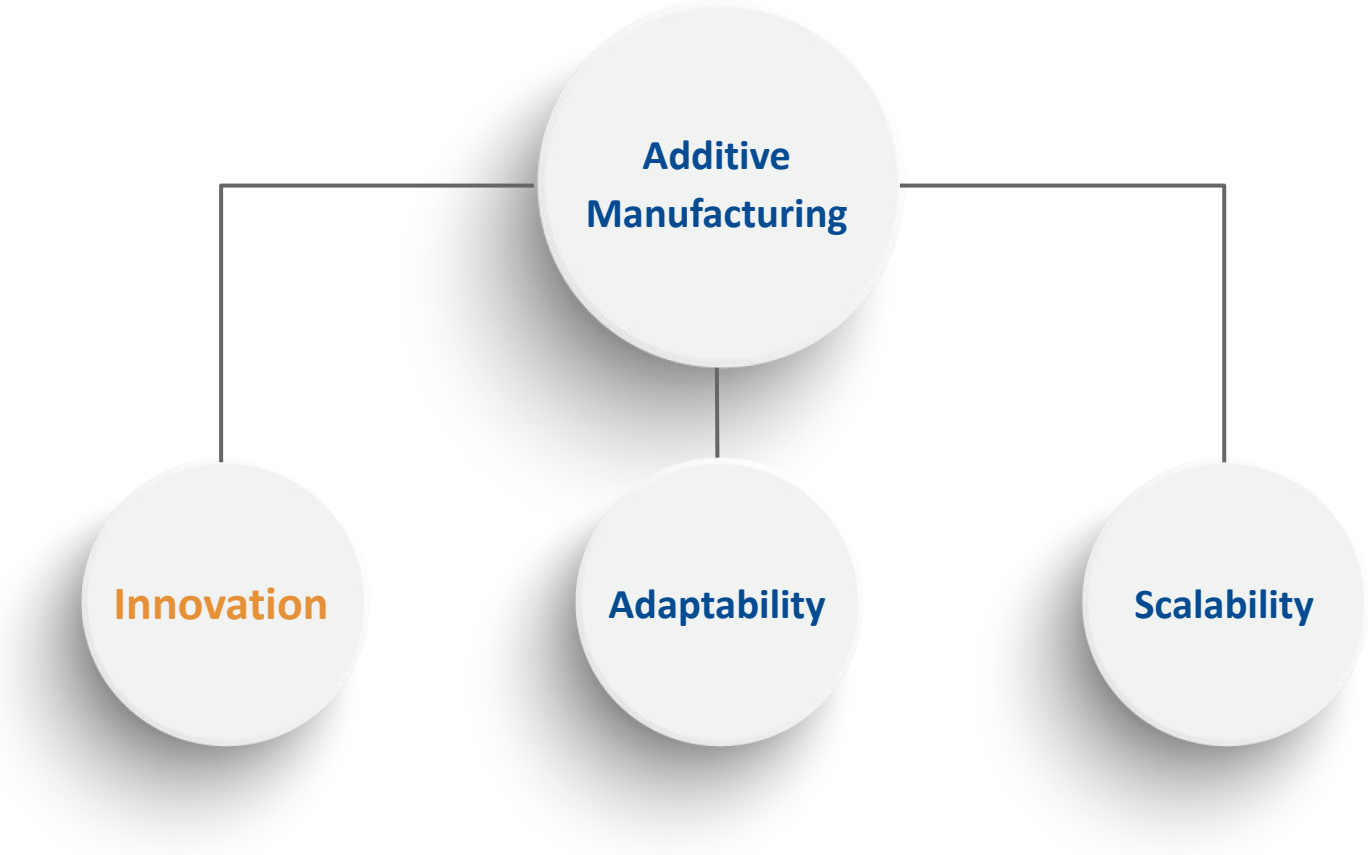
Additive Adoption A - Z:

The Product Development Playbook

How to optimize your product development process with 3D printing?

sculpteo
A brand of BASF - We create chemistry

Contents



01. Introduction

Facing manufacturing challenges and allowing your business to grow is only possible with the right tools and strategy. To develop your competitive advantage while meeting the needs of an ever-changing market, using Additive Manufacturing allows for rapid innovation, adaptable supply chains, and scaled manufacturing. To stay ahead, businesses must invest in efficient product development processes.

Product development is a crucial aspect of your project that will take you from the early stages until the final manufacturing process. At first, you will only have an idea for your product, but this idea will go through design creation, testing of functional parts, and finally result in the launch of your first series.

This playbook will focus on how 3D printing (also known as Additive Manufacturing) supports your product development, the benefits and possibilities created by an optimized product development process, and, more concretely, how to implement 3D printing for optimized product development.

02. Product Development

Product development refers to the stages between the elaboration of an idea and the market release of your product, which includes conceptualization, design, prototyping, tests, iteration cycle, market validations, first production runs, and the final product launch.

The stages in product development bring an idea to life by working on its feasibility and elaborating how well it answers the market's needs and satisfies consumer demand. More than any other part of your manufacturing journey, product development requires flexibility and adaptability to meet your business goal.

Relying on a solid manufacturing technique and process will help you cultivate a competitive advantage with confidence by developing better products with shorter lead times. Rapid prototyping unlocks the freedom of iteration to test and validate every detail of your project. Open new opportunities without the limitations of traditional manufacturing.

Additive manufacturing will be your best ally for these three main steps: Conceptualization, functional prototyping, and pre-series and manufacturing. Additive manufacturing offers the freedom of innovation needed for the conceptualization and design of your project. It guarantees the flexibility and adaptability required to achieve your goals and reach the first steps of your manufacturing process in the best conditions.

01	Conceptualization	• Creating a 3D file • Designing for Additive Manufacturing • Rapid Prototyping
02	Functional Prototyping	• Choosing a Material • Testing for fit/form/function • The Iteration Cycle
03	Pre-Series & Manufacturing	• Market Validation • The First Production Run • Tooling for Traditional Manufacturing

03. Conceptualization

Conceptualization is a crucial step in your project, and it is where the idea will start to take shape. Suppose you decide to use additive manufacturing for your product development process. In that case, several exciting opportunities open up during the conceptualization stage of your project, helping you optimize your final part's design.

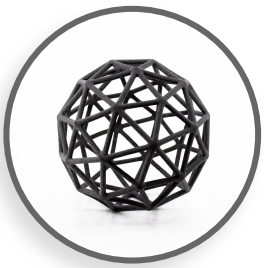
3.1 Creating a 3D file

To start the conceptualization of your project, you will need to create a printable 3D model. This means the 3D model has to respect the guidelines of the technology and material to ensure its printability. Minimum wall thicknesses, crossed-volumes, or non-manifold geometries can all make a design unprintable. Aside from these basics, digital manufacturing technologies allow for advanced 3D modeling techniques, parametric modeling, and generative design.

Parametric Modeling: a CAD tool based on algorithmic thinking, helping to create a 3D file thanks to a series of pre-programmed rules and parameters. This process clarifies the relationship between design intent and design response. Every time one of the design dimensions is modified, there is no need for a design engineer to redraw the whole product; the software will recalculate your 3D model according to the parameters and rules previously set. Using parametric design will be time-saving, easier to iterate, and make the most of mass customization.

Generative Design: an iterative design process that will generate a certain number of outputs meeting specified constraints. This technique will create an iteration of a design based on defined real-world constraints and needs. Designers or engineers input parameters, constraints, intended outputs, requirements, materials, and manufacturing methods into the generative design software. The software explores all the possibilities and permutations of a solution; thanks to all this information, the software will design multiple solutions.

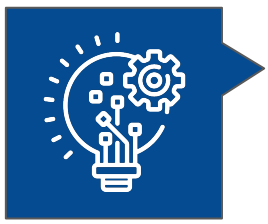
According to Sculpteo's State of 3D Printing 2021, 87% of the respondents say their speed of innovation improved thanks to 3D printing.



3.2 Designing for Additive Manufacturing

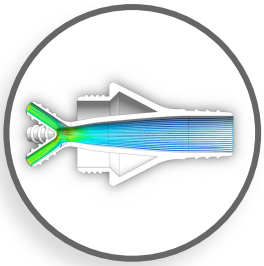
Design for Additive Manufacturing (DfAM) allows innovation by recreating your part, optimizing, and improving it, without the manufacturing constraints of traditional manufacturing methods. Here is an overview of what DfAM can do for you:

- **Integrated assembly**: Integrate features directly in the structure of your product to get an even more functional product and save time during the assembly process.
- **Lattice structures**: Strengthen and lighten your products thanks to innovative structures. Lattice structures have high strength and low mass mechanical properties and multifunctionality, which can be found in parts for the aerospace, robotics, or drones industries.
- **Compliant mechanisms**: 3D printing will improve compliant mechanisms with new design solutions such as interlocking parts. But more importantly, you can actually design a mechanism that can be entirely 3D printed in one piece.
- **Topological optimization**: Optimize the material layout of your product according to given constraints thanks to this mathematical method and maximize the performance of your parts.



40% time saved during product development for Icelandic drone manufacturer, Svarmi.

Source: Sculpteo



3.3 Simulation/Virtual Engineering

Simulation for Additive Manufacturing is complementary to DfAM to optimize your most complex parts, to understand where they need to be strengthened for example, and to improve the capabilities of your components. Developing design for 3D printing is also about part consolidation and improvement of the durability and functionality of the parts.

Simulation means you try to predict what is going to happen with the part in real life. You don't need any part in your hands, virtual engineering covers all things that are interesting to know, all-around 3D printing, from processing to using the part, from doing better designs to simulating tests. Simulation brings important insights, only available with a thorough numerical simulation.

Sometimes after these tests, parts have to be redesigned, sometimes a contour change that homogenizes the surface stress is sufficient. It is also possible to model the 3D printing process to some extent. This means it could induce material changes (e.g., anisotropy) and incorporate them in the mechanical simulation. Teams working on virtual engineering are using engineering software related to doing Finite Element Simulations, a general numerical method for solving partial differential equations in two or three space variables.

3.4 Rapid Prototyping

Before the functional prototyping stage, rapid prototyping will help you communicate your design intent, form, and dimensions. Benefit from low-risk concept explorations that look like real products to easily communicate your idea. Generally, a proof of concept would not require industrial 3D; turning to desktop 3D printing will be your easiest, cheapest, and fastest option for your first iterations. Rapid prototypes take form overnight with Fused Deposition Modeling (FDM) and Stereolithography (SLA) technologies.

For small details and smooth surfaces, SLA desktop 3D printing with technologies such as Formlabs' Form 3 will be an ideal solution. FDM desktop solutions are generally less expensive, producing a rapid prototype that doesn't require a curing process.

04. Functional Prototype

3D printing is the shortest path between your ideas and a functional prototype in your hands, the ultimate link between the conceptualization of your idea and the manufacturing process. The feasibility of your project will be tested with adapted materials and technologies. You can optimize the testing process with shorter lead times and reduce costs with additive manufacturing.

4.1 Choosing a Material

The additive manufacturing market now offers an extensive catalog of 3D printing materials for professional technologies such as stereolithography, selective laser sintering, and HP Multi Jet Fusion. Choosing the adapted material for your functional prototype will determine the success of your process. It is now easy to access cost-effective and accurate 3D printing materials to give life to your functional prototypes.

- **Nylon PA12**: A solid and versatile 3D printing material adapted to functional prototyping.
-
- **PA11**: Approved for skin contact and offering good impact resistance, prototyping with PA11 will be adapted for the most demanding projects.
-
- **Ultrasint® TPU 88A**: Rubber-like, with excellent shock absorption, particularly adapted for prototypes requiring flexibility.

At this stage of product development, it's critical to use a material with mechanical properties similar to the final material choice. A functional prototype gives you the chance to test the functionality of your part under real-world conditions. Thanks to many developments in 3D printing materials, high-performance materials often feature properties as good as (and in some cases better than) traditional injection molding or vacuum casting materials.

4.2 Testing for fit/form/function

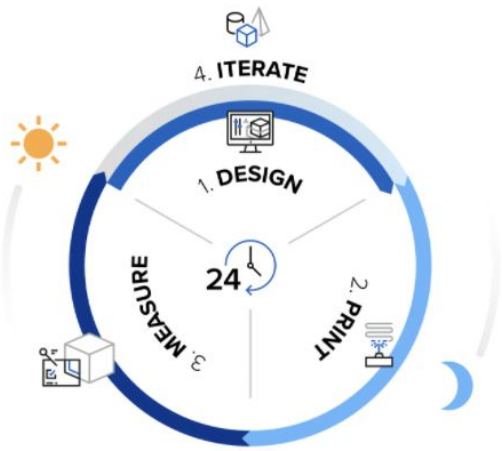
The development of your functional prototype has to validate the feasibility of your product, and more importantly, the fit, form, and function of your product.

- **Fit:** Verify the assembly of components
- **Form:** Finalize the visual design, ergonomics, and dimension
- **Function:** Test all working mechanisms to validate the critical functionality of the part

Industrial 3D printing produces accurate, resistant, and functional parts ready to be put to the test.

4.3 The Iteration Cycle

One of the most significant advantages of additive manufacturing is its capacity to accelerate the iteration process. With a shorter iteration cycle, you can design, test, and modify your part within as little as 24 hours. 3D printing also allows you to test multiple versions of the same part at once. The accelerated iteration cycle lets you work on specific attributes of the part in isolation reducing overall costs and giving engineers genuine parts to put to the test.



Source: Formlabs

60% cost savings during prototyping for General Motors' 3D printed brake cooling ducts.

Source: General Motors

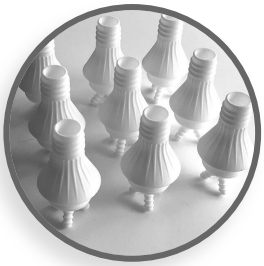
05. Pre-series and Manufacturing

Additive manufacturing is not only an asset for the earliest stages of your product development; for small series, or initial production, 3D printing can be a cost-effective and timely solution. The big question surrounding Additive Manufacturing is finding the breaking point where using traditional manufacturing methods will be more efficient? While there is no “one size fits all” answer to this question, in this section, you’ll consider the different elements to make this decision for your product.

5.1 Market Validation

Not only is 3D printing the fastest way to test your product, but it’s also the quickest way to go to market. Launching a crowdfunding campaign is a low-barrier entry to the market, which quickly gives you feedback from real users allowing for further product improvement. Let’s look at how 3D printing is used for market validation.

- **Create a high-fidelity demonstration part to launch your campaign.** Give potential backers a complete view of your project with detailed, high-quality, finished parts. With industrial 3D printing and post-processing technologies, your demonstration parts will have the look and feel of injection molding.
- **Fulfill your first orders to meet customer orders quickly**. Rather than waiting for offshore production and costly injection molding, use additive manufacturing to deliver your finished parts to campaign backers. Avoid unexpected costs and delays of offshoring by getting your first editions manufactured with a reliable manufacturing partner closer to your location.
- **Accelerate the feedback loop** by integrating real user experiences into your V2. Your first users will have the most important evaluation of your product; by using additive manufacturing, you can directly integrate their suggestions without incurring wasteful additional tooling costs. Optimized time-to-market can save you at least 8-10 weeks compared to injection molding.



5.2 The first production run

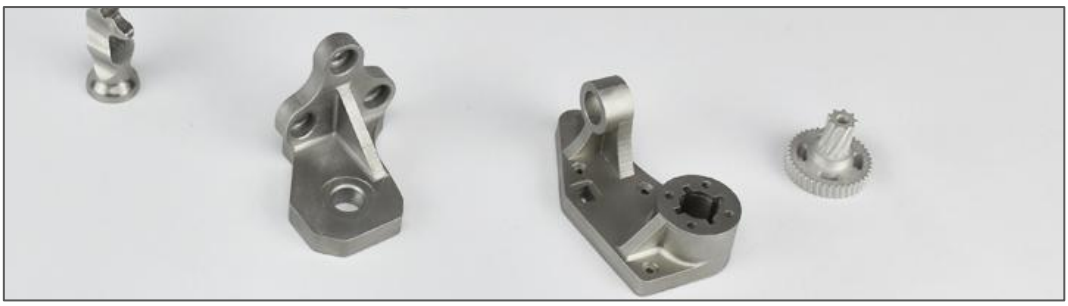
Short series can quickly become an issue while using traditional manufacturing. With handcrafting, molding, or machining, limited editions can be cost-prohibitive!

With an on-demand manufacturing technique such as 3D printing, you don't need to invest in producing or storing huge quantities. You pay only for the parts needed and eliminate inventory and warehouse costs. Additive manufacturing is all about scalability, getting the right quantity for your demand. Manufacture the number of products you need and get the feedback of your customers before investing in more costly mass-manufacturing techniques. Let the market dictate your investments based on the performance of these short series runs and adapt your production accordingly.

5.3 Tooling for traditional manufacturing

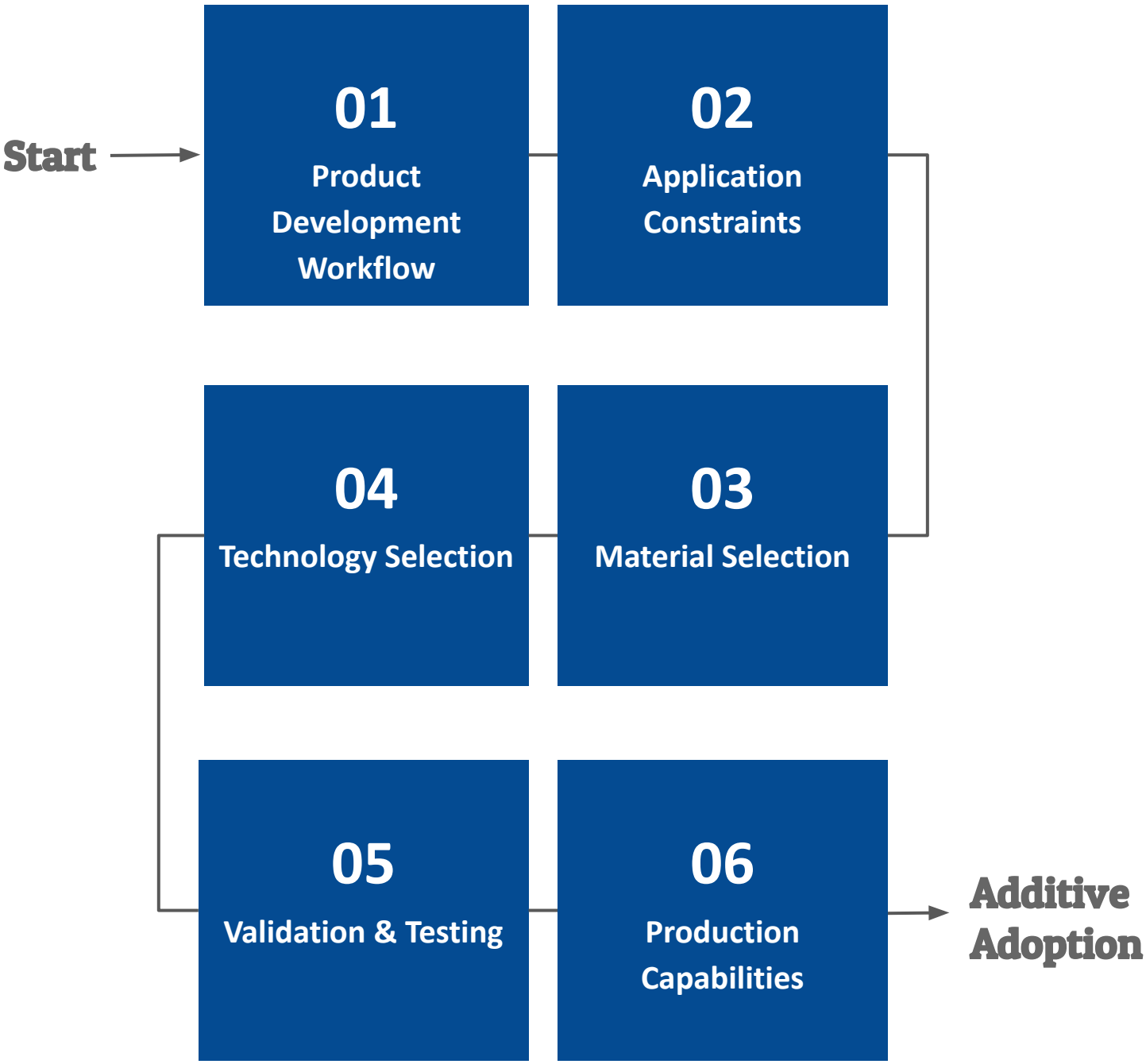
In order to be a real competitive advantage, 3D printing has to be used wisely. Depending on the scale of production and geometry of the parts, you will (sooner or later) reach a point where traditional manufacturing techniques are more cost-effective than additive manufacturing. While there are some unique geometries which are only possible with additive manufacturing, lattices structures, for example, most parts are possible with injection molding or vacuum casting.

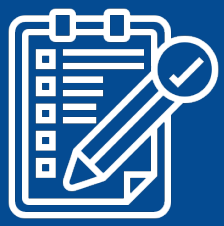
Nevertheless, 3D printing can still be an asset for your production. Using 3D printing to manufacture molds, jigs, or fixtures can save significant time and money in the overall production process. Traditional manufacturing and additive manufacturing can be complementary to cultivate your competitive advantage!



06. The Product Development Playbook

Let's get practical! It is your turn to **evaluate where you can take advantage of the flexibility and performance of additive manufacturing in your business**. 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 Product Development Workflow

Identify the different steps of your product development and the role of additive manufacturing for each of them.

Design

Create an optimized design of your product for additive manufacturing and facilitate the tests using virtual engineering.

Proof of concept

Validate your project thanks to an object with a good appearance. Feel free to iterate and boost your rapid prototyping process with desktop 3D printing.

Functional prototype

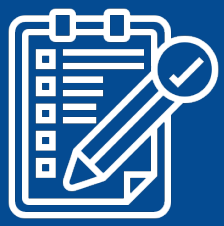
3D print your functional prototypes with adapted 3D printing materials and run the tests needed to validate the fit, form and function of your part.

Iteration cycle

Iterate, 3D print and test your product until it meets your expectations. Save time by speeding up your iteration process with 3D printing.

Go to market design

Run your first production thanks to an on-demand and flexible manufacturing technique. Get validation from your customer and accelerate the feedback loop.



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 Selection

Use the guide to choose the best 3D printing material according to the property required by your project.

VERSATILE	**Nylon PA12**	**Properties**		**Technology available**
	Accurate, affordable and versatile, Nylon PA12 material can suit project from prototyping to production for diverse industries.	Details Surface look Strength Flexibility	●●●○○ ●●●○○ ●●●○○ ●●○○○	SLS MJF
FLEXIBLE	**TPU**	**Properties**		**Technology available**
	With a good resilience after deformation and a high UV stability, TPU offers numerous advantages for your projects requiring an elastomeric material and shock absorption.	Details Surface look Strength Flexibility	●●●○○ ●●○○○ ●●●○○ ●●●●●	SLS MJF FDM
IMPACT RESISTANCE	**PA11**	**Properties**		**Technology available**
	PA11 is a bio-derived powder with exceptionally high toughness. This material has the particularity of offering high ductility and impact strength for all applications.	Details Surface look Strength Flexibility	●●●○○ ●●●○○ ●●●●○ ●●○○○	SLS MJF
ACCURACY	**Ultracur3D EPD 1006**	**Properties**		**Technology available**
	Ultracur3D® EPD 1006 offers the opportunity to create highly detailed parts and can be used by any industry to create realistic prototypes.	Details Surface look Strength Flexibility	●●●●● ●●●●● ●●○○○ ●○○○○	LCD

For more information about 3D printing materials, check out our material selection guide.

6.4 Technology Selection

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

Conceptualization

This step requires speed and good appearance.

SLA

Pros

- Speed
- Accuracy
- Details

Cons

- Low strength

FDM

Pros

- Affordable

Cons

- Surface finish
- Resolution

Prototype

This step might require specific properties or complexity to test fit, form and function.

FDM

Pros

- Easy iteration
- Large parts

Cons

- Surface finish
- Low strength

SLA

Pros

- Excellent surface finish

Cons

- Breaks easily
- Not suited for functional test

MJF

Pros

- Large material choice for mechanical properties

Cons

- Rough surface without finishes

Pre-series

This step requires stability, ability to produce quantities, complexity, some mechanical properties and quality finishes.

SLS

Pros

- Large material choice
- Tolerance

Cons

- Rough surface without finishes

MJF

Pros

- Large material choice
- Stability

Cons

- Rough surface without finishes

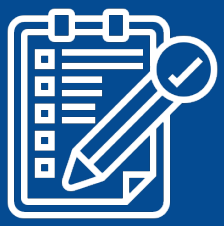
DLP/LCD

Pros

- Complexity

Cons

- Costly



6.5 Validation & Testing

Use this checklist to see what kind of tests has to be done to ensure the quality of your parts.

☐ 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)

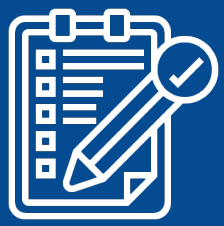
Using a high-precision 3D scanner, we can measure the deviation between the 3D model and the effective print.

- ☐ **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**



6.6 Production Capabilities

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?			
Repeatability What systems are in place to ensure consistency?			

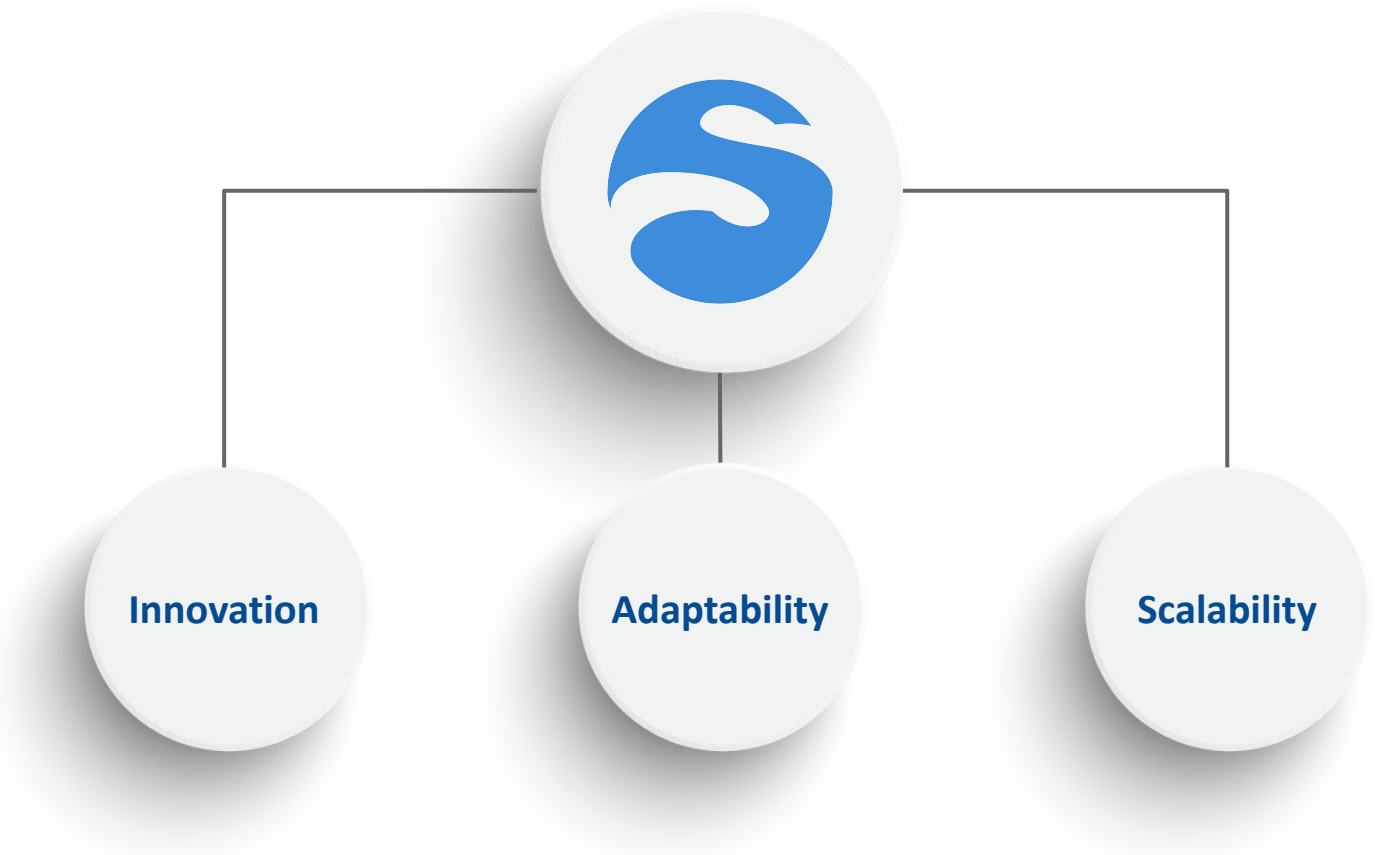
07. Putting It All Together

Ready to put additive manufacturing to work in your product development process?

If you are looking for more guidance, Sculpteo's experienced team of 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 helping them integrate 3D printing in their manufacturing process.

With the outstanding expertise of our digital manufacturing specialists from Sculpteo Studio, offering consulting, training, and design services, you'll be able to identify your 3D printing opportunities and optimize your product development 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 can access industrial 3D printing technologies and materials to get the results you expect for technically demanding industries.



MAKE YOUR BUSINESS THRIVE WITH 3D PRINTING

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

...all in one place.

A brand of BASF - We create chemistry

Paris

+33 1 83 64 11 22

San Francisco

1-800-814-1270

www.sculpteo.com

hello@sculpteo.com