Blockchain Forming the Foundation of Next Manufacturing Renaissance

The promise and perils of of using distributed ledger technology in manufacturing

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Amid predictions of global economic slowdowns and several recent PMI readings indicating manufacturing contraction, it becomes easy to see how slow production performance and data inefficiencies throughout the manufacturing supply chain contribute to economic uncertainty and concerns for future business. At the same time, manufacturing's history is replete with numerous "Great Leaps Forward" in technology and technology application, each of which was followed by enormous business opportunities and economic expansion for the agile and articulate. The application of blockchain, the distributed ledger science behind Bitcoin, is demonstrating great promise for being a breakthrough of historic proportions for the entire manufacturing supply chain in many critical industries.

In framing such statements,consider the "Gartner Hype Cycle." In this cycle, innovations trigger expectations, expectations rapidly inflate and peak, followed by a steep decline into the "Trough of Disillusionment," then by a measured rise up the "Slope of Enlightenment," opening on to the "Plateau of Productivity." New technologies move through the cycle in times ranging from less than two years to more than ten. Many become obsolete less than halfway through.

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Another model I use every day is a decision strategy called the OODA Loop, developed by fighter pilot John Boyd. OODA stands for Observe (everything from a business competitor or market to a military adversary in combat operations), Orient, Decide, and Act. In business, the Act step is being able to apply emerging technologies that allow you to pivot as conditions evolve.

Peer-to-Peer Trust

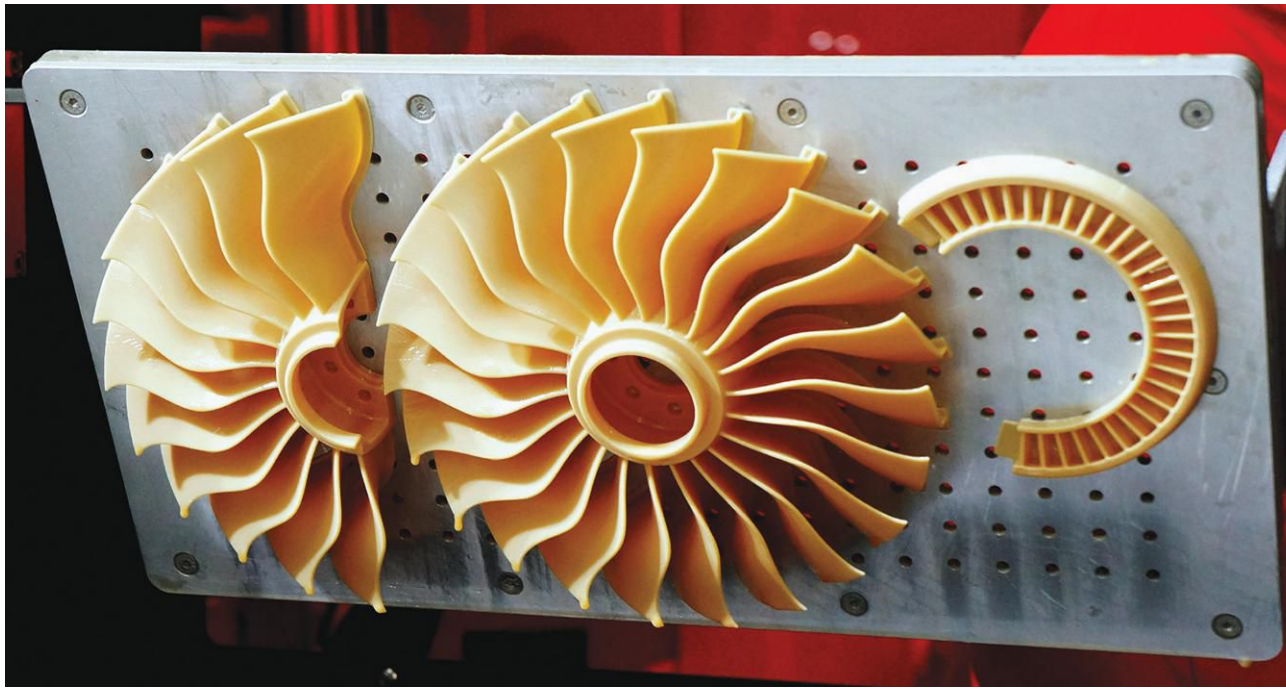
In his book "Sapiens: A Brief History of Humankind," Yuval Noah Harari noted, "For the first time in the 50,000 years of modern human history, we now have the opportunity to establish peer-to-peer trust." Trust is a powerful enabler in business as it fundamentally anchors relationships. Blockchain now allows individuals and companies to manufacture trust in their business relationships and transactions.

Industries with critical part-performance requirements—including aerospace, defense, energy, automotive, and medical—are well-acquainted with trust relationships, having part-checking requirements and verifications built into the supply chain. What they're not acquainted with is top supply chain efficiency. Manufacturers spend millions of dollars verifying part and process quality with varying degrees of success, from antiquated and time-consuming job tickets and paper trails to complex, Big Data-inspired computerized systems requiring extensive, customized, and costly IT infrastructures. Manufacturing companies without the knowledge or resources are effectively cut out from acquiring or growing any business in complex part manufacturing.

In addition, industries from aerospace and defense to vitamins and supplements are fraught with counterfeit parts or ingredients. Every action in the supply chain—obtaining raw materials, confirming and finalizing part-design adjustments, manufacturing, post-processing, shipping—generates microbursts of data, energy, and bandwidth. Blockchain-based technology captures this data and verifies each transaction digitally along every step of the process. Essentially, this creates an append-only digital ledger system, available anytime, to any participant, whenever it is needed.

The Fourth Modality

In a 2015 article titled "The Great Chain of Being Sure About Things," *The Economist* said, "the cryptographic technology that underlies Bitcoin, called the 'blockchain,' has applications well beyond cash and currency. It offers a way for people who do not know or trust each other to create a record of who owns what that will compel the assent of everyone concerned. It is a way of making and preserving truths."



With digital part designs whose files not only establish design provenance but also power CNC machining and 3D printing equipment, establishing and preserving truth along each process step of design, manufacturing, and customer handoff is an essential commodity.

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In a manufacturing world of digital part designs whose files not only establish design provenance but also power CNC machining and 3D printing equipment, establishing and preserving truth along each step of design, manufacturing, and customer handoff is an essential commodity. The blockchain as we know it began life in the mind of Satoshi Nakamoto, the brilliant, pseudonymous and so far unidentified creator of Bitcoin. It is a "purely peer-to-peer version of electronic cash," as he put it in a paper published in 2008. To work as cash, Bitcoin had to be able to change hands without being diverted into the wrong account and to be incapable of being spent twice by the same person. The avoidance of such abuses had to be achieved without recourse to any trusted third party, such as banks that stand behind conventional payment systems.

When pilots fly airplanes, trust is everything. When they walk out to an airplane, as long as the forms are signed and dated correctly, they can get in the airplane and fly with confidence.

The blockchain becomes this trusted third party. A database that contains the payment history of every Bitcoin in circulation, the blockchain provides proof of who owns what at any given juncture. This distributed ledger is replicated on thousands of computers—Bitcoin's "nodes"—around the world and is publicly available. But for all its openness, it is also trustworthy and secure. This is guaranteed by the mixture of mathematical subtlety and computational brute force built into its "consensus mechanism"—the process by which the nodes agree on how to update the blockchain in the light of Bitcoin transfers from one person to another.

Adjusting blockchain to part production and verification essentially and efficiently digitizes the paper trail for design through manufacturing and logistics. Digital assets created with the digital part design and blockchain pedigree can now be "transported" anywhere in the world or even into outer space through the cloud via a digital network. Logistics is no longer bound to the modalities of land, sea, and air; blockchain creates and supports a critical fourth logistics modality: digital.

Today, manufacturing is deliberately pushed to the "edge," and companies can transform that digital part to a physical part at the time of consumption when needed. Hundreds of distributed process participants—designers, engineers, raw-material buyers, equipment operators, process specialists, assemblers, schedulers, shippers, and all the supervisors in between—can be generating and appending thousands of ledger pages across ad-hoc networks that effectively establish peer-to-peer trust as parts move through production.

Such a process also becomes self-policing, quickly identifying underperformers and thereby strengthening the supply chain. Design and manufacturing owners retain their ownership and can collect and reward intellectual property from all stakeholders. Part and process provenance—which means to establish the true origin or source (from the Latin provenire, "to come forth")—is determined at every step along the way.

Establishing Use Cases

Bloomberg, the information service, said recently that 86 percent of U.S. industry has either finished or has an ongoing blockchain project. What are the challenges? It

pays to remember here that technology does not solve any problems. It is the application of technology that solves every problem.

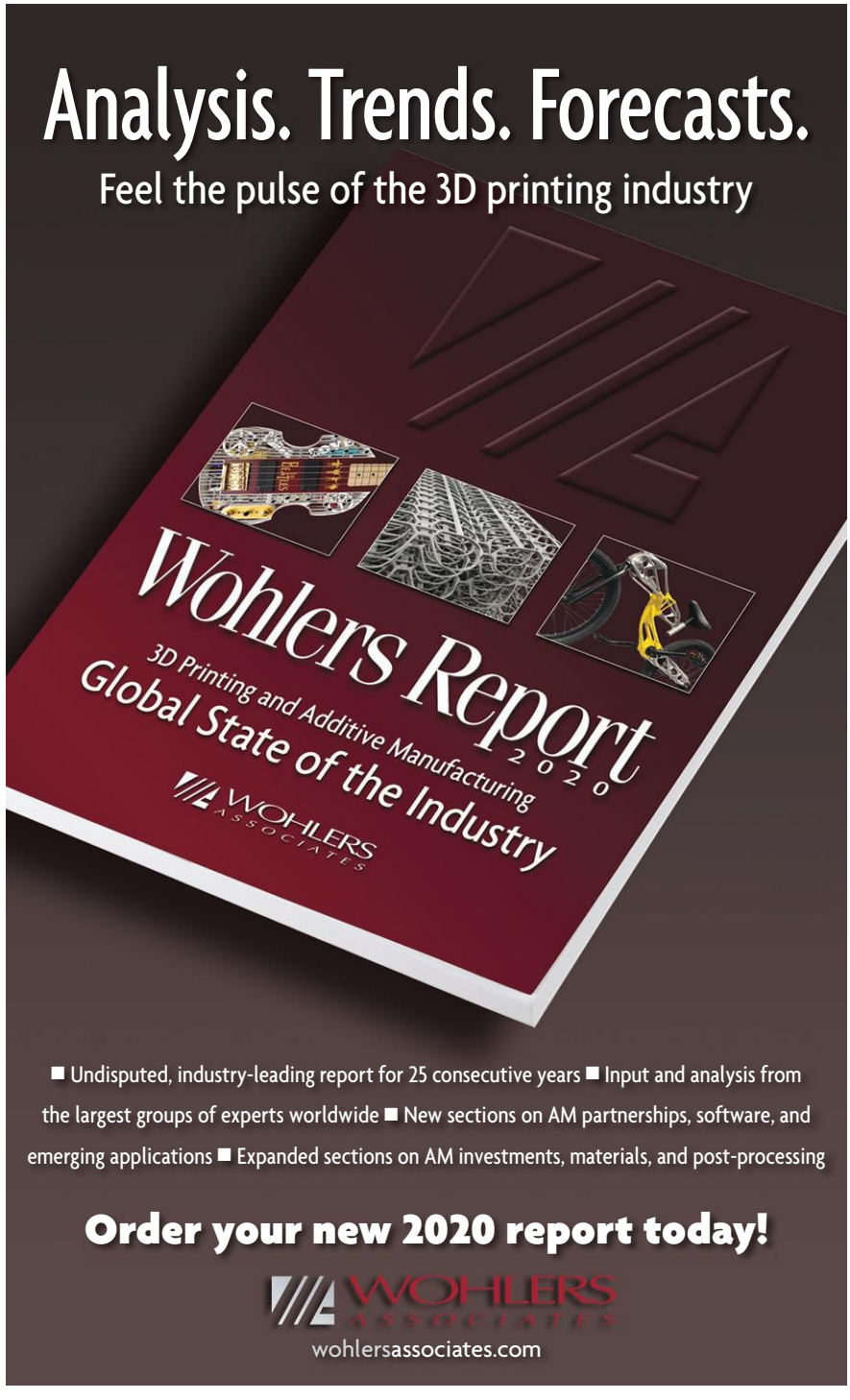
That said, blockchain challenges in the manufacturing supply chain include both technical and business-related hurdles. On the technical side, there is interoperability and scale. One of my collaboration partners is a company called AION. It has created a project that allows users to move from blockchain to blockchain and not lose immutablity and transparency. It's a big deal. There are numerous blockchains existing at the moment that will eventually funnel down to a general-purpose technology, like hypertext transfer protocol secure (HTTPS), that provides assurance that one is communicating with the website that one intended to, as opposed to an impostor and without interference by cyber attackers.

The business challenges are value creation and behavior modification. Value creation, or tying technology application to a problem's solution, is where we earn our keep. Blockchain will allow for the creation of new value and new business models as it is applied to solve industry challenges. Behavior modification naturally follows as suppliers move into the "trust" ecosystem. A company's ability to modify the behavior of supply chain participants depends on its position in the value chain. The best example recently is Walmart telling its lettuce suppliers they now must be on Walmart's blockchain. Suppliers either comply or sell elsewhere. Walmart and others are hopeful blockchain can increase food safety. In contrast, if the lettuce fertilizer company said "get on my blockchain or I won't sell you fertilizer," farmers are free to buy fertilizer somewhere else.

Enter 3D Printing

In 2015, the company I worked for, Moog Inc., acquired a 3D-printing service bureau, and being in business development, I was involved with examining what value 3D printing

brought to our businesses and customers. We were supplying support to the military depots tasked with supporting legacy fleets for the Air Force, such as the Boeing KC-135 Stratotanker military refueling aircraft. As an Air Force pilot, I flew the KC-135. Most of these aircraft were built in the late 1950s and early 1960s and as such suffered obsolescence problems and diminishing sources of replacement components. This proved a great use case for 3D printing.



Consider this scenario. You're on an aircraft carrier in the middle of the Indian Ocean, at sea state level 3 with the deck pitching and rolling. You have an F-18 that's just received a critical mission. Lives are at stake. Your plane has to fly, and it needs a part.

Even with the case of your having a 3D printer on board, how do you know (1) your design data for the part is secure, that it has not been tampered with by an adversary, and (2) that your processes, materials, and build conditions are such as to produce a good performance part?

What I quickly realized is that when I flew airplanes, trust was everything. I would walk out to an airplane and as long as the forms were signed and dated correctly, I could get in the airplane and fly. In contrast, getting a travel voucher processed required five signatures, a DNA sample, and a kidney. Zero trust.

So, standing on the carrier deck, I quickly distilled the challenge was to find out how to put "trust" in this process. We became aware of blockchain and started asking questions. Can we provide data integrity with blockchain? Can we provide transparency, traceability, and process integrity? How much data and information is required to manufacture trust?

We began to build out models of what solutions might look like, starting by asking ourselves, "What does blockchain really enable and what is the end state?" Through many months of thinking, we established we could create a distributed manufacturing network—a

distributed network of 3D printers and the capabilities of delivering a finished part verified to industry and regulatory standards. We could now push trust outside the four walls of the factory to a distributed network and not be overwhelmed with transaction costs. Another thing we realized was the value of this process wasn't simply monetary. Value creation in this case was the ability to access remote locations and be able to get these parts out securely and quickly. Using this new type of logistics, we realized we could actually reduce non value-added costs that burdened traditional supply chains, like packaging, transportation, warehousing, and managing physical inventories. We also saw value creation in that companies could now order a lot size of one and not be burdened with a minimum quantity order or be forced to buy a kit to get one part.

Reduced lead times, coupled with the ability to push a part to the point of need, is tranformative for supply chains.

This also drove down part lead times substantially. In our proofs of concept for the U.S. Department of Defense (DoD), we reduced part lead time on an F-15 part from 265 days to a matter of hours. On another F-15 part, we reduced it from 133 days to hours. Reducing lead times, coupled with the ability to push a part

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Creating New Expectations

to the point of need, is transformative for supply chains. This is true whether it is an aircraft part needed on an aircraft carrier, or a part for the space station or a Formula 1 racer.

To modify the behavior of the DoD, we looked to the Defense Federal Acquisition Regulations Supplement (DFARS) and how we could leverage it to create new business models. Today, companies are required to prove provenance of all electronic components and systems. This prevents an adversary from corrupting military supply chains with bad components loaded with malware. You don't have to look any further than Peter Singer's book, "Ghost Fleet," to see how such a scenario can have a catastrophic effect on U.S. combat forces. With that in mind, we sought to get congressional action to change the DFARS and require the DoD to implement processes to prevent counterfeit 3D-printed parts from entering the supply chain. Today, most counterfeit aircraft parts are low-complexity parts, but that dynamic can change with 3D printing. Blockchain provenance allows us to verify and secure our supply chains.

I took the DFARS regulations for proving electronic components aren't counterfeit, substituted "additive manufactured" for "electronic," and got it included in the National Defense Authorization Act for 2018. This now requires the DoD to provide a report back to Congress on how they will mitigate for counterfeit additive-manufactured parts in the DoD supply chain. Then I went to the DoD and said we had just the thing, a blockchain solution. The DoD is keenly focused on using emerging technologies to secure its supply chains and we are playing a part.

Proof of Concept

Out of that came six proof-of-concept use cases. We partnered with Microsoft and its cloud computing platform, Microsoft Azure, and a number of other companies. We also worked with Microsoft to develop "smart contracts," which led to the first all-digital transactions in the aerospace industry. This meant we could send a part request via blockchain to a company in Singapore. When they download the part, they can receive instantaneous settlement. This is a powerful tool because users can set terms to shape the behavior of their supply chains. For example, users can offer net-zero terms or even partial payments prior to delivery to their best suppliers or push payments out to net 60 or 90 to troubled suppliers. Users can now quickly and easily use blockchain smart contracts as a carrot or a stick to get their supply chains in order.

Blockchain also enables rapid forensics. Let's say there's a malfunction on an aircraft. Doing a root-cause analysis can take months. In a distributed manufacturing network, each decision—from material specifications and purchasing through production, post-processing, and shipping—is documented, verified and recorded in a digital manner. Unlike the paper records of today, reverse forensics are accomplished very quickly in blockchain.

In a use case, a plane en route from Auckland, New Zealand, to Los Angeles simulated a cabin part that failed. A digital part at one of the airline's supply chain partners was purchased, and the part was then securely and quickly manufactured on site and installed upon the plane's landing.

As mentioned previously, reducing part lead times in the DoD has the net effect of increasing mission capable rates and decreasing aircraft downtime. We further advanced this potential with our latest proof of concept in the commercial aerospace market.

Aerospace Scenario

The scenario went like this: A plane en route from Auckland, New Zealand, to Los Angeles simulated a cabin part that failed. The crew radioed to their maintenance facility that they needed a part. The maintenance team checked to see if Los Angeles had a physical part available and the answer was no. Prior to execution, we seeded a digital part with one of the airline's supply chain partners. The maintenance team was able to see a digital part was available; they purchased the part and pushed it through the cloud to the facility in Los Angeles. The part was then securely and quickly manufactured on site and installed upon the plane's landing. Had that part not been available digitally, that aircraft would have flown the next three legs until it returned to Auckland. If the airline had to purchase a new physical part, it could have taken up to 44 days if one was not in inventory in Auckland. The value and new business applications are apparent and it's easy to see how this scenario could play out at a remote mining operation or an oil platform or a farmer's field during harvest.

Convergence Becomes a Reality

The convergence of blockchain, 3D printing, and Industry 4.0 principles is becoming a reality. We recently debuted VeriTX, an on-demand digital marketplace for suppliers and customers of aerospace components that will later expand to medical and industrial markets. VeriTX leverages blockchain technologies to create a digital twin of parts as they are tracked through their lifecycle. Now, data can be collected and aggregated across part families and fleets as VeriTX provides verification

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and trust. Design integrity, material integrity, and process integrity are assured, rapid forensics are available in the event of an incident, long lead times and non-value-added costs are greatly reduced, smart contracts provide immediate settlement, and counterfeit parts are pushed out of the supply chain.

Imagine how manufacturing will change when critical items are available in their most flexible, digital state—not only in aerospace and defense, but medical, automotive, or even living tissue. Not only can that part be "pushed" to where it's needed in seconds across the Fourth Modality, there also is a distributed, transparent ledger proving design, material, process, and part integrity while protecting intellectual property every step of the way. This reshapes and significantly improves the manufacturing supply chain. This changes the world.

Using blockchain, design integrity, material integrity, and process integrity are assured.

About the author: James Allen Regenor served 31 years in the United States Air Force where he commanded the 521st Air Mobility Operations Group and served three years in the White House with the National Security Council. He is co-founder of Blockchain Resources Group in Charleston, S.C., and founder and president of VeriTX, East Aurora, N.Y., an Industry 4.0 digital supply chain platform for the aerospace industry. For more information, visit veritx.com.

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