Application Brief

Get to Market Faster with Large 3D Printed Manufacturing Quality Aids, Jigs & Fixtures

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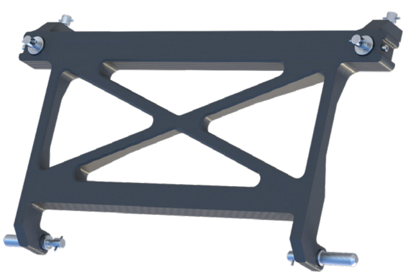
3D SYSTEMS
Additive Manufacturing Solutions

Background

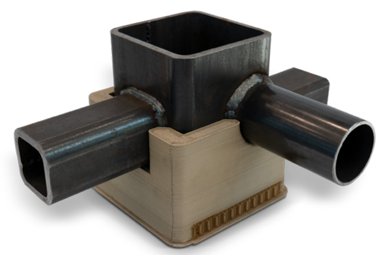
In today's rapidly evolving manufacturing landscape, the demand for efficient, cost-effective, and high-quality production tools has never been greater. Additive manufacturing (AM), or 3D printing, is transforming how industries produce fixtures, jigs, and assembly tools by reducing lead times, lowering costs, and enhancing precision.

Large-format industrial 3D printers, like 3D Systems' EXT Titan Pellet series, now enable single-piece printing of large fixtures, overcoming past size limitations. Their pellet extrusion technology further cuts material costs and print times compared to filament-based systems, making AM even more cost-effective.

AM's flexibility allows manufacturers to create complex, high-performance fixtures with minimal waste and fewer errors. On-demand production reduces inventory costs, while advanced materials ensure durability and longevity. As AM adoption grows, manufacturers gain efficiency, quality, and innovation, positioning themselves for a more agile and competitive future.


Quality Gages


Masking Fixtures


Welding Fixtures


Fiberglass/Carbon Fiber Molds


Layup Tools


Metal Forming Tools

Examples of 3D printed tools, gages, and fixtures

General advantages of additive manufacturing

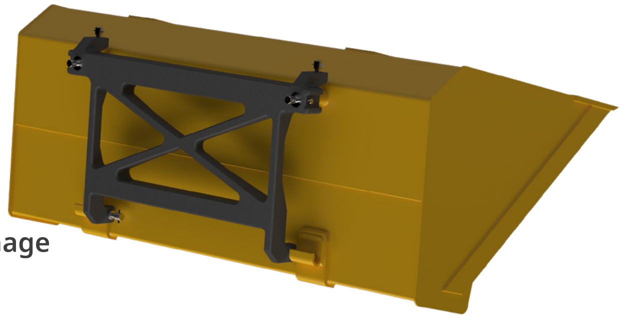
Some of the advantages of AM over traditional 'subtractive' manufacturing include:

- Design freedom to consolidate features and reduce part count for your jigs and fixtures
- Tools and molds optimized for weight reduction and ergonomics
- Faster time-to-market with streamlined production process and reduced inventory management through on-demand, on-site production
- Rapid iteration during development compared to traditional manufacturing techniques
- Fast and cost-effective ways to develop low-mid volume and customized tools and fixtures

Why choose pellet extrusion for large manufacturing aids, jigs, and fixtures?

- Lowest cost feedstocks available in the AM market
- Speeds of up to 10X over filament-based printers
- Broader raw material availability compared with other 3D printing technologies
- Use the same thermoplastics and composites as injection molding and other traditional manufacturing methods
- Recyclability and reuse possible by using thermoplastic materials

Application Example



Example Part: Quality Gage Go-NoGo for Front Bucket
Technology: EXT Pellet Extrusion
Printer: EXT 1070 Titan Pellet
Material: PC CF30 (20% Carbon Fiber Filled Polycarbonate)
Functionality: Large-Size/Light-Weight Single-Piece Quality Gage
Post-processing: CNC Machining

Workflow Solution and Best Practices

1. Identify main characterisitcs to select the right material and the right process

The most important characteristics in a quality gage are:

- Accuracy
- Repeatability
- Dimensional stability
- Light weight for ergonomics and handleability

Historically, aluminum alloys have been the preferred materials for large quality gages. However, composite plastics are increasingly being adopted for this application due to their lighter weight, ease of post-processing, and comparable thermal expansion coefficients.

Material	Process	Post-Process	Density (g/cm^3)	CTE (µm/m-°C)
Aluminum Alloy	Subtractive	Intensive	2.7	21 - 24
PC BPT 10% Carbon Fiber	Additive	Simple	1.25	30 - 40
PC 20% Carbon Fiber	Additive	Simple	1.29	20 - 23

As seen in the above table, PC with 20% CF is a compelling alternative over aluminum because of the similar CTE and much lower material density. And if we consider that additive manufacturing allows us to produce semi-hollow objects with lattice-structured infill, total weight could be even lower than half of the conventional aluminum gage.

In quality control and inspection processes, ISO and ASTM standards require normalized measurements when product and instruments are at 20°C (68°F). This pre-condition sets a limitation to produce a quality gage directly out of a 3D printer, no matter how precise the printer is, because the material is deposited at its ideal fusion temperature, well above the target usage temperature.

Due to the difference in material deposition temperature and standards temperature, the 3D printed gage must be finished via CNC-machining at the ISO and ASTM-governed temperature to assure it has the proper dimensions. Fortunately, bench properties for most composite thermoplastics are very good, enabling easy and accurate machining.

Workflow Solution and Best Practices

2. Design for Additive Manufacturing (DFAM) Tips

In this specific application, the critical features for quality control are the true position of the pin locators, and those are what we need to consider for post-processing.

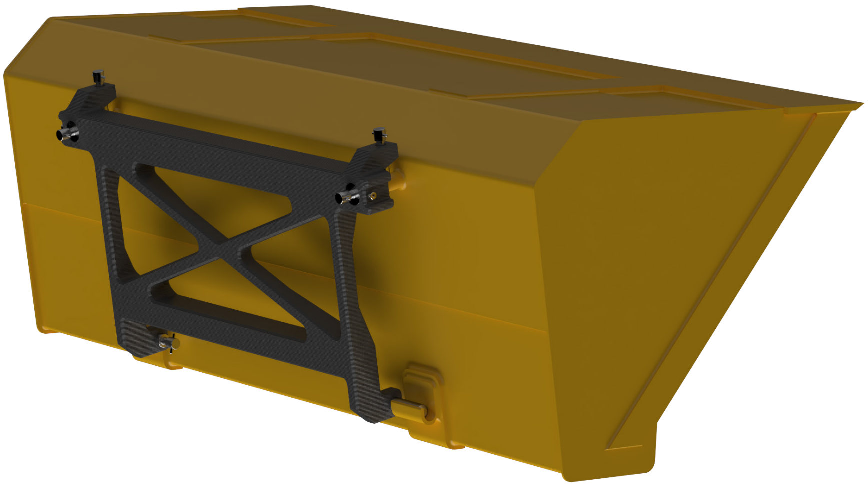


Fig 1 – Quality gage in intended use on front bucket

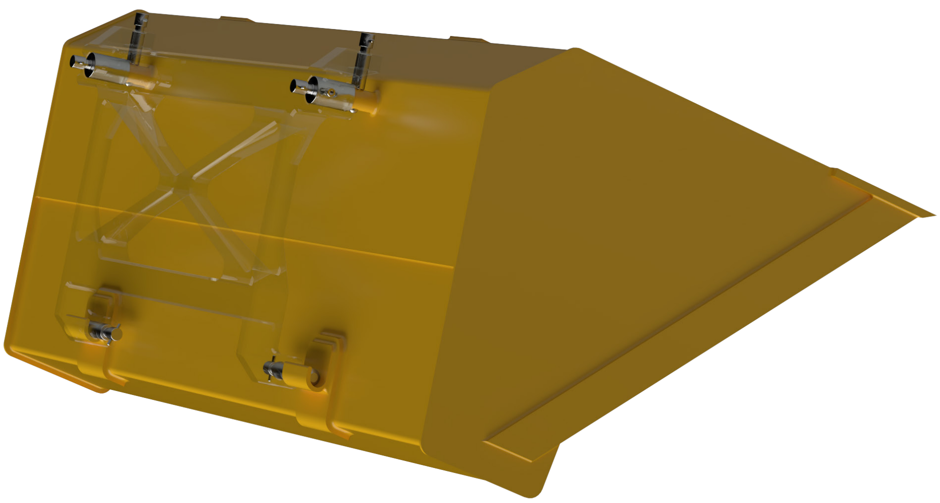


Fig 2 – Critical features showing locator pins

Workflow Solution and Best Practices

The common practice when designing a part to be post-processed after printing is to add stock material in CAD at the surfaces that will be machined.

However, when utilizing the typical file preparation process for 3D printing (slicing), wall thickness and infill density are not optimized for machining, rather to maintain strength while minimizing weight/material usage. Thus, the risk of removing too much material during machining is relatively high. The best approach is to add stock material as separate objects in CAD, allowing the use of different printing parameters between them and the quality gage.

Fig 3 – Stock material added as separate object in CAD

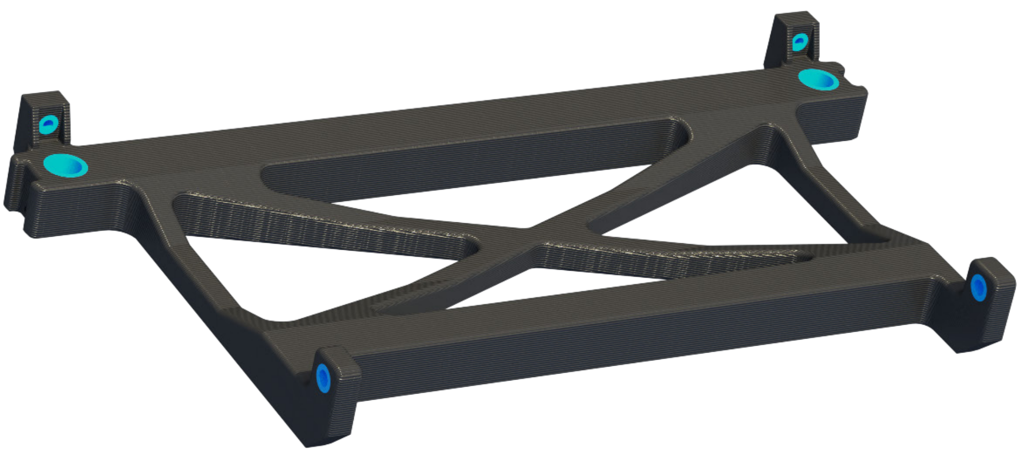


Fig 4 – Quality gage in CAD with added stock material

The added objects are independent but saved in the same CAD file as the gage to keep them on a common coordinate system. They are then exported as independent STL files.

Workflow Solution and Best Practices

3. File Preparation

STL files for the gage and added stock are imported in the slicer software, in this case Simplify3D, and then we align them.

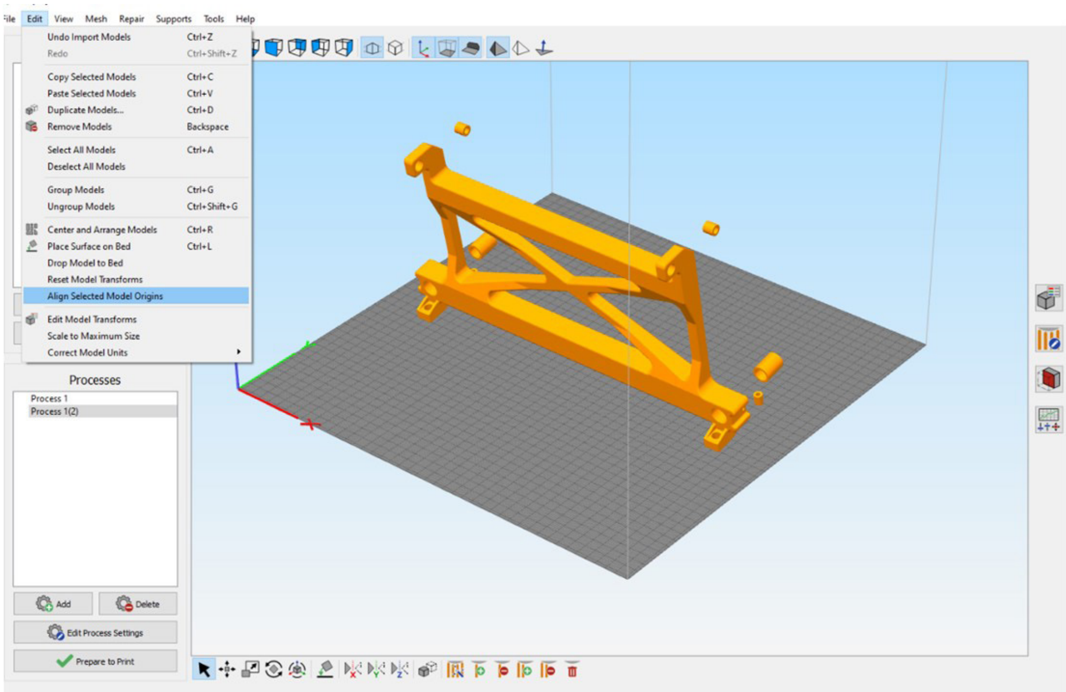


Fig 5 – Aligning models' origins in Simplify3D

Once they are aligned, we group them to facilitate proper orientation on the print bed.

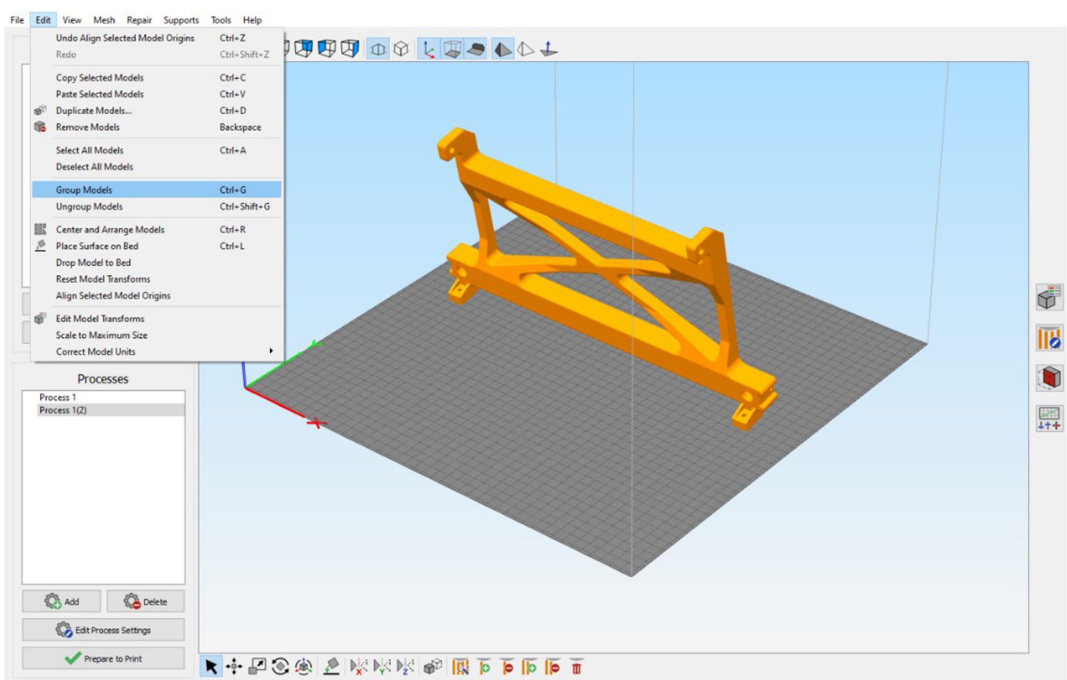


Fig 6 – Models aligned and grouped in Simplify3D

Workflow Solution and Best Practices

With the STLs aligned and grouped, we can orient the part on the print bed for printing. Simplify3D enables defining multiple processes within a single gcode file. We will utilize this feature to print this part.

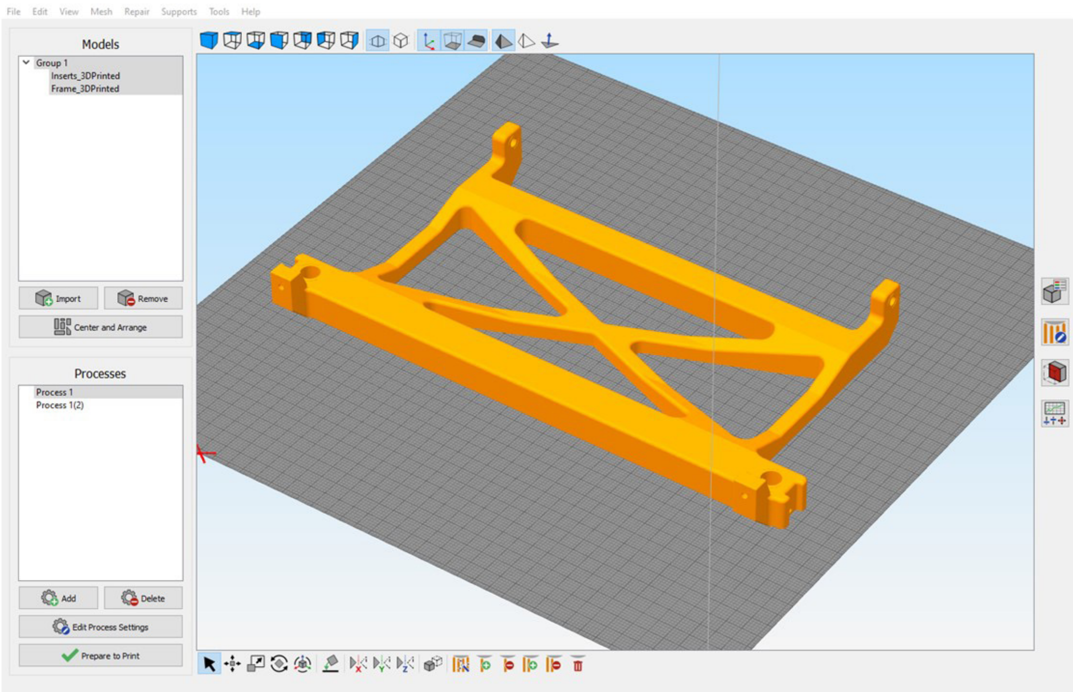


Fig 7 – Models aligned and oriented, ready for slicing with two independent processes

In process #1 we assign the primary model of the gage and set the number of layers and perimeters.

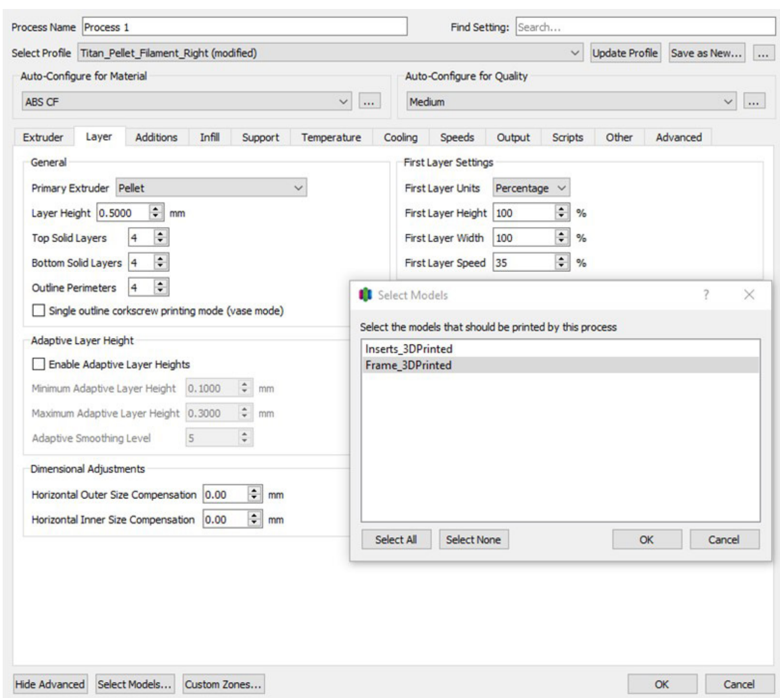


Fig 8 – Selecting the model for process #1

Workflow Solution and Best Practices

And we do the same with process #2 selecting the second model, in this case the stock material, aiming to print them as solid as possible with multiple walls and layers.

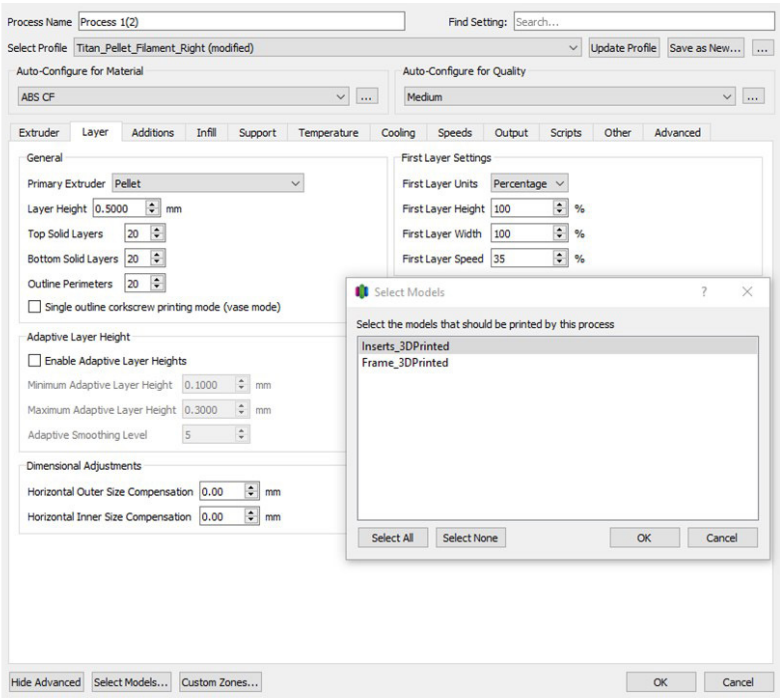


Fig 9 – Selecting the model for process #2

With the processes defined and assigned to the models, we can slice for printing.

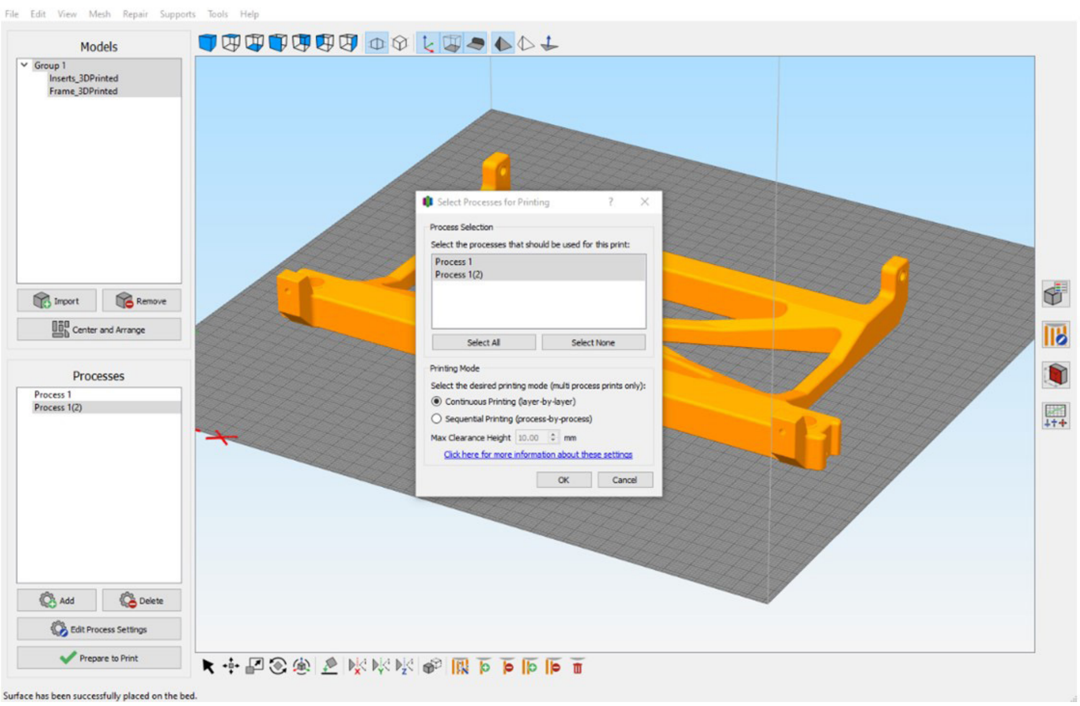


Fig 10 – Slicing to print both models continuously as one object

Workflow Solution and Best Practices

Analyzing the build simulation in Simplify3D we can confirm the quality gage is set with 4 walls as perimeter and 25% infill density while the provision for the locating pins should have more than 10 perimeter walls to force no void sections allowing the post-machining operation without compromising object stiffness.

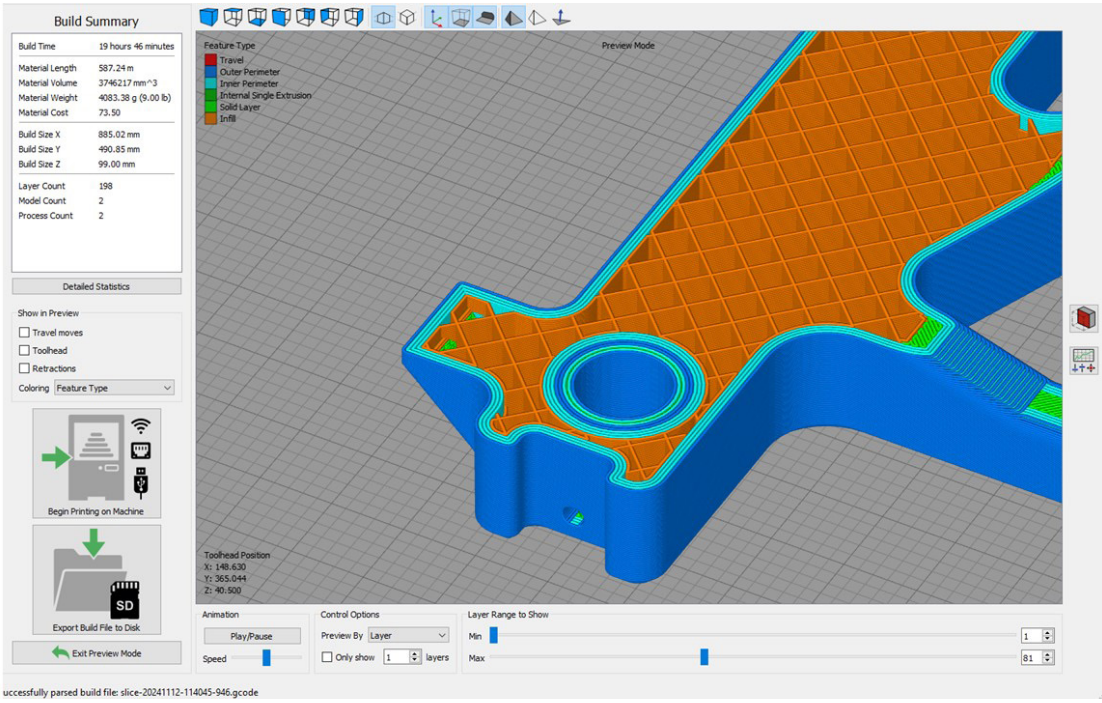


Fig 11 – Build simulation showing two process parameters in a single print

Fig 12 – Locator pin hole shown in Fig 11, as-printed

Workflow Solution and Best Practices

4. Post-processing

After the print has completed and the gage has cooled to the target temperature of 20°C (68°F), the next step is to machine the 3D printed quality gage. In order to meet the design requirements, a large size multi-axis CNC machine is needed to perform the machining operation in a single set-up.

Fig 13 – Printed quality gage ready for machining

Fig 14 – Render of gage with locator pins installed

Workflow Solution and Best Practices

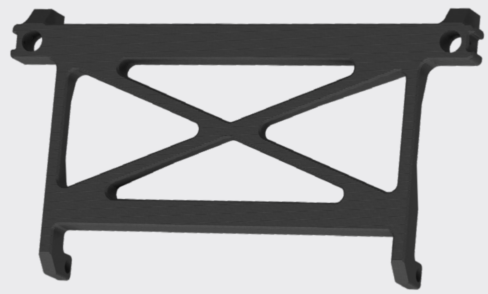
5. Benefits

Part Count Reduction

Thanks to AM design freedom and using a large printer, it is possible to consolidate the gage in a single piece, eliminating part inventory, assembly labor and improving reliability. In our case we were able to consolidate 48 individual parts into a single frame.

Conventionally Manufactured

Additively Manufactured



	Conventionally Manufactured	Additively Manufactured
Part Count	48	1
Weight	8.1 kg	4.8 kg
Cost (USD)	$1,760	$344
Lead Time	3-4 weeks	2 days

Fig 15 – Conventional vs. Additive Comparison

Weight Reduction

Traditionally, jigs and fixtures are made from lightweight metals like aluminum. Composite plastics, however, offer an opportunity to reduce weight even further, combining high strength with lower material density for a superior strength-to-weight ratio. In our case the weight of the quality gage was reduced by 41% from an estimated 8.1 kg to 4.8 kg.

Cost reduction

The cost of the additively manufactured gage is $344, including post-processing operations, with $155 attributed to the raw material. In comparison, manufacturing the same gage using a conventional process is estimated to cost $1,760, of which $720 is the material cost. Overall, the cost decreased by over 80%.

Lead time

Another advantage of using additive manufacturing is the significantly higher speed to obtain parts on hand. 3D printing the gage requires less than 20 hours, and including post-processing, the gage is completed in just 2 days. In contrast, the conventional manufacturing process takes 3 to 4 weeks to produce the same part.

Workflow Solution and Best Practices

5. Solution Components

Printers

Pellet extrusion printers for cost-effectively and quickly producing large manufacturing and quality aids. EXT Titan Pellet large-format industrial 3D printers are engineered for high-throughput and reliable operation. Standard with pellet extrusion technology, select Titan platforms are available with multi-toolhead configurations including pellet extrusion, filament extrusion and CNC milling toolheads, enabling dual material printing as well as additive and subtractive processes on the same platform.

Materials

Pellet materials —EXT Titan Pellet 3D printers use widely available pellet feedstocks that range from commodity plastics to high-performance, high-temperature and fiber reinforced materials and cost up to 10X less compared to traditional 3D printing filaments.

Software

Simplify3D is our recommended slicing software for 3D Systems EXT Titan Pellet printers. Simplify3D gives users control and flexibility to modify and adjust all printing parameters, enabling the use of cost-effective open-market materials and custom blends. As shown in our example, the software also allows users to combine different print processes into a single gcode file, enabling targeted areas of added or reduced deposition.

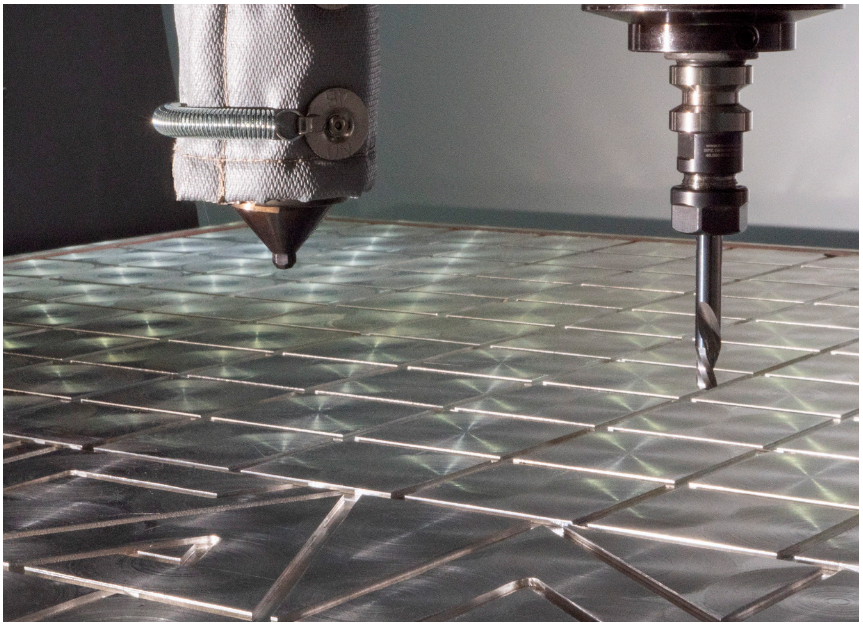


Fig 16 – Pellet Extruder and Milling Spindle Toolheads on EXT 1070 Titan Pellet 3D Printer

Workflow Solution and Best Practices

6. Critical Success Factors

The right AM solution is only part of the equation for success. How AM is onboarded, integrated, and implemented all contributes to its impact.

Onboarding – Training a Technology Champion

Having at least one trained, in-house AM expert goes a long way in a company's successful adoption of AM. 3D Systems offers a variety of training courses through our Application Innovation Group to bring your technology champion up to speed and help your company get a running start. 3D Systems customizes training content to your specific needs and guides you in how to use AM to maximize the effectiveness of your applications.

Integration – Training on End-to-End Processes for Optimizing Effectiveness of AM

3D Systems partners with you throughout the entire AM process, from file set-up to finished part. As part of equipment installation, 3D Systems provides essential knowledge on operating the system, as well as tips and tricks to get the most out of your AM applications. A strong partnership helps deliver a smooth and effective AM experience, both when working with 3D Systems and interdepartmentally. To maximize the productivity and output of your system, regular communication between the designer, AM expert, and post-processing experts is essential.

Implimentation – Realizing the Advantages of AM

AM delivers tangible impacts to your bottom line by speeding up production and validation of manufacturing and quality aids compared to traditional manufacturing with CNC.

Technical Support – Development of Print Parameters

If needed, the 3D Systems team of application experts can support you to accelerate your development and optimization of extrusion printing parameters for new and 3rd party materials.

Choosing the right 3D printer for your application

Printing in a single piece is ideal, when possible. When manufacturing and quality control teams need accurate tools, jigs, fixtures and gages they should consider 3D printers large enough to produce the items with a minimum number of individual pieces to minimize stack-up tolerance issues, save on manual labor, and reduce deterioration through time.

The other important aspect when producing large tools, manufacturing and quality aids, is considering how to produce them quickly while keeping them at a reasonable cost. The high material deposition rates possible through pellet extrusion along with the cost-effective raw materials, are often the best approach to achieve these objectives.

3D Systems offers EXT Titan Pellet 3D printers in multiple configurations to meet the needs of the application:

	EXT 800	EXT 1070 LT	EXT 1070	EXT 1270
Print Volume	31.5 × 23.6 × 31.5 in (80 × 60 × 80 cm) 23,417 in^3 (0.38 m^3)	42 × 42 × 48 in (106 × 106 × 121 cm) 84,672 in^3 (1.36 m^3)	42 × 42 × 44 in (106 × 106 × 118 cm) 77,616 in^3 (1.33 m^3)	50 × 50 × 72 in (127 × 127 × 182 cm) 180,000 in^3 (2.94 m^3)
Toolheads	Single Pellet	Single Pellet, + Single or Dual Filament	Single or Dual Pellet, + Single or Dual Filament, + Spindle – up to 3 toolheads total	

Selecting the right material for the application

Selecting the right material for 3D printing is crucial when producing manufacturing aids, gages, and fixtures. The first critical step is to assess the specific requirements of the application. Consider factors such as mechanical strength, temperature resistance, and chemical exposure.

For instance, if the fixture is subjected to high loads or harsh environments, materials like composite ABS or Nylon may be more suitable due to their durability and impact resistance. Conversely, if the application requires dimensional precision and thermal stability, a composite PC might be preferred for its minimal thermal expansion, equivalent to aluminum. Understanding these requirements helps in narrowing down the material options effectively.

Once the application requirements are clear, the next step is to evaluate the material properties in relation to the intended use. This involves looking at the material's tensile strength, flexibility, and thermal properties. Additionally, consider the ease of printing and post-processing capabilities, as some materials may require specific settings or additional treatments to achieve the desired finish.

By carefully matching the material properties to the application needs, you can ensure that the final product is not only functional but also reliable and efficient in its intended role.

What's next?

Learn more about AM for tooling, jigs, fixtures and quality aids.

Talk to our experts.

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