# BETTER BE RUNNING!

## TOOLS TO DRIVE DESIGN SUCCESS


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## Chapter 3

# Selective Laser Sintering

**POWDER TO THE PEOPLE!**

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*"SLS is evolutionary low-volume manufacturing."*

### QuickSMART

**Definition**: Selective Laser Sintering (SLS) is an AF process based on free-form technology and is used to create prototypes and functional parts. This AF method creates solid 3D objects by fusing or sintering particles of powdered material with a hot $CO_2$ laser. A thin layer of powdered thermoplastic material is rolled onto a heated build platform. The laser beam directs cross-sectioned CAD data onto the surface of the powder bed. The heat laser then traces each layer, melting plastic particles to the previous plastic layer. After each cross section is scanned, the powder bed is lowered by one layer thickness, then a new layer of material is applied on top. The process is repeated until the part is complete.

**Why You Need It**: To skip the prototyping process and directly manufacture end-use, functional parts; to get durable, heat-resistant parts (200 to 300°F); to quickly make parts for use in tough environments; to test parts in a real environment; and to create complex geometries.

**Ideal Uses**: Durable, thick, bulky parts, such as engine blocks, engine components, mounting brackets, and hot liquid dispenser components; trade show models, and concept models for reviewing ideas, form, and style; functional models and working prototypes; master patterns, investment and sand-casting patterns; heavy industrial use in automotive and aerospace; durable low-volume production parts; snap fits and living hinges; hot airflow model, used for testing.

## SLS Background

Borderline magic, SLS turns powder into parts in a matter of hours, typically building at a rate of one cubic inch per hour. SLS technology is widely used around the world for its ability to produce complex, durable, functional parts directly from a digital CAD model. While SLS began as a way to build prototype parts early in the design cycle, it is now being used in low-volume manufacturing to produce strong, fully functional parts with an accuracy of 0.005 inch (five thousandths).

Originated by DTM Corporation, SLS was acquired by 3D Systems, Inc., in 2001. 3D Systems, based in Rockhill, South Carolina, now manufactures and sells SLS systems and materials worldwide. At present, there are only a few known powder-based AF systems and 3D printers.

Another major player in SLS equipment is EOS (Electro Optical System) GmbH of Munich, Germany. While technically better, EOS leads SLS sales only in Europe. Leading sales in the US, 3D Systems has benefited from replicating many features of the EOS system. EOS continues to manufacture laser sintering systems that are quickly developing the future with variants of materials combined with polymers and metal for a wide range of production and foundry applications.

## SLS Process—Inside the Magic Oven

SLS offers the key advantage of making functional parts in end-use materials, such as ABS-like plastic. However, the system is mechanically more complex than the SLA and most other AF technologies. A variety of thermoplastic materials such as nylon, glass-filled nylon, and polystyrene are used in the SLS process. Surface finishes and accuracy are not quite as polished as those made with SL, but material properties can be quite close to those of the end-use materials. The SLS method has also been extended to provide direct fabrication of metal and ceramic objects and tools. SLS uses a hot $CO_2$ laser to sinter powder-based materials together, layer-by-layer, to form a solid 3D object. Equipment for the SLS system consists of a sealed chamber containing the build envelope, roller, and pistons; a $CO_2$ laser; and a scanning system.

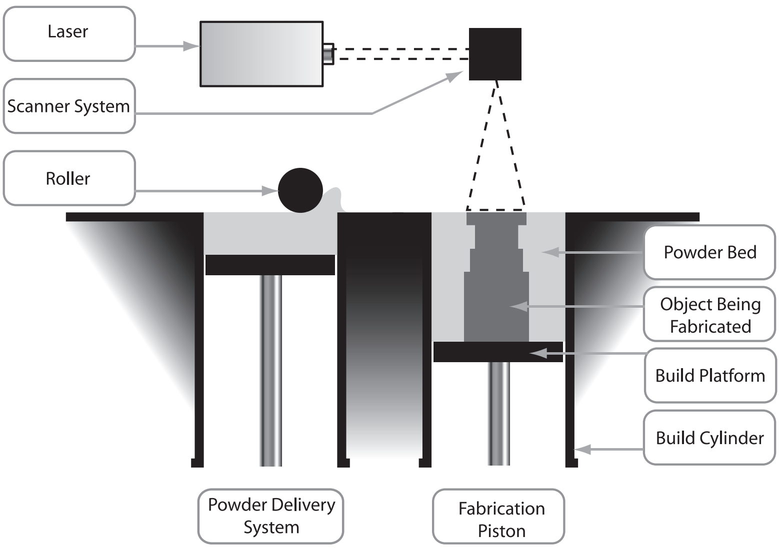
### *Step by Step with SLS*

First, an operator converts your CAD file to a Standard Tessellation Language (STL) file, then the SLS system software processes the file and orients the part for optimum build. Next, the SLS software slices the STL file into electronic layers and sends it as instructions to direct the operation.

Thermoplastic powder is spread by a roller over the surface of a build cylinder. The piston in the cylinder moves down one layer thickness to accommodate each new layer of powder. The powder delivery system is similar in function to the build cylinder. Here, a piston moves upward incrementally to supply a measured quantity of powder for each layer.

A laser beam is then traced over the surface of this compacted powder to selectively melt and bond it to form a thin layer of the object. The fabrication chamber is maintained at a temperature just below the melting point of the powder so that heat from the laser raises the temperature slightly to cause sintering. A nitrogen atmosphere inside the fabrication chamber prevents the material from burning. The process is repeated until the entire object is fabricated.

SELECTIVE LASER SINTERING (SLS)




The remaining unsintered powder surrounds the object and acts as support for the part. Therefore, **no additional supports are required with SLS** since more fragile features, such as overhangs and undercuts, are supported by the powder bed. The SLS machine must cool down before the part can be removed from the machine. Large parts with thin sections may require as much as two days of cooling time.

After the object is completely built and the machine has cooled down, the part chamber is moved to a breakout station. Technicians excavate the part from a mound of powder. Excess powder is brushed away and manual sanding smoothes the unavoidable stair-stepping effect.

Sintered objects are porous. Therefore, it may be necessary to infiltrate the part, especially metal composites, with another material to improve mechanical characteristics. SLS parts are typically dipped in a "super glue" to fill the voids and make the parts smoother and more durable.

## SLS Applications—Shift Happens

Look around you. A profound, paradigm shift is happening, almost beyond our awareness. Some people call this a "sea change," a great metaphor for this sudden technology shift. Have you ever been sailing on the open sea when weather comes up rapidly? The water turns from a clear aquamarine to impenetrable darkness in what feels like seconds. The wind comes out of hiding, as if it had always been blustery. The change was gradual but you weren't watching every micro-movement of clouds that changed your world. In the same way, we tend to notice the accumulation of change all at once. Suddenly everything looks and feels entirely different. A new reality leaps into our awareness and we adapt to it as quickly as possible. This is how technology moves. Suddenly the coffee shops are filled with customers talking on their wireless headsets—as if things had always been that way. Nothing can undo these shifts except the next shift.

Layered manufacturing for low volumes has made it possible to experience a manufacturing "sea change" in our generation. Seemingly, all of a sudden, low-volume production of 100 to 30,000 parts is available as a reasonable manufacturing strategy for product development. With the enhancements in the technologies and materials, the use of layered manufacturing makes it possible to skip rapid prototyping (RP) and go directly to end-use, functional parts. Maybe our culture of instant gratification has driven us to innovation. You want it now. You get it now.

### *Industry Overview—A Nerd's Eye View of SLS*

SLS is a dynamically growing industry because the world wants mass customization now. Designers want parts faster. Managers want to save money by utilizing a process that allows them to make parts without the tooling time and expense. SLS means that you can shave weeks off the traditional product development cycle so that the process yields greater flexibility in the products you produce. The technology of SLS provides a basis for producing functional parts that withstand heat and environmental conditions, making it the clear choice for high-heat and chemically-resistant applications.

SLS has a strong reputation for making parts that can be used in a real environment. By using strong plastic materials—nylon—that provide very good mechanical properties, these parts bridge the chasm from being mere prototypes to being functional parts. An intake manifold is an excellent application for SLS. The heat-resistant SLS part can effectively be airflow-tested in an engine's exhaust system. The SLS part will be durable enough to be mounted on the engine and used in its real environment. Door handles are another good application for SLS because that SLS withstands a lot of force. Despite repeated use in the real world, these tough parts won't break.

While laser sintering technology and materials have not changed much in 15 years, EOS GmbH is making some exciting headway with experiments in composite materials. To really move the technology to the next level, materials have to become much more functional and practical. Parts have to resemble real-life parts. Unfortunately, a real part "look and feel" is still missing from the process. The technology and materials used are close to delivering real parts but are not quite there yet.

Engineers can view SLS as an option that allows for more creative thinking. Because they can get functional parts directly from CAD, engineers can cut guesswork out with revisions early in the design cycle. SLS is also an excellent solution for low-volume production of parts, meaning 100 to 30,000 parts. It is not recommended for high volume because, at a certain level, it makes more sense cost-wise to build a tool and produce from that to lower your price per part.

To understand the AF market competition, think of the competing sodas: Coke, Pepsi, and a third place cola. Like Coke, SL leads the parts market, with FDM and SLS in a close race for the second and third slot. A deeper knowledge of each process will help you choose the best way to support your thirst for innovative design.

### *Resolution—The Nitty Gritty*

Because the SLS laser beam spot size is relatively large, standard resolution for SLS is typically ± 0.005 to 0.006 inch (five to six thousandths) for the first inch, and ± 0.003 inch (three thousandths) for each additional inch, with a layer thickness of 0.004 inch (four thousandths).

With the additive process, the z height (vertical axis) standard tolerances of ± 0.01 inch (one ten-thousandth) will impact the first inch, and ± 0.003 inch (three thousandths) for every inch thereafter. Orientation defines how these will impact the part.

Unlike SL, with SLS there is no option for higher or super-high resolution. The spot size of the laser beam reduces the precision of the SLS system which cannot produce fine features. Being a heat-based system, the SLS material expands and contracts with changes in temperature, causing warpage and tolerance issues at a microscopic level.

### *Benefits—The Buzz is Real*

SLS is the bridging technology to get your parts right now without tooling development and cost. It allows you to skip the prototyping process and get your hands on durable, real parts fast. The chief benefits of SLS are tougher, heat-resistant, functional parts that embrace complex geometry. Thermoplastics used in SLS are also easily bondable and machinable, being less brittle than SL materials.

While SL encourages optimization of a 2D build platform, SLS features a full 3D build envelope. Parts can be “nested” electronically, so that boxes can be built inside boxes inside boxes. A fully utilized 3D build cube and its ability to utilize powdered materials make for fast production throughput. Since SLS does not require support structures, post-processing is already at a minimum.

A key advantage of SLS over SL revolves around material properties. Evolving into greater flexibility with new composites, SLS companies are now experimenting with a wide range of materials that approximate the properties of thermoplastics, composites, nylon, glass-filled nylon, metal composites, and ceramics.

To get the best result with SLS, remember that it favors thick, prismatic parts and does well with complex geometries if they are not too thin. Fine features, thin walls, and organic details are a no-no with this somewhat brutish process designed to make thick parts that last. SLS does not need post-curing but it does have a long cool-down period. A design with thin walls can be problematic, resulting in distortion and longer cooling times.

While the technology has not changed that much since its inception, SLS makes tough, durable parts that can be used in production. These parts and prototypes can withstand high temperatures; therefore, SLS is used frequently in aerospace and automotive applications where, for example, an engine part may be mounted and tested in its real environment. An SLS part is also very useful if you need to test a design for a hot liquid dispenser because it can stand the heat. Well-documented in manufacturing trade journals, here are some brief examples of SLS applications from industry leaders.

A major automotive company used SLS to compress cylinder head development time from 16 weeks to 4 weeks and reduce cost from $75,000 down to $12,000. A military jet project containing over 80 SLS parts makes full use of rapid technologies. Race car manufacturers, including Formula 1 teams, have used SLS for several years to make diverse parts such as housings and aerodynamic components. A high-end luxury car maker eliminated the need for an expensive injection molding tool by using SLS to produce parts for a window lifter assembly. Many case studies report the use of SLS for medical purposes such as hearing aids or prosthetics. Consumer product and electronics design is the largest industry sector using SLS, making up one-quarter of the SLS applications pie. Medical, automotive, and aerospace applications trail close behind as top industry users.

The future is bright for SLS. Because of part durability, it's a natural foundation of layered manufacturing and the future of custom plastic manufacturing. Reminiscent of the cartoon world of *The Jetsons*, this new technology will soon be able to reproduce replacement parts directly from the machine that needs one. In fact, space colonization how-to is based on using machines that can "build themselves" once they are shipped to the moon.

**SLS applications are unlimited.** Wander through the superstores and study the kitchen gadgets. It's all plastic, it's all relevant, and it's all good. You never know what invention this field trip may inspire.

As we head into mass customization in the product market, the flexibility of SLS will continue to reduce time and cost in product development and eventually allow the consumer more variety at or near the point of purchase.

Let's stop by Acme Design Corporation to see how our gentle hero Johnny Quickparts uses SLS to promote world peace, but only after his power nap.

### A Very Tall Tale—Johnny Quickparts and the Night of 1,001 Brackets

This time, Mr. Overrun was really scared. Something very strange had come up. A new clip design had to be submitted the next morning or, as Mr. Overrun believed based on a turbulent voice mail, his own head would be FedExed to the Sahara Desert.

The customer, a tyrannical computer manufacturer, in the tiny village of Mama-Khan, shipped computers by rail, which shook the daylights out of them. To make matters worse, the train would often get stopped by a sandstorm and sit baking under a fierce sun. Due to a failed clip, the printed circuit board internals were jumbled and melted by the time they arrived at the end-customer in the desolate village of Daddi-Khan-Tu. Then the entire emotional transaction would start all over again. Needless to say, billing disputes were mounting and bad blood was flowing back and forth between the small but passionate villages.

The clip designed to hold computer internals in place had failed nine train rides out of ten, but both parties continued to hope. This SSDD (same stuff, different day) rationale led to a modern-day feud between Mama-Khan and Daddi-Khan-Tu, involving indignant extended families and carrier pigeons that dropped mildly insulting notes back and forth.

Mr. Overrun begged on bended knee, "This is my absolute last emergency—I swear. It is a matter of life and death." Overrun had never pulled the Death Card before, so Johnny replied, "Okay, but how about a large Everything Pizza and a Big Gulp?" Mr. Overrun took off like a laser-guided missile.

Johnny loved the notion of saving Mr. Overrun's head, promoting world peace, and solving another impossible technical challenge, all in one whack. He donned his magic creation cap and left a voice mail for Sally Savealot in Procurement. He was surprised to hear himself barking like a tough manager to grease his purchase order. She just didn't get it that he was a technological Elvis.

Johnny munched a stack of Pringles while his engineering mind soared across an expanse of golden sand dunes. He put on his head phones, cranked up the theme to *Lawrence of Arabia* and began a new CAD file. "Freaky-deaky," Johnny exclaimed. This was indeed an impossible order. The customer needed a design in the morning and 1,001 brackets in a week. Acme typically needed six weeks and $10,000 to make a tool, plus $5 per plastic part. Johnny had to find a way to make 1,001 parts without going through the tooling process. His new clip also had to be heat-loving, train-friendly, and durable. This was serious pressure.

Johnny imagined himself swathed in flowing white cotton, riding a stately camel around the trainload of jiggled computers. He could imagine exactly what the customer needed: a durable, heat-resistant plastic bracket to hold down the printed circuit board (PCB) inside the computer cases. It would have a very cool shape as well.

Johnny was thrilled to have a bona fide reason to call Helen Helpalot of Quickparts. In her special way, Helen confirmed his superior choice for this unique application: SLS was an excellent choice for mounting PCBs in a super-hot computer chassis, using nylon to low-volume manufacture without tooling. Then she added, "Johnny, you really understand that layered manufacturing for low-volume production is more than just parts; it's a way of *seeing*. Did anyone ever tell you that you are really special?" Johnny choked and managed to squeak out a few words, "Only my Grandma but she has distorted non-rational thinking." They laughed their first belly laugh together which made the shy bachelor really nervous. He scraped himself off the ceiling and got back on his camel. It was time to work. The clamoring harem would just have to wait.

After the call, Johnny took a long drag on his candy cigarette. That Helen could fill up his senses like Christmas, Easter, and Halloween, all rolled into one. Just guessing her hair color unraveled him into a state of grinning non-productivity.

Johnny turned the failed PCB clip over and over in his hand until he became the part. All of a sudden he felt weak and unstable, being thin, flat, and poorly designed in two mating halves. If he squinted his eyes, he could see into the misty past; the designer of the old part was so low on endorphins that he had used two halves to accommodate the constraints of tooling—not a visionary way to design. In the old world, producing two pieces would have doubled his tooling cost.

Johnny called upon his creative powers to find a design combining grace and efficiency. His new clip design would rock from concept to materials. Those people in Daddi-Khan-Tu would smile ear to ear when they inspected the snug-fitting goods. Being a true hero, Johnny wanted the two villages to live in peace at last.

Knowing the material limitations of SLS, Johnny could only imagine the old clip design bowing like a Tupperware lid in the fierce Sahara sun. He decided to design a complex U-shaped clip, merging two parts into one. This would not only reduce distortion but add strength. He knew that SLS could handle it, since it was friendly to complex geometries.

By the time Johnny had finished designing, he realized he had been singing, "I Did It My Way" all night long. The first rooster crowed in a nearby cornfield. He emailed his new clip design file to Mama-Khan for the fly-through. He slurped down his last bag of Tang for Astronauts and waited for a happy email approving the CAD model for low-volume production parts in seven days.

Johnny recounted the beauty of his latest job's impact. If he were the customer, he'd be ecstatic to discover that the hefty tooling cost had been eliminated completely. He would also consider it pure magic that he could get his 1,001 parts in only seven days. Thanks to layered manufacturing, the customer would pay only $25 per SLS part and save six weeks on tooling. This would generate a million dollars in revenue by getting it to market that much quicker. He could see that engineers really do affect business.

Just then, a new email flew in, commanding Genius Johnny to

**"Go forth and multiply my parts!"**

With the click of the mouse, Johnny gave the green light to Helen Helpalot at Quickparts then stumbled home to his most exotic sleep ever. Johnny Quickparts dreamed of silk tents in the desert, a celebration feast of pomegranates and barbequed goat, happy sheiks with laptops, and super-approachable belly-dancers, all in a day's work.

## Boring but Necessary—Understanding SLS Limitations

In all AF processes, resolution is very important because all of the parts are created from minute layers. The resolution or detail that can be attained for each layer accumulates from layer to layer, and drives the output of the final part.

Because the SLS laser beam is relatively large, standard resolution for SLS is typically 0.005 to 0.006 inch (five to six thousandths). There is no option for higher or super-high resolution. As mentioned previously, these durable SLS parts can withstand high temperatures. However, part geometry determines the result since it is a heat-based process. Geometry will determine whether a part curls up or keeps its form. For example, a large flat part such as a cookie tray would bow up due to the residual stresses of heat in the process, whereas thick parts would typically do well. **Avoid using SLS for super-detailed parts or large, flat parts.** Mountable flat parts with bolt holes can work using this process. During the build, parts will warp slightly, but once mounted and fastened, the part will flatten and stay in place from pressure.

### *Part Features*

Features smaller than 0.005 inch (five thousandths) will not build well using SLS. If your part is finely detailed, you may want to consider other options. Features less than 0.030 inch (thirty thousandths) are considered high-risk. Think of SLS as a "man's man" process, making **tough parts for tough environments.**

### *Tolerances and Accuracy—Real World*

SLS is not nearly as accurate as SL. Accuracy for SLS ranges between 0.010 to 0.020 inch (ten to twenty thousandths). Parts that mate will need tolerances to support this difference in SLS. As previously mentioned, heat makes it difficult to control material properties. Don't expect tight tolerances in SLS, and be sure to adjust your design accordingly.

### *Part Orientation—How to "Grok" XYZ*

As with SL, part orientation is very important. Orientation in SLS also determines the definition of the layers and affects the resulting features. For example, a spherical part with a circular cross section must be oriented perpendicular to the laser beam to keep its roundness. Because SLS does not have support structures like SL, there is no orientation concern for supports.

### *Size Matters—Are We Surprised?*

Size options vary with SLS based on vat size and shape. Parts must fit onto build platforms measuring 11 x 13 x 17 inches. If you want to build an uncut, single-piece part, its dimensions must be less than 10 square inches. Otherwise, it will have to be electronically split, built in two parts, and then rejoined after the build. If your parts are large, the typical option is to split and rejoin; however, there are options. Service providers should be able to advise you on how splits are geometry-driven.

For serious designers and engineers ready to get started, please note that while the maximum dimension for instant quoting is 11 x 13 x 17 inches, the SLS build envelope is much bigger than that. For bigger parts, you may consider SL as an option. There will be some manual guesstimating in the quoting process related to splitting and rejoining pieces. When splitting a part, remember that thin parts are difficult; blocky parts work well.

Because SLS features a fully 3D build envelope, opportunities for orientation and creative nesting of parts abound. Here's a simple way to explain nesting to your grandma: just imagine a magic oven that can stack and bake 20 cookie sheets all at once. Don't confuse her by telling her that she could bake small cookies inside of bigger cookies, all at different angles.

### *Material Types—It's All Powder*

The good news is that the SLS process provides one of the most functional AF parts available. The bad news is that these powdered materials and their variations are about as exciting as competing aspirin labels.

Material choices for SLS include Duraform (a polyamide nylon material), DuraformGF (glass-filled), Somos 201 (flexible, rubber-like), and Castform (wax). If that means absolutely nothing to you, don't panic. All you really need to remember is that SLS uses a variety of plastic materials and binders to produce parts. Parts made by SLS are about 10 times tougher than SL parts and the same strength as FDM parts. Because of porosity at a microscopic level, SLS is not water-resistant. A super glue-like sealant is needed in finishing.

### *How Will My Part Look?*

Don't be mad or sad if you open your FedEx box only to find that your SLS parts are not very pretty. SLS parts have a sandy, porous surface. While SL can be processed and painted to look aesthetically pleasing, SLS does not take kindly to sanding, priming, or painting. It *could* be done if it had to be done, in the same way that you *could* fit a refrigerator in a car trunk, but only if you are really looking for that kind of fun.

Because there are no support structures with SLS, no strip-and-ship option is available. These parts are always sanded before delivery into customer hands. Because SLS is naturally rough, it can be sanded smooth but not sleek. Although it affects tolerance, SLS parts are dipped into a "super glue" to make them stronger and smoother.

- **Finishes**

With SL there are a number of options for finishing, but with SLS you get a standard, sanded finish. SLS is the functional workhorse, while SL is the show pony.

### *How Long Does it Take to Get My Part?*

Like SL parts, delivery of most SLS parts is fast—typically three to five working days. But, depending on the part size and complexity, your parts can take weeks to build. There is no Next Day offered with SLS. While parts do build fast, the machine takes hours to cool before the parts can be removed. With SL, there is no cool-down time.

With SLS, you can have build failures, but you won't know it until the part is completely built then excavated out of a pile of white plastic powder. Imagine an archaeologist carefully brushing away small amounts of dust until the treasure, your part, is revealed. With SLS post-processing, take extra care to avoid damaging the part. With the SL process, you can watch as the part is building. With SLS, you are going on blind faith until it is ready, hoping that the part turns out well. But take heart—the failure rate of SLS is low, so it is not a huge concern.

## Saving Time, Saving Money—Saving Thousands with SLS

### *How Do I Save Money Using SLS?*

Although SLS costs approximately 20% more than SL, its advantages more than justify the cost increase. The SLS process typically saves the entire cost of tooling; therefore, the cost per part is justifiably higher.

- **Family Build Concept**

As mentioned in the SL discussion, economies of scale also relate to SLS. While SL builds on a 2D platform, SLS builds in a fully 3D envelope so parts can be run with high efficiency. The operational waste is distributed among all the parts in the vat: the more parts you build at one time, the less they cost. A good way to visualize the 3D envelope is to remember the magic oven that stacks 20 cookie sheets fully loaded, all at the same time.

- **Multiple Quantity Part Orders**

As with SL, informed customers know that the cost per unit dramatically drops when you order multiple quantities of different parts. In traditional pricing, the first widget costs $300, so traditional quoting would estimate that 10 different widgets would cost $3,000. However, with family builds, the first widget costs $300 because the operational overhead is factored into the first part, but the next 9 are made without a factor of operational waste, so the total price of 10 would be $1,500. Buyers like seeing the cost per unit drop from $300 to $150 each. With family build, everybody wins. The savings are considerable.

- **Multiples of One Part**

Experienced customers also know that the cost per unit dramatically drops when ordering multiple quantities of one part. In traditional pricing, a battery door costs $200, so 3 battery doors would cost $600. However, using family build thinking, the first battery door costs $200, and the next 2 are made without operational waste. Therefore, the total price of 3 battery doors is $350.

- **Single Material**

Significant savings result from building all of your SLS parts in a single material, combined with a family build. Every time the SLS machine stops to change materials, extra labor and operational overhead are factored into the order. Plan carefully to find one material that suits all your needs.

### *How Do I Waste Money in the SLS Environment?*

If you are really committed to wasting money, be sure to ask for the wrong part orientation, order parts one at a time, and use several materials to increase the operational overhead factor. You can also send bad or outdated CAD or STL data, and haggle using the old-fashioned manual quoting methods. Service providers will avoid you at all costs.

Joking aside, cutting and rejoining big parts in SLS is a real challenge that can waste money. The SLS process often presents tolerance issues resulting from material warpage and heat, making splitting and rejoining a part very tricky. Twist and distortion in a part are usually not visible until it's too late. Design thick areas that can easily be rejoined, or consider using another process.

### *How Do I Save Time Using SLS?*

Because parts are built in a vat of powder without support structures, SLS parts require less finishing. While an SL part takes hours to finish, SLS is a batch finishing process where all the parts are dug out of the powder at once. The only time-eater here is that SLS powder takes hours to cool down.

SLS is unique in its capacity to build nested parts, like the hollow, egg-shaped Matrioshka dolls of Russia that have progressively smaller versions inside. If that's hard to visualize, imagine how a chef makes a Thanksgiving "Turducken." He stuffs a chicken inside a duck inside a turkey. With SLS you can also build a box inside a box inside a box. Therefore, you can use this process to build functional parts that fit together. So, you can build fully functional assemblies with SLS since the supports are not in the way. If you need a meshing gear and housing, the SLS system can build rotating gears inside a housing. Moving parts make great samples for your customers. They love to see and play with actual working parts.

Another huge timesaver is using layered manufacturing to build parts for production. Companies needing a low-volume run—only 100 to 30,000 parts—use SLS to completely bypass the hassles and expense of tooling.

As with all AF processes, be sure you learn as much as possible about materials before launching an SLS project. Always double-check your CAD files for faceting, and be sure to send the correct version or latest CAD data to your service provider. Get comfortable using instant quoting and save valuable engineering hours by eliminating the laborious, manual quoting process.

### *How Do I Waste Time in the SLS Environment?*

Typical time-eaters lurk in every process. Informed customers understand the pitfalls of great expectations based on wrong assumptions. If you select the wrong material based on your part's geometry, you can get a warped surprise. If you need flat, thin parts or fine features, SLS is not the process for you. **Be sure to understand the limitations inherent in any process you choose.**

## The Keys to a Brand New Maserati

By now you're revved up about SLS technology and the functional, durable, heat-resistant parts it offers. You've witnessed Johnny Quickparts as he saved Overrun's head with an ingenious design and a low-volume production run in SLS. You've learned that SLS builds in a fully 3D envelope, and makes macho parts out of thermoplastic powder. You know the most common mistakes in the SLS process result from sending wrong CAD files and designing out of tolerance. Wrong orientation and poor communication can make an SLS project flop.

You also know that SLS has no support structures and that its tolerance is less than SL. By now you are loving economies of scale and you want to apply it to everything, especially pizzas. You know how to avoid the SLS pitfalls that can happen with flat parts or fine features, and you are one step closer to becoming QuickSMART.

As Johnny would say,

**"Fire it up."**

## About the Author

**Ronald L. Hollis, Ph.D., P.E.** is the President, CEO, and Co-founder of Quickparts.com, Inc. He provides experience, leadership, and knowledge in the development of a leading business in the product development market. With his vision and drive, he has been able to lead an innovative, entrepreneurial, and fast-growing company that helps product developers succeed.

Ron and his company have received many awards and recognitions including: 2005 and 2006 Deloitte Fast 500; Finalist Small Business Person of the Year from Atlanta Metro Chamber of Commerce and Atlanta Business Chronicle; 2004 Ernst and Young Finalist Entrepreneur of the Year; 2004 Innovator of the Year by Catalyst Magazine; Top 50 Entrepreneurs of Atlanta; Hot 100 List from Entrepreneur Magazine; 2004 INC 500 company.

Ron is a graduate of MIT/INC Birthing of Giants, the former President of the Atlanta Chapter of Young Entrepreneur's Organization (YEO), a member of Young President's Organization (YPO), a corporate sponsor of Hands-On Atlanta charity organization, and serves on the boards of other entrepreneurial companies.

He earned a BS in Mechanical Engineering from the University of Alabama, worked as a design engineer on Space Station Freedom for Boeing, earned an MS in Engineering and a Ph.D. in the management of technical business, and is a registered Professional Engineer. He is also a private pilot and enjoys boating.

Ron currently lives in Atlanta with his wife, Melanie, of more than 15 years and their son, Jackson.