THE 2017 CANADIAN ADDITIVE MANUFACTURING GUIDE

Produced by
Design ENGINEERING

Design ENGINEERING

www.design-engineering.com

Publisher
Alan Macpherson (416) 510-6756
amacpherson@design-engineering.com

Editor
Michael McLeod (416) 442-5600 ext. 3231
mmcleod@design-engineering.com

Associate Editor
Lindsay Luminoso (416) 510-5233
lluminoso@design-engineering.com

Account Manager
Ron Salmon (416) (905) 713-4362
rsalmon@design-engineering.com

Art Director
Mark Ryan (416) 442-5600 ext. 3541

Account Coordinator
Cheryl Fisher (416) 510-5194
cfisher@annexbizmedia.com

Circulation Manager
Beata Olechnowicz (416) 442-5600 ext. 3543
bolechnowicz@annexbizmedia.com

Vice President
Tim Dimopoulos (416) 510-5100
tdimopoulos@canadianmanufacturing.com

COO
Ted Markle
tmarkle@annexweb.com

President & CEO
Mike Fredericks

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Customer Service:
email: blao@annexbizmedia.com
Tel: 416-442-5600 ext 3552
Fax: 416-510-5170
Mail: 80 Valleybrook Drive, Toronto, ON M3B 2S9
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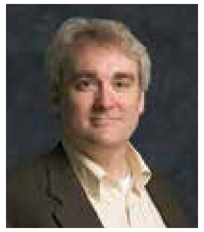
An AM State of Mind



Each year, we at Design Engineering strive to improve the magazine, website and DEX tradeshow in at least one significant way. We may not be able to realize all our plans at once but, bit by bit, we hope to incrementally build up and improve things toward our ultimate vision.

This year, that layer of improvement is The 2017 Canadian Additive Manufacturing Guide. In it, we've included an overview of the various AM processes currently available, plus a brief description of how they work for those who are new to the technology. We've also done our best to track down all the professional-grade service bureaus and equipment resellers in Canada complete with their contact information, what machines they run or sell and what services they offer beyond creating parts.

Given our audience, we chose not to include those who target the hobbyist or prosumer end of the 3D printing market. We've also largely limited the list to those companies operating in Canada. We have, however, included companies outside Canada that sell into North America on the whole.

Even with our best effort, we may have missed a few relevant players. Any exclusions are unintentional. If you feel your company was unfairly overlooked, please let us know so we can update and maintain our listings. We will be releasing the guide online through our website as a downloadable PDF, and we anticipate updating that document regularly so it remains current and relevant.

Beyond the listings, the supplement also includes a detailed analysis of the design rules specific to additive manufacturing. As the article's author, Nigel Southway, VP of Engineering at Additive Metal Manufacturing Inc., points out, AM requires a paradigm shift in design thinking that is 180 degrees away from subtractive design guidelines.

For example, subtractive techniques are like sculpting; you start with a block of material and discard what isn't needed. The more material removed, the more expensive the part. In AM, the opposite is true; the more material added, the more expensive the part becomes. As a result, additive manufacturing is too often dismissed because companies apply the new technology directly on their traditionally produced parts without first redesigning them to leverage AM's advantages. Inevitably, the per-part cost is too high and the return on investment too low.

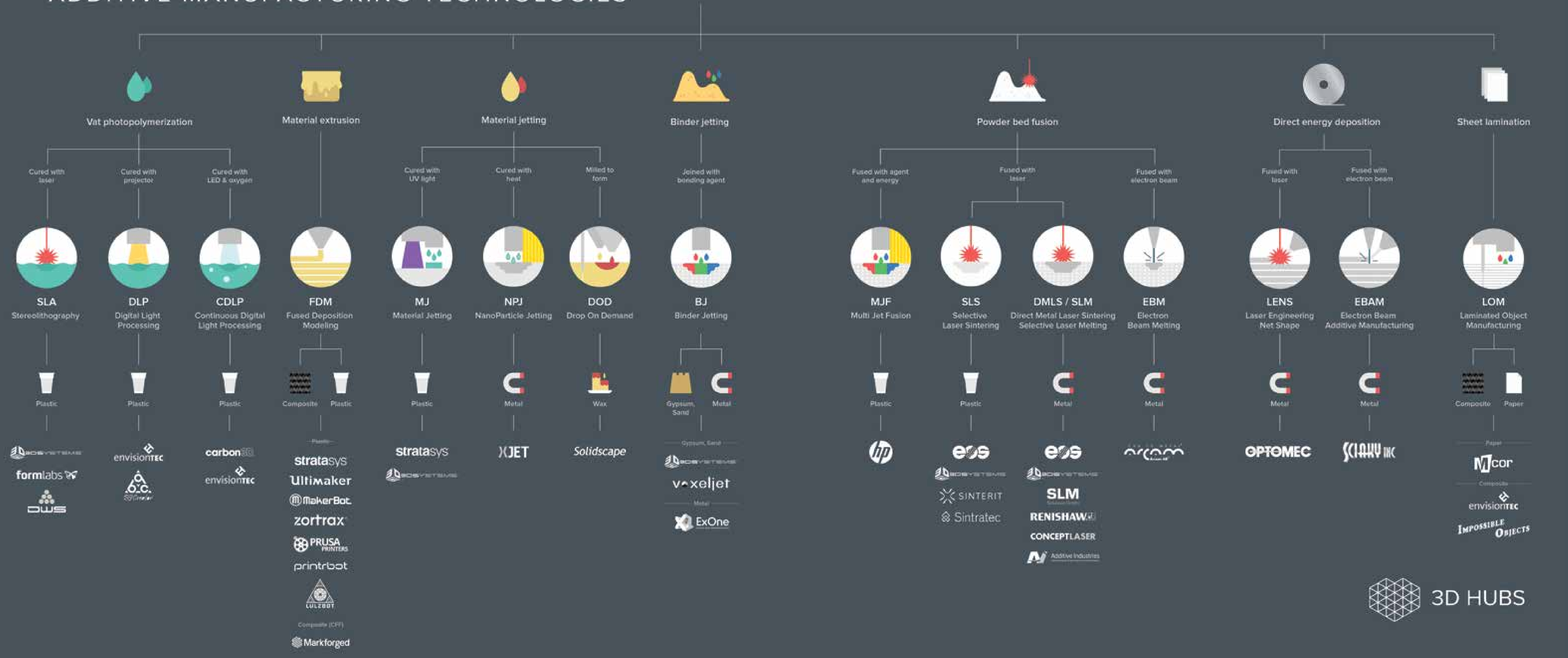
An additional challenge is that the tools design engineers use heavily steer them toward procedures that put additive manufacturing at a disadvantage from the get go. CAD parts typically start from one or more geometric primitives (e.g. blocks, spheres, cones, etc.) from which virtual material is removed. The operations common to CAD applications, such as chamfer, drill, shell and the like, virtually replicate the subtractive shop-floor operations that will be eventually used to create the part.

For designers to make the cognitive shift in thinking necessary for additive manufacturing to "make sense" from a business point of view, a new class of design software may be required. For example, such a tool might replace the 'extrude' tool with 'create lattice' or would, by default, fill any enclosed geometry with a crisscross matrix rather than solid material. I'm sure there are other and better examples but the point is to create tools that put designers in an AM state of mind.

Mike McLeod

@ I enjoy hearing from you so please contact me at MMcLeod@design-engineering.com and your letter could be published in an upcoming issue.

ADDITIVE MANUFACTURING TECHNOLOGIES



Stereolithography (SLA) uses a build platform submerged into liquid photopolymer resin. A single point laser then traces a cross-sectional area (layer) through the bottom of the tank and solidifies the build material. The platform lifts up slightly to let a new layer of resin flow beneath the part. This process is repeated layer by layer to produce a solid part. Typically, finished parts are cured by UV to improve mechanical properties.

Direct Light Processing (DLP) is similar to SLA, except that DLP uses a digital light projector to flash a single image of each layer all at once. Because the projector is a digital screen, the image of each layer is composed of 3D pixels – small rectangular bricks called voxels. DLP can achieve faster print times compared to SLA for some parts, as each entire layer is exposed all at once.

Continuous Direct Light Processing (CDLP) (or Continuous Liquid Interface Production or CLIP) produces parts in the same way as DLP however it relies on continuous motion of the build plate in the Z direction (upwards). Projecting the layer image through an oxygen permeable UV screen allows uncured resin to separate the object and window by controlling the oxygen flux. This allows for faster build times since the printer doesn't stop to separate the part from the build plate after each layer is produced.

Fused Deposition Modeling (FDM) (or Fused Filament Fabrication) uses a filament of solid thermoplastic material, extruded through a heated nozzle. The printer precisely and continuously lays down melted material at a location, where it instantly cools and solidifies. This builds up a part layer by layer.

Material Jetting (MJ) dispenses a photopolymer from hundreds of tiny print-head jets. This deposits build material in a rapid, line-wise fashion compared to point-wise deposition technologies that follow a path to complete the cross sectional area of a layer. As the droplets are deposited to the build platform, they are cured by UV light. Material jetting processes require support structures that are printed during the build and composed of a dissolvable material that is removed during post-processing.

Nano Particle Jetting (NPJ) uses a liquid, which contains metal nanoparticles or support nanoparticles, loaded into a printer cartridge and jetted onto the build tray in extremely thin layers of droplets. High temperatures inside the build envelope cause the liquid to evaporate leaving behind metal parts.

ADDITIVE MANUFACTURING TECHNOLOGIES

Drop On Demand (DOD) material jetting printers have two print jets: One to deposit the build materials (typically a wax-like material) and another for dissolvable support material. DOD printers follow a set path and jet material (in a point wise fashion) to print a cross-sectional layer. These machines also employ a fly-cutter that skims the build area after each layer is produced to ensure a perfectly flat surface before printing the next layer.

Binder Jetting (BJ) is similar to SLS in that an initial layer of powder is required. The print head moves over the print surface depositing binder droplets (typically 80 microns in diameter) to produce a layer. The powder bed is then lowered and a new layer of powder is applied. Once a solid part is generated, it is then left in the powder to cure and gain strength. The part is then removed from the bed and the unbound powder removed via pressurized air. Sometimes an infiltrant is added to improve mechanical properties. The binder jetting nozzles can contain color droplets, allowing for complex color printing.

Multi Jet Fusion (MJF) works similarly to other Powder Bed Fusion technologies with an added step: A detailing agent. A layer of build powder is first applied to a work area. A fusing agent is then selectively applied where the particles are to be fused together, followed by a localized detailing agent that is administered where the fusing action needs to be reduced or amplified. The detailing agent reduces fusing at the boundary of the parts to produce features with sharp and smooth edges. The work area is then exposed to fusing energy to solidify the powder particles.

Selective Laser Sintering (SLS) uses a laser to sinter thin layers of powdered material one layer at a time to create a solid structure. The process begins by spreading an initial layer of powder over a build platform. The cross section of the part is then sintered by the laser (solidifying it) at which point the build platform drops down one layer thickness. A fresh layer of powder is applied and the process is repeated until a solid part is produced. The completed component is encased in unsintered powder, which acts as support. The part is removed from the powder and cleaned, typically with pressurized air.

Direct Metal Laser Sintering (DMLS) and **Selective Laser Melting (SLM)** produce parts via the same method as SLS, except that DMLS and SLM are used in the production of metal parts. SLM achieves a full melt of the powder while DMLS sinters the powder. This means that DMLS only works with alloys while SLM can use single component metals. Unlike SLS, DMLS and SLM require support to compensate for the high residual stresses generated during the build process. This helps limit the likelihood of distortion occurring.

Electron Beam Melting (EBM), in contrast to other PBF technologies, uses a high energy beam that scans across a thin layer of metal powder causing localised melting and solidification over a specific cross sectional area. These layers are built up to create a solid part. Electron beam systems produce less residual stress in parts, resulting in less distortion and less need for anchors and support structures. While EBM uses less energy and is faster than SLS, minimum feature size, powder particle size, layer thickness and surface finish are typically larger. EBM parts are also produced in a vacuum and the process can only be used with conductive materials.

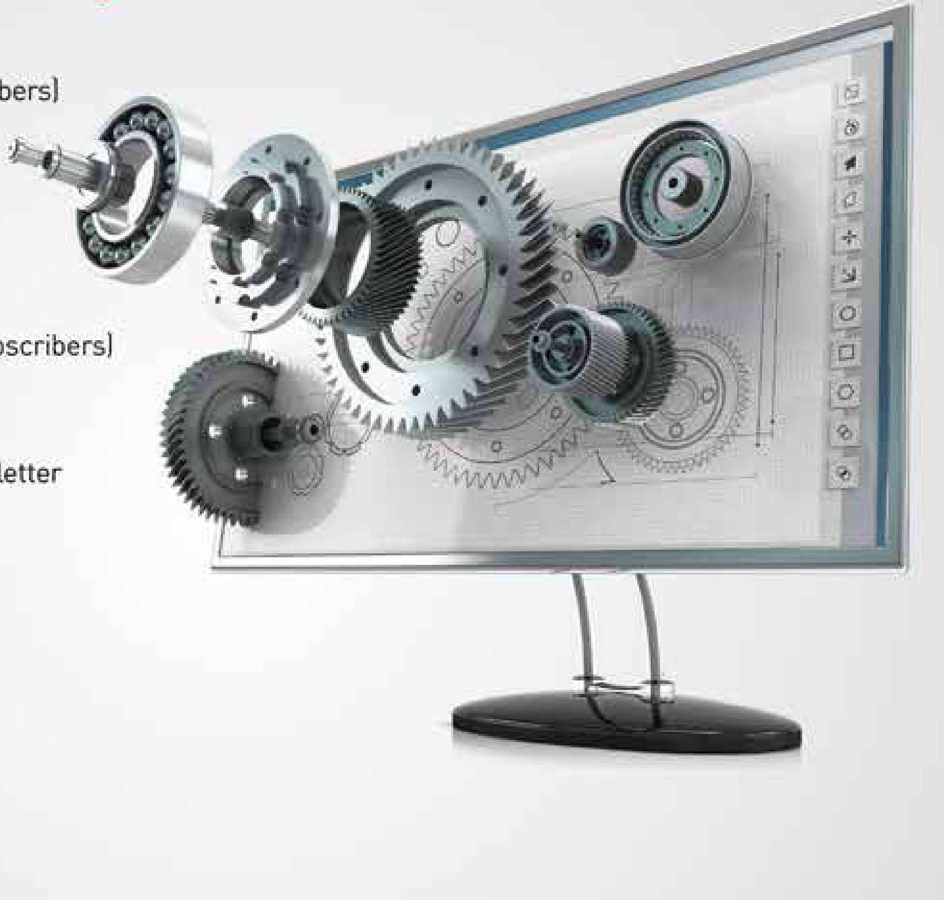
Laser Engineered Net Shape (LENS) utilizes a deposition head comprised of laser optics, powder nozzles and inert gas tubing to melt powder as it is deposited, layer by layer. The substrate is typically a flat metal plate that the part is built up upon or an existing part that material is added to. The laser creates a molten pool on the build area and powder is sprayed into the pool, which then melts and solidifies.

Electron Beam Additive Manufacture (EBAM) creates parts using metal powder or wire welded together using an electron beam as the heat source. Producing parts in a similar fashion to LENS, electron beams are more efficient than lasers and operate under a vacuum. The technology was originally designed for use in space.

Laminated Object Manufacturing (LOM) uses layers of adhesive-coated paper, plastic or metal laminates that are glued together and cut to shape with a knife or laser cutter. Finished parts can be further modified by machining or drilling.

www.3dhubs.com

The preceding infographic and AM process descriptions have been reprinted here with permission from 3D Hubs, an international network of 3D printing services. 3D Hubs' extensive additive manufacturing education knowledge-base is available online at www.3dhubs.com/knowledge-base.



AM SERVICE BUREAU CAPABILITY GUIDE

Service Bureau	Contact Info	Additional Services	SLA	DLP	CDLP	FDM	MJ	NPJ	DOD	BJ	MJF	SLS	DMLS/SLM	EBM	LENS	EBAM	LOM	Specifications
3DPhaktory	1134 Dundas St E, Toronto, ON, M4M 1S1 416-462-0994 I www.3dphaktory.com	In-house design; Chemical welding and CNC services	●			●	●					●						SLA - max. build vol. of 600x900x1200mm; FDM - 203x203 x152mm; MJ - 490x390x200mm; SLS - 200x250x330mm
3D Print Western	15825 118 Ave NW Edmonton, AB, T5V 1B7 780-991-6859 I www.3dprintwestern.com	3D scanning services; Deviation analysis (3DSystems Geomagics Studio and Design X)	●	●		●												1x Stratasys Fortus 900mc - max. build vol. of 914.4 x 609.6 x 914.4mm; 2x Autodesk Ember - 64 x 40 x 134mm
3DX Production	12 Bram Ct - Unit 12, Brampton, ON, L6W 3V1 855-208-8659 I www.3dxproduction.com	Surface finishing and packaging services; Specializes in large quantities of custom parts										●						1x 3DSystems ProX 500 - max. build vol. of 381 x 330 x 457mm
Additive Metal Manufacturing	131 Citation Dr - Unit 17&18, Concord, ON, L4K 2R3 905-738-0410 I www.additivemet.com	Design consultation and Online teaching process											●					2x EOS 290 - max. build vol. of 250 x 250 x 325mm
Agile Manufacturing	141 Reach St - Unit 9, Uxbridge, ON, L9P 1L3 905-852-0794 I www.agile-manufacturing.com	3D scanning for reverse engineering; Casting of urethanes for low volume production and metals	●			●	●			●		●						25 production machines
Anubus 3D	4100A Sladeview Cr - Unit 3&4, Mississauga, ON L5L 5Z3 I 800-905-6073 I www.anubus3d.com	Specializes in SLS technology; Design/build end of arm tooling and end use mechanical components										●						3 machines; EOS P395 and P100
Axis Prototype	6956, rue Jarry Est, Saint-Léonard, QC, H1P 3C1 888-320-8851 I www.axisproto.com	High-end finishing; Design & scanning; Foundry pattern processing	●	●		●	●					●	●					14 machines; 7x SLA, 1x DLP, 1x FDM, 1x MJ, 3x SLS, 1x DMLS
Burloak Technologies	354 MacNab St, Dundas, ON, L9H 2L2 905-592-0244 I www.burloaktech.com	R&D production; Machine shop/CNC services; Metrology lab				●						●	●					9 machines; 1x FDM; 1x SLS; 7x DMLS
CIMETRIX Empowering Innovation	1143 Wentworth St W - Suite 100, Oshawa, ON, L1J 8P7 I 905-728-6962 I www.cimetrixsolutions.com	Artec 3D scanning: Reverse engineering; Design for additive manufacturing				●	●		●									29 machines; 21x FDM - max build vol. of 914 x 610 x 914mm; 7x MJ - max. build vol. of 490 x 390 x 200mm; 1x DOD - max build vol. of 152 x 151 x 101mm
Custom Prototypes	214 Evans Ave, Toronto, ON, M8Z 1J8 416.955.0857 I www.customprototypes.ca	3D scanning; Post-processing/finishing; CAD design	●	●		●						●						6 machines - max. build vol. of 600 x 600 x 400mm
Envirolaser	199 Colonnade Rd, Nepean, ON, K2E 7K3 613-225-4726 I www.envirolaser.com	2D and 3D printing				●	●			●		●						7 machines
Forge Labs	480 Smithe St - #103, Vancouver, BC, V6B 5E4 604-259-1399 I www.forgelabs.ca	3D CAD modeling & design; Proprietary online quoting & order system direct to website	●			●	●					●						7 machines - max. build vol. of 406 x 406 x 355mm
FusiA	2485 rue Guenette, Saint-Laurent, QC, H4R 2E9 514-377-9961 I www.fusia.fr	Design support services; Machining and Post-processing services											●					EOS M280 and M290
Hot Pop Factory	215 Spadina Ave - b05, Toronto, ON, M5T 2C7 416-306-6468 I www.hotpopfactory.com	Laser cutting; CNC machining				●						●						Max. build vol. of 140 x 220 x 140mm
Industrial Technology Centre	78 Innovation Dr - #200, Winnipeg, MB, R3T 6C2 204-480-0344 I www.itc.mb.ca	Shape capture services; Accredited material testing/metrology services				●												1x Stratasys Fortus 400mc - max. build vol. of 406 x 355 x 406mm
KUZMA Industrial	421 7th Ave SW - #3000, Calgary, AB, T2P 4K9 866-406-5461 I www.kuzmaindustrial.com	Design and rapid prototyping; CNC machining; Casting services	●			●						●	●					General max build vol. of 590 x 600 x 600mm; Renishaw AM250 - 250 x 250 x 365mm
LAE Technologies	145 Welham Rd., Barrie, ON, L4N 8Y3 705-728-7000 I www.laetechnologies.com	CNC machining; Quality/Inspection; Design and Prototyping services	●			●	●					●						Stratasys Fortus FMD; Stratasys Objet 3D Polyjet printer
Nova Product Development Services	7 Labatt Ave, Toronto, ON, M5A 1Z1 416-368-0896 I www.novaproduct.com	Model finishing; Relationships with other service bureaus to provide SLA, SLS and DMLS models				●												2 machines
Objex Unlimited	36 Fieldway Rd, Etobicoke, ON, M8Z 3L2 416-233-7165 I www.objexunlimited.com	Design and digital sculpting; 3D scanning sales and services; 3D body scanning (Selftraits)	●			●	●			●								14 machines - max. build vol. of 1000 x 500 x 500mm
Openforge AM	3 Rue des Pins, Cantley, QC, J8V 3L9 819-208-5721 I www.openforge.ca	Rapid prototyping; Reverse engineering; Low-volume manufacturing	●			●						●						6 machines; SLA - max. build vol. of 145 x 145 x 175mm; FDM - 300 x 300 x 300mm; SLS - 110 x 110 x 110mm
Precision ADM	1595 Buffalo Pl - Unit A, Winnipeg, MB, R3T 1M1 204-289-4491 I www.precisionadm.com	CNC machining; EDM; Inspection services				●							●					2x DMLS EOS M290 - max. build vol. of 250 x 250 x 290mm
Proto3000	6260 Highway 7 - Unit 8, Vaughan, ON, L4H 4G3 905-738-1779 I www.proto3000.com	3D scanning and metrology; CAD engineering	●			●	●					●	●	●				30 machines with a max. build vol. of 914.4 x 609.6 x 914.4mm
Proto Labs	5540 Pioneer Creek Dr, Maple Plain, MN, 55359 877-479-3680 I www.protolabs.com	CNC machining; Injection molding	●				●				●	●	●					80 machines - max. build vol. of 737 x 635 x 533mm
RAPID-FAB	278 Cook St, Meaford, ON, N4L 1H4 855-560-5673 I www.rapid-fab.com	3D scanning; Design services; Post-processing/ Finishing services	●			●						●						3D Systems Projet HD3000 Plus; Stratasys Objet500 Connex; Stratasys Fortus 250mc, 400mc, 900mc
Solaxis	11A Du Pacifique St E, Bromont, QC, J2L 1J4 450-919-1515 I www.solaxis.ca	Dimensional metrology; Painting and Finishing	●			●												1x SLA 3D Systems Viper SI2 - max. build vol. of 254 x 254 x 254mm; 5x FDM Stratasys Fortus - 914 x 609 x 914mm
Troadey	1020 Rue Bouvier - #400, Québec City, QC, G2K 0K9 418-476-8252 I www.troadey.com	3D printing technologies; Automation and Robotisation; Binder jetting mass-production	●			●	●			●		●						3x SLA; 4x FMD; 1x MJ; 11x BJ; 1x SLS; Overall max. build vol. of 508 x 610 x 406 mm
Westech Labs	7106 42 St - Unit 104, Leduc, AB, T9E 0R8 780-436-5200 I www.westechlabs.com	Calibration; Inspection; Laser engraving	●			●						●						SLA Experts

AM DISTRIBUTOR & RESELLER LISTING

Company	Brands Sold	Address	Phone Number	Email	Website
3D Printers Canada	Stratasys	6260 Hwy 7 Woodbridge, ON, L4H 0K9	905-738-1779	info@3dprinterscanada.com	www.3dprinterscanada.com
		43 Boul. Samson - Suite 396 Laval, QC, H7X 3R8	514-664-2016		
Agile Manufacturing	3D Systems	141 Reach St - #9 Uxbridge, ON, L9P 1L3	905-852-0794	agile@agile-manufacturing.com	www.agile-manufacturing.com
Arcam Cad to Metal Inc.	Arcam Direct Sales	6 Gill St - #6B Woburn, MA, 01801	781-281-1718	N/A	www.arcam.com
CAD MicroSolutions	Markforged	225 Pinebush Rd - Unit 102 Cambridge, ON, N1T 1B9	519-642-8222	info@cadmicro.com	www.cadmicro.com
		65 International Blvd - Suite 103 Toronto, ON, M9W 6L9	416-213-0533		
Carbon	Carbon Direct Sales	1089 Mills Way Redwood City, CA, 94063	650-285-6307	info@carbon3d.com	www.carbon3d.com
CIMETRIX Empowering Innovation	Stratasys	1143 Wentworth St. W - Suite 100, Oshawa, ON, L1J 8P7	905-728-6962	info@cimetrixsolutions.com	www.cimetrixsolutions.com
Concept Laser	Concept Laser Direct Sales	1000 Texan Tr - Suite 150 Grapevine, TX, 76051	817-328-6500	info@conceptlaserinc.com	www.conceptlaserinc.com
Creative CADworks	MiiCraft; B9 Creations	27 Queen St. E - Suite 1401 Toronto, ON, M5C 2M6	416-368-7266	sales@creativecadworks.ca	www.creativecad.works
DWS Systems	DWS Systems Direct Sales	Viale della Meccanica, 21 36016 Thiene, VI, Italy	+39 0445 810 810	info@dwssystems.com	www.dwssystems.com
EOS of North America	EOS Direct Sales	28970 Cabot Dr - # 700 Novi, MI, 48377	248-306-0143	info@eos-na.com	www.eos.info
Evolv3D	3D Systems	225 Industrial Pkwy S - Suite 29, Aurora, ON, L4G 3V5	905-727-5019	info@evolv3dlabs.com	www.evolv3dlabs.com
Genistar	Prodways	6956, rue Jarry Est Saint-Léonard, QC, H1P 3C1	438-738-4133	info@genistar.com	www.genistar.com
Hawkridge Systems	3D Systems; Markforged	5915 Airport Rd - Suite 120 Mississauga, ON, L4V 1T1	866-587-6803	info@hawkridgesys.com	www.hawkridgesys.com
		1661 Portage Ave - Suite 307 Winnipeg, MB, R3J 3T7			
		4208 97th St. NW - Suite 110 Edmonton, AB, T6E 5Z9			
		7101 5th St. SE - Suite 100 Calgary, AB, T2H 2G2			
		10451 Shellbridge Way - Suite 204 Richmond, BC, V6X 2W8			
Hewlett Packard	Hewlett Packard Direct Sales	N/A	404-774-7828	N/A	www.hp.com
Javelin Technologies	Stratasys	3457 Superior Court - Unit #1 Oakville, ON, L6L 0C4	905-815-1906	sales@javelin-tech.com	www.javelin-tech.com
		10060 Jasper Ave, Tower 1 - Suite 2020, Edmonton, AB, T5J 3R8	780-822-4700		
		10 Morris Dr - Unit 9 Dartmouth, NS, B3B 1K8	902-332-3210		
		675 Berry St - Unit G Winnipeg, MB, R3H 1A7	204-474-0982		
		480 Smithe St - Unit 103 Vancouver, BC, V6B 5E4	604-343-1890		
Machine Tool Systems	EOS	4025 Sladeview Cr - Unit 3 Mississauga, ON, L5L 5Y1	416-254-6298	JohnManley@MachineToolSystems.com	www.machinetoolsystems.com
NOVACAD Systems	3D Systems; Markforged	3890 Kencrest Ave Halifax, NS, B3K 3L6	902-292-7443	mfanning@novacad3d.com	www.novacad3d.com
Objex Unlimited	3D Systems; MarkForged; FormLabs	36 Fieldway Rd Toronto, ON, M8Z 3L2	416-233-7165	sales@objexunlimited.com	www.objexunlimited.com
Optomec	Optomec Direct Sales	3911 Singer Blvd N.E. Albuquerque, NM, 87109	505-761-8250	sales@optomec.com	www.optomec.com
PrintYourMind3D	LULZBOT; Ultimaker	Calgary, AB	587-226-2645	support@printyourmind3d.ca	www.printyourmind3d.ca
Proto3000	Stratasys	6260 Highway 7 - Unit 8 Vaughan, ON, L4H 4G3	905-738-1779	info@proto3000.com	www.proto3000.com
		43 Boul. Samson - Suite 369 Laval, QC, H7X 3R8	514-370-5548		
Renishaw	Renishaw Direct Sales	41 Ardelt Pl Kitchener, ON, N2C 2C8	905-828-0104	canada@renishaw.com	www.renishaw.com
Sciaky	Sciaky Direct Sales	4915 W 67th St Chicago, IL, 60638	877-450-2518	rsalo.sciaky@psi-corp.com (West) johara.sciaky@psi-corp.com (East)	www.sciaky.com
Shop3D	Ultimaker; FormLabs; BCN3D	2005 Clark Blvd - Unit #4 Brampton, ON, L6T 5P8	905-799-1133	sales@shop3d.ca	www.shop3d.ca
SLM Solutions	SLM Solutions Direct Sales	48561 Alpha Dr - Suite 300 Wixom, MI, 48393	248-243-5400	info@slm-solutions.us	www.slm-solutions.com
Thor3D	Stratasys	109 Saskatchewan Ave E - Box 268, Outlook, SK, S0L 2N0	306-867-9888	Greg@Thorstad.ca Steven@Thorstad.ca	www.thor3d.ca
XJET	XJET Direct Sales	Science Park, 10 Oppenheimer St Rehovot 7670110, Israel	+972 8 9314620	info@xjet3d.com	www.xjet3d.com

The Design Rules of AM Metal Technology

Why designers need to lead the next wave of additive manufacturing adoption.

By Nigel Southway

In this article, I want to talk directly to product designers, as they hold the key to how Additive Metal Technology (AMT) gets adopted within their industry and product set. AMT offers significant advantages to the product design community to develop innovative solutions for the next generation of products. But product designers need to understand how these liberating options should to be approached.

Design for Manufacturing (DFM) procedures for AMT will become a huge paradigm shift for most designers, and it's going to take supportive collaboration between product designers and AMT service providers before learning cycles are completed and experiences aligned so future designs benefit from AMT.

Why use AMT?

With the correct design efforts, AMT offers the following functional advantages that improve product design.

Light-weighting: Additive approaches yield far lighter parts. Mass reduction can be three or four times that of other technologies. This is because AM can grow much thinner wall structures and supports that would be difficult, and far more expensive, using subtractive technologies. Also, these solutions are performed without expensive tooling or casting expenditures.

Thermal management: AMT liberates designers to build in thermal management features by increasing surface area for the same part mass or topology.

Adding complex features: On the external and inside surfaces of parts, AM can, at almost no cost, add features that just cannot be done in conventional machining, as well as features that most casting tooling cannot do. Also, it can now offer casting or mold tooling designers internal cooling channels and pathways for both molding and casting tooling.

Part consolidation: AMT lets design engineers integrate multiple parts into one single component rather than make and assemble them together using conventional technologies. This may also eliminate assembly fit-up and integration issues associated with part interchange tolerance issues or, in the case of weldments, debilitating distortion due to excess fabrication. And we all know how much adding screws to a design attracts costs and reliability issues.

Tooling free rapid prototyping: These are always possible with AMT. Taking a typical subtractive part with excessive mass and applying AMT to it will provide a part that can be delivered far more rapidly with no tooling. However, your purchasing department may get sticker shock unless a panic delivery with no concern for price is what they have in mind.

Assembly fit up elimination: This may make AMT an advantage since AM structures have a homogeneous metallurgical structure. Parts machined from a solid block of material may not be able to provide this without quality and end-use reliability issues.

How to start with AMT

Ensure you start at the concept design stage, since a lot of the advantages of AMT rely on how you conceptualize the product design. Here is the most important design paradigm shift you need to undertake.

Traditionally, in conventional subtractive technology (milling turning, pressing etc.), we have learned that the more material we subtract, the more expensive the part. But, with AMT, the more material we add, the more expensive the part. In fact, most features can be added without additional cost.

This suggests that, to make this DfAM paradigm shift, you will need to adopt a design mentality of "wire frame thinking" rather than the huge trap of starting your design thinking with a block of metal and carving material off and drilling holes in it.

Here is an example. In the design below, you may be tempted to adopt a design like Fig 1. It's either a milled block or a welded plate fabrication with holes bored through. The best way to proceed for an additive design is to think of the same design differently (Fig 2). It's essentially 4 z-planes with 4 small holes between 2 planes, 2 small holes between 2 planes and 1 large hole between 2 planes.

Then you'd look at the part strength requirements and design in minimal wall sections to support the application. Remember that you can factor in stronger materials to achieve this minimum wall design thinking. This gets you to a design as in Fig 3. From this base design, you could then remove even more material as progressions (Figs 4 to 6). Just look at the design paradigm shift between Fig 1 and Fig 6. Both have the same Fit and Function, but not the same Form.

Of course, we all know that this won't always work from a design strength point of view, but now you can add back material as gussets or radius where needed. Remember, these features are free in AMT, and the more material you can remove, the lower the cost.

This approach can sometimes be an advantage in terms of thermal mass and heat transfer, and of course overall weight improvement. Also, if the conventional approach was to make the parts in pieces and fasten or weld them together, then you have eliminated many process steps and quality issues with the one-piece AMT design. But it requires that you define the real mission of the part and forget manufacturing rules until you have got that mission clear.

Fig 1

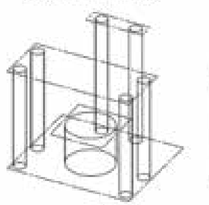


Fig 2

Fig 3

Fig 4

Fig 5

Fig 6

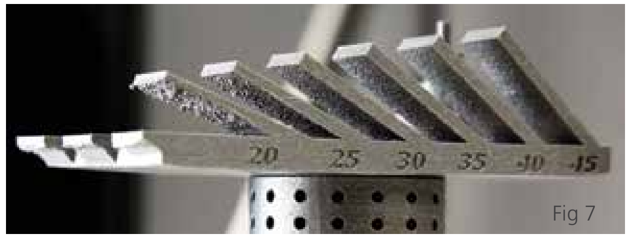


Fig 7

Fig 8

AMT Design Constraints

Currently, AMT does have design constraints worth mentioning. Again, a suitable AMT provider will help you navigate the limitations. Most have documented DfAM guidelines and some provide reference samples to illustrate the constraints. In a nutshell, here are the major constraints.

Surface finish and accuracy is about the same as a casting finish, with tight tolerances being managed with stock added in the build stage and then a machining operation performed. As AMT evolves, this is always being improved, but smart design tolerancing can eliminate this constraint.

Down-facing surfaces have the worst surface finish and may be degraded (Fig 7). A slope above 30 degrees can be built without adding supports. Sometimes the provider can solve this problem by changing the part's orientation during the build. Radius and gussets can also be added to create less "negative surfaces," but striving to design all surfaces in one plane is optimum.

Holes and passages built in the horizontal build plane (Fig 8) are a challenge with the top of the hole being degraded due to unsupported powder at the top of the hole. Part orientation can be the solution but designs with holes in both horizontal and vertical planes will need attention. As the hole becomes smaller, however, this degradation effect is reduced.

If it's a passage hole that doesn't need to be round, one solution is to redesign the hole as a sharp apex. Once you realize that you don't have to drill round holes or put them in a straight line, it's amazing how much you can design using this apex hole concept.

Wall thickness is not a huge constraint and is typically much better than casting. Design limits will vary depending upon material used, but the typical minimum is 0.4mm, which is certainly more difficult to machine, especially when you have high complexity.

Threads, male or female, in any plane are not a good candidate for AMT; the "negative" surfaces will be too rough without at least a thread chasing process or the maximum or minimum diameter processed in the AMT build and then post threaded.

Some Do's and Don'ts

Based on everything presented so far, here are some additional pointers:

- **Do** find a suitable AMT service provider who can consult on the AM technology. The best ones will have a strong engineering capability and a process to explain these new game changing DfAM rules. They will also be able to provide hands-on prototyping and early production capability.
- **Don't** compare the costs associated with AMT vs subtractive technologies until you have looked at designing for AMT and also factored in all the commercial advantages of no tooling and rapid delivery.
- **Do** shift your design paradigm and start the transition to design in AMT at the concept stage of your product. Remember to define the mission of your parts so you fully understand how to leverage the advantages of AMT while avoiding the technology's constraints.
- **Don't** lock down the choice of materials until you understand which AMT powders are available. Keep an open mind and design your parts first. Then, based on the design requirements, decide which material will work best.

AMT is a rapidly emerging new tool in the designer's kitbag. For some, it's very exciting. Others may feel heavy pressure to change and manage new risk.

Remember, it's a disruptive technology. You can either adopt it into your industrial sector effectively or be disrupted if your competitor takes the lead. **DE**

www.additivemet.com

Nigel Southway is VP of Engineering at Additive Metal Manufacturing Inc. in Concord, Ontario.

ASSEMBLED with EASE

This door seal assembly jig, additively manufactured by Solaxis for anautomotive client, is 100 pounds lighter than a standard jig and cut four seconds per cycle from the process

Solaxis' 3D printed automotive assembly jigs cut weight, improve accuracy and speed assembly.

Jigs used to assemble automotive parts traditionally share two downsides: They can be difficult to maintain and, because they're made of metal, they're heavy – up to 150 pounds. For a single worker, that's too heavy to move easily amid a bustling factory floor.

But as the engineers at Solaxis Ingenious Manufacturing have demonstrated, jigs don't need to possess any of those negatives. The Bromont, Quebec-based company specializes in 3D printing, 3D scanning, design, prototyping and tooling for clients.

With the help of Fortus 3D printers from Stratasys, the company designs and manufactures jigs for automotive suppliers, among its other work for clients in the aerospace, ground transportation, defense, robotics and manufacturing industries.

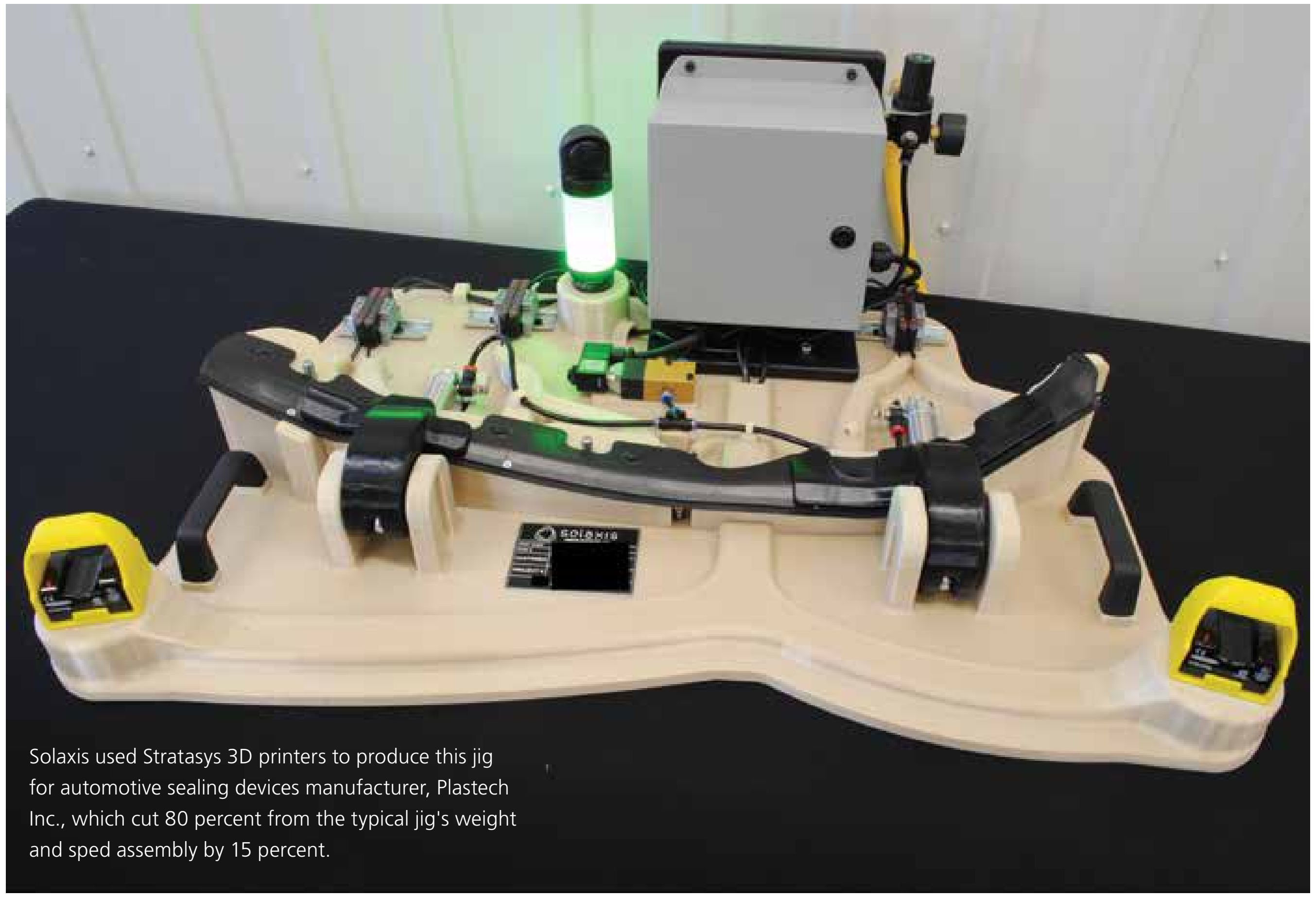
Iterations on Demand

One such automotive supplier uses a Solaxis designed jig to assemble high-volume plastic door seals. After developing several iterations of the jig, Solaxis was not only able to produce a 3D printed jig that is more than 100 pounds lighter than a typical jig for this application, but it also slashed the design and manufacturing time by two thirds compared with traditional methods.

Solaxis design engineers continued to refine the door seal assembly jig, producing at least a dozen different design iterations over the last couple of years. The rapid speed at which the designs could be built using Solidworks and Fortus 3D printers was relatively new for their automotive customer. This particular company was used to its own in-house injection molding, and its machine shop with mold and die tooling capability.

"From design to design, we could easily make changes," says Solaxis President François Guilbault. "It's not like we had to come back (to the customer) and say, 'We have to redo your tooling'."

This agility increases the flexibility of design, enabling Solaxis engineers to integrate minor adjustments, such as the placement of buttons and handles, the addition of chutes and other ergonomic improvements. This also enabled Solaxis to lessen the number of parts in the design, integrating off-the-shelf internal hardware that can be quickly replaced by the customer if a switch or wire breaks.



Solaxis used Stratasys 3D printers to produce this jig for automotive sealing devices manufacturer, Plastech Inc., which cut 80 percent from the typical jig's weight and sped assembly by 15 percent.

Depending on the part complexity, engineers can make CAD iterations in just eight to 20 hours, Guilbault says. Solaxis and the customer's engineers shared files to quickly confirm the design and produce a new jig within days. Unlike a jig produced primarily by an operator using a CNC machine, Fortus 3D printers can run without supervision, with production scheduled at any time of the day or night, and on weekends.

"We shrank the overall design/manufacturing cycle time, which is traditionally 16 to 20 weeks, to three to five weeks," Guilbault says.

The Solaxis jig measures 34 inches by 22 inches and weighs just 28 pounds, light enough for anyone to pick up and move. Now, every operator is expecting one of these jigs at their workstation.

In addition, by using the Solaxis jig, workers save an average of four seconds per cycle. With 250,000 cycles a year performed by a typical employee assembling the seals, the supplier has saved hundreds of hours in labor time.

"Just that cycle time gain alone justifies the price of the jig," Guilbault says. "So their ROI is achieved within 12 months."

Before working with Solaxis, the customer had recurring compliance issues. Deliveries to the OEMs were returned, resulting in substantial time and cost to re-inspect and fix the shipments.

Stratasys 3D printing technology enabled Solaxis to continuously improve the jig, saving the customer production time and money. In turn, the automotive supplier has significantly increased the reliability of the door seals it provides to its OEM customer. With zero compliancy issues the last two years, that means higher profits for the company.

Lightweight Parts

In addition to enabling the development of specialized tooling, production components, and surrogate parts more quickly, Solidworks and Stratasys solutions allow Solaxis to offer innovative approaches that improve both performance and safety.

For example, during the development of a 36 x 24-inch jig with grippers for an automotive production application, Solaxis reduced the weight of the jig by one-fifth, from 150 to 28 pounds. Lightweighting the jig not only improved safety, it also cut four seconds per cycle from the process, a productivity improvement of 15 percent.

"Because we are able to provide customers with substantial productivity gains in a fraction of the time of conventional approaches, we're realizing dramatic growth," Guilbault says. "Initially, we did mainly prototypes. Now, our tooling and 3D printed production parts businesses have both grown significantly; each makes up roughly 20 percent of our revenue. We anticipate these services will soon become the core of our business." DE

www.solaxis.ca

This story was contributed by Stratasys.