Generative Design in Revit and Beyond

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About the speaker

Lilli Smith, AIA

Lilli is an architect with a passion for re-envisioning the way that buildings are designed. After working for several years as an architect, she joined Revit Technology as a fledgling start up and helped grow it to where it is today in almost every architect’s toolbox. She has gone on to work on many Autodesk tools including Vasari, FormIt, Dynamo, Project Fractal and Project Refinery which recently graduated to a suite of tools for generative design studies in Revit.
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General Motors Technical Center in Warren Michigan.
AutoCAD Release 1 - A major impact on CAD industry
GENERATIVE DESIGN FOR ARCHITECTURE, ENGINEERING & CONSTRUCTION

Generative design is a definitive shift in conceptualizing, designing, and building. Discover how design automation and design optimization deliver a new freedom and possibilities.

GENERATIVE DESIGN IN REVIT
Use cases

What's new?

What's next?
How are people using Generative Design?
University of Toronto Coastal Resilience

How can we plan for growing coastal communities in the face of rising coastal flooding incidents?

Land Value
How can we get the most value out of the available land?

Flood Risk
As floods become more common, how can we minimize flood risk?

7 Metrics
Defined to perform automated design exploration on how to best meet the 2 goals.
University of Toronto: Costal Resilience

How should the urban and physical landscape evolve in response to rising sea levels?

How can we leverage big data to generate resilient architectural typologies?
Phase 1: Defining Design Goals

**Flood Risk**
As floods become more common, how can we minimize flood risk?

**Land Value**
How can we get the most value out of the available land?
Phase 2: Defining Evaluation Metrics

**Goals**
- Increase Land Value
- Decrease Flood Risk

**Evaluation Metrics**
- Maximize coverage by critical infrastructure
- Minimize distance of property parcel to road network
- Maximize below grade utility space
- Maximize percentage of land above ground

**Parameters**
- Location of Critical Infrastructure
- Radius of Critical Infrastructure Coverage
- Areas to Cut
- Areas to Fill
- Flood Height
Phase 3: Optioneering, Optimization and Curation
Phase 3: Optioneering, Optimization and Curation
4 hours
The traditional design process took 4 hours for a typical design of one standard layout.

Automate
Layout store design and optimize design options.

15 Minutes
The new process took 15 minutes to gather information, run the script, and receive 40 optimized design options.
Hufft Hobbs Trail Structure

5 Metrics
Including efficiency of components, reduction of waste, and cost guided the design.

Teamwork
Team members in addition to logic authors, created studies and participated in evaluating them.

Optimization
of the shell's form, components, and connections were all completely informed by the generative design process.
Meaningful Spaces and Objects, Inspired by People and Places
What to know

Hobbs is Arkansas's largest state park, spanning a 12,054-acre tract of Ozark landscape along the southern shore of Beaver Lake. It’s an asset to the ecosystem and water with minimum human impact.

Highlights of this day-use park include a diverse, 52-mile trail system with hiking, ADA, mountain biking, and horseback riding trails, and 5 primitive campsites. It’s the only state park in Arkansas to allow regulated hunting. The visitor center includes exhibits about the park’s natural resources, limestone landscape, and history. Interpretive programs and workshops are offered...
What’s new?
New!

Generative Design in Revit 2021

“As an Architect who uses Revit, but is not a skilled computational designer, I want to perform generative studies so that I can evaluate better performing design options.”

“It will be a huge time saver to generate and evaluate options so quickly”

AU Idea Exchange Participant

“This will automate repetitive work and create better designs”

AU Idea Exchange Participant
Generative Design for Revit – Create Study

- Create and explore generative studies directly from Revit
- Learn from included sample content
- Create custom studies

Create Study

Select a study type

- Grid Object Placement
  Places elements in a rectangular grid pattern inside a room.

- Maximize Window Views
  Generates various viewpoints. Calculates scores that represent the quality of views to the outside from those points.

- Randomize Object Placement
  Creates clusters of elements inside a selected room.

- Stepped Grid Object Placement
  Places elements in a stepped grid pattern inside a room.

- Three Box Massing
  Generates simple massing models by varying the heights and relative positions of three boxes. Calculates facade area and floor area.

- Workspace Layout
  Generates rows of desks in a room, considering doors, windows, and columns. Calculates distance to exits, views to outside, and more.
Generative Design for Revit – Define Study

- Select Revit elements to use in study
- Set design goals
- Generate design options
- Save Default Values
- Create and Explore generative studies directly from Revit

Select a room (Element: 281513), select desk family instance (Element: 281510), choose variables (Desk row rotation: -90 to 90, Spacing between rows (ft.): 10 to 16), set goals, set constraints, generation settings.
Generative Design for Revit - Explore Outcomes

Explore outcomes
Create Revit elements
Evaluate goals
Track studies
Filter and rank results
Drop-down inputs

Drop-down nodes can be set as “Is Input”

Drop-down input list for selection similar to Dynamo Player
Clear settings for constant and variable inputs

- Variables labelled
- Unchecking box changes label to “constant”
- Constant value can be set with a slider
- Boolean Value can be set with a toggle instead of a slider
New Revit Generative Design license for collections and enterprise customers enables direct access from Revit.
Student Licensing Now Available

https://www.autodesk.com/education/edu-software
OR all users can access Generative Design via Dynamo for Revit

Export scripts for use in GD for Revit

Create Study

Explore outcomes

Tweak samples or create new logic
Dynamo Export of Generative Design studies

Describe logic

Provide a preview image

Validate logic

Automatic dependency handling

Keep or clear test data

Export logic for use in generative design studies

Description
Generates rows of desks in a room, considering doors, windows, and columns. Calculates distance to exits, views to outside, and more.

When exported, a copy of this graph and all its dependencies will be saved to this folder:
C:\Users\smith\Documents\AEC Generative Design

Any previous exports of graphs with the same name will be overwritten!

How should cached data in all Remember nodes and Select nodes be handled?
- Keep cached data
- Clear cached data

Cancel  Export
Dynamo access to Create and Define Studies

EXCEPT No direct selection of Revit elements from UI

Same experience as from Revit
Dynamo access to Explore Outcomes

EXCEPT No creation of Revit elements from UI - Open in Dynamo instead
Available in the 14 languages supported by Revit
Autodesk Desktop App Updates
What’s new in Dynamo?
Dynamo Performance Improvements

Large node count graphs that create Revit Elements 23 seconds reduced to 23 MILLIseconds

General and intersection specific PolyCurve improvements now up to 100x faster
Dynamo Usability: Graph Performance monitoring

Accessible from View Menu with other team extensions.

Shows total execution time at a glance.

“TuneUp” available on Dynamo Package Manager.
Dynamo Usability: Understanding Warnings and Errors

Accessible directly from node UI.

Extensible for third party package authors.
Dynamo Usability: Enhancing the graph authoring experience

Node ports that do not require an input are now shown in italics

Codeblock Nodes now have line numbers

Renamed nodes now have a tag to show users which nodes are customized
Dynamo for Revit: New nodes
Dynamo for Revit: New nodes for Generative Design

Let's study author set the context for the Revit Selection
What’s Next?
Roadmap

PEOPLE INVOLVED IN THE PROCESS

CLIENT

PROJECT MANAGER

MORE PROJECT DESIGNERS

PROJECT DESIGNER

DESIGN TECHNOLOGIST

CAPABILITIES

We are here

Cloud Compute and Store

Outcomes in BIM360

GD in FormIt

GD in Civil 3D

GD in Revit

Refinery Beta

Outcomes in BIM360
1. Study Type Editing
Study Type Editing: Help placing the remember node
Study Type Editing Workflow Improvements

Image of a computer screen showing a warning message in Dynamo software. The message reads:

**Missing Dependencies**

The Generative Design study you are opening was exported with third-party packages or custom nodes that aren't currently installed in Dynamo. How would you like to resolve the issue?

- Load temporarily

All missing dependencies will be loaded in Dynamo for this session only. The packages will not be loaded the next time you open Dynamo.

Ok
2. Study Type Sharing
Sharing Generative Design study types - before
Sharing Generative Design study types - improved
3. Outcome Sharing
Better export so that people can use their automatically generated design data in other programs such as PowerBI and Excel.
4. GD in more Autodesk Applications
Generative Design in More Autodesk Applications

CIVIL 3D

ROBOT STRUCTURAL ANALYSIS PROFESSIONAL

AUTODESK® FORMIT®
5. Analysis tools
Generative Design access to analysis tools

- Sun and Shadow Studies
- Solar Radiation Studies
- Energy Analysis
- Daylighting Studies
- Embodied Carbon Analysis
6. Dynamo Usability
Dynamo Usability: Node Auto-complete
Dynamo Usability: Friendlier code block nodes

OLD WAY

NEW APPROACH
Dynamo: Python 3

Node indicates selected Python engine outside of editor window

Graph author can choose the Python engine

Graph author can understand context in the Documentation Browser

Since the introduction of Python 3 in 2008, Python 2 and 3 have been supported side-by-side by the Python Software Foundation (PSF) and the broader Python Community. This stopped on January 1st 2020, when Python 2 support from the PSF officially ended.

Backwards Compatibility
Dynamo 2.7 introduces a new Python engine, CPython3, that provides access to Python 3 inside of Dynamo. There is no guarantee that any code written in the CPython3 environment will work in previous versions of Dynamo. Code authors should ensure backwards compatibility with both the IronPython2 and CPython3 versions as desired.

Why did we need to change the Python version
Dynamo, and many other CP based environments, uses a tool called IronPython to move data between .NET objects and Python scripts. Unfortunately, IronPython has not been updated to Python 3, so Dynamo is now transitioning to use the standard native Python interpreter (aka CPython.)

In addition, this means it will be possible for Dynamo graphs to benefit from Python libraries that include native extensions that were not accessible in IronPython, such as NumPy, SciPy, and Pandas.

Moving Dynamo to Python 3 will allow Dynamo users to access popular modern libraries and continue to access new platform features, essential maintenance, and security patches.
7. Dynamo Performance
Dynamo Performance: updated graphics engine

- Improved rendering performance
- Fewer graphics related crashes

More info: https://dynamobim.org/dynamo-graphics-updates/
Dynamo Performance Improvements

Package Manager speed improvements of up to 25x
Pop Quiz!
Roadmap Themes Feedback Wanted

Please visit [http://autode.sk/AU20GDinRevitFeedback](http://autode.sk/AU20GDinRevitFeedback) and tell us what you think about our roadmap!

1. **Study Type Editing** make graph authors more successful in creating design study types for use in Generative Design.

2. **Study Type Sharing** make it easier for graph authors to share generative design study types with Revit designers to run in Generative Design in Revit.

3. **Outcome Sharing** make it easier to export results for sharing with stakeholders and telling data-backed design story

4. **Generative Design in more Autodesk Applications**
   – extend Generative Design tools to other Dynamo enabled applications including Civil 3D, Robot Structural, and FormIt.

5. **Analysis Tools for Dynamo and Generative Design**
   – provide access to environmental and other kinds of analysis tools for generative workflows.

6. **Dynamo Usability** – make Dynamo more friendly and easy to use

7. **Dynamo Performance** – make Dynamo faster and more stable
2020 AUTODESK UNIVERSITY COURSES

• Generative Design in Revit for Workspace Layout - Tomasz Fudala
• Non-Geeks Guide to Optimizing Daily Workflows with Generative Design - Raquel Bascones Recio
• Using Generative Design and Machine Learning for Faster Analysis Feedback - Varvara Toulkeridou
• Generative Design at Hogwarts: Using Tech Instead of Magic - Jacob Small
• Generative Design für Revit in der Praxis - Lejla Secerbegovic
• Diseño Generativo en Revit para todos los públicos - Raquel Bascones Recio
• Generative Design—Daylighting and CFD: A Practical Application for a Nonprofit - Luc Wing
• Generative Design of Landforms with Dynamo in Civil 3D - Andreas Luka
Resources

**GENERATIVE DESIGN PRIMER**
https://www.generativedesign.org

**DYNAMO PRIMER, FORUM & BLOG**
https://primer.dynamobim.org/
https://forum.dynamobim.com/
https://dynamobim.org/blog/

**PAST AUTODESK UNIVERSITY COURSES**
- Geometry Systems for AEC Generative Design: Codify Design Intents into the Machine
- MEP Explore: Generative Design for MEP Designers
- Getting Started with Generative Design for AEC
- Using Generative Design in Construction Applications

**PRODUCT HELP**
Product help
Release notes