WHEN TECHNOLOGY HITS A WALL

THE PROBLEM
Technologies from batteries to weather forecasting stop improving at some point.

WHY IT MATTERS
The costs and frustrations to businesses and people are enormous.

THE SOLUTION
AI may be able to help, if it doesn't hit a tech wall.

Why haven't battery power, aircraft speed, or weather forecasting improved more? And what is the toll on the business world and people's blood pressure?

BY PETER LAURIA

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What was supposed to be a dream vacation was turning into a nightmare. The electric vehicle had nearly lost its charge on the way to the airport, then the flight was delayed by a fast-moving storm that materialized without warning. Unless the plane suddenly became capable of supersonic speeds, the delay was going to cost the vacationers a day of their trip.

In ways maybe not quite as dramatic, we've all dealt with similar frustrations: a battery that doesn't last, an unexpected weather event that isn't in anyone's forecast, or travel that doesn't move at our preferred pace. “Everyone would love to have a faster plane,” says Babak Parviz, a distinguished scientist and engineer who has led major AI efforts in eyewear, surgery, aeronautics, and other areas. So, too, would people love a longer-lasting battery and an accurate forecast.

The problem, however, is that for these and other technologies, the period of exponential growth in innovation appears to have plateaued. Instead of massive breakthroughs, advances now tend to be measured in tiny steps. Or, as Bryan Ackermann, head of AI strategy and transformation at Korn Ferry, puts it, “There are constraints in all of these areas that need to be worked through before the next plateau can be reached.”

For the business world, the constraints go far beyond planes that can’t go faster or laptops dying in the middle of a Zoom call. The cost of global economic losses from natural disasters—which weather forecasters often can’t warn about in time—were estimated at just under $225 billion last year. Meanwhile, according to the Federal Aviation Administration, delays caused by planes flying at slower speeds to manage fuel or air-traffic congestion cost the airline industry $24 billion annually. As for those frustrating battery failures, studies show they’re costing workers up to 50 minutes of productivity per shift, or the equivalent of $1 million in lost profit for a midsize company.

All of these plateaus matter as we face the advancement of AI, a once-in-a-generation technology. Will it hit a knowledge wall someday, and if so, what will that cost? Before that happens, though, AI may offer a glimmer of hope—and find the critical breakthrough other technologies are facing. It could, for example, help meteorologists detect natural disasters sooner, or uncover new fuel sources to make air travel faster. “AI gives researchers a new way that we never had before to solve these problems,” says Parviz. Here’s where things stand with today’s tech bottlenecks.

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01 BATTERY LIFE

THE PLATEAU: Battery life tops out at around 20 hours, depending on usage.

LENGTH OF PLATEAU: Incremental gains of 3 percent to 5 percent for about a decade.

WHAT NEEDS TO CHANGE: New materials that create greater energy density at lower costs.

The evolution of the lithium-ion battery serves as a perfect analogy for the challenge of extending battery life. Lithium-ion technology was first developed for use in batteries in the 1970s but wasn’t commercialized until 20 years later. From there, innovation happened rapidly, with the optimization of the technology for smartphones, drones, electric vehicles, and pretty much every other smart device. “The first wave of lithium-ion development produced massive advances in energy density, rechargeability, and cost reduction,” says Shirley Meng, a professor of molecular engineering at the University of Chicago and director of the Energy Storage Research Alliance.

To be sure, lithium-ion batteries got lighter, smaller, and more powerful in parallel. Today’s smartphone batteries can last 20 hours or more, depending on usage, versus just five hours in the 1990s.

But the pace of improvement hasn’t kept up with society’s voracious computing needs. The smaller devices get, and the more computing power they require to run AI and other applications, the more difficult it is to engineer enough power to meet demand. “There’s a thermodynamic limit to how much energy batteries can draw,” says Meng.

It’s not that researchers aren’t trying; indeed, extending battery life is one of the most studied topics in modern engineering. Third Derivative, a subsidiary of global-energy-transition nonprofit Rocky Mountain Institute, is currently helping fund more than two dozen start-ups working on the issue, says Chetan Krishna, head of research and diligence at the firm. Alternatives such as sodium-ion, solid-state, and lithium-sulfur batteries show tremendous promise, but moving them out of the laboratory and into the market is still a challenge. “All next-generation chemistries have one issue or another to overcome,” says Krishna.

Lithium-sulfur batteries can store much more energy than lithium-ion batteries, for instance, but they degrade much faster (within about 300 to 500 cycles, versus more than 1,000). Solid-state batteries are prohibitively expensive, costing about five to

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10 times as much to manufacture as lithium-ion batteries, and they are harder to configure to fit into devices.

AI comes into play by helping researchers identify new chemistries, accelerate lab testing, and improve manufacturing processes to lower costs for scaling and commercialization. The hope is that AI can not only assist in making the next breakthrough, but also in getting current ones to market faster. “We’re not at the physical limit with batteries yet,” says Krishna. “We’re one breakthrough away from taking the dominant tech for batteries to the next level.”

02 WEATHER FORECASTING

THE PLATEAU:
Ten-day forecasts are still only 50 percent accurate.

LENGTH OF PLATEAU:
Over 20 years.

WHAT NEEDS TO CHANGE:
Better data and AI models to run more simulations and forecast outcomes.

The meteorologist was gesticulating wildly in front of a weather map, where Doppler radar showed a massive snowstorm would hit the city the next morning. He urged viewers not to pay attention to their weather apps, which at the time showed just a 30 percent chance of snow. Instead, he put the chances at more than 80 percent, even predicting the storm's exact time of arrival. Of course, neither he nor the app was right—no snow fell at all.

To the chagrin of anyone who has ever cancelled plans or hoped for a day off from school, inaccurate weather forecasts still happen with stunning regularity. "Meteorologists use a lot of different models to make their forecasts," says Tom Weber, author of *Cloud Warriors: Deadly Storms, Climate Chaos—and the Pioneers Creating a Revolution in Weather Forecasting*. "But it's not a perfect science."

Data shows that 7-day weather forecasts are still less than 80 percent accurate.

The prediction of weather events and natural disasters isn't perfect, but it is a science, and one that has improved greatly thanks to technology. The deployment of advanced radar and satellite systems in the 1980s and 1990s, along with the emergence of computer models that can mimic atmospheric conditions, have, within the span of a few decades, made once-useless five-day forecasts 90 percent accurate. Short-term hurricane tracking has improved by 50 percent since 2007, and technology has extended tornado-detection times to 20 minutes from just five minutes. "You used to have to wait to see a tornado to know one was coming," says Weber.

At the same time, however, extreme events like flash floods, wildfires, and earthquakes are no more predictable today than they were during the last millennium. That's partly due to the randomness with which they occur, but a bigger factor is how they behave, says Lucy Jones, one of the world's most prominent seismologists and earthquake scientists. "Weather events are predictable because changes in the atmosphere can be measured," she says, "but nothing observable changes before an earthquake happens." To be sure, she adds, despite early-warning systems, high-resolution fault imaging, sensors, and other modeling advances, earthquake prediction is "not much better than random."

As for basic predictions like whether it will be cloudy or sunny a week from now, accuracy decreases the further out the forecast gets. Data shows that seven-day weather forecasts are still less than 80 percent accurate, while 10-day forecasts are essentially a coin flip, averaging 50 percent accuracy. The industry rule of thumb is that weather models gain about a day's worth of accuracy per decade.

The hope is that AI will compress that timeline. AI can run more simulations and identify patterns in bigger datasets better and faster than any human can, allowing meteorologists to run more simulations and explore a wider range of forecast outcomes. But AI is itself constrained by the fact that it's trained on historical data, and with extreme weather events happening not just more frequently but also more randomly than ever, past patterns—if they exist—may no longer be reliable. As Weber puts it: "What if a weather event happens that we've never experienced before?"

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BREAKTHROUGH BOTTLENECKS

In many cases, it isn't technological innovation that's hitting a plateau—rather, it's other factors holding up a breakthrough. Here are five constraints that often stall innovation.

01 FUNDING:
Capital to fund research or extend the development cycle often dries up before innovations are ready to be commercialized.

02 REGULATIONS:
Laws and policies around safety, public impact, and other concerns can slow or block adoption of new tech.

03 PLANNED OBSOLESCENCE:
Designing products with limited lifespans can prevent more durable innovations from coming to market.

04 COMMERCIALIZATION CHALLENGES:
What works in a laboratory sometimes doesn't work in the real world if consumer demand isn't there or the costs are too high.

05 SUPPORTING SYSTEMS:
Adjacent networks and infrastructure (e.g., charging stations for electric vehicles) aren't advanced enough to drive adoption or scale innovation.

03 COMMERCIAL AIRSPEED

THE PLATEAU: Commercial flights can't exceed 600 mph.

LENGTH OF PLATEAU: About 50 years.

WHAT NEEDS TO CHANGE: Economics around fuel and operating costs, along with safety and regulations.

In 1975, a flight between New York and London took between seven and eight hours. Fifty years later, how long does it take? Maybe 30 minutes less.

Planes are still flying at the same speed, up to 600 mph. It's not that they can't go faster: The Concorde, a supersonic jet that began operating in 1976, proved that they can. It's that optimizing speed isn't financially viable for airline carriers—which the Concorde proved as well. Only 14 Concorde planes were produced for commercial use during the 27 years the aircraft was in operation, and the entire fleet made fewer than 100,000 flights.

Massive operating costs, prohibitively high ticket prices—a round-trip flight between New York and London cost about $12,000—and one high-profile crash conspired to make the Concorde commercially untenable. "When it comes to flying, people care about cost and safety even more than they do about speed," says Parviz, the scientist and engineer.

Concorde flights cost so much because they averaged about 16 passenger miles per gallon of fuel, whereas a typical 747 plane averages 50 to 80 passenger miles. Fuel prices, smaller seating capacity, high maintenance expenses, and other factors made the Concorde's operating costs more than 80 percent higher as well.

Over the last half-century, carriers have optimized for cost and safety, rather than speed. This year, global net profit margins across the airline industry are projected at 3.9 percent—firmly in the "razor-thin" category. But some of the world's smartest investors are betting that advances in technology and thermodynamics will eventually make supersonic flights commercially viable. One firm has raised $1 billion from investors and completed a successful civilian test flight, prompting outfits like United Airlines and American Airlines to order new supersonic planes.

And there are other start-ups underway in China, Russia, and elsewhere. And again, as with batteries and weather forecasts, AI is driving much of renewed interest. Parviz says AI is being deployed to help design planes that are more aerodynamic, optimize routes, improve fuel efficiency, and—with the goal of loosening restrictions on flying over land—reduce noise pollution, including sonic booms. "AI can fundamentally change the economics for faster planes," Parviz says. "We're not even midflight with it right now, no pun intended."

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