IOT, DATA, AND
THE LAST MILE

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IoT, Data, and the New Last Mile

GEORGE BERGHORN

Domicology: A New Way to Fight Blight Before Buildings Are Even Constructed
By Rex LaMore, George H. Berghorn, and M.G. Matt Syal

The Conversation | November 19, 2018
https://theconversation.com/domicology-a-new-way-to-fight-blight-before-buildings-are-even-constructed-82582

We've coined the term domicology to describe our study of the life cycles of the built environment. It examines the continuum from the planning, design and construction stages through to the end of use, abandonment and deconstruction or reuse of structures. Domicology recognizes the cyclical nature of the built environment. Ultimately we're imagining a world where no building has to be demolished. Structures will be designed with the idea that once they reach the end of their usefulness, they can be deconstructed with the valuable components repurposed or recycled.

See also in the TTI/Vanguard archive:

- Marwan Khraisheh: *Towards Sustainable Manufacturing*, Vienna, Austria, July 2013.
- Heidi Kujawa: *Transforming Plastic*: San Francisco, California, Dec 2016.

PETER CALTHORPE

Peter Calthorpe Is Still Fighting Sprawl—With Software
By Richard Florida

CityLab | Apr 17, 2018
https://www.citylab.com/design/2018/04/peter-calthorpe-is-still-fighting-sprawlwith-software/558164/

The architect and urban designer Peter Calthorpe was an advocate of transit-oriented development (TOD) and smart growth long before those concepts were buzzwords. In fact, as one of the founders of the Congress for the New Urbanism and the author of the first TOD guidelines (as well as numerous influential books), Calthorpe has done as much as anyone to re-focus American urbanism on walkable, dense, sustainable, transit-rich environments. Now, in an attempt to spread this knowledge even more widely, Calthorpe has released a new urban-planning software, Urban-Footprint, which will soon be available to virtually every city and government agency in California.

See also in the TTI/Vanguard archive:

- Zabe Bent: *Autonomous Future: Planning for the City*, McLean, Virginia, September 2017.

JAMES CANTRELL

He Worked in Russia and Palled Around with Elon Musk. Now This Entrepreneur Has Big Plans for His Own Rocket Company

By Kevin J. Ryan

Inc | October 8, 2018
https://www.inc.com/kevin-j-ryan/vector-building-rockets-jim-cantrell-spacex.html

Russian rockets. Elon Musk. Entrepreneur Jim Cantrell is ready to put it all behind him—if he can.

See also in the TTI/Vanguard archive:

- Steve Jurvetson: *Disruptive Investment: Forging the Near Future*, San Francisco, California, December 2018.

ELVIS CAO

Shine On: Dimensional Energy Turning Carbon Dioxide into Fuel

By Jeff Kart

Forbes | Aug. 30, 2018
https://www.forbes.com/sites/jeffkart/2018/08/30/shine-on-dimensional-energy-turning-carbon-dioxide-into-fuel/#592a82cf3b5e

Burning fossil fuels releases carbon dioxide, a greenhouse gas that contributes to climate change. But what about turning carbon dioxide back into fuel? A Cornell University startup has reportedly developed a way, by adding sunlight to carbon dioxide to transform it into syngas or methanol.

See also in the TTI/Vanguard archive:

- Matthew Atwood: *Closing Loops*, Vienna, Austria, July 2013.

FELIX EJECKAM

Ultra-Cool GaN on Diamond Power Amplifiers for SATCOM

By Felix Ejeckam, Ty Mitchell, Kris Kong, and Paul Saunier

Microwave Journal | June 13, 2018
http://www.microwavejournal.com/articles/30451-ultra-cool-gan-on-diamond-power-amplifiers-for-satcom

The most advanced commercial satellites transmit data down to Earth at rates of 100 to 200 Mbps; some advanced larger single satellite concepts target 1 to 4 Gbps. These data rates are substantially limited by state-of-the-art RF power amplifiers used to make the transmitters. Akash is building, for the first time, a small satellite system (12U) that will exhibit a preliminary downlink data rate of 14 Gbps. The next demo will feature data rates of over 100 Gbps. The ultimate technical goal is to demonstrate a downlink data rate of 1 Tbps from a single, modest size satellite—using GaN on Diamond RF power amplifiers.

See also in the TTI/Vanguard archive:

- Jordi Puig-Suari: *CubeSat: An Accidental Space Revolution*, Boston, Massachusetts, April 2017.
- Mike Cassidy: Google's Project Loon: Internet via High-Altitude Balloons, San Francisco, December 2016.

JUDY ESTRIN

The World Is Choking on Digital Pollution
By Judy Estrin and Sam Gill

Washington Monthly | Jan/Feb/Mar 2018

https://washingtonmonthly.com/magazine/january-february-march-2019/the-world-is-choking-on-digital-pollution/

Society figured out how to manage the waste produced by the Industrial Revolution. We must do the same thing with the Internet today.

See also in the TTI/Vanguard archive:

- Judy Estrin: *Sustainable Innovation*, Phoenix, Arizona, December 2008.
- Judy Estrin: *Real-Time Multimedia in Internet and Intranet Solutions*, Irving, Texas, July 1996.
- Richard DeMillo: *Virtual Blight*, Atlanta, Georgia, February 2008.

GEORGE HOTZ

The First Person to Hack the iPhone Built a Self-Driving Car. In His Garage
By Ashlee Vance

Bloomberg Businessweek | December 16, 2015
http://www.bloomberg.com/features/2015-george-hotz-self-driving-car/

A few days before Thanksgiving, George Hotz, a 26-year-old hacker, invites me to his house in San Francisco to check out a project he's been working on. He says it's a self-driving car that he had built in about a month. The claim seems absurd. But when I turn up that morning, in his garage there's a white 2016 Acura ILX outfitted with a laser-based radar (lidar) system on the roof and a camera mounted near the rearview mirror. A tangle of electronics is attached to a wooden board where the glove compartment used to be, a joystick protrudes where you'd usually find a gearshift, and a 21.5-inch screen is attached to the center of the dash. "Tesla only has a 17-inch screen," Hotz says.

See also in the TTI/Vanguard archive:

- Marco Della Torre: *Designing Intelligence for the 270M Vehicles Already on Our Roads Today*, Los Angeles, California, March 2018.

CASEY LINDBERG

Effects of Office Workstation Type on Physical Activity and Stress

By Casey M Lindberg, Karthik Srinivasan, Brian Gilligan, Javad Razjouyan, Hyoki Lee, Bijan Najafi, Kelli J Canada, Matthias R Mehl, Faiz Currim, Sudha Ram, Melissa M Lunden, Judith H Heerwagen, Kevin Kampschroer, and Esther M Sternberg

Occupational & Environmental Medicine | 2018
https://oem.bmj.com/content/75/10/689

Office environments have been causally linked to workplace-related illnesses and stress, yet little is known about how office workstation type is linked to objective metrics of physical activity and stress. We aimed to explore these associations among office workers in US federal office buildings. What we found was, workers in open bench seating were more active at the office than those in private offices and cubicles. Office workstation type was related to enhanced physical activity and reduced physiological and perceived stress. This research highlights how office design, driven by office workstation type, could be a health-promoting factor.

See also in the TTI/Vanguard archive:

- Sara Armbruster and Donna Flynn: *Designing for Human Resiliency in the Future Workplace*, Washington, D.C., September 2015.
- Martin Keen: *Humanizing the Way We Work*, London, England, July 2014.

ADAM MILLARD-BALL

How Pedestrians Will Defeat Autonomous Vehicles
By Karinna Hurley

Scientific American | March 21, 2017
https://www.scientificamerican.com/article/how-pedestrians-will-defeat-autonomous-vehicles/

Self-driving cars are already on the way; by some projections autonomous capability could even be standard by 2030. As drivers, cars will behave differently than humans, and they will almost surely be programmed to avoid hitting people. The idea that roads will become safer, with fewer traffic accidents, is a driving force behind the new technology. But, as pedestrians quickly figure out the cars' behavior, they will certainly adapt theirs as well. The effects could be dramatic: instead of more consistent, traffic flow could become chaotic.

See also in the TTI/Vanguard archive:

- Simon Tong: *Testing Autonomous Vehicles: Safety Drivers and Simulation*, Brooklyn, New York, June 2018.
- Ben Kuipers: *Robots, Trust, and Ethics*, Brooklyn, New York, June 2018.

RODNEY MULLEN

How Do You Rebel Against Rebellion? Skating Legend Rodney Mullen Keeps Reinventing Himself
By Krisztina 'Z' Holly

Forbes | May 11, 2017
https://www.forbes.com/sites/krisztinaholly/2017/05/11/rodney-mullen/#1b2d91af4d92

Rodney shares crazy stories of forklift races, mutiny, and hobnobbing with the Communist Party in China as he and his partner built World Industries. The company went on to become the biggest skateboard company in the world, with novel designs and a unique way of harnessing talent. The characters in the story are colorful for sure, but the most fascinating stories to me are those that give deep insight into the process of innovation.

JEREMIAH PATE

University of Arizona Student Owns Lunasonde, a Satellite Research Company
By Samantha Jorgens, Central Michigan University

Study Breaks Magazine | February 21, 2018
https://studybreaks.com/college/university-of-arizona/

Jeremiah Pate, a freshman at the University of Arizona, has been conducting research involving satellite exploration, Parkinson's disease and more. This variety of research is important for Earth and its resources, along with the medical field. Pate's satellite research led him to start his own company, Lunasonde, which focuses on mining minerals and targeting the same regions as mining companies in order to provide mining corporations with data.

DIPANKAR RAYCHAUDHURI

PAWR Platform COSMOS: Cloud Enhanced Open Software Defined Mobile Wireless Testbed for CityScale Deployment

National Science Foundation Award Abstract #1827923
April 2, 2018
https://www.nsf.gov/awardsearch/showAward?AWD_ID=1827923

Radio nodes in COSMOS provide a mix of fully programmable software defined radios (SDRs) for flexible wireless experimentation as well as commercial hardware capable of supporting networking and applications research with currently available enduser devices. COSMOS is built in a bottomup manner with commodity components and customized opensource hardware and software modules. The developed wireless platforms cover the full range of spectrum including the sub 6 GHz bands used for today's services as well as emerging 28 GHz and 60 GHz millimeter-wave (mmWave) bands. SDRs utilize a new design that achieves an orderofmagnitude performance headroom over current technology, achieving realtime processing of wide bandwidths (~500 MHz) via novel acceleration techniques. The COSMOS platform incorporates fast programmable core network technology to keep pace with significant increases in wireless link bandwidth and to effectively integrate emerging radio access networks with edge cloud computing. The design includes novel 100 Gbps+ fiber, free space optical, and microwave backhaul technologies interconnected with a softwaredefined network (SDN) switching fabric for minimum latency and flexibility in setting up experimental network topologies.

See also in the TTI/Vanguard archive:

- David Reed: *Computational Radio Networking*, Los Angeles, California, February 2013.
- Robert Heath: *Millimeter Wave Cellular Systems*, San Francisco, California, May 2016.
- Sundeep Rangan, Marco Mezzavilla, David Reed, and Bob Lucky: *An Afternoon of 5G at NYU Wireless*, Brooklyn, New York, October 2016.

ADRIAN WESTAWAY

Magic UX

Special Projects
http://specialprojects.studio/project/magic-ux/

Magic UX is a new smartphone interface inspired by the physical world. It uses your view of the real world to help you navigate computer generated content in the digital world. It's a practical, subtle use of augmented reality.

See also in the TTI/Vanguard archive:

- Mark Skwarek: *Augmented Reality in Business and Gaming: An Overview*, San Francisco, California, December 2016.

BRUNO ZAMBORLIN

HyperSurfaces Turns Any Surface into a User Interface Using Vibration Sensors and AI

By Steve O'Hear

TechCrunch | November 19, 2018
https://techcrunch.com/2018/11/20/hypersurfaces/

Imagine any surface, such as a wooden table, car door or glass wall, could be turned into a user interface without the need for physical buttons or a touch screen. That's the ambition of HyperSurfaces, the London startup originally behind the Mogees line of music devices and software, which today is unveiling what it claims is a major breakthrough in UI technology. Dubbed "HyperSurfaces," the new technology, for which the company has four related patents pending, combines vibration sensors and the latest developments in machine learning/AI to transform any object of any material, shape and size into an intelligent object able to recognize physical interactions.

See also in the TTI/Vanguard archive:

- Laura Lahti: *Interface Designs for Next-Generation Computers*, Miami, Florida, December 2011.
- Nazim Kareemi: *Electronic Perception Technologies*, San Diego, California, November 2002.

BONUS

The wired household: Teletext services pave the way for a variety of useful monitoring and control features in the home

By E. Bryan Carne, GTE Laboratories

IEEE Spectrum | October 1979

The real challenge of providing effective man-to-machine communications will culminate in man's home and his office. The future household will, in all probability, be a giant electric "appliance" that will be plugged into a nationwide communications network. The building blocks are available in the telephone and the television receiver. Today experimental information services for the home are in operation globally in test communities. They are based on two-way television. In the future, besides information retrieval, other more complex chores will be performed by specialized terminals that will combine microprocessors with conventional hardware. Laboratory systems being developed are based on a residential power center, the television receiver, and the telephone.

In the office, sophisticated tools need to be integrated into automated work stations. To meet that goal, both the manufacturer and the user of the equipment must chart the course. Methods of integration must be found in both hardware and software so there is easy access by man to machine in the "office of the future." Also, communication paths that facilitate access to equipment in other offices must be charted. As local nodes are built up and become self-sufficient, they will become part of nationwide information networks. New equipment, in addition to changing the office environment, will cause upheavals in the organizational structure. As in the home, the availability of new services and novel systems will depend to a great extent on relaxed regulation by government agencies.

Domicology: A new way to fight blight before buildings are even constructed

November 19, 2018
https://theconversation.com/domicology-a-new-way-to-fight-blight-before-buildings-are-even-constructed-82582

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Detroit has been demolishing about 200 vacant houses per week since December 2014, with a goal to take down 6,000 houses in one year. Much of the demolition work is concentrated in about 20 neighborhoods where the blight removal is projected to have immediate positive effects of improving remaining property values and clearing land for future development.

While Detroit may be an extreme example, economic decline, disinvestment, racial segregation and natural and human-made disasters have left other American communities with unprecedented amounts of structural debris, abandonment and blight, too.

As scholars who focus on understanding the complex circumstances that have led to blight, we also have some ideas about potential solutions that could prevent this cycle the next time around.

We've coined the term domicology to describe our study of the life cycles of the built environment. It examines the continuum from the planning, design and construction stages through to the end of use, abandonment and deconstruction or reuse of structures.

Domicology recognizes the cyclical nature of the built environment. Ultimately we're imagining a world where no building has to be demolished. Structures will be designed with the idea that once they reach the end of their usefulness, they can be deconstructed with the valuable components repurposed or recycled.

As people abandon homes the effects ripple through the community.
AP Photo/Carlos Osorio

Thinking about the end at the beginning

The U.S. reached a record high of 7.4 million abandoned homes in 2012. When people leave homes, the local commercial economy falters, resulting in commercial abandonment as well. The social, environmental and economic consequences disproportionately affect already struggling communities. Abandoned buildings contribute to lower property values and are associated with higher rates of crime and unemployment. Due to the scale of the problem, local governments are often unable to allocate enough resources to remove blighted structures.

All human-made structures have a life cycle, but rarely do people embrace this reality at the time of construction. The development community gives little thought to the end of life of a structure, in large part because the costs of demolition or deconstruction are passed on to some future public or private entity.

Currently, publicly financed demolition and landfilling are the most frequent methods used to remove abandoned structures, but these practices generate a huge amount of material waste. Upwards of 300,000 houses are demolished annually, which generates 169.1 million tons of construction and demolition debris – about 22 percent of the U.S. solid waste stream.

Here's where a shift to a new domicology mindset can help. Unlike demolition, deconstruction is a sustainable approach to systematically disassembling buildings, which can result in up to 95 percent material reuse and recycling. This method, however, may increase time and cost, while at the same time potentially creating a vibrant reuse market for salvaged materials.

Domicology's comprehensive paradigm shift from landfill-dependent demolition waste streams to sustainable construction, deconstruction and material salvage will affect both methods of construction and the materials used. For example, in design and construction of structures, modular components tend to be easier to dismantle than "stick-built" methods. Construction techniques that rely more on connectors like screws instead of glues or nails mean dismantlers can remove materials with less damage, increasing the value of the salvaged material.

On the materials side, using salvaged wood products to create new structural wood products can reduce reliance on virgin timber, which has recently experienced shortages and price fluctuations. Salvaged concrete can be used as aggregate in new construction. In some cases, even roof shingles can be melted for asphalt road surfacing. In the Midwest, where there are substantial numbers of abandoned properties, an underground "scrapper" economy has emerged that salvages copper and other valuable metals from structures.

To make deconstruction a viable alternative to demolition on a large scale, some things need to change.

What needs to change?

All of this requires forethought in recognizing that structures have an end of life. There is value in planning, designing and building in such a way that when a structure reaches the end of its usefulness, people can maximize the salvage of the materials removed from these structures. Creating a value in the end of life of a structure also decreases the likelihood of walking away from these valuable resources – reducing private sector abandonment in a community experiencing distress.

Governments can help by putting in place policies, incentives and regulations to prevent abandonment and facilitate removal. Domicology will depend on figuring out the best processes and technologies for safe removal. Deconstructors will need to hire differently skilled laborers than for a standard demolition. And for domicology to work there will need to be a way to take the removed material to a place where it can be given a second life of some kind.

As with any paradigm shift, the most challenging issue is to change current mindsets. People need to leave behind a "build it, use it, demolish it" perspective and replace it with a "plan it, design it, build it, use it, deconstruct it and reuse the materials" view. Builders must imagine at the beginning of a structure's life what will happen at the end of it.

Economics do add up

Our domicology team recently tested the economic feasibility of using deconstruction practices rather than demolition as a way to reduce blight. We also wanted to explore how feasible it would be to establish a deconstruction-based repurposing economy.

Our findings suggest that the central collection, reuse and repurposing of material from legacy cities in the Great Lakes region is feasible with the help of specific policies, practices and targeted economic development strategies.

A crucial support would be a strong supply chain for salvaged materials. In Europe, California and the East Coast of the U.S., deconstruction firms can more easily acquire the material from blighted structures, access a skilled deconstruction labor force and use low-cost modes of transportation to move salvaged materials to processing facilities. All these advantages make deconstruction cost-competitive in those regions against demolition and disposal.

As a result of the work done so far, we and our colleagues have begun to incorporate the concepts and practices of domicology in targeted courses for students. By introducing this emerging science in the classroom, students here at Michigan State University are helping to pioneer a new 21st-century conception of a sustainable built environment.

As these ideas take hold and spread through planning, design, financing and construction industries, the goal is to prevent another blight epidemic like the one we see today in Detroit.

cityLab
https://www.citylab.com/design/2018/04/peter-calthorpe-is-still-fighting-sprawlwith-software/558164/

Peter Calthorpe Is Still Fighting Sprawl—With Software

BY RICHARD FLORIDA
APR 17, 2018

In an interview, the leading New Urbanist Peter Calthorpe discusses autonomous rapid transit, Buckminster Fuller, NIMBYism, and his new urban-planning software.

The architect and urban designer Peter Calthorpe was an advocate of transit-oriented development (TOD) and smart growth long before those concepts were buzzwords. In fact, as one of the founders of the Congress for the New Urbanism and the author of the first TOD guidelines (as well as numerous influential books), Calthorpe has done as much as anyone to re-focus American urbanism on walkable, dense, sustainable, transit-rich environments.

Now, in an attempt to spread this knowledge even more widely, Calthorpe has released a new urban-planning software, UrbanFootprint, which will soon be available to virtually every city and government agency in California. (The company behind the software, which is co-led by Calthorpe and Joe DiStefano, is separate from the planning firm Calthorpe Associates.) Calthorpe compares UrbanFootprint to Sim City because it allows non-experts to model the impacts of different urban planning scenarios, such as zoning changes and road reconfigurations. He hopes it will help planners, politicians, and citizens' groups communicate the benefits of the kind of urban environments he has spent his career advocating for and creating.

In the interview that follows, Calthorpe discusses some of the most pressing challenges in urbanism today, including NIMBYism, the emergence of autonomous vehicles, and the urbanization of the developing world.

What originally got you interested in urbanism?

I was born in London and I spent the first five years of my life amidst rubble and coal-laden air, kind of a nightmare domain. Then we moved to Florida and it was like the Wizard of Oz, you know—I landed, and the world became Technicolor.

We moved to Palo Alto in the early '60s. In those days, it was a landscape filled with orchards. As I grew up, I watched it erode into subdivisions and office parks, and it became clear that it was just being degraded. I guess I grew up being sensitive to the physical environment and the kinds of ways communities shape people and their sense of identity.

I became a radical teenager and I looked at what was going on from an environmental standpoint, and felt that there was really great harm at work in the way people were living. I just kept on from there. I fell in with Buckminster Fuller's idea of whole systems: You just can't think of one issue at a time.

"The amazing thing about the city is that it touches everything."

I really quickly realized that urban design had a much bigger impact on all the important outcomes than individual buildings. So I started the Congress for the New Urbanism with Andrés Duany. What we proposed was a viable alternative to sprawl.

That gathered a huge amount of momentum, and as we made the case for the alternative to sprawl, we realized that we had to be able to speak in many languages. There was energy and carbon and climate change, or land or fiscal impacts to cities; mobility; air quality; health. The amazing thing about the city is that it touches everything.

The Bay Area when you were growing up was one of the most interesting places in the world: the explosion of the tech scene, the early hackers, the birth of the personal computer. And on top of that there was the counterculture movement and the music scene. How did those things influence you?

They totally influenced me. It was a community that connected the dots all the time. Stewart Brand was the guy who started the *Whole Earth Catalog*, but he also started The WELL [an acronym for "Whole Earth 'Lectronic Link"], which was [one of] the very first email [services]. Stewart was a really good friend and mentor to me. The community of people who were willing to think in a broad way, but also to absolutely reject norms and posit completely different approaches, was ubiquitous. It was all over the place.

You had the Human Potential Movement in its heyday there. You had environmentalists who were really beginning to think about things as an ecology for the first time. And you had political activism, sometimes really extreme, like the Black Panthers.

The underlying principle was to question the norms, and when you question norms, you get innovation. That's the foundation of innovation.

What do you think of what's happening now in the Bay Area—its crisis of housing affordability and displacement, and the great shift in how the tech industry is perceived?

I don't think technology and the city are at odds. I think that there's a deeper phenomenon: We really still have not shaken the suburban sprawl paradigm that was born after World War II. The environmental community, some dimensions of it, are just anti-growth, which inhibits housing. Since the recession, jobs have grown in the Bay Area 11 times faster than housing. We've added over 600,000 jobs, and only 56,000 housing units.

But I also think that there's something beyond that. It's what we're watching with Trump and all the rest of that tribalism, which is people being fearful and marking their territory and wanting to protect it. You know, a NIMBY is a little bit like a miniature version of Trump and his Mexico wall. It's like he's got a neighborhood and he wants to build a wall around it, and nobody else should be able to come now. We all have to realize this is a very powerful human emotion.

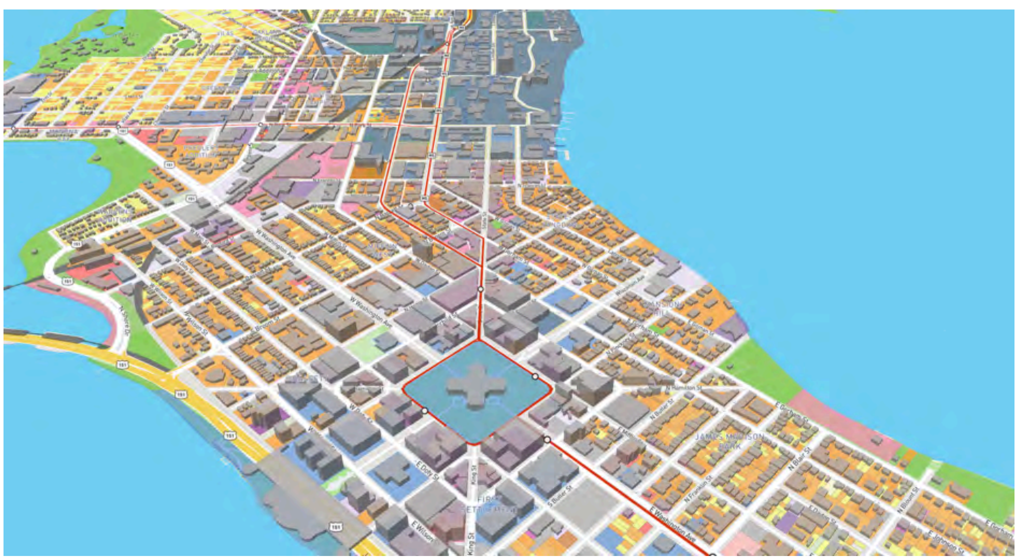
The only way you overcome that kind of feeling is with powerful coalitions. If enough groups can see common cause, and identify co-benefits and get behind a change, they can overcome that negative impulse to say, "Change is bad and I've got mine."

You recently introduced a new urban planning software called UrbanFootprint. It's got the backing of venture capitalists and is being used by the State of California. What makes it unique, and what kinds of projects will it be used for?

UrbanFootprint is a cloud-based software built to help planners, designers, architects, and advocates create sustainable, resilient communities. It supports a board range of stakeholders to enhance cities with the agility of data science and scenario-building. [They can use] UrbanFootprint's extensive data library anywhere in the United States to assess existing environmental, social, and economic conditions in just a few minutes.

Once users get a sense of current conditions, they can lead community input to create alternative land-use and policy scenarios. Then they can evaluate their impacts across a range of key community metrics, including emissions, water use, energy use, land consumption, [pedestrian] and transit accessibility, and more.

We recently announced our partnership with the State of California, which will bring UrbanFootprint free of charge to over 500 cities, counties, and regional agencies. We're thrilled to support California's public planning efforts with this technology.



Land-use patterns in Madison, Wisconsin, visualized on UrbanFootprint (UrbanFootprint)

You've done a lot of work on transit and how it shapes urban form, and you have a growing interest in autonomous rapid transit. Tell us more about that.

The really exciting thing is that we're going to have really affordable transit, in the form of autonomous rapid transit, coming online much quicker, quite frankly, than private autonomous vehicles. In dedicated rights of way, these things are safe, because they're not mixing with ordinary vehicles. And because they're driverless, the operation costs are so small that we can afford to build many more miles of this stuff.

We can basically grid our cities and suburbs with high-quality transit. The moment you do that, you have the armature for infill and redevelopment. So all the strict commercial environments—the six-lane roads lined with parking lots and single-story buildings, which, by the way, are losing value rapidly as Amazon steals all the economic activity from them—are these ribbons of opportunity throughout our metropolitan regions. By adding autonomous rapid transit and zoning for a range of housing types, we can solve the housing problem and the transportation problem.

But if you just let autonomous vehicles be privately owned or run as taxis, they're going to make the situation much worse: anywhere from 30 percent to a doubling of vehicle miles traveled. It's just like any amazing technology. If you use it well, you benefit, and if you use it poorly it can be catastrophic.

What do you think of this bill in California, SB 827, that would upzone all the areas near high-quality mass transit?

I don't like the law as it's written now, because it entitles redevelopment on single-family lots. I think that's just a political formula for disaster. It won't go anywhere. Disrupting existing single-family neighborhoods is really the last thing you want to do politically, and, quite frankly, [that you] need to do. The amount of land in ... single-story parking-lot environments, that nobody is in love with and that many people would actually like to see change, is more than enough to satisfy housing needs.

You've done a lot of work in China and the rapidly urbanizing parts of the world. What are some of the opportunities and challenges for good urbanism in these places?

In China, at the highest levels of government, the policy has completely shifted. Mixed-use, small blocks, [and] transit-oriented development are all now the norm and required. They appreciate that they can't continue to add more ring roads. I think Beijing's up to six of them now, and they're all still in gridlock. And, by the way, in Beijing only 35 percent of households own cars. Just imagine if there was more auto ownership.

It's just an impossible proposition, a high-density city whose mobility is dependent on private cars. It's an oxymoron. It never works. And I think the Chinese really recognize that now.

Jane Jacobs, who had a very big influence on both of us, and who was so optimistic when she was young, called her last book *Dark Age Ahead.* Would you say you're optimistic about the future of our cities in the United States and elsewhere? Or are you pessimistic?

I'm both. I think you can't be intelligent and not be both. I am optimistic because cities offer the best, least-cost solution to so many of our challenges. Better than just technological fixes, healthy urban forms can resolve multiple issues simultaneously. For example, housing [units] placed in walkable mixed-use areas near transit and jobs cost no more than scattered subdivisions, but they are more affordable to homeowners, need less energy and water, cost less for cities to service, generate less carbon, and create stronger communities. These are the co-benefits I was talking about, co-benefits that can generate new, powerful coalitions.

I am pessimistic when I realize most cities don't have the tools or processes to uncover these synergies—and too often default to piecemeal planning driven by professional and agency silos.

About the Author

Richard Florida is a co-founder and editor at large of CityLab and a senior editor at The Atlantic. He is a university professor in the University of Toronto's School of Cities and Rotman School of Management, and a distinguished fellow at New York University's Schack Institute of Real Estate.

Inc.

https://www.inc.com/kevin-j-ryan/vector-building-rockets-jim-cantrell-spacex.html

He Worked in Russia and Palled Around with Elon Musk. Now This Entrepreneur Has Big Plans for His Own Rocket Company

Russian rockets. Elon Musk. Entrepreneur Jim Cantrell is ready to put it all behind him—if he can.

By Kevin J. Ryan

The call came through while Jim Cantrell drove his top-down convertible through northeastern Utah, the Rocky Mountains rising in the distance. He looked at his Motorola flip phone and didn't recognize the number. He picked up anyway.

The man on the other line spoke rapidly with an accent he couldn't place. Before Cantrell could get out more than a few words, the stranger was babbling about fossil fuels and space travel and the need to make humanity multi-planetary. "He's giving me his entire life philosophy," Cantrell says, "in like 30 seconds on the phone."

The person, as Cantrell eventually gathered, was Elon Musk. Not that the name meant anything to him; it was July 2001 and PayPal was just beginning to make its way into the mainstream. Cantrell, though tech savvy, had never heard of it.

Musk wanted to set up a meeting. "Where do you live?" he asked Cantrell. "I have a private plane. I can fly in tomorrow."

Cantrell was taken aback. He didn't know Musk. After his work overseas with the Russian space program, he'd become suspicious of strangers trying to get close to him. So he lied. "I fly internationally out of Salt Lake City on Sunday," he told Musk. This was pre-September 11, when a ticket wasn't a requirement to get through airport security. He told Musk to meet him in the Delta Crown Room. "That way," Cantrell says, "I knew he couldn't pack a gun."

The meeting, it turned out, was about Russian rockets. Cantrell had developed a reputation as someone who could get a hold of Russian space equipment. Musk wanted to build a company that sent payloads into space and, one day, could get to Mars.

It took a few months, but Cantrell eventually decided to join him and became one of the first four employees at SpaceX, a venture that Musk was financing solely by himself at the time.

A decade and a half later, SpaceX is valued at $25 billion and, according to Bloomberg, is the third-most valuable venture-backed private company in the world.

Cantrell, however, hasn't been along for the ride. Like Musk, he also saw an opportunity to build rockets in a way that hadn't been done before. His two-year-old startup Vector is betting that an assembly line-style of manufacturing will allow it to build and launch hundreds of small-cargo rockets annually--rather than the industry standard of handful of launches a year--and sell space on those rockets to small satellite companies for only a few million dollars per launch. In September, the company received a patent for an engine that uses an innovative type of fuel that is expected to make missions more cost effective.

"Building cars and building rockets are two very different worlds right now," Cantrell says. "I thought, how could we get [building rockets] to work more like a system? The market is big enough to sustain a lot of these small launches. If we can bring mass production to rockets, we can let the buyer go where they want when they want."

Investors seem sold on Vector's potential: Cantrell says the startup is in the process of closing a funding round of about $60 million, bringing its total raised to about $90 million. In the coming weeks, the Tucson, Arizona-based company will attempt its most sophisticated test launch to date. Its founder, an avuncular 52-year-old who can tell a half-hour story without pausing for a breath, says it will make its first commercial launch by the end of the year.

Getting here has been quite a journey.

A test launch of the Vector-R rocket in the Mojave Desert.
CREDIT: Courtesy Vector

A 'gray' area

Growing up in California, Cantrell wasn't really interested in space. "I was a machines and cars guy," he admits. At age 14, Cantrell took a job as a mechanic at an auto body shop. Four years later, he enrolled in the mechanical engineering program at Utah State University but his grades were only passable. During his senior year in 1986, he saw a poster on campus for a NASA-sponsored course during which students would design a Mars rover. The best designers would present their blueprints directly to NASA. Cantrell signed up. For weeks, instead of doing homework for his other courses, he worked on the design on the drafting board he kept in his bedroom.

Cantrell's group ended up competing nationally in Washington, D.C.--and winning. He soon landed a fellowship at NASA's Jet Propulsion Laboratory in

California. While there, he helped design a mechanism called the Mars Snake, essentially a balloon that would bob along Mars's surface and collect samples. The French Space Agency decided to hire Cantrell to work on the project on its behalf, and it soon became a joint venture between France and the Soviet Union--the U.S.'s biggest rival.

"It was a gray area," Cantrell says. "Today I probably wouldn't be allowed to do it, but then I just did it. You ask forgiveness, not permission, right?"

Cantrell continued working with the Soviet space program until the USSR collapsed in 1991. The program fell with it, and Cantrell returned to the States.

Back home, he found it hard to land a job. "Nobody would hire me," he says. "They all saw me as a traitor." His meetings with the big aeronautics companies proved fruitless. "At Lockheed Martin," he says, "they would escort me into the friggin' bathroom and stand outside the stall. That's how dangerous they saw me."

Cantrell ended up returning to Utah State to work at the Space Dynamics Lab. His work kept bringing him back to Russia: After the 1995 Norwegian rocket incident, when Russia almost fired on the U.S. after mistakenly believing America was launching an attack, Cantrell helped the country improve its missile detection systems.

It was while he was working at the lab that Musk reached out to recruit him. "I was known as someone who knew how to do things cheap," Cantrell says. "And as a bit of a Russian expert, which was not really something you'd write home about. But it was an expertise."

The Musk meetings

Between 2001 and 2002, Cantrell made several trips to Moscow with Musk. The Russians, according to Cantrell, didn't take Musk seriously. Barely 30 years old, Musk had no formal training in rocketry, and he drove a hard bargain.

On the plane home after another failed meeting in Russia, Musk typed away on his laptop while Cantrell and Michael Griffin, who had joined the trip and later would be named NASA Administrator by President Bush, chatted over glasses of bourbon a few rows back. Musk turned around in his seat. "I think," he announced, "that we can build this rocket ourselves."

Cantrell and Griffin snickered.

"Fuck you both," Musk said. "I've got a spreadsheet."

Cantrell and Griffin burst into laughter. Now it was full-on comedy.

Musk passed his laptop to them. The pair saw tank weights, structure sizes, thrust calculations. As it turned out, the guy knew an awful lot about rockets, Cantrell thought. Musk had been reading up on his own and studying with John Garvey, an engineer who'd been building rockets in his garage in Southern California.

"We were trying to find something wrong," Cantrell says. "The interstage structures were a little light, but everything looked pretty good. It was essentially the Falcon One. Elon said, 'You know, when we get back to the U.S., we're going to start a company and build this rocket.' And that's how SpaceX started."

Over the next few months, Cantrell's main role was to use his network to pull in top talent, helping grow SpaceX from Musk's passion project into a 30-person company. He successfully recruited early employees like Chris Thompson, who became vice president of operations, and Tom Mueller, the company's chief technology officer of propulsion.

Then, less than a year later, Cantrell quit suddenly. "Elon yelled at me one too many times," he says. "I was done. And frankly, I just wasn't interested in what he was doing at the time. I really didn't think he treated this as a commercial activity." (SpaceX did not return requests for comment on Cantrell's accounts of the company's early days.)

Yet his time with Musk taught Cantrell an important lesson, one that he didn't fully absorb for many years: Do what you're passionate about, and do what you're inherently good at.

Cantrell spent the next few years consulting for the space industry. After the U.S. invaded Iraq and Afghanistan, much of his work began to focus on space warfare. Eventually, he grew disillusioned with the industry. "I became a conscientious objector to the war," he says. "I began to see my son's friends, who I'd known since they were little kids, coming back maimed and killed. I just couldn't take it anymore. I said, 'I'm done with the government.' " He returned to his first love, launching a car restoration company called Vintage Exotics.

Around 2013, Cantrell started noticing a large number of startups springing up in the space industry. When he read about Google buying five-year-old satellite company Skybox for $500 million the next year, it erased any doubts he had that the private sector was ripe for entry. "I began to see that space was getting fun again," he says. "People were building things and actually getting stuff done."

Cantrell saw particular potential in launching small satellites, also known as nanosats, that have become commonplace in recent years thanks to manufacturing upstarts like Spire, Planet Labs, and Capella Space. Cantrell sold his SpaceX stock (he won't say for how much), and in March 2016 he officially founded Vector with space vet Eric Bresnard and Garvey, the engineer who had taught Musk about rockets in his garage. Cantrell soon convinced some of his staff at the car company to join him. Within a year, the startup had raised more than $30 million from VC firms including Sequoia Capital and Shasta Ventures.

Ready for launch

Though he's long left government work, Cantrell's past sticks with him. When he visits me at *Inc.*'s office, he brings with him his publicist and a tall burly man whose role in the meeting isn't made entirely clear. The man grasps my hand with his giant paw and grunts his name to me through what appears to be a lip of chewing tobacco; then, during my interview with Cantrell, he pulls up a chair and sits behind me, facing my back.

Cantrell won't tell me more about the man or why he's tagging along. Separately, though, he tells me in passing that he's extra cautious after his time in Russia. He won't expand on why.

Cantrell would much rather focus on the future with Vector. The startup has already performed two test launches of its 40-foot-tall Vector-R rocket. In the coming weeks, it will "take the training wheels off," as Cantrell says, performing a launch without the use of fins to keep the flight path straight. The company hopes its first full-scale launch in Kodiak, Alaska follows soon after that, with its inaugural commercial flight coming later this year.

CREDIT: Courtesy Vector

The driving principles behind Vector's business model are economies of scale: saving costs by manufacturing in larger volumes, much like in the automotive industry. Thanks to the team's car-building experience, it's applying assembly line tactics to build its rockets, creating a finished product in a matter of days, as opposed to the 12 months or more usually required.

The entire worldwide rocket industry currently makes only around 100 launches per year, according to Iain Boyd, professor of aerospace engineering at the University of Michigan and a scientific adviser to the U.S. Air Force. Boyd says the main factor that has prevented companies from seriously pursuing mass production of rockets isn't technical, but economic: The demand for more launches simply hasn't been there.

"It's all about cost," Boyd says. "Getting to space has been tremendously expensive." (To launch with SpaceX--the company that has revolutionized space travel by creating reusable, cheaper rockets--costs about $60 million.) But the calculus is changing. "It's now possible to build useful spacecraft, like nanosats, that are much smaller than ever before. That will require many more launches."

Still, Boyd says, while there are plenty of small satellite companies out there looking to hitch rides aboard rockets, there aren't enough yet to support an entire small rocket industry. "It's not like the market is there now and needs to be serviced," he says. "The potential is there. It's not guaranteed."

Cantrell looks at it somewhat differently: He thinks Vector will inspire more small-spacecraft companies. "The very existence of these rockets," he says, "stimulates demand for them."

The company also hopes it will gain a distinct advantage from its new liquid oxygen-propylene rocket engines, for which it received a patent in September and says no other company is using in operational launches. According to NASA program manager Timothy Chen, this type of propellant maximizes thrust while reducing costs. "It allows for a design that meets vehicle performance requirements while minimizing the volume needed," he says. "So in essence, it allows Vector to design a rocket with lowest cost possible."

A flight on the startup's smaller Vector-R will start at $1.5 million; the larger Vector-H will start at $3.5 million.

Plenty of rivals already exist. Rocket Lab, for one, launched its 56-foot Electron rocket for the first time earlier this year, carrying small satellites for two startups. Relativity Space is currently building 3-D printed rockets that it hopes will send up midsize payloads. And while SpaceX focuses primarily on clients with larger cargo, the company remains a reliable option and the industry leader for companies looking to launch satellites into space.

Vector has a minimum manifest of eight commercial flights next year, followed by 25 in 2020. By that time, though, Cantrell hopes the company will be performing 100 launches per year--or as many as will take place in the entire world in 2018.

Cantrell says Vector has signed or is close to signing letters of intent for launches valued at about $1 billion. The company, which has already grown to 130 employees, is in the precarious position of trying to grow quickly and box out any new competitors that might spring up--while also being careful not to eat through all its cash and scare away investors with its burn rate. "That," Cantrell says, "is the balance of terror that I live daily."

But the entrepreneur is confident. "There's no fundamental science to prove here," he says. "It's really just execution. So as long as we don't stumble, I truly think we can eclipse our goals."

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Forbes

Shine On: Dimensional Energy Turning Carbon Dioxide into Fuel

By Jeff Kart

https://www.forbes.com/sites/jeffkart/2018/08/30/shine-on-dimensional-energy-turning-carbon-dioxide-into-fuel/#592a82cf3b5e

Burning fossil fuels releases carbon dioxide, a greenhouse gas that contributes to climate change. But what about turning carbon dioxide back into fuel?

A Cornell University startup has reportedly developed a way, by adding sunlight to carbon dioxide to transform it into syngas or methanol. The fuel is said to be environmentally friendly and useful for transportation, energy, heating and cooking. Dimensional Energy is the name of the startup, working on a reverse combustion process, aka artificial photosynthesis.

Cornell officials say Dimensional Energy has joined a university business incubator, McGovern Family Center for Venture Development, to bring the idea to the commercial level. Company leaders hope to produce larger scale reactor prototypes and deploy a pilot with an already identified partner in 2020.

The CO_2-to-fuel process happens in a photoreactor where the key ingredient is sunlight. "In industrial uses, we can capture carbon dioxide from commercial entities before it leaks into the atmosphere," according to David Erickson, a mechanical engineering professor and co-founder and partner in the company. "We put it into our reactor, add hydrogen and sunlight. All of this goes into our machine and comes out as a useful fuel."

Dimensional Energy engineer Mihir Gada conducts syngas and methanol research in the company's laboratory at the McGovern Center incubator.
CREDIT: JAMIE LOVE

Erickson adds that since the resulting methanol was formed from a process that removed carbon from the atmosphere, it's neutral and "we can use it guilt free."

Talk about breathing new life into the climate change fight. Carbon dioxide would be a feedstock rather than a planetary menace in this scenario.

Erickson and a founding partner in the company, Associate Professor Tobias Hanrath, helped formed Dimensional Energy in 2016, with initial support from a New York business incubator called NEXUS-NY. They've since received funding from the National Science Foundation (NSF) and Shell GameChanger program.

As noted in a 2017 project abstract on the NSF site:

> The broader impact/commercial potential of this Small Business Technology Transfer (STTR) project relates to the fact that the extraction and consumption of fossil carbon accounts for over 6 billion metric tons of CO_2 emissions each year.
>
> While some mitigation approaches are fairly mature, like capturing CO_2 for equestration or for enhanced oil recovery, they are very expensive in terms of both variable and capital costs and have little chance of ever providing a return on investment.
>
> By not viewing fossil fuels and feedstocks through a circular economy lens, we estimate these companies miss an opportunity for approximately $50 billion per year in potential profit from hydrocarbons, including methanol, that could be made with waste CO_2.

A video below explains the technology. It's from a 2017 NASA design contest, in which the research team of Erickson and Hanrath won the $20,000 grand prize for "HI-LIGHT - Solar Thermal Chemical Reactor Technology for Converting CO_2 to Hydrocarbons."

By the way, Dimensional Energy Co-founder and Chief Executive Office Jason Salfi is considered a leader in the skateboarding industry for innovative design and a focus on sustainability, according to a Cornell bio. He co-founded Comet Skateboards in the late 1990s.

Microwave Journal

Ultra-Cool GaN on Diamond Power Amplifiers for SATCOM

June 13, 2018
Felix Ejeckam, Ty Mitchell, Kris Kong and Paul Saunier, Akash Systems Inc., San Francisco, Calif.
http://www.microwavejournal.com/articles/30451-ultra-cool-gan-on-diamond-power-amplifiers-for-satcom

The most advanced commercial satellites transmit data down to Earth at rates of 100 to 200 Mbps; some advanced larger single satellite concepts target 1 to 4 Gbps. These data rates are substantially limited by state-of-the-art RF power amplifiers used to make the transmitters. Akash is building, for the first time, a small satellite system (12U) that will exhibit a preliminary downlink data rate of 14 Gbps. The next demo will feature data rates of over 100 Gbps. The ultimate technical goal is to demonstrate a downlink data rate of 1 Tbps from a single, modest size satellite—using GaN on Diamond RF power amplifiers.

GaN on Diamond

Felix Ejeckam, co-founder of Akash Systems Inc., invented GaN on Diamond in 2003[1] as a way to extract heat effectively from the hottest locations in a GaN transistor. The basic concept is that a cooler GaN amplifier would make the system more energy efficient, and less wasteful. On a GaN on Diamond wafer, the GaN channel or epitaxy is extracted from its original substrate of Si and situated on a CVD diamond substrate via a 35 nm SiN interfacial layer. This nanometer-scale proximity of a 200°C GaN channel to CVD diamond, the most thermally conductive industrial material, drastically reduces the thermal rise between the amplifier's base plate and the channel temperature. ***Figure 2*** *[there is no figure 1—ed]* shows the process of making GaN on Diamond wafers and devices. Many parties over the years have quantified the aforementioned thermal improvement.[2] A GaN on Si HEMT wafer is bonded to a temporary Si carrier. The original Si substrate is etched away, followed by CVD deposition of diamond via a 35 nm interfacial layer below the GaN. Finally, the temporary Si carrier is etched away. The eventual GaN on Diamond wafer is then processed into an array of HEMTs or MMICs.

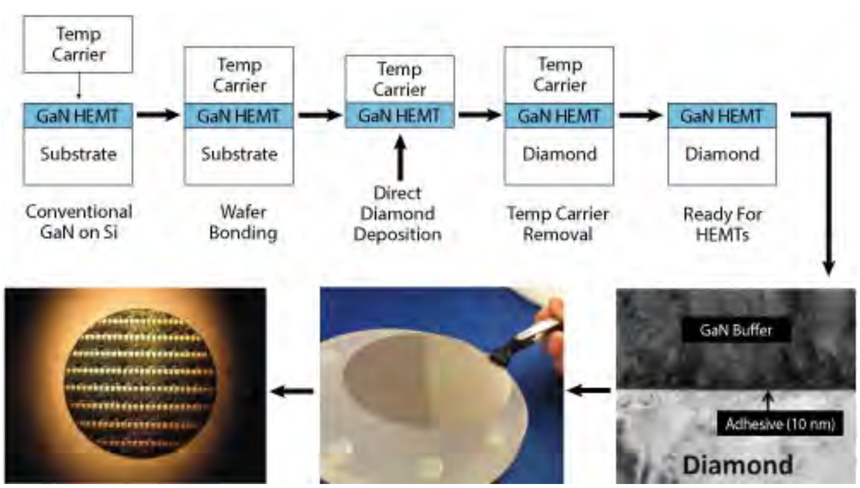

Figure 2 GaN on Diamond wafer process.

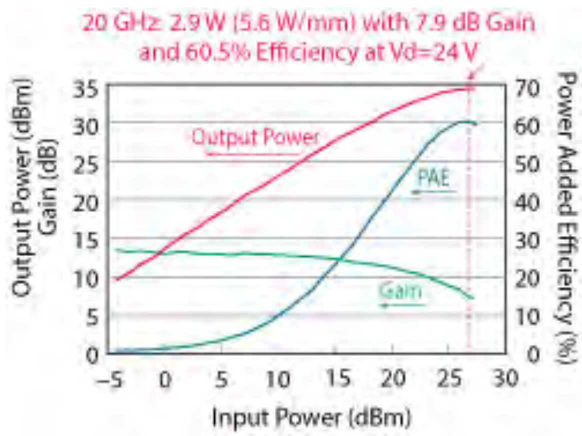

Figure 3 Example device shows 61 percent PAE from a 2.9 W (5.6 W/mm) HEMT with 7.9 dB gain. Bias point is 24 V.

System Impact

If the thermal rise of a GaN MMIC can be shrunk by 40 to 50 percent compared to GaN on SiC, then greater power density can be squeezed into a smaller volumetric space.[3] Power is a direct parameter in a satellite's downlink data-rate budget calculation; more information can be transmitted if there is more power. Cooling requirements in a very compact space are relaxed with GaN on Diamond since the ambient temperature can be allowed to rise higher than with a typical GaN on SiC power amplifier system—without compromising performance or reliability. This reduction in cooling gear also means less weight and size, both key parameters in the cost of launching a satellite system into orbit.

Performance

Akash designers have recently demonstrated high performing GaN on Diamond transistors (i.e., simplified power amplifiers) at K-Band exhibiting 60 percent power added efficiency (PAE) at 20 GHz (see ***Figure 3***). In another recent work, funded by DARPA and performed by a team of researchers at Georgia Tech, Stanford, UCLA and Element Six, the GaN device's thermal rise—change in temperature from the GaN channel to the substrate bottom—was found to reduce by 80°C when compared to the same device on GaN on SiC.[2] The wafer used in the work is identical to the GaN on Diamond process used by Akash Systems.

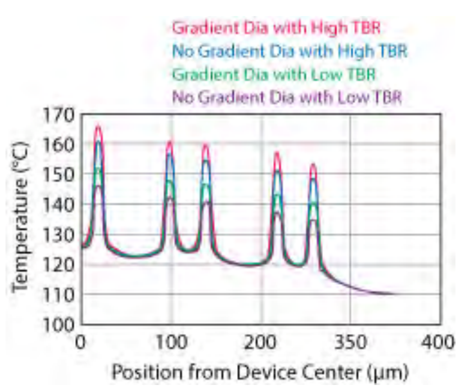

Figure 4 Graph showing the temperature distribution for the channels from the center to the edge of the 10 finger HEMT for various types of GaN on Diamond wafers.

Figure 4 shows the temperature distribution for the channels from the center to the edge of the 10 finger HEMT for various types of GaN on Diamond wafers. Akash Systems uses the “Gradient Diamond with Low Thermal Boundary Resistance (TBR)” process GaN on Diamond wafers (in green); this curve registers 152°C peak temperature (the first peak). GaN on SiC registers 232°C at the same point on the device.[2]

Akash Systems is planning to launch into a LEO orbit in 2019, a 24 kg 12U (36 cm x 24 cm x 23 cm) satellite system that will contain a 20 W transmitter radio built on a GaN on Diamond power amplifier. The system will exhibit a landmark 14 Gbps data rate unique for a system that size.

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https://washingtonmonthly.com/magazine/january-february-march-2019/the-world-is-choking-on-digital-pollution/

The World Is Choking on Digital Pollution

Society figured out how to manage the waste produced by the Industrial Revolution. We must do the same thing with the Internet today.

By Judy Estrin and Sam Gill

Tens of thousands of Londoners died of cholera from the 1830s to the 1860s. The causes were simple: mass quantities of human waste and industrial contaminants were pouring into the Thames, the central waterway of a city at the center of a rapidly industrializing world. The river gave off an odor so rank that Queen Victoria once had to cancel a leisurely boat ride. By the summer of 1858, Parliament couldn't hold hearings due to the overwhelming stench coming through the windows.

The problem was finally solved by a talented engineer and surveyor named Joseph Bazalgette, who designed and oversaw the construction of an industrial-scale, fully integrated sewer system. Once it was complete, London never suffered a major cholera outbreak again.

London's problem was not a new one for humanity. Natural and industrial waste is a fact of life. We start excreting in the womb and, despite all the inconveniences, keep at it for the rest of our lives. And, since at least the Promethean moment when we began to control fire, we've been contributing to human-generated emissions through advances intended to make our lives easier and more productive, often with little regard for the costs.

As industrialization led to increased urbanization, the by-products of combined human activity grew to such levels that their effects could not be ignored. The metaphorical heart of the world's industrial capital, the Thames was also the confluence of the effects of a changing society. "Near the bridges the feculence rolled up in clouds so dense that they were visible at the surface, even in water of this kind," noted Michael Faraday, a British scientist now famous for his contributions to electromagnetism.

Relief came from bringing together the threads needed to tackle this type of problem—studying the phenomenon, assigning responsibility, and committing to solutions big enough to match the scope of what was being faced. It started with the recognition that direct and indirect human waste was itself an industrial-scale problem. By the 1870s, governmental authorities were starting to give a more specific meaning to an older word: they started calling the various types of waste "pollution."

A problem without a name cannot command attention, understanding, or resources—three essential ingredients of change. Recognizing that at some threshold industrial waste ceases to be an individual problem and becomes a social problem—a problem we can name—has been crucial to our ability to manage it. From the Clean Air Act to the Paris Accords, we have debated the environmental costs of progress with participants from all corners of society: the companies that produce energy or industrial products; the scientists who study our environment and our behaviors; the officials we elect to represent us; and groups of concerned citizens who want to take a stand. The outcome of this debate is not predetermined. Sometimes, we take steps to restrain industrial externalities. Other times, we unleash them in the name of some other good.

Now, we are confronting new and alarming by-products of progress, and the stakes for our planet may be just as high as they were during the Industrial Revolution. If the steam engine and blast furnace heralded our movement into the industrial age, computers and smartphones now signal our entry into the next age, one defined not by physical production but by the ease of services provided through the commercial internet. In this new age, names like Zuckerberg, Bezos, Brin, and Page are our new Carnegies, Rockefellers, and Fords.

As always, progress has not been without a price. Like the factories of 200 years ago, digital advances have given rise to a pollution that is reducing the quality of our lives and the strength of our democracy. We manage what we choose to measure. It is time to name and measure not only the progress the information revolution has brought, but also the harm that has come with it. Until we do, we will never know which costs are worth bearing.

We seem to be caught in an almost daily reckoning with the role of the internet in our society. This past March, Facebook lost $134 billion in market value over a matter of weeks after a scandal involving the misuse of user data by the political consulting firm Cambridge Analytica. In August, several social media companies banned InfoWars, the conspiracy-mongering platform of right-wing commentator Alex Jones. Many applauded this decision, while others cried of a left-wing conspiracy afoot in the C-suites of largely California-based technology companies.

Perhaps the most enduring political news story over the past two years has been whether Donald Trump and his campaign colluded with Russian efforts to influence the 2016 U.S. presidential election—efforts that almost exclusively targeted vulnerabilities in digital information services. Twitter, a website that started as a way to let friends know what you were up to, might now be used to help determine intent in a presidential obstruction of justice investigation.

And that's just in the realm of American politics. Facebook banned senior Myanmar military officials from the social network after a United Nations report accusing the regime of genocide against the Muslim Rohingya minority cited the platform's role in fanning the flames of violence. The spread of hoaxes and false kidnapping allegations on Facebook and messaging application WhatsApp (which is owned by Facebook) was linked to ethnic violence, including lynchings, in India and Sri Lanka.

Concerns about the potential addictiveness of on-demand, mobile technology have grown acute. A group of institutional investors pressured Apple to do something about the problem, pointing to studies showing technology's negative impact on students' ability to focus, as well as links between technology use and mental health issues. The Chinese government announced plans to control use of video games by children due to a rise in levels of nearsightedness. Former Facebook executive Chamath Palihapitiya described the mechanisms the company used to hold users' attention as "short-term, dopamine-driven feedback loops we've created [that] are destroying how society works," telling an audience at the Stanford Graduate School of Business that his own children "aren't allowed to use that shit."

The feculence has become so dense that it is visible—and this is only what has floated to the top.

For all the good the internet has produced, we are now grappling with effects of *digital pollution* that have become so potentially large that they implicate our collective well-being. We have moved beyond the point at which our anxieties about online services stem from individuals seeking to do harm—committing crimes, stashing child pornography, recruiting terrorists. We are now face-to-face with a system that is embedded in every structure of our lives and institutions, and that is itself shaping our society in ways that deeply impact our basic values.

We are right to be concerned. Increased anxiety and fear, polarization, fragmentation of a shared context, and loss of trust are some of the most apparent impacts of digital pollution. Potential degradation of intellectual and emotional capacities, such as critical thinking, personal authority, and emotional well-being, are harder to detect. We don't fully understand the cause and effect of digital toxins. The amplification of the most odious beliefs in social media posts, the dissemination of inaccurate information in an instant, the anonymization of our public discourse, and the vulnerabilities that enable foreign governments to interfere in our elections are just some of the many phenomena that have accumulated to the point that we now have real angst about the future of democratic society.

In one sense, the new technology giants largely shaping our online world aren't doing anything new. Amazon sells goods directly to consumers and uses consumer data to drive value and sales; Sears Roebuck delivered goods to homes, and Target was once vilified for using data on customer behavior to sell maternity products to women who had yet to announce their pregnancies. Google and Facebook grab your attention with information you want or need, and in exchange put advertisements in front of you; newspapers started the same practice in the nineteenth century and have continued to do it into the twenty-first—even if, thanks, in part, to Google and Facebook, it's not longer as lucrative.

But there are fundamental and far-reaching differences. The instantaneity and connectivity of the internet allow new digital pollution to flow in unprecedented ways. This can be understood through three ideas: scope, scale, and complexity.

The *scope* of our digital world is wider and deeper than we tend to recognize.

It is *wider* because it touches every aspect of human experience, reducing them all to a single small screen that anticipates what we want or "should" want. After the widespread adoption of social media and smartphones, the internet evolved from a tool that helped us do certain things to the primary surface for our very existence. Data flows into our smart TV, our smart fridge, and the location and voice assistants in our phones, cars, and gadgets, and comes back out in the form of services, reminders, and notifications that shape what we do and how we behave.

It is *deeper* because the influence of these digital services goes all the way down, penetrating our mind and body, our core chemical and biological selves. Evidence is mounting that the 150 times a day we check our phones could be profoundly influencing our behaviors and trading on our psychological reward systems in ways more pervasive than any past medium. James Williams, a ten-year Google employee who worked on advertising and then left to pursue a career in academia, has been sounding the alarm for years. "When, exactly, does a 'nudge' become a 'push'?" he asked five years ago. "When we call these types of technology 'persuasive,' we're implying that they shouldn't cross the line into being coercive or manipulative. But it's hard to say where that line is."

Madison Avenue had polls and focus groups. But they could not have imagined what artificial intelligence systems now do. Predictive systems curate and filter. They interpret our innermost selves and micro-target content we will like in order to advance the agendas of marketers, politicians, and bad actors. And with every click (or just time spent looking at something), these tools get immediate feedback and more insights, including the Holy Grail in advertising: determining cause and effect between ads and human behavior. The ability to gather data, target, test, and endlessly loop is every marketer's dream—brought to life in Silicon Valley office parks. And the more we depend on technology, the more it changes us.

The scope of the internet's influence on us comes with a problem of *scale*. The instantaneity with which the internet connects most of the globe, combined with the kind of open and participatory structure that the "founders" of the internet sought and valorized, has created a flow of information and interaction that we may not be able to manage or control in a safe way.

A key driver of this scale is how easy and cheap it is to create and upload content, or to market services or ideas. Internet-enabled services strive to drain all friction out of every transaction. Anyone can now rent their apartment, sell their junk, post an article or idea—or just amplify a sentiment by hitting "like." The lowering of barriers has, in turn, incentivized how we behave on the internet—in both good and bad ways. The low cost of production has allowed more free expression than ever before, sparked new means of providing valued services, and made it easier to forge virtuous connections across the globe. It also makes it easier to troll or pass along false information to thousands of others. It has made us vulnerable to manipulation by people or governments with malevolent intent.

The sheer volume of connections and content is overwhelming. Facebook has more than two billion active userseach month. Google executes three and a half billion searches per day. YouTube streams over one billion hours of video per day. These numbers challenge basic human comprehension. As one Facebook official said in prepared testimony to Congress this year, "People share billions of pictures, stories, and videos on Facebook daily. Being at the forefront of such a high volume of content means that we are also at the forefront of new and challenging legal and policy questions."

Translation: *We're not sure what to do either*. And, instead of confronting the ethical questions at stake, the corporate response is often to define incremental policies based on what technology can do. Rather than considering actual human needs, people and society evolve toward what digital technology will support.

The third challenge is that the scope and scale of these effects relies on increasingly *complex* algorithmic and artificial intelligence systems, limiting our ability to exercise any human management. When Henry Ford's assembly line didn't work, a floor manager could investigate the problem and identify the source of human or mechanical error. Once these systems became automated, the machines could be subjected to testing and diagnostics and taken apart if something went wrong. After digitization, we still had a good sense of what computer code would produce and could analyze the code line by line to find errors or other vulnerabilities.

Large-scale machine-learning systems cannot be audited in this way. They use information to learn how to do things. Like a human brain, they change as they learn. When they go wrong, artificial intelligence systems cannot be seen from a God's-eye view that tells us what happened. Nor can we predict exactly what they will do under unknown circumstances. Because they evolve based on the data they take in, they have the potential to behave in unexpected ways.

Taken together, these three kinds of change—the scope of intertwining digital and non-digital experience, the scale and frequency leading to unprecedented global reach, and the complexity of the machines—have resulted in impacts at least as profound as the transition from agricultural to industrial society, over a much shorter period of time. And the very elements that have made the internet an incredible force for good also come together to create new problems. The shift is so fundamental that we do not really understand the impacts with any clarity or consensus. What do we call hate speech when it is multiplied by tens of thousands of human and nonhuman users for concentrated effect? What do we call redlining when it is being employed implicitly by a machine assigning thousands of credit ratings per second in ways the machine's creator can't quite track? What do we call the deterioration of our intellectual or emotional capacities that results from checking our phones too often?

We need a common understanding, not just of the benefits of technology, but also of its costs—to our society and ourselves.

Human society now faces a critical choice: Will we treat the effects of digital technology and digital experience as something to be managed collectively? Right now, the answer being provided by those with the greatest concentration of power is no.

The major internet companies treat many of these decisions as theirs, even as CEOs insist that they make no meaningful decisions at all. Jack Dorsey warned against allowing Twitter to become a forum "constructed by our [Twitter employees'] personal views." Mark Zuckerberg, in reference to various conspiracy theories, including Holocaust denialism, stated, "I don't believe that our platform should take that down because I think there are things that different people get wrong. I don't think that they're intentionally getting it wrong."

These are just the explicit controversies, and the common refrain of "We are just a platform for our users" is a decision by default. There can be no illusions here: corporate executives are making critical societal choices. Every major internet company has some form of "community standards" about acceptable practices and content; these standards are expressions of their own values. The problem is that, given their pervasive role, these companies' values come to govern all of our lives without our input or consent.

Commercial forces are taking basic questions out of our hands. We go along through our acceptance of a kind of technological determinism: the technology simply marches forward toward less friction, greater ubiquity, more convenience. This is evident, for example, when leaders in tech talk about the volume of content. It is treated as inevitable that there must be billons of posts, billions of pictures, billions of videos. It is evident, too, when these same leaders talk to institutional investors in quarterly earnings calls. The focus is on business: more users, more engagement, and greater activity. Stagnant growth is punished in the stock price.

Commercial pressures have impacted how the companies providing services on the internet have evolved. Nicole Wong, a former lawyer for Google (and later a White House official) recently reflected during a podcast interview on how Google's search priorities changed over time. In the early days, she said, it was about getting people all the right information quickly. "And then in the mid-2000s, when social networks and behavioral advertising came into play, there was this change in the principles," she continued. After the rise of social media, Google became more focused on "personalization, engagement . . . what keeps you here, which today we now know very clearly: It's the most outrageous thing you can find."

The drive for profits and market dominance is instilled in artificial intelligence systems that aren't wired to ask why. But we aren't machines; we can ask why. We must confront how these technologies work, and evaluate the consequences and costs for us and other parts of our society. We can question whether the companies' "solutions"—like increased staffing and technology for content moderation—are good enough, or if they are the digital equivalent of "clean coal." As the services become less and less separable from the rest of our lives, their effects become ever more pressing social problems. Once London's industrial effluvia began making tens of thousands fall ill, it became a problem that society shared in common and in which all had a stake. How much digital pollution will we endure before we take action?

We tend to think of pollution as something that needs to be eradicated. It's not. By almost every measure, our ability to tolerate some pollution has improved society. Population, wealth, infant mortality, life span, and morbidity have all dramatically trended in the right direction since the industrial revolution. Pollution is a by-product of systems that are intended to produce a collective benefit. That is why the study of industrial pollution itself is not a judgment on what actions are overall good or bad. Rather, it is a mechanism for understanding effects that are large enough to influence us at a level that dictates we respond collectively.

We must now stake a collective claim in controlling digital pollution. What we face is not the good or bad decision of any one individual or even one company. It is not just about making economic decisions. It is about dispassionately analyzing the economic, cultural, and health impacts on society and then passionately debating the values that should guide our choices—as companies, as individual employees, as consumers, as citizens, and through our leaders and elected representatives.

Hate speech and trolling, the proliferation of misinformation, digital addiction—these are not the unstoppable consequences of technology. A society can decide at what level it will tolerate such problems in exchange for the benefits, and what it is willing to give up in corporate profits or convenience to prevent social harm.

We have a model for this urgent discussion. Industrial pollution is studied and understood through descriptive sciences that name and measure the harm. Atmospheric and environmental scientists research how industrial by-products change the air and water. Ecologists measure the impact of industrial processes on plant and animal species. Environmental economists create models that help us understand the trade-offs between a rule limiting vehicle emissions and economic growth.

We require a similar understanding of digital phenomena—their breadth, their impact, and the mechanisms that influence them. What are the various digital pollutants, and at what level are they dangerous? As with environmental sciences, we must take an interdisciplinary approach, drawing not just from engineering and design, law, economics, and political science but also from fields with a deep understanding of our humanity, including sociology, anthropology, psychology, and philosophy.

To be fair, digital pollution is more complicated than industrial pollution. Industrial pollution is the by-product of a value-producing process, not the product itself. On the internet, value and harm are often one and the same. It is the convenience of instantaneous communication that forces us to constantly check our phones out of worry that we might miss a message or notification. It is the way the internet allows more expression that amplifies hate speech, harassment, and misinformation than at any point in human history. And it is the helpful personalization of services that demands the constant collecting and digesting of personal information. The complex task of identifying where we might sacrifice some individual value to prevent collective harm will be crucial to curbing digital pollution. Science and data inform our decisions, but our collective priorities should ultimately determine what we do and how we do it.

The question we face in the digital age is not how to have it all, but how to maintain valuable activity at a societal price on which we can agree. Just as we have made laws about tolerable levels of waste and pollution, we can make rules, establish norms, and set expectations for technology.

Perhaps the online world will be less instantaneous, convenient, and entertaining. There could be fewer cheap services. We might begin to add friction to some transactions rather than relentlessly subtracting it. But these constraints would not destroy innovation. They would channel it, driving creativity in more socially desirable directions. Properly managing the waste of millions of Londoners took a lot more work than dumping it in the Thames. It was worth it.

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http://www.bloomberg.com/features/2015-george-hotz-self-driving-car/

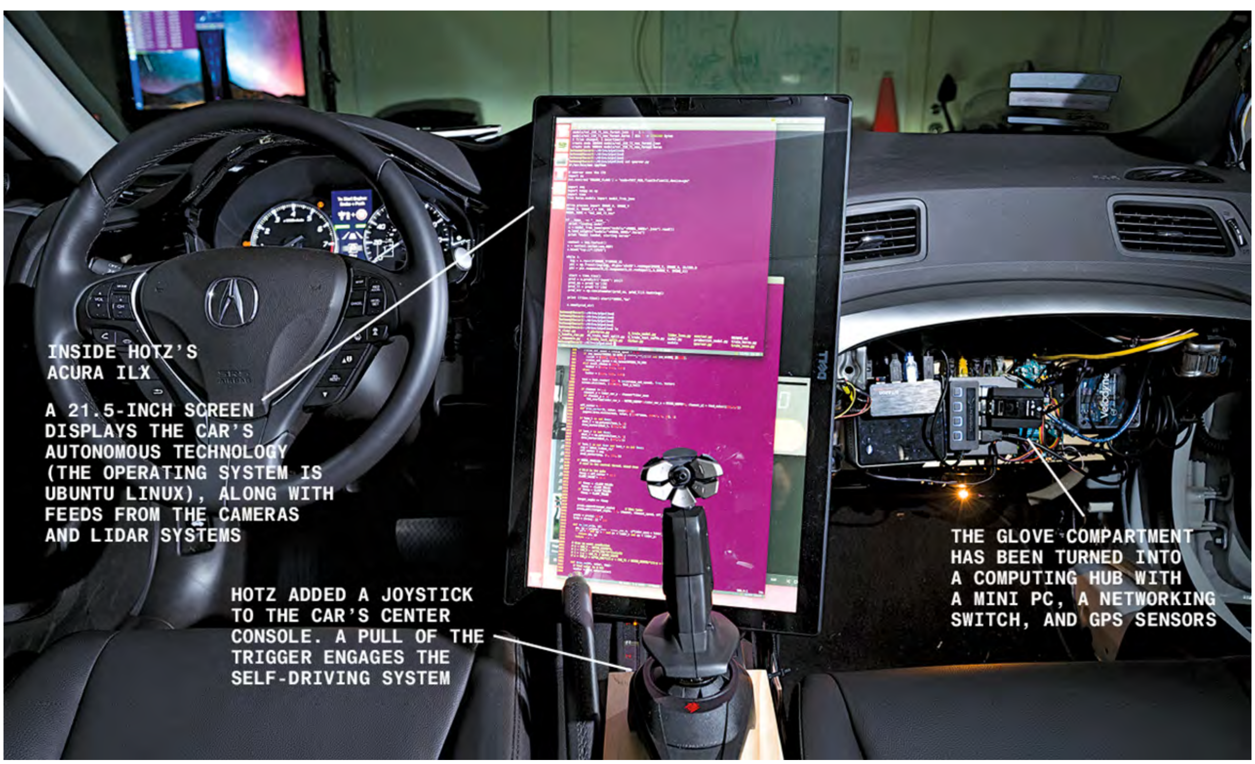
The First Person to Hack the iPhone Built a Self-Driving Car. In His Garage

George Hotz is taking on Google and Tesla by himself.

By Ashlee Vance l December 16, 2015
Photographs by Peter Bohler
From Bloomberg Businessweek

A few days before Thanksgiving, George Hotz, a 26-year-old hacker, invites me to his house in San Francisco to check out a project he's been working on. He says it's a self-driving car that he had built in about a month. The claim seems absurd. But when I turn up that morning, in his garage there's a white 2016 Acura ILX outfitted with a laser-based radar (lidar) system on the roof and a camera mounted near the rearview mirror. A tangle of electronics is attached to a wooden board where the glove compartment used to be, a joystick protrudes where you'd usually find a gearshift, and a 21.5-inch screen is attached to the center of the dash. "Tesla only has a 17-inch screen," Hotz says.

He's been keeping the project to himself and is dying to show it off. We pace around the car going over the technology. Hotz fires up the vehicle's computer, which runs a version of the Linux operating system, and strings of numbers fill the screen. When he turns the wheel or puts the blinker on, a few numbers change, demonstrating that he's tapped into the Acura's internal controls.



After about 20 minutes of this, and sensing my skepticism, Hotz decides there's really only one way to show what his creation can do. "Screw it," he says, turning on the engine. "Let's go."

As a scrawny 17-year-old known online as "geohot," Hotz was the first person to hack Apple's iPhone, allowing anyone—well, anyone with a soldering iron and some software smarts—to use the phone on networks other than AT&T's. He later became the first person to run through a gantlet of hard-core defense systems in the Sony PlayStation 3 and crack that open, too. Over the past couple years, Hotz had been on a walkabout, trying to decide what he wanted to do next, before hitting on the self-driving car idea as perhaps his most audacious hack yet.

"Hold this," he says, dumping a wireless keyboard in my lap before backing out of the garage. "But don't touch any buttons, or we'll die." Hotz explains that his self-driving setup, like the autopilot feature on a Tesla, is meant for highways, not chaotic city streets. He drives through San Francisco's Potrero Hill neighborhood and then onto Interstate 280.

With Hotz still holding the wheel, the Acura's lidar paints a pixelated image on the dash screen of everything around us, including the freeway walls and other cars. A blue line charts the path the car is taking, and a green line shows the path the self-driving software recommends. The two match up pretty well, which means the technology is working. After a couple miles, Hotz lets go of the wheel and pulls the trigger on the joystick, kicking the car into self-driving mode. He does this as we head into an S curve at 65 miles per hour. I say a silent prayer. Hotz shouts, "You got this, car! You got this!"

The car does, more or less, have it. It stays true around the first bend. Near the end of the second, the Acura suddenly veers near an SUV to the right; I think of my soon-to-be-fatherless children; the car corrects itself. Amazed, I ask Hotz what it felt like the first time he got the car to work.

"Dude," he says, "the first time it worked was this morning."

Breakthrough work on self-driving cars began about a decade ago. Darpa, the research arm of the Department of Defense, sponsored the Grand Challenge, a contest to see how far autonomous vehicles could travel. On a course through the desert in the inaugural 2004 event, the top vehicle completed just 7 of 150 miles. In subsequent years, the vehicles became quite good, completing both desert and city courses.

It took a great deal of sophisticated, expensive technology to make those early cars work. Some of the Grand Challenge contestants lugged the equivalent of small data centers in their vehicles. Exteriors were usually covered with an array of sensors typically found in research labs. Today, Google, which hired many of the entrants, has dozens of cars in its fleet that use similar technology, although dramatic advances in computing power, sensors, and the autonomous software have lowered the overall cost.

Artificial-intelligence software and consumer-grade cameras, Hotz contends, have become good enough to allow a clever tinkerer to create a low-cost self-driving system for just about any car. The technology he's building represents an end run on much more expensive systems being designed by Google, Uber, the major automakers, and, if persistent rumors and numerous news reports are true, Apple. More short term, he thinks he can challenge Mobileye, the Israeli company that supplies Tesla Motors, BMW, Ford Motor, General Motors, and others with their current driver-assist technology. "It's absurd," Hotz says of Mobileye. "They're a company that's behind the times, and they have not caught up."

Mobileye spokesman Yonah Lloyd denies that the company's technology is outdated. "Our code is based on the latest and modern AI techniques using end-to-end deep network algorithms for sensing and control," he says. Last quarter, Mobileye reported revenue of $71 million, up 104 percent from the period a year earlier. It relies on a custom chip and well-known software techniques to guide cars along

freeways. The technology has been around for a while, although carmakers have just started bragging about it. Tesla, in particular, has done a remarkable job remarketing the Mobileye technology by claiming its cars now ship with "Autopilot" features. Tesla's fans have peppered the Internet with videos of its all-electric Model S sedans driving themselves on freeways and even changing lanes on their own. (In an e-mailed statement, Tesla spokesman Ricardo Reyes writes: "Mobileye is a valued partner, but supplies just one of a dozen internally and externally developed component technologies that collectively constitute Tesla Autopilot, which include radar, ultrasonics, GPS/nav, cameras and real-time connectivity to Tesla servers for fleet learning.")

Hotz camera kit
The exterior of Hotz's Acura ILX.
Photographer: Peter Bohler for Bloomberg Businessweek
Hotz plans to best the Mobileye technology with off-the-shelf electronics. He's building a kit consisting of six cameras—similar to the $13 ones found in smartphones—that would be placed around the car. Two would go inside near the rearview mirror, one in the back, two on the sides to cover blind spots, and a fisheye camera up top. He then trains the control software for the cameras using what's known as a neural net—a type of self-teaching artificial-intelligence mechanism that grabs data from drivers and learns from their choices. The goal is to sell the camera and software package for $1,000 a pop either to automakers or, if need be, directly to consumers who would buy customized vehicles at a showroom run by Hotz. "I have 10 friends who already want to buy one," he says.

The timing for all of this is vague. Hotz says he'll release a YouTube video a few months from now in which his Acura beats a Tesla Model S on Interstate 405 in Los Angeles. The point of the exercise is twofold. First, it will—he hopes—prove the technology works and is ready to go on sale. Second, it will help Hotz win a bet with Elon Musk, chief executive officer of Tesla.

Hotz lives in the Crypto Castle. It's a white, Spanish-tiled house, which, other than the "Bitcoin preferred here" sticker on the front door, looks like any other in Potrero Hill. The inside is filled with a changing cast of 5 to 10 geeks. The bottom floor largely belongs to Hotz. His room is a 15-by-5-foot closet with a wedged-in mattress. The space is lined with shelves packed with boxes, car parts, towels, and a case of women's clothes left behind by a former resident. There's a living room in the back with couches and a television. "I hate living alone," Hotz says. "I was playing Grand Theft Auto with my roommates last night. It was super fun."

Just a couple feet from his closet is the garage where Hotz works. His two-monitor computer sits on a desk next to a water heater. On a wooden table, there's a drill, a half-dozen screwdrivers, a tape measure, some black duct tape, a can of Red Bull, and a stack of unopened mail. Most of the garage is taken up by the white Acura. Hotz has decorated its hood with a large, black comma, and the back bumper reads "comma.ai"—the name of his new company—in big, black letters. "A comma is better than a period," he says.

Hotz grew up in Glen Rock, N.J. His father oversees technology for a Catholic high school, and his mother is a therapist. "Like, Freud talking and stuff," Hotz says. At 14, he was a finalist in the prestigious Intel International Science & Engineering Fair for building a robot that could scan a room and figure out its dimensions. A couple years later he built another robot called Neuropilot that could be controlled by thoughts. "It could detect different-frequency brain waves and go forward or left based on how hard you were focusing," he says. The next year, 2007, he won one of the contest's most prestigious awards, a trip to attend the Nobel prize ceremony in Stockholm, by designing a type of holographic display. "I did terrible in high school until I found these science fairs," he says. "They were the best thing for me. I could build things, and there was the salesmanship, too, that I loved."

He hacked the iPhone in 2007 while still in high school and became an international celebrity, appearing on TV news shows. Three years later, he hacked the PlayStation 3 and released the software so others could use it. Sony responded by suing him, and the two parties settled their feud shortly after, with Hotz agreeing never to meddle with Sony products again. These achievements were enough to earn him a profile in the New Yorker when he was 22. "I live by morals, I don't live by laws," Hotz declared in the story. "Laws are something made by assholes."

But Hotz wasn't a so-called black-hat hacker, trying to break into commercial systems for financial gain. He was more of a puzzle addict who liked to prove he could bend complex technology to his will.

From 2007 on, Hotz became a coding vagabond. He briefly attended Rochester Institute of Technology, did a couple five-month internships at Google, worked at SpaceX for four months, then at Facebook for eight. The jobs left him unsatisfied and depressed. At Google, he found very smart developers who were often assigned mundane tasks like fixing bugs in a Web browser; at Facebook, brainy coders toiled away trying to figure out how to make users click on ads. "It scares me what Facebook is doing with AI," Hotz says. "They're using machine-learning techniques to coax people into spending more time on Facebook."

On the side, Hotz produced an application called towelroot, which gave Android users complete control over their smartphones. The software is free to download and has been used 50 million times. He kept himself entertained (and solvent) by entering contests to find security holes in popular software and hardware. In one competition, Pwnium, he broke into a Chromebook laptop and took home $150,000. He scored another $50,000 at Pwn2Own by discovering a Firefox browser bug in just one day. At a contest in Korea designed for teams of four, Hotz entered solo, placed first, and won $30,000.

By the fall of 2012 he was bored with the contests and decided to dive into a new field—AI. He enrolled at Carnegie Mellon University with the hope of attaining a Ph.D. When not attending class, he consumed every major AI research paper and still had time for some fun. At one point, the virtual-reality company Oculus Rift failed to man its booth at a job fair, and Hotz took it over, posing as a recruiter and collecting résumés from his fellow students. None of this was enough to keep him interested. “I did two semesters and got a 4.0 in their hardest classes,” he says. “I met master’s students who were miserable and grinding away so that they might one day earn a bit more at Google. I was shocked at what I saw and what colleges have become. The smartest people I knew were in high school, and I was so let down by the people in college.”

Although Hotz makes his university experience sound depressing, it left him brimming with confidence and eager to return to Silicon Valley. He’d devoured the cutting-edge AI research and decided the technology wasn’t that hard to master. Hotz took a job at Vicarious, a highflying AI startup, in January to get a firsthand look at the top work in the field, and this confirmed his suspicions. “I understand the state-of-the-art papers,” he says. “The math is simple. For the first time in my life, I’m like, ‘I know everything there is to know.’ ”

He quit Vicarious in July and decided to put his conviction to the test. A friend introduced him to Musk, and they met at Tesla’s factory in Fremont, Calif., talking at length about the pros and perils of AI technology. Soon enough, the two men started figuring out a deal in which Hotz would help develop Tesla’s self-driving technology. There was a proposal that if Hotz could do better than Mobileye’s technology in a test, then Musk would reward him with a lucrative contract. Hotz, though, broke off the talks when he felt that Musk kept changing the terms. “Frankly, I think you should just work at Tesla,” Musk wrote to Hotz in an e-mail. “I’m happy to work out a multimillion-dollar bonus with a longer time horizon that pays out as soon as we discontinue Mobileye.”

“I appreciate the offer,” Hotz replied, “but like I’ve said, I’m not looking for a job. I’ll ping you when I crush Mobileye.”

Musk simply answered, “OK.”

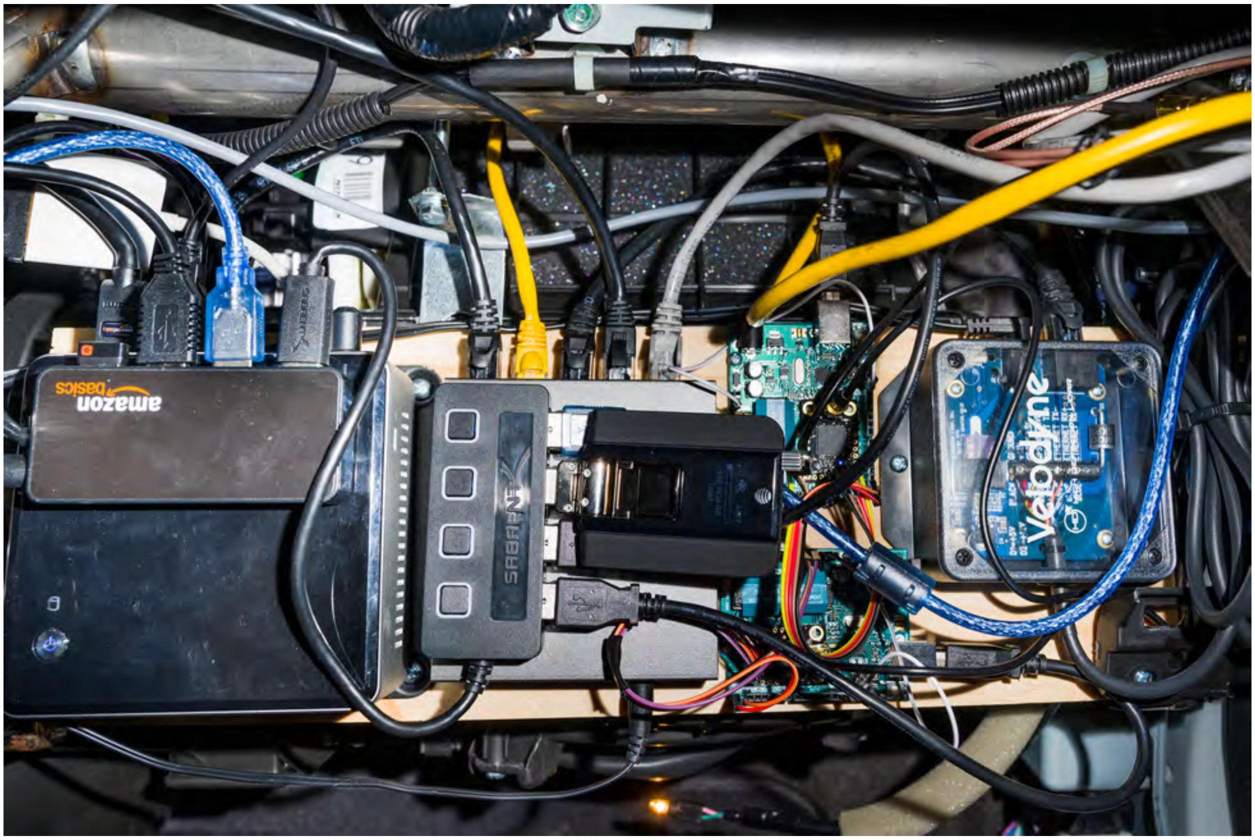
Hotz has filled out since his days as a scrawny teenage hacker, although he dresses the same. Most often, he wears jeans and a hoodie and shuffles around the garage in socks. He has a beard of sorts, and some long, stray whiskers spring out from his Adam’s apple. His demeanor doesn’t match the slacker get-up. Hotz’s enthusiasm is infectious, and he explains just about everything with flailing hands and the wide eyes of someone in a permanent state of surprise.

It’s easy enough to draw a connection between Hotz and Steve Wozniak. Like Hotz, Wozniak began his hacking days on the fringes of the law—in the early 1970s, before he and his pal Steve Jobs founded Apple. Woz was making small devices that let people place free long-distance phone calls. Even in Silicon Valley, few people are equally adept at hardware and software. Woz was, and so is Hotz.

Hotz began working in earnest on his self-driving technology in late October. He applied online to become an authorized Honda service center and was accepted. This allowed him to download manuals and schematics for his Acura. Soon enough, he’d packed the glove compartment space with electronics, including an Intel NUC minicomputer, a couple GPS units, and a communications switch. Hotz connected all this gear with the car’s main computers and used duct tape to secure the cables running to the lidar on the roof.

There are two breakthroughs that make Hotz’s system possible. The first comes from the rise in computing power since the days of the Grand Challenge. He uses graphics chips that normally power video game consoles to process images pulled in by the car’s camera and speedy Intel chips to run his AI calculations. Where the Grand Challenge teams spent millions on their hardware and sensors, Hotz, using his winnings from hacking contests, spent a total of $50,000—the bulk of which ($30,000) was for the car itself.

The second advance is deep learning, an AI technology that has taken off over the past few years. It allows researchers to assign a task to computers and then sit back as the machines in essence teach themselves how to accomplish and finally master the job. In the past, for example, it was thought that the only way for a computer to identify a chair in a photo would be to create a really precise definition of a



chair—you would tell the computer to look for something with four legs, a flat seat, and so on. In recent years, though, computers have become much more powerful, while memory has become cheap and plentiful. This has paved the way for more of a brute-force technique, in which researchers can bombard computers with a flood of information and let the systems make sense of the data. “You show a computer 1 million images with chairs and 1 million without them,” Hotz says. “Eventually, the computer is able to describe a chair in a way so much better than a human ever could.”

The theory behind this type of AI software has been around for decades. It’s embedded in products consumers take for granted. With the help of Google, for example, you can search for “pictures of the beach,” and AI software will comb through your photo collection to turn up just that. Some of the biggest breakthroughs have come in voice recognition, where smart assistants such as Apple’s Siri and Microsoft’s Cortana can pick up a person’s voice even in noisy situations. The same goes for instantaneous translation applications, which have largely been taught new languages via deep-learning algorithms that pore over huge volumes of text. With his car, Hotz wants to extend the same principles to the field of computer vision.

In the month before our first drive on I-280, Hotz spent most of his time outfitting the sedan with the sensors, computing equipment, and electronics. Once all the systems were up and running, he drove the vehicle for two and a half hours and simply let the computer observe him. Back in his garage, he downloaded the data from the drive and set algorithms to work analyzing how he handled various situations. The car learned that Hotz tends to stay in the middle of a lane and maintain a safe distance from the car in front of him. Once the analysis was complete, the software could predict the safest path for the vehicle. By the time he and I hit the road, the car behaved much like a teenager who'd spent only a couple of hours behind the wheel.

Two weeks later, we went on a second drive. He'd taken the car out for a few more hours of training, and the difference was impressive. It could now drive itself for long stretches while remaining within lanes. The lines on the dash screen—where one showed the car's actual path, and the other where the computer wanted to go—were overlapping almost perfectly. Sometimes the Acura seemed to lock on to the car in front of it, or take cues around a curve from a neighboring car. Hotz hadn't programmed any of these behaviors into the vehicle. He can't really explain all the reasons it does what it does. It's started making decisions on its own.

In early December, Hotz took me on a third ride. By then, he'd automated not only the steering but also the gas and brake pedals. Remarkably, the car now stayed in the center of the lane perfectly for miles and miles. When a vehicle in front of us slowed down, so did the Acura. I took a turn "driving" and felt an adrenaline rush—not because the car was all over the place, but because it worked so well.

Hotz's approach isn't simply a low-cost knockoff of existing autonomous vehicle technology. He says he's come up with discoveries—most of which he refuses to disclose in detail—that improve how the AI software interprets data coming in from the cameras. "We've figured out how to phrase the driving problem in ways compatible with deep learning," Hotz says. Instead of the hundreds of thousands of lines of code found in other self-driving vehicles, Hotz's software is based on about 2,000 lines.

The major advance he will discuss is the edge that deep-learning techniques provide in autonomous technology. He says the usual practice has been to manually code rules that handle specific situations. There's code that helps cars follow other vehicles on the highway, and more code to deal with a deer that leaps into the road. Hotz's car has no such built-in rules. It learns what drivers typically do in various situations and then tries to mimic and perfect that behavior. If his Acura cruises by a bicyclist, for example, it gives the biker some extra room, because it's seen Hotz do that in the past. His system has a more general-purpose kind of intelligence than a long series of if/then rules. As Hotz puts it in developer parlance, "'If' statements kill." They're unreliable and imprecise in a real world full of vagaries and nuance. It's better to teach the computer to be like a human, who constantly processes all kinds of visual clues and uses experience, to deal with the unexpected rather than teach it a hard-and-fast policy.

In the coming weeks, Hotz intends to start driving for Uber so he can rack up a lot of training miles for the car. He aims to have a world-class autonomous vehicle in five months, something he can show off for Musk. He's heard that Teslas struggle when going across the Golden Gate Bridge because of the poor lane markings. So he plans to film a video of the Acura outperforming a Tesla across the bridge, and then follow that up by passing the final test on I-405 in Los Angeles where Musk lives. Hotz's YouTube videos get millions of views, and he fully expects Musk will get the message. "I'm a big Elon fan, but I wish he didn't jerk me around for three months," he says. "He can buy the technology for double." (Says Tesla spokesman Ricardo Reyes: "We wish him well.")

There's really no telling how effective Hotz's software and self-learning technology ultimately will be. His self-funded experiment could end with Hotz humbly going back to knock on Google's door for a job. "Yeah, of course there will be skepticism," he says. "This is part of a great adventure. All I can say is, 'Watch.'"
Sitting cross-legged on a dirty, formerly cream-colored couch in his garage, Hotz philosophizes about AI and the advancement of humanity. "Slavery did not end because everyone became moral," he says. "The reason slavery ended is because we had an industrial revolution that made man's muscles obsolete. For the last 150 years, the economy has been based on man's mind. Capitalism, it turns out, works better when people are chasing a carrot rather than being hit with a stick. We're on the brink of another industrial revolution now. The entire Internet at the moment has about 10 brains' worth of computing power, but that won't always be the case.

“The truth is that work as we know it in its modern form has not been around that long, and I kind of want to use AI to abolish it. I want to take everyone’s jobs. Most people would be happy with that, especially the ones who don’t like their jobs. Let’s free them of mental tedium and push that to machines. In the next 10 years, you’ll see a big segment of the human labor force fall away. In 25 years, AI will be able to do almost everything a human can do. The last people with jobs will be AI programmers.”

Hotz’s vision for the future isn’t quite as bleak as The Matrix, where robots mine our bodies for fuel. He thinks machines will take care of much of the work tied to producing food and other necessities. Humans will then be free to plug into their computers and get lost in virtual reality. “It’s already happening today,” he says. “People drive to work, sit in front of their computer all day, and then sit in front of their computer at home.” In 20 years, the sitting in front of the computer part will be a lot more fun, according to Hotz, with virtual worlds that far exceed anything we’ve managed to build on earth. “Stop worrying about the journey,” he says. “Enjoy the destination. We will have a better world. We will be able to truly live in a society of the mind.”

Hotz started the autonomous car work because he sees it as Step 1 in the revolution. Transportation is an area where AI can have a massive impact. He hopes to take his technology to retail next, building systems that provide flawless self-checkout at stores. His desire to have AI take over so many jobs stems partly from a near-religious belief in the power and ultimate purpose of technology. “Technology isn’t good or bad,” he says. “There are upsides like nuclear power and downsides like nuclear bombs. Technology is what we make of it. There’s a chance that AI might kill us all, but what we know is that if you’re on the other side of technology, you lose. Betting on technology is always the correct bet.”

All this talk represents an evolution in Hotz’s hacker ethos. He used to rip apart products made by Apple and Sony, because he enjoyed solving hard puzzles and because he reveled in the thought of one person mucking up multibillion-dollar empires. With the car, the retail software, and the plans to roil entire economies, Hotz wants to build a reputation as a maker of the most profound products in the world—things that forever change how people live. “I don’t care about money,” he says. “I want power. Not power over people, but power over nature and the destiny of technology. I just want to know how it all works.”

ORIGINAL ARTICLE

Effects of office workstation type on physical activity and stress

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ABSTRACT

Objective Office environments have been causally linked to workplace-related illnesses and stress, yet little is known about how office workstation type is linked to objective metrics of physical activity and stress. We aimed to explore these associations among office workers in US federal office buildings.

Methods We conducted a wearable, sensor-based, observational study of 231 workers in four office buildings. Outcome variables included workers' physiological stress response, physical activity and perceived stress. Relationships between office workstation type and these variables were assessed using structural equation modelling.

Results Workers in open bench seating were more active at the office than those in private offices and cubicles (open bench seating vs private office=225.52 mG (31.83% higher on average) (95% CI 136.57 to 314.46); open bench seating vs cubicle=185.13 mG (20.16% higher on average) (95% CI 66.53 to 303.72)). Furthermore, workers in open bench seating experienced lower perceived stress at the office than those in cubicles (−0.27 (9.10% lower on average) (95% CI −0.54 to −0.02)). Finally, higher physical activity at the office was related to lower physiological stress (higher heart rate variability in the time domain) outside the office (−26.12 ms/mG (14.18% higher on average) (95% CI −40.48 to −4.16)).

Conclusions Office workstation type was related to enhanced physical activity and reduced physiological and perceived stress. This research highlights how office design, driven by office workstation type, could be a health-promoting factor.

Key messages

What is already known about this subject?

- Office workers are at risk for low levels of physical activity and associated poor health outcomes, and workplace-related illnesses cost the US economy $225 billion a year, yet little is known about how office design elements may impact objectively measured health outcomes.

What are the new findings?

- This study applies recent advances in wearable sensors to the workplace setting.
- It is the first to investigate the effects of office workstation type on objective measures of both stress and physical activity.
- Across four different federal office buildings in the USA, workers in open bench seating exhibited higher levels of physical activity compared with those in cubicles and private offices.
- Higher physical activity at the office was in turn related to lower physiological stress outside the office as measured by heart rate variability.

How might this impact on policy or clinical practice in the foreseeable future?

- Objective measurements using wearable, sensor-based methods can inform policies and practices that affect the health and well-being of hundreds of millions of office workers worldwide.
- The US General Services Administration will use these findings to inform design practices used to provide over 370 million square feet of office space and house over 1 million federal employees.
- The findings demonstrate the need for additional interventional research to improve our understanding of how elements of office design contribute to physical activity levels at work.

Nearly 50 million workers in the USA spend over one-fifth of their time in office settings.[1 2] Technological advancements over the past several decades have led to an increasing share of the workforce being concentrated in office-based occupations. Office workers have an increased risk of physical inactivity at work compared with other professions and do not tend to engage in compensating behaviour outside of work.[3 4] Sedentary patterns and inactivity are related to negative health outcomes, including fatigue, poor mood,[5] as well as cardiovascular diseases and other chronic diseases,[6 7] which are in turn associated with increased rates of work exit.[8] Importantly, lower physical activity levels at work have been linked to higher levels of perceived stress,[9] a major public health risk associated with cardiovascular disease, metabolic syndrome and poor diet.[10 11]

Such health outcomes have enormous economic consequences, as modern office environments in the USA have been linked to workplace-related illnesses costing up to $225 billion, or more than 10% of office workers' contribution to the US gross domestic product,[12] and work-related stress and mental health problems in the European Union cost up to €269 billion annually.[13] Thus, although occupational safety and health programmes have eliminated many health risks, changes to policies and best practices in workplace design and operation aimed at health promotion could lead to further positive effects on health measures.

The vast majority of studies investigating how characteristics of the built office environment affect workers are survey-based, and suggest that there are worker performance, worker satisfaction and economic trade-offs between types of office workstations.[14–16] Few studies have included objective, continuous measures of stress in workplace settings,[17–19] and no known study has investigated how characteristics of the built office environment relate to objective measures of stress and physical activity.

The purpose of our study, part of the US General Services Administration's Wellbuilt for Wellbeing research project, was to explore the relationship between workplace design, health and well-being across four federal office buildings. To test whether behaviours and physiological and psychological responses to the working environment may differ based on spatial design characteristics, we measured participants' physiological stress response in real time using heart rate variability (HRV), perceived levels of stress through survey tools and objectively measured physical activity levels.

METHODS

Participants and setting

Self-described healthy adult workers involved in a variety of office-based roles for the US government were recruited across four federal office buildings in the Mid-Atlantic and Southern regions of the USA. Buildings were selected for their representation of common office workstation types across the US General Services Administration's portfolio of over 370 million square feet of office space that houses over 1 million employees. Staff in sections of each office building from organisations with leadership approval were offered the opportunity to participate.

After giving written informed consent, participants completed an intake survey consisting of demographic questions. Participants then wore a chest-worn heart and physical activity monitor for three consecutive workdays and two nights while answering hourly surveys on a smartphone during work hours related to a range of items including their current mood. Finally, participants completed an exit survey including a global measure of stress. Pregnant women and those wearing pacemakers or insulin pumps were excluded. Participants taking medication known to affect HRV were noted but not excluded. Participants were enrolled serially across the four sites, between 5 May 2015 and 25 August 2016. Between five and ten volunteers typically participated during each week of observation at each site.

Office workstation type and work type

Office workstation type varied across the four sites of the study and belonged to three categories: (1) private office (completely walled enclosure); (2) cubicle (high-walled partitions that one cannot see over while seated; and (3) open bench seating (no partitions or partitions that are readily seen over while seated) (figure 1).

Because we recruited participants from a variety of work divisions, work type varied and was coded (yes/no) for having 'computer-dominant', 'managerial' and 'technical' qualities. For more information, see the online supplementary material.

Measures of perceived stress

During the intake survey, participants used online survey software (Qualtrics, Provo, Utah) to provide demographic information on age, gender, height and weight (used to calculate body mass index (BMI)), and the highest education level obtained.

While participants were working at the office, ecological momentary assessments (EMA) of current mood were taken over the 3 days of observation. Randomly each hour, but never closer than 30 min apart, participants were prompted on smartphones with Android operating systems using the movisensXS application (movisens, Karlsruhe, Germany) and rated their momentary affect based on the circumplex model. Relevant for the purpose of this study, participants reported how 'tense' they currently felt on a 1–7 scale (1='not at all' to 7='very much').

Finally, during the exit survey, a one-time measure of long-term perceived stress over the past month was taken using the validated Short Form Perceived Stress Scale (PSS-4).[20]

Cardiac activity

Cardiac activity was recorded using a small, chest-worn sensor, EcgMove 3 (movisens). Details of the characteristics of this device have been published elsewhere.[21] To quantify the physiological stress response, we calculated the mean of the standard deviation of normalized interbeat intervals (SDNN).[22] SDNN is a global index of HRV and reflects longer term circulation differences. Lower SDNN values indicate an increase in the sympathetic stress response, and higher SDNN values have consistently been found to indicate better health.[23] SDNN index, the mean of each 5 min period of SDNN, was calculated according to the guidelines of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology.[22] In order to better capture stressful moments, we then calculated the 10th percentile of the SDNN index variable.[24] The 10th percentile value represents relatively low HRV values during

Figure 1 Examples of office workstation types from the study. From left to right, open bench seating, cubicle and private office.

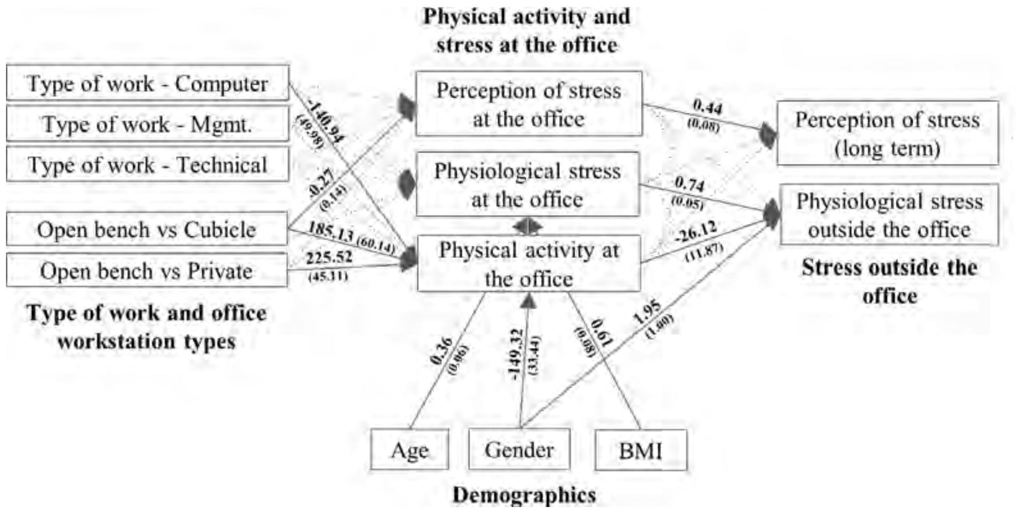

Figure 2 Structural equation model results. Solid lines represent significant paths and include unstandardised coefficient estimates (SE). Minus (–) signs indicate negative relationships between variables. BMI, body mass index.

the observation periods and serves as an indicator of relatively high sympathetic activation.[24] For more information, see the online supplementary material.

Physical activity

Participants' average physical activity levels were assessed in mG from the EcgMove3's triaxial accelerometer sensor using algorithms[25 26] validated for day-to-day monitoring.[27] The intensity level of physical activity has been shown to be a reliable predictor of physical health.[28] This method captures the overall intensity of movement throughout the entire workday. It provides a finer granularity of movement data for office workers, who tend to sit for the vast majority of their time at the office, than traditional parameters such as step counts and sit-stand transitions. In other words, the method used in this study captures the intensity of movement throughout the entire workday during all activities (eg, sitting, standing, walking). For more information, see the online supplementary material.

Statistical methods

Structural equation modelling (SEM) was used to estimate the direct and indirect effects of aspects of the office environment on outcome measures (figure 2). SEM is a multivariate statistical analysis technique that is used to estimate the relationships among multiple variables simultaneously in a single analysis.[29] It is a suitable data analysis method in this study because it allows for the exploration of complex relationships between types of office workstations, types of work, individual characteristics, and physical activity and stress outcomes within one comprehensive model. Significant, unstandardised path coefficients (B) represent the total effect of one variable's influence on another, taking into consideration all of the other variables' contributions to the model. We reverse-coded 10th percentile SDNN values for ease of interpretability, as they are inversely proportional to physiological stress. To facilitate further understanding of the SEM results, the total effects for work type and office type on workers' stress outcomes and physical activity were also analysed using analysis of variance (ANOVA). For more information, see the online supplementary material.

RESULTS

Participants

A total of 248 office workers expressed interest in participating in the study, representing approximately 12% of the workers located in areas of the office buildings where recruitment took place. Due to scheduling problems, sickness and exclusionary criteria, 17 office workers did not participate, resulting in a total enrolment of 231 participants. Due to unexpected changes in work schedules, 8 of the 231 participants were only observed for two workdays, rather than the full 3 days. Demographic characteristics and descriptive data for measures of interest are provided in tables 1 and 2.

Type of work characteristics are not mutually exclusive, and thus sums across rows may not equal office workstation type frequencies. The total for type of work and office workstation type, along with missing values, can be found in table 1.

Effects for office workstation type and work type

Stress and physical activity

All results described below are based on the SEM, unless otherwise specified. Workers in open bench seating exhibited significantly higher physical activity compared with workers in private offices (B=225.51 mG; 95% CI 136.57 to 314.46). Workers in open bench seating also exhibited significantly higher physical activity compared with workers in cubicles (B=185.13 mG; 95% CI 66.53 to 303.72). To further illustrate the magnitude of these differences, we compared the mean differences between office workstation types. Workers in open bench seating exhibited 31.83% higher physical activity compared with workers in private offices, and 20.16% higher physical activity compared with workers in cubicles.

Workers in open bench seating experienced significantly lower perceived stress at the office compared with those in cubicles as measured by the average 'tense' EMA ratings (B=−0.27 units; 95% CI −0.54 to −0.02). Importantly, the significant differences found between the types of office workstations reflect differences above and beyond any differences found due to types of work being performed. Only one work type difference was found in the model, where workers with computer-dominant jobs exhibited significantly lower physical activity compared with those with jobs that were not rated as

Table 1 Sample characteristics

Variable	n (%)
Age, mean (SD)	44.15 (12.22)
Missing	30 (12.98)
Gender	
Male	88 (38.09)
Female	115 (49.78)
Missing	28 (12.12)
BMI, mean (SD)	27.60 (6.10)
Missing	31 (13.41)
Ethnicity	
African–American	32 (13.85)
American Indian, Alaska Native, Native Hawaiian or other Pacific Islander	4 (1.73)
Asian	14 (6.06)
Hispanic	16 (6.92)
White, non-Hispanic	134 (58.01)
Other	3 (1.30)
Missing	28 (12.12)
Education	
No high school degree	1 (0.43)
High school degree	5 (2.16)
Some college	15 (6.49)
Two-year college degree	3 (1.30)
Bachelor's degree	76 (32.90)
Master's degree	86 (37.23)
Doctorate degree	16 (6.93)
Missing	29 (12.55)
Computer-dominant work	
Yes	93 (40.26)
No	118 (51.08)
Missing	20 (8.66)
Management work	
Yes	69 (29.87)
No	142 (61.47)
Missing	20 (8.66)
Technical work	
Yes	90 (38.96)
No	121 (52.38)
Missing	20 (8.66)
Office workstation type	
Open bench seating	97 (41.99)
Cubicle	66 (28.57)
Private office	42 (18.18)
Missing	26 (11.25)
EMA 'tense' ratings at the office, mean (SD), 1–7 scale	2.81 (0.98)
Missing	7 (3.03)
10th percentile SDNN at the office, mean (SD), ms	51.98 (16.99)
Missing	17 (7.36)
ActLevAvg at the office, mean (SD), mG	1198.98 (452.07)
Missing	13 (5.63)
PSS-4: long-term perceived stress, mean (SD), 1–7 scale	3.13 (1.17)
Missing	45 (19.48)
10th percentile SDNN outside the office, mean (SD), ms	48.12 (16.36)
Missing	48 (20.78)
Duration of study	5 May 2015–25 August 2016
Total data in hour:minute (postprocessing)	2883:35:00

ActLevAvg, average physical activity level; BMI, body mass index; EMA, ecological momentary assessment; PSS-4, Short Form Perceived Stress Scale; SDNN, standard deviation of normalized interbeat intervals.

Table 2 Distribution of office workstation type and type of work across the four sites

Office workstation type	Site	n	Computer-dominant	Managerial	Technical
Open bench seating	1	85	37	26	34
	2	10	2	6	3
	3				
	4	2	1		1
Cubicle	1				
	2	5	2		4
	3	48	20	15	19
	4	13	5	2	5
Private office	1	1			1
	2				
	3				
	4	41	19	15	13

computer-dominant (B=−140.94 mG; 95% CI −239.49 to −42.39).

We then further tested the relationships identified between office workstation type and types of work on outcome variables at the office in one-way ANOVA models. We found significant differences between office workstation types in 'tense' EMA ratings at the office ($F(2,194)=3.377$, $p=0.036$, $\eta^2=0.03$), between office workstation types in physical activity at the office ($F(2,188)=9.476$, $p<0.001$, $\eta^2=0.09$), and between workers with and without computer-dominant jobs in physical activity at the office ($F(1, 200)=6.179$, $p=0.0137$, $\eta^2=0.03$), thus revealing effects that converge with the findings obtained from the SEM.

Consistent with the idea that there may be elements of the workplace that we take home in the form of stress, higher physical activity at the office was significantly related to lower levels of physiological stress outside the office as measured by the 10th percentile SDNN (B=−26.12 ms/mG; 95% CI −40.48 to −4.16). To further illustrate this relationship, a median split of physical activity at the office showed that compared with workers with lower physical activity, those with higher physical activity had 14.18% lower physiological stress outside the office. However, physical activity at the office was not significantly related to physiological stress while at the office. Furthermore, physiological stress at the office was significantly related to physiological stress outside the office as measured by the 10th percentile SDNN (B=0.74; 95% CI 0.64 to 0.85).

In line with what is understood in the literature about the relationship between age, body composition and HRV,[30 31] we found that physiological stress at the office was significantly higher among older participants (B=0.36; 95% CI 0.24 to 0.48) and was significantly higher among participants with higher BMI (B=0.61; 95% CI 0.46 to 0.76). We also observed that, compared with male workers, female workers exhibited significantly lower physical activity at the office (B=−149.32 mG; 95% CI −215.26 to −83.38) and significantly higher physiological stress outside the office (B=1.95 ms; 95% CI, 0.01 to 3.92). Lastly, higher perceived stress at the office was significantly related to higher long-term perceived stress as measured by the PSS-4 (B=0.44; 95% CI 0.27 to 0.60).

Model fit

The SEM exhibited good model fit with a comparative fit index of 0.983 and a standardised root mean square residual of 0.032. The solid and dashed directed lines in figure 2 indicate significant and non-significant coefficients in the model, respectively.

DISCUSSION

Key results

We found a statistically significant relationship between participants' office workstation type and their physical activity while at the office using a statistical model controlling for factors including type of work, demographics, and perceived and physiological stress levels. Workers in both private offices and traditional, high-partition cubicles exhibited lower levels of physical activity than workers in open bench seating arrangements at a degree shown to be clinically meaningful in other populations.[32] Furthermore, we found that higher physical activity levels at the office were related to lower physiological stress levels outside the office. The magnitude of this association has also been shown to be clinically meaningful in prior research.[33] This finding is consistent with research showing that the effects of certain office characteristics may carry over to non-office hours and affect diurnal patterns of physiological stress.[17] Consistent with prior research, we found higher stress levels at the office among older participants and those with higher BMI. Interestingly, our analyses also revealed that women exhibited both lower levels of physical activity at the office and higher levels of stress outside the office compared with men. This observation warrants further investigation of workplace and non-workplace factors and mechanisms contributing to these gender differences.

Taken together, this study establishes a new paradigm for objectively investigating the behavioural, well-being and health consequences of built environments, and it provides, for the first time, empirical evidence for associations between office workstation type, physical activity, and objective and subjective stress responses both at and outside of the office. These findings have important implications, as economic forces and the changing nature of work patterns are driving more and more office spaces towards open designs.[34] This is the first study to show that open bench seating may be an unrecognised positive factor in promoting physical activity levels at work. Given the importance of physical activity to health, the fact that office workstation type may influence how much people move at work should not be overlooked in the health field.

Limitations and interpretation

Because this is an observational study, we cannot confirm a causal relationship between office workstation type and physical activity, nor confirm causal relationships for any other significant paths in our model. Importantly, we verified that participants in the study did not self-select but instead were assigned to consistent office workstation types based on location and organisation. While we controlled for relevant variables such as certain demographics, perceived stress and work type in the statistical models, there may be other contributing factors to these findings. For instance, because of the sample size, we were limited in the number of variables that we could include in the SEM. We prioritised modelling variables such as BMI, age, gender and work type over other factors such as ethnicity and education level.

Office workstation size, materiality, appearance, ambient environmental characteristics, common workspace availability and work culture differences may vary systematically among participants. Such factors should be considered in future research. For instance, the total area allocated to office workstations tends to differ by design between the three office workstation types. In our sample, 97.9% of open bench seating workstations were under 36 square feet in area, 96.9% of cubicles were between 36 and 64 square feet in area, and 95.2% of private offices were at least 100 square feet in area. Since workstation type and size tend to be related, the effect of workstation type on physical activity and stress apart from any possible effect of workstation size cannot be disentangled in this study. Moreover, the distribution of office workstation type was closely tied to study site. To account for this, we recruited participants from a variety of work types within each site (table 2) and statistically accounted for these characteristics. However, ultimately, the natural inability to fully insulate workstation effects from influences of clustering of workstations by building or departments remains a limitation.

We also explored the relationships of several other characteristics of the built environment on physical activity and stress responses. For instance, we were interested in investigating the effect of window views to nature and the office workstation distance to windows on other variables, but the limited amount of available data for these two variables prevented inclusion in our model. There are many more workplace design features that may help explain differences in levels of observed physical activity, including circulation patterns, the availability of informal meetings spaces and the accessibility of stairwells.

In this study we have only used SDNN measures to represent HRV. While previous studies suggest a high correlation between SDNN and other HRV measures, other metrics provide a different window into the stress response. When the root mean square of successive differences, a stronger indicator of parasympathetic activity, is used in the SEM analysis, the link between physical activity at the office and stress response outside the office is not present (see online supplementary table A and supplementary figure A). This may be due to the fact that SDNN represents both sympathetic and parasympathetic activity,[35] but further analyses, which are beyond the scope of this paper, are needed to clarify this.

Little empirical evidence exists on the mechanism by which office workstation type can affect physical activity, yet this finding suggests an important potential health benefit of open bench seating that must be weighed against other office space design trade-offs.

Workers tend to rate private offices as more desirable than other office workstation types,[16] but there may be other consequences when compared with open bench seating arrangements. For instance, valuable, impromptu conversations may be an unintended benefit to this design strategy, as well as improved communication and an increased awareness of others.[14] It is possible that the open nature of a space leads to increased physical activity by encouraging interaction and mobility, including movement to spaces designed for unplanned meetings and phone calls, when available. Individuals in open bench seating may also be more aware of others and more dependent on shared services (eg, meeting rooms, printing and filing areas, social spaces) than those in private offices.

Similarly, there may be unintended trade-offs between cubicles and open bench seating. Past research has shown that workers in cubicles tend to report higher levels of visual privacy compared with those in open bench seating, yet this pattern does not hold for perceived auditory privacy. In fact, there is evidence that workers in cubicles report less auditory privacy compared with workers in open bench seating.[16] It is possible that because there is less of a visual connection between workers in cubicles, people in cubicles may be less aware of the presence of other workers nearby and thus less sensitive to the impact on others when they engage in conversations and phone calls.[15 16] It is possible that this greater awareness of others enhances physical activity and encourages better sound etiquette.

While the relationship between physical activity patterns and built environment design elements is rarely simple and often contains cultural elements,[36] this study suggests that in some cases, design modifications may be employed to overcome the negative health impact features of different types of office workstations. To explore potential mechanisms for behavioural changes associated with office design characteristics, we are currently investigating the relationship between sound levels, types of work tasks and office workstation type. Moreover, the process employed to transition workers to new office workstation types may influence workers' perceptions. There is evidence that the process of engagement with both management and individual workers, to effectively understand needs and communicate design intent before a move, may increase subsequent satisfaction levels and achievement of design goals.[37 38] Communicating the health implications of different office workstation types to future occupants may also help transitions.

The results of this study are an important step towards establishing best practices and guidelines for office design and operations. There are ongoing and accelerating trends towards reducing dedicated individual workspace in offices in order to save rental and other overhead costs, and to reduce environmental impacts of underutilised space. The US federal government in particular views reduction and consolidation of office space as a critical cost-saving measure as indicated by the recent passage of the Federal Property Management Reform Act of 2016.[39]

While many US government programmes are not informed by research,[40] the US General Services Administration seeks to use the best research available to shift the focus of occupational health programmes from risk avoidance to health promotion. Indeed, the current study's methodology can be applied to other types of office workspaces and to other building types, such as healthcare and education settings. Doing so will help to better understand how the behaviour and health of millions of people are affected by the built environment in which they spend so much of their lives. The findings of this study suggest that features of office design may play a role in office workers' levels of physical activity. While further interventional research is required to better understand the related mechanisms, this study can inform designers' thinking about how office design elements might encourage physical activity and potentially even reduce levels of stress, thus facilitating a healthier lifestyle.

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Contributors All authors contributed to the study conception and design. CML, BG and KJC contributed to the acquisition of data. All authors contributed to the analysis and interpretation of data. CML, KS, BG, JR, HL, BN, MRM and EMS drafted the first version of the manuscript. All authors critically revised the manuscript and approved the final text.

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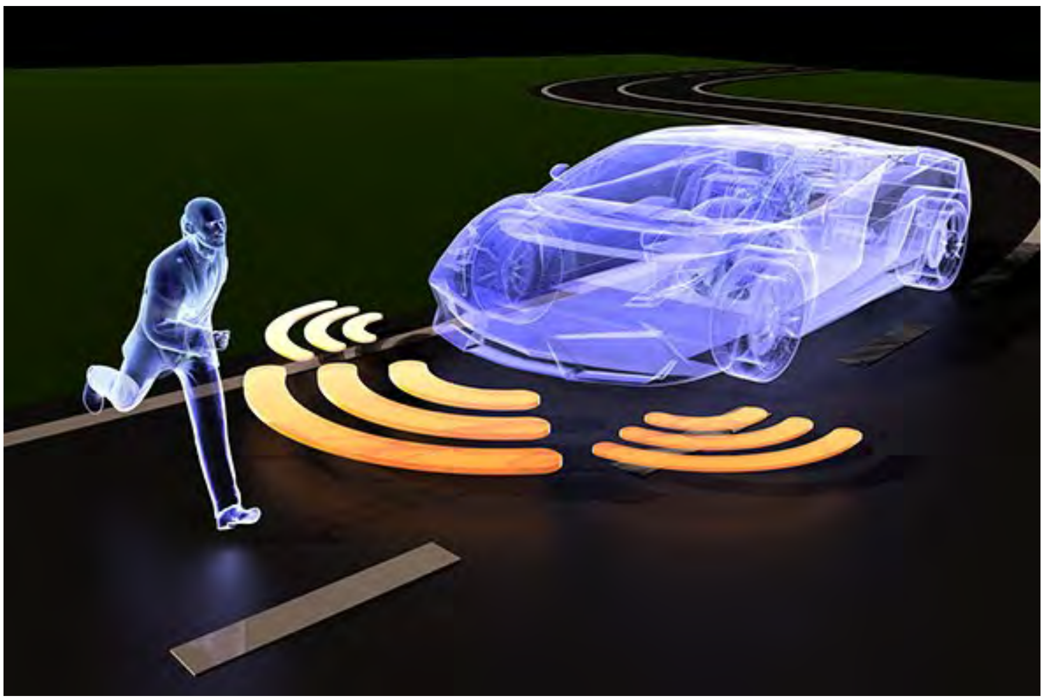
SCIENTIFIC
AMERICAN

How Pedestrians Will Defeat Autonomous Vehicles

The 'game of chicken' which could be a serious problem for driverless cars

- By Karinna Hurley, March 21, 2017

https://www.scientificamerican.com/article/how-pedestrians-will-defeat-autonomous-vehicles/



Credit: Devrimb *Getty Images*

Stand at any corner along *via del Babuino* and it won't be hard to tell the locals from the tourists. The guidebook holders navigate the swirling vespas and honking Fiats with a mix of hesitation and mad dashing, while the neighborhood residents cross with relative ease; assertive and calm. And it's not just in Rome: in cities around the world local pedestrians, with a different sense of how drivers will behave, stand apart from occasional visitors. Unless you are on an isolated country road, walking and driving are social interactions, and only residents come to know behavioral customs of their city.

But, a big change might be coming soon. Understanding the psychology of other road users — when and if they will yield — won't be helpful in cross-walk calculations when the other driver isn't a person. Self-driving cars are already on the way; by some projections autonomous capability could even be standard by 2030. As drivers, cars will behave differently than humans, and they will almost surely be programmed to avoid hitting people. The idea that roads will become safer, with fewer traffic accidents, is a driving force behind the new technology. But, as pedestrians quickly figure out the cars' behavior, they will certainly adapt theirs as well. The effects could be dramatic: instead of more consistent, traffic flow could become chaotic.

A recently published paper in the Journal of Planning Education and Research explored how interactions between humans and self-driving cars could change the rules of the road. Author Adam Millard-Ball first explains a current model of how pedestrians decide when to cross the street. Each crossing involves a mental calculation: a choice between crossing as quickly as possible and risking being hit vs. waiting, for who knows how long, or even choosing a new route. Drivers also have a decision to make, to yield or not to yield. The set-up is a cross-walk game of chicken between driver and pedestrian. While intuitively it may seem that pedestrians, more likely to be hurt by a collision, would always yield first, their actions are in fact shaped by social norms. Drivers are likely to yield when hampered by busy traffic or, for example, unpredictable tourists. But, if the local norm is always for pedestrians to wait, the risk of crossing is greater and waiting then makes even more sense.

In a game of cross-walk chicken with a self-driving car, things will be very different. Unlike people, cars will always act predictably; no temptation to glance at a cell phone, need to break-up a fight between squabbling toddlers, or attempts to balance a steering wheel and a drive-through burger. And, cars will almost surely be programed to avoid hitting people. Local customs will be irrelevant; pedestrians will be up against exclusively law-abiding yielders — no matter the corner or block, the pedestrians will have the psychological upper-hand. With full confidence cars will yield, they can be emboldened crossers, even in situations when they do not have the right-of-way. Humans will be free to take advantage of cars.

Millard-Ball outlines three possibilities for how new human-car interactions will alter the roads of the future, starting with *pedestrian supremacy*. In this scenario, if you need to get somewhere within the center of town you'll probably go by foot. Your car can drop you off on the outskirts, but will effectively be curbed in urban areas as pedestrians' impunity to cross streets at their convenience could potentially slow car traffic to a halt. The density of urban areas will continue to increase as walking becomes more efficient than driving.

In the *regulatory response* outcome, pedestrians will still think twice about crossing the street, but instead of focusing on the risk of being hit by a car, being hit with a potential traffic ticket will come to mind. Attempts to reign in pedestrians could come through a combination of new regulations and infrastructure designed to keep people and cars separated. Planning focused on shared spaces for cars and people will decline and fences and road barriers will increase. Liability for pedestrian-car accidents would primarily fall on the (now) law-breaking pedestrians, and not car manufacturers, further constraining their behavior.

Finally, according to a *human driver* scenario, the slower travel time incurred by using a self-driving car would outweigh the benefits of a passenger lifestyle. The freedom to check-your email, call-in on a business meeting, or watch Netflix on the drive to work simply won't be worth taking the extra travel time to get there. Indeed, retaining the advantage in the game of crosswalk chicken will override the convenience of being driven. But, pedestrian-oriented designs only makes sense if most vehicles drive themselves. Ultimately, how neighborhoods evolve to accommodate and incorporate self-driving cars will depend on all the various policy, legal, and technological factors. No matter what scenario prevails, transportation in the future will likely be shaped by the ability of humans to exploit the driverless machines.

About the Author
Karinna Hurley received her PhD in Human Development from the University of California, Davis, where she studied in the Infant Cognition Lab.

Forbes

How Do You Rebel Against Rebellion? Skating Legend Rodney Mullen Keeps Reinventing Himself

By Krisztina 'Z' Holly
May 11, 2017
https://www.forbes.com/sites/krisztinaholly/2017/05/11/rodney-mullen/#1b2d91af4d92

I had a chance to sit down with Rodney Mullen to hear his perspectives on the history and future of the skateboard industry. To hear the entire conversation, tune in to The Art of Manufacturing podcast here.

Rodney shares crazy stories of forklift races, mutiny, and hobnobbing with the Communist Party in China as he and his partner-built World Industries. The company went on to become the biggest skateboard company in the world, with novel designs and a unique way of harnessing talent. The characters in the story are colorful for sure, but the most fascinating stories to me are those that give deep insight into the process of innovation.

Authenticity

The skate community might be the toughest environment for a brand or athlete to make it into the big leagues. They have to manage an unparalleled tension between authenticity and mass appeal. In skating, the culture is *defined* by rebellion. “Selling out” is just about the worst thing you could do.

So what happens when *rebellion* becomes the establishment? How can you rebel against rebellion? You might assume it means doubling down on the skulls and Satanic images, but you couldn’t be more wrong. It usually means going in an entirely opposite direction: Winnie the Pooh with tridents, silly cartoons, or stick figures.

Rodney and his company pioneered an approach to talent, one that today might seem obvious. They would bring athletes just passing their peak under their wing and invite them to run a whole new brand. These skaters were given incredible latitude to design their own boards. It gave riders a chance to stay in the game, at a point where their brand value was still high but their bodies struggled to keep up.

It was a form of "influencer marketing" before the term even existed. But more than just using the core riders for promotion purposes, harnessing their talent as brand managers let the parent company stay relevant and drive innovation from a place of authenticity.

Reinvention

Rodney not only helped reinvent the skate industry, he has reinvented himself more than once. He was originally known for a style of skating called freestyle, which fell out of favor as “street” became popular. It wasn’t until years later, famously egged on by his partner Rocco, that he would give it up.

CREDIT: RODNEY MULLEN

Freestyle involves staying on flat ground, while in street, elements in the urban landscape like stairs, picnic tables, and embankments become the canvas for new moves.

The hard part about learning a new discipline for Rodney was that he was already an “expert.” After winning 35 freestyle championships, he was expected to be great. When he tried to learn street, he found himself bumping into things like a beginner again. He felt like an idiot.

But he recognized an urgent need to evolve. Being a beginner can be especially hard when you’re in the public eye– as a professional athlete, a public company, or a venture-backed startup with milestones. Rodney manages to reinvent himself, with a combination of fierce determination in pursuit of his new goals and a discipline around staying out of the limelight.

Staying away from scrutiny isn’t always possible, but it’s critically important during times of early creativity and iteration.

Unique perspective

Fortunately, Rodney’s freestyle background never fully disappeared. His “hillbilly accent,” as he calls it, became so ingrained that it has given him a different perspective and a unique style.

He will tell you the best skaters are not the ones who perfect their craft. Competitions and media exposure will often promote precision or big moves for their mass appeal. Yet the "core" skaters judge each other by their style. It's more an art than sport. It's about being unique.

Rodney is known for his incredible tricks, and his unique accent became a permanent imprint that fueled his creativity. It might have been the biggest inspiration for dozens and dozens of foundational tricks he helped popularize—including the flatground Ollie, which enables skaters to pop their boards off the ground.

Rodney explains how he developed the "darkslide," which involves flipping the board upside down and sliding on its top surface. Like most good innovations, it came from a process of iteration. He was trying to figure out how to flip the board on a cross-country team trip, doggedly experimenting at each of the truck stops. The lightbulb went off in Oklahoma City; suddenly he saw how the leverage from the ledge, which made it a street trick, was the same as he'd always used from an old freestyle trick. At that moment he immediately knew how to flip out of it. He translated the motion into a new form, and by the time he reached California the darkslide was born. That innovation is still being felt, 20 years later.

CREDIT: RODNEY MULLEN

His latest creation, a film called Liminal, also illustrates the importance of having a unique perspective. The project, in collaboration with famed photographer Steven Sebring, used a unique photography setup with 100 SLR cameras firing in quick succession around a dome. Rodney's skating artistry collided with that of the photographer, the editor, and a hacker who built the setup.

The resulting film was beautiful. Not because it showed tricks never before seen, but because it combined two orthogonal world views to create something totally new. He describes how the creators' different perspectives combined—in a push-pull manner "like a Slinky"—to make a skate video unlike anything anyone had seen before.

Iteration

This push-pull approach has pervaded Rodney's work from the beginning. As an engineering student at the University of Florida, he dropped out of school to pursue his skating career. His biggest joy at World Industries was applying his engineering talents to designing new products. He shares stories from the early days, including details behind how their boards were developed and manufactured.

CREDIT: RODNEY MULLEN

Rodney's maker mentality was critical in pioneering new board shapes. They partnered with a furniture factory down the street, and he spent hours every day testing out new ideas.

As they grew, they moved production to China. Building a new factory had its advantages; they were not limited by existing infrastructure or convention. They were ahead of their time in their industry, building a fully digital factory that used CAD software and CNC machines. They invented new ways to mold more consistent board shapes. They optimized the manufacturing process.

But the experience was hardly straightforward. He chuckles about drinking with the communist party (he's a teetotaler) as he and Chinese men in shiny suits and Rolexes rode around like mobsters in a black Mercedes. They struggled with intellectual property theft. "A competitor once ended up with a tool before even I had seen it," he say, shaking his head. They also struggled with quality, as the factory often rushed the drying process. They had to ship hardwood maple logs from Canada all the way to China, and the ship the boards back again.

Despite the advantages of setting up shop overseas, the spark of iteration and innovation was lost once the production moved off shore.

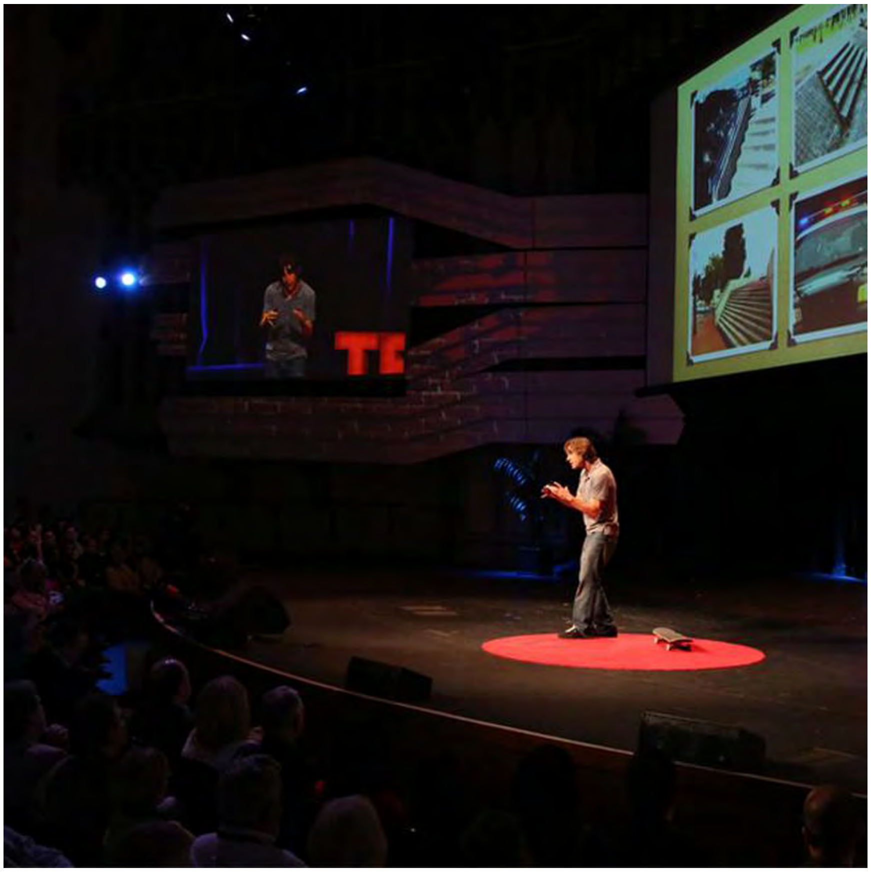
"Bring manufacturing back to the U.S.? With all my heart I'd love to do that." Although for the most part, there isn't much innovation left in skateboards—it's become commodified. While the boards changed every six months in the early days, Rodney hasn't seen anything change in the last 15 years.

What's next?

So if skateboarding hasn't changed, what's left to innovate?

The best way to step outside convention is to make sure you're not trying to beat other people at *their* game, but creating a new playing field. It's easy to get caught up in pushing the limits in conventional ways, like winning competitions and perfecting tricks. But as we saw with Liminal, the real innovation comes from combining ideas, collaborating, iterating. Know your strengths and play to them.

In Rodney's case, he has spent the last ten years recovering from a skate injury and realigning his body to erase his stance. For a decade he was convinced he would just fade away, until he finally hit a breakthrough. In Liminal, he pioneered some tricks that no one else in the world is capable of doing. There will probably be more to come.



CREDIT: TEDXUSC

He has some ideas from a business perspective, too; he shares that he's working a new venture with a friend. He isn't ready to completely spill the beans quite yet, but it's clear he's going to rebel against the establishment once again. If his past is any indication, Rodney will drop out of the limelight for a bit, and will return yet again with something new and truly authentic.

And I'm confident it will be bold. Because in the process of reinventing himself the first time, he realized, "I have to be willing to part with everything that I've done. At some point, you can't sit halfway, or you become a slave to what you've done. Which included freestyle for me."

"I'll never make that mistake twice."

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Krisztina "Z" Holly is the host of The Art of Manufacturing podcast and Chief Instigator of LA Mayor Garcetti's MAKE IT IN LA initiative. Listen to more episodes at artofmfg.com.

FEBRUARY 21, 2018

University Of Arizona Student Owns Lunasonde, A Satellite Research Company

The college freshman is the founder of Lunasonde, a satellite mining company, and has extensively researched both space and Parkinson's disease.

BY SAMANTHA JORGENS, CENTRAL MICHIGAN UNIVERSITY

https://studybreaks.com/college/university-of-arizona/

Jeremiah Pate has been tirelessly searching for a cure for Parkinson's disease, as well as balancing his satellite research company and his studies. (Image via Kyle Ryan)

Science and innovation are constantly changing and evolving. With a variety of different fields, it can often be hard to choose just one project to research and explore. The balance between getting an education and focusing on the many types of innovative research can be quite the challenge, but not without its rewards.

Jeremiah Pate, a freshman at the University of Arizona, has been conducting research involving satellite exploration, Parkinson's disease and more. This variety of research is important for Earth and its resources, along with the medical field. Pate's satellite research led him to start his own company, Lunasonde, which focuses on mining minerals and targeting the same regions as mining companies in order to provide mining corporations with data.

Samantha Jorgens: What is your company Lunasonde?

Jeremiah Pate: We have changed our mission a little bit and we have tweaked our business model, but in essence, we still have the same idea. We are building these small satellites for applications in mining. What Lunasonde is doing is collecting data from our satellites and making that available to different companies such as mining or even utility.

JP: I've always been interested in space. When I was two years old, I lived in Florida. My earliest memory is actually seeing a shuttle launch. I can still see that day clearly in my mind. From that moment on I knew I wanted to do space research and one day I had hoped to go into space.

SJ: Where do you want to see Lunasonde at in the future?

JP: I founded Lunasonde with the idea of making space accessible to everyone. I want to use these satellites to map underground resources. That could be anything from water to minerals to different geological features.

SJ: What is one of the hardest parts of your research and managing your company?

JP: The hardest part is getting the initial money to fund and launch our satellites. We've had several venture capital companies say "Once you have your satellites flying, we'll be interested in investing." Finding that initial money to get our satellites on a rocket launch is a challenge that I have faced.

SJ: How have you tried to deal with this investment problem?

JP: I have actually traveled halfway across the world trying to find investors. I went to Australia, talked to Luxembourg and to people from London to the States, and I got the same reply: "Once you have something flying, then we'll be interested in investing." Right now we have had a shift in strategy and we're talking to people who are interested in our mission and in our overarching idea to see if they would like to personally fund that initial investment.

SJ: How do you balance your research, education, family and friends?

JP: It is quite an undertaking. Since I started this when I was in high school, it was even more extreme, but my work with Lunasonde has impacted many aspects of my education and it's encouraged me to take different classes.

Right now, I'm in an entrepreneurship class. Even though it doesn't count towards my major directly, it has been very rewarding to take these courses and learn from these different fields and how to apply that to my entrepreneurial future.

A lot of the time, I find the friends I have are in the same industry and interested in space research. You end up talking to those people who share that same interest and the same drive of exploring space and bringing humanity forward through industry in space.

SJ: In your interview with University of Arizona's News site (UANews) you said "You can't spend your whole life going deeper in (only) one area and expect to find something new." Is that still true?

JP: Yeah, absolutely. I've done research on cybersecurity, aerospace and I have worked extensively and am continuing to work on a project in Parkinson's disease.

The really interesting thing is, after a while in all these different fields, you learn something in one that helps you in another or vice versa. You never know how those fields will connect and it is often those unexpected connections that really leads to innovation.

SJ: How did you get into your Parkinson's research?

JP: A few years ago, I went to this church with about 30 people. I met a man named Jesse and three other members of the congregation who had Parkinson's. That's when I realized Parkinson's disease is really a major issue in modern medicine.

SJ: How has your research in Parkinson's been going?

JP: I found a promising treatment for Parkinson's. I created a computer algorithm that can design a tailored treatment strategy. I programmed these fruit flies to have Parkinson's and introduced a piece of the molecule.

I discovered a complete reversal of their Parkinson's symptoms. In the next several weeks I'm going to do a second test in a human cell culture.

SJ: How do you see the future of your research and company in relation to pursuing your education?

JP: I'm hoping both these projects take off before I graduate. I'm pursuing my educational and research timeline at the same time. I hope to get my Ph.D. and to pursue these interests of mine in business and the medical field.

Award Abstract #1827923

PAWR Platform COSMOS: Cloud Enhanced Open Software Defined Mobile Wireless Testbed for City-Scale Deployment

NSF Org:	CNS Division Of Computer and Network Systems
Initial Amendment Date:	April 2, 2018
Latest Amendment Date:	April 2, 2018
Award Number:	1827923
Award Instrument:	Cooperative Agreement
Program Manager:	Monisha Ghosh CNS Division Of Computer and Network Systems CSE Direct For Computer & Info Scie & Enginr
Start Date:	April 1, 2018
End Date:	March 31, 2023 (Estimated)
Awarded Amount to Date:	$3,637,416.00
Investigator(s):	Tommaso Melodia melodia@ece.neu.edu (Principal Investigator)
Sponsor:	Northeastern University 360 HUNTINGTON AVE BOSTON, MA 02115-5005 (617)373-3004
NSF Program(s):	CISE RESEARCH RESOURCES
Program Reference Code(s):	044Z
Program Element Code(s):	2890

ABSTRACT

This project creates a city-scale platform for advanced wireless research that will be deployed over the period 2018 - 2023 in New York City, NY. This Cloud Enhanced Open Software Defined Mobile Wireless Testbed for City-Scale Deployment (COSMOS) supports at-scale experimentation of novel advanced wireless broadband and communication technologies in the sub-6 GHz bands and in the millimeter wave frequency bands in a densely populated, urban setting. The project features interactions with regional networks and smart community initiatives including municipalities, non-profits, and various tech communities with interest in contributing to and/or using the testbed for application development. The ability to use this platform by early adopter companies/startups, global telecom industry and application developers to evaluate technologies in their pre-commercial phase will have a significant positive impact on the speed of innovation in the data networking and application domains. This effort will also benefit educators and students at all levels of study in communications-related disciplines.

Radio nodes in COSMOS provide a mix of fully programmable software defined radios (SDRs) for flexible wireless experimentation as well as commercial hardware capable of supporting networking and applications research with currently available end-user devices. COSMOS is built in a bottom-up manner with commodity components and customized open-source hardware and software modules. The developed wireless platforms cover the full range of spectrum including the sub 6 GHz bands used for today's services as well as emerging 28 GHz and 60 GHz millimeter-wave (mmWave) bands. SDRs utilize a new design that achieves an order-of-magnitude performance headroom over current technology, achieving real-time processing of wide bandwidths (~500 MHz) via novel acceleration techniques. The COSMOS platform incorporates fast programmable core network technology to keep pace with significant increases in wireless link bandwidth and to effectively integrate emerging radio access networks with edge cloud computing. The design includes novel 100 Gbps+ fiber, free space optical, and microwave backhaul technologies interconnected with a software-defined network (SDN) switching fabric for minimum latency and flexibility in setting up experimental network topologies. Sub-microsecond optical switching technology offers the option of passive Wavelength-Division Multiplexing (WDM) switch fabrics and radio over fiber interfaces for the purpose of achieving ultra-low latency connections to edge computing services, which will be built in as an integral part of the system. Together, this will enable comprehensive end-to-end experimentation across diverse applications and users with tools for scientific workflow management, collaboration, and artifact sharing, all with a goal towards promoting rigorous standards for reproducibility in this field.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

Magic UX

Magic UX is a new smartphone interface inspired by the physical world. It uses your view of the real world to help you navigate computer generated content in the digital world. It's a practical, subtle use of augmented reality.

Smartphones and small screens have made their way into our everyday lives, transforming the way we communicate and work. Despite many benefits over traditional analogue tools, some digital interactions are actually more complex and frustrating than their physical equivalents.

The moment when you move between apps, copying text from a webpage into an email, for example, is more complex on a small screen than it would be in the physical world, interrupting flow and increasing the cognitive load of a simple task.

We discovered that this was a problem many people experienced across all apps - it didn't matter if you were writing a report for work or booking a holiday. The problem lived in the space between the apps, a sort of no man's land.

This doesn't happen when you work at your desk. We found that people often lay out their work tools, such as notepads, pens, and reports in specific arrangements in front of them, allowing them to move between tasks by simply shifting their gaze and moving their hands.

Inspired and intrigued by these natural and fluid interactions we have with the physical world, we became interested in ways of recreating them in the digital space.

PROBLEM
Having to move between different apps on a smartphone in order to complete tasks results in increased cognitive load and disrupted flow.

SOLUTION
A mindful user interface that reduces your cognitive load allowing you to remain focused on the task at hand.

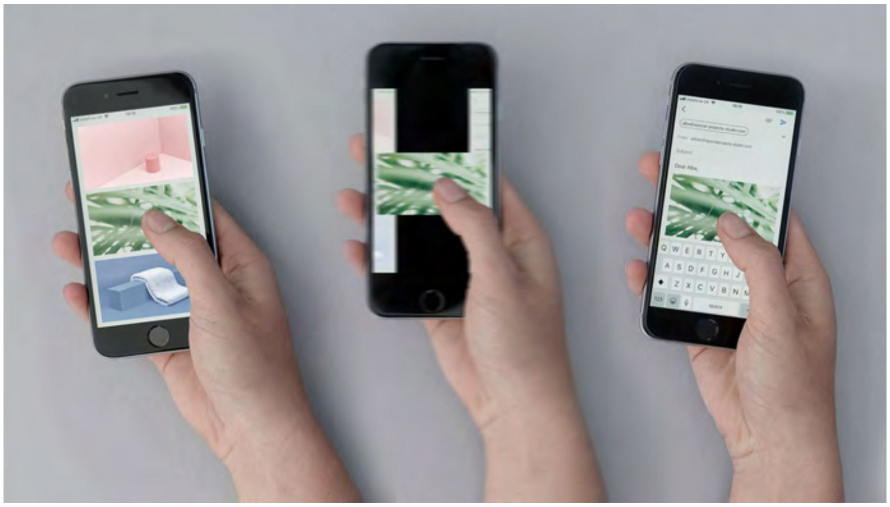
AWARDS
2018 London Design Awards Gold Winner
2019 IxDA Interaction Awards Shortlist

PATENTS
WO2018167501

Magic UX is a spatial user interface which allows users to virtually "pin" apps to a physical space. Every time you move your device to that space, the same app will open on your screen. There's no limit to how many apps you can pin, allowing you to build a virtual desktop to suit your needs at that moment in time.

You can physically move content between apps just by dragging it through space. For example, you can copy text from one app to another by simply selecting it and dragging and dropping it into another app by moving your phone. The natural flow and familiarity of this movement reduces your cognitive load and allows you to stay focused on the task at hand.
Metadata linked to content can be copied and moved too. For example, dragging a calendar entry into an email will automatically create a text invitation. Dragging a map entry into that same email will update the text with the location.

Multiple desktops can be created temporarily based on your needs or linked to a location, for example, a suite of apps could automatically open when you arrive at your WeWork desk. Also multiple users can share the same virtual space, allowing them to drag and drop content into each others devices seamlessly.



While the invention is destined to be integrated into the operating system, it can also be used within an app, helping the user navigate between the different parts of that app.

We have fully patented the invention and created a working prototype, and looking to license the technology with leading technology companies to integrate this interaction into every smartphone operating system, making our everyday interactions simpler and more delightful.

Building on existing smartphone technologies, Magic UX is both a practical solution to the problems of smartphone multitasking and – as our physical and virtual worlds converge – a timely vision for the future of navigation in the digital realm. This is an interaction designed to become invisible and forgotten, letting you focus on the task at hand.

HyperSurfaces Turns Any Surface into a User Interface Using Vibration Sensors and AI

Steve O'Hear
TechCrunch | November 19, 2018
https://techcrunch.com/2018/11/20/hypersurfaces/

Imagine any surface, such as a wooden table, car door or glass wall, could be turned into a user interface without the need for physical buttons or a touch screen. That's the ambition of HyperSurfaces, the London startup originally behind the Mogees line of music devices and software, which today is unveiling what it claims is a major breakthrough in UI technology.

Dubbed "HyperSurfaces," the new technology, for which the company has four related patents pending, combines vibration sensors and the latest developments in machine learning/AI to transform any object of any material, shape and size into an intelligent object able to recognise physical interactions.

Equally important is that once trained for a particular object, the HyperSurfaces neural network-trained algorithms are able to run on dedicated microchips that don't require connection to the cloud for processing. This means that gestures can be instantly recognised and in turn trigger specific commands entirely locally and at much lower cost.

The idea, co-founder and CEO Bruno Zamborlin tells me, is to merge "the physical and the data worlds" in a more seamless way than has been previously possible, ridding us of unnecessary keyboards, buttons and touch screens.

"The HyperSurfaces algorithms belong to the current state of the art in deep learning research," he explains. "On top of this, the computational power of microchips literally exploded over the last years allowing for machine learning algorithms to run locally in real-time whilst achieving a bill of material of just a few dollars. These applications are possible now and were not possible 3 or 5 years ago."

Zamborlin says it is difficult to imagine what the applications of HyperSurfaces technology might end up being, in a similar way as it was difficult to imagine 10 years ago all of the applications a mobile phone could enable. The most immediate ideas include the possibility of creating technological objects made of materials that until now haven't been associated with technology at all, such as wood, glass and different kinds of metal etc.

"Imagine a new wave of 3D wooden IoT devices," he says, only half jokingly.

This could result in a wooden kitchen table becoming the controller for your living room smart lights and smart thermostat. Or perhaps your home's floor becomes an advanced security system able to accurately distinguish the steps of a thief from those of your cat. HyperSurfaces has also already seen a lot of interest from car manufacturers.

"Other initial applications will probably include accommodating the desire of car manufactures to eliminate buttons and switches from their car doors and cockpits, creating a brand new experience for the user," adds Zamborlin. "We are used to flat plastic surfaces, but this won't be a requirement anymore."

The HyperSurfaces team

To get this far — the video demos are very impressive and can't help but fire your imagination — HyperSurfaces (then called Mogees) raised $1.1 million in seed funding about a year ago and has been heads down ever since. This included Zamborlin recruiting a team of top AI scientists and completely re-focusing on research and development. "They are all from Goldsmiths [University of London], like myself, where we specialise in the niche of AI for real-time interaction," he says.

The real challenge of providing effective man-to-machine communications will culminate in man's home and his office. The future household will, in all probability, be a giant electric "appliance" that will be plugged into a nationwide communications network. The building blocks are available in the telephone and the television receiver. Today experimental information services for the home are in operation globally in test communities. They are based on two-way television. In the future, besides information retrieval, other more complex chores will be performed by specialized terminals that will combine microprocessors with conventional hardware. Laboratory systems being developed are based on a residential power center, the television receiver, and the telephone.

In the office, sophisticated tools need to be integrated into automated work stations. To meet that goal, both the manufacturer and the user of the equipment must chart the course. Methods of integration must be found in both hardware and software so there is easy access by man to machine in the "office of the future." Also, communication paths that facilitate access to equipment in other offices must be charted. As local nodes are built up and become self sufficient, they will become part of nationwide information networks. New equipment, in addition to changing the office environment, will cause upheavals in the organizational structure. As in the home, the availability of new services and novel systems will depend to a great extent on relaxed regulation by government agencies.

The wired household

Teletext services pave the way for a variety of useful monitoring and control features in the home

Information retrieval is not the only capability that advanced electronics can offer to households. Other, more complex chores can be performed by specialized terminals that combine microprocessors with relatively conventional hardware. Three experimental systems now in the laboratory would do the following in homes:

1. Control the use of electricity to avert overloading at utilities that can lead to blackouts.
2. Turn the television receiver into a programmable information/entertainment center.
3. Use the telephone at idle times for meter reading, alarm reporting, and the remote monitoring and control of lighting, heating, and air-conditioning.

Controlling power consumption automatically

When there is excess demand by consumers for power, utilities have no choice but to shed load to maintain system stability. For the householder, this generally means a period of intermittent or total blackout. Shaving these peak loads can reduce the frequency of such occurrences, conserve fuel, and reduce the need for expensive, inefficient peak-load generating equipment. Automatic load control can help achieve these goals.

In the experimental load-control and energy-management system in Fig. 1, the primary power circuit of the load center is divided into individual circuits connected to such loads as lights and appliances. These connections are controlled by commands either from the utility or the customer. Major loads like the water heater, a space heater, or air-conditioner can be turned off or on by the utility via a command carried by radio, telephone line, CATV cable or power line. These and other loads can also be controlled by customer use of a programmable device, manual controls or an adaptive control that prevents the total load from exceeding some limit.

E. Bryan Carne GTE Laboratories Inc.

The system may include a display. In its simplest form, this may be a signal lamp that lights on command from the utility to indicate that cycling of the major loads has begun, that all but essential loads should be shed or that a blackout is imminent. The display may also include a household demand meter that gives information on current load. More sophisticated units could give historical information and perform limited analysis of recent consumption. In areas where time-of-day pricing is employed, time would be an important input to the householder's programmer and display.

Wider use of TV receivers planned

In a television receiver, microprocessor and electronic actuation permit the random selection of channels. But new conveniences are in the offing:

The receiver can also be programmed to provide automatic reception of specific channels at specific times for viewing or recording. A sequence of instructions can be entered to insure that interesting programs are not missed throughout the week. Day, date, time, and channel number can be superimposed on the picture at will. What's more, simple messages can be composed, stored, retrieved, and displayed as a means of family communication. If a teletext service is available, signal decoding, page selection, and storage of additional information are possible. Graphics can be generated, and with the addition of joysticks, games can be played.

The degree of flexibility of such an information/entertainment center (Fig. 2) largely depends on the capability of the

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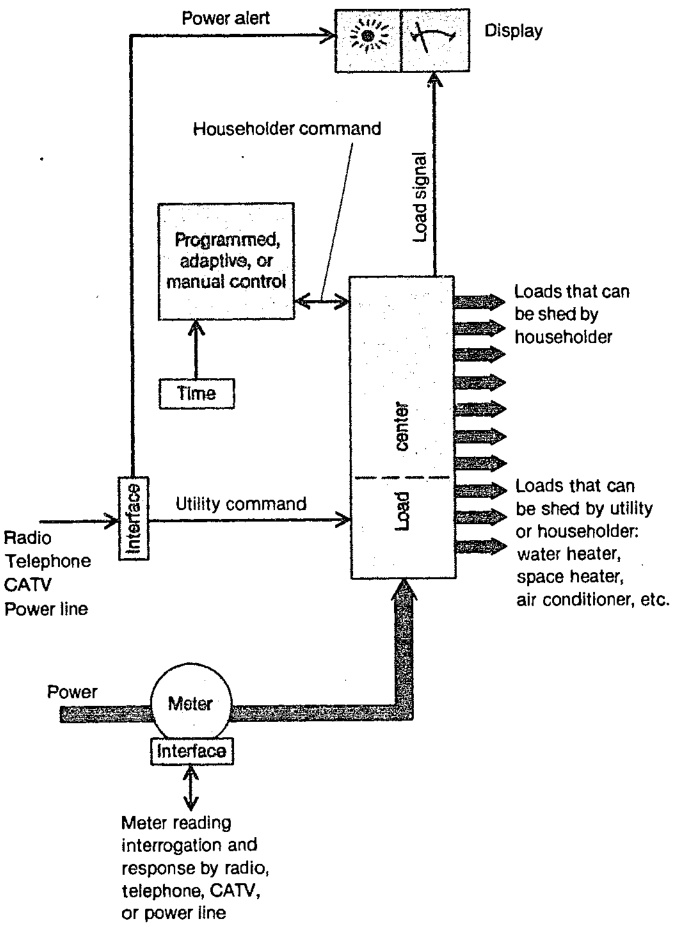
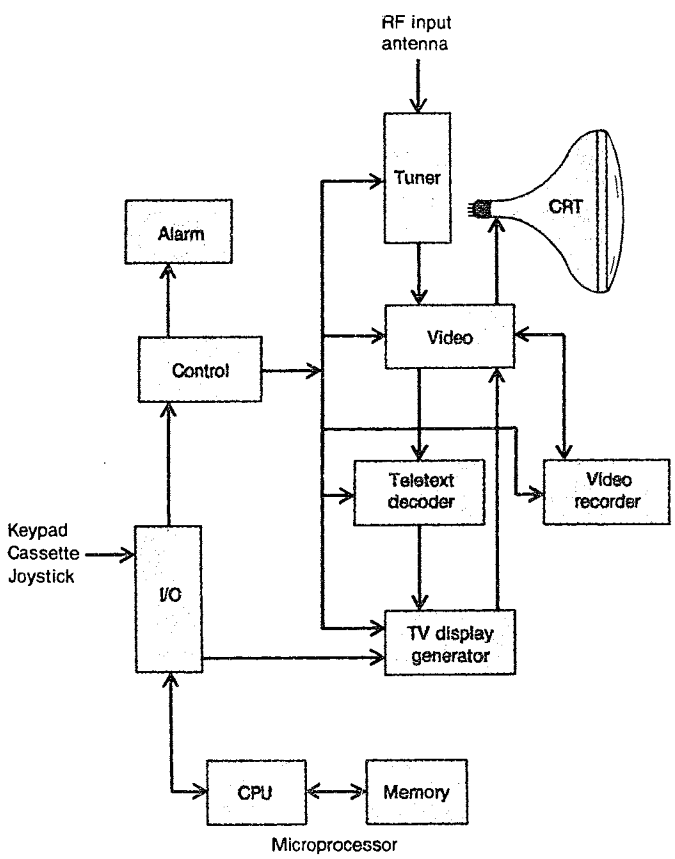




microprocessor. With the exception of teletext, which is already formatted, all other functions and displays can be constructed from information placed in memory.

For time-dependent control of the receiver functions, a programmable, nonvolatile memory stores the channel selections programmed by the viewer for automatic activation. An audible alarm indicates the receiver has been automatically turned on. In one experimental system, approximately 4000 bytes of memory are used to list preprogrammed channels, provide automatic activation, and display date, time, and channel number on demand.

More memory is needed for playing games. Sophisticated coding and presentations of limited complexity permit a color picture to be described in about 2000 bytes. Movement of the entire picture in a wrap-around mode can be achieved through scanning of a larger memory. Additional foreground memory or dedicated symbol hardware provide fast, smooth, complex motion. The detection of symbol-to-symbol and symbol-to-background collisions, required in many games, can be performed in hardware, which may also contain rules indicating which symbol shall dominate. New game programs can be loaded from a cassette or a different ROM module.

Using the phone to monitor the home

The average household uses the telephone circuit as a talking path only a small fraction of the day—perhaps 30 minutes. With additional electronics, the line can be used for new services.

With a system like the one in Fig. 3A, the customer could monitor the status of a household device by calling the home telephone. If no one was at home, the ringing would activate a message recorder. The customer would transmit a coded signal with the pushbuttons on the originating phone. Upon receipt of the correct coded signal, the recorder would generate a short acknowledgement tone. The recorder would then disconnect, and the equipment would be ready to receive codes from the customer to be turned on or off.

The input/output circuitry for such a system contains a ring detector, a tone detector, an A/D converter to digitize the signal tones for decoding in the microprocessor, and an answering tone generator. The microprocessor interprets the received signals, executes the appropriate functions, and sends the proper code to the answering tone generator.

Besides responding to a call, the system can also place calls in response to signals from alarms and can transmit data messages to answering points. Approximately 2000 bytes of memory are used in the experimental unit in Fig. 3B, which contains an information display and includes wired teletext.

Three fields hold key to progress

Developments like these will depend largely on continuing advances in three major areas: increased levels of integration

[1] In load control and energy management applications, a "smart" load center (top, left) receives a command from the utility or householder to manage the load. This may be done to contain peak demand or to minimize cost.

[2] With the addition of a microprocessor, input devices, control logic, and a display generator, a conventional television receiver (bottom, left) can be made to turn off and on at times determined by the householders. Or it can display information or be used to play games.

Teletext and viewdata—a primer

In the home of the future, teletext and viewdata information-retrieval systems are expected to be as common as TV entertainment is today. Teletext and viewdata are mediums for transmitting text and simple graphics to a television receiver. In both, the information is digitally encoded for transmission and is organized into pages.

In teletext, the digital code is included in a television signal and is cyclically repeated. The television receiver grabs the page of interest and stores it locally.

In viewdata, the digital code is modulated onto an audio-frequency carrier that is usually transmitted over a telephone channel. The terminal requests pages, which are sent individually and stored locally. Unlike teletext, viewdata is interactive.

Teletext signals are analog representations of digital bits inserted on two lines of the television receivers's vertical blanking signal. A threshold sensor device makes the transition from the analog television signal to the digital signal-handling circuits. The teletext data base is usually organized on a menu basis.

Teletext signals consist of a clock run-in burst, a framing code, a preamble, and an ASCII-like code. The viewdata signals are of an asynchronous nature, similar to teletype writer signals. They contain a start bit and a stop bit. Clock run-in and framing codes are unnecessary. The bits are modulated onto the audio-frequency carrier by use of frequency-shift-keying modulation techniques.

In teletext—because the data is coded onto normally unused lines of a television transmission—faults that would be tolerated for television may cause data-recovery problems. And because the number of unused lines is limited, the total data content is limited.

The viewdata decoder is connected to the user's telephone line and uses the public telephone network to transmit characters to and from the computerized data base. System capacity is limited only by physical restraints. Because individual connections are used, service can be personal.

Teletext evolved as an extension of British efforts to transmit captions to the deaf. Developed by the British Broadcasting Corp. in the early 70s, the system is in use on more than 50 000 sets in the United Kingdom. It is known as Ceefax on the two noncommercial BBC channels and as Oracle on the commercial channels. To view the service, a subscriber pushes 1-0-0 on a keypad, which produces an index of major headings, such as News, Weather, and Travel, Sports, Finance, and Entertainment. Sub-indexes give a specific number for particular subjects—for example, 1-2-6 calls up a stock-market report. Pushing another button restores the regular program to the screen.

Prestel is the trade name for the British Post Office's viewdata service—the first such public service. Last March the initial service was made available to London-based residential users. By the early 80s, the viewdata service will be offered to customers in Manchester and Birmingham, with over 60 percent of all telephone users having toll-free access to the service.

The Prestel data base is structured in free form. The user progresses down the tree by keying numbers alongside the information required from a handheld keypad. The same procedure—that of selecting one item from each frame—is repeated at each level until the required information is received. For example, the customer might select Travel and follow successive branches in the tree-structure search technique to obtain a listing of hotels in the city of his choice.

Any organization can become an information provider to Prestel for an initial charge of $500 plus $2 per page per year, with a minimum of 100 pages. Over 160 organizations have subscribed to the initial 185 000-frame capacity of Prestel. The index includes 1000 topics ranging from Accident Prevention to Yoga.

Ceefax, Oracle, and Prestel information is transmitted asychronously in 8-bit ASCII code, decoded into 5 × 7 dot matrix elements, and displayed in color in 24 lines of 40 characters. In the broadcast systems, 6.9-Mb/s data is inserted on two lines per field. It may take up to 20 s after a request is made for a page to appear. In the wired system, data is sent to the subscriber at a rate of 1200 b/s. Requests from the subscriber are sent at a rate of 75 b/s. A page of information can be called up in a few seconds.

Countries conducting research and trials based on Prestel standards include; Sweden (Datavision), Finland (Telset), and Bell Canada (Vista). France is developing a similar viewdata system called Telitel (formerly Antiope), which uses somewhat different standards but has much in common with Prestel—data rate, for instance. The French teletext version, Didon, uses a nonsynchronous transmission scheme that is suited to all television formats. The British system uses a synchronous method in which character position on the screen is tied to a specific position in the television line used to broadcast the digital data.

Two developments differ markedly from Prestel. Japan's Captains system uses a central character generator to cope with the complexity of the Katakaha alphabet. In Canada, the Department of Communications has developed Telidon, an alphanumeric technique that provides high-resolution graphics displays. Characterized as a second-generation information retrieval system, Telidon incorporates a complex coding scheme that makes it possible to display photograph-like images as well as standard graphics and alphanumerics. Other improvements relate to economy of transmission and use with variable resolution terminals.

Several other countries—including West Germany, the Netherlands, Spain, and Switzerland, along with Hong Kong—are planning or testing national services based on one or another of these sytems.

In the United States, CBS is testing two teletext systems: the British Ceefax/Oracle and the French Antiope. Test transmissions are being conducted at KMOX-TV in St. Louis. The station is transmitting teletext on lines 15 and 16 of the television signal to produce a page comprising 20 lines, each of 32 characters.

In June 1978, KSL-TV in Salt Lake City became the first U.S. station to transmit teletext for test purposes. The system uses British standards (24 rows of 40 characters each) modified to the U.S. page of 20 lines of 32 characters each. The advertiser-sponsored service will permit the user to request a desired page by punching appropriate codes into a Touch-Tone phone. There will be no connection between telephone and receiver.

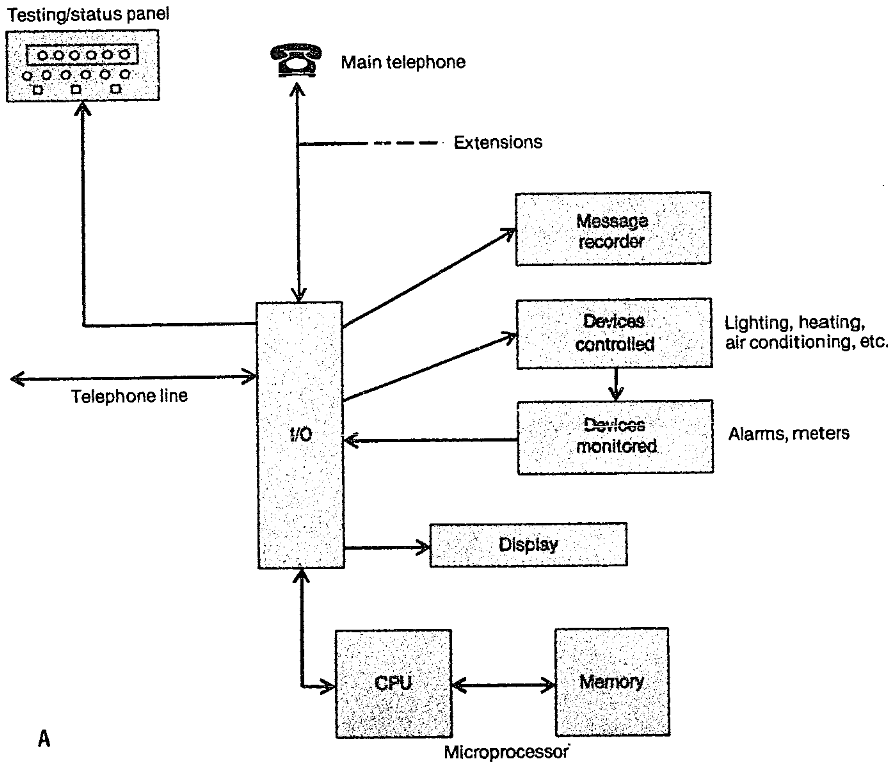
Oak Communications Inc., a CATV supplier in Crystal Lake, Ill., has developed a teletext system called Videotext that will allow cable operators to supply alphanumeric information to customers. And Micro-TV Inc. of Philadelphia is offering the Info-Text teletext system to send the news services of Reuters, United Press International, and the Associated Press to cable operators.

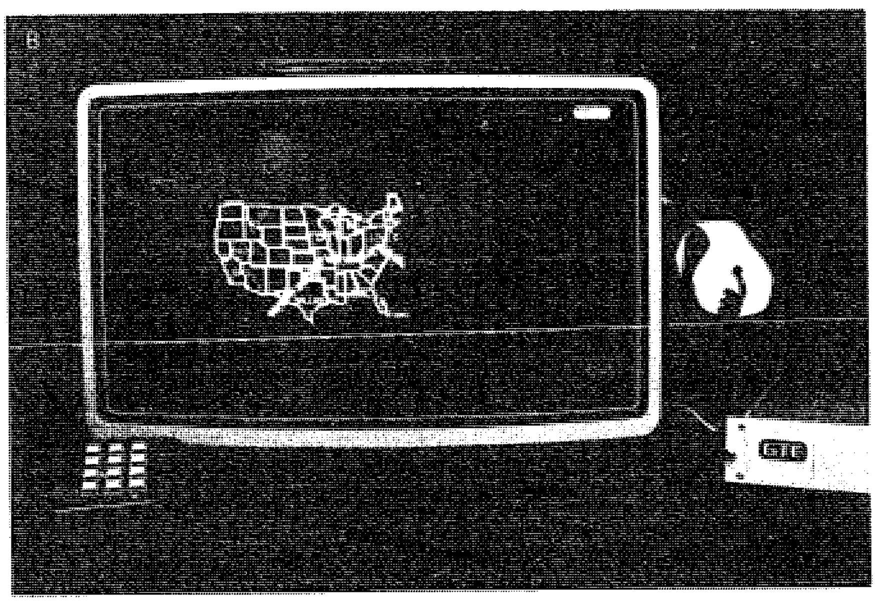
Some 200 farmers in Kentucky will soon begin receiving weather and crop information over a modified wired teletext system known as Green Thumb, supported by the U.S. Department of Agriculture.

The New York Times Corp. has announced a two-year pilot project to test interest in wired teletext. Plans call for weather, sports, news, and movie schedules to be made available to 150 to 200 homes.

The General Telephone & Electronics Corp. has recently been licensed to offer Prestel service in the U.S. A market trial is planned after modification of the software and identification of information providers.

Although the United States has more communications equipment per capita than any other country in the world, the development of advanced communications and information systems lags other countries. This can be attributed in part to an uncertain regulatory environment and the absence of a central standardization tradition. —*Ed.*





[3A] Adding a microprocessor and other devices to a conventional telephone allows household equipment to be monitored and controlled remotely. In addition emergency services can be summoned automatically, and information can be displayed.

[3B] This version of a remotely-controlled telephone uses a color display for retrieval of information from a wired teletext service.

in digital circuits, the operation of satellite circuits at higher frequencies, and improved optical communications products.

Today the most complex IC chip in a memory contains 64 000 bits. By 1985, advances in chip size, element density, and circuit design are expected to produce chips containing at least one million elements. These super chips will provide renewed impetus to the implementation of more features digitally, and they can be expected to produce a continuing demand for low-cost A/D and D/A conversion.

Higher frequencies for orbiting satellites provide the potential for distribution of information and entertainment signals of value to communications/information services. Although the orbital slots for satellites operating at 4/6 GHz are virtually filled, space is still available at 11/14 GHz, and the entire orbital arc is available at 18/30 GHz. At these very high frequencies, the radiation pattern from the satellite can be split into many spot beams, each illuminating a small area of the earth. This allows the same frequencies to be used in different geographical areas.

Optical fibers provide a wideband transmission path of extremely small physical cross section that is free from power and radio-frequency interference. Point-to-point communications applications have already been demonstrated—including the transmission of digital signals inside the telephone network and the transmission of video signals for video conferencing and cable TV. Effective local distribution of mixed signals—voice, data, and video—will be possible as soon as adequate networking components have been perfected and some form of optical switch has been developed. The latter could be an important component in the local distribution of personal video services.

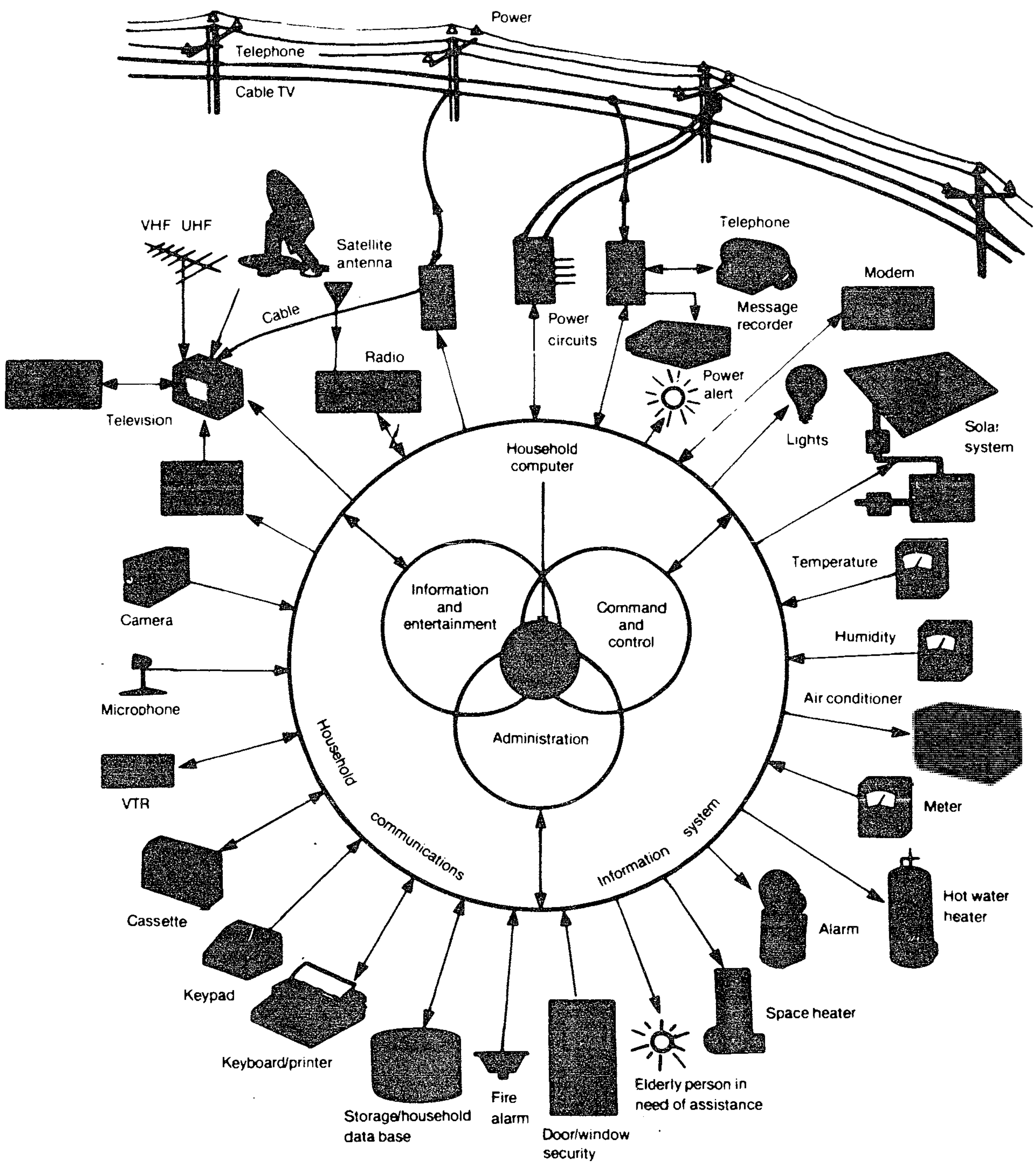
Putting the computer into the home

An all-encompassing household communications/information system (Fig. 4) centers on a home computer that supports three subsystems: information and entertainment, command and control, and administration. It receives radio signals transmitted over the air; television signals from terrestrial, cable, and satellite facilities; administrative signals from an electric utility, and signals from the telephone network. A myriad of household products and applicances can be controlled by the system. In principle, a single wideband connection like an optical fiber could link the system with the world.

The information and entertainment subsystem could provide the following:

• Retrieval, schedule, and library information, as well as news and reports. It would use the television receiver, a teletext decoder, telephone, modem, and keypad or keyboard/printer, supported by broadcast teletext services, wired teletext services, community services or other sources.

[4] A "total" household communications/information system, in which communications are provided by power line, telephone, cable television, and broadcast services. Household activities are supported by a computer.



• Interactive education for preschool or in-school students and interested adults.
• Interactive games and intellectual entertainment for children and adults.
• Interactive opinion polling and preference sampling.

The command and control subsystem could:
• Adjust electrical load by time-of-day requirements or by a remote command from the utility.
• Provide meter information to the utility on demand or at preset intervals.
• Optimize the use of solar panels, air-conditioning or space heaters to maintain a living environment within preset temperature and humidity limits, while limiting energy consumption.
• Monitor fire, intrusion, and assistance alarms and notify emergency services or a community center.
• Provide system status information to the householder.
• Turn on the lights, radio, and heat on command or in accordance with a preset scenario.

The administration subsystem would be capable of doing these tasks:

• Providing interactive information retrieval.
• Maintaining family records, such as accounts, medical histories, addresses, and phone numbers.
• Paying bills by electronic funds transfer.
• Computing taxes.
• Sending and receiving messages from other subscribers (electronic mail).

These listings are by no means exhaustive. Many more types of household equipment—washers, dryers, ovens, freezers, and water and gas meters—could be controlled. Suffice it to say that a computer and ancillary equipment could automate almost all household functions requiring intellectual activity. To implement the full package with today's technology would be enormously expensive—but possible. In fact, some microprocessor-supported control systems for home use are already available, although they do not provide the sophisticated communications and information-retrieval capabilities of the systems discussed here. They can, however, turn lights on and off by program; control appliances and fire and security systems; and remind homeowners of anniversaries or other important dates.

It's likely that rather than one unified system for the home, such as that in Fig. 4, many individual systems will emerge. With the availability of domestic satellites and optical-fiber communications, the prospects for innovative household services would be wide open. ◆

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Office automation: a challenge

Better tools simplify some office tasks, but serious problems block the integrated office of the future

Upcoming communications services, to be made available with new commercial satellite and microwave systems, will greatly accelerate the drive toward the fully automatic "office of the future." The concept received impetus from the introduction of word/text processors in the mid-1970s, but so far the average office continues to operate with a potpourri of mechanized tools but no integrated automated system. The efficiency of isolated tasks has been improved perhaps, but there has been little dramatic effect on productivity.

Nicolas Mokhoff Associate Editor

What remains to be done is to incorporate today's electromechanical tools for white-collar workers into hardware/software systems that will process and handle information with a minimum of human involvement. Such a system would have two-day communications.

The coming decade promises to do this. Five interdependent steps will lead to success:
1. Development of intelligent hardware to perform a majority of the repetitive, mundane functions without the operator's assistance.
2. Design of common-language software for ready access by untrained managers, the key contributors to making the automated equipment acceptable by the full organization.

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