore the potential for Acoustic Comfort modeling
- Develop other ways to navigate / communicate large volumes of options to stakeholders

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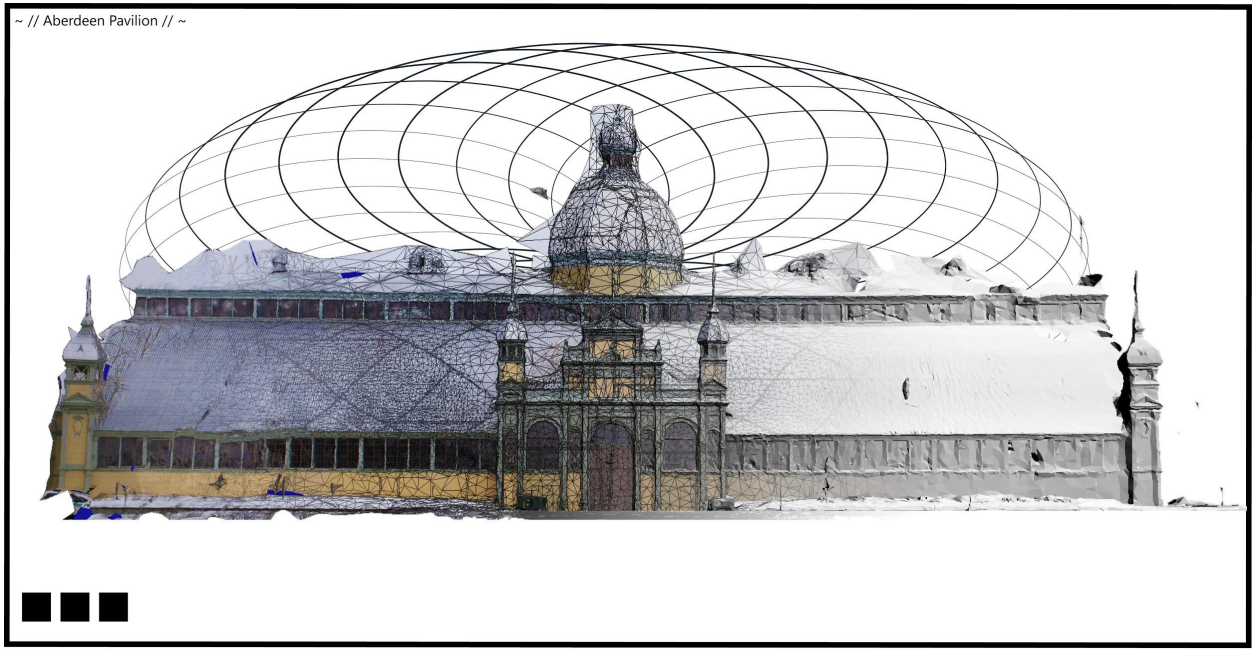

Thank You

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SLIDE ANNEX

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IEQ Category	Metric Name	Ideal Range
LIGHT	· Average light intensity · Work surface lighting intensity · View access distance · Spatial daylight autonomy · Annual sunlight exposure · Useful Daylight Illuminance	· > 215 lux at 0.76 m · 300 lux—500 lux · 7.5 m - 12.5 m · > $sDA_{300,50\%}$ · < $ASE_{1000,250}$
Acoustic COMFORT	· Exterior Noise Intrusion · Perceived Noise Criteria · Reverberation Time · Sound Transmission Class · Speech Transmission Index	· > 50 dBA · 20 - 40 · RT60, 0.5 s—0.6 s · 45 STC—60 STC · 0.2— 0.5
AIR	· Formaldehyde · TVOC · CO · $PM_{2.5}$ · PM_{10} · Ozone · Radon · CO_2 · RH · Odor	· < 27 ppb · < 500 µg/m³ · < 9 ppm · < 15 µg/m³ · < 50 µg/m³ · < 51 ppb · < 4 pCi/L · < 800 ppm · 30% - 90% · 0 - 4 OLF
COMFORT	· PMV · PPD	· ASHRAE Standard 55