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Designer's dilemma

Can you have it all?
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Fast, good, and affordable?

How to have it all

The designer's reality is often expressed as the holy triangle—that is, "Fast, good, or cheap, pick two." However, with an adjustable multi-gantry platform that includes additive and subtractive manufacturing with a robotics feature, 3DP's Excel 100 Series may break these limitations that constrain manufacturers from investing in additive technology.

Jonathan Schroeder • President, 3D Platform

It's no secret that the promise of 3D printing is sweeping across the breadth of manufacturing globally. Digitalist research firm Gartner predicts that nearly 50% of manufacturers in the consumer products, heavy goods, and life sciences industries will be harnessing 3D printing by 2018.

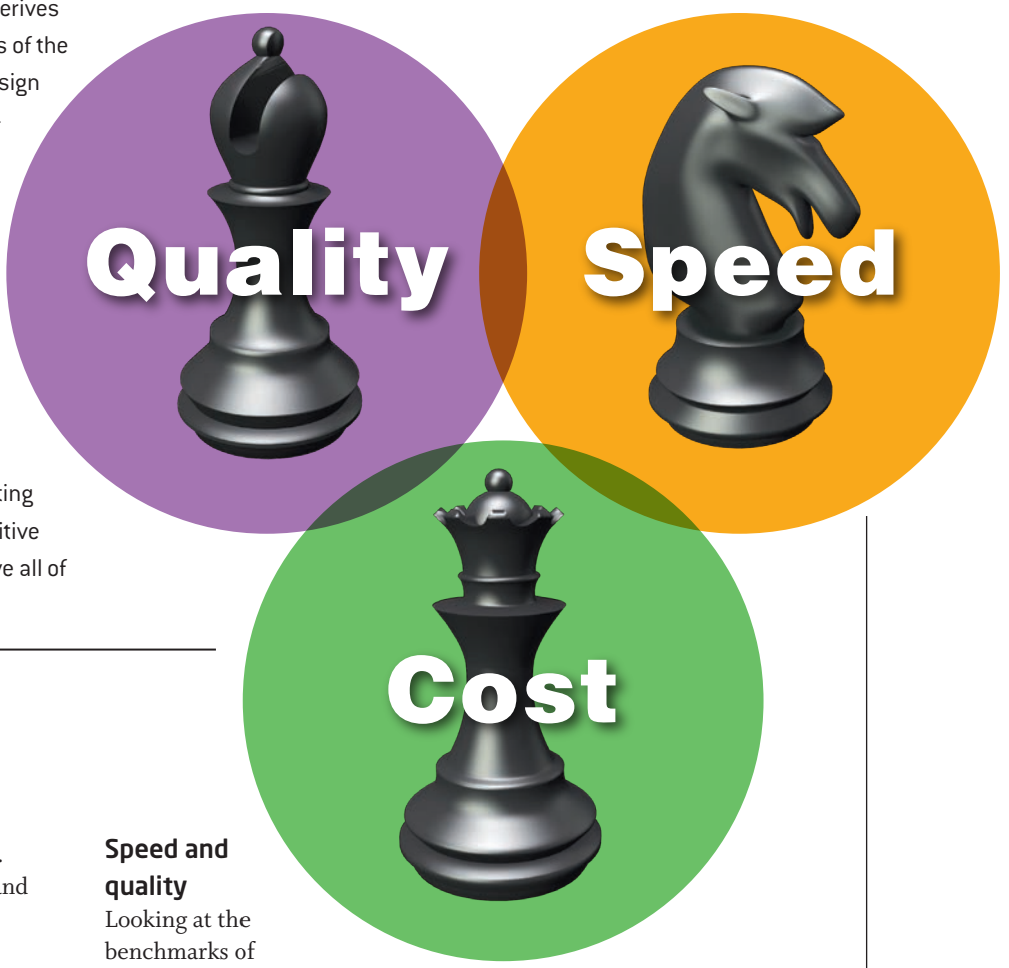
With the price point of printers decreasing, the integration of IoT, and innovations in print materials, more industries (such as aerospace, automotive, healthcare, and so on) are moving additive manufacturing (AM) to key roles in their main production processes.

As this 3D printing momentum continues, design engineers have identified the need for AM machines to step up and drastically improve the basic features found in the first generations of 3D printing machines. These needed features include:

- Reliability
- Print space
- Speed and accuracy
- Affordability

These demands, though, run into a common dilemma in design—one that constrains businesses, and stands in the way of realizing the full promise of this vital technology and its ability to help vault manufacturing to the venerated 4th generation.

The designers dilemma derives from the three constraints of the "iron" triangle found in design and project management--these constraints are typically shown as speed, quality, and affordability. With traditional manufacturing methods and processes, you can only choose two of the points from the triangle, eliminating the third as a choice. Additive manufacturing can remove all of those constraints.



The 3 points of the dilemma

The dilemma derives from the three constraints of the "iron" triangle found in design and project management. These constraints are typically shown as speed, quality, and affordability.

When using traditional manufacturing methods and processes, the dilemma is you can only choose two of the points from the triangle. That is, you can have it fast, good, or cheap, pick any two. Whichever two points are chosen will typically eliminate the third as a viable choice.

If a design engineer managing a business-critical project defines requirements of high speed and high quality, the project will likely need to sacrifice affordability. Conversely, if they want affordable and fast, then they will sacrifice quality; and if high quality at an affordable price needs top billing, speed gets the ax.

The promise of next generation additive manufacturing machines is the realization of all three at once: speed, quality, and affordability.

3D Platform's newest line of large-format 3D printers, the Excel Additive Manufacturing Series (Excel 100 Series) offers a solution to this dilemma with its extended work areas, increased throughput, multiprocessing capabilities, and open market features. Not only will it allow manufacturers to print larger, higher quality prints at faster rates, but it will also give them the capability to do additive and subtractive manufacturing, as well as robotic assembly that's affordable in the same setting.

Speed and quality

Looking at the benchmarks of speed and quality with our current generation of printers, 3D Platform designers took a standard open-loop stepper motor and replaced it with a SurePrint Servo – a closed-loop stepper motor. Because the stepper motor is closed-looped, it is more accurate and more repeatable, improving the quality and speed of the printer (or prints), while maintaining affordability.

They also improved speed and print time with a high flow material extruder (HFE900 series). Many extruders have an average throughput of 36 grams per hour; thermal capacity limits throughput. The HFE 900 provides a 6-mm diameter for a material throughput capacity that ranges from 2 kg/hr to 55 kg/hr.

Customers also have the option to use standard plastic pellets in addition to filament, which can decrease the cost of materials. However, the spool fed extruder is easier to manage than the pellet fed extruders, so the needs of the customer will determine which type of material to use for printing.

Key features of the Excel 100 Series

User needs and wants continue to drive development in additive manufacturing. The Excel 100 Series additive machines address the following user desires.

- **Open market**

  Materials development is a key factor driving the additive manufacturing industry. Open market solutions are a way to harness the energy of global material scientists who specialize in blending various polymers to achieve specific end goals for certain projects.

  Manufacturers can print virtually any material on the Excel Series machines, provided the material's melting temperature, bed temperature, and recommended ambient temperatures match the capabilities of the machine. By allowing an open market for materials, customers can determine how much they want to spend for each project they decide to print.

  Open-market platforms also facilitate innovation by providing real-time 3D printed models that can be easily accessed and shared.

- **Robust industrial technology**

  To answer the market demands of reliable performance, companies need to use industry-proven mechanical and electrical components, along with the appropriate software integrations. Linear guides, motion control, and industrial robotics components from THK, Yasakawa, Xtrution, and Shimpo, contribute to the Excel Series robustness.

- **Larger print space**

  Traditional desktop 3D printers are perfect for prototype parts, but may not be suitable for other engineering applications. Larger additive machines, like the Excel 100 Series, can build large parts, in this case up to 4 m x 4 m x 100 m. The extended work areas allow parts to reach 2.5+ meters across and 2 meters in height.

- **Speed and accuracy**

  The use of robust industrial components, such as linear guides and motion controls delivers an industrial-sized printer that offers:
  - High torque for quick acceleration and deceleration
  - High precision and positioning accuracy and reliability
  - Simpler wiring
  - Low complexity of control
  - Large print/work areas
  - A parallel gantry configuration
  - Support of multi-processes (additive, subtractive, and robotics)

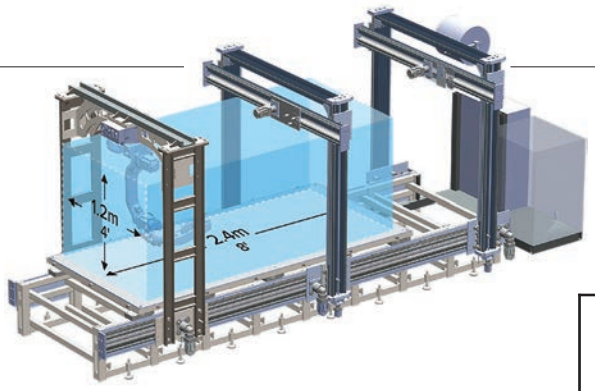
- **Flexible design**

  A flexible machine design allows the integration of multiple processes (additive, subtractive, and robotics) simultaneously. With parallel gantry configurations, consumers can 3D print a part (additive), remove its support structures (subtractive), and finish the print near-net shape (robotics) – decreasing production costs.

- **Open software**

  The Excel 100 Series software is also open source, so customers can select a software package that's right for them:

  Freeware programs have no cost and work best for simple files.
  - Simplify3D is an economical program that suits medium-level complexities.
  - Materialise Magic or Autodesk's Netfabb suit advanced prints.



The Excel 100 Series is a parallel gantry system that includes 3D printing extruders and CNC equipment, creating a hybrid (additive and subtractive manufacturing) capability. Robotic equipment can also be installed for assembly functions. 3DP's robust industrial technology of linear guides, motion control components, and robotics is included to improve cycle time and final part quality.

The Excel design is parametric; it can stretch in any of the Cartesian directions. Thus, the machine can be customized to the customer. In terms of print volume, the machine can be stretched by 5 (w) x 3 (h) x 100 m (l) and beyond.

Near net shape

The Excel 100 Series has multiple gantries on an 8-foot-long bed, which allow manufacturers to print one large part or simultaneously create multiple parts.

By combining additive and subtractive manufacturing abilities within the same enclosure, the Excel prints on scale of 2, 3, and 4-meter square surfaces up to 100-meters in length.

Manufacturers can also install robotic equipment for assembly functions or post processing and finishing. The robotics can deliver subtractive manufacturing or pick-and-place functions, such as embedding various components into 3D printed parts (such as PEM nuts or threaded metal fasteners) in a streamlined process.

The Excel is available with an enclosure to control the environmental variables over the entire part. The enclosure minimizes thermal shrink on certain areas of the part, allowing it to shrink as it is cooling in one unified motion.

Additive manufacturing gives you more options in terms of speed and part feature accuracy. Depending on the nozzle size and print material, you can choose the level of quality needed for a part.

Investment considerations

When evaluating an investment into large format 3D printers, there are several key considerations:

- What are the manufacturing goals and objectives the printer will help to accomplish?
- In-house 3D printing production versus outsourcing
- Cost of investment

Several factors drive costs—oftentimes the capital investment is small relative to the ongoing cost of operation. Material consumption and the costs to run such a machine can exceed the cost of the machine itself.

Cost of materials

The cost of materials is the most significant driver. The Excel additive machine, for example, is open sourced/open market. Thus, users can take advantage of the materials that would yield savings—provided the materials' melting temperature, bed temperature, and recommended ambient air temperatures match the Excel's capabilities.

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> ***"Looking** at the benchmarks of speed and quality with our current generation of printers, we took a standard open-loop stepper motor and replaced it with a SurePrint Servo – a closed-loop stepper motor."*

The machine is a general industrial use printer, so it can't print ultra-high temperature materials.

Machine time

The next major cost is the time it takes to initiate the machine. Set-up costs include software and machine installation, as well as preparing files for printing and getting the machine ready to print. Companies should have a skilled operator available to run the machine once it's ready to print. The run time of the part will also affect operation costs.

Post processing

Almost every part that comes off an additie machine requires some amount of post processing, which ranges from quick to labor intensive. The amount of post processing needed is dependent on the part and its desired use—some parts only require a simple rinse or dusting off of unused gel or powder; others require trimming, sanding, polishing, and painting.

Nozzle size affects post processing as well. Larger nozzle sizes print rougher shapes that require man-hours for polishing and finishing. But more parts can be printed quickly. Smaller nozzle sizes produce more of a near-net shape, but fewer parts in the same time frame. In some cases, printing rough and finishing is more economical than attempting to print near-net shape.

Other potential costs include maintenance, replacement parts and software packages.

The Excel design offers a reliable additive machine for manufacturers demanding faster speeds, higher quality, and a more economical large format printer for production purposes. With its multi-gantry platform, additive and subtractive manufacturing, and robotics feature, this machine eliminates addresses the issues that constrained manufacturers from investing in this vital technology that can add to their business values.

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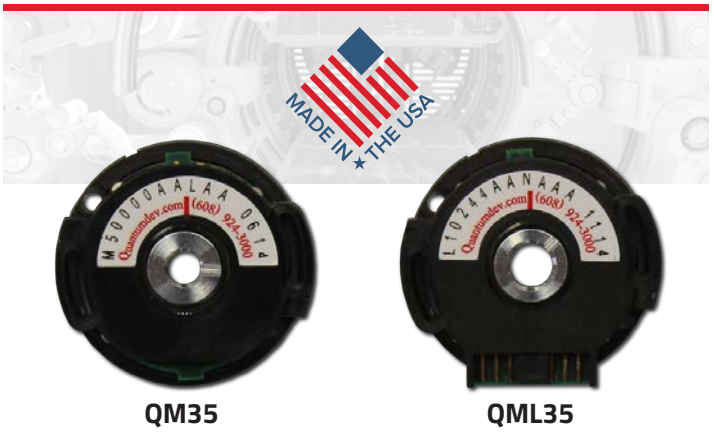

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