

Mark P. Mills: The infrastructure of the cloud, which is the biggest infrastructure that humanity has ever built and we're still building out at a torrid pace, whatever measure we want to use for a scale: dollars, miles, reach, connections, nodes... no infrastructure has ever been as big as the cloud.

Jason Lopez: Mark Mills is a senior fellow at the Manhattan Institute and a faculty fellow at Northwestern university's McCormick school of engineering. I'm Jason Lopez. This is tech barometer in examining the cloud mills takes us through sort of a thought experiment.

Mark P. Mills: History doesn't repeat, it rhymes.

Jason Lopez: Suppose you were born in 1870. In 1876, you're six years old. You don't know it yet, but Alexander Graham Bell patents the telephone. Three years later, Edison invents a practical light bulb. 1885, Carl Benz in Germany comes up with a car that has an internal combustion engine. You're 15 years old. Three years later Tesla invents an alternating current motor and transformer. By the time you're 21, in 1891, indoor plumbing -- once the province of the wealthy -- is raising substantially the standard of living. That year the modern toilet is invented. 1895, the Lumiere brothers show the world's first movies to a paying audience. 1901, you're 31, Marconi broadcasts a radio signal across the ocean. 1903, the Wright brothers invent the airplane. 1905, Einstein publishes his theory of relativity. 1908, Ford introduces a groundbreaking affordable car, the model T. 1913 Neil's Bohr publishes the quantum model of the atom. 1918, the number of Bell Telephone customers has risen to 10 million. In 1925, you turn 55. Werner Heisenberg publishes a groundbreaking paper on quantum mechanics. In your lifetime, you witnessed the rise of telephones, electricity, automobiles, cinema, radio, airplanes, among many other amazing innovations. 1927, a global technology consciousness is set in motion by Charles Lindberg's flight from New York to Paris.

Mark P. Mills: So the Lindberg moment, it ignited the imagination of people and they felt excited about the future. But the important thing is they felt excited about the future based on the evidence already before them.

Jason Lopez: Mark Mill's latest book is the Cloud Revolution, How the Convergence of New Technologies Will Unleash the Next Economic Boom and a Roaring 2020s. Just as the incredible innovations of the late 1800s into the early 1900s led to the greatest technological and economic advance the world had ever seen, a similar moment is coalescing now. There's an important feature in this comparison. People around the world went crazy over Lindberg's achievement. A hundred thousand people greeted him in Paris. And when he returned to New York to make an appearance, 4 million people showed up. And yet airplane technology had been around for more than 20 years.

Mark P. Mills: It's pretty cool. When you first have an airplane actually work, you say, well, that's pretty amazing. But after a couple of decades of actual airplanes doing things, you don't have to guess that airplanes can exist. There still waits the moment where people get excited about it.

Jason Lopez: When talking about his book on the cloud, Mills references other authors like Bill Bryson, who wrote One Summer in America, 1927. Bryson wrote that people were enchanted by Lindberg's flight. It seemed like science fiction. An airplane could leave New York and reappear hours later in Paris or Los Angeles as if materializing from thin air. And he notes that

Lindberg's flight brought the world a moment of sublime, spontaneous, unifying joy on a scale never seen before. Charles Lindberg was forevermore the touchstone for that feeling.

Mark P. Mills: The stunt matters. It matters because if it's the right stunt, that is if it resonates in echoing what's true -- not what the stunt people want to believe would be true -- then I think it can be incendiary. So it was true that aviation was about to take off. You could tell and smell it.

Jason Lopez: So the question is, is the cloud our Lindberg moment?

Mark P. Mills: Cloud computing will enable the Lindberg moment, but it isn't the Lindberg moment.

Jason Lopez: Then what could be that moment when technology inspires public euphoria?

Mark P. Mills: What's going on today to use an analogy as a specific to a stunt? I think a lot of people think things like electric cars are the exciting thing of the future. I like them fine but I beg to disagree.

Jason Lopez: We began this podcast with Mills saying no infrastructure humankind has ever built has been as big as the cloud.

Mark P. Mills: Sounds hyperbolic because the data actually... they're hyperbolic. When you describe the scale of what's going on.

Jason Lopez: Mills compares it to the world's supply chain. It's an intermodal system that relies on people, trucks, ships, airplanes, robots, computers, and everything else to get a product from farm fields and factories to businesses, store shelves, and on doorsteps.

Mark P. Mills: The cloud's the same thing. The cloud involves communications networks, fiber old fashioned, copper, and wireless, both high speed wireless of the kind in the cellular networks and high speed point to point, wireless microwave connections, satellite connections involves data centers, edge data centers, hyperscale data centers, buildings. As you know, the size of shopping mall includes devices that people use or that are connected to the machines. That system isn't owned by one company or one person. But these are intermodal. They're different modes of communicating different modes of transporting, storing data. So all kinds of modes of moving and storing and computing as well. We can use straight compute. We can use GPUs. You know, we can use inferential calculations, which are AI and machine learning. When we need them all different modes of compute, all different modes of communication, but it's a single system that is interconnected and can perform a function. Supply chain function is to move physical goods around the world. The cloud's function is to move information around the world, not data, but information. Data is one of the features. Communications are feature.

Jason Lopez: One of the reasons Mills mind goes to the 1920s when thinking about the cloud is because of the parallel that technology is ultimately about people. When Lindberg landed in Paris, the technical aspects of aerodynamics were important. But the that's not what the flight was ultimately about. The parallel is compute is important in the cloud.

Mark P. Mills: But that's not what the cloud's used for. It's used for inference and advice. And once you change an nomenclature in people's heads, especially business people, to think about it, the way HG Wells wrote about it. I mean, Wells imagined in a book he wrote in 1936 called

World Brain, HG Wells imagined the cloud. He got everything right about what the cloud would do and why except one thing. But he couldn't imagine silicon and software. He imagined the centralization because the communications would be like a giant library. He imagined utility efficiencies of centralizing it, communicating information, you know, not just a message to the world. It was probably the first articulation of a radical vision ever made in human history. Because up to that point from the library of Alexandria, to every library that Mellon built, you had to go to it to get the information. And HG Wells was probably the first person to figure out, no I'm going to, I'm going to take the information to everybody. This is the cloud.

Jason Lopez: In the title of Mill's book, *The Cloud Revolution: How The Convergence Of New Technologies Will Unleash The Economic Boom and a Roaring 2020s*, the boom he refers to is huge. Crypto, social media, the dot com boom and even Moore's law are small in comparison.

Mark P. Mills: What Moore's law did is delivered a billionfold improvement in computing power per decade, over 50 years. Right? That's really amazing. Right? But what the cloud law does is, you use a different metric, which is not the delivery of computing power, it's the cost of computing power. How many MIPS can you buy per dollar. It's improving at a hundred billion fold per decade rate a hundred times faster. The Moore's law in the decline of the cost. Do what people use cloud for which people call compute.

Jason Lopez: But again, Mills is careful to say that, although the cloud operates with computers, it's not about compute. It provides tools that give people information and insight.

Mark P. Mills: As those things get better and better. They're giving individuals in real time useful advice, which has extraordinary economic value, because it's profoundly productive, because it saves the most precious commodity in the universe: human time.

Looking at history through the lens of big inventions. It's interesting way to write a story. And it's an interesting way to think about companies, but it's not informative in terms of what happens to economies. The reason I chose the subtitle, the Roaring 2020s is because of what happened to the world's economies in particular to the United States right around 1920, is exactly what's going on today in terms of its pattern, the rhyming. And by that, I mean, if you look at what was going on, technologically, the things that propelled the 20th century: cars, airplanes, communications, radio, telephone, new materials, polymers and pharmaceuticals, high strain steels, and high strain concrete... all of those things in combination happened contemporaneously and not because they were in the same businesses. But they just, through a beautiful and fortuitous convergence of contemporaneous maturity of all those things, it ignited 20th century growth like nothing ever in history. No period in history had so much wealth creation in a proven of prosperity measured in lifespan terms in America, average lifespan went up 30 years in economic terms, the per capita wealth inflation adjusted terms, rose 700%

Jason Lopez: In the book, *The Rise and Fall of American Growth*, Northwestern University economist, Robert Gordon makes the case that growth is built on innovation. The greater the innovation, the greater the growth. Electrification, for example, in the 1920s was pretty profound, unleashing major growth. But it leveled off and became normal. Gordon argues that that economic gain happened once. In order to substantially grow again, you need another substantial innovation like the car or indoor plumbing or the combine harvester. Computers and the internet, he points out, while transforming our lives have only contributed incrementally to growth. He wonders what's the next innovation to have the kind of tectonic impact of those of a hundred years ago? Will there even be one?

Mark P. Mills: It's both comforting and not a coincidence that you should mention that book because to a very significant extent Gordon's book and his lectures before that were the motivation for me to write my book, specifically as the answer.

Jason Lopez: Of course Mills' answer is the cloud.

Mark P. Mills: Gordon is right. We have had an interregnum. We've harvested all of the profound changes that the 1920s could yield for us. It took 80 years to really perfect all the constellation of tools invented and maturing in the 1920s.

Jason Lopez: The full economic potential of technologies like airplanes, cars and broadcasting took time to make an impact. The cloud, it seems, is in the same position almost exactly a hundred years later.

Mark P. Mills: It will take another 80 years to perfect and mature it. But along the way, what we get is I think growth that's going to surprise the pessimistic economists.

Once you invent the wheel you can never invent it again. Once you invent the airplane, it's a one shot deal. We're not going to invent the toilet again. Okay. So what else are we going to invent? So what historians challenge you with is, so what else is new. Using an app? Okay. That's nice. You know, email, that's good, but it's not like the toilet, it's true. The cell phone by itself is a great communications device, not the smart phone but the cell phone, It's not like inventing the phone in the first place. That's also true.

Jason Lopez: Mills says you have to look at the whole, not the sum of the parts. How will technologies that have been around for decades: microprocessors, remote computing, mobile, AI, and many others; suddenly bring about a major economic boom. What's different?

Mark P. Mills: This is what's different. The 1920s efflorescence of technology occurred into three domains where all technologies reside on everything we use to build civilization. One domain is the information domain. What we know, how we know things, and how we communicate things. Obviously important pencil and paper, the tablet, if you like, you know, pre whatever, whatever the papyrus, the paper invention itself was a big deal. The printing press, these are all information tools. The library was an information invention. So you have the information space. You have the materials space. What we make everything from because everything has to be fabricated. All services are based on products that are fabricated. And the third domain is the machine domain. The machines we use to make things, to move things, to service things. That's the universe of everything.

In the 1920s, we had contemporaneous revolutions in each of the three spheres occurring, not by design, just by luck. Key with revolutions is the maturation of technology so they become commercially useful. It's not just imagining an airplane. Francis Bacon imagine a powered airplane in 1500s. But once it was built that wasn't a revolution until it was commercially viable. It took more than a couple decades to reach commercial viability and another couple decades to take off. So those three domains, we saw the maturation of telephony going into lots of homes in the twenties by 1927, as Bryson also writes about, it was already over two thirds of homes had a radio. The same was true for cars. Very few people owned cars in 1920. By 1930, 30% of homes had a car. The chemistry age began in the late 1800s, by 1920, we had practical polymers and pharmaceuticals becoming viable.

Fast forward to 2020, exactly the same three realms. What do we have in the material space? We have the expansion of new classes of materials that were here to, for impossible to make. We're using classes of semiconductors, which are make possible not just computers, but power control systems at scale safe electric cars that never existed in human nature before make possible light admitting diodes, new classes of biological materials for healthcare, new classes of biocompatible computing, which were literally impossible until just 10 years ago. All started to mature. The materials domain is exploding with growth in what's called computational materials, right? There's a new word for materials called "computational" materials. The machine's domain is similarly undergoing an efflorescence in maturing of things that were previously invented. Drones being one. Obviously they're now starting to be commercially viable, not theoretical new classes of manufacturing machines that fabricate things at the molecular scale. Again, this is something that we've imagined for decades in fact centuries now is done commonly, not just the manufacturer microprocessors, which is by itself miraculous. And finally the information domain is on the cusp of a change as profound as going from the telegraph to the cell phone.

Jason Lopez: The kind of boom Mills predicts, the roaring 2020s, might happen without any fanfare, but he doubts it. Mills thinks we'll have our Lindberg moment.

Mark P. Mills: So I'll make a prediction. You're the first place I will make a specific prediction about the Lindberg moment because you are the only person I've talked to who got this idea. It's the robot. We're back to the robot. The robot's been imagined for a long time too. Actually the Greeks imagined robots. The idea of a robot's been around for a long time, the ability to build what we will call a robot, an anthropomorphic kind of untethered walking machine that can do useful things in my space.

Jason Lopez: Another parallel with the innovation boom of century ago that Mills cites is the cost of cutting edge products. An anthropomorphic robot is too expensive for the average person. So were early automobiles before Ford figured out how to make them more cheaply. The robot-Lindberg moment, Mills believes, happens when an anthropomorphic robot costs about what a car costs.

Mark P. Mills: So the guy who's going to pull the stunt off, I think, will be Elon Musk. I'll bet, we'll see, in the coming few years in, in our roaring 2020s Elon Musk. And if he does that, he'll have been able to achieve that because the three key things that make that technology possible, that product are exactly the same is the economic revolution. You need information systems, artificial intelligence, and navigation that he's been working on very hard, extraordinary proportions. You need the ability to have a machine manufacturing capability to make these very complex thing reliably and inexpensively. He's got that. And you need materials that allow the lightweighting, the durability, what's called softer robotic for the actuators and the motors and the battery. Those are all material centric, revolutions, Elon Musk invented none of those. He's just perfecting them because they could be perfected now much as Henry Ford invented none of the things that things have made a car possible.

The stunt's probably the robot, because it's more tangible and visible than the invisible cloud, but it'll only operate in a function it's only going to be feasible because of the cloud. It's going to have to borrow cloud compute to navigate properly. You're not going to be able to put enough compute horsepower in the robot's brain to solve all the problems that it'll have to solve to navigate safely around you and me. But with 5g and edge computing, boy, I'll bring a supercomputer into the robot's brain in real time. And that changes the world.

Jason Lopez: Mark Mills is a senior fellow at the Manhattan Institute and a faculty fellow at Northwestern University's school of engineering. His latest book is "The Cloud Revolution: How the Convergence of New Technologies will Unleash the Next Economic Boom and a Roaring 2020s." Other resources that you might be interested in that we used for this story, The "Rise and Fall of American Growth: The U.S. Standard of Living Since the Civil War" written by Robert Gordon published in 2016, Bill Bryson's "One Summer America, 1927," and Stephen Kern's, "The Culture of Time and Space, 1880 to 1918." This is the Tech Barometer podcast, I'm Jason Lopez. Tech Barometer is produced by The Forecast and you can find more articles and stories at www.theforecastbynutanix.com.

Jason Lopez is executive producer of Tech Barometer, the podcast outlet for The Forecast. He's the founder of Connected Social Media. Previously, he was executive producer at PodTech and a reporter at NPR.

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