World Trends & Forecasts

Governance

Reversing the Mexican "Brain Drain"

Investing in more tech opportunities may lure the best and brightest back home.

By Concepción Olavarrieta

After investing more than a billion dollars (or 25% of the Ministry for Education's budget) in postgraduate studies for young students abroad, Mexico is looking for a return on that investment—literally. Many of those students never come back to Mexico once their studies are completed. Their reasons for remaining abroad include superior wages and salaries; the ability to work in research centers, offices, and labs equipped with the latest technologies; and the opportunity to be involved in cutting-edge research projects.

Of these former students, 66% reside in the United States, 26% in Europe, and the rest in Canada and elsewhere. Half of the 5,000 scientists who did not return to Mexico obtained PhDs, and some went on to obtain postdoctoral positions. An estimated 575,000 Mexican professionals and academics now live and work in the United States and Europe, and this number is growing. Every year, 20,000 highly educated Mexicans search for better working conditions outside Mexico. Most of them ultimately get hired.

This brain drain has policy repercussions as far as investment in higher education is concerned, but, more importantly, it signifies an irreplaceable drain of human resources, the retention of which is vital for the country's development. For every five Mexicans with master's degrees and every three with PhDs working in Mexico, there is one with an equivalent degree working in the United States.

Both public and private investment in science and technology research and development is needed in order to attract and retain these "brains." However, that investment is currently precipitously low.

In 2010, the amount set aside in the Mexican government's budget for research and development represented 0.4% of the GDP, while the contribution from the private sector was 0.1%. Together, this amounted to a mere 0.5% of Mexico's GDP, placing the country last among members of the Organization for Economic Cooperation and Development, which recommends that developed countries devote 4% of the GDP to R&D.

Not surprisingly, *The OECD Reviews of Innovation Policy: Mexico* (2009) recommends that the government increase public spending on science and technology. It adds that, given the current global crisis and economic recovery, there are two fundamental issues to which the Mexican government should give priority.

First, the government should mitigate the negative impact of the world's financial crisis on the actors involved in innovation. Continuous support by the National Council on Science and Technology (CONACYT) and the Ministry of Economy is critical for maintaining research and development as well as preserving long-

term projects in the public sector and in partnerships between the public and private sectors.

Second, it should view the innovation process as a key component of a green recovery program. Green technologies, green jobs, and innovation and investment in renewable energy will drive future growth.

Moreover, the OECD has proposed that the Mexican government create a Ministry of Science.

Currently, Mexico's National Researchers Program is intended to abate the brain drain. It offers researchers and academics the ability to earn an annual tax-free bonus calculated on the basis of individual performance. The OECD recommends that the bonuses be incorporated into the regular salaries of all 15,000 participants in this program. Within the criteria used for assessing the performance of researchers, the organization advocates that more credit be given to collective work and research carried out by international teams and networks as well as in university research institutes. The OECD argues that these steps will enable the National Researchers Program—which consumes a third of CONACYT's budget—to fulfill its aims.

The Mexican government has taken steps toward implementing these recommendations, including the creation of an Innovation Stimulus Program and a Sector Funds program for monitoring and evaluating scientific, technological, and innovation activities. There are also plans to invest more in graduate education programs in Mexico.

These funds enable financial speculation in certain sectors of the economy, such as alternative energy, information technologies, poverty alleviation, and others, fostering greater investment in science and technology. By the end of 2009, there were 20 such funds with federal support, and contributions exceeded $2 billion.

Mexico has also become the leading promoter of the Latin America and Caribbean Innovation Network. This network purports to further the exchange of ideas concerning the ways in which innovation policies can be evaluated, and to identify the common challenges and effective policy responses that will benefit the strategic analytical frame that the OECD will soon launch.

AARON M. COHEN

Concepción Olavarrieta speaks during the Millennium Project's "2008 State of the Future" presentation at WorldFuture 2008 in Washington, D.C.

Further enhancing science and technology opportunities at home are programs such as the Institute of Mexicans Abroad, the Mexican USA Foundation for Science, and CONACYT, which have all been promoting the Mexican Talent Network. This network encourages liaisons, synergies, business development, and education for global innovation; fosters Mexico's prestige abroad; supports Mexican communities in other countries; and facilitates a better understanding of Mexicans' contributions to their adopted countries. These efforts also aim to introduce Mexican technology companies to the world market. There are associations of the Mexican Talent Network in tech hotspots such as Silicon Valley, Houston, Austin, Boston, Los Angeles, and Redmond.

Former NASA astronaut José Hernández, an American of Mexican descent, has predicted that, if Mexico were to invest seriously in space, in five years the Mexican Space Agency could be reaping its first fruits, and within 10 years it could count itself as one of the eight major space agencies in the world. Studies have shown that, for every dollar spent by NASA, it gains six from the technology it develops and commercializes. According to Hernández, Mexico has to use its reservoir of talent at home and abroad in developing such technologies.

With these proposals, the brain drain could be transformed from a net loss into an opportunity for globalization.

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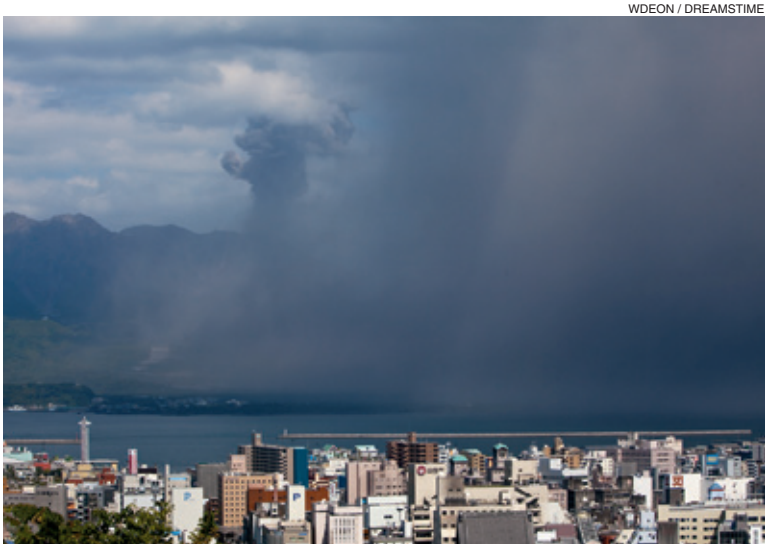
WDEON / DREAMSTIME



Dust from a June 3, 2010, volcanic eruption darkens the sky above Kagoshima City, Japan. Solar radiation management processes would, in like fashion, disperse clouds into the atmosphere to reduce sunlight and offset global warming—but they would use safer substances than volcanic ash.

Climate Change

Dimming the Sun

Humans could reduce Earth's sunlight intake, but are they playing with fire?

When a volcano erupts and dims the sun with ash-laden clouds, one noteworthy effect is immediate cooling. Can this effect be replicated worldwide—without the ash?

The British government is sponsoring prospective studies of "solar radiation management" procedures to halt global warming by blocking some of the sun's radiation from reaching Earth. But some of the studies' researchers are not sure that solar radiation management's benefits will outweigh its harms.

Solar radiation management would deploy clouds of gas, sulfate aerosols, or water vapor into Earth's upper atmosphere to reflect some of the sun's rays back into space. The Southwest Pacific Ocean Circulation and Climate Experiment (SPICE) is assessing candidate gases, how to deploy them, and the likely impacts. SPICE is one of several solar radiation management projects receiving grants from the Engineering and Physical Sciences Research Council, the main UK government agency for funding science and engineering research and training.

Peter Braesicke, a SPICE researcher and Cambridge University atmospheric science professor, suspects that solar radiation management might cause major disruptions in world weather patterns. In a study published January 2011, he argued that interfering with sunlight could change the "teleconnections" that link Earth's wind, water, and temperature currents. As he told THE FUTURIST, the consequences could include increased droughts in some parts of the world.

"Circulation regimes like monsoons and associated precipitation patterns are likely to change—and that might mean that some areas will be drier than now," he says, adding that some countries will suffer more than others. "Regional changes will almost certainly always produce winners and losers."

Ben Kravitz, a doctoral student in Rutgers University's Atmospheric Sciences Department, wrote a companion paper to Braesicke's study. Kravitz evaluated the consequences of using sulfate aerosols to manage solar radiation and concluded that they might reduce summer rainfall in Africa and Asia, thus threatening billions of people's food supplies.

There are other technical issues, too, as Kravitz explained to THE FUTURIST. First, the sun's radiation rises and falls over time, so any clouds created for radiation management would have to be adjusted continually.

"This involves changing the amount of aerosols you make, which—assuming everything works as it's supposed to—would not be particularly hard to do. The most effective climate modification ideas will be adjustable and reversible in a certain time frame," he says.

A more serious problem, according to Kravitz, is knowing when and how to stop these sun-dimming measures. If engineers cease it too quickly, the rebounding sunlight would shock Earth's whole climate system.

"If you stop solar radiation management abruptly, the climate will rebound according to greenhouse gas concentration. Since adaptation to climate change depends upon how long you have to adapt, this rapid change would be disastrous," he says.

Adapting to climate change includes reducing the emissions of climate-changing pollutants, Kravitz adds. But achieving this could actually be more difficult in a solar radiation-managed world: As Kravitz notes, less sunlight tends to mean less solar energy.

"If we decide to switch to a greener economy and vastly increase the portion of our energy that comes from solar power, solar radiation management could have a huge impact," says Kravitz, adding that, if solar generators no longer produce as much electricity, people might try to fill the energy void by burning more coal, oil, and natural gas. "If we're generating less energy from one source, we have to compensate for it from a different source, and that's likely fossil fuels."

According to Kravitz, that could defeat solar radiation management's whole purpose. To cool Earth's climate and keep it cool, the world needs to let atmospheric greenhouse gases dissipate and not replace them by continuing to emit them in large quantities. Otherwise, solar radiation management's benefits, if any, will not last.

"The only permanent solution is to stop putting CO_2 into the atmosphere," says Kravitz. *—Rick Docksai*

Sources: Peter Braesicke, National Centre for Atmospheric Science, Cambridge University, www.atm.ch.cam.ac.uk/.

Ben Kravitz, Rutgers University, http://envsci.rutgers.edu/~benkravitz/.

Personal Futures

Predicting Our Own Happiness

Why we're usually wrong about how we'll feel in the future.

Will acing an exam truly make you happy? Will the snub of a cute co-worker send you into throes of despair? Maybe not. New research shows that people routinely discount their own personality biases when they envision how happy or sad they will be as a result of changing external circumstances.

Individuals who are naturally pessimistic imagine that they will be far more euphoric as a result of big life events than usually turns out to be the case. Folks who are usually in a great mood underestimate how much happier particular events will make them (which must make for a pleasant surprise later on).

The new study comes from psychological researchers Jordi Quoidbach of the University of Liege, Belgium, and Elizabeth Dunn of the University of British Columbia. To test their hypothesis that both pessimists and optimists tend to incorrectly predict their future happiness, they surveyed a group of college students to determine their base-level personality (from "optimistic" to "neurotic"). The subjects were then asked to imagine how they would feel, on a scale from one to five, if they received a certain grade in a class.

Six weeks later, when grades actually came out, the researchers surveyed the subjects again. They found a wide gap between how the students expected to feel and how they actually felt. But Quoidbach and Dunn did find a close correlation between how the subjects felt earlier and how they felt when they received their grades.

"Results supported our hypothesis that dispositions would shape participants' actual feelings but would be largely neglected when people made affective forecasts," they write.

In a second test, participants (Belgian adults) were asked to describe how happy they would be in the event that Barack Obama won the 2008 U.S. presidential election. After the election was called, the researchers again found that the participants' actual level of happiness reflected how happy they were when they were asked the question, not how happy they expected to be later.

Why are people so bad at predicting their future happiness levels? The problem may be in the brain. Previous studies have shown that the part of the brain responsible for envisioning future states is the same part tasked with remembering situations we've already experienced, the episodic memory center. Neurologically, the

"Why are people so bad at predicting their future happiness levels? The problem may be in the brain."

act of imaging a scenario is a lot like the act of remembering. But we process thoughts and ideas about our own personalities in a different part of the brain, the semantic memory center, which is tasked with learning and analyzing abstract concepts but not remembering specific events.

"For example, an amnesic patient was able to rate his personality in a highly reliable and consistent manner even though he was unable to recollect a single thing he had ever done," write the researchers. When we envision the future, we use the part of the brain we use to remember the past, not the part that knows our personality the best. This is why our personal-happiness forecasts are so often off the mark.

"Individuals high in dispositional happiness who are planning their next vacation might not need to waste money and effort finding the perfect location (because they will be happy in the end anyway)."

Jordi Quoidbach and Elizabeth Dunn

Quoidbach and Dunn's research provides further support for Hedonic Adaptation, a 40-year-old theory that says that most people have a baseline level of happiness, whether or not they're aware of it. So while we may experience blips of joy when we rush out to make a big consumer purchase, or bouts of melancholy when we suffer a setback, eventually we return to a default emotional setting.

Quoidbach and Dunn hope their research will help people take their personality into account when making big decisions or forming expectations. "For example, individuals high in dispositional happiness who are planning their next vacation might not need to waste money and effort finding the perfect location (because they will be happy in the end anyway). By contrast, people with less happy dispositions might be more prone to regret the slightest annoyance, so carefully planning every detail of the trip might be the best strategy for their future well-being," they write.

In other words, if you want to know how a big event will make you feel in the future, consider how you feel right now and you'll have your answer.

—Patrick Tucker

Source: "Personality Neglect: The Unforeseen Impact of Personal Dispositions on Emotional Life" by Jordi Quoidbach and Elizabeth W. Dunn, *Psychological Science* (December 2010), www.psychologicalscience.org.

Computing

Computers Making the Quantum Leap

One branch of physics holds huge implications for information technologies.

Quantum computational devices with calculating power greater than any of today's conventional computers could be just a decade away, says Bristol University physicist and electrical engineer Mark Thompson. He anticipates accelerated research and development breakthroughs in many fields of science, thanks to quantum computing.

At a January 2011 Cambridge University forum, Thompson presented two Bristol-developed quantum photonic computer chips, which process photons (particles of light). One chip used a quantum algorithm to find the prime factors of 15. Thompson says that factoring numbers is hard for conventional computers but would be relatively easy for quantum computers.

With further development, quantum processing could create powerful simulation tools for modeling many natural processes, such as superconductivity and photosynthesis. Quantum computers might also model molecular and subatomic systems with greater precision than today's computers can.

"We plan to perform calculations that are exponentially more complex, and will pave the way to quantum computers that will help us understand the most complex scientific problems," says Thompson.

A conventional computer stores information in bits, each bit either a 0 or 1. A quantum computer would store information in "qubits," and each qubit could be both 1 and 0 at the same time. David Lee Hayes, a researcher at the University of Maryland's Joint Quantum Institute, explains that a particle in a quantum state is in "superposition": It can be in more than one place at the same time. It assumes one location, however, once someone observes it.

"You can think of the observer as getting

entangled with the quantum bit in a weird way," says Hayes.

Entanglement, another property of quantum particles, means that one quantum particle links telepathically to another particle far away. The second particle then exactly imitates all its partner's properties.

Since qubits can hold more than one location at once, a quantum computer could compute many more problems at once, according to Carl Williams, chief of the Atomic Physics Division at the U.S. National Institute of Standards and Technology.

Such a computer would be a powerful tool for pharmaceutical developers, says Williams. Drug researchers now use conventional computers to model the human body's chemical systems and project how certain chemical compounds might interact with it. The models guide the researchers' synthesis of experimental new drugs.

The modeling processes involve millions of calculations. A quantum computer might complete the same calculations much more quickly and speed up drug development.

"Our time scale for developing new drugs would become cheaper and faster," says Williams. "Researchers would only have to synthesize those things that are going to work."

The quest to build a quantum computer is becoming a race, according to Martin Rotteler, head of the quantum computing research group at NEC Laboratories. He says that NEC has built a quantum computing device that has two qubits of memory, but other labs have built devices with three qubits of memory, and someone may build a four- or five-qubit device in another three to five years.

Rotteler says that quantum computers would be optimum for working on problems in which there is a lot of structure, such as a graph. They could also map magnetic fields, protein folding, and other natural systems down to magnitudes of detail that are impossible today.

Building a quantum computer will require more efficient ways of controlling quantum phenomena, according to Williams. Quantum particles can easily entangle with particles they are not supposed to entangle with, or interact with each other in ways that the researchers do not intend.

Also, creating qubits and photons requires massive system components. But just as the first conventional computers filled entire rooms and were later replaced by progressively more-compact successors, quantum computing could evolve into smaller and cheaper systems.

"Build the first one," says Williams, "and in 25 years, they will be 25% of the size. I bet that, after the first quantum computer, the cost of one 10 years later will be significantly reduced." —*Rick Docksai*

Sources: David Lee Hayes, University of Maryland Joint Quantum Institute, http://jqi.umd.edu.
Martin Rotteler, NEC Labs, www.nec-labs.com.
Mark Thompson, Bristol University, www.bris.ac.uk.
Carl Williams, NIST, www.nist.gov.

"Our time scale for developing new drugs would become cheaper and faster. Researchers would only have to synthesize those things that are going to work."
Carl Williams, NIST

Indicators

Envisioning a Global Economic Dashboard

Economic futurist Hazel Henderson offers alternative measures.

A growing number of economists and policy makers argue that statistics such as gross domestic product (GDP) and gross national product (GNP) may be useful as snapshots of a nation's total economic activity, but they are limited in scope. Critics advocate for a new metric that calculates the overall standard of living in a country by factoring in environmental and public health, social welfare, infrastructure, and other quality-of-life factors.

While there has been much talk around the issue, little reform has actually occurred at the national level, says economist and futurist Hazel Henderson. The United Nations' Human Development Index, which includes education, health, and income, is perhaps the best-known and most widely cited alternative.

"The good news is that we no longer need to have macroeconomists control the GDP model."
Hazel Henderson, Ethical Markets Media

VERONICA MARTINSON

Futurist and alternative economist Hazel Henderson of Ethical Markets Media says that a majority of people support expanding GDP to incorporate long-term quality-of-life indicators as well as financial data.

Henderson, author of *Ethical Markets: Growing the Green Economy* (Chelsea Green, 2006) and president of Ethical Markets Media, tells THE FUTURIST that a revamping of GDP hasn't happened for a number of reasons. Chief among them is the potential drawback that factoring in social and environmental costs "would lower the apparent performance, both of companies and of a country," she says.

Nonetheless, a majority of people around the world agree that a new model is needed, according to Ethical Markets' research.

"Health, social, and environmental statistics are as important as economic data, and the governments should also use those to measure national progress," according to more than two-thirds of the approximately 12,000 individuals in a dozen countries surveyed in 2010 by Ethical Markets Media and the international polling firm GlobeScan. Less than a quarter of respondents identified most strongly with the second statement—that national progress is best gauged by "money-based economic statistics" such as GDP and GNP.

These findings update the initial GlobeScan–Ethical Markets public opinion survey, which was undertaken at the behest of the European Commission as part of the 2007 Beyond GDP conference. (The follow-up survey was conducted independently, Henderson says.)

However, in some countries, support for the traditional GDP/GNP methodology has risen slightly during the three-year interim. These include the United States and several European countries. Furthermore, people in emerging economies such as Kenya were less likely overall to side with GDP reform than those in developed countries. Henderson believes that this may be due to financial concerns brought about by the recession—and overall financial well-being in general. The executive summary of the report notes: "The stronger support in developed countries for this expanded measure suggests that, once a level of material well-being has been attained, many people feel that it is critical to take other measures of life quality and sustainability into account, and that these are a valid way of expressing national progress."

Henderson emphasizes that significant numbers in all 12 countries included in the survey expressed interest in reforming traditional economic metrics to incorporate long-term quality-of-life indicators. She hopes that the survey contributes to a growing awareness of GDP's limitations in terms of depicting a country's overall quality of life. Purely economic statistics neglect countries' genuine wealth, she says: "Well-educated workforces, efficient infrastructure, and productive ecosystems and resources ... all [are] ignored and missing from GDP.

"The good news is that we no longer need to have macroeconomists control the GDP model," she continues. "We can now use the Internet and Web sites to unbundle these indicators (as we do at Calvert-Henderson.com) and display these 12 indicators of quality of life on a 'dashboard.' This is the new approach and it simply bypasses the current formulations of GDP and makes them politically transparent and available to all who are interested."

Another Ethical Markets project is the Green Transition Scoreboard, which tracks private investment in green businesses around the world. The latest Scoreboard reveals a growing economic emphasis on environmental sustainability. It also shows that interest and speculation continue to rise. By mid-2010, total private investment in the so-called "green economy" had surpassed $1.6 trillion, which represents an increase of approximately $400 million since the end of 2009. Henderson projects that there could soon be a cumulative $1 trillion annual investment in green businesses.

—Aaron M. Cohen

Sources: Hazel Henderson (interview), Ethical Markets Media, www.EthicalMarkets.com.

Beyond GDP International Initiative, www.beyond-gdp.eu.

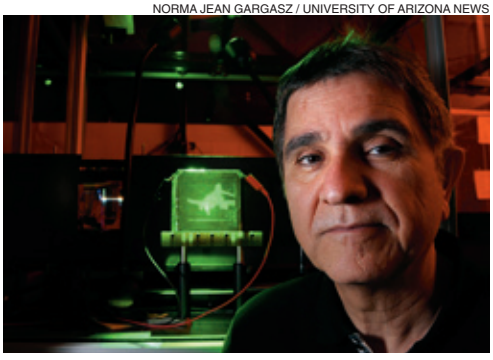
Technology

Holographic Videoconferencing

The next breakthrough in digital communications may be 3-D and 360.

Nasser Peyghambarian, University of Arizona professor of optical sciences, poses with the 3-D telepresence system developed by the Engineering Research Center for Integrated Access Networks.

NORMA JEAN GARGASZ / UNIVERSITY OF ARIZONA NEWS



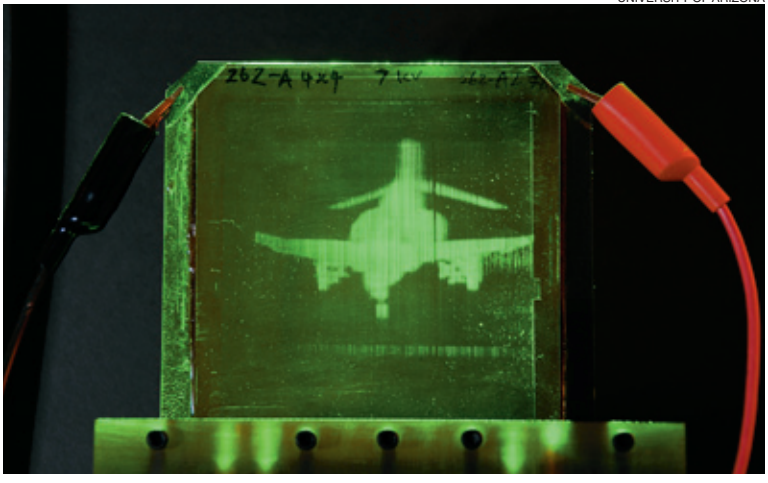
Imagine having a long-distance conversation with a colleague who, to your eyes and ears, appears to be right in front you. Now, 3-D telepresence has moved closer to reality, thanks to research by the University of Arizona and supported by the National Science Foundation.

The system they are working on features a holographic video display that refreshes every two seconds. That two-second refresh rate represents a huge step up from where the technology was a couple of years ago, when the display refreshed once every four minutes.

A three-dimensional image of a moving person or object, with 360-degree viewing capability, projected from afar in something approximating real time, could represent a major breakthrough in communications technology. Unlike depictions of holograms in popular science-fiction movies, however, the images are not projected into empty space but onto a transparent sheet of plastic—a key part of the process.

An image of an F-4 Phantom fighter jet, created with the 3-D telepresence system, appears on a photorefractive polymer.

UNIVERSITY OF ARIZONA



"The heart of the system is a new plastic material that we have come up with which we call … a photorefractive polymer," says Nasser Peyghambarian, project leader and chair of photonics and lasers at the University of Arizona. Peyghambarian is also the director of the National Science Foundation's Engineering Research Center for Integrated Access Networks.

As new images are "written" on the polymer screens, old ones are erased. The material is also able to store the projected images, and, unlike face-to-face conversations, there is a pause button. Viewers can circle the projection and view it practically in its entirety, which results in a more realistic simulation.

The process begins with 16 computer-controlled cameras arranged in a semicircle around the person or object, taking two-dimensional pictures from different angles simultaneously. "The 16 views are processed into hogel data by the host computer and sent to the holographic recording controller through an Ethernet link," Peyghambarian explains. Hogel is a nickname for holographic pixel; hogels are the 3-D version of pixels.

When the recording has been sent, a pulsed laser inscribes the images into the polymer screen. "Once a hologram has been written, the system uses the next available hogels to update the information. The hologram is displayed using a color LED that gets scattered off the image to the viewer's eyes," Peyghambarian adds. This optical effect renders the 3-D image perceptible to the naked eye, no special glasses required.

The designers' main goal is to achieve full-motion video rate—30 frames per second. They point out that other improvements need to be made as well before commercializing the technology. For instance, the color palette is very limited right now (although it is worth noting that adding color into the process doesn't slow down the refresh rate at all). Size also presents a challenge—the maximum projection size is currently 17 inches, but the design goal is

to increase that to encompass at least the average size of a person. The resolution of the projection and sensitivity of the materials need improvement as well, and the research team is working on ensuring that the optics can competently handle indoor low-light settings.

Many other important uses for the technology exist besides holding long-distance business meetings, say the researchers. These uses include digital design and engineering, and telemedicine for complex surgical procedures. Such a telepresence system would also improve 3-D printing capabilities, better enable 3-D mapping, and enhance entertainment experiences.

Affordable large-scale holographic projections may still be a long way off; however, they are moving closer to becoming a reality. *—Aaron M. Cohen*

Sources: The National Science Foundation, www.nsf.gov. Nasser Peyghambarian, University of Arizona (e-mail interview). ❑