

CHAIN DRAIN

**Why the Built Environment Struggles
to Learn and How to Fix It**

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Table of Contents:

- 1.0 Introduction
- 2.0 What is Chain Drain?
- 3.0 Can Technology Fix Chain Drain?
- 4.0 Scenarios: Four Futures of the Built Environment Sector
 - Play
 - Fast Forward
 - Eject
 - Pause
- 5.0 Unchaining the Built Environment
 - Future Competitive Dynamics
 - Future Talent Needs
 - Learning Mechanisms Across the Sector
- 6.0 The Case for a Radically Better Built Environment
- 7.0 A Tug of War for the AECO Sector
 - Past: Barriers to Reinvestment
 - Present: Technological Transformations
 - Future: How the Built Environment Serves Society
- 8.0 End Notes
- 9.0 Contributors and Acknowledgement

Cite as: Boyer, B. and Lindsay, G. (2026) Chain Drain: Why the Built Environment Struggles to Learn and How to Fix It. v1.0. White Paper. University of Michigan. <https://doi.org/10.7302/dspace/30234>

Final content, pre-layout version. Pagination and formatting subject to change.

1.0 - Introduction

The sector charged with creating and stewarding the built environment – planning, architecture, engineering, construction, operations, and real estate, or AECO collectively – is caught in a decades-long productivity crisis that has diminished its ability to build. One could argue this decline is the sector’s own responsibility, but because the built environment is critical to so many societal needs – ranging from housing and health to environmental quality and quality-of-life in general – it’s incumbent to correct its trajectory as these issues continue to increase in importance.

Meeting this challenge requires fixing an inherent flaw in the industry. The AECO sector’s outputs – physical places such as buildings, public spaces, and urban infrastructure – are separated from its outcomes. A static structure is capex; its life is opex. One you can buy, the other can only be managed. One has a completion date, the other is ongoing. One is necessary but not sufficient, the other sufficient but too often treated as unnecessary. There are sustainable buildings and healthy places, of course, but they’re all-too-often the purview of high-agency individuals and institutions rather than the default setting for American urbanism.

The most effective way to connect these outputs and outcomes into a virtuous cycle of learning-and-improvement is to address a boogeyman so fundamental to the sector that it’s easy to overlook. The supply chain producing physical spaces in the US structurally enforces a degree of discoordination between actors and a disconnection between outputs and outcomes. The former leaks efficiency and the latter effectiveness. We’ve dubbed this *chain drain*, because of the way that it mimics “brain drain.” In that case, talent educated and cultivated in one place decamps to another, degrading the prospects of the location they left behind. Translated to chain drain, intelligence created within the context of each project inevitably leaks away, failing to produce residual lessons and value for the firms left behind.

Chain drain is underappreciated as the cause of the industry’s productivity crisis, as prior explanations have tended to focus on inefficiencies in individual fields or offloaded responsibility to the political- and regulatory context the sector works within. While these factors are real, chain drain explains why there are limits to optimization within any given link, and why uneven technology adoption has not led to increased productivity and downstream benefits such as cheaper or faster design and development.

To better understand all of the issues in play – and the dynamics of chain drain in particular – we interviewed dozens of practitioners across the sector, with roles ranging from architects and engineers at firms such as SHoP, HOK, Sasaki, Thornton Tomasetti, VHB, and MASS, to developers and asset owners at the Related Companies and the Durst Organization, to modular and industrialized-construction leaders at Assembly OSM, MOD X, and the American Housing Corporation, to technologists and platform builders at Hypar, Zero RFI, and Cedar. We also spoke with venture capitalists at Camber Creek and Suffolk Technologies, with leaders of certification bodies such as Fitwel and Living Future, and with academics at Yale, Northeastern, and Toronto Metropolitan University.

While it’s impossible to represent the whole sector with any sense of completeness, our goal was to triangulate across positions that often sit at the same table but rarely occupy the same theoretical framework – a structural engineer and a venture capitalist, the modular housing founder and the city planner, the architect principal and the CTO vibe-coding new tools, or all of them in one boisterous room. What we found was a panoply of domain experts reaching for new tech and business approaches to help them escape chain drain,

as well as a growing crop of well-meaning and opportunistic outsiders seeking to extract financial rewards by “fixing” what they perceive as a broken field.

Can the supposedly unstoppable force of new technologies and business models, coupled with mounting demands from clients, markets, governments and the public, budge a seemingly immovable industry beset with supply chain woes? Only if these dysfunctional dynamics are solved in parallel. To test where and how these various forcing functions might intersect, we construct four scenarios.

The first scenario, titled **PLAY**, describes the AECO industry doubling down on its present trajectory, only to discover it cannot retrench efficiently enough for new projects to pencil. This results in increasing pressure from asset owners and capital partners leading to even more cutthroat competition than exists today.

In **FAST FORWARD**, the industry harnesses AI and more prosaic digital technology to create an unbroken chain of shared value and data, transforming itself while retaining its structure.

In **EJECT**, the persistence of chain drain inspires new entrants to vertically integrate the functions they can and shun the ones they cannot. In this scenario, *projects* give way to *products* allowing for testing and iteration.

Finally, in **PAUSE** radical changes in climate governance, finance, and demographics awaken the public to the realization that the built environment is responsible for 37% of global CO2 emissions,¹ and thus equally culpable in climate change. *First, do not build...* becomes the oath of a new generation of practitioners who undertake a radical campaign of adaptive reuse on behalf of society.

FAST FORWARD is won by AECO firms who prioritize digital transformation to optimize collaboration. The startups that come out on top in EJECT embrace fierce competition and optimize their business model to beat traditional ways of working in AECO. In PAUSE, it's local and regional networks that come out on top, using shared values to enable widespread cooperation.

Which of the scenarios illustrates where you currently find yourself, and whichever represents where you want to be in the future — as a firm, practitioner, educator, or student — will dictate the choices and paths available. They also reveal missing or emerging roles in an industry transformed, ranging from construction data scientists to agentic workflow orchestrators to regenerative supply chain managers. Which part do *you* want to play?

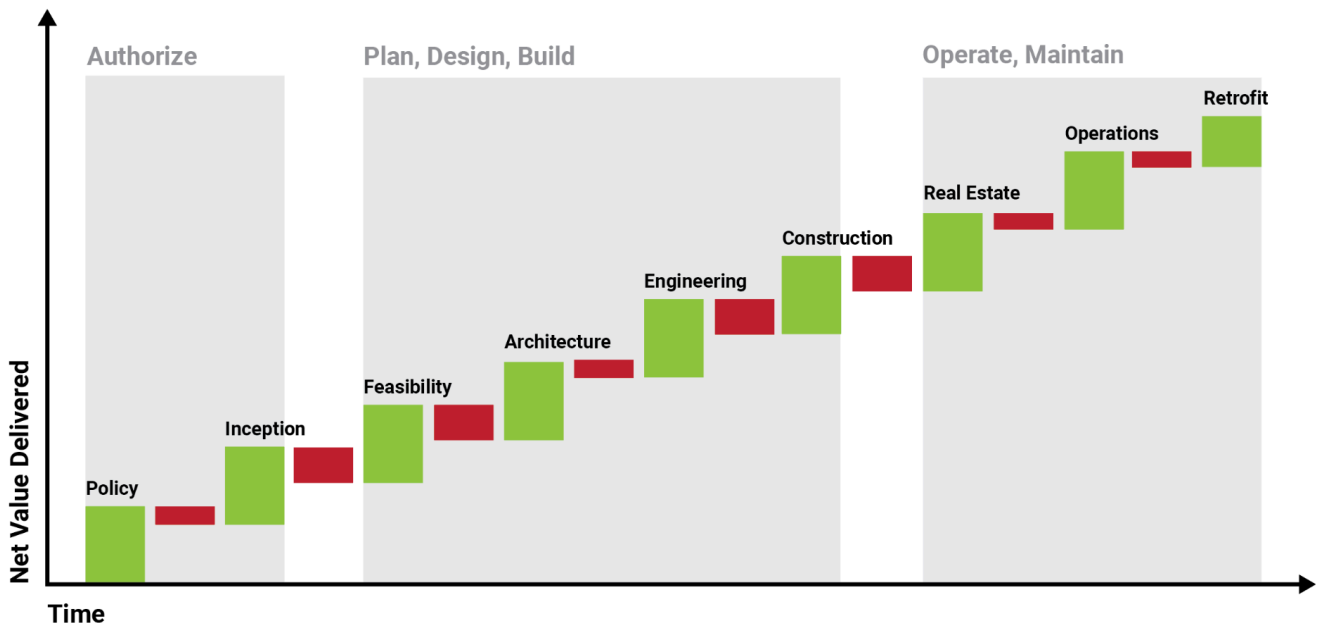
This paper is written for two audiences in particular. The first is current practitioners — the architect, engineer, developer, contractor, or public-sector planner who senses the ground shifting beneath their feet and desires a map of where it might be heading. The second is the next generation entering the field, and the educators preparing them. The University of Michigan, where this work is grounded, is one of many institutions grappling with what skills, literacies, and orientations the built environment will demand a decade from now. There is no one answer for either, but we hope to demonstrate that urgent innovation in *how* we create is now as important as the longstanding tradition of innovation in *what* we create.

2.0 - What is Chain Drain?

Chain drain is the cumulative loss of value and intelligence across the industry's horizontally organized delivery model, resulting from discoordination and disconnection. Both issues inhibit the sector from building more quickly, cheaply, and effectively. One way or another, chain drain affects every participant, but is the ultimate responsibility of none.

The delivery model of the built environment involves a wide variety of actors – consultants, vendors, asset owners, financiers, government entities – coming together in the context of a project. This creates a horizontal supply chain marked by a series of handoffs from one party to the next as the project moves toward completion. In the diagram below showing a typical project by way of example, the work of each actor is represented by a green bar showing some quantum of value created, while the handoffs are represented as red. The sum is a “two steps forward one step back” kind of rhythm.

Figure 1. The Supply Chain of the Built Environment



Intent:	Project Purpose	>	Design Intent	>	Means & Methods	>	Performance Intent
Requirements:	Program & Needs	>	Plans & Specifications	>	Submittals	>	User needs
Resources:	Financing	>	Fee	>	Construction Cost	>	Operating Expenses
Regulation:	Zoning	>	Codes	>	Inspections	>	Compliance

This chain extends well beyond the job site. Developers write the brief and secure the financing. Lenders and equity investors sign off according to their own criteria. Local officials issue permits and inspections. And occupiers typically demand custom fit-outs tailored to their end users. Upstream of this sits feasibility studies, site selection, entitlement, and so on.

Historically, this horizontal model was a feature, not a bug. “Design-bid-build” allowed each segment to specialize, compete on price, and (theoretically) drive down owners’ and users’ costs over time. In practice, it has produced something closer to the opposite. Each participant rationally pursues their own ends, making the supply chain’s overall performance difficult to ascertain, let alone improve. In the blunt framing of Yale School

of Architecture deputy dean Philip Bernstein, “the building industry is sub-optimized to the point of failure.” Misaligned incentives and a lack of overall accountability have left enormous costs embedded between every link. Projects are built, everyone gets paid, and individual firms do their best to learn new methods, but the chain itself “learns” at the glacial pace of zoning ordinance and building code updates.

2.1 Discoordination

Cumulatively, the red “steps backward” in the diagram above represent the cost of discoordination that comes as a result of each actor maintaining their own independence. All along the chain, well-intentioned actors operate in their respective silos, diligently improving what sits within the scope they control and can see the results of – better and faster drawings by a designer or more efficient sales by a broker. Business scholar Peter Senge identifies this as the “learning horizon” within which an organization can readily experience the results of their actions, and beyond which they have no easy way to learn or drive self improvement from those experiences. It’s common (and forgivable) for each link to reassert themselves at each transition, by virtue of the fact they are applying a unique perspective and expertise onto the chain’s shared challenge.

For example, an architecture firm may execute the client’s brief, but in doing so inflects the project with its own interpretation, seeking to add value by bringing a design vision that adds new layers of requirements. At the handoff to engineers, the structural and MEP teams reinterpret the architect’s drawings, bringing literal and metaphorical gravity to the discussion as a project moves through design development. The contractor receives the final set of construction documents and, trusting in its own hard-won expertise, makes last-minute changes of means and methods according to ground truth. Each reinterpretation manifests downstream as coordination- or interface costs in the best-case scenarios, along with redesigns, requests for information (RFIs), change orders, schedule slippage, and increased contingency costs in less rosy ones. In some cases, interface costs are pure wasted effort, such as an asset owner wading through voluminous and conflicting zoning rules to determine if a project can be built or not.

Taken together, these costs are staggering. According to 2018 research by Autodesk and FMI, construction professionals spend a third of their time – more than 14 hours a week – on non-productive activities such as looking for project data, resolving conflicts, and reworking mistakes, totalling \$177 billion in wasted productivity annually. The biggest time-suck, according to survey participants? “Poor communication among project stakeholders,” i.e. chain drain.² RFIs, the construction industry’s built-in triage against chain drain, are a costly fix. Navigant Construction Forum found 9.9 RFIs for every \$1 million of construction value, meaning a \$100 million project will routinely generate more than a thousand RFIs. The bigger the project, the more chain there is to drain.

Procurement tells a similar story. As specifications pass through the chain, building systems may accumulate 30–40% in stacked markups as each link claws back margin. Clients eat the overage, while manufacturers hear only distant echoes of actual demand. The chain leaks value downstream and information upstream, and that loss of signal, more than any single line item, is chain drain in its purest form.

Which isn’t to say the chain has done nothing to address this. Popular methods such as design-build and integrated project delivery (IPD) are deliberate attempts to tighten the chain by compressing multiple links at the outset until they overlap, which accelerates decision-making while reducing drain. One widely cited study claims design-build delivers projects twice as fast, at slightly lower cost, and with equal quality compared to

traditional design-bid-build.³ While these and other methods have certainly made progress in tackling discoordination, they haven't succeeded — and cannot solve disconnection.

2.2 Disconnection

The other set of gaps the chain drain diagram depicts are the gaps between phases in gray. These gray highlights represent Authorization, which is the realm of policy, comprehensive plans, zoning, codes, incentives, and other regulatory mechanisms shaping built projects at a remove. Next is Plan, Design, Build which is the work of the “AEC,” followed by Operate & Maintain which is the “O” in AECO. The gaps between these phases are where mismatches between output and outcomes emerge due to missing or anemic feedback mechanisms.

The connection between Authorization and Plan, Design, Build is the domain of urban planning scholars who study things such as the relationship between housing policy and housing markets or between transportation policy and the accessibility of daily needs in a given geography. This scholarship applies the tools of social science to the built environment to build stable knowledge. It generally relies on publicly available data such that the scholarship can happen without requiring special agreements.

By contrast, the link between Plan, Design, Build and Operate & Maintain is structurally weak and academically marginal. Architects rarely have a contractual right to inspect their buildings or once they are in use, nor do they have much incentive to do so at their own cost.⁴ Academic building performance research exists in pockets — notably Berkeley's Center for Built Environment and Carnegie Mellon's Building Performance and Diagnostics degree — but it is not considered core to the profession of architecture in the US. Post occupancy evaluation (POE) enjoyed a moment of popularity in the mid-20th century, but as a standalone service has struggled commercially.

Today, such analysis of whether the output of the Plan, Design, Build phase enables desired outcomes most often occurs when a new design team is called in to fix the underperforming work of a previous designer. The Danish firm Gehl has built an entire line of business around the disconnection between the Plan, Design, Build and Operate & Maintain phases.⁵ Initiatives to address disconnection in the chain do exist. Notably, the UK's Government Soft Landings mandate⁶ aims to smooth the transition from construction into operations for public buildings, and certification schemes such as WELL and BREEAM In-Use require performance monitoring to achieve their seals of approval.

The commonality of these corrective efforts is why our diagram includes “retrofit” as the final step in delivering value from a place. It's not the designers' fault these places need it so often! On the contrary, it's typically the result of disconnections within the chain depriving them of a feedback loop between design intent and actual outcomes. Questions such as, “Did the open floor plan actually lead to an uptick in innovation?” or “Did the skip-stop staircase improve residents' health?” are rarely-if-ever answered empirically. Firms undertaking POE studies do so at their own expense, making them an outlier.⁷ In infrastructure, Design-Build-Operate-Maintain contracts are a mechanism to align incentives across the entire lifecycle, but for other asset types this responsibility usually falls to the landlord — with decidedly mixed results.

Because of this disconnection, each new project begins from approximately where the last one began, with marginal improvements by individual practitioners and their firms. Whose job is it to close that loop? The natural candidate is the owner — the only participant with standing across the entire chain — who is present at

both the beginning and the end. In fact, they're poorly cast to play the part. To quote a commercial real estate executive who is unsparing in their assessment of what owners care about: "It's extremely financial." In other words, they wish to convert projects into feasible, financeable, finished assets as fast as possible, because any delay risks capital markets going sideways in the meantime. The irony of chain drain is that it produces owners who desperately desire speed and certainty from their suppliers, both of which are rare under current conditions.

3.0 Can Technology Fix the Chain?

Whereas productivity has increased in manufacturing by something on the order of 700% since the 1950s and increased about 200% in the overall economy, construction's productivity is flat over the same period.⁸ Digital tools such as computer aided drafting (CAD), building information modeling (BIM), and a proliferation of cloud-based services have accelerated a broken industry rather than fixing it. Efficiency gains that might have been reinvested or led to higher margins were instead frittered away either as lower fees in commodity work, or as rising complexity in signature projects — typically in the form of parametric façades and complex geometry. Younger practitioners bore the brunt of both burdens as firms took on more projects to offset reduced rates while pushing staff harder to compensate. If anything, digitalization risks making chain drain even worse.

"If we don't fix this, you will spend more money on digital investments than you would have with conventional approaches," warns Ivan Rupnik, co-founder of MOD X, an advisory firm devoted to spreading the gospel of industrially-manufactured housing. Because interface costs aren't additive, but *multiplicative*. Every phase boundary not only generates re-documentation, reviews, and knowledge transfers, but new inspections woven in. Frictionless digital communication compounds the problem, as more messages, alerts, and back-and-forth consume cognitive bandwidth, creating new opportunities for errors and miscommunication.⁹

These examples are focused on buildings, but the logic applies to the sector's output as a whole. So-called "proptech" is a category of startups seeking to modernize real estate and property operations using digital technologies, while "contech" is the same applied to construction. Investments in the former ramped up around 2014 and the latter around 2016,¹⁰ but the combination of tech and the built environment is still easier said than done. Katerra blew \$2 billion on this thesis with nothing to show for it. WeWork, once valued at \$47 billion, actually built its own internal supply chain to fit out office spaces but collapsed under financial mismanagement and became a punchline. Despite their best efforts, neither could survive the financial pressures of building a microcosm of the industry on a single balance sheet.

And yet there remains widespread interest in vertical integration and digital workflows alike. A study from 2024 analyzed nearly 4,000 papers to determine which AEC technologies received the most attention from academia. The top four were BIM, augmented and virtual Reality, prefabricated construction, and 3d printing. The first two speed up the chain, while the last two promise to shorten it. If so many participants want these twin revolutions to happen, why are they still so slow in coming?

Ultimately, each link's obligations to the others constrain its individual ability to innovate, as backward compatibility with the rest of the chain acts as a brake on optimization. Until the chain stops hemorrhaging value, individual productivity gains will keep failing to compound at the sector level. The implications of this cut against the prevailing narrative of proptech or contech investments. Solving the industry's inertia isn't merely a matter of making slow firms move faster through workflow- and process improvements; it also requires a leaky supply chain to become tighter and a case for what will drive adoption to overcome the built-in inertia of the chain, which we describe more thoroughly in the appendix section, Weight of the Past (see page 32).

Casey Berman, a founder and managing partner at the proptech VC firm Camber Creek, describes how the recent advances in AI are showing one path forward to a "third phase" of digital transformation in the built environment:

Phase zero is the paper phase where everything sits in a folder on your desk. Then there was the Excel spreadsheet phase — BlackBerries and spreadsheets... that's how real estate was run. The next phase started when the iPad and iPhone launched and created a massive increase in efficiency for the boots on the ground. This technology was incredibly siloed but way better than a spreadsheet. Phase three, which we're in now, takes all of these vertical software solutions and puts an AI layer on top, tapping into each even if they weren't designed to work with each other.

What's different this time, in Berman's telling, is the ability to use AI large language models (LLMs) to ingest and interpret data dynamically across a heterogeneous landscape of individually-siloed tools while understanding the larger context. Whereas the BIM demanded that it eclipse all other tools in the name of linking the chain, LLMs promise to make it possible to integrate disparate applications and data sources across the chain in a more dextrous manner. Then again, similar claims were made by every previous generation of software.

4.0 - Scenarios: Four Futures of the Built Environment Sector

Building on our chain drain thesis, we surveyed current innovation in the sector by examining companies in the variously-named proptech, contech, and AECtech space, totaling some 11,000 receiving over \$160 billion in investment since 2006¹¹. We then conducted a closer analysis of 150 companies, discovering a wide variety of business propositions ranging from new building materials and products to tools for automating government reviews, upstarts struggling to disrupt hegemonic software packages, and products offering to replace AECO consulting services with a user-friendly app.

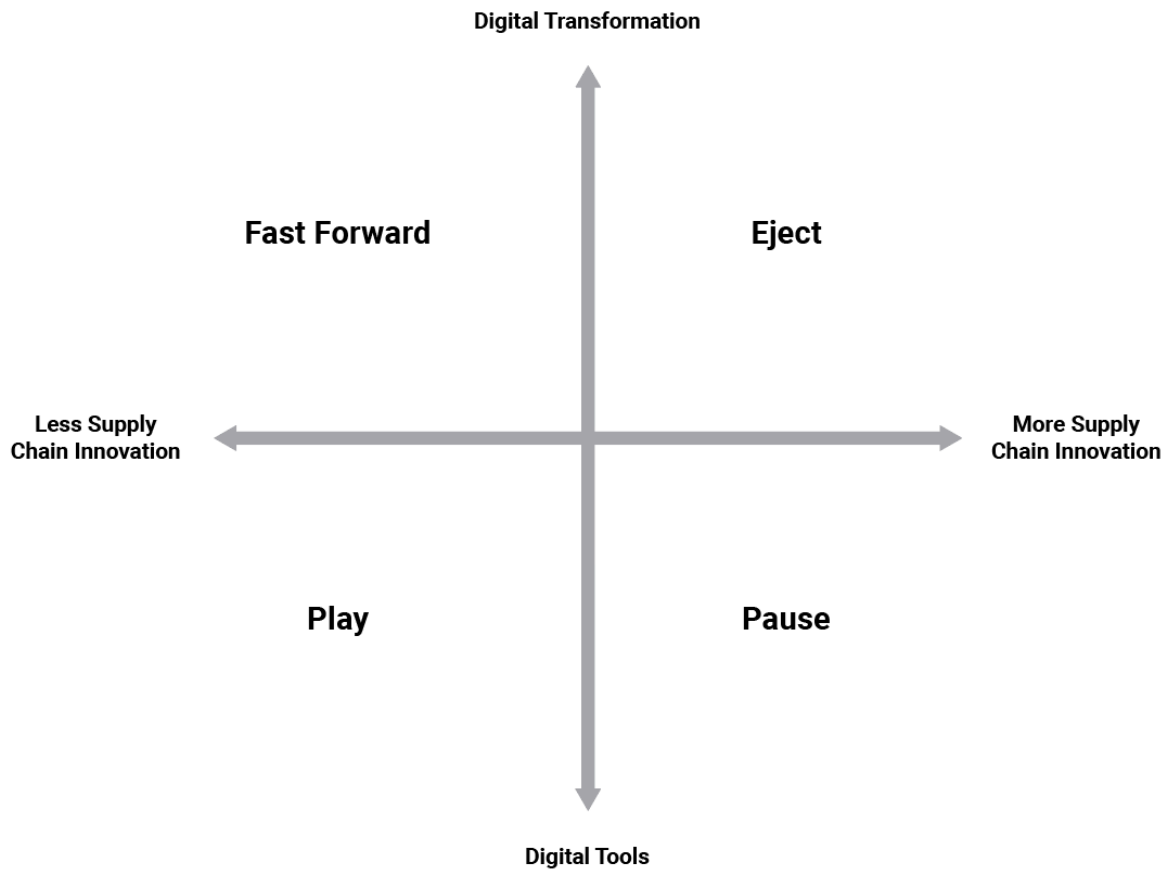
Next, we used a foresight methodology named the “futures triangle” to pit three sets of forces pushing and pulling on the AECO sector: the business dynamics of the status quo within the built environment (see Weight of the Past, page 32); widespread efforts to digitize and integrate work within the sector (see Push of the Present, page 35); and the emerging definitions of quality asked of the sector to achieve meaningful social, health, and environmental outcomes *in addition to* being more predictable, affordable, and timely (see Pull of the Future, page 38).

From these variously competing-and-complimentary forces, we created four scenarios for the future of the built environment sector as it attempts to manage, mitigate, or escape chain drain. Each exists within a matrix of two factors. One determinant is how readily firms adopt digital tools and workflows to accelerate their own decision-making and (potentially) create the end-to-end accountability their clients will soon demand. At the bottom of the matrix, new tools are simply applied to existing firms, teams, and workflows, while placement nearer the top indicates how holistic adoption has unlocked deeper transformation in the form of new business practices, team structures, and talent composition.

The other determinant is scope, which captures how much of the chain firms are willing to reorganize or internalize in hopes of solving chain drain. The far left of the matrix assumes business-as-usual within the AECO sector, while the far right represents business models that span multiple phases of the delivery process – in this pursuit, many have diversified away from client services via product-based offerings better suited to continuous improvement using the data that is spun off from digital tooling. Plotting these axes against each other, four quadrants appear. We call them **Play**, **Fast Forward**, **Eject**, and **Pause**, named for the buttons on a VCR controlling the timeline.

Play is the present running at normal speed, and for this reason it is a story of retrenchment cast as a less happier ending than the others. **Fast Forward** keeps the horizontal structure of the industry, but uses technology to tighten the chain, producing better collaboration and better outcomes. **Eject** rejects projects in favor of products, escaping the silos of business-as-usual, and encouraging competition that puts the end-user in the driver’s seat. Finally, **Pause** disavows the industry’s obsession with physical growth in favor of rethinking existing structures and reusing existing materials, relying on cooperative networks to build values in place of building for value. Each of the three scenarios take a different path toward a built environment that is healthier, more sustainable, and ultimately more responsive to the needs of society.

Figure 2. Four Scenarios for the Future of the AECO Sector



4.1 - Play

Incumbents ignore the “leaky linkages” of the supply chain and use digital technology without letting it substantially transform their business practices

The renderings had stunned the world, but the rumors surprised no one. By 2031, New Dubai was rising from savannah leased from Tanzania’s government — a back-up metropolis for a half-million native Emiratis fleeing the Gulf’s lethal wet-bulb summers and errant drone strikes. MEGABUILD CO had won the contract four years earlier on the promise of one-stop shopping. After swallowing a global management consultancy, it could not only deliver a master plan, but also the new city’s governance frameworks, public services, and utilities under a single agreement — which effectively made it the project’s largest investor. That hadn’t prevented the firm from falling years behind schedule, according to leaks by disgruntled contractors. Just as McDonnell Douglas’ bean counters once hollowed out Boeing from within, the new acquisition had immediately set to work outsourcing, offshoring, and arbitraging every link in the chain. Leadership quietly traded coordination for margin, and the MEP conflicts compounding across its drawings were proof that there are limits to efficiency.

Play is the future in which the industry’s present trends continue. It’s less a trajectory than a holding pattern, as neither the push of the present nor the pull of the future are strong enough to budge the past. Chain drain isn’t solved so much as managed through vertical integration, complementary acquisitions, and sweating the assets — anything to avoid the sector transforming itself. Money keeps pouring in while buildings trickle out. Productivity languishes while the talent agitates for better outcomes and conditions — providing management with a pretext for the next round of cuts.

The winners in this scenario are those best at maintaining relationships with asset owners, their partners, and lenders — whether as a *feted* boutique practice or a chain-spanning acronym firm. Trust is paramount, because demonstrating performance beyond total square footage delivered, press coverage, and timely completion remains costly, if not completely elusive.

Chain drain becomes a competitive moat for the fewer-and-fewer — and larger-and-larger — firms able to absorb the pain while holding onto a slice of the pie. The sector’s resolve to deliver on its promises of decarbonization withers in the face of clients’ apathy and even well-meaning clients lower their ambitions as the matter battle plays out.¹² Despite a mounting sense of stagnation, the spoils continue accruing to savvy firms with the right combination of scale, capabilities, and defensible niches, along with a lucky few acting more like luxury brands than professional services.

BUSINESS DYNAMICS

Firms in the Play scenario operate in the upper arm of the [K-shaped economy](#), pursuing a handful of free-spending clients. In practice, this means private wealth, government, and institutions straddling the two. Universities and hospital systems relentlessly expand their footprints; mega-cap owner-occupiers such as Apple and JPMorgan Chase erect monuments to themselves, and private equity funds led by Blackstone quietly complete the financialization of housing. Behind them all are governments as both clients and arbiters, ranging from municipalities working hand-in-hand with philanthropy to realize prestigious public spaces, to the sovereign wealth funds

underwriting nation-scale reconstruction at the behest of their royal patrons. Business seeks opportunity in jurisdictions that can move quickly, and that primarily means overseas markets.

Capture, in other words, is the name of the game. Play's winners specialize in courting difficult-to-win clients. Some flex their hard-won expertise in responding to the complex RFPs of mega- and even giga-projects such as airports and entire city-states. Others retreat into specialties such as healthcare, education, and infrastructure, where the weight of the past makes it even harder to dislodge them.

Industry consolidation has less to do with internalizing chain drain than rationalizing operating costs using tried-and-true playbooks for juicing margins. This commonly takes the form of financial and labor arbitrage, relying less on automation and digital transformation than passing drawings from Global North offices to Global South offshoring hubs — with the attendant increase in chain drain.

TECHNOLOGY

Play firms aren't tech averse, per se — they'll eagerly grasp the latest model or agentic plug-in if it helps them meet deadlines. What they won't do is transform. New tools only accelerate existing workflows, yielding more of everything — options, drawings, billable hours... and chain drain. Winning firms translate their fleeting productivity gains into ever lower fees, betting they can absorb the loss of margin better than competitors.

Occasional forays into building or buying genuinely new capabilities are typically foiled by internal squabbling and a chastening hit to the share price. Beneath their caution lies the conviction that an analog moat is the most defensible one, in the vein of the starchitect whose quasi-mysterious process (and charisma) is the product. Technology is something you buy or use — never something you become.

TALENT

The most sought after talent comes with strong relational capital. The careers that flourish belong to rainmakers and typology sages such as the partner with a thirty-year client relationship, or the planner who carries the intricacies of local zoning in their head, because trusted-advisor networking is the one asset no technology can disrupt and no rival can underbid.

Everyone else faces the squeeze: constant pressure to adopt flat or falling fees; serial layoffs; and a rising tide of unionization as associates realize loyalty flows in only one direction. Individuals able to make sense of the panoply of digital tools being pitched to Play firms will have an advantage in assisting leadership make wise investments with limited resources. Likewise, a small premium will persist for those investing in certifications enabling them to meet low-hanging demands from the pull of the future, such as LEED or SITES certification.

POLICY

Firms insulate themselves against competition from outside the sector through regulation, using licensure regimes to require AI-generated engineering drawings be reviewed by humans, for example – or by outlawing them altogether.

By leaning into chain drain rather than trying to fix it, the sector ensures its nasty case of Baumol's cost disease only worsens.¹³ Jurisdictions attempt to solve productivity single-handedly through increasingly permissive policies. Firms able to track and react to these policy changes quickly will have an advantage. This is already visible in the successful firms' use of thought leadership to explore (and exploit) possibilities such as office-to-residential conversations. Such work highlights their upstream thinking as they build or acquire in-house strategy teams.

4.2 - Fast Forward

Highly coordinated networks of firms embrace digital technology. They share learning and efficiencies, and translate it into improved outcomes for clients and society.

The groundbreaking featured a poker-faced mayor and grinning president sharing a gold-plated shovel over a trench in Queens. Only a few years later, America's largest affordable housing project in a generation was well underway at Sunnyside Yards, courtesy of a three-way compact binding the city, the White House, and a consortium of developers who had tackled similar sites. The latter had won on their promise to deliver 12,000 mixed-income units on time and under budget, while proving each met the emissions- and health targets written into the contract. Assembling their partners at the outset, they promised their patented "aggressive" design-build would be the easy part – proving how well it worked to the powers-that-be was a different matter altogether...

Where Play pointedly ignores chain drain, Fast Forward attacks it head-on while keeping the horizontal structure of the industry intact. Firms transform their own workflows at first, using AI and other tools as strategic forcing functions, then turn to squeezing the costs between links through shared data and common platforms. *Find the leak at every handoff, their thinking goes, instrument it, and seal it.* A simultaneous top-down and bottom-up embrace of digital collaboration – with a corresponding change in business models to match – takes hold as the traceability of every decision improves like commits piling up in a GitHub repository.

The winners here are first movers, particularly as digital-native firms. It exerts the strongest pull of these scenarios, as the place where Play firms land if they truly commit to transformation, and where Eject's refugees crash when they run out of runway. Fast Forward tightens the chain without questioning its motives, and reassigns accountability and agency in ways participants may not have intended.

That's because the scenario's real protagonists are super-empowered clients and their representatives able to bend the chain toward their will. Having solved disconnection through their own efforts, they now demand coordination – using standards and regulations as contractual sticks, paired with the carrots of better outcomes. Rather than Boeing or Toyota, Fast Forward's saviors more closely resemble Walmart – which delivered its own supply chain an unprecedented scale of operations in exchange for nearly unbearable demands.

BUSINESS DYNAMICS

Business leaders in Fast Forward bet that speed kills. They embrace technology and change in hopes of building a sustainable competitive advantage against their closest competitors, gambling whoever stops chain drain first, wins. Early adopters tend to build their own tools quietly on the backs of projects, or else lash partners to common technology stacks that quickly evolve into cross-chain alliances.

From there, the chain begins tightening from both ends at once. At one end, owners combine design-build and similar methods with new platforms to compress as many

links at the outset as possible. At the opposite end, agentic operations fuels an unprecedented wave of centralization and consolidation producing asset owners big enough to single-handedly solve disconnection and begin dictating how and what gets built. In between are thriving firms such as Suffolk Construction, which uses its job sites as proving grounds for its venture arm's portfolio, folding the successes into its own workflows.

And once the chain is drawn tight? That's where the real fun begins, as super-empowered owners demand concessions that were formerly someone's margins, while coalitions of the willing bid for a share of projects' total value, distributing the proceeds amongst themselves. Squeeze the chain before the chain suffocates you.

TECHNOLOGY

Some firms start by building their own tools — Sasaki's Dashi, Thornton Tomasetti's CORE studio — to wring speed and efficiency out of the links they already own. As their usage of analytics and simulation increases, the chain becomes hungry for evidence-based practices connecting design intent to actual outcomes, kicking off a flywheel of continuous improvement. This drives a tightening of the chain, driven by AI and a new layer of machine-machine communications that finally brings the sector up to speed with cloud-based tools prevalent in manufacturing and other domains decades ago.

Unlike BIM, in which all links in the chain would have needed to adopt it to maximize value, AI excels at stitching together disparate software and data management practices, enabling the digital transformation of *Fast Forward* to happen organically, with more agency at the level of individual firms while still adding up to a net reduction on drain across the chain.

TALENT

Talent is digital-native and data-fluent. Firms restructure their hiring, training, and org charts to maximize their potential for transformation. As the importance of the lone genius fades, the sector is finally able to make good on its vow that collaboration is everything. Project teams focus on a shared readiness for adaptation, selecting for members aligned on their willingness to confront and tackle disruption. Digital product development groups pop up in design and real estate firms, and even policy-oriented think tanks lean on bespoke digital tooling to be the change they want to see in the world. Digital transformation also brings new challenges as data management and technical support shift from IT support functions to critical infrastructure needed to sustain the slight advantage of any single firm. Just as every company grew an IT function in the 1990s, every firm will grow a product function in the 2020s. Among the new issues they will contend with is the technical debt accrued from maintaining self-built tools. The only question is whether Claude can handle that part too.

POLICY

Fast Forward might happen within the regulatory status quo, but it achieves its full potential if-and-when governments and asset owners operationalize their intentions through contractual and compliance obligations. This doesn't fortify incumbents against competition, as it does in Play. Rather, it shines a spotlight on gaps between

links in the chain. This, in turn, manufactures the demand for exactly the kind of data-sharing and evidence-based practices Fast Forward's technology stack exists to enable. Regulatory complexity across myriad jurisdictions results in AI-powered attempts to abstract that fragmentation into scalable products. It's a rational (and semi-successful) response to the problem, but even massive compute cannot fully paper over a whole country's worth of different practices and priorities.

4.3 - Eject

Businesses reinvent the supply chain by pursuing vertical integration and eliminating links in the supply chain altogether

Loyalty started with the lease. A brand best known for churning rent into rewards had quietly become a homebuilder, having acquired one of many modular startups out of bankruptcy. Backed by private equity, it began mass-producing master-planned communities in 2033. It didn't sell homes, but peace of mind. Festooned with sensors, hardened against wildfires, and packaged as part of an annual membership, the house wasn't the product — the points program was. Everything else — the fireproofing, maintenance, and token budgets — were fixed costs carried by the company itself, which treated them as a necessary evil underwritten and amortized across a portfolio it intended to own for decades. Welcome to home-as-a-service.

In Eject, firms are displaced by startups. These entities walk away from the client-services model on which the sector is built, eschewing one-off projects in favor of products. Where Fast Forward keeps the horizontal chain and tightens it, Eject is characterized by firms internalizing as much of the chain as they can sustainably own. Absorb a handful of links and you can specify, produce, and inspect under one roof, iterating the way a manufacturer does rather than relitigating every handoff with a partner that has already moved on. The reference model is the business-to-consumer platforms of the 2010s — Uber, Airbnb, productized and networked — pointed at the built environment.

The winners in Eject are those who identify a niche they can own, apply disciplined specialization to win that niche, and use the internalized links in the chain to collect learnings that enable continuous improvement of the product. American Housing Corporation builds only on land it controls, for example, touching nothing that isn't already entitled. Not every escapee is consumer-facing, however. Some are selling the escape route to peers in the chain. Austin-based startup Cedar has productized the design feasibility process, while Hypar offers a CAD alternative collapsing design intent and technical specifications into one set of modules that can be endlessly recombined. These are the B2B SaaS equivalent of supplying picks-and-shovels to chain gangs, all while quietly harvesting usage data to make their products even more sticky.

The potential win in this scenario is huge: crack productization and you escape chain drain outright, replacing leaky handoffs and interface costs ingrained in the project model with a learning flywheel in the form of product development and deployment. But the escape is conditional, and that condition is capital. Capex to build factories, working capital to fulfill orders, and patient capital waiting out or lobbying for regulatory change to reduce the friction of approvals for what is inevitably a novel product delivered through a proprietary process.

As tantalizing as it is to eject from the issues of chain drain once and for all, this scenario is the highest risk-reward of the four. May the odds be ever in your favor.

BUSINESS DYNAMICS

This scenario is a bet against the chain itself, and carries a risk profile to match: high complexity; high reward; and a graveyard full of indispensable innovators. The Icarus here is Kattera, which went all-in and discovered the hard way you cannot re-engineer the entire chain with Softbank's backing alone. Choosing the subset of the chain that can be internalized while maintaining compatibility with the rest of the industry on either side is the hardest choice to make. What separates survivors in this scenario from punchlines is knowing which links to internalize and which to leave alone. Eject companies operate as black boxes taking in inputs (e.g. cash, users' needs) and spitting out usable products (e.g. homes or approved plans). For this reason, they will be hard-pressed by the markets and regulators to prove their products are cheaper, faster, more sustainable, or flat-out better than chain-based competitors.

TECHNOLOGY

Tech is represented by the data-driven feedback loop propelling product development and continuous improvement. Fast Forward needs a regulatory stick to force firms to measure outcomes; Eject requires no such compulsion, because any startup that puts its customer relationship within its learning horizon collects performance data by default. Every unit seeds the redesign of the next, passing intel back to its manufacturer. This is why these firms build their own tools rather than wait for the market to catch up — the optimization platform is the point, not an accessory to it. Even the narrowest plays fit this pattern, such as Gradient — a startup manufacturing heat pumps for New York City apartments — which has augmented its products with an insights-driven platform learning from every install. Productization is the engine; proprietary feedback loops are the fuel that make it go. In this scenario, understanding user needs and crafting products are what Ian Keough, founder of Hypar, calls the “wet work of software development,” and such work maintains value even if software engineering becomes fully automated.

TALENT

Among the new roles that Eject requires is the full-stack product manager, which does not exist in the project model and is generally foreign to the sector. These individuals will need to be literate across the entirety of the chain internalized by a firm in this scenario — from policy to design to financial feasibility implications. Teams here tend to be lean, often a fraction of their headcount in the equivalent project-based universe. They orchestrate fleets of AI agents rather than armies of staff. This is the scenario that most thoroughly scrambles the inherited professional boundaries. A career path into Eject risks — or promises?! — being a one-way trip.

POLICY

At its most ambitious, Eject is enabled by thoughtful efforts to smooth out bumps in policy and regulatory efforts, such as making off-site inspections of modular construction viable at scale. When including physical construction, these businesses have capital needs exacerbated by the first customer problem, which presents an opportunity for local jurisdictions to combine economic development incentives with building code and zoning ordinance approvals to produce special construction zones enabling them. Proponents of red-tape lightened “pink zones,” a favorite tactic of the

lean urbanism community, have argued for much the same.¹⁴ One of the strongest opportunities for Eject isn't the private- but the public sector, with multiple firms vying to assist municipalities in modernizing their approvals processes, including Open Systems Lab's Plan X, Anori, and AutoSitu.

4.4 - Pause

Cooperative networks rewrite the rules of the economy to create a built environment that delivers on local values

Ann Arbor had stopped waiting for the market to solve its housing crisis and rewrote its own rules instead. The city put no money down and gave nothing away — it simply legalized building “missing middle” housing by right, clearing the way for homeowners to become homebuilders. Before long, empty-nesters began razing their five-bedroom homes in favor of six-plex apartments for themselves, their friends, and their adult children’s families. Their instrument was the “baugruppen” — collective building groups in which the occupants are also the clients. They answered to no developer or landlord, recruited their own architects, and hired their own contractors. Lumber came from within the state, thanks to years of punishing tariffs on Canadian imports and local ordinances targeting Scope 3 carbon emissions. Negotiating directly with lenders and insurers, they typically chose costlier high-performance materials in exchange for lower premiums. Whether you called it “up-zoning” or “downsizing,” the results spoke for themselves.

This scenario is heretical only because commercial builders refuse to state the obvious: America is overbuilt and under-demolished. Demography, depopulation, and serial climate disasters have left behind more square footage than residents can use or maintain, scattered unevenly across a country rapidly hollowing-out.¹⁵ Meanwhile, small metros still expecting to grow — like Ann Arbor — struggle to maintain their affordability and quality of life in the face of demand. In this future, the work of the built environment is no longer to build, but to protect, reinforce, and reuse what’s still standing through a more local- and circular approach to labor and resources, meeting local needs while aggressively protecting against long horizon climate risks.

Exemplars of Pause exist today. Lacaton & Vassal won the Pritzker Prize for a practice founded on the refusal to demolish. New York City’s MetroLoft has made its specialty office-to-residential conversions. Groups such as [Ouroboros](#) and [RotorDC](#) are pushing the limits of “deconstruction.” Finnish architecture firm NEMO turned a build-to-be-demolished into gallery and meeting space,¹⁶ while Pihlmann Architects in Copenhagen made a former factory into “a building that recycles itself” by renovating only with materials found onsite.¹⁷ In a way, they are all following in the footsteps of DEGW co-founder and POE pioneer Frank Duffy, who insisted the sector’s mission wasn’t to mindlessly build, but to evaluate, rationalize, and repurpose the built world by paying close attention to its variably-changing speeds.

The win, when it comes, is huge — although not what anyone in the Play or Fast-Forward scenarios would have ever expected. Net-zero compliance. Hyper-local resilience. Communal forms of living long-mooted but rarely built — including co-housing and community land trusts — offer an escape hatch from financialization while paying dividends through intergenerational families and reduced loneliness. While Pause may strike some as utopian, it’s the only scenario taking climate change seriously. It’s what happens when the embodied costs of carbon no longer pencil out. The winners in Pause are the ones who see this as an opportunity rather than wishful thinking.

BUSINESS DYNAMICS

Successful practitioners speak directly to communities and local governments, making the case for building less or not at all to decision-makers, their constituents, and asset owners who see a horizon beyond the market's typical 5-7 years. The pitch is measuring value in terms of use rather than prices — as occupancy and health, durability and adaptability (née resilience), and the social and economic vitality of a place. Pause may require more than a bit of Eject's entrepreneurial ingenuity to create financial mechanisms that channel public subsidies and programs toward community benefit. For this reason, Pause is also likely to involve non-traditional commercial actors in the capital stack, such as philanthropic capital or family offices who are comfortable making mission-driven investments. Where Play sells relationships and Eject sells products, Pause sells stewardship. That reorientation is everything. The skill is no longer extracting the most value from an asset, but demonstrating maximum value to the people using it. "Value" in this context is pluralistic: financial, social/civic, environmental, and cultural.

TECHNOLOGY

Technology in Pause isn't absent, but it's entirely in the background as an enabling factor. Computer vision models may win as the default way to analyze existing building stock and determine how best to reuse the material corpus, but human experts with accrued experience (including retirees) may prove to be equally capable, not to mention more able to navigate the long tail of edge cases that are a defining feature of the built environment. Though it's basic, multiplayer technologies like what Figma has done for visual asset creation or Google Docs has unlocked for written documents are likely to be a hallmark for this scenario's use of technology, which is more often by a community than a singular user. Rather than driving the creation of new tech, Pause is about stringing together LIDAR, LLMs, and other off the shelf technologies in new ways that are 100% in service to tight meshes of local relationships in collectives, collaboratives, and consortiums.

TALENT

The protagonist in Pause is the maintainer — a tinkerer and steward who starts from what's at hand and matches it to a vision through an iterative process of finding the right fit. Similar degrowth perspectives are popular among the avant garde of the AECO sector today, one example being Certain Measures' motto of "design with what you have" — which in their case means marrying machine vision and algorithmic design in the name of material recycling.¹⁸ To realize these types of projects, fluency is needed across domains that rarely meet in a single training: materials, to know what can be salvaged and what can be sourced locally; civics, to navigate community governance; and finance, to assemble novel capital stacks and model returns patient enough to pencil. And it's all changing at a clip, according to Juliette Morgan, former ESG consultancy director at Gensler: "Buildings are no longer allowed to be just an asset. They have to meet societal goals in a way that they didn't have to [previously].... Now the building's job is to fix the environmental crisis and improve social prosperity outcomes. Those are very different skill sets for people who were raised to design something with very clever engineering, at a given price, and to get rid of it in the market."

POLICY

The Pause scenario arrives under one of two conditions. One is dramatically tightened regulation, including comprehensive carbon caps, embodied-carbon accounting, and cradle-to-cradle deconstruction-and-diversion mandates. The other is economic blunt force trauma delivered through tariffs, severed supply chains, energy shocks, and climate disasters rendering the local and recycled cheaper than the new. The stick of policy enforcing a slower and more local approach can only be held at bay by a carrot of programs highlighting the potential of Pause-based approaches to create truly unique spaces in cities — the kind that may assist those needing all the help they can get in drawing people back together again.

5.0 Unchaining the Built Environment

The built environment has been shaped by chain drain down to the bedrock. It's codified by the sector itself in specifying a series of handoffs and their attendant interface costs. It's enshrined in the business model of client-services firms working on an hourly clock. It's run by the tick of complex regulatory frameworks and compliance regimes, and the tock of financial underwriting and investment decisions that have little room for error – and even less for experimentation.

Organizing our four scenarios around how they change the timeline of the AECO sector is not just a cute metaphor, but also a reminder that the sector's predominant business model and overall structure shape its destiny. Altering the status quo for the better of society requires migrating from today's **Play** scenario to something more like the **Fast Forward**, **Eject**, or **Pause** scenarios by overhauling business-as-usual. The professions of the AECO sector will continue to innovate, but there's an even larger opportunity to reimagine how they work together. New outcomes require new inputs.

Firms in the AECO sector deal with “the weight of the past,” which describes the accumulated barriers to scale making it challenging for individual firms within the sector to seriously invest in R&D or new ways of working (See page 32 for more depth). The geographic nature of regulatory fragmentation isn't firms' fault or even their responsibility, and yet it routinely compromises their ability to scale in a way that produces enough margin to invest seriously in changing how they work. Being an innovation practice with nearly every project representing some unique combination of geography, team, and needs is the nature of the game, and yet this level of complexity is rarely priced appropriately. Despite genuine appetite from firms and industry leaders to experiment with new policy, design, and delivery approaches, the decision-makers who need to say “Yes!” to these approaches rarely want to be the first customer of an untested methodology or approach.

Despite this sense of inertia, digital technology is transforming the sector by automating and productizing it, which we describe in more detail as the “push of the present” (see page 35). But beware of the word “digital.” What matters isn't code *per se*, but how digitalization enables new processes and their corresponding feedback loops. This includes usage data fed into digital twins and other simulations for improving the next generation of designs. It also includes vertically-integrated product teams able to collaborate and solve potential points of failure with the fluidity and speed of a tech company, skipping over the contractual and other inter-firm barriers that exist in a horizontally-linked supply chain. Whereas other sectors have constantly updated their priors and practices for decades, AECO is one of the last to reach this point. This might sound frightening, based on the prior disruptions of industries such as music, publishing, and software. On the other hand, how exciting is it that fifty years of declining productivity might finally be reversing?

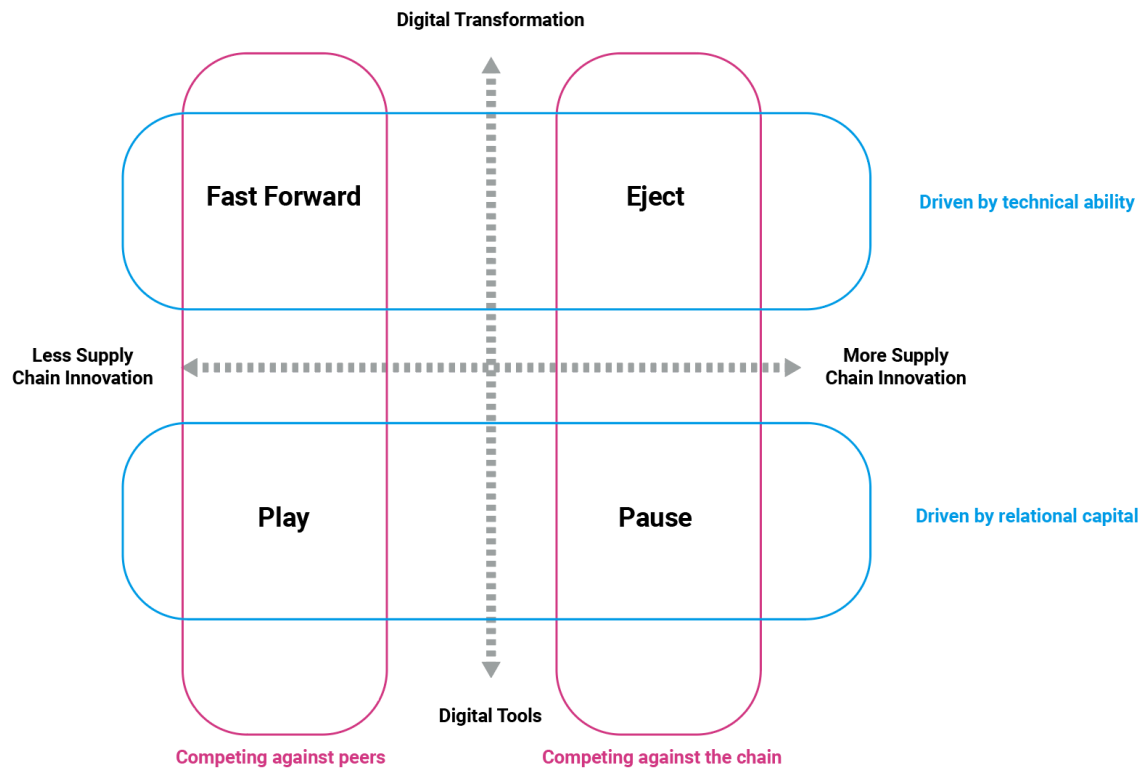
Lastly, for a field dominated by client-services firms, it's not surprising that the “pull of the future” (page 38) and its demands are the true source of leverage for overcoming the weight of the past, or lending just enough lift to the push of the present to overcome chain drain. We itemized these forces and developed our scenarios to provide a language with which to discuss the competing interests in the field.

Pursuant to being one of humanity's oldest pursuits, the making of dwellings, common spaces, and the built world at large persists in all of our scenarios. We expect the basic roles of financing, designing, coordinating, constructing, and maintaining the built environment will certainly continue. What's in question is not the

“disciplines” or intellectual lineage of these fields, nor the human need for shelter and cultural expression, but their professional boundaries and expectations — and what must change for them to collectively succeed.

Zooming out from the individual scenarios helps us identify strategies for firms and individuals looking to navigate the irreducible uncertainty of the present. To borrow from *The Leopard*, it may very well be the case that everything must change for things to stay the same.

Figure 3. Competitive and Talent Dynamics Within the Scenarios



5.1 Future Competitive Dynamics

From a competition standpoint, the two left quadrants describe business models where firms are primarily trying to best their peers within the sector, leading to increasingly fierce competition. This model can be seen in the marketing industry, where competitive dynamics fueled acquisitions (like our Play scenario) producing mega-firms such as Dentsu, while corresponding investments in quantitative and tech-enabled approaches (and the rise of the internet as the primary medium) led-in-turn to the “Moneyball-ification” of the industry (much like our Fast Forward scenario). Entities occupying the right two quadrants of our diagram compete against tradition rather than their peers. This strategy makes actors responsible for a level of education and case-making not necessary on the left side of the diagram. On the left, firms win by beating inertia better than their peers. On the right, firms win through innovation, with the prize going to those who are bolder and better — and can actually deliver.

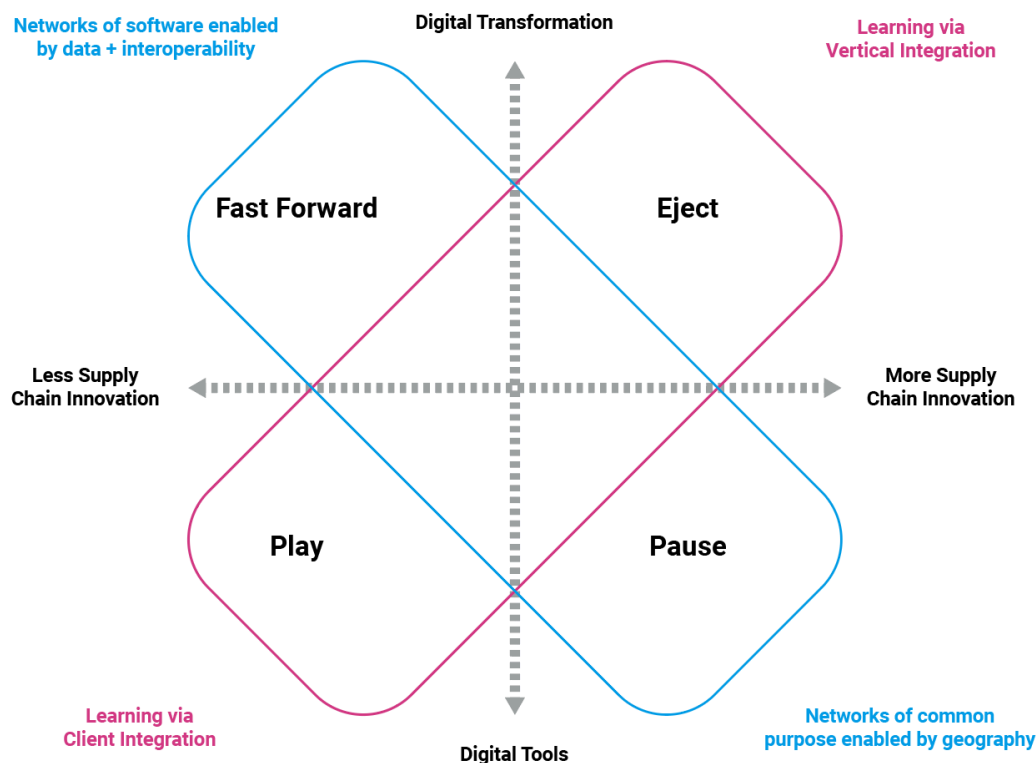
5.2 Future Talent Needs

Slicing the diagram horizontally reveals the dominant talent needs supporting all paths forward. The bottom two quadrants run on relational capital. Play rewards trusted advisor bonds with clients, while Pause thrives along hyper-local ties amongst collectives forged by shared values. The top two quadrants privilege digital transformation skills in the form of technical acumen. The top row will reward firms hiring hardware and software know-how, while structuring teams with the runway to experiment, test, and integrate successful workflows and tools. The bottom row asks for bridge-builders, the top for mold-breakers.

5.3 Learning Mechanisms Across the Sector

Looking at the scenarios diagonally reveals two methods of learning and improvement over the long run. These are about how new knowledge is produced, captured, and used within businesses or other entities, including the government departments that oversee the built environment. Drawing a line between Fast Forward and Pause, we find strong networks as the primary mechanism of attacking the leakage of chain drain. In both futures, syndicates of practitioners sharing values, goals, and data enable the work of diverse actors to produce large-scale change. Learning happens across the network and, like the internet itself, network effects are a source of power.

Figure 4. Learning Dynamics Across the Chain



By contrast, Eject and the most successful versions of Play focus on learning within organizations. Play firms succeed when they connect project delivery with upstream strategic advisory services, expanding the scope of services in a manner that transacts on their high relational capital. This is already playing out as the top firms – almost all of which have some kind of strategic advisory team – gain early understandings of clients' needs, and then succeed on those metrics through their projects. Startups in Eject ingest as many links as they can swallow and then are forced to work through any issues at the edges of those links on their own. Sometimes,

they succeed; sometimes — like Katerra’s fruitless pivoting — they don’t. Either way, by virtue of working under a single roof, these entities gain agility and have a mandate to eliminate interface costs. Any efficiencies they find accrue to the firm instead of evaporating. In this diagonal, complexity is managed by learning across generations of products and people, by reliably capturing institutional knowledge, and by strong process management enabling continuous improvement.

Take the diagram above and shade in the boundaries of the future you personally want to see, or perhaps the market you see yourself currently operating within. Neither is likely to be wholly contained within a single quadrant. Careers and portfolios criss-cross the lines on this diagram, as they should! Our scenarios aren’t meant to constrain possible futures, but are an attempt to establish a way of talking about the sector as a whole, and how its internal structure shapes its output. Call it our corollary to Churchill’s famous maxim: First we shape our industry; thereafter it shapes us.

Much remains to be done at the policy level to improve the underlying conditions on which all of these scenarios are built. But the responsibility for attacking chain drain is ours and ours alone, and we should seize an opportunity to bring creativity to the workflows, processes, business models, organizations, and networks collectively responsible for making and maintaining the built environment.

Fast Forward is a bet that digital disruption in the AECO sector will reward first movers with a disproportionate financial windfall. Based on our analysis of tech investment in the sector, the ugly truth is that it’s just as much the status quo as Play could be. Eject represents a larger bet in the power of clients, governments, and end users to demand better outcomes from the built environment and force new business models and business practices along the way. And Pause is an existential wager on reconciling the planet’s material limits with human ingenuity to solve escalating externalities.

Hunkering down in Play is a gamble, too — one that judges the risks of inaction to be less than any of the others. If this gambit sounds familiar, hopefully by now you see why the odds are against you.

6.0 Appendix: The Case for a Radically Better Built Environment

Key ingredients America needs to thrive — housing, infrastructure, climate resilience — comes from the one industry that has spent fifty years getting worse at building anything at all. Between 1970 and 2024, U.S. labor productivity more than doubled, while the construction industry's fell by roughly 30 percent.¹⁹ In that regard, the industry exhibits all the symptoms of "Baumol's cost disease," contracted when stalled productivity growth leads to rising wages (and prices) with no uptick in outputs.²⁰ Classically, Baumol's malady assumes a sector is at least holding its output level steady — the teacher still leads a class, the orchestra still plays a symphony — while AECO, by most measures, is steadily losing ground. Building less with more is a bad outcome from an economic lens to be sure, but a purely economic framing is also obsolete. The more urgent question is how the sector can do right by itself in order to better serve all Americans, and not just clients.

Housing is first on the list for a reason. The White House Council of Economic Advisors (CEA) asserts the precipitous fall in the rate of new housing construction following the 2008 financial crisis has led to a shortfall of more than 10 million single-family homes,²¹ nearly doubling previous estimates. That gap has persisted even as new home completions reached their strongest pace since 2007.²²

The industry's failure to provide an abundance of housing is not only a direct contributor to the steadily rising rents and home prices fueling America's affordability crisis, but has indirectly led to falling fertility rates²³, widening inequality,²⁴ and perhaps even political polarization.²⁵ High housing costs have contributed to impaired geographic- and labor mobility compounding over decades, which in turn may have dampened cumulative GDP growth by up to 36% between 1964 and 2009 — before being made worse by the housing crash during the Great Financial Crisis.²⁶

The CEA lays much of the blame on a worsening "bureaucrat tax" composed of various fees, mandates, regulations, and assorted red tape imposed by federal, state, and local authorities. These restrictions not only add to the cost of a new home (by some estimates up to \$100,000), but also reduces the ability of the sector to develop economies of scale by instituting local fragmentation.²⁷ For this reason, AECO is one of the least digitized industries and also has some of the lowest rates of R&D.²⁸ Not coincidentally, construction patenting declined precipitously around 1970,²⁹ following the same trendline as productivity. The fact that the 21st Century ROAD to Housing Act is a rare bipartisan success story in 2026 tells you how dire the situation is. The bill is poised to address housing through modest but important moves: deregulation of modular housing, streamlining of lengthy environmental review, and underwriting pro-density initiatives like single stair residential buildings.³⁰

Ironically, the CEA singles out building codes and energy performance standards as the most egregious examples of the bureaucrat tax, and yet the scale of America's housing crisis pales in comparison to the challenges cities face in adapting to climate risks. The U.S. suffered 27 billion-dollars worth of weather and climate disasters in 2024, three times the average of the preceding four decades.³¹ Hurricanes Helene and Milton alone caused \$113 billion in damage across multiple states.³² Several months later, the 2025 Los Angeles wildfires sparked another \$50 billion in losses, making them the costliest wildfire event in U.S. history measured by insurance losses.³³

These onetime tail risks have since become permanent line items. Bloomberg Intelligence estimates the U.S. has absorbed roughly \$7.7 trillion in climate-related costs since 2000, and that climate disaster preparation-and-recovery spending between 2024-2025 totaled nearly \$1 trillion — a twelve-fold increase over the annual average of the 1990s.³⁴ The impacts on labor markets, supply chains, insurance, and inflation are “pronounced, prolonged, and pervasive,” in the words of a former deputy treasury secretary.³⁵

The corresponding climate opportunity is equally enormous. McKinsey projects that a narrow subset of roughly 50 mature climate-resilience technologies — e.g. building hardening, grid reinforcement, water infrastructure, etc. — will constitute an addressable market between \$600 billion and \$1 trillion by 2030.³⁶ Similarly, Bloomberg’s proprietary “Prepare and Repair” Index of roughly 100 large public companies ranging from waste hauling to hardware stores to self-storage facilities has significantly outperformed the S&P 500 over the last decade.³⁷ Each example points to a second trillion-dollar demand signal matching the shock of the first, both aimed squarely at the built environment.

The climate and affordability crises will continue fueling the demographic upheaval unleashed by the pandemic. Over a two-year period (2020-21), millions of Americans abandoned the densest, most walkable, and expensive housing markets in favor of more affordable suburbs and exurbs in the Sun Belt. Both trends have since ameliorated³⁸ — a post-pandemic rebound in urban populations has stalled due to declining international migration, while the search for affordability has moved on to smaller, even less-dense metros in the South and Midwest. These shifts, coupled with newfound preferences for remote work and e-commerce, have led to seismic changes³⁹ in demand for commercial properties that have anchored urban districts and suburban developments for decades.

For instance, falling downtown foot traffic⁴⁰ and office vacancy rates⁴¹ have deeply impaired asset owners⁴² and triggered fire sales of distressed properties.⁴³ In a sign of the times, spending on AI data centers has surpassed the *entirety* of new office construction.⁴⁴ This change in priorities by investors and consumers alike is reflected in how remote workers choose to reinvest their time saved commuting at home, alone, with screens.⁴⁵ A corresponding surge in home delivery has weakened demand for brick-and-mortar restaurants and retail.⁴⁶

This has all fueled fears of either an *urban* doom loop⁴⁷ of falling property values, reduced tax revenues, and cuts to public services, or a *human* one⁴⁸ in which fewer personal interactions and activities lead to worsening physical- and mental health. In either case, there is a pressing need for new and repurposed public and private “third places” designed for conviviality. Cushman & Wakefield has found that as much as \$340 billion could be unlocked from the conversion of obsolete offices to walkable mixed-use developments across downtown and suburban portfolios in 15 major cities⁴⁹, providing a new tax base and local amenities. But it also cautioned the current pace of change is too slow, held up once again by the sheer expense of renovations and construction, coupled with regulatory barriers such as permitting and zoning.

In other words, the same sector tasked with helping America recover faster from the pandemic and a trillion dollars annually in climate disasters is also the one whose productivity has flat-lined for half a century. A sector that cannot produce more with less — that in fact produces less with more — has no hope of meeting these exponentially-growing demands.

7.0 Appendix: A Tug of War for the AECO Sector

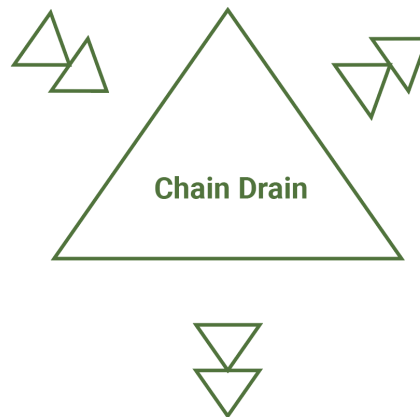
We adopted the futures triangle from Sohail Inayatullah for its usefulness in bundling a set of forces and describing their interactions as a three way tug-of-war.⁵⁰ In this case, aggregated barriers to reinvestment form the weight of the past, tech-driven innovation represents the push of the present, and “new demands” are pulling the sector into the future by redefining what high quality means in the built environment. Each of the four scenarios is derived from this nexus and informed by the research we conducted to understand how actors in the AECO space are navigating it. This appendix describes the forces that collectively have the power to plug the gaps in the chain, or continue to let it drain.

Present:

Technological, financial, and competitive pressures give firms a push toward digital transformation

Future:

New demands from clients, regulators, and the public pull firms in the direction of higher-performing and evidence-based outcomes



Past:

Regulations and structural barriers prevent the built environment from achieving the level of reinvestment seen in other industries

Figure 5. Futures Triangle Diagram Three sets of forces all act on the status quo of the built environment supply chain. The tug of war here informed our PLAY, FAST FORWARD, EJECT, and PAUSE scenarios.

7.1 Weight of the Past: Barriers to Reinvestment

Silicon Valley knows well there are limits to bootstrapping innovation, which is why the tech sector is fueled by vast sums of venture capital underwriting risk and experimentation in hopes of capturing outsized profits. By contrast, risk in the AECO sector is something to be managed down. There is no equivalent of the hundredfold return that VCs hunt. A project's best-case outcome is largely fixed before ground is broken and takes years to realize, so there's little reason to gamble. Innovation *does* happen, but typically in the form of singular projects. Breakthroughs are predisposed to solve individual design- or construction problems rather than addressing the larger issues of chain drain.

Below we outline five factors that stack the deck against firms eager to translate their hard-earned experience into fresh opportunities. Would-be innovators aren't necessarily to blame for the conditions outlined below, but neither can they unilaterally undo them. Each is a liability on its own; together they prevent firms from solving one piece without solving the others simultaneously. Firms denied capital cannot build the tools that would then let them make the case for it. And so it goes.

7.1.1 Fragmented Regulatory Environment

America's built environment is constructed from a patchwork of local regulations effectively outlawing standardization. Zoning determines what can be built where, building codes dictate how it can be built, and permitting decides whether it can be — and if so, when. (Not any time soon; the average federal environmental impact statement for major infrastructure projects takes four-and-a-half years.⁵¹) Sprinkled on top of this layer cake are procedural regimes such as design review boards, community engagement requirements, and/or community benefits ordinances. Beyond the sheer volume of overlapping compliance requirements, the occasional contradiction creates ambiguity that proceeds to accelerate chain drain through conference calls and meetings between links searching for a resolution.

Even when regulations match, the same designs must still be reformatted to satisfy local conventions, compliance, and stakeholders' preferred order of operations. "The building itself doesn't change, but how the planning department wants you to *talk* about the building changes from place to place," laments Edward West, founder of the panelized modular housing developer Tesseract. The cost of this complexity isn't borne by local authorities but the industry — and society more broadly.

7.1.2 The First Customer Problem

Even if zoning and all other supply constraints were to be abolished tomorrow, the sector would still face stubborn resistance to change on the demand side. New methods, new materials, and new technologies all hit the same dead end at procurement. Nobody wants to go first.

Modular construction startups feel this keenly. Kattera, for example, failed due to a lack of product-market fit—it could never run its facilities at the pace necessary to achieve profitable economies of scale because its potential customers balked.⁵² This raises an unsettling question: *what if innovation is impossible because clients refuse to innovate?*

Survivors think they know the answer. Assembly OSM's Alexandra Donovan, who joined the company shortly after its founding in 2019 and has since become director of design and innovation, describes the dilemma

thusly: “Developers are bought into the idea at first. ‘Okay, it actually pencils, it makes sense. But we don’t want to build your first, second, or third building. We want to come back when you’ve done five and it’s proven.”

Seeing no other recourse, Assembly proposed to build a handful of what Donovan calls “guinea pig projects.” (“Because no one else wants to be the guinea pig.”) This pushed the firm towards greater vertical integration by necessity until internal frictions and steep costs steered it back to working with clients more willing to entertain its methods. It’s a bitter lesson in how developers’ risk aversion impedes the entire chain.

In their defense, most owners procure new assets at a far slower cadence than the sector designs and builds them, which puts them at a disadvantage with regards to evaluating new processes and technologies. Their defensive posture is a rational response to this information asymmetry, which has the effect of reflexively filtering out any proposals to reduce chain drain. “Let’s say you’re a general contractor who wants to do design-build with off-shore, off-site, 3D-printed manufacturing,” says KP Reddy, a technologist, venture capitalist, and serial startup founder. “The owner just looks at you, and the architect looks at you, and both are like, *Just give me a bid, man. I don’t need all these ideas.* Because nobody can absorb them.”

Government as a purchaser is a promising tactic to address the first customer problem. New York has earmarked \$950 million to install heat pumps across 20,000 public housing apartments⁵³, with Mayor Zohran Mamdani suggesting the city could use its purchasing power to acquire thousands of heat pumps at a discount and sell them to landlords at cost.⁵⁴ Commitments such as these – by a city with a GDP larger than Switzerland’s and a state with one larger than India’s – send a clear market signal, but the Federal government has an even larger antenna. Owning and leasing 363 million square feet of space across 8,300 buildings, makes the General Services Administration (GSA) the nation’s largest tenant and that doesn’t include the Department of Defense, which has a nearly \$20 billion annual construction budget domestically⁵⁵ and a housing portfolio in wide disrepair.⁵⁶ Late last year, it announced the Barracks Resilience Through Industrialized Construction (BR-IC) program, a solicitation designed to seed multiple prototype projects for modular housing delivered 30% faster and for 20% less than current methods.⁵⁷

7.1.3 Liability

Legal liability only serves to entrench the position of asset owners and developers, with the constant threat of lawsuits hardening their adherence to practices perceived as safe bets. For example, some of the nation’s largest homebuilders – including leaders D.R. Horton and Lennar – have earmarked hundreds of millions of dollars to battle or settle suits by homeowners alleging harm from construction defects. In many cases, they have pointed the finger at their subcontractors, pushing the blame down the chain in order to recover costs from firms already starved for capital. “It takes so much to litigate a construction defect, you spend more than you do to build a house,” one attorney told *The Wall Street Journal*.⁵⁸ Even the lawsuits suffer from chain drain!

7.1.4 Client Dependence

Bottlenecks caused by the hesitation of clients highlights tensions between a sector composed of creative professionals excited to push the boundaries of conceptualization, design, and dealmaking, and the immense inertia of chain drain. Especially in the plan/design/build portion of the chain, most firms ultimately sell their time, not a product. They have few real assets to underwrite, no competitive moat and limited IP to attract investors, and insufficient profits to self-fund the creation of either. Their inability to scale is part and parcel of the industry’s project-based delivery model.

The combination of selling billable hours and professional services (so called “soft costs”) being a minor portion of most projects’ capital budgets produces cascading effects. One is exclusion from the capital stack that has underwritten digital transformation in industry-after-industry, especially manufacturing. AECO firms desiring to do the same must bootstrap them in the margins of active projects, paying for new tools and practices out of the same fee structure eroded by those very tools. Not only is innovation hindered by clients’ equivocation, it’s nearly impossible without their budgets. “There’s not a lot of money out there for us to just do R&D,” says Christopher Sharples, founding principal at SHoP Architects and a member of the AEC Angels investment consortium. “We can’t treat R&D as a separate effort. It has to be integrated into the design process and evolve alongside the work.”

This bootstrap approach is complicated by chain drain, namely how the same billable-hour services model preventing plan/design/build firms from externally raising capital also disciplines what workers are permitted to do with their time. Originally a tool for project cost accounting, timesheets have become the principal management instrument of most firms, which in turn treat every unallocated hour as waste. Internal tool-building, training, and process improvements all require time their business model is opposed to providing.

“The challenge is that you’re building a prototype each time, so anything that can create standardization is super valuable,” says Andrew Cantor, executive vice president of development at Related Companies, the country’s largest owner of affordable housing. “Even with process review, we just don’t do a lot of that because there isn’t a lot of slack in the system – the margins don’t really provide for it.” Firms desperate to invest in the future must first defeat accounting.

7.1.5 Vendor Lock-in

These conditions leave the sector beholden to outsiders for any technology more ambitious than it can underwrite itself, and thus prone to vendor lock-in and monopoly pricing. Autodesk’s \$133 million acquisition of BIM pioneer Revit in 2002 now generates more than \$3 billion in annual recurring revenue with 95% market penetration. Esri occupies a similarly unassailable position in geospatial information systems. On the opposite flank, VC firms such as Andreessen Horowitz probe these fortresses for weaknesses while allocating funds to startups alternately aimed at usurping Revit (Motif - “intelligent workspace for the people who build our world,” a clear FAST FORWARD example), embracing and extending it (LightTable - “catch costly issues early with AI-powered quality control”), or using the \$150 billion MEP design market as a Trojan horse to incept it (Endra - “The AI-powered MEP platform,” an EJECT candidate).

7.2 Push of the Present: Technological Transformations

Two technologies are repeatedly invoked in solving the issues of chain drain. First is the dream of digital coordination, born with BIM and reinvigorated by AI, which inspired Fast Forward. Second, seeding Eject, is the dream of modular construction, which is periodically revisited by a new crop of startups determined to finally make the economics work.

7.2.1 Pushing Toward Automation

Upon conducting its own analysis of chain drain, Andreessen Horowitz was scandalized to discover “every building you’ve ever been in was designed by software built in 1997.”⁵⁹ Setting aside nearly thirty years of continuous updates, comparing Revit to Netscape or Napster is surprisingly apt. Roughly a decade later, enterprise software began migrating from clunky, desktop applications to cloud-based software-as-a-service products with rigorously refined interfaces on top of reengineered data pipelines and protocols running underneath. A new generation of apps designed with generalists in mind, such as Canva or Figma, reset expectations for creative software’s capability as well as look-and-feel.

The built environment’s tech stack remains naggingly manual and disaggregated. BIM was meant to dissolve all this into a single collaborative model, but chain drain confined it to a drawing tool, and not an especially fluid one. Enter artificial intelligence, which had begun reshaping the industry well before ChatGPT’s debut in November 2022. Algorithms had underpinned generative design for decades by then, while a new wave of image generators such as Midjourney made image production accessible to actors across the chain.

Out on the jobsite, Suffolk Construction stood up its data-science team in 2018 to both learn from and streamline its hundreds of job sites. That work laid the foundation for its “Jobsite of the Future,” a new operating model embedding technology and AI Engineers directly on jobsites to make faster, more informed decisions.

“The first phase of construction’s digital transformation was about collecting data and creating visibility,” says Wan Li Zhu, co-founder and managing director of Suffolk Technologies, the venture capital platform affiliated with Suffolk. “The next phase is AI-powered orchestration—connecting design, procurement, field operations, and asset management into a single system of execution. AI creates the opportunity to coordinate work across the project lifecycle and learn from every project by capturing past decisions, outcomes, and lessons learned so they can continuously improve future performance.”

AI has reverberated throughout the chain at different frequencies of adoption, depending on use-cases and ROI. Usage is heaviest at both ends — planning and feasibility at the front, operations at the back — and lighter in the middle. At the front, a startup named Acres (spun out of a farmland investment company) runs agentic search to screen and rank land parcels against flooding-, zoning-, infrastructure proximity, and a host of other criteria. Similarly, Sasaki’s in-house Dashi platform runs digital twins for large portfolio owners such as universities, mapping existing assets against future space-planning needs and capital improvement projects over decades. And Archistar is one of many startups administering automated permitting plan review on behalf of cities such as Austin⁶⁰ and Los Angeles⁶¹, with the latter straining to rebuild after 2025’s devastating wildfires.

Each tool delivers real time savings — in Acres’ case, compressing weeks of desk research into minutes — but only touches the rest of the chain glancingly. Acres stops short of automating entitlements, while Archistar cannot surmount lengthy delays from waiting for human inspection. Sasaki’s Siqi Zhu — the firm’s director of planning & urban technology — explicitly rejects linking Dashi to the rest of the chain. “It’s compelling to imagine a universal data model for the built environment,” he says, “but it presents a ton of integration challenges I’m not sure are worth it.”

It’s the middle of the chain where things get messy, as usage diverges from one link to the next. Architects, for instance, have conscripted AI’s prodigious output into the same brute-force methods they’ve practiced for decades.⁶² According to the head of design technology at one large firm, it now offers clients five or even fifteen possibilities where they once offered three. Thornton Tomasetti’s engineers, by contrast, are vibe-coding tools its CORE studio — led by chief technology officer Robert Otani — refactors and folds into its own custom software.⁶³

For example, its software might generate a dozen structural-column options across seven floors and code-check each of them in seconds, rather than taking hours by hand — a savings Otani earnestly describes as “100x, or even 1,000x.” Even so, final validation still requires human judgement, and the output is only feasibility-grade, not a finished building.

The gap between Thornton Tomasetti’s thousand-fold savings and the architects’ tripling of output is due to the nature of their work. “Engineers work with closed solutions, and architects with open ones,” is how Otani puts it. The latter doggedly pursues new designs while the former more efficiently calculates known equations. AI better suits one’s business model than the other, for that reason is destined to be destabilizing to the chain’s current configuration.

Planners and developers have welcomed it because an LLM’s inherent fuzziness can deliver value without anyone worrying whether it’s hallucinated a load-bearing column. Landlords are realizing returns from centralized operations and reduced headcount. The middle of the chain, where human safety informs all major decisions, enjoys no such tolerance.

One question is how the chain responds to these diverging outcomes — as torque builds from both ends, will it fly apart or wind more tightly together? Thesis Driven founder Brad Hargreaves winkingly calls this “vibes pressure” — just as cloud-based SaaS rewrote the rules for enterprise software, the gulf between an operations layer with real-time visibility and the rest of the chain might widen until asset owners finally sit up and take notice. This is the bet Reddy is making with his latest venture, Zero RFI. Rather than sell software, he’s positioning his firm as an AI super-powered owner’s representative wielding proprietary tools to reach down into the chain and rearrange it at his clients’ request.

Perhaps the ultimate sign of change pushing from outside the chain is Google X’s latest “moonshot,” Anori. It aims to solve drain early in pre-development by front-loading a project’s coupled constraints onto a single, shared platform, so the bleeding at handoffs never happens. “If each iteration takes three-to-five months, minimum, then there is no innovation cycle, because you can’t afford more than one or two cycles of that,” says Astro Teller — Google’s X “captain of moonshots” — identifying chain drain in his own words.⁶⁴ In that sense, it fulfills the dream of BIM in 1997, albeit shifting the gains earlier in the chain, to speed of feasibility instead of BIM’s promise of design and plan coordination.

7.2.2 Pushing Toward Production

Not coincidentally, Anori CEO Adrian Walker began his career as a data scientist for Ford, supporting the lean manufacturing and kaizen continuous-improvement methods that remade global manufacturing starting in the early 1970s, just as American construction productivity began its long decline. The second push of the present follows from the era's promise of modular construction to disrupt craft production — especially when it comes to housing, where manual labor still accounts for roughly half the cost of a single-family home.⁶⁵

This push is the shift to products over projects. Manufacturers typically specify their designs to exacting tolerances, mass-produce components with vanishingly small defect rates, and inspect results only at the end. By eliminating the organizational and contractual barriers bedeviling each link, they're the ones best positioned to learn from every snag or misstep in the production process and convert those lessons into refined processes. With regards to construction, the aim is to solve chain drain by compressing design, engineering, and fabrication into a single high-throughput facility.

The last generation of venture-backed manufactured housing startups fared no better than Kattera: Veev, Blu Homes, Mighty Buildings, and Entekra raised nearly a billion dollars between them before closing up shop or exiting. What will it take for the latest crop of founders to succeed where so many others have failed?

The first answer echoes Sweden and Japan, where homebuilders long ago stopped touting cost in favor of quality. Today, that pivot reappears as resilience. Kohala's non-combustible panelized homes are engineered for fire-, wind-, and earthquake resistance — features that resonate with once-burned customers in Hawaii and LA's Pacific Palisades.⁶⁶ Productization may prove to be the most effective path for propagating more resilient features and materials if the market will bear it.

Quality-focused firms such as Kohala hope that by tightening their product- and geographic scopes further, they can achieve product-market fit more quickly. American Housing Corporation, for instance, is focused on two- and three-story panelized row houses intended for families in Austin. "Because we can erect a unit in less than two weeks," explains co-founder Bobby Fijan, "we can change or improve things as we move, even on the same project. Others who want to make large changes to large things can't do it until the next project two years down the road."

7.3 Pull of the Future: How the Built Environment Serves Society

The changing needs, desires, and expectations of the built environment's constituents — not only clients and tenants, but also governments, markets, end-users, and the public — are its ultimate driver of change. In *Fast Forward* and *Eject*, we assume various combinations of these actors agree more value can be derived by a higher-performing built environment rather than one simply delivered on-time and under-budget. Conversely, *Pause* assumes governments and asset owners with a long-term outlook take a larger role in mandating such a shift.

What “performance” means in each instance is open to interpretation, but it might include outcomes such as sustainability, health-and-wellness, and social cohesion, along with a long tail of desires super-imposed onto individual projects: bird-safe; dark sky-compliant; union-built; locally-sourced labor; recycled materials, walkable urbanism, autonomous-vehicle ready, pro-social, and so on. Once outputs are eclipsed in importance by outcomes, a more fundamental shift is unlocked — checklists occurring once in a project's lifecycle are replaced by continuous measurements.

If the ennobling of buildings, cities, and public spaces is to become the default for American urbanism, it will be due to a realignment in how government, gatekeepers, consumers, certification bodies, and collectives cumulatively define quality in the built environment.

7.3.1 Government

Today, the laboratory of democracy is most active at the local level, through initiatives such as New York City's Local Law 97, which caps and gradually tightens large buildings' GHG emissions under pain of financial penalty. Aspirationally similar state- and local ordinances range from Washington's Clean Buildings Performance Standard — which mandates energy efficiency planning and tracking — to Berkeley, California's Building Emissions Saving Ordinance requiring homeowners to upgrade their properties with electric heat pumps or similar features as a condition of sale. All three measures are designed to compel retrofits that should reduce emissions *and* operating costs over time, in a grudging win-win for owners.

With housing costs untenably high in many jurisdictions, a growing number of cities and states are attacking zoning- and permitting reform in a desperate attempt to cut loose the dead weight of the past. California, for example, passed a raft of housing bills in 2025 instituting a “shot clock” for permitting approvals, exempting sufficiently dense infill projects from environmental review, and expanding the scope of allowable commercial-to-residential conversions.⁶⁷

7.3.2 Gatekeepers

A thicket of gatekeepers including equity partners, lenders, insurance companies, and appraisers all need to say yes for the money to flow. ESG (environmental, social, and governance) may be a four-letter-word of late, but real estate benchmarks such as the Global Real Estate Sustainability Benchmark indicate slowly-improving performance⁶⁸, steadily-growing investor participation, and finally collecting enough energy, GHG, water, and waste data to model, learn from, and optimize building operations. Insurers are brandishing their own carrots-and-sticks to encourage climate-positive movement with dropped coverage⁶⁹ and skyrocketing premiums⁷⁰ on the one hand and adaptation discounts on the other. The industry's own FORTIFIED standard for

reinforced roofing⁷¹ is formally recognized by a half-dozen states mandating discounts in return. California has done the same for homeowners mitigating wildfire risk,⁷² while commercial property insurer FM has taken this approach a step further by offering policyholders \$825 million in discounts on premiums as an incentive for those who upgrade to prevent climate-related and operational losses.⁷³

Matthew Claudel and Simon Giles, of the Portland, OR and London based consultancy Field States, describe a mismatch between past economic models and the worldview of gatekeepers, “The rate of urban change now exceeds the response capacity of the institutions designed to manage it.”⁷⁴ Echoing Frank Duffy’s famous concept of shearing layers, they argue the built environment sector has fallen hopelessly behind the public’s mercurial desires. “By the time you finish building,” the pair write, “the world has moved on.” As they see it, the task ahead is to systematically retrofit not only trillions of dollars in stranded assets, but also the chain itself, on the principle that flexibility is the lowest-risk strategy under extreme uncertainty. An obvious example is the surge in office-to-residential conversions – more than 90,000 units are currently under construction, a 28% annual increase and nearly quadruple 2022’s total.⁷⁵ Fueled by tax breaks and relaxed zoning in cities such as New York, Boston, and Chicago, they constitute nearly half of all future adaptive reuse units in the country.⁷⁶

New clients and capital are needed to pair with new forms of practice. Pension funds, municipal bonds, and education savings accounts could all potentially fund a transition, argues Pamela Robinson, a professor at Toronto Metropolitan University’s School of Urban and Regional Planning. They share the mission-driven principles and long-term horizons necessary for nominally riskier investments. “Shareholders want double digits, but maybe it needs to be high single digits,” she says. “Unless we change the profit-taking math, I don’t know how we build the infrastructure we desperately need.”

7.3.3 Consumers

For a developer like the Durst Organization – whose holdings include America’s first LEED Platinum commercial high-rise, One Bryant Park – a reputation for sustainability tends to attract tenants demanding it in turn. One is Durst itself, which salvaged and recycled 22 tons of interior glass from its own offices with the help of a self-described “glass nerd” specializing in mechanically stripping films from laminates.⁷⁷ That one-off has since expanded into an alliance of architects, contractors, recyclers, and city agencies reclaiming 800 tons of glass across 20 projects, all for less than it would cost to landfill it.

Owner-operators such as JPMorgan Chase are not immune to the fickle opinions of employees as internal consumers. The bank spent six years and \$4 billion demolishing Manhattan’s Union Carbide Building and erecting 270 Park Avenue in its place. Hailed as one of the world’s most luxurious office building, its costly investments in double-height ceilings, outdoors gardens, and state-of-the-art indoor air quality are signals that they felt a need to attract the highly-mobile, highly-profitable employees who would rather be working from home (but are required to be at their desks five days a week) through the creation of an office that delivers on more than beauty alone.

Theoretically, an asset owner like JPMorgan Chase have all the data they need to measure their “return on place,”⁷⁸ but nearly all organizations fail to harness it for improving outcomes on behalf of their users. Imagine pulling together air quality scoring matched with badge swipes and performance reviews, for instance. Each of these is buried in proprietary building and enterprise resource planning systems scattered across corporate departments including IT, finance, HR, and real estate. It takes a proactive and powerful leader to cut through this internal chain drain to pull these together, which is rarely prioritized.

Smaller demand signals are also shaping the market via an emerging class of collectivist housing experiments originating from Europe. In Berlin's multi-family *baugruppen*, for example, the residents are the clients. Pooling their funds into a "building group" that collaboratively designs and develops the project, they solve one link in the chain by removing profits in favor of more affordable homes that better suit their needs. Community land trusts go further by sequestering land costs in perpetuity – and hence their reliance on philanthropy. Each poses the same heretical question: if the built environment is the world's largest reliable asset class, what happens when it isn't?

7.3.4 Certification Bodies

Today, the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) is synonymous with sustainability (although not without criticism⁷⁹), and a prerequisite for lenders and tenants. It has since been expanded, applied at different scales, and joined by a host of competing and complementary standards such as WELL, Fitwel, Living Building Challenge, BREEAM, and PassivHaus.

In practice, certifications tend to be boxes checked at the end of projects in exchange for a plaque mounted in the lobby. The alternative is to embed sustainability at every step, in every spec, and using those line items to hold the rest of the chain to a higher standard throughout. "You need to ensure your design goals are still there at [design development], and that they're not considered alternatives when you go to pricing exercises," explains Sydney Mainster, the Durst Organization's vice president of sustainability & design management. "We're there at every procurement meeting, at every bid leveling meeting, and when the final bids are awarded. We ensure contractors will meet the criteria before they've even given a submittal for review. Because if you're *not* sure and leave those goals to be met by a sub.... Don't be surprised when other project priorities usurp yours."

The plaque was never the point. Certification was always meant to be a means for validating expected performance outcomes, not an end unto itself, argues Joanna Frank, CEO of the Center for Active Design, which administers the Fitwel standard for building health performance. "There's no lack of data in real estate," she says. "But there's inconsistent integration of health outcomes data into financial metrics that actually matter." Proving that better air quality, thermal comfort, and lighting is tied directly to ROI – and then enshrining them contractually, as Durst has done – potentially offers a mechanism for solving the disconnect at the heart of chain drain. One of Frank's clients is doing just that by training its own models on Fitwel's historical evidence base before linking them to real-time data arriving from building sensors. Their goal isn't compliance, she says, but competitive differentiation. Operationalizing performance standards and metrics in this way might succeed where an earlier generation of "smart buildings" failed, by finally making a business case for sharing outcomes with the rest of the chain while collectively and continually learning from them.

8.0 End Notes

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Disclosure: This report was developed with the assistance of Claude Opus 4.8 and Claude Fable 5 for editorial work, including interview coding using a custom workflow developed by the authors, proofreading, and contributing to literature review. All content and final edits were made by the authors.