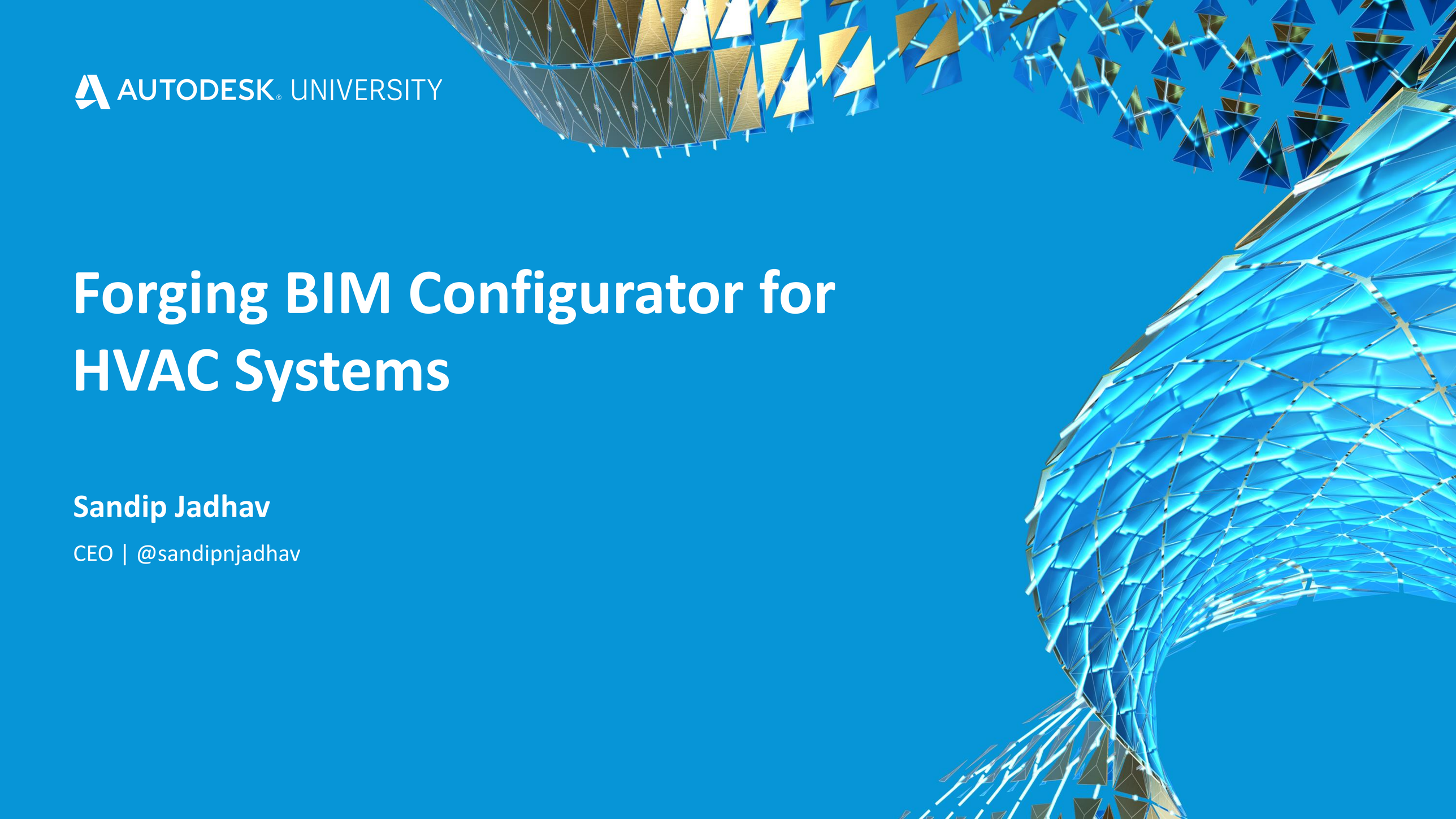
AUTODESK. UNIVERSITY

Forging BIM Configurator for HVAC Systems

Sandip Jadhav

CEO | @sandipnjadhav



About the speaker

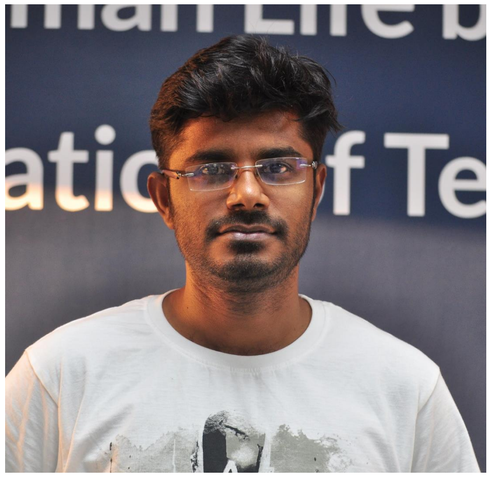
Sandip Jadhav, CEO, CCTech

Sandip is a successful entrepreneur in the CAD/CAE space. He has co-founded CCTech, Zeus Numerix, Adaptive 3D Technologies, LearnCAx and recently simulationHub, a cloud-based fluid flow simulation web service. Sandip has led several product development teams in conceptualizing, designing software, and implementation of apps in CAD and simulation space. Sandip is a passionate software developer and loves to tinker with technology.

Co-Speaker

Rohit Chavan, SDM, CCTech

Rohit is Software development Manager of the simulationHub CFD cloud platform. Rohit is an agile leader who has helped to build the multiple simulations apps for the simulationHub team. He has deep expertise in building scalable, resilient, beautiful webapps using Autodesk Forge, AWS, SWS and a range of full stack technologies. He is a scrum advocate to build cross-functional and self organizing teams to create high value products. Rohit is a graduate in Computer Science from Pune University.



Praveen Kumar, PM, CCTech

Praveen is a Product Manager of simulationHub, a flagship CFD platform of CCTech. Praveen has deep expertise in converting real world problems into accurate computational problems. He has been instrumental in conceptualizing the building simulation apps for the simulationHub team. With more than 13 years of strong domain experience in CFD, he has also developed flavor for user experience. Praveen holds a Bachelor's degree in Mechanical Engineering and Postgraduate DACFD.

Outline

- **Understanding the HVAC Design**
  - Challenges
  - Opportunity
- **Autonomous HVAC CFD App**
- **Building Blocks**
- **Implementation**
- **BIM Designer Studio**
- **Revit Design Automation**
- **Signup for Private Beta**

HVAC system for best Thermal Comfort

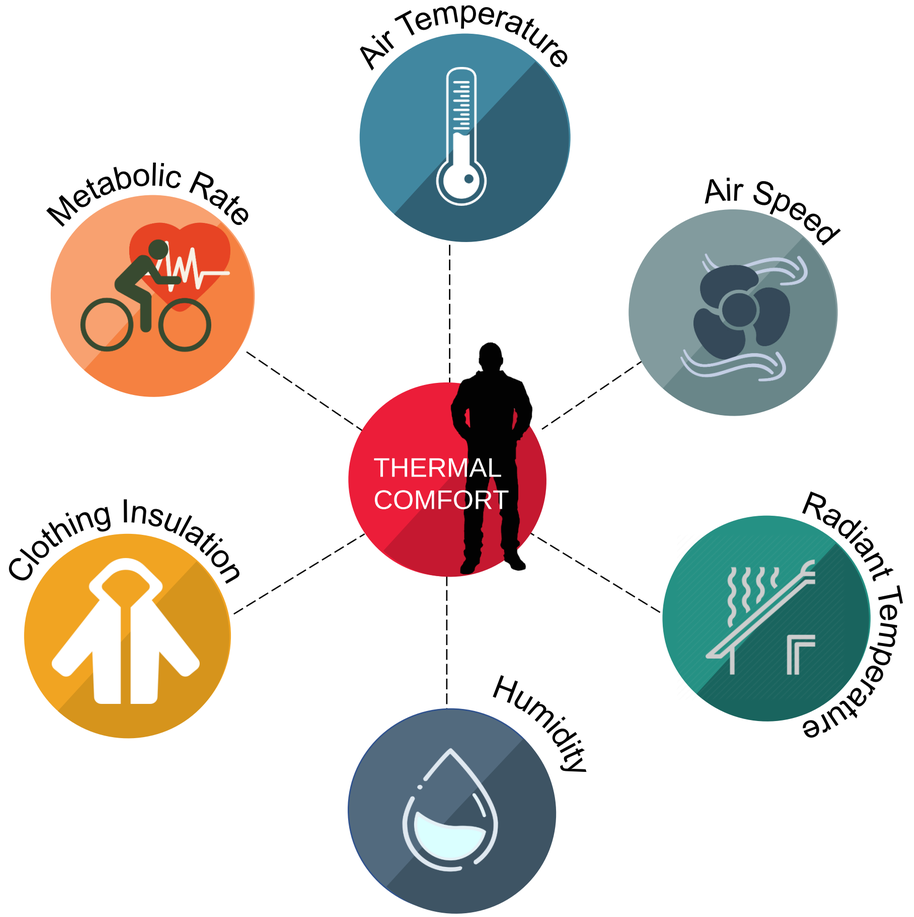
Indoor Air Quality

Occupant Thermal Comfort

Thermal Comfort of occupant is that condition of mind that expresses satisfaction with thermal environment

Personal Factors

- Metabolic Rate
- Clothing Insulation



Factors affecting Human Thermal Comfort

Environmental Factors

- Air Temperature
- Air Velocity
- Mean Radiant Temperature
- Relative Humidity

Evaluating Occupant Thermal Comfort

Standards

ASHRAE 55
Thermal Environmental Conditions for Human Occupancy

ASHRAE 113
Method of Testing for Room Air Diffusion

ISO 7730
Ergonomics of the thermal environment

Thermal Comfort Indices

- Predicted Mean Vote (**PMV**)
- Percentage of People Dissatisfied (**PPD**)
- Draft Rating (**DR**) index
- Effective Draft Temperature (**EDT**)
- Air Diffusion Performance Index (**ADPI**)
- Local Discomfort
  - Draft
  - Vertical temperature difference
  - Floor temperature
  - Radiant temperature asymmetry

Democratization of Technology

www.simulationHub.com

CAD Clean-up & repair

Water tight geometry

Structured Mesh

Conditions

Prism generation

Boundary layer

Result Interpretation

High Performance Computing

Navier-Stokes

Compressible

Second order

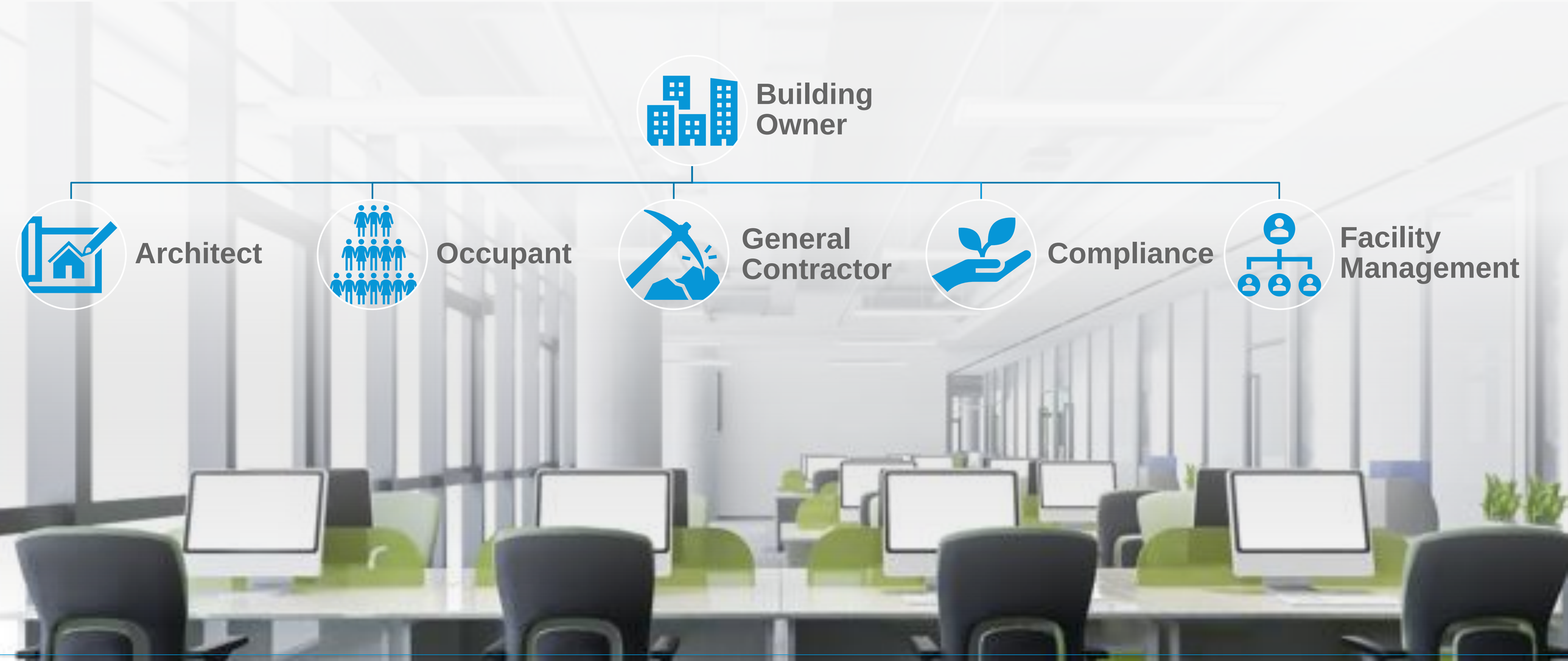
Convergence

Material

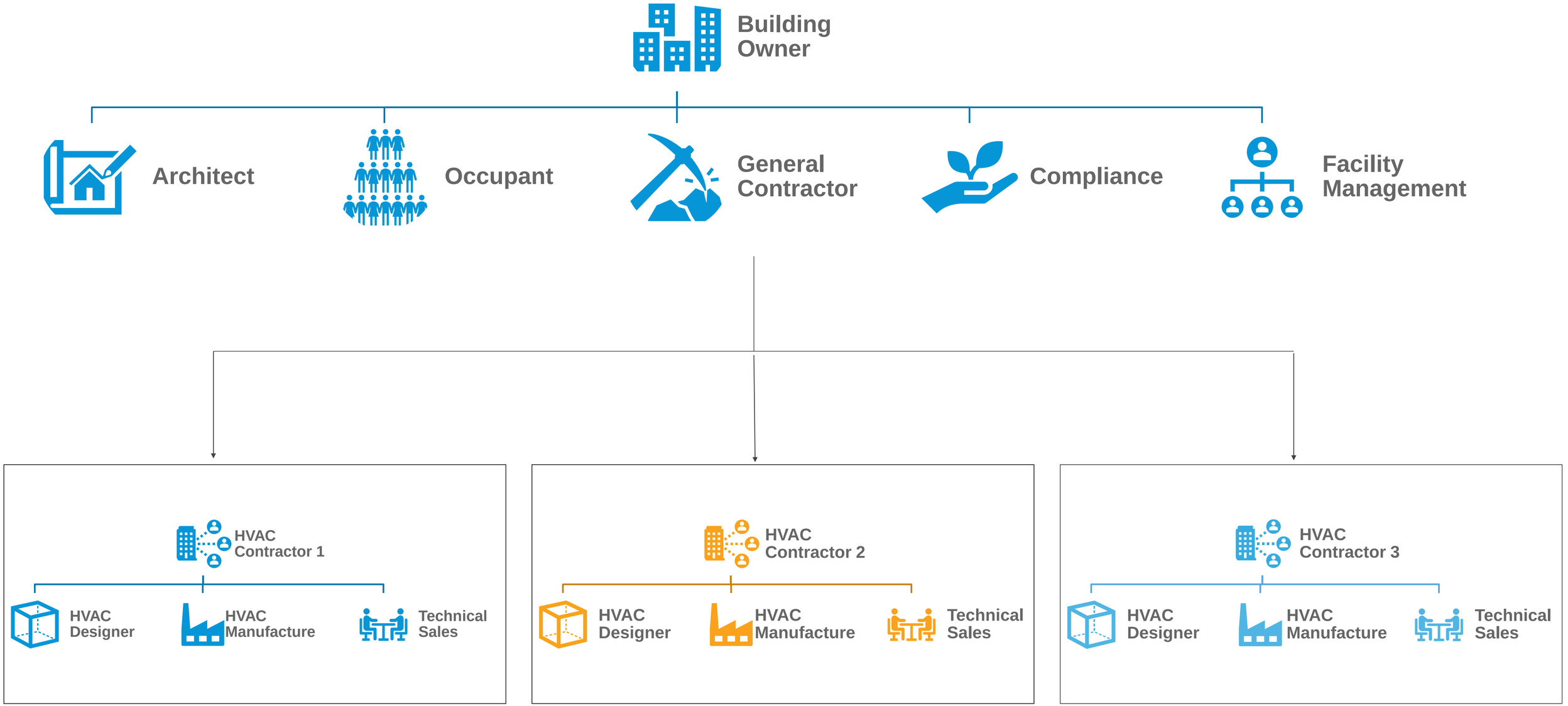
First order

Only **1 out of 100** CAD designer uses
Computational Fluid Dynamics in his design workflow.

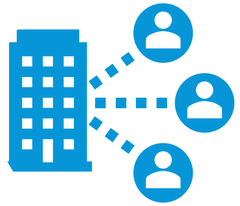
Business Case – HVAC Commercial Project



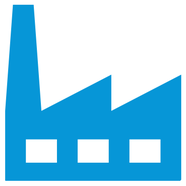
Exploring different HVAC solutions



HVAC Contractor - Roles

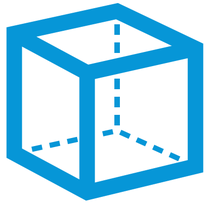


HVAC Contractor



HVAC Manufacture

- New HVCA Systems
- Evangelize the new product
- Equipment Catalogues
- Performance Data



HVAC Designer

- Understands the space, occupancy and scenarios
- Creates design configuration
- Performs the CFD simulations
- Provides the success scenarios to sales team

Technical Sales

- Collecting the space layouts
- Collaborates with HVAC designer and manufacture
- Demonstrate the proposed solution
- Close the deal

HVAC Manufactures

DAIKIN

TRANE

Ingersoll Rand

MITSUBISHI ELECTRIC
AIR CONDITIONING SYSTEMS

Johnson Controls

LENNOX
Air is life. Make it perfect.™

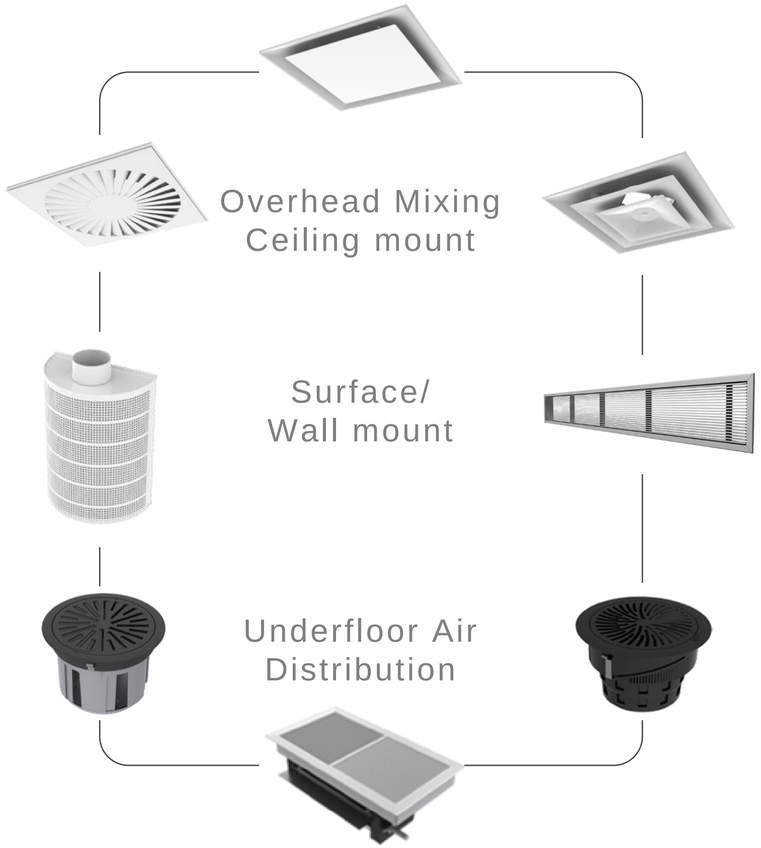
NORTEK
GLOBAL HVAC

SAMSUNG
Heating and Cooling

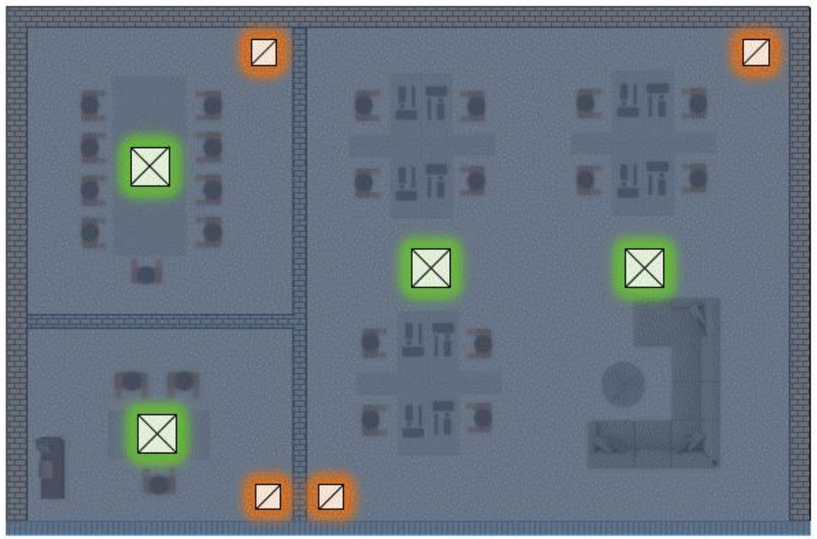
LG
Air Conditioning Technologies

HVAC Systems and Design Configurations

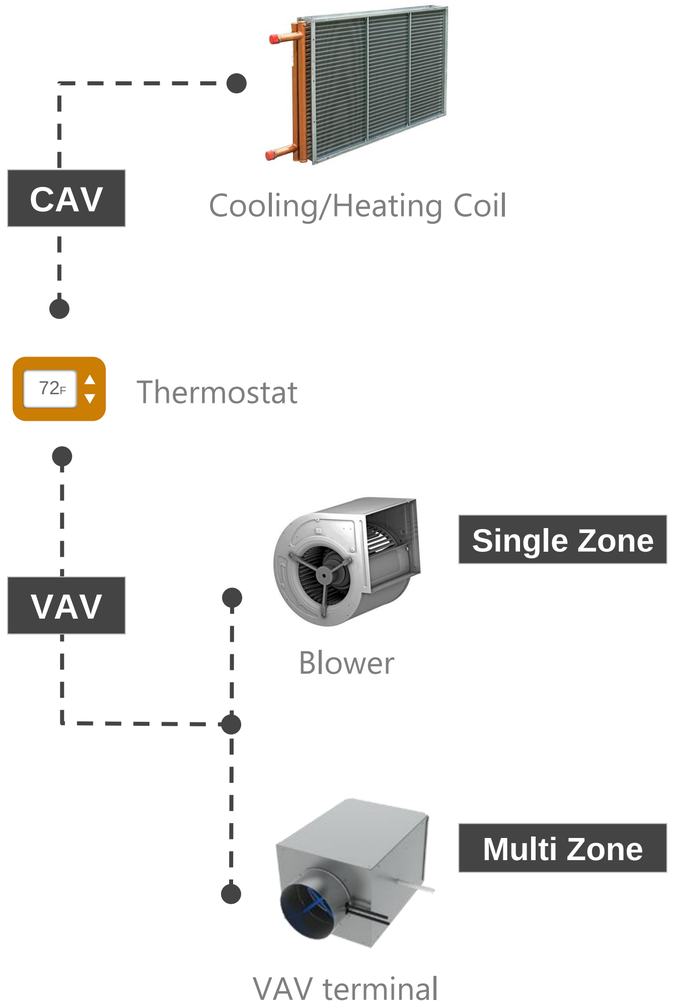
Diffuser Type



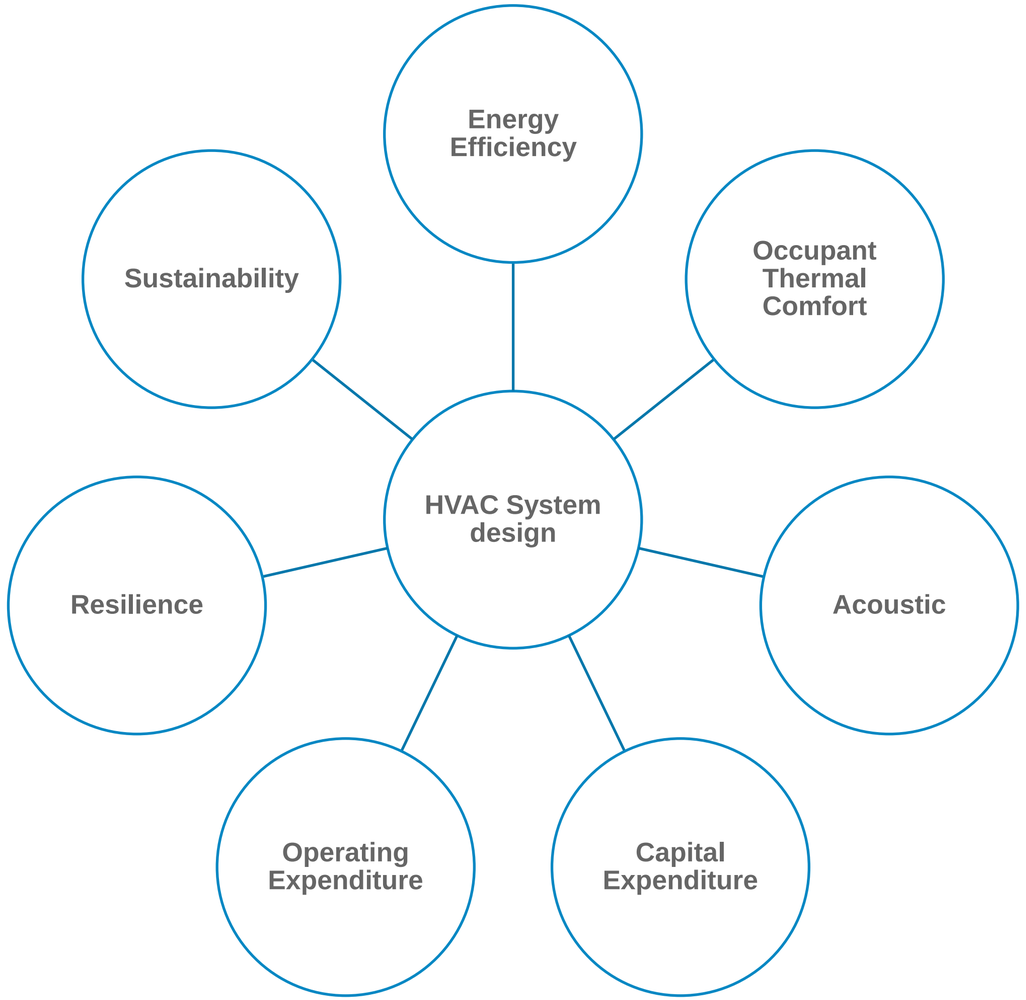
Supply-Return Positions



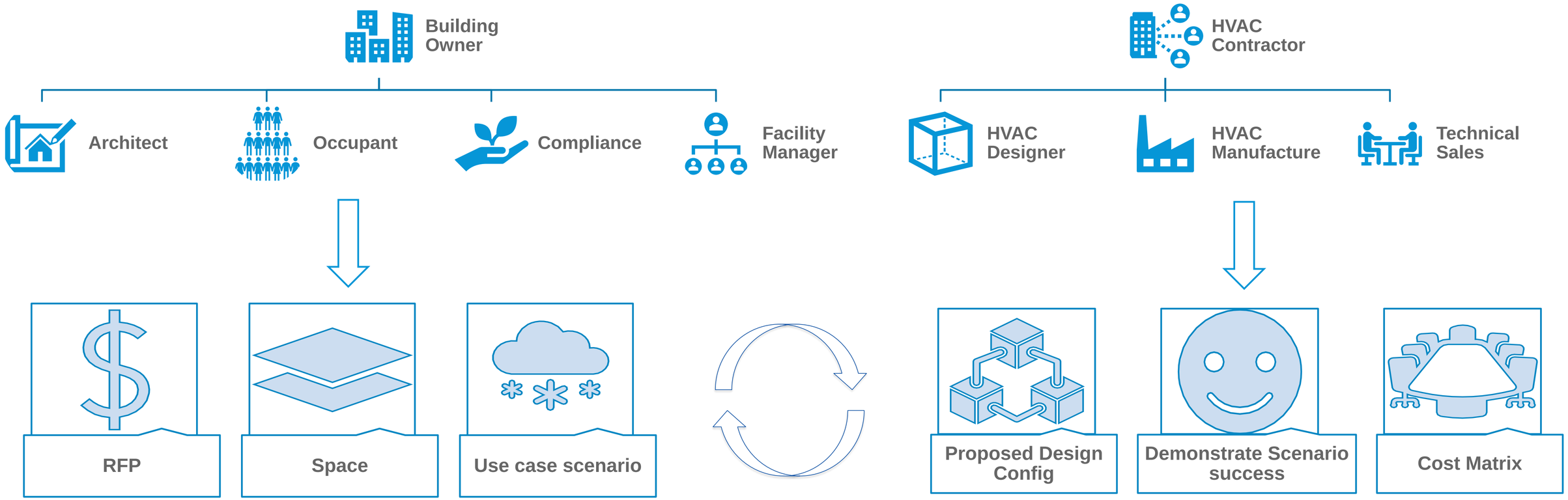
HVAC System



HVAC System Design - Multi-Objective Optimization



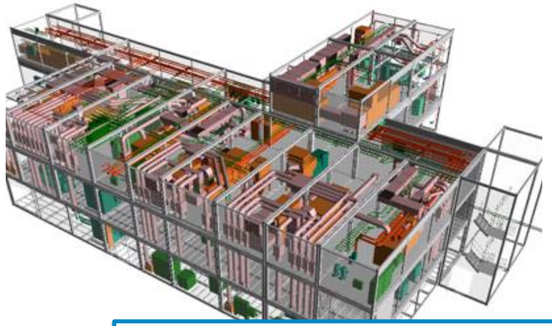
HVAC Contract Process



Months spend in negations and reworking the design to satisfy customers need

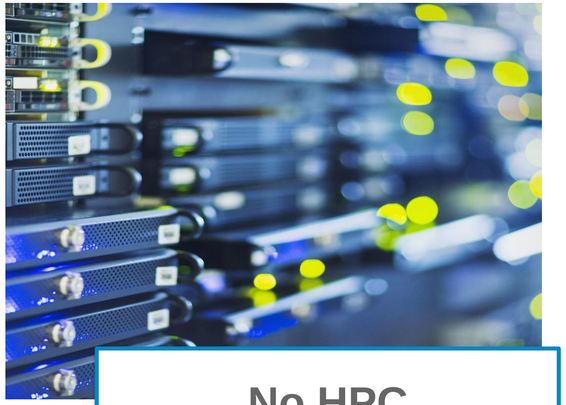
Limitation HVAC Contractor firm

2D CAD as a Reference

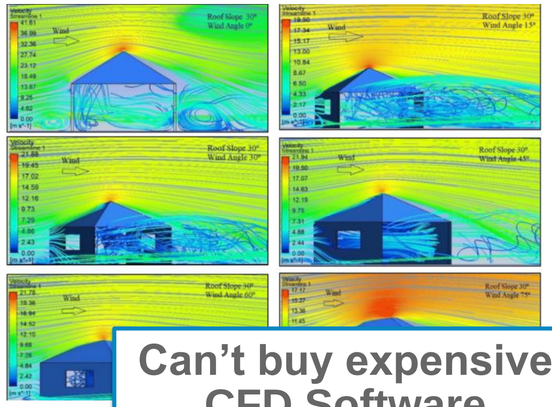


Can’t afford BIM

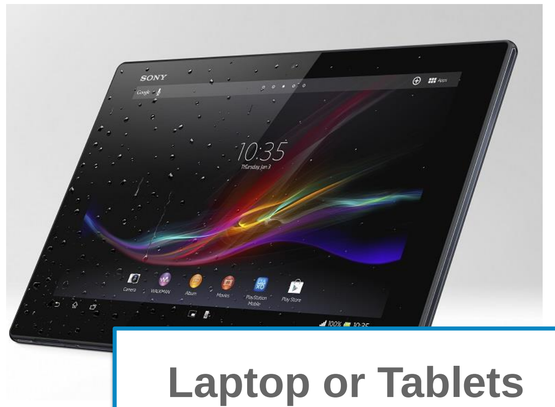
No CFD Experts



No HPC



Can’t buy expensive CFD Software



Laptop or Tablets

How to win a client and contract with available resources ?

A solution with Three innovations

1

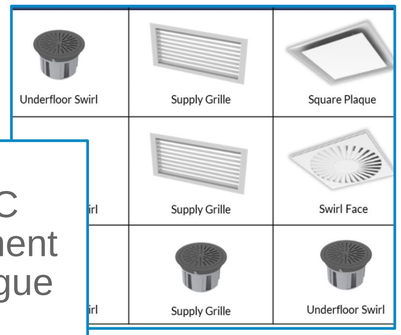
WebApp based BIM Modeler

HVAC Contractor

HVAC Manufacture

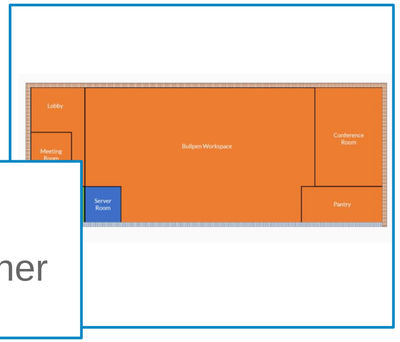
HVAC Designer

Technical Sales



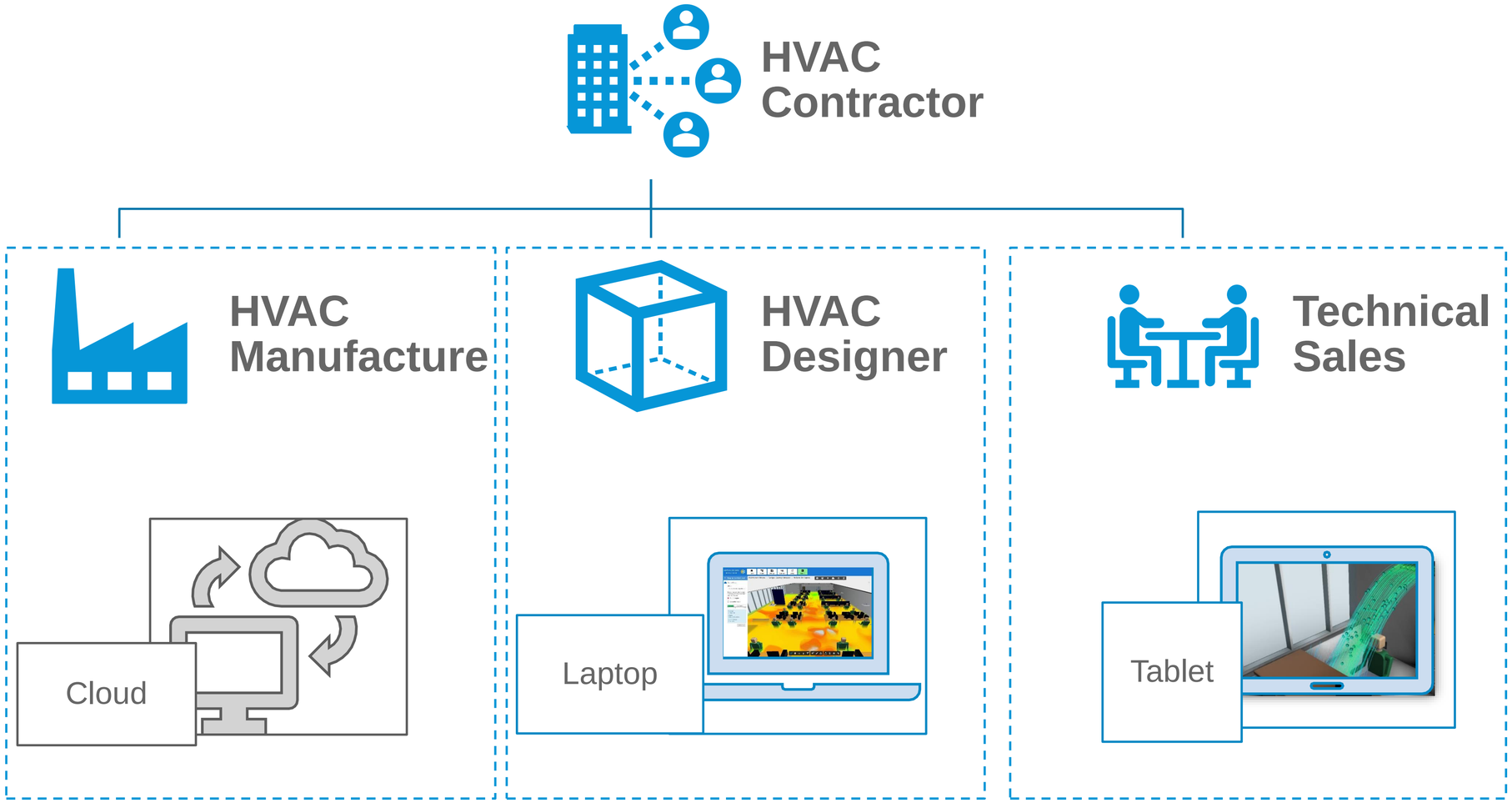
HVAC Equipment Catalogue

BIM Modeler



2D Sketcher

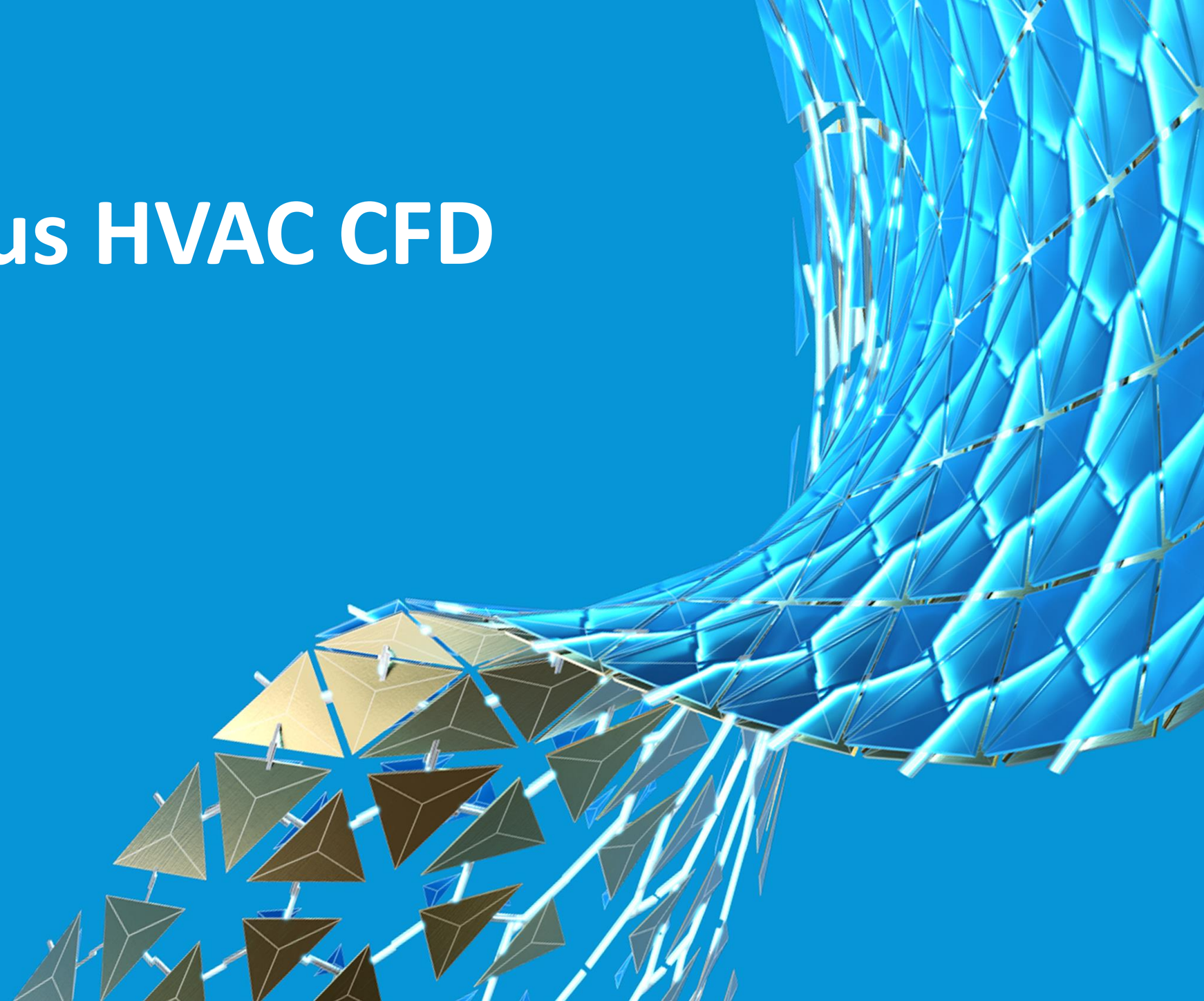
A multi-devices HVAC CFD solution



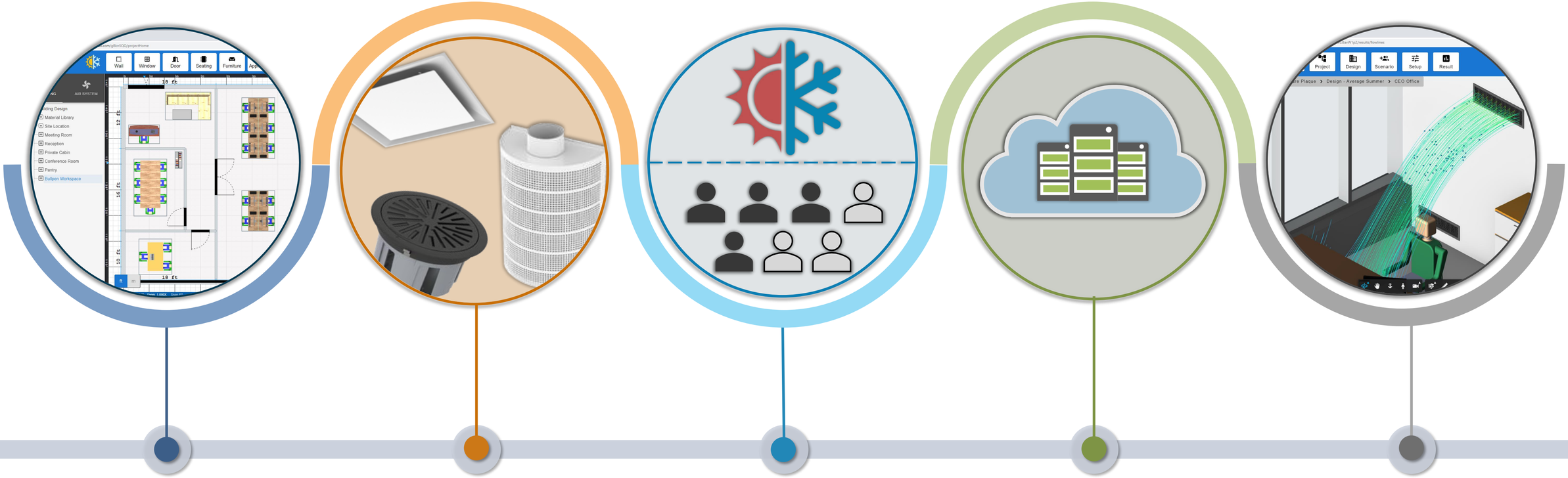
Autonomous = Automation + Intelligence

Eliminate the need of CFD expert or HPC cluster

Autonomous HVAC CFD

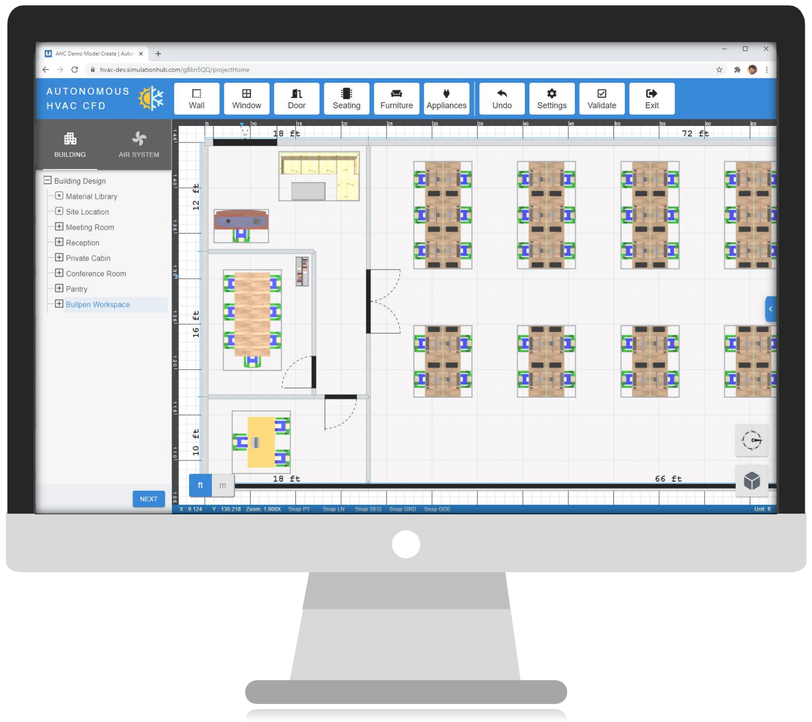


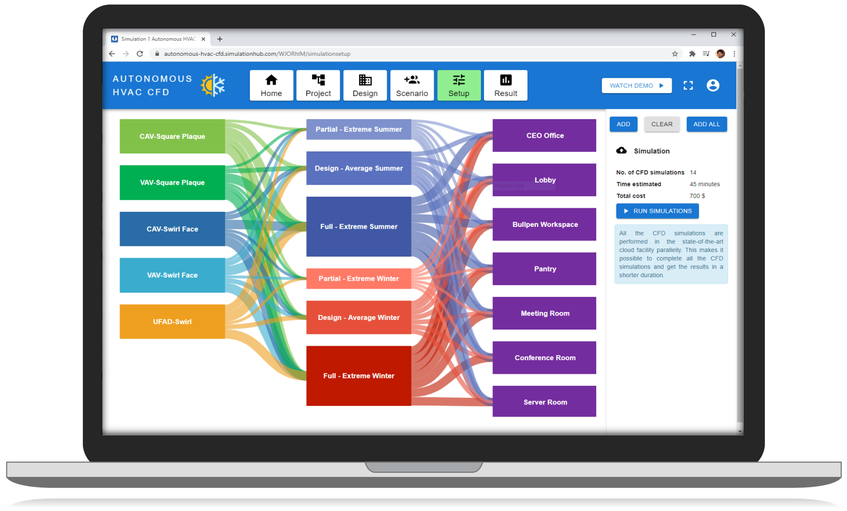
Autonomous HVAC CFD

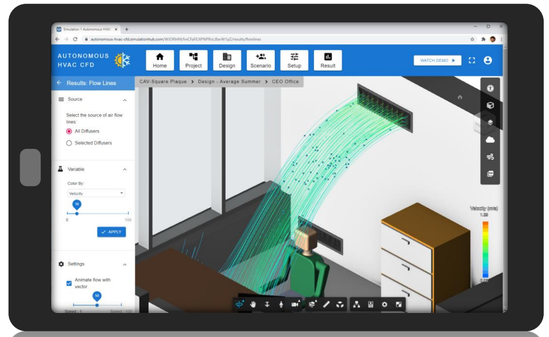


BIM Design Studio **Design Configurator** **Scenario Studio** **Simulation** **Result Visualization**

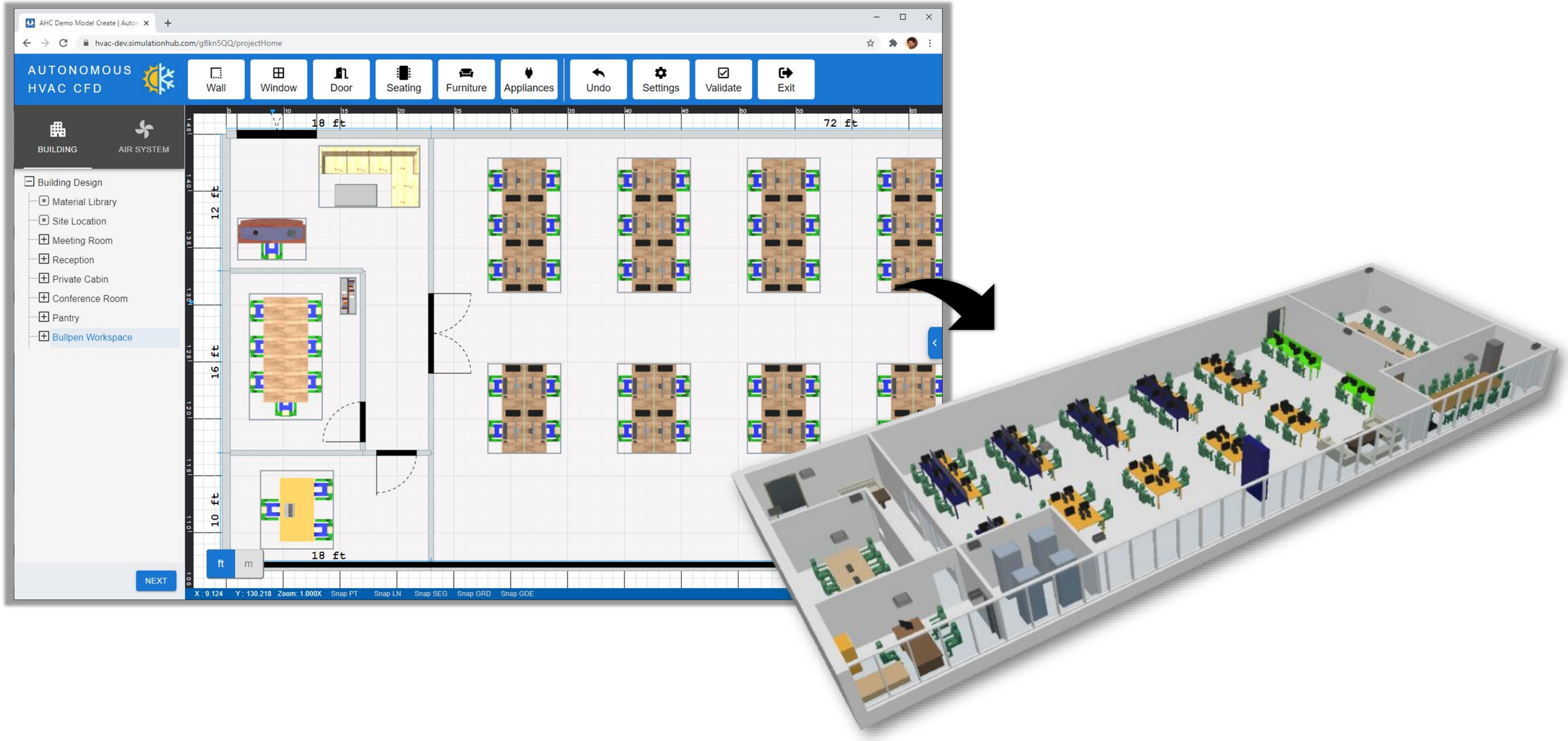
Autonomous HVAC CFD- Any device Anywhere





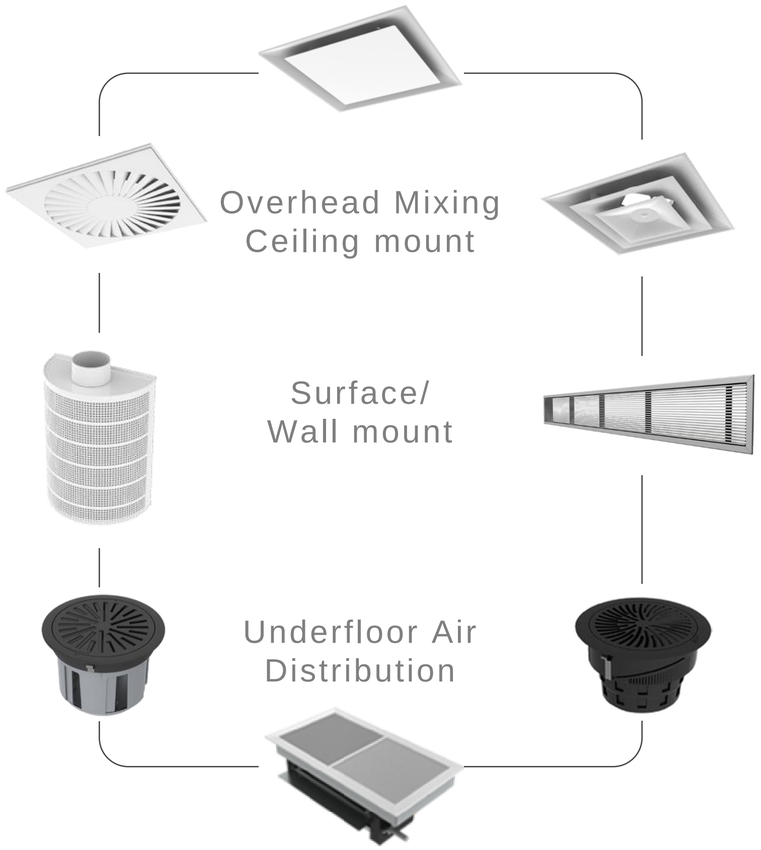


BIM Design Studio

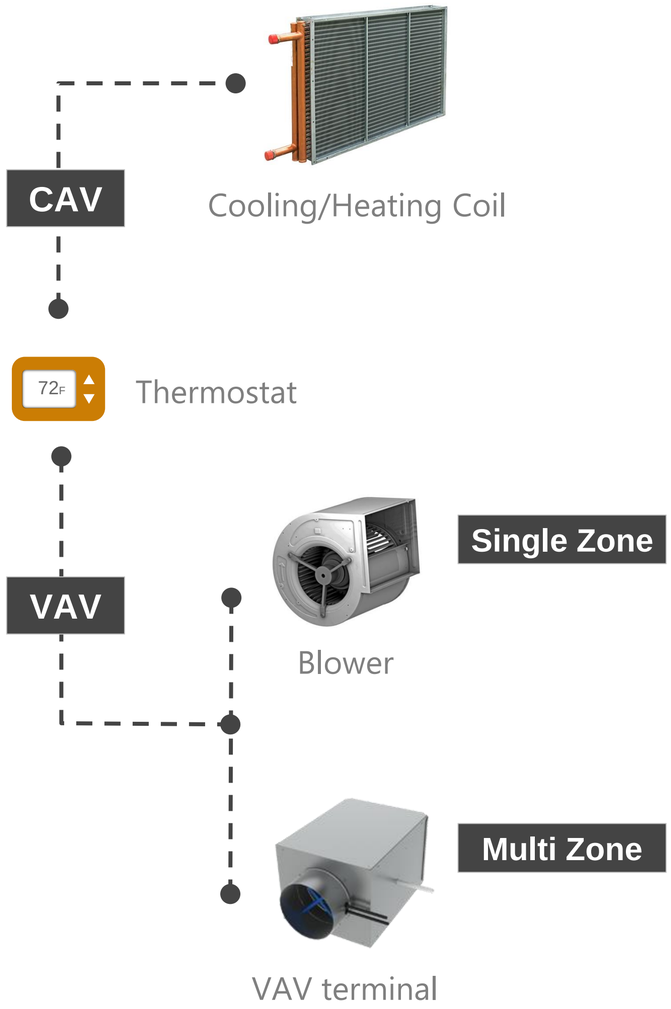


Design Configurations

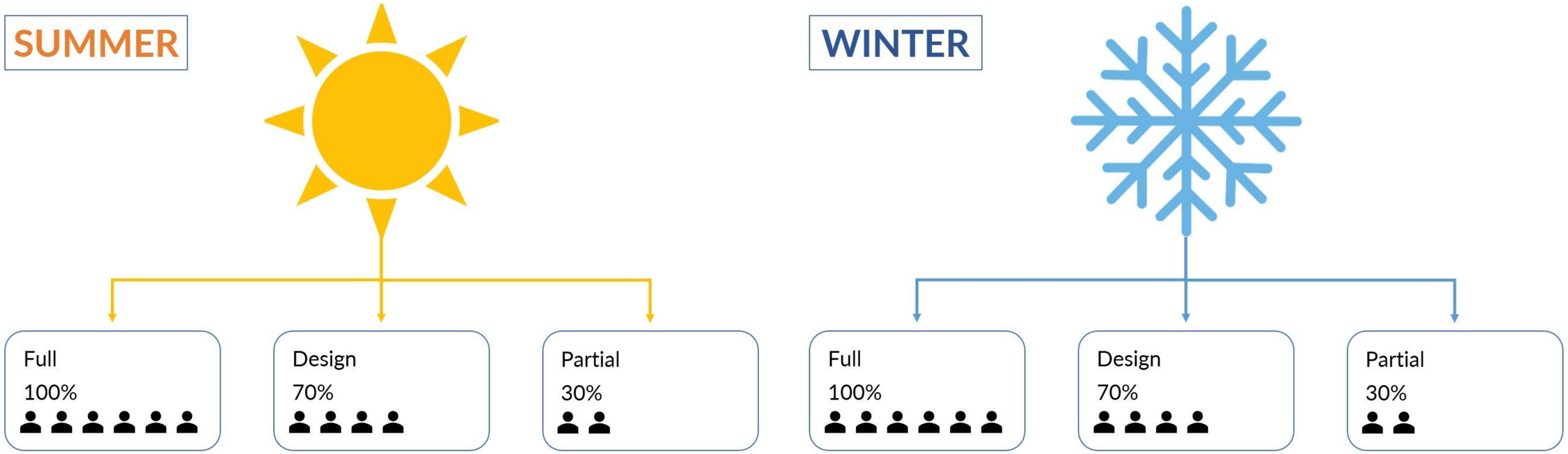
Diffuser Type

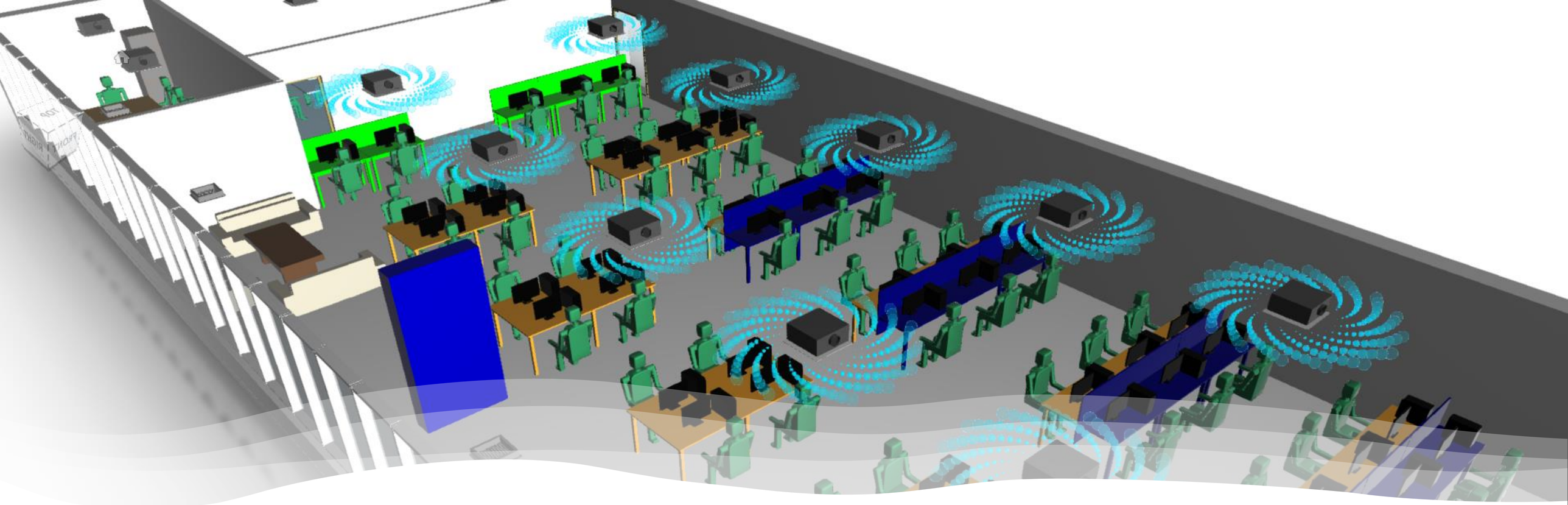


HVAC System



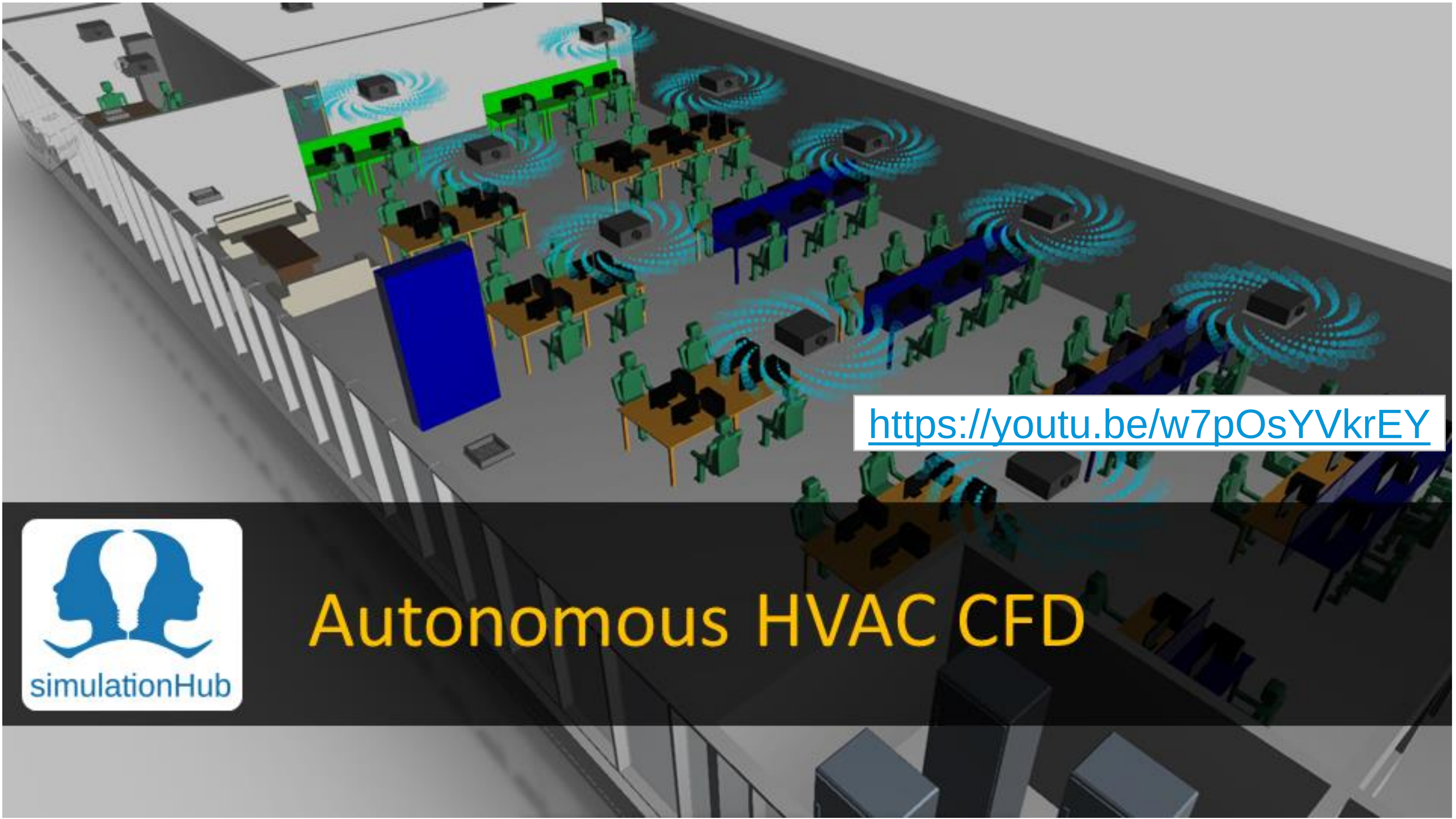
Scenario Studio



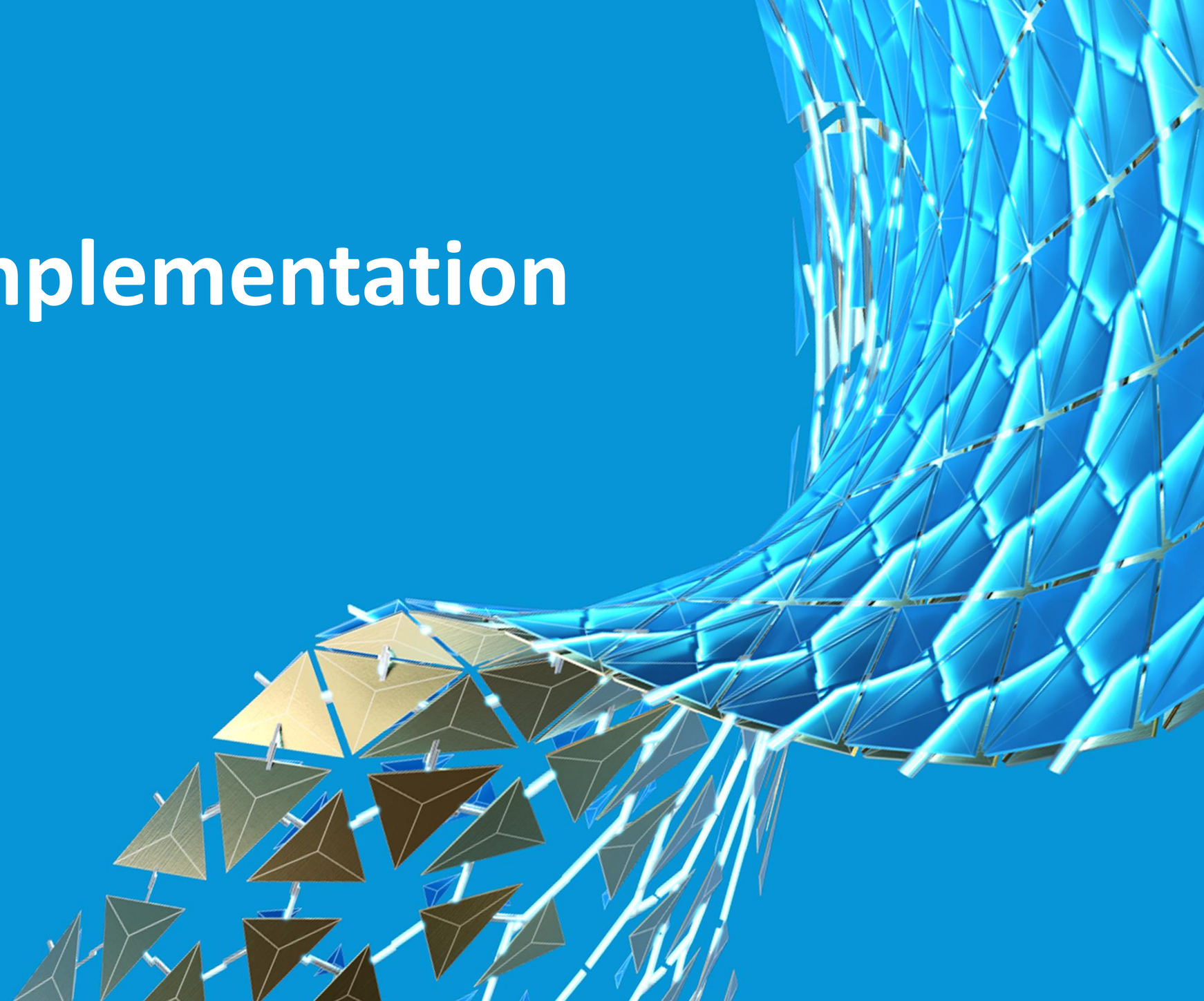


Autonomous HVAC CFD

App Demo


https://youtu.be/w7pOsYVkrEY
simulationHub
Autonomous HVAC CFD

God is in Implementation



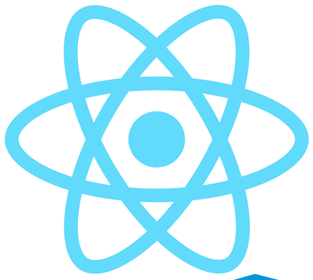
Building Blocks

Autodesk Forge

React Planner

Revit Design Automation

SimulationHub
Web Services



ReactJS

AWS

DynamoDB

Lambda

App Architecture

Individual users

Multiple users

Enterprise

Autonomous HVAC CFD App

BIM Design Studio

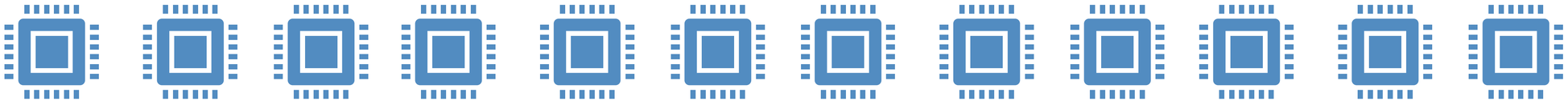
Design Configurator

Scenario Studio

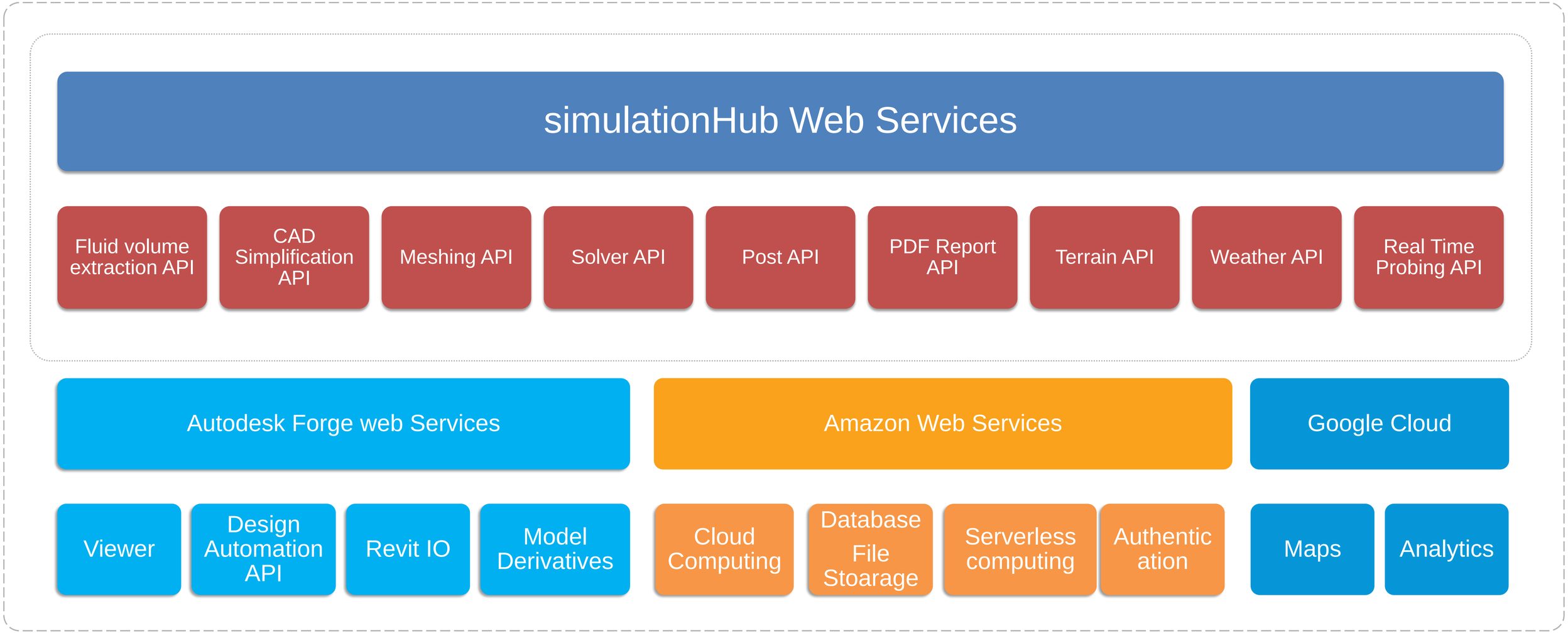
Simulation Setup

Result Visualization

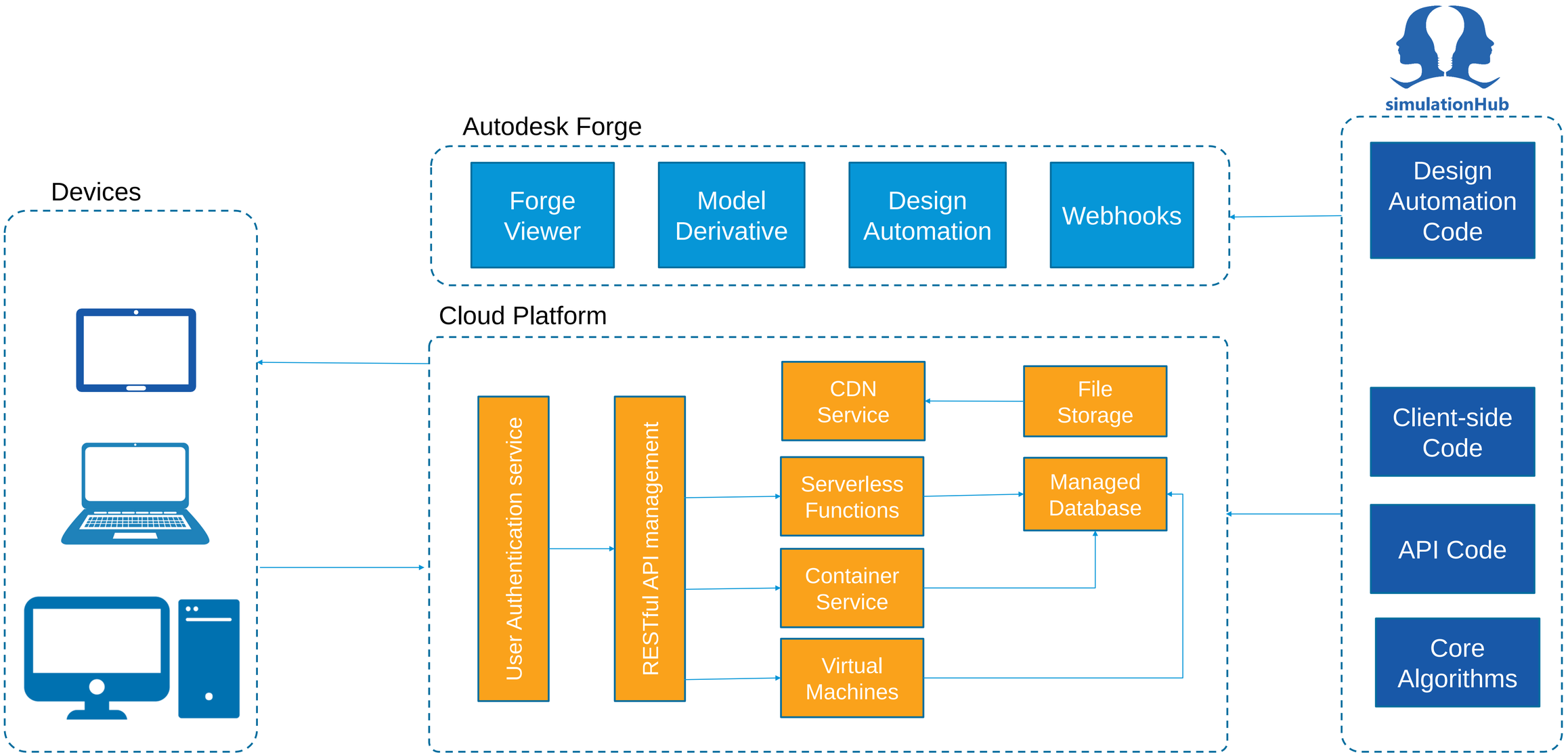
simulationHub Web Services



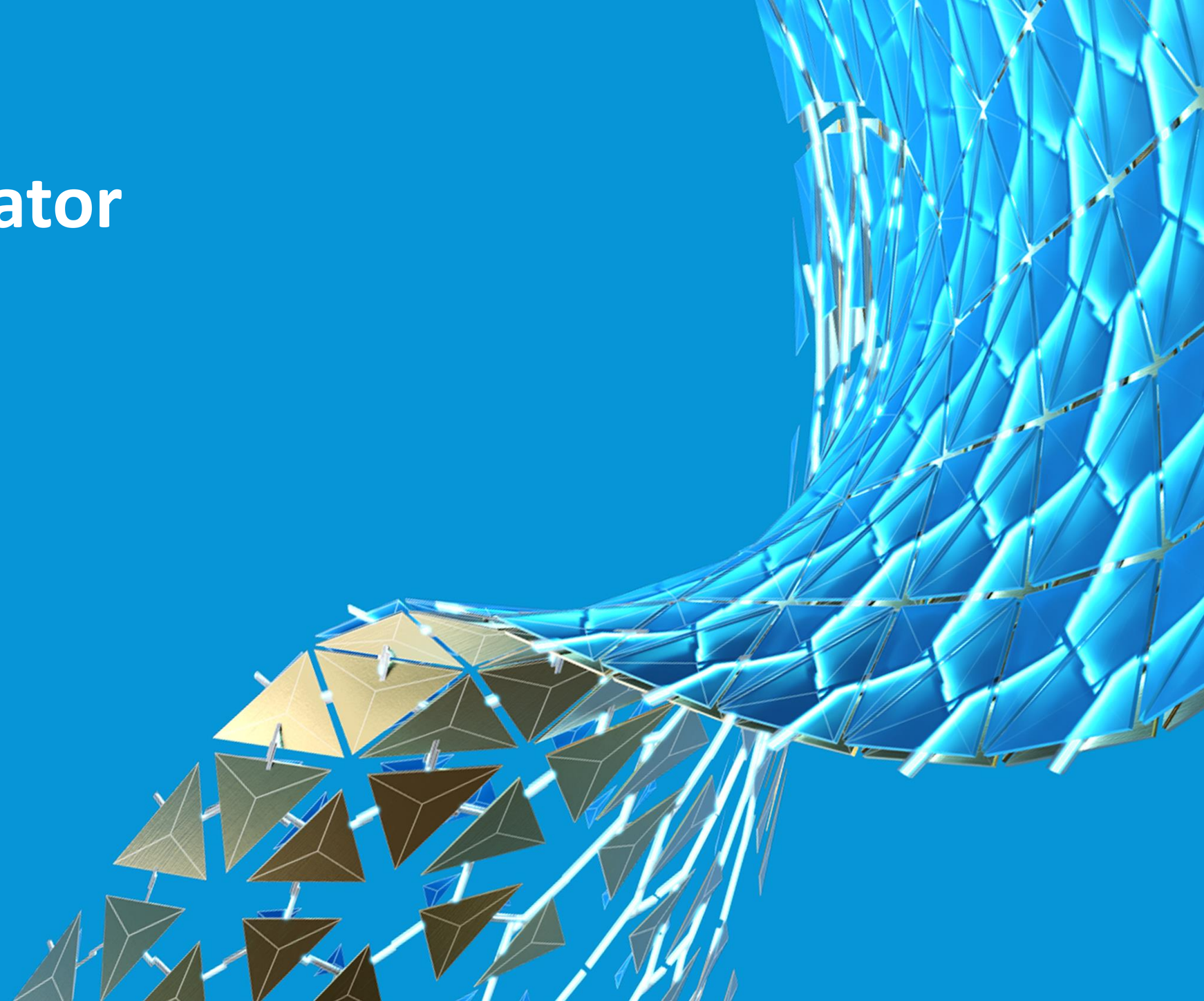
simulationHub Web Services



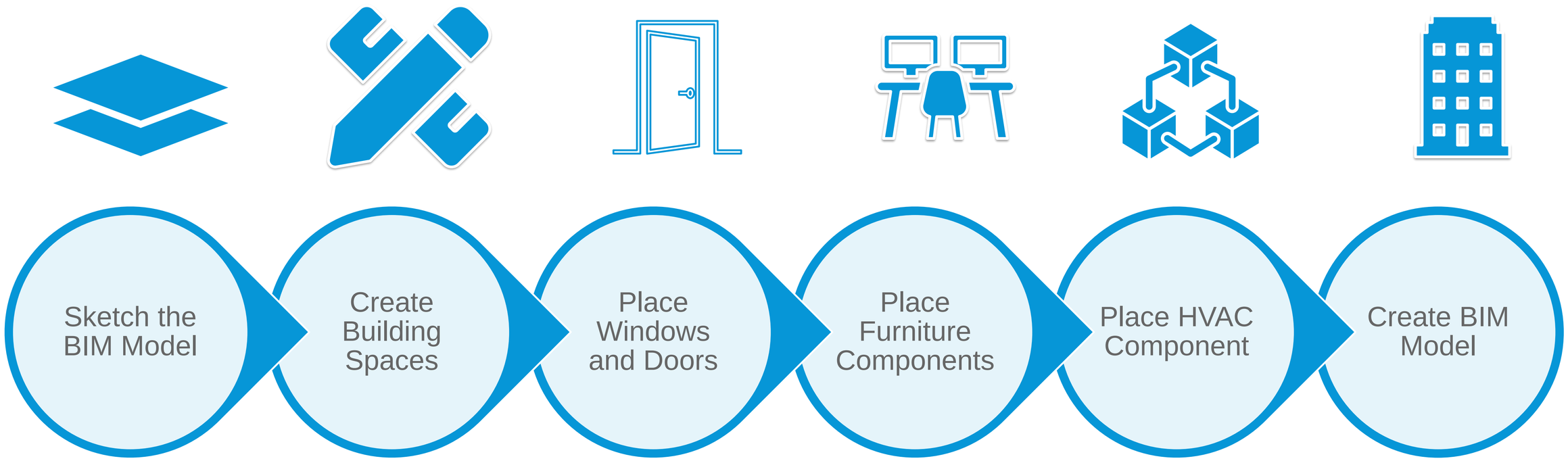
Serverless Advantage



BIM Configurator



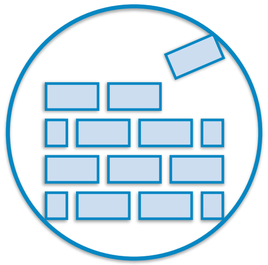
BIM Design Studio- Workflow



React Planner – Data Model

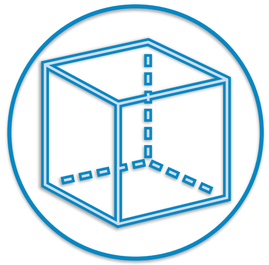
Vertex Class

- Vertex ID
- Wall IDs
- X
- Y



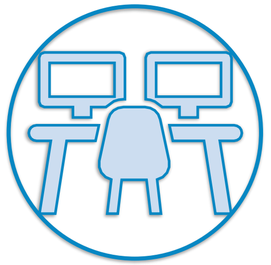
Wall Class

- Wall ID
- Name
- Wall Type
- Holes
- Vertices IDs



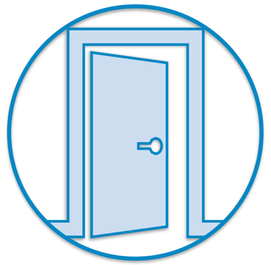
Area Class

- Area ID
- Name
- Vertices IDs



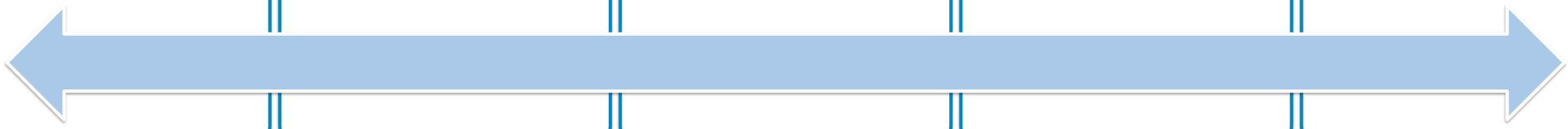
Item Class

- Item ID
- Name
- Rotation
- X
- Y
- Properties

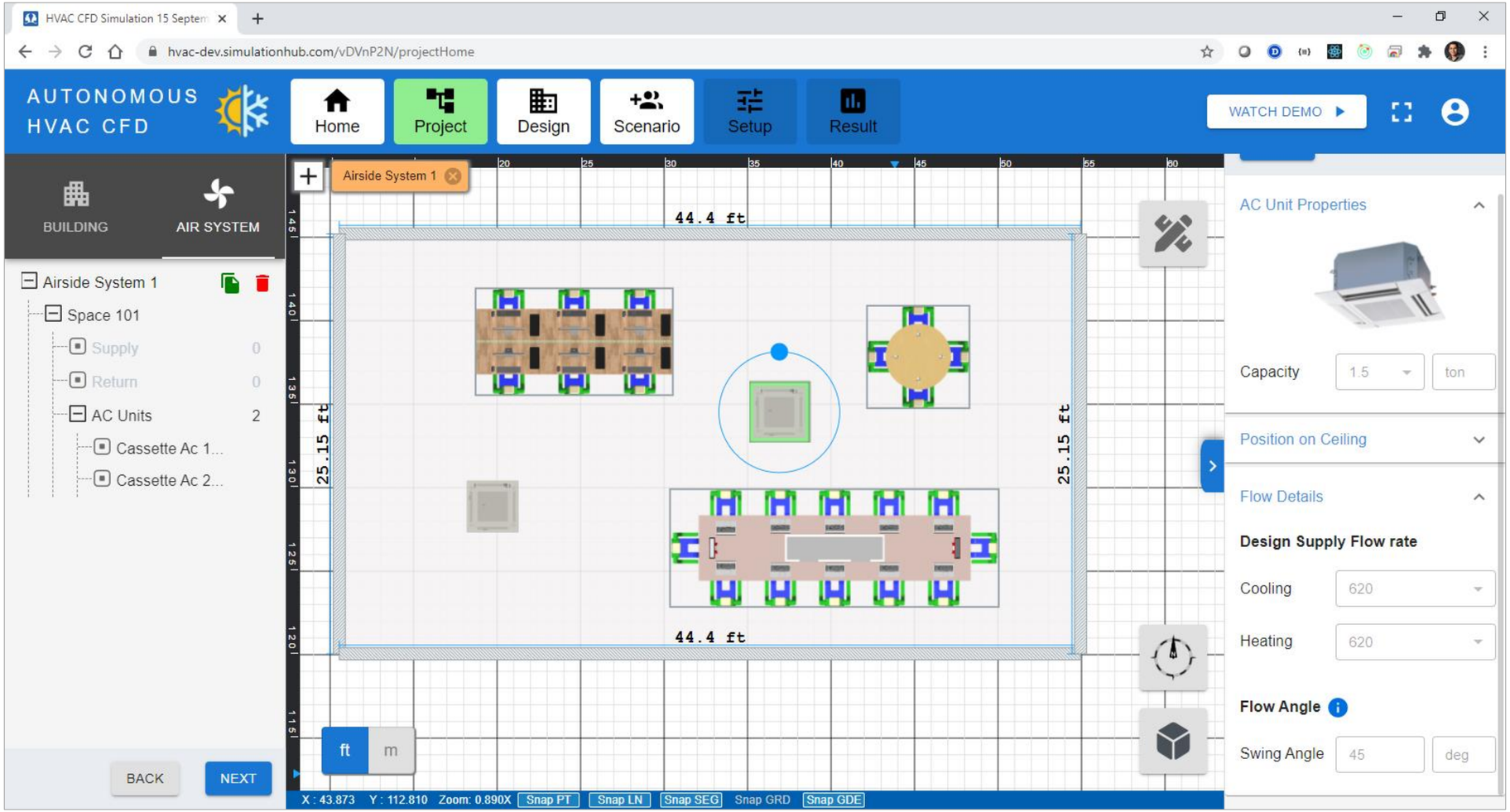


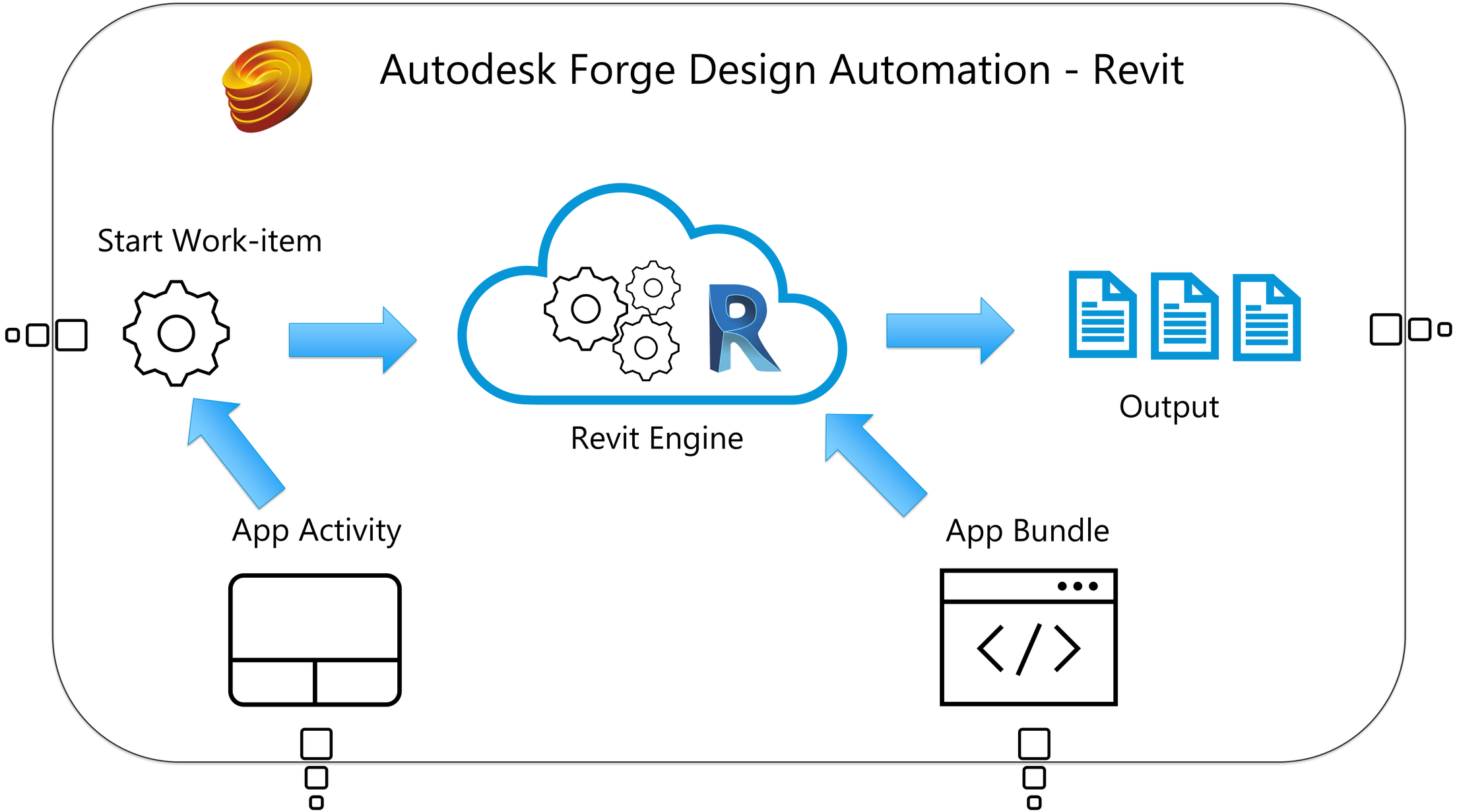
Hole Class

- Hole ID
- Name
- Type
- Wall ID
- Offset
- Properties



BIM Component Property




Autodesk Forge Design Automation - Revit
Start Work-item
Revit Engine
Output
App Activity
App Bundle

Step in Revit Design Automation

CONVERT REVIT TO DESIGN AUTOMATION ADD-IN

UPLOAD APP BUNDLE

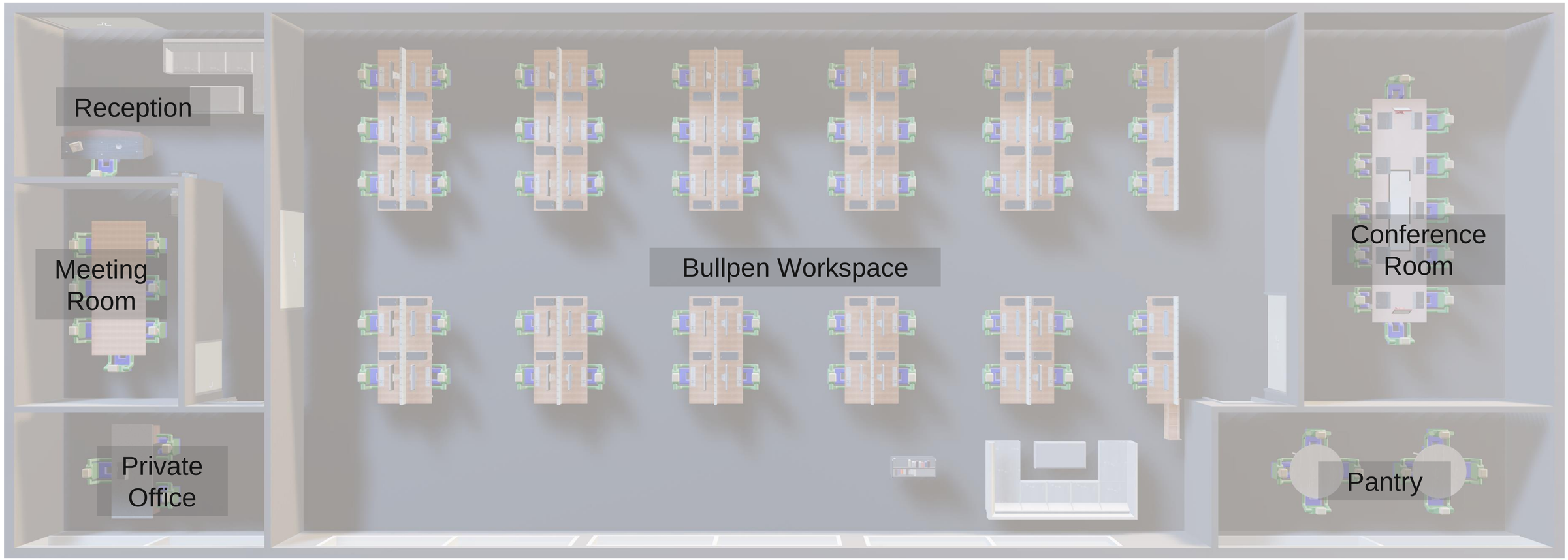
CREATE AND PUBLISH ACTIVITY

CREATE ALIASES FOR ACTIVITY AND APP BUNDLE

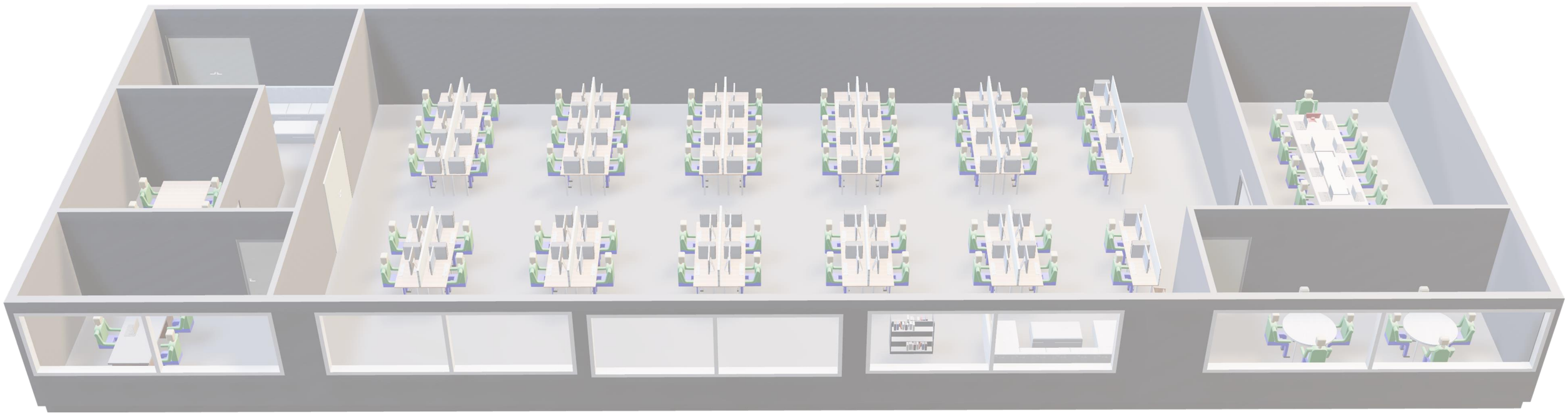
PREPARE INPUT OUTPUT

RUN WORKITEM

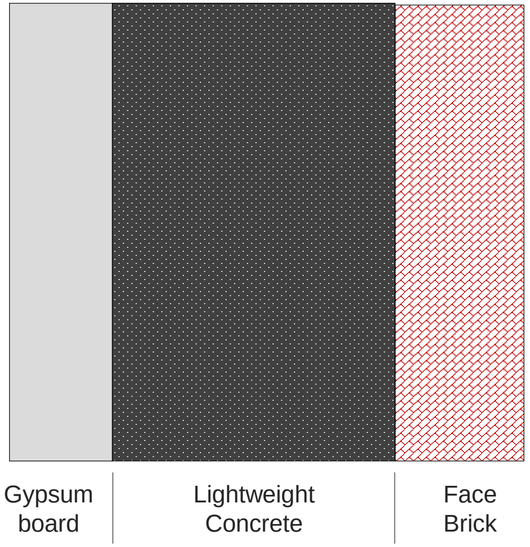
BIM Design Studio



BIM Design Studio

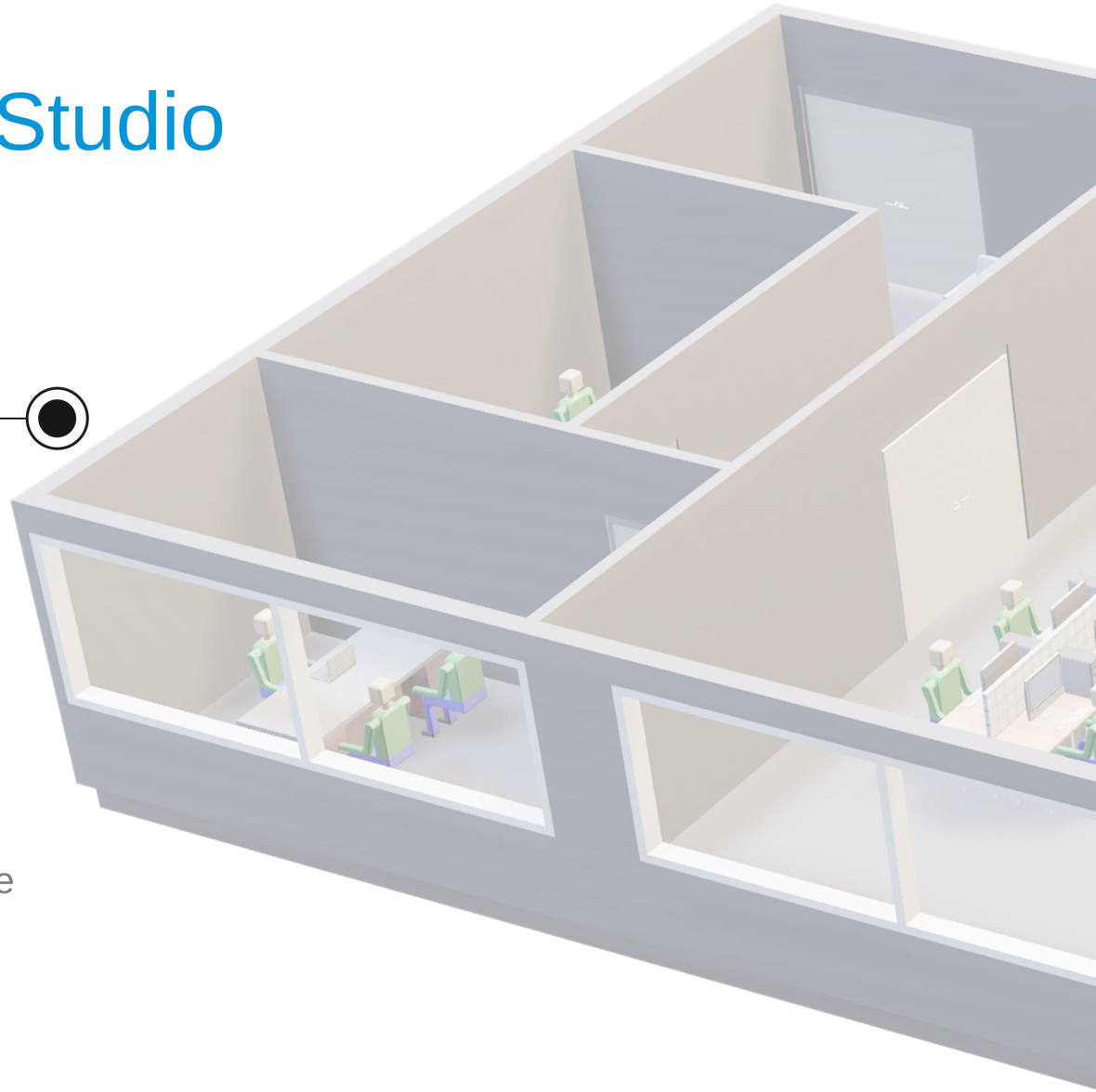


BIM Design Studio



Wall Information

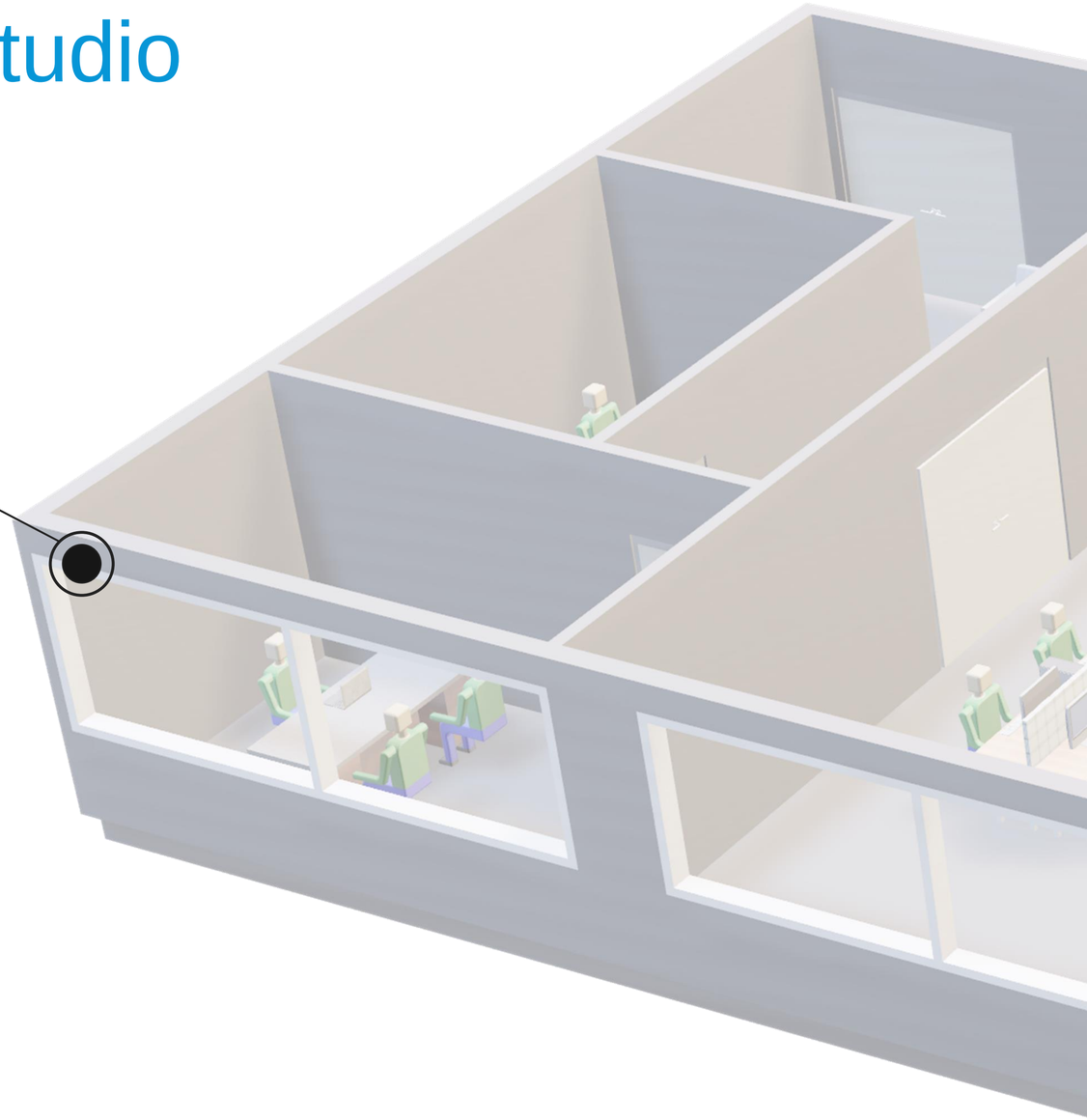
- Wall ID
- Wall Type
- Length
- Height
- Thickness
- Material Assembly
- Thermal Transmittance U-value
- Absorptivity
- Reflectivity



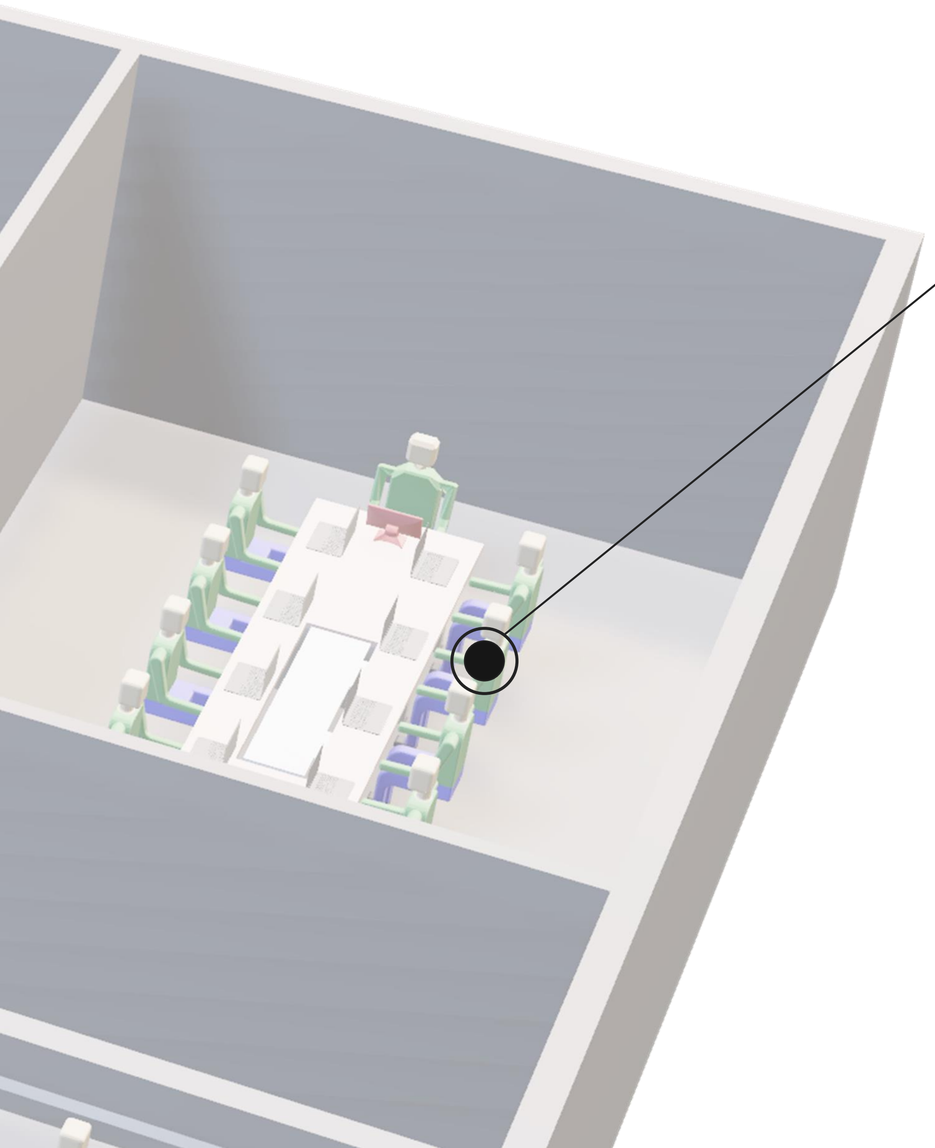
BIM Design Studio

Glass Window Information

- Glass ID
- Location on Wall
- Length
- Height
- Thickness
- Material Assembly
- Thermal Transmittance U-value
- Absorptivity
- Transmissivity
- Reflectivity

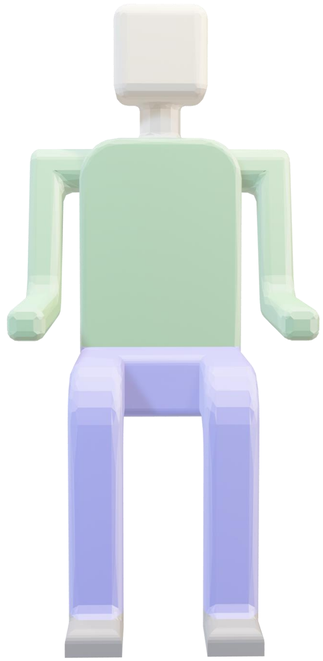


BIM Design Studio

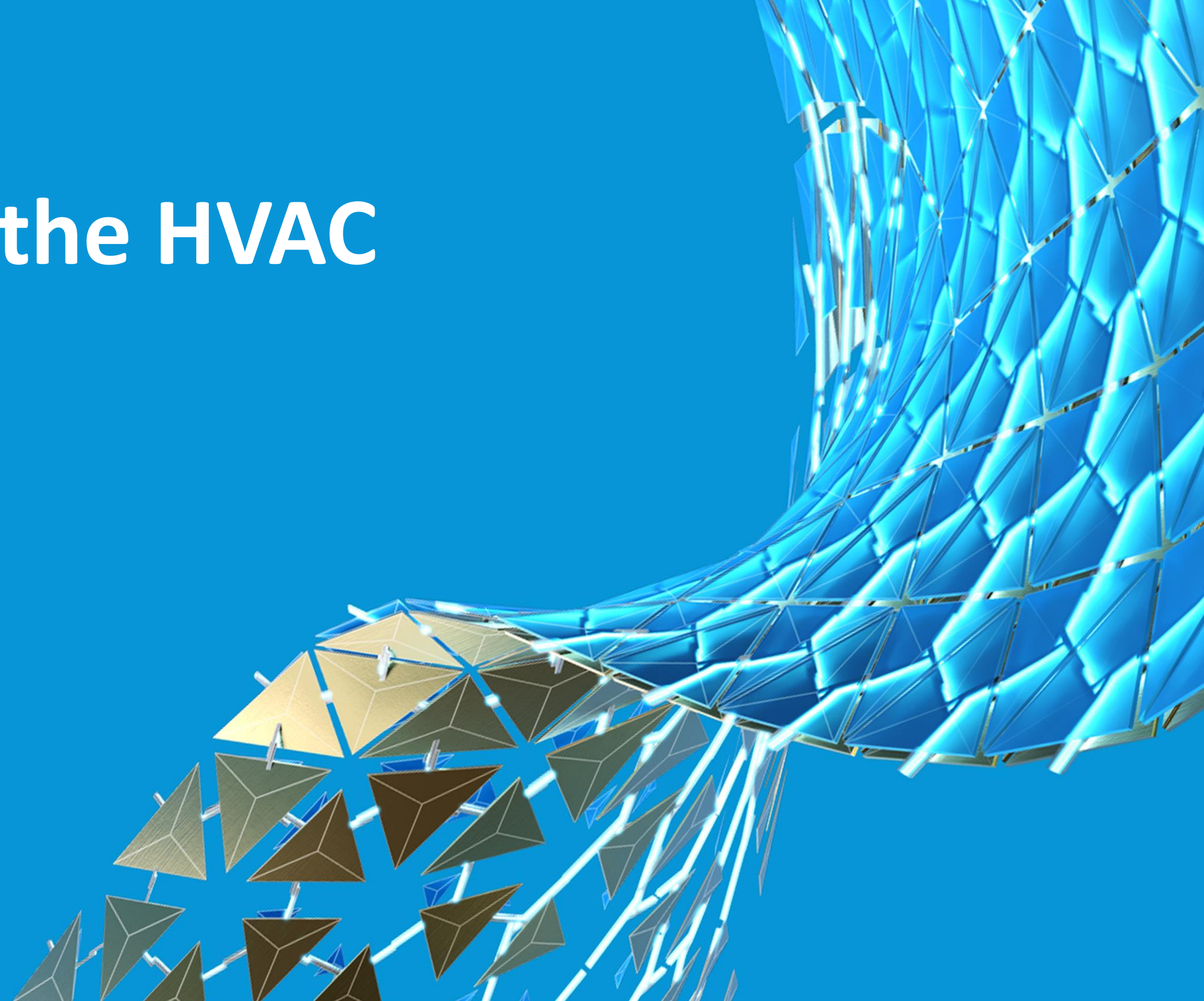


Manikin Information

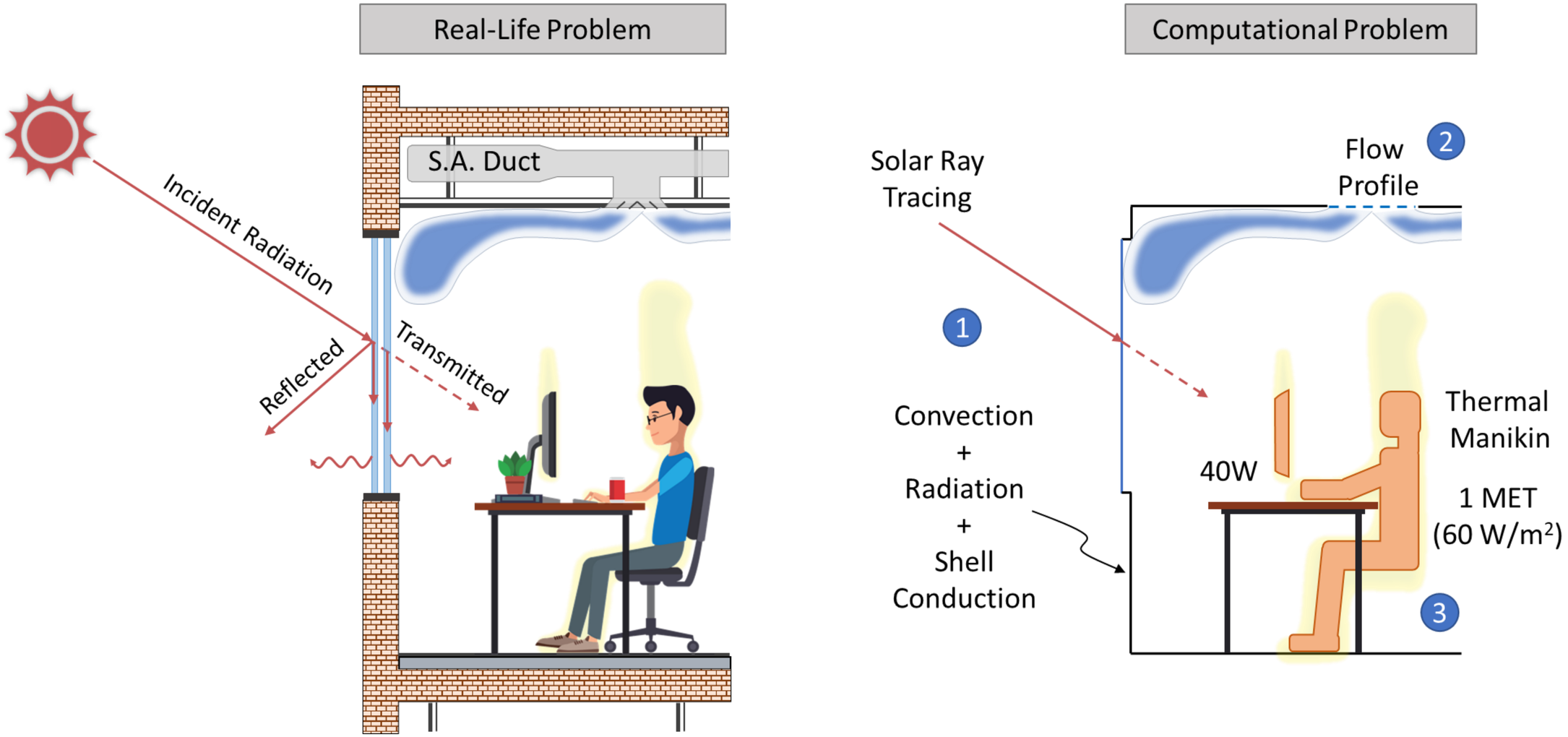
- Manikin ID
- Seating Layout
- Surface Area
- Position
- Metabolic Rate (MET)
- Clothing Insulation (clo)



Simulating the HVAC



Real-World Problem to a Computational Problem



Autonomous HVAC CFD

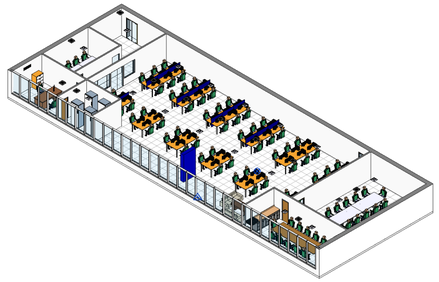
BIM Model

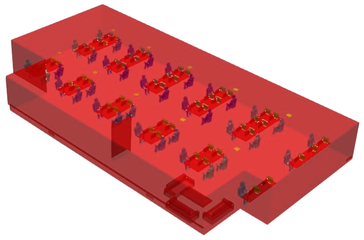
Fluid Volume Extraction

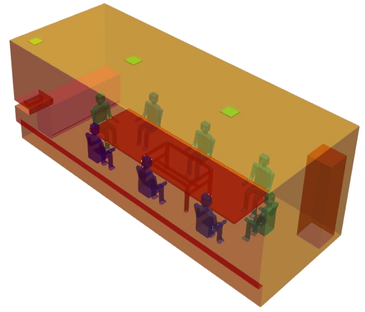
Mesh Generation

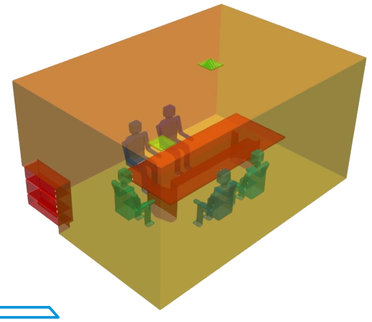
Solve Run

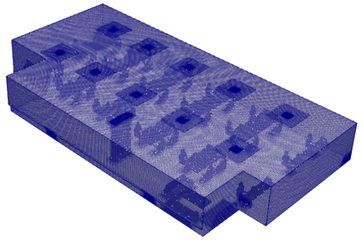
Occupant Thermal Comfort

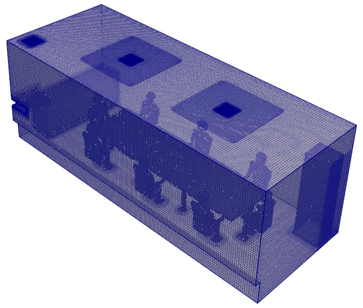


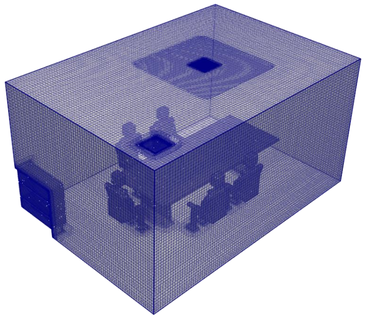


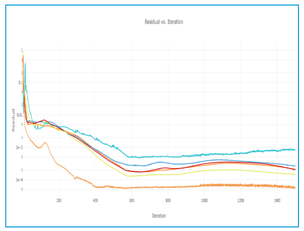


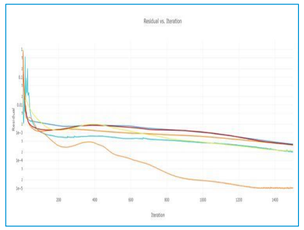


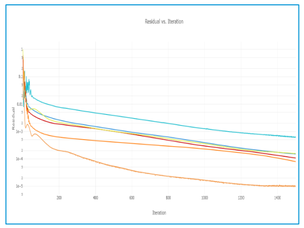


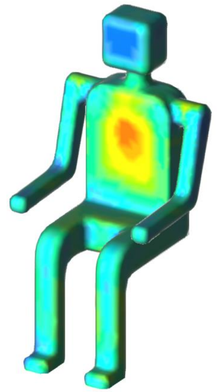


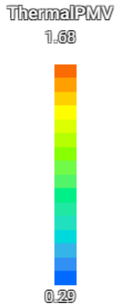






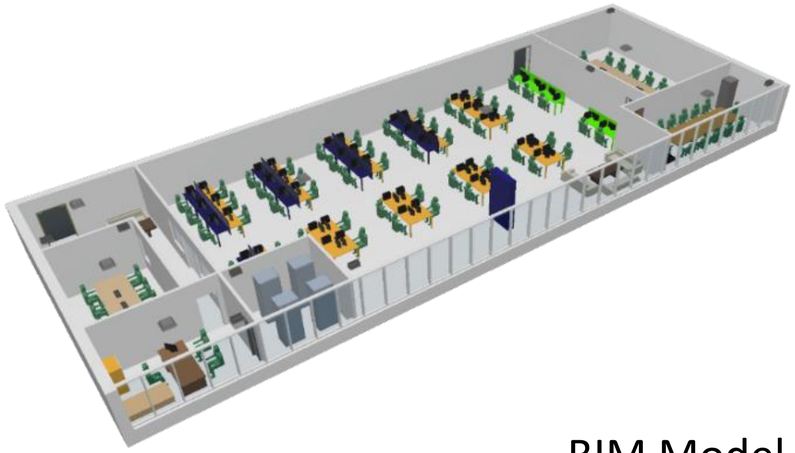






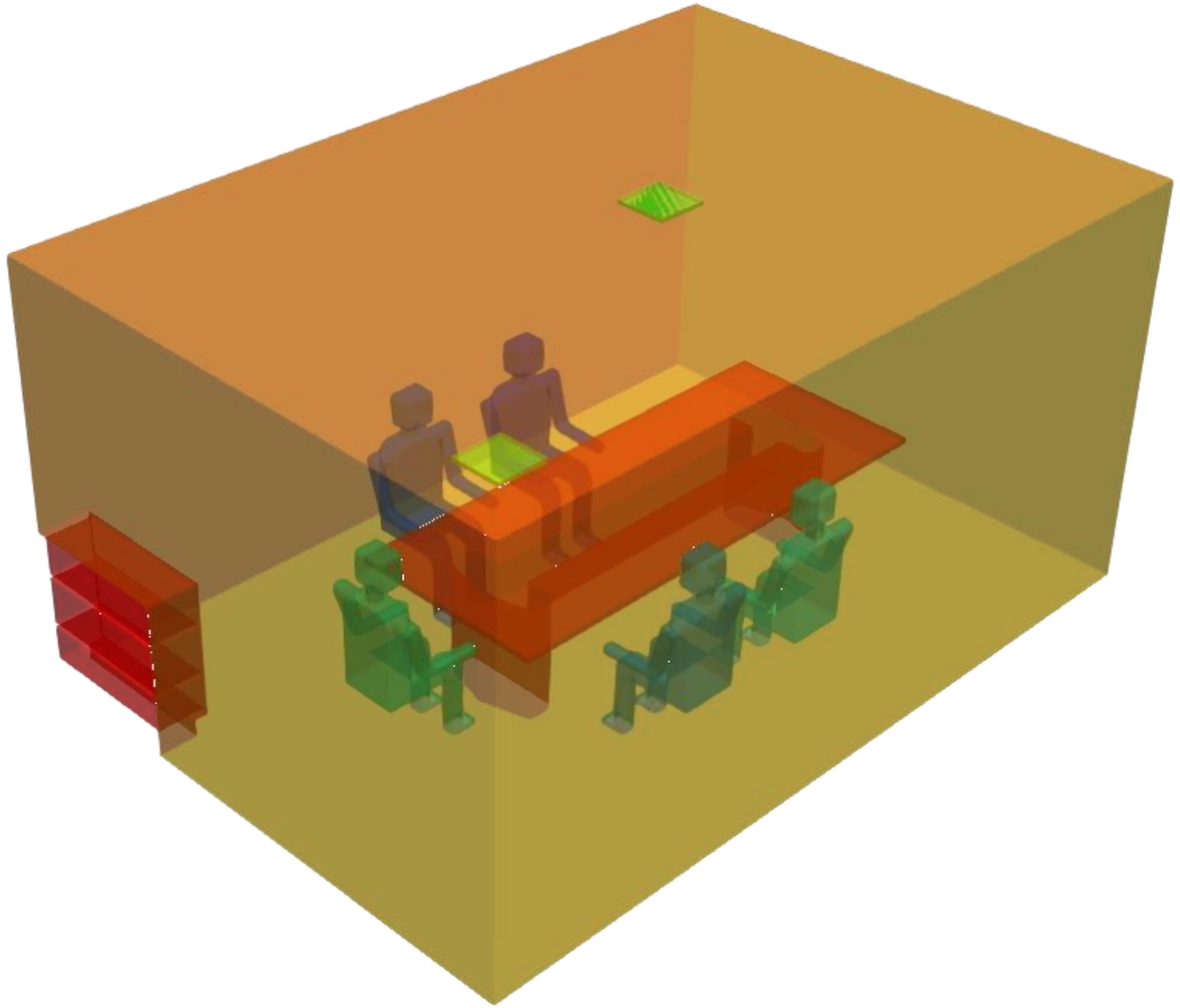
BIM to Fluid Volume

- **Consumes days for analyst**
- **simulationHub Propriety Algorithms**
- **Automatic Wet surface identification and Extraction**
- **Intelligence build to close the small gaps and extract the right surfaces**

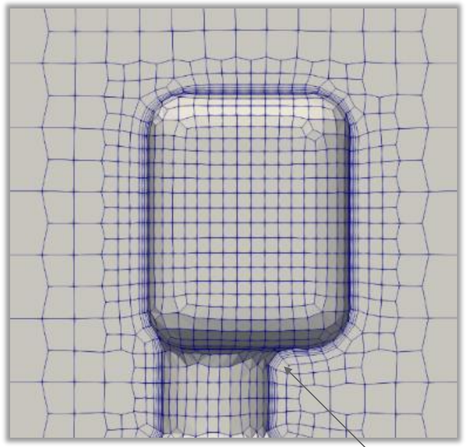


BIM Model

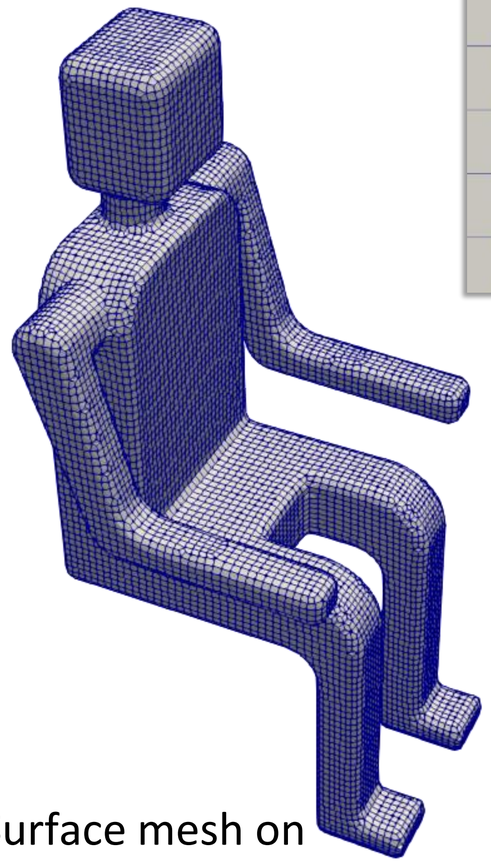
Fluid Volume Extracted



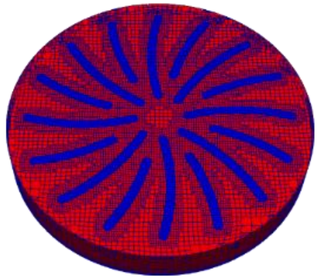
Mesh



Prism mesh cells
To resolve boundary layer

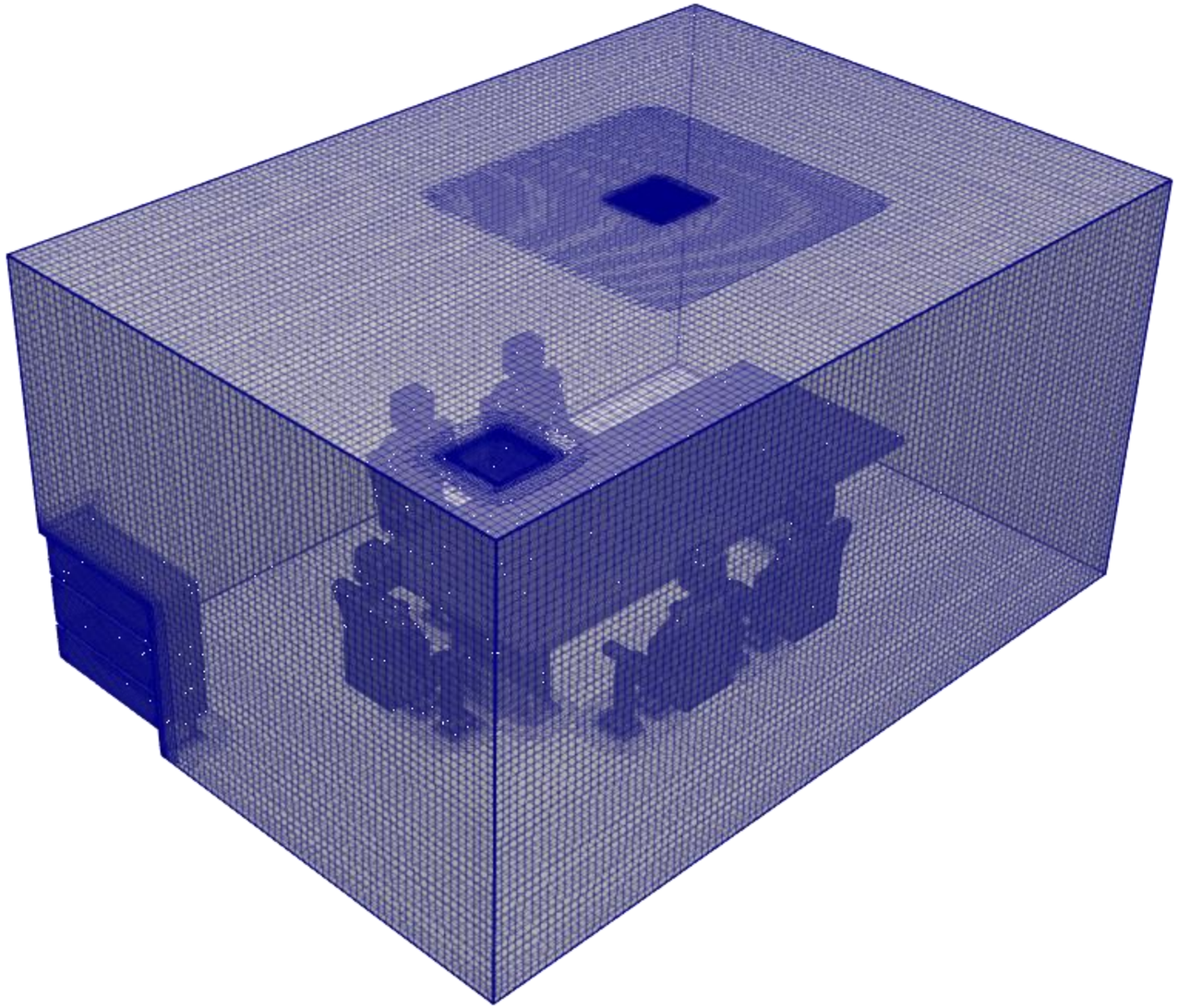


Surface mesh on
thermal manikin

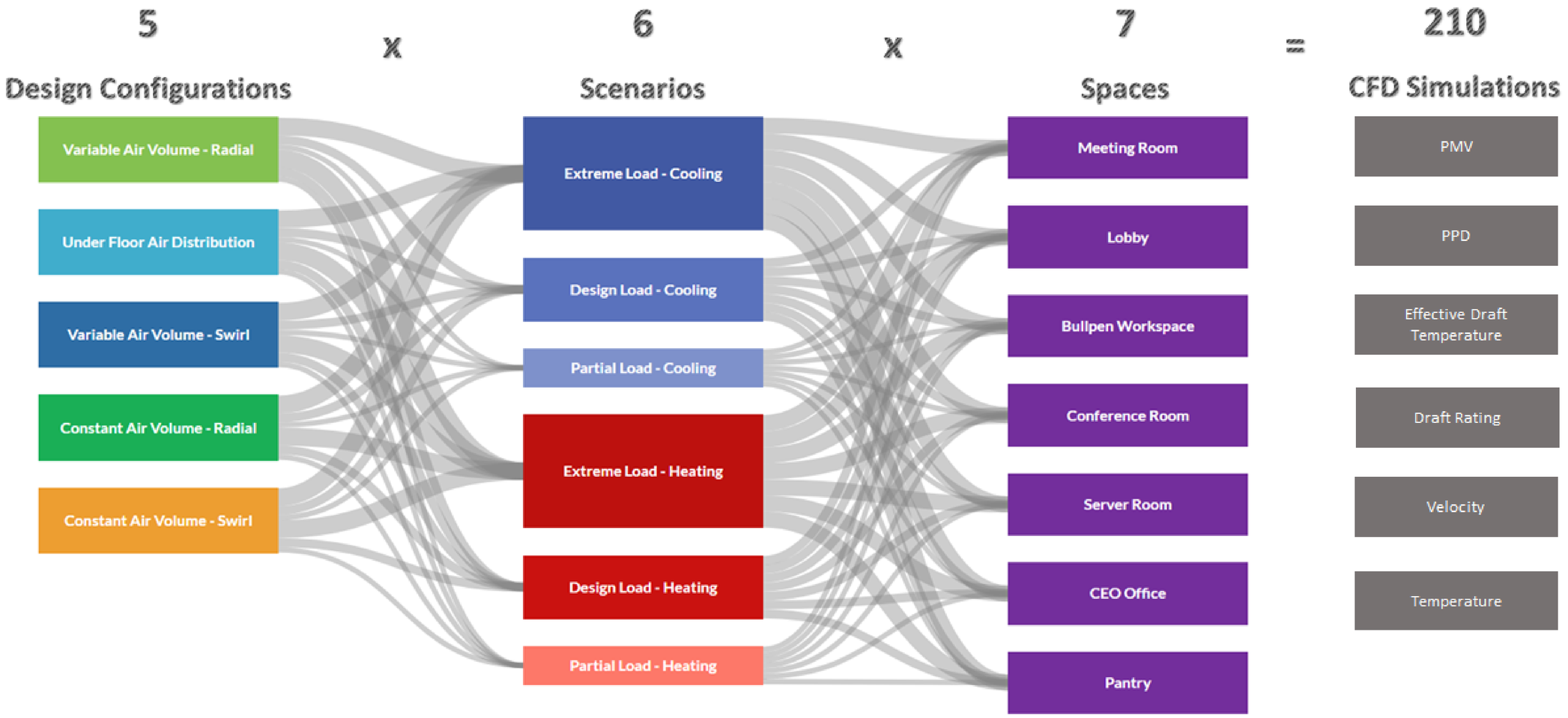


Surface mesh on
supply diffusers

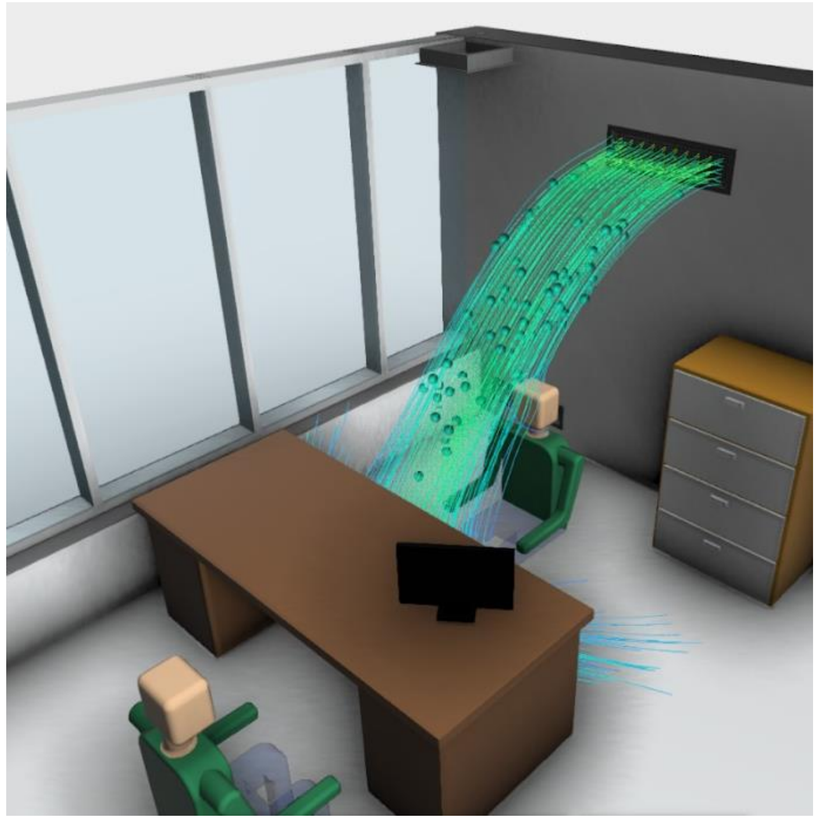
Automated mesh generation



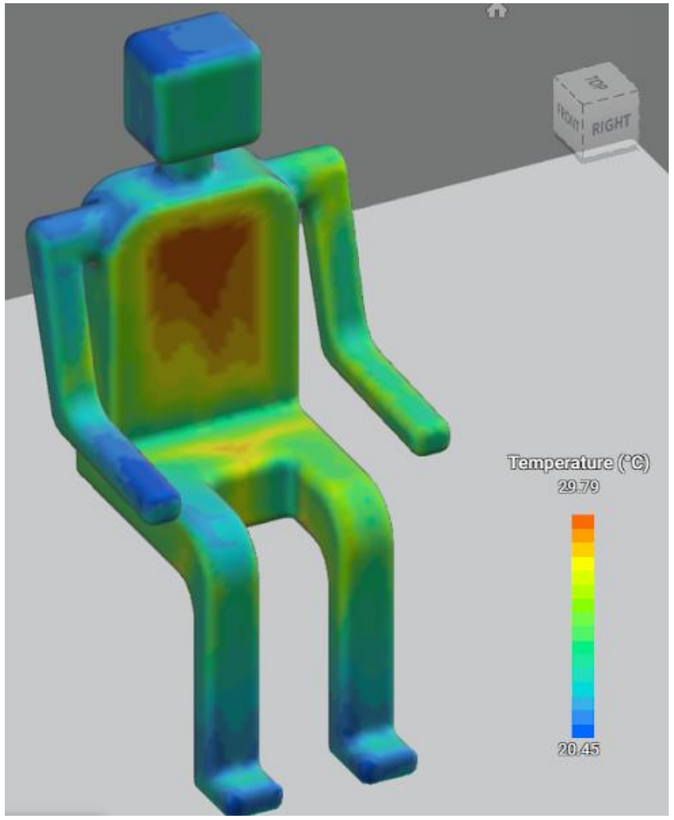
Simulation setup



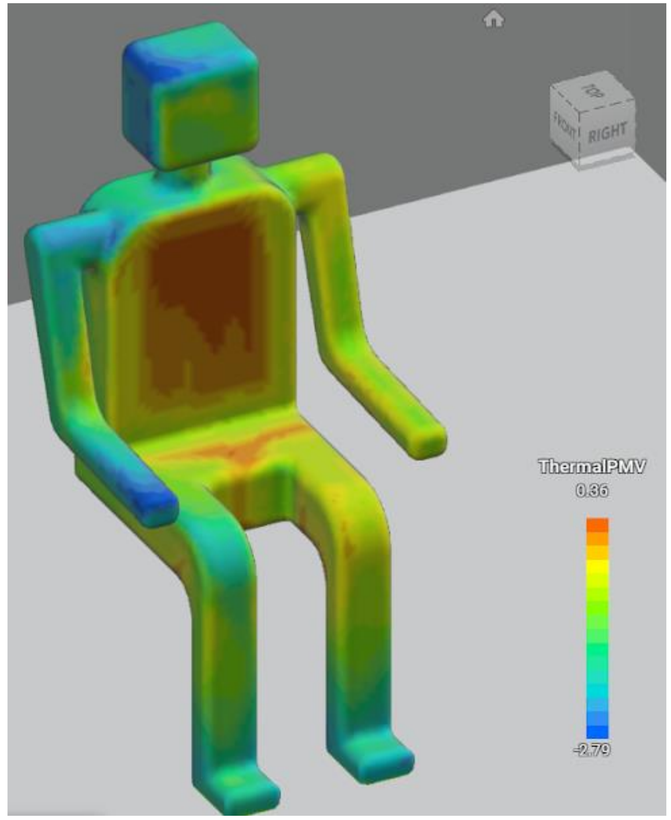
Post processing Results



Direct airflow over occupant



Low temperature region



Low PMV – Discomfort (Cold)

PDF report

simulationHub

Table 6: Internal heat load – Partial Occupancy

Space	Occupant		Equipment Heat load (W)	Total Internal Load (W)
	Number	Heat Load (W)		
Meeting Room	2	204	0	204
CEO Office	1	102	0	102
Server Room	0	0	4000	4000
Pantry	3	306	0	306
Conference Room	3	306	0	306
Bullpen Workspace	11	1122	3575	4697
Lobby	1	102	0	102
Total	**21**	**2142**	**7575**	**9717**

5.2 Weather Conditions

The external heat load on the building is applied on the external wall (walls that are in direct exposure to atmosphere) based on the outside weather conditions i.e., wind speed and air temperature. The heat transfer coefficient is calculated accordingly and applied on the external wall surfaces. The summer and winter conditions considered are shown below.

Figure 9: Outside weather conditions for summer and winter

For the current study, the supply air temperature for summer is set to 13°C, while it is set to 30°C for winter conditions.

6 Simulation Results

For the current study, a total of 210 CFD simulations are perform
configurations, 6 scenarios and 7 spaces. The different combir
scenarios, and spaces are shown in the Sankey chart.

Figure

Parameters like P
occupant therr
based on th

6.1.1 Pre

Predi
vot
fr

Comfort comparison

ir movement. Draft rating is an index
e of occupants dissatisfied due to the

$$5)^{3.62}(0.37 \times V_a \times T_a + 3.14)$$

ating % calculation

Technical Report – Control Valve Perform

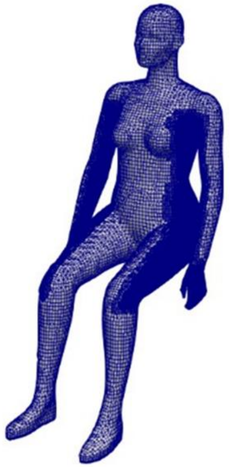
App Validation

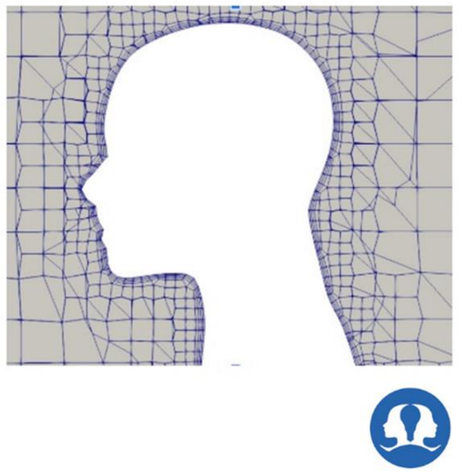
“**Benchmark Test for a Computer Simulated Person – Manikin Heat Loss for Thermal Comfort Evaluation**”
- Hakan O. Nilsson, Henrik Brohus and Peter V. Nielsen, 2007 Aalborg University

Test setup

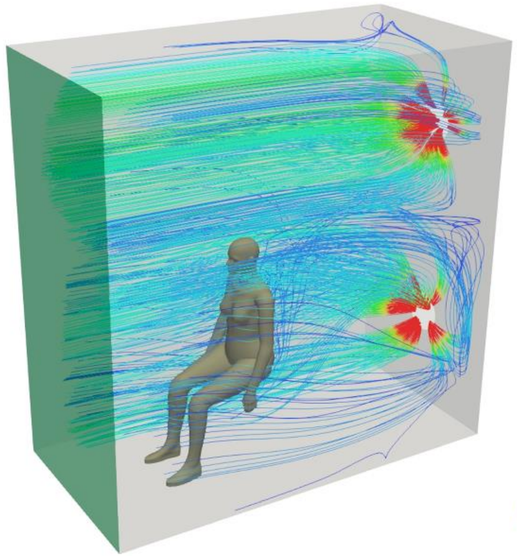
Image source

AHC - Mesh Generation



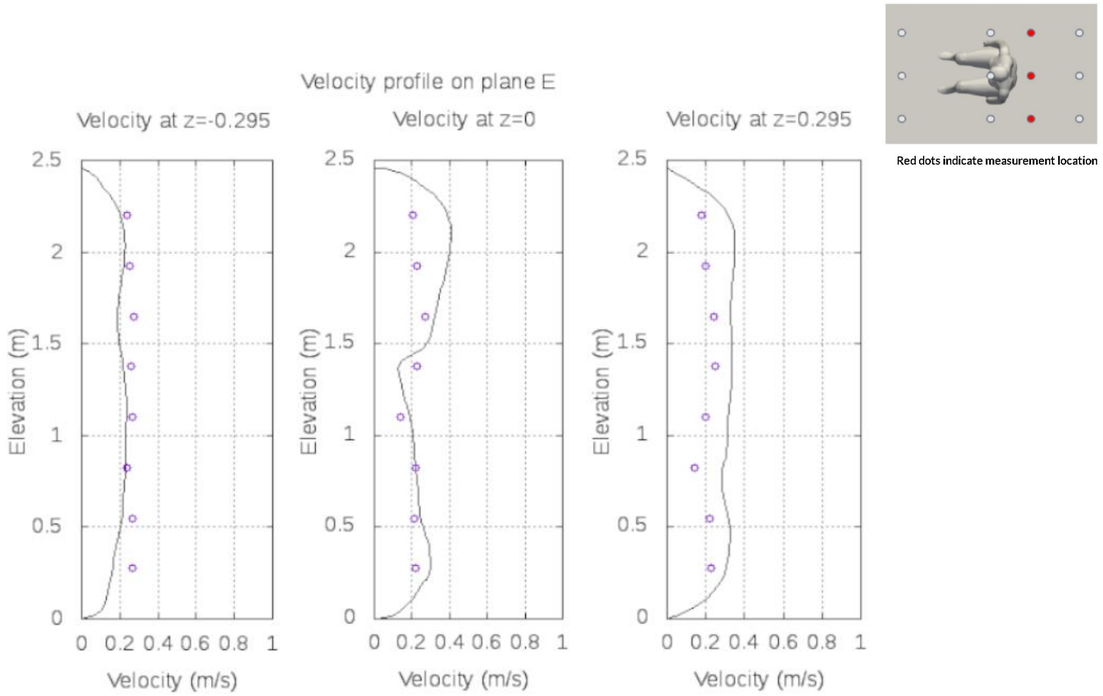


AHC - Results



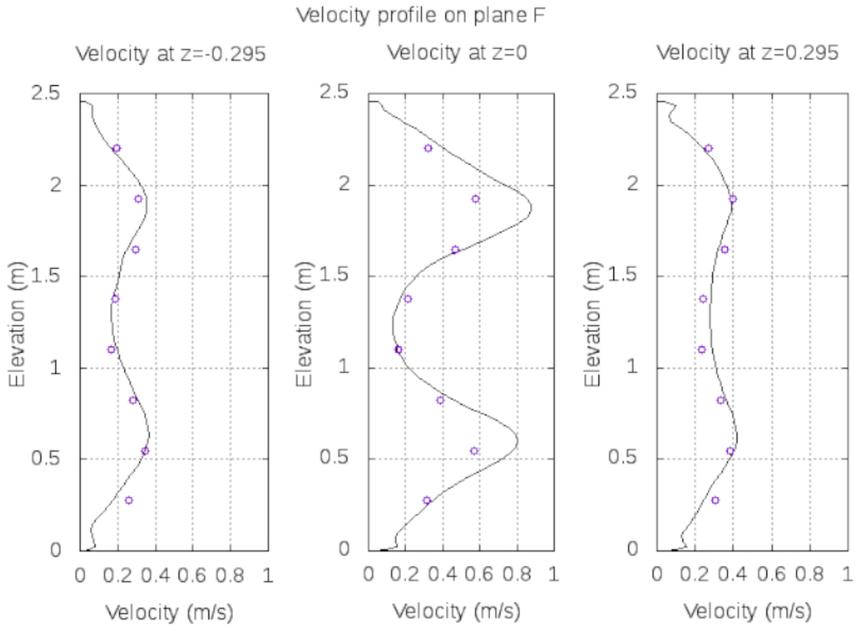
App Validation

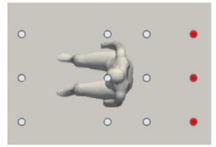
“**Benchmark Test for a Computer Simulated Person – Manikin Heat Loss for Thermal Comfort Evaluation**”
- Hakan O. Nilsson, Henrik Brohus and Peter V. Nielsen, 2007 Aalborg University



Experimental

CFD



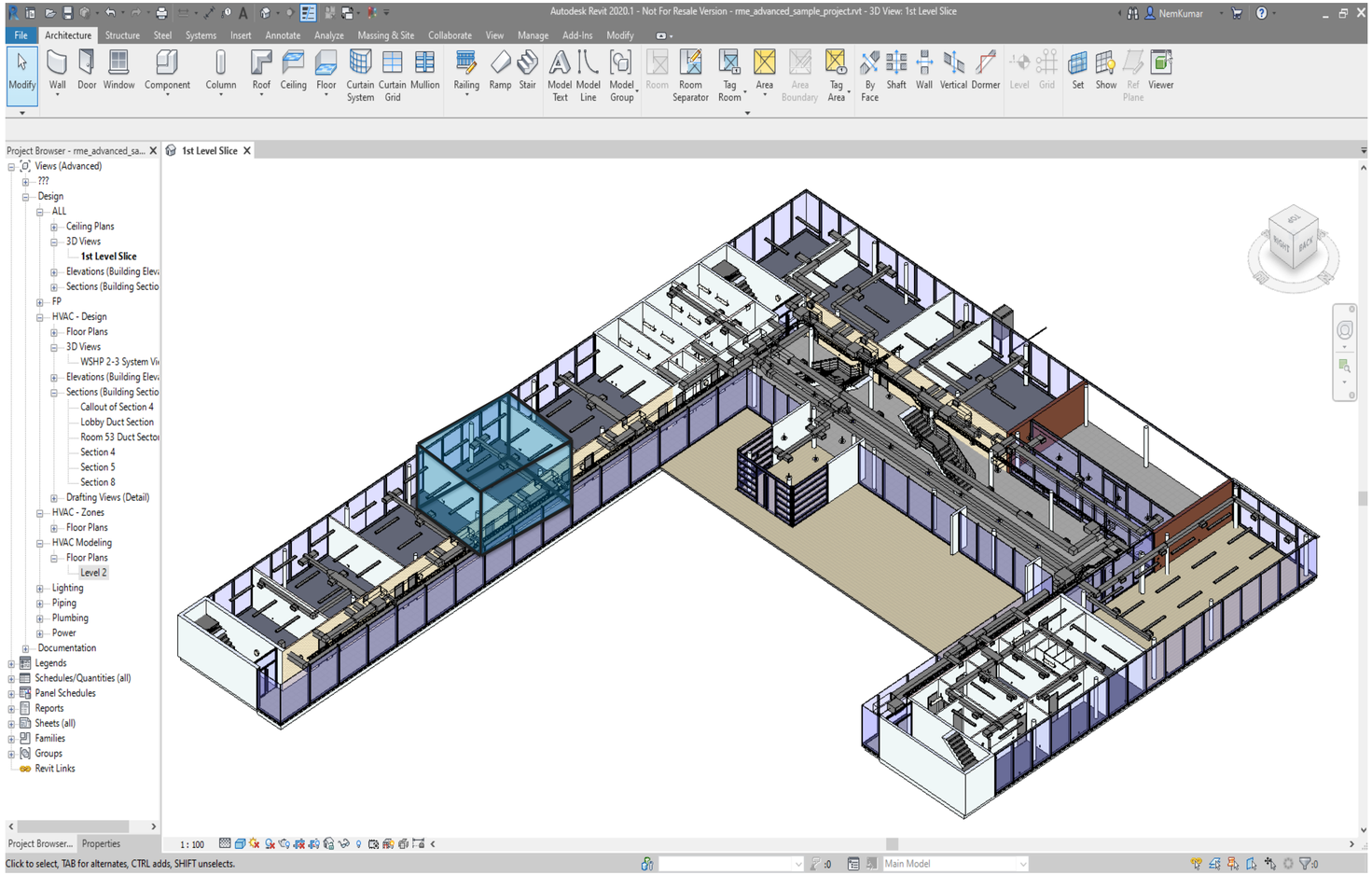


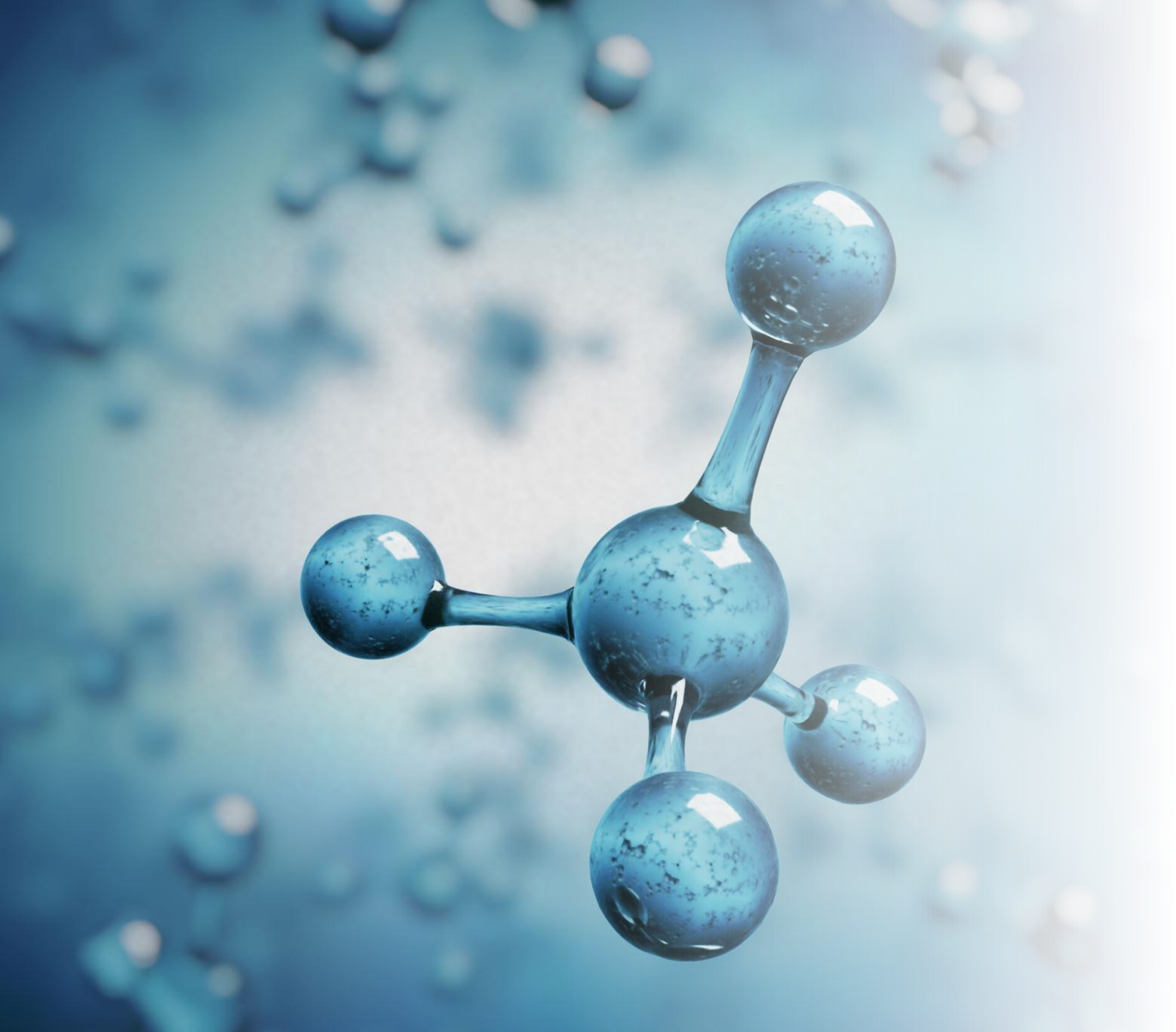
Experimental

CFD

AHC Future Plans

- Revit file support
- 3D BIM model from 2D floor plan drawing
- Building the Air diffuser manufacturers co-marketing space to add BIM components of product library
- Build the large public space templates such as Airports, Auditorium, Indoor stadium.
- Develop new Air quality indices – CO_2 concentration, Contaminant, Odor tracking, ADPI





Signup for private beta

https://www.simulationhub.com/autonomous-hvac-cfd-private-beta