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Beyond prototyping: accelerating the business case for 3D printing

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Introduction

3D printing (3DP) has left behind its status as niche technology. As a key element of the Industry 4.0 revolution, 3DP is evolving as a practicable alternative for both product development and conventional manufacturing. The time for further analysis and pilot projects within your R&D division has passed. The issue of 3DP in its broadest sense should now be top of mind at board level as they should drive the value of additive manufacturing throughout the organisation of their company.

3DP – the process of implementing manufacturing technology 'layer by layer' – is changing the way we design, manufacture, distribute and sell products, opening up new digital production methods, revolutionising value chains and initiating new business models. This enabling technology simplifies the manner in which complex and costly parts are manufactured in industries such as automotive, industrial machinery, healthcare and aerospace, while also providing the ability to easily make bespoke parts for the automotive aftermarket and produce medical implants.

One of eight

Within the domain of 'smart industry', PwC considers 3DP as one of the eight indispensable disruptive technologies companies need to integrate and deploy in order to be future-proof, alongside the likes of robotics, blockchain and artificial intelligence. We have therefore been following developments in the 3DP world closely, regularly issuing advice both in specific terms to clients and in general to the wider market. The latter included an earlier white paper published at the end of 2015. It is worth noting in the light of that publication that very few companies have made progress since then in terms of knowing what sort of 3DP business model they require to gain market share and broaden their product & services portfolio.

Growing awareness

This slow rate of change is certainly not due to a lack of awareness. A recent PwC Strategy& survey* showed that over 37% of respondents intend to use 3DP in their digital factories over the next five years. The issue is, rather, that there are still many questions around 3DP and significant uncertainty about when to apply it. For instance, what is the cut-off point in relation to the long tail in order to reach batch size 1?

The real added value

At the same time, there is a growing recognition that 3DP involves much more than just implementing another high-tech tool in your production environment. To truly access its benefits, companies need to look beyond how the technology can be used in practice and explore broader areas of customer value. They need to identify the real added value of 3DP and other applications from a business perspective and in terms of how they run their organisation. In the very near future, 3DP will have an impact on the entire organisation and its underlying business model and value chain.

A foundation for dialogue

Taking this conviction as a starting point, this white paper offers you an insight into the very latest status of 3DP in the current marketplace. We also examine PwC's work over the past two years within one of the current 3DP focussed FieldLabs**, being the Multi Material 3D Printing FieldLab. One of our roles within this project has been to carry out market consultations on the current challenges and inhibitors related to the introduction of 3DP. Based upon in-depth interviews, the main findings of these consultations are shared in this white paper and can hopefully serve as the foundation for a dialogue on whether the insights are also relevant to your company and its future outlook.

There is one conclusion that we can share from the get-go: the time has now come to initiate actions on how to best embrace the potential of 3DP technology. There is a clear and present need to work out how 3DP will impact all the different functions within your company, from marketing to sales, from supply chain to logistics from R&D to tax issues. To be frank: if you don't think about this subject now you can be sure at least one of your competitors actually does.

* The future of spare parts is 3D – A look at the challenges and opportunities of 3D printing (*https://www.strategyand.pwc.com/media/file/The-future-of-spare-parts-is-3D.pdf*).

** RAMLAB – Rotterdam. 3D Makers Zone – Haarlem. Utrecht3DMedical - Utrecht.

Business value of 3D printing

3DP is a manufacturing method where objects are printed layer by layer based on a three-dimensional digital representation. The printing process uses various materials, or inks, most commonly plastic polymers and metals, and more recently glass and ceramics. Key implications for businesses looking to capture the full value of 3DP include the digitisation & integration of horizontal and vertical value chains, the digitisation of product & service offerings, digital business models and customer access.

3DP is also opening up all kinds of opportunities as an enabling technology in terms of mass customisation, minimizing production costs (in case of high market unpredictability) and reducing the total cost of ownership (TCO). In addition, a move to more local production can lead to a decrease in import duties. And what influence do the changes in your business model, the geographical spread of your activities and the change in the flow of goods have on your tax position?

Unrivalled potential

While 3DP was principally used for prototyping when it first started making headlines, it is now increasingly being applied to end-products. In some cases it can be seen as a supplement to conventional production technologies, while in others it serves as the only means by which complex products can be fabricated. In addition it can be considered as a cost-effective and low-risk solution to upscale production capacity in order to serve new verticals and new geographies and create new products for testing purposes. In essence, we can identify five key generic **advantages** of 3D printing:

1. Complete design freedom: 3DP allows products to be designed based on exact function without worrying about conventional manufacturing constraints such as the added costs of complexity.
2. The technology offered by additive manufacturing makes it both technically feasible and cost effective to produce complex shapes
3. A minimum batch size of one: every part produced costs the same, removing the dependency on large batch sizes.
4. Increasing manufacturing flexibility by being able to go into production at or near the point of use.
5. Enhancing the circular economy: material is added not subtracted during the production process, minimising waste.

Current business value and models

So where is the business value currently being created? In terms of processes, it is clear that the time-to-market for new parts and products can be significantly reduced, providing a huge boost to the speed of product innovation. The maintenance of assets and machinery in the field is also easier as spare parts and specialised tooling can always be available on demand. Moreover, there is a reduction in assembly time and tooling costs when products/ parts can be printed in one go with no need for sub-assembly.

This latter point decreases costs and complexity for business in the sense that 3DP also makes design optimisation possible by printing a product in one go which used to require multiple sub-assemblies. As well as resulting in lower error rates during its lifetime, the average 3DP product will also have a longer lifespan. In addition, the fact that the minimum production quantity is a single unit will make mass-customisation possible. Rapid prototyping and testing allows for designs to be optimised efficiently, and makes it possible to include customer opinions in new product development seamlessly and organically.

Ultimately, when it comes to making the business case for 3DP, it is essential to consider how the total cost of ownership will impact the full cash flow of their company, so from R&D to after-sales.

New business models

The ability to mass produce custom-fit items in a cost-effective manner is one of several new business models which have already been made possible by 3DP. Co-creation between suppliers and customers is another, with the added benefit of suppliers obtaining relevant data from the users of 3D printed products. Lifecycle management is becoming an increasingly prominent application of 3DP in terms of improving customer service as well as in relation to supply chain excellence by eliminating manufacturing steps, reducing cooling costs and simplifying maintenance processes. We also see an increase in companies looking to act as service providers in supplying 3DP solutions.

"It is time to move 3D printing from the R&D lab to the boardroom."

Wolter Kersbergen, manager Innovation & Development, PwC.

The overall developments in 3DP will be driven not only by progress in the underlying technologies, but also by their rate of integration into existing business models. PwC has developed a proprietary market model which, among other things, provides a detailed cost analysis, part by part, allowing companies to see for the first time whether 3DP makes commercial sense for their activities.

Growth figures

So how are these and other models likely to be translated into concrete business numbers? Recent research by PwC Strategy& shows that we are entering an era of major growth in 3DP. It predicts that the industrial market for 3DP products and technologies will grow to €22.6 billion by 2030. Aerospace (23%), medical technology (23%) and automotive (15%) are the sectors with the largest annual growth potential. While 18% of manufacturing companies make use of 3DP at present, this is expected to increase to one-third of all businesses over the next five years. So you need to start thinking about the best ways to profitably integrate 3D technology into your business model and strategically expand product portfolios.

For 3DP within the aerospace industry, we expect the global market volume to reach €9.59 billion in 2030. While only 0.49% of the products in this sector were manufactured using 3DP in 2015, this proportion is expected to increase to 5.2% by 2030. The initial growth factor will be the certification of 3DP technologies, after which the focus will be on the development of new print designs.

In the medical technology sector, the market volume for 3DP will grow from €260 million in 2015 to €5.59 billion in 2030.

In the automotive sector, the market volume is expected to increase from €341 million in 2015 to €2.61 billion by 2030. In this industry the emphasis to date has been on the development of prototypes. In the future, it is conceivable that manufacturers will self-print components of which they need only small quantities, saving time and money compared to using the existing supply chain.

3DP growth: €22.6 billion by 2030

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Aerospace industry
2015: ***€430*** **million**
2030: ***€9.59*** **billion**

Medical technology sector
2015: ***€260*** **million**
2030: ***€5.59*** **billion**

Automotive sector
2015: ***€341*** **million**
2030: ***€2.61*** **billion**

"Germany is much more serious about Additive Manufacturing than the Netherlands. In the Netherlands we are in the sleeping/snoozing mode while the German market is in the action mode."

Willem-Jan van Loon (Beamler):

Facing up to challenges

For these predictions to come true, many companies will need to move beyond searching for 3DP applications and small-scale experimentation and implementation. The five main challenges identified by our consultation partners in the previous white paper remain relevant today.

1. Business cases

The first is knowing how best to develop a proper business case for introducing the technology, one which actually estimates the likely ROI. Experience has shown that most business case exercises fail when the scope is too narrow – success depends upon including the lifetime of the product as well as the value chain and supplies. It can also be especially difficult to make the business case for applications on the customer side.

2. Collaboration

The second challenge is deciding on whether to start 3DP operations on your own or to join forces with other parties. Taking the latter approach opens up various issues related to intellectual property (IP).

3. Intellectual property

The answer to this third challenge may well be to look for new or revised legislative frameworks. What is sure is that a modernisation of IP laws would help provide legal certainty for companies as they embark on their 3DP journey. A recent PwC survey showed that while suppliers remain doubtful about the quality, maturity and technical feasibility of 3DP and their own level of technical expertise, issues of customer acceptance and copyright are, surprisingly, of less concern. Companies appear to still think in an overly traditional way: in the future they will sell IP (data) rather than actual parts. How to manage IP is not yet a major concern among either manufacturers or suppliers, but it should be.

4. Risk factors

The fourth challenge is to identify the risks involved in terms of product liability and data protection. Who is responsible for part integrity and maintenance errors? Which safety norms should a 3D printed part meet? How to protect the data and processes from malicious interference? Here too there is a clear need for legislators and certification organisations to revisit their standards and provide legal frameworks, guidance and best practices to support companies within their 3DP innovation strategies.

5. Internal organisation

The final challenge is to ensure that people within a company are actually aware of the opportunities offered by 3DP. Personnel need to be encouraged to learn about the subject and look beyond current applications. Are your people aware of the unprecedented possibilities in terms of customisation and co-creation that are ripe for exploration if they abandon their current ideas on design, business models and proposition?

Data protection

Cyber threats continue to be a major concern for companies. According to PwC's Global State of Information Security Survey 2018 (GSISS) many companies recognize that a successful cyberattack on automated or robotic systems (which also includes 3DP systems) could have major consequences. Disruption of operations and the compromise of sensitive data are common issues, but could leverage the 3DP technology as attack vector. More specific are the impact of cyber threats on influencing the quality of the products created with 3DP or leveraging 3DP technology to damage physical property like production facilities. Some additional examples to proof the point: infiltrating into the 3DP systems, allows the attacker to change the product specifications of production method to alter the product quality. Attacking the 3DP technology itself might allow changing the machine settings or sensor readings, leading to out of control motors or overheated printer parts. Implementing 3DP technology demands a threat analysis and strong cyber controls.

Use case Admatec – Precision printing

Dentsply Sirona is one of the world's largest full service dental suppliers. One application they provide is a ceramic support structure to enable glazing artificial teeth homogeneously.

Various complex designs apply, with the need for form freedom and redesign. Additive manufacturing is a cost-effective solution compared to conventional, technologies like molding with higher ramp-up cost and throughput times. This is where Admatec stepped in, as they are dedicated to 3D print ceramic through their patented Admaflex technology. First providing a prototype for feasibility and design optimization, now supplying Dentsply Sirona year-round through producing 100+ pieces on a monthly basis.

The open architecture of the Admaflex 130 and the capability to manufacture high dense, fully functional complex ceramic geometries with minimal waste, has proven that 3DP is the way to go in today's industry.

The Field Lab project

*In addition to our ongoing research and client/partner consultations, over the past two years the 3DP specialists at PwC have also been involved in the **Multi-Material 3DP Field Lab**. Being part of the Dutch government's 'Smart Industry' agenda, this specific FieldLab is a co-creation platform where we have worked with a range of partners from across the value chain, namely TNO/ TUe (AMSYSTEMS CENTRE), Admatec, ECN, Eindhoven University of Technology, NextDent, Signify, Océ Technologies and DoMicro. Our specific role and contribution is focussed on identifying the added value of 3DP, collaborate on prototypes and new technologies and develop business cases that facilitate the validation and wider uptake of multi-material solutions.*

While there are several Field Labs in the Netherlands focused on 3D printing, this one has a special focus on multi-material 3D printing. 3D printing technologies initially worked primarily by building up layer upon layer of a single specific type of material: the aim here has been to specify how different kinds of material and polymers can be combined as part of a long-term vision for multi-material use.

A decision was taken early on to focus on three specific use cases within the project:

- Large surface ceramic printing for high-tech applications,
- Multi-colour printed dental crowns with a 'natural' hue,
- Integrated electronics with new opportunities in product design and functionality of electronic products.

In addition to addressing the issue of making technologies market-ready and demonstrating them as such, the Field Lab also serves as a network platform, with various events enabling people to meet and discuss how they might go forward with 3DP and help each other in the process.

Focus on business

One of the ways in which PwC distinguishes itself from competitors is its ability to offer business insights into new technologies. One of our roles within the Field Lab has therefore been to consider 3DP not only from a technology perspective but moreover from a business angle. More specifically, we have been examining how these three use cases should be developed and made available for the market in a multi-material perspective in five years.

Insights from market consultation

All the companies we consulted are exploring the opportunities of 3DP for their current and future business. While they may yet have a strategy in place or a clear view on the full potential and impact on their organisation of the technology, most firms are investing in R&D (sometimes with partners) experiments with 3D printers and acquiring relevant knowledge and skills.

Although the responders identified several advantages from a product, market and process point of view, companies are not ready to embed 3DP in their business model (see graph on page 10). The main reason is that the technology is mostly perceived as not being sufficiently mature, while for medical applications regulatory challenges need to be overcome as well.

Despite the fact that companies are intensively monitoring the development of 3DP technologies, there is a need for a greater insight into what is available. This information is currently difficult to access: it requires openness and transparency within the 3DP arena in view of the development of novel technologies in combination with diverse materials and their characteristics and (potential) application areas.

Step by step, as technologies further develop, companies will need to adapt their organisational model to allow for a swift uptake when technologies become available and the market demand is present. This will also require substantial alignment of the (digital) production processes such as linking databases in a standardised and harmonised way, sometimes over a variety of supply chain partners.

A major market consultation was carried out as one of the primary work packages within the Field Lab. With the three use cases being in niche sectors, PwC broadened the scope of their consultation activities to the high-tech sector, medical industry and wider industrial manufacturing. Five main elements were addressed:

1. Ambition and strategy
[What are the short and long-term goals for incorporating 3DP within your company strategy?]
Companies see 3DP as valuable mostly for the prototyping phase and the potential to produce small batches. Although some have already defined a clear strategy around the embedding of 3D printing, most companies merely invest time and money in networking and internal experimenting with acquired 3D printers to see how it might suit their business in the near term.

2. Skills
[Do you have sufficient in-house technical skills and knowledge about 3DP?]
Most companies are investing in acquiring relevant knowledge and skills on 3DP either on a more individual basis or through a dedicated centre of excellence.

Partners in the Multi-Material 3DP Field Lab

"3D Printing is more than a technological innovation. It is a technology that has an impact on your entire business model and value chain."

Roger Quaedvlieg, Senior Manager - Innovation & Incentives, PwC.

3. Alliances

[Are you working with other kinds of companies to further develop your own expertise?]

All the companies that PwC consulted are part of some sort of partnership or network/ecosystem, with a number even having this as part of their business model. When partnering with others in the area of 3DP, including in open innovation environments, it is becoming more and more important to boost technology development. Challenges faced in this respect include a reluctance to share designs and lack of trust.

4. Business drivers

[Which product aspects, printing processes and market opportunities are driving progress?]

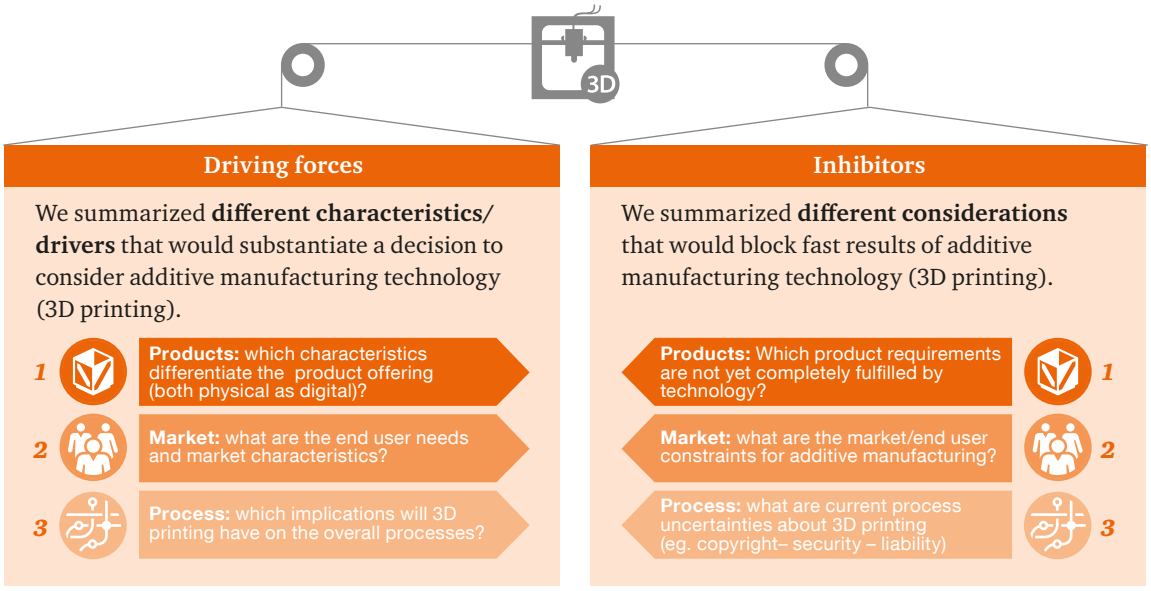
While most companies recognise that 3DP makes the development of more complex and customised products possible in smaller batches, they do not yet feel that the technology is mature enough. The specific bottlenecks cited are the comparatively low resolution (especially for the medical sector) and the difficulty to combine material characteristics. In the medical sector some of the technologies for potential applications do not exist, while the materials are yet to become available for the intended applications in 'industrial manufacturing'. The latter sector also sees a reluctance to share designs. All of the above makes clear the need for a knowledge network and database.

5. Sectoral differences

Companies see major differences between sectors with respect to the actual use of 3DP. In aerospace and aviation, 3DP in metal is already quite well accepted because it reduces the mass of components, adding substantial value. In contrast, the adoption of 3DP is slowed by regulatory requirements in the medical sector, something which is much less of an issue in other industries. The size of a company is also a factor according to responders: larger companies demand that the business case be made clear upfront due to the fact that they have less flexibility.

Most companies do see opportunities in diverse markets relevant to their business, depending on technology availability and market demand. However, for the medical industry in particular, there are regulatory challenges that first need to be overcome.

The 3DP feasibility framework can be used to assess different applications in different market environments, and uses three lenses: products, market, process



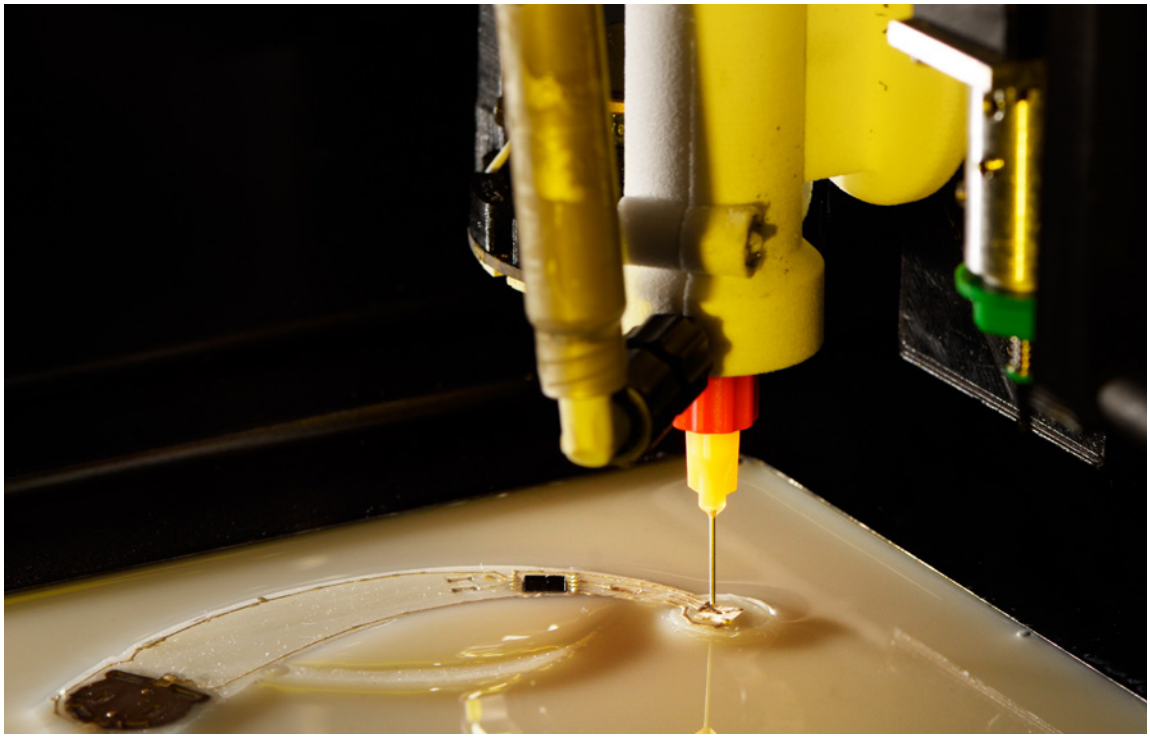
Challenges encountered

All companies looking to master 3DP for the next decade and beyond will need to make the right strategic decisions. In the broadest terms, as this white paper has made clear, we can identify four areas in which companies have become stuck in their journey towards making the most of the 3DP revolution:

1. While many organisations are exploring the benefits of 3DP and aware of quite a few of those benefits, they have yet to fully investigate the potential impact across their entire value chain.
2. Finding the right business case is a major challenge for lots of companies, including those who analysed the potential with a narrow scope several years ago when the technology was less mature.
3. Although a good number of firms are now aware of the developments and are keeping their finger on the pulse via networks, partnerships, events, trade shows and the like, they remain unsure of when the right moment is to step in.
4. The majority of companies have made some investments in 3DP, albeit on a limited scale. However, only a small part of the organisation has been involved in this, meaning the true potential remains hidden.

To unlock the full potential value of 3D printing for businesses, actually the time has come to move 3D printing from the lab into the boardroom. Business leaders should adopt a wider strategic perspective and ask themselves how 3D printing may transform – or disrupt – their business model.

PwC has developed a range of models and tools, like the 3DP Cost Modelling app, that provide a valuable perspective into the opportunities that lie within the 3DP revolution and offer a better understanding of how to harness them. If you recognise your organisation in one or more of the examples above, feel free to contact us for further discussion.



Use case Luxecel – Personalisation

Luxexcel is the only company in the world able to 3D print lenses. Their focus is on 3D printed lenses for ophthalmic applications (eye glasses). The company has won a price of most innovative SME in the Netherlands in 2015. Luxecel has locations in Eindhoven (NL), Turnhout (B) and Alpharetta (USA).

The Luxexcel technology combines hardware, consumables and design-software in one 3D printing solution. This turnkey technology solution is installed at ophthalmic labs which provide lenses for opticians and optometrists. Ophthalmic labs receive the complete Luxexcel VisionPlatform™, which includes a printer, resins, support and software solutions in return for a click fee payment. Lenses produced with the 3D print solution are ISO compliant and compatible with today's industry coatings and customary processes like edging and frame mounting.

The Luxexcel printer called the VisionEngine™ forms the lenses by using print heads to deposit multiple layers of a mid-index acrylic material called VisionClear™ onto a substrate sheet. The process can produce four lenses an hour. Opticians and optometrist can create customized lenses by making use of the VisionMaster™ a proprietary lens design software.
3D printed lenses are user customized without any polishing, grinding and the usual compromises of the traditional industry. Luxecels lenses also offer numerous new benefits for future products, like the ability to integrate all kind of filters and sensors in the lenses, for example sunglasses with optical power that switch electrically.

Food for thought – self assessment

3DP is a disruptive technology, the effect of which will be felt on the full value chain from design to production. Manufacturers big and small are assessing how to shape or expand a 3DP program. Doing so is becoming easier, as more 3DP hardware, software products are entering the market and as costs of the technology are falling swiftly. As with any disruptive technology adoption, businesses take different directions and wade in at different speeds—as evidenced by our findings in this report/the market consultations. No matter the trajectory of 3DP adoption a company may be on—from mulling to aggressively expanding--there are probing questions all manufacturers ought to be asking themselves to exploit the technology in ways that both expand their business and make them more competitive.

As companies consider what 3DP means to their companies, they can start with a self-assessment. Some questions that can help companies to make a first self-assessment of where they are heading in terms of 3DP (a complete list is available upon request):

1. ***Can 3DP help improve the design and performance of your existing products made through conventional manufacturing processes?***

In traditional manufacturing, the journey from design to production moves through various distinct stages. At this stage, the digital thread is cut as a physical manifestation of the product design in order to be able to test and validate the digital design. Even when 3DP is used to create a prototype, this breaks the digital thread, since the prototype is often not made with the same materials or imbued with the same performance capacities that the final product will have. Keeping the digital thread intact throughout design and production will drive the integration of otherwise separate solutions. Start to assess your current products (parts), processes and markets. Moreover, think about the value you want to deliver to your customers and how additive manufacturing can help in adding this value.

2. ***Are there any new products in your portfolio that can be partially or even wholly 3D printed to accelerate your go to market or with greater latitude for customisation?***

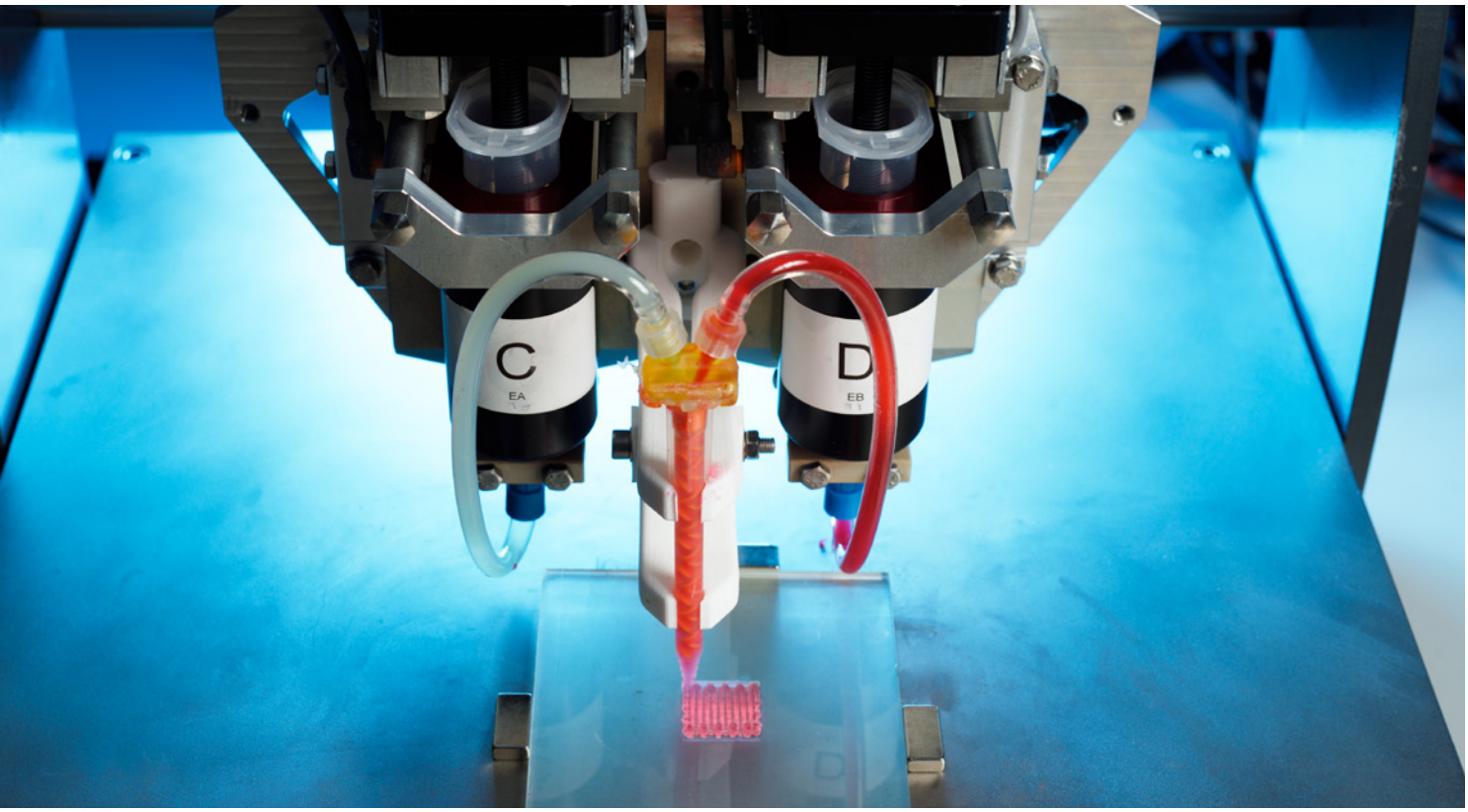
Designs developed for conventional manufacturing have traditionally been constrained by manufacturing processes that require the creation of separate components that are assembled to create the end product. This is one reason why many products are the results of components that are manufactured separately and assembled afterwards. 3DP has the potential to remove many of the constraints of the traditional manufacturing process. 3D printers can create complex and intricate geometries as easily as they can print a solid cube. With 3DP, there is no additional cost to create a complex design.

3. ***At what point does it become economically attractive to use 3DP over traditional manufacturing (i.e., injection moulding, casting, subtractive manufacturing, machining, milling and turning), and in which parts of the business (e.g., R&D, testing and custom-production)?***

Traditional manufacturing processes will never entirely disappear. They are very cost-effective and efficient for many types of products, and that is unlikely to change. In fact, most manufacturing operations will likely consist of a hybrid of traditional and 3DP operations. So for 3D printers to become a part of the production process, an effective integrating with existing production lines and processes is necessary to optimize operations. Adoption of 3DP has been highest in industries where its higher production costs are outweighed by the additional value 3DP can generate: improved product functionality, higher production efficiency, greater customization, shorter time to market.

4. ***Have you assessed the barriers of 3DP for your company (e.g., limited ability to use multiple materials printing one object, process quality, feedstock availability and price, the right talent and skill sets)? Does your company have a plan to adopt 3DP when or if those barriers drop?***

The learning curve on working with 3DP technology can be steep. Leading organizations are already doing proof of concepts and pilots to learn the practical aspects of using 3D printers,



what skills they need to develop, and how they should reorganize their operations to use this technology in the most effective and productive manner.

5. *Does your organisation have the **talent and resources** to launch a 3DP program, or does it make more sense to outsource to a third-party service specialising in all facets of the technology (3D scanning, prototyping, reverse engineering, etc.)? Has your company identified the best vendors/suppliers that could help you wade into 3DP adoption?*

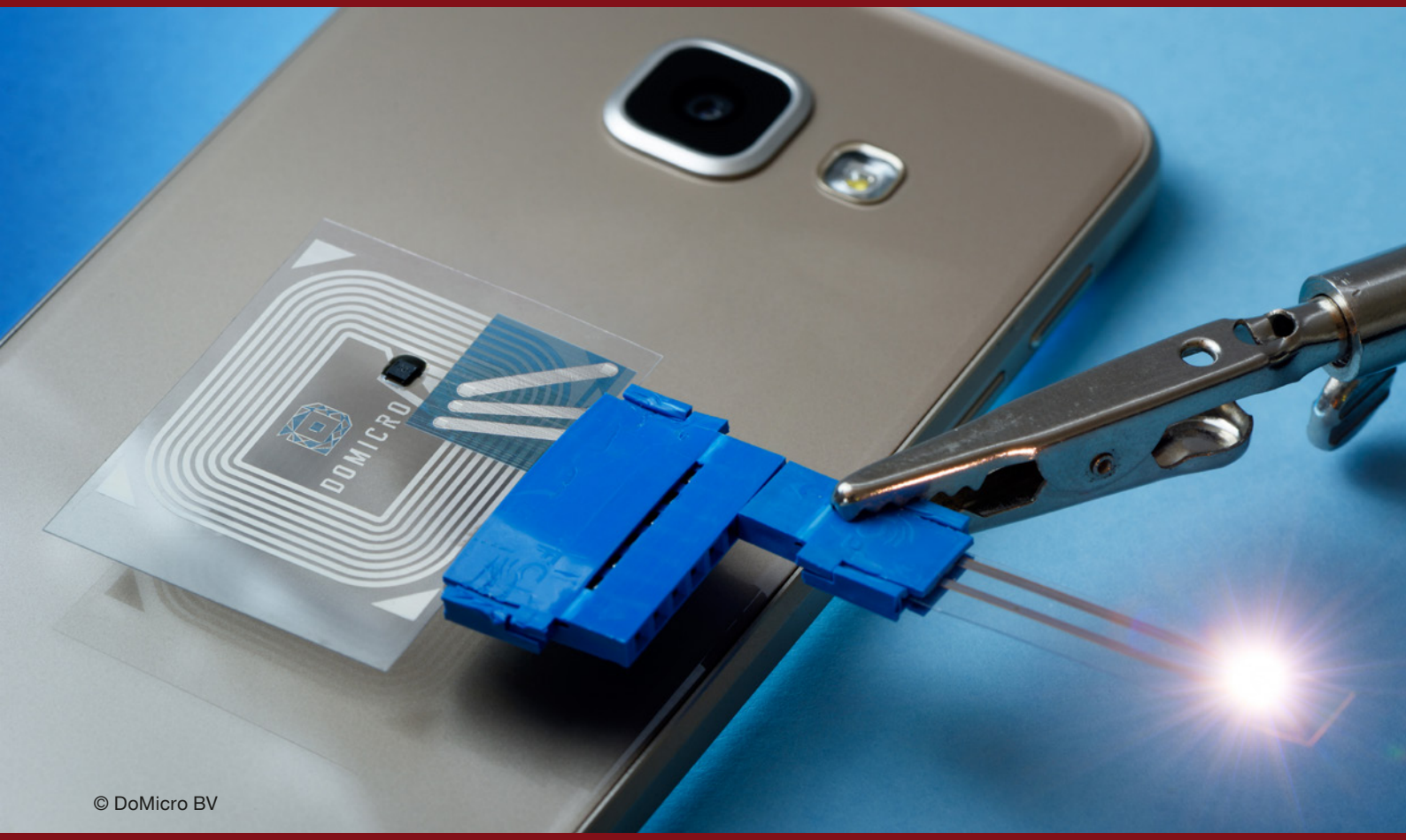
Complex problems demand to be tackled by more than just one department or organization. Collaboration is an undeniable force in the 3DP industry. No one department, business unit, or company will be able to 'do it all'. As more companies have realized the importance of working with the best partners, the amount of partnership agreements within the sector has increased over the last year. So, actively plan an ecosystem approach. Real breakthroughs happen when you actively understand consumer behavior and can orchestrate your company's role within the future ecosystem of partners, suppliers and customers. The same is applicable to the internal organisation. Companies with successful 3DP operations integrate their design and manufacturing teams. If you have a siloed organization, consider reorganizing to increase communication and collaboration between these teams.

Create cross-functional teams, clear roles and responsibilities. Align senior leaders to clarify the path forward and develop the governance to provide guidance along the way.

6. *Is 3DP **economically viable** now? Have you considered **experimenting** with a desktop printer before considering purchasing or leasing an industrial 3D printer?*

Pilot projects are essential for testing, improving, and adapting the capabilities and strategy needed to succeed at 3DP. The selection of the right pilot programs is important for future funding and management support, and for a company's capability development. It will support change management, in creating the necessary culture. Pilot projects will also lay the foundation for new ecosystems and value chains. For example rolling out a complete spare parts printing program will transform the manufacturing and distribution of spare parts. As such, it will require a detailed road map and a dedicated execution team.

Use case DoMicro – Flexible Hybrid Electronics



© DoMicro BV

DoMicro BV is a high-tech provider creating value by additive technologies in electronic manufacturing. DoMicro develops inkjet printing processes for flexible hybrid and printed electronics. The company delivers R&D services, small series production, system architecture and project management for customers exploring new markets and technologies for circuitry on flexible substrates like transparent conductive films, OPV electrodes, OLED, Lab-on-chip, wearables, IC and MEMS integrations.

Flexible Hybrid Electronics

The market for flexible hybrid electronics is growing exponentially due to the increased demand for integration of electronics and wireless applications such as IoT, healthcare and sensors for big data applications. By developing innovative printing technology, new capabilities arise. Especially for products and applications beyond conventional PCBA integration. These solutions can include batteries, RFID or WIFI functionality for wearables or other data collectors.

Integrating electronic functionality in everyday life enables products to be smart and sensing. Wireless connected to the network, seamlessly gathering, adapting and giving real-time response to users and operating systems for home, office or e.g. transportation or traffic environments.

Blueprint for becoming a 3D printing champion

The process of becoming a 3DP champion requires six key steps:

1. Assess your value chain

The analysis should cover key performance indicators that represent the challenge of the value chain, your current portfolio and the opportunities 3DP offers. This is the foundation for building the business case. It also allows you to clearly identify the parts where 3D printing will deliver the biggest benefit.

2. Identify a use case

Identify the potential application areas. Start with a technical analysis to determine which products or parts within your portfolio are "printable," then group the portfolio based on the 3DP technology needed for each. Low volume, high value articles could be the starting point. High turnover articles could indicate an opportunity for improved part functionality by redesign.

3. Analyze current and future TCO

The full potential of 3DP does not become evident until companies factor in its effects on the entire value chain, and ultimately the total cost of ownership (TCO) as well as the potential benefits of radical changes in product design. Analyze the impact on the TCO from purchasing and manufacturing costs to warehousing and replacement costs (including obsolescence, current unavailability, transport, storage, and interest costs).

4. Develop the business case

Determine the business case of 3DP within the value chain, i.e. the savings potential of tooling costs and development costs, as well as the savings potential of the individual parts and handling costs as factors in the TCO.

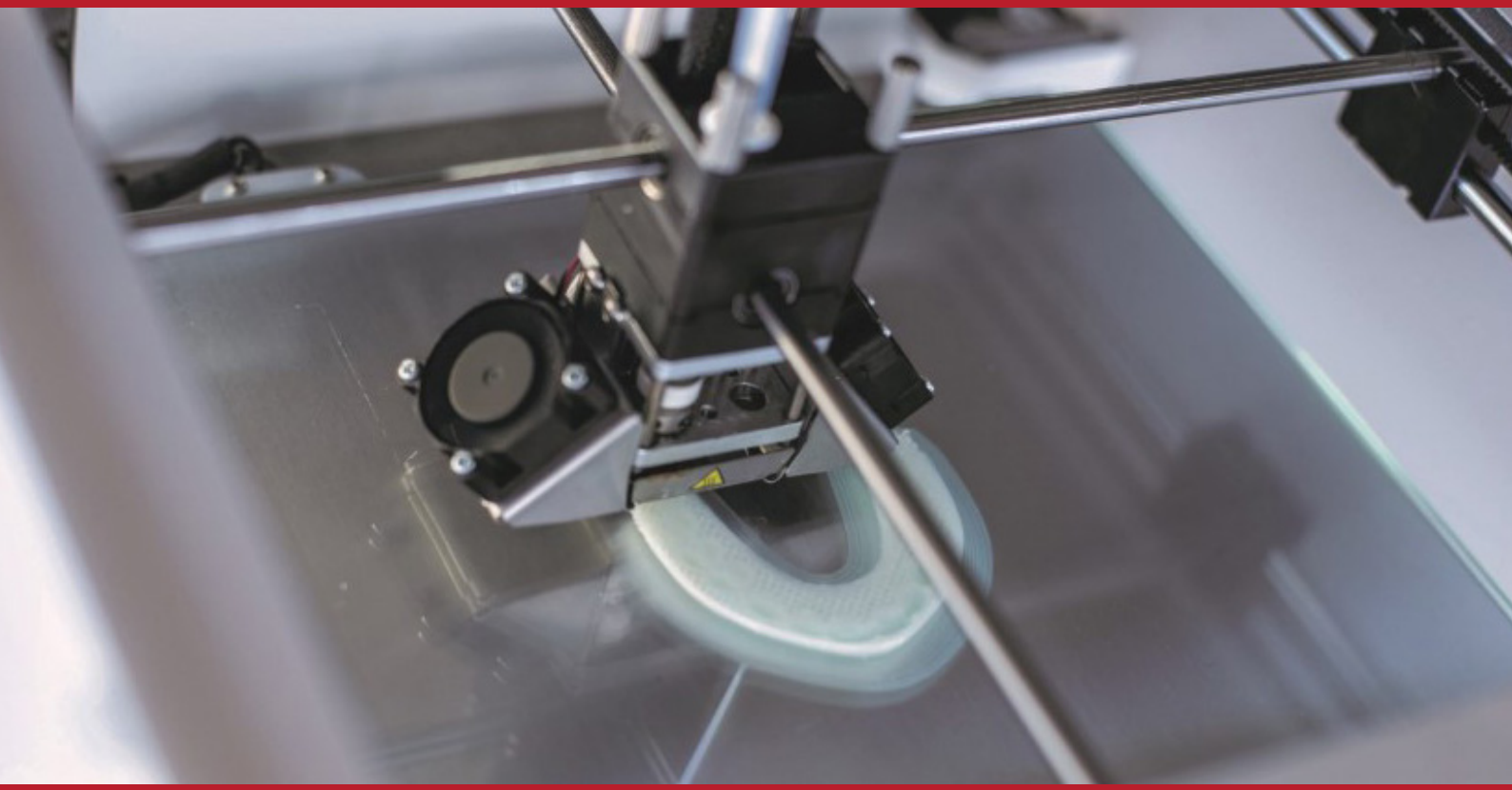
5. Define you 3DP strategy

Your strategy should cover the entire value chain as well as the potential for selling data instead of actual parts. Research the impact on operating model elements: strategy and vision, E2E process redesign, IT infrastructure, legal and tax consequences and cybersecurity.

6. Pilot and roll out your 3DP strategy

Pilot projects are essential for testing, improving, and adapting the capabilities and strategy needed to succeed at 3DP. The selection of the right pilot programs is important for future funding and management support and for a company's capability development.

Use case DSM – Partnership approach



Royal DSM, a global science-based company active in Nutrition, Health and Sustainable Living, by the end of 2017 announced a new approach for its additive manufacturing (AM) activities. By aligning all its AM activities within the Materials cluster and promoting a partnership approach, DSM can provide customers an open and flexible infrastructure. This will help customers to find exactly the right materials and production systems for their AM driven applications.

One of the recent examples of those AM driven applications are custom-made and instantly on the spot printed 3D mouthguards to protect teeth and mouth injuries in any type of sport. This specific application has been developed in close collaboration with Carestream Dental and NHL Stenden Hogeschool.

By scanning the upper jaw with video technology and digitally capturing all curves and shapes of mouth and teeth, a perfectly fitted mouthguard can be printed on the spot using fused filament technology. The additive manufacturing (AM) process uses a continuous filament of DSM's Arnitel®, a bio-based material that meets all strength, flexibility and health requirements. The new AM technique, combined with the 3D filament material characteristics, completely automates and digitizes the process of producing customized mouthguards and prints them instantly.

https://www.dsm.com/markets/engineering-plastics/en/products/arnitel/markets/3d-printing.html

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Many businesses face the same challenges when adopting new technologies, such as 3DP. Early adopters have emerged and they are encountering challenges and experimenting with solutions from which others may learn. In this paper, we present the lessons learned and challenges experienced by organisations. The market consultations consisted of several steps including desk-research and exploratory conversations followed by a series of in-depth interviews.

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Contact

Roger Quaedvlieg
Senior Manager - Innovation & Incentives
E: roger.quaedvlieg@pwc.com
T: +31 (0)6 2080 8007

Wolter Kersbergen
Manager - Innovation & Development
E: wolter.kersbergen@pwc.com
T: +31 (0)6 2021 3892