Additive Adoption A - Z:

The Adaptable Manufacturing Playbook

The guide to make your business more adaptable with 3D printing.

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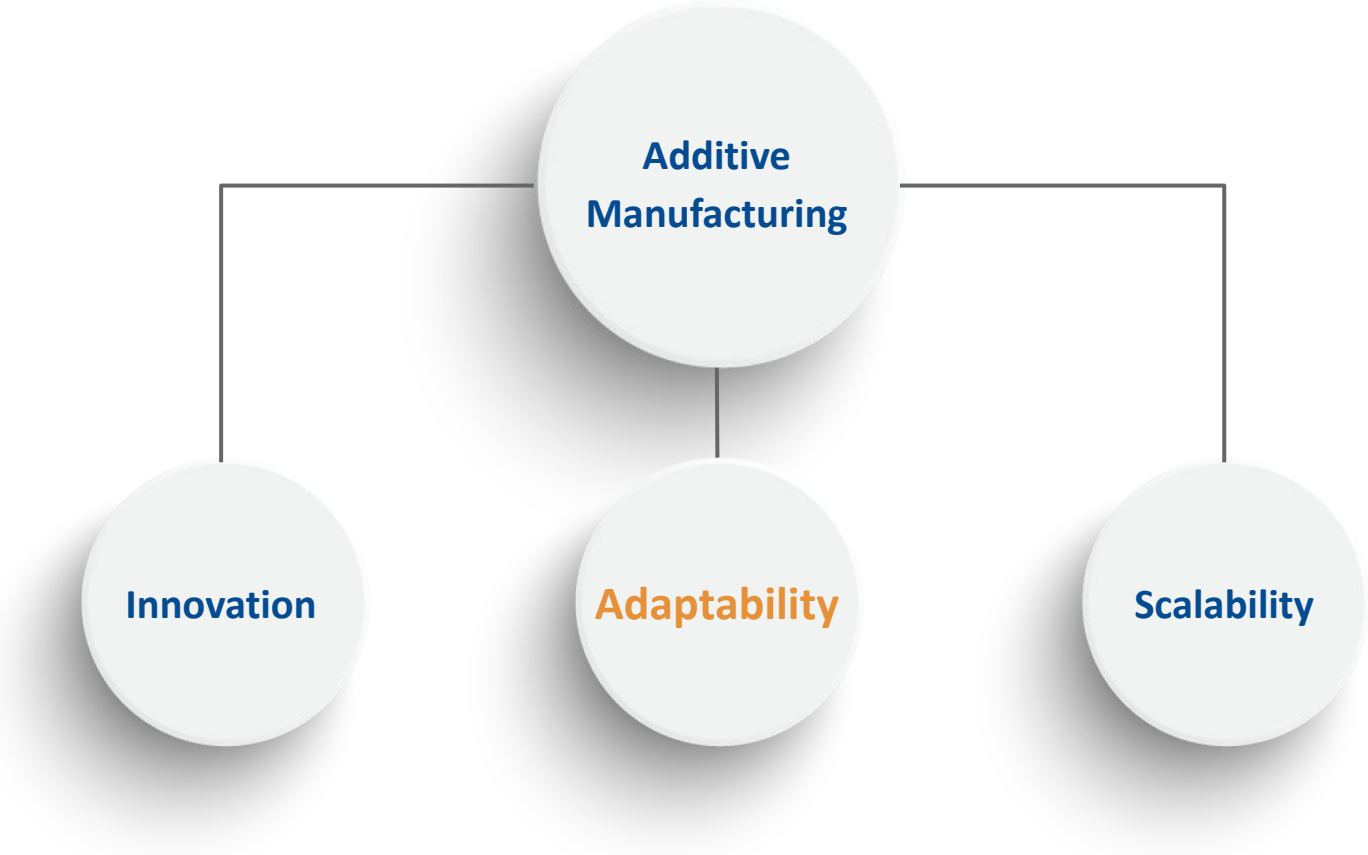
Contents



01. Introduction

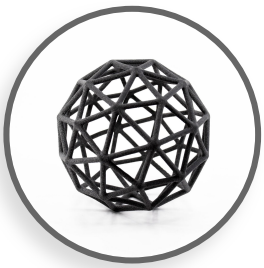
Additive manufacturing technology can be a real revolution for your business, offering the opportunity to innovate, adapt, and scale to meet the needs of an ever changing market.

The challenge of modern business is to stay relevant amid a growing number of competitors. **With new startups taking to Kickstarter and Indiegogo each day, innovation has never been more critical for keeping ahead of the competition.** And given the uncertainty of supply chains, economic events, and natural disasters, having the flexibility to scale production when and where it's needed is quickly becoming a real competitive advantage.

Innovation, adaptability and scaled manufacturing are the axes of improvement offered by additive manufacturing, which also participate in adding more flexibility to your business. They will allow you to grow your business, push your boundaries, face brand new challenges, and bring your manufacturing process to the next level!

In this playbook, we are going to f**ocus on how 3D printing (also known as Additive Manufacturing) is driving businesses to be more adaptable,** the benefits and possibilities created by adaptability, and concretely how to implement 3D printing for more adaptability in your business.

02. Adaptable Manufacturing



We all have examples of businesses that suffered from a lack of adaptability, from MySpace to Kodak. There are plenty of ways to demonstrate the real value of adaptability. According to a study made by McKinsey, **84% of executives say that innovation is important to their growth strategy,** and 80% think their current business models are at risk of being disrupted in the near future.

Rethinking and reframing a strategy is particularly essential as **unexpected events, such as a global pandemic can disrupt your whole strategy**. The more adaptable your business is, the more prepared you will be.

Indeed, the best example of the importance of adaptability is the ongoing COVID-19 pandemic. Industries and businesses who knew how to adapt were better able to face these troubled times.

Thanks to innovative manufacturing techniques, such as additive manufacturing, there are three different ways your business can be more adaptable to build a solid competitive advantage to stay ahead of your competitors:

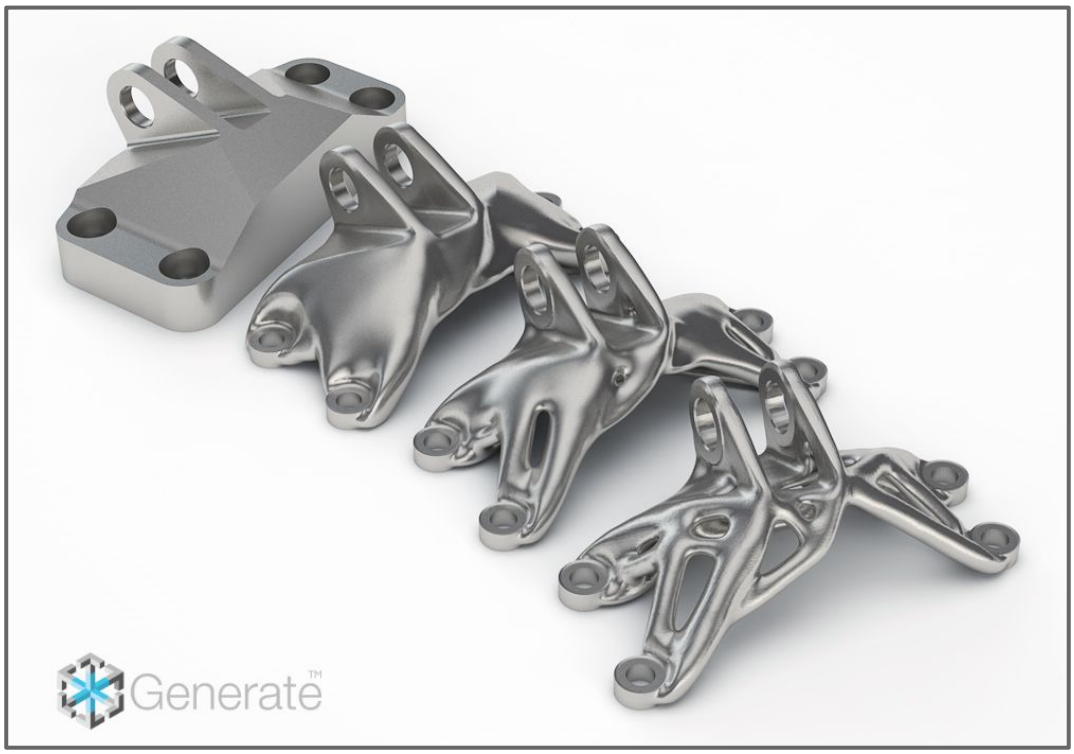
Adaptability		
Design	**Manufacturing**	**Product Lines**
Weight/Topology Optimization	Digital inventory	Faster go-to-market
Integrated assembly (reduce the number of parts)	Spare parts	Small series / Limited editions
Adapted parts to physical constraints	Flexible production line	Mass-Customization

03. Adaptability of Design

Design for Additive Manufacturing (DfAM) can not only optimize your products, but also your whole business strategy. “Thinking additive” is the key to optimization of your products and will offer new possibilities on the design side to gain adaptability. Free from traditional manufacturing constraints, you can take advantage of increased flexibility in your design development process.

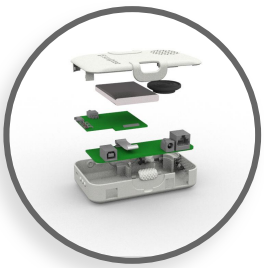
3.1 Optimize the weight of your parts

Reducing weight is a perpetual challenge in industries such as automotive and aeronautics. By making use of additive manufacturing, **new geometries can be imagined which can drastically reduce the weight of common components**. With topological optimization software and experienced additive manufacturing designers/engineers, completely new forms can be produced, which were previously impossible to produce with CNC machining or injection molding. These **organically inspired forms are perfectly adapted to the forces and stresses they will face and often perform better than the original**. Lattice structures can also be integrated to maintain structural integrity while reducing the amount of material used.



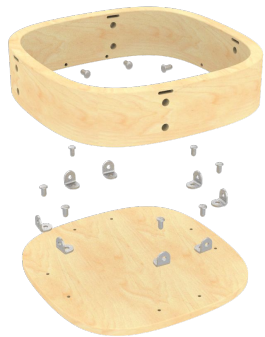
Credit: 3DPrint.com

GE Aviation used Design for Additive Manufacturing to create a helicopter engine with 16 parts instead of 900, greatly reducing the complexity of their supply chain.



3.2 Reduce the number of parts with integrated assembly

Each additional component of an assembly not only complicates the part itself but also necessarily adds additional cost, inventory, requisitioning, warehousing, and of course assembly time. Many common fasteners, brackets, fixings, and supports can be designed directly into the part and thus eliminate the need for these components. **Not only does each eliminated component reduce the overall cost, it also increases the adaptability of the whole assembly line by simplifying the supply chain.** Additive manufacturing allows you to adapt your design to its purpose, to optimize the whole process.



-50%
assembly time

-70%
components

3.3 Adapt to physical constraints

The flexibility offered by 3D printing allows designs to be perfectly adapted to the actual situation rather than depending on “off-the-shelf” solutions. **You’re no longer restricted to standard components, meaning that your design can be optimized to the conditions in which it will be used.** In the case of electronics, robotics, drones, pipe fittings, or general flow management, having a custom solution allows you to meet the unique needs of each situation.

04. Adaptability in Manufacturing

Adaptability can also be key to success on the manufacturing side: more adaptability during the manufacturing process leads to better risk management. **From inventory issues, to supply chain delays and breaks in production, these problems can cause significant damage to your business**. Being more adaptable in manufacturing will help you be more prepared and ready to face unexpected situations.

4.1 Start thinking about a digital inventory

Rethinking your supply-chain and your inventory might be a perfect solution to add more adaptability to your business. Have you ever thought about a digital inventory? Instead of storing parts which take space in a warehouse, **additive manufacturing allows you to produce the parts when they're needed**. Thanks to on-demand manufacturing, you don't have to warehouse and inventory all your parts, you can **dematerialize your production and store 3D files.** This digital inventory allows you to produce the exact amount of parts you need, when you need them.

64% of US manufacturers expect 3D printing to be used to make obsolete part in the next 3 to 5 years.

30% of manufacturers believe that the greatest disruption to emerge from widespread adoption of 3D printing will be restructuring supply chains.

Source: PwC analysis of Zpryme Research survey data

34% of CFOs said supply chain issues had moved up among their top three concerns amid the coronavirus outbreak, and are considering making changes to their operations as a result.

Source: PwC CFO Pulse Survey

4.2 3D printing your spare parts

3D printed spare parts could also be a great asset for your company. A lot of companies are relying on physical inventory to meet aftermarket needs. If these products are not sold, they become obsolete, which represents a massive waste for the company.

Car manufacturers, such as Jaguar and Porsche are actually making the most of 3D printed spare parts. Indeed, it can be difficult to find replacements, especially for older car models. But, by combining 3D scanning, 3D modeling and additive manufacturing it's possible to produce rare (spare) parts for cars.

4.3 Use a flexible production line

More than just for products, you can also use 3D printing on your production line, to create tooling and adapted parts for your manufacturing process.

A device, such as a gripper, can be adapted to different products but connect to existing robotic arms and machinery. With 3D printing you can adapt the gripper to any manufacturing need.

The use of 3D printing for adapted Jigs and tooling is widely used in many industries to ensure consistency as new products are created.

05. Adaptable Product Lines

Offering custom products, limited editions, and testing new products with small series runs can be a great way to **set yourself apart with respect to product offering**. This adaptability as well as the opportunity to scale your production when necessary will help you build a solid competitive advantage. Put your **product development process into hyperdrive to reduce the time to market, save money on product samples and test runs, and find the most economical way to customize your products**.

5.1 Accelerate Product Development

Time to market is increasingly becoming a vital factor for success as competition grows. From conception to product launch, additive manufacturing is a game-changer. Initial designs can be quickly produced and tested, hundreds of iterations and tests can be made in a single production batch, and final **prototypes can be produced for market testing and validation within the span of weeks rather than months**.

Free from the costs and limitations of molds or machining, 3D printing is the most cost effective and timely way to develop products.

As competition increases, **accelerating product development** has becomes an important focus for

41%

of companies using 3D printing

80% say 3D printing had a significant improvement on their **speed of innovation**

73% say **Lead time** is one of the most important measures of success for 3D printing activity

Source: The State of 3D Printing 2020, Sculpteo

5.2 Feel free to launch limited editions

Making limited editions, or short series can quickly become an issue while using traditional manufacturing. With **hand crafting, molding, or machining, limited editions can be cost prohibitive.** However, with 3D printing, there is no minimum quantity while using additive manufacturing. **From a single object to 10 000+ parts, you can 3D print the exact amount of parts you need**. This is why additive manufacturing is particularly adapted to the creation of limited editions.

This freedom of quantity is also an opportunity for your business to test the market with a short series run before launching a product and starting mass production. R**ather than heavily investing in new production lines, you'll let the market dictate your investments based on the performance of these short series runs.** You'll also benefit from the sense of exclusivity, think of streetwear brand, Supreme.

5.3 Customize your products

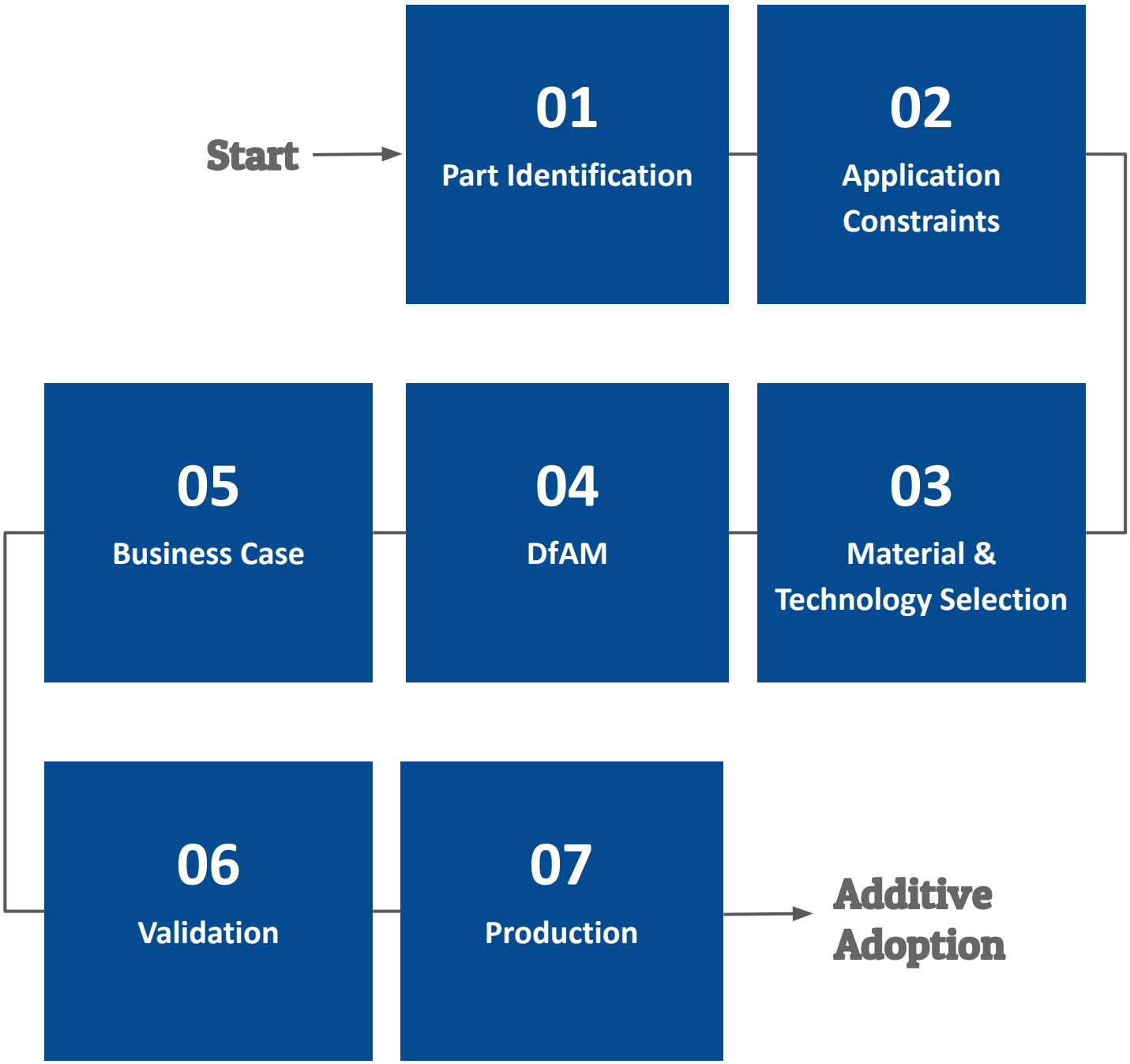
Many companies are realizing the potential of customization to put the power into their customers hands and give them a unique experience. Whereas using traditional manufacturing techniques makes customization expensive, time consuming, and generally reserved for only the most exclusive clients, with 3D printing it can be cost efficient and present an added value for any customer.

The flexibility of additive manufacturing offers the opportunity to adapt to your requirements and to your customers' needs, just by modifying your 3D model. Customization is now possible at scale using software such as Twikbot by the Belgian company Twikit which allows users to parametrically adapt designs to their specifications either online or using in-store solutions.

Source: Twikit - SealMask

06. The Adaptable Manufacturing Playbook

Let's get practical! It is your turn to **evaluate where you can find adaptability in your business by implementing additive manufacturing**. Going through these exercises and checklists with your design engineers, product managers, quality engineers, supply chain managers, and additive experts (either internal or external) will help you determine your additive opportunity and put it into action.



6.1 Part Identification

Use the framework below to identify potential parts that could be interesting for Additive Manufacturing.

Design

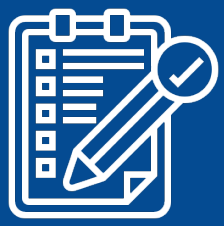
- Complex shapes
- Innovative systems
- Lightweight design
- Adapting to existing systems
- Parametric design
- Functional integration
- Part count reduction

Manufacturing

- Hard to find parts
- Frequent changes to production line
- Reduce warehousing costs
- Shorten lead-time for parts
- Unpredictability/variability of quantity

Product Line

- Shorten time to market
- Limited editions / medium size series
- Mass customization
- Tailor-made/ bespoke products



6.2 Application Constraints

Use the checklist to identify the properties required for the intended application.

Production

- [ ] Part Size _____
- [ ] Quantity _____
- [ ] Accuracy _____

Environmental Constraints

- [ ] Biocompatible / Skin contact
- [ ] Flame Retardant
- [ ] Chemical Resistance
- [ ] UV Resistance
- [ ] Water tightness
- [ ] Sterilizable
- [ ] Electrostatic Discharge (ESD)
- [ ] Corrosion Resistance
- [ ] Temperature _____
- [ ] Pressure _____

Mechanical Constraints

- [ ] Vibration _____
- [ ] Traction / Pressure / Flexure _____
- [ ] Shock Absorption _____

Aesthetics

- [ ] Color _____
- [ ] Surface finish _____

Other

6.3 Material & Technology Selection

Use this comparison to narrow down the material / technology options before consulting with a specialist

☐ SLS (Selective Laser Sintering)

Materials: PA12, PA11, PP, PA6, TPU

Applications	Quantity	Resolution	Durability	Cost
Automotive, electronics, industrial & consumer goods	1 - 200k	●●●●○	●●●●○	$$$$$

☐ HP Jet Fusion

Materials: PA12, PA11, PP, TPU

Applications	Quantity	Resolution	Durability	Cost
Automotive, electronics, industrial & consumer goods	1 - 200k	●●●●○	●●●●○	$$$$$

☐ FDM

Materials: PLA, ABS, PETG, ULTEM, PEEK

Applications	Quantity	Resolution	Durability	Cost
Prototypes	1 - 1k	●●○○○	●●●○○	$$$$$

☐ SLA

Materials: Prototyping resin

Applications	Quantity	Resolution	Durability	Cost
Prototypes, Dental	1 - 1k	●●●●○	●●○○○	$$$$$

☐ DLS

Materials: RPU, EPU

Applications	Quantity	Resolution	Durability	Cost
Automotive, consumer goods	1 - 1k	●●●●●	●●●○○	$$$$$

☐ DMLS/SLM

Materials: ALSi7Mg0.6, Titanium, Stainless Steel 316L

Applications	Quantity	Resolution	Durability	Cost
Tooling, mechanical parts	1 - 200	●●●●○	●●●●●	$$$$$

☐ Binder Jetting

Materials: Steel / Bronze, Stainless Steel 316

Applications	Quantity	Resolution	Durability	Cost
Jewelry, decorative pieces	1 - 1k	●●●○○	●●●●○	$$$$$

6.4 Design for AM

Depending on your project, you might benefit from Design for Additive Manufacturing for design or production optimization. Use the framework below to identify your opportunities for DfAM.

☐ Design Optimization

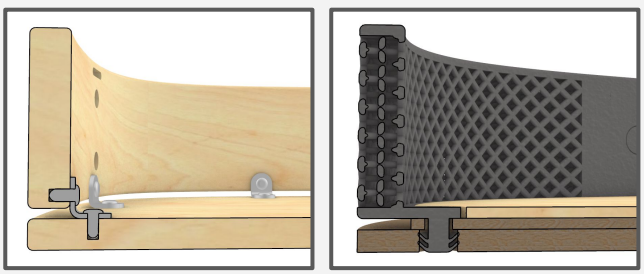
Improve the function or use of the part and improve performance given the application's constraints

When should you consider it?

- ▫ **The weight of the part is critical**
- ▫ **The part contains many small elements (i.e. brackets, screws)**
- ▫ **The functions of parts can be combined (Functional integration)**
- ▫ **The overall geometry can be optimized to improve functionality**

What skills are needed?

- ✓ Knowledge of the design guidelines for the technology and material
- ✓ Mechanical engineering
- ✓ Industrial design
- ✓ Parametric design
- ✓ Lattice generation
- ✓ Simulation
- ✓ Topology optimization



-60% weight,- 70% components, -50% assembly time

☐ Production Optimization

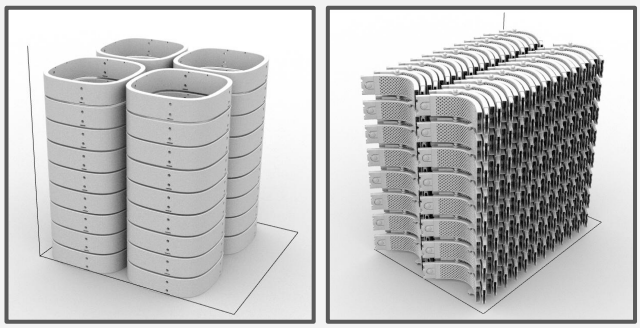
Improve the manufacturability or reduce the production cost given the constraints of the manufacturing process

When should you consider it?

- ▫ **To make the best use of technology/machine constraints (i.e. powder based technologies vs photopolymer vs filament)**
- ▫ **To find the optimal print orientation**
- ▫ **To anticipate potential repeatability issues**
- ▫ **To integrate post-process constraints in the design (supports, cleaning, finishing)**
- ▫ **To reduce cost for series production**

What skills are needed?

- ✓ Job build preparation (Nesting/slicing tools)
- ✓ Knowledge of production constraints
- ✓ Knowledge of additive manufacturing processes including job builds, printing processes, and post-processing
- ✓ Experience working with different 3D printing technologies

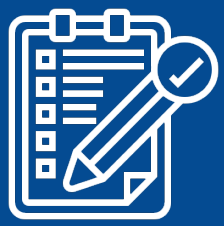


36 complete structures vs. 96 in a single batch. -66% cost

6.5 Business Case

Consider the overall impact of additive manufacturing for each potential project by evaluating the criteria below.

Criteria	Business Impact Less Relevant for AM — No Change — Game Changer
Quantity - Volume of parts for the total production run	100k+ — 10k — 1 - 1k
Production Interval - Is there a variability or unpredictability about the production quantity?	All at once — Regular intervals — On-demand
Production Delay - When will you need the parts?	6-12 months — 3-6 months — Days - Weeks
Cost - Cost per part with AM vs traditional manufacturing	+50% — No change — -50%
Project Timeline - What is the total timeline of the project including design, validation, and production?	12+ months — 6-12 months — 1 - 3 months
Material Properties - How do the properties of 3D printing materials compare to the original?	Inferior properties — Comparable properties — Superior properties
Geometry Complexity - Is the geometry of the part especially complex or intricate?	Possible with traditional mfg — Traditional mfg with slight modifications — Only possible with AM
Weight Reduction - Will the new part be lighter than the original?	+50% — No change — -50%
Parts Reduction - Will the redesign reduce the number of parts?	+50% — No change — -50%
Assembly Time - Will they redesigned part be faster to assemble?	+50% — No change — -50%
Other non-economic value - Are there other gains that can be made by 3D printing? (i.e brand hype, customization)	Not Significant — No change — Significant Improvement



6.6 Validation

Consider the criteria below to determine the types of testing which will be necessary to validate the redesigned 3D printed part.

☐ Structural Study (compliant mechanism, stress simulation, lifetime estimation)

Using a FEA software (finite element analysis), we simulate the behaviour of the part under mechanical constraints.

- **The part will be 'loaded'**
- **The part directly uses the mechanical properties of the material (compliant)**

☐ Fluid Study (flow analysis, aerodynamism)

Using a CFD software (Computational Fluid Dynamics), we compute how fluids behave inside or around the part. We can even combine this study with a structural one to simulate inflation of deflation of a flexible part.

- **The part pipes fluids**
- **The part has aerodynamic constraints**
- **The part must deflate or inflate under specific pressure**

☐ Heat Transfer Study

Using a FEA software (finite element analysis), we simulate the behaviour of the part under thermal constraints. **Can be combined with CFD.

- **The part will be exposed to high, low or variation of temperature**
- **The part must dissipate or contain heat**

☐ Structural Testing (tensile & flexural testing, cyclic loading)

Using a tensile test machine, we can submit the 3D-printed part to a series of mechanical stresses and verify the properties of the design.

- **The part will be 'loaded'**
- **The part directly uses the mechanical properties of the material (compliant)**
- **The parts contains clips the strength of which must be qualified**

☐ Metrology (scanning, weighing, other on-demand process)

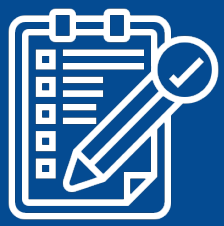
Using a high-precision 3D scanner, we can measure the deviation between the 3D model and the effective print.

- **The design is part of a high-precision assembly**
- **Lightweight structures**
- **Quality assurance**

☐ Other (waterproofing, heat resistance)

Our engineers can develop on-demand protocols to validate the parts that you order.

- **Watertightness**
- **Impact resistance**
- **Geometrical properties**
- **Optical properties**



6.7 Production Evaluation

Use the criteria below to evaluate your internal capabilities for using 3D printing and potential production partners

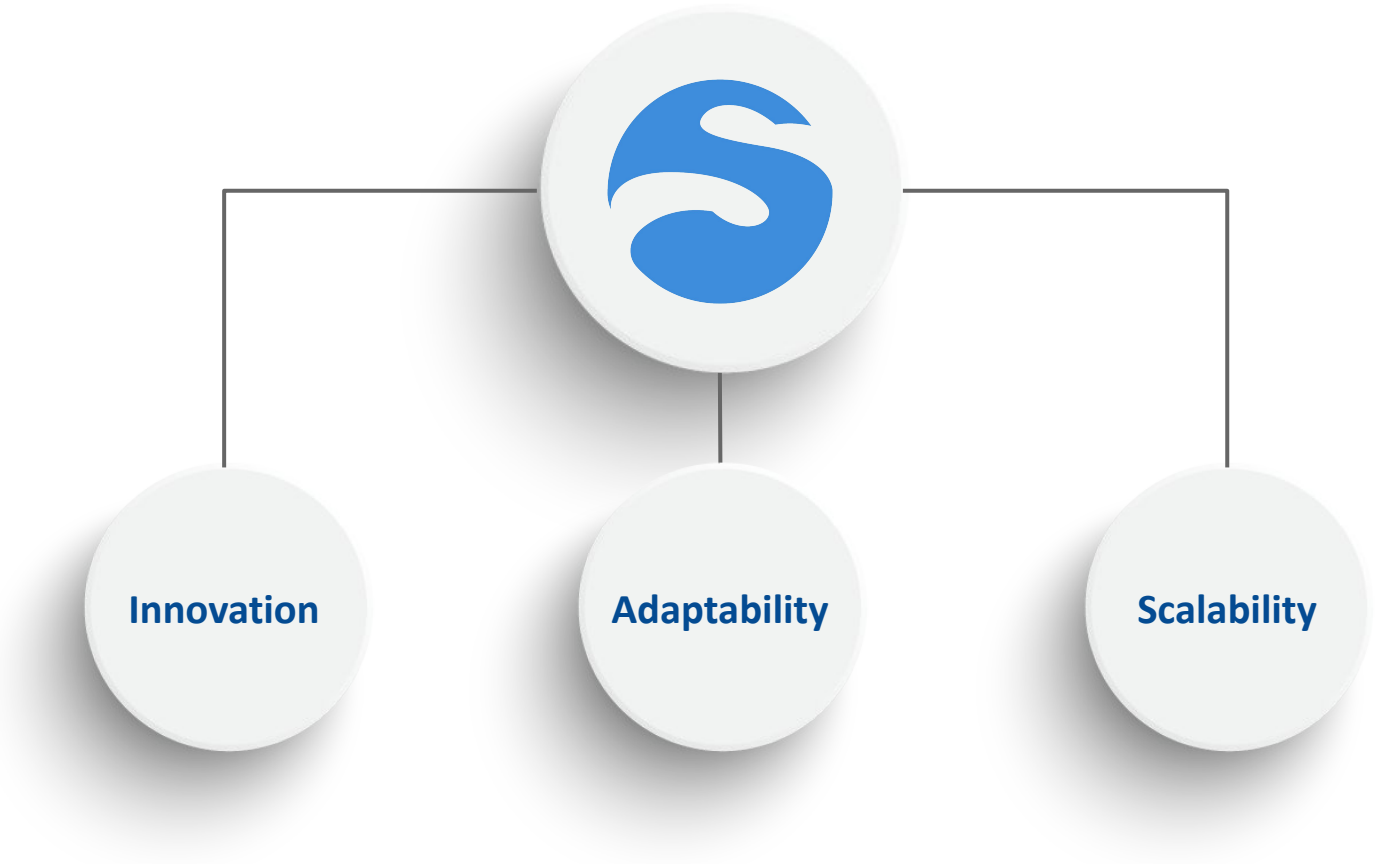
Criteria	Internal Capability	Potential Partner 1:	Potential Partner 2:
Production location - Where will the production center be located?			
Dedication capacity - Will the production center be able to reserve dedicated capacity for your volume of production?			
Quality control - What systems of quality control does the production center have in place?			
Ordering process - How will you place orders? Through a sales team, directly online, integrated with your ERP?			
Production delay - What is the expected production delay for the technology/material?			
Certifications - Does the production center have the necessary certifications for your industry? (ISO 9001, ISO 14001, ISO 13485, etc)			
Post-processing - What types of post-processing do they offer to get the desired finished quality?			
Other			

07. Putting It All Together

Now that you understand all the benefits of digital manufacturing for the adaptability of your business and have considered how to put these plans into action, you might realize you'll need expert guidance. Sculpteo's experienced engineers, industrial designers, and production specialists are here to support you in your project, at all stages of its development. Sculpteo has been a **leader in digital manufacturing since 2009, working with innovative companies and supporting them to integrate 3D printing in their manufacturing process**.

With the great **expertise of our digital manufacturing specialists from Sculpteo Studio**, offering consulting, training and design services, you will have the opportunity to identify your 3D printing opportunities and optimize your whole process. These experts will support you from the early stages of your process to the end of the production run!

With a professional 3D printing service you have access to industrial 3D printing technologies and materials to get the results you expect for technically demanding industries.



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Access our
MasterClass resources
and develop your AM strategy

Think additive & Gain an adaptive advantage for your business.

Access to a one-stop-shop of resources to discover your Additive Advantage and develop a strategy that will **put game-changing technology into your hands**.

Use it to unlock the full potential of 3D printing, and:

- **Create room for innovation,**
- **Scale your production,**
- **Make adaptability one of your greatest strengths**.

We've compiled our best ebooks, playbooks, guides, and customers' stories, made for professionals who want new additive manufacturing opportunities

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