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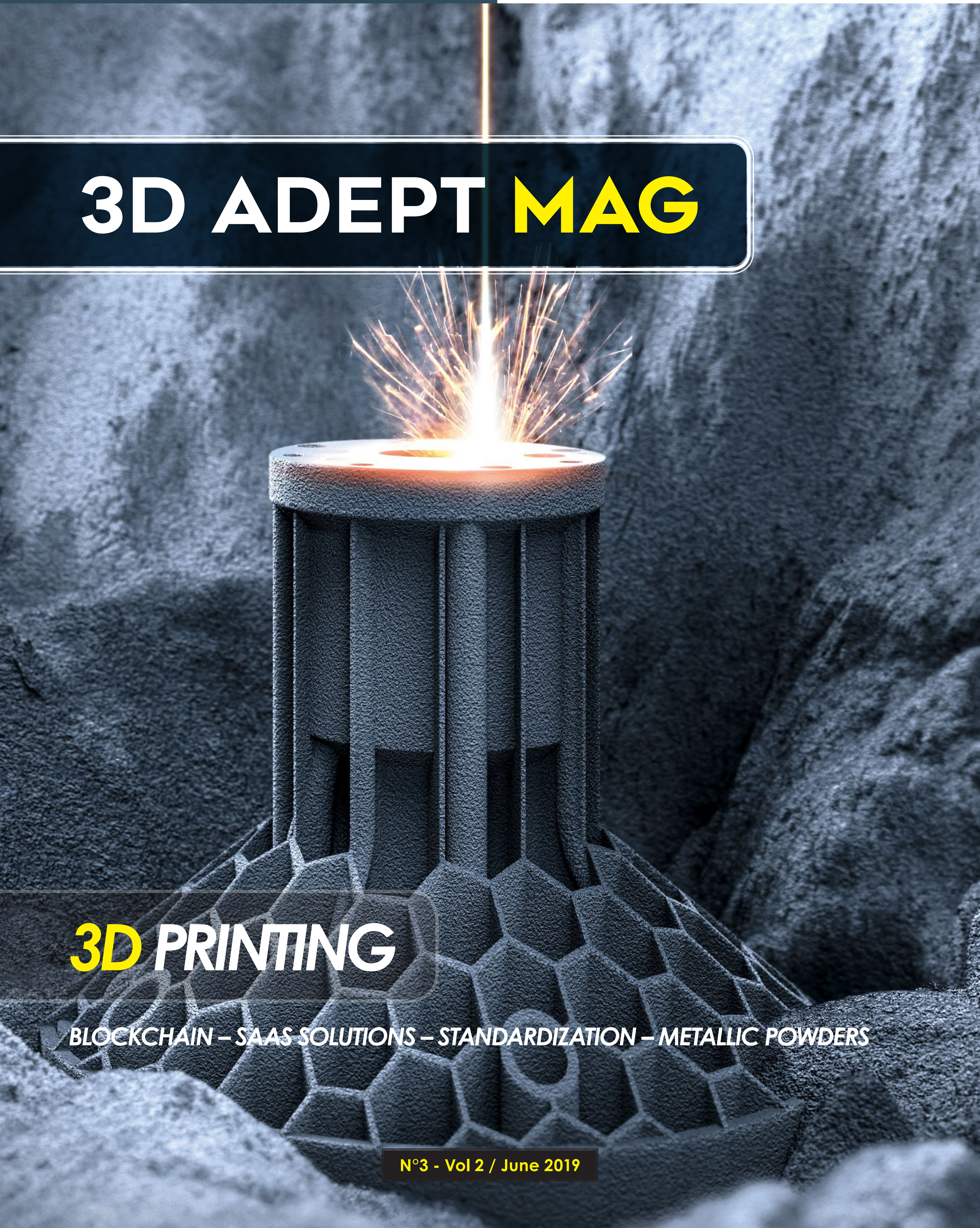
3D ADEPT MAG



3D PRINTING

BLOCKCHAIN – SAAS SOLUTIONS – STANDARDIZATION – METALLIC POWDERS

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3D Adept Mag
ADDITIVE MANUFACTURING/ RAPID PROTOTYPING/ TECHNOLOGICAL INNOVATIONS

Edited by
3DA Solutions
Creative Director
Benell Delano
Editor in chief
Kety Sindze
Graphic Designer
Martial Y., Charles Ernest K.
Editorial team
Laura Depret, Yosra K., Yves Marcial D.
Proofreaders
Jeanne Geraldine N.N., Laura Depret

Questions and feedback:
Belgium / Rue Borrens 51 - 1050 Brussels
Phone: +32 (0) 4 89 82 46 19
Email: contact@3dadept.com
Online: www.3da-solutions.com
www.3dadept.com
3D ADEPT SPRL
VAT: BE / 0681.599.796

Editorial

Playing by the same rules

In every game, there are three main points: a starting point, a purpose and a set of instructions that tells you what you are allowed to do and what you are not allowed to do.

When we look around us, we realize that in everything we do, in every activity we undertake, there is at least one basic rule. In the additive manufacturing industry, it's the same.

The general principles governing the additive manufacturing industry are well known and enable the players to find their bearings. However, an array of instructions still needs to be established but, in the meantime, players are following their own rules, and are ensuring they meet the best their market.

In different ways, in different cases, we have addressed this issue and have analyzed the current evolution of additive manufacturing in different sectors such as standardization, blockchain, SaaS solutions and materials.

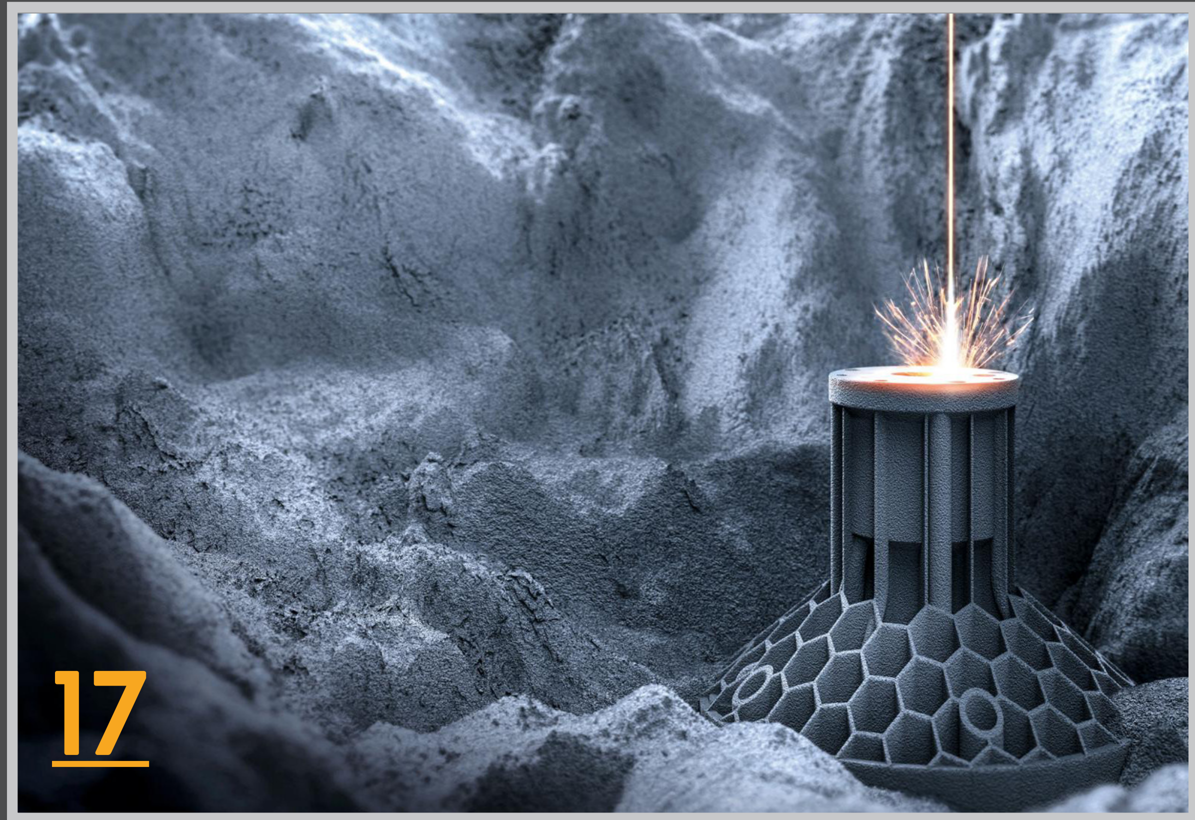
Moreover, with summer around the corner, and the excitement of fashion-addicts during this period, it was impossible to not mention the current role and stakes of 3D Printing in the advancement of this industry.

Enjoy your time with us,

Kety

Contenu

N°3 - Vol2 / Juin 2019



Additive Manufacturing

With contributions from

LEO Lane, Identify3D & DigiFabster.

How to choose a SaaS solution for additive manufacturing?

The more digitalization increases, the more SaaS (Software as a Service) solutions evolve and become valuable assets for businesses. One advantage we all agree with, is their ability to integrate alongside and ideally inside the applications a company uses on a daily basis. In the additive manufacturing industry, we still wonder why they are so valuable and how companies can select the SaaS solution that best meets their needs.

*We have discussed this dossier with **LEO Lane, Identify3D** and **DigiFabster**.*

Simply put, LEO Lane controls, protects, and tracks additively manufactured products files.

***Identify3D** provides its customers with software solutions that addresses their security, IP, quality, authenticity, and traceability needs.*

DigiFabster's software on the other hand, emulates the actions and work-flow of a sales engineer. The software does not generate any g-code to figure out the cost of a part to the last digit before offering -and neither would the sales engineer- but the cost is worked out by the rule of thumb. Once the offer is accepted, the real investment in engineering labour can be calculated to optimize production costs and product quality.

Let's start from the very beginning. A SaaS solution is an application/a software distribution model in which a third-party provider hosts some applications and makes them available to customers over the Internet.

A survey from BetterCloud, a SaaS Operation Management platform, showed that, two years ago, companies used an average of 16 SaaS apps, 33 percent up from 2016, and 73 percent of organizations say nearly all their apps will be SaaS by 2020. However, the additive manufacturing landscape tells another story.

Even though the role of SaaS solutions is undeniable, it remains confusing for companies to select a SaaS solution, either because of lack of knowledge or because of lack of matches.

First, beginners in this industry should know the difference between a simple software used in AM and a SaaS solution. Software often include Design and CAD Software, Simulation Software, Workflow Software as well as Security/IP software. That's the first step to know in which category falls the SaaS solution they are looking for.

Secondly, to achieve an appropriate match between a company's need and a SaaS solution, there are usually four measurable aspects users take into account: availability, reliability, scalability, and security.

How do experts see these measurable aspects

In order to find the "flavour" that is appropriate for a particular company, Lee-Bath Nelson, Co-founder and VP Business at LEO Lane gives an interesting view on the benefits of SaaS solutions in general and the features to consider in the AM industry:

"In general, the main advantages of SaaS solutions that everybody knows include: the fact that there is no need to install anything, the flexibility of the solution, the fact that the software is always up-to-date and can be updated without disrupting the company's work.

In Additive Manufacturing (AM), SaaS has special advantages where the knowledge and the ecosystem is so fragmented. Throughout the workflow, there can be many contributors and one important advantage is that none of them has to install anything to use the software and they can all be sure they're using the same, compatible version of the (SaaS) solution.

With regards to the different features a company should consider before choosing a SaaS solution, there are two key issues all companies have to check. The first is to check that the chosen software solution is compatible with their corporate policies and procedures, and make sure that these policies are not disrupted by the chosen software. Secondly, check that the selected software solution can integrate easily and quickly with all the existing software in the company. Those are two key issues and, for service providers (3D printing service bureaus), I would add that it's important to consider their customers' corporate policies as well. One of the best examples of a corporate policy to consider when it comes to SaaS is how the solution handles files. Companies have many corporate policies around files (back-up, redundancy, security, etc.) so they often don't mind SaaS software but they don't want their 3D printable files to be saved in the vendor's cloud."

Lee-Bath Nelson

Mistakes can happen, said **LEO Lane** so do disasters. That's the reason why Peter van der Zouwen, CPO DigiFabster, Inc laid emphasis on availability; in other words, the responsiveness of the support and the development teams. For DigiFabster, users should look at how the provider is equipped to handle disasters. Taking example on their team, he explained that DigiFabster has a median first response time of 4 minutes, as monitored by Intercom and implements on average 3 user-suggested enhancements per week.

Joe Inkenbrandt, CEO of **Identify3D** shares an insight into what their customers expect from a SaaS solution provider and this can be summarized into three words: security, repeatability and traceability. Obviously, expectations vary from one customer to another, and are influenced by a specific AM technology. Taking the example of 3D printing service bureaus, the co-founder of Identify3D explains that:

Joe Inkenbrandt, CEO d'Identify3D

"customers worry about their IP. That's why, they want to make sure that their digital supply chain is secured throughout the entire process. As far as repeatability is concerned, they want to make sure on the way we manufacture their product using a 3D printer. Two years from now for instance, if somebody else attempts to print it, he should be able to make it exactly the same way that it was made before, with the same quality. As for traceability, we should be able to record and account everything that was manufactured on-demand."

Speaking of security for instance, a few examples of areas to discuss with a SaaS provider include the use of managed servers, compliance with acknowledged information security standards, encryption methods used for all communications, separated data storage for each customer's information or even the use of international data centres to meet local regulations and ensure there is no need to transfer customer data out of the country of origin.

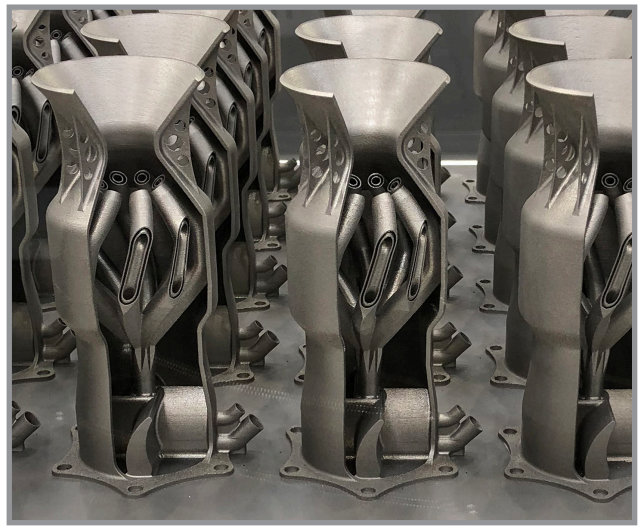


Image - LEO Lane3D

Issues and critical applications

Although one might think that SaaS providers share the same issues and concerns in their journey, they do not. This can be understandable since there are various types of SaaS solutions. Participants in this dossier share different issues they might face when providing their clients with their services.

Let's start by **DigiFabster**. To better explain their challenges, Peter van der Zouwen first describes their services:

"Our goal is to increase our customers' turnover and lower their sales overhead. We're not involved in, for example, optimizing scanning strategies for laser applications (metal AM, SLS) or g-code generation (FDM, CNC).

At the beginning of the sales cycle for a printed part, a lot of time can be spent by both parties figuring out what the other party's abilities and wishes are. Transparency policies on the purchaser's side lower the odds that this investment in time will pay back: as a rule, there are at least 3 suppliers invited for every RFQ, so it's a 3:1 gamble against the supplier when he invests in labor for quoting.

Since these costs have to be recovered somehow, they will end up in the price of the next offer, thereby lowering the probability that, that offer will lead to a sale. This vicious circle can be broken with a quoting software like DigiFabster's, which reduces the cost per quote to a fraction of a man-made quote.

DigiFabster's software emulates the actions and work-flow of a sales engineer, but much faster and thus cheaper. The software does not generate g-code to figure out the cost of a part to the last digit before offering -and neither would the sales engineer- but the cost is worked out by the rule-of-thumb. Once the offer is accepted, the real investment in engineering labor can be made to optimize production costs and product quality."

Peter van der Zouwen, CPO DigiFabster

Moreover, vis-à-vis their customers, data collection is often misinterpreted in DigiFabster's work. The company explains: *"given our data structure it is mainly a point of perception, we do not, for example, gather credit card information, but the idea that this could be an issue keeps potential customers and end users away."*

Lee-Bath Nelson on her side, did not mention any issue LEO Lane might encounter in its journey. Speaking of SaaS solutions in general and what's crucial for users, the co-founder laid emphasis on the fact that "not holding the file" is a major issue.

"It's an issue of integrity and keeping the file correct and consistent without anybody changing it by mistake.

To carry on the file example, some SaaS software require the user to hold the file with them or in a dedicated appliance (on premise or in the cloud) and that's not desirable for most corporations. If you are holding files in the cloud, then corporations usually require some form of extra security, not just a standard encryption... and that's also something to consider.

On the other hand, some SaaS software, like ours, can manage this without holding files thanks to a sophisticated yet simple architecture. In these cases, adoption is much easier in terms of corporate policies.

When you move to AM production in a corporation, you must have corporate-grade solution in place. We make sure that the AM process is secure, consistent (repeatable), and tracked. Consistency enforcement means parts can only be manufactured in a way that they were specified by the expert yielding consistent parts regardless of when or where they are produced. This is crucial for a brand's reputation."

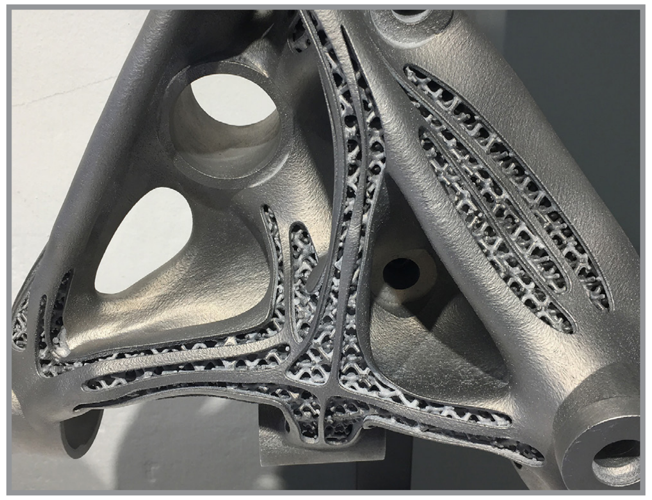


Image LEO Lane– Metallic 3D Printed support

Looking ahead

The more SaaS companies proliferate, the more hyper-specialization is observed within the industry, and arguably that's a good thing because companies that are only looking for satisfying customer needs along while lowering and containing costs, needs a certain level of expertise to address their use cases.

That's why, rapid prototyping services should increasingly take advantage of software solutions offered by the market, in order to provide their customers with reproducible and quality 3D printed components.

If you are a software buyer, and if you need to know more about the hundreds of solutions that build this market segment, we also recommend to read reviews on comparison sites which are also of a great help.

Furthermore, in this challenging environment (challenging with regards to competition and companies), one expects a SaaS solution to run relatively quickly. In the additive manufacturing industry, considerable improvements have been observed in data security for SaaS services. At this point of digitalization, it would be impossible not to mention GDPR. Every SaaS user must ensure its existing and potential customers know about its corporate policies and procedures.

Lastly, cloud adoption - especially SaaS - is showing no signs of slowing, since almost every organization utilizes some form of cloud service. However, whilst organizations are stepping up their SaaS usage, they are also grappling with an array of complexities regarding the cloud's modus operandi. But, that's another story.

Interview: Nikon

Metrology & additive manufacturing: Nikon becomes a manufacturer of metal 3D printers

Yoshiki Kitamura

MarCom Supervisor, Marketing section, Business Planning Department Semiconductor Lithography Business Unit & Corporate Branding Section Corporate Communications Dept. Corporate Strategy Division, NIKON CORPORATION

For the average consumer, Nikon is the company that helps him capture the essential moments in his daily life by providing optical lenses (including those for the first Canon cameras) and equipment used in cameras, binoculars or even microscopes. For companies, Nikon is one of those players that brings a significant contribution in the resolution of industrial challenges. In the additive manufacturing in particular, Nikon is known as the supplier of inspection and metrology equipment.

The Japanese manufacturer has recently added a new core business to its activities in the additive manufacturing industry. By combining its expertise in inspection equipment to the requirements of additive manufacturing operators, the company has developed its first metal 3D printer.

Before talking about the metal 3D printer, it was important to first understand the link between, metrology and additive manufacturing, and what explains Nikon's move in the manufacturing of 3D printers. #OpinionoftheWeek

Metrology for additive manufacturing

There are various metrology methods: X-ray computed tomography (XCT) for defect detection, surface structure and morphology characterization, as well as microstructure characterization.

There's not enough data for designers and manufacturers to accurately predict the performance of some 3D Printed parts, measurement methods therefore come into play to help achieve this prediction.

Furthermore, in order to make factories faster and flexible, inspection is absolutely necessary. In other terms, the more companies take advantage of measurement methods in AM, the more they will be able to work in an Industry 4.0 environment.

As far as Nikon is concerned, in addition to its measurement products, the company has recently unveiled its first metal 3D printer Lasermeister 100A and has celebrated the opening of a Lasermeister Technology Center in Nikon Kumagaya Plant. The center offers both a practical experience on metal processing experience and advice to users. Moreover, the company uses its original calibration & metrology technologies to facilitate operations within the AM industry.

Explaining the move in the manufacturing of 3D Printing technologies and the focus on metal 3D printing technology.

For several years, Nikon has been involved in the development, manufacturing and sales of semiconductor lithography systems .

Using this expertise in advanced optical technology and precision control technology, the company wanted to go further in new technologies, and chose a field of activity whose potential in the upcoming years has already been stated: Additive manufacturing, hence the development of this smaller sized and less expensive processing machine.

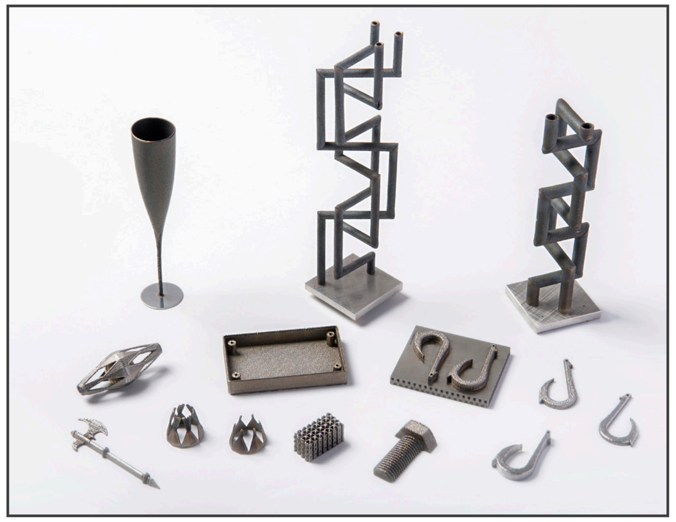
The choice goes for metal 3D printing because plastic 3D printers are widespread enough. For the company, *"metal 3D printers are so large, heavy and expensive, that they are not [yet] widely used. One main reason that explains that is the expensive cost of optical components."*

How does the 3D Printer distinguish itself among others of the same range?

"This optical processing machine is a Nikon's proprietary metal processing machine that performs various metal processing with ease and with high precision using laser. Its capability encompasses not only additive manufacturing as a 3D printer, but also, laser marking & welding and even polishing.

The Lasermeister 100A requires no cumbersome "initial set-ups" that are typically performed for metal processing machines because it automatically recognizes the part and automatically starts processing it."

Nikon is offering the market a 3D printer that can satisfies several targets. With 1.7 m in height with a footprint of 0.64 m2, the 3D printer does not require too much place and is convenient for projects in R&D facilities, companies, schools or in a simply office.



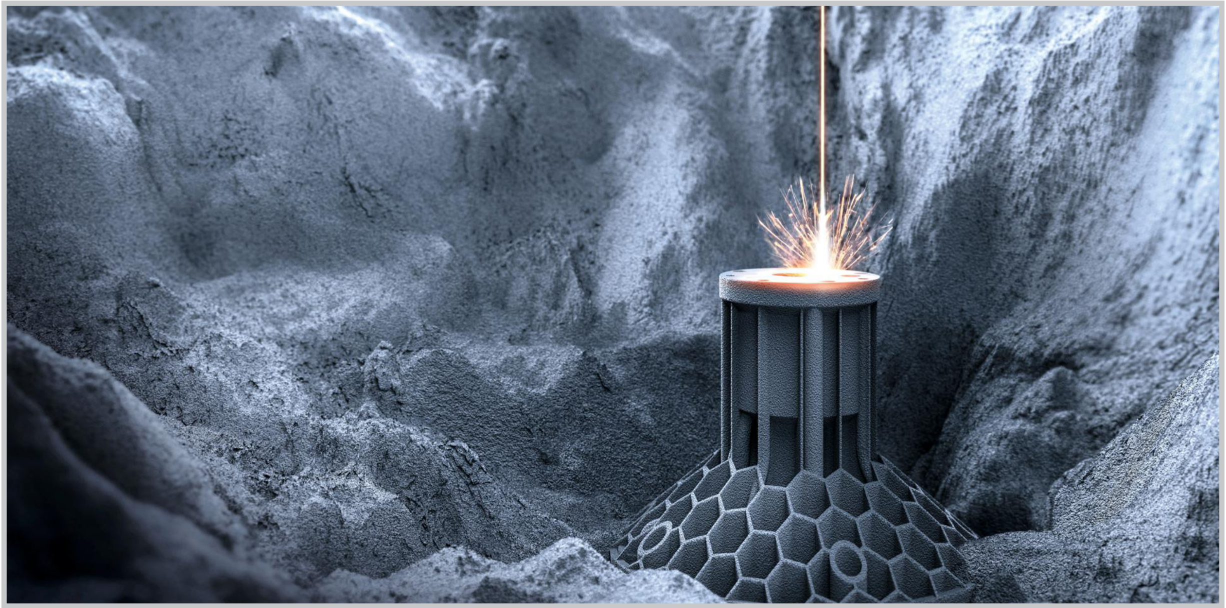
Availability of the 3D printer

For now, the 3D Printer is only available on the Japanese market. The Japanese company will definitely sell this product in other countries in the US and/or in Europe in the future but timing is not yet defined about that.

In the meantime, the company strongly believes that conventional metal processing machines conjure up the image of being “big” “expensive” and “hard to use.” An image that the Lasermeister 100A is going to drastically change by providing an affordable solution to a wide range of people and industries.

Materials

The impact of metallic powders on the final part



Metal powders are the base materials for powder metallurgy operations such as uniaxial pressing and some types of additive manufacturing processes. These operations have already demonstrated that somehow, metal powders characteristics play a big role in the properties of the end-product. This role necessarily depends on the quality of the material, the printing process and costs (material cost vs cost of the printed part). This article will discuss these points.

There are various techniques to produce metal powders and each of these techniques delivers a unique morphology and properties to metal powders. Despite these differences in the way they are produced, metal powders must include properties that ensure repeatable manufacturing of metallic parts. Indeed, metal powders designed for additive manufacturing are spherical and their particle size distribution aims to ease good packing behavior. This way, the finished printed part integrates desired mechanical properties. However, before getting to the end-part, there are too many factors to discuss. One of these factors is the quality of the powder vs its price.

Does the quality of the metallic powder impact its price?

Materials price is definitely an important issue for manufacturers because, as we said earlier, they constitute an essential part of powder metallurgy operations. So, their choice matters to achieve the desired finished part.

Furthermore, given the fact that, in the additive manufacturing industry, metal additive manufacturing remains one of the most expensive additive manufacturing technologies, manufacturers often believe that purchasing a "cheap powder" would not affect the quality of the finished product.

First, the term "cheap" might be tricky itself, because, before anything else, a product is often considered "cheap" according to the buyer's budget. Furthermore, it goes without saying that the price of a specific metallic powder varies from one producer to another, and obviously, this price is based on the quality of the metallic powder.

For **LPW Technology,** a materials producer, quality *"means consistency of supply, full traceability and reliable material performance. Consistency of supply and traceability are factors which are controlled by robust Quality Management Systems, optimised manufacturing methods and trusted supply chains".*

In general, features that enable to profile powder specification and quality include physico-chemical properties, chemical compositions and purity, morphology, apparent or packed density, specific surface, granulometry, and grain porosity.

According to **Valentina Vicario**, Technical Manager of **MIMETE**, producer of metal powders, among all of these features, *"the first feature that impacts the powder price is obviously chemical composition. Usually Fe powders are less expensive than Ni, Co and Ti-base ones. Inside every "family" of alloys, there are expensive alloys, usually customized and/or characterized by special combination of elements, and other "commodities", less demanding and more widely spread. In general, the more numerous and stricter are requirements on different powder properties (chemical analysis, granulometric range, density, etc.), the higher is the cost, because special customized processes are required and production planning can be heavily affected."*

Another aspect that can influence the choice of a specific metallic powder is the ability to reuse a batch of material. The user or a specific industry standard can determine the number of times a material can be reused but properties delivered in the printed parts (material performance) will be the key performance indicator of the powder's quality.

Valentina Vicario from **Mimete** precises that *"powder recycling is possible, but can be applied only for some alloys and for some applications. After a first usage, depending on printing parameters (i.e. protective atmosphere), powder can be affected by oxidation and agglomeration: a sieving is always needed to remove clusters and deformed particles before a new printing process, while higher oxygen content might theoretically reduce mechanical properties of the parts printed by the second cycle."*

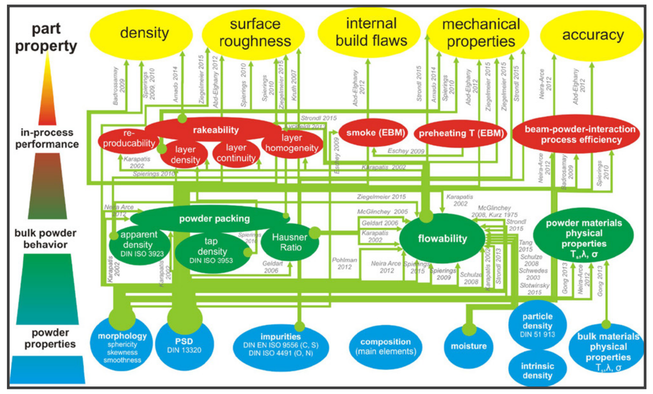
Speaking of metal powders designed for additive manufacturing, LPW explains in a case study that: *"Oxygen levels in powder are primarily driven by oxygen levels in the feedstock material, the process parameters and gas purity used during atomization. For this reason, it is typically more costly to produce powders with low oxygen levels. It may seem more cost effective to use powder with a higher oxygen content but at a lower cost, but this is only true if a user does not consider reusing the metal powder."*

LPW & Mimete raise through these statements, another issue that impacts both the price of a metallic powder and the price of the printing process: gases.

The impact of metallic powders on the finished printed part

During an interview, Pierre Forêt, Head of the AM unit at Linde, told us that customers often worry about the purchase of metallic powders – especially titanium whose price can go up to 300€ per kg. Speaking of one customer that needed to buy a significant amount of powder, he explained that, *"in addition to be expensive, the powder is very sensitive to humidity, which means that it is easy to lose the essence of the powder; and that will definitely impact the printing process. In order to avoid this waste of money, the ideal solution was to develop a system that could both spur the powder and remove humidity."*

Mimete reminds that powder properties have a strict relationship with final printed part features. Multiple and complex correlations can be found as demonstrated by the chart below:



Let's take the example of Powder-Bed AM technologies, which are the most common used metal AM techniques within the demanding industries. Powder-Bed EBM is one of the rare technologies that can achieve full-density metallic parts.

The density of the powder layers as well as the porosity of the particles themselves are important factors for this printing process. Indeed, true density is an inherent property of a material, while apparent density takes into consideration any occluded voids within a material.

Users should therefore be aware of the true and/or apparent density of a material feedstock since it allows to achieve powder bed formation and sintering kinetics in the AM process as well as the porosity, or lack of porosity in the end product.

What about the final cost per part?

Several factors can influence the final cost per part. Additive manufacturing systems, machine data, materials, construction job parameters, consumables data or even operational calculations are some of the factors that can influence the final cost per part

At the materials level, it should be noted that AM technologies can be complementary. Indeed, manufacturers can take advantage of the benefits brought by two technologies. Furthermore, the increasing use of AM may result in a reduction in raw material cost through economies of scale.

According to **Thomas Douglas**' research on *"Costs, Benefits, and Adoption of Additive Manufacturing: A Supply Chain Perspective"*, *"the reduced cost in raw material might then propagate further adoption of additive manufacturing. There may also be economies of scale in raw material costs if particular materials become more common rather than a plethora of different materials."*

As far as metal AM processes are concerned, Mimete believes that, *"the cost of the powder might affect the final cost of the part from less than 10% to 20-30% depending on the alloy and the complexity of the printed component."*

LPW Technology on the other side, explains that two other key factors that influence the final cost per part are the number of viable builds that can be completed from a single batch of powder, and the number of parts that can be produced in each build. *"The number of parts produced in a single build depends on the size of the part and the size of the available build volume. The number of builds that can be completed for a single batch is dependent on how quickly the powder breaches the specification limits. At this point we must consider the influence of powder evolution, how a material varies from initial specification."*

In a nutshell...

Cost has always been (and will certainly always be) the holy grail for OEMs and other industrials. There are too many factors to take into account, and every choice should be made wisely.

At the materials stage, controlling the dimensional characteristics is one of the main reasons that explains the success of powder metallurgy processes, and AM processes in particular.

In other terms, controlling the characteristics of materials in additive manufacturing should enable professionals to produce high volumes of duplicate parts with desired properties, and of course at a reasonable price compared to other metal-fabrication processes. So far, demanding industries such as automotive or aerospace have been able to take advantage of this solution.

Is Additive Manufacturing ready for Blockchain?

Three years ago, the integration of blockchain in additive manufacturing processes was an idea that professionals had not studied yet in-depth. In 2018, companies really started sharing the first applications of Blockchain in additive manufacturing processes. However, so far, the concept remains vague and uncertain for additive manufacturing operators. Hopefully, this article will remove these uncertainties.

Blockchain is seen as a chain of records stored in the forms of blocks that no authority controls. The first link with additive manufacturing is that, blockchain is resistant to data modification. It is an open, distributed ledger that can record transactions between two parties efficiently and in a permanent way.

While blockchain is mostly known in the financial world, enthusiasts are also trying to determine its potential in the AM industry. They believe that it can make additive manufacturing more accessible to industrial and supply chain managers around the world on the one hand, on the other hand, it can solve the problem of data storage for complex and certified parts. In other terms, to add value to the "digital thread".

What's that digital thread?

According to an analysis of Deloitte on "3D Printing opportunities for blockchain", *"for AM processes to scale at the industrial level, a series of complex, connected, and data-driven events likely needs to occur. In this way, successfully deploying AM is less a physical- or hardware-associated production challenge and more a data- or records-management one. This is referred to as the digital thread for additive manufacturing (DTAM)".*

The digital thread can therefore be considered as this crucial box "that carries information" throughout the manufacturing process. Such information are data of the design, modeling, production, validation, use, and monitoring of a manufactured part.

The ability to exploit data as well as to manage intense computing demands, allows manufacturers to scale AM production.

When does blockchain come into play?

One essential use of AM among 3D printing service bureaus suggests to implement a distributed model across a number of partners around the world. This AM supply chain is only possible thanks to the transmission of data and interconnectivity.

In that sense, the DTAM includes other technologies such as topology optimization and advanced Multiphysics modeling to enable true product innovation.

"In the same way that the DTAM supports both supply chain scale and product innovation, the blockchain for AM has the potential to serve as a backbone and security layer for the DTAM, underpinning all of the transactions that occur throughout the digital and physical life cycle for AM", explained analysts from Deloitte. It really looks like a chain of trust between stakeholders.

The chain of trust and its advantages

A group of scientists that published the study, *"Intellectual Property Protection and Licensing of 3D Print with Blockchain Technology,"* explained that a license can be issued to specific users to print a certain number of parts. Speaking of "Chain of Trust" between several parties including trusted printers, copyright holders and service providers, they explained that such type of process is built from the development of digital 3D data to the labeling of 3D printed components with RFID chips.

In other terms, if everyone in the database, uses the same blockchain database, it would drastically improve transparency at the global level in the AM network.

The concept of trust also lays emphasis on a certain validation of a given 3D printing technology. Let's take the example of GE Additive, a company that leverages blockchain in its AM processes:

When a third-party reproduces a replacement part for an industrial player, end users cannot verify whether the replacement part *"was produced using a correct build file, using correct manufacturing media, and on a properly configured additive manufacturing device."*

For GE, "It would therefore be desirable to provide systems and methods for implementing a historical data record of an additive manufacturing process with verification and validation capabilities that may be integrated into additive manufacturing devices."

However, this concept of trust between parties is controversial. While researchers talk about building trust between stakeholders, the audit firm Deloitte explains that trust still needs to be strengthened. For the auditing firm, the blockchain technology does not eliminate the need for trust between parties. *"It replaces the existing mechanism for gaining trust (bank, escrow, and so on) with cryptography, and maintaining that trust is not cost-free. The method via which trust is achieved is called the consensus mechanism, and the cost is referred to as the incentive structure—how the maintenance of trust is sustained. These are the two fundamental pillars of blockchain, referred to as the consensus mechanism, and an incentive structure to sustain the expenditure of effort for that validation to take place and continue. The exact features of those two elements are tailorable across different ecosystems, but the success of the protocol often depends on those two foundations."*

Security, obviously

It seems obvious, but remains important to mention. Once the chain of trust is installed, partners can evolve in an extremely secured database. Such type environments require the use of cryptography for validation of transactions which offer protection against risks of unauthorized data access. Military applications for instance, require a maximum security. The US Navy uses the blockchain technology to exchange 3D files in a safe way. The good news is, data are encrypted, which removes any risk of hacking. The bad news is that every action is irreversible. Actions can't be modified or deleted.

Getting faster

Another advantage that derives from this chain of trust is speed. In AM, one advantage that manufacturers use to highlight is that, once a part is designed and the 3D file ready, it can be reproducible on a wide range of manufacturing systems. With the integration of blockchain, this advantage is even blatant. Indeed, since there is no need for data mining, manufacturing processes are nearly instantaneous.

This being said, this argument can also be seen at a global level. Companies increasingly implement distributed networks of 3D printers. Blockchain remains the ideal common thread of these 3D printers as the technology enables to connect several 3D Printers.

Where is the market?

The use of blockchain in the AM industry is still nascent. The technology itself has evolved because, it was firstly used in the financial world.

However, despite this progression, only five companies out of twenty in the AM industry can effectively say they take advantage of this technology. For now, these companies do not see other advantages rather than the ones mentioned above.

That's a good point to the extent that companies still have time to make up for it. However, it can also be seen as a limitation and the blockchain could be labelled as a technology that does not have any future.

So, in order to reply to the very first question, let's say, additive manufacturing does seem ready to integrate the blockchain technology, but that wasn't maybe the good question to ask. The good question would have been to know if AM operators are ready for blockchain.

Focus on Standards for Additive Manufacturing

Where are We?

Every major progress achieved in the Additive Manufacturing industry comes with an array of challenges that might slow the wider adoption of this technology in industrial environments. An accurate observation demonstrates that, at the heart of these challenges, there are standards. Companies keep innovating, but seem to take one step forward and two steps back because of a lack of points of reference. And yet, organizations do exist, do follow the various roads that AM technologies are taking… So, let's take a deep breath to discover where the market is.

Speaking of standards is not very 'sexy" for a debate but it is a necessary one since it provides a basis on which the industry might be built. So, to avoid any confusion, we refer to "standards" as those technical methods, processes, specifi-cations, and definitions with respect to a sector of activity on which a general agreement has been promulgated by recognized standards organizations.

Let's be clear. We will not talk about the technical specifications of every method, only about the framework that enables the industry to move forward.

Vincenzo Renda, Innovation Policy Officer at **CECIMO**, the European Association of the Machine Tool Industry and related Manufacturing Technologies, has provided key answers to our questions in this paper. In a few words, the innovation policy officer, is responsible for EU Additive Manufacturing, policy advocacy, engaging with the European Institutions and stakeholders on various issues including skills, standardization and market access requirements.

We met Vincenzo at the conference "3D Printing within the Plastics Converging Industry" that took place on May 14th at Brussels.

Organizational structures for AM Standards

There are a lot of organizations that are in charge with developing a consensus for AM standards. The well-known structures are: ASTM International, ISO – International Organization for Standardization, Nadcap, ANSI – American National Standards Institute, SAE international, ASD-STAN, bsi., and NIST.

Even though some of these organizations have offices worldwide, it should be noted that standards differ from one continent to another.

However, experts plan to define a common roadmap for Europe & the USA regarding the application of 3D Printing technologies.

So far, among the joint standards that are currently being developed, one notes: ISO TC261 and ASTM F42. The two organizations (ASTM & ISO) have agreed to normatively reference their standards in the publications of the other. According to ISO website, the working group that includes 23 participating members and 9 observing members has already published 9 ISO standards and are developing 25 other ones. These standards mainly concern specifications for Extrusion Based Additive Manufacturing of Plastic Materials.

In the European market in general, only 23 international standards are already released (for terminology design, powders, materials, test methods, health and safety) and 40 more standards are in progress.

ASTM F42/ISO TC 261 Develops Additive Manufacturing Standards

Key factors to consider while developing AM standards

At the European level, organizations take in charge 4 main features in the implementation of a standard: compliance, right level of regulation, trade deals and product nomenclature.

First, compliance. Products manufactured within the European Union usually have the CE-mark. However, as mentioned in the Bonus Topic of 3D ADEPT Mag – April Issue, medical devices show other constraints regarding this issue.

Right level of regulation. This seems obvious when we take into account the increasing number of counterfeit risks. Both companies and individuals are increasingly looking for solutions to exercise their intellectual property rights when it comes to their technology or files.

As far as trade deals are concerned, it is no secret that the additive manufacturing industry is an industry that is both globally & locally based. Even though there is an increasing interest in the Asian market, for now, there are a lot of regulations that are currently being implemented regarding AM Trade barriers; regulations in terms of double certification and costly conformity assessment. As a matter of fact, the EU-US industrial good deal is a recent example.

Lastly, product nomenclature. New codes are required to track AM machine exports more accurately.

Challenges & benefits of standards application to AM

Deloitte's recent report on standardization for AM points out 4 great benefits when applying standards to AM: Mitigating and controlling risks, Greater efficiencies, Improved repeatability and More consistent quality.

However, three main challenges still remain at the levels of **materials, process control and certification.**

Let's take Metal AM for instance. Metallic powders are used by various demanding industries but materials experts keep underlining that there are still a lot of standards that do not exist for these materials. As a result, manufacturers cannot for instance determine all values. Furthermore, due to the lack of 3D printing material specifications – which definitely affect the way the part is manufactured -, there is also a certain limitation in terms of design and process control data.

Figure 2. Four benefits of standards application to AM

Source: Deloitte Insights.

Deloitte Insights | deloitte.com/insights

Some companies believe that, one way to overcome this challenge (at least, to partially overcome it) is to adopt existing standards, that have been implemented for conventional materials. However, it should be noted that, this solution cannot be applied in its entirety as there is a big difference between the mechanical behavior of AM parts and conventionally made counterparts.

Lastly, if certification requires time and resources, process control mainly highlights the inability (or unwillingness) of some manufacturers to share data on process variable optimization which may affect some properties of 3D printed parts, hence the need of collaboration and open platforms.

To sum up, there is still a long way to go to achieve standardization for all AM-related issues. The good news is that, companies rely on partnerships/collaborations to move forward.

INTERVIEW KEYVAN KARIMI

CEO of AMFG

Autonomous Additive Manufacturing: AMFG's software solves volume problems in the market

As additive manufacturing technology continues to evolve, so too will software solutions from companies. Taking advantage of real-time production data alongside machine learning algorithms to obtain accurate insight into a specific manufacturing process might still seem a distant concept for some companies — but not for AMFG's customers.

The company was founded in 2014, when the industry's main challenge was innovation. Over time, while companies have proven their ability to innovate, their innovations have led to other issues among OEMs. One of these issues is the scalability of additive manufacturing (AM) processes. In order to tackle this issue, software companies such as AMFG are striving to make AM autonomous through automation. The London-based companyprovides its customers with a single and modular software platform; a software solution that is available today in over 60 countries; a platform whose launch was a milestone towards a digitalized and autonomous AM process.

Keyvan Karimi, CEO of **AMFG**, is our guest in this Opinion of the Week. Unlike other Opinions of the Week, Keyvan will not discuss any specific topic today. By revealing the contribution of the company so far, he also reminds a striking point: the journey towards industrialization is not a solitary one.

Based on your customers' feedback, and speaking of software, what are the issues encountered by companies that want to take advantage of AM technologies?

The main challenge we see is that traditional software packages are disconnected. In other words, they lack consistency and traceability. As a result, the production process is slow and very time-consuming…hence the need to automate it.

How do you manage to provide your services?

Our software is a single platform that integrates different modules. How it is integrated into a customer's workflow depends on the needs of the customer. Before integrating our product into a customer's workflow, we first need to understand their business and how they intend to operate and scale in the future. Based on their needs, we identify the modules that best meet each process: manufacturing process, operational process, etc.

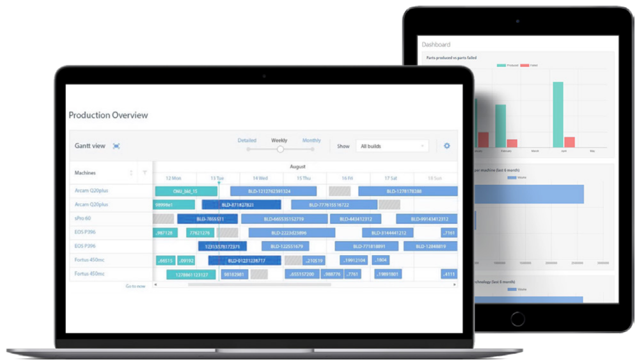
A customer that does end-part production, for instance, will have a different need from one who wants to use our software to manage their prototyping facility. Therefore, the modules we will supply won't be exactly the same for both customers. Indeed, end-part production will require good flexibility and repeatability of parts, whereas prototyping requires understanding the high variability of different parts, the different manufacturing requirements and different technologies. The operational process is also very important in this situation, especially if it is a service that is dedicated to prototyping.

So, one of our unique selling points is the flexibility we offer.

What are the main features of your software?

Our software solution connects and automates the manufacturing process. It enables the customer to save time during the production and it ensures quality control of the process and flexibility. So broadly speaking, we have modules that standardise the request management process, and streamline the production management and scheduling as well as post-processing management.

Simply put, our product only targets professional users, since we're solving a volume problem in the market. If the volume of a customer is just 100 parts, for example, then he will not really need AMFG's software. However, if a customer aims to scale up AM and wants to achieve bigger production volumes, our product will certainly bring great value. Our customers usually produce between 10 000 and a few million parts annually.



Is it compatible with all AM technologies?

We have technical integrations with a range of machines. Our product is generally used across both plastic and metal markets as well as silicone 3D printing, and we have a range of customers that come from different sectors. However, in terms of benefits, we realize that the volumes are much higher in the polymer 3D printing market.

What type of partners can you have in this industry and for which purpose?

As far as technology partners are concerned, we mainly work with software companies and hardware companies.

Our product is "a horizontal solution" and we can't always solve issues internally. Collaboration with other software companies enables us to address issues we can't address internally. - As a reminder, AMFG has recently partnered with LEO Lane. This partnership has enabled AMFG to improve its MES system by integrating LEO Lane's security solutions to its offering. On the other hand, LEO Lane has integrated AMFG's workflow management solutions into its customers' manufacturing processes. --

As for hardware companies, we work with companies that already use our product in order to improve it in their workflow.

You have recently opened an office in Germany. Do you have any other plans for expansion?

Germany is indeed a key market for us. Aside from that, we have offices in the UK, Eastern Europe and we aim to expand gradually globally. We also have a large database of customers in the US so our next location would probably be North America.

Your last word?

I will recommend any company that aims at scaling up AM to look at automation. Automation can really leverage the benefits of AM.

ADDITIVE MANUFACTURING

CASE STUDY

Met Gala : 3D Printing makes stars shine

Deepika Padukone in a metallic pink lurex jacquard gown
Credit : Getty Images

Nina Dobrev's bustier / Credit : Getty Images

A line of 3D printed sculptural garments and accessories showcased at fashion's 'biggest night out'.

"The Met Gala is special for designers because it's the biggest fashion event in the world", said **Zac Posen**, acknowledged fashion designer. This year, it has become even special for the additive manufacturing industry because of 3D Printing input in the creation of eye-catching original outfits.

Zac Posen, GE Additive and **Protolabs** collaborated to produce a range of innovative, sculptural 3D printed garments and accessories - inspired by the concept of freezing natural objects in motion.

A 6 month-collaboration to produce creations that should meet the theme 'Camp: Notes on Fashion'.

The more Zac Posen heard about 3D printing and digital technologies, the more he was intrigued and wanted to explore their potential. He had this opportunity while working with design engineers and 3D printing specialists from GE Additive and Protolabs. "I dreamt the collection, GE Additive helped engineer it and Protolabs printed it," said Zac Posen.

The teams unveiled four gowns, a headdress and a number of structural elements worn by Jourdan Dunn, Nina Dobrev, Katie Holmes, Julia Garner and Deepika Padukone.

The rose gown of Jourdan Dunn

After 1,100 hours of fabrication, British supermodel's gown integrates 21 total petals averaging 20 inches in size. Each petal weighs 0.45 kg (1 lb) and was attached to a Titanium cage additively manufactured using GE Additive Arcam EBM system. The 3D printed cage is invisible from the outside (as you can (not) see in the picture below). Made of Accura Xtreme White 200 durable plastic, the petals are finished with primer and color shifting automotive paint (DuPont "Twilight Fire" Chromalusion).

Nina Dobrev's bustier

A clear 3D printed dress, sanded and sprayed with a clear coat to give it a glass appearance. 3D Printed at Protolabs' facility in Germany, engineers chose an SLA system to produce the dress. Made of Somos Watershed XC 11122 plastic, more than 200 hours were required for both the printing and post-process.

Katie Holmes and the purple leaves

Katie Holmes' dress was simple and beautiful. The purple palm leaves that were attached to the gown constituted the perfect jewel. Produced using an SLA 3D printing system, the team used Accura 60 plastic to make it and finish the structure with pearlescent purple paint (Pantone 8104C). The printing and finish of the palm leaves took over 56 hours and was printed at Protolabs in North Carolina.

Katie Holmes and the purple leaves
Credit : Getty Images

Actress Garner in an ombré silver gown
Credit : Getty Images

Actress Garner in an ombré silver gown

Julia Garner's printed vine headpiece has leaf and berry embellishments. Made of Nylon 12 plastic, it was printed in 22 hours as a single piece on a Multi Jet Fusion (MJF) machine. The headpiece is finished by brass plating.

Deepika Padukone shined in a metallic pink lurex jacquard gown

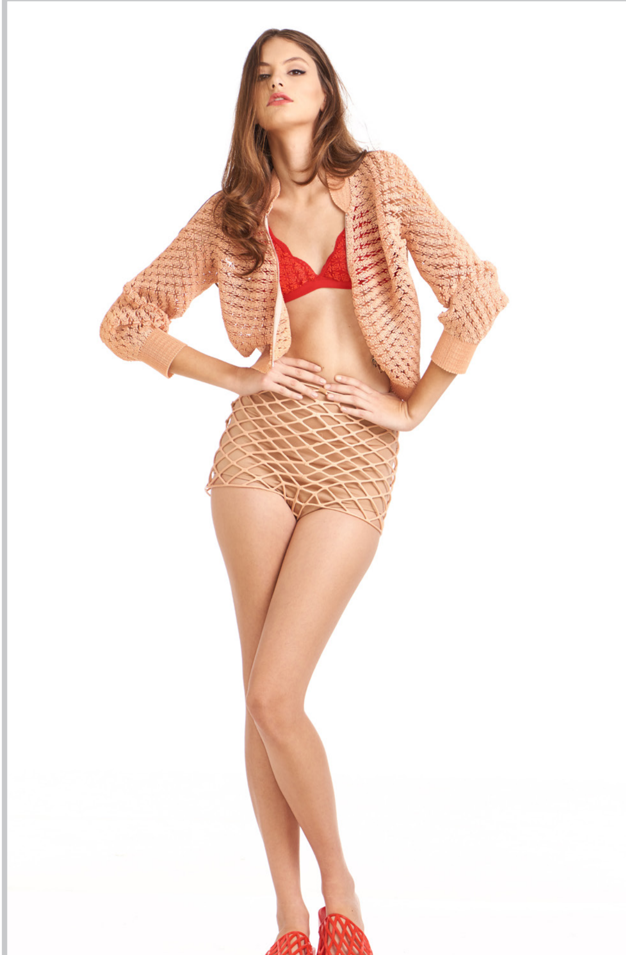
Embroidery was a key part in the manufacturing of this dress. Made of Accura 5530 plastic and printed on a stereolithography (SLA) machine, the dress took over 160 hours. The embroidery is vacuum metalized, and center painted with Pantone 8081 C. These 408 delicately printed embroidery pieces are attached to the outside of the gown.

From traditional fashion to modern fashion?

Fashion designers traditionally use hand-drawn sketches, before draping fabric on a mannequin to form and shape their creations. By combining conceptual thinking, tried and tested techniques from fashion design, computer aided design and 3D printing, GE Additive and Protolabs have been able to prove the potential of 3D printing in general, and their technology in particular in the fashion world.

As the companies said, *"what might seem like an unlikely collaboration of design engineers and Zac Posen - in fact makes complete sense when you consider the transformative impact 3D printing is having on our everyday lives."*

Bonus Topic



Crédit : Daria Ratiner

The Fashion industry in the era of 3D Printing

It's hard to say who was really the first designer to use 3D printing in the fashion industry. Some people give this credit to Iris Van Herpen who presented her first 3D Printed dress during the Haute Couture Paris Fashion Week in 2011. For others, this credit goes to Michael Schmidt who 3D printed a complete dress with Francis Bitonti. But, does it really matter? The most important is not to know who was the first designer to bring this technology in the fashion world, but above all, to be able to take advantage of the added value brought by this technology on the one hand, on the other hand, be aware of the way the technology is still disrupting this area of activity.

In this vein, we asked two designers their insights into this area. The first one is Danit Peleg. We have been watching the Israel-based fashion designer's activities for a few years now. The creator is known for launching the first 3D printed ready-to-wear clothing lines. What's even more interesting about her path is that she goes beyond the simple act of creation. Peleg launched last year master classes to help enthusiasts embrace the fashion world using 3D Printing.

Then comes **Sylvia Heisel.** Two years ago, we had a first talk with the designer. At that time, Sylvia Heisel had already brought a significant contribution to the industry, partnering with 3D printing companies and fashion companies to give life to events that highlighted contemporary design, art, fashion and new technologies. In 2017, she believed the fashion tech market wasn't that mature. Two years later, where are we?

The reality shows that 3D printing opens up a wide range of opportunities for fashion designers in the creation of innovative and futuristic designs. Like in demanding applications of the industry, going beyond the traditional boundaries of design is no exception in the fashion world. According to researchers from the International Journal of Fashion Design, five types of 3DP methods show a true potential in fashion: stereolithography, selective laser sintering, fused deposition modelling (FDM), PolyJet, and binder jetting. However, FDM and SLS seem to be the most used technology by designers.

Selective Laser Sintering enables to produce plastic parts by fusing plastic powder particles layer by layer, before the product cools down. As for FDM, the technology does not require any laser. Affordable, it remains the most used technology in the world of makers.

Danit Peleg for instance takes advantage of a farm of FDM 3D printers. She explained: *"I have a number of 3D printers that work simultaneously, and I've also recently begun collaborating with BlackBelt, a company that has developed a 3D printer with a belt, like a conveyor belt, that can print longer strips of Textile. The technology is improving every day, so I'm confident that the [long] process to print garments will [keep decreasing]."*

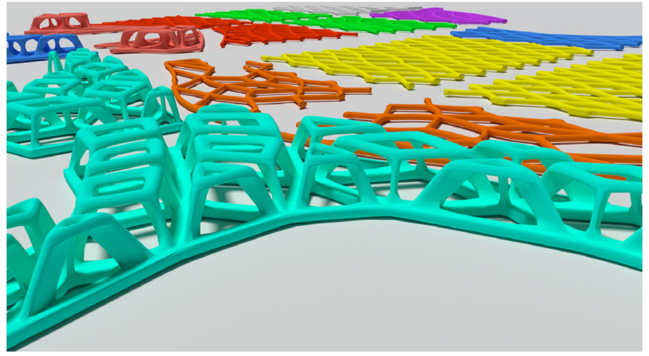
Even though she mostly uses FDM technology, Heisel is also open to use other types of AM technologies: *"[I use] mostly FDM right now but our philosophy is to use the best form of additive manufacturing for the project we are working on. Fashion includes a huge range of things and there isn't one type of manufacturing for all products or situations."*

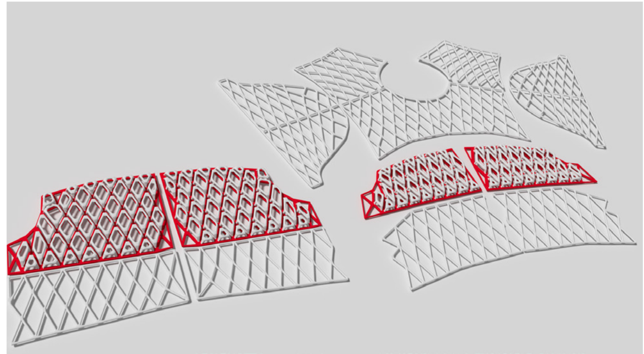
However, despite their willingness to create futuristic clothes, the use of 3D printing also comes with an array of challenges.

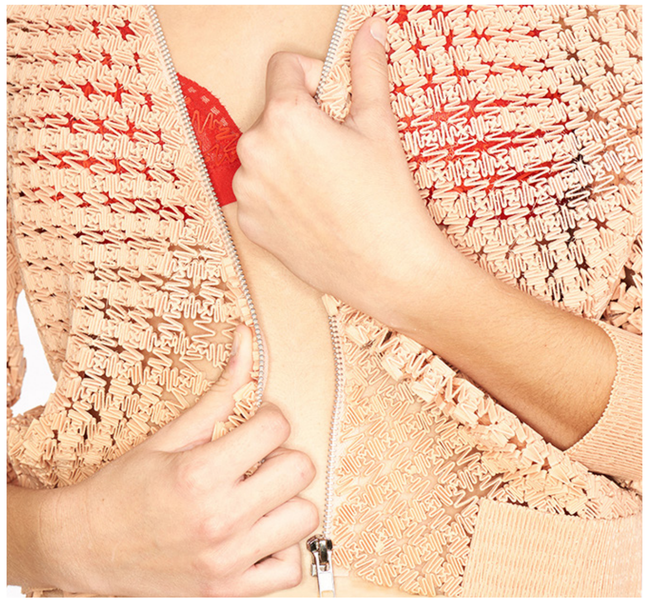
From personal challenges to common challenges

Challenges usually vary from one designer to another. However, in this specific case, our designers face the same issues at the manufacturing stage.

Heisel explained: *"very few currently available printers and materials were designed with fashion products in mind so we are constantly working around issues with printers and materials that aren't optimum for the things we're making. There is a lot of innovation happening in materials (recycled, flexible materials, colors) and industrial printing*







solutions (HP, Carbon) for fashion but we are still very limited by what is available."

This lack of hardware explains the current partnerships fashion companies sign with 3D Printing companies to produce wearable products. adidas, Nike, Under Armour and Chanel are a few examples of brands that have already showcased 3D printed products.

In the other hand, to overcome a part of these challenges, Lepeg has decided to create her own 3D Printing materials. *"My designs are almost a proof of concept - it took 100 hours to print one garment so it's not something that can be done easily. So, [in order to make it a standard practice], 2 main things need to improve: the speed of the printers, and the materials (filaments). The filaments I produced are flexible and feels good on the body, but they are not like cotton yet. I believe it's only a matter of time until we see better printers and more wearable materials."*

Despite these issues at the technical level, it should be noted a bigger challenge is yet to overcome.

A challenge faced by a wide range of industries

A common challenge encountered by industrials in the use of 3D printing is the protection of intellectual property rights. Intellectual property has become a real issue for a wide range of industries (including the fashion industry) that have adopted 3D printing.

One thing is certain, 3D printing did not bring counterfeit or pirate products in the market but does exacerbate the production of such products due to its affordability. Indeed, once he/she is in possession of a CAD file, the customer is able to customize an item to his/her size and 3D print it.

As 3D printers are becoming more and more available for personal use, we might notice a rise in digital counterfeiting, customers who possess an illegal or legal copy a of a CAD file, might easily bypass regulations for counterfeits in the fashion industry.

While raising the question of 3D Printing for mass production, this issue also warns fashion companies which should not only be investing to improve their products but also to protect them.

Lastly, should we believe in 3D printing for mass production in the fashion industry?

So far, companies of the fashion industry have showed that it is possible to wear 3D Printed garments. However, until now, given the expensive cost of the technology, and the production time required to manufacture a 3D printed product, compared to conventional manufacturing techniques, it should be noted that these companies always release a limited collection of their products. Anyway, that's what we observed with Nike, Under Armour and adidas.

Danit Peleg is one of these fashion designers who strongly believe in the use of 3D printing for mass production in the fashion industry. *"I see it as a better alternative to the way we produce and consume fashion.*

If the technology continues to improve, then this could be the future of fashion. The possibilities are endless, and the impact on the industry could be huge. There will be fewer shipping costs, no inventory, and most importantly, the democratization of design — anyone could design clothes. 3D printers are getting better and more efficient, so mass production is definitely the future", explains Danit Peleg. For her, the biggest advantage remains the fact that companies won't have to create an excess of garments that they may or may not sell. They'll be able to print recycle on demand, with no waste. *"I also envision designs going viral and individuals printing the latest fashions right at their own home. And when something newer and cooler comes along? Recycle and reprint!"*, adds **Peleg**.

Sylvia Heisel believes on the other hand, that it will take a few more years before we really talk about mass production of 3D Printed fashion. For the specialist of wearables, we will first witness the production of trimmings, shoes, accessories and parts of garments.

Both visions are relevant and enable to understand the different long-term objectives of the experts. Peleg has a more holistic approach of the use of 3D Printing in fashion, an approach that places the end-consumer at the heart of everything she does: *"I like to share my knowledge and give inspiration to everyone who is interested"*, she said. In the future, she hopes to sell 3D fashion files that customers can print at home.

Heisel believes the end-consumer does not really care about the manufacturing process. That's the reason why her work remains more "corporate". *"Currently we do a lot of catwalk, costume and exhibition garments, prototyping and samples for large brands and trims and accessories in recycled and eco filaments for independent fashion and interior designers",* she concludes.

In a nutshell, 3D printing demonstrates a big potential for reinvention and innovation. The technology seems a natural fit for women, both newcomers and experts, as they have a natural inclination to the fashion world and constitute a big part of this market. However, the gap is still big between the reality of fashion designers and fashion companies and the likelihood end-users get interest in fashion tech.

News Round Up

Since the release of 3D ADEPT Mag's April issue, a lot of things happened in the additive manufacturing industry. In a few words, discover below what you shouldn't have missed:

Business

Two companies have unveiled their new brand:

- We will no longer talk about **LPW Technology Carpenter Additive**, but simply **Carpenter Additive**. Carpenter Technology renames the company it acquired last year while defining a range of services specifically designed to meet the requirements of 3D Printer materials.
- On its side, Spain-based Dynamical Tools announced its partnership with American Carbon while unveiling its new brand: **Dynamical 3D**. The latter is divided into 3 entities: Dynamical Printing (for 3D Printing services), Dynamical Materials (for materials solutions) and Dynamical Tools (3D printers).
- **Evonik** has shut down its Witten-based plan to focus on 3D Printing materials whereas **Sintavia** has celebrated the opening of its new headquarters.

- **SLM Solutions** joined the 15 companies that will draw up a guide for additive manufacturing in oil, gas and maritime industries. These companies are currently working on two Joint Innovation Projects (JIPs) which aim to define a business model for these sectors. We should be able to have a first release this month of June.

3D Printers

- Stratasys is increasingly getting out of its «comfort zone» and is demonstrating its ability to supply every field of the market. After launching its metal 3D printing service last year, the FDM specialist unveils its first SLA 3D printer. Called V650 Flex, the 3D printer is compatible with DSM resins.

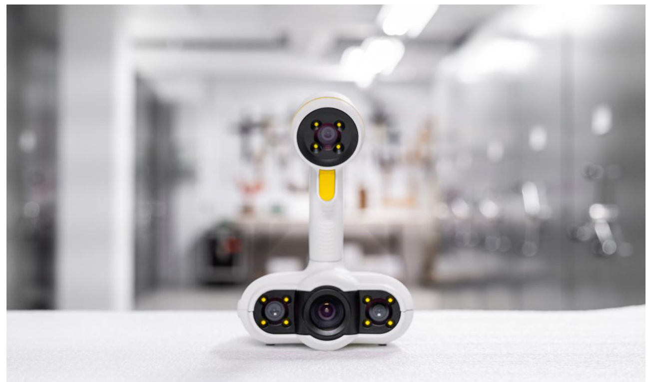
- We can't forget HP and the launch of the Jet Fusion 5200 3D printing solution and new partnerships.

Matériaux

- **Markforged** launched a flame-retardant 3D Printing material named Onyx FR.
- After removing the commercialization of its materials from 3D printing service offices, the Italian CRP Group added Windform® P1 to its portfolio.

3D Scanners

- **Creaform** and its company Peel 3D unveiled their new 3D scanners: the Go!SCAN SPARK™ 3D scanners for product development professionals and Peel 2, for artists and doctors.



Peel 2

Community

- Markers are excited! Prusa launched his marketplace of 3D models and now allows each user to supply 3D printing services on demand.

Postprocessing

- **AMT marks its entrance on the market with BLASTTM, a post-processing solution for polymer 3D printing.**

Application

It was hard to choose but **Sandvik** won an award for making an «unbreakable» 3D printed guitar.

WARNING

DELETE AFTER READING II: IT'S THEIR FAULT!

It's always nice if you can blame someone else when things aren't moving the way they should. I think I've found the perfect scapegoat for us, the "AM-ish" (any resemblance to actual persons is purely coincidental): it's (low, scary voice) the Traditional [peoples = understand "users"].

The Traditional [peoples] want to order their parts according to specs dating back from Medieval Times. They're not open to change; they're not thinking out of the box. They're playing soccer, and we would love to play rugby - anyway something a little rougher on the edges. Pity they don't seem to understand that our game is just better!

Technology and industry are thriving when there is a well-defined game and playing field. It's not always a perfectly level playing field, but there are at least goal posts, a set of rules, referees and lines. On the Tech & Industry Fields, you have winners and losers, there are players that ought to consider a career as an actor (I'm thinking Jean Valjean, for example), and there are rules which are continuously challenged.

Yes: we do challenge the rules. New rules are being written. Politicians-referees are waking up to the promising call of the potential of Additive Manufacturing (not always with the right vision though; they ought to consider a Video Assistant Referee in order to spot the odd offside?). Quite often it is a give-and-take with other technologies: they also want to play their game. But things are changing, and they are changing at a relatively rapid pace: for example, there is the unique partnership agreement between ISO and ASTM International aiming to create a common set of ISO/ASTM standards on Additive Manufacturing. That's the power of money, but it's also an indication of how seriously the traditional rules are being challenged.

On a side note: I have never understood why norms and standards aren't freely accessible.

It looks like this exchange between a seller of food products and a consumer:

- "You want to know the ingredients of this jar of jam? Well, that's fine sir, if you buy it, you can read it.

- Can't I have a taste? Or rent or lease the jar, at least?

- No, sir, the proof of the pudding is on the label only."

There are a few "good" reasons why norms aren't freely available. But I tend to keep on forgetting those reasons – they don't stick to my memory, somehow. To me, this barrier to trade is like a game in which some players aren't allowed to know the rules.

Yes: some players ought to consider a career as an actor. I mentioned Jean Valjean, but I also see opportunities for actors aspiring roles as - yippee ki yay - John McClane or a wannabe Darth Vader. Just like in soccer: if they're good players, they're usually forgiven their bad acting. No further comment on this one, I anyway don't like soccer.

Yes: there are winners and losers. Some business plans just don't work out. Some technologies just aren't up to speed. Sometimes it was just the right pass at the wrong moment. It's sad for the losers… But, hey: we are playing on a world cup field; even those players usually playing at amateur level 18 get their once-in-a-lifetime opportunity. "I was tackled by Messi", isn't exactly something to be ashamed about, right? Let's honour the ones that lost.

Actually, those maligned Traditional [peoples] aren't the problem. We are playing Additive Manufacturing on the field of The Global Manufacturing Industry. We have to play the game mostly in accordance with the rules of the Traditional [peoples]. Specs? Materials Certificate? Certificate of conformity? DIN-123, ISO-456, ASTM-789…? Here's the bad news: yes, we'll have to step up.

Instead, we should be looking at ourselves when looking for causes if "things aren't moving the way they could or should". One cause is that we're not playing one single game: some of us want to apply the rules of rugby, others those of American football, futsal, jorkyball or indoor soccer (I admit: I had to look these up). We ought to be looking for those rules that are common in all our games. Who's joining the effort, or will we keep on pushing our own agendas?

We quite often are competitors. But sometimes we should be brave enough to show up as a team. We all know rugby is a better game, and more fun than soccer. And the core is to convince the Traditional [peoples] to play along. Not a game to win by ourselves, and not a game we'll win by just playing rugby on the soccer field. We have to be even more convincing, invest even more in research and development in order for us to meet their "traditional specs".

Writing the rules of Additive Manufacturing is a challenge and will remain one for quite a few years to come. Let's tackle it together. So: delete this text and get back to work. Passionately.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