[MARVIN CETRON, PH.D.]

ADVANCES IN TECHNOLOGY

2010 to 2040 and Beyond

What does technology have in store for us? When can we look forward to giving automated tours in self-driving cars or booking the first trips to a hotel in orbit? And how will all this change the hospitality industry and our lives?

In 1970, futurist Alvin Toffler pointed out in his best-selling book, *Future Shock*, that technology had accelerated the pace of change so much that people were beginning to lose their moorings. The old, familiar world in which they had grown up was vanishing so quickly that they no longer knew where they stood. The result was a pervasive insecurity that could only get worse as the transformation gained still greater speed.

In 1970 the insights in Toffler's book appear to have been well ahead of their time. The personal computer, which would prove to be the greatest single force for change since the Industrial Revolution, had yet to be invented. Genetic engineering was barely a fantasy. And it would be nearly 1980 before anyone remembered that in 1959 physicist Richard Feynman had suggested that there might be big opportunities in the incredibly small. It would be longer still before nanotechnology delivered its first products. In 1970, technology still had a lot of accelerating to do. Chances are that it still does.

The hospitality industry has seen the results of this change. Small computers have streamlined business processes from accounting to guest relations. The Internet has created an entire industry segment in online hospitality and travel marketing. RFID (radio-frequency identification) chips are beginning to cut the cost of inventory management for hotels, cruise lines, restaurants, and any other market with physical goods to manage. This is likely to be just the beginning.

THE PRODUCT CYCLE

Look at the product cycle. The useful life of a product goes through four stages:

- Idea is the theoretical breakthrough that earns a Nobel prize;
- Invention delivers a patentable prototype;
- Innovation gives us the first consumer product;
- Imitation sees cheap competitors flooding the discount stores.

Early in the 20th century, the product cycle was 40 years; the powerful new explosives used in World War I were based on discoveries made by theoretical chemists in the 1870s and '80s. By World War II, the cycle had begun to shrink, all the way down to 30 years. Today, for most consumer products it is about six months. In computers and cutting-edge electronics, it is more like six weeks. Bring out a really hot product, and it is likely to be reverse-engineered, manufactured in China, and available on e-Bay in two weeks or less!

TIMELINE OF THE FUTURE

The timeline presented here was first developed by British Telecommunications in 1991. It has been updated every two or three years under the leadership of consulting futurist Ian Pearson, of Futurizon GMBH, in Ipswich, UK. The most recent version, developed with Ian Neild, appears on Pearson's Web site at http://www.btinternet.com/~ian.pearson/web/future/2005timeline.doc. A new edition reportedly should be available shortly.

Since the 2005 timeline appeared, some innovations on that list have already come to pass, while others appear to have been made obsolete by even more promising new technologies. For this article Forecasting International has deleted any obsolete entries while adding a few new ones.

In choosing target dates for the timeline, Pearson and Neild appear usually to have chosen to cite a date of "first practical use," rather than focusing either on the original invention or on widespread dissemination of the technology. In this edition, we have departed slightly from that policy. Most dates assume that the item will be readily available, but not yet a commodity item. Consumer products will be found at specialty stores and perhaps high-end department stores, but not yet at Wal-Mart. A new airliner might be seen on a few high-profit routes, but fleets will be some years short of full.

A good example of this is the use of artificial precipitation induction and control, slated to appear in 2025. If we were tracking only new inventions, this item would not even be on the list. Some early research was able to trigger rain quite successfully more than 20 years ago. However, the experiments were on a small scale, and they were limited to a very narrow range of conditions. The technology never made it into practical use. The forecast assumes that by 2025 artificial precipitation induction will at least occasionally be used to bring rain where nature has not, most likely to save parched crops.

Not all the innovations on this list were chosen for their specific significance. Instead, many represent a general kind of change. As a small example, people may not really be decorating their living rooms with virtual-reality scenes in 2015. That is as much a matter of taste as it is of technology. Yet, technology is certain to bring new decorating options over the next few years, and some form of virtual reality is likely to be among them.

We really are dealing here with opportunities, and with their impact on our industry and lives, rather than with any particular toys. "What must be remembered by anyone preparing for the future is that technology change isn't very important in itself," says Ian Pearson. "What matters is what this change enables or destroys."

82909982/DON FARRALL/GETTY IMAGES

RESULTS

In most cases, our panel members agreed fairly well about when new technologies could be expected. In many, all six participants chose the same date. However, in a few there was a wide spread among the target dates. To some extent, this may reflect the differences between scientists and engineers. One group deals with proof of concept, the other with practical use, and their forecasts are likely to vary accordingly.

Where due dates were spread, we generally took the median date. If we at Forecasting International felt especially strongly about the

2010-2014

Artificial Intelligence and Life

Behavior alarms based on human mistake recognition **2010**
Software is trained rather than written **2010**
Artificial nervous system for autonomous robots **2010**
AI chatbots indistinguishable from people **2014**

Biotechnology: Health and Medicine

Retinal implants linked to external video cameras **2010**
Designer babies **2012**
All patients tagged in hospitals **2010**

Business and Education

80% of US homes have PCs **2010**
Virtual reality used to teach science, art, history, etc. **2012**
All government services delivered electronically **2014**
3-D video conferencing **2014**

Computing Power

Petaflop computer **2011**
Optical neurocomputers **2012**
DNA computer **2014**
Supercomputer as fast as human brain (20 petaflops) **2014**

Environment and Resources

Sensors widely used in countryside to monitor environment **2010**
Commercial magma power stations **2011**
Clothes collect and store solar power **2012**
Multilayer solar cells with efficiency >50% **2012**
Systems based on biochemical storage of solar energy **2012**
Effective prediction of most natural disasters **2014**

Home and Leisure

Fiber-optic plants used in gardens **2010**
Chips in packaging control cooking **2011**
Smart paint containing computer chips is available **2013**

Hospitality, Travel, and Transportation

Resort-based simulators provide realistic experience of space travel **2014**

Machine-Human Interface

Voice interface for home appliances **2010**
Voice synthesis quality up to human standard **2010**
Voice control of many household objects **2010**
Computer screens in clothes **2010**
Tactile sensors comparable to human sensation **2012**
Computers linked to biological sensory organs **2012**

Robotics **2010**

Security, Law, War

First Net war fought between cybercommunities **2011**
People's courts on Internet for minor disputes **2012**
Logic checkers highlight contradictory evidence **2012**
VR routinely used in courtrooms for evidence presentation **2013**
ID cards replaced by biometric scanning **2014**

Space

Next generation space telescope is launched **2010**
Near-Earth space tours (suborbital) **2012**

Wearable and Personal Technology

Cameras built into glasses that record what we see enter wide use **2009**
Polymer video screens built into clothes **2009**
Portable translation device for simple conversation available on consumer market **2010**

2015-2019

Artificial Intelligence and Life

25% of TV celebrities are synthetic **2015**

Biotechnology: Health and Medicine

Artificial heart (lab-cultured or entirely synthetic) **2015**
Some implants seen as status symbols **2017**
Shower body scan **2017**
Artificial lungs, kidneys **2017**

Computing Power

Quantum computer **2015**
AI technology imitates thinking processes of the brain **2018**

Environment and Resources

Insect-like robots used for crop pollination **2015**
Carbon dioxide fixation technologies for environmental protection **2015**
Synthetic, non-petroleum aviation fuel (JP-8) **2018**
Wave energy provides up to 50% of UK requirements **2018**

Home and Leisure

Bore filter screens dullards out of digital communications **2015**
Holographic windows redirect sunlight **2015**
Living rooms decorated with virtual-reality scenes **2015**

Hospitality, Travel, and Transportation

Cruises by icebreaker through the Northwest Passage **2015**
Assisted lane-keeping systems used for trucks and buses **2016**
Hybrid cars plug into hotel garage, sell excess power for reduced room rate **2017**
Reservations required to use some key roads **2018**
Underwater theme park opens in Dubai **2019**

Machine-Human Interface

Global sensor grid **2018**

Robotics

Self-diagnostic, self-repairing robots **2015**
Houses built by robots **2015**
Self-monitoring infrastructures use smart materials, sensors **2015**
Robots for almost any job in homes or hospitals **2015**
VR becomes popular entertainment in nursing homes **2016**
Holographic TV **2018**

Security, Law, War

Electromagnetic communications disrupted **2015**

Space

Space tugs take satellites into high orbits **2015**
Orbital space tours **2019**

Wearable and Personal Technology

Spectacles that translate signs, labels **2015**

2020-2024

Artificial Intelligence and Life

Machine knowledge exceeds human knowledge	2020
Electronic life form given basic rights	2020
Artificial insects and small animals with artificial brains	2020

Biotechnology: Health and Medicine

Artificial liver	2020
Nanobots in toothpaste attack plaque	2020
Fully functioning artificial eyes	2020
Artificial peripheral nerves	2020

Business and Education

Learning superseded by transparent interface to smart computers	2020

Computing Power

Library of Congress contents available in sugar-cube-sized device	2020
Desktop computer as fast as human brain	2021

Home and Leisure

Experience-recording technology developed	2023

Hospitality, Travel, and Transportation

Airplanes 75% more fuel-efficient	2020
Ice theme parks in the Antarctic	2021
Driverless truck convoys using electronic towbar	2022

Machine-Human Interface

Thought recognition becomes everyday input means	2020
First Bionic Olympics	2020

Robotics

Realistic nanotech toy soldiers are built	2020

Space

Antimatter production and storage becomes feasible	2020
First real—i.e., non-reconstituted—food cooked in space	2020

Wearable and Personal Technology

Computer-enhanced dreaming	2020

2025-2029

Artificial Intelligence and Life

Living genetically engineered electronic toy/pet developed	2025

Biotechnology: Health and Medicine

Only 15% of deaths worldwide due to infectious diseases	2025

Business and Education

Molecular manufacturing	2025
Individual education program	2025

Environment and Resources

Artificial precipitation induction and control	2025

Home and Leisure

Sports league begins competition in space	2027

Hospitality, Travel, and Transportation

Tele-travel	2025
Space hotel accommodates 350 guests	2025
FAA approves autonomous drone airliners	2026
Hydrogen-fueled executive jets (cryoplanes)	2028

Machine-Human Interface

Full direct brain link	2025

Robotics

Robots surpass developed world population, including manufacturing robots, military swarms	2025

Security, Law, War

Emotion control chips used to control criminals	2025

Space

First orbital hospital opens	2027

2030-2039

Artificial Intelligence and Life

Robots are physically and mentally superior to humans	2032

Biotechnology: Health and Medicine

Artificial brain	2030

Computing Power

10^8 improvement in computing power through nano/atomic computers	2030

Environment and Resources

Renewable energy replaces fossil carbon	2030

Robotics

Robots replace humans in workforce completely	2035

Space

Orbital factories for commercial production	2035
Automated factory refines lunar metals, stockpiled for use by future settlers	2037

Wearable and Personal Technology

Dream-linked technology built for nighttime networking and beyond	2035

2040 and Beyond

Hospitality, Travel, and Transportation

Tele-everything replaces most physical travel	2040
Tours begin on the moon	2042

Security, Law, War

Asteroid diversion technology used as weapon	2040

Space

Moon base size of small village built	2040
First manned mission to Mars	2040
Start of construction of manned Mars laboratory	2048
Space solar power stations, built by Dubai, begin operation	2050
Regular manned missions to Mars	2050
Use of human hibernation in space travel	2052

issue, we may have had our thumbs on the scale when making the final decision. It did not happen often.

In some cases, this process led to odd results. A number of developments in space had widely varied target estimates, from 2030 to 2080—a full half-century. Yet, when we looked at the median dates, they all fell into a 12-year period beginning in 2040.

So far, so good. Yet, the event distribution wound up strangely compressed. The timeline says that in 2040 humanity will both construct a sizable base on the moon and launch the first manned mission to Mars. That seems a lot to take on in a single year. Similarly, construction of the first laboratory on Mars is set to begin in 2048, with regular flights to Mars beginning two years later. Again, that seems awfully quick work.

No matter. The data are all we have to work with. In such cases, we have simply reported the results and left conflict resolution to our grandchildren.

Forecasting International's update of the 2005 timeline has been assembled from the work of six contributors. Our panelists were:

- Dennis Bushnell, chief scientist at the NASA Langley Research Center and one of the smartest technology forecasters we know;
- Ian Pearson, the forecaster most familiar with this timeline;
- Prof. William Halal, of George Washington University, whose company, TechCast LLC, periodically devises a similar timeline;
- Dr. Frederick J. DeMicco, Professor & ARAMARK Chair of HRIM Global Strategy & Development and Conti Distinguished Professor at the Pennsylvania State University's School of Hotel, Restaurant and Recreation Management;
- A senior R&D expert at the Department of Defense, who chose to remain anonymous;
- And of course the staff of Forecasting International.

ADOPTING TECHNOLOGICAL INNOVATION

Often, when a technology reaches practical use depends less on any technical obstacles than it does on external factors. To be adopted, an innovation must be technically feasible, economically feasible, and both socially and politically acceptable.

The space program is one obvious example. The United States went to the moon in less than ten years. Then other matters took precedence, and the country retreated to near-Earth orbit. Human activities there have found it more difficult to inspire political support, and therefore to obtain funding.

We are in a similar position today. The space-related events on our timeline all come from a future in which putting human beings into space remains a priority. However, that is not guaranteed. At the dawn of the Mercury program, automated probes were not nearly capable enough to carry out most research, and space pioneers were driven by a vision of humanity moving out among the stars. Today, neither is true, and there is a substantial possibility that future administrations in Washington will downgrade manned spaceflight in favor of automated probes. In that case, the events on our timeline will be replaced by safer, if less stirring activities, and the dates will need significant adjustment.

In some cases, the fate of a technical innovation can be decided by a very small group of managers. When I worked for the Navy Department, my admiral once asked when the metal we needed to make deep-diving submarines would reach the market. My answer was, "Never. Not until you order it." Making that kind of specialty steel or titanium was technically feasible. It would not be economically feasible until the manufacturers knew they had a market for it. Predicting that something will occur if we fund it is called a self-fulfilling forecast.

Executive jets may be an even better example. Against the common wisdom, Bill Lear chose to build a bizjet, and he made it happen. Many technical innovations and an entire industry followed from that individual commitment.

In other cases, the decision must be reached by a much broader consensus. For example, solar power satellites were first conceived by Dr. Peter Glaser, of the Massachusetts Institute of Technology, in 1968. At the time, he estimated that the first satellite could be transmitting pollution-free power back to Earth within 30 years after the commitment was made to build it. In this, we believe he was correct.

It would still take 30 years to build the first solar power satellite. It's a big job. Yet, most of the necessary technologies have been available all along, and they would produce electricity at a price that looks reasonable compared with many of the alternatives. Only the political will is missing. We do not expect it to appear in the near future.

Many important problems fall into this category. Technically, we could end America's addiction to foreign oil. If Republicans and Democrats worked together, the country could be energy-independent within ten years. This would not take the equivalent of the Manhattan Project, pulling out every stop. Instead, it would require a dedicated, systematic effort, adequately funded, much like the Apollo project that took astronauts to the moon. We even have a working model in Europe, which is much further along in this process than the U.S.

A similar effort could bring greenhouse gas emissions under control to curb global warming. Solving these problems is technically feasible, but it would require the social consensus and political will to fund a long-term development program. Thus far, it does not exist.

The accompanying timeline should be considered in light of some work Forecasting International did with the Navy Department. Over a period of some 15 years ending in the mid-1960s, we made a continuing study of forecast outcomes. We wanted to know how accurate our predictions turned out to have been. The results were interesting. Whenever we predicted that something would occur within about 2.5 years, we had to double the estimate. Engineering and production problems almost always made getting an invention into use a lot slower than we expected. But forecasts 15 years or more ahead had to be cut in half! New discoveries, the benefits of collaboration, and other unexpected forces usually intervened to speed things along. On that basis, most developments on the timeline could arrive sooner than the consensus date, and perhaps much sooner.

We do not recommend trying to plan the future of, say, a major hotel chain beyond the singularity. Personally, we will take things as they come. Until then, however, business and life both require management that is becoming ever more difficult in a time of accelerating change. We hope that this timeline will help to make the future just a bit less shocking and bring it a bit more under control. ■