The State of Generative Design for Critical Infrastructure

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In a world grappling with rapid urbanization, the intense impacts of climate change, and a dire need for sustainable, resilient, and affordable infrastructure, generative design emerges as a beacon of hope. The introduction of generative design into the architecture, engineering, and construction landscape is ushering in a new era of efficiency & sustainability for 'leveling up' our built environment.

This report offers an exploration of how algorithm driven, automated, and outcome-based design methodologies are poised to redefine our built world; and specifically, critical infrastructure: transportation systems, water and energy assets, housing, and more. Utilities, engineering firms, technology providers and investors - join us in uncovering how critical infrastructure projects are being transformed through this State of the Industry Report on Generative Design for Critical Infrastructure.

Table of Contents

June 19th, 1987

"Almost without noticing, we have entered an era where the fundamental question is not "What can be done" but "What should be done.

Truly, this is the golden age of engineering.

But even more, it is a golden age for the individual engineer. Driven by technology, design is not dominated by the all-encompassing government design bureaus many imagined in the 1930's, nor by an oligopoly of giant companies as many saw in the 1960's. Instead, the basic tools to invent, design, and manufacture have become so inexpensive and widespread that "downsizing" has become at least as much an imperative in management as in design.

We are entering the age where we are limited primarily by our creativity. Our ability to imagine, and the courage to make our dreams into reality will be our most precious resource. In this age, the designer has a resource that most designers of the past could hardly imagine—the computer. Engineers who, less than twenty years ago, toiled into the night with log tables, slide rule, and pencils, making parts, then breaking them on testing machines, or designing circuits and struggling to get them to work can now design on their desktops with productivity hundreds to thousands of times greater. And the products of their minds in turn accelerate the process. Anybody who attempts to predict what we can do in our lifetimes should first reread predictions made in 1960. Anybody who draws a limit to what our children can achieve is a fool."

John Walker
Autodesk Co-Founder
May 16, 1949 – Feb. 2, 2024

Introduction: The Second Golden Age of Engineering

Despite its introduction into the engineering and manufacturing industries in the 1990's, generative design is largely misunderstood and intermittently used in critical infrastructure applications. The recent introduction of artificial intelligence into the conversation with ChatGPT-style generative AI tools has further complicated the narrative of generative design and its practical applications in designing, constructing, and operating our built world.

It is imperative that responsible parties, including utilities, developers, engineering consultants, and others stay informed of emerging trends and applications of generative design. This report is a compilation of data & insights from leading players of how generative design is revolutionizing project planning, design, and execution within water, power, housing, transportation, and other critical infrastructure sectors.

This is second golden age of engineering. An age where software can help design a sustainable, resilient future throughout the full lifecycle of critical infrastructure projects.

Read on to learn about the forcing factors at play that are rapidly changing the way those responsible for designing, building, and operating our built world are being forced to adopt to new realities.

Forcing Factor 1: Critical infrastructure spending is through the roof - no signs of slowing down

Total construction spending stood at **US $1.98 trillion** in August 2023, a 7.4% increase since the previous year. This total spending was primarily driven by nonresidential construction spending (the majority of which is critical infrastructure), which **recorded growth at a 17.6% year-over-year** increase in August 2023.

And this doesn't include the backlog of projects that already exist. As of August 2023, backlogs in the nonresidential segment had increased to 9.2 months and are expected to sustain the segment going into next year.

Figure 2

Total construction spending will likely continue to grow in 2024, driven heavily by the manufacturing and infrastructure categories

Share of residential and nonresidential (US$ trillion)

Nonresidential construction spending by category (US$ billion)
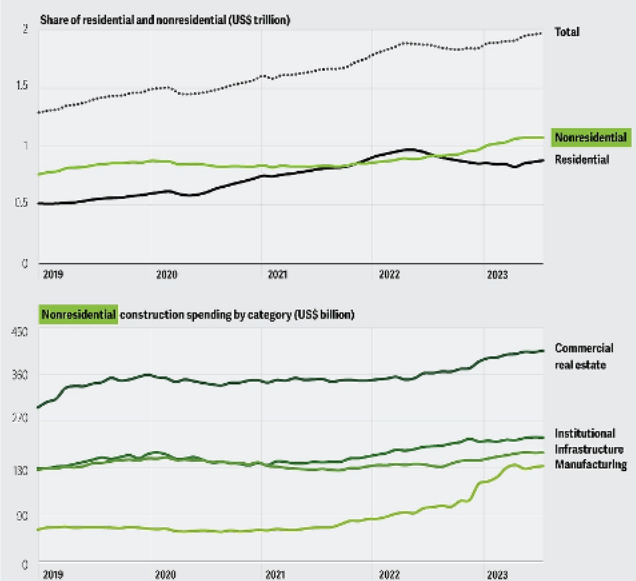
Note: Commercial real estate includes lodging, office, and commercial. Institutional includes health care, educational, religious, public safety, and amusement and recreation. Infrastructure includes transportation, communication, power, highway and street, sewage and waste disposal, water supply, and conservation and development.

Source: Deloitte analysis of data from US Census Bureau.

Deloitte. | deloitte.com/us/en/insights/research-centers/center-energy-industrials.html

Forcing Factor 2: All this infrastructure work to be done… and nobody available (or wants) to do it!

92% of leaders of global companies rank attracting and retaining talent among their top three priorities.

Engineering talent is in short supply, with a growing gap between supply and demand that puts the progress of important industries at risk and threatens to have a tremendous negative impact on the economy— equal to nearly 40% of the projected GDP impact of all talent gaps expected in the US through 2030.

A BCG analysis of Bureau of Labor Statistics (BLS) data indicates that demand for engineering skills will grow by about 13% from 2023 to 2031.

The Japanese Ministry of Economy has predicted a deficit of over 700,000 engineers in Japan by 2030, and the German Economic Institute reported a shortage of 320,000 STEM specialists in Germany as of April 2022.

There is a 133,000 person engineer gap in the U.S. today, where 33% of roles go unfulfilled, and a projected 186,000 engineering job vacancies by 2031.

"Everywhere in the world right now [there] is the need for more talent, better talent," says Martin Fischer, professor of civil and environmental engineering at Stanford University. Fischer has observed an "expectation of the younger generation to not do stupid work that could be automated. They don't tolerate it. They just leave."

Forcing Factor 3: Regulatory & customer requests are requiring innovations in sustainability & resiliency for critical infrastructure projects

According to the International Energy Agency (IEA), **buildings account for 30% of global energy consumption and 26% of global energy-related emissions.**

The IEA has set a Net Zero Emissions by 2050 Scenario, which requires **all new buildings and 20% of existing structures to be zero-carbon-ready by 2030.**

According to the US Green Building Council's 2023 report, **sustainability is a top priority for most surveyed Engineering & Construction (E&C) firms**, as it aligns with their organizational mission and business strategies.

The U.S. recently announced their Greenhouse Gas Reduction Fund (GGRF) NCIF award. $20B will need to be deployed in 7 years; much of which involves design &

engineering of critical infrastructure projects.

Sustainability requirements are finding their way into building codes, and Governments from the United Kingdom to Brazil to Mexico are **mandating or heavily pushing the use of building information modeling (BIM).**

"E&C companies are expected to begin prioritizing sustainable design tactics and structural performance during the conceptual phase. Such early planning can result in substantial reductions in carbon emissions. E&C companies can also incorporate circular economy principles early within the design and construction process. Based on these principles, companies may engage in reusing materials, designing structures for disassembly, and reducing waste to address environmental concerns and support business growth."

Deloitte - 2024 engineering and construction industry outlook

Forcing Factor 4: Big infrastructure $ + lack of talent + desire for 'resilient infrastructure = prime opportunity for early engineering & construction firm adopters to excel

McKinsey analysts found engineering & construction **front-runners in artificial intelligence (AI) adoption could double their cash flow** (economic benefit captured minus associated investment and transition costs) by 2030, with a 122% cumulative change.

Whereas **nonadopters [of artificial intelligence] "might experience around a 20% decline in their cash flow from today's levels,"**

"With integrated digital technologies, our project managers can objectively assess project status, productivity, and any risks, and [can] make data-based decisions more quickly to improve safety, performance, and outcomes," says Francesco Tizzani, group manager of digital construction at Leighton Asia, an international construction contractor headquartered in Hong Kong and part of CIMIC Group. "The technologies also reduce manual reporting, enabling our people to focus on analyzing intelligent data to improve project delivery."
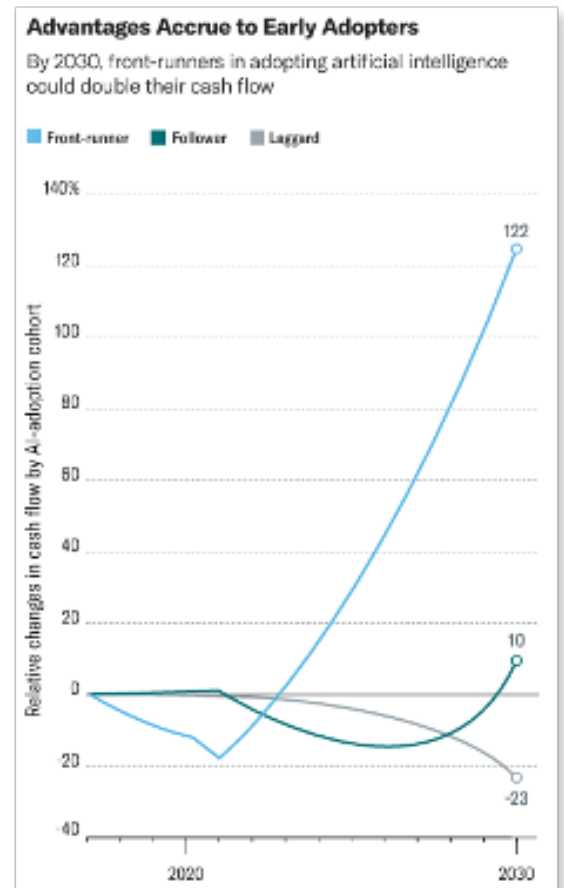

Advantages Accrue to Early Adopters
By 2030, front-runners in adopting artificial intelligence could double their cash flow

Legend: Front-runner, Follower, Laggard

Y-axis: Relative changes in cash flow by AI-adoption cohort (140%, 120, 100, 80, 60, 40, 20, 0, -20, -40)
X-axis: 2020, 2030

Data points at 2030: 122, 10, -23

Table of Contents

Objective 1 – Detail how generative design is the leading viable option to thrive in the second golden age of engineering

If it hasn't already become apparent, something needs to change.

The way we've designed our infrastructure in the past is not going to succeed in this new era. There's too much work to be done, not enough talent to do it, and too many new requirements to effectively and affordably build the infrastructure of the future we need.

As you read on, our objective is to educate interested parties on how critical infrastructure projects are, and will be, transformed with generative design technologies. We will focus on real world applications of generative design in real infrastructure projects around the world, as well as key success metrics for organizations

adopting generative design as part of their workflows.

But before we get there, we'd like to propose one other objective: a new success metric by which all relevant industry players should measure themselves by…
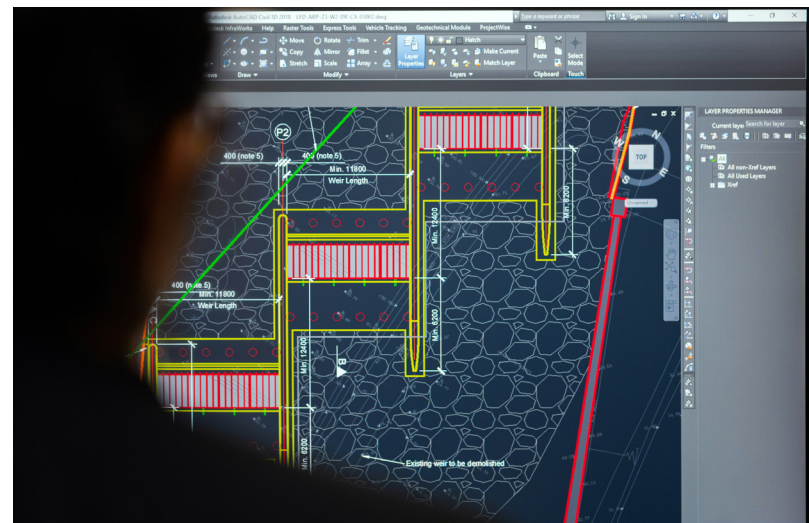
Objective 2 – Propose a new metric for the success of critical infrastructure projects

Critical infrastructure projects—such as roads, water treatment facilities, and energy systems—are fundamental to healthy, vibrant societies and economies. These projects have long lifespans and significant impacts on the environment and communities.

This makes sustainability paramount - not only to reduce environmental impact but also to ensure resilience, adaptability, and cost-efficiency over decades.

For too long we've focused on measuring the success of projects after the asset is built. Were we within budget? How long did the project take? Does this meet the needs of our communities, now and into the future?

In other words, we are reactively measuring our success. We track the intimate details of lagging success indicators like the total cost to operate and every iota of carbon produced, but fail to proactively address these concerns during the planning phases of projects.

We need to shift to proactive measurements of success. And one measure, in particular, stands head and shoulders above the rest...

The New Success Metric: The total number of options created & assessed using generative design in critical infrastructure projects

By focusing on this leading indicator of project success, we can guarantee the best outcome before it's too late.

1. The first and greatest advantage of maximizing the number of design options is the **expansion of the solution space**. This enables the consideration of a broader range of possibilities, including those that may not be intuitive or traditionally considered by human designers. It encourages innovation and creativity, leading to more efficient, effective, and sustainable infrastructure solutions.

2. By generating this array of design options, generative design allows for the **optimization of projects with sustainability as a key parameter**. This includes reducing material usage, maximizing energy efficiency, utilizing new technologies, minimizing carbon footprint, and optimizing for local environmental conditions. This approach ensures that the selected design performs exceptionally well across various sustainability metrics.

3. Many design options also means that designs can be **tested against future scenarios**, such as climate change impacts, population growth, or technological advancements. This anticipatory approach ensures that infrastructure is resilient and adaptable to future challenges; contributing to its long-term sustainability.

4. Engaging a wide range of stakeholders in the decision-making process is crucial for the success of infrastructure projects. Having a **multitude of design options facilitates a more transparent, inclusive, and democratic process**, as stakeholders can see the trade-offs between different options and contribute to selecting the most sustainable outcome.

5. While assessing more design options may seem resource-intensive initially, it leads to **significant cost savings in the long term** by avoiding costly redesigns, maintenance, and adaptations. Investing in comprehensive design exploration upfront can optimize lifecycle costs and save public funds.

Table of Contents

Setting the record straight – definitions of various terms

For purposes of this report, we are comparing **generative design** and **AI-powered design** methodologies to manual design in critical infrastructure projects.

Manual design can be broadly defined as 'design as it's always been done' – whether in spreadsheets, with CAD or BIM tools, or drafting tables… a computer is not expected to generate options; it's all on the human to create outputs.

Generative design, on the other hand, is an iterative design process that involves the use of algorithms and computational techniques to generate a broad spectrum of design options, typically optimized for specific predefined criteria.

Artificial intelligence is often used to power generative design software and the design generation & options assessments that come with use of these programs.

Critical infrastructure refers to the physical assets that society relies upon for everyday functioning and overall well-being. For context of this report, we focus on critical infrastructure in the built environment. The next slide outlines the exact asset types we're referring to.

Critical infrastructure as defined in this report is broken down into three categories: Class, Vertical Assets, and Horizontal Assets.

Class of Critical Infrastructure	Vertical Asset Examples	Horizontal Asset Examples
Transportation Systems	Airports, railway stations, bus terminals, EV charging stations, and seaports.	Roads, highways, railways, bridges, tunnels, and runways
Energy Infrastructure	Power generation plants (hydroelectric dams, wind farms, solar parks, waste-to-energy plants, and nuclear facilities), oil refineries, and gas processing plants	Power lines, pipelines for oil and gas, and related distribution networks
Water & Wastewater	Water and wastewater treatment plants, water towers, pumping stations, and solid waste	Aqueducts, pipelines, drainage systems, and water distribution networks
Communication	Cell towers, communication hubs, satellite dishes, data centers	Fiber-optic lines and cable networks
Housing & Residential	Single-family homes, multi-family apartments, condominiums, and public housing facilities	Sidewalks, driveways, yards
Public & Commercial Buildings	Government buildings, hospitals, schools, malls, office towers, cultural institutions (like museums or theaters), and sports facilities	Parking lots, green spaces
Emergency & Protective Services	Police stations, fire stations, emergency response centers, and military installations	
Industrial Infrastructure	Manufacturing, warehouses, hazardous waste plants, chemical plants, and storage facilities	Industrial parks and related distribution systems

For further clarity... Generative Design is often powered by AI, but Generative Design is NOT Generative AI

Generative Design	Generative AI
Quantitative	**Qualitative**
Defined **rules-based procedure**	Train, **learn**, and **create**
Deterministic outcomes	**Indeterministic** outcomes
Adaptable **parametric rules**	Statistical **model weights**
Predictable and **explainable** results	**Unpredictable** response

In simpler terms...

Generative Design "please create an apple."	Generative AI "please create an apple."
Generative Design software will create an apple - based on specific rules and parameters it's previously been given and/or that the user inputs. You'll know exactly how it produced the output and why.	Generative AI will create an apple... but from data and sources that are hard to pinpoint... and may even 'hallucinate' when producing an answer. You don't really know what you're going to get, or why. (I wanted an apple... not an Apple!)

And remember... Generative Design can deploy AI to help generate an output... but a human in the loop is critical!

AI: The Other Designer In The Room

Emily Suzuki | SEPTEMBER 12, 2022

Generative design harnesses the power of artificial intelligence (AI) to generate design iterations based on constraints identified by the designer or engineer. Generative design uses AI to some extent, but it is just one step in the process. Humans are required at the beginning of the process to define constraints and at the end of the process as the final decision-maker. After all, someone needs to sift through the list of design iterations generative design creates!
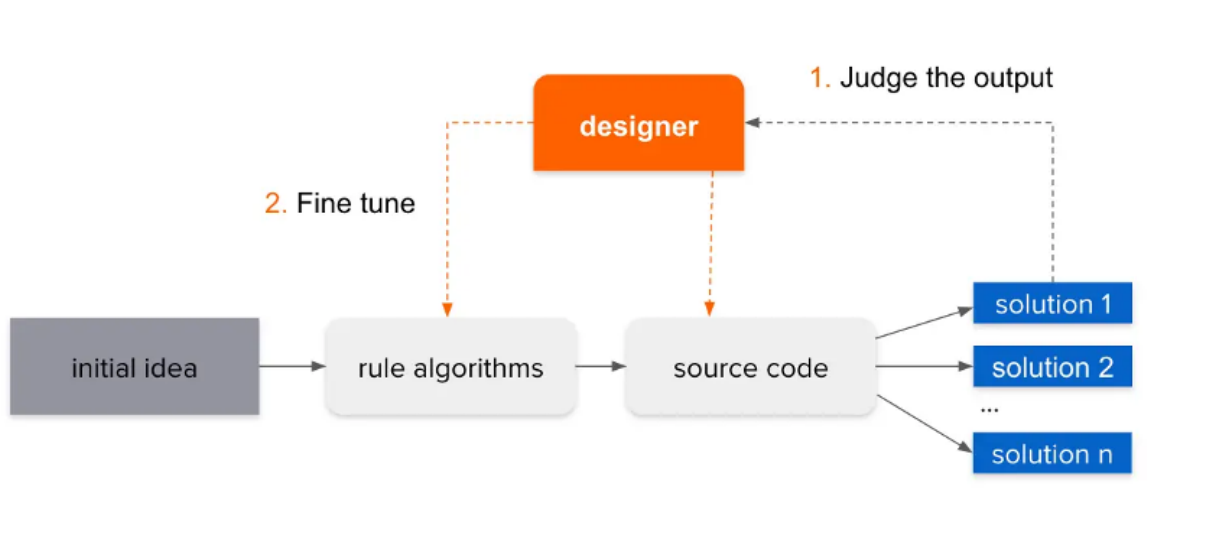
Table of Contents

Generative design is not a new concept... but generative design applied to systems level critical infrastructure is

Depending on the definition, generative design can be traced back to Gerald L. Delon's 1970 paper [A Methodology for Total Hospital Design.](#)

As CAD software began to proliferate throughout the 1980's and 1990's, programmers began applying generative design to component level design – and continue to do so today. Generative design aids engineers in creating new options like individual parts of a car, variations of a type of sneaker, and unique architectural arrangements.

But only recently has generative design hit the 'mainstream' in critical infrastructure projects – and even then, many industries are not yet served by a specific company or solution.

This section of the report provides a (non-exhaustive) list of generative design companies solving challenges in specific industry verticals, as well as the project phases they are best applied in.

Companies building generative design software for critical infrastructure projects

Class of Critical Infrastructure	Vertical Asset Examples	Horizontal Asset Examples	Companies Serving the Infrastructure Class
Transportation Systems	Airports, railway stations, bus terminals, EV charging stations, and seaports.	Roads, highways, railways, bridges, tunnels, and runways	ALICE Technologies, Autodesk, Bentley, ALLPLAN
Energy Infrastructure	Power generation plants (hydroelectric dams, wind farms, solar parks, waste-to-energy plants, and nuclear facilities), oil refineries, and gas processing plants	Power lines, pipelines for oil and gas, and related distribution networks	Transcend, Dassault Systèmes SE, SBS, Aurora Solar, OpenSolar, PVComplete, Verdiseno, Hexagon AB, PVcase, XENDEE, Enverus
Water & Wastewater	Water and wastewater treatment plants, water towers, pumping stations, and solid waste	Aqueducts, pipelines, drainage systems, and water distribution networks	Transcend
Communication	Cell towers, communication hubs, satellite dishes, data centers	Fiber-optic lines and cable networks	Cadence, CoolSim, OpenTower, ASMTower
Housing & Residential	Single-family homes, multi-family apartments, condominiums, and public housing facilities	Sidewalks, driveways, yards	Autodesk Forma, Hypar, Finch, Urbio, Augmenta, Fotor, Parallelo, AiHouse, Binary Habitats, Archistar, ARK, CONIX, TestFit
Public & Commercial Buildings	Government buildings, hospitals, schools, malls, office towers, cultural institutions (like museums or theaters), and sports facilities	Parking lots, green spaces	Infrared.city, Sidewalk Labs, MetricMonkey, AgiliCity, Outline AI, CITYPLAIN, Arcol, Consigli, PassiveLogic, Plooto, Spacio, TestFit, Omrt, Digital Blue Foam
Emergency & Protective Services	Police stations, fire stations, emergency response centers, and military installations		
Industrial Infrastructure	Manufacturing, warehouses, hazardous waste plants, chemical plants, and storage facilities	Industrial parks and related distribution systems	FlexSim, WZL Aachen, smartdraw, CreateASoft

The landscape of generative design & AI powered companies working on critical infrastructure, broken out by project phase

Generative design software can be applied during various phases of critical infrastructure projects.

Generally, we find generative design software most applied in the planning & conceptual design phases of projects; however, there are uses cases throughout detailed design and construction.

The 'Cheat Sheet' on the next slide provides a nice overview of some of the companies and the phases of projects they support – while not all are generative design (some are purely AI or generative AI) – it paints a nice sample of examples throughout project lifecycles.
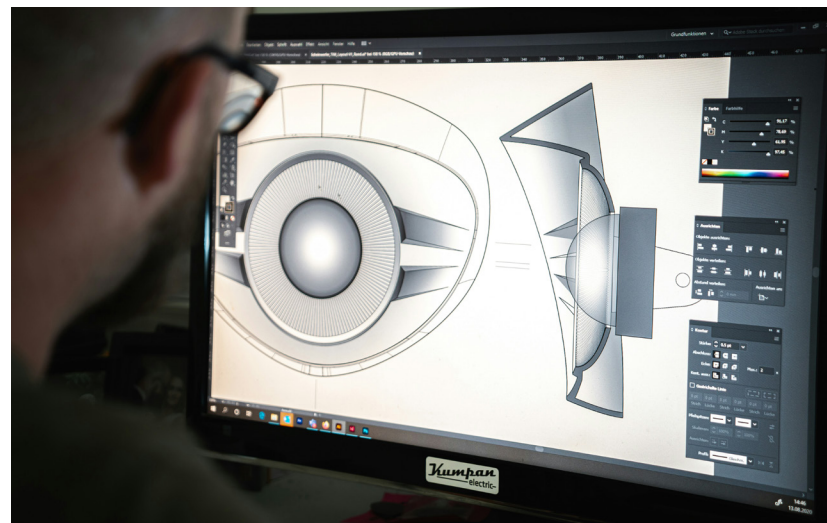
AI in AEC: AI Tools per Design Stage CHEAT SHEET

Special credit to Stjepan Mikulic of the AI in AEC Hub for creating the initial version of this one

AI in AEC: AI Tools per Design Stage CHEAT SHEET

DESIGN

CONCEPT DESIGN & PROGRAMMING

PROPTECH

Flythroughs, Luke, Elise, Getfloorplan, Deepblocks, Josh.ai, Local Logic, EarlyBuild

DESIGN CREATION

NVIDIA Canvas, Adobe Firefly, Midjourney, Canva AI, DALL-E3, LookX, Image Computer, Mokker, Coohom, Stable Diffusion, VERAS, Uizard, Interior AI, mnml, BlueWillow, LatentLabs

GENERATIVE DESIGN

ARK, CityBldr, CITYPLAIN, Digital Blue Foam (DBF), Omrt, Conix, TestFit, Forma, Parafin3D, Consigli, Outline AI, Architectures, Archistar, PassiveLogic, Transcend

CONCLUSION Design and Architecture are completely different than they were a year ago. The ability to visualize your ideas quickly, create and edit your renders, iterate designs, make spatial analyses, easily access urban planning tools - the possibilities are vast. And we are just getting started...

EXPAND

DETAIL DESIGN & ENGINEERING

BUILDING DESIGN

Augmenta, Hypar, BricsCAD BIM, Finch3D, Forma, Modulous, Parallelo, Transcend

CALCULATIONS

Plooto, PlanFinder, AECforward, DAISY AI, Pathw.ai, Structure Plus, Transcend

CONCLUSION BIM is about to have a revolution. The data is being used in various ways: to automate building design, generate floor plans, or even text prompt your way to the BIM model - almost unbelievable! As for the engineers - AI can help you find the best solution immediately - how great is that?

SPECIFY

DOCUMENTATION & SPECIFICATION

AI-DRIVEN

SWAPP, Blueprints AI, Modumate, Aurivus, Archilyse, Mosaic, Stylib, Transcend

FUTURE-PROOF

Planner5D, Higharc, Snaptrude, Arcol, Infurnia, Qonic, BlenderBIM, Transcend

CONCLUSION You have your design ready, and you just need to create drawings - automated construction documentation surely sounds like what you might need! Moreover, finding the BIM tool of the future, stable, flexible, and powerful is surely something we all could use more of. AI is here to stay!

DEPLOY

CONCEPT DESIGN & PROGRAMMING

CONSTRUCTION

Need2Say, Sparkle, StructShare, Slate AI, Disperse, Buildots, OpenSpace, Imerso, Versatile, Constru, SmartBarrel, Naska.ai, Doxel, viAct, StructionSite, Construction IQ

SURVEYING

Cyvl.ai, Neuralangelo, AirWorks, Lepei AI, Luma AI, Strayos, Syte, Kreo

CONCLUSION AI is making construction smarter. Comparing your as-built BIM models with the building site, expecting clashes, or being able to see how well your plan is holding up, are just some of the tasks these tools can do - and the power of being able to turn your scans into BIM... AMAZING!

ASSIST

GENERAL & STAGE-INDEPENDENT

Bard, ChatGPT, MS Copilot, ChatwithData.ai, Quivr, eesel AI, Civil.ai, Plannerly, CADSOMA, ADDD, G-Prompter, Help Kit, Arrow, Snipo

CONCLUSION Finding the right answer in the right format, talking with your data, making your workflows smarter and your tasks faster is unbelievably lifechanging. Imagine all the hours saved, all the databases alleviated, and the ability to find just what you need much quicker... AI is that great!

Interestingly, generative design technologies can also be further broken down by use case at the asset level. Here are some examples of where generative design is used on bespoke applications.
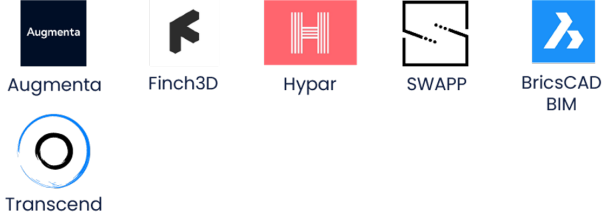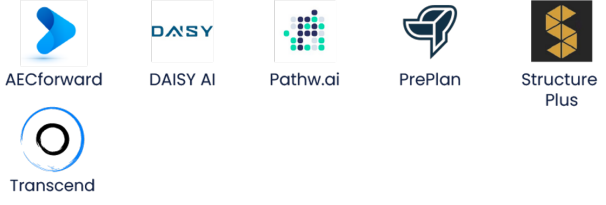
Generative Modeling	Site Analysis Automation, Building Data Assessment, Real Estate Feasibility, Sun & Wind Analyses, Parking Layouts, Urban Planning, Environmental & Financial Analysis, Walking Accessibility, Buyer/Seller	Forma, TestFit, Parafin3D, Omrt, Digital Blue Foam, Architectures, CityBldr, CITYPLAIN, Build Flow AI, Transcend
BIM & AI	Automated Building Design or Generation of Floor Plans, Text-to-BIM, Construction Documentation Automation	Augmenta, Finch3D, Hypar, SWAPP, BricsCAD BIM, Transcend
Structural Design	Low Carbon Design, Timber Design, Steel Structures, Automated & Optimized Concrete Design	AECforward, DAISY AI, Pathw.ai, PrePlan, Structure Plus, Transcend

Table of Contents

The impact of generative design around the world

Despite its emerging importance in critical infrastructure, generative design is already making real impacts in projects around the world.

In this section, we break down case studies by critical infrastructure vertical – showcasing the tangible impacts of generative design on project workflows and project outcomes achieved.

We then end the section with a call to action for Utility and AEC/EPC companies interested in adopting these technologies, recommending KPI's by which they can measure the success of the use of generative design within their organizations.
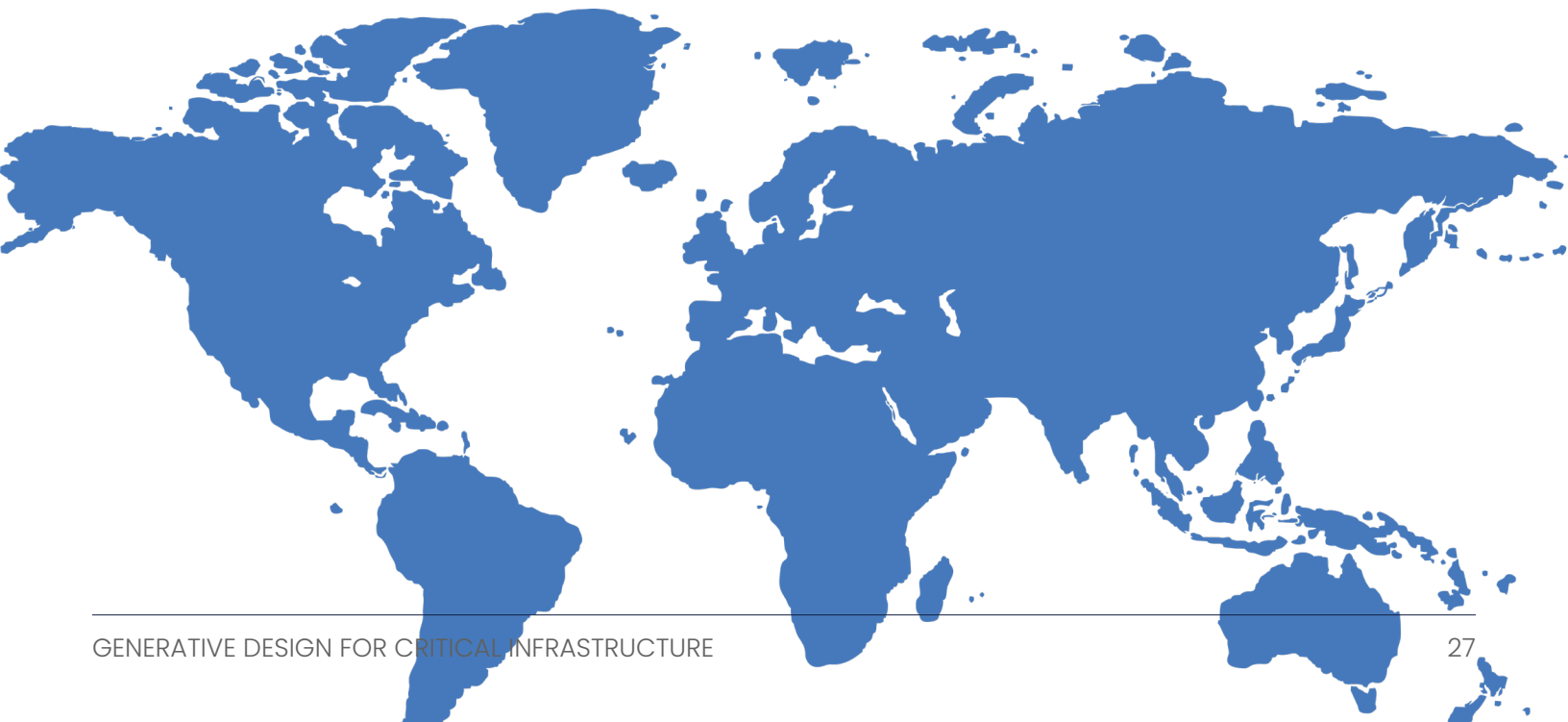
Tangible Benefits of Generative Design in Transportation Projects

"The Bipartisan Infrastructure Law will make a **once-in-a-generation investment of $350 billion in highway programs** through 2026. This includes the largest dedicated bridge investment since the construction of the interstate highway system 67 years ago.

The need for new infrastructure is urgent, with **1 in 5 miles of highways and major roads, and 45,000 bridges in the US alone in poor condition.** State DOTs and the industry have more reasons than ever to transform the way transportation infrastructure projects are designed, built, operated, and maintained."

Theo Agelopoulos
VP, AEC Design & Engineering Strategy
Autodesk

ALICE Technologies drives £2M savings on UK High Speed 2 Railway

The Challenge

Three major European general contractors – Skanska, Costain, and STRABAG – formed a joint venture, SCS JV, to optimize the construction of the London tunnels of HS2, a national high-speed railway linking London, Birmingham and the north of the country. The HS2 network will ultimately carry more than 30 million travelers each year. SCS JV is constructing 13 miles of twin-bore tunnels on the HS2 route, terminating at Euston station in central London. The company has divided its tunnels work into three areas – west, central, and east – and in its initial work with ALICE, SCS JV has focused on the east area, where HS2 emerges from the tunnels on its final 0.6-mile route to Euston station.

In its first work with ALICE, the question at hand for SCS JV was: could it use ALICE to find efficient sequencing options to enable an earlier construction start for the Euston cavern shaft, which provides critical access to the main tunnels that lead to Euston station.

The Solution

Through "what-if" analysis with ALICE, the SCS JV team was able to identify several ways to re-sequence and improve the build time for the pre-shaft sinking activities. Changing when they would construct the spoil conveyor, which would remove soil from the excavation and work area, was one such important influencer of the schedule.

SCS JV also determined that they could save time and improve efficiency by having concurrent workforce teams constructing activities to the cavern headhouse base slab, and key milestones, which would enable construction of the cavern shaft earlier than planned.

The Results

With the ALICE platform, the SCS JV team was able to trim the build time for the shaft by 86 working days, a savings worth £2M in associated overhead expenses.

"Construction optioneering with ALICE has enabled us to quickly and effectively explore alternative ways to build," said Andy Irwin, SCL Agent at SCS JV. "The savings of both time and money that we've identified with this initial work on SCS East has been significant, and we're now looking forward to expanding our use of ALICE to other portions of the project."

GENERATIVE DESIGN FOR CRITICAL INFRASTRUCTURE
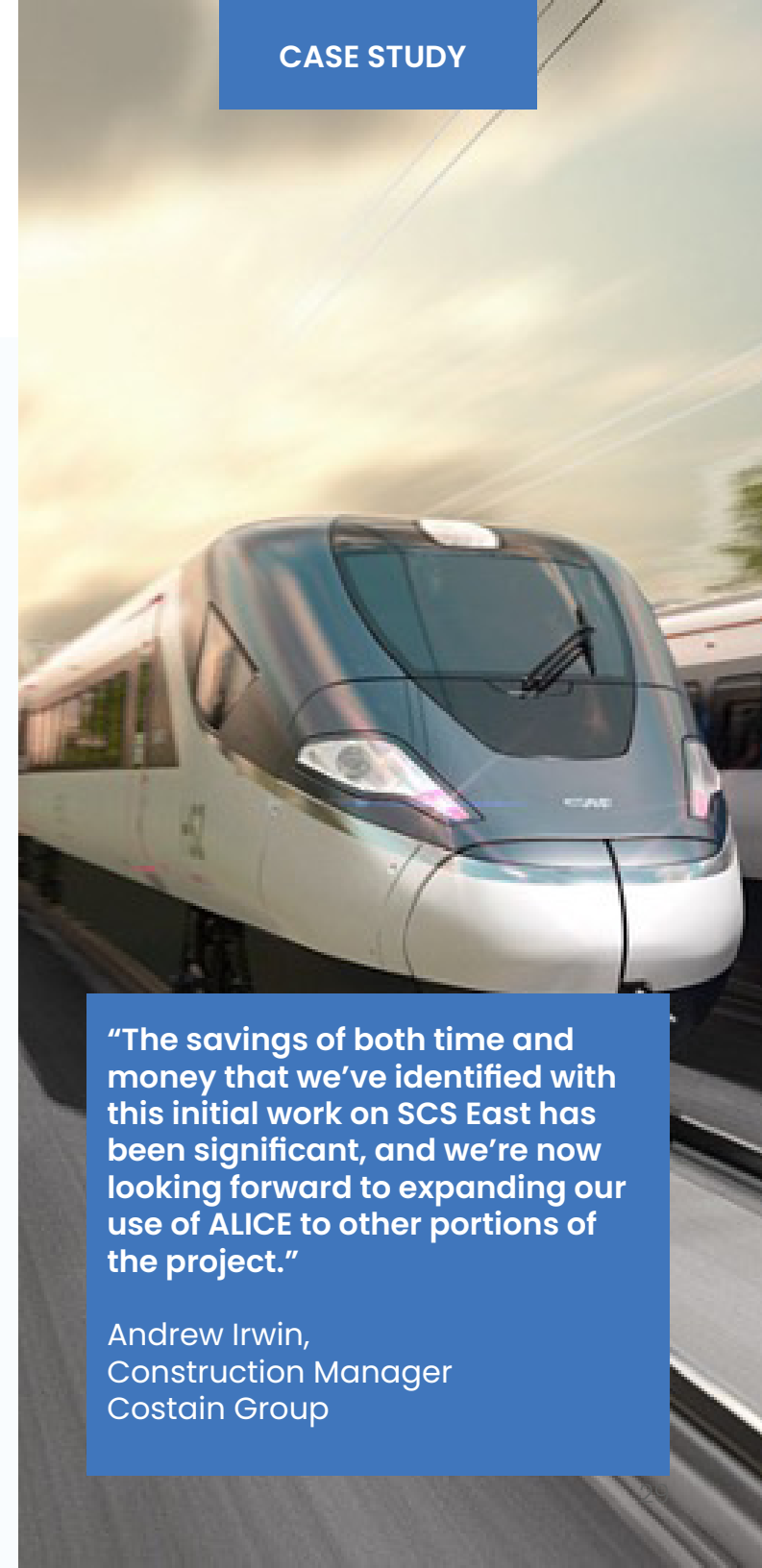
"The savings of both time and money that we've identified with this initial work on SCS East has been significant, and we're now looking forward to expanding our use of ALICE to other portions of the project."

Andrew Irwin,
Construction Manager
Costain Group

Montgomery County, MD saves up to $185k and 6+ weeks time savings with Remix Streets
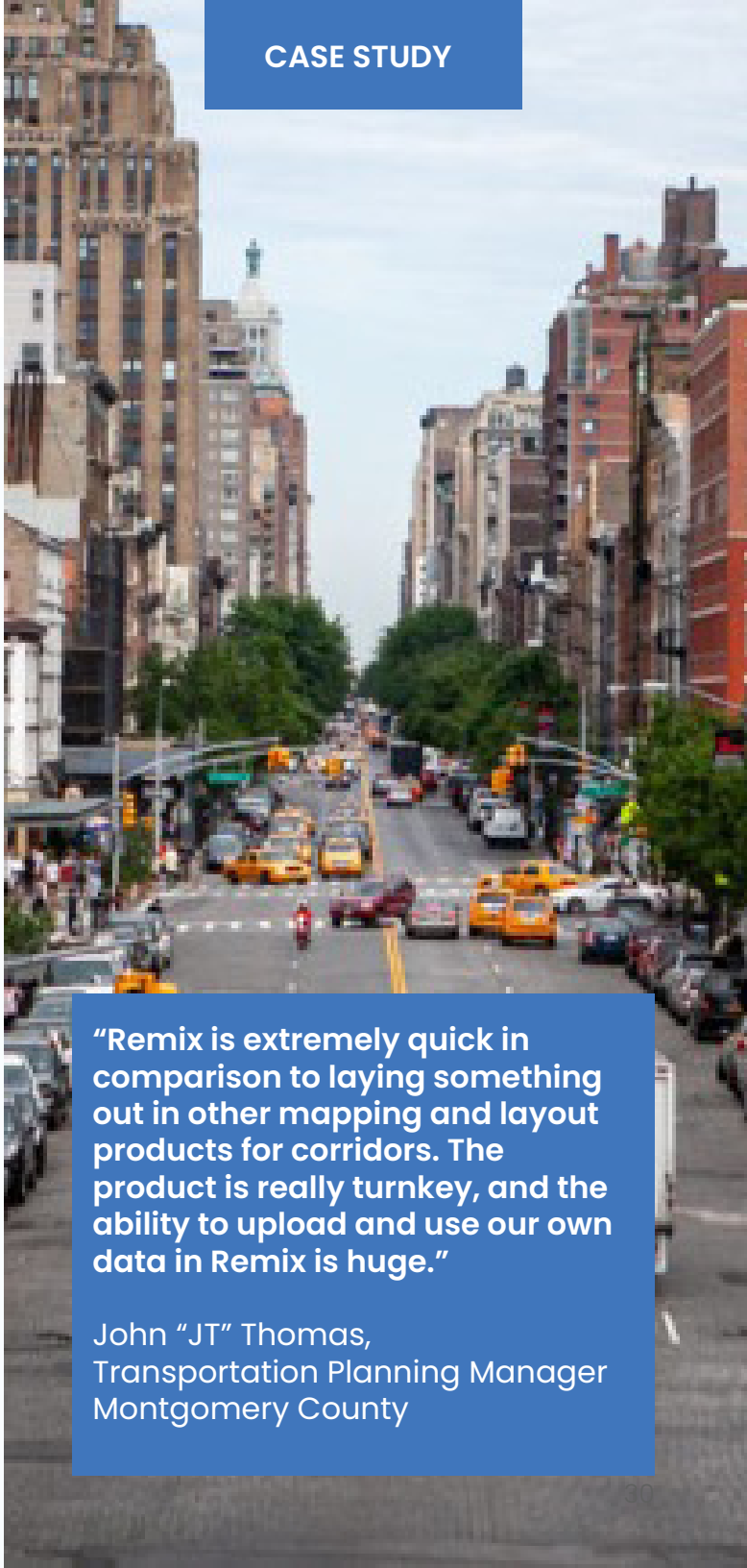
The Challenge
Montgomery County's Department of Transportation was using a mix of generic and traditional tools to complete conceptual street design alternatives. This process was cumbersome, siloed, and slower than the pace they were striving for. They needed an all-in-one tool that could allow the County to deliver quickly on the early phase work for their community.

The Solution
The County introduced new conceptual street design technology, powered by Remix, that enabled them to save money and staff time, accelerate project timelines, and gain valuable process efficiencies, all leading to better outcomes for the County.

The Results
- An estimated $185,000 USD savings in 18 months: dollars spent before vs. dollars spent with Remix
- Accelerated project kickoff timeline by 4-6 weeks
- Increased efficiencies: 2-3 weeks time savings for every conceptual design modification
- 5 projects in progress in the first 6 months

GENERATIVE DESIGN FOR CRITICAL INFRASTRUCTURE

"Remix is extremely quick in comparison to laying something out in other mapping and layout products for corridors. The product is really turnkey, and the ability to upload and use our own data in Remix is huge."

John "JT" Thomas,
Transportation Planning Manager
Montgomery County

Tangible Benefits of Generative Design in Power Projects

"When it comes to the **design of next-gen power systems**, the **technologies that will be most useful will be those that operate (or empower engineers to operate) across domains and disciplines.** AI and ML are increasingly seen as being at the nexus between data, describing what is or what has been, design objectives (or the desired future state), and design constraints (or best practices). This nexus is where the magic is happening in the industry right now."

Lorenzo Slay
Director, Energy
Transcend

PVcase saves Iberica Solar 50% of the hours in initial project phases

The Challenge
Designing solar power plants is a detailed and intricate process. Traditional methods can be slow and susceptible to mistakes, particularly as the scale and complexity of the projects increase. Large-scale projects, involving extensive layouts with roads and transformer station locations, require precision and efficiency to avoid costly errors and delays. The company faced challenges in managing these complexities efficiently while maintaining high standards of accuracy and speed in their design processes.

The Solution
The company adopted PVcase Ground Mount software to address these challenges. PVcase stands out for its seamless integration with widely-used engineering software like AutoCAD, enhancing its utility and flexibility. Its user-friendly interface and powerful features streamline the entire design process, from basic to detailed engineering, and support execution engineering. The software enables quick development of project layouts, reducing the time spent on design phases significantly. One of the key advantages of PVcase is its capability to minimize human errors early in the design process, thus ensuring a higher level of accuracy in the final layouts.

The Results
The introduction of PVcase Ground Mount software had a transformative impact on the Iberica Solar's operations. The time savings realized with PVcase were substantial, especially in the initial phases of project development, where more than 50% time reduction was observed.

This efficiency gain was even more critical in the context of very large solar plants, where the complexity and number of variables increase exponentially. The ability to generate several layouts for the same project within a single day allowed the company to offer more options to their clients, enhancing customer satisfaction.

For a practical example, a project that previously took three days to layout could now be completed in just one day with PVcase, including multiple versions of the layout without any compromise on accuracy. Additionally, the software's topographical 3D cabling features provided precise cable length estimates for both level 1 and level 2 of plant design, facilitating more accurate budgeting and planning.

GENERATIVE DESIGN FOR CRITICAL INFRASTRUCTURE

"Being able to remove the human error early in the design stage is a key advantage, but above all, from my perspective, the speed at which we design the plants in a more efficient way, reducing the response times during the design stage."

David Velasco
Industrial Engineer
Iberica Solar

Tangible Benefits of Generative Design in Communication Projects

"**Unprecedented demand** for digital infrastructure is **driving technological innovation. Customers are seeking to optimize efficiency and flexibility** in a tight market, and that's increasingly **pushing providers to develop new solutions and approaches.** This includes everything from leveraging alternate power sources for added reliability to **embracing the technological and infrastructure changes needed to accommodate AI."**

Andrew Schaap
CEO and Board Member
Aligned Data Centers

Larsen & Toubro uses Cadence Data Center Design Software to improve cooling design for new business venture
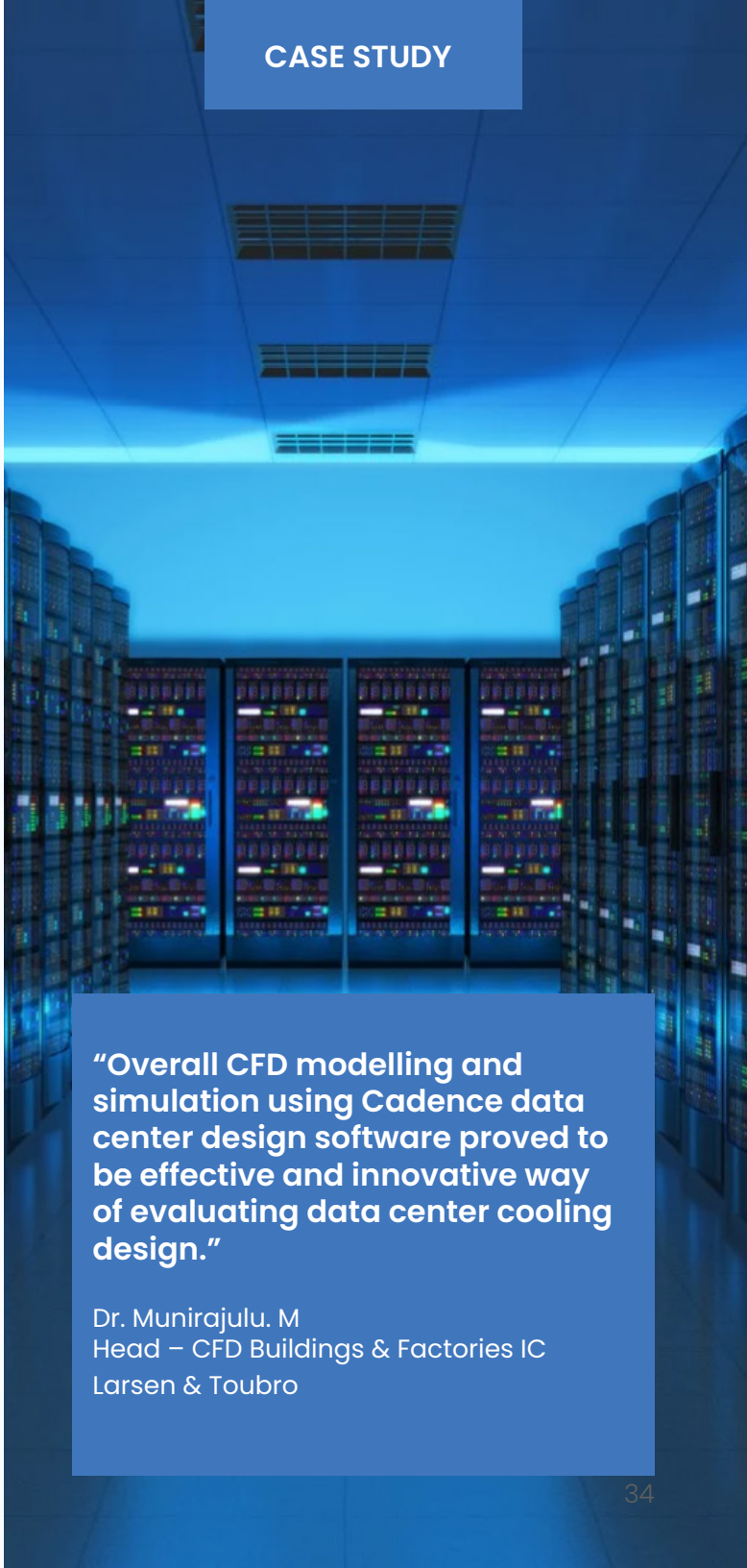
The Challenge

The effectiveness of a cooling system depends on airflow distribution to provide uniform IT inlet temperature without hotspots in any of the data center server halls. Larsen & Toubro needed a tool to help design a data center cooling system that would be effective for different modes of operation. They needed to do a detailed analysis of airflow and transfer in data center design, conduct "what if" scenarios to check design effectiveness, and get insight into data center performance issues.

The Solution

To minimize rework and risk of failure, Larsen & Toubro turned to the Cadence DataCenter Design Software. They found it useful for simulation and analysis of the cooling system to gain insight into the design and to make the necessary changes to meet the performance requirements.

The Results

The variety of CFD results from the DataCenter Design Software helped them visualize and evaluate performance characteristics such as temperature, velocity, and pressure, as well as identify opportunities to improve design modifications.

"Overall CFD modelling and simulation using Cadence data center design software proved to be effective and innovative way of evaluating data center cooling design."

Dr. Munirajulu. M
Head – CFD Buildings & Factories IC
Larsen & Toubro

Tangible Benefits of Generative Design in Residential projects

"With **rising housing needs** and **land shortages**, getting more out of the buildings that we build is of primary concern. **Generative Design enables each individual designer to optimize—giving us more in a world of scarcity.**"

Laura Paciano
Senior VP, Growth
TestFit

TESTFIT

RBA Architects became an early adopter and transformed their design process; resulting in over $750k+ fees won with TestFit.

The Challenge
On average RBA spent about 20-30 hours in AutoCAD to create a site plan for a project including:

- Sketching out concepts
- Getting initial client approvals
- Modeling building blocks for units
- Trying out 1-2 layouts

On top of that, they would need to then model the 3D massing in Revit for an additional 30-40 hours.
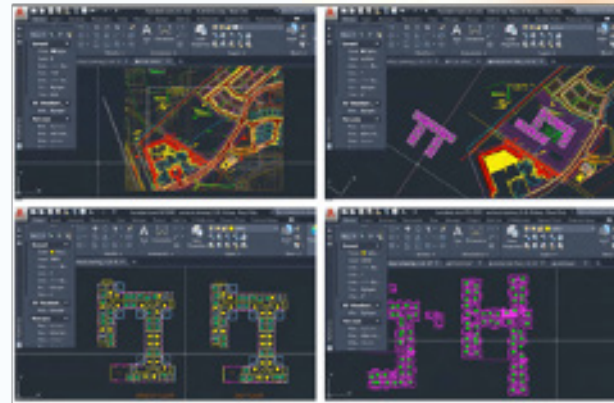
The Solution
RBA was looking for a tool that could check off all their requirements: The team kept coming back to TestFit during the evaluation process not only because it met all the core criteria, but also because it offered the customization that RBA needed. From the very beginning, RBA was able to import its configuration and standards into TestFit without compromising its existing unit standards—a feature that other platforms couldn't offer in their evaluation.

The Results
With TestFit's real-time AI configurators, RBA were able to get their work done 10x faster - 4-6 hours - and see the design from 2D to 3D instantly.

"We're actively marketing TestFit as our competitive advantage to win new projects, which has resulted in winning over $750K in project fees. A lot of the projects we would not have worked on without TestFit."

Thomas Retnauer
President
RBA Architects

Epcon communities fast-tracked their design portfolio by 10x with Higharc

The Challenge

Epcon Communities has won numerous awards for its floor plans and kitchen layouts, but it had been years since they overhauled the curb appeal of their home designs. But in 2022, after participating in the Parade of Homes near their headquarters in Columbus, Ohio, their leadership decided it was time for a chang.

Epcon wanted to level up their exterior, make it more contemporary and at the same time, make some updates to the interior layouts of our homes.

The Solution

Unlike other rendering services, Higharc creates high-quality 3D renderings directly from the model in the system, eliminating errors and drastically increasing the speed at which renderings can be produced. Renderings are ready in 2-3 days instead of weeks, allowing the Epcon Team a visual crosscheck of the changes they had made in design. The result? Peace of mind that they were on the right track.

The Results

Higharc's ability to render a large number of home variations quickly and accurately allowed Epcon to drastically increase the number of renderings they ordered, providing more transparency in the design process and more visual decision-making support tools for their customers.
"In the past, because it was so labor intensive and expensive, we would select only a handful of elevations to render within the unit type, and we typically wouldn't do secondary or community-specific color palettes in renderings," said Mats Alstrom, Epcon's Director of Design. "But since it's so quick to do and so cost-effective with Higharc, we're providing our salespeople with many more renderings than we have in the past."

"Comparing the process with Higharc to how we have done things in the past, the renderings were always a last-minute thing. It was really nice to see that in an earlier stage,"

Mats Alstrom
Director of Design
Epcon

GENERATIVE DESIGN FOR CRITICAL INFRASTRUCTURE

Tangible Benefits of Generative Design in Water & Wastewater projects

"Infrastructure worldwide is evolving with digital and physical tools making a big impact. For instance, the **UK water industry has committed to becoming carbon neutral by 2030**, unlike the U.S. with its 50,000 utilities lacking similar mandates. The future of critical infrastructure involves using generative design to thoroughly assess project impacts. **The key opportunity is to design resilient infrastructure now**, rather than dealing with problems later."

Adam Tank
Co-Founder
Transcend

Transcend

Asian Development Bank reduced risk and optimized planning with 5x more options using Transcend

The Challenge
Rayerbazar WWTP is a new plant being planned by Dhaka WASA & proposed for ADB funding. The biggest risk factors for this project were the cost and time related to land constraints and acquisition. Dhaka is a dense city and it was imperative that the footprint of this WWTP be minimized as much as possible.

The Solution
ADB partnered with Transcend to pilot its generative design software to streamline project planning and design for the Rayerbazar WWTP. ·Transcend Design Generator (TDG) enabled ADB and Dhaka WASA to generate 10+ concept design options, compared to 2-3 options typically evaluated for a project. Compact WWTP site-specific options included features like deeper reaction tanks, rectangular vs. circular clarifiers, and a phased facility build-out.

The Results

Reduced risk with 5x more options
ADB and Dhaka WASA used TDG to minimize the project's risk by generating 5x more design options with lower physical footprint, translating to significant cost-savings

More detail, better insights
TDG's automated engineering documents, including a 3D BIM model, informed ADB and Dhaka WASA with details for project planning and future construction bidding. This level of detail was not previously available for concept designs

Faster Decisions: 8 Months to 8 Weeks
TDG produced outputs within hours significantly speeding up the decision-making process. Decisions that typically take 8-10 months can now be accomplished within 8-12 weeks using generative design software.

"With Transcend's generative design capabilities, we identified options that reduced project risk and cost by minimizing the facility's footprint. Transcend sped up our decision-making by generating actionable data, including CAPEX, OPEX, and footprint information within hours."

Momoko Nitta,
Senior Urban Development Specialist
Asian Development Bank

Tangible Benefits of Generative Design in Public & Commercial Building projects

"If you **think of the city as a platform, and design in the ability for people to change it as quickly as you and I can customize our iPhones**, you make it authentic because it doesn't just reflect a central plan."

Rit Aggarwala
Commissioner
NY Department of Environmental Protection

Intep uses Urbio to reduce data collection & design time by 95% for a municipal energy plan

The Challenge
Intep approached Urbio to overcome 3 challenges:
- Inefficient process for gathering accurate data over a perimeter
- Tedious combination of spreadsheets and GIS tools
- Inadequate macro analysis made it hard to deliver actionable solutions to quickly implement

The Solution

Structure the data
Relying on Urbio's curated data and on the municipality's own data, the energy engineer quickly set up an accurate digital twin of the building stock characterized by dozens of criteria.

Visualize the current state
Once the Digital Twin was built, the engineer selected the most relevant criteria to illustrate the municipality's current state.

The instant creation of customized maps contextualized the analyzes and served as figures for the discussions with the stakeholders.

Identify the key levers
The engineer applied its custom filters and summary templates to quantify the impact of specific measures on the municipalities objectives.

The Results
Based on these metrics, the city was able to take strategic decisions such as targeting the most impactful buildings for retrofit measures or renewable electricity production.

"In Urbio, complex data is clearly prepared and concentrates on the really important statements. This brings everyone on the same page when starting interdisciplinary projects."

Max Talmon-Gros
Project Engineer
Intep

Miller Electric Company Reduces Electrical Design Time Modeling for Medical Facilities by 40% with Augmenta

The Challenge

Miller Electric Company is an American electrical engineering firm established in 1928 with an annual revenue of around $600M, 19 office locations, and more than a thousand employees. Miller Electric Company faces typical but urgent industry challenges associated with designing electrical raceway systems for large-scale commercial buildings:

- A process that is highly complex and time consuming
- A shortage of experienced design talent
- Tight schedules and cost constraints

They are eager to find ways to make their design teams more efficient, using new processes and technologies.

The Solution

Miller Electric Company undertook a pilot project led by Adam S. Davis, Sr. Manager, Fabrication & Modularization, to partner with Augmenta. Using Augmenta's automated Electrical Design Module, they completely automated the process of designing electrical raceway systems. Running Augmenta's software on historical projects, Miller Electric Company compared the solutions generated and the time to create those designs with the output of their traditional design processes. They retroactively automated the design of electrical conduit for two medical facilities.

The Results

Augmenta enabled Miller Electric Company to significantly increase the capacity of their VDC team. They realized around 40% time-savings in electrical modeling time across their Augmenta pilot projects - the equivalent of adding 2-3 BIM team member's time, without adding more overhead costs. Furthermore, they predict that with time-savings and the Augmenta platform's capability to estimate material and labor costs, their VDC team will be able to provide detailed estimates both during bidding and when responding to change requests. Ultimately, Augmenta will enable Miller Electric Company's VDC team to maintain a competitive edge in the evolving construction sector.
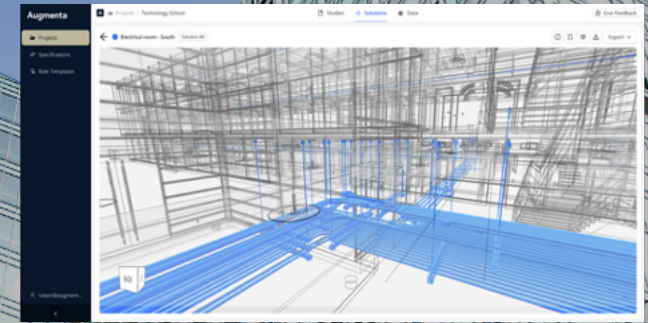
"In Urbio, complex data is clearly prepared and concentrates on the really important statements. This brings everyone on the same page when starting interdisciplinary projects."

Max Talmon-Gros
Project Engineer
Intep

Considering hopping on the generative design train? Here are the three key indicators to measure the success of your journey.

PR – how your firm talks about generative design

Projects & Profit – how your firm recoups ROI with generative design software

People – how you attract, train, and retain individuals that utilize generative design

Let's break each of these down a bit further...

Public Relations, Marketing, & Brand KPI's

1 How often does your marketing (website, advertisements, collateral, etc.) emphasize generative design as part of the value your organization brings to your customer?

2 How often are you mentioned in news outlets, social, etc. (Share of Voice) for topics related to generative design?

3 How often are leaders sharing topics related to generative design, both inside and outside of the company?

4 Is generative design listed as a strategic priority on your organizational communication roadmap?

5 Do you showcase case studies around outcomes created for customers by utilizing generative design tools?

People driven metrics

1 % of applicable employees familiar with the concept of generative design

2 % of applicable job descriptions mentioning generative design or requiring experience in building and/or utilizing generative design tools

3 % of applicable employees using generative design software on critical infrastructure projects

4 % increase in job satisfaction for employees using generative design tools

Table of Contents

Generative design is the gold standard for the betterment of critical infrastructure projects
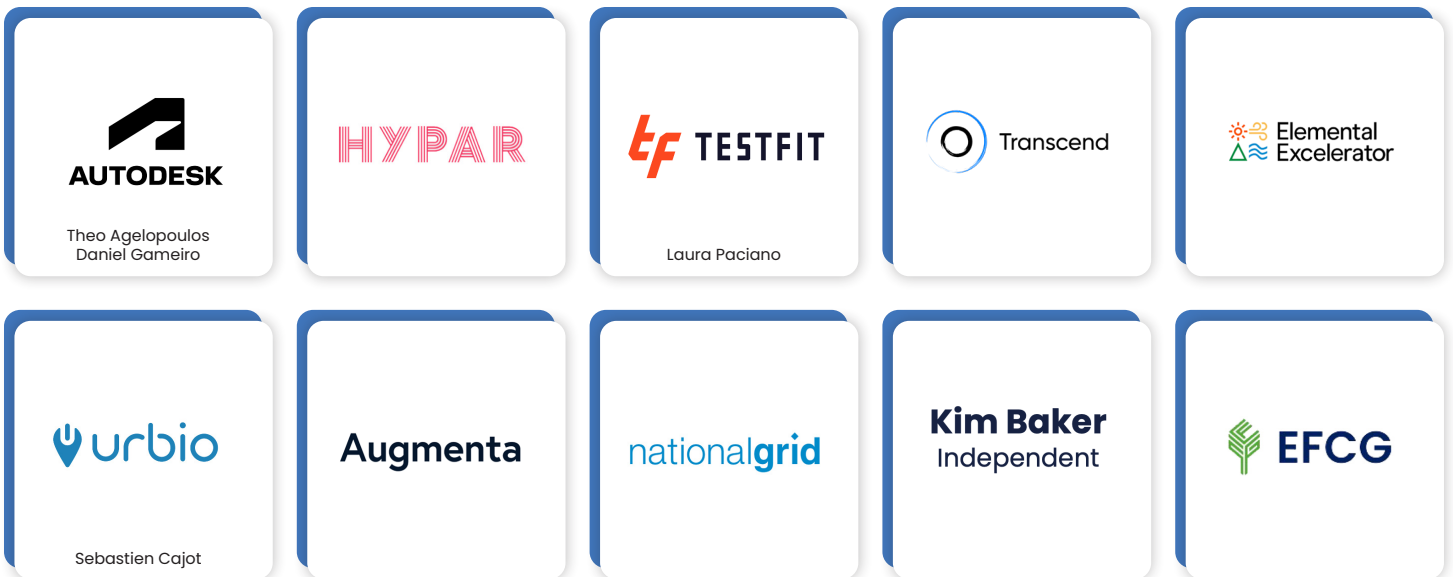
The use of generative design in critical infrastructure projects represents a transformative approach in how we plan, design, and optimize infrastructure projects in the second golden age of engineering.

By leveraging generative design tools, the world's designers can effectively address the most complex infrastructure challenges; leading to substantial cost savings, streamlined project planning phases, and ultimately the reshaping of entire urban landscapes...

Creating sustainable, adaptable, inclusive, and resilient cities of the future.

Our sincere appreciation to the following companies and individuals...

AUTODESK
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The State of Generative Design for Critical Infrastructure

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