A 21st Century Supply Chain

CIMdata Commentary

Key takeaways:

- *As Additive Manufacturing (AM) comes into widespread use it may upend supply chains by separating the digital and the physical. PLM can enable this transformation; PLM's absence could be chaotic.*
- *Manufacturers working in supply chains may be able to shift production to customers equipped for AM. Instead of physical parts, customer will buy products in digital form as technical data packages (TDPs).*
- *Moog Inc. is developing this capability with AM, Blockchain, and PLM and it expects significant, measurable benefits.*

A&D Supply Chain Issues

Companies in aerospace and defense (A&D) supply chains have many problems, which seem to grow with the rising proportion of information in their supply chains; this data growth is in part due to surging inflows of data from the Internet of Things (IoT) and lifecycle-based precise replicas of products and processes known as digital twins and digital threads. While physical parts are the reason supply chains exist, there has been an explosion in the amount of highly detailed, proprietary data—materials, requirements processes, inspections, verifications, certifications, and more—that accompanies components from producer to prime contractor and manufacturer to airfield and depot. Monitored and verified with Product Lifecycle Management (PLM), this data ensures that the product—anything from a flight control system component to a wing or a turbine engine—meets its buyers' requirements, complies with government regulations, and conforms to export controls on armaments.

What has long been lacking in these transactions is security and transparency, always a difficult balance to achieve. Technical data packages (TDPs) are still largely "taken on faith;" as yet there is no reliable way to authenticate them. The traceability of data in transmittals is still verified with paper—the costliest and least reliable way to manage data, making PLM essential. Intellectual property (IP) is always at risk and counterfeit parts keep appearing. Supply chain security and transparency problems are highlighted by a growing push toward on-demand, quantity one, anywhere / anytime production. Generating spare parts at or near their point of use, for example, speeds up deliveries while avoiding costs for freight and inventory management—all of which is readily measurable.

A Radical Solution

One solution to these problems is making supply chains entirely digital, which means detaching the physical from the digital but keeping them in sync. This separation solves many supply chain problems and does away with non-value-added services such warehousing and export-import middlemen. More importantly, in supply chains this separation is radical and profoundly disruptive. Manufacturers can move away from selling physical, tangible products by licensing customers to make parts themselves. This entails selling the digital equivalents of products as technical data packages.

The essentials for using technical data packages to separate the physical from the digital in supply chains are secure information transmittals and customers with in-house production capabilities. This is where additive manufacturing and Blockchain enter the picture. AM

(a.k.a. 3D printing) is now in many manufacturing organizations, allowing manufacturers to shift physical production to customers that use AM. Upending supply chains to digital from physical could not be done without AM's rapid and widespread adoption. Industry analysts' reports predict global shipments of AM machines could reach as high as 6.7 million in 2020, a growth rate that some supply chain experts have labeled phenomenal.

Blockchain meets the huge and stringent data transmittal needs of the physical-to-digital shift. Blockchain is a distributed digital ledger that maintains a continuously growing list of ordered records called blocks. Existing on a large number of file servers, these ledgers are virtually impossible to counterfeit. Data recorded in a block cannot be altered because each block contains a "hashed" timestamp; a hash is a cryptographic math function that guarantees, as just one example, the genuineness or provenance of whatever object is represented by a TDP. There is a third essential supporting element: PLM with its unmatched ability to manage, allow access to, and secure information no matter how it's generated, where it's stored, who is responsible for it, or how it is gathered into digital twins and digital threads.

What is 3D Printing?

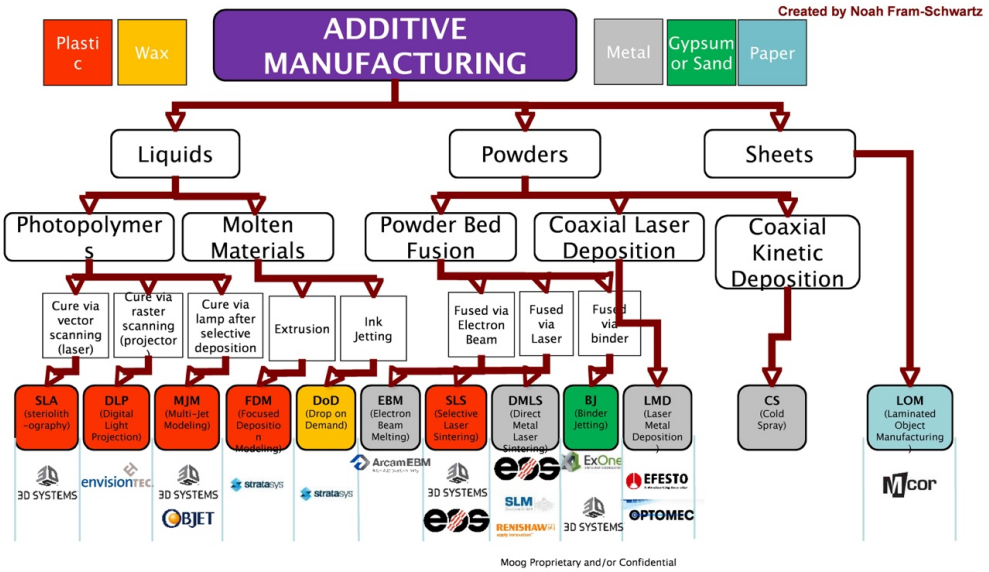

Figure 1— Extensive Additive Manufacturing Capabilities at Moog
(Image courtesy of Moog)

A pioneering physical-to-digital supply chain is being refined and enhanced by Moog—an innovation born from the convergence of three insights:

- That now widely available AM offers manufacturers far greater flexibility than conventional or "subtractive" machine tools and manufacturing.
- That Blockchain can make supply chain transmittals both transparent and secure to an unprecedented degree.
- That shortcomings of an aging product data management (PDM) system can be remedied with a PLM "overlay," currently being implemented. Any need to migrate 20 years of manufacturing information, a costly undertaking by any measure, has been eliminated.

The Moog Aerospace & Defense Solution

By separating the digital from the physical in its supply chains, Moog is transforming the way it provides its complex control systems to customers. This is done with a revolutionary product delivery platform called VeriPart™. VeriPart integrates AM, Blockchain, and PLM—possibly for the first time ever. As in many manufacturing enterprises, PLM helps keep supply chains running smoothly. PLM plays a vital role in VeriPart by providing information at what Moog terms "point of use and time of need." Moog notes that smoothly operating supply chains make manufacturing as a service secure, verifiable, traceable, and certifiable.

Drivers of Moog's PLM transformation include moving to model-based definition (MBD) for better requirements management, implementing better classification and workflow processes to eliminate data chases, and managing intellectual property (IP) more directly. Moog's PLM initiative includes Teamcenter's Active Workspace environment for collaboration, bringing thousands of standard data objects and hundreds of standards up to date. Leveraged by data from the IoT, PLM's digital twin contains everything known about a given product and is continually undated while a digital thread monitors everything done to develop and manufacture a product.

PLM is a strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination, and use of product definition information across the extended enterprise, and spanning from product concept to end of life. This approach integrates people, processes, business systems, and information in all the distinct phases through which a product passes during its life—requirements definition, concept design, production, inspection, verification, et cetera. While there is overlap between PDM and PLM, older PDM systems are generally constrained by the outputs of computer-aided design / computer-aided manufacturing (CAD/CAM) and CAD/CAM's extensions into computer-aided engineering, or CAE. Moog is focused on the gains PLM offers over PDM; hence its PLM project justifications were qualitative.

The nature of Moog's products both impels and sustains VeriPart. Based in East Aurora, N.Y., the company manufactures complex, precision motion controls for commercial and military aviation and manned and unmanned spacecraft as well as medical equipment. Sold worldwide, Moog's products must meet stringent quality specifications and traceability requirements. Aircraft flight controls are Moog's largest business segment but nearly all its products require some form of certification to establish suitability for service; conformance must always be verified. (The company has over 11,000 employees working from 100-plus locations in 28 countries. Sales for 2017 were $2.5 billion.)

Moog got into AM in 2015 with an acquisition. Engineers and managers quickly grasped how 3D printing tightens the links between digital designs and as-built physical products. After its engineers were exposed to Blockchain—at a hackathon, no less—they "connected the dots" to come up with VeriPart. VeriPart provides traceability of the history and provenance of each part's design, manufacture, and use. Blockchain ensures that 3D printed parts and assemblies can be authenticated, that data transmittals won't be hacked (stolen by counterfeiters, for example), and that transactions (such as manufacturing) can be licensed to third parties.

NCMS Evaluates VeriPart

VeriPart's use in A&D is being demonstrated, evaluated, and adapted in a research and development collaboration with ST Aerospace, a unit of Singapore Technologies, and the National Center for Manufacturing Sciences, or NCMS. "Supply chain management in digital

manufacturing (AM, in other words) is important for carrying out secure digital transactions and creating binding contracts in an efficient way, as well as verifying the quality of manufactured parts through proper establishment of qualification and certification standards," NCMS observed on its work with Moog and ST Aero. "This quality control is particularly crucial in fields such as nuclear energy or aerospace, where the use of a part that isn't up to standards can have serious negative consequences."

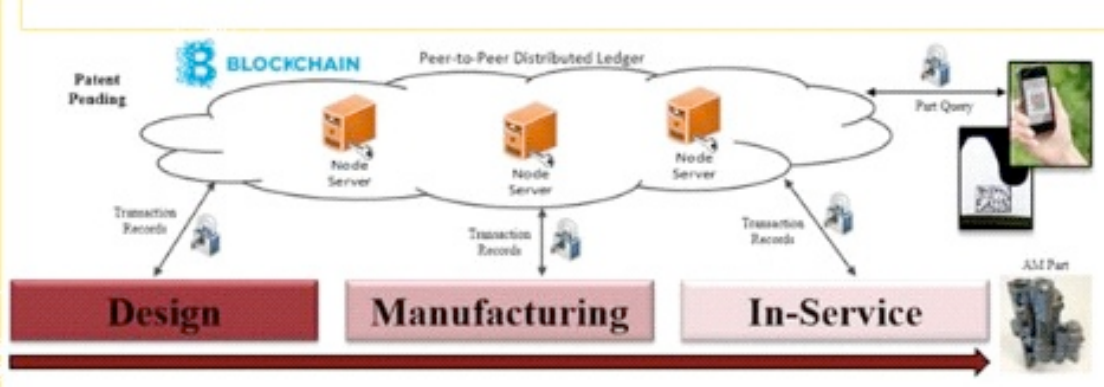

Figure 2—The breadth of the Moog VeriPart concept
(Image courtesy of Moog)

Also participating in the NCMS project are Siemens PLM Software; Identify3D, a provider of digital supply chain software; and Guardtime Federal, developer of a Blockchain based digital signature solution. NCMS is based in Ann Arbor, Michigan, as is CIMdata.

Moog demonstrated the first end-to-end Blockchain-enabled digital transaction in A&D in February 2018. The company is executing proofs of concept with a major airframe manufacturer and, through NCMS, with the U.S. Department of Defense. Moog is a founding member of the Blockchain Research Institute. Blockchain capabilities and VeriPart may even form the basis of a new Moog business. Challenges remain, however. Blockchain technology needs tighter integration with PLM, with ERP, and with AM itself. Mechanical CAD solutions do not always apply smoothly to AM; features and toolsets are aligned with "subtractive" manufacturing. If mechanical CAD's use with AM is to be optimized, functionality must continue to evolve.

Conclusion

In a Mechanical Engineering magazine article on Blockchain, Mr. George Small, Moog Chief Technology Officer observed that "Blockchain lends itself to rethinking how the manufacturing value chain is laid out." Moog is doing exactly that. Although initially developed for AM, VeriPart is extensible to any manufacturing process and any manufacturing market. CIMdata observes that managing supply chains and traceability requirements applies to a wide range of industries, not just A&D. Moog may need a great deal of ingenuity and hard work to bring VeriPart into widespread use. CIMdata believes that organizations needing to bring their supply chains into the 21st Century should monitor VeriPart's ongoing refinement at NCMS—and replace aging PDM systems with up-to-date, end-to-end PLM business solutions.

About CIMdata

CIMdata, an independent worldwide firm, provides strategic management consulting to maximize an enterprise's ability to design and deliver innovative products and services through the application of Product Lifecycle Management (PLM). CIMdata provides world-

class knowledge, expertise, and best-practice methods on PLM. CIMdata also offers research, subscription services, publications, and education through international conferences. To learn more about CIMdata's services, visit our website at http://www.CIMdata.com or contact CIMdata at: 3909 Research Park Drive, Ann Arbor, MI 48108, USA. Tel: +1 734.668.9922. Fax: +1 734.668.1957; or at Oogststraat 20, 6004 CV Weert, The Netherlands. Tel: +31 (0) 495.533.666.