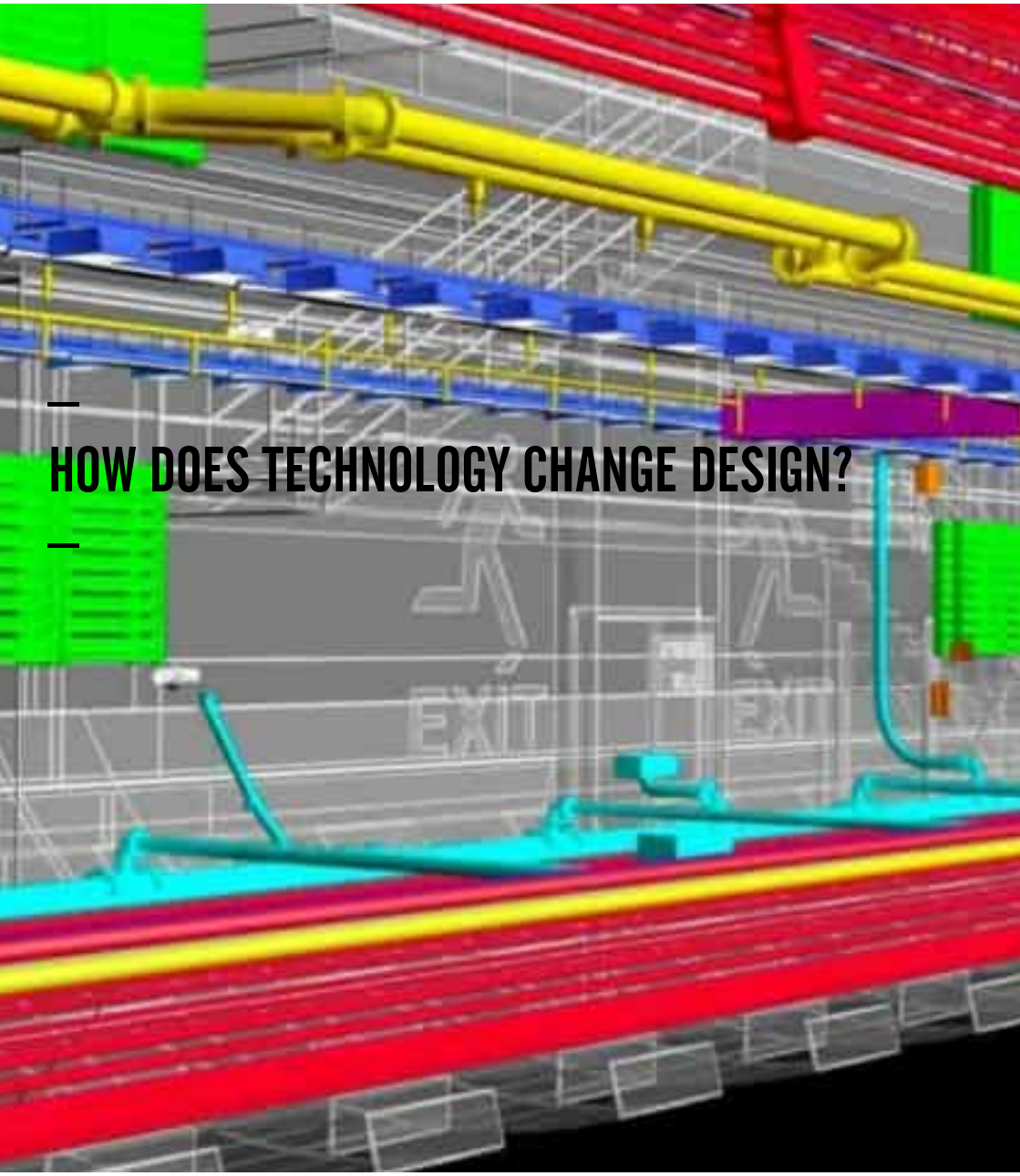
IMAGINE
DESIGN
CREATE

WHY DOES DESIGN MATTER?

HOW DOES DESIGN INSPIRE?

HOW DO WE MAKE DESIGN?



HOW DOES TECHNOLOGY CHANGE DESIGN?

HOW DOES DESIGN MAKE US FEEL?

HOW DO WE DESIGN DESIGN?

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WHERE WILL DESIGN TAKE US NEXT?

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pages 2–3, Cathedral of Christ the Light, Oakland, California; pages 4–5, U.K. Pavilion, Expo 2010 Shanghai; pages 6–7, Kartal-Pendik Masterplan, Istanbul, Turkey; pages 8–9, detail, digital model of Alaskan Way Viaduct; pages 10–11, still from *Cloudy with a Chance of Meatballs*; pages 12–13, Visualization of aquarium and museum site concept, designed in AutoCAD software, rendered in Autodesk 3ds Max; pages 14–15, Ansari X Prize–winner SpaceShipOne.

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FOREWORD

previous spread: **The Shanghai Tower under construction**

EVEN WITH ALL THE DRAMATIC CHANGES BEING WROUGHT BY TECHNOLOGY, DESIGN REMAINS, AND LIKELY ALWAYS WILL, A FUNDAMENTALLY HUMAN ENDEAVOR, FUELED BY THE INSIGHTS, IDEAS, PASSIONS, AND TALENTS OF PEOPLE IN PURSUIT OF PROGRESS.

of the projects and people and ideas seen in this book attest, is that our capacity to produce good design is expanding and improving at a breathtaking pace. Technology is a driving force in this unfolding revolution. It is beginning to provide designers with tools that can enable them to take on the thorniest, most complex challenges facing business and the world at large. In the process, technology is in some ways altering the very nature of design and the role of the designer—which can be inspiring or, for some, unsettling. But even with all the dramatic changes being wrought by technology, design remains, and likely always will, a fundamentally human endeavor, fueled by the insights, ideas, passions, and talents of people in pursuit of progress.

DESIGN IS CHANGING OUR WORLD

The urge to design—to reimagine, reorder, and reshape the world around us—is deep in our DNA. History takes us back to the most primitive stone tools—which, archaeologists tell us, were not necessarily as primitive as one might presume. One recent discovery of Stone Age objects in Colorado included a set of hand tools with rounded, ergonomic handles worthy of OXO-brand peelers. Early examples of such well-planned and thoughtful creations just confirm that from the beginning, design has always been purposeful. It always had a job to do. Often, that job was to improve life in some way.

Skills were required, of course, but beyond that, the best designers had to have vision. To bring

about improvements in the world around them, they needed to be able to look beyond the existing realities and see new possibilities—not just what was, but what *might be*. There's a philosophical aspect to the design mind, as designers grapple with the notion that *something isn't quite right with the world*. And, as experience designer and educator Nathan Shedroff relates on page 224, designers have the capacity to make it better. Designers don't just think and theorize. They model. They make. They build.

Whatever lofty visions design may sometimes aspire to, the process itself is grounded in solid principles and a bias toward action. It's a process that is, itself, designed—for the purpose of transforming possibility into reality. And while it may often begin with the vagaries of human insight and creativity, these first sparks quickly beget an iterative methodology, a process that involves exploring options, sifting through what works and what doesn't, and refining solutions.

The design process is often rigorous and disciplined. Yet design cannot be reduced to a formula. Give a hundred designers the same challenge, with the same constraints and raw materials, and chances are you'll end up with countless different solutions, including (if fortune smiles and all goes well) possibilities that no one could have predicted. Indeed, the ability to produce diverse solutions is a key driver of innovation, as designers explore multiple approaches.

Likewise, it is difficult to predict how successful these various new ideas and possibilities will be once they are actually tested in the real world—by all those complex human beings who wait at the other end of the design process. Upon interacting with the design in question, these end-users may find it frustrating or functional, confusing or refreshingly simple, mundane or inspiring. For a multitude of reasons, some of which are not easily explained, *good design* fully lives up to that label only when people actually engage with the design and discover that "it works beautifully," or "it just feels right." In those moments, design's power to transform an everyday experience becomes evident: Suddenly, the act of listening to music, living in a high-rise, peeling a potato, engaging with a film, is entirely different and improved. And at that moment, the world—or at least one aspect of living in it—has been changed forever.

Is that change always for the good? Even as design helped tame and shrink and connect the planet, it has also played a role in cluttering, polluting, and overheating it. Some of design's greatest successes have also yielded problems we now must grapple with. And it has made us increasingly aware of the dual nature of the design challenge: Yes, it must strive to make things better, but simultaneously, and always, it must strive to not make things worse. First, do no harm.

Some recognized this dual nature of design—and the responsibility that comes with it—earlier than others. Nearly a half-century before green became fashionable in design, Buckminster Fuller urged designers to "do more with less" and to be conscious of the planet's limited resources. By the 1970s, design activists and writers like Victor Papanek warned us that designers, in the service of booming industry, were propagating far too much unnecessary "stuff," while also giving us (to use just one example) unsafe cars that fouled the environment. Papanek spoke of the moral and social imperative to use design as "an innovative, highly creative, cross-disciplinary tool responsive to the true needs of men."

Today we are seeing a new interest in design's moral and social realm. Designers and leaders such as Cameron Sinclair, Kate Stohr, Emily Pilloton, and John Cary have helped bring empowering, socially responsible design into the limelight. The idea that design—

THE BAR IS RAISED. IT IS NO LONGER ENOUGH FOR DESIGN TO BE CLEVER; NOW IT MUST BE THOUGHTFUL. IT MUST CONSIDER, ANTICIPATE, ANALYZE AS NEVER BEFORE, TAKING INTO ACCOUNT MULTIPLE VIEWPOINTS AND HUMAN NEEDS. IT MUST TAKE THE LONG VIEW ON PROBLEM-SOLVING, RATHER THAN FOCUSING JUST ON THE IMMEDIATE FIX. AND IT MUST BEGIN TO TRAVERSE THE OLD VERTICAL BOUNDARIES AND DISCIPLINES.

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whether architecture or urban planning or new products—can play an important role in empowering people and improving lives has captured our attention and produced extraordinary, innovative work. And there is barely a designer today who is not keenly aware of the imperative to practice environmentally sustainable design.

Having finally come to appreciate that there are consequences to design—and that they can be devastating—we cannot help but alter the way we define and measure "good design." The bar is raised. It is no longer enough for design to be clever; now it must be *thoughtful*. It must consider, anticipate, analyze as never before, taking into account multiple viewpoints and human needs. It must factor in all the variables that can influence how a design will perform (or fail to do so) once it is exposed to the real-world pressures—social, environmental, political, economic—that are

environmental conditions. It's a radical new approach to designing that promises to help designers preempt some of those inadequacies or unintended consequences that, in the past, would become evident only after a building or bridge was in use.

What this means is that we are now beginning to expect *good design* to predict the future and know the unknown—in addition to figuring out what we need, even though we may not realize we need it yet. We want design to do all this and, oh by the way, make it all affordable, functional, simple, scalable, sustainable, and, of course, delightful.

WE ARE NOW BEGINNING TO EXPECT GOOD DESIGN TO PREDICT THE FUTURE AND KNOW THE UNKNOWN—IN ADDITION TO FIGURING OUT WHAT WE NEED, EVEN THOUGH WE MAY NOT REALIZE WE NEED IT YET.

That's a lot to ask of design, and of designers. Fortunately, designers have never been better armed for the task—whether they're conceiving massive machines or developing new building materials, modeling entire cities or rendering 3D worlds indistinguishable from the real thing. This has a great deal to do with the explosion of information and the development of new tools that can help designers access and utilize that information. Good design is nourished and inspired by rich and diverse sources of information, whether it takes the form of documented human experience, lessons from nature, or mathematical algorithms—designers are apt to draw on anything and everything to solve problems.

As more information has become immediately available to designers, new technology is making it possible to connect that vast base of knowledge to the particular design challenge at hand. The result is a potential game-changer. While design, in its essential nature and process, remains, as ever, a uniquely human activity that involves working within constraints, envisioning potential outcomes, and prototyping possible solutions, technology is having an impact at each of these stages. By enabling designers to instantly tap into vast sources of information and analysis previously unavailable or even unimaginable, technology is deeply augmenting the designer's ability to consider more possibilities, try more options,

WITH OUR TOOL SETS FOR DESIGN GROWING SO QUICKLY AND PROVIDING SO MANY NEW APPROACHES, OPTIONS, AND TECHNIQUES, WE NOW NEED TO THINK ABOUT UPDATING OUR MIND-SETS.

different material in a different configuration—might the structure perform more efficiently? Designers are in a position to tap into a knowledge base that instantly tells them what they need to know about available materials and their properties, about the experiences of other designers on similar projects, about product life cycles, or geographic or weather conditions. And if the designer wonders, *How would nature solve this problem?* the answer will soon be readily accessible from massive biomimicry databases—putting 3 billion years' worth of nature's research and development at our fingertips.

Armed with this knowledge, designers can optimize designs by way of tinkering, testing, and refining, done on digital prototypes placed in ultrarealistic simulated environments—in effect, the outside world is being scanned and brought to life on-screen (and quickly: an entire city can be scanned and digitally reproduced in a few hours). These advanced simulations not only help the designer foresee how a project will look and perform but help others see it, too. This kind of sophisticated visualization—showing people what the future will look like before it happens—can be key to winning support for projects, particularly ambitious ones that may be difficult for others to envision. If design is, as the designer Brian Collins has defined it, "hope made visible," then visualization technology can show us hope in high definition.

THE FUTURE OF THE DESIGNER

These revolutionary changes are bound to alter the role of the designer. With our tool sets for design growing so quickly and providing so many new approaches, options, and techniques, we now need to think about updating our mind-sets. One hopeful possibility is that designers will now be able to draw less and dream more. Freed from some of the time-consuming technical burdens of modeling and visualizing ideas, designers can focus more on the exploration of possibilities. This could mean that for the designer of tomorrow, the ability to conceive and communicate far-reaching ideas will be prized

DOES GOOD DESIGN MATTER? THE ANSWER BECOMES MOST CLEAR WHEN WE ARE CONFRONTED WITH THE FAILURE OF DESIGN.

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previous spread: **Emily Pilloton's Design Revolution Road Show championed products like the LifeStraw, which puts clean drinking water within anyone's reach.**

"THE QUESTIONS [THE DIOCESE] ASKED WERE SORT OF IMPONDERABLES: HOW WOULD YOU MAKE A PLACE THAT IS BOTH CIVIC AND SACRED? HOW WOULD YOU MAKE A PLACE THAT IS BOTH NOBLE AND SOARING, YET INTIMATE?"

first century. If we would have replicated a design from earlier centuries, it would convey the message that we don't have the tools or resources in the twenty-first century to adequately glorify God, that we have to imitate. And that is the last message we would want to send through this building."

It was important to the diocese to erect a building that would reflect not only its place in time but also its diverse congregation, which includes speakers of seventeen different languages. Hartman, a modernist perhaps best known for his design of San Francisco Airport's soaring international terminal and the U.S. Embassy Complex in Beijing, explains, "The question was, How do you make a place that has cultural and critical authenticity for today, yet still resonates with this history? That was the biggest design challenge, and inspiration, for me."

The diocese, which had stood without a true cathedral for more than a decade, sought to bring people together by building a place that would first and foremost serve its community. It wanted not just a cathedral but, in essence, a large urban mixed-use project: a two-and-a-half-acre complex with a rectory, clergy offices, a café, a bookstore, a parish hall, a conference center, and underground parking.

Hartman recalled that the Catholic Church has, throughout history, developed and utilized the newest, most innovative ideas in construction methods and technology, such as the enormous stained-glass windows of Sainte-Chapelle and the flying buttresses of Notre Dame, both in Paris.

To design a building relevant for a house of worship, Hartman found his answer in light. "What is the essence of sacred space?" he asks. "For me, that comes down to a question of the nature of light. You can see this quest for the introduction of light in all the great cathedrals."

In creating his design, Hartman's more traditional influences were Eero Saarinen's MIT Chapel and Le Corbusier's Chapelle du Nôtre Dame du Haut, both built in the mid-1950s. "Le Corbusier's building," Hartman says, "is for me one of the great touchstones of modern architecture and the way I think about design. It is about raking light across modest materials." On a trip to New York City, Hartman happened to see two concurrent exhibits of minimalist artists: Richard Serra's "Torqued Ellipses" and Fred Sandback's yarn sculptures. Serra's massive

The diocese had another bold goal for the cathedral: They wanted it to endure for at least the next three hundred years, to declare that it was built not for a specific generation, but for generations to come. "This is where structural design and theology overlap in a wonderful way," says Father Minnihan. "A cathedral is meant for the ages. That is why we strive to use the latest technologies to ensure that it lasts for centuries; a place where the story of Christianity continues to be unpacked and told."

The cathedral was built on a site near two active earthquake faults, so ensuring such longevity was a tall order. Hartman's colleague at SOM, Mark Sarkisian, PE, SE, LEED AP, director of seismic and structural engineering, solved this issue with seismic base isolation technology—essentially floating the structure on a series of thirty-six friction-pendulum base isolators that will allow the building to move thirty inches in any direction during a large seismic event. The bulk of the cathedral could be lifted from its foundation if there were a strong enough crane to do so.

"To try to be reductivist, to reduce it to just the essence, that is what good architecture is about. That is what this building is about," says Hartman. Sarkisian was on board with Hartman's minimalist approach; together they designed all of the building materials to unite in purpose, integrating the architecture with the engineering. "Everything that you see is basically essential. Everything visible in the space is working structurally," says Sarkisian. "It is a very honest structure. The outside shell is tied to the inner core to create greater structural depth. Even the louvers that control the light create the building's shell."

The result is organic and ever-changing; the space is spare but not industrial. "Light is never the same at any two times of the day. It changes day to day, and it changes seasonally," explains Father Minnihan. "What that illustrates is that light is not static but organic. If you consider Christ as light, then Christ is on the move. Here and now."

The visual focus of the cathedral is the "Omega Window," a 58-foot-tall image of Christ holding the Book of Life. Although it resembles a projection, the image is created by natural light passing through perforated aluminum screens.

"WHAT IS THE ESSENCE OF SACRED SPACE?" SOM'S CRAIG HARTMAN ASKS. "FOR ME, THAT COMES DOWN TO THE NATURE OF LIGHT. YOU CAN SEE THIS QUEST FOR THE INTRODUCTION OF LIGHT IN ALL THE GREAT CATHEDRALS."

TIM BROWN

Popular engagement with design is helping us find a balance among what's demanded, what's possible, and what works, according to IDEO's CEO.

How do you define good design?
Good design is all about successfully managing tensions. It's about successfully managing the tension between user needs, technological feasibility, and the viability of business; between desirability, feasibility, and viability; between functional performance and emotional performance. The tension between something that works well and something that connects to people in some deeper way. And it is about managing the tension between what's appropriate and able to be produced, and what's appropriate and needs to be consumed.

When you say managing tensions, does that mean there's an equal balance?
Not at all. You're looking for whatever the best balance point might be for that given situation, which, for different companies, or different markets, or different users, or different moments in time might be entirely different. The process has to include the exploration of multiple solutions.

"There is never a perfect, for all time, completely rational, simple single answer in design. That's what makes design so interesting."

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There is never a perfect, for all time, completely rational, simple single answer in design. That's what makes design so interesting.

How has design evolved over the past decade, a time when some of your ideas about design thinking have taken root?
The scope of design has grown. Designers are now getting invited into a much broader range of conversations than we were twenty or thirty years ago, or even ten years ago. And that increases the opportunity to work on things beyond the next products and services, toward things that have strategic impact: how businesses design themselves and present themselves to their communities of consumers and customers and partners and stakeholders. That's a big change.

And the language of design is no longer the preserve of an elite priesthood, which it had been for a long time. It has begun to be popularized. Which some people don't like. But until you begin to popularize a topic, it's hard to get the kind of broad engagement that I think design needs.

You've seen some resistance to the broadening of design thinking. Where is that coming from?
It comes mostly from designers. [*Laughs*] None of us who are trying to expand the awareness of design believes that design is easy to do and anybody can do it. But I believe that it's understandable by most people, and most people can participate in it somehow.

I've always liked something the writer Virginia Postrel said: I'm an author, but I don't say other people can't write. For me, this is not about saying that there aren't truly skilled, deeply capable, elite designers who are able to


BOEING

NEW ENTRYWAY

Neither Boeing nor its airline customers can do much about endless airport lines or the dehumanizing security process. So the 787's calm, welcoming entry is designed to create a moment of transition—a clear shift from the frustrations of airport-land. Teague's Dowd says, "We wanted to use the moment of boarding as an opportunity to reconnect passengers to the magic of flight." The 787's entryway is arched to create a more open space, and the ceiling is bathed in sky-like blue light. The cabin design also includes oversized windows and wider aisles, which make the plane feel more expansive. After visiting the 787 mock-up, one potential buyer declared, "I didn't realize that the 787 was going to be bigger than a triple 7!" In fact, the new plane is 16 inches (41 cm) narrower than its older cousin.

“WE NOW EXPECT PRODUCTS TO DO MORE THAN FUNCTION,” SAYS RESEARCHER JULIANE TRUMMER. “WE WANT THEM TO PROVIDE US WITH AN EXPERIENCE AND GIVE US MEANING.”

9/11, struggling airlines were eager to boost efficiency. Airbus, meanwhile, had been distracted by the introduction of its A380 superjumbo, so it had no comparable aircraft to sell—leaving Boeing with the field to itself. But efficiency alone didn’t clinch the deal. Emery also credits design advances such as the 787 cabin with helping to spur sales. “When we built the mock-up”—which gave potential customers a true sense of the 787’s experience—“we wanted airline customers to walk into the mock-up and say ‘Wow!’” says Emery. “That’s when sales took off.”

In July 2004, All Nippon Airways ordered fifty Dreamliners for a reported $6 billion, the first 787 order and the single largest for a new jet in Boeing’s history. British Airways, Virgin Airways, and Air Canada soon followed, with the latter’s CEO declaring the 787 a “game-changer.”

The consensus is that the Dreamliner raised the bar for innovation and design that all manufacturers are now measured against. According to aviation expert Jennifer Coutts Clay, “All other aircraft development programs will need to take into account the new standards associated with this aircraft.” Ⓐ

BIGGER WINDOWS

The 787 team knew from the start that the carbon fiber fuselage would allow for larger windows—but how big could they be? The designers built a mock-up at Boeing’s PERC to capture the input of the center’s steady stream of visitors. The resulting windows—the largest in the industry at almost 19 inches (48 cm) tall and 11 inches (28 cm) wide—even give passengers in non-window seats a view of the horizon and bring more natural light into the cabin, adding to the feeling of spaciousness. The windows also feature an innovative electro-chromatic dimming technology that replaces clunky plastic shades.

LED LIGHTING

The initial choice to go with LED lighting was based on cost and energy efficiency: LEDs last 50,000 operational hours, much longer than traditional incandescents. But the design team also took full advantage of the unique capabilities of LED technology because, as Teague's Lau explains, "lighting has a huge impact on how you perceive and experience a space." Designers used optical tricks, such as skylike ceiling lights, to make the cabin space feel larger, and created colorful lighting modes that mimic dawn, dusk, and any time of day in between.

BIGGER BINS

Teague's designers learned quickly that personal storage space is a critical issue for cabin passengers. "We heard a lot of complaints about carry-on luggage," says Dowd. The 787's overhead bins are each large enough to hold three large carry-ons—a nicety for passengers and flight attendants, who won't have to lug the bags of late-boarding passengers up and down the aisle to find empty space. The bins pivot upward, rising toward the ceiling to create more space in the aisle. Teague's team also designed latches that open whether they are pulled down or pushed up. All those details add virtually no cost to the aircraft, but they should deliver real value by expediting the boarding process and reducing the number of passengers who need assistance.

DREAMLINER GALLERY

The multidisciplinary 787 team thought beyond the airplane itself to redesign elements of the sales experience, emphasizing customer touch points that had previously been overlooked. Traditionally, airline teams might spend up to a year traveling from supplier to supplier selecting seats, carpets, coffeemakers, lavatories, and so on, products that are shipped to Boeing for installation. As an alternative to this expensive, time-consuming process, Boeing built the Dreamliner Gallery, a 54,000-square-foot (5,000-square-meter) one-stop shop where airline buyers can view all of the available options in one place, under accurate lighting conditions, and, in some cases, within a full-scale cross-section of the plane. Like so many of the 787's design features, the Dreamliner Gallery reflects a heightened focus on serving the needs of customers.

SPACIOUS COCKPIT

The 787 cockpit was a design challenge: Instrument panels need to accommodate flight and navigation technology, while designers want the space to reflect the newness of the 787. At the same time, Boeing wanted "commonality"—industry jargon for cockpit configurations that are consistent across different aircraft models to reduce pilot-training costs. To strike the right balance, the 787 team relied heavily on the input of pilots themselves. The result: The cockpit borrows the arched ceilings and larger windows of the passenger cabin to enhance the feeling of spaciousness. The color scheme draws on the gray and black of titanium and carbon fiber. New ergonomic seats, a digital instrument panel with larger screens, and heads-up displays provide a more comfortable workspace. Lastly, commonality means that captains who have flown Boeing's 777 will need just five days of training to adapt to the 787.

JOHN CARY

The social architecture leader explains how good design promotes human dignity.

What are some of the challenges that America is facing in its built environment? What power does design have to address them?

The two greatest challenges are the economy and expectations. There is some real attention being paid to some of our most challenged cities, like Detroit, Baltimore, and New Orleans. But the scale of economic despair facing those cities is pretty unprecedented.

Design in this environment can easily be seen as frivolous, as a luxury, and as nonessential. Yet this is a moment where design is needed more than ever to raise expectations; design can dignify otherwise very unfortunate conditions and human experiences.

Think about what design could do for a homeless shelter, to enhance education, to improve care and recovery within a hospital environment, to improve the quality of one's experience in virtually any and every kind of space. There's just so much need in terms of improving the quality of our built environment.

How does design dignify?

In my opening essay in *The Power of Pro Bono*, a book that represents the culmination of my long tenure as director of the nonprofit Public Architecture, I start off by painting a picture of design disparities to illustrate opportunities to dignify. Often in the same city, there are technologically sophisticated grade-school classrooms, with natural light and every imaginable accessory to enhance learning and stimulate the experience of students and teachers alike. In another school across town, there's not even chalk or Kleenex. The kids are sitting at rickety desks. There's the buzz of fluorescent lights above them. There's no technology whatsoever.

Holding images of those two environments side by side, there's no question that one will—in every way that we can expect—lead to better outcomes, better students, higher-quality education, improved literacy rates, etc. It doesn't take much effort to look at the quality of an environment that is reserved for people who can afford it versus the ones that are reserved for the rest. It's imperative that we get those more in balance.

It sounds like there is a choice, a moral choice to put human dignity at the center of the undertaking.

Absolutely. Furthermore, this is a really unique time in our country and for all strata in our government and society. Overall, I think that everyone is looking for impact. People are searching for new meaning around public life. Design can increasingly play a role in those things.

Design does that through example. Having some really successful projects and products to point to is an incredibly handy thing, and I'm not sure we had as much of that in the past. A lot of current public-interest design projects carry really compelling narratives that appeal to non-designers.

Do you have any favorite examples of public spaces with great, meaningful design?

There's a space on the South Side of Chicago that is home to an organization called SOS Children's Village Illinois. It reunites foster children with their biological parents and houses them in this community for extended periods of time. The building was designed by Studio Gang as a community center, and it truly serves as an anchor. It is a safe place while these families go through these transitions, but


GET
EXCITED
AND
MAKE
THINGS

"WE NEED TO CHALLENGE THE DESIGN WORLD TO TAKE THE 'PRODUCT' OUT OF PRODUCT DESIGN AND DELIVER RESULTS AND IMPACT RATHER THAN FORM AND FUNCTION."

geodesic dome, and Victor Papanek, author of the 1971 book *Design for the Real World*. More recently, important groundwork was laid down by the likes of Alice Waters, the celebrated chef and local-food agitator, and Paul Hawken, an advocate for sustainable business practices. That tradition gained a new sense of urgency and—thanks to the Internet—momentum, as growing numbers of designers and creative professionals sought to integrate social responsibility into their work. Pilloton, now twenty-nine, is one of the movement's leading voices, joined by such designer/activists as Cameron Sinclair and Kate Stohr, authors of the architecture-focused book *Design Like You Give a Damn*; Bruce Mau, the force behind the book and traveling exhibition *Massive Change*; and Valerie Casey, founder of the Designers Accord, a sustainable-design initiative.

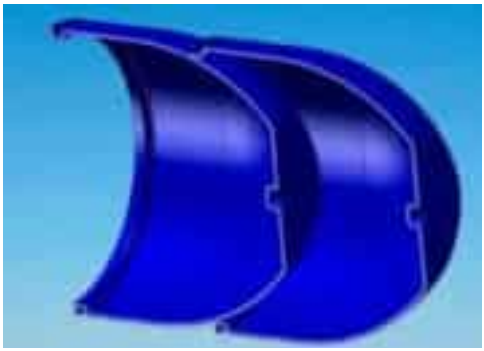
"The tide is turning," Pilloton writes in her book, in an essay clearly intended to wake designers from the haze of consumerism. "We need nothing short of an industrial design revolution to shake us from our consumption-for-consumption's-sake momentum." In making her case for a new breed of "citizen designers," Pilloton lays out the tools and tactics needed to spark her revolution, including what she calls "The Designer's Handshake." Part code of professional conduct, part blueprint for personal action, the Handshake commits those who sign it "to serve the underserved" and "to use design as a tool to empower people."

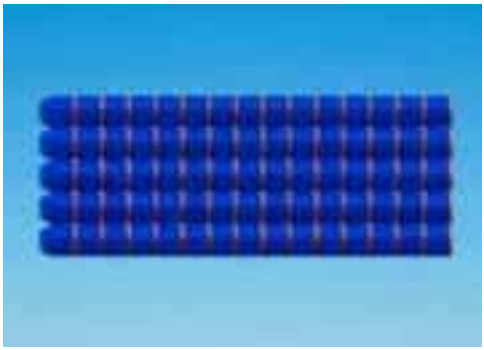
"It's time to stop talking and start walking," Pilloton urges. As if to lead by example, she has since taken off on her own at a fast clip.

On February 1, 2010, Pilloton and her partner, Matthew Miller, an architect and Project H coconspirator, kicked off a cross-country publicity tour. Rather than flying from city to city for book signings, the couple hitched their Ford pickup to a 1972 Airstream trailer rebuilt to serve as a rolling gallery for forty of the products featured in the book. Dubbing it the Design Revolution Road Show, the duo then set out on an 8,000-mile trek, stopping at thirty-five design colleges and high schools between San Francisco and Savannah, Georgia.

Pilloton eschewed the traditional book tour, in part because of her contrarian streak. "I've always associated being like everyone else as a bad thing," says Pilloton, who started a calculus club at her Northern California high school and points to guerrilla artist Shepard Fairey as a source of inspiration. But more than that, the goal of her tour—with its lectures and hands-on demonstrations of designs intended to

After leaving the corporate world of design, Pilloton and her Project H partner, Matthew Miller (top right), staged the Design Revolution Road Show—a traveling, hands-on exhibition of designs meant to improve lives. Among the featured products were, clockwise from middle right: the Whirlwind RoughRider wheelchair, which can withstand rigorous rural landscapes; adaptive-lens eyeglasses that can correct vision for nearly 90 percent of patients; the Hippo Roller water carrier; and Spider Boots, which safely raise the feet and legs of land mine clearers.





CREATING IMPACT

Project H looks beyond products to create impactful humanitarian design solutions

Emily Pilloton's Project H aims to broaden design's social and human impact. Its six tenets of design focus on solving the world's real problems and on helping to put new tools in the hands of those who need them. According to Pilloton, this requires a shift in the way designers think about their work and who it serves, leading to a broader concept of design as something that grows from the bottom up to transform lives.

Roller in use, her design work was done back home in San Francisco. "We were so enchanted by the potential of this object that we forgot about the people. It was incredibly arrogant, and it was 'design as charity,' not design as empowerment and user engagement."

Her redesign of the Hippo Roller—intended to make it easier to manufacture and distribute—was not realized. "We learned a lot from seeing it fail so terribly," she adds. Her studio now works only locally, for example. And it helped them discover and focus on their strengths as designers, such as design for public education.

Another Project H effort, perhaps its most successful to date, exhibits that focus. The Learning Landscape is a playground originally designed to teach math. Created in 2008, the Learning Landscape is a sandbox filled with a grid of partially buried tires, each numbered in chalk. Intended for use with an accompanying lineup of games that combine physical play with educational exercises, it was first introduced at the Kutamba AIDS Orphans School in Uganda. Today there are ten built and more on the way. The system is free, open source, and easily built in a day.

The Learning Landscape is a clear demonstration of Project H's core values, but over time the specifics of the organization—its structure and the kinds of projects it takes on—have evolved. Gradually, Project H shifted from an organization with international chapters and a global approach to humanitarian design, toward a U.S.-based effort with a small core group, led by Pilloton and Miller. The shift didn't represent a retrenchment so much as a refinement; Pilloton had always believed in co-creation—designing with users rather

Pilloton and Miller's current focus is "Studio H," an ambitious design education project in Bertie, North Carolina. The high school–level "design/build" curriculum is meant to spark development in the rural community through real-world projects. The studio's thirteen students learn design thinking through intensive hands-on education, as well as construction skills and critical thinking.

PILLOTON DESCRIBES STUDIO H AS “SHOP CLASS WITH A PURPOSE.” “ONCE WE STARTED TALKING TO THE STUDENTS, TOGETHER WE BEGAN TO VISUALIZE OTHER PROJECTS,” SHE SAYS. THE STUDENTS DIRECTED THE PROJECT’S AMBITIONS. NOW, THIRTEEN 11TH-GRADERS IN THE STUDIO ARE WORKING TOGETHER TO DESIGN AND BUILD A FARMERS’ MARKET IN DOWNTOWN WINDSOR, NORTH CAROLINA.

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MOST OF US LOOK AROUND AT THE WORLD AND SEE WHAT IS. DESIGNERS HAVE AN UNCANNY KNACK FOR ENVISIONING WHAT MIGHT BE. BUT WHAT INSPIRES THESE FRESH VISIONS OF NEW POSSIBILITIES? WHAT CAUSES THEM TO BEGIN TO TAKE SHAPE?

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previous spread: **Inside Thomas Heatherwick's Seed Cathedral at Expo 2010 Shanghai**

SIR KEN ROBINSON

The creativity expert describes the constant creative dialogue between speculation and judgment.

What are your thoughts on the relationship between creativity and design?

I always feel it is relevant to first back up and offer definitions of *imagination*, *creativity*, and *innovation*.

To me, the fundamental capacity is imagination. It's where everything comes from—the ability to bring to mind things that aren't present to our senses, to step outside of the immediate sensory environment and to form images in consciousness of other places, other possibilities. That may be the fundamental gift of human consciousness.

Creativity is a very practical type of process. It's the process of having original ideas that have value. Innovation is putting original ideas into practice, trying them out, testing them, and applying them. I think of innovation as applied creativity.

Those three ideas are really continuous. And design, in the way it's commonly termed, is a very deliberate application. I think of design as a subset of creativity.

Is the nature of creativity changing? Or is it a fundamental of the human psyche?

I don't think the fundamental nature of creativity is changing. Yet some things are changing. There are more and more tools available for creative work. There's always been an intimate and powerful relationship between technology and creativity.

The tools themselves are always neutral. They rely on the intentions of people. It's all about the possibilities people see in them and the opportunities the tools provide for imaginative work.

I think they are changing the game in two respects. They are allowing many more people than ever before, probably in history, to be involved in creative work. These are tremendous instruments of the democratization of creativity. Particularly, I'm talking about online tools. They have a reach that is unprecedented.

Second, at the heart of these technologies is the principle of collaboration. There's a tendency to think of creativity as a solo performance, but for the most part, it's not. It's about people working together. Online tools and social media tools make available mental collaboration that has simply not been seen before.

What fosters the creative spark in the three domains that you've described, imagination, creativity, and innovation? What kills it?

The human spirit, the spark for creativity, can be sparked by absolutely anything. Anything could be a starting point, a point of entry. But there are all kinds of things that will stop it and that will prevent it.

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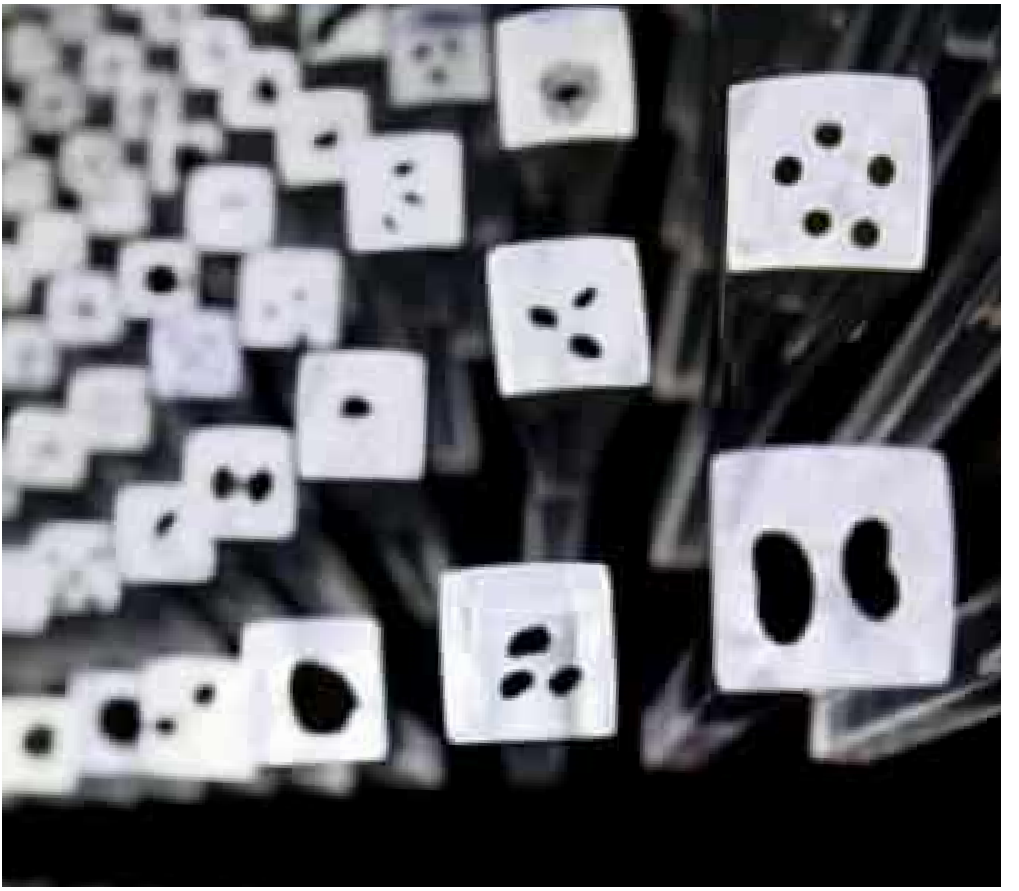
"Tools themselves are always neutral....It's all about the possibilities people see in them and the opportunities the tools provide for imaginative work."



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WHILE MANY PEOPLE HAD HEARD OF KEW GARDENS' SEED PRESERVATION EFFORTS, NO ONE HAD SEEN THE SEEDS.


UK Pavilion

She is referring to the Sitooterie II, a smaller pavilion the studio designed for the National Malus (crabapple) Collection in Barnards Farm, Essex. The permanent pavilion is designed to encourage guests to "sit oot" and enjoy the grounds, and is named for a Scottish term for just such a structure: a Sitooterie. Much like the Seed Cathedral, the 25.8-square-foot (2.4-square-meter) Sitooterie boasts 5,000 hollow "staves" glazed at their tips, which act as miniature windows. The play of light extends both inward and outward. In the evening, the Sitooterie projects an array of light through its numerous staves, creating a dappled burst of color in the middle of the field.

Heatherwick's studio collaborated with Adams Kara Taylor Engineers to ensure that the arrangement of the filaments took into account the fact that they sway and quiver. This required the architects and engineers to work and communicate within a highly detailed 3D modeling system. In addition to milling the filaments and their sleeves to the exact specifications of the parametric model (which also guided the computer-driven milling machine), there was the added complication of embedding the seeds.

Wolfgang Stuppy, a seed morphologist and director of the Millennium Seed Bank Project, acted as a consultant for the Pavilion. He was an invaluable resource for describing the qualities and tolerances of the various seed specimens. Stuppy and his associates at Kew's sister institute in China, the Kunming Institute of Botany, set out to curate a seed collection that achieved the highest possible diversity within the physical limitations of the Cathedral, including both surplus material of wild species from the Kunming Institute as well as cereals and legumes available locally. When the structure is eventually dismantled, the rods will be sent to schools in the U.K. and China.

The seed as a symbol of life could have become clichéd or overwrought. Heatherwick and his team avoided these trappings by working through an honest form-making process, and through collaborating with highly specialized consultants.

Troika, a London-based design firm, articulated some of the ideas presented in

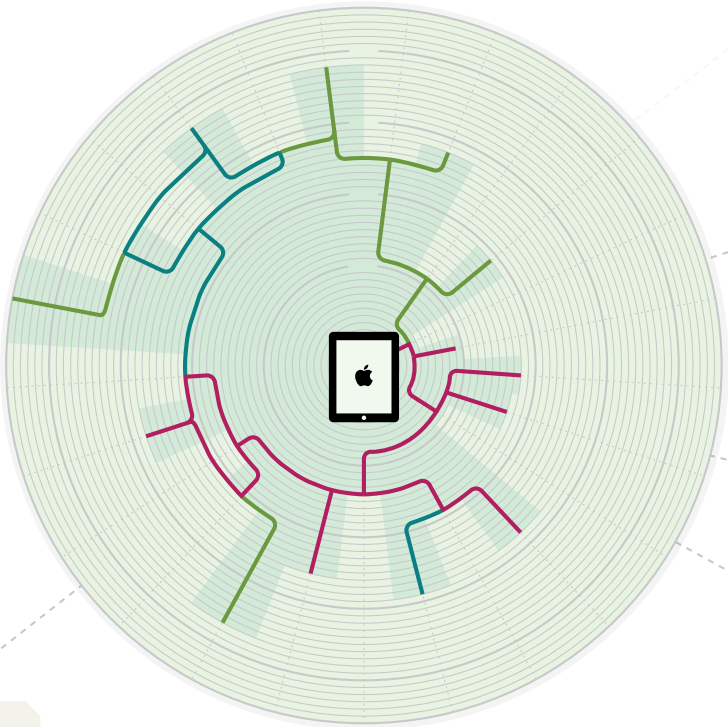
THE ORGANIC MATERIAL INSIDE THE SEED CATHEDRAL IS ENCASED IN SO MANY GLIMMERING, UNDULATING SURFACES THAT, AT TIMES, IT SEEMS THE INTERIOR IS COVERED IN A HIGHLY STYLIZED MOSAIC OF METALLIC TILES.

the U.K. Pavilion with a three-part exhibition: "Green City," "Open City," and "Living City." "Green City" is a map that isolates the green spaces of four British cities. Rendered in bas-relief Astroturf, the map adheres to the canopy of the Pavilion's entrance. Visitors then move through "Open City," in which a series of icicle-like models depicting various British buildings clings to the roof. The organic material inside the Pavilion is encased in so many glimmering, undulating surfaces that, at times, it seems the interior is covered in a highly stylized mosaic of metallic tiles. The play of reflective opacity and translucence makes the interior a dizzying array of light that feels at once fully enclosed yet discreetly linked to the outside elements. In this way, the Seed Cathedral almost behaves as if it were a living organism, interacting with its habitat. This is heightened by the fact that all of the service-related spaces in the Pavilion are tucked beneath its outer grounds. "We wanted to give the impression that everyone who visits the Pavilion has access to all spaces," explains Dionysopoulou.

Upon exiting the Seed Cathedral, visitors encounter "Living City," where they first glimpse living plants, which run along the canopy in a faultlike depression. The 30 species chosen for this display can all be used for medicinal purposes. These ancillary exhibition materials ensure that the experience of visiting the Pavilion is edifying on multiple levels, and that its organic, nature-inspired themes are presented with a fresh and sophisticated sensibility.

That these private spaces are hidden speaks to one of the unique elements of the Pavilion: Only a fraction of the Pavilion's space is taken up by the Seed Cathedral. The rest is an active, engaging landscape and popular public space. That space, like the "dandelion" sitting at its edge, is also metaphor made real. The multiplanar park is meant to seem like the creased folds of wrapping paper, as if the Seed Cathedral were a freshly opened gift to China. A

What visitors found inside the Seed Cathedral was open to their own interpretation. The thousands of fiber-optic bristles created a dramatically lit space that was also an oasis of calm in the hyperstimulating environment of Expo Shanghai.



Shoulders of Giants
s of some of the iPad's technologies
ck centuries.

1703
Mathemetician Gottfried Wilhelm Leibniz invents and publishes the modern binary system.

1783
George Atwood builds the first accelerometer in order to demonstrate Newton's first law of motion.

1820
Thomas de Colmar patents the Arithmometer, the first mass-produced portable calculating machine.

Like most real-world design problems, the limitations of FIRST's rules—and the fact that each team receives the same set of standard issue parts to build their robot—is a primary instigator for creative solutions. With Kickoff behind them, the teams were now cast into *Build Season*. Teams read lists of rules and opened up their boxes of parts. Then it was time to brainstorm and work out how they would face the challenge to design, build, and program a robot for the challenge. They hoped to build something capable of winning their regional competition, go to the national championships in Atlanta's Georgia Dome, and beat the field. That was the plan for at least two different teams in 2010—each with a varied approach.

BUILD SEASON

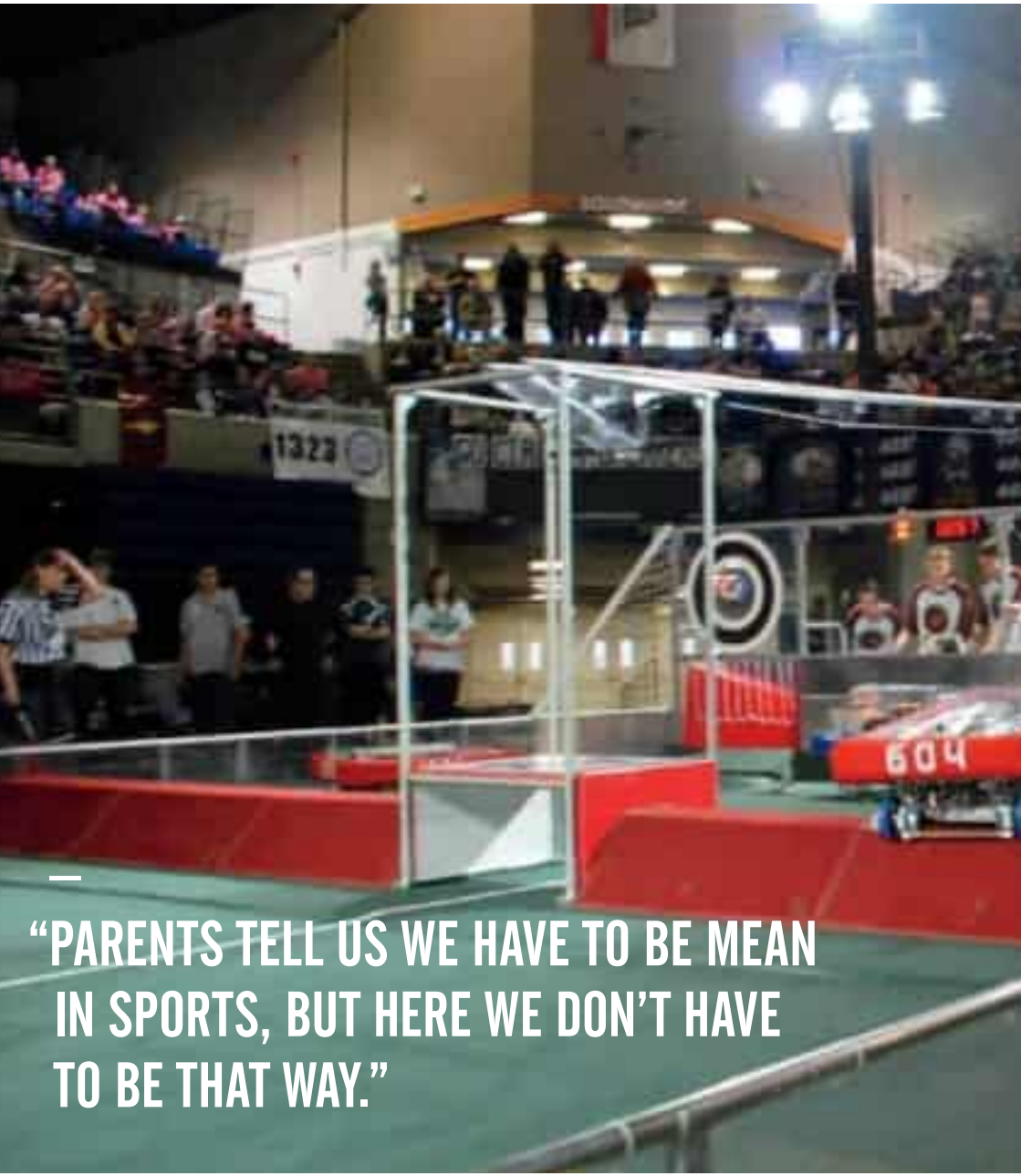
Oregon City is a city of twenty-five thousand just south of Portland, Oregon, and home to FIRST Team 2550, OCPRO—the three-year-old Oregon City Pioneer Robotics Organization. In January, Team 2550 hosted fifteen other teams for its annual "all-nighter," its pre-Announcement sleepover. After the Announcement, Team 2550, in typical community-outreach mode, helped some of the regional rookie teams to brainstorm before huddling around their own well-used whiteboard.

Team 2550 was founded in 2007 by Roger Collier and Sean Hally, two dads who sought an extracurricular challenge for their sons. After stumbling on FIRST's junior Lego league robotics, the dads moved to the more advanced Robotics Competition and patched together a team of students from local high schools. The dads, joined eventually by five other adults, serve as mentors and coaches to the students but take a largely hands-off approach.

In brainstorm mode, the team's concepts and designs started flowing. Each new idea brought questions that launched debates. The team began to set priorities: First they had to build a robot that would *move*, then a robot that *scored*. Wouldn't it be cool to build something like a *Star Wars* AT-AT walker? What about a circular- or triangular-shaped robot? How about a monster-truck design, a lowrider, or a Formula One design? Should they try to build multiple subsystems or focus? "We had to decide if we wanted to score in every way or specialize in one thing," recalls Andrew, an eighteen-year-old team member.

Discussions on form led to questions of function. Should their robot be designed to go over the bumps or under them? That choice, they decided, would most shape their design and subsequent building. *Over*

The limitations of FIRST competition, including the necessary tasks for robots to complete and the stock set of parts, roughly define how FIRST robots will look. Yet those limitations are a primary instigator for the students' creative solutions. Every FIRST robot presents unique adaptations to those limits; as a group, the robots evidence the enormous creativity and effort of the participating teams.



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“PARENTS TELL US WE HAVE TO BE MEAN IN SPORTS, BUT HERE WE DON’T HAVE TO BE THAT WAY.”

was a programming group that used Java, C++, and LabVIEW coded for the robot movements; electronics and drivetrain groups; a manipulator group; and team spirit, design, building, leadership, fundraising, business, and marketing groups. Two weeks into Build Season, Team 604 had completed the CAD for most of the initial robot design. The team and its mentors invited in local engineers for a design review. The review was a way to hear criticism that would tighten the team's design, and it followed what one mentor called a "corporate model." The visitors' concerns were primarily about the lifting mechanism. After looking carefully at the range of options for scoring points, the team decided to scrap the hanging arm mechanism and to instead build a superb kicking mechanism.

Once the team finalized general concepts, various prototypes were made to test the concepts. A select group of team members, primarily seniors James and Eugene, then worked out the details of every design and put them into a CAD program. As the digital model grew more complete, the team found some constraints it had to follow (such as limited motion of the kicker due to space constraints). The team tried to tweak its prototypes to match the model and see if they would still work. First-year students Tyler and Sebastian helped with the digital rendering of the robot. They realized that they would need shock mounts to hold the robot's battery—its heaviest part—and Tyler ran stress tests in the CAD software to test the battery's forces and the forces on the spokes of the wheels. Tyler designed the wheels and then machined them with his dad's assistance.

Build Season was soon over, and the team had moved through a lot of ideas. Initially, the team was going to use a pneumatic-powered kicker, but it found that when prototyped, the force generated was weak compared with a superior surgical tubing–powered kicker. Originally, the

The 2010 FIRST competition (above) was a form of robot soccer, with each team scoring points for goals. In the final seconds of a match, teams could earn extra points by connecting their robots to a tower in the middle of the field (below) and having it lift itself at least 30 inches (76.2 cm) off the ground.

"THERE ARE INFINITE POSSIBILITIES WHEN SOLVING A PROBLEM," SAYS TEAM 2550'S KRISTINA. "AMONG THE HUNDREDS OF TEAMS THAT COMPETED THIS YEAR, ONLY ONE TEAM CAME UP WITH THAT SOLUTION TO FUNNEL THE BALLS. THAT WAS BEAUTIFUL."

—

them out of aluminum. "Just knowing that my design was going to be cut out on a lathe was such a great thought," says Andrew.

Meanwhile, the electronics team, chaired by first-year students Oliver and Morgan, tore apart the robot. After four weeks of careful designing and building, they disassembled the frame and rebuilt it in forty-eight hours. Morgan, fifteen, saw himself as a tinkerer first, then a builder, and not necessarily a designer. "I'm not good at imagining things and getting them down on paper," he says. "I'll give input and analyze design." From an outside point of view, though, it's clear that all of the team members are deeply engaged with design—often, design as a seat-of-the-pants, learn-as-you-go operation. "I love working on it with my hands," adds teammate Oliver. "We knew what we needed to do," recalls Morgan. "The design formed as we worked."

At the Portland Regional games in early March, their shiny custom-machined metal wheels showed up just in time and fit into a newly designed chassis with a higher wheelbase. A poorly placed pneumatic solenoid was ripped off by a chain, but the team managed to quickly rebuild it.

Team 2550 landed fortieth out of sixty teams and, for a second year in a row, won a coveted Engineering Inspiration Award, which recognized the huge amount of work that the team had done showing off its past robotic creations and otherwise inspiring young people in its community. The award also qualified the team for a trip to the national championships in Atlanta. "Inspiring others," says team captain Amy, fifteen, "is part of our normal."

"What people don't really get is that it is not about crushing the opponent," says teammate Ryan. "We call it gracious professionalism." Says thirteen-year-old Kristina, "If we are in a competition here and another team needs a charged battery, and we have one, we'll hand it over." Sixteen-year-old Clarissa continues, "Parents tell us we have to be mean in sports, but here we don't have to be that way."

DESIGN AND REDESIGN

Team 604, in its first competition at the Sili-

DEAN KAMEN

The famed innovator says invention begins with banishing the fear of failure.

How does design begin for you?

It starts with looking at a need or a problem and seeing a way to approach it that nobody else is doing. It may be a challenge everybody else has looked at before, perhaps for decades—but you look at it and maybe you see an opportunity at the intersection between a newly available technology and this old problem. And suddenly you say: "Hey, maybe we can do this differently."

Usually, for [my company] DEKA to take it on, it has to be something that will have an impact: "If I can do this, it'll improve the lives of lots of people." Then I look at the resources I have around me: Smart technology people with a broad base of interdisciplinary capability. And we'll get together and ask, "Can we collectively design a system that's likely to be accepted by the world?"

If we can convince ourselves that we can design a twenty-first-century solution to a problem that is currently being addressed with a nineteenth- or twentieth-century perspective—well, we'll give it a shot.

At those early stages, how do you gauge what's possible to do and what isn't?

That's a question I think about all the time. But you never really know the answer. Sometimes, after you've decided to take on a tough project, things start going badly. And that's when you roll around in bed at night and wonder, *Is it time to face reality and move on? Or is this one of those times where you're in a dark spot but the big breakthrough is just about to happen?* If you've had even one of those breakthroughs, I think it convinces you that you shouldn't give up. Every once in a while you succeed at something and you are chilled by the thought, *Wow, only six months ago, we were about to kill this project.* I can look at every project we're working on now and know that some will succeed and some will fail. My big frustration is not knowing which are which.

You take on a broad range of projects. What do they have in common?

People say that we work on so many different types of things—a diabetes pump or a dialysis machine, a way to make water, a way to make power. Yes, they're different, but I see them as all the same. It's about using a new approach and new technology to try to change the world in some way. Sometimes people talk about "the world of design," and it's about designers getting together at conferences and pontificating. That doesn't interest me. Instead, I think we should be focused on "the design of the world," meaning, the world is a certain way, but we want to use our understanding and whatever tools we have to try to impact that.

"We should be focused on 'the design of the world,' meaning, the world is a certain way, but we want to use whatever tools we have to try to impact that."

CONTI'S LATEST BOAT FANTASY WAS A WAY FOR HIM TO ANSWER THE SIMPLE QUESTION THAT HAD PLAGUED HIM FOR YEARS: "IS THERE A BETTER WAY TO GO TO SEA?"

the problem of motion on the sea, not just motion as the cause of motion sickness, but motion as a problem of safety and stability for watercraft. His new boat creation would be founded on the idea of flexibility in the water: "Not fighting the waves, but dancing with the waves," Conti explains.

As anyone who spends any length of time on the open ocean can tell you, the amount of pitching that a boat does in the face of wave action is significant. As a sailor for more than thirty years, Conti held an idea in his head that there had to be a better way. "The boat itself would adapt to the waves instead of fighting through or smashing them or jumping them," he says. "I kept working on this idea. When you're old, there's very little to lose."

For Conti, committing to building a new boat was a big step. Doing so meant jumping into the task head on, working 12- to 14-hour days, seven days a week. "I started thinking about ways to really go outside the box completely," recalls Conti. "When I retired, quote unquote, I just decided to go for it. My wife was absolutely resistant to another boat business, because when I build a boat, I don't exist. I'm capable of doing that because I get obsessed. Nothing else exists, and that's what I do. And at the end, you don't understand anything anymore because your brain is cooked."

The morning decision to turn a fantasy into a dream led Conti (and his wife) to found Marine Advanced Research, undertake four years of initial boat development, raise more than $500,000, and build three separate prototype boats within eight years.

"I think if you go down deeper," says Conti, "the motivation is to create something that doesn't exist. There's an attraction to that. It's not something I'm copying. I'm doing something completely new."

In the Conti way, when you are building things that don't exist, modeling on a computer is not the fastest or least expensive approach. Modeling, beyond being slow and expensive, often stifles experimentation. With boats—and planes, for that matter—there's a problem with modeling and scale, says Conti. "You know those little airplanes that they make out of balsa wood? They put an engine on them. They go like hell because it's not linear; it doesn't scale."

As Conti shared his nascent idea of the Wave-Adaptive Modular Vessel (or WAM-V) with experts and colleagues, he was advised to use computer models. But what he wanted to make had no easy computer model solution, because there was no precedent for a flexible boat. In a world that runs heavy on computer-aided design, Conti is a rare breed in that he prefers to

Insects such as water striders (top right) were another inspiration for Conti, who was attracted by their flexibility on water. It turned out that his craft's flexibility needed to be controlled; modeling in Autodesk Inventor (bottom right) helped turn Conti's ideas into a buildable, sailable boat.

"I THINK IF YOU GO DOWN DEEPER, THE MOTIVATION IS TO CREATE SOMETHING THAT DOESN'T EXIST. THERE'S AN ATTRACTION TO THAT. IT'S NOT SOMETHING I'M COPYING. I'M DOING SOMETHING COMPLETELY NEW."

work with his hands. "I'm an old-fashioned experimentalist," he says. "I stick my fingers in stuff."

Conti finds it easier to model things in his head and build with his hands. "I see things in 3D, and I can turn them around and feel if they work or not," he explains. "I can think of what to do physically. I'm not a computer person anyway, so I have to make it, because I have to see it, touch it, drive it." (As it evolved and neared production, the WAM-V was brought into Autodesk Inventor 3D modeling software.)

Conti is unique—an inventor who spends time thinking about how his ideas are born and what genre of invention they will fall into. There are three types of inventions, he says. A "one whammy" is a better mousetrap, and it has a good chance of success. A "double whammy" is not only a new thing but something that people will have to learn before they can use, which often poses too great a threat to any sort of adoption or sale. A "triple whammy" is something new that you have to learn, but "it's a fantasy that catches the imagination. It's a new species."

"Working without knowledge" is something Conti talks about a lot. "I have an intuition, and first they tell me that I'm crazy. Then I solve a problem that they have been working on for months without knowing what the hell it is. And I solve it, just out of intuition."

For Conti's new boat idea—building a boat that would be suspended above waves like a four-wheel-drive Jeep over rocky roads—the model he would build was 50 feet long. He called it POF, for "Proof of Feasibility." Built out of carbon fiber with manufacturing defects, it failed during an early test—which seemed to prove his critics right.

"I started with completely flexible legs, everything flexible. It didn't work. I actually built a prototype, and I went out in the San Francisco Bay and tried it. You can say, 'Well, wasn't that a little stupid?' because it cost money and effort—tremendous effort on my part. For physical reasons, it's not that simple. It has to be a certain size to try.

"The error was this idea of complete flexibility. I was studying insects. They're extremely efficient, and they're flexible. But they're also controlled. So if you have flexibility without control, it doesn't work."

Conti says that making the WAM-V was more like building a car than a boat, because it has components that move in relation to one another.

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THE BOAT ITSELF WOULD ADAPT TO THE WAVES INSTEAD OF FIGHTING THEM.

TO SPEAK OF DESIGN IN TERMS OF "PROCESS" IS TO INVITE DEBATE. WHILE THERE ARE THOSE WHO VIEW DESIGN AS SOMETHING THAT OCCURS METHODICALLY, IN AN ORGANIZED SEQUENCE OR SERIES OF STEPS, OTHERS SEE IT AS A VERY DIFFERENT PHENOMENON—ONE THAT RESULTS NOT FROM FOLLOWING A PROCESS BUT RATHER FROM THE UNIQUE VISION AND TALENT OF THE INDIVIDUAL DESIGNER. WHO'S RIGHT? UNDOUBTEDLY, BOTH SIDES ARE.

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previous spread: **Zaha Hadid Architects' Chanel Mobile Pavilion, whose form evolved from spiraling shapes in nature**

The Shanghai Tower is divided into distinct "vertical neighborhoods," each anchored by a sky lobby at its base. The light-filled lobby spaces will create a sense of communities within the large skyscraper.

client—a consortium of three state-run entities—calls it a symbol of "a nation whose future is filled with limitless opportunities" and a celebration of "China's economic success."

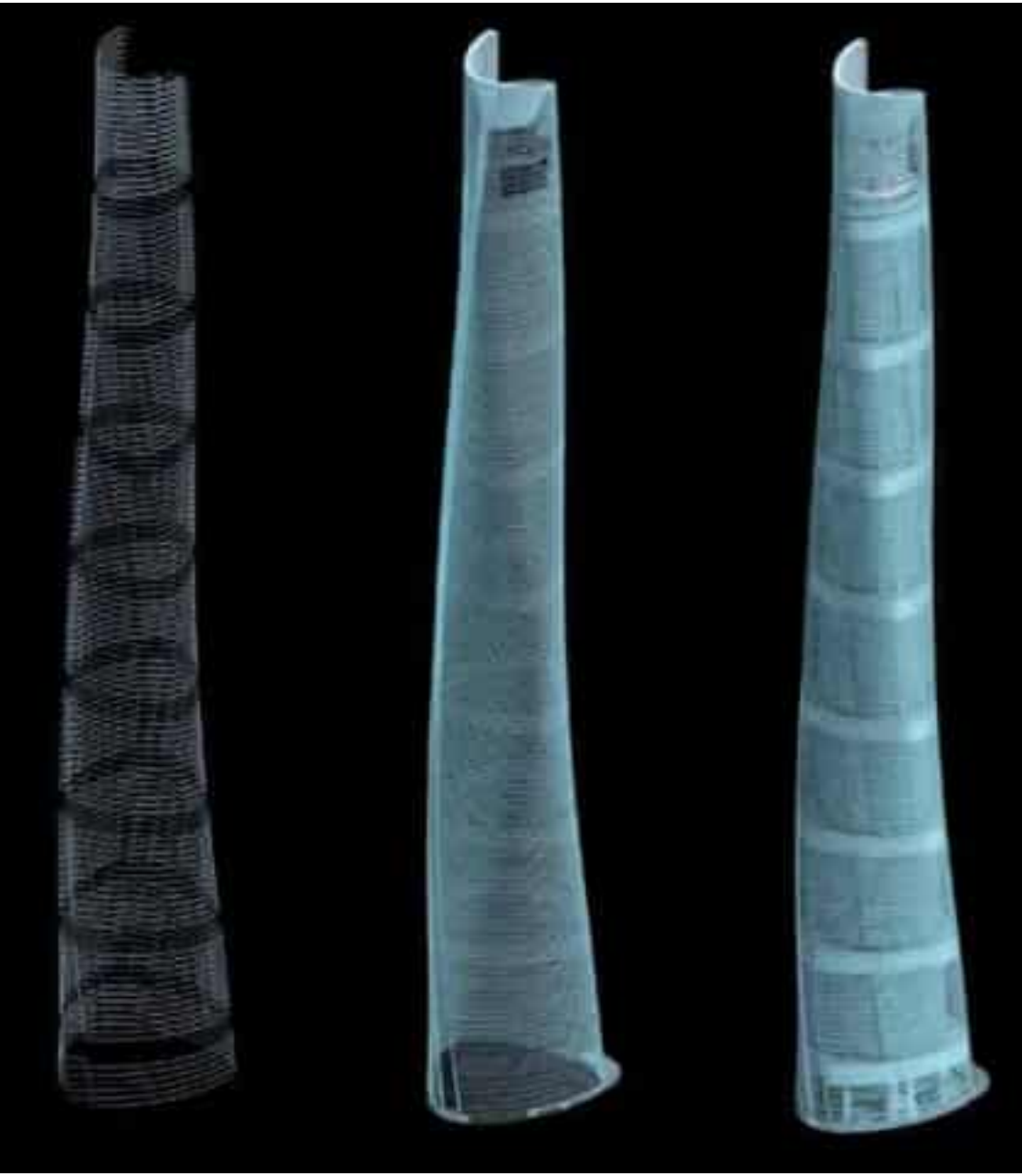
Gensler could seem an unlikely candidate for the job. The largest architecture firm in the United States, it has plenty of high-rises to its credit, but its tallest building to date is the fifty-four-story Ritz-Carlton Hotel & Residences and JW Marriott at L.A. Live; the Shanghai Tower will rise 121 stories. In 2008, the forty-five-year-old firm won a competition to design the Shanghai Tower, beating out a field of major firms all eager for this opportunity. "We wanted to create something unique, beautiful, and appropriate for Shanghai," firm founder and chairman Art Gensler says. "And we had the most successful design solution." Gensler also has a pragmatic approach to design that informs everything from its giant interiors practice to its skyscrapers. Consider the firm's Workplace Performance Index, which gauges the link between employee productivity and corporate office design. Gensler tackled the Shanghai Tower the same way: performance first.

It's a method that cuts to the very geometry of the building. From bottom to top, the tower rotates 120 degrees, tapers, and has a long notch up its back that looks like the seam of a twisted stocking. "The notch breaks the force of the wind, and the twisting sheds it," says Gensler. "By incorporating those features into the design, we were able to reduce the structural loads dramatically." These measures slash material costs as well as wind loading.

You can imagine the kind of gusts you get at the top of a 2,074-foot (632-meter) skyscraper surrounded by other skyscrapers. Now imagine the skyscraper in a typhoon. But why not a 90-degree rotation? Or 210 degrees? Why not a pinpoint taper? Or no taper at all? By modeling various options in 3D software and then conducting wind-tunnel tests, the design team discovered that a 120-degree twist and 55 percent taper combination reduced wind

Digital models (right and following page) represent, from left, the tower's structure, composite floors, inner skin, hub-and-spoke supports, outer skin, and the complete composite building.

The tower will complete Shanghai's "super-high-rise precinct," next to the Jin Mao Tower and the bottle-opener-shaped Financial Center. The trio symbolizes Shanghai's past, present, and future.



SOFTWARE HAS PROVED ESPECIALLY INTEGRAL TO THE FACADE. IT'S A DESIGN CHALLENGE UNRIVALED ELSEWHERE IN THE BUILDING, TASKED AS IT IS WITH NEARLY EVERY PERFORMANCE GOAL IMAGINABLE.

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HUGH DUBBERLY

A design innovator argues that design learning is a prerequisite for design thinking.

You have said that design is stuck. What do you mean?
Design practice does not learn. As a profession, we don't even know *how* to learn.

We're stuck. Trapped in the past. Unable to move forward. Unclear on what forward might mean. Lacking mechanisms to build and share knowledge. Lacking even a model of design knowledge.

In fact, the problem is so structurally embedded, so pervasive, so deep, that we don't see it.

Can you give an example?
In 1985, in Boston, the AIGA held its first national conference; speakers included Nicholas Negroponte (a famous technologist) and Milton Glaser (a famous designer). Twenty years later, the AIGA conference returned to Boston and again included Negroponte and Glaser.

In his 2005 speech, Negroponte talked about the One Laptop Per Child project. Glaser showed some beautiful posters and talked movingly about human rights.

What struck me was how much things had changed in Negroponte's world and how little things had changed in Glaser's world.

During the intervening twenty years, computing power, storage capacity, and network speeds doubled more than ten times, while costs remained roughly the same. Personal computers grew from toys to necessities. Mobile phones, the Internet, and social networks arrived.

During the same twenty years, the big changes in design were not about design; they were about technology—computers and the Internet. Changes forced on Glaser's world by Negroponte's world.

The world of computers evolves. Like the worlds of biology and physics, it has learned how to learn. It bootstraps existing knowledge to create new knowledge. That's what academic disciplines do, but it rarely happens in design.

Why not? What's holding design back?
The short answer is art schools. Most design programs are housed in art schools. And art school teaching still follows a medieval model: master and apprentice.

Studio courses are mostly about socialization—sharing and creating tacit knowledge through direct experience. Students learn by watching one another. Teachers rarely espouse principles. Learning proceeds from specific to specific. Knowledge remains tacit.

Practice is much the same as education. Over the course of a career, most designers learn to design better. But what they learn is highly idiosyncratic, dependent on their unique context. The knowledge designers gain usually retires with them. Rarely do designers distill rules from experience, codify new methods, test and improve them, and pass them on to others. Rarely do designers move from tacit to explicit.

—

"Drawing and form-giving are *not* the essence of design. Seeing patterns, making connections, and understanding relationships are."

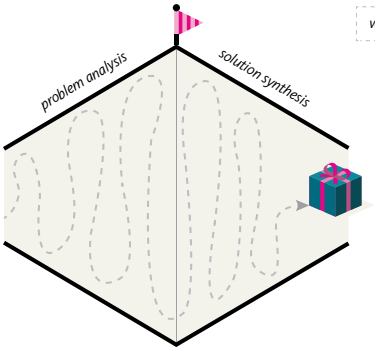
SIX DESIGN PROCESSES

Diagramming the ways we design

These illustrations represent the most common design processes. Some are suited to solo or small-team projects, while others are tailored to large, complex projects with multiple stakeholders and outcomes.

Diverge & Converge

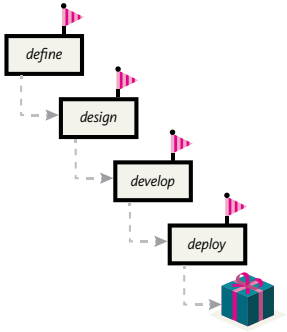
At some point, most design processes incorporate this fundamental archetype of analyzing a question, expanding on possible solutions, then synthesizing those possibilities down to an optimal solution— even if that solution is another question.



word clouds reflect the emphasis of each archetype

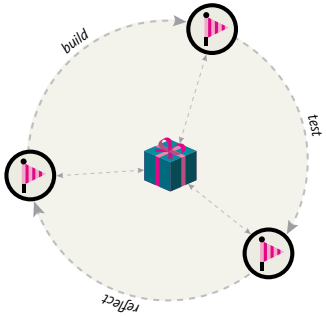
Waterfall

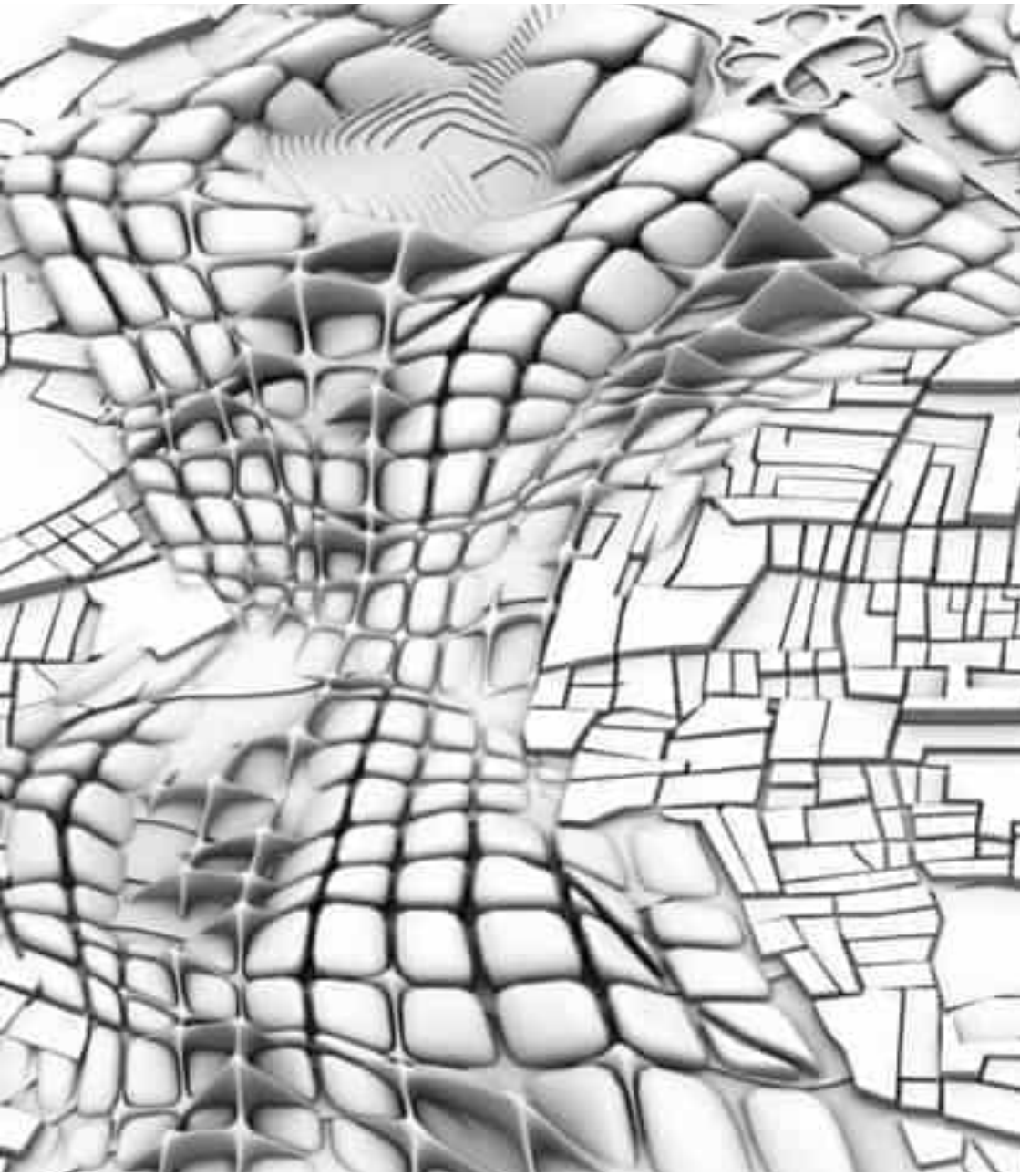
In this archetypal linear process, a design project moves from one distinct phase to the next only after the previous one is complete. This approach, which is commonly used in software design, often focuses on implementing variations of previously tested design solutions.



Cyclical

The cyclical process emphasizes prototyping, testing, and reflecting on results before beginning the cycle again. This process is suited to incorporating feedback at each step on the cycle, which can keep the design user-focused.





same time, the resulting geometry is varying at each point."

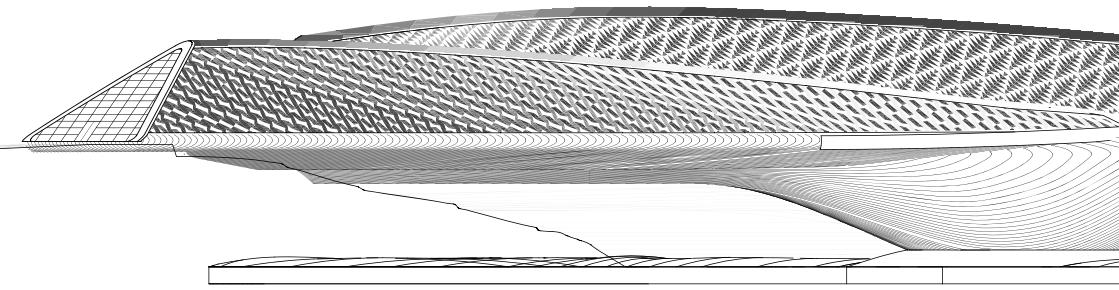
The more layers of information input into a model, the more dynamic the result. According to Fischer, "the ability to manage or interweave more and more complex data into a clear solution is a kind of key to success for high-quality design." For Spain's Zaragoza Bridge Pavilion, ZHA created a hybrid pedestrian bridge and exhibition space that spans the Ebro, one of Spain's most voluminous rivers. The resulting 886-foot (270-meter) passageway comprises four "pods" that act as both structural support and shelter for exhibition-goers. The firm's most recent bridge project, the Zaragoza Bridge Pavilion required both sophisticated engineering systems and a sensitively designed interior experience. The structure withstands the force of the river while the interior and exterior traverse it, defining the form of the bridge/pavilion.

According to Fischer, this approach requires both a facility with increasingly complex modeling systems and strong management skills: "Technology makes available more and more parameters, so we have to judge the relevance of data and strategize at a very early point in time." Sixty percent of ZHA employees have basic programming knowledge, and there are managers who help shepherd the design process. The studio also employs a couple of programmers who are able to develop tools to bring more and more data into the architects' repertoire.

Instead of feeling overwhelmed by the glut of information, Fischer and other architects who use parametric modeling use their increasingly content-rich data sets, visualized and understandable in highly intuitive 3D environments to get ever closer to design. And for a firm like ZHA, the real-time feedback regarding economic, structural, and environmental viability enables the studio to find clients who will sign off on seemingly inconceivable programs.

Whether used for a traveling building, like the Chanel Mobile Pavilion, or an entire cityscape like the Kartal-Pendik Masterplan, parametricism changes the manner of construction and level of efficiency. "I think a key part of our work is to demonstrate the viability of our designs, because at the end of the day, if we can't sell it, it's not architecture," says Fischer. With great accuracy, ZHA can assure clients at a very early stage of the process that their parametric models are buildable in ways that, ten years ago, would have seemed completely unfeasible to the average client. Ⓐ

For the Zaragoza Bridge Pavilion in Zaragoza, Spain, ZHA researched the potential of a diamond-shaped section that would offer both structural and programming opportunities. The diamond structure is able to distribute force along its surface while maintaining a triangular pocket of space beneath the structure, which can be used for exhibition space.



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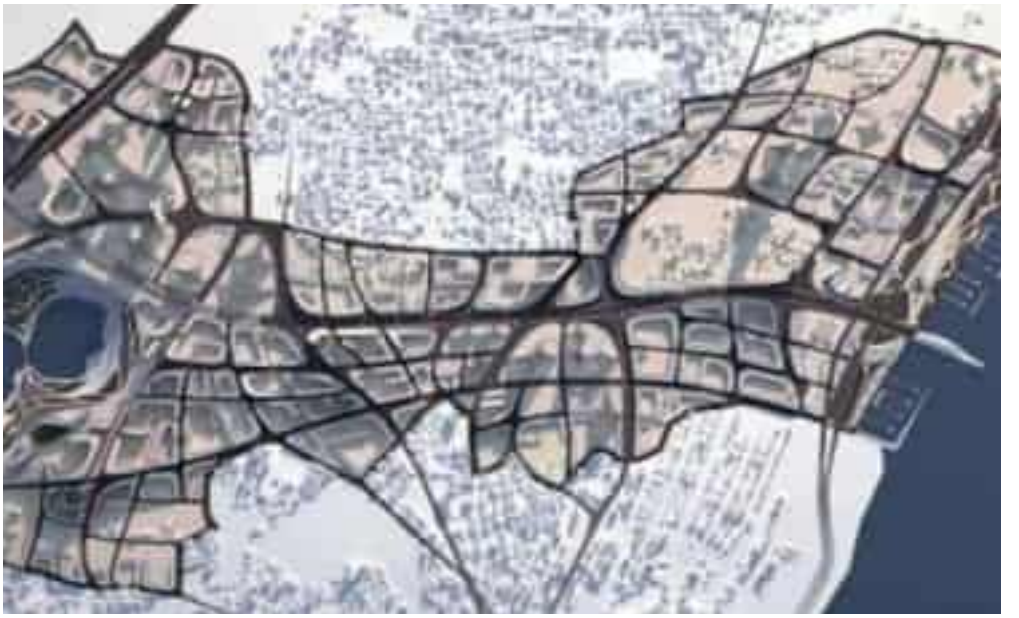
FOR A FIRM LIKE ZHA, THE REAL-TIME FEEDBACK REGARDING ECONOMIC, STRUCTURAL, AND ENVIRONMENTAL VIABILITY ENABLES THE STUDIO TO FIND CLIENTS WHO WILL SIGN OFF ON SEEMINGLY INCONCEIVABLE PROGRAMS.



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IN A BURST OF CONTEMPORARY CREATIVITY, ZAHA HADID ARCHITECTS HAS EXPLOITED THE CAPABILITIES OF PARAMETRIC RENDERING TOOLS TO CREATE PROGRESSIVE BUILDINGS AND WHOLE CITYSCAPES.

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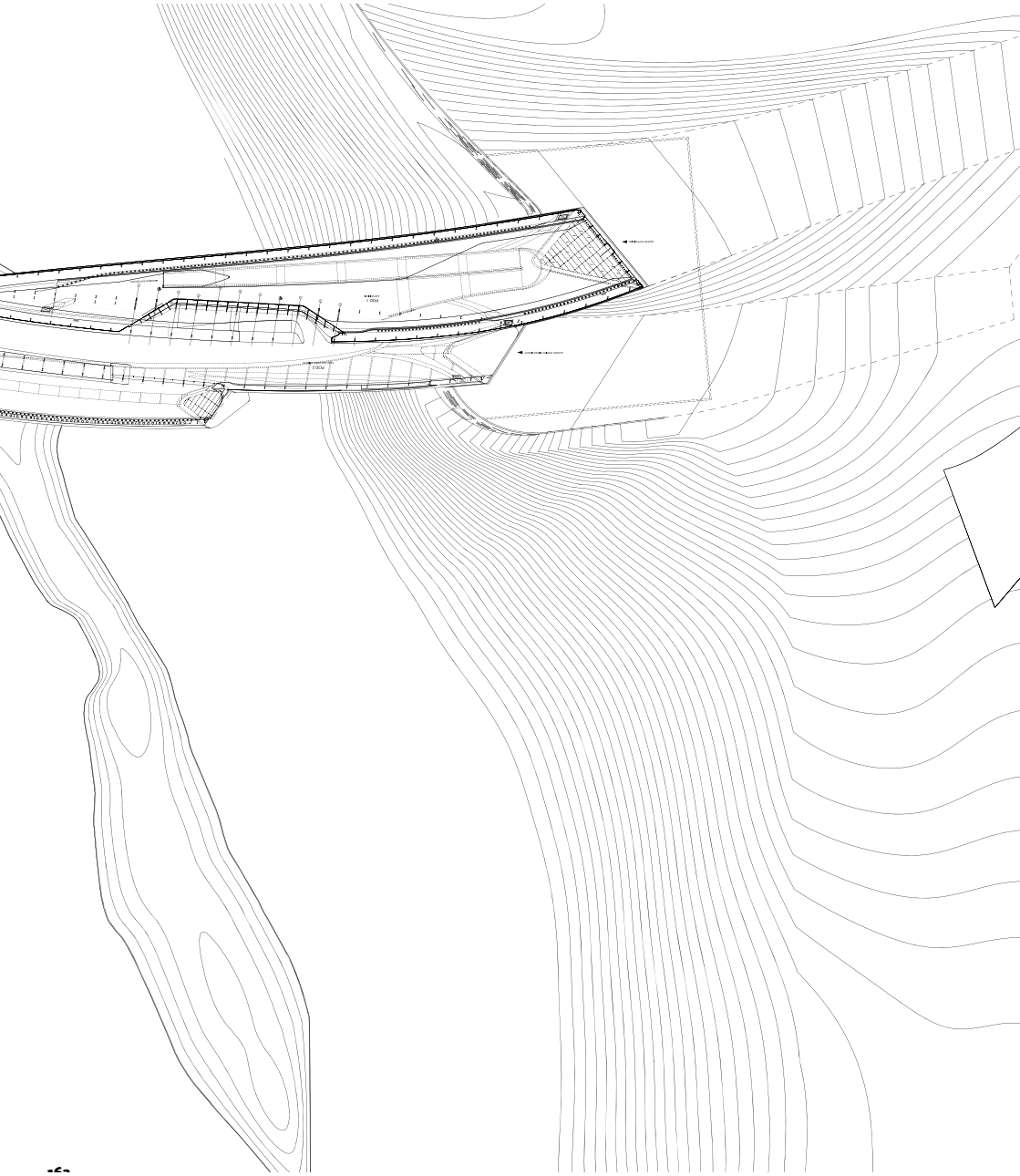

"Understanding how to harness the new process and how to build computation design models may require a new way of thinking on the part of the designer."

—

ROBERT AISH

A computing leader describes emerging tools and processes for design.

Design computation, the use of computing to generate and analyze form and performance, seems to mark a change in the way designers think. What is significant about design computation?

Until recently, the majority of design tools used computer-graphics technologies to mimic the way users interact with existing design media. The engagement between the designer and subject, as mediated through these design tools, is very similar to the designer interacting with the original physical media.

With design computation, designers have the possibility to create a framework within which they can generate and explore different design alternatives.

What's different about using design computation in practice?

I would characterize the difference between a regular design application and a design computation application as the difference between a word processor and a spreadsheet.

Let's say I'm working out my mortgage. With the word processor, I can make a table of numbers and add them up. The numbers might not add up properly, but the program doesn't know that. I am not constrained: Anything goes.

With a spreadsheet, you define relationships. You set up rules for the mortgage calculation. Here I want to be constrained to the underlying mortgage calculation, because I want to play "What if?" What if I buy a bigger house or the interest rate goes up? It may not be worthwhile to use a spreadsheet for a single calculation, but if you anticipate exploring alternative scenarios, then you understand the value of designing your own spreadsheet. Once you've done that, you can play "What if?" And you get, potentially, much more interesting results.

It's up to you to build the model that works for you. With the spreadsheet, as with design computation, you have to spend some time setting up the rules that you think are important. Then you can play "What if?" on two levels. You can play within that one set of rules, or you can change the rules and play within a different set.

How does one approach design using a framework?

The designer is creating a framework within which he can make a "design exploration" by generating and evaluating alternatives. To do that, he has the opportunity to reformat the design process into a system with inputs and outputs.

What are the input or "driver" variables that will be used to generate the alternative design solutions? These might include aspect ratio, floor-to-floor height, column spacing, percentage glazing, etc. What are the measures that will

“ORIGINALLY WE WANTED TO BE THE SAME THING TO EVERYBODY, EVERYWHERE. NOW, WITH EACH BRAND, WE’RE REALLY LOOKING AT EXPERIENCES THAT ARE MORE UNIQUE, AND WE’RE ALSO EXPANDING INTO DIFFERENT MARKETS AND DIFFERENT AREAS.”

—

“Over the past few years, owners, franchisees, and especially guests have become far more design savvy, as they’ve digested it through magazines, popular media, and television shows,” says Bauer. “Our hotels have had to be far more sophisticated in their approach to design. We’ve really had to amp up the amount of design that goes into our hotels.”

Almost all of the hotels in Marriott’s large portfolio are not owned by the company itself but by separate hotel owners or franchisees. These owners turn to Marriott initially to brand their properties—and then to continue to change and upgrade them over time with Marriott’s focus group– and research-driven new ideas. A typical hotel sees a “soft” upgrade every three years and a larger-scale “hard” upgrade or renovation every six years—such are the demands of the industry for change.

These days, Marriott is essentially an innovation company in which a constant loopprocesses consumer research and yields new and different hotel alterations. In recent years, for example, this has included transforming once bare lobbies into more engaging spaces. With each innovation comes a slew of concepts that need to be vetted by a range of interested parties, including Marriottexecutives and the owners of the many hotels.

With the rising importance of design, old ways of working hindered Marriott’s forward progression, cost it a lot of money, and slowed down its time to market with new concepts. All of this has meant that time-tested techniques for altering and modernizing hotel interior design had to be streamlined and made more efficient. Across the board, Marriott has turned to a range of sophisticated technologies to address change in its products—from lamps to entire lobby redesigns.

Listening to executives from Marriott’s broad design team discuss the changes that have swept the company, one hears a constant refrain of “in the past” versus the present. Thanks in large part to the implementation of Autodesk software, workflow has been quickly migrating from 2D to

to make sure that they are appropriate for the goals of the initiative," says Deborah Huguely, vice president of product development. "With a quick click of the button, you're testing out fabrics, patterns, colors, architectural features, and lighting styles."

Huguely was one of the Marriott executives in charge of proving the concept of using 3D visualization to approve new ideas and room designs. The big idea was that instead of actually building new rooms and lobbies to gain consensus and approval, such "building" would happen on the computer. Large photos could subsequently be printed and hung to give a sense of the actual scale of the new environments. It was a bold idea with the potential to save a lot of time and money—but it was also a big change.

Huguely and her group created a 3D model of a guest room that happened to be one built in Marriott's corporate headquarters and that all the participating executives knew well. "We did a review of that 3D model for our senior executives and presented the photographs," she explains. "Those photographs represented the room, as well as how we would see it in advertising. We showed them to the executives, but did not tell them that it was the 3D model. They said, 'Oh, this is great. Now show us what you can do with 3D modeling.' And we said, 'Well, you're looking at it,'" says Huguely. "We said, 'Aha!' We had broken through. We could move forward with getting reviews from our owners, our franchisees, and our senior executives on design and innovation."

Visualization, or digital prototyping, in essence replaces the centuries-old process of model building, material selection, and drawing. In the past, Marriott used AutoCAD for just building and design documentation. Now, designers at the company are using AutoCAD software to make vivid 3D renders and photorealistic depictions of guest rooms and lobbies. One example of the new process is a recent décor

Marriott's designers presented new room and lobby visualizations on life-sized walls, allowing property owners to experience the designs in full fidelity and in a way they were comfortable with from past design reviews.

IN THE PAST, THE TEAM WOULD CREATE A PHYSICAL PROTOTYPE, WITH LIGHTING, FABRICS, AND FURNITURE, AND DISPLAY IT IN AN EXISTING HOTEL LOBBY. TYPICALLY, THIS PHYSICAL PROTOTYPE COST $250,000 AND GREATLY DISTURBED HOTEL GUESTS.

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THE IMPACT OF TECHNOLOGY ON DESIGN OVER THE PAST HALF CENTURY HAS BEEN UNDENIABLE. BY AUGMENTING HUMAN SKILLS AND, IN PARTICULAR, BY AUTOMATING SOME OF THE MECHANICAL ACTIVITIES ASSOCIATED WITH THE DESIGN PROCESS (SUCH AS SKETCHING AND MODELING), NEW TOOLS HAVE ENABLED DESIGNERS TO WORK FAR MORE EFFICIENTLY. BUT EFFICIENCY IS ONE THING AND EFFICACY IS ANOTHER. ARE THE TOOLS OF DESIGN ACTUALLY HELPING TO PRODUCE BETTER DESIGN?

—

previous spread: **Parsons Brinckerhoff built a complete 3D digital model of its SR 520 Bridge replacement near Seattle.**

CAMERON WANTED AVATAR TO FEEL ABSOLUTELY REAL. THAT MEANT HE NEEDED A WAY TO DIRECT THE ACTORS IN EACH SCENE USING TRADITIONAL FILMMAKING TECHNIQUES, SUCH AS FINESSING TIMING AND POSITIONING TO AMPLIFY THE TEXTURE OF EMOTIONAL EXCHANGES.

the essentials of a scene were just a director, a camera, and an actor. That, in turn, enabled Cameron to bring a more human touch to his computer-generated film.

"When you see photos of Cameron on the set of *Avatar*, you might think of those shots of Cecil B. DeMille shouting through the megaphone at his actors," says film professor Bob Rehak of Swarthmore College. "In some blockbusters, you know the director is in there somewhere, but you know others supply the razzle-dazzle. Cameron's system puts him back into the filmmaking process, so we understand him to be the author of the film—not just a cog in an elaborate production."

The virtual camera was a relatively late addition to *Avatar*'s production process, and it started out as a clever hack. On a cue from his friend Rob Legato, the visual-effects supervisor from *Titanic*, Cameron started looking for a device that would help him control the camera movement in *Avatar*. His production team had already designed an entire Pandora world of plants, trees, and animals, rendered in low-resolution 3D inside its computers. The trick, as Cameron envisioned it, would be to create a device that could capture a camera-like view of this world in a realistic way.

Cameron asked Hollywood camera and prop expert Glenn Derry to build something that might get the job done. A relentless tinkerer, Derry had worked on the animatronic dinos in *Jurassic Park* early in his career, and he now runs Technoprops, a small electronics-prototyping workshop in Los Angeles. "The only resources I had at my disposal were Jim, who pushed the concepts, and the software coders, who connected it to Autodesk MotionBuilder [animation software]," Derry recalls.

Derry started by modifying a traditional camera. He hollowed out the film mechanism, removed the eyepiece, and replaced it with a small video screen. A piece of software called Overdrive recorded the camera's moves through the virtual space, while engineers at Derry's shop prototyped hard nylon buttons for zoom, film speed, and other controls and then coded the electronics to talk to the software. Covering

INSIDE HIS VIEWFINDER, HE SAW SOMETHING VERY DIFFERENT: THE LUSH TERRAIN OF PANDORA, WHICH HE COULD NAVIGATE AND SHOOT AS IF IT WERE A PHYSICAL SET.

like sophisticated video games rather than photorealistic movies—but nevertheless, the virtual camera could grab their performances from any direction and provide a useful perspective on how the finished scene would look.

With the new equipment in place, the shooting schedule proceeded like no animated film before. First thing in the morning, before the actors arrived for work, Cameron would walk around the motion-capture soundstage with the virtual camera, scouting Pandora for appropriate locations for the day's shoot. Handmade plywood platforms matched the terrain of the virtual world, reproducing the alien planet's bumps and valleys exactly. Later, the actors—say, Sam Worthington (who played Jake Sully) and Zoe Saldana (Neytiri)—would arrive on the motion-capture stage covered in reflective dots. They would play the scene using the powers of imagination to envision themselves as 9-foot-tall blue creatures, surrounded by Pandora's exotic plants, vines, and ferocious beasts. But as seen through Cameron's virtual camera, the scene unfolded with all those features in place as he established the exact camera angles he wanted to use in the film.

Feature films are typically shot using both wide and tight camera shots in the same scenes to provide a variety of perspectives on the actors' performances. To do that for *Avatar*, Cameron waited until the end of the day, when the motion-capture room was empty. Alone again in the space, he would replay the scenes that had been captured that day—including the actor's performances and the 3D backgrounds—through the virtual camera, so that it looked as if the scene was unfolding right in front of him during a live-action shoot. He could walk around this world, picking new camera angles for additional shots or reshooting the original camera work from the live performance. "We always shot in real time, but whether Jim chose to use that camera move was up to him," says Derry. "Typically, Jim wanted a more refined camera move, so he would look for something better later."

When he was satisfied, Cameron's work with the virtual camera captured a final scene that functioned as the template for the way it would look in theaters. From there, the template was shipped to animators at Weta Digital, who replaced the relatively crude, video-game-style backgrounds with high-resolution art and digitally manipulated the characters' gestures to enhance their subtle facial expressions. For anyone who saw *Avatar*, the intricate detail and verisimilitude of the final product are unforgettable.

Handheld virtual cameras allowed Cameron to direct performers at the same time as he manipulated the rendered, virtual scene within the computer.

PETER SKILLMAN

The product-design veteran discusses the origins of the design impulse—and the next step in the evolution of our design tools.

Where does good design originate for you? How do you lead and foster the design spark outside of yourself?
I took a class from a Bay Area figurative painter, Nathan Oliveira, many years ago. He was part of the Bay Area Figurative Movement that included David Park, Elmer Bischoff, and a number of other people. We were in the studio, and he had just painted this incredible abstract expression of a hawk's wing. It was from a series of paintings he did based on found objects. I asked him whether he had just created it or whether there had been a big process that had resulted in it—and does the process matter?

His answer has really influenced my thinking about process and how you manage design, how you can influence it, and how you inspire people. He said it doesn't matter if you implement a structured process or if, in a flash of inspiration, you just create something without any process at all.

People in business school have been trying to train and manage creative people for decades. It usually fails, because it's so unbelievably difficult to manage the process of creativity. It was Linus Pauling who said, "If you want to have a good idea, you have to have thousands of ideas." And Einstein said that if an idea doesn't sound absurd at first, then there's no hope for it.

You have to let this messy process go on, sometimes in the absence of process, and just trust that creative people—with the right amount of support and input and even critical design reviews—can do something great. Then you have to find out which people would benefit from process and which people are better left alone.

What can spark good design is often letting go, and other times you need to micromanage it. And the genius in managing great design is in deciding when to apply the right rules based on your empathy for the problem and the individuals and teams involved.

That sounds like it's more of an art than a science.
What Nathan Oliveira said is that it doesn't matter. As long as a solution is great, it doesn't matter how you get there. In the context of what I learned at IDEO, originally it was enlightened trial and error succeeding over the lone genius. But I've since learned through many examples that another completely valid way to manage or inspire people is the lone genius succeeding over enlightened trial and error.

Dennis Boyle taught me that a picture is worth a thousand words, and a prototype is worth a thousand pictures or ten thousand words. Nurturing those vulnerable things is really important. I also think that communities and teams benefit from diversity, and in my experience, teams with women are always better than all-male teams—and cultures for that matter.

Another thing that is important in making good design happen is that you must connect to how things are made. That concept is really being challenged with the rapid loss of manufacturing to Asia. If you don't connect to the processes of how things are made, you really lose your ability to design effectively.

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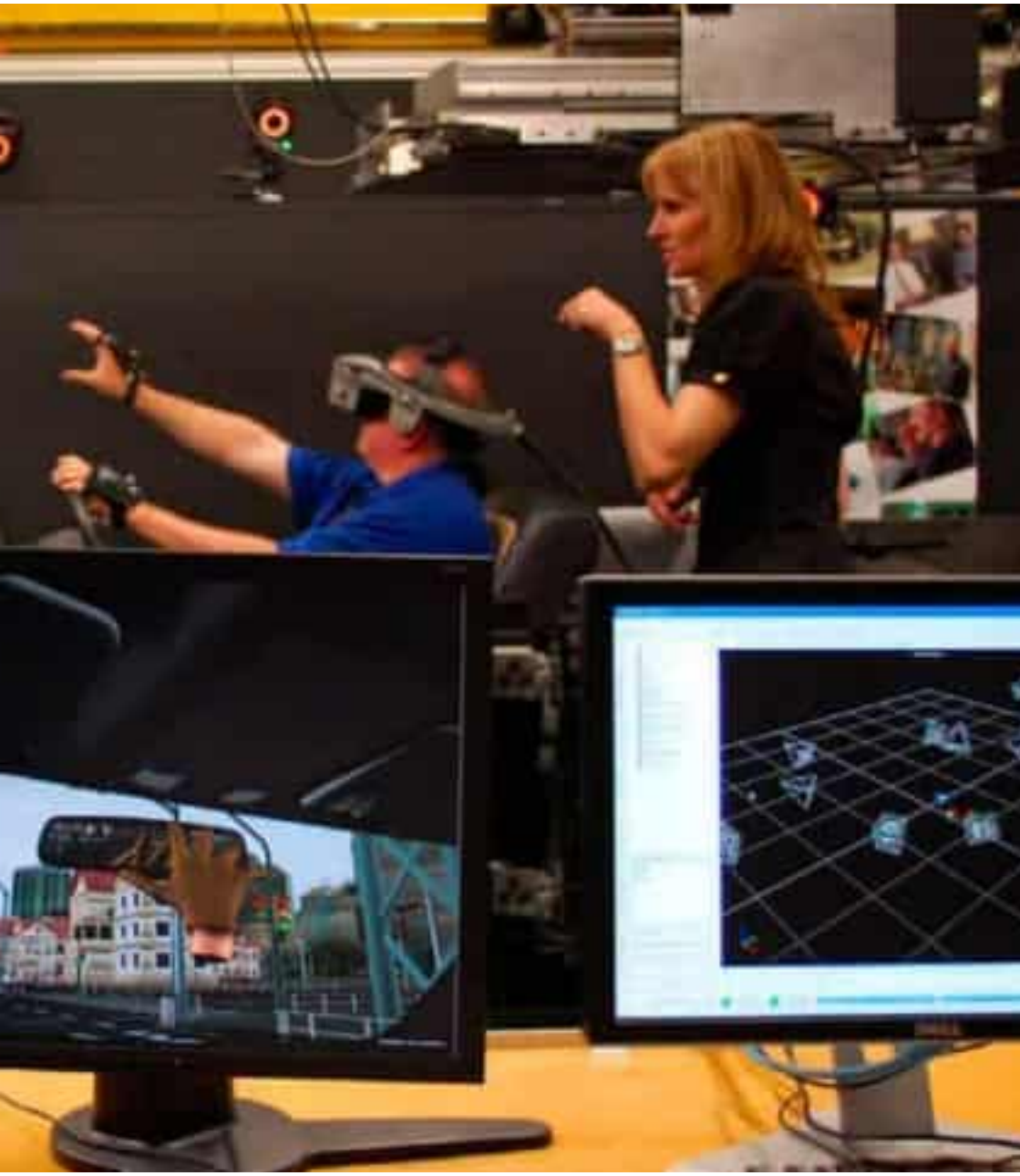
"Ultimately, tools and technology can give you the power to create mediocrity on a vast scale."



manufacturing experts. Engineers use them to adjust early prototypes. Interior designers use them to test cockpit ergonomics. Market researchers don virtual-reality helmets to evaluate their appeal.

In the case of the 2011 Explorer, the process began with four designers sketching on tablet computers and then meeting to compare notes in a room called the Advanced Visualization Center. Superficially, the Advanced Visualization Center looks like a typical conference room, with a couple of meeting tables, a phone, and a big screen at one end. But when the lights go out and the Powerwall lights up, the space is transformed into a large-scale virtual-reality chamber for visualizing vehicle designs. "As designers, we knew we had to reinvent the Explorer for the twenty-first century," says Mel Betancourt, exterior design manager for the 2011 Explorer. "We tried to look at how we could modernize things to appeal to a younger demographic."

For the 2011 Explorer, Betancourt's team created digital sketches of a vehicle with distinctly muscular details, such as a sporty bump in the hood above the engine that's called a "power dome." To give the Explorer a more modern feel, one designer suggested blackening out the structural pillars on each side of the windshield so that at a quick glance, the roof looks cantilevered. But would those ideas look right on a family vehicle? The Powerwall enabled designers to judge for themselves by looking at high-def models of the new concepts and a dozen other variations. Ford's design team looked at new grilles, new body colors, competitors' vehicles, and even competitors' vehicles that morphed into their own prototype—all while working with images that were nearly indistinguishable from photographs, even

hues across three shades of color depending on the viewing angle.

Of course, the most important test will take place in the showrooms, when the Ford Explorer arrives. That's when Ford will at last learn if enough consumers gravitate toward the new vehicle to again make it a best-seller. Yet even after the launch, Ford's digital renderings will continue to represent the essence of what the new Explorer is about, by appearing in billboards and magazine ads that will be seen by millions of potential customers. "Our computer-generated images look better than a photo," admits Nowak. "The reflections and highlights are better, so we use those images to show the vehicles in their best light." Few potential car buyers will ever know that they are looking at a vehicle that doesn't actually exist in physical form. Fewer still will understand that the digital images represent the final stage of Ford's digital design process. But if Ford is right and the Explorer's bold design plays a role in making it a hit, few are likely to care. Ⓐ

Though the 2011 Explorer began with a concept sketch, high-quality digital renderings were a driving force through its many iterations on the way to market.

"Once you use this model-based approach and compare it to the traditional design process, you find that the benefits outweigh the investment."

—

JAY MEZHER

Parsons Brinckerhoff's design visualization guru describes how large-scale projects are changing with the introduction of new digital modeling tools.

How does Parsons Brinckerhoff use large-scale 3D models? How did your practice with them evolve?

The largest two projects that I've worked on are the Alaskan Way Viaduct Replacement Project (AWV) in Seattle and the SR 520 Bridge Replacement and HOV lanes, between Seattle and Bellevue.

When the design process was initiated, Parsons Brinckerhoff supported the AWV project with visual simulations that showed the visual effects of the proposal in the Environmental Impact Statement (EIS). Our approach was model-based, so we created a 3D model of the proposed design. Because it's an infrastructure project that impacts the whole region, we have to model the proposed design, the supporting road networks, the building context, and the city. As we were building the model, the tools continued to evolve to the point where we were getting greater capability to handle higher geometry count and attribute data.

The more context we added—the terrain in 3D, the road networks, the traffic, the different design options—the more it contributed to the design process. It also was used to effectively engage the public and the stakeholders, communicate the alternatives, analyze performance, and compare the designs visually and analytically.

For the SR 520 floating bridge, we've built the entire Seattle and Bellevue region in 3D and then added the different alignments to show the varying impacts of the proposed designs. Along with the San Francisco–Oakland Bay Bridge and the Presidio Parkway in San Francisco, those four mega-infrastructure projects were pilot projects for the application of virtual design.

How do these new tools affect the way engineers and designers at Parsons Brinckerhoff work?

Just having access to all this information in one database has been the most significant change. It used to be that if you wanted to know anything about the project, you'd have to go to 2D plans, profiles, or elevations, or have someone generate cross-sections to evaluate what the impacts were, or to look at conflicts. These virtual modeling tools and building information models gave us access to any piece of information that we wanted without going back to the drawing board.

The other thing we did was model all of the underground utilities along the alignment of the Viaduct. Adding all this existing information to the current model has been a great communication tool to show the public and project stakeholders where the project is located and how it would work.

This building information modeling approach serves the

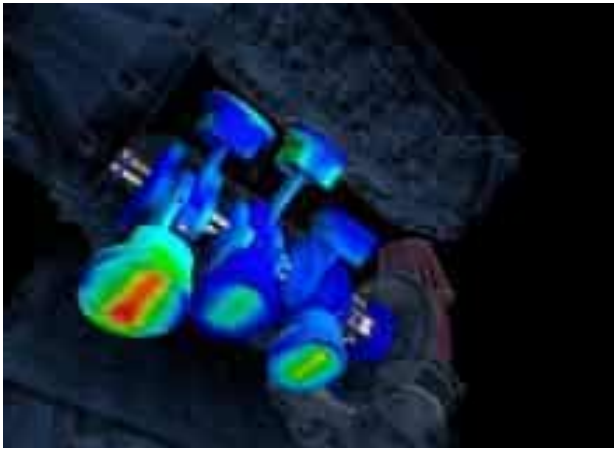
“IT’S DIFFICULT TO IMAGINE HOW DESIGNERS USED TO GO ABOUT IT FIFTY YEARS AGO. YOU’D BE DRAWING SOMETHING ON A PIECE OF PAPER, AND THEN A PATTERNMAKER WOULD BE TRYING TO INTERPRET IT TO CREATE A CASTING.”

standard for general aviation.

The seven years of development and testing may have been grueling, but nothing compared with what the process would have been using older tools. “It’s difficult to imagine how designers used to go about it fifty years ago,” says Bakker. “You’d be drawing something on a piece of paper, and then a patternmaker would be trying to interpret it to create a casting.”

As a new company pioneering a fresh approach to aviation engines, ADEPT was at a disadvantage. It couldn’t purchase off-the-shelf components or adapt older designs. Every component had to be designed, and every component’s tooling had to be designed. In addition, with a lean development budget, ADEPT had to keep its costs low. The key solution was to develop a digital prototype that would let the company test and refine every element without expensive tooling changes. “You can test an idea very quickly,” says Bakker. “Digital prototyping allows us to see exactly what we want out of a component.”

The first indications of ADEPT’s new ways of thinking and its prototype-focused approach lie in the engine’s weight. At less than 350 pounds—130 less than similar-sized engines—its smooth architecture necessitates compactness. Inside, everything weighs less: A shortened crankshaft tips the scale at just over 24 pounds; pistons are



Digital modeling, prototyping, and aerodynamic simulation were used at each step of ADEPT’s process to increase performance while sticking to a budget.

THE SALIENT DIFFERENCE IN THE ENGINE'S DESIGN, HOWEVER, LIES IN ITS SUPERIOR FUEL EFFICIENCY. DESIGNED FOR AN ERA OF VANISHING RESOURCES, HIGH OIL COSTS, AND GLOBAL WARMING, THE 320T CONSUMES ABOUT 30 PERCENT LESS FUEL THAN ITS COUNTERPARTS.

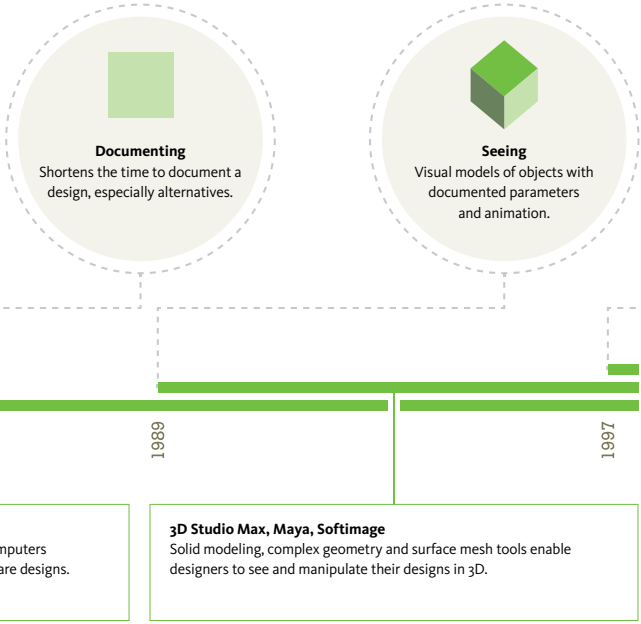
—

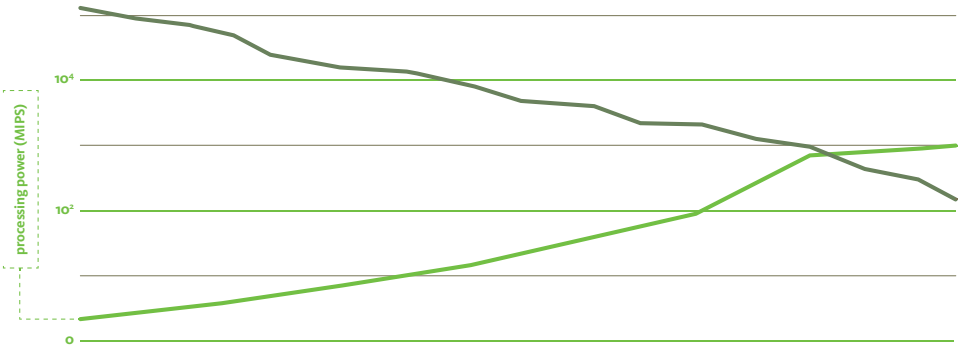
THE EVOLUTION OF CAD

Increasingly advanced CAD capabilities enable more-complex design processes.

Fueled by constant increases in processing power and the falling price of hardware, each progressive era of CAD evolution builds on the capabilities of the previous ones, enabling designers to create designs at higher fidelity, model expanding amounts of context around a design, and bring more imagination into reality.

CAD Eras
Each new era expands the capabilities of CAD and the power of designers.



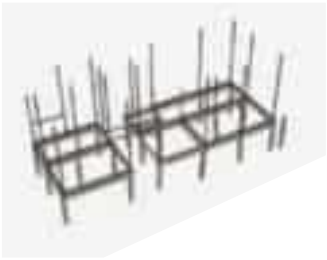


THE PRECISION OF THE JOINERY NOT ONLY ALLOWED FOR THE TIMBER FRAME TO FIT TOGETHER SEAMLESSLY, IT ALSO ACCOUNTED FOR THE CONNECTIONS BETWEEN THE TIMBER FRAME AND THE SCAFFOLDING SYSTEM.

evoked the natural environment without compromising it—and to achieve this goal through the use of parametric BIM modeling and off-site fabrication. "It's a very fragile wetland site," explains Kieran, "and the less time we had to spend building it, the better." BIM enabled the architects to build virtually within highly specified parameters before any physical construction began. Simply stated, BIM enables architects, engineers, manufacturers, contractors, and clients to communicate and share information through a highly sophisticated, multidimensional model. That model simulates everything from geographic and site specifications to geometric and spatial relationships. Individually manufactured components can be rendered within the overall model, allowing designers to project every element of a building's potential life cycle. BIM also allows collaborators to extract and share information regarding materials and assembly sequences, and can generate precise information for material and permit submittals.

For example, Loblolly's off-site fabricator, Bensonwood Homes, was able to cut the timber frame to the exact specifications

Having the model of the house in Autodesk Revit allowed the architects to diagram the sequence of assembly—planning the complicated choreography of parts arriving on-site.



This is perhaps BIM's most important feature: the ability to mitigate the loss of information between the architect, construction crew, manufacturer, and client, and to promote simultaneous construction process. Of traditional design and construction processes, Kieran and Timberlake wrote, "If we are lucky, we get to keep ourselves on the job all the way through construction, acting as interpreters and arbiters of what we really intended but neither foresaw nor conveyed. All the while, as the instructions that lie between intention and outcome become obscure, we bemoan the ongoing decline in productivity, quality, and control."

Contrast that degradation of communication with the fidelity of BIM. Because communication happens within the form of a model, it isn't necessary to translate information from one format to another. Structural and mechanical drawings are no longer distinct from architectural drawings; each collaborator contributes to a unified design scheme, and the architect's vision remains intact. At Loblolly House, Kieran explains, "we could go directly from our digital models to fabrication equipment and drive that equipment from the digital models."

In adopting off-site fabrication and parametric modeling, KieranTimberlake looked to the automotive, aeronautical, and shipbuilding industries for guidance. As car manufacturing evolved, for example, a car console that was once composed of two hundred separate parts is now collapsed into one integrated piece. Similarly, Boeing engineers have long used parametric models to develop highly sophisticated building plans for their aircraft. The simulative models achieved with BIM provide a complete three-dimensional structure as opposed to an interpretive two-dimensional drawing. Large, complex portions of a structure can be broken into integrated components, which can be fabricated anywhere in the world and brought together for final assembly. All of the parts, joints, and corners are suffused with structural information and design constraints and can be viewed from multiple points of view. All of this information allows for a higher degree of control and technological sophistication within each element.

The defining feature of architecture, of course, is that it is somehow tied to the earth. Thus, the labor needs to be broken up into off-site fabrication and on-site assemblage. The traditional sequential construction model is supplanted by a simultaneous prefabricated process, where integrated components are delivered for on-site assembly. Coupled with the geometric and technical certainty of the parametric model, all of this happens with little to no error.

KieranTimberlake likens this prefabricated method of assemblage to quilting, versus the piece-by-piece weaving in the current system. “We propose to simplify, merge, and unify these materials and environmental systems—structures, windows, doors, and finishes—into integrated assemblies, which we consider to be the elements of a new architecture,” the architects wrote in their book *Loblolly House*.

The information available to designers using BIM can provide new insight into areas outside of construction. “Our research on Loblolly House and Cellophane House suggests that the embodied energy in the materials and the making of a house is far more than most would like to believe,” Kieran says, referring also to a related, off-site-fabricated house built for a show at New York’s Museum of Modern Art. “Practically forty years’ worth of operating energy is embedded in a house before it is even occupied, even in an energy-efficient home. That is an awful lot of embodied energy. Our position is that we as designers need to assume ethical responsibility and control of the life cycle of the materials going into our building. We can do this by creating mechanisms that allow them to be disassembled rather than demolished, so that we can recover those materials whole and bear the cost of reconstituting them.” Loblolly’s aluminum scaffolding frame, which uses dry joints (bolted as opposed to welded fastening), holds great potential in this regard. Instead of demolishing it, the house and its framing components can be broken down and reassembled elsewhere. The same BIM tools used for its design and construction will also be essential for its efficient disassembly.

The technology can be applied to a variety of projects, not only ground-up endeavors. “The more accuracy one has in the model, the more you can start to change the way we are actually building things,” explains Kieran. He gives the example of a renovation the firm recently completed for Silliman College at Yale University. The architects created a parametric model of the preexisting structure, which included the miles of conduit and wiring stuffed into

The house’s major systems were integrated off-site in “cartridges” designed to be lifted and fitted into the aluminum frame.

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THE SAME BIM TOOLS USED FOR THE HOUSE’S DESIGN AND CONSTRUCTION WILL ALSO BE ESSENTIAL FOR ITS EFFICIENT DISASSEMBLY.




DESIGN USED TO BE ASSOCIATED WITH THE CREATION OF OBJECTS, BUT INCREASINGLY, THE FOCUS HAS SHIFTED FROM "OBJECT" TO "EXPERIENCE." THIS EVOLUTION HAS BEEN DRIVEN BY THE GROWING RECOGNITION THAT GOOD DESIGN DOES NOT EXIST MERELY WITHIN THE THREE-DIMENSIONAL CONFINES OF A MADE OBJECT.

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previous spread: **Production designer and immersive-design guru Alex McDowell's work includes Tim Burton's psychedelic update to *Charlie and the Chocolate Factory*.**

NATHAN SHEDROFF

An experience-design pioneer describes the elements of experience, the need for deeper research, and the payback of great design.

Let's start with the obvious. What is experience design?
On one level, it's really simple: designing experiences for other people. Obviously most people want successful, wonderful, and delightful experiences.

The next question is, What do you mean by experience? The design part isn't the big problem. It's the experience part that's challenging because it's abstract. That's why I call experience design an approach, not a discipline. It's not its own category like fashion design, or interaction design, or car design. Experience design is how you approach design of anything.

Some people will say that you don't design experiences, you design for people having experiences. Is that a worthwhile distinction?
The reality is, we design amazing experiences every day. We design weddings, and dinner parties, and birthday parties. In the commercial realm, we design everything from theme parks to operas to products and services. Go to Cirque du Soleil. You are having an amazing experience that is highly designed. We design experiences all the time. So it becomes an academic distinction without much value.

Designers' inspiration has always been around experience, or has had elements of experience. This isn't something that we just started doing. But because we've never been taught a vocabulary about it, it ends up being called "intuitive." We haven't been deliberate about it, or had a way to tangibly put it into the design process. That's what we can do now.

What are the elements of experience design?
There are six dimensions of experience that we've identified: Duration, or how time flows through the experience. The level of interaction. The level of intensity of engagement. The level of significance—that's where meaning lives. The breadth of touch points in the experience. And the last one is triggers.

What do you mean by triggers?
How designers practice today is more as curators. It's not about what you do and don't like. It's about how you curate design decisions to trigger the effects that you want in your customers. Should I use natural wood? Does that trigger the reaction of more human, more natural, or more organic? Or maybe I want to trigger feelings of industrial machine

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"It's not about what you do and don't like. It's about how you curate design decisions to trigger the effects that you want in your customers.... It's my job as a designer to make choices that trigger the right responses."

In January 2008, Béland, along with producer Alexandre Parizeau, took over as director of *Conviction*, the fifth title in the *Splinter Cell* lineup. Their first job was to focus the project after an initial two years of creative development. Béland and Parizeau's overarching mission was no small task: to redefine the franchise in part by cranking up its immersive elements. In short, their task was to design a new gaming experience that would raise the bar in terms of engagement and immersion.

"We are in a world where everything is competing with everything. You want to watch a movie, but if it gets boring, you are going to send an SMS. Or tweet about how the movie sucks," says Béland. In the new gaming world exploding with options, a successful game must draw a gamer in for an extended multiple-hour experience or he will simply look around to replace it with a better one.

In their quest to build an immersive new sequel, Béland and Parizeau rolled up their sleeves to conduct wide-reaching research before they set about rejiggering the title. They read the online forums to see what was loved and what was hated in past games.

Splinter Cell is an intricate stealth game with a deep narrative, the gameplay of which is filled with ambushes, sneaking, lurking in shadows, and evasion of enemies. The game is a story of a splinter cell—a one-man National Security Agency special-operations officer who takes on impossible military tasks. And *Splinter Cell* games had long been associated with one character, the elite stealth agent Sam Fisher. In the new incarnation, none of this would change. Light and shadow would remain a key part of gameplay.

Games live and die by differences in action and story line, and *Splinter Cell* and its Sam Fisher character had succeeded in many respects. Fisher was the much-loved hero of a franchise that had sold in excess of 19 million games between 2002 and 2009. Voiced by Hollywood cult action hero Michael Ironside, Sam Fisher would be going rogue in the latest installment; ejected by the U.S. government and its top-secret Third Echelon outfit, he was seemingly on his own. That was a different story line, but much about Sam Fisher would stay the same. What would change in the next *Splinter Cell* would be a far-reaching push into new levels of immersion.

"There is something we call the 'player fantasy,'" says Béland. If you are playing *Madden*, you want to feel like an invincible NFL player—that is your game fantasy. "To me, the *Splinter Cell* fantasy is that you want to feel like the best stealth special agent in the world," he says. As a character, Sam Fisher shares a lot with *24*'s Jack Bauer, James Bond, and Jason Bourne, all of whom are ex-military, or ex–special forces. One of the problems Béland identified early on with *Splinter Cell* was that the players he polled could not easily connect with the game fantasy of *Splinter Cell*, the fantasy of being a clandestine operative who can go anywhere, do anything, and get away with it. Béland could sympathize: "I never felt like the guy on the box," he says.

"Sam Fisher is the kind of agent who sleeps in a sewer pipe somewhere in North Korea for a week until the time is right to strike," says Béland's colleague Patrick Redding, who led the development of the game's cooperative multiplayer modes.

As his team set about rebooting *Splinter Cell*, the Coke-drinking kid stood as a talisman of sorts for Béland. He knew that he had to keep players immersed, otherwise they would bail out. *Splinter Cell*'s creator and publisher, Paris-based Ubisoft, strives to ensure that its triple-A blockbuster games like *Splinter Cell* have mass appeal.

Founded in 1986, Ubisoft employs more than six thousand people and takes gameplay seriously; classes in game-design

One strategy for full immersion was to communicate with players within the game; instead of breaking for a movie sequence or using subtitles, game goals were projected within the gaming space.

theory are compulsory for high-level creative managers, and the company runs state-of-the-art game-testing facilities in many of its global studios, including the one in Montreal. "We are competing at an Olympic level, where everything we mess up costs us a hundred thousand players," says Redding. "We are really vulnerable, but the rewards are very high."

As part of the review of the game and how to best move forward for the new *Splinter Cell* title, Béland and Parizeau decided to not force stealth on the player as a type of inferior mode of competition, but to fully embrace stealth. "We decided to make stealth something that is appealing for the player, something that makes him feel strong and like a predator," says Béland.

Béland further developed a metaphor of Sam Fisher as a panther to explain to his team that he wanted a player to feel like a feline predator in the game—stealthily and cunningly walking amid the game's shadows until he found the right time to attack. The panther worked because Sam Fisher was to be a character who used stealth and hid not because he was afraid and weak, but because he was powerful and it was an intelligent tactical decision to hide and wait for the proper moment. "It was magical. As soon as I talked to the developers about the concept of being a panther and not a grandmother, I was getting sparks in their eyes," says Béland.

Béland and Parizeau decided to embrace stealth, but they did want to change the mechanics of the gameplay—how the player operates and maneuvers in the game environment, the literal actions of the player.

Another innovation in *Splinter Cell: Conviction* was marking a player's last-known position—allowing for new stealth-movement strategies.

BÉLAND WANTED A PLAYER TO FEEL LIKE A FELINE PREDATOR IN THE GAME—STEALTHILY AND CUNNINGLY WALKING AMID THE GAME'S SHADOWS UNTIL HE FOUND THE RIGHT TIME TO ATTACK.

As producer for *Conviction*, Parizeau served as the guardian of the main objectives for the game. To get where they wanted to with the new mechanics, there was a lot of team experimentation and idea prototyping, overseen by him. "The ideal situation for a game is when you have a really strong vision, or philosophy, so you can communicate to the team what the game is about," explains Parizeau. "And you have a feedback loop where the team is allowed to contribute other ideas and influence the core vision through prototyping."

BÉLAND CALLED FOR TWO OVERARCHING IDEALS THAT WOULD BUILD PLAYER IMMERSION—NO NOTICEABLE LOADING OF GAME DATA, AND NO CUTS IN THE ACTION.

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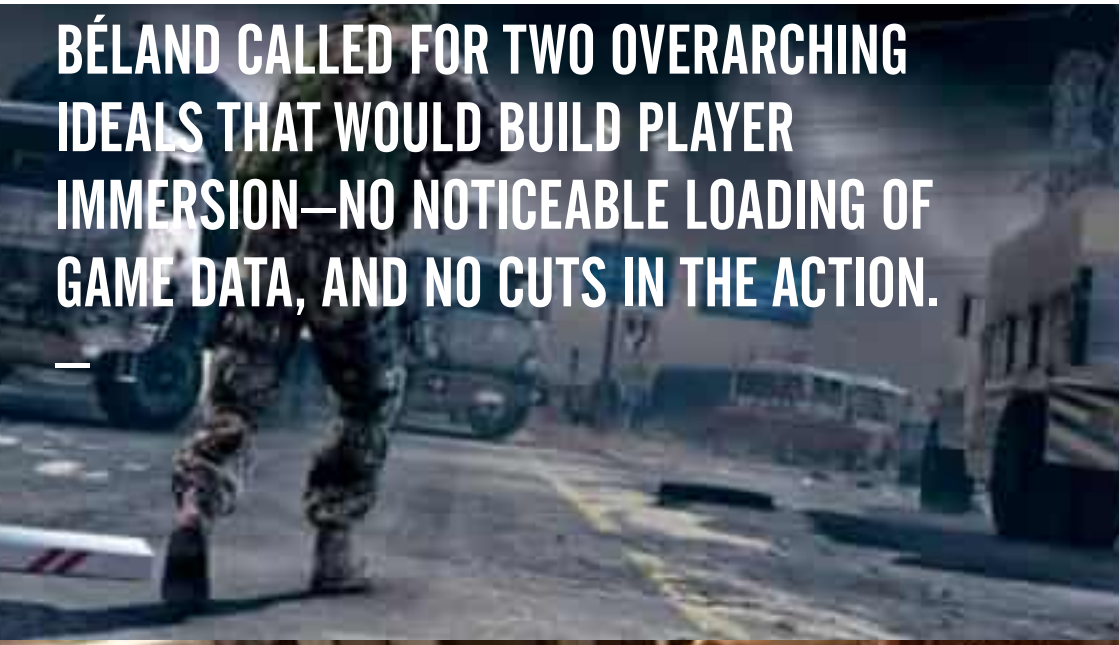


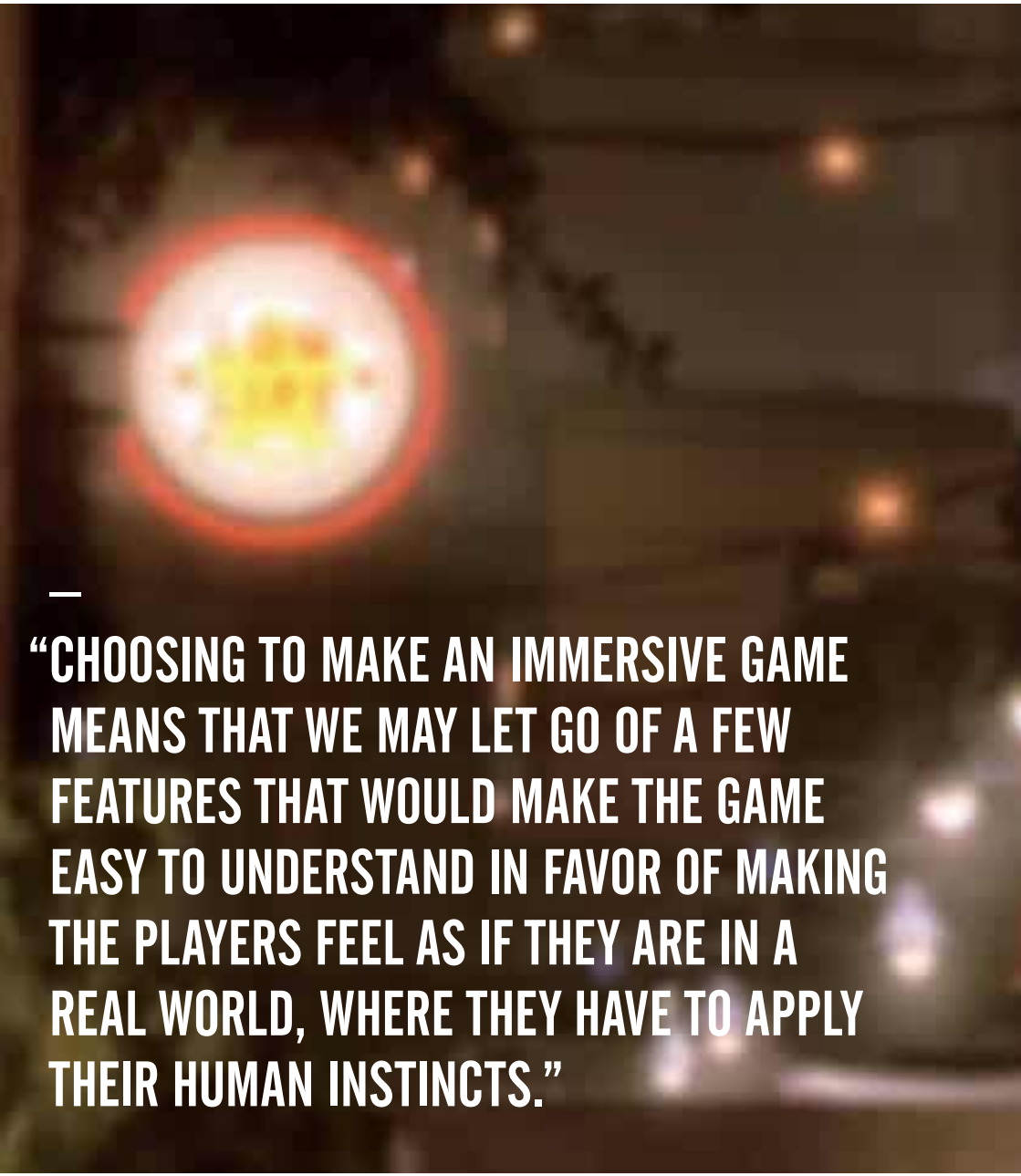
(third person). The in-game camera with third-person shooters usually cuts from the main character to other action surrounding the character. But in the latest iteration of *Splinter Cell*, Béland sought to never cut Sam Fisher in the game's single-player mode. This camera-induced tension would create a real-time feel that invoked a sense of urgency for the player. "Our cameras in *Conviction* are related to, and inspired by, the TV show *24*," says Béland.

"We want the players to be the instruments of action," says Redding. Echoes Béland: "I don't want to force the story down the player's throat. That is part of sharing the authorship with the player. We have a two-way discussion with our audience. The player is an actor, and the player is the cameraman in a way. That is part of the challenge, but also part of what we have to embrace."

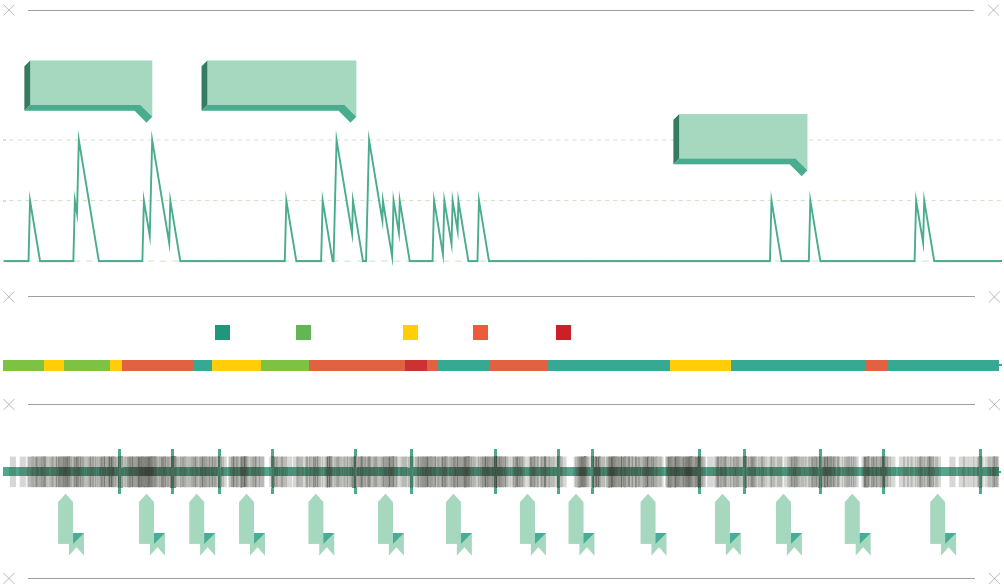
Modern video games have evolved into ambitious works of narrative fiction in which presenting a story is critical to pass on information to the gamer. How to do so without cutting from play to backstory video is a challenge. In *Conviction*, the game's creators had to tell a story to players that did not always revolve around the main character. The solution to avoid cutting away from the real-time action to backstory was solved when Béland saw the Denzel Washington film *Man on Fire,* which showed video sequences within the real environments of the film, pictures inside pictures.

Conviction's presentation editor, Jean-Philippe Rajotte, went on to design an innovative style that used the game's environment as a canvas. Instead of removing the texture of in-game walls, he found a way to use dynamic film-esque light and project movies on walls. "Because it is an actual light in our world, the characters are affected by the light," says Béland. These new projections allowed the *Conviction* team to avoid cuts in action by projecting movies in the

A subtle but key visual design tactic was to keep the player at the center of the action at all times. There is no cutting away, no shifts in perspective that might break the engagement with the game.



“CHOOSING TO MAKE AN IMMERSIVE GAME MEANS THAT WE MAY LET GO OF A FEW FEATURES THAT WOULD MAKE THE GAME EASY TO UNDERSTAND IN FAVOR OF MAKING THE PLAYERS FEEL AS IF THEY ARE IN A REAL WORLD, WHERE THEY HAVE TO APPLY THEIR HUMAN INSTINCTS.”



ASURING EXPERIENCE

oes *Cloudy with a Chance of Meatballs* emotional engagement?

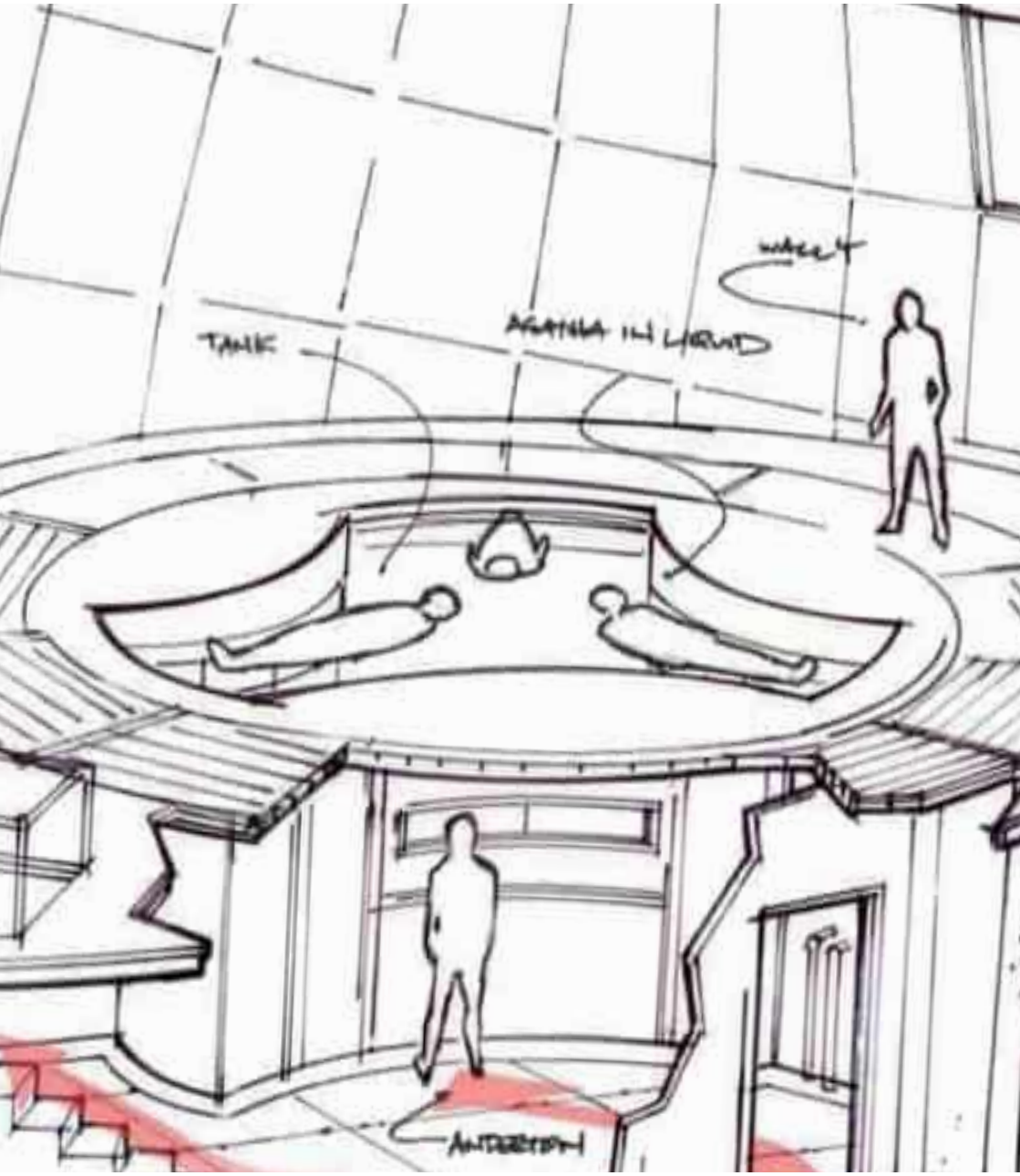
Sony Pictures Imageworks' *Cloudy with a Chance of Meatballs* creates an engaging experience through its use of plot devices, pacing, and color. The Galvanic Skin Response chart below visualizes subconscious reactions, the Emotion Graph shows subjective responses, and the Camera Cuts convey rhythm and action. The Color Script illustrates the emotional tone of each scene, revealing another important tool designers use to develop and accentuate the experience of the movie.

c Skin Response and Key Plot Events

t test of the
d machine

The food machine destroys Sardine Land

Sam and Flint bond over being nerdy


TANK

the latter. Ebert was impressed by the visual consistency of the movie, and the seamless experience it created, adding, "It's not often that movies can use miniatures and special effects and sets and visual tricks to create a convincing place, rather than just a series of obvious sets."

McDowell's work on *Fight Club* further boosted his reputation for creating sets that capture and amplify a film's central themes. Take *Fight Club*'s Paper Street House: Once a grand Victorian, the house has fallen on hard times. The wallpaper is peeling, the faucets run brown, and the basement floods when it rains. The decrepit house becomes a metaphor for mental breakdown and the end-of-the-millennium philosophy espoused by Brad Pitt's character, who believes society itself has decayed under the corrosive influence of corporate interests and cheap commercialism.

Fight Club was where McDowell had his "aha moment." That's when he saw how director David Fincher used software to visualize scenes he wanted his special-effects team to create. "Right around then, for the first time, you could put $2,000 worth of software on a Mac and have the rough equivalent of the $100,000 workstations that the special-effects team used in post-production," McDowell says. Using similar technology, he began building visually rough but detail-rich digital versions of sets known as pre-visualizations, or "pre-vis." His pre-vis sets provided a way to explore potential spaces and think through the practical elements that might make a scene more immersive.

"Visualization has created the most dynamic, creative, collaborative space that has ever existed," says McDowell, who calls this collaborative approach "immersive design." (He has since cofounded the 5D: Immersive Design conference.)

Minority Report was a pivotal project for McDowell's use of the new technology and an opportunity to fully exploit its potential.

For McDowell, architecture is a key element to a film's narrative. The complex layout of the Precrime headquarters—a visual echo of the immersive design mandala—tracked with the plot intricacies that happened there, while the abundance of glass alludes to the radical transparency of precognition.

The dark, decaying house in David Fincher's film *Fight Club* constituted another character with a distinct personality. The decrepit structure became a metaphor for mental breakdown and the nihilistic philosophy espoused by Brad Pitt's character.

Consider the film's Hall of Containment, a subterranean room that serves as a sort of jail for those arrested by the Precrime unit for murders they were about to commit. For the scene, Steven Spielberg "had this image of Arlington National Cemetery, and digital gravestones, stored vertically, that contained each person's data," recalls McDowell. He imagined a jailer in the center of the vast space, traveling on a movable platform to access individual gravestones. "It was a great visual, but it was hard to figure out how to contain it."

Using pre-vis, McDowell developed the mechanics of the scene: Pre-perps are stacked one atop the other in columns that slide up and down. The set is part panopticon (the eighteenth-century prison design that allows jailers to watch every prisoner) and part cathedral (with its connotations of an omnipotent God). The sheer number of gravestones, extending row after row in three dimensions, packs a profound psychological punch. The Hall of Containment doesn't get a lot of screen time in *Minority Report*, but it is a powerful space, and it sparks an awakening of sorts for the main character, John Anderton—and for viewers of the film. "I never knew there were so many," says Anderton, suddenly aware of the inhumane reality of the seemingly enlightened idea of capturing people before they commit a crime. In the brilliant design of this one space, McDowell captured the central idea of the movie: That *Minority Report*'s seemingly utopian world has a dark and troubling core.

As a planning tool, pre-vis also proved invaluable for *Charlie and the Chocolate Factory*, a production that had more sets than

wouldn't have even attempted decades ago.

Just as important, however, McDowell believes that visualization enables a richer collaboration between the people who are actually producing a film. "Think about the origins of storytelling, with a group of primitives sitting around the campfire, trying to make sense of the world around them," McDowell explains. Fast-forward to Hollywood, where a script writer goes off to his room and writes a story that reflects his experience—a story that is then broken apart and reassembled by dozens of others who have a creative hand in a movie. With immersive design, McDowell argues, "the storyteller, the designer, the cinematographer, the director—everyone can sit around that campfire, experience the same environment, and start shaping the story around it." Ⓐ

Fight Club **was where McDowell had his "aha moment," when he saw how director David Fincher used software to visualize scenes he wanted his special-effects team to create. After that experience, he began building visually rough but detail-rich digital versions of sets known as pre-visualizations, or "pre-vis."**

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"THE BEST DESIGN IS OFTEN THAT WHICH THE AUDIENCE NEVER NOTICES."

WITH IMMERSIVE DESIGN, MCDOWELL ARGUES, “THE STORYTELLER, THE DESIGNER, THE CINEMATOGRAPHER, THE DIRECTOR—EVERYONE CAN SIT AROUND THAT CAMPFIRE, EXPERIENCE THE SAME ENVIRONMENT, AND START SHAPING THE STORY AROUND IT.”

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IRENE AU

The director of user experience at Google discusses how speed, objectivity, and research shape the search giant's design approach.

Google's design can seem very neutral. Does Google have a design philosophy?
Very much so. It ties back to our values as a company. We value objectivity. At Google, we use powerful algorithms, rather than human editors, to find the best of the Web. We value openness, so we often allow interconnectedness with third parties through APIs (Application Programming Interfaces). We also value speed. We want the Internet as a whole to be faster, and we want our products to perform extremely quickly. Those three values translate into a set of design principles that inform the design of all our products.

How are those values manifested in Google's products?
Google's machine-driven look and feel is very deliberate. We don't want our designs to look too handmade, because then they will look editorialized. It's also minimal because we want to be fast, and any kind of adornment added to a page contributes to longer load times—even if it's 4 milliseconds. We're all about getting people to the information that they're looking for very quickly; this is our point of view.

Also, especially in search results, we use high-contrast color schemes—black text or dark blue links against a white background. We reference human interface research that shows that black text against a white background is optimal for on-screen reading and scanning.

Our interfaces are often dense. We're constantly looking at how much information we put "above the fold." If you're looking at your Gmail inbox or your Docs list, we try to get as much of that content above the fold as possible. We care about speed, not only in terms of page latency but also the speed of information retrieval via human perception and cognition. Those principles are overarching across all of Google's experiences.

"We value objectivity. We value openness. We also value speed. We want the Internet as a whole to be faster, and we want our products to perform extremely quickly. Those three values translate into a set of design principles that inform the design of all our products."

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LEGO
UNIVERSE
MASSIVELY MULTIPLAYER
ONLINE GAME

KIDS LOVE BECOMING ENTANGLED IN THE TYPE OF OVERHEATED STORY LINES THAT JOLT THE IMAGINATION. THEY ALSO WANT A COMMUNITY OF LIKE-MINDED BUILDERS TO SHARE THEIR EXPERIENCES AND CREATIVITY.

enjoyed success but reached a limited market; networking them online wouldn't add much. "We said to them right up front that we don't want to just make a literal interpretation of what it is to build with LEGO bricks in real life," Seabury recounts from his office chair while fiddling with a multicolored penguin he constructed from the random bricks strewn across his desk. "There will always be this nice reward of snapping the bricks together—the sound it makes, how it feels in your fingers. You can't replicate that on a computer screen—not even with haptic devices [that give tactile feedback] or the new motion capture devices for gamers. It's always going to feel disconnected."

The game would feature building stuff, but it would surely need something more. Seabury pointed executives to the brilliance of the LEGO Group's bestselling licensed

LEGO Universe **comes with a large backstory—about protecting Imagination from a dark force known as the Maelstrom. That simple setup allows for a nearly endless series of quests as well as a wide variety of characters for the game's players to identify with.**

THE DEVELOPERS WERE PRESSED TO COME UP WITH A “RED THREAD”—A DEFINING ELEMENT THAT PULLS EVERYTHING TOGETHER.

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CAN GOOD DESIGN BE...DESIGNED? THE ANSWER IS THAT IT NOT ONLY CAN, IT MUST. FOR DESIGN TO FULFILL ITS POTENTIAL TO ADDRESS OUR BIGGEST, MOST DIFFICULT CHALLENGES, WE NEED NEW SYSTEMS FOR IT THAT WILL ENCOURAGE DESIGNERS TO THINK BIG, TO MAKE MAXIMUM USE OF AVAILABLE RESOURCES AND SOURCES OF INSPIRATION, AND TO APPROACH PROBLEMS IN AN INTEGRATED OR HOLISTIC MANNER.

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previous spread: **The Empire State Building recently underwent an energy retrofit, led in part by Amory Lovins and Rocky Mountain Institute.**


OGRESSIVE

DIAMANDIS CONTENDS THAT THE ELABORATE AND SOMETIMES DRACONIAN RULES ESTABLISHED FOR X PRIZES ARE ESSENTIAL TO MEET HIS ULTIMATE GOAL: CULTIVATING DISRUPTIVE TECHNOLOGIES.

While the X Prizes seem tailor-made for a media-saturated, reality-show-friendly time, Diamandis notes that this kind of system for spurring design has a long history. In 1714, the British government established the Longitude Prize, one of the earliest incentive awards. It sought a technique to determine a ship's longitude while under sail. Today's marine chronometer is based on the invention of the English carpenter who won the £20,000 prize—the equivalent amount today is in the range of an X Prize. Trying to figure out how to feed his far-flung troops, Napoleon sponsored a prize to devise a way to preserve food. You can thank the winner for that twelve-year-old can of Chef Boyardee ravioli in your pantry.

It was the Orteig Prize that most inspired Diamandis. In 1919, New York hotelier Raymond Orteig offered $25,000 to the first pilot who could make a nonstop flight between New York and Paris. Eight years later, Charles Lindbergh completed the 33.5-hour crossing in the *Spirit of St. Louis* and as a result jumpstarted the modern aviation industry.


ITERNATIONAL SPEEDWAY
PROGRESSIVE


10

Another stated aim of the X Prize is that the technology developed for competition be adapted for the market. The Finnish RaceAbout team shared that goal, developing a powertrain made primarily from Finnish technology.

twenty-six different designs tackling the problem. It was extraordinarily fulfilling to see this sort of Darwinian evolution taking place. We wanted to set up a structure that would allow for really exciting, surprising, and unexpected solutions with unexpected benefits."

Diamandis has said of the X Prize approach: "One of the precepts that I'm learning is, fail often and fail early, until you make it happen right." Of the twenty-four teams that initially enlisted for the Automotive X Prize, all but seven had been eliminated by the final stage of the competition. The high knockout rate is typical—a challenge's stringent rules ensure what Diamandis calls the "proper balance of audacity and achievability."

In 2009, Diamandis set forth his convictions in a self-published paper. "The prize rules should define a problem to be solved, not a specific solution to be implemented," he wrote. "An incentive prize can support a wide variety of approaches/solutions to come into existence to address a challenge, thereby creating an entire industry." Market research and consulting firm McKinsey & Company recently sought to quantify whether incentive awards like the X Prize make a meaningful impact on advancing innovation. They cite a study from Harvard and the Norwegian School of Economics and Business Administration that examined prizes offered between 1839 and 1939. Winners, it turned out, had a far better chance of getting their inventions patented, and even the losers applied in record numbers to protect their creations.

The Orteig Prize had similar repercussions: Within eighteen months of Lindbergh's flight, the number of airline passengers soared from 6,000 to 180,000. The population of pilots tripled, and there were four times as many airplanes buzzing the

The Edison2 team took an unconventional approach, entering four different cars, each with varying bodywork and characteristics but using the same drivetrain.


Virgin

DIAMANDIS IS "EXCITED ABOUT THE FUTURE OF DESIGN....ALL OF US WILL HAVE WHAT MIGHT BE CONSIDERED GODLIKE POWERS TO CREATE, TO MANIFEST OUR DREAMS IN A WAY THAT IS MAGICAL."

skyways of the United States as there had been before. Soon after *SpaceShipOne* made its historic suborbital flights, and Branson spun off the technology into Virgin Galactic, private spaceflight companies with names like Armadillo, Blue Origin, Rocketplane, and SpaceX, among dozens of others, gathered momentum, kindling further investment and attracting new talent. Diamandis explains, "We insist that the competition's design has a back-end business model, meaning that when the prize is won, the teams are able to take their technology to market." Of the Auto X Prize, Mathis says, "if the intent was to introduce new solutions and fresh thinking to the world of car design, the organizers succeeded hands down. They recognized the possibility for small groups of people to do uncommon things—and created an arena to make that happen. They should be commended for it, and we should thank them."

For his part, Diamandis is confident that the X Prize will continue to evolve in sync with advancing technology—artificial intelligence, robotics, nanotech, biotech—enabling the awards to take on increasingly ambitious feats. He points out that "creating the future is all very hard, and you will likely have multiple failures along the way." Even so, Diamandis is "excited about the future of design. It's all about the ultimate personalization, where the design tools fade from perception and empower us to turn our whimsy into reality. All of us will have what might be considered godlike powers to create, to manifest our dreams in a way that is magical." Ⓐ

The Ansari X Prize, the first such competition, awarded $10 million for a vehicle (right) that could enter low-space orbit three times. The winning entrant has become Virgin Galactic's *SpaceShipTwo* (preceding pages).

JANINE BENYUS

The renowned biomimicry expert homes in on life's design principles and lessons.

What is biomimicry? Why is it important?
Biomimicry is the process of learning from and then emulating life's designs. It's innovation inspired by nature. We look at form. We look at processes: strategies, relationships, how photosynthesis works, for instance, or green chemistry. And at the ecosystem level, we look at how you put all the pieces together in a framework that has a consistent criteria for success. How do ecosystems actually work? What are the principles?

Can you elaborate on these three areas that you focus on in biomimetic design?
Form is mimicking nature's physical designs—shape and topography. That might include mimicking the tubercles on the fin of a humpback whale to reduce turbulence, or solar cells that mimic photosynthesis. Mimicking process is everything from green chemistry to mimicking natural selection in a genetic algorithm. So, once you create a fan based on that form, how do you manufacture it? What kind of chemistry do you use? What kind of materials do you use? What energy source do you use to manufacture it?

The third level is taking a whole system as a model. So that's where you get into looking at a native ecosystem in a region and saying, "This is a model for how to run our city, or to run an economy."

Can you describe a successful design based on these principles?
One is Pax Scientific's water mixer—a device that sits at the bottom of the big, million-gallon water tanks that you have in many municipalities. It is a logarithmic spiral, the Fibonacci spiral, which you find in so many places in the natural world. It runs on a very small amount of energy—it's nature's perfect flow structure.

The mixer creates a kind of tornadic form, and it starts the water moving after a few minutes. The entire thing starts to circulate, and it's beautiful. The important thing is that a well-mixed water tank means that you can use less chlorine to purify the water.

What was the inspiration for the water mixer?
[Pax Scientific CEO] Jay Harman's initial inspiration was a giant kelp in Australia, which he saw when he was eight.

A kelp looks like a ribbon. And when it gets pulled by the current, that flat ribbon spirals into a tube—the same thing that leaves do. If you watch leaves in a storm, large leaves will fold with the wind to create a Fibonacci sequence spiral that wind goes through very easily. What that means is that very powerful winds can't yank the leaf off or powerful currents can't yank the kelp out.

Jay was sitting at the shore as a little kid, and he was able to pick up the holdfast [where the kelp is anchored

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"Biomimicry is the process of learning from and then emulating life's designs. It's innovation inspired by nature."

What are you exploring at the third level of biomimicry, the systems level?

We began our consultancy in 1998, thinking that we were going to go in and give people ideas about how to lightweight products by changing the shape, how to change packaging, how to solve technical problems. We were just going to keep our heads down and solve engineering problems.

What happened was that once we got into companies, they were interested in the solutions. They might say, "Oh, a new way of doing water repellency. Now we can get away from Teflon. That's terrific. Now, what can you tell us about running our company differently?"

That brought us to the systems level. Managers would begin to come down and say, "Tell us about biomimicry." And of course, they were interested in something at a systems level, and so they said, "Are there ubiquitous principles in the natural world?" I mean, you can mimic the bumps on the Namibian beetle's back, and you can harvest fog water out of it. That's amazing. But that's one beetle. Is there something that all living creatures have in common? Are there principles? And indeed there are, and they're quite informative.

"Once we got into companies, they were interested in the solutions. They might say, 'Oh, a new way of doing water repellency. That's terrific. Now, what can you tell us about running our company differently?'"

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"We came up with this list and taught it as an eco-checklist of sorts. Is my design locally attuned, and what does that mean? Does it use local, raw materials wherever it possibly can? Is my design self-healing?"

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So we began to gather. It was actually very difficult to find life's principles—to find the general rules. We're trained to find the exception to the rule rather than the general rule. We're rewarded for *disproving* someone's theory.

What these principles are is a systemic framework. There are very technical things, like life does chemistry in water rather than organic solvents. There are also very large concepts like life banks on resilience, and there's a very deep scientific basis for what we mean by "resilient."

Life's principles have all of these levels, and we began to teach these as a system of best practices that were pulled from the biological and ecosystem literature that happened to be relevant to this complex, adaptive system called a company.

We came up with this list and taught it as an eco-checklist of sorts. Is my design locally attuned, and what does that mean? Does it use local, raw materials wherever it possibly can? Is my design self-healing?

What surprised us was that a lot of companies would take the word *design* in that sentence and put the word *company* in: Is my company locally attuned? Is my company self-healing? Ⓐ

Janine Benyus is a natural sciences writer, innovation consultant, and the author of *Biomimicry: Innovation Inspired by Nature*.

THE MAIN IDEA OF INTEGRATIVE DESIGN IS THAT EVEN WHEN EACH COMPONENT OF A SYSTEM IS INDEPENDENTLY OPTIMIZED, THIS TENDS TO LEAD TO COMPLETE SYSTEMS THAT ARE NONOPTIMAL.

You work with big issues within large, complex systems. How does RMI approach these kinds of challenges?

At Rocky Mountain Institute, we start with the proposition that there are three main foci of power and action in the world—business, civil society, and government—and those are generally in order of decreasing effectiveness. I tend to look for solutions that not only make sense but also make money so that they can be pursued by the private sector in its coevolution with civil society. They can then spread those ideas through "Aikido politics" and "institutional acupuncture" to figure out where the business logic is congested and not flowing properly. We do solutions, not problems; practice, not theory; transformation, not incrementalism. At the core of our practice is integrative design.

When designing a new car today, for example, is there a system or set of rules that car designers are working with to make a more efficient car? In previous years, was there as much thought about making a car that could drive farther on less gas?

There was quite a lot of thought about it. And powertrains even got about a third more efficient, although that was all

One of the foremost examples of Lovins's integrative design approach is his residence in Snowmass, Colorado (left and far right). The superefficient house uses components with more than one function, such as the atrium, which collects energy in five different ways.

"THE COEVOLUTION OF BUSINESS WITH CIVIL SOCIETY IS VERY POWERFUL AND ACTIVE AS A LEARNING PROCESS. IT IS ALSO [FOR US] ESSENTIAL TO ENGAGE WITH COMMERCE. THE CHOICES THAT HAVE LANDED US IN THIS MESS ARE BILLIONS OF INDIVIDUAL DECISIONS."

—

years, with an American automaker to good effect. But what I did was, first of all, invent a new way to design cars, which we called Hypercars, back in 1991. And we spent a couple of years working mainly with GM hoping they would adopt this concept for strategic advantage. It turned out they were not culturally ready to do so.

So in 1993, I open-sourced the concept and, working with automakers worldwide, got them all worried that their competitors would do it first. And that simple technique leveraged our $3 million R&D investment into about $10 billion of industry commitments. Three-thousand-fold leverage suited me just fine. And we're continuing to work in that way. We're also getting better at relating the technical opportunity to a breakthrough competitive strategy.

Can you explain a bit more about this strategy?

There are four boxes in which one must play to transform big, complex systems like the energy or automotive industry. The ones people normally talk about are technology and policy. The other two, which may be even more important, are design and strategy—or, if you like, business innovation. And if you play with a full deck, with all four of those, you reach your goals a lot faster, make more money, have more fun, and have less risk.

The example you just shared, how you open-sourced that concept and then saw the industry follow suit, do you have a name for the steps you took to do that?

It's part of a broader strategy we've always used at RMI. And that is to use competition to do our work. We typically use soft money—grants and donations—to develop valuable new concepts. We then work with early adopters in the private sector who have a real problem they're highly motivated to solve, and we have a solution for it. So together we learn rapidly. This gives us precious hands-on implementation experience, unrestricted revenue, and buzz. But more important, it gives us teachable cases and

competitive pressure for emulation. That is, we help early adopters become so conspicuously successful using advanced energy and resource efficiency and other tenets of natural capitalism that their competitors are forced to follow suit or lose market share.

The Empire State Building retrofit that RMI was part of—does this work fit into that approach? Getting a large office building to adapt and change, with the idea that other buildings in Manhattan and elsewhere will follow suit?

Yes. We agreed to do the project precisely because of that kind of leverage. The owner, Tony Malkin, is a very demanding and aggressive developer who will not hesitate to walk up to his peers at a cocktail party—a very competitive crowd—and say, "Hi, I made more money than you did last year. Let me tell you how. It's called integrative design for advanced energy efficiency."

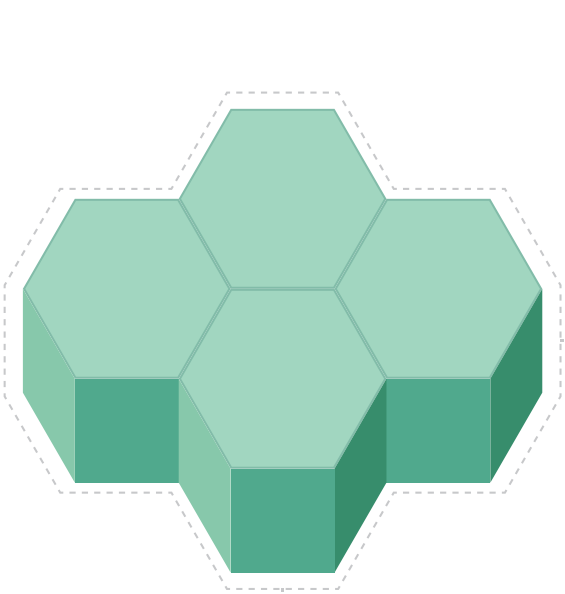
Moreover, we got to work with a major energy service company and a major property manager—Johnson Controls and Jones Lang LaSalle—in ways that may motivate them to switch their business model toward deep retrofit to gain competitive advantage. And that's a way to drive their respective sectors in the same direction.

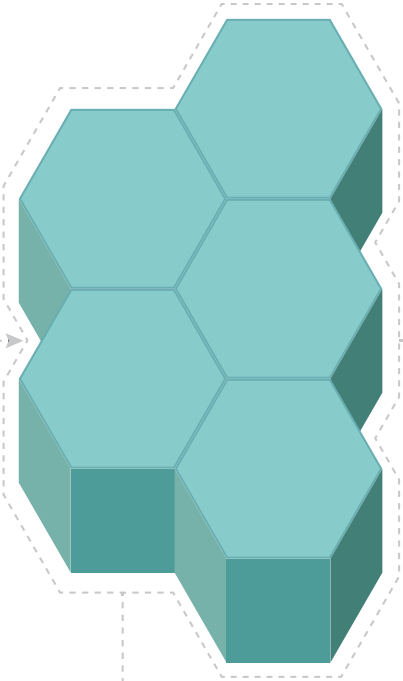
So the Empire State Building wasn't just another client.

We don't have "just other clients." We choose them strategically to get that kind of leverage. We don't just do whatever job comes in the door.

Is there a phrase you use to describe the ideal types of clients and how they'll have this cascading effect on other members of their industry?

We might call that "leverage" or "influence."





actor Ten Engineering Principles underpin the
hich can yield radical resource efficiency.
stem as a whole, rather than its parts in isolation.
eering Principles throughout a collaborative
l into three stages: Ready, Set, Go.

7
optimize over time
and space

12
start downstream

5
define the end-use

10
start with a clean sheet

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8

It's both. Indeed, they're different faces of the same decision, because if you vote with your wallet, as we all do, business is exquisitely sensitive to what you do or don't buy and why they think you do or don't buy stuff. The coevolution of business with civil society is very powerful and active as a learning process both ways. It is also essential [for us] to engage with commerce.

The choices that have landed us in this mess are billions of individual decisions. More mindful, better-informed individual decisions in the billions can lead us out of this mess. So you need both of these: individual choices of what to do or refrain from doing and the ability of business to provide solutions in a way that none of us has the individual capacity to make and market.

Your work at the Empire State Building is an example of a project that changed a whole system. Is the consulting work that you did largely creating metrics that will allow a client to believe in making the changes proposed?

Understanding metrics is an important part. But we mainly work with designers of record in buildings, vehicles, and industry to help them do what they didn't know how to do or didn't even realize they could do. When we went into the Empire State Building project, we worked on the conceptual design and early phases of the schematic, and design development after that. The conventional wisdom was that you could save about 7 to 10 percent of the energy with a few years' payback. We're ending up saving 38 percent of the energy with a three-year payback, even though it's a very difficult building and the windows had already been switched from single- to double-pane glass.

In the case of the Empire State Building, 38 percent savings with a three-year payback was considered quite exceptional. And it arose from integrative design.

Basically, we were remaking the windows, in an improvised temporary window factory on-site, into superwindows that blocked winter heat loss three times better and summer heat gain twice as well. And that, combined with better lights and some other improvements, cut the peak cooling load by a third. This enabled us to save $17.4 million versus renovating and redesigning, rather than replacing and expanding, the chillers. Then we used that savings to help pay for everything else.

In working with the other stakeholders in the project, such as Johnson Controls, were you serving as an efficiency consultant for each of those designers, and then bringing all of them together?

Our most important role is in convening everybody in a disciplined but imaginative framework that fits all of the moving parts together in a new way, yielding bigger savings and lower costs. That's integrative design. Ⓐ

Some finished retrofit floors of the Empire State Building (right) have been transformed into full, green office space (above).

"I had access to senior executives in influential organizations, but I wasn't taking advantage of the opportunity to have an impact."

—

VALERIE CASEY

The founder of the Designers Accord is leading a new generation of designers who are determined to be part of the solution.

What was your inspiration for the Designers Accord?
I have been a designer for sixteen years. Four years ago, I was working for several *Fortune* 50 companies, traipsing back and forth across the country, and designing products without accounting for the environmental impact they would have. I was creating consumer electronics and fast-moving consumer goods—disposable cell phones, disposable diapers, and disposable packaging—but even then I knew that none of them were truly disposable. I had access to senior executives in influential organizations, but I wasn't taking advantage of the opportunity to have an impact—to change the course of my products and their portfolios.

Personal responsibility prompted me to investigate environmental issues more seriously, but I also had a professional motivation. I knew my clients would expect me to have expertise in sustainability, just as designers are now called upon to integrate brand, technology, and business acumen in the things we create.

The backbone of my design work has always been about finding new ways to collaborate and solve problems. I decided to apply some core principles—leveraging distributed intelligence, learning through experimentation, and exciting cooperative competition—to the question of sustainability, and that culminated in a "Kyoto Treaty" of design, which is now known as the Designers Accord. The basic idea is to enable designers and creative firms to share perspectives, experiences (good and bad), and sustainability case studies, so others can learn from them, build on them, and share their results within the Designers Accord community. It's about encouraging collaboration among competitors to develop our collective environmental intelligence, and it's led to smarter and more-efficient innovation.

What are the goals of the Designers Accord?
It's a five-year project with three goals. One goal is to increase awareness about the principles of sustainability throughout the professional design community and in design education. About seven hundred design firms, forty universities, and forty corporations across one hundred countries have adopted the Designers Accord guidelines. The second goal is to help shape the values of practicing designers by enabling practitioners all over the word to share strategies and stories. The last goal is aspirational: We want designers to have a seat at the table with lobbyists, economists, and scientists when it comes time to develop policy and influence regulation. If a designer's greatest strength is the ability to generate new kinds of solutions, then shouldn't designers use those skills to address problems we all face? I don't expect design thinking to save the world. But I know it can be an important part of the solution.

PREDICTING THE FUTURE IS NOTORIOUSLY HARD, ESPECIALLY IN THE MIDST OF THE BLIZZARD OF CHANGE SWIRLING AROUND US TODAY. BUT ONE THING WE CAN BE SURE OF IS THAT THE REMARKABLE DESIGN ADVANCES OF THE PAST FEW YEARS—MANY OF THEM CHRONICLED HERE—ARE JUST A PRELUDE TO THE REVOLUTION JUST AHEAD.

—

previous spread: **The undulating "living roof" of Renzo Piano's design for the California Academy of Sciences.**

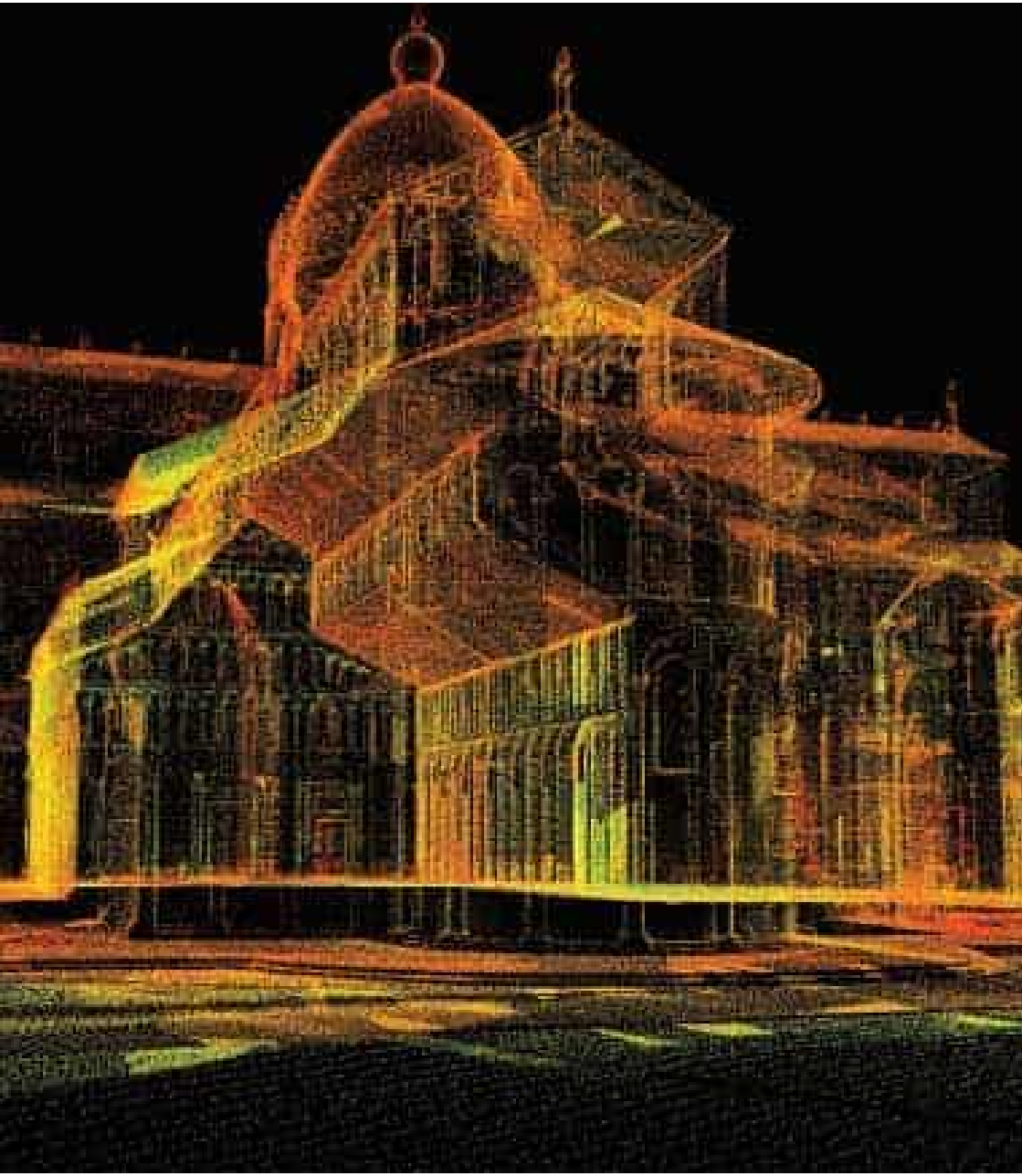
HAVING SO MUCH MORE POWER, INFORMATION, AND OPTIONS TO CHOOSE FROM, THE QUESTION ARISES: IS MORE ALWAYS BETTER?

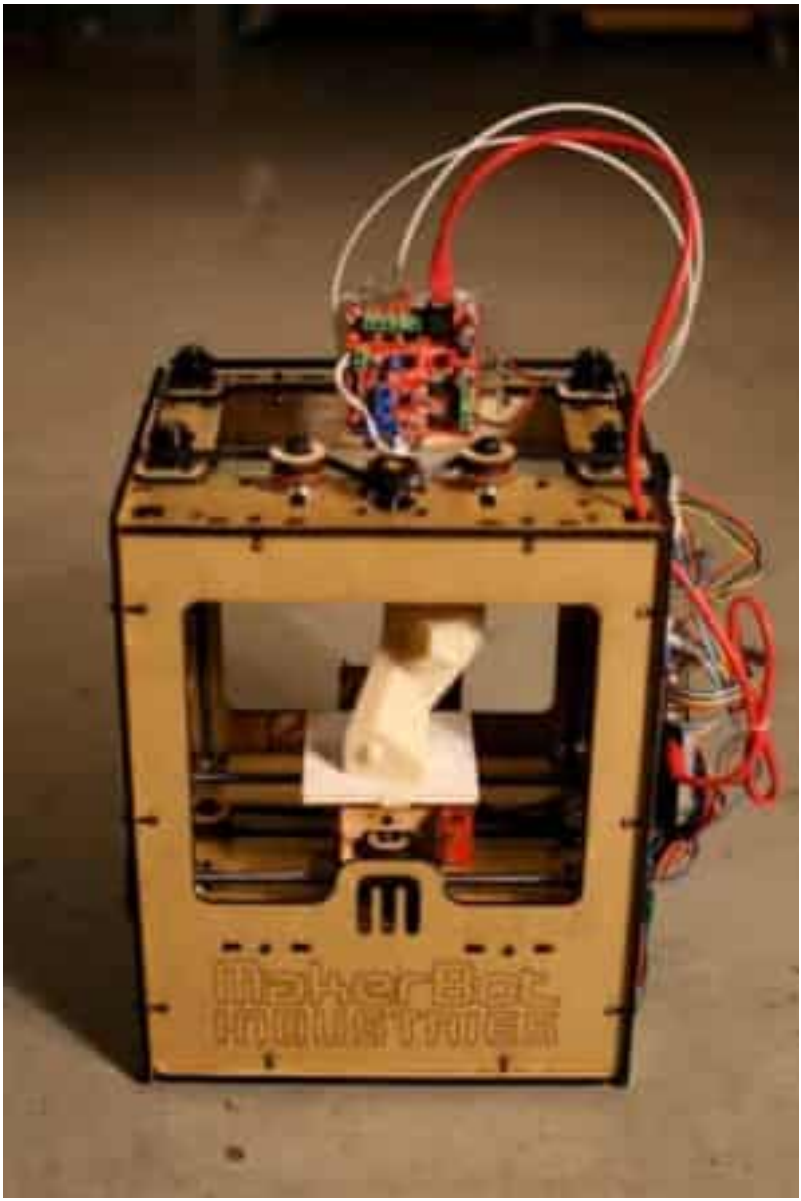
arises: Is more always better? If designers can avoid being overwhelmed by the onslaught of massive data and complexity, there is good reason to believe that the quality of design will be enhanced. Because instead of just creating a design and then hoping that it passes the test of acceptability and practicality, the new methodology will be about trying as many options as possible in order to get to an optimal result.

Moreover, by having the computer do some of the drudgery of constant analysis, the designer frees himself to focus more on creative exploration and the art of design—while being less burdened by technical demands. Consider the Centre Pompidou in Metz, France, as an example. The roof structure is based on a complex surface inspired by a traditional Chinese hat and was constructed using custom-fabricated "glue-lam" wood beams. Figuring out the complexity of the support beams for each shape change would have been impractical as design options were explored. But by using scripted computer languages to generate and optimize the structure's geometry, the architect didn't have to work out construction details with the fabricator; nor did those details have to be drawn or modeled. They were computed each time the designer changed the overall form. With the computer doing instantaneous calculations on every change of the shape, it ensured the designer would only spend time exploring shapes that could actually be built.

Which takes us back to that question: *What would you build if you could build anything you wanted?*

Shigeru Ban's design for the Centre Pompidou in Metz, France, includes a highly complex system of wooden supports that create the museum's distinctive shape. That complex system would have been impractical without a smart, scripted design approach that calculated the buildability of the design.





DESIGNERS WILL PROVIDE THE GUIDANCE THAT WILL ENABLE OTHERS TO DESIGN WELL.

This is all very exciting, but it also leads to a question: If "everyone is a designer," where does that leave all of the professional architects, engineers, product designers, and filmmakers? To put it simply, they'll be leading the revolution: Highly trained, talented designers will provide the inspiration, knowledge, and guidance that will enable others to design well. They'll be able to understand, and sometimes actually establish, the constraints that the citizen-designers will work within. But while designers will be guiding the way toward good design, it doesn't necessarily mean that they'll be creating rigid templates, because there will be plenty of room for designing parameters that still allow the layperson to be highly creative en route to the finished design.

Meanwhile, professionals can expect to get something back from the amateurs—in the form of information, and even inspiration. If more people are designing and doing so digitally, the professional designer can capture that information and learn from the experiments and variations that work or don't work—which in turn can lead to design choices that are more informed. There will be a near-infinite supply of creative influences to draw from—more components with which to build.

The design community of tomorrow will be as big as the world itself. It will be more competitive, for certain, but also more cooperative. The DIY and DIT (do it together) movement is inspiring and enabling designers and innovators to band together in trying to solve problems. This "extreme collaboration" approach often involves opening up design challenges to a wider community and inviting the members of that community to work together (or compete with one another) to find the best design solution. This movement toward open innovation and open-source design will continue to grow because it offers the irresistible benefit of having many minds working on a single problem at the same time. But there are inherent pitfalls, too—including the temptation for companies to undercut professional designers by trying to get low-cost or even free design "from the crowd." One of the challenges ahead will be to find ways to tap into the mass creativity of tomorrow's citizen designers while still respecting the perspectives and abilities of more experienced and knowledgeable practitioners. Because even in a world where "everybody is a designer," not all designers are created equal.

The burgeoning DIY (do-it-yourself) and DIT (do-it-together) movements are inspiring new generations of professional and amateur designers, engineers, and inventors.

"Technology will give us many more tools for exploration at the conceptual stage. Designers will be more able to explore different alternatives."

—

CARL BASS

Autodesk's CEO discusses the roles and skills of future designers, the rise of an "Internet of things," and the changing way we make things.

How will the nature of what a designer does change? What do you expect a future designer to be able to do more of, or need to do less?

Designers will document less and explore more. Technology will give us many more tools for exploration at the conceptual stage of a project. Designers will have more power to explore different alternatives involving aesthetic and functional choices right from the start.

Part of the design process is analytical. I have an idea—what are the implications of it? What does it look like? How does it fit together? Does it bump into something else that already exists? How does the light reflect off it? Based on these questions, I'm going to decide to change the idea to make it better. That kind of feedback is much more immediate in a technology-based design process. So there will be less analysis that we have to do ourselves and more synthesis of the data that comes back to us more quickly and easily.

Much of what's going on technologically is enabling better prototyping, so that people can experience their ideas before they are real and improve them accordingly. The better our tools are at helping them do that, the more they can focus on exploring and creating.

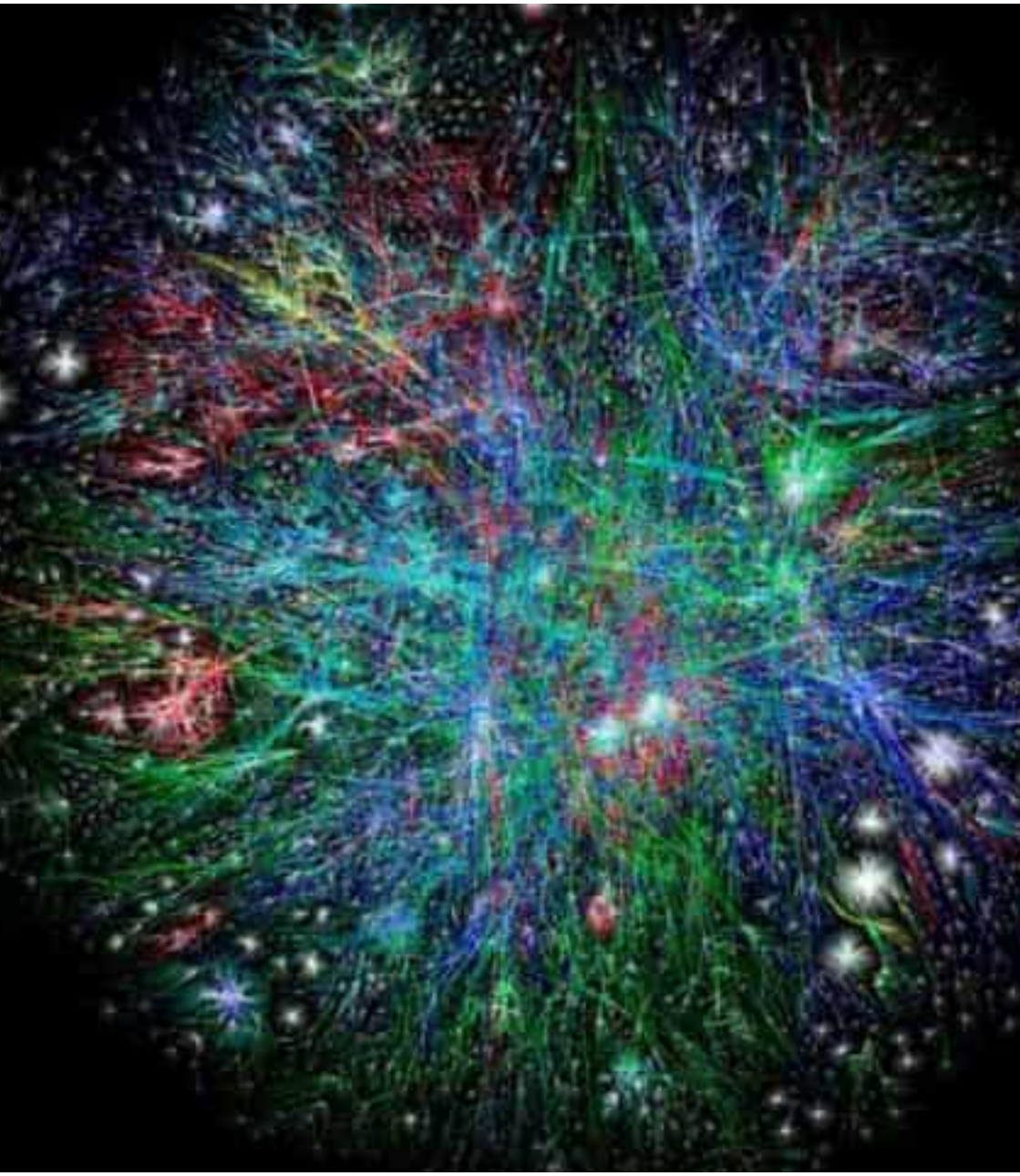
What else is changing about the practice of design?

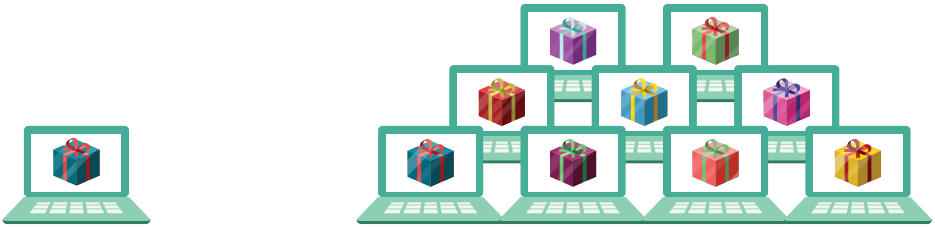
Well, first of all, it's good to keep in mind that some things never change; I'm reminded of what my old boss used to call "the problem of the computer," the systematic generation of useless alternatives. Even with a really great computer, you can still manipulate the digital model in a way that does not provide useful information or insight.

But on the plus side, the increasing power of computers creates entirely new areas of exploration for people who design and create things. One example: We're accustomed to the idea of design as the human brain making decisions. But now there's the new question of "meta-design": You have to design a process, or write a script, or parameterize a problem space, within which the design problem will operate.

Over time, I think we're going to be delegating parts of complex design problems to these kinds of automated processes so that we can focus on the stuff that we really care about. Imagine if a digital model would just automatically tell you that something you were doing was a code violation. It'd say, "Hey, dummy, that's a dead-end corridor." Or, "Hey, that staircase isn't wide enough!"

Another example: Our director of software development, Robert Aish, has talked about the new roof over the British Museum's Great Reading Room. The idea was to create a faceted glass surface where none of the facets were larger than *this* in area, and the angle between any two adjacent pieces



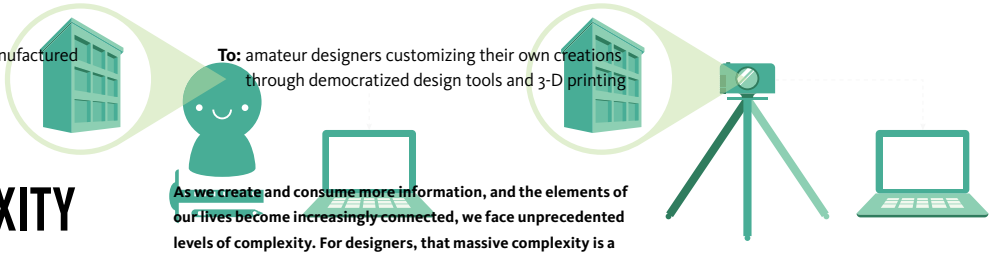


DESIGNER

Low-cost, widely distributed design tools make it easy for non-designers to shape, manipulate, and manufacture everyday objects at home, fulfilling the growing desire to have more control over the objects in our lives. Instead of design that is mass-produced, we'll see personalized creations designed for production units of one.

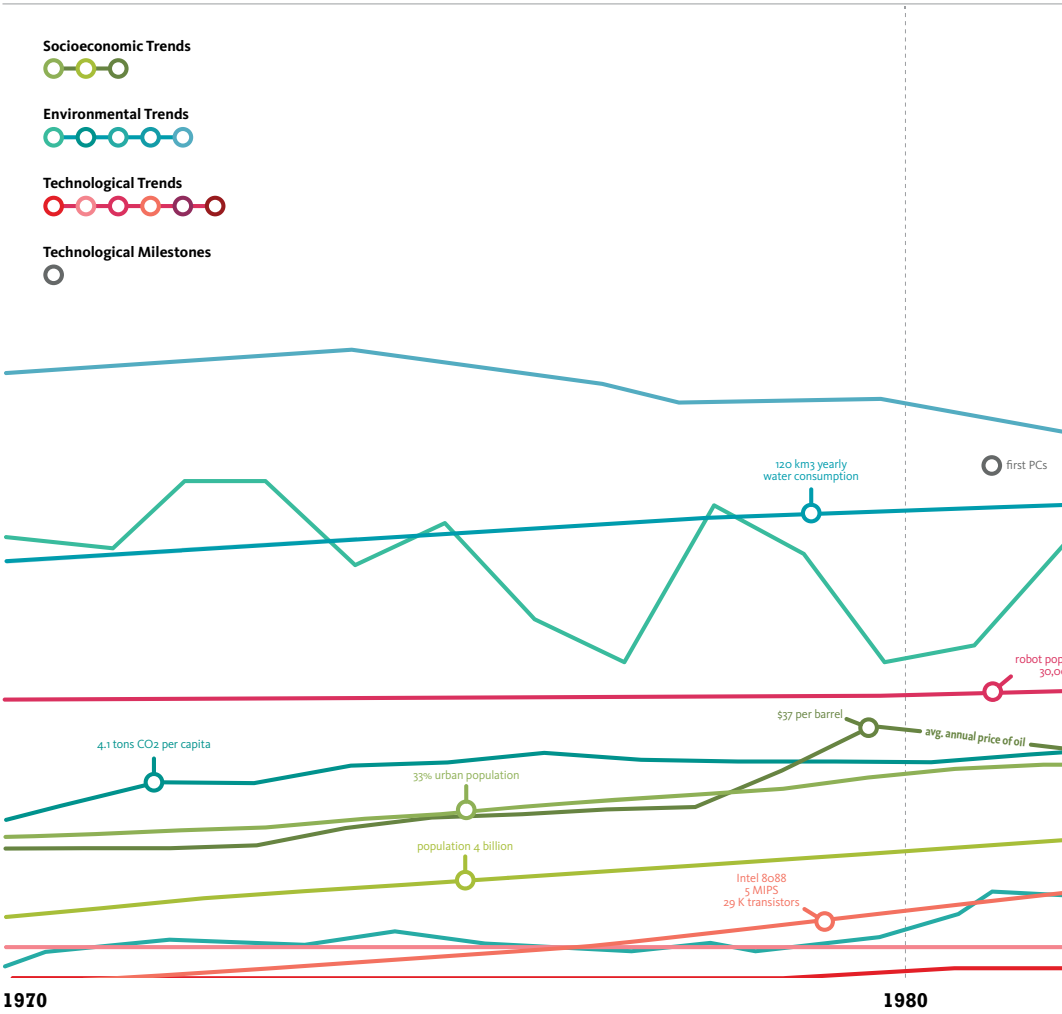
ng manufactured

To: amateur designers customizing their own creations through democratized design tools and 3-D printing



LEXITY

As we create and consume more information, and the elements of our lives become increasingly connected, we face unprecedented levels of complexity. For designers, that massive complexity is a major challenge that will intensify in years ahead, making it critical for them to distill clarity from chaos.


Socioeconomic Trends
Environmental Trends
Technological Trends
Technological Milestones
120 km3 yearly
water consumption
first PCs
robot pop
30,0
$37 per barrel
avg. annual price of oil
4.1 tons CO2 per capita
33% urban population
population 4 billion
Intel 8088
.5 MIPS
29 K transistors
1970
1980

and collectives—to take the initiative in tackling these grand challenges. Design professionals must move from thinking of themselves as doing "only" design to intentionally engaging in a broader range of activities with a mind-set geared toward innovation.

For example, some leading-edge companies have begun to apply principles of sustainable design to the challenge of minimizing the harmful environmental impact of what they make, spurred on partly by consumers who are beginning to demand more sustainable and responsible approaches from the companies they do business with. At the center of this burgeoning movement are individual designers such as Valerie Casey, founder of the Designers Accord (which encourages business to design products and practices far more sustainably), as well as companies such as Autodesk, which has developed a new approach that corporations can follow in setting targets to reduce greenhouse gas emissions. If all companies were to adopt this approach, private sector emissions would be on track to help stabilize the climate by 2050.

In the quest for clean energy, companies like Tesla Motors and Green Ocean Energy are using innovative design to create groundbreaking products that reduce our dependence on oil. Tesla Motors' Roadster and Model S cars are proving that electric automobiles can compete not just on the moral high ground but also on the high-speed freeway. Green Ocean Energy, located in Scotland, has created a remarkable technology that harnesses energy from ocean waves in an entirely new way, using huge devices—usually around 50 meters long and weighing 300 tons—that must be able to survive harsh ocean storm conditions. Designing and building these machines would be virtually impossible without using digital modeling and advanced simulations.

In the educational realm, designers such as Yves Behar and the team at Nicholas Negroponte's One Laptop Per Child (OLPC) group have demonstrated that it's possible to apply innovative design to the challenge of bringing affordable laptop computers to children in developing nations. Although the OLPC project has encountered political and cultural roadblocks along the way, it has nonetheless helped more than 1 million children in poor, often remote areas to connect with the resources of the Internet. Meanwhile, designer Emily Pilloton is redesigning classrooms and learning approaches geared to at-risk children. Pilloton is an example of one designer who crosses over into various areas of need: Before focusing on education design, she had left the practice of product design to create a traveling road show of design objects that improve people's lives.

The sophistication of our design tools, and the sources of design inspiration, will continue to grow as we harness everything from the power of algorithms to the wonders of nature to make it increasingly possible to design and create almost anything we can imagine. And as design's ability to do more increases, it will become ever more important to design thoughtfully, elegantly, and ethically.

And while many of the aspects of design will undergo radical change over the next few years, the *timeless* aspects of design—and our instinctual desire to imagine, design, and create a better world—will be with us as long as someone is around to ask the question, "What if?"

The challenge of building a clean, sustainable energy infrastructure is already inspiring new design approaches, such as this tidal generator by Marine Currents Limited.

ARE WE READY TO EMBRACE THE CHALLENGE?

THE TECHNOLOGIES DESCRIBED HERE SUGGEST THAT WE NEEDN'T WORRY ABOUT HAVING THE TOOLS REQUIRED TO DESIGN A BETTER FUTURE. Armed with unlimited processing power, vast amounts of information, greater connectivity, and widespread manufacturing capabilities, the toolset will be there. But what about the mind-set?

Design is, in essence, a way of thinking. It is dependent on the ability and willingness to explore ideas and options, to question what is and what might be, to experiment, and to consider multiple viewpoints and potential outcomes. These are the mental and emotional activities that will be increasingly critical to navigating a world of complex, interconnected challenges. So here's the question: Do we have what it takes?

Judging by the insightful and innovative designers, problem-solvers, and thinkers profiled here, there is good reason to be hopeful. The challenge is to foster this way of thinking and problem-solving, this mind-set, among the many, not just the few.

The Masdar Headquarters building in Abu Dhabi, designed by Adrian Smith + Gordon Gill Architecture, will be the world's first large-scale positive-energy building

That may require bold changes in the way we educate and encourage tomorrow's designers—including both professionals and motivated amateurs empowered by accessible, inexpensive tools. As Sir Ken Robinson and inventor Dean Kamen have both pointed out, it all starts with nurturing the creative spark in people when they're young—teaching them that there is usually no single right answer, encouraging them to experiment, to be open to all possibilities, and to let their imaginations roam.

When these students leave academia, they will be entering a realm where complexity is the norm and innovation is critical to success. While there is no shortage of inventive minds coming out of universities, there is a considerable gap between invention (creating something new) and innovation (introducing something new into the world). And because design is often the bridge that connects one to the other, it behooves everyone to know how to think like a designer. That means knowing how to generate and synthesize ideas; to develop those ideas over time; to learn the subtle skills of evaluating, analyzing, and making choices; and knowing how to work across disciplines and collaborate with a wide range of people. It involves listening, communicating, empathizing, and myriad other "soft" skills that are so essential to solving the hardest problems.

Adopting this mind-set, this way of thinking, is a lifelong undertaking. Fortunately, the "classroom" now is all around us; through social networking and crowdsourcing, today we can get answers and feedback, and find expert partners to help on our most important projects.

It's an ideal environment for the bold and the brainy, the curious and the flexible and the people who thrive on improvisation and love nothing more than the feeling of amazement when they surpass even their own high expectations with a great idea or a brilliant execution. We'll still need the elite thinkers, the experienced craftsmen, the bright-eyed newcomers, and just about everyone else to pitch in as we confront the immense challenges ahead.

Designing this new world is no solitary pursuit, but rather one that demands the very best of our collective imagination and effort. We'll need to share our ideas and our visions in an ongoing conversation about tomorrow that, hopefully, begins now. That conversation—and the ideas and innovations it will generate—is the first step in the next chapter of the timeless story of design, as we work together to imagine, design, and create a better world. Ⓐ

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