Stratasys Competitive Landscape Q12'19

Date: 2019 08 12   - Jon Hedlund

Topics Covered in this report

Topics Coming in Q3 report

- **Latest AM Trends**
- **Significant AM News for Q3'19**
- **Spotlight on Surveys**
- **Context Q2'19 Summary**

Latest AM Trends Q2'19

Trends from Q2'19

- **FFF Metals accounted for over 30% of metal printers sold in Q1**
  - Cost is a major factor as systems are significantly less expensive than most DMLS
  - Not having to deal with the safety concerns of metal powder
- **Investment still coming into AM**
  - Carbon $260M
  - Markforged $82M
  - Xometry $50M
  - Fast Radius $48M
  - Shapeways $30M
  - 3D Hubs $18M
- **Speed increases in printing are still in the headlines - aimed at manufacturing – but nothing proven**
  - HP with 40% more productivity in the 5200 series than the 4200 series
  - BigRep 5X faster (They just started to ship so we should soon know the reality)
  - Essentium 10X faster (Jabil now suing as they say Essentium stole their 10X technology)
  - Farsoon 4X with FLIGHT technology
- **Lower cost DLP ($3K-$20K) is leading the growth in polymer printer market**
  - Big numbers from 3D Systems FabPro, NextDent, and Figure Four standalone
  - EnvisionTEC, UnionTech (Evodent), XYZ Printing, Formlabs
- **FFF manufacturers are increasing capabilities and increasing prices**
  - 3DXtech ($62K)
  - BigRep ($60K and $190K)
  - Essentium ($75K-$105K)
  - Intamsys ($27K and $100K)
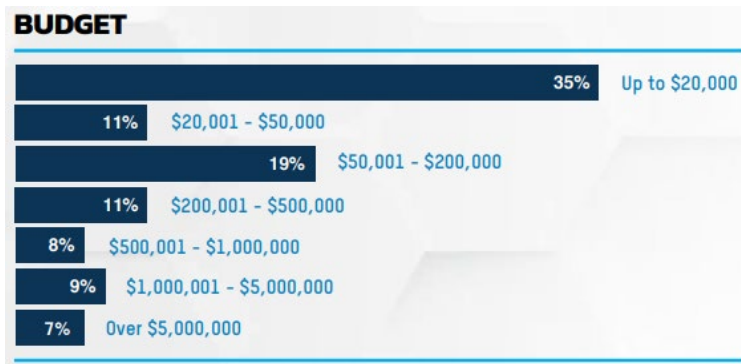
Rapid 2019 Summary

Rapid continued to grow this year with quite a few companies making their first appearance at the show.

This section will go over general statistics and link in some high-level recaps. The new releases announced at RAPID are included in the next section, Significant AM News from Q2'19.

- **Rapid 2019 Statistics and Demographics**

TOTAL CONFERENCE AND EXHIBITS-ONLY ATTENDANCE:	5,203
TOTAL EVENT ATTENDANCE*:	8,870
TOTAL EXHIBITING SPACES:	397
TOTAL EXHIBITING COMPANIES:	434
TOTAL SQUARE FOOTAGE:	112,200

*INCLUDES EXHIBIT STAFF, MEDIA, AND STUDENTS

NEW ATTENDEES

73% of RAPID + TCT 2019 attendees were first-time attendees.

NEW USERS

42% of the RAPID + TCT 2019 audience had little or no experience with additive manufacturing technologies.

BUDGET

35%	Up to $20,000
11%	$20,001 - $50,000
19%	$50,001 - $200,000
11%	$200,001 - $500,000
8%	$500,001 - $1,000,000
9%	$1,000,001 - $5,000,000
7%	Over $5,000,000

PURCHASING POWER

74% of RAPID + TCT attendees influence equipment purchase decision in their companies.

35% of RAPID + TCT attendees had equipment budgets that exceeded $200,000.

TOP TECHNOLOGIES EVALUATED

RAPID + TCT attendees indicated they came to the show to evaluate the following technologies, among others: (multiple responses)

3D Printing	86%	Fused Deposition Modeling (FDM)	25%
Additive Manufacturing	64%	CAD/CAM	25%
Advanced Materials	49%	Product Design & Engineering	24%
3D Imaging/Scanning	49%	Rapid Tooling	23%
Design for Additive Manufacturing (DFAM)	30%	Composites	23%
Metals	28%	Hybrid Additive Manufacturing Machines	23%
Metal Laser Sintering	27%	Metal Deposition	23%
Laser Sintering	27%	Post Processing	23%
Plastics/Polymers	26%	Automation	20%
3D Printed Electronics	25%	Lasers	20%

The complete post show statistics can be found here: Post Show Statistics

- **Videos of** Keynotes from RAPID and a recap
  - https://www.youtube.com/playlist?list=PLR6N8258i6XqRlkSIDfH9DdxuqnCIFGsh
- **TCT Magazine Daily Recaps**
  - https://rapid3devent.com/rapid-tct-daily-recaps/
- **TCT News from Rapid**
  - https://rapid3devent.com/rapid-tct-news/

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Significant AM News from Q2'19

(* In this section, Facts/Specs are in DARK BLUE, *my opinions are in ORANGE & Italics*)

I chose to group the news by material and process to keep similar news within the same group. Todd Grimm presented the new announcements at RAPID this way and it seemed to be easier to take in. If a company has news with a different ASTM process, they could be listed more than once by each process.

Also included is an Impact level of the news based on how it will affect/impact Stratasys. (Low, Medium, High)

Hardware — Non-Metals

Material Extrusion

- Dyze Design | Typhoon / Pulsar   Impact: Medium

    o Typhoon is a high flow 2.85mm filament extruder coming end of 2019

        ▪ Quad drive, dual heat zones, capable of 0.9 kg/hr, polymers up to 500 C, liquid cooled. Can print in a 100 C environment and up to 200 C with an additional heat shield

    o Pulsar is a pellet extruder coming end of 2019, ~$5K

        ▪ Custom screw, 3 heat zones, capable of 4.5-5.5 kg/hr, polymers up to 500 C, liquid cooled, can print in 100 C environment and up to 200C with an additional heat shield, weight is 2.2 kg (

    o *Up and coming extruder/hot-end company. Already supplying pellet extruders to 3D Platform and filament extruders to many OEMs like Dynamical tools*

    o *Enabling Printer OEMs to get a base level of extrusion so they can focus on other challenges. Water cooling enables printing in hot environments without bellows*

    o *Issues they will contend with are oozing and speed changes (start/stopping/corners)*

- E3D | Tool Changer   Impact: Medium

    o Will start to ship a tool changer platform for a larger desktop sized printer late July, capable of multiple extruders and other tool heads. Components can be bought separately

    o Initial pricing estimates for the components for a full system are around $3K

    o *They are shipping 25K hot ends/extruders a month. This includes to OEMS such as Prusa and Lulzbot.*

- Many notable OEMs developing offshoot 3D printing innovations are choosing to use E3D hardware. Heard rumors that there is commercial/industrial 3D printing interest in their tool changer

- BigRep | STUDIO G2 / PRO / EDGE   Impact: High

    o Studio G2 ($60K) is an upgraded version of the Studio. Now enclosed, hardened ruby nozzle, dual higher temp extruders, 100 C bed, Nylon 6/66, ASA, and carbon and glass filled materials.

        ▪ A significant jump in price from the original ~$25K Studio showing a decided effort to get into industrial printers. BigRep still has not shown any prints with engineering materials, filled or unfilled so the success of this printer is yet to be determined.

        ▪ The open air BigRep one may not be sold much longer with the move to enclosed printers

    o The PRO started shipping in June. Price is now $190K

        ▪ No word on actual extruder throughput. Now just enclosing the printed volume, trapping heat from the heated bed. Environment of 40 C, Possible to reach 60 C with some materials. This means that there will not be a uniform temperature needed to print high-quality parts.

    o No further word on dates for the Edge except that it is still in development

    o Leadership changes, CEO Stefan Beyer switching to advisory role, Stefan Kaufmann now listed as CTO. Nothing in the press, but Moshe Aknin looks to no longer be with the company.

- Essentium | HSE 180-S   Impact: High

    o 10 units in Beta, set to begin shipping in July (2019) at a "slow trickle", more than 50 systems by the end of 2019 (mfg. limited), more than that on pre-order

    o Current partners are BASF, Materialise, Mitsubishi Chemical, Midwest Prototyping, and Reebok.

    o Currently focused on the factory floor with a big push in ESD materials

    o Jabil filed suit against Essentium as they claim former employees stole TenX technology. The big takeaway is that Jabil is going to commercialize their TenX system which is said to be superior to Essentium's version.

- Roboze | One Xtreme Series   Impact: Medium

    o Xtreme Series introduced in the Americas

- Improved rack and pinion with closed loop control, high viscosity extruder, vacuum platen, heated material storage cabinet, 300x200x200mm build volume

- Marketing them as desktop production systems, The One+ 400 Xtreme is ~$78K

- Still no support material, claiming high repeatability but because they only have an enclosed build with heated bed, any parts taller than a few inches will be subject to temperature fluctuations which will affect dimensional stability along with z layer strength.

- Roboze markets their rack and pinion motion system as an improvement over belts. Racks suffer from backlash causing poor layer uniformity. A rack will also expand as temperature increases, leading to part scaling issues.

  o Ramping Argo 500 production (Estimated price ~$168K)

- RIZE | XRIZE   Impact: Low

  o NIAR put an XRIZE printer in its 3DEXPERIENCE Center at WSU

  o Pushing messaging that their printers are purpose built for safety - claiming zero emissions (mostly due to their base model material)

- MakerBot | Method   Impact: Low

  o Released PETG for Method – 70C HDT, better chemical resistance, compatible with water soluble support

- Markforged | Onyx FR   Impact: Medium

  o Onyx FR is a flame retardant version of their Onyx (short chopped fiber) material. It can also be used as a base material for their continuous fiber.

  o While Markforged claims it is a UL94 V-0 rated material, it actually has not been rated by UL. It has only passed testing in a 3rd party lab

  o Onyx FR is only available in the Industrial Series Printers. Markforged is looking for ways to move customers away from the desktop series.

  o Markforged opened an EU headquarters in Dublin with plans to employ 100 people including engineering and manufacturing positions

  o Blacksmith AI – See notes below in Metals for how Markforged will try to solve the metal shrink variability in the sintering process

- 3DXTech | Gearbox HT2   Impact: High

- o High temp oven, dual extruder. Filament moisture control. $62K for 457x457x813mm print area. Available in September.

- o Presets to run their extensive line of build material and support. Will allow 3rd party materials.

- o Lots of big name companies in their booth at Rapid. The allure of this system is the ability to run their choice of materials. Will be a threat to the Fortus 450/380MC as a lower cost open alternative. A big factor will how well it can print 3DXtechs standard materials as well as others from 3rd parties.

- • Diabase | Engineering H-Series   Impact: Low

  - o Showed a hybrid FFF printer/CNC called the H-Series that included a rotary 5 head tool changer. Price is around $10K but each system is custom built.

  - o This machine is very unique. It has a lot of capability but is slow. The printed parts that were milled looked as good as a typical CNC part. Even more impressive were the TPU printed parts that were burnished with a specially coated and heated tool.

Vat Photopolymerization

- • Nexa3D | NXE 400   Impact: Low

  - o Now in production, shipping soon, expecting 170-200 units this year and planning for around 1K units next year.

  - o Prices – Around $20K for 7L volume, around $50K for 16L volume (speeds up to 1 cm/min)

- • Formlabs | Rebound Resin   Impact: Low

  - o Developed a proprietary resin called Rebound that will be used in New Balance Triple Cell Platform. It will enable the soles to be 10% lighter

  - o Formlabs sales were declining as the Form2 was older and competitors have improved. The Form3 came just in time for them. (Table data from Context)

Formlabs	2017				2018				2019
quarter	Q1'17	Q2'17	Q3'17	Q4'17	Q1'18	Q2'18	Q3'18	Q4'18	Q1'19
Units	3,677	4,151	3,866	4,717	3,621	4,209	4,173	3,191	2,751

- • Carbon | Additional Investment   Impact: High

  - o Raised $260M to expand into Europe and Asia.

  - o Establishing an advanced development facility and Investing more into recyclable and biocompatible materials.

- o [Teaming with Covestro](#) to produce resin at high volumes to support mass production demand

- Origin | Programmable Photopolymerization (PPP)   Impact: Low

  - o Announced the [Origin One](#) 3D printer – DLP based with 192x108x350mm build volume and open materials. (BASF and DSM resins have been announced)

  - o Calling their technology "Programmable Polymerization Process" (P3) that monitors polymerization data such as light, heat, and force to optimize production conditions.

  - o They claim that with the materials and scalable architecture, it is a viable solution for mass production. Origin does not offer much in terms of true differentiation from other DLP printers except that they have done a good job in marketing and making minor technology improvements look more significant than it really is.

  - o The big question that needs answering is with materials. Have the chemical companies like BASF and DSM really made significant leaps in new materials for part strength, durability, and longevity to where parts can be mass produced? If so, other

- 3D Systems | Figure4 Modular System   Impact: Medium

  - o The long announced DLP based [Figure4 Modular System](#) has started to ship. With a scalable architecture, it is meant for medium volume printing.

  - o A control unit and single print engine start at $50K. The Base system can be upgraded with additional print engines (up to 24), job management and queuing, material delivery, and centralized post processing (rinsing, drying, and UV curing).

  - o 5 new materials announced for the Figure4: FLEX-BLK 10, TOUGH-BLK 20, MED-AMB 10, MED-WHT 10, and HI-TEMP_AMB 250. The MED materials are biocompatible and serializable. The HI-TEMP has an HDT>250 C.

Powder Bed Fusion

- NXT Factory | QLS-350   Impact: Medium

  - o Announced the QLS 350 SLS printer, $200K, 350x350x400mm build volume, Quad laser (4x100W), autonomous removable printing cart, up to 4200 ccm per hour (equivalent to the HP 4200). Not sure if powder handling and refreshing stations are included in the base price.

  - o Beta units shipping starting September, hoping to have 15-20 beta/early systems by the end of the year.

  - o Started as a company called Sand Made in Poland. Showed parts that were almost full build volume with very fast build times. The self-driving build cart can remove itself for cooling and have another one load and start the print without user interaction.

- HP | Jet Fusion 5200   Impact: High

    o Released the JF 5200 and 5210/5210 Pro systems. Focus was on improving productivity, reliability and part accuracy. The 5200 series is said to deliver up to 40% improvement in productivity and up to 30% reduction on running costs versus HP's previous series

    o New individual natural cooling containers reduce the bottleneck of the material processing unit and improves workflow

    o TPU for the 5200 series – expected general availability is end of 2019

    o The 5210/5210 Pro bring reduced material pricing with an initial higher purchase price.

    o New HP 3D Process Control allows greater accuracy and repeatability via a specific calibration for each printer after going through a series of prints and measurements.

    o New HP 3D Center offers remote real-time monitoring and historical data analysis

- Formlabs | Fuse1   Impact: Low

    o Still no word on when the low cost SLS printer ($20K) will ship or why it has been delayed (it was announced over 2 years ago)

Hardware — Metals

Binder Jetting

- GE | H2   Impact: Low

    o Going forward with H2 (formerly ATLAS) powder binding system. Cummins is investing in A Beta unit.

Directed Energy Deposition

- Formalloy | Alloy Development Feeder   Impact: Low

    o New Alloy Development Feeder (ADF) that will simplify development of new DED alloys. It allows much less material needed to test alloy printing.

- Spee3D | WarpSPEED   Impact: Low

    o New larger format WarpSPEED supersonic 3D deposition printer. Build volume of 1M x 0.7M, copper and aluminum, deposition rate of 100g/minute.

    o New bronze material was released

- o Low cost metal printing, they quote around $100/kg for a part. (The part is near net and will require CNC machining).

Powder Bed Fusion

- Aurora Labs | RMP1 / MCP   Impact: Low

    - o Now in Beta for their DMLS printer called the RMP1 with a build plate of 450x400mm. Further details are not available.

    - o Announced a new technology called Multilevel Concurrent Printing, or MCP. It sweeps a bar with multiple terraced landings (up to 25) that can be laser sintered in a single pass, allowing a tremendous increase in build speed.

- Protolabs   Impact: High

    - o launched a production service for metal 3D printing. Termed high requirements direct metal laser sintering (DMLS) the new offering has been developed to help customers produce high performance metal 3D printed parts and integrate industry-appropriate quality inspection procedures in line with the client.

Material Extrusion

- Rapidia | Rapidia Metal Printing System   Impact: High

    - o Similar to other bound metal processes where the part is printed in an extrusion based printer. The material is a water based paste that does not require a debinding step. Support can be printed from a "disappearing" ceramic support, hand removable metal supports, or eliminated by water bonding 2 components together before sintering to make a more complex shape.

    - o Printer has a build envelope of 200x280x200mm and priced at $50K, can be bought separately.

    - o Sinter Furnace can use 3% Hydrogen, Vacuum, and other gases, volume of 235mm dia by 400mm long, 240V single phase 45A, 1400C, 10" touch screen with preset programs for each type of metal. Priced at $125K.

    - o Wide range of metal materials and some ceramics. Materials priced at $100-$125/kg. A typical cartridge weighs 4-5 kg. It looks like some materials may need to be sintered in a higher temp furnace not offered.

- Markforged | Blacksmith AI   Impact: High

    - o In Markforged's words, "Blacksmith creates a continuous feedback loop to make parts more accurate. It analyzes a design, compares it to the scanned part, and automatically adapts the end-to-end process to produce in-spec parts. Blacksmith learns continually and adapts to variations in the process over the lifetime of your machine."

- o Planning to roll out a pilot trial of the platform for partners in Q3 of 2019

- o Markforged is betting on Blacksmith AI as the solution to the sintering distortion problem for its Metal X printer. They have given up trying to simulate and predict distortion (Desktop Metal is still going down the simulation route without much success to date). The software will also work with the X7 polymer printer.

- o For the AI portion of Balcksmith to work, it requires that users will upload their original file and scan data to the cloud so that the AI can learn and predict the required tweaks. Users will have to supply a quality scanner themselves.

- o No word on exactly what Blacksmith is tweaking, right now it looks like the print file is tweaked after a part is scanned for accuracy. That means that each new part would have to go through the scanning and correction iterations (it may take more than one iteration) until the part is within spec. It won't correct for sintering distortion due to oven temp fluctuations and other variable factors.

- o Markforged just opened up a new [innovation center](#) in Cambridge, MA for the Blackforge software development team, hoping to attract top tier AI talent from the area (re: MIT).

- o A similar workflow should be able to work with any of the 3D printing processes to create more accurate parts.

- BASF | Ultrafuse 316L   Impact: Medium

  - o Officially released their [Ultrafuse 316L](#) bound metal filament. To be sold by Essentium and Matterhackers. Releasing with print settings on Ultimaker's Marketplace.

  - o Allows desktop printers to print green parts. Requires the user to have their own debinding and sintering solution or to use a BASF certified sintering network partner. None announced yet in the US.

- Desktop Metal   Impact: Low

  - o Fast Radius and Desktop Metal announced partnership to help companies accelerate the discovery and launch of applications on the Desktop Metal Production System

Sheet Lamination

- Fabrisonic | SonicLayer 1200   Impact: Low

  - o New, smaller footprint Ultrasonic Additive Manufacturing (UAM) system, called the SonicLayer 1200. 254x254x254mm build volume, price is <$200K.

Software

Pre-Process

- ParaMatters | CogniCAD 2.1   Impact: Low

    o Update of generative design software that minimizes unsupported areas or support volume

    o Offers a one-click solution that exports smooth and watertight models

- Link3D | Shape Nesting   Impact: Low

    o Added true shape nesting for MJF and SLS for use in build prep and planning

- Teton Simulation | Intelligent Slicing Automation   Impact: Low

    o Announced Intelligent Slicing Automation

    o Not many details available but it sounds like they are trying to identify what (3rd party) slicer settings to use based on part intent. Not sure how they can predict results when they are not actually responsible for the slicer code.

Process

- 3DQUE | QPoD / QSuite   Impact: Low

    o QSuite offers end to end suite of hardware and software compatible with most FFF printers

    o QPOD is a rack of 9 low end FFF printers that print on their side, when the part is done the print bed is heated causing the part interface to melt, allowing the part to drop and fall onto a conveyor belt.

    o Started by a father son team, they have some interesting ideas but they require a lot of development.

- 3Degrees | TRACE   Impact: Low

    o Released TRACE software that tracks the 3D printing workflow ensuring part traceability and quality management for AM

- Sigma Labs | PrintRite 5.0   Impact: Low

    o Metal AM quality printing software that mines and identifies thermal signatures of melt pool disturbances and discontinuities using thermal emission spectroscopy, and verifies thermal signatures in both temperature and coordinates with Co-Axial Planck Thermometry

    o A graphical user interface provides users a real-time display of part quality results

- Bluestreak | Bright AM   Impact: Low

- Released a real-time manufacturing execution and quality management system focused on AM production

- 3YourMind   Impact: Medium

    - Raised 1.3M Euro to incorporate machine learning into its AM workflow software.

    - They have a unique AM part identifier that can look through a part library and highlight which parts are good candidates for AM.

Post Processing

- DyeMansion   Impact: Low

    - Internally testing their VaporFuse Surfacing technology for TPU.

    - New Color lines specific to industry applications, called ColorX series.

- AMT | PostProMini / PostPro Color   Impact: Low

    - The PostProMini is a smaller version of the PostPro smoothing station. 300x350x300mm volume, $32K, available Q4'19. Compatible with Nylon 6, 11, 12, ULTEM, PMMA, PTU, and TPE

    - PostPro Color smooths but also allows dying parts.

Service Bureau

- 3D Hubs   Impact: Medium

    - Raised $18M to advance automation in quoting, design validation, and order routing

- Xometry   Impact: Low

    - Raised $50 million in a new funding round to expand its business that includes a supplier arm to sell raw materials to the small manufacturers in its network

- Shapeways   Impact: Medium

    - Raised $30M in series E funding to make them a complete end to end solution provider. From Design, Make, and Sell.

    - Already released a Design with Shapeways tool to make it easier for users in various stages of product design.

Competitive Benchmarks of Stratasys Printers

I wanted to highlight two recent competitive benchmark studies that were recently published comparing our printers versus the competition. These benchmarks were initiated internally but done with outside testing so that they could be published by a third party. These studies are great because they go beyond anecdotal arguments, they show significant differences in accuracy, reliability, variability and print quality that Stratasys FDM has over other 3D printers or 3D printing processes.

FFF DESKTOPS VS STRATASYS FDM®3D PRINTERS COMPARATIVE STUDY

The study was done by Pragmatek, which is a consulting company specializing in business process efficiency across a wide range of industries. In the study, the Stratasys F170, Markforged Onyx One, Lulzbot Taz 6, Ultimaker S5, and Ultimaker 3 were benchmarked for reliability and quality. All of these low end desktops claim they can be used for functional applications, so it was decided to see how well they printed engineering grade materials. ABS was used for all but Markforged, which used their Nylon based Onyx material.

The part suite consisted of tensile bars, a 4 piece assembly, and a couple of challenging parts that required support. Quantitative measurements were done for tensile strength, XY accuracy, 3D accuracy, and print reliability. Parts were also qualitatively judged on critical to quality features, design intent met, and surface finish. With all that said, here are some of the results:

RELIABILITY

The reliability of each printer was calculated as the percentage of parts completed out of parts attempted. The base number of builds was 18, though some printers required more attempts.

Parameter	Stratasys F123'	Markforged Onyx	Lulzbot Taz 6	Ultimaker S5	Ultimaker 3
Builds	18	21	23	18	22
Successful Builds	18	12	18	15	12
Parts Printed	77	90	98	77	79
Parts Completed	77	49	78	61	45
Reliability %	100%	54%	79%	79%	57%
Print Time (hrs.)	146	335	233	211	276
Downtime (hrs.)	0	92	80	32	97.5

- The Stratasys F123 was the only model to print every part correctly the first time
- The Stratasys F123 printed the parts in significantly less time than the other models
- Only the Stratasys F123 performed without any downtime or stoppages

The F123 Series excels in print reliability compared to these other printers.

Print Accuracy Comparison

Design	Stratasys F123	Markforged Onyx	Lulzbot Taz 6	Ultimaker S5	Ultimaker 3
Relative Dogbone Tensile Strength (average of X/Y, and Z)	100%	64%	82%	67%	66%
XY Dimensional Check Part (Points in spec) *	95%	86%	62%	55%	39%
Interlocking 4-Piece Box (Dimensional accuracy) **	92%	33%	13%	17%	Fail
Vacuum Sanding Pad (Design intent met)	100%	30%	Fail	50%	Fail
Complex Duct (Design intent met)	100%	70%	Fail	10%	Fail
Overall Quality	97%	57%	31%	39%	21%

*XY Dimensional Check Part Tolerance +/- 0.010 inches (+/-250 microns)

**Interlocking 4-Piece Box Tolerance +/-0.005 inches (+/-125 microns)

- The Stratasys F123 achieved an overall quality score of 97%, while no other printer topped achieved more than 57%.
- Quote from the study: "The F170 performed the best in the Fine Feature Detail Testing as measured by the dimensional accuracy of the parts and the reproduction accuracy to the CAD file."

Quite a few things stand out here. Dimensional accuracy is a big separator. The study showed a big gap with XY measurements, but an even bigger gap with the 4 piece box measurements as that accounted for 3 dimensional accuracy. This really shows the advantage of a controlled heated environment. The design intent values are also telling, it is showing that most other printers can build parts, but not parts that are of high value to the customer.

These are just some of the highlights from the study. It is in the hands of the sales teams from each region and should help them differentiate true industrial printing from these low-cost imitations.

Variability of Additive Manufacturing Process

The Variability of Additive Manufacturing Process report was authored by Todd Grimm. The underlying work was managed within Stratasys using 3rd party parts providers and a 3rd party testing agency. It looked at factors necessary for AM to be adopted for manufacturing uses. Those factors were variability (of mechanical properties) and accuracy. This study was intended to highlight the Stratasys AIS configuration (Aircraft Interiors Solution) for the F900 and it did not disappoint.

To measure variability, the coefficient of variability (COV) was used as it does not factor in the specific measurement values, just the variability in those values. The lower the number, the more precise or repeatable the process is. The more precise the process, the more suited it is for manufacturing.
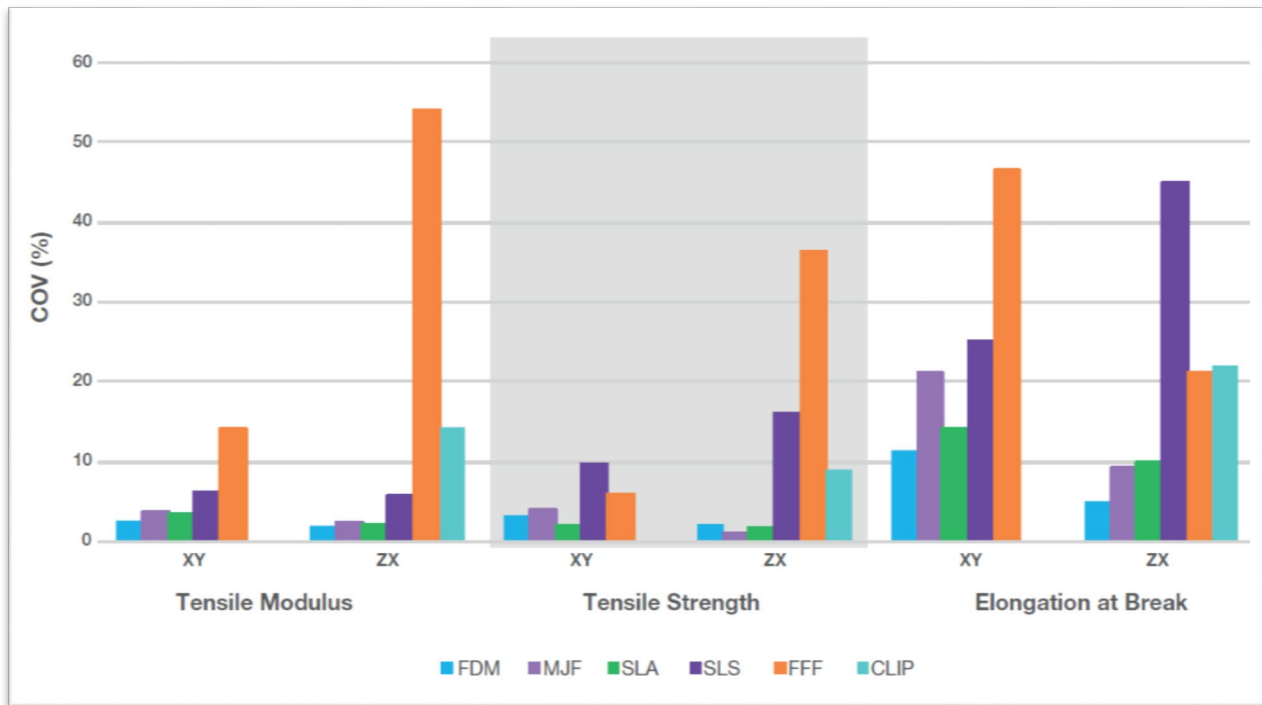
The chart above shows that FDM has the lowest COV in overall mechanical properties. MJF and SLA were good in Tensile Modulus and Strength but not in elongation variance. This means that a manufacturer could design a part for FDM and trust that the mechanical properties won't vary from part to part.

The X-Y accuracy of each printer/process was then measured. For use in manufacturing, what is important is that the dimensional repeatability is very tight and consistent throughout the build volume. If that is the case, then adjustments for accuracy can be made by the end user/manufacturer to dial in the feature accuracy to the desired result.

Large Features

Small, Positive Features
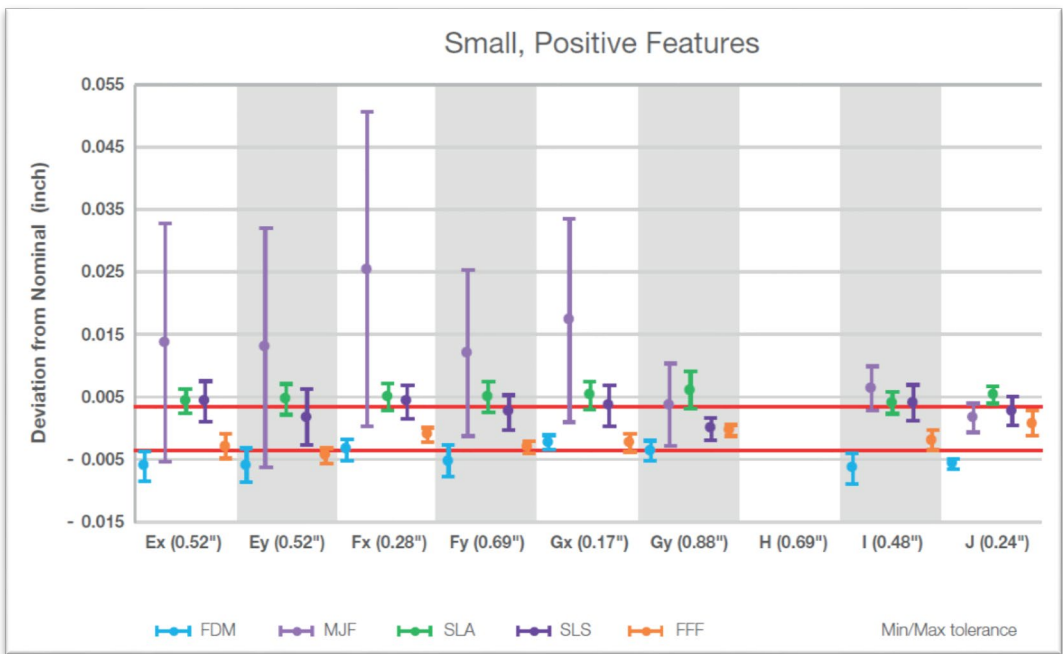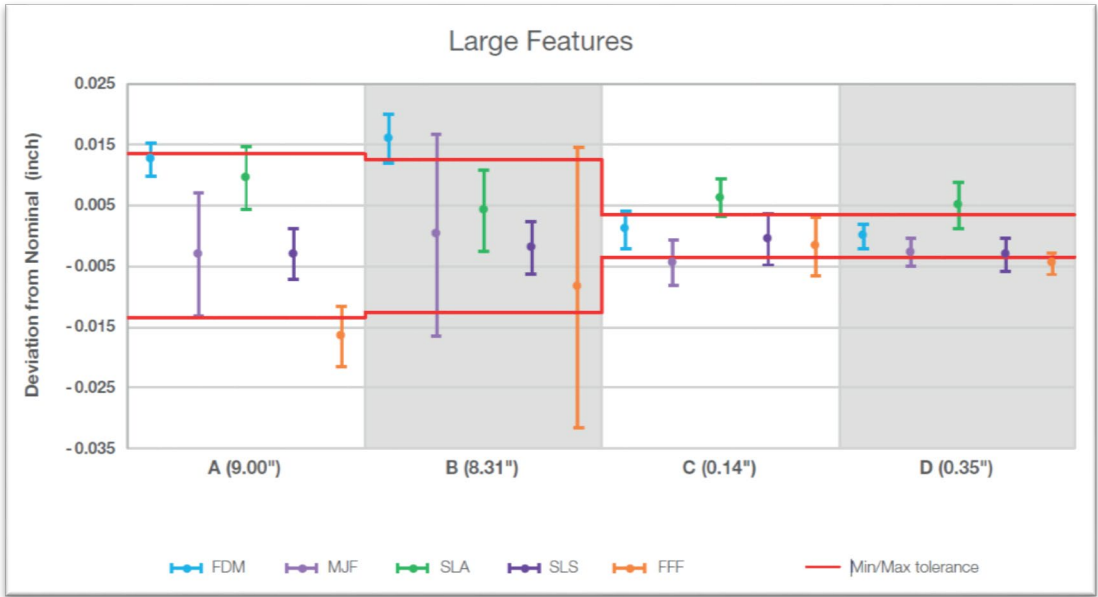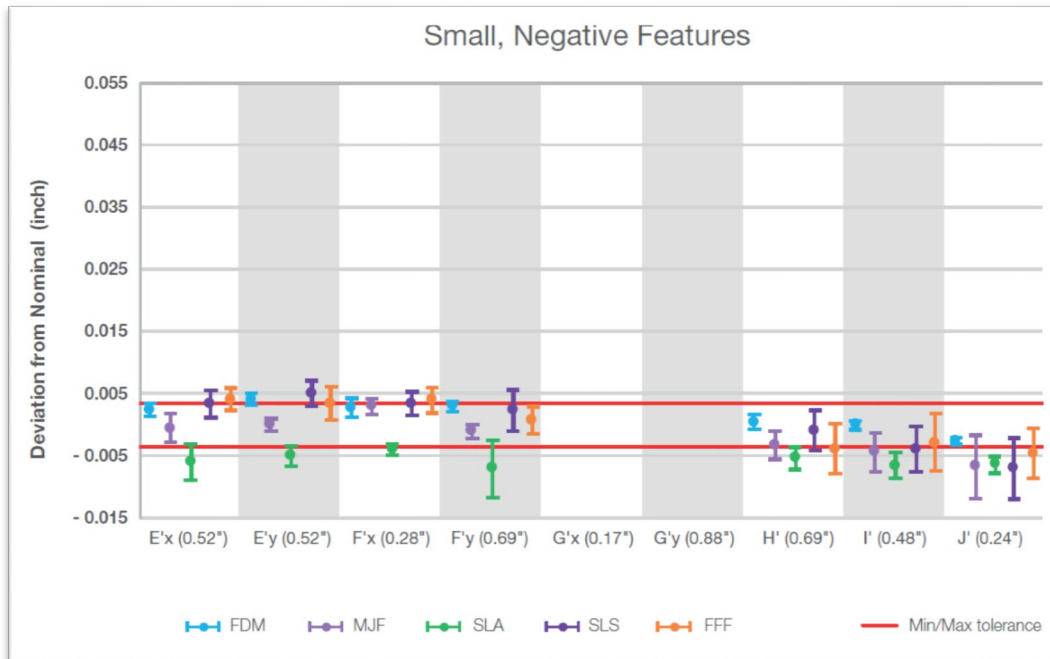
The accuracy measurement bands show the results from 2 printers for each process and multiple builds on each printer. The FDM bands are very tight and consistent, a little on the big side for large features and a little small for smaller positive features. The small negative features are a little big, but again are very tight. That means that manufacturers could compensate for the accuracy results of FDM and dial in the accuracy of their parts. The other processes (SLA, SLS, MJF, and FFF) had inconsistencies that were too large from printer to printer to expect consistently accurate output from those printers.

The overall finding of the report was that when both COV of mechanical properties and accuracy are considered for manufacturing with AM, FDM is the process that is most ready for manufacturing. This of course assumes that the materials meet the requirements for the manufacturing application.

The full Variability Report was published on 3DPrint.com in 4 postings, and if interested, they can be found in the links below.

4 Part 3DPrint Series
https://3dprint.com/246277/variability-of-additive-manufacturing-processes-part-one/
https://3dprint.com/246285/variability-of-additive-manufacturing-processes-part-2/
https://3dprint.com/246295/variability-of-additive-manufacturing-processes-part-3/
https://3dprint.com/246300/variability-of-additive-manufacturing-processes-part-4/

Context Report for Q1 of 2019

Takeaways from the Context Report with data through Q1 of 2019

Original 2 Class System		Newer 4 Class Segmentation	
Personal/Desktop	**<$5K**	**Personal**	**$2.5K or less**
Industrial/Professional	**>$5K**	**Professional**	**$2.5K to $20K**
		Design	**$20K to $100K**
		Industrial	**$100K and up**

- Overall shipments were down -2% in unit shipments as Personal/Desktop systems was only down -3% from a year ago
- Market was up +1% for total printer revenue from the prior year's quarter.
- Weighted ASPs for Industrial/Professional (>$5K) were down -23% while ASPs for Personal/Desktop (<$5K) systems were up 24%.
- Industrial/Professional unit shipments were up +25% from Q1'18 thanks to increased unit shipments from 3D Systems (mostly from their new Figure-4/NextDent and new DLP systems at the lower end), Desktop Metal, Markforged as well as to net-new players on this side of the market like XYZprinting.
- SLM Solutions was again a major story in the period, seeing Machine Sales revenues drop -57% from a year ago with the company continuing to struggle.
- 3D Systems struggled in the period with quality issues again in their metal series as well as with the "shift out" of a significant order from a plastics customer. It noted a +90% growth in unit shipments however dues to low priced DLP systems.
- EnvisionTEC – like 3D Systems also saw growth at the low-end with their new DLP EnvisonONE system
- UnionTech – as part of the same trend, even though they have stepped away from the US and Europe with their high-end systems, UnionTech still did well in China and with the DLP based EvoDent (NB : EvoDent is its own company/brand in the US and Europe but is part of UnionTech in China)
- Desktop Metal – having just really begun shipping a year ago, Desktop Metal was the top metal machine shipper globally in Q1'19!
- Markforged– Desktop Metal's top rival in the Material Extrusion metals business Markforged also did well in the quarter after initially shipping mostly to its reseller base in the 2nd half of 2018
- GE Additive – saw great internal demand for EBM Arcam systems from GE Aviation
- EOS – calendar Q1 is typically a slow period for EOS with collective (Polymer + Metal) machine shipments down -17% from a year ago.
- The quarter belonged to Vat Photopolymerization with unit shipments up +45% from a year ago mostly due to new DLP systems from 3D Systems but also from EnvisionTEC and UnionTech/EvoDent.
- Material Extrusion shipments were also up in the period but not due to the traditional Polymer FDM shipments that many have come to associate with Material Extrusion but to the multi-ASTM process Metal Material Extrusion solutions from Desktop Metal and Markforged.
- More specifically, Material Extrusion Metal printer shipments were up 20x+ from a year ago while more traditional laser based Powder Bed Fusion Metal solutions saw a Y/Y decline in shipments of -15% (so to say that "Metal 3D Printer shipments were up" in the quarter now requires a bit more explanation than in recent past).
- Service revenues from the major publicly traded companies were flat compared to a year ago and down -7% sequentially.
- On a Rolling 4-Quarter basis (Q2'18 to Q1'19 compared to Q2'17 to Q1'18), aggregate revenues were up 3% with Protolabs being particularly strong, seeing a 22% increase on a rolling 4Q basis.
- While Q1 is typically a weak quarter and can often impact perceptions of demand, overall it seems that the industry remained positive with forecasts largely unchanged from the beginning of the year.