

 **WÜRTH** | **ADDITIVE GROUP**

ALWAYS IN STOCK.

Streamlining Inventory Management
with Additive Manufacturing

A joint whitepaper with

**Additive Manufacturing
Research**

Risk mitigation is hard, boring work. But in a world filled with chaos, the ability to keep things as boring as possible is increasingly valuable.

Indeed, amidst the financial volatility of the 2020s, businesses across every industry have been accelerating their adoption of digital solutions in order to mitigate the impact of macroeconomic disruptions. Meanwhile, the manufacturing sector lags behind, and its stakeholders need clarity concerning the proper role for digitization at the level of the whole enterprise. This raises the question – how can digital solutions help manufacturers decrease the potential for risks to their operations?

An overwhelming amount of information has been written on that topic. Perhaps the most compelling argument, though, is that manufacturers can use digital technologies to streamline their inventory management processes, especially by reducing to whatever extent possible the number of components that have to be sourced from overseas.

One particularly exciting, promising example of that lies in the intersection between digital inventory platforms and additive manufacturing (AM) near or even at the point-of-need. This paper analyzes what's driving the rise of the digital inventory market, and how a new product in this space, Würth Additive Group's Digital Inventory Services, is aiming to address the key catalysts at play.



WHY DIGITAL INVENTORY?

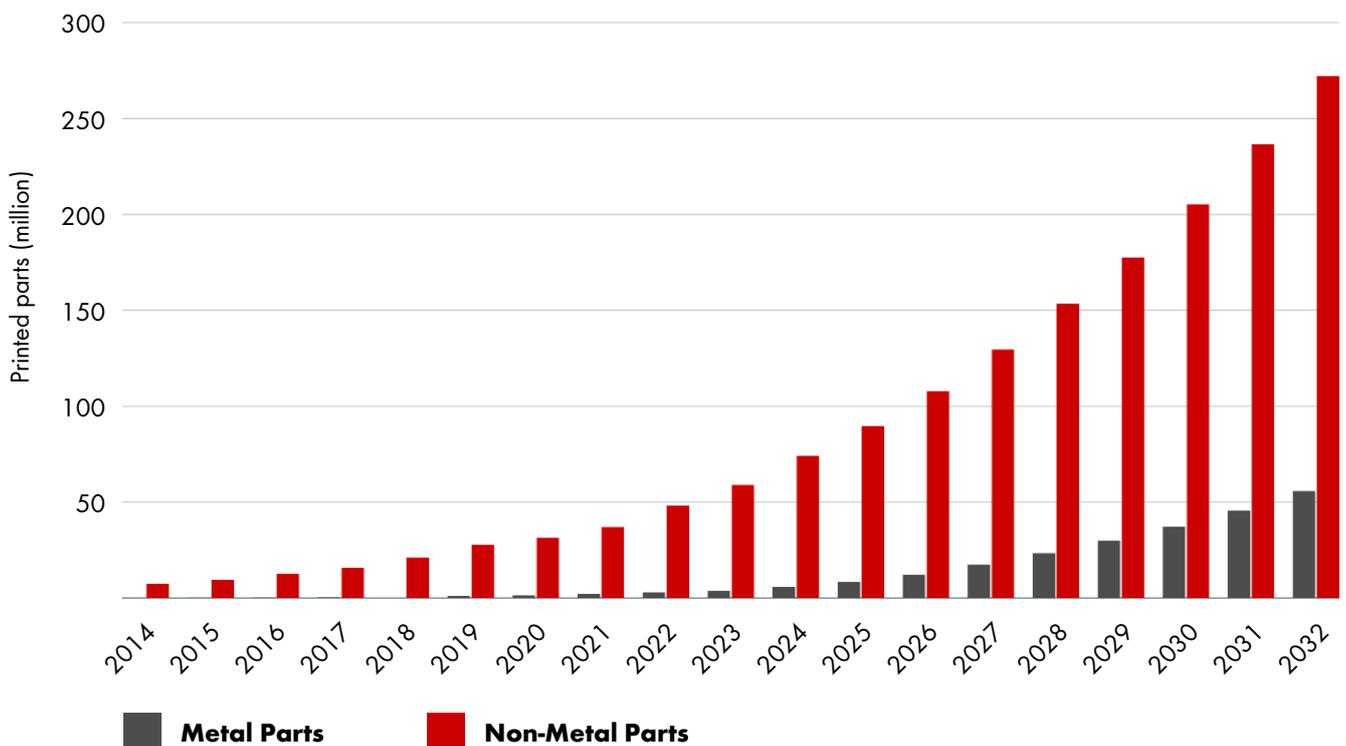
THE ROADBLOCKS INVOLVED IN ADDITIVE ADOPTION

Distributed manufacturing means being able to source parts from a diversity of suppliers, in such a way that producers are prioritized in terms of the best mix between geographical proximity, lead time for delivery, and cost per part. In order for organizations to access the advantages of distributed manufacturing, they need to cultivate and maintain digital inventory platforms across the whole enterprise.

In this context, AM is the best tool that exists for enabling the optimal combination between distance

from supplier to customer, production time, and purchase price. AM permits profitability to be achieved at lower production volumes and facilitates on-demand output. Additionally, AM maximizes purchasers' ability to source parts from domestic suppliers, which reduces the complications involved in dealing with far-flung supply chains and customs authorities. Once confined to use as a prototyping tool, AM's role in producing end-use parts is rapidly growing, a trajectory that is forecast to intensify significantly in years ahead.

Global Additive Production of End Use Parts



Source: Additive Manufacturing Research (data excludes dentistry)

The premise of production near or at the point-of-need with AM is rather straightforward: digitize components of your inventory with 3D files, and 3D print those parts on-demand.

In practice, on the other hand, it is still quite difficult to effectively execute that elegantly simple concept.

At this point in the AM industry's evolution – at least on the polymers side – the problems with accelerating new adoption have less to do with technological maturity, than they do with organizational readiness. For a manufacturing operation that is attempting to incorporate an entirely new technique into its workflow and repeat that technique routinely at scale, the capability to produce the component itself is merely one piece in the equation.

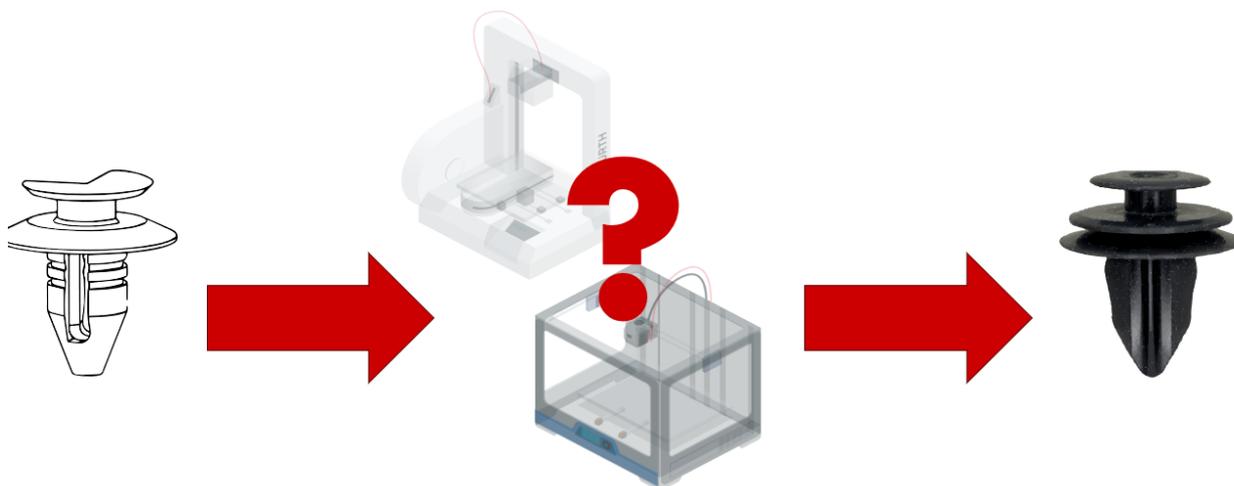
Some of the issues for new adoption are related to the lag in qualification/characterization and certification when it comes to certain materials and techniques. These issues are most daunting in newer areas of the AM industry, especially concerning metals and other materials with less proven track records, such as ceramics. But manufacturers who are turning to AM for parts made from polymers and composites also must recognize the potential liability involved in utilizing a novel production process. And, no matter the materials, traceability of the manufacturing and

distribution processes remains a challenge for all users.

For new adopters of AM, digital inventory combined with a robust quality assurance protocol is just as essential a piece of the equation as is the capacity of a given 3D printer to produce the desired component. Having a digitized "paper trail" of the entire manufacturing process is the bare minimum starting point towards ensuring end-to-end operational accountability.

Here, digitization creates a new set of requirements at the same time as it helps enterprises keep up with fulfilling their existing demands. Above all, fully digitizing a manufacturing process necessitates the enterprise's implementation of a cybersecurity protocol that is up to the task at-hand. Among other considerations, any such protocol must encompass protection of print files, data rights management for users, and customers' privacy rights vis-à-vis their manufacturing and inventory data.

Further, while considerably easier to handle than most other production processes, the enterprise must nonetheless devote resources towards ensuring that its workforce is sufficiently trained for production with AM. And finally, in order for an enterprise to fully capitalize on the potential to leverage the benefits of distributed manufacturing, the desired parts need to be printable in as many different AM ecosystems as possible. This means machine agnosticism is paramount, as it opens up the largest network of available suppliers.



Source: Würth Additive Group

DIGITAL INVENTORY'S EARLY ADOPTERS KEY TAKEAWAYS

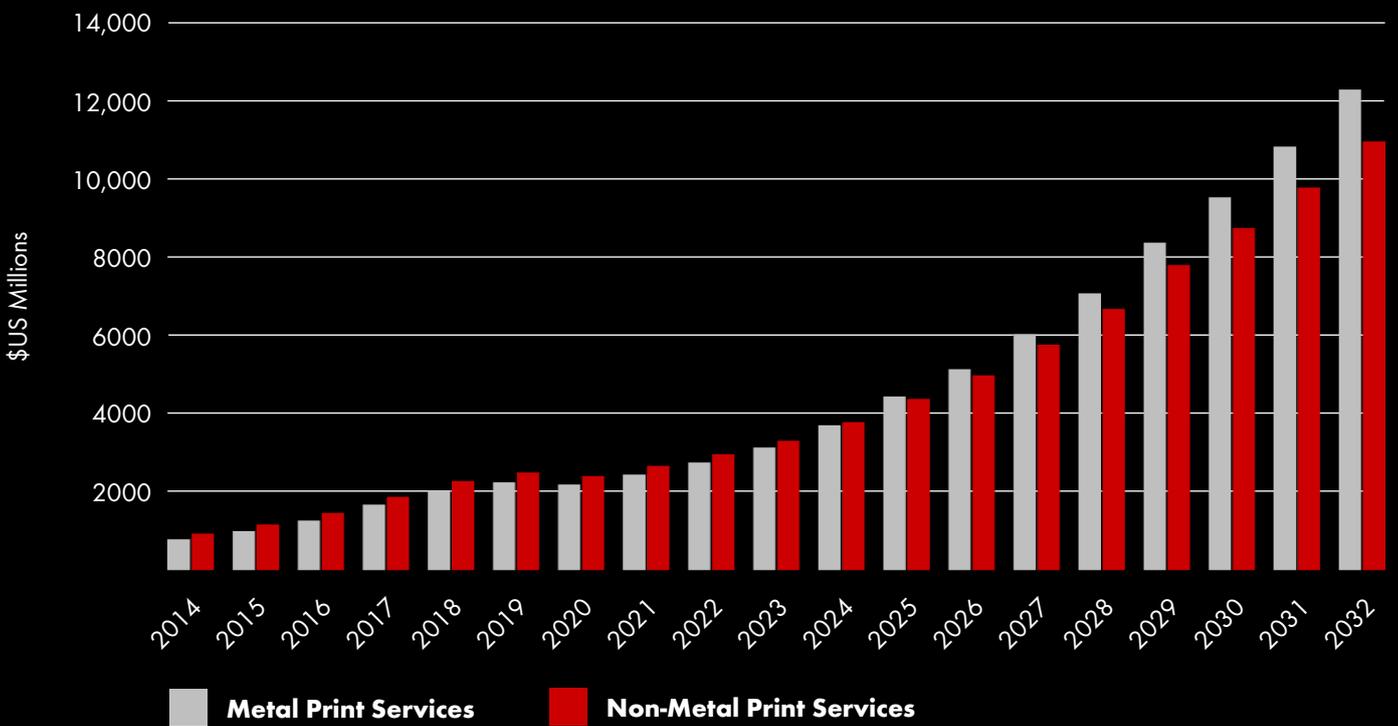
Thus far, it may seem like adopting AM creates as many problems as it solves. While that is not at all the case once AM has been successfully implemented into an enterprise's workflow, potential new adopters do need to be cognizant of the challenges that commonly arise on the road to successful implementation.

Fortunately, though, many enterprises and organizations have identified these challenges, are addressing them, and have developed solutions to facilitate precisely what AM is currently capable of:

enabling the achievement of agile, decentralized production in targeted cases. Amidst their progress, these early adopters have established an instructive model for all other aspiring new adopters of AM-enabled digital inventory management.

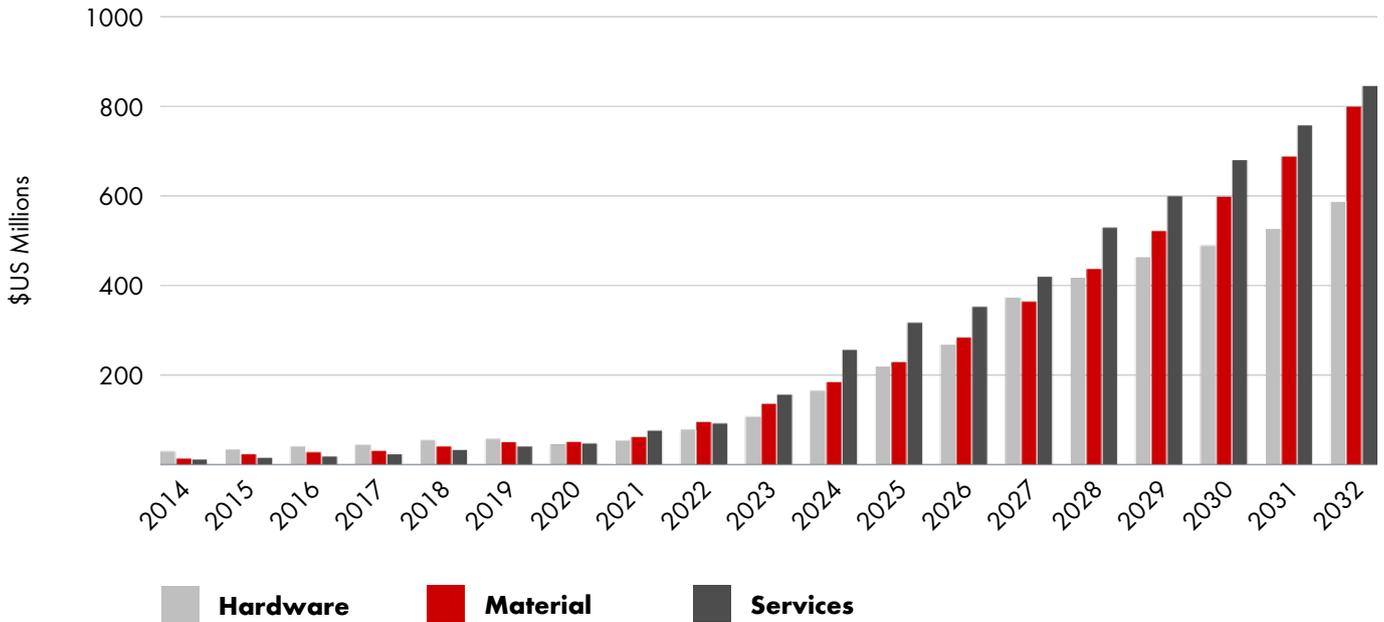
Some of these users are dedicated AM service bureaus, who have seen their revenues rise from growing adoption of distributed manufacturing for an expanding number of increasingly valuable parts:

Global Additive Print Services Revenue, all Materials and Industries



Source: Additive Manufacturing Research (data excludes dentistry)

Additive Manufacturing Revenue in the US Defense Industry



Source: Additive Manufacturing Research

There are other users, however, who aren't getting their needs met by what's available from third-party suppliers, and have therefore taken it upon themselves to begin creating their own distributed manufacturing networks. Here, users from the most strategically critical sectors are at the forefront – defense, aerospace/space, energy, automotive, etc. To date, all of their progress points toward cultivation of comprehensive digital inventory platforms as the key to optimizing AM adoption.

The US Department of Defense (DoD) is perhaps the most striking case, estimated to have spent around 300 million dollars on AM hardware alone in 2023. In support of its AM and general advanced manufacturing buildup, DoD has for years devoted considerable resources, across every one of its branches, towards digitizing its inventory management processes. This includes assessing parts regarding their viability for 3D printing and developing digital repositories and cybersecurity infrastructure to store and transmit the files safely. It also requires substantial funding of workforce development initiatives related to latest-generation advanced manufacturing ecosystems.

Over the last several years, companies in the oil & gas industry have also consistently expanded their own initiatives in these same areas, digitizing their

spare parts catalogs and ramping up qualification/certification of printed parts. In 2023, for instance, a group of some of the world's largest oil & gas companies signed an agreement to jointly develop a digital spare parts inventory. Additionally, governments in the Gulf region have been spending millions of dollars to fund the establishment and growth of AM service bureaus, primarily to secure supply chains for the oil & gas industry.

Similarly, for at least a decade, the rail sector has been one of the most enthusiastic early adopters of AM-enabled digital inventories. Deutsche Bahn – the national railway company of Germany and the largest railway company in the world – keeps a digital inventory containing files for around 1,000 parts. By the spring of 2023, the company had achieved the milestone of 3D printing 100,000 spares.

In addition to being indispensable components of the global economy's core infrastructure, a major connecting thread between all of these industries is that they require enormous inventories filled with expensive spares that, in many cases, are only still produced at this point in low volumes. Additionally, their supply chains overwhelmingly rely on parts sourced from overseas.

The organizations comprising these industries are turning to decentralized production with AM-enabled digital inventory

This is because it ensures future access to spares in all those cases where sourcing them from any other supplier would be prohibitive, from the perspective of lead-time and/or cost – and soon enough, may be more or less logistically impossible to source from manufacturers relying solely on legacy techniques.

There is at least one more thread which connects all these organizations and companies that are developing AM-enabled digital inventory platforms. Given the exceptional size of such entities, as well as their roles as leaders in setting the pace of global industrial change, their need to implement more sustainable practices is especially urgent.

There are a variety of factors that make AM an appealing option for enterprises that are in the manufacturing sector, or directly dependent on that sector, that are seeking to improve the environmental sustainability of their operations. One factor is simply

the ability to reduce material waste thanks to on-demand production.

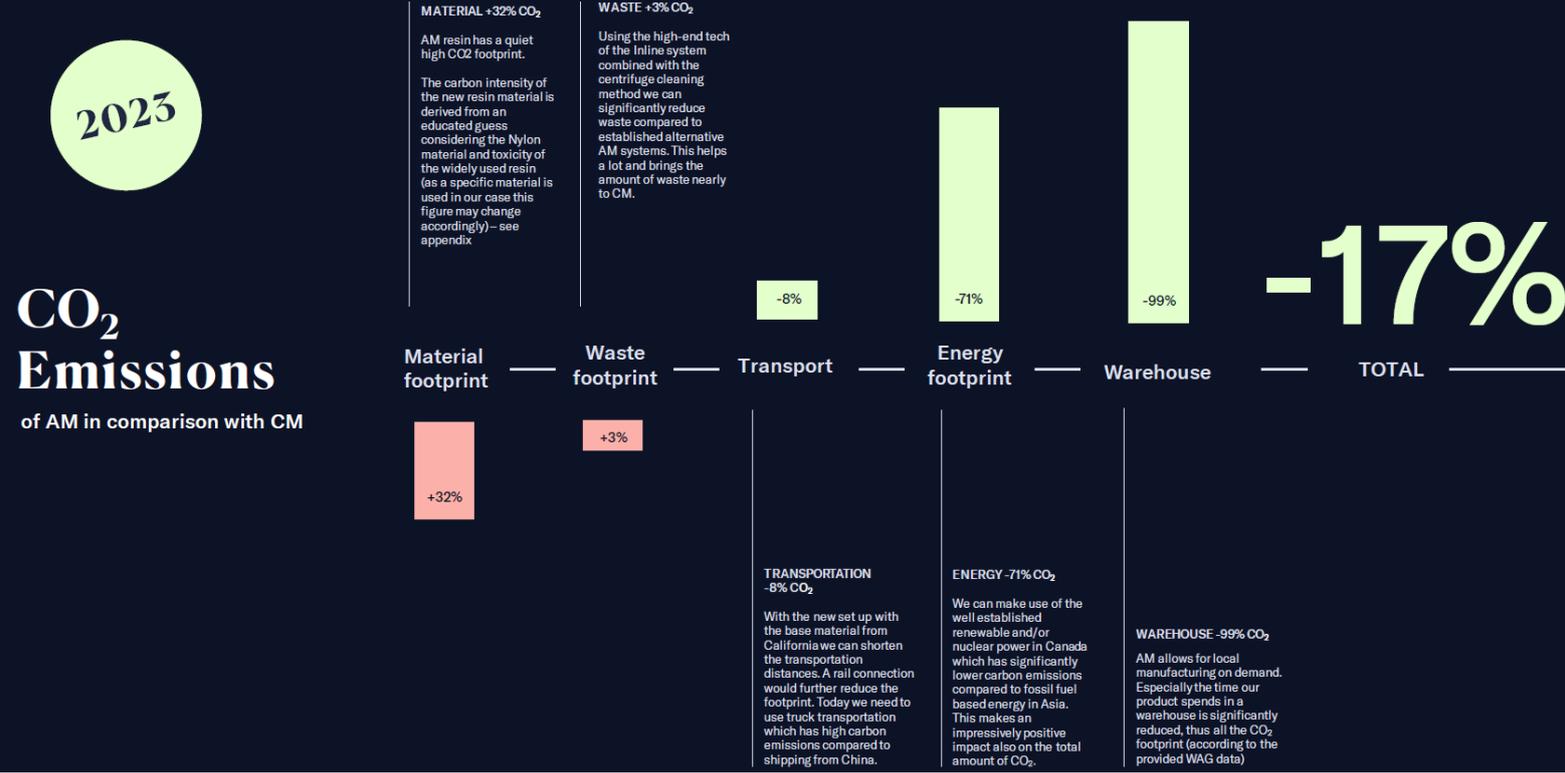
More specifically, a growing body of life cycle assessments (LCAs) conducted in recent years illustrate the potential carbon emissions savings related to lower electricity consumption and lower fuel usage yielded by on-demand production closer to the point-of-need. For instance, Würth Additive Group conducted a study on 3D printing auto clips for the Canadian market, a solution driven by the unusually high costs of storing and shipping parts in such a sparsely populated market.

With AM, Würth can reduce emissions in the transport process by shortening the distance between the materials supplier and the end-user. The company can now transport 3D printing resins from California to Canada and transform them into the final product at or near the point-of-use, instead of transporting finished goods from China to North America. Further, making the parts in a nation like Canada, which gets 82 percent of its electricity from non-greenhouse gas (non-GHG) sources like hydropower and nuclear, also contributes substantially to the overall carbon footprint reduction.

Analysis via streamlined LCA comparison



Source: Würth Additive Group



Source: Würth Additive Group

The chart above shows the estimated carbon emissions reduction for parts that Würth Additive is currently printing. By 2030, assuming that global deployment of AM continues to expand, which would yield an ever-larger network of available production capacity, emissions reductions compared to conventional manufacturing processes could amount to as much as 65 percent.

While not typically thought of as strategic in the same sense as fields like aerospace and energy, the fastener industry nonetheless fits much the same description as those industries referenced above, in terms of its criticality to global infrastructure. The volume and range of parts involved, geographic reach, and diversity of other industries that it touches all make the fastener industry indispensable to the global economy.

Würth Group of Germany is unequivocally the largest company in that industry. Additionally, the company’s prowess in supplying fasteners gave it the positioning to enter a variety of other adjacent markets over the decades, such as personal protection equipment (PPE), tooling, and other general industrial supplies. Altogether, Würth can be considered the world’s

Image: Würth Additive

largest manager of a thoroughly diversified industrial physical inventory.

That background gives the conglomerate’s AM division, Würth Additive Group, a distinct advantage in the form of its quality control know-how and unrivaled capacity for inventory management. Thus, the company’s entry into the AM digital inventory market presents a useful opportunity to examine how the same advantages driving strategic sector giants to digitize their inventory with AM, might be made accessible to the broadest possible audience.



DIGITAL INVENTORY IN ACTION: WÜRTH ADDITIVE CASE STUDY

What does it take in order to succeed at digital inventory management with AM? To a large extent, the answer is much the same as it would be if you asked this question about physical inventory management: a global network of top-notch suppliers, relentless commitment to documentation and quality control, and the consistent ability to respond to customers' demands at a moment's notice.

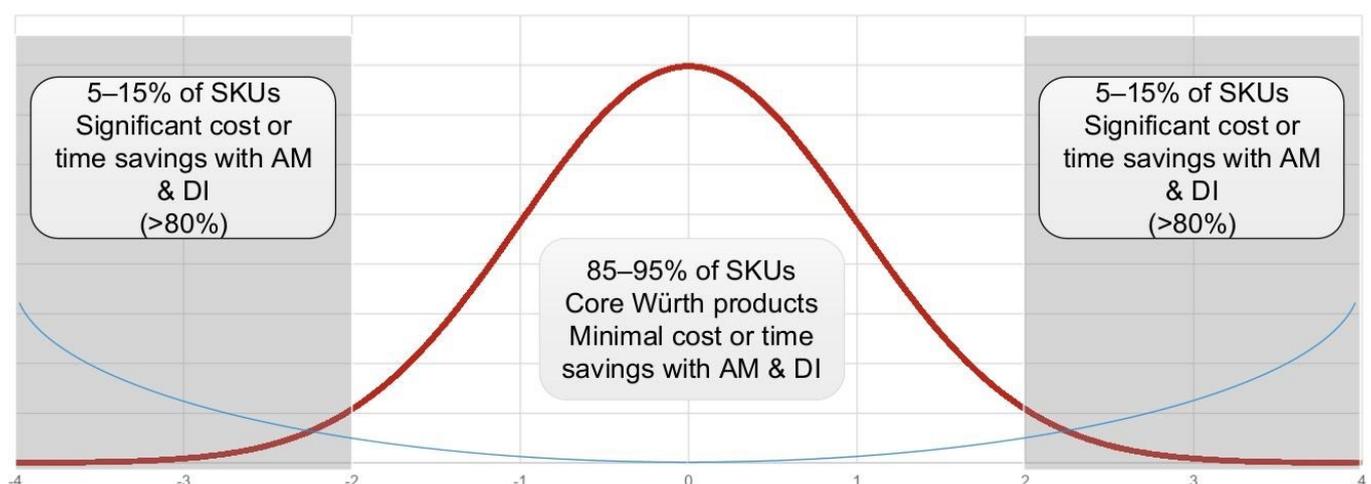
The key additional nuances involved in AM-enabled digital inventory management are robust intellectual property (IP) cybersecurity protocols, and, of course, a proficiency in printing parts. Perhaps most importantly, the latter includes an understanding of where the sweet spots are in terms of deploying AM most profitably. One challenge here for new adopters is that determining where those sweet spots are requires a familiarity with/access to data related to quite a large number of parts.

This is what's so fitting about the entry into the digital inventory market by a division of industrial supplies giant Würth Group. Würth Additive Group's (WAG's) launch of its Digital Inventory Services (DIS) platform leverages an ability to draw upon the parent

brand's foothold of over 400 different companies, located in every region worldwide, and responsible for managing the supply of over a million different "core" products. That catalog increases by millions when one takes into account all the many customized parts that Würth handles for its global roster of clients, which includes a who's-who of the world's largest suppliers of manufactured goods.

Notably, WAG began as Würth Group's own internal AM division, assessing the latter's catalog for all potential opportunities to incorporate AM into the conglomerate's supply chain. (Along those lines, WAG's arc towards offering its services to the general marketplace is comparable to that of Amazon Web Services, originally launched as an internal Amazon project before ultimately becoming the most profitable part of the tech giant's business.) In the process of establishing Würth's AM capabilities, WAG determined that, currently, between 5 and 15 percent of the components in its inventory are good candidates for being replaced with AM. Generally, demand volume for these parts is so low that sourcing them becomes unprofitable. AM unlocks profitability at those lower volumes.

Where do Digital Inventory & Additive Manufacturing make sense?



Total SKU-Range **Number of High potential DI & AM SKUs**

Source: Würth Additive Group



WAG's initial success at digitizing portions of the catalog of the world's largest inventory manager provided the impetus for the development of DIS. Naturally, one of the first DIS users is IMS, a German supplier of fasteners founded in 1975, and a member of the Würth Group for almost 30 years. IMS does about half of its business in automotive aftermarket sales, and the other half in assorted industries. On its own, the company manages a catalog of about 40,000 different components.

Thus far, IMS has digitized around 100 components within its inventory, with the company estimating that, by the end of 2025, this could increase to as much as 500, and so on. The advantages compelling IMS towards managing its inventory digitally with AM are much the same as those pushing strategic sectors like defense and energy in that direction: reducing the complexity of overseas deliveries, ensuring continued supply of parts that are increasingly difficult and expensive to source and store, and facilitating entry into new markets.

That last point wasn't discussed in the previous section, but, long-term, it is just as compelling a motivator for AM adoption as are supply chain simplification, inventory security, and sustainability. In fact, there is even extensive overlap between sustainability and entry into new markets. The need to reduce carbon emissions is the primary driver behind so many of the emerging product categories, such as electric vehicles (EVs), which represent the manufacturing sector's best available opportunities for revenue growth. This trajectory will only accelerate in years to come.

Along with new product categories, AM also lets users access new markets in terms of new geographies. A representative from IMS explained how, previously, there may not have been strong enough financial incentive to justify the German company's targeting of a body shop in, say, Argentina. However, AM-enabled digital inventory changes the business model to the point where any business within reasonable range of a compatible 3D printer is now in play as a potential customer.

This brings up some of DIS's other key differentiators, which should become the standard for the digital inventory market – ease-of-use and flexibility.

With regards to ease-of-use, WAG has focused on making DIS as foolproof as possible. This is probably the most comprehensive realization of supply chains via an app that currently exists, enabling file storage, 3D printing, real-time monitoring capabilities, and the ordering of parts and materials all on the same interface. In these and all of its other functions, DIS owes its capabilities to WAG's cultivation of an ecosystem at the cutting-edge overlap between digital manufacturing processes and Internet of Things (IoT) connectivity.

Harnessing the advantages made possible by those new technological capabilities, WAG works with OEMs to control the distributed production of a part. This could include manufacturing instructions, safety tips, material controls, etc.

The Würth Group, established in the 1940's, has already been in the practice of securing an enormous amount of critical manufacturing data for decades. Thus, the launch of DIS illustrates how AM-enabled

digital inventory is just the latest phase in the evolution of cybersecurity in the manufacturing industry. As opposed to an exotic tool far beyond the frontier of large-scale conventional manufacturing, what WAG delivers with DIS seems to be where the entire manufacturing mainstream will be headed soon enough. Digital inventory platforms should in that sense prove to be crucial gateways for accelerating the path to the future of manufacturing for large pools of new users.

As for DIS's other major advantage that was just mentioned – its flexibility – it is important to point out here that one major contributing factor to the manufacturing sector's digitization lag is the discrepancy between manufacturing giants and small and medium enterprises (SMEs). While there are certainly variations between industries and regions, the general situation is that the giants are excelling at digital manufacturing, while the SMEs are struggling.

Although many factors are surely involved, one key explanation lies in those same macroeconomic issues driving manufacturers toward digitization, in the first place. SMEs are simply disproportionately affected by higher interest rates and inflation compared to



their larger counterparts, making it far more difficult to justify the expense and effort of a whole-enterprise transformation like inventory digitization.

WAG addresses that issue by allowing customers to incorporate DIS as much or as little as they prefer, with multiple different options for leveraging the platform. Customers can digitize as many components within their inventory as makes sense for them at the time, and add new components going forward as they become more comfortable with the underlying technologies. Customers can turn out parts on-site with their own 3D printers, or order those parts from local in-network suppliers. It's easy to envision a customer that owns a printer ultimately becoming one of those in-network suppliers itself, similar to how homeowners with rooftop solar panels sell electricity back to the grid.

Against that background, the representative from IMS gave a particularly compelling insight into IMS's rationale for adopting AM via DIS. As useful as the platform is for the company's present purposes, the real motivators lie in IMS's plans for the years ahead. The pace at which AM is accelerating means that manufacturing businesses can hardly afford to wait to incorporate AM into their operations five or so years from now. By that time, not only will the technology have changed in ways that may make later adopters' attempts to play catch-up more difficult: additionally, substantial portions of the competition can be expected to have long-since implemented their own AM ecosystems.

In turn, IMS – like DoD, the oil and gas industry, Deutsche Bahn, etc. – sees the present moment as the right time to strike, for the purposes of resilience and sustainability, as well as for its future potential to grow into new markets. IMS can now gradually digitize an expanding percentage of its existing inventory, which at the same time serves its additional objective of building up the capacity to produce parts that haven't even been imagined yet.



IT'S TIME FOR MANUFACTURERS TO FACE THE FUTURE

Globally, the manufacturing sector is in a moment of transition, to an extent greater than that, even, being undergone by the economy at-large. Realization seems to be growing that this isn't a fleeting transition, but instead, the beginning of a generational shift. The situation couldn't be otherwise, considering how giant is the ship that global manufacturing stakeholders are attempting to redirect.

Thus, manufacturing businesses must be equal parts proactive and cautious, preparing for the decades in front of them without haphazardly rushing ahead: they shouldn't dive headfirst into the future, but they should face fully in that direction. Würth Group is itself an ideal model of that approach, with its future-facing strategy directly embodied in WAG and DIS.

AM-enabled digital inventory isn't just a tool, but a blueprint for how manufacturers can reorganize themselves in real time, with no risk of destroying the

foundations they've already built. DIS is among the very first entries into this space, and others will surely follow. Prospective partners for companies like WAG can in turn help shape manufacturing's digital future as much as they're helping to revitalize their own enterprises.

As pervasive as uncertainty may be in the global business environment for manufacturers, certain trends seem like the start to long-term transformations. Most significantly, reshoring is here and it isn't going away. Supply chains will continue to be pushed in the direction of shorter distances between the site of production and the point-of-need.

At its heart, this is because the costs of logistics, both monetary and environmental, will keep rising. Digitization can't make that problem go away, but it can make many of the challenges associated with it far more manageable.

 **WÜRTH** | ADDITIVE GROUP

Additive Manufacturing
Research

